SITE CONCEPTUAL MODEL UPDATE AND CONTAMINANT ATTENUATION ZONE DELINEATION

WASTE MANAGEMENT RICHMOND LANDFILL SITE

Submitted to:

Waste Management of Canada Corporation
1271 Beechwood Road
R.R. #6 Napanee, ON K7R 3L1

Prepared by:

BluMetric Environmental Inc.
4 Cataraqui Street
The Woolen Mill, The Tower
Kingston, ON K7K 1Z7

Project Number: 180150-02
15 October 2018

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1. INTRODUCTION

This report is an update to the Site Conceptual Model (SCM) Update and Contaminant Attenuation Zone (CAZ) Delineation report dated January 2016 (BluMetric, 2016a), Addendum dated April 2016 (BluMetric, 2016b) and SCM Update and CAZ Delineation report dated July 2017 (BluMetric, 2017). The purpose of this document is to provide supplementary technical information to support Waste Management of Canada Corporation's (WM) upcoming application to amend Environmental Compliance Approval (ECA) No. A371203 for the WM Richmond Landfill (the Site), to incorporate the use of a land parcel as a CAZ to bring the Site into compliance with the Reasonable Use Limits (RULs) in Guideline B-7, and the continued use of the property for general rural purposes. The site location is presented on Figure 1.

The complementary hydrogeological work described in this report was conducted to address the concerns outlined in the technical review comments from Ministry of the Environment, Conservation and Parks (MECP) hydrogeologist Shawn Trimper, as outlined in his letter dated November 10, 2017. These review comments and a possible work plan to address outstanding concerns were discussed with MECP hydrogeologists during a meeting held on February 23, 2018.

The proposed scope of work, outlined in a memorandum dated March 20, 2018[1], was reviewed and accepted by MECP technical staff in their letter dated April 5, 2018. The work plan was developed to further characterize:

- The shallow groundwater flow zone within the central proposed CAZ area, with principal objectives to (1) define shallow groundwater occurrence and flow direction, and (2) delineate the extents of landfill leachate derived impacts; and
- Groundwater conditions (quality and flow) within the western area of the proposed CAZ to the south of Beechwood Road.

The methodology associated with these tasks, including additions and adjustments made based on interim results obtained throughout the investigation, are described in more detail in Section 2 while results from the complementary investigation are provided in Section 3. Section 4 provides a discussion and interpretation of the results including an update to the hydrogeological SCM

[1] *Proposed Work Program for Complementary Investigation of Groundwater Flow and Potential Impacts in South-Central and Western Areas of the Proposed CAZ, Waste Management Richmond Landfill, Town of Greater Napanee*, BluMetric, March 20, 2018

based on historical and recent results. Finally, Section 5 provides updated recommendations regarding the proposed CAZ associated with the Richmond Landfill.

2. FIELD PROGRAM

The reader is referred to the site plans on Figure 2a (including landfill area and proposed CAZ) and Figure 2b (proposed CAZ only) where monitoring locations are shown, including new and existing locations discussed in the following sections.

2.1 SHALLOW FLOW ZONE IN CENTRAL AREA OF PROPOSED CAZ

The objective of this task was to provide additional information on the shallow groundwater flow regime and quality in the area located in the south-central proposed CAZ area where a shallow groundwater divide has been inferred based on local ground surface topography and information from previous investigations.

Thirteen (13) new shallow monitoring locations were established (Table 1), generally comprised of a shallow bedrock or bedrock/overburden contact well and a shallow overburden drive point piezometer (exceptions are noted in Table 1). The locations of additional shallow monitoring wells and drive point piezometers (labelled with suffix "DP") in the central portion of the proposed CAZ, along with the existing monitoring network, are shown on Figure 2b.

Table 1: Shallow monitoring locations and rationale

Location	Rationale
North Side of Shallow Groundwater Divide	
M207 M207-DP	Area of minimal groundwater discharge marking the eastern extent of the central discharge area. Provides shallow horizontal gradient information and quality evaluation
M206 M206-DP	Area of shallow groundwater discharge with ephemeral pond. Provides shallow horizontal gradient information and quality evaluation
M204 M204-DP	Provides shallow vertical gradient information, groundwater elevation and quality evaluation
M203	Shallow groundwater well only. Required for horizontal triangulation and piezometric surface contouring north of groundwater divide
M200 M200-DP	Provides vertical gradient information (shallow and intermediate bedrock zones) similar to M178R nest, groundwater elevation and quality evaluation
M199 M199-DP	Provides shallow vertical gradient information, groundwater elevation and quality evaluation
South Side of Shallow Groundwater Divide	
M201 M201-DP	Provides shallow vertical gradient information, groundwater elevation and quality evaluation

Location	Rationale
M202	Shallow groundwater well only. Required for horizontal triangulation and piezometric surface contouring south of groundwater divide
M205 M205-DP	Provides shallow vertical gradient information, groundwater elevation and quality evaluation
M209-DP	Added after installation and testing of M199 through M208 to provide additional control on groundwater flow direction to the south since M202 was slow to recover and the water level was not static (discussed in Section 3.1)
M210-DP	Added after installation and testing of M199 through M209-DP to provide a control point on groundwater flow direction in the southeastern portion of the central CAZ
M211-DP	
In Vicinity of Groundwater Divide	
M208-DP	Drive point piezometer only. Area of shallow groundwater discharge. Provides groundwater elevation for horizontal triangulation

2.1.1 Borehole Drilling

Shallow boreholes M199 through M207 were drilled between April 3 and 18, 2018 (Figure 2b). Drilling was completed by GET Drilling Ltd. of Napanee, ON, using air-rotary techniques. Supervising BluMetric staff made notes regarding stratigraphy and water encountered during drilling. Borehole logs are provided in Appendix A.

2.1.2 Monitoring Well Installation

The target monitoring well screen elevations were identified from all available results and discussed with MECP hydrogeologists prior to installation. A summary of monitoring well construction details is provided in Table 2 while complete borehole logs and monitoring well installation details are provided in Appendix A.

Table 2: Summary of Shallow Monitoring Well Construction Details

Monitoring Well	Easting	Northing	Ground Surface Elevation (masl)	Bedrock Elevation (masl)	Screened Interval (masl)
M199	335717	4902027	115.51	115.08	112.00 - 113.53
M200	335793	4902060	115.40	114.97	112.05 - 113.58
M201	335829	4901991	115.47	113.64	111.20 - 112.73
M202	335932	4902013	116.48	116.18	113.16 - 114.68
M203	335709	4902128	118.18	117.11	115.13 - 116.66
M204	335910	4902186	116.06	114.54	111.49 - 113.01
M205	336077	4902128	115.83	114.92	112.32 - 113.85
M206	335938	4902329	118.89	117.98	115.69 - 117.21
M207	336131	4902261	116.45	115.99	113.04 - 114.56

2.1.3 Hydraulic Testing

Single-well response tests were conducted at each of the new shallow monitoring wells on June 20 and 21, 2018 to estimate transmissivity/hydraulic conductivity in the immediate vicinity of the well. Rising-head tests (instantaneous decrease in water levels) were conducted in each monitoring well.

The analysis software AquiferTest™ was used to estimate hydraulic conductivity from the rising head test data. Hydraulic testing analytical data sheets are provided in Appendix C and are discussed in Section 3.1.2 below.

2.1.4 Drive-Point Piezometer Installation

Eleven (11) drive-point piezometers, labelled M199-DP, M200-DP, M201-DP, M204-DP, M205-DP, M206-DP, M207-DP, M208-DP, M209-DP, M210-DP and M211-DP, were installed between April 17 and 24, May 4, and July 10, 2018. The drive-point piezometers were constructed of 1.25" (31.75 mm) diameter stainless steel with a 0.46 m screen length, driven down to refusal, believed to correspond to bedrock surface at these locations based on known depth to bedrock information from nearby wells. A summary of piezometer construction details is provided in Table 3. Complete installation details are provided in Appendix A.

Table 3: Summary of Piezometer Construction Details

Monitoring Well	Easting	Northing	Ground Surface Elevation (masl)	Screened Interval (masl)
M199-DP	335722	4902014	115.17	114.45 - 114.95
M200-DP	335804	4902054	115.19	114.34 - 114.84
M201-DP	335828	4901991	115.21	113.52 - 114.02
M204-DP	335909	4902187	116.01	114.70 - 115.20
M205-DP	336077	4902130	115.67	114.79 - 115.29
M206-DP	335961	4902294	117.79	116.35 - 116.85
M207-DP	336135	4902191	116.36	115.22 - 115.72
M208-DP	336063	4902196	115.70	114.56 - 115.06
M209-DP	335838	4901957	116.20	113.86 – 114.32
M210-DP	336146	4902133	116.34	115.55 – 116.01
M211-DP	336087	4902048	116.76	115.54 – 116.00

2.1.5 Groundwater Level Measurements

Water levels were recorded using an electronic water level meter from the new and existing shallow groundwater monitoring wells and drive point piezometers in the central area of the proposed CAZ on May 14, June 11, June 28 and July 12, 2018.

2.1.6 Groundwater Sampling

Groundwater samples were collected on June 11 and September 6, 2018 from all new, as well as existing shallow monitoring wells located in the central CAZ area (M178R-5 and M188-2), using dedicated Waterra inertial lift pumps (foot valves) connected to dedicated polyethylene tubing. Monitoring wells M178R-5, M205 and M206 were re-sampled June 28, 2018 for verification of the initial results.

A minimum of three casing volumes of water were removed from each monitoring well prior to the collection of groundwater samples. During purging, readings for pH, conductivity and temperature were recorded on a regular basis. The stabilization of the parameters was used to assess when well purging was complete. However, if the monitoring well purged dry it was allowed to recover until sufficient volume was available for sampling. Purge water was collected for transport to the Napanee WWTP for disposal.

All water samples were placed in bottles supplied and prepared by the laboratory. The samples were packed in coolers with ice and shipped by courier to the laboratory. Samples were analysed by Maxxam Analytics Inc. of Mississauga, ON, which is accredited by the Canadian Association for Laboratory Accreditation Inc. (CALA).

The samples were analyzed for general/inorganic parameters and VOCs shown in Table 4, which correspond to those in Tables 2 and 3 from the Interim Environmental Monitoring Plan (EMP) dated April 2016 (BluMetric, 2016c).

Table 4: Groundwater Quality Analytical Parameters

Inorganic and General Parameters	Total Dissolved Solids (TDS), Conductivity, Alkalinity, Calcium, Magnesium, Sodium, Potassium, Boron, Iron, Manganese, Ammonia (total), Nitrate, Nitrite, Chloride, Sulphate, Dissolved Organic Carbon (DOC)
Volatile Organic Compounds (VOCs)	1,4-Dioxane, Benzene, Toluene, Ethylbenzene, m&p-Xylene, o-Xylene, Styrene, 1,3,5-Trimethylbenzene, Chlorobenzene, 1,2-Dichlorobenzene, 1,3-Dichlorobenzene, 1,4-Dichlorobenzene, Chloromethane, 1,1,2,2-Tetrachloroethane, 1,1,1,2-Tetrachloroethane, 1,1,1-Trichloroethane, 1,1,2-Trichloroethane, 1,1-Dichloroethane, 1,2-Dichloroethane, Chloroethane, 1,1-Dichloroethylene, Cis-1,2-Dichloroethylene, Trans-1,2-Dichloroethylene, Trichloroethylene, Tetrachloroethylene, Vinyl chloride

2.2 Intermediate Bedrock Flow Zone in Western Area of Proposed CAZ

Three boreholes (M196, M197 and M198) targeting the intermediate bedrock groundwater flow zone were drilled in the western portion of the proposed CAZ to characterize groundwater conditions in this area. The locations of the boreholes and existing monitoring wells are shown on Figure 2b.

2.2.1 Borehole Drilling and Downhole Geophysical Testing

Boreholes M196, M197 and M198 were drilled between April 2 and 16, 2018. Drilling was completed by GET Drilling Ltd. of Napanee, ON, using air-rotary techniques. After drilling through the overburden, steel casing was installed from ground surface and cemented into the upper portion of the bedrock. Supervising BluMetric staff made notes regarding stratigraphy and water encountered during drilling. Borehole logs are provided in Appendix A.

DGI Geoscience Inc. of Toronto, ON conducted downhole geophysical surveys of the new boreholes; optical televiewer (OTV) logs, along with caliper logs and interpreted features encountered in the boreholes, are provided in Appendix B.

2.2.2 Hydraulic Testing

Water levels were monitored at each of the open boreholes over 21 days and the recovery data were analyzed using the analysis software AquiferTest™ to estimate hydraulic conductivity. Hydraulic testing analytical data sheets are provided in Appendix C and are discussed in Section 3.2.2 below.

2.2.3 Groundwater Level Measurements

Groundwater level measurements were collected over 21 days as part of the hydraulic testing as indicated above, and on May 14, 2018 as part of the full round of water levels collected during the Spring 2018 sampling event using an electronic water level meter in the open boreholes (M196, M197 and M198).

2.2.4 Groundwater Sampling

Samples were collected from the open boreholes on May 4, 2018 using disposable bailers and submitted to Maxxam for analysis of 1,4-dioxane.

2.2.5 Borehole Decommissioning

Boreholes M196, M197 and M198 were decommissioned following receipt of sample analysis results as the hydraulic conductivity measurements revealed that the rock was very tight and not appropriate for monitoring well installation.

3. RESULTS

3.1 Shallow Flow Zone in Central Area of Proposed CAZ

3.1.1 Geology

The conditions encountered in boreholes M199 through M207 are consistent with previous interpretations of the local geology. The overburden thickness at these locations was thin, ranging from 0 to 1.8 m, and where present consisted of clay, sandy clay, or clayey sand till. Limestone bedrock was encountered in the boreholes at elevations between 113.64 and 117.11 masl. Borehole logs are provided in Appendix A.

3.1.2 Hydraulic Conductivity

Table 5 presents the hydraulic conductivities estimated at each monitoring well, ranging between 3.7×10^{-10} and 2.2×10^{-5} m/s, while the analysis data sheets are included in Appendix C.

Table 5: Hydraulic Conductivities in New Shallow Groundwater Monitoring Wells

Well	Hydraulic Conductivity (m/s)
M199	5.5×10^{-09}
M200	1.1×10^{-05}
M201	5.1×10^{-10}
M202	3.7×10^{-10}
M203	1.2×10^{-06}
M204	4.8×10^{-09}
M205	2.2×10^{-05}
M206	2.0×10^{-05}
M207	2.7×10^{-09}

3.1.3 Groundwater Elevations

Groundwater levels were measured as part of the routine spring monitoring event from all shallow groundwater flow zone monitoring locations, including previously existing and new

wells and drive point piezometers, across the WM Richmond Landfill site and south of Beechwood Road within the proposed CAZ area.

A map showing the groundwater elevations and the potentiometric contours interpreted from the data for the landfill area is presented on Figure 3. The groundwater flow patterns in the shallow groundwater flow zone within the landfill property North of Beechwood Road have been observed from previous results over several years to be highly predictable. The most recent groundwater contour map from May 14, 2018 (Figure 3) is consistent with historical results and shows that shallow groundwater elevation is influenced by topography and surface water features. The Empey Hill drumlin, a local topographic high located southwest from the landfill, creates a local flow divide, with shallow groundwater being directed both to the north and the south towards areas of lower hydraulic heads. North of the landfill, shallow groundwater converges towards Marysville Creek in the area immediately east of County Road 10 (Deseronto Road), while shallow flow in the southern portion of the site converges on Beechwood Ditch and the southern pond system. Shallow groundwater east of the landfill is influenced by a local zone of higher water levels in the vicinity of monitoring well M96; shallow groundwater north of M96 flows to the north-northwest and ultimately Marysville Creek, while groundwater south of M96 flows to the south-southwest, towards Beechwood Ditch and the stormwater management ponds.

Further south, within the central portion of the proposed CAZ, shallow groundwater elevations were measured on May 14, June 11, June 28 and July 12, 2018 from the newly installed monitoring wells and drive point piezometers[2], as well as existing shallow monitoring wells M178R-5 and M188-2, and piezometers DP01-16, DP02-16 and DP03-16. Results are shown in Table 6 and on Figure 4a. Figure 4b shows the groundwater elevations from June 11, 2018 relative to ground and bedrock surfaces in cross-sectional view oriented approximately perpendicular to the inferred east-west shallow groundwater flow divide in this topographically low area.

Table 6: Groundwater Elevations in New Shallow Groundwater Monitoring Wells and Drivepoint Piezometers – May 14, June 11, June 28 and July 12, 2018

Monitoring Location	GW Elevation (masl)			
	May 14, 2018	June 11, 2018	June 28, 2018	July 12, 2018
M199	115.71	115.58	115.67	115.30
M199-DP	115.56	115.51	115.58	115.05

[2] Piezometers M210-DP and M211-DP were installed July 10, therefore, only July 12, 2018 water level data are available from these locations.

Monitoring Location	GW Elevation (masl)			
	May 14, 2018	June 11, 2018	June 28, 2018	July 12, 2018
M200	115.49	115.58	115.46	115.00
M200-DP	116.49	116.36	116.38	115.80
M201	115.53	115.47	115.48	115.03
M201-DP	115.16	115.16	115.19	114.90
M202	115.08	115.04	115.08	114.58
M203	115.12	115.01	115.06	114.45
M204	115.14	115.01	115.15	114.53
M204-DP	115.21	114.28	113.91	114.58
M205	115.23	115.17	115.12	114.83
M205-DP	114.12	113.80	113.58	113.85
M206	116.94	116.93	116.90	116.64
M206-DP	115.49	115.24	115.16	115.04
M207	116.02	115.74	115.91	115.14
M207-DP	115.79	115.68	115.70	115.13
M208-DP	115.61	115.60	115.55	115.07
M209-DP	118.75	118.63	118.44	118.25
M210-DP[2]	-	-	-	Dry
M211-DP[2]	-	-	-	115.46

Water levels at monitoring wells M201 and M202 were excluded from potentiometric contouring (Figure 4a) because water levels are very slow to recover at these locations, likely due to very low hydraulic conductivities in the immediate vicinity of these wells (Section 3.1.2). M210-DP was dry during the July 12, 2018 water level round.

Results were consistent between dates and showed that the shallow potentiometic surface within the central area of the proposed CAZ is highest to the north (M203, M206, M178R-5) and south (M209-DP, M211-DP) and lowest in the area closest to the east-west topographic low and surface water course (M199, M200). Shallow groundwater in this area correlates well with the elevation of the ground and bedrock surfaces. The groundwater elevations confirm the presence of a shallow groundwater divide in the central portion of the proposed CAZ.

Vertical hydraulic gradients were evaluated by comparing groundwater elevations at locations where both a shallow monitoring well and nearby drive point piezometer were installed. Upward vertical gradients were observed at monitoring locations M178R, M199 and M205, consistent with historical observations of groundwater discharge at some locations north of the inferred shallow groundwater divide. This suggests that shallow groundwater discharges to surface in this area of the proposed CAZ. Examination of the shallow groundwater elevations in plan and cross-sectional views (Figures 4a and 4b) confirms the presence of an east-west trending

groundwater divide, with shallow groundwater converging from the north, east and south towards the low hydraulic head area. This shallow groundwater divide corresponds to the low lying area where a local surface water course runs from east to west between two dug ponds.

Vertical gradients were inconsistent between monitoring events at M200 and M201 where hydraulic conductivity was extremely low and water levels were likely not static, while downward vertical gradients were observed locally at location M204.

3.1.4 Groundwater Chemistry

The shallow groundwater chemistry results for samples collected from the new wells, and existing monitoring wells M175R-5 and M188-2, on June 11 and September 6, 2018 are presented in Table A. Confirmation re-sampling results from June 28, 2018 at monitoring wells M178R-5, M205 and M206 are also included in Table A.

Background concentrations for leachate indicator parameters in the shallow flow zone at the WM Richmond Landfill site are presented in the EMP (BluMetric, 2016c) for the site along with the calculated Guideline B-7 Reasonable Use Limits (RULs) for those parameters that have Ontario Drinking Water Standards.

Existing monitoring well M178R-5 had 1,4-dioxane concentrations ranging from 0.0056 to 0.0059 mg/L, and several parameters exceeding RULs (alkalinity, DOC, iron and TDS). Results for M205 and M206 also reported detectable concentrations of 1,4-dioxane (between 0.001 and 0.003 mg/L), as well as RUL exceedances of iron and manganese (M206 only) and TDS. Low concentrations (below applicable RUL) of some VOCs were also measured at these wells: 1,1-dichloroethane (M178R-5 and M206), benzene (M178R-5), chloroethane (M178R-5 and M205), xylene (M205) and toluene (M178R-5).

1,4-dioxane was not detected in any other shallow monitoring wells in the central area of the proposed CAZ (M199, M200, M201, M203, M204, M207 and M188-2). Results for several wells, M199, M200, M201, M203, M204 and M207, indicate that manganese exceeded the RUL, and iron and TDS also exceeded the RUL at M203; however, all other parameters were below the RULs. Low concentrations (below applicable RUL) of some VOCs were also measured at these wells: 1,3,5-Trimethylbenzene (M201), benzene (M207), xylene (M199, M201 and M207) and toluene (M207).

These results are consistent with the presence of a shallow groundwater flow divide in the central portion of the proposed CAZ, corresponding with the topographic low area and surface water course. The extents of impacts in the shallow flow zone of the central area of the proposed CAZ

are well defined based on chemistry and hydraulic gradients. Shallow groundwater impacted by landfill leachate is present at M178R-5, M205 and M206, located in an area where discharge of leachate impacted groundwater has been observed as seeps at surface during wet periods. Groundwater characteristic of background chemisty and exempt of landfill leachate impacts was observed at other shallow groundwater monitoring wells installed at locations along the surface water course.

3.2 Intermediate Bedrock Flow Zone in Western Area of Proposed CAZ

3.2.1 Geology

The overburden materials and bedrock encountered in boreholes M196, M197 and M198 were consistent with previous interpretations of the local geology. The overburden thickness at these locations was 0.7, 1.6 and 3.3 metres, respectively, and consisted of topsoil and silty or sandy clay over till (till unit absent at M196). Limestone bedrock was encountered in boreholes M196, M197 and M198 at elevations of 116.61, 117.96 and 116.43 masl, respectively. Borehole logs are provided in Appendix A.

Downhole geophysical log results do not reveal any notable open joints/fractures in the new boreholes (Appendix B).

3.2.2 Hydraulic Conductivity

Hydraulic testing analytical results are provided in Appendix C. Hydraulic conductivity values derived from open borehole recovery data are summarized in Table 6 below and comfirm the extremely low permeability of the rock mass in this area (5.6×10^{-12} to 3.3×10^{-11} m/s). This is consistent with observations from previous investigations, where boreholes M120 and M124 (see Figure 2b) were observed to have extremely low rock mass permeabilities.

Table 7: Summary of Hydraulic Conductivity Values

Borehole	Hydraulic Conductivity (m/s)
M196	2.6×10^{-11}
M197	5.6×10^{-12}
M198	3.3×10^{-11}

3.2.3 Groundwater Levels

Groundwater levels were measured on May 14, 2018 at 71 Intermediate Bedrock Flow Zone monitoring locations as prescribed in the EMP (BluMetric, 2016c). A map showing the

groundwater elevations and the potentiometric contours interpreted from the data is presented on Figure 5.

The groundwater in the intermediate bedrock flow zone has been observed from previous results to generally flow to the north, west, and south relative to the landfill. South of the landfill footprint, the groundwater flow orientation is to the south and southeast, and continues onto the proposed CAZ properties south of Beechwood Road.

The most recent groundwater contour map (Figure 5) is consistent with historical results and shows that the water levels in the monitoring wells within the areas to the west, east and directly south of the landfill and Beechwood Road are very similar with a relatively large region with groundwater elevations between approximately 122 and 123 masl. This is indicative of an area of rock with a relatively higher bulk hydraulic conductivity, and with a well-connected fracture network resulting in lower hydraulic gradients. Conversely, the areas to the southwest and southeast exhibit steep hydraulic gradients (closely spaced piezometric contours and rapidly declining hydraulic heads over short distances) and artesian conditions in some locations (e.g., M167, M178R-2 and -3).

Boreholes M196, M197 and M198 (see Tables 7&8 and Figure 2b) were dry immediately after drilling and exhibited a very slow recovery rate (between 0.05 and 0.29 m/day), and had not reached static conditions after several weeks.

Table 8: Groundwater Elevations in New Intermediate Bedrock Boreholes – May 14, 2018

Borehole	Easting	Northing	GW Elevation (masl)
M196	335321	4902128	Not static
M197	335177	4902253	Not static
M198	335007	4902294	Not static

3.2.4 Groundwater Chemistry

1,4-dioxane was below the detection limit of 0.001 mg/L in all three open borehole samples (Table A).

4. INTERPRETATION AND UPDATE TO SITE CONCEPTUAL MODEL

The current SCM for the WM Richmond Landfill was initially introduced in BKA and WESA (2009). Refinements to the SCM were developed as part of the Action Plan investigation documented in BKA and WESA (2012). Subsequent phases of hydrogeological investigation

beginning in 2012 have focused on properties south of Beechwood Road, as well as the adjacent property to the east of the WM property and north of Beechwood Road. The information obtained from these complementary investigations has been used to further refine and extend the SCM, and to establish the extent of the proposed CAZ for the site. The most recent updates to the SCM were provided in BluMetric (2016a, 2016b and 2017). The information has also been used to develop the interim EMP for the landfill (BluMetric, 2016c).

This section provides an up-to-date conceptualization of the SCM for the WM Richmond Landfill, building on the previous SCM updates presented in the documents listed above, among others, and taking into account the findings from the latest hydrogeological investigation documented in sections 2 and 3 of the present report. Section 5 provides recommendations related to the proposed CAZ boundary based on the updated SCM and delineation of landfill leachate impacted groundwater.

4.1.1 Geology

The Richmond Landfill Site is located within the Napanee Plain which, on a regional scale, is a flat to slightly undulating plain of limestone dipping slightly to the south and typically covered with a relatively thin veneer of overburden. In the immediate vicinity of the Site, the ground surface slopes approximately 1 m to 3 m per kilometre to the south. A drumlin (Empey Hill) is present on the Site southwest of the landfill. The dominant drainage feature on the Site is Marysville Creek located north of the landfill, while Beechwood Ditch provides Site drainage south of the landfill.

The overburden consists of less than 0.5 m to 10 m of clayey silt till and thickens to approximately 20 m in the area of Empey Hill to the southwest of the landfill. The overburden is underlain by the Verulam Formation which consists of horizontally bedded, medium to coarse crystalline limestone with interbedded shale layers. The Verulam is interpreted to be a few metres thick at the Site and is underlain by the Bobcaygeon Formation which generally consists of horizontally bedded, crystalline limestone with interbedded shale in the upper part and interbedded calcarenite in the lower part. The thickness of the Bobcaygeon Formation beneath the Site varies from approximately 11 m to 15 m. The Bobcaygeon Formation is underlain by the Gull River Formation which consists of horizontally bedded limestone and exhibits a thickness of approximately 75 m beneath the Site.

Three distinct karst conditions are also present within the proposed CAZ south of Beechwood Road: 1) a deep, likely paleokarst-controlled, conduit system in the west; 2) a shallower conduit system developing under post-glacial conditions in the east (represented by a groundwater trough); and, 3) a very shallow epikarst, located in areas of shallow soil over bedrock (BluMetric, 2017).

4.1.2 Physical Hydrogeology

The active groundwater flow zone at the Site extends to a depth of approximately 30 m below the top of bedrock. The dominant fracture orientation in the upper 30 m of bedrock is parallel to bedding (horizontal to sub-horizontal) distributed throughout the upper 30 m of bedrock, implying that there are no particular depth horizons exhibiting anomalous amounts of fracturing. Some borings do exhibit a shallow weathered zone, however, in which fracturing is more pronounced. A moderate amount of vertical to sub-vertical fractures exist providing hydraulic connections between the various horizontal fractures.

The area south of the landfill footprint and east of the landfill entrance road is characterized by interconnected fractures that appear to be well connected to recharge/discharge features, which are likely in direct connection to surface infiltration. The well-connected area has a significant role in the local variation of the potentiometric surface as the water levels vary throughout the year by as much as 4 to 6 m. The results of various CAZ investigations over the past several years, which demonstrated hydraulic connection between monitoring wells north and south of Beechwood Road, have confirmed that the hydraulically well-connected area extends onto the proposed CAZ properties, as far south and southeast as well locations M188-1, M190 and M167.

The results of hydraulic conductivity tests conducted in boreholes and monitoring wells within the well-connected area have been compiled, and compared to the results from tests conducted outside of the apparent boundaries of this area (BluMetric, 2016a). The geometric mean of the hydraulic conductivities measured inside the area of well-connected boreholes was slightly higher than the geometric mean of the hydraulic conductivities measured outside the area and the distribution of results showed a much higher proportion of hydraulic conductivities greater than $1x10^{-5}$ m/s within the area of well-connected boreholes, relative to the area outside. The increased distribution of higher hydraulic conductivities and the observed connections between monitoring wells within this area are consistent with the interpretation that this area consists of a well-connected fracture network through which groundwater can flow at a greater rate than outside of the area.

Hydraulic conductivity values measured at boreholes M196, M197 and M198 during the field program described above in Sections 2 and 3, were much lower than hydraulic conductivities measured in the area of well-connected boreholes. These low hydraulic conductivity values are consistent with results obtained from nearby boreholes M120 and M124 (see Figure 2b). Observations from these five boreholes drilled in the northwestern portion of the proposed CAZ revealed a lack of significant water-bearing fractures, indicating that the well-connected area does not extend to the west in this area.

It is important to emphasize that the area of well-connected bedrock fractures described above interacts hydraulically with other areas of the Site. It is distinct due to its behavioral differences during recharge/discharge time periods, but does not represent a separate flow regime. Furthermore, the zones of lower hydraulic conductivity surrounding the area to the west, south and east do not represent a barrier to flow; rather the rate of groundwater flow is slower within these lower permeability zones within the fractured bedrock. The presence of the less permeable zones is clearly seen by comparison of temporal water level variations inside and outside of the area of well-connected fractures.

Flow out of the area is controlled by the lower hydraulic conductivity in the surrounding rock. Infiltrating water recharging into the well-connected area is stored, resulting in the noticeable rise in water levels, which then dissipate as groundwater flow moves through and out of the area.

Another area that exhibits a distinct hydraulic behaviour was identified in the southern portion of the proposed CAZ. Static groundwater elevations in intermediate bedrock zone monitoring wells located within this area (eg, M173, M174, M181, M187, M189, M194-1, M194-2 and M195) were observed to be much deeper compared to wells in the area of higher hydraulic conductivity monitoring wells introduced previously. Static water levels at these locations were deep, between 15 and 30 mbgs (105 masl or lower) compared to 5 mbgs typically (116 masl or greater) within the higher conductivity area (see Figure 5). Similarly, groundwater elevations at M176 and M179, while not as deep (2.0 and 6.1 mbgs, respectively), also exhibited static groundwater elevations of 111 masl or lower.

While most wells in this group exhibit low permeability across the vertical profile, relatively more permeable fracture zones were identified in some boreholes (eg, M189, M187. M194-1). At well location M187, a highly permeable fracture was encountered at a depth of approximately 26 mbgs (~90 masl). Despite the limited drawdown that could be achieved during the pumping test at this location with a relatively high pumping rate of more than 100 L/min, M187 was confirmed to be hydraulically connected to other wells defining the periphery of the area of responsive monitoring wells (eg, M64-2, M173, M179 and M185).

Similarly, significant water bearing fractures were identified in M194-1 at comparable depths (29-33 mbgs or 82-86 masl), and also hydraulically connected to the network of hydraulically active wells (M187, M174, etc) and new well M195 (active fracture at 30 mbgs or 89 masl).

The karst conduits found within the southwestern and central portions of the CAZ (BluMetric, 2017) do not appear to be directly influencing water levels in the aforementioned area of higher hydraulic conductivity in the northern portion of the proposed CAZ and south part of the landfill property. This higher hydraulic conductivity area lies upgradient of the karst and includes an area of artesian conditions near its southern/eastern boundary (e.g. M167, M178R-2 and -3). The presence of artesian conditions in juxtaposition to karst is of interest as karst conduits are characterized by relatively high hydraulic conductivities. If the entire site were affected by the karst, one would not expect the presence of areas with such high hydraulic heads (artesian conditions), rather the karst would serve to act as a drain, keeping heads low.

4.1.2.1 Shallow Groundwater Zone

The shallow groundwater flow zone comprises overburden, the overburden-bedrock contact, and the first one to two metres of depth into bedrock. Water level monitoring indicates that these three portions of the shallow flow system act in concert and can be treated as a single flow zone or hydrostratigraphic unit. The directions of groundwater flow in the shallow flow zone are strongly influenced by ground surface topography, which is typical where the water table is generally shallow.

Shallow zone flownets are constructed seasonally (spring, summer and fall) at the site using water level data from hydraulically responsive wells. Figure 3 presents the most recent piezometric surface for the shallow groundwater flow zone in the area of the landfill. The flownets, documented in semi-annual reports, show that there is a water level high beneath Empey Hill stemming from the elevated topography of this feature. Empey Hill creates a flow divide west of the landfill with shallow groundwater being directed both to the north and the south. The northerly flowing groundwater discharges to Marysville Creek.

The southerly flowing groundwater flows towards Beechwood Ditch in the southwest portion of the Site. Shallow groundwater south of the landfill and south of Beechwood Road also flows towards the area of lower water levels in the southwest portion of the Site.

Shallow groundwater east of the landfill is influenced by a local zone of higher water elevations in the vicinity of monitoring well M96. Shallow groundwater north of well location M96 flows to the north and ultimately into Marysville Creek while groundwater south of well location M96

flows to the south-southeast. The shallow groundwater flow directions described here do not vary significantly with season despite the fact that water levels at the Site can be up to approximately 2 m higher in the spring months compared to the fall months. The lack of variation of shallow groundwater flow direction with season stems from the fact that the shallow flow system is topographically controlled and indicates that an appropriately located monitoring well network will detect a potential contaminant plume in the shallow zone.

Farther south, shallow groundwater discharges into a low-lying area in the central portion of the proposed CAZ south of Beechwood Road where a surface water course is present. The land surface rises south of this low-lying area which acts as a local divide for the shallow groundwater flow in this part of the CAZ, as is apparent from the interpolated shallow groundwater contours recorded between May 14 and July 12, 2018 (Figure 4a), and from the vertical cross sections shown on Figure 4b. Shallow groundwater flows towards the local divide from the north, east and south, consistent with the local ground surface topography.

4.1.2.2 Intermediate Bedrock Groundwater Zone

The intermediate bedrock groundwater flow zone extends from approximately one to two metres below the top of bedrock to a depth of approximately 30 m below the top of bedrock. The 30 m limitation was selected on the basis of the fact that groundwater salinity increases significantly below depths of approximately 30 m into bedrock and the fact that fresher groundwater, including leachate, does not have the ability to displace the denser, saline groundwater. In addition, because of the significant anisotropy exerted by the dominance of horizontal to sub-horizontal fractures, the primary groundwater flow direction in bedrock is horizontal. This does not, however, rule out localized occurrences of vertical flow within the intermediate flow zone. The deep groundwater below 30 m depth into bedrock is classified as non-potable according to the Ontario Drinking Water Standards, Objectives and Guidelines. At some well locations, naturally saline waters exist in the intermediate bedrock at depths of less than 30 metres, particularly in areas of lower hydraulic conductivity and slower groundwater flow rates. These waters are distinguishable by naturally elevated sodium, chloride and TDS concentrations, low alkalinity and often the presence of ammonia and BTEX compounds.

As with shallow groundwater, the intermediate zone groundwater will always flow from regions of high hydraulic head to regions of low hydraulic head, with flow velocity controlled by hydraulic conductivity along the groundwater flowpaths. The hydraulic testing programs conducted since 2009 have revealed that there is continuity of hydraulically connected fractures in the intermediate flow zone surrounding the landfill to the west, south and southeast. Pumping of individual wells at various depths induced hydraulic responses up to 450 m away, supporting

the interpretation that groundwater flow occurs primarily through horizontal and sub-horizontal fractures that are connected to each other by vertical to sub-vertical fractures.

The intermediate bedrock groundwater flow zone potentiometric surface (Figure 5) illustrates that groundwater flowing under the landfill generally flows to the west from the western edge of the landfill, to the south-southeast from the southern edge of the landfill, and to the southwest from the southwest corner of the landfill. The hydraulic influence of Empey Hill is seen in the intermediate flow zone in that a relatively stagnant zone (weaker hydraulic gradients) is created southwest of the landfill. Unlike the shallow groundwater zone flow system, however, the intermediate zone flow system exhibits significant flow direction changes with season. This stems from the fact that the intermediate flow zone is not as constrained by topographic control as the shallow zone flow system. The regional groundwater flow direction is southward, following the dip of the limestone bedrock as well as the general slope of the topographic surface.

Area South of Landfill

The groundwater piezometric contours and orientations of groundwater flow for the intermediate bedrock in the area of well-connected fractures south of the landfill and east of the landfill access road can be distinguished by periods of higher groundwater levels and periods of lower groundwater levels. During periods of high groundwater levels, the groundwater generally flows south-southeast across this area toward Beechwood Road (see BluMetric (2017), Figure 5(b)). Groundwater from the southern edge of the landfill east of the entrance road flows towards the southeast in the direction of well location M105 and continues southeastward toward Beechwood Road.

During periods of lower water levels, groundwater flow is oriented toward the central portion of the well-connected area from the north; west and south (see BluMetric (2017), Figures 5(a) and 5(c)). Flow from the eastern half of the landfill footprint is directed toward the central portion of this area, as is flow from west of the landfill entrance road, as well as flow from properties south of Beechwood Road. Based on the water level contours, groundwater flows eastward south of the landfill, and continues toward the east-southeast. During periods of low water level, the data suggest that a groundwater divide is established south of Beechwood Road, along an approximate orientation from northwest to southeast. This is particularly apparent on the potentiometric surface for October 2013 (BluMetric (2016a), Figure 5(a)), where groundwater north of the divide flows onto the landfill property from the properties south of Beechwood Road, and groundwater south of the divide flows southward. The groundwater divide is present only during periods of low water levels; at other times, the flow is more consistently southeastward.

Flownets developed over the past several years indicate that the groundwater flow continues in a southeastward orientation across the properties that are proposed to be used for the CAZ. Monitoring wells outside of the well-connected area typically exhibit much lower water levels than the wells within the area. Monitoring wells within this area had similar water levels to each other, which is indicative of an environment of higher bulk rock hydraulic conductivity and lower hydraulic gradients. The identification of karst systems in the southwest and southeast portons of the proposed CAZ area is consistent with this interpretation.

The implication of the changing flow direction seen in the intermediate bedrock is that hydraulically downgradient locations within the intermediate flow zone will vary with season, and that an appropriate monitoring network to assess groundwater quality in the downgradient flow direction will need to comprise a network of monitoring wells at various locations. A corollary to this is that the changing groundwater flow directions in the intermediate flow zone will cause potential leachate plumes to shift in flow direction with season, thereby ensuring that a network of monitoring wells is capable of detecting their presence.

Groundwater from the intermediate bedrock groundwater flow zone is believed to be naturally discharging to ground surface in a large wet area located in the central portion of the proposed CAZ. Covering approximately 500 m by 100 m, this low lying area extends between well locations M178/M178R and M173/M194. This diffuse discharge area is located on the north side of the local shallow groundwater flow divide that corresponds to the topographically low area, as described above in section 4.1.2.1 and shown on the vertical cross-sections on Figure 4b.

Multiple lines of evidence confirm that groundwater discharge is occurring in this area:

- Strong vertical hydraulic connections exist within the intermediate bedrock groundwater flow zone in this area, for example between M178R-4 (screened 4.5 m below bedrock surface) and the deeper wells at this location (M178R-2 and M178R-3, screened 17 and 11 m below bedrock, respectively);
- Artesian conditions exist in several intermediate bedrock monitoring wells in this area (eg, M178, M178R where hydraulic heads have been observed to reach as much as 4.9 m above ground surface, at M178R-2 on May 15, 2015), indicating the presence of strong upward vertical hydraulic gradients;
- Groundwater discharge points have been observed at ground surface in various locations within this diffuse area, and found to flow intermittently depending on the conditions, including during winter where some discharge points remain flowing and wet at times when temperatures are well below freezing; and

- Areas where groundwater was observed to discharge to surface were sampled and found to be impacted with low 1,4 dioxane concentrations (between 0.0015 and 0.004 mg/L in fall 2015, well below the PWQO compliance limit for surface water (0.02 mg/L)). The results from the new shallow monitoring well M178R-5, located near the discharge area, had 1,4 dioxane concentrations 0.007 to 0.0074 mg/L in fall 2015 (NOTE: recent results at M178R-5 exhibited lower 1,4 dioxane concentrations between 0.0056 and 0.0059 mg/L (March and June, 2018, see Tables A and B).

Karst features have been observed south of Beechwood Road in the central portions of the proposed CAZ area. The karst assessment (BluMetric, 2017) revealed that three distinct karst conditions exist within the proposed CAZ:

1. A deep, likely paleokarst-controlled, conduit system in the west;
2. A shallower conduit system developing under post-glacial conditions in the east (represented by a groundwater trough); and,
3. A very shallow epikarst, located in areas of shallow soil over bedrock.

The karst conduits drain portions of the southwestern and central portions of the CAZ but do not appear to be influencing water levels in the area of the leachate impacted plume (see section 4.1.3). Downgradient monitoring wells located within or adjacent to the karst (e.g. M187, M194, M174, M176 and M179) have not been impacted (below detection for 1,4 dioxane and alklalinity below 400 mg/L). Additionally, the supplementary study conducted by the karst expert (BluMetric, 2017) of the unnamed creek running from northeast to southwest along the southeast limits of the proposed CAZ (see Figure 2b) confirm that, while minor losses or gains from shallow bedrock in the vicinity of the creek cannot be ruled out, there is no evidence of karst interconnections within the proposed CAZ.

Area North and Northwest of Landfill

The area north and northwest of the landfill footprint, between the landfill and Marysville Creek, has been identified through hydraulic testing as an area where relatively lower hydraulic conductivity exists. This does not imply that there is zero groundwater flow through this area, but rather that the groundwater flow rate is lower than in other areas around the landfill site.

Marysville Creek is the primary potential receptor and should continue to be monitored north of the landfill. The extensive amount of monitoring to date, including testing for 1,4 dioxane and other primary leachate indicators, demonstrates that impacts have not been identified in the groundwater adjacent to the creek or in the surface water in the creek. Impacts are seen in the groundwater within approximately 50 metres north and west of the unlined Phase 1 portion of

the landfill (see section 4.1.3); however, because of the lower hydraulic conductivity and slow rate of groundwater flow, no impacts are observed in groundwater along the creek.

4.1.2.3 Deep Bedrock

The deep bedrock zone is defined as groundwater occurring greater than approximately 30 m below the top of bedrock. The deep groundwater is saline and not suitable for potable use. There is limited hydraulic interaction between the intermediate bedrock flow zone and the deep bedrock because of the differences in groundwater density related to salinity. Deep bedrock groundwater generally flows to the south in a horizontal direction, although vertical components of flow may also exist. Bulk rock hydraulic conductivity is generally lower at depths greater than 30 m below the top of bedrock, and fracture apertures are generally smaller below this depth. It follows that the movement of groundwater in the deep bedrock will be slower than in the shallow and intermediate bedrock flow zones.

4.1.3 Groundwater Quality and Extent of Impacts

Background groundwater quality in the shallow and intermediate bedrock flow zones is characterized by geochemistry in several monitoring wells on the landfill property, as described in the latest EMP (BluMetric, 2016c).

The primary indicators that are used to delineate impacts from landfill leachate at the site are 1,4 dioxane and alkalinity. 1,4 dioxane is a synthetic volatile organic compound (VOC) used as a chemical stabilizer for chlorinated solvents that does not exist in nature, is entirely miscible in water and does not readily biodegrade or adsorb onto soils or rock (U.S. EPA, 2014). Consequently, the presence of 1,4 dioxane in groundwater at detectable concentrations (> 0.001 mg/L) is used to indicate the furthest extent of impacts. In addition, where 1,4 dioxane is detected, alkalinity has been found to be generally above 400 mg/L. Other parameters are also used to assist in determining impacts and are included in the routine monitoring program.

Groundwater sample data collected from on-site monitoring wells indicate that leachate impacted groundwater is flowing from the northwest corner of the unlined Phase 1 footprint of the landfill in the shallow and intermediate bedrock groundwater flow zones. Figure 6 and Figure 7 illustrate on a site plan the approximate extents of the impacted area in the shallow and intermediate bedrock flow zones, respectively.

In the shallow groundwater zone north of Beechwood Road (Figure 6), impacts from landfill leachate are evident at monitoring wells M100, M101, M103 and M104 north and west of the Phase 1 landfill cell. These monitoring wells are all located in close proximity to the landfill.

Further downgradient, in particular along Marysville Creek, no impacts have been observed in the shallow groundwater. Similarly, monitoring well M41, located approximately 25 m south from the landfill footprint, has been impacted by leachate while no subsurface impacts from landfill leachate have been observed at shallow groundwater monitoring locations farther downgradient (e.g., M54-4 or M70-3, located south and southeast of the landfill, respectively).

An area of shallow groundwater discharge exists within the proposed CAZ, approximately 400 m south of Beechwood Road in an area just upgradient (north) from the local surface water course that extends between two dug ponds (see Figure 6). The shallow groundwater in this area shows detectable concentrations of 1,4 dioxane. The extent of shallow groundwater impacts within the proposed CAZ (shown on Figure 6) has been delineated based on shallow groundwater chemistry. In this area, upward hydraulic gradients, groundwater seeps and generally wet conditions are observed (e.g., BluMetric, 2016a). Sampling results from shallow monitoring wells M178R-5, M205 and M206 (Table A) show evidence of landfill impacts at those locations (presence of 1,4 dioxane at detectable but low concentrations), while no landfill leachate impacts have been detected to the immediate west (M199, M200, M201, M203 and M204), south (M188-2, M201 and M202) or east (M207). Similarly, no landfill derived impacts have been detected in the local surface water course sampled three times per year as part of the EMP (which corresponds to a local divide for shallow groundwater as described in section 4.1.2.1).

In the intermediate bedrock groundwater zone (Figure 7), impacts are evident within 50 m north of the landfill footprint at monitoring wells M6-3 and OW4 where the highest concentrations of 1,4 dioxane (up to 0.35 and 0.13 mg/L respectively) have been measured (Table A), while no evidence of impacts is seen further downgradient, closer to Marysville Creek. This is consistent with the hydraulic testing results which show an area of low hydraulic conductivity north and northwest of the landfill.

There is no evidence of impacts in any of the monitoring wells located to the west of the landfill footpring, nor to the south of the landfill footprint and west of the site entrance road.

Along the eastern boundary of the landfill property, 1,4 dioxane has been detected above the RUL of 0.001 mg/L at montoring wells M168 and M170 (0.0072 and 0.012 mg/L, respectively, in spring 2018). The leachate impacted groundwater plume extends onto the southwestern corner of the property located to the east of the southeast limit of the WM property, up to monitoring well M192.

South of the landfill, 1,4 dioxane has been detected in monitoring wells located on the landfill property, north of Beechwood Road and east of the site access road. Landfill leachate impacts are also seen in intermediate bedrock groundwater monitors located within the north and central

portion of the proposed CAZ at concentrations above the RUL of 0.001 mg/L and show impact to groundwater quality originating from the landfill. These impacted monitoring wells have all been determined to be hydraulically responsive to pumping tests, including monitoring well M64-2 which did not respond to most pumping tests and only responded subtly to pumping at M187. This location appears to correspond to the western boundary of the area of higher hydraulic conductivity. However, contrary to what has been observed at most of the other impacted wells, other leachate indicator parameters, particularly alkalinity and tritium (BKA and WESA, 2009), are not elevated at M64-2. Ongoing monitoring since 2013 has confirmed the presence of 1,4 dioxane at this location at low but stable concentrations between 0.002 and 0.003 mg/L. The presence of 1,4 dioxane in this monitoring well demonstrates that lower hydraulic conductivity monitoring wells, even if non-responsive during pumping tests, are also part of the intermediate bedrock flow system and can be utilized to monitor groundwater impacts from the landfill.

Based on the results of previous hydrogeological investigations and the latest iteration reported in this document, it is concluded that groundwater impacts have been delineated and extend downgradient from the landfill onto the proposed CAZ as far southwest, south and southeast as well locations M64-2, M178R and M167, respectively (see Figure 7). The monitoring wells within the proposed CAZ and located outside of the extent of impacts are listed in Table 9.

Table 9: Intermediate Bedrock Monitoring Wells in Proposed CAZ Outside of the Extent of Impacts

M63-2	M179	M185-2	M190
M173	M181-1	M186	M191
M174	M181-2	M187	M194-1
M176	M182	M188-1	M194-2
M177	M185-1	M189	M195

5. RECOMMENDATIONS FOR CONTAMINANT ATTENUATION ZONE

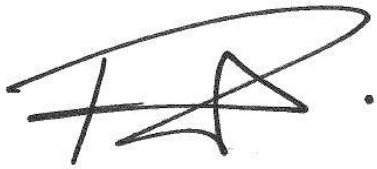
Eastern CAZ Limits: Recent monitoring results have confirmed that the groundwater in a small portion of the southwest corner of the property located to the east of the southeast corner to of the landfill property limit has been impacted by landfill leachate. WM proposes to extend the eastern limit of the proposed Contaminant Attenuation Zone (CAZ) north of Beechwood Road by adding an area of approximately 20 acres east of the landfill property if an agreement can be reached with the property owner. If such a negotiated agreement cannot be achieved, WM will implement an alternative solution consisting of a purge well system located along the eastern landfill property limit, and designed to hydraulically control the off-site migration of landfill leachate groundwater in the intermediate bedrock flow zone.

Western CAZ Limits: WM proposes to extend the proposed CAZ westerly to Deseronto Road to include additional buffer. This is conservative considering the low permeability bedrock encountered in the western portion of the proposed CAZ area south of Beechwood Road, and the well-defined direction of groundwater flow in the intermediate bedrock in the northern portion of the CAZ in this area.

Figure 8 shows the properties south of Beechwood Road where WM owns or controls the groundwater rights, as well as the updated proposed CAZ including the extended area to the west. The impacted area has been delineated conservatively using the detection limit for 1,4 dioxane (0.001 mg/L). Based on 1,4 dioxane concentration results collected since 2013 from an extensive network of hydraulically active groundwater monitoring wells, the extent of the contaminant plume originating from the landfill has been adequately defined. The limits of the proposed CAZ extend a minimum buffer of 400 m outside of the outer extent of the plume, which includes a number of unimpacted downgradient groundwater monitoring wells suitable for detection potential landfill leachate impacts.

Respectfully submitted,
BluMetric Environmental Inc.

Madeleine Corriveau, M.Sc., P.Geo.
Senior Environmental Geochemist



Phil Tibble, M.Sc., P.Geo.
Senior Hydrogeologist

Francois Richard, P.Geo., Ph.D.
Senior Hydrogeologist

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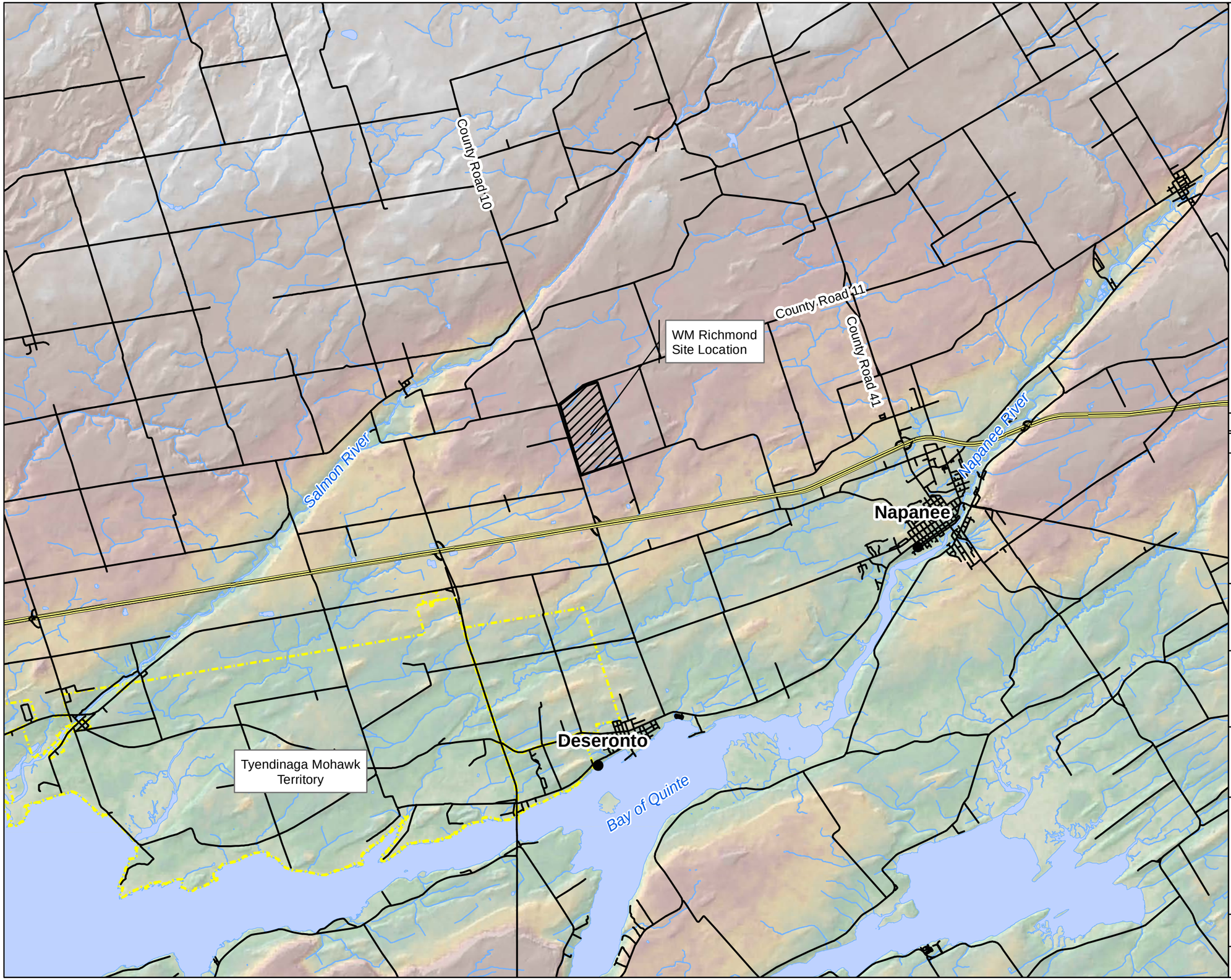
TABLES

Table A: Groundwater Chemistry from New Monitoring Wells

			M178R-5			M188-2		BOREHOLE M196	BOREHOLE M197	BOREHOLE M198	M199		M200		M201		M203		M204		M205			M206			M207	
Parameter	**Units**	**RUL***	**2018-06-11**	**2018-06-28**	**2018-09-06**	**2018-06-11**	**2018-09-06**	**2018-05-04**	**2018-05-04**	**2018-05-04**	**2018-06-11**	**2018-09-06**	**2018-06-11**	**2018-09-06**	**2018-06-11**	**2018-09-06**	**2018-06-11**	**2018-09-06**	**2018-06-11**	**2018-09-06**	**2018-06-11**	**2018-06-28**	**2018-09-06**	**2018-06-11**	**2018-06-28**	**2018-09-06**	**2018-06-11**	**2018-09-06**
General and Inorganic Parameters																												
Alkalinity	mg/L	**390**	***430***	***420***	***410***	290	290	-	-	-	310	320	250	260	270	270	310	320	280	300	310	310	360	330	330	370	260	280
Ammonia	mg/L		0.31	0.22	0.27	< 0.15	< 0.15	-	-	-	1.02	0.99	0.26	0.26	0.41	0.23	0.58	0.4	0.38	0.29	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	0.59	0.57
Boron	mg/L		0.17	0.21	0.2	0.38	0.68	-	-	-	0.7	0.95	0.17	0.2	0.22	0.34	0.4	0.58	0.51	0.79	0.062	0.07	0.098	0.057	0.057	0.081	0.44	0.67
Calcium	mg/L		110	110	100	72	69	-	-	-	62	57	73	78	51	67	120	120	57	59	99	100	130	93	98	110	75	84
Chloride	mg/L	**130**	50	48	43	2.3	2.2	-	-	-	4.4	3	5	3.4	11	6.7	11	8.8	25	29	16	16	42	27	28	41	56	68
Conductivity	µS/cm		950	950	880	600	610	-	-	-	720	680	510	510	690	710	840	820	680	760	650	660	810	700	730	820	730	770
Dissolved Organic Carbon	mg/L	**3.6**	***4.2***	***4.1***	***4***	1.5	1.7	-	-	-	1.5	1.9	1.3	1.9	1.5	1.4	2.2	2.2	2.1	***(note 1)***	2.3	2.4	2.7	2.8	3.1	3.6	2.2	2.1
Iron	mg/L	**0.18**	***0.19***	0.17	0.16	< 0.1	< 0.1	-	-	-	< 0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	***0.55***	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	***0.56***	***0.48***	***0.62***	< 0.1	0.15
Magnesium	mg/L		24	24	22	21	22	-	-	-	31	30	16	14	19	27	26	25	23	25	12	12	15	16	16	19	25	30
Manganese	mg/L	**0.034**	0.025	0.026	0.024	0.023	0.031	-	-	-	***0.077***	***0.064***	0.017	***0.087***	***0.07***	0.031	***0.22***	***0.19***	***0.073***	***0.043***	0.034	0.018	0.027	***0.14***	***0.13***	***0.21***	***0.064***	***0.08***
Nitrate	mg/L		< 0.1	< 0.1	< 0.1	0.43	0.39	-	-	-	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.49	< 0.1	0.11	< 0.1	0.91	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Nitrite	mg/L		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	-	-	-	< 0.01	0.033	< 0.01	< 0.01	< 0.01	0.073	< 0.01	0.023	< 0.01	0.035	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Potassium	mg/L		3.9	4.2	4.6	4.7	6.8	-	-	-	11	12	3.2	3.5	5.5	7	7	7.4	6.3	9	1.1	1.1	1.4	4.2	4.8	4.9	6.2	8
Sodium	mg/L	**109**	49	52	48	24	33	-	-	-	33	33	6.8	7.2	60	34	17	14	34	62	16	16	19	22	23	28	33	18
Sulphate	mg/L		16	17	16	66	68	-	-	-	77	58	24	23	88	110	150	130	44	73	26	27	21	15	17	17	33	34
Total Dissolved Solids	mg/L	**452**	***540***	***690***	***485***	380	340	-	-	-	450	375	305	270	420	395	***555***	***470***	395	415	390	***510***	445	415	***510***	435	440	430
Volatile Organic Compounds																												
1,1,1-Trichloroethane	mg/L		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	-	-	-	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.00011	< 0.0001	< 0.0001	< 0.0001
1,1,2,2-Tetrachloroethane	mg/L		< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-	-	-	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
1,1,2-Trichloroethane	mg/L		< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-	-	-	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
1,1-Dichloroethane	mg/L		0.00047	0.00052	0.00053	< 0.0001	< 0.0001	-	-	-	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.00075	0.00075	0.0011	< 0.0001	< 0.0001
1,1-Dichloroethylene	mg/L	**0.004**	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	-	-	-	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
1,2-Dichlorobenzene (o)	mg/L		< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-	-	-	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
1,2-Dichloroethane	mg/L		< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-	-	-	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
1,3,5-Trimethylbenzene	mg/L		< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-	-	-	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
1,3-Dichlorobenzene (m)	mg/L		< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-	-	-	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
1,4-Dichlorobenzene (p)	mg/L		< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-	-	-	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
1,4-Dioxane	mg/L	**0.001**	***0.0056***	***0.0059***	***0.0058***	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	***0.0011***	***0.0014***	***0.003***	***0.001***	***0.0013***	***0.0028***	< 0.001	< 0.001
Benzene	mg/L	**0.001**	0.0001	< 0.0001	0.0001	< 0.0001	< 0.0001	-	-	-	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.00011	< 0.0001
Chlorobenzene	mg/L		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	-	-	-	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chloroethane	mg/L		< 0.001	0.00063	< 0.0003	< 0.0002	< 0.0002	-	-	-	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.001	0.00033	< 0.0003	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chloromethane	mg/L		< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	-	-	-	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Cis-1,2-Dichloroethylene	mg/L		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	-	-	-	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Dichloromethane	mg/L		< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	-	-	-	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Ethylbenzene	mg/L	**0.001**	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	-	-	-	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
m+p-Xylene	mg/L		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	-	-	-	< 0.0001	0.00014	< 0.0001	< 0.0001	< 0.0001	0.00028	< 0.0001	< 0.0001	< 0.0001	0.00013	0.00022	0.00014	0.00011	< 0.0001	< 0.0001	< 0.0001	0.00019	0.00014
o-Xylene	mg/L		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	-	-	-	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.00015	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Styrene	mg/L		< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-	-	-	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Tetrachloroethylene	mg/L		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	-	-	-	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Toluene	mg/L	**0.012**	0.0004	0.00023	< 0.0002	< 0.0002	< 0.0002	-	-	-	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Total Xylenes	mg/L	**0.15**	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	-	-	-	< 0.0001	0.00014	< 0.0001	< 0.0001	< 0.0001	0.00043	< 0.0001	< 0.0001	< 0.0001	0.00013	0.00022	0.00014	0.00011	< 0.0001	< 0.0001	< 0.0001	0.00019	0.00014
Trans-1,2-dichloroethylene	mg/L		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	-	-	-	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Trichloroethylene	mg/L		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	-	-	-	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Vinyl Chloride	mg/L		< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-	-	-	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002

*RUL: Reasonable Use Limit
Note 1: No results for dissolved organic carbon from M204 because of insufficient volume of sample

FIGURES



LEGEND

- Streams
- Water bodies
- Site Location

Topography (m)

- High : 180
- Low : 50

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1				

REFERENCES

0 1 2 4 Kilometres

CLIENT

WASTE MANAGEMENT

PROJECT

WASTE MANAGEMENT RICHMOND - COMPLEMENTARY CAZ INVESTIGATION

TITLE

SITE LOCATION MAP

BluMetric™ Environmental

The Tower - The Woolen Mill,
4 Cataraqui St.,
Kingston, Ontario K7K 1Z7
TEL: (613) 531-2725
FAX: (613) 531-1852
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE
180150-02	July, 2018

DRAWN	CHECKED	FIG NO.	REV
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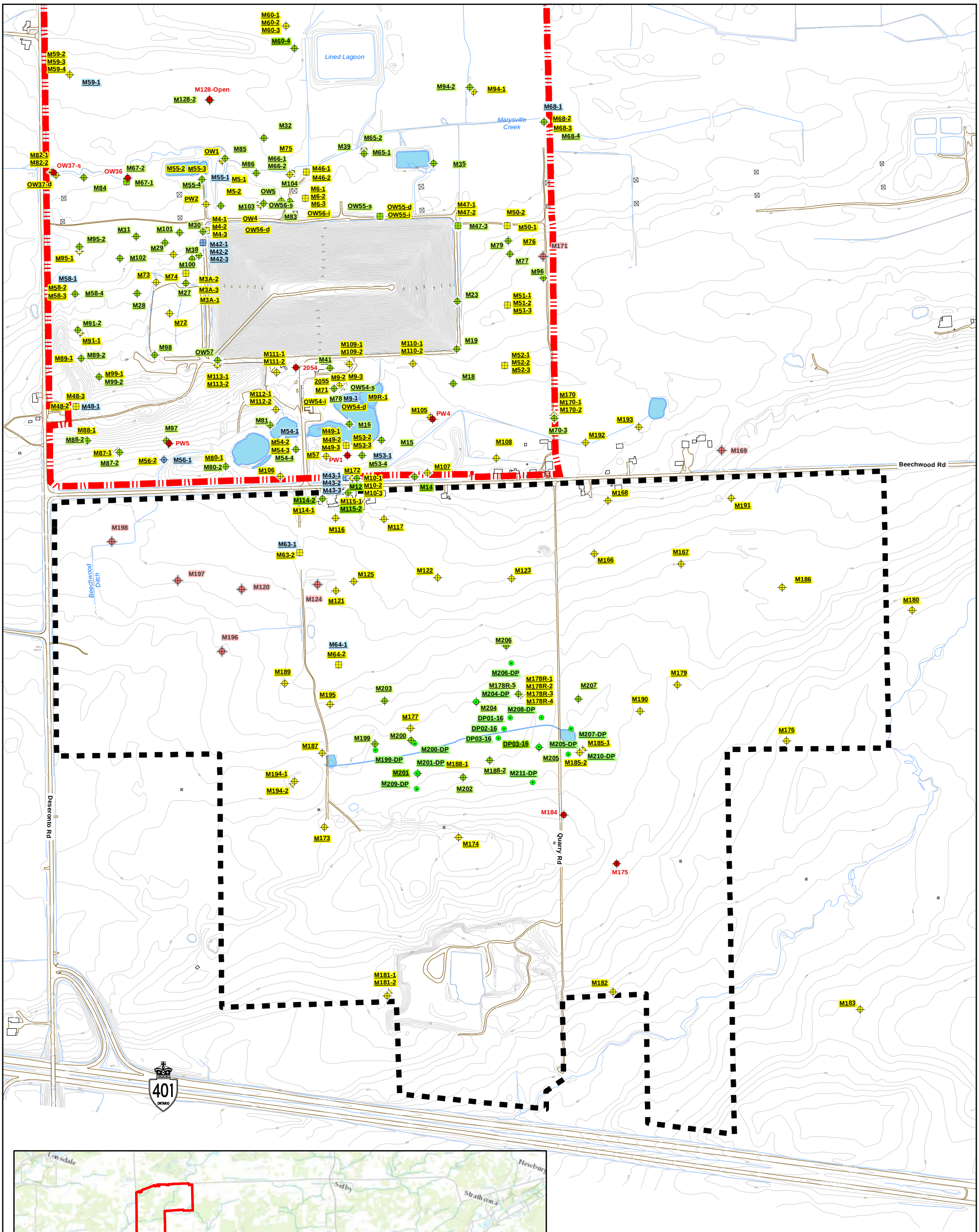

LEGEND

- OW36 Open Borehole
- M198 Decommissioned Borehole
- DP Drive Point Piezometer

Single Well

- M39 Active Shallow Monitoring Well
- M9R-1 Active Intermediate Monitoring Well
- M69-1 Active Deep Monitoring Well

Multi-Level Wells

- M65-2 Active Shallow Monitoring Wells
- M63-2 Active Intermediate Monitoring Well
- M42-1 Active Deep Monitoring Wells

- Hydro Tower
- Buildings
- Roads
- Topographic Contours (1 m)
- Watercourses
- Property Boundary
- Water bodies
- Previously Proposed Contaminant Attenuation Zone (CAZ), BluMetric (2016a)

REFERENCES

THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED ARE BASED ON 11"x17" FORMAT DRAWINGS.
-UNITS: METERS
-PROJECTION: UTM NAD83 ZONE 18
-DATA SOURCE: WM CANADA, BLUMETRIC, MNRO, NRCAN

0 25 50 100 150 200
Metres

BluMetric™ Environmental
The Tower - The Woolen Mill,
4 Cataraqui St.,
Kingston, Ontario K7K 1Z7
TEL: (613) 531-2725
FAX: (613) 531-1852
Email: info@blumetric.ca
Web: http://www.blumetric.ca

CLIENT
WM WASTE MANAGEMENT

PROJECT
WASTE MANAGEMENT RICHMOND - COMPLEMENTARY CAZ INVESTIGATION

TITLE
SITE PLAN AND MONITORING LOCATIONS

PROJECT #	DATE
180150-02	August, 2018

DRAWN	CHECKED	FIG NO.	REV
AL	FR	2a	0

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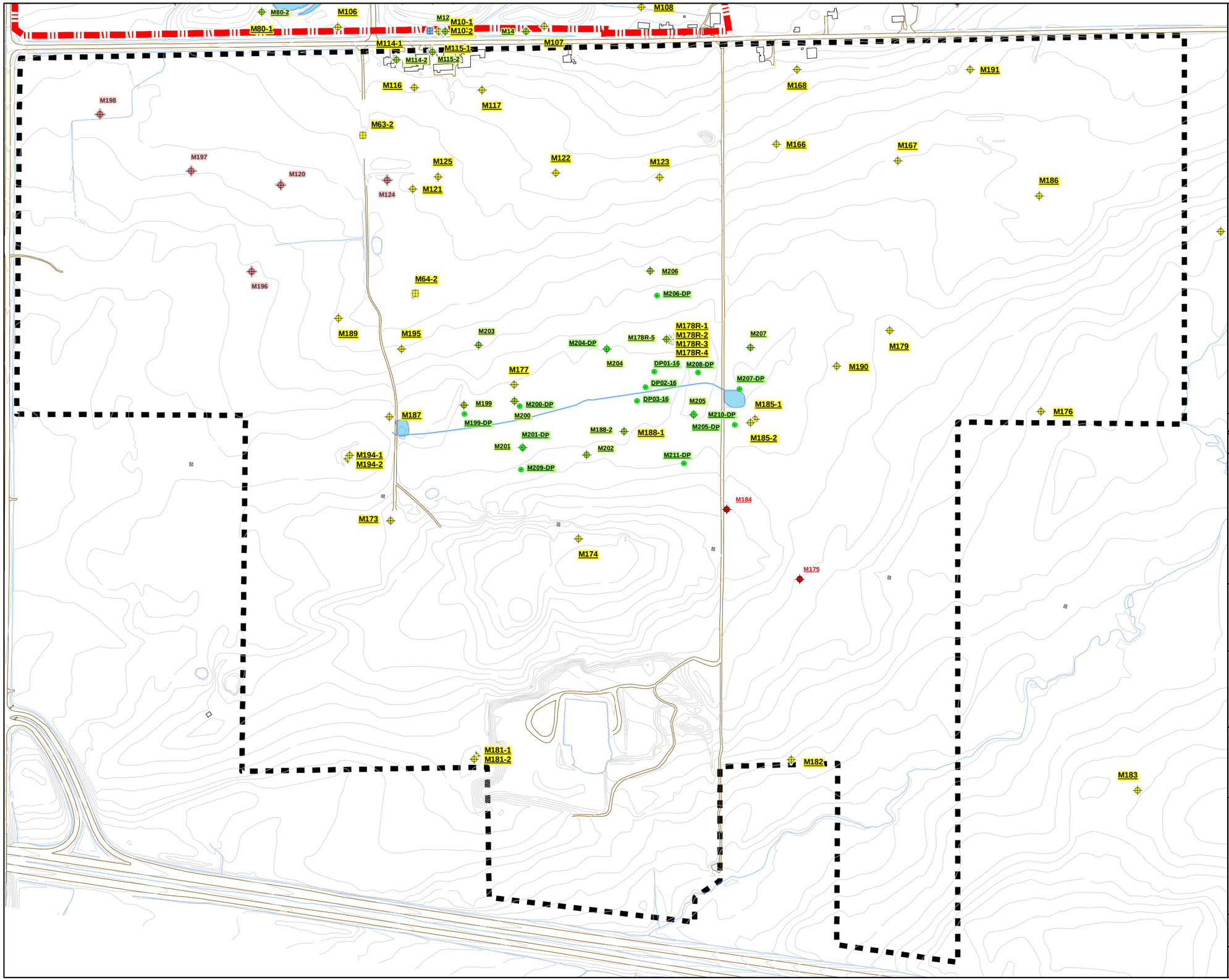

LEGEND

- OW36 — Open Borehole
- M198 — Decommissioned Borehole
- DP — Drive Point Piezometer

Single Well

- M39 — Active Shallow Monitoring Well
- M9R-1 — Active Intermediate Monitoring Well
- M69-1 — Active Deep Monitoring Well

Multi-Level Wells

- M65-2 — Active Shallow Monitoring Wells
- M63-2 — Active Intermediate Monitoring Well
- M42-1 — Active Deep Monitoring Wells

- Hydro Tower
- Buildings
- Roads
- Topographic Contours (1 m)
- Watercourses
- Property Boundary
- Water bodies
- Previously Proposed Contaminant Attenuation Zone (CAZ), BluMetric (2016a)

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1				

REFERENCES

DO NOT SCALE DRAWING.
THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED ARE BASED ON 11"x17" FORMAT DRAWINGS.

N, W, E, S

0 50 100 200 Metres

CLIENT

WASTE MANAGEMENT

PROJECT

WASTE MANAGEMENT RICHMOND - COMPLIMENTARY CAZ INVESTIGATION

TITLE

PROPOSED CAZ SITE PLAN AND MONITORING LOCATIONS

BluMetric™ Environmental

The Tower - The Woolen Mill,
4 Cataraqui St.,
Kingston, Ontario K7K 1Z7
TEL: (613) 531-2725
FAX: (613) 531-1852
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE
180150-02	August 14, 2018

DRAWN	CHECKED	FIG NO.	REV
GM	MC	02b	0

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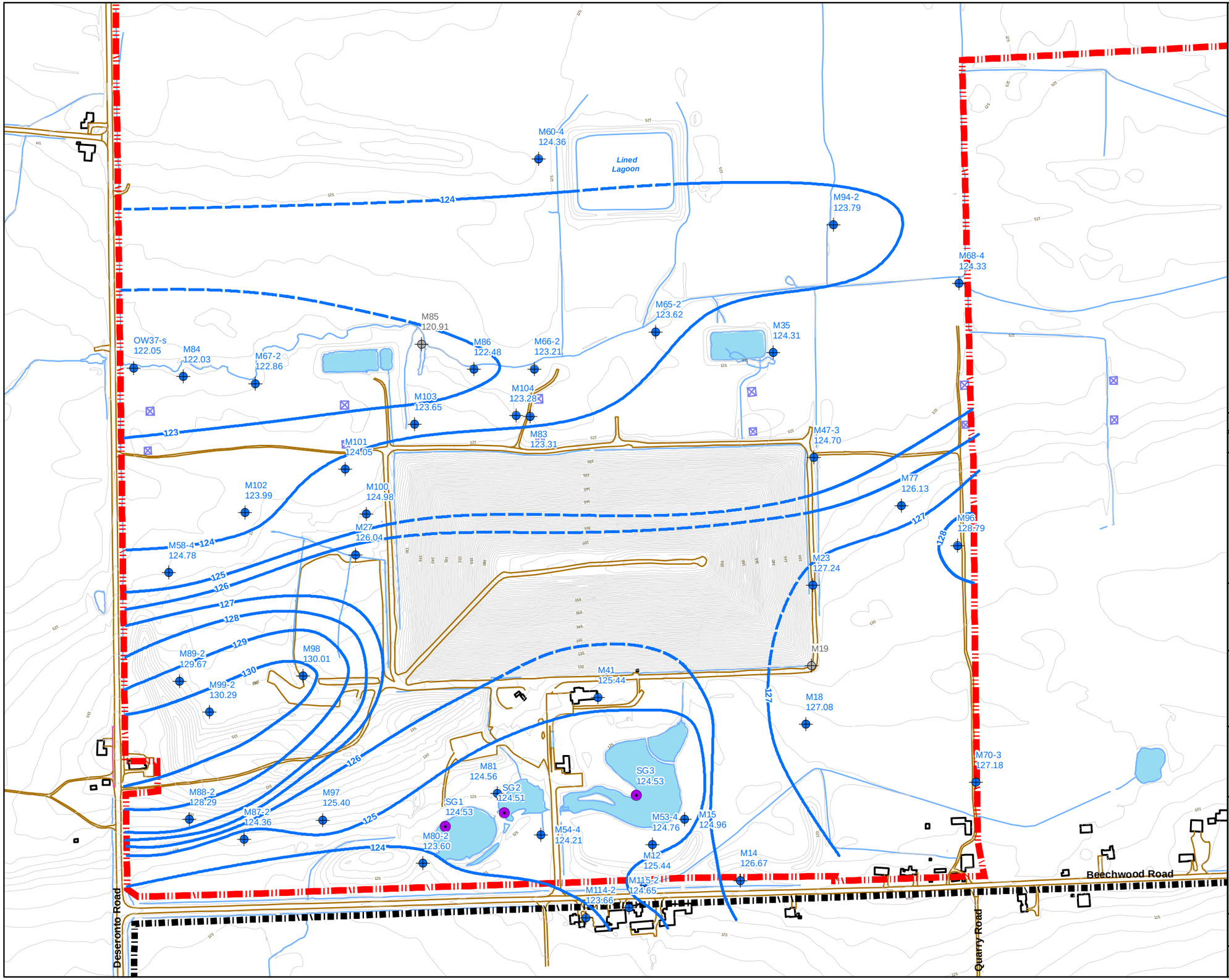


LEGEND

- Potentiometric Surface (masl) - May 14, 2018
- Topographic Contour Lines
- Surface Water
- Property Boundary
- Proposed CAZ Boundary
- M53-4 Shallow Groundwater Zone Elevation Monitor
- M5-3 Monitor Not Used in Contouring
- M35 Staff Gauge Location

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1				

REFERENCES

THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED ARE BASED ON 11"x17" FORMAT DRAWINGS.

0 40 80 160 240 320
Metres
1:5,000

CLIENT

WM WASTE MANAGEMENT

PROJECT

WASTE MANAGEMENT RICHMOND - COMPLEMENTARY CAZ INVESTIGATION

TITLE

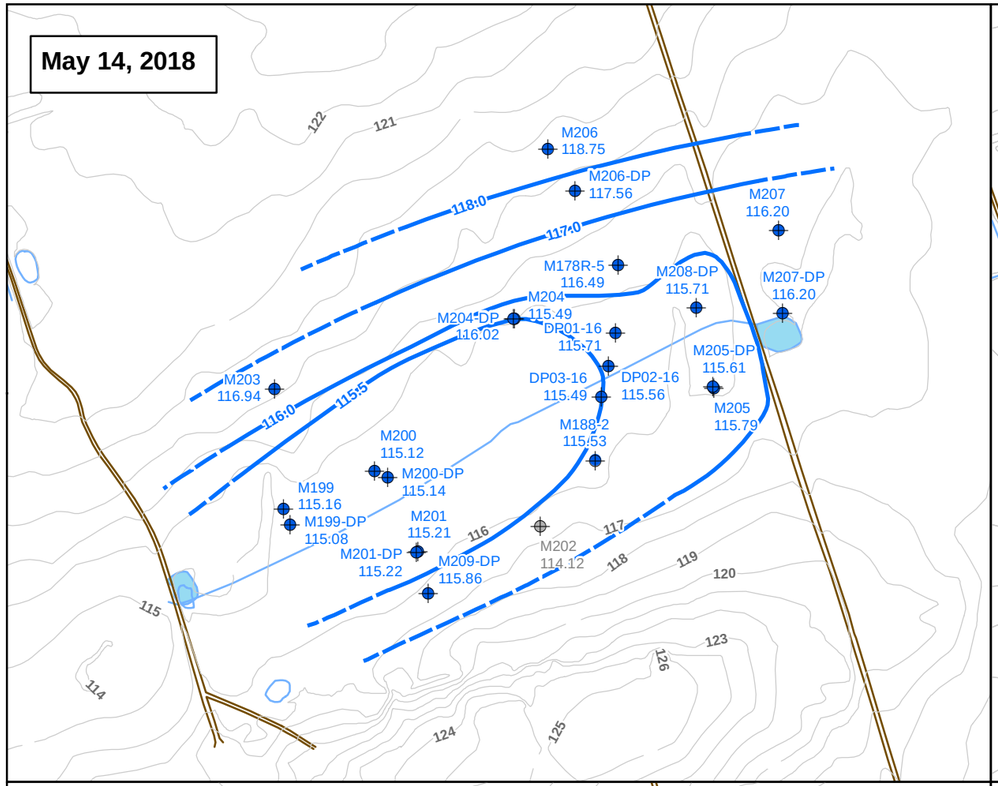
SHALLOW GROUNDWATER FLOW ZONE POTENTIOMETRIC SURFACE – LANDFILL AREA

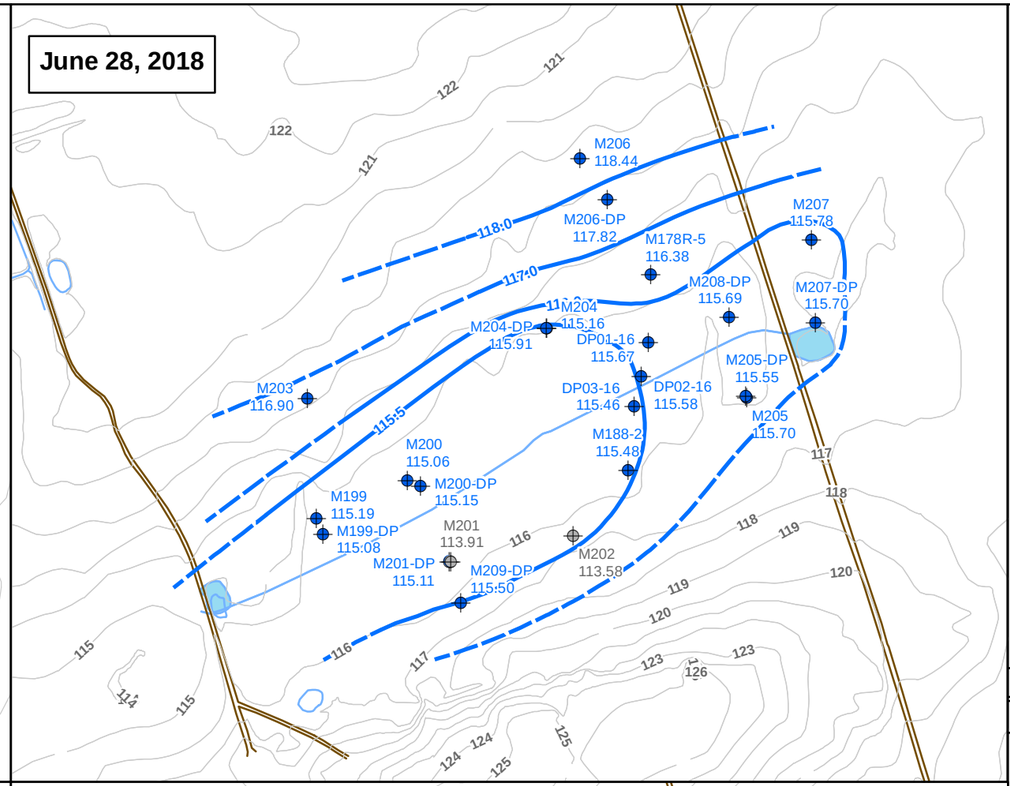
BluMetric™ Environmental
The Tower - The Woolen Mill,
4 Cataraqui St.,
Kingston, Ontario K7K 1Z7
TEL: (613) 531-2725
FAX: (613) 531-1852
Email: info@blumetric.ca
Web: http://www.blumetric.ca

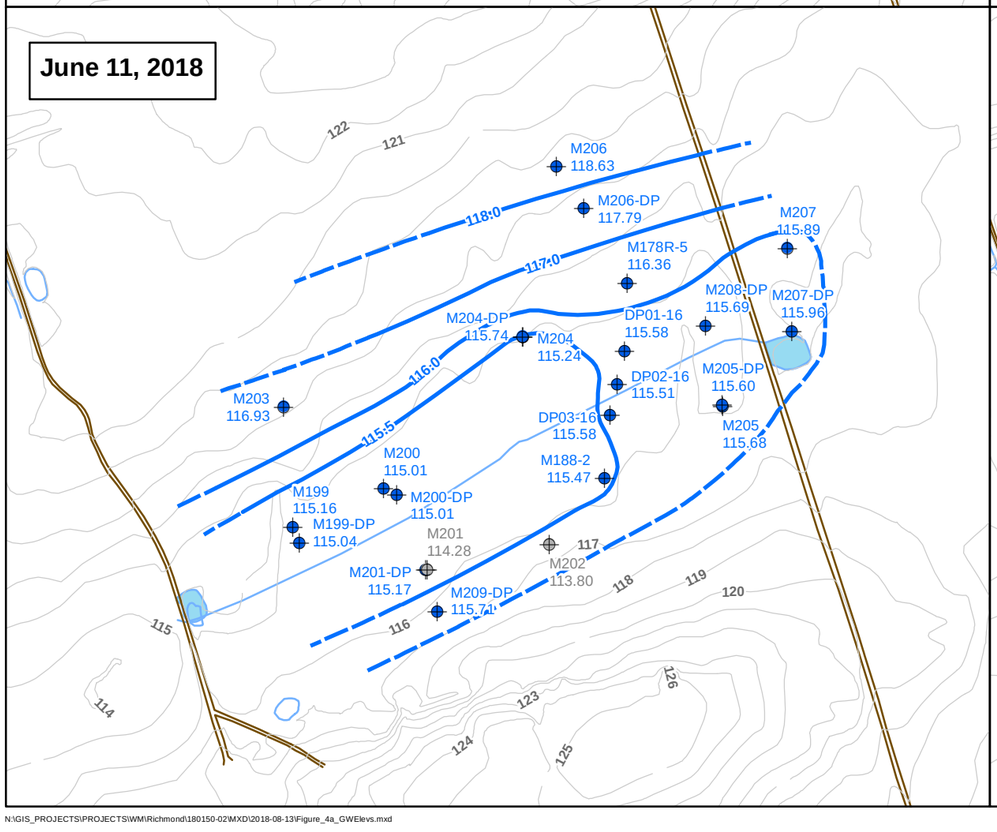
PROJECT #	DATE
180150-02	July, 2018

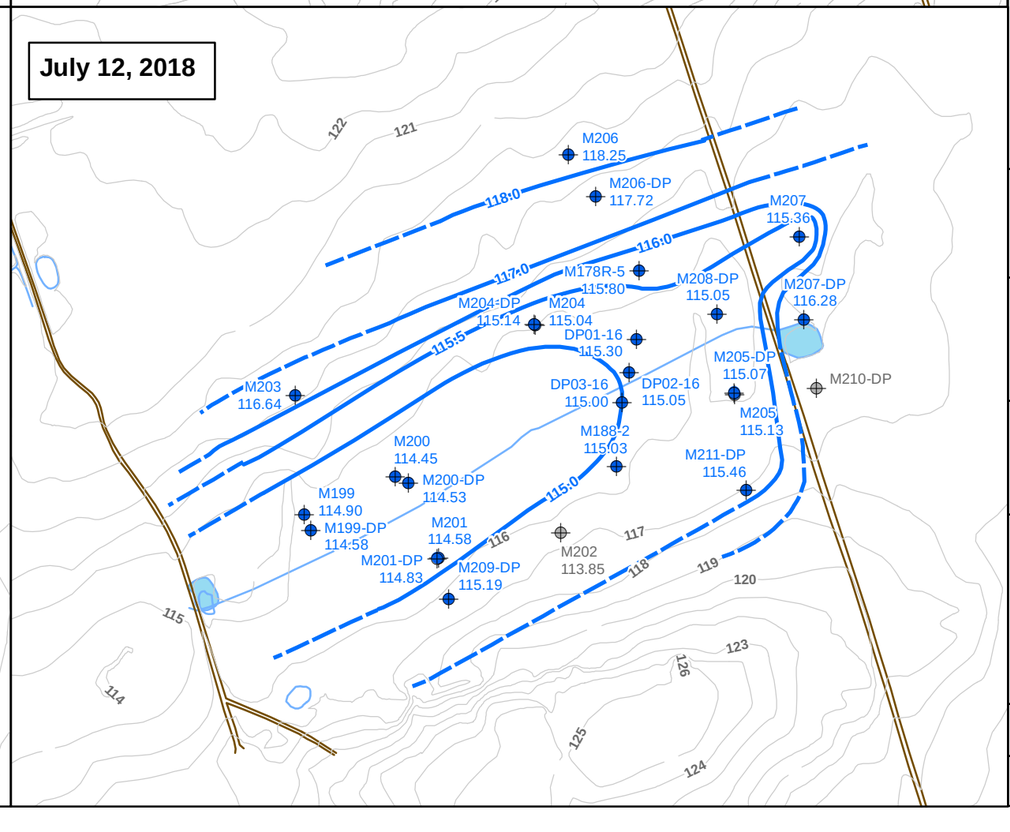
DRAWN	CHECKED	FIG NO.	REV
AL	FR	3	0

N:\GIS_PROJECTS\PROJECTS\WM\Richmond\180150-02\MXD\2018-07-18\Figure_3_ ShallowGWFlowZonePotentiometricSurface_P.mxd









LEGEND

- M202 — Shallow Monitoring Well
- M202 — Monitoring Well Not Used in Contouring
- 30000 — Groundwater Elevation (masl)
- Potentiometric Surface (masl)
- Inferred Potentiometric Surface (masl)
- Hydro Tower
- Topographic Contours (1 m)
- Buildings
- Roads
- Watercourses
- Proposed CAZ Boundary
- Waterbody

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1				

REFERENCES

THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED ARE BASED ON 11"x17" FORMAT DRAWINGS.

N W E S

0 50 100 Meters

CLIENT

WM WASTE MANAGEMENT

PROJECT

WASTE MANAGEMENT RICHMOND - COMPLEMENTARY CAZ INVESTIGATION

TITLE

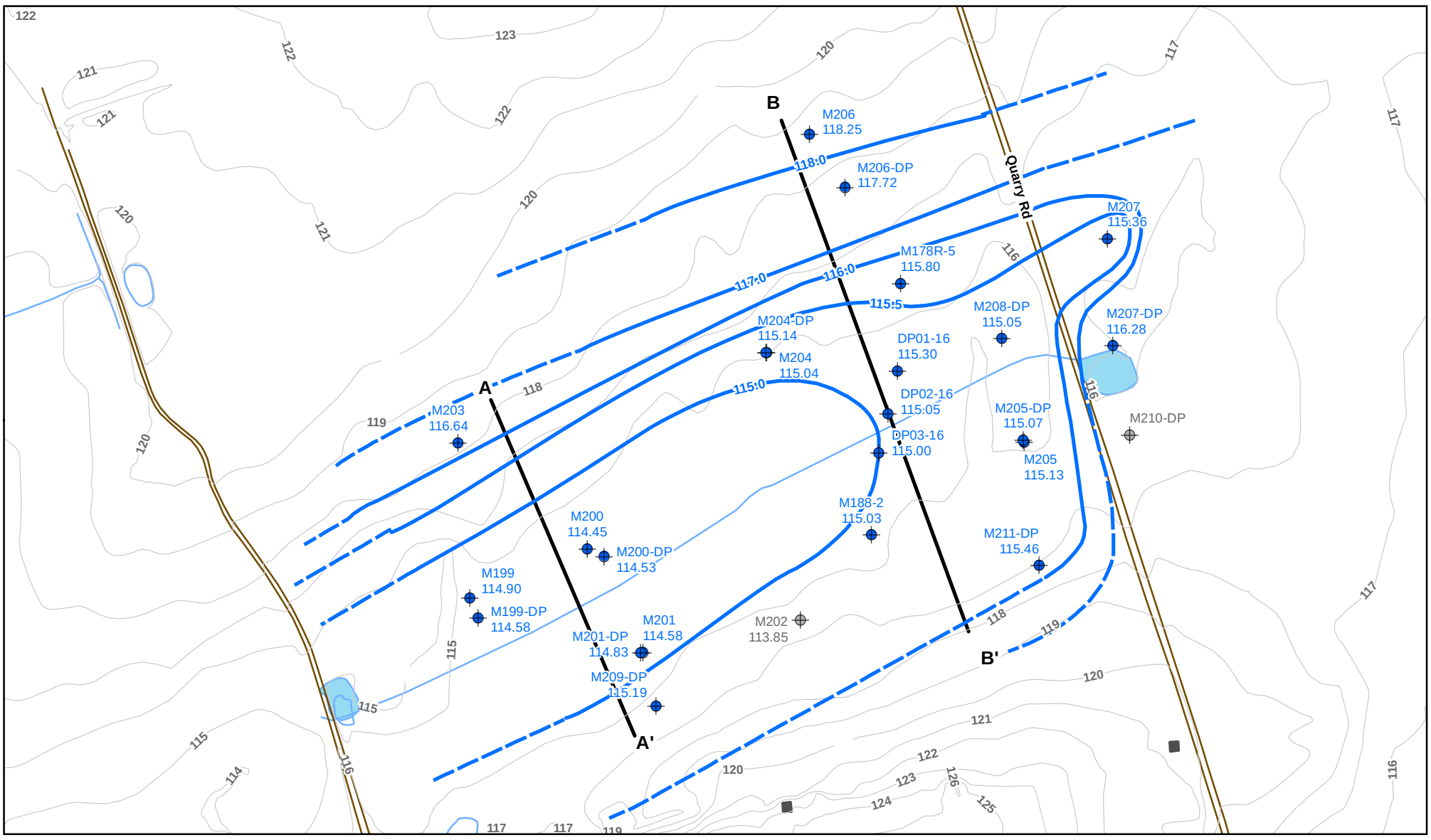
SHALLOW GROUNDWATER FLOW ZONE POTENTIOMETRIC SURFACE - PROPOSED CAZ

BluMetric™ Environmental
The Tower - The Woolen Mill,
4 Cataraqui St.,
Kingston, Ontario K7K 1Z7
TEL: (613) 531-2725
FAX: (613) 531-1852
Email: info@blumetric.ca
Web: http://www.blumetric.ca

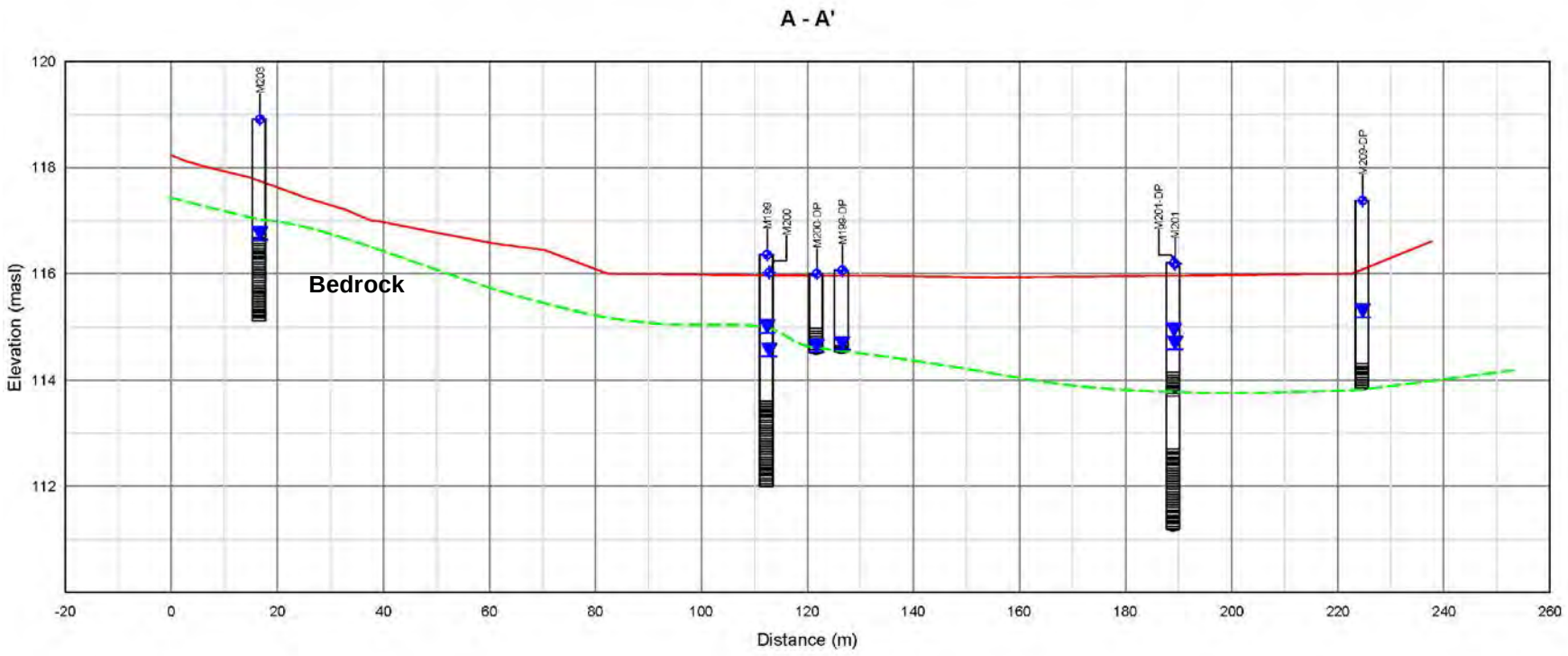
PROJECT #	DATE
180150-02	August 2018

DRAWN	CHECKED	FIG NO.	REV
AL	FR	04a	0

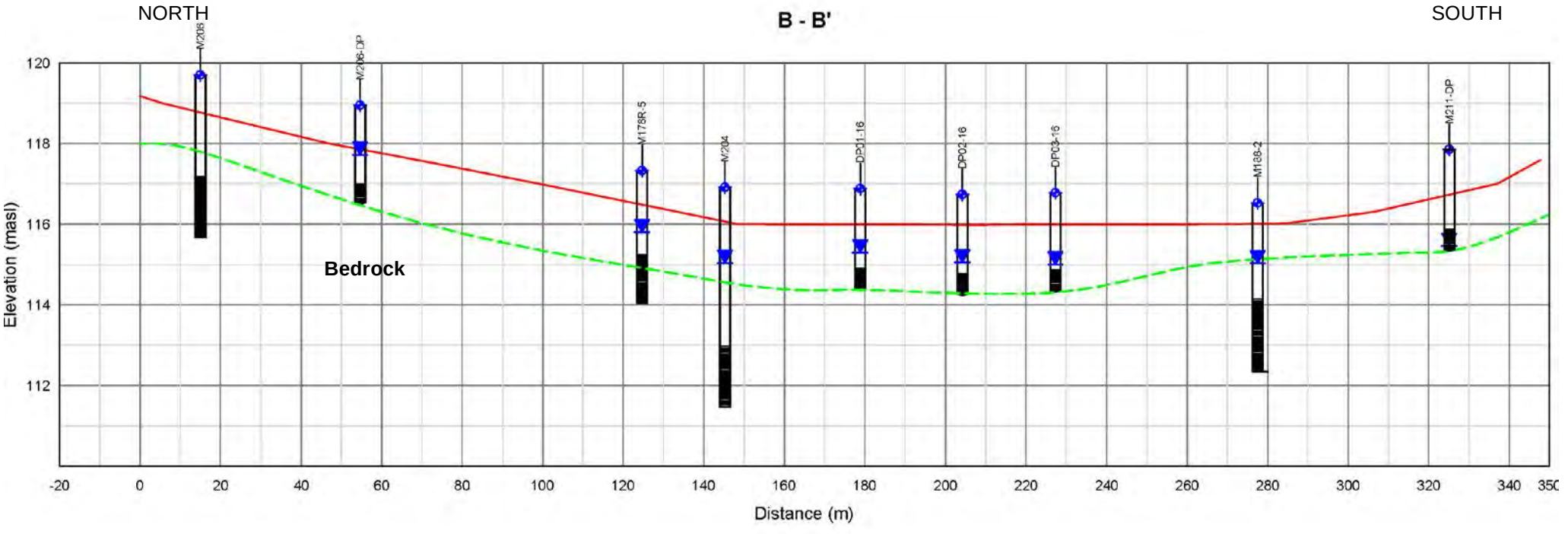
N:\GIS_PROJECTS\PROJECTS\WM\Richmond\180150-02\MXD\2018-08-13\Figure_4a_GWElevs.mxd



NORTH SOUTH



NORTH SOUTH



LEGEND

M204
117.01
Shallow Monitoring Well

Groundwater Elevation (masl) - July 12, 2018

Ground Surface

Bedrock Surface

REFERENCES

-UNITS: METERS
-PROJECTION: UTM NAD83 ZONE 18
-DATA SOURCE: WM CANADA, BLUMETRIC, MNRO, NRCAN
-VERTICAL EXAGG.: 25X

0 10 20 40 60 80
Metres

BluMetric™ Environmental
The Tower - The Woolen Mill,
4 Cataraqui St.,
Kingston, Ontario K7K 1Z7
TEL: (613) 531-2725
FAX: (613) 531-1852
Email: info@blumetric.ca
Web: http://www.blumetric.ca

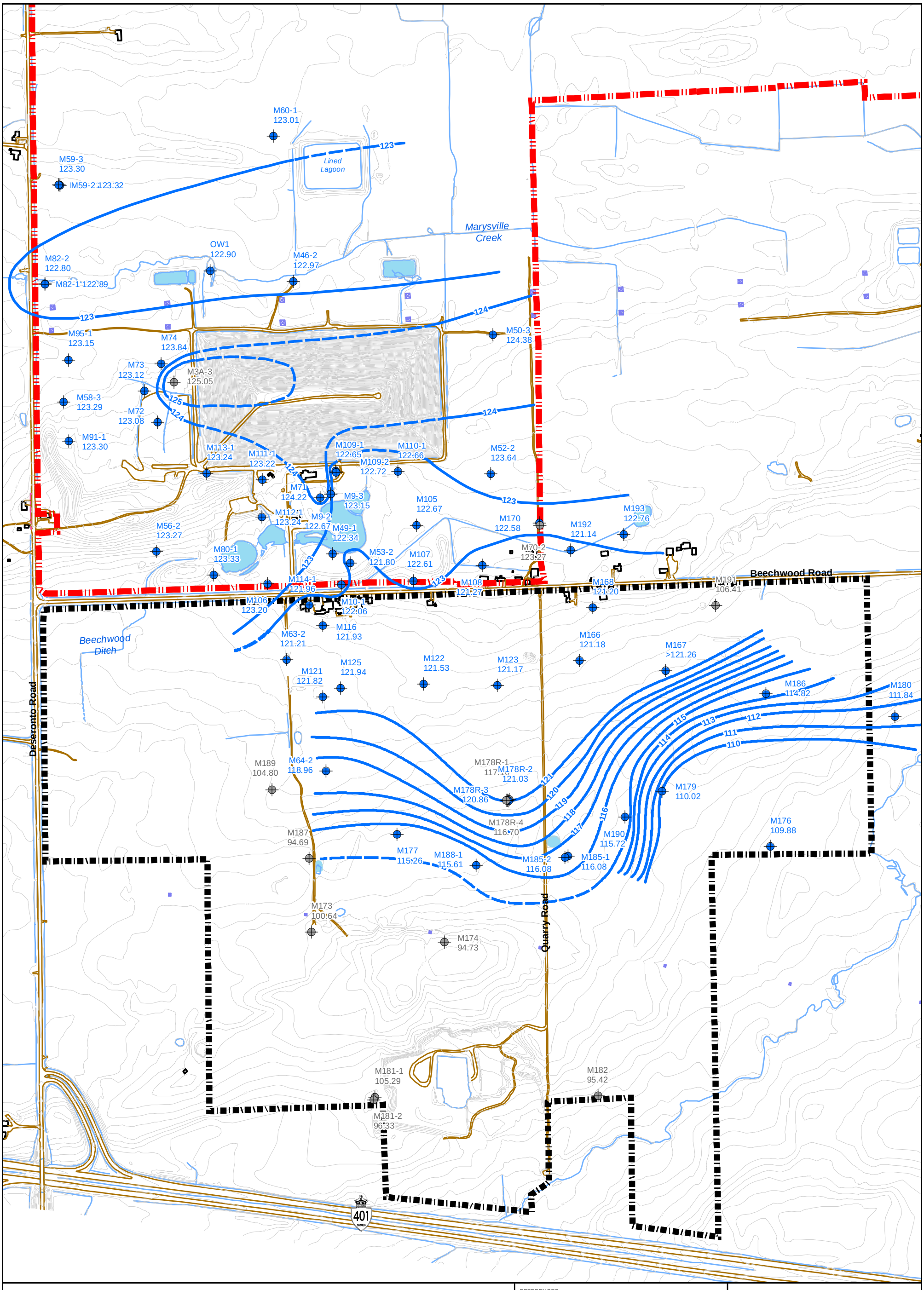
CLIENT: WM

PROJECT: WASTE MANAGEMENT RICHMOND - COMPLEMENTARY CAZ INVESTIGATION

TITLE: VERTICAL CROSS-SECTION SHOWING SHALLOW GROUNDWATER FLOW DIVIDE IN PROPOSED CAZ

PROJECT #	DATE		
180150-02	August, 2018		
DRAWN	CHECKED	FIG NO.	REV
AL	FR	4b	0

N:\GIS_PROJECTS\PROJECTS\WM\Richmond\180150-02\MXD\2018-08-13\Figure_4b_CrossSections.mxd



LEGEND

- Potentiometric Surface (masl) - May 14, 2018
- Topographic Contour Lines
- Surface Water
- Property Boundary
- Proposed CAZ Boundary
- M166 Intermediate Groundwater Zone Elevation Monitor
- M189 Monitor Not Used in Contouring

REFERENCES

-UNITS: METERS
-PROJECTION: UTM NAD83 ZONE 18
-DATA SOURCE: WM CANADA, BLUMETRIC, MNRO, NRCAN

0 25 50 100 150 200
Metres
1:8,000

BluMetric™ Environmental
The Tower - The Woolen Mill,
4 Cataraqui St.,
Kingston, Ontario K7K 1Z7
TEL: (613) 531-2725
FAX: (613) 531-1852
Email: info@blumetric.ca
Web: http://www.blumetric.ca

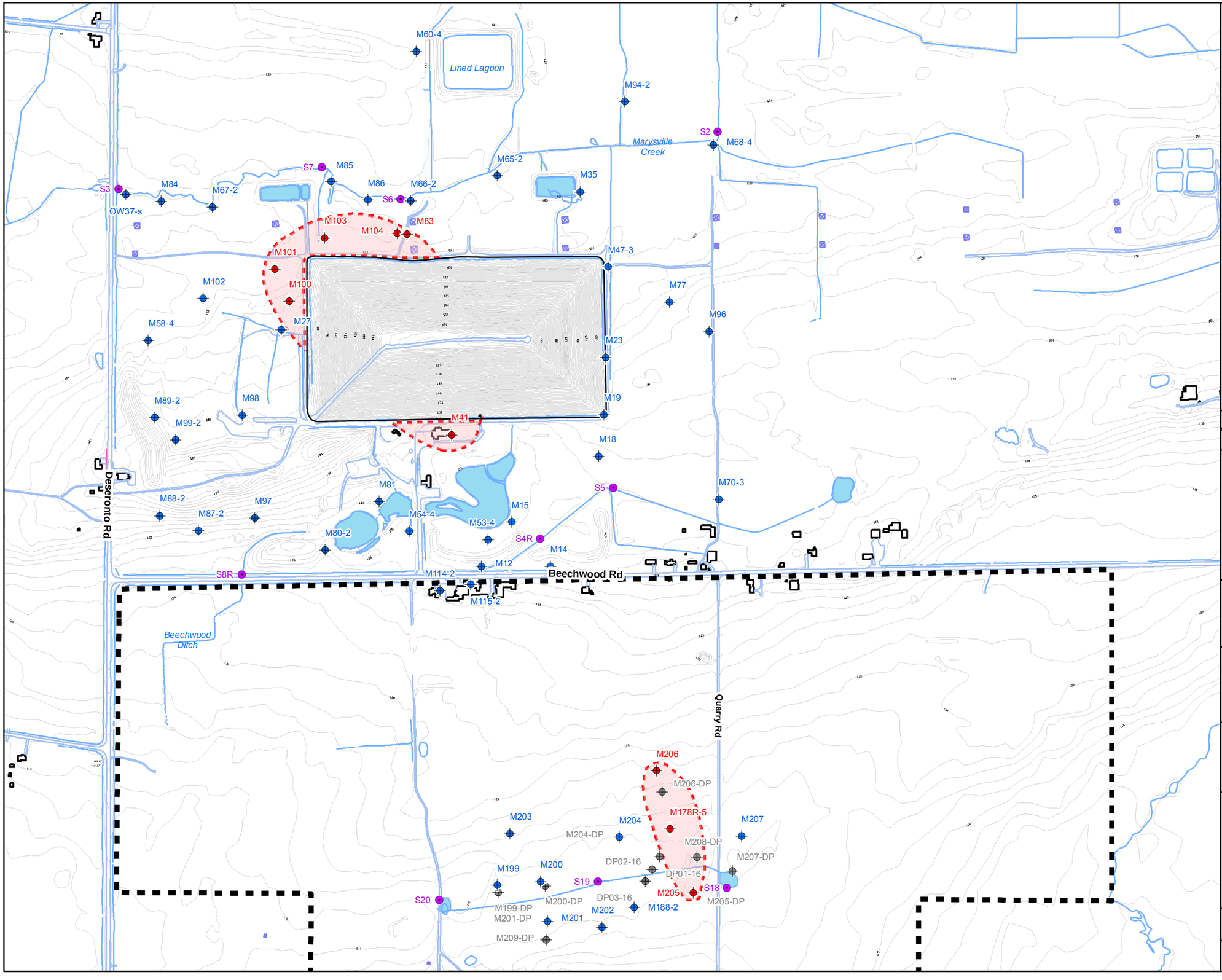
CLIENT
WM WASTE MANAGEMENT

PROJECT
WASTE MANAGEMENT RICHMOND - COMPLEMENTARY CAZ INVESTIGATION

TITLE
INTERMEDIATE BEDROCK GROUNDWATER FLOW ZONE POTENTIOMETRIC SURFACE

PROJECT #	DATE
180150-02	July, 2018

DRAWN	CHECKED	FIG NO.	REV
AL	FR	5	0



LEGEND

- M202 — Shallow Bedrock Monitoring Well (1, 4 dioxane ≥ 0.001 mg/L)
- M202 — Shallow Bedrock Monitoring Well (No 1,4 dioxane impacts)
- M202 — Drivepoint Piezometer (not sampled)
- S2 — Surface Water Monitoring Location
- Proposed Contaminant Attenuation Zone (CAZ)
- Extents of 1,4 Dioxane Impacted Area
- Topographic Contours (1 m)
- Surface Water

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1				

REFERENCES

DO NOT SCALE DRAWING.
THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED ARE BASED ON 11"x17" FORMAT DRAWINGS.

0 25 50 100 150 200
Metres

CLIENT

WASTE MANAGEMENT

PROJECT

WASTE MANAGEMENT RICHMOND - COMPLEMENTARY CAZ INVESTIGATION

TITLE

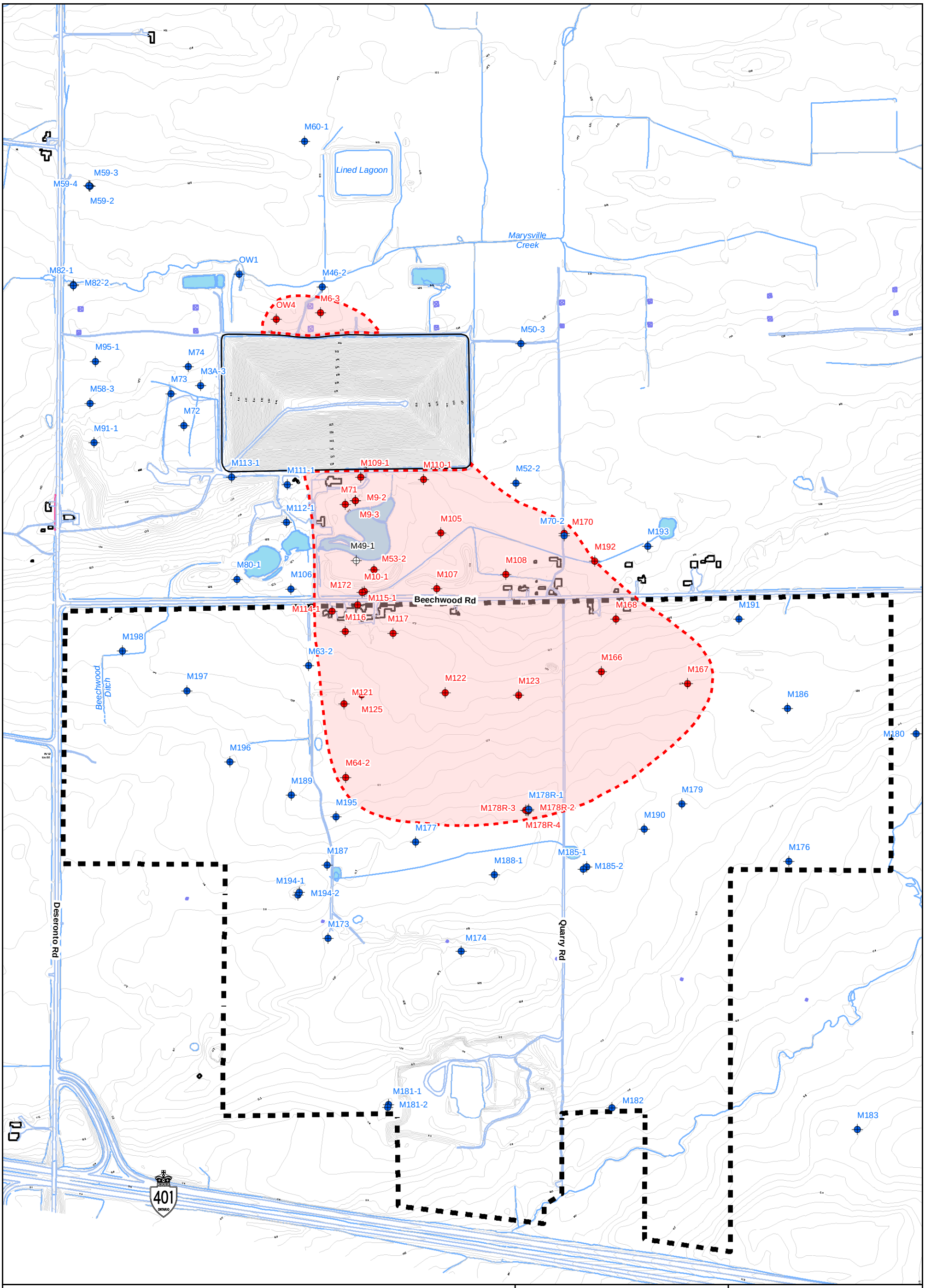
DELINEATION OF 1,4 DIOXANE IMPACTED AREA – SHALLOW GROUNDWATER FLOW ZONE

BluMetric™ Environmental
3108 Carp Road PO Box 430
Ottawa, Ontario K0A 1L0
TEL: (613) 839-3053
FAX: (613) 839-5376
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE
180150-02	July, 2018

DRAWN	CHECKED	FIG NO.	REV
AL	FR	6	0

N:\GIS_PROJECTS\PROJECTS\WM\Richmond\180150-02\MXD\2018-07-24-CAZ Report\Figure_6_Delineation_ShallowBedrock.mxd



LEGEND

- M64-2 — Intermediate Bedrock Monitoring Well (No 1,4 dioxane impacts)
- M121 — Intermediate Bedrock Monitoring Well (1,4 dioxane ≥ 0.001 mg/L)
- M121 — Intermediate Bedrock Monitoring Well (no results1,4 dioxane)
- Topographic Contour Lines
- Surface Water
- Proposed Contaminant Attenuation Zone (CAZ)
- Approximate Extent of Known 1,4 Dioxane Impacted Area

REFERENCES

THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED ARE BASED ON 11"x17" FORMAT DRAWINGS.
-UNITS: METERS
-PROJECTION: UTM NAD83 ZONE 18
-DATA SOURCE: WM CANADA, BLUMETRIC, MNRO, NRCAN

0 25 50 100 150 200
Metres
1:8,000

BluMetric™ Environmental
The Tower - The Woolen Mill,
4 Cataraqui St.,
Kingston, Ontario K7K 1Z7
TEL: (613) 531-2725
FAX: (613) 531-1852
Email: info@blumetric.ca
Web: http://www.blumetric.ca

CLIENT: WM WASTE MANAGEMENT

PROJECT: WASTE MANAGEMENT RICHMOND - COMPLEMENTARY CAZ INVESTIGATION

TITLE: DELINEATION OF 1,4 DIOXANE IMPACTED AREA – INTERMEDIATE BEDROCK GROUNDWATER FLOW ZONE

PROJECT #	DATE		
180150-02	July, 2018		
DRAWN	CHECKED	FIG NO.	REV
AL	FR	7	0

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LEGEND

- WM Owned Property
- Lot Parcels
- Updated Proposed Contaminant Attenuation Zone (CAZ)

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1				

REFERENCES

N W E S

0 100 200 Metres

CLIENT

WM WASTE MANAGEMENT

PROJECT

WASTE MANAGEMENT RICHMOND - COMPLEMENTARY CAZ INVESTIGATION

TITLE

PROPERTIES INCLUDED IN THE PROPOSED CAZ

BluMetric™ Environmental
3108 Carp Road PO Box 430
Ottawa, Ontario K0A 1L0
TEL: (613) 839-3053
FAX: (613) 839-5376
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE
180150-02	July, 2018

DRAWN	CHECKED	FIG NO.	REV
AL	FR	8	0

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APPENDIX A

Borehole Logs

Project No: 180150-02

Project: Complementary CAZ Investigation

Client: Waste Management

Location: Richmond Landfill, Napanee, ON

Well ID: M196

Easting: 335325
Northing: 4902194
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth (ft / m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
-3 / -1		Ground Surface	117.31				- Elev. M196 117.89m TOC - S/U 0.58m	
1		Topsoil over brown silty Clay.	117.00				- 200mm HSA to depth 1.83m - 140mm OD steel casing cement grouted to - broken shaley limestone.	
3								
5								
7 / 2			116.00					
9								
11			115.00				- weakbedrock 3.0m - weak bedrock3.4m	
13 / 4			114.00				- weak bedrock3.9m - weak rock 4.2 - 4.3m and 4.8m	
15			113.00					
17							- weak bedrock4.9m and 5 - 5.06m - weak bedrock 5.4m and 5.6 - 5.7m	
19 / 6			112.00				- weak bedrock, sulfur odours 5.9 - 6.0m - weak bedrock 6.2m	
21			111.00					
23		***Limestone*** Light grey, lithographic fossiliferrous limestone with undulating shale partings. Stylolites are common. Numerous calcite stringers throughout. Occassional coarse crystalline zones.					- weak bedrock 6.2m	
25			110.00					
27 / 8			109.00				- weak bedrock 8.2m	
29							- weak bedrock 9, 9.2, 9.4, and 9.45m	
31			108.00					
33 / 10			107.00				- weak bedrock 10.4,10.6, 10.75 m	
35							- weak bedrock 11, 11.1, 11.5, 11.9m	
37			106.00					
39 / 12			105.00				- weak bedrock 12, 12.4, 12.6, 12.86m	
41								
43			104.00				- weak bedrock 13,13.1, 13.25, 13.4m	
45								
47 / 14			103.00				- weak bedrock 14.1, 14.5m	
49								
51			102.00					
53 / 16			101.00				- weak bedrock 15.9 and 16.5m	
55								
57			100.00					

Drilled By: GET Drilling Ltd.
Drill Method: Rotary Tri-cone
Hole Size: 3.87" (98mm)
Drill Date: April 2, 13, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

BluMetric™ Environmental

Project No: 180150-02
Project: Complementary CAZ Investigation
Client: Waste Management
Location: Richmond Landfill, Napanee, ON

Well ID: M196

Easting: 335325
Northing: 4902194
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth (m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
60–106		***Limestone*** Light grey, lithographic fossiliferrous limestone with undulating shale partings. Stylolites are common. Numerous calcite stringers throughout. Occassional coarse crystalline zones.	99.00 – 85.00		20 – 60		- weak bedrock 19.4 and 19.5m - weak bedrock 21.1m	
108–118		End of Borehole	84.00 – 81.00					

Drilled By: GET Drilling Ltd.
Drill Method: Rotary Tri-cone
Hole Size: 3.87" (98mm)
Drill Date: April 2, 13, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

BluMetric™ Environmental

Project No: 180150-02

Project: Complementary CAZ Investigation

Client: Waste Management

Location: Richmond Landfill, Napanee, ON

Well ID: M197

Easting: 335175
Northing: 4902260
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth (ft / m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
-3 / -1		Ground Surface	119.56				- Elev. M197 120.03m TOC - S/U 0.48	
1		Topsoil						
3		***Silty Clay*** Brown, dry.	119.00				- 200mm HSA to depth 3.05m - 140mm OD steel casing cement grouted to - broken shaley limestone.	
5			118.00					
7 / 2		***Till*** Brown, silty sand, some clay, trace gravel.	117.00					
9								
11			116.00					
13 / 4			115.00					
15								
17			114.00				- weak bedrock 5.5m	
19 / 6			113.00					
21								
23			112.00					
25								
27 / 8		***Limestone*** Light grey, lithographic fossiliferrous limestone with undulating shale partings. Stylolites are common. Numerous calcite stringers throughout. Occassional coarse crystalline zones.	111.00				- weak bedrock8.5m	
29								
31			110.00					
33 / 10			109.00					
35								
37			108.00					
39 / 12			107.00					
41								
43			106.00					
45 / 14			105.00				- weak bedrock14m	
47								
49			104.00					
51								
53 / 16			103.00					
55								
57			102.00				- weak rock 17.5m	

Drilled By: GET Drilling Ltd.
Drill Method: Rotary Tri-cone
Hole Size: 3.87" (98mm)
Drill Date: April 2, 13, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

BluMetric™ Environmental

Project No: 180150-02
Project: Complementary CAZ Investigation
Client: Waste Management
Location: Richmond Landfill, Napanee, ON

Well ID: M197

Easting: 335175
Northing: 4902260
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (% 20 60)	Fracture Frequency/Run	Comments	K (m/sec)
60			101.00					
62	19						- weak bedrock19m	
64			100.00					
66								
68			99.00				- weal bedrock 20.5m	
70	21							
72			98.00					
74			97.00					
76	23							
78			96.00				- weak bedrock 23.5m	
80								
82	25	***Limestone*** Light grey, lithographic fossiliferrous limestone with undulating shale partings. Stylolites are common. Numerous calcite stringers throughout. Occassional coarse crystalline zones.	95.00				- weak bedrock 25m	
84								
86			94.00					
88	27		93.00				- weak bedrock 26.5m	
90								
92			92.00				- weak bedrock 28m	
94			91.00					
96	29							
98			90.00				- weak bedrock 29.5m	
100								
102	31		89.00				- weak bedrock 31m	
104			88.00					
106								
108	33		87.00				- weak bedrock 32.5m	
110			86.00				- weak bedrock 34m	
112		End of Borehole						
114	35		85.00					
116								
118			84.00					

Drilled By: GET Drilling Ltd.
Drill Method: Rotary Tri-cone
Hole Size: 3.87" (98mm)
Drill Date: April 2, 13, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

BluMetric™ Environmental

Project No: 180150-02

Project: Complementary CAZ Investigation

Client: Waste Management

Location: Richmond Landfill, Napanee, ON

Well ID: M198

Easting: 0
Northing: 0
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth (ft / m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
-3 / -1		Ground Surface	119.73				- M198 120.24m TOC - S/U 0.51m	
1		Topsoil						
3 / 5 / 7 / 2		***Sandy Clay*** Brown, wet.	119.00 118.00				- 200mm HSA to depth 3.66m - 140mm OD steel casing cement grouted to 3.66m	
9 / 11		***Till*** Brown, with cobbles.	117.00					
13 / 4			116.00					
15 / 17			115.00					
19 / 6			114.00					
21 / 23			113.00				- weak bedrock 6.5 - 6.7m	
25 / 8			112.00					
27 / 29		***Limestone*** Light grey, lithographic fossiliferrous limestone with undulating shale partings. Stylolites are common. Numerous calcite stringers throughout. Occassional coarse crystalline zones.	111.00				- weak bedrock8.4m - weak bedrock8.7m	
31 / 33 / 10			110.00					
35 / 37			109.00					
39 / 12			108.00					
41 / 43			107.00					
45 / 14			106.00				- weak rock 13.5m	
47 / 49			105.00					
51 / 53 / 16			104.00					
55			103.00					
57			102.00					

Drilled By: GET Drilling Ltd.
Drill Method: Rotary Tri-cone
Hole Size: 3.87" (98mm)
Drill Date: April 2, 16, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

BluMetric™ Environmental

Project No: 180150-02

Project: Complementary CAZ Investigation

Client: Waste Management

Location: Richmond Landfill, Napanee, ON

Well ID: M198

Easting: 0
Northing: 0
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (% 20 60)	Fracture Frequency/Run	Comments	K (m/sec)
60–114		***Limestone*** Light grey, lithographic fossiliferrous limestone with undulating shale partings. Stylolites are common. Numerous calcite stringers throughout. Occassional coarse crystalline zones.	101.00 to 85.00				- weak bedrock 20m	
114–118		End of Borehole	85.00 to 84.00					

Drilled By: GET Drilling Ltd.
Drill Method: Rotary Tri-cone
Hole Size: 3.87" (98mm)
Drill Date: April 2, 16, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

BluMetric™ Environmental

Project No: 180150-02

Project: Complementary CAZ Investigation

Client: Waste Management

Location: Richmond Landfill, Napanee, ON

Well ID: M199

Easting: 335717
Northing: 4902031
Field Personnel: B.Mc.

SUBSURFACE PROFILE

Depth (ft / m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
-3 / -1		Ground Surface	116.00 / 115.51				MOE Well tag # A228296 - Elev. M199 116.36m TPVC - s/u 0.84m	
1 – 11		***Clay*** Brown. ***Limestone*** Light grey, lithographic fossiliferrous limestone with undulating shale partings. Stylolites are common. Numerous calcite stringers throughout. Occassional coarse crystalline zones.	115.00 114.00 113.00				- 150mm solid flight auger to 1.04m - Fracture or weak bedrock 0.5m - 100sqmm steel casing with bentonite gravel seal - Fracture or weak bedrock 0.87m - water bearing fracture 1.35m - 1.5m x 50mm slot 10 PVc screen within #3 silica sand pack - fracture/weak bedrock 2.35m - weaker bedrock or fracture 2.55m - weak bedrock 2.85 - 3.0m - water bearing fracture 3.1 - 3.18m - weak bedrock 3.43m	
13		End of Borehole	112.00					

Drilled By: GET Drilling Ltd.
Drill Method: Rotary Air Hammer
Hole Size: 5" (127mm)
Drill Date: April 3, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

BluMetric™ Environmental

Project No: 180150-02
Project: Complementary CAZ Investigation
Client: Waste Management
Location: Richmond Landfill, Napanee, ON

Well ID: M199-DP

Easting: 335722
Northing: 4902012
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth (ft / m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
-4 /			116.00				- Elev. M199-DP 116.06 m TOC - TOC s/u 0.89m	
-2 /								
0 /		Ground Surface	115.17					
		Clay Brown	115.00				- bentonite gravel seal - 0.5m x 32mm Steel screen	
2 /								
		End of Borehole						
1 /								

Drilled By: BluMetric Environmental Inc.
Drill Method: Drive Point
Hole Size: 1.25" (32mm)
Drill Date: April 24, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

Project No: 180150-02

Project: Complementary CAZ Investigation

Client: Waste Management

Location: Richmond Landfill, Napanee, ON

Well ID: M200

Easting: 335796
Northing: 4902060
Field Personnel: B.Mc.

SUBSURFACE PROFILE

Depth (ft / m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
-3 / -1		Ground Surface	116.00 / 115.40				MOE Well tag # A228384 - Elev. M200 116.02m TPVC - s/u 0.62m	
1 / 3 / 5 / 7 / 9 / 11		***Clay*** Brown. ***Limestone*** Light grey, lithographic fossiliferrous limestone with undulating shale partings. Stylolites are common. Numerous calcite stringers throughout. Occassional coarse crystalline zones.	115.00 114.00 113.00				- 150mm solid flight auger to 0.91m - 100sqmm steel casing with bentonite gravel seal - Fracture trace water 1.37m - Fracture trace water 1.82m - 1.5m x 50mm slot 10 PVc screen within #3 silica sand pack - weak bedrock, water bearing fractures, sulfur odour 2.44 - 3.05m	
13		End of Borehole	112.00					

Drilled By: GET Drilling Ltd.
Drill Method: Rotary Air Hammer
Hole Size: 5" (127mm)
Drill Date: April 17, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

BluMetric™ Environmental

Project No: 180150-02
Project: Complementary CAZ Investigation
Client: Waste Management
Location: Richmond Landfill, Napanee, ON

Well ID: M200-DP

Easting: 335804
Northing: 4902056
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (% 20 60)	Fracture Frequency/Run	Comments	K (m/sec)
ft m -4			116.00				- Elev. M200-DP 116.00m TOC - TOC s/u 0.81m	
-2								
0		Ground Surface	115.18					
		Clay Brown	115.00				- bentonite gravel seal - 0.5m x 32mm Steel screen	
2								
1		End of Borehole						

Drilled By: BluMetric Environmental Inc.
Drill Method: Drive Point
Hole Size: 1.25" (32mm)
Drill Date: April 24, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

Project No: 180150-02
Project: Complementary CAZ Investigation
Client: Waste Management
Location: Richmond Landfill, Napanee, ON

Well ID: M201

Easting: 335830
Northing: 4901993
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth (ft / m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
-3 / -1		Ground Surface	116.00 / 115.47				MOE Well tag # A228378 - Elev. M201 116.18m TPVC - s/u 0.71m	
1 / 3 / 5		***Till*** Brown, clayey Sand.	115.00 / 114.00				- 150mm solid flight auger to 2.40m - 100sqmm steel casing with bentonite gravel seal	
2 / 7 / 9 / 11 / 4 / 13		***Limestone*** Light grey, lithographic fossiliferrous limestone with undulating shale partings. Stylolites are common. Numerous calcite stringers throughout. Occassional coarse crystalline zones.	113.00 / 112.00				- water bearing fracture 3.05m - water bearing fracture 3.2m - 1.5m x 50mm slot 10 PVc screen within #3 silica sand pack - weak bedrock with sulfur odour 3.87m	
15		End of Borehole	111.00					

Drilled By: GET Drilling Ltd.
Drill Method: Rotary Air Hammer
Hole Size: 5" (127mm)
Drill Date: April 18, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

BluMetric™ Environmental

Project No: 180150-02
Project: Complementary CAZ Investigation
Client: Waste Management
Location: Richmond Landfill, Napanee, ON

Well ID: M201-DP

Easting: 335828
Northing: 4901991
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth (ft / m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
-4 /								
			116.00				- Elev. M201-DP 116.20m TOC - TOC s/u 0.99m	
-2 /								
0 /		Ground Surface	115.21					
			115.00				- bentonite gravel seal	
2 /		***Till*** Brown, clayey Sand.						
1 /								
			114.00				- 0.5m x 32mm Steel screen	
4 /								
		End of Borehole						
6 /								

Drilled By: BluMetric Environmental Inc.
Drill Method: Drive Point
Hole Size: 1.25" (32mm)
Drill Date: April 18, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

Project No: 180150-02

Project: Complementary CAZ Investigation

Client: Waste Management

Location: Richmond Landfill, Napanee, ON

Well ID: M202

Easting: 335929
Northing: 4902013
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth (ft / m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
-3 / -1			117.00				MOE Well tag # A228379 - Elev. M202 117.22m TPVC - s/u 0.75m	
		Ground Surface	116.48					
		Overburden						
1 / 3			116.00				- 150mm solid flight auger to 1.37m - 100sqmm steel casing with bentonite gravel seal	
5 / 2		***Limestone*** Light grey, lithographic fossiliferrous limestone with undulating shale partings. Stylolites are common. Numerous calcite stringers throughout. Occassional coarse crystalline zones.	115.00				- weak bedrock, multiple fractures, trace water 1.68 - 2.29m	
7							- weak bedrock 2.37m	
			114.00				- weak bedrock zones 2.5 - 2.74m	
9							- weak bedrock 3.05m	
11		End of Borehole	113.00					

Drilled By: GET Drilling Ltd.
Drill Method: Rotary Air Hammer
Hole Size: 5" (127mm)
Drill Date: April 18, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

BluMetric™ Environmental

Project No: 180150-02
Project: Complementary CAZ Investigation
Client: Waste Management
Location: Richmond Landfill, Napanee, ON

Well ID: M203

Easting: 335708
Northing: 4902128
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth (ft / m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
-3 / -1		Ground Surface	118.18				MOE Well tag # A228386 - Elev. M203 118.91m TPVC - s/u 0.73m	
1 / 3 / 5 / 7 / 9		***Limestone*** Light grey, lithographic fossiliferrous limestone with undulating shale partings. Stylolites are common. Numerous calcite stringers throughout. Occassional coarse crystalline zones.	118.00 117.00 116.00				- 150mm solid flight auger to 1.07m - 100sqmm steel casing with bentonite gravel seal - weak bedrock 2.13m - 1.5m x 50mm slot 10 PVc screen within #3 silica sand pack - fracture trace water 2.59m	
11		End of Borehole	115.00					

Drilled By: GET Drilling Ltd.
Drill Method: Rotary Air Hammer
Hole Size: 5" (127mm)
Drill Date: April 18, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

BluMetric™ Environmental

Project No: 180150-02

Project: Complementary CAZ Investigation

Client: Waste Management

Location: Richmond Landfill, Napanee, ON

Well ID: M204

Easting: 335912
Northing: 4902187
Field Personnel: B.Mc.

SUBSURFACE PROFILE

Depth (ft / m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
-3 / -1		Ground Surface	116.06				MOE Well tag # A228385 - Elev. M204 m TPVC - s/u 0.86m	
1 / 3 / 5		***Sandy Clay*** Brown, wet to saturated.	116.00 115.00				- 150mm solid flight auger to 1.5m - 100sqmm steel casing with bentonite gravel seal	
7 / 9 / 11 / 13 / 2 / 4		***Limestone*** Light grey, lithographic fossiliferrous limestone with undulating shale partings. Stylolites are common. Numerous calcite stringers throughout. Occassional coarse crystalline zones.	114.00 113.00 112.00				- weak bedrock 2.19m - 1.5m x 50mm slot 10 PVc screen within #3 silica sand pack - weak bedrock trace water 4.11 - 4.42m	
15		End of Borehole						

Drilled By: GET Drilling Ltd.
Drill Method: Rotary Air Hammer
Hole Size: 5" (127mm)
Drill Date: April 17, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: F.R.

BluMetric™ Environmental

Project No: 180150-02
Project: Complementary CAZ Investigation
Client: Waste Management
Location: Richmond Landfill, Napanee, ON

Well ID: M204-DP

Easting: 335909
Northing: 4902187
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth (ft / m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
-4 / -2			117.00				- Elev. M204-DP 117.15m TOC - TOC s/u 1.14m	
0		Ground Surface	116.01					
0			116.00				- bentonite gravel seal	
2		***Sandy Clay*** Brown, wet to saturated.						
1			115.00				- 0.5m x 32mm Steel screen	
4		End of Borehole						
6								

Drilled By: BluMetric Environmental Inc.
Drill Method: Drive Point
Hole Size: 1.25" (32mm)
Drill Date: April 17, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

Project No: 180150-02

Project: Complementary CAZ Investigation

Client: Waste Management

Location: Richmond Landfill, Napanee, ON

Well ID: M205

Easting: 336078
Northing: 4902129
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth (ft / m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
-3 / -1							MOE Well tag # A228367 - Elev. M205 116.58m TPVC - s/u 0.75m	
		Ground Surface	116.00 115.83					
1 / 3		***Sandy Clay*** Brown, wet to saturated.	115.00				- 150mm solid flight auger to 1.07m - 100sqmm steel casing with bentonite gravel seal	
5 / 2 / 7		***Limestone*** Light grey, lithographic fossiliferrous limestone with undulating shale partings. Stylolites are common. Numerous calcite stringers throughout. Occassional coarse crystalline zones.	114.00				- weak bedrock, fracture, water bearing 2.07m - water bearing fracture 2.59m - 1.5m x 50mm slot 10 PVc screen within #3 silica sand pack	
9 / 11			113.00				- fracture trace water 3.17m - water bearing fracture 3.29m	
13 / 4		End of Borehole	112.00					

Drilled By: GET Drilling Ltd.
Drill Method: Rotary Air Hammer
Hole Size: 5" (127mm)
Drill Date: April 17, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

BluMetric™ Environmental

Project No: 180150-02
Project: Complementary CAZ Investigation
Client: Waste Management
Location: Richmond Landfill, Napanee, ON

Well ID: M205-DP

Easting: 336077
Northing: 4902130
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth (ft / m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
-4 / -2			116.00				- Elev. M205-DP 116.55m TOC - TOC s/u 0.88m	
0		Ground Surface	115.67					
0 / 2		***Sandy Clay*** Brown, wet to saturated.	115.00				- bentonite gravel seal - 0.5m x 32mm Steel screen	
4 / 1		End of Borehole						

Drilled By: BluMetric Environmental Inc.
Drill Method: Drive Point
Hole Size: 1.25" (32mm)
Drill Date: April 17, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

Project No: 180150-02

Project: Complementary CAZ Investigation

Client: Waste Management

Location: Richmond Landfill, Napanee, ON

Well ID: M206

Easting: 335939
Northing: 4902329
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth (ft / m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
-3 / -1		Ground Surface	119.00 / 118.89				MOE Well tag # A228368 - Elev. M206 119.70m TPVC - s/u 0.82m	
1 / 3 / 5 / 7 / 9		Overburden						
		Limestone Light grey, lithographic fossiliferrous limestone with undulating shale partings. Stylolites are common. Numerous calcite stringers throughout. Occassional coarse crystalline zones.	118.00 117.00 116.00				- 150mm solid flight auger to 1.07m - 100sqmm steel casing with bentonite gravel seal - weak bedrock, fracture, water bearing 2.13m - 1.5m x 50mm slot 10 PVc screen within #3 silica sand pack	
11		End of Borehole						

Drilled By: GET Drilling Ltd.
Drill Method: Rotary Air Hammer
Hole Size: 5" (127mm)
Drill Date: April 17, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: F.R.

BluMetric™ Environmental

Project No: 180150-02
Project: Complementary CAZ Investigation
Client: Waste Management
Location: Richmond Landfill, Napanee, ON

Well ID: M206-DP

Easting: 335960
Northing: 4902295
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth (ft / m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
0		Ground Surface	118.00 117.79				- Elev. M206-DP 118.95m TOC - TOC s/u 1.16m	
0 – 2		Overburden.	117.00				- bentonite gravel seal	
2 – 4							- 0.5m x 32mm Steel screen	
6		End of Borehole	116.00					

Drilled By: BluMetric Environmental Inc.
Drill Method: Drive Point
Hole Size: 1.25" (32mm)
Drill Date: April 24, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

Project No: 180150-02

Project: Complementary CAZ Investigation

Client: Waste Management

Location: Richmond Landfill, Napanee, ON

Well ID: M207

Easting: 336132
Northing: 4902264
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth (ft / m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
-3 / -1			117.00				MOE Well tag # A228297 - Elev. M207 117.31m TPVC - s/u 0.86m	
		Ground Surface	116.45					
1 / 3		Overburden, brown, clayey	116.00				- 150mm solid flight auger to 1.43m - W/L elev. 115.89m recorded June 11, 2018 - weak bedrock, fracture 0.6, 0.76m - 100sqmm steel casing with bentonite gravel seal - weak bedrock 1.03, 1.40m	
5 / 2		***Limestone*** Light grey, lithographic fossiliferrous limestone with undulating shale partings. Stylolites are common. Numerous calcite stringers throughout. Occassional coarse crystalline zones.	115.00					
7 / 9			114.00				- weak bedrock 2.13, 2.40,2.52m - 1.5m x 50mm slot 10 PVc screen within #3 silica sand pack - weak bedrock 2.7m	
11							- weak bedrock 3.17 - 3.26m - water bearing fracture 3.29m	
13 / 4		End of Borehole	113.00					

Drilled By: GET Drilling Ltd.
Drill Method: Rotary Air Hammer
Hole Size: 5" (127mm)
Drill Date: April 3, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

BluMetric™ Environmental

Project No: 180150-02
Project: Complementary CAZ Investigation
Client: Waste Management
Location: Richmond Landfill, Napanee, ON

Well ID: M207-DP

Easting: 336138
Northing: 4902190
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth (ft / m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%, 20–60)	Fracture Frequency/Run	Comments	K (m/sec)
-4 /								
							- Elev. M207-DP 117.71m TOC - TOC s/u 1.35m	
-2 /			117.00					
0 /		Ground Surface	116.36					
							- bentonite gravel seal	
			116.00					
2 /		Overburden, brown, clayey.						
							- 0.5m x 32mm Steel screen	
1 /								
4 /		End of Borehole	115.00					

Drilled By: BluMetric Environmental Inc.
Drill Method: Drive Point
Hole Size: 1.25" (32mm)
Drill Date: April 24, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

Project No: 180150-02
Project: Complementary CAZ Investigation
Client: Waste Management
Location: Richmond Landfill, Napanee, ON

Well ID: M208-DP

Easting: 336061
Northing: 4902197
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth (ft / m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
-4 /								
							- Elev. M208-DP 117.14m TOC - TOC s/u 1.44m	
-2 /								
			116.00					
0 /		Ground Surface	115.70					
		Overburden, brown, clayey.					- bentonite gravel seal	
2 /			115.00				- 0.5m x 32mm Steel screen	
1 /								
4 /		End of Borehole						

Drilled By: BluMetric Environmental Inc.
Drill Method: Drive Point
Hole Size: 1.25" (32mm)
Drill Date: April 24, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

Project No: 180150-02
Project: Complementary CAZ Investigation
Client: Waste Management
Location: Richmond Landfill, Napanee, ON

Well ID: M209-DP

Easting: 335840
Northing: 4901958
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth (ft / m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
0		Ground Surface	116.20				- Elev. M209-DP 117.38m TOC - TOC s/u 1.17m	
0 – 8	1	Overburden, brown, clayey.	116.00 – 114.00				- bentonite gravel seal - 0.5m x 32mm Steel screen	
		End of Borehole						

Drilled By: BluMetric Environmental Inc.
Drill Method: Drive Point
Hole Size: 1.25" (32mm)
Drill Date: May 4, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

Project No: 180150-02
Project: Complementary CAZ Investigation
Client: Waste Management
Location: Richmond Landfill, Napanee, ON

Well ID: M210-DP

Easting: 336146
Northing: 4902133
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth (ft / m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
-4 / -2		Ground Surface	117.00				- Elev. M210-DP 117.93m TOC - TOC s/u 1.59m	
0 / 2		Overburden, brown, clayey.	116.34				- bentonite gravel seal	
1 / 4		End of Borehole	116.00					

Drilled By: BluMetric Environmental Inc.
Drill Method: Drive Point
Hole Size: 1.25" (32mm)
Drill Date: July 10, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

Project No: 180150-02
Project: Complementary CAZ Investigation
Client: Waste Management
Location: Richmond Landfill, Napanee, ON

Well ID: M211-DP

Easting: 336087
Northing: 4902048
Field Personnel: B.McC.

SUBSURFACE PROFILE

Depth (ft / m)	Stratigraphy	Description	Elevation (m)	Well Construction	Rock Quality Designation (%)	Fracture Frequency/Run	Comments	K (m/sec)
-4 / -2			117.00				- Elev. M211-DP 117.86m TOC - TOC s/u 1.10m	
0		Ground Surface	116.76					
0 / 2 / 4 (1)		Overburden, brown, clayey.	116.00	- bentonite gravel seal				
		End of Borehole						

Drilled By: BluMetric Environmental Inc.
Drill Method: Drive Point
Hole Size: 1.25" (32mm)
Drill Date: July 10, 2018

Drill Angle: Vertical
Azimuth: n.a.
Datum: NAD83
Checked By: M.C.

APPENDIX B

Downhole Geophysical Logs (DGI Geoscience Inc.) (on CD)

ACOUSTIC and OPTICAL TELEVIEWER ANALYSIS

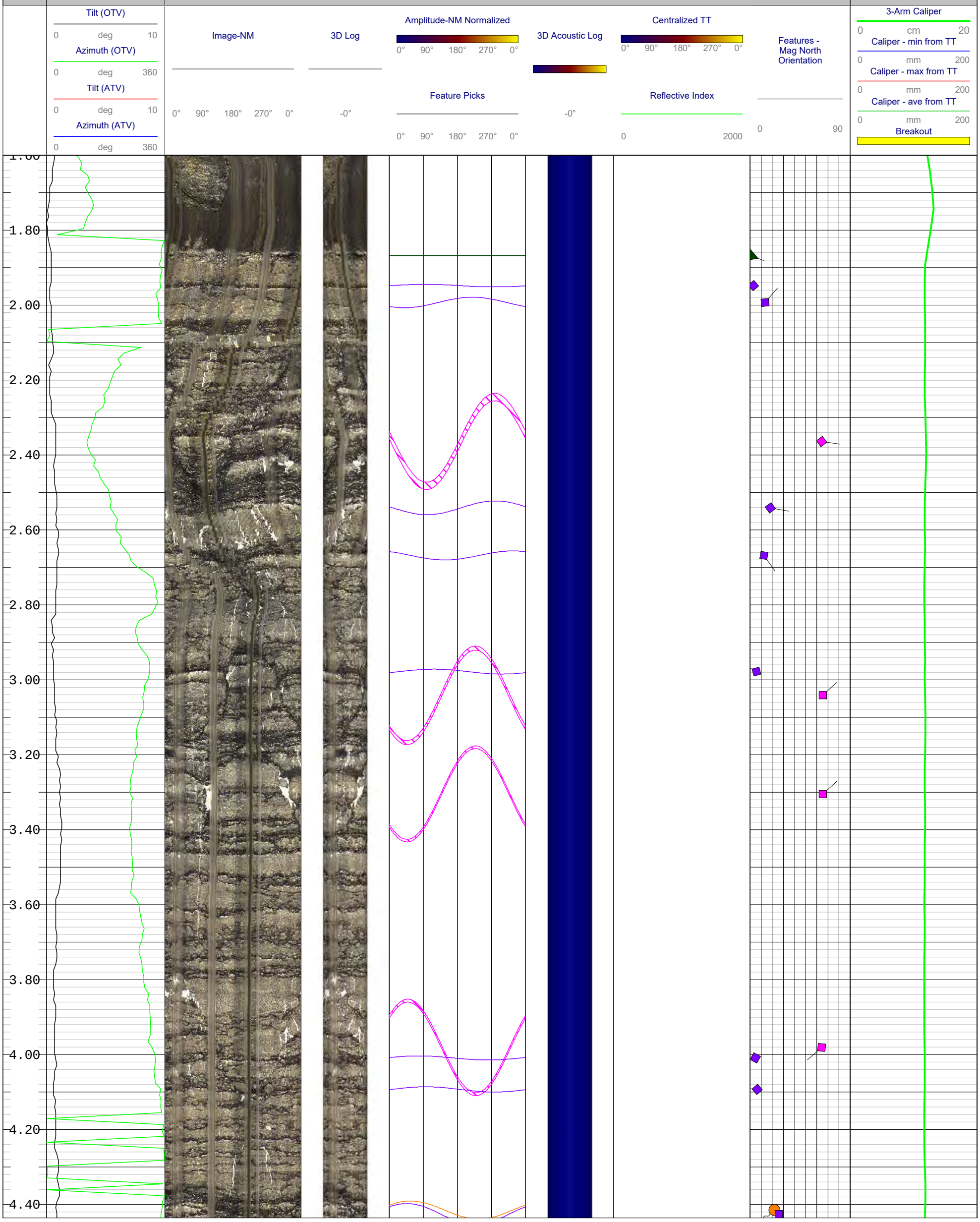
DGI GEOSCIENCE INC.

Company:	WESA	**UTM X (Easting):**	---	**Hole Diameter:**	117 mm
Hole ID:	M196	**UTM Y (Northing):**	---	**Hole Type:**	RC
Acquisition date(s):	Apr. 18-19, 2018	**UTM Z (Elevation):**	---	**Fluid Type:**	---
Field Personnel:	K. Smylie, O. Fomenko	**Total Depth:**	32 m	**Witnessed by:**	---
Legal Location:	Napanee, ON	**Surveyed Depth:**	31 m		
Survey Day(s):	2	**Casing Depth:**	1.9 m		

LEGEND - STRUCTURE TYPE

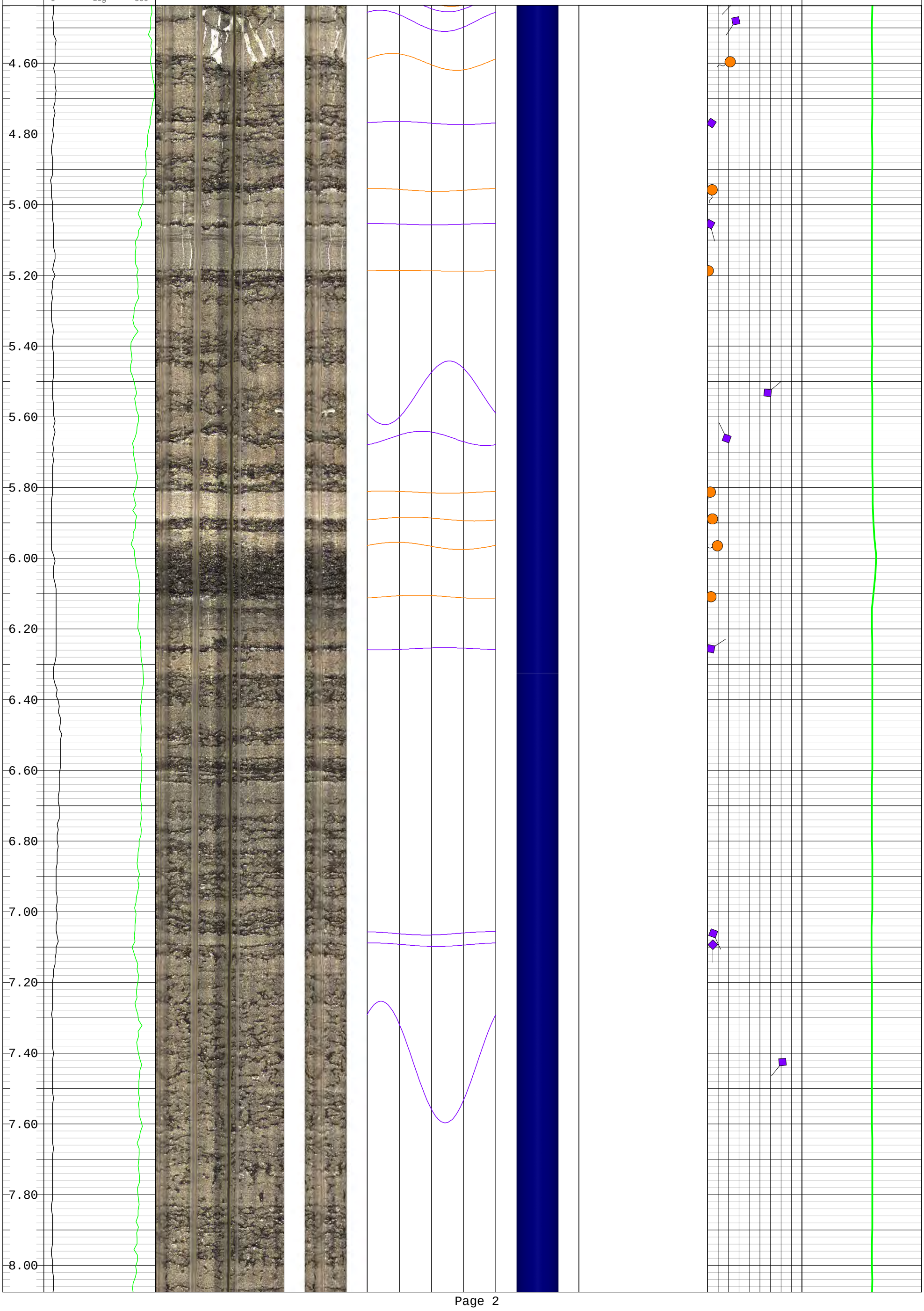
Btm of Casing | Partially Open Joint/Fracture | Minor Joint/Fracture | Vein - Group 1 | Lithology Contact

*** View tadpole orientation from _Structure Analysis.xlsx**



Depth 1m:10m	Orientation	Televiewer Analysis	Caliper

Tilt (OTV) 0 deg 10
Azimuth (OTV) 0 deg 360
Tilt (ATV) 0 deg 10
Azimuth (ATV) 0 deg 360
Image-NM 0° 90° 180° 270° 0°
3D Log -0°
Amplitude-NM Normalized 0° 90° 180° 270° 0°
Feature Picks 0° 90° 180° 270° 0°
3D Acoustic Log -0°
Centralized TT 0° 90° 180° 270° 0°
Reflective Index 0 2000
Features - Mag North Orientation 0 90
3-Arm Caliper 0 cm 20
Caliper - min from TT 0 mm 200
Caliper - max from TT 0 mm 200
Caliper - ave from TT 0 mm 200
Breakout



Depth 1m:10m	Orientation	Televiewer Analysis	Caliper

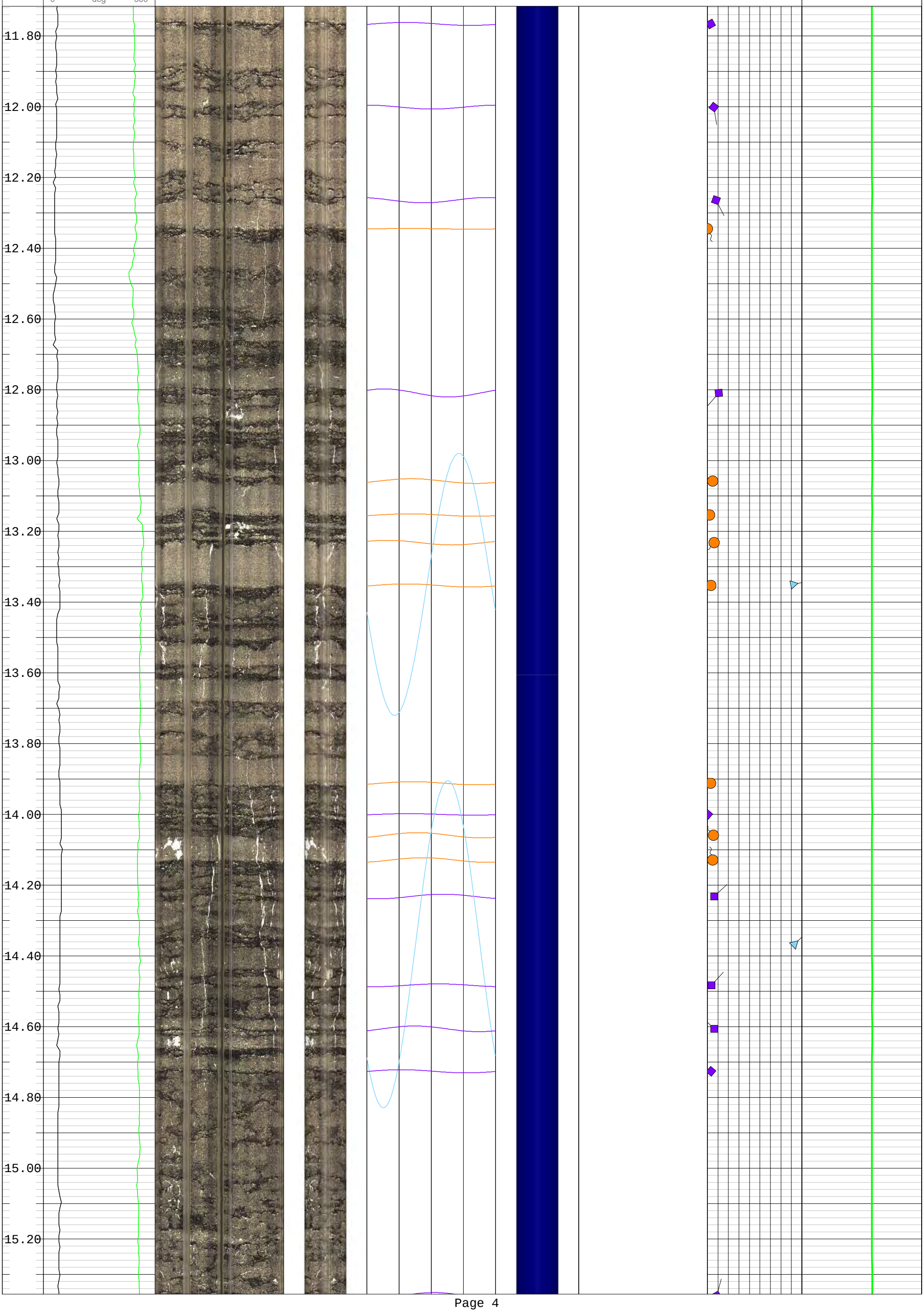
Tilt (OTV) 0 deg 10
Azimuth (OTV) 0 deg 360
Tilt (ATV) 0 deg 10
Azimuth (ATV) 0 deg 360

Image-NM 0° 90° 180° 270° 0°
3D Log -0°
Amplitude-NM Normalized 0° 90° 180° 270° 0°
Feature Picks 0° 90° 180° 270° 0°
3D Acoustic Log -0°
Centralized TT 0° 90° 180° 270° 0°
Reflective Index 0 2000
Features - Mag North Orientation 0 90

3-Arm Caliper 0 cm 20
Caliper - min from TT 0 mm 200
Caliper - max from TT 0 mm 200
Caliper - ave from TT 0 mm 200
Breakout

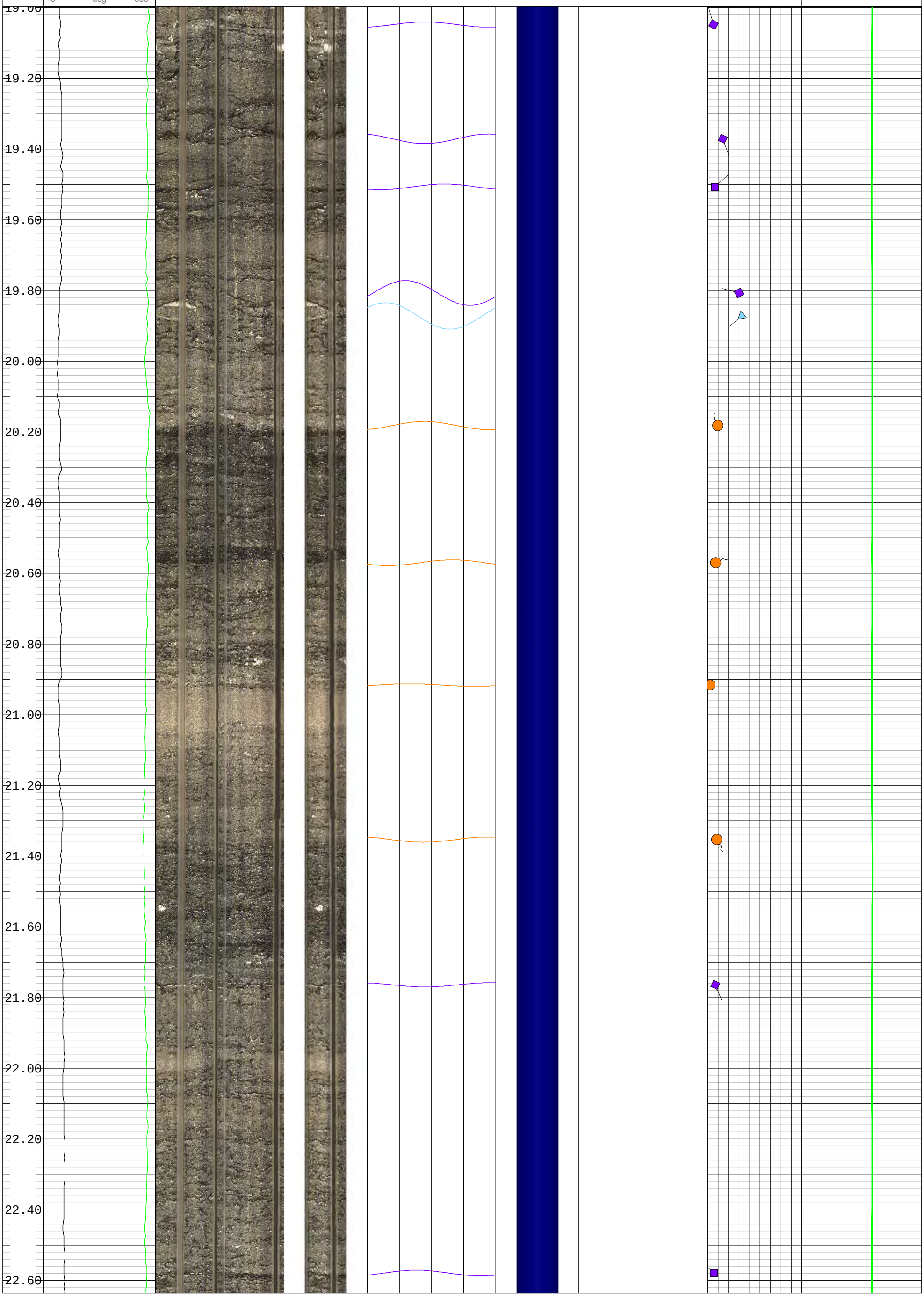
8.20
8.40
8.60
8.80
9.00
9.20
9.40
9.60
9.80
10.00
10.20
10.40
10.60
10.80
11.00
11.20
11.40
11.60

Depth 1m:10m	Orientation	Televiewer Analysis	Caliper
	Tilt (OTV) 0 deg 10 Azimuth (OTV) 0 deg 360 Tilt (ATV) 0 deg 10 Azimuth (ATV) 0 deg 360	Image-NM 0° 90° 180° 270° 0° 3D Log -0° Amplitude-NM Normalized 0° 90° 180° 270° 0° Feature Picks 0° 90° 180° 270° 0° 3D Acoustic Log -0° Centralized TT 0° 90° 180° 270° 0° Reflective Index 0 2000 Features - Mag North Orientation 0 90	3-Arm Caliper 0 cm 20 Caliper - min from TT 0 mm 200 Caliper - max from TT 0 mm 200 Caliper - ave from TT 0 mm 200 Breakout



Depth 1m:10m	Orientation	Televiewer Analysis	Caliper
	Tilt (OTV) 0 deg 10 Azimuth (OTV) 0 deg 360 Tilt (ATV) 0 deg 10 Azimuth (ATV) 0 deg 360	Image-NM 0° 90° 180° 270° 0° 3D Log -0° Amplitude-NM Normalized 0° 90° 180° 270° 0° Feature Picks 0° 90° 180° 270° 0° 3D Acoustic Log -0° Centralized TT 0° 90° 180° 270° 0° Reflective Index 0 2000 Features - Mag North Orientation 0 90	3-Arm Caliper 0 cm 20 Caliper - min from TT 0 mm 200 Caliper - max from TT 0 mm 200 Caliper - ave from TT 0 mm 200 Breakout
	15.40 15.60 15.80 16.00 16.20 16.40 16.60 16.80 17.00 17.20 17.40 17.60 17.80 18.00 18.20 18.40 18.60 18.80		

Depth 1m:10m	Orientation	Televiewer Analysis						Caliper
	Tilt (OTV) 0 deg 10 Azimuth (OTV) 0 deg 360 Tilt (ATV) 0 deg 10 Azimuth (ATV) 0 deg 360	Image-NM 0° 90° 180° 270° 0°	3D Log -0°	Amplitude-NM Normalized 0° 90° 180° 270° 0° Feature Picks 0° 90° 180° 270° 0°	3D Acoustic Log -0°	Centralized TT 0° 90° 180° 270° 0° Reflective Index 0 2000	Features - Mag North Orientation 0 90	3-Arm Caliper 0 cm 20 Caliper - min from TT 0 mm 200 Caliper - max from TT 0 mm 200 Caliper - ave from TT 0 mm 200 Breakout



Depth 1m:10m	Orientation	Televiewer Analysis	Caliper

Tilt (OTV) 0 deg 10
Azimuth (OTV) 0 deg 360
Tilt (ATV) 0 deg 10
Azimuth (ATV) 0 deg 360

Image-NM 0° 90° 180° 270° 0°
3D Log -0°
Amplitude-NM Normalized 0° 90° 180° 270° 0°
Feature Picks 0° 90° 180° 270° 0°
3D Acoustic Log -0°
Centralized TT 0° 90° 180° 270° 0°
Reflective Index 0 2000
Features - Mag North Orientation 0 90

3-Arm Caliper 0 cm 20
Caliper - min from TT 0 mm 200
Caliper - max from TT 0 mm 200
Caliper - ave from TT 0 mm 200
Breakout

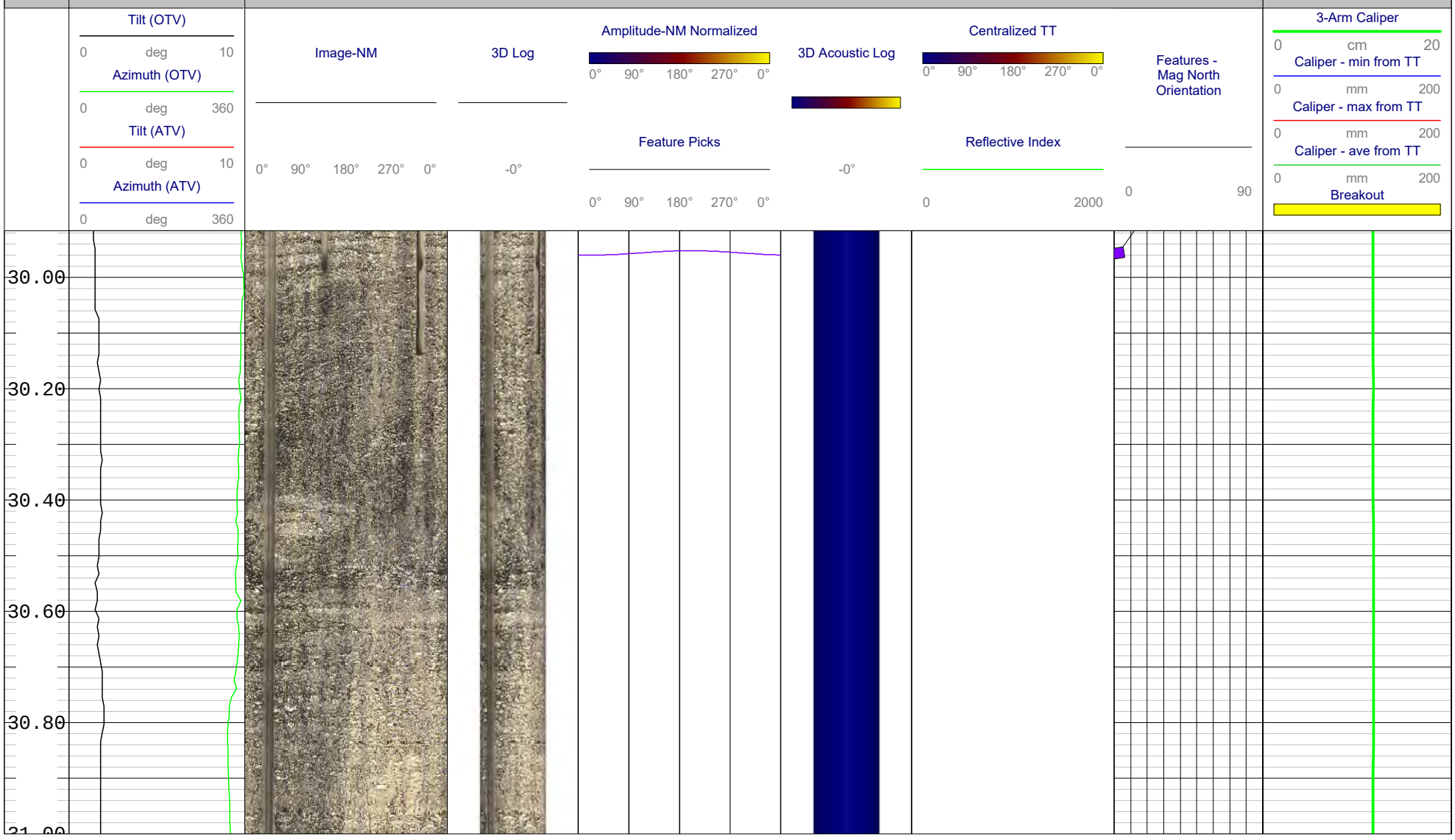
22.80
23.00
23.20
23.40
23.60
23.80
24.00
24.20
24.40
24.60
24.80
25.00
25.20
25.40
25.60
25.80
26.00
26.20

Depth 1m:10m	Orientation	Televiewer Analysis	Caliper

Tilt (OTV) 0 deg 10
Azimuth (OTV) 0 deg 360
Tilt (ATV) 0 deg 10
Azimuth (ATV) 0 deg 360
Image-NM 0° 90° 180° 270° 0°
3D Log -0°
Amplitude-NM Normalized 0° 90° 180° 270° 0°
Feature Picks 0° 90° 180° 270° 0°
3D Acoustic Log -0°
Centralized TT 0° 90° 180° 270° 0°
Reflective Index 0 2000
Features - Mag North Orientation 0 90
3-Arm Caliper 0 cm 20
Caliper - min from TT 0 mm 200
Caliper - max from TT 0 mm 200
Caliper - ave from TT 0 mm 200
Breakout

26.40
26.60
26.80
27.00
27.20
27.40
27.60
27.80
28.00
28.20
28.40
28.60
28.80
29.00
29.20
29.40
29.60
29.80

Depth 1m:10m	Orientation	Televiewer Analysis	Caliper



ACOUSTIC and OPTICAL TELEVIEWER ANALYSIS

DGI GEOSCIENCE INC.

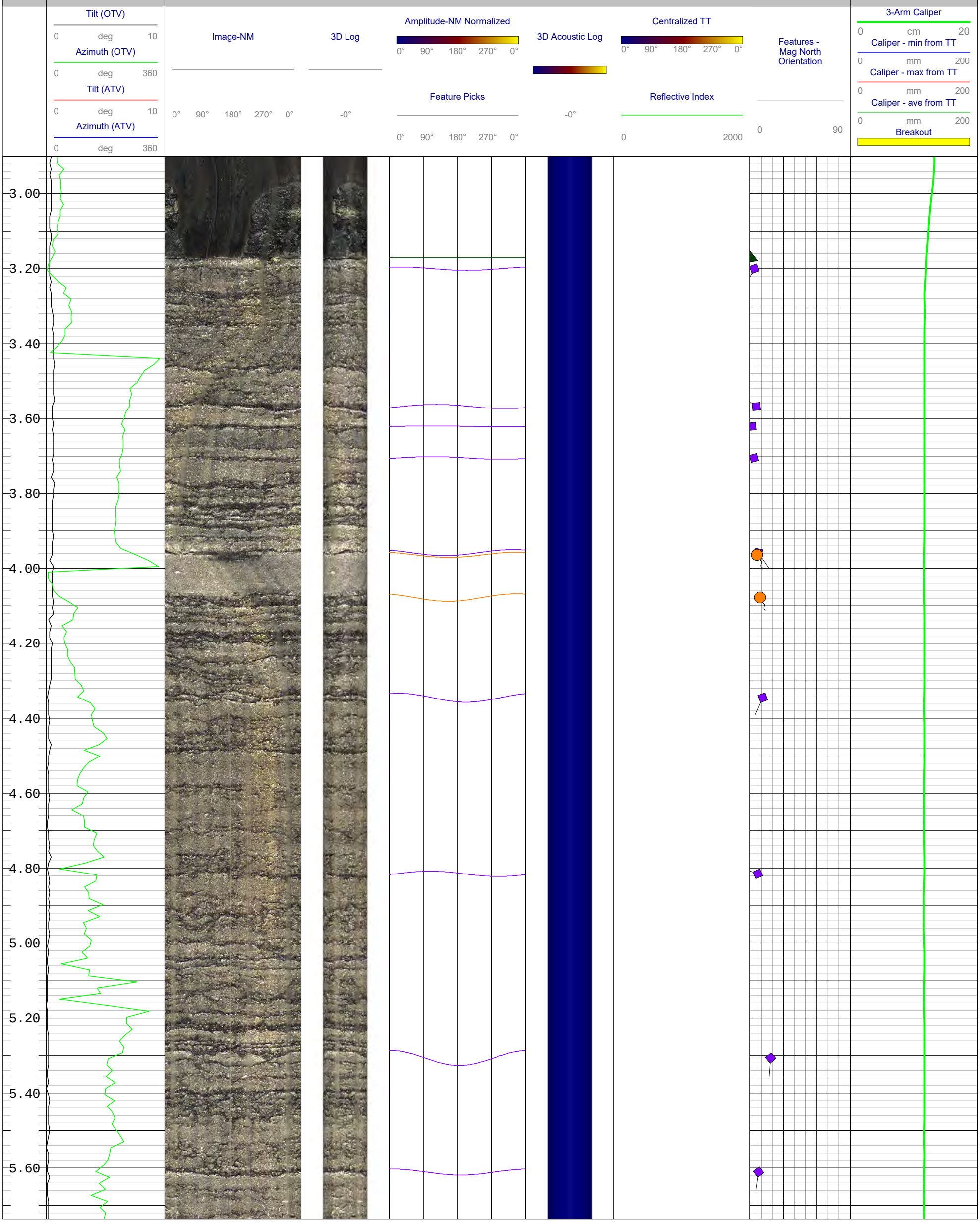
Company:	WESA	**UTM X (Easting):**	---	**Hole Diameter:**	117 mm
Hole ID:	M197	**UTM Y (Northing):**	---	**Hole Type:**	RC
Acquisition date(s):	Apr. 18-19, 2018	**UTM Z (Elevation):**	---	**Fluid Type:**	---
Field Personnel:	K. Smylie, O. Fomenko	**Total Depth:**	32 m	**Witnessed by:**	---
Legal Location:	Napanee, ON	**Surveyed Depth:**	30 m		
Survey Day(s):	2	**Casing Depth:**	13.2 m		

No acoustic televiewer was collected on this borehole due to lack of water.

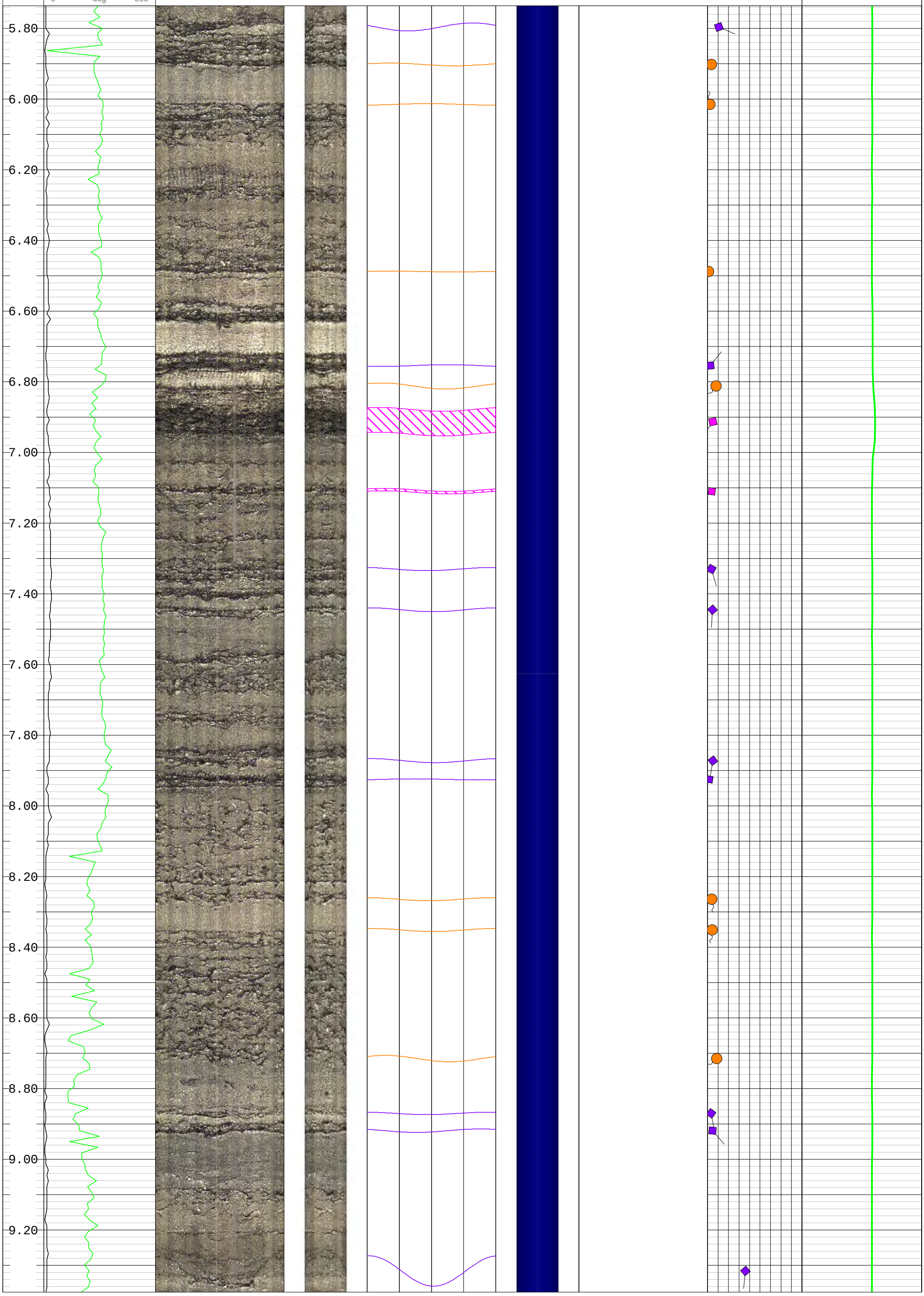
LEGEND - STRUCTURE TYPE

Btm of Casing | Partially Open Joint/Fracture | Minor Joint/Fracture | Lithology Contact

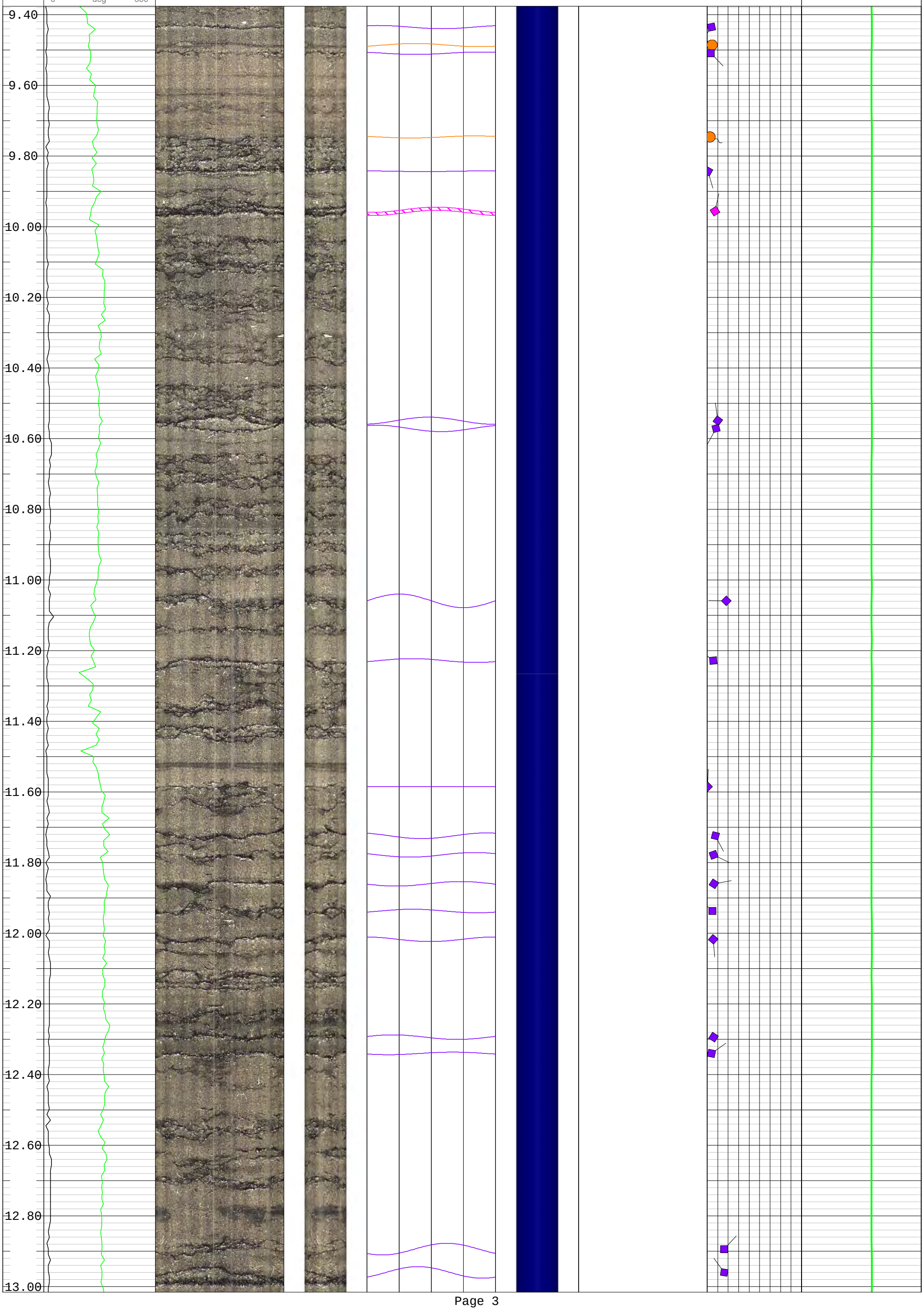
*** View tadpole orientation from _Structure Analysis.xlsx**



Depth 1m:10m	Orientation	Televiewer Analysis						Caliper
	Tilt (OTV) 0 deg 10 Azimuth (OTV) 0 deg 360 Tilt (ATV) 0 deg 10 Azimuth (ATV) 0 deg 360	Image-NM 0° 90° 180° 270° 0°	3D Log -0°	Amplitude-NM Normalized 0° 90° 180° 270° 0° Feature Picks 0° 90° 180° 270° 0°	3D Acoustic Log -0°	Centralized TT 0° 90° 180° 270° 0° Reflective Index 0 2000	Features - Mag North Orientation 0 90	3-Arm Caliper 0 cm 20 Caliper - min from TT 0 mm 200 Caliper - max from TT 0 mm 200 Caliper - ave from TT 0 mm 200 Breakout



Depth 1m:10m	Orientation	Televiewer Analysis						Caliper
	Tilt (OTV) 0 deg 10 Azimuth (OTV) 0 deg 360 Tilt (ATV) 0 deg 10 Azimuth (ATV) 0 deg 360	Image-NM 0° 90° 180° 270° 0°	3D Log -0°	Amplitude-NM Normalized 0° 90° 180° 270° 0° Feature Picks 0° 90° 180° 270° 0°	3D Acoustic Log -0°	Centralized TT 0° 90° 180° 270° 0° Reflective Index 0 2000	Features - Mag North Orientation 0 90	3-Arm Caliper 0 cm 20 Caliper - min from TT 0 mm 200 Caliper - max from TT 0 mm 200 Caliper - ave from TT 0 mm 200 Breakout



Depth 1m:10m	Orientation	Televiewer Analysis	Caliper

Tilt (OTV) 0 deg 10
Azimuth (OTV) 0 deg 360
Tilt (ATV) 0 deg 10
Azimuth (ATV) 0 deg 360
Image-NM 0° 90° 180° 270° 0°
3D Log -0°
Amplitude-NM Normalized 0° 90° 180° 270° 0°
Feature Picks 0° 90° 180° 270° 0°
3D Acoustic Log -0°
Centralized TT 0° 90° 180° 270° 0°
Reflective Index 0 2000
Features - Mag North Orientation 0 90
3-Arm Caliper 0 cm 20
Caliper - min from TT 0 mm 200
Caliper - max from TT 0 mm 200
Caliper - ave from TT 0 mm 200
Breakout

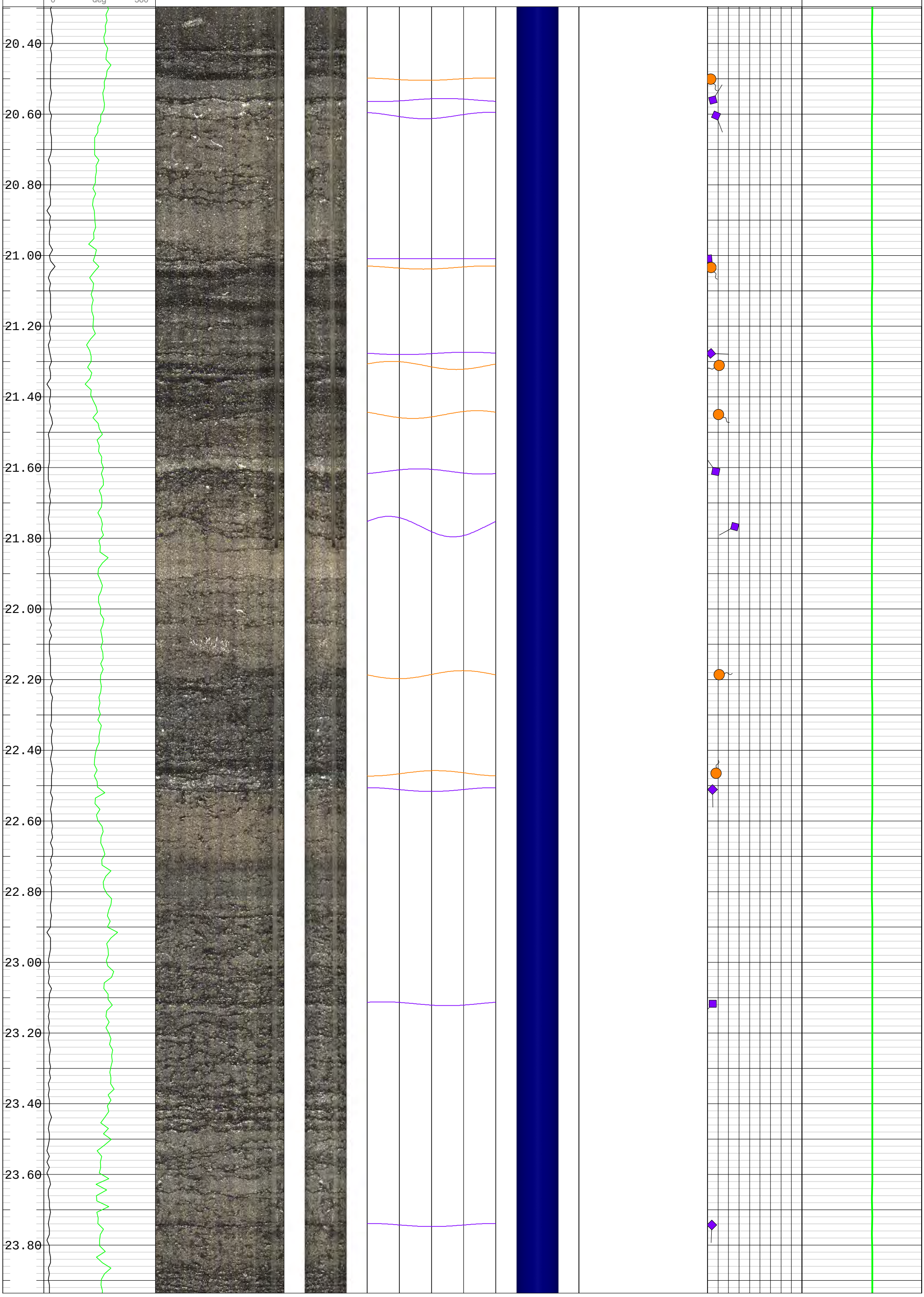
13.20
13.40
13.60
13.80
14.00
14.20
14.40
14.60
14.80
15.00
15.20
15.40
15.60
15.80
16.00
16.20
16.40
16.60

Depth 1m:10m	Orientation	Televiewer Analysis	Caliper

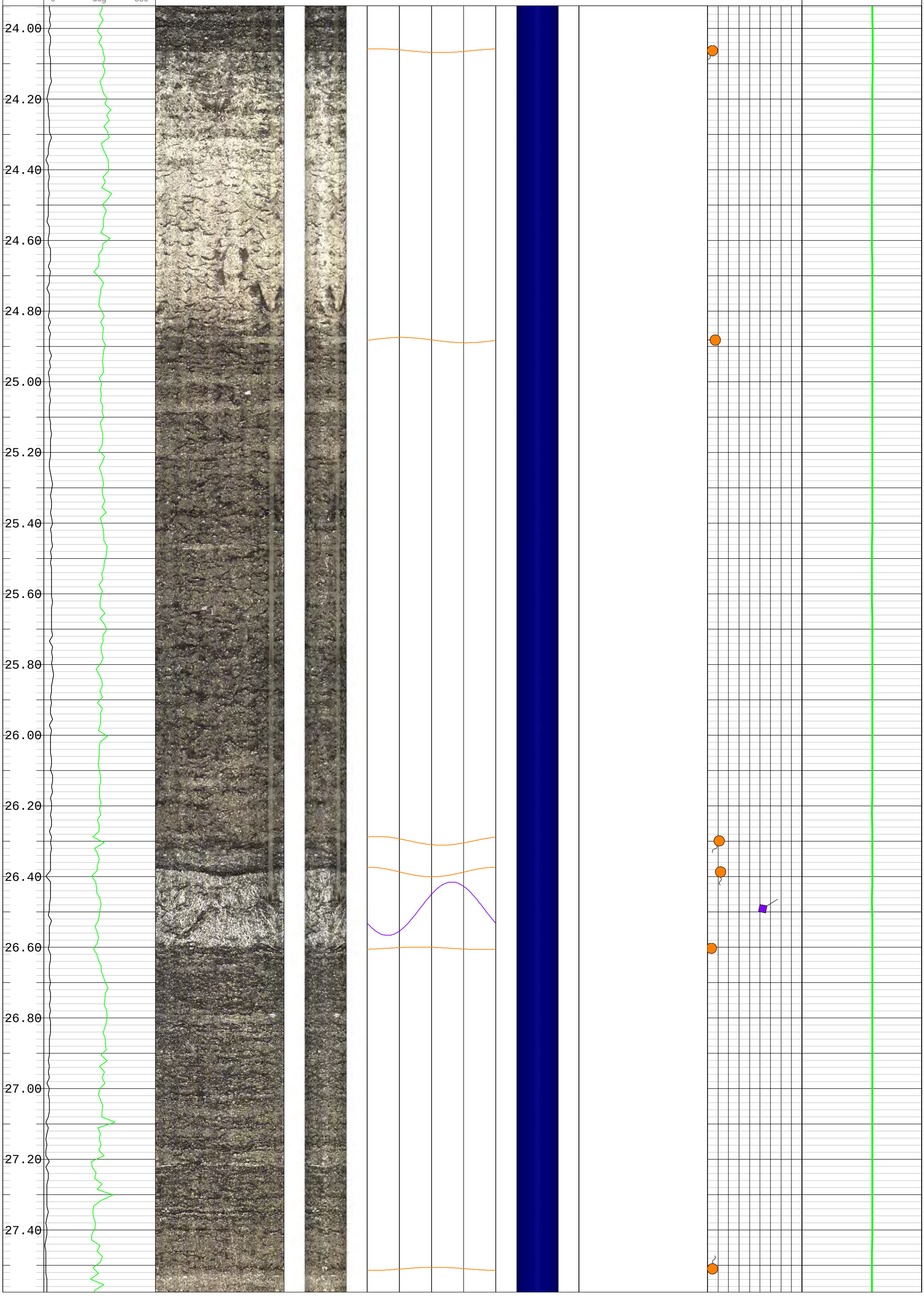
Tilt (OTV) 0 deg 10
Azimuth (OTV) 0 deg 360
Tilt (ATV) 0 deg 10
Azimuth (ATV) 0 deg 360
Image-NM 0° 90° 180° 270° 0°
3D Log -0°
Amplitude-NM Normalized 0° 90° 180° 270° 0°
Feature Picks 0° 90° 180° 270° 0°
3D Acoustic Log -0°
Centralized TT 0° 90° 180° 270° 0°
Reflective Index 0 2000
Features - Mag North Orientation 0 90
3-Arm Caliper 0 cm 20
Caliper - min from TT 0 mm 200
Caliper - max from TT 0 mm 200
Caliper - ave from TT 0 mm 200
Breakout

16.80
17.00
17.20
17.40
17.60
17.80
18.00
18.20
18.40
18.60
18.80
19.00
19.20
19.40
19.60
19.80
20.00
20.20

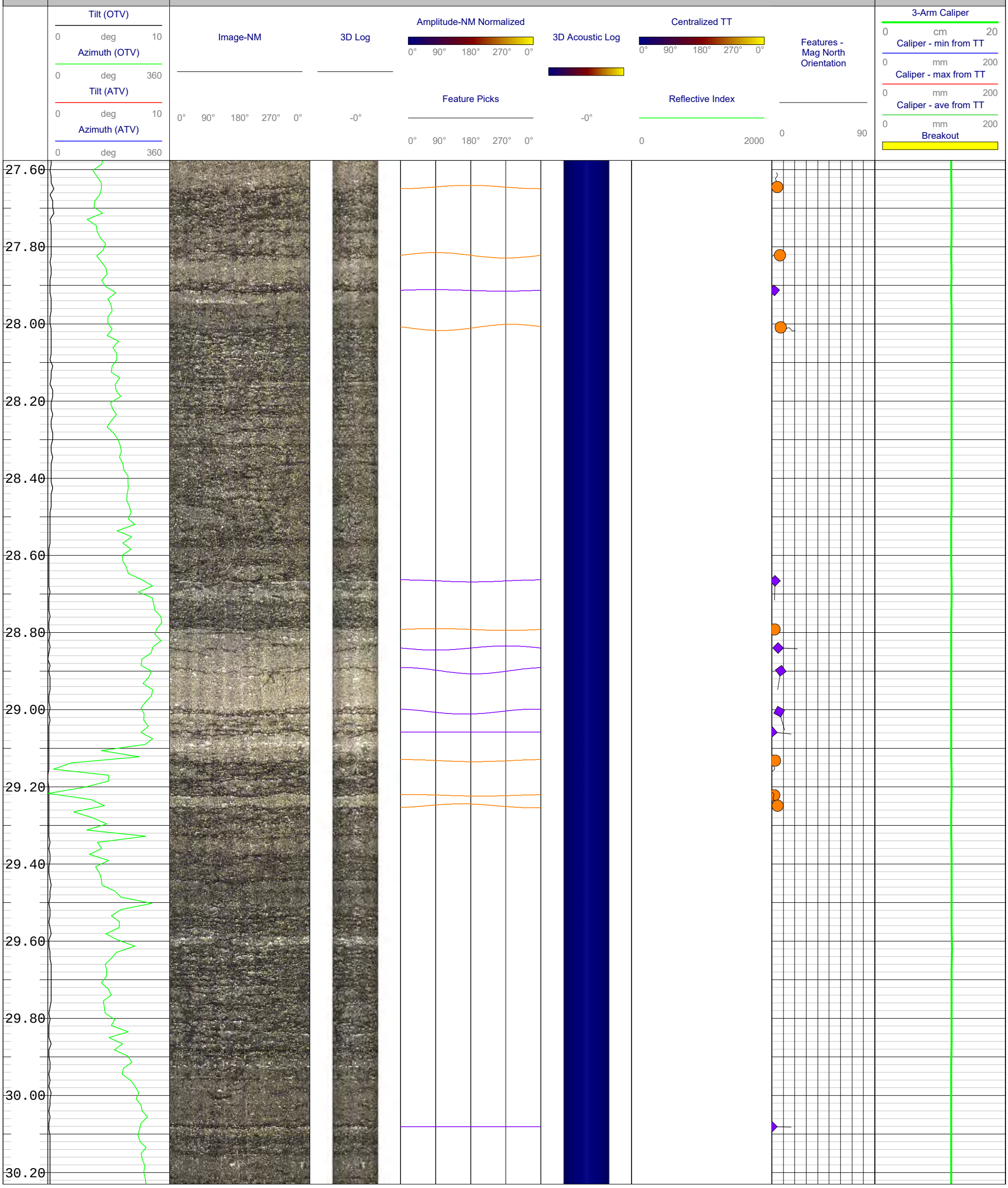
Depth 1m:10m	Orientation	Televiewer Analysis	Caliper
	Tilt (OTV) 0 deg 10 Azimuth (OTV) 0 deg 360 Tilt (ATV) 0 deg 10 Azimuth (ATV) 0 deg 360	Image-NM 0° 90° 180° 270° 0° 3D Log -0° Amplitude-NM Normalized 0° 90° 180° 270° 0° Feature Picks 0° 90° 180° 270° 0° 3D Acoustic Log -0° Centralized TT 0° 90° 180° 270° 0° Reflective Index 0 2000 Features - Mag North Orientation 0 90	3-Arm Caliper 0 cm 20 Caliper - min from TT 0 mm 200 Caliper - max from TT 0 mm 200 Caliper - ave from TT 0 mm 200 Breakout



Depth 1m:10m	Orientation	Televiewer Analysis						Caliper
	Tilt (OTV) 0 deg 10 Azimuth (OTV) 0 deg 360 Tilt (ATV) 0 deg 10 Azimuth (ATV) 0 deg 360	Image-NM 0° 90° 180° 270° 0°	3D Log -0°	Amplitude-NM Normalized 0° 90° 180° 270° 0° Feature Picks 0° 90° 180° 270° 0°	3D Acoustic Log -0°	Centralized TT 0° 90° 180° 270° 0° Reflective Index 0 2000	Features - Mag North Orientation 0 90	3-Arm Caliper 0 cm 20 Caliper - min from TT 0 mm 200 Caliper - max from TT 0 mm 200 Caliper - ave from TT 0 mm 200 Breakout



Depth 1m:10m	Orientation	Televiewer Analysis	Caliper



ACOUSTIC and OPTICAL TELEVIEWER ANALYSIS

DGI GEOSCIENCE INC.

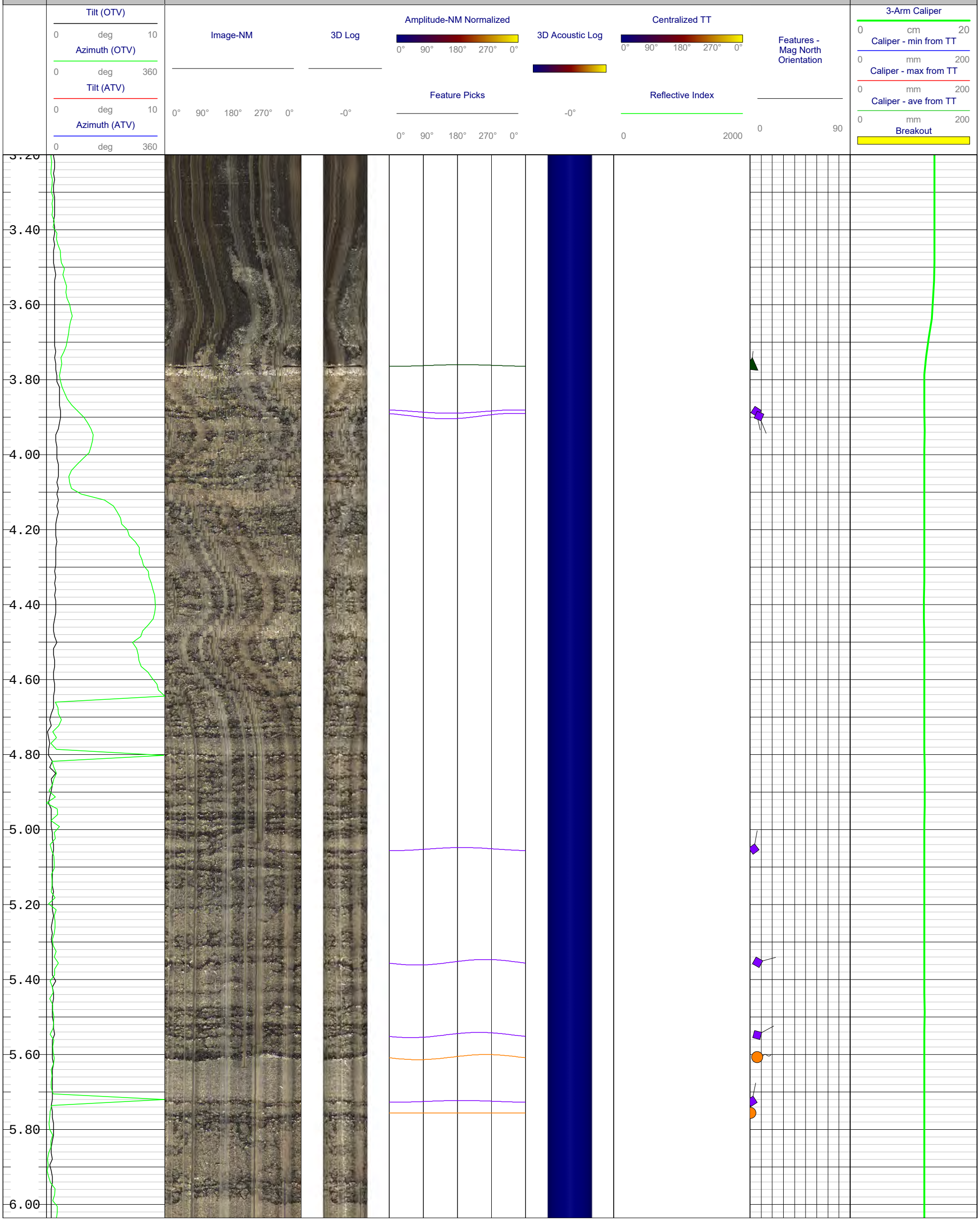
Company:	WESA	**UTM X (Easting):**	---	**Hole Diameter:**	117 mm
Hole ID:	M198	**UTM Y (Northing):**	---	**Hole Type:**	RC
Acquisition date(s):	Apr. 19, 2018	**UTM Z (Elevation):**	---	**Fluid Type:**	---
Field Personnel:	K. Smylie, O. Fomenko	**Total Depth:**	34.5 m	**Witnessed by:**	---
Legal Location:	Napanee, ON	**Surveyed Depth:**	33.4 m		
Survey Day(s):	1	**Casing Depth:**	3.8 m		

No acoustic televiewer was collected on this borehole due to lack of water.

LEGEND - STRUCTURE TYPE

Btm of Casing | Partially Open Joint/Fracture | Minor Joint/Fracture | Vein - Group 1 | Lithology Contact

*** View tadpole orientation from _Structure Analysis.xlsx**



Depth 1m:10m	Orientation	Televiewer Analysis	Caliper

Tilt (OTV)
0 deg 10
Azimuth (OTV)
0 deg 360
Tilt (ATV)
0 deg 10
Azimuth (ATV)
0 deg 360

Image-NM
0° 90° 180° 270° 0°

3D Log
-0°

Amplitude-NM Normalized
0° 90° 180° 270° 0°

Feature Picks
0° 90° 180° 270° 0°

3D Acoustic Log
-0°

Centralized TT
0° 90° 180° 270° 0°

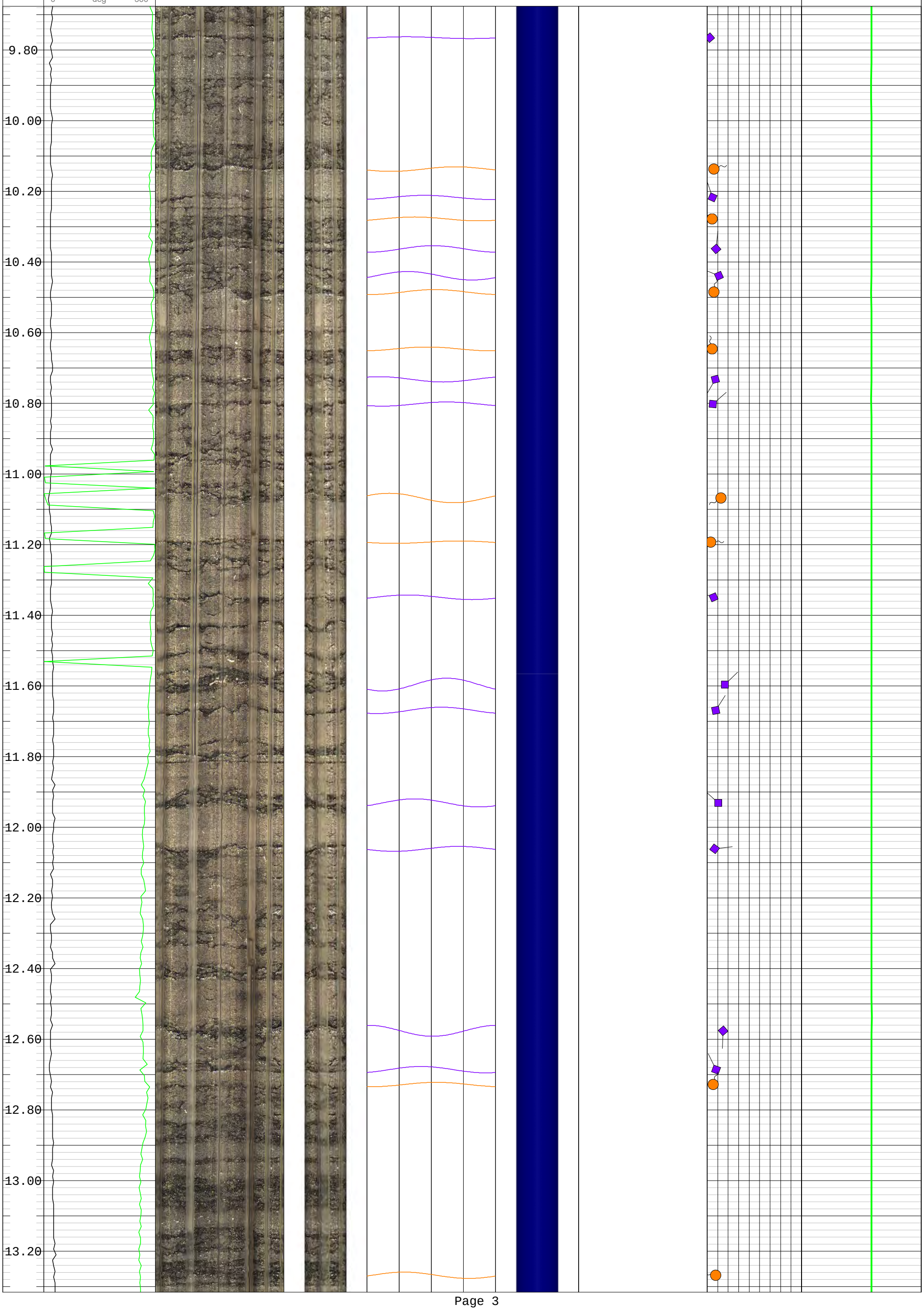
Reflective Index
0 2000

Features - Mag North Orientation
0 90

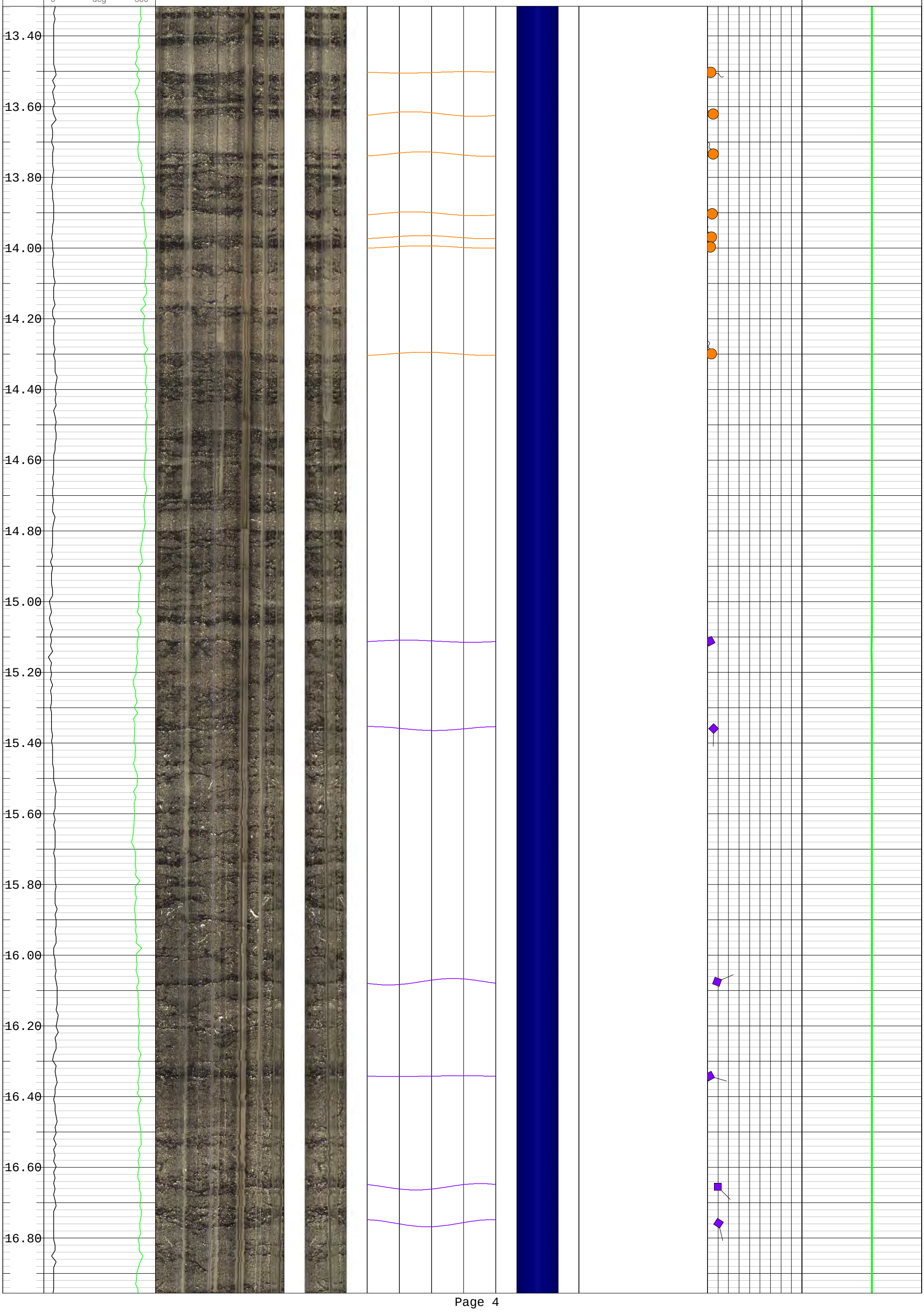
3-Arm Caliper
0 cm 20
Caliper - min from TT
0 mm 200
Caliper - max from TT
0 mm 200
Caliper - ave from TT
0 mm 200
Breakout

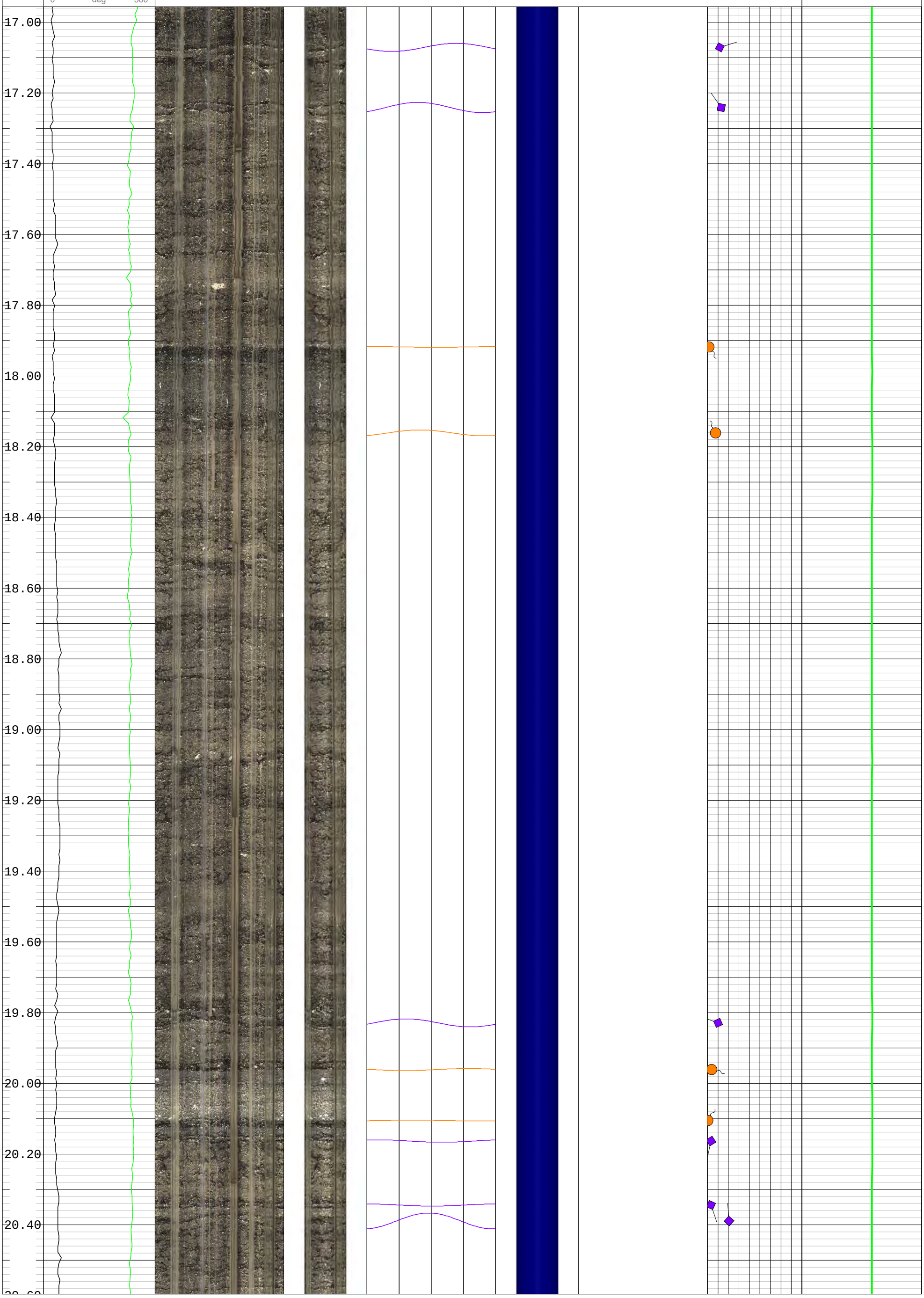
6.20
6.40
6.60
6.80
7.00
7.20
7.40
7.60
7.80
8.00
8.20
8.40
8.60
8.80
9.00
9.20
9.40
9.60

Depth 1m:10m	Orientation	Televiewer Analysis						Caliper
	Tilt (OTV) 0 deg 10 Azimuth (OTV) 0 deg 360 Tilt (ATV) 0 deg 10 Azimuth (ATV) 0 deg 360	Image-NM 0° 90° 180° 270° 0°	3D Log -0°	Amplitude-NM Normalized 0° 90° 180° 270° 0° Feature Picks 0° 90° 180° 270° 0°	3D Acoustic Log -0°	Centralized TT 0° 90° 180° 270° 0° Reflective Index 0 2000	Features - Mag North Orientation 0 90	3-Arm Caliper 0 cm 20 Caliper - min from TT 0 mm 200 Caliper - max from TT 0 mm 200 Caliper - ave from TT 0 mm 200 Breakout

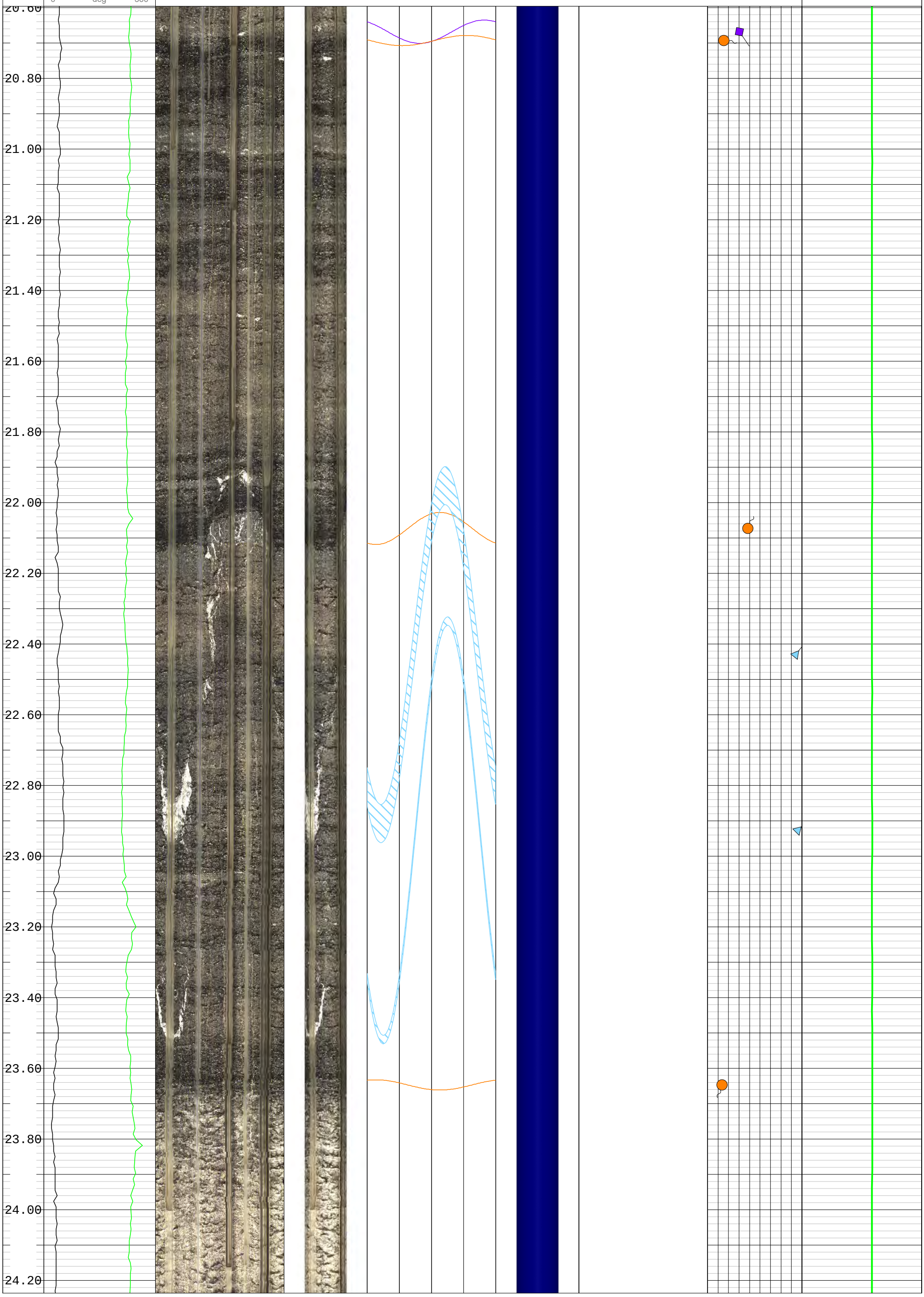


Depth 1m:10m	Orientation	Televiewer Analysis						Caliper
	Tilt (OTV) 0 deg 10 Azimuth (OTV) 0 deg 360 Tilt (ATV) 0 deg 10 Azimuth (ATV) 0 deg 360	Image-NM 0° 90° 180° 270° 0°	3D Log -0°	Amplitude-NM Normalized 0° 90° 180° 270° 0° Feature Picks 0° 90° 180° 270° 0°	3D Acoustic Log -0°	Centralized TT 0° 90° 180° 270° 0° Reflective Index 0 2000	Features - Mag North Orientation 0 90	3-Arm Caliper 0 cm 20 Caliper - min from TT 0 mm 200 Caliper - max from TT 0 mm 200 Caliper - ave from TT 0 mm 200 Breakout

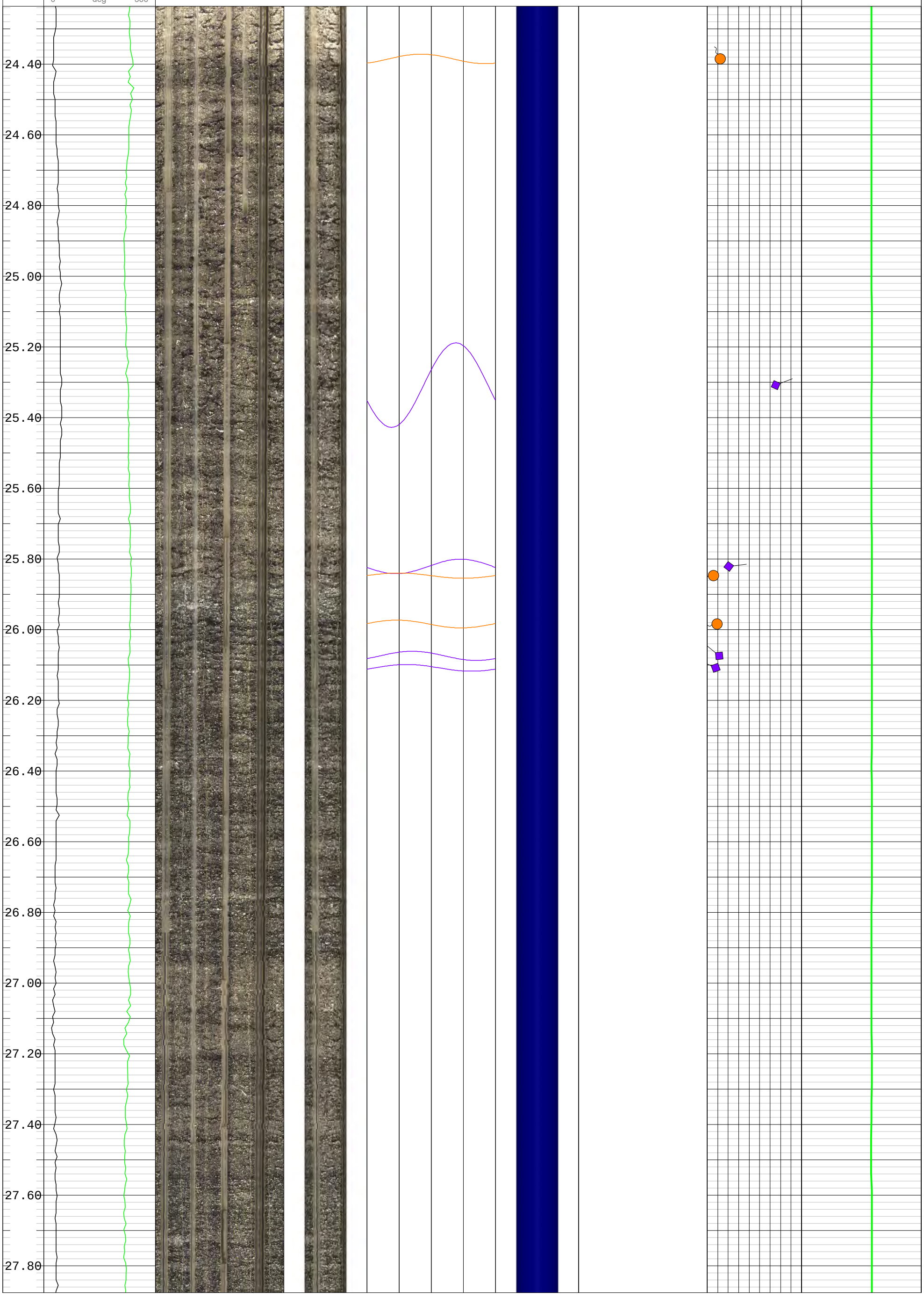


Depth 1m:10m	Orientation	Televiewer Analysis	Caliper
	Tilt (OTV) 0 deg 10 Azimuth (OTV) 0 deg 360 Tilt (ATV) 0 deg 10 Azimuth (ATV) 0 deg 360	Image-NM 0° 90° 180° 270° 0° 3D Log -0° Amplitude-NM Normalized 0° 90° 180° 270° 0° Feature Picks 0° 90° 180° 270° 0° 3D Acoustic Log -0° Centralized TT 0° 90° 180° 270° 0° Reflective Index 0 2000 Features - Mag North Orientation 0 90	3-Arm Caliper 0 cm 20 Caliper - min from TT 0 mm 200 Caliper - max from TT 0 mm 200 Caliper - ave from TT 0 mm 200 Breakout
			

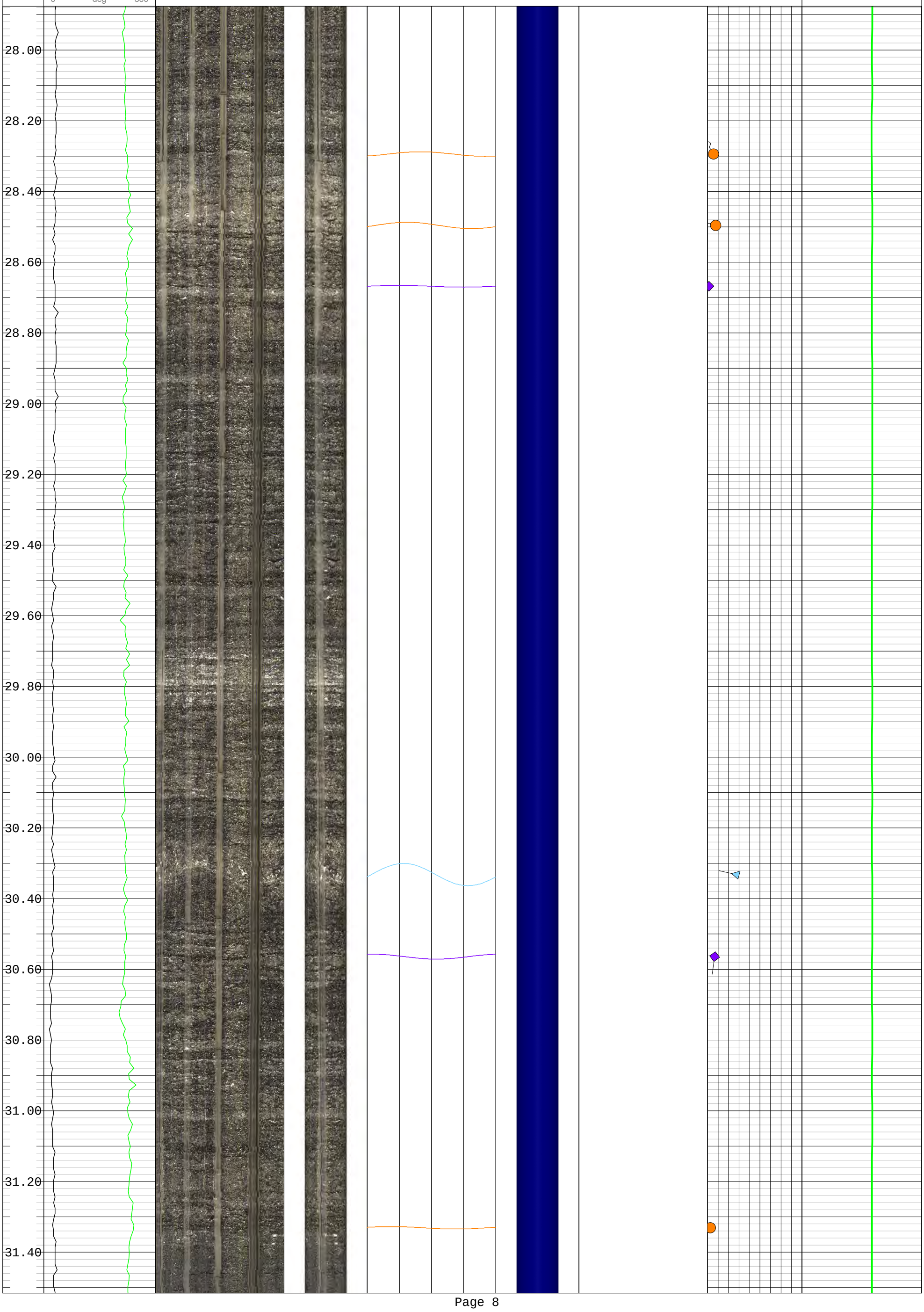
Depth 1m:10m	Orientation	Televiewer Analysis						Caliper
	Tilt (OTV) 0 deg 10 Azimuth (OTV) 0 deg 360 Tilt (ATV) 0 deg 10 Azimuth (ATV) 0 deg 360	Image-NM 0° 90° 180° 270° 0°	3D Log -0°	Amplitude-NM Normalized 0° 90° 180° 270° 0° Feature Picks 0° 90° 180° 270° 0°	3D Acoustic Log -0°	Centralized TT 0° 90° 180° 270° 0° Reflective Index 0 2000	Features - Mag North Orientation 0 90	3-Arm Caliper 0 cm 20 Caliper - min from TT 0 mm 200 Caliper - max from TT 0 mm 200 Caliper - ave from TT 0 mm 200 Breakout

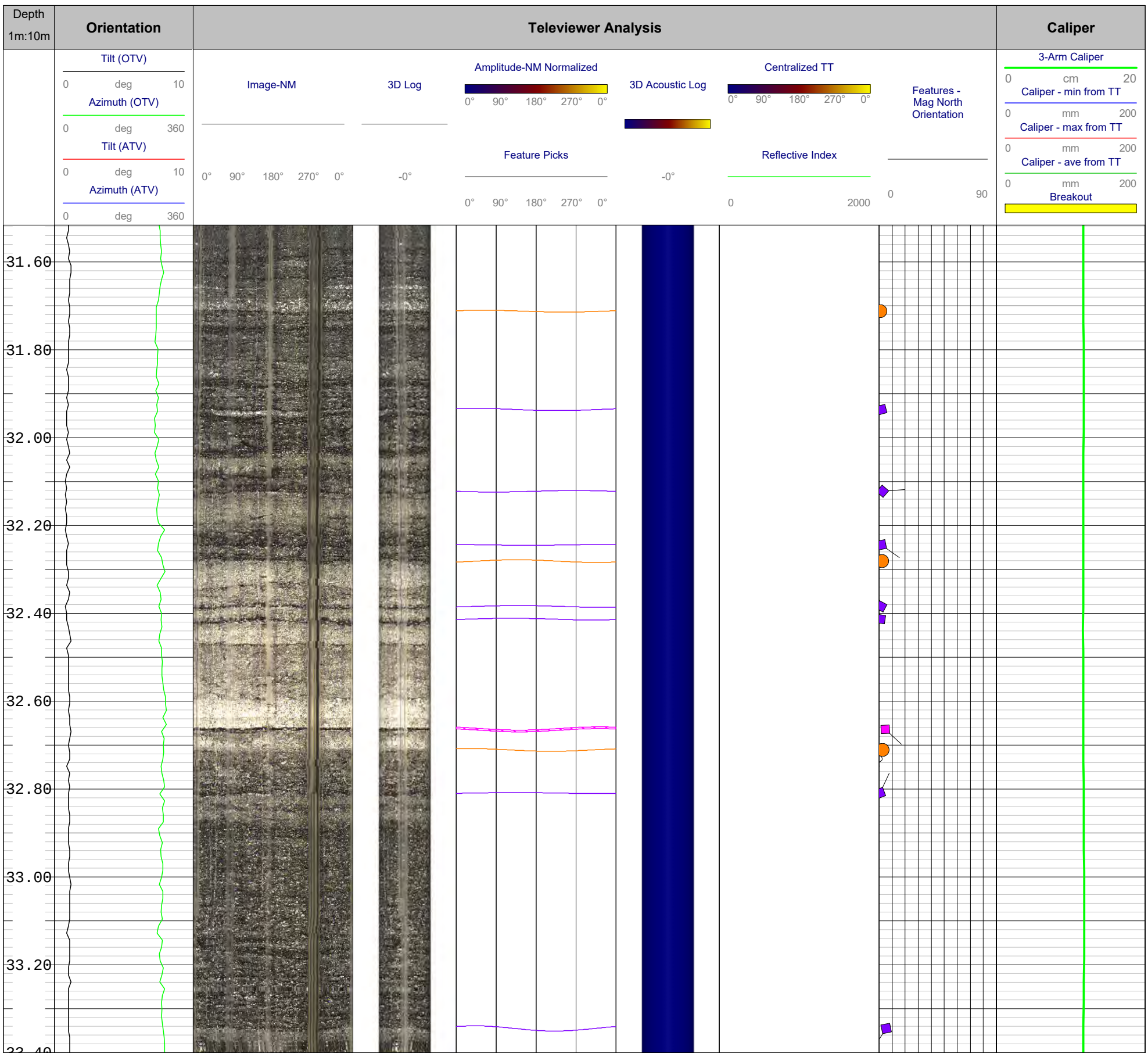


Depth 1m:10m	Orientation	Televiewer Analysis	Caliper
	Tilt (OTV) 0 deg 10 Azimuth (OTV) 0 deg 360 Tilt (ATV) 0 deg 10 Azimuth (ATV) 0 deg 360	Image-NM 0° 90° 180° 270° 0° 3D Log -0° Amplitude-NM Normalized 0° 90° 180° 270° 0° Feature Picks 0° 90° 180° 270° 0° 3D Acoustic Log -0° Centralized TT 0° 90° 180° 270° 0° Reflective Index 0 2000 Features - Mag North Orientation 0 90	3-Arm Caliper 0 cm 20 Caliper - min from TT 0 mm 200 Caliper - max from TT 0 mm 200 Caliper - ave from TT 0 mm 200 Breakout



Depth 1m:10m	Orientation	Televiewer Analysis	Caliper
	Tilt (OTV) 0 deg 10 Azimuth (OTV) 0 deg 360 Tilt (ATV) 0 deg 10 Azimuth (ATV) 0 deg 360	Image-NM 0° 90° 180° 270° 0° 3D Log -0° Amplitude-NM Normalized 0° 90° 180° 270° 0° Feature Picks 0° 90° 180° 270° 0° 3D Acoustic Log -0° Centralized TT 0° 90° 180° 270° 0° Reflective Index 0 2000 Features - Mag North Orientation 0 90	3-Arm Caliper 0 cm 20 Caliper - min from TT 0 mm 200 Caliper - max from TT 0 mm 200 Caliper - ave from TT 0 mm 200 Breakout




Depth
1m:10m
Orientation
Televiewer Analysis
Caliper
Tilt (OTV)
0 deg 10
Azimuth (OTV)
0 deg 360
Tilt (ATV)
0 deg 10
Azimuth (ATV)
0 deg 360
Image-NM
0° 90° 180° 270° 0°
3D Log
-0°
Amplitude-NM Normalized
0° 90° 180° 270° 0°
Feature Picks
0° 90° 180° 270° 0°
3D Acoustic Log
-0°
Centralized TT
0° 90° 180° 270° 0°
Reflective Index
0 2000
Features - Mag North Orientation
0 90
3-Arm Caliper
0 cm 20
Caliper - min from TT
0 mm 200
Caliper - max from TT
0 mm 200
Caliper - ave from TT
0 mm 200
Breakout
31.60
31.80
32.00
32.20
32.40
32.60
32.80
33.00
33.20

APPENDIX C

Hydraulic Test Results

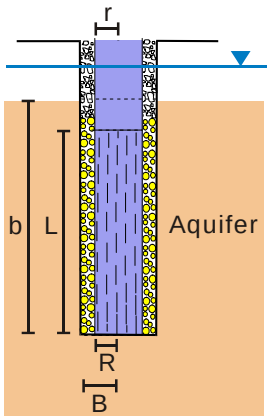
Wells

Project: Hydraulic Testing April 2018

Number: 180150-02

Client: WM

Location: Richmond



	Name	X [m]	Y [m]	Elevation (amsl) [m]	Benchmark [m]	Penetration	L [m]	B [m]
1	M196					Fully	30	0.057
2	M197					Fully	30	0.057
3	M198					Fully	30	0.057

Slug Test - Water Level Data

Project: Hydraulic Testing April 2018

Number: 180150-02

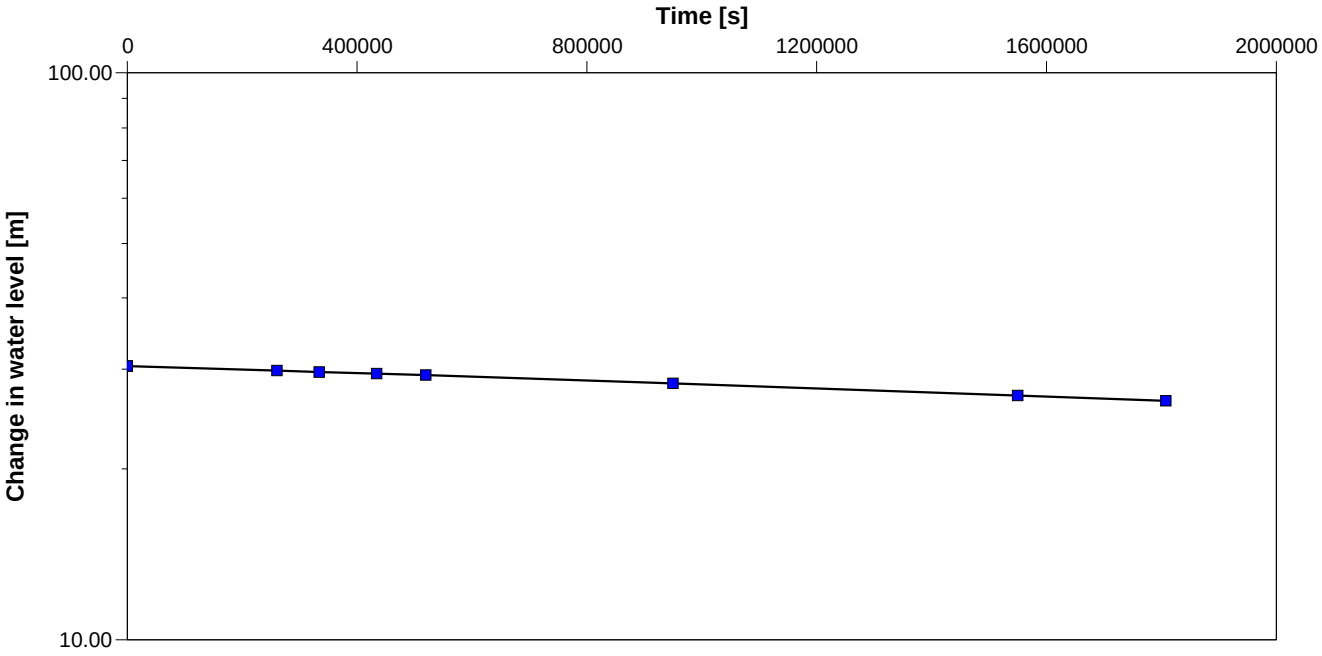
Client: WM

Location: Richmond	Slug Test: M196	Test Well: M196
Test Conducted by:	Test Date: 30/04/2018	
Water level at t=0 [m]: 33.35	Static Water Level [m]: 3.00	Water level change at t=0 [m]: 30.35

	Time [s]	Water Level [m]	WL Change [m]
1	0	33.35	30.35
2	260100	32.82	29.82
3	333900	32.68	29.68
4	433800	32.46	29.46
5	520200	32.28	29.28
6	950400	31.31	28.31
7	1549800	29.94	26.94
8	1808100	29.38	26.38

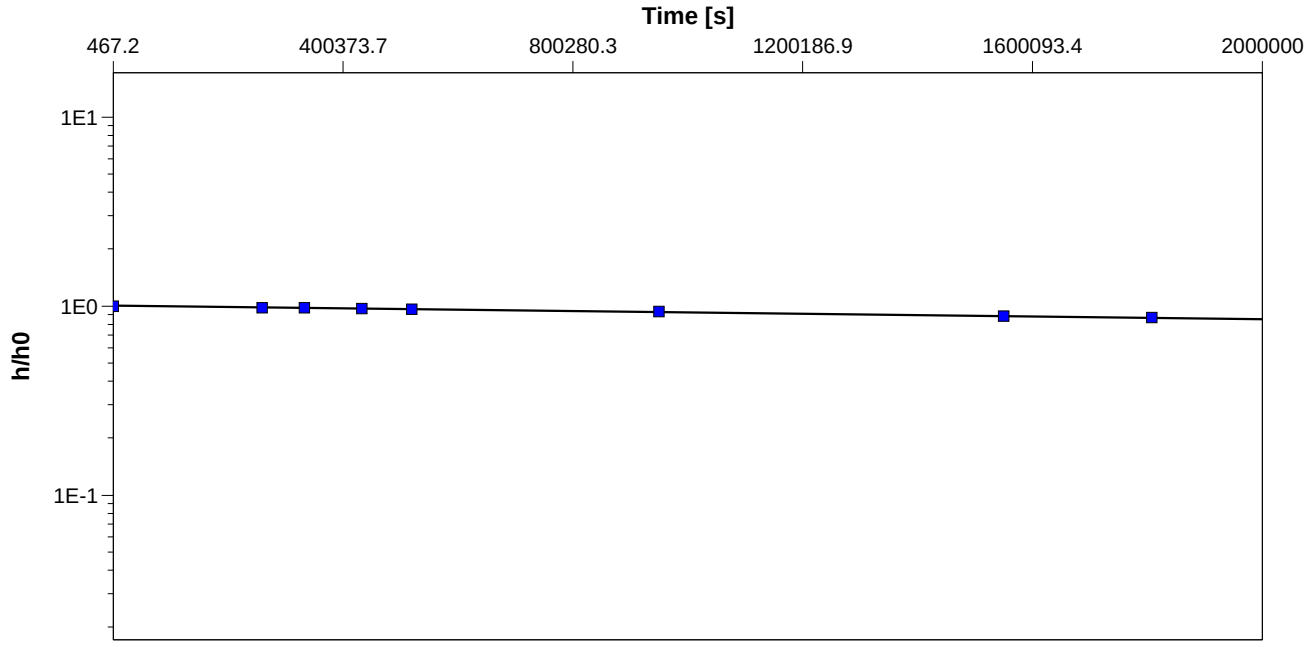
Slug Test Analysis Report	
Project: Hydraulic Testing April 2018	
Number: 180150-02	
Client: WM	

Location: Richmond	Slug Test: M196	Test Well: M196
Test Conducted by:		Test Date: 30/04/2018
Analysis Performed by:	M196 - Time vs. Change in WL	Analysis Date: 30/04/2018
Aquifer Thickness:		



Slug Test Analysis Report	
Project: Hydraulic Testing April 2018	
Number: 180150-02	
Client: WM	

Location: Richmond	Slug Test: M196	Test Well: M196
Test Conducted by:		Test Date: 30/04/2018
Analysis Performed by:	M196 - Hvorslev	Analysis Date: 30/04/2018
Aquifer Thickness:		

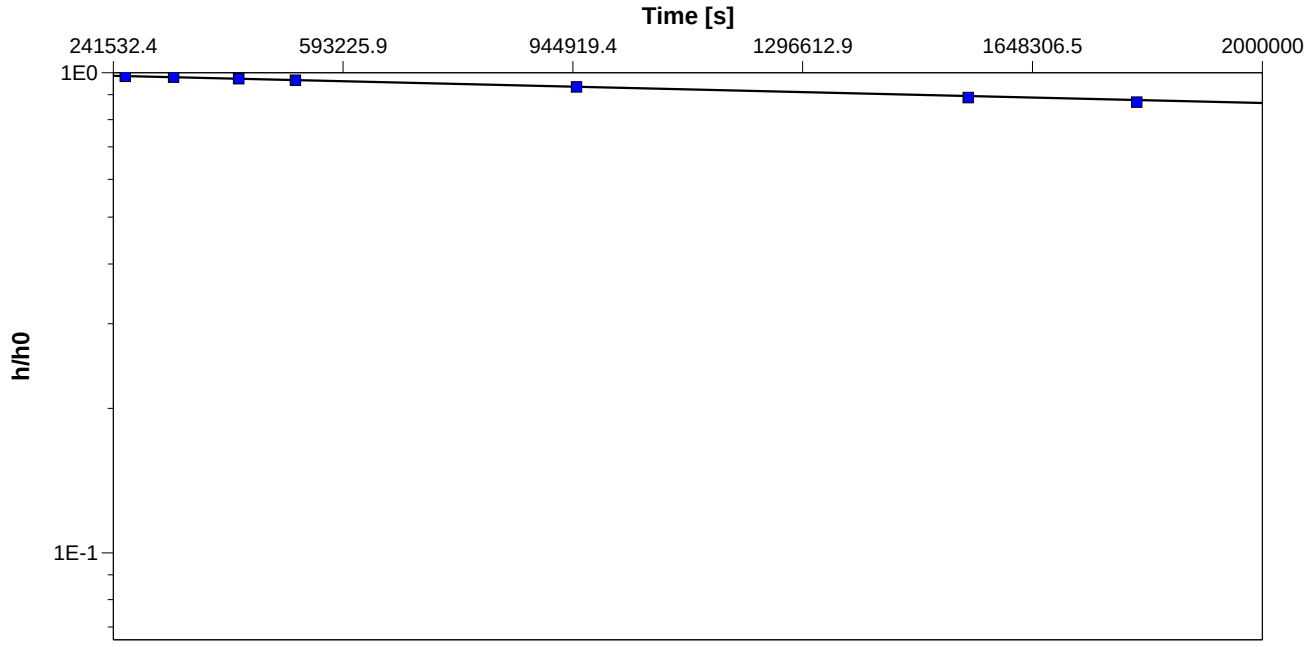


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
M196	2.72×10^{-11}	

Slug Test Analysis Report	
Project: Hydraulic Testing April 2018	
Number: 180150-02	
Client: WM	

Location: Richmond	Slug Test: M196	Test Well: M196
Test Conducted by:		Test Date: 30/04/2018
Analysis Performed by:	New analysis 3	Analysis Date: 01/05/2018
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
M196	2.56×10^{-11}	

Slug Test - Analyses Report

Project: Hydraulic Testing April 2018

Number: 180150-02

Client: WM

Location: Richmond	Slug Test: M196	Test Well: M196
Test Conducted by:		Test Date: 30/04/2018
Aquifer Thickness: NAN m		

	Analysis Name	Analysis Performed by	Analysis Date	Method name	Well	T [m²/s]	S
1	M196 - Hvorslev		30/04/2018	Hvorslev	M196		2.72×10^{-11}
2	New analysis 3		01/05/2018	Hvorslev	M196		2.56×10^{-11}

Slug Test - Water Level Data

Project: Hydraulic Testing April 2018

Number: 180150-02

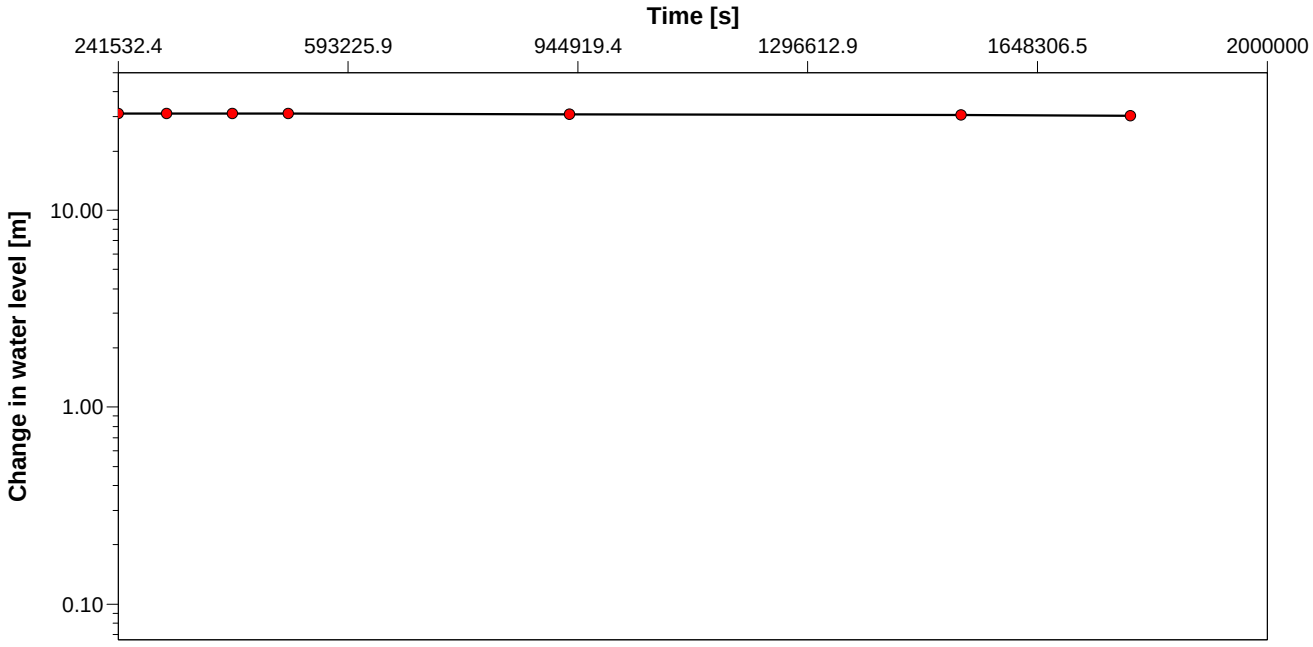
Client: WM

Location: Richmond	Slug Test: M197	Test Well: M197
Test Conducted by:	Test Date: 30/04/2018	
Water level at t=0 [m]: 34.32	Static Water Level [m]: 3.00	Water level change at t=0 [m]: 31.32

	Time [s]	Water Level [m]	WL Change [m]
1	0	34.32	31.32
2	242100	34.14	31.14
3	315900	34.11	31.11
4	415800	34.08	31.08
5	502200	34.05	31.05
6	932400	33.85	30.85
7	1531800	33.445	30.445
8	1790100	33.255	30.255

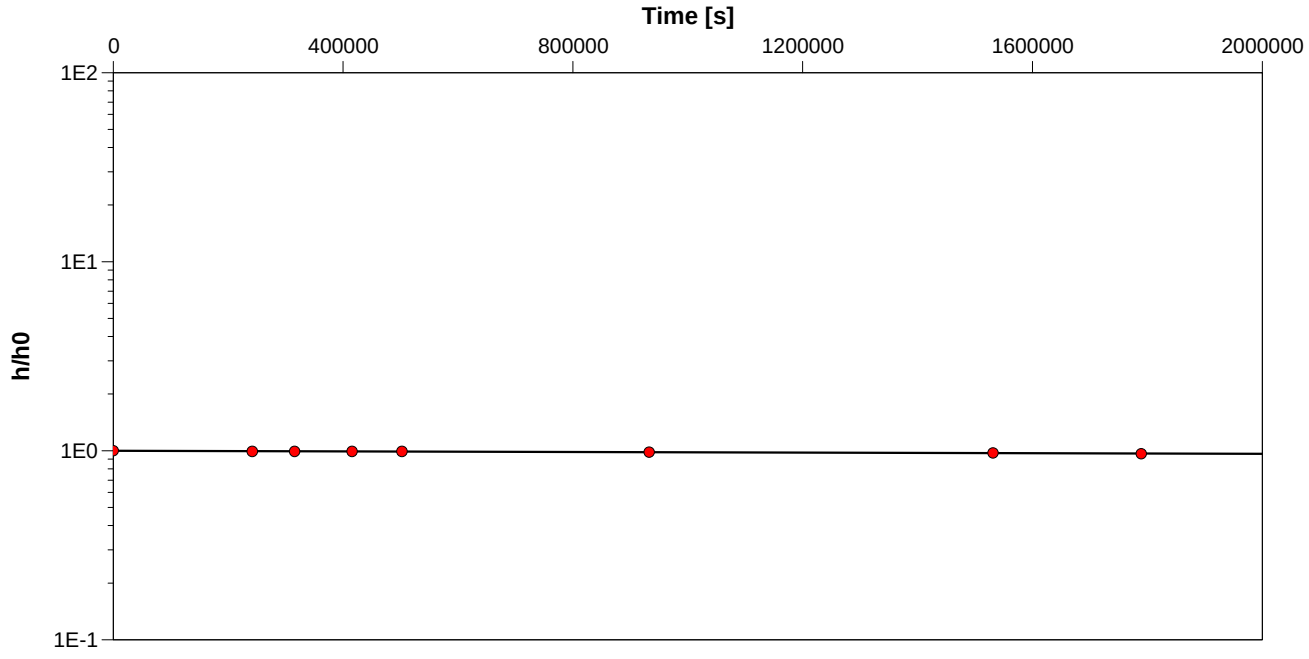
Slug Test Analysis Report	
Project: Hydraulic Testing April 2018	
Number: 180150-02	
Client: WM	

Location: Richmond	Slug Test: M197	Test Well: M197
Test Conducted by:		Test Date: 30/04/2018
Analysis Performed by:	M197 - Time vs. Change in WL	Analysis Date: 30/04/2018
Aquifer Thickness:		



Slug Test Analysis Report	
Project: Hydraulic Testing April 2018	
Number: 180150-02	
Client: WM	

Location: Richmond	Slug Test: M197	Test Well: M197
Test Conducted by:		Test Date: 30/04/2018
Analysis Performed by:	M197 - Hvorslev	Analysis Date: 30/04/2018
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
M197	6.34×10^{-12}	

Slug Test - Analyses Report

Project: Hydraulic Testing April 2018

Number: 180150-02

Client: WM

Location: Richmond	Slug Test: M197	Test Well: M197
Test Conducted by:		Test Date: 30/04/2018
Aquifer Thickness: NAN m		

	Analysis Name	Analysis Performed by	Analysis Date	Method name	Well	T [m²/s]	S
1	M197 - Hvorslev		30/04/2018	Hvorslev	M197		6.34×10^{-12}

Slug Test - Water Level Data

Project: Hydraulic Testing April 2018

Number: 180150-02

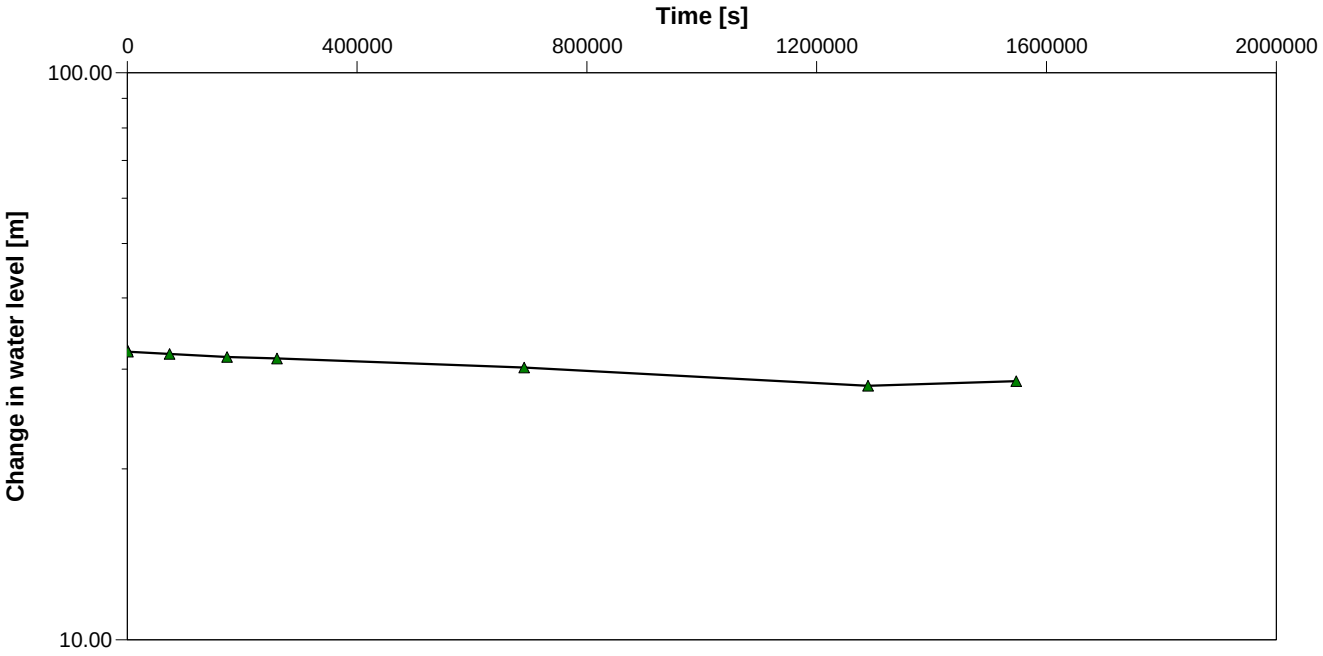
Client: WM

Location: Richmond	Slug Test: M198	Test Well: M198
Test Conducted by:	Test Date: 30/04/2018	
Water level at t=0 [m]: 35.42	Static Water Level [m]: 3.00	Water level change at t=0 [m]: 32.42

	Time [s]	Water Level [m]	WL Change [m]
1	0	35.42	32.42
2	900	35.19	32.19
3	73800	34.90	31.90
4	173700	34.55	31.55
5	260100	34.29	31.29
6	690300	33.21	30.21
7	1289700	31.075	28.075
8	1548000	31.555	28.555

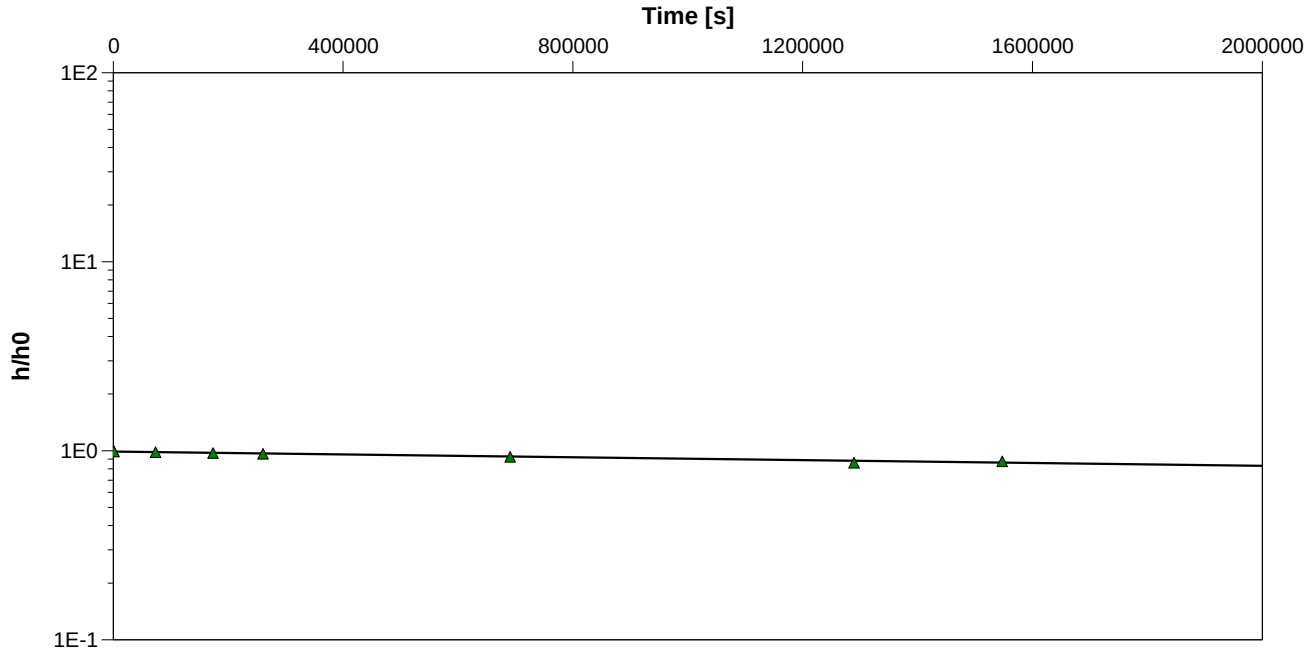
Slug Test Analysis Report	
Project: Hydraulic Testing April 2018	
Number: 180150-02	
Client: WM	

Location: Richmond	Slug Test: M198	Test Well: M198
Test Conducted by:		Test Date: 30/04/2018
Analysis Performed by:	M198 - Time vs. Change in WL	Analysis Date: 30/04/2018
Aquifer Thickness:		



Slug Test Analysis Report	
Project: Hydraulic Testing April 2018	
Number: 180150-02	
Client: WM	

Location: Richmond	Slug Test: M198	Test Well: M198
Test Conducted by:		Test Date: 30/04/2018
Analysis Performed by:	M198 - Hvorslev	Analysis Date: 30/04/2018
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
M198	2.95×10^{-11}	

Slug Test - Analyses Report

Project: Hydraulic Testing April 2018

Number: 180150-02

Client: WM

Location: Richmond	Slug Test: M198	Test Well: M198
Test Conducted by:		Test Date: 30/04/2018
Aquifer Thickness: NAN m		

	Analysis Name	Analysis Performed by	Analysis Date	Method name	Well	T [m²/s]	S
1	M198 - Hvorslev		30/04/2018	Hvorslev	M198		2.95×10^{-11}

BluMetric Environmental Inc.
102-957 Cambrian Heights Drive
Sudbury, ON P3C 5S5

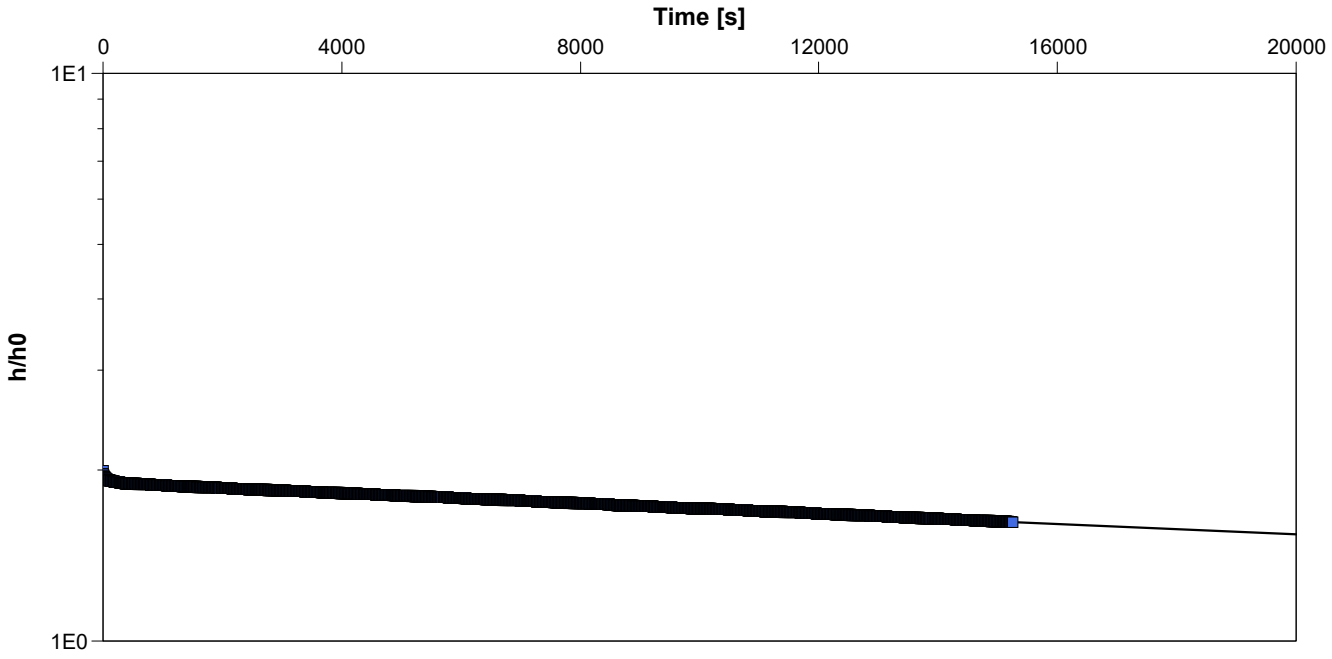
Slug Test Analysis Report

Project: WM Richmond - CAZ Investigation

Number: 180150-02

Client: Waste Management

Location: Richmond Landfill, Napanee ON	Slug Test: M199 Bail Test	Test Well: M199
Test Conducted by: Brad McCallum		Test Date: 2018-06-20
Analysis Performed by: MC	Hvorslev	Analysis Date: 2018-06-22
Aquifer Thickness: 3.13 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
M199	5.48×10^{-9}	

BluMetric Environmental Inc.
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Sudbury, ON P3C 5S5

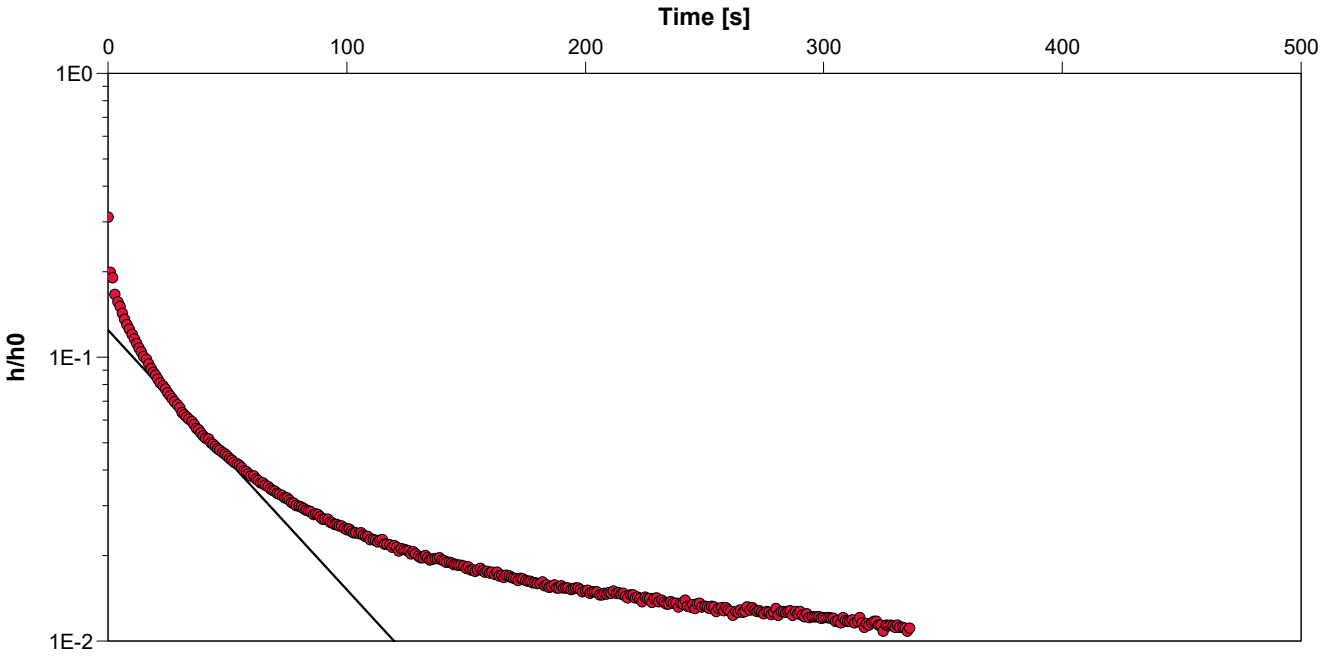
Slug Test Analysis Report

Project: WM Richmond - CAZ Investigation

Number: 180150-02

Client: Waste Management

Location: Richmond Landfill, Napanee ON	Slug Test: M200 Bail Test 1	Test Well: M200
Test Conducted by: Brad McCullum		Test Date: 2018-06-22
Analysis Performed by: MC	Hvorslev	Analysis Date: 2018-06-22
Aquifer Thickness: 3.23 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
M200	1.10×10^{-5}	

BluMetric Environmental Inc.
102-957 Cambrian Heights Drive
Sudbury, ON P3C 5S5

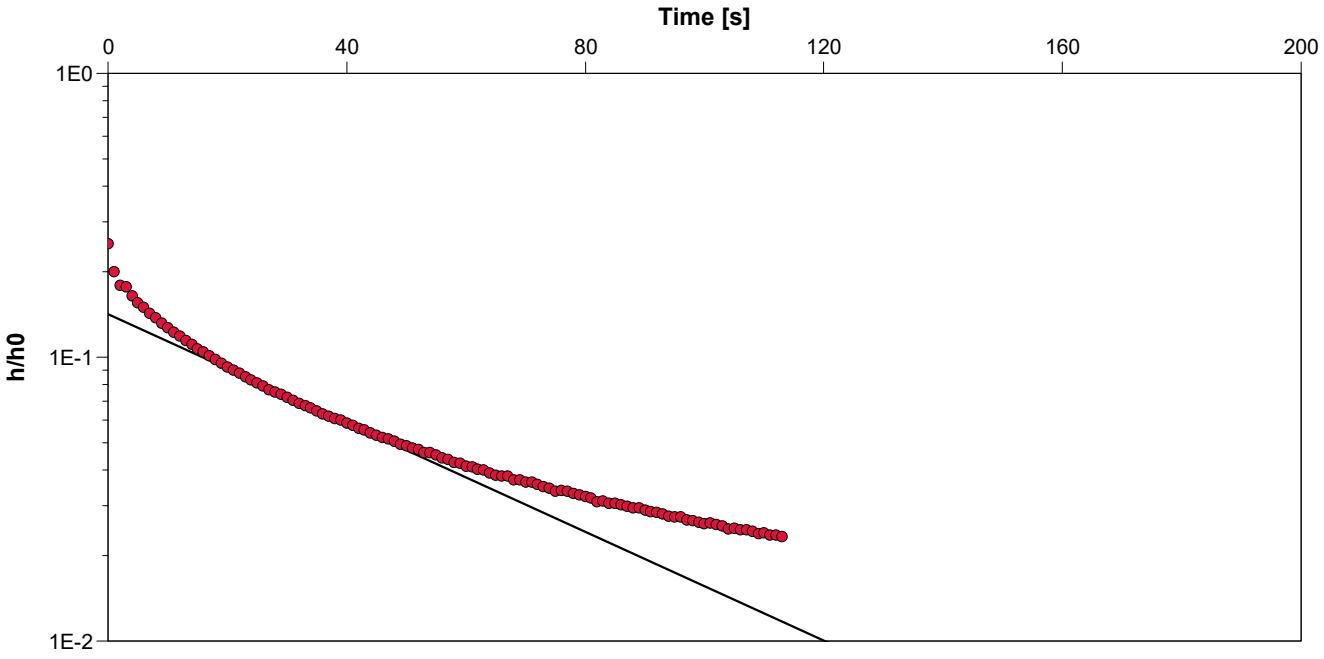
Slug Test Analysis Report

Project: WM Richmond - CAZ Investigation

Number: 180150-02

Client: Waste Management

Location: Richmond Landfill, Napanee ON	Slug Test: M200 Bail Test 2	Test Well: M200
Test Conducted by: BM		Test Date: 2018-06-20
Analysis Performed by: MC	Hvorslev	Analysis Date: 2018-06-22
Aquifer Thickness: 3.23 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
M200	1.15×10^{-5}	

BluMetric Environmental Inc.
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Sudbury, ON P3C 5S5

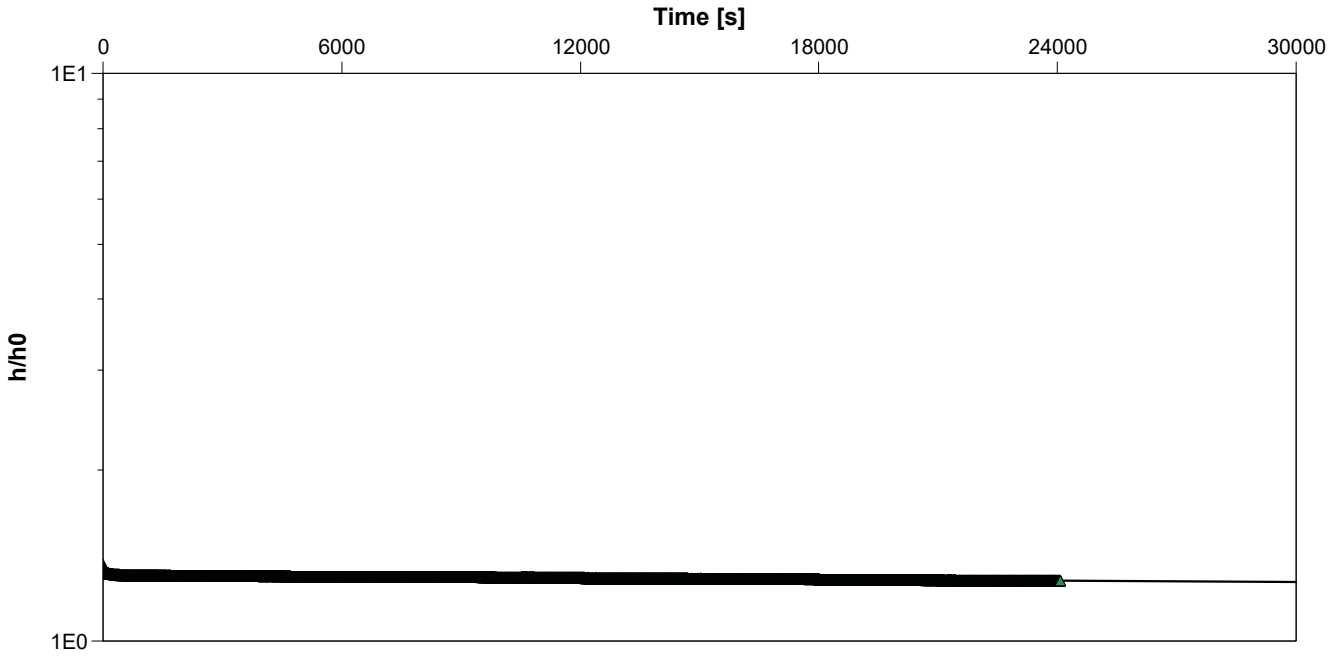
Slug Test Analysis Report

Project: WM Richmond - CAZ Investigation

Number: 180150-02

Client: Waste Management

Location: Richmond Landfill, Napanee ON	Slug Test: M201 Bail Test	Test Well: M201
Test Conducted by: BM		Test Date: 2018-06-21
Analysis Performed by: MC	Hvorslev	Analysis Date: 2018-06-22
Aquifer Thickness: 2.75 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
M201	5.14×10^{-10}	

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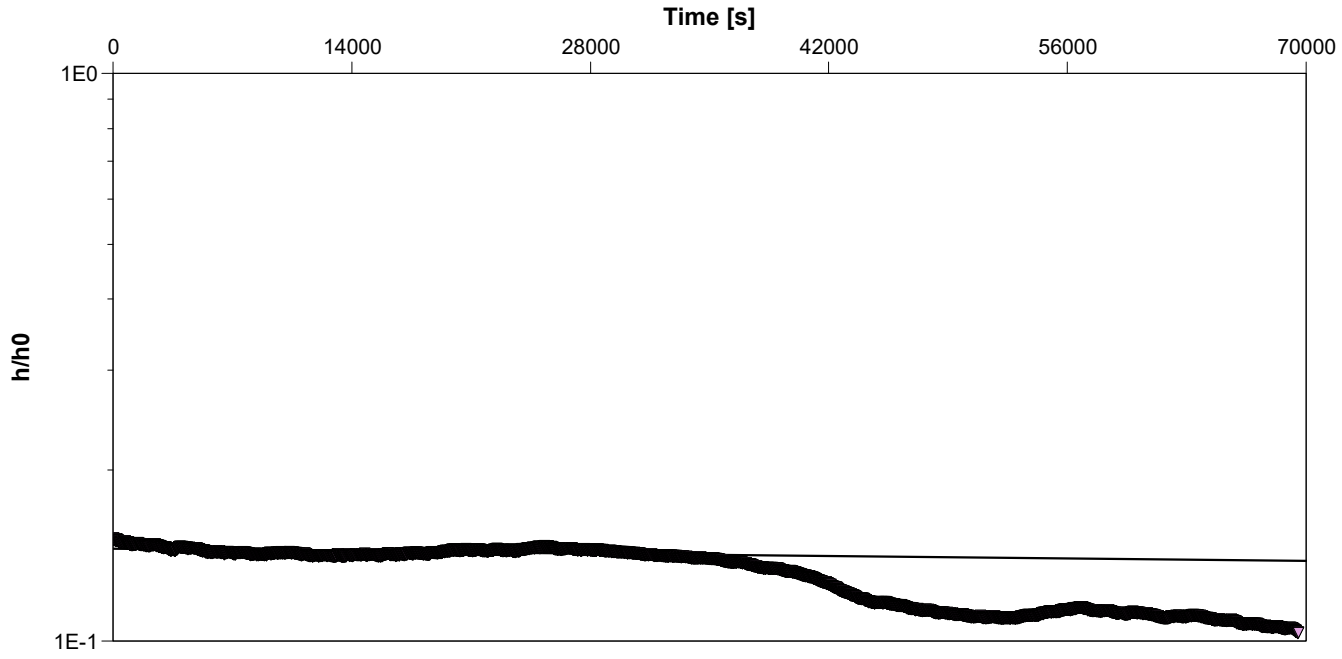
Slug Test Analysis Report

Project: WM Richmond - CAZ Investigation

Number: 180150-02

Client: Waste Management

Location: Richmond Landfill, Napanee ON	Slug Test: M202 Bail Test	Test Well: M202
Test Conducted by: BM		Test Date: 2018-06-21
Analysis Performed by: MC	Hvorslev	Analysis Date: 2018-06-22
Aquifer Thickness: 0.64 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
M202	3.72×10^{-10}	

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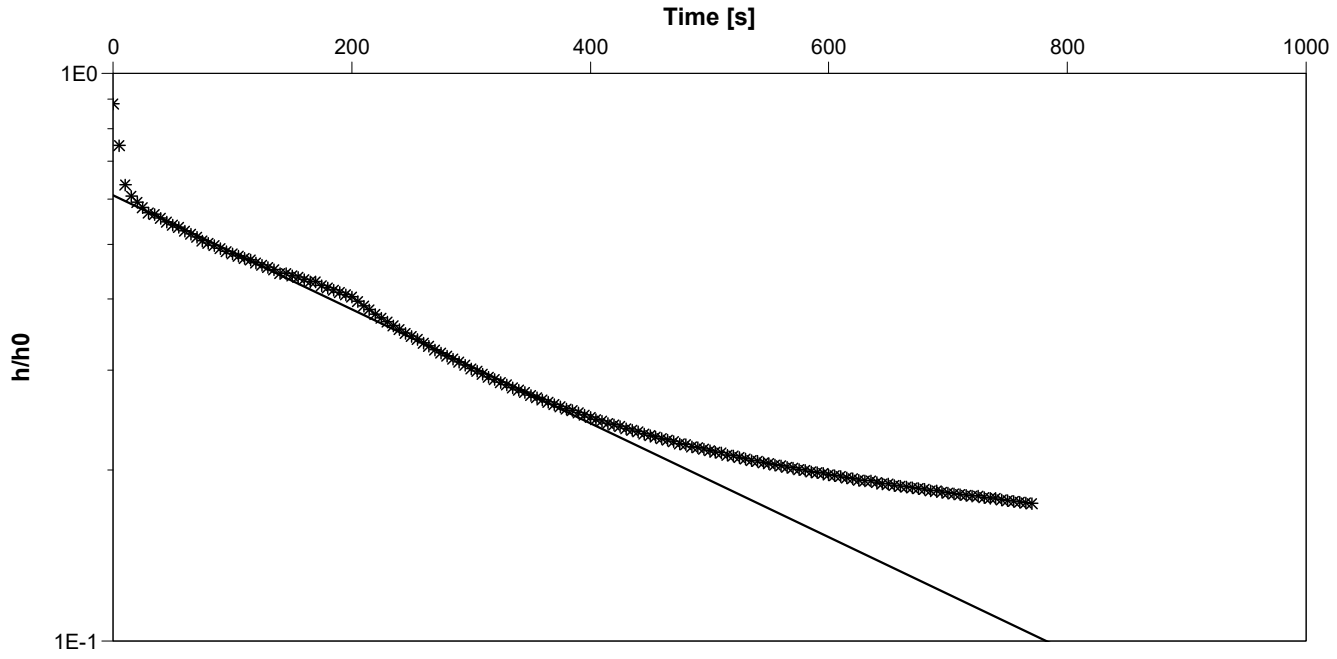
Slug Test Analysis Report

Project: WM Richmond - CAZ Investigation

Number: 180150-02

Client: Waste Management

Location: Richmond Landfill, Napanee ON	Slug Test: M203 Bail Test	Test Well: M203
Test Conducted by: BM		Test Date: 2018-06-22
Analysis Performed by: MC	Hvorslev	Analysis Date: 2018-06-22
Aquifer Thickness: 1.93 m		

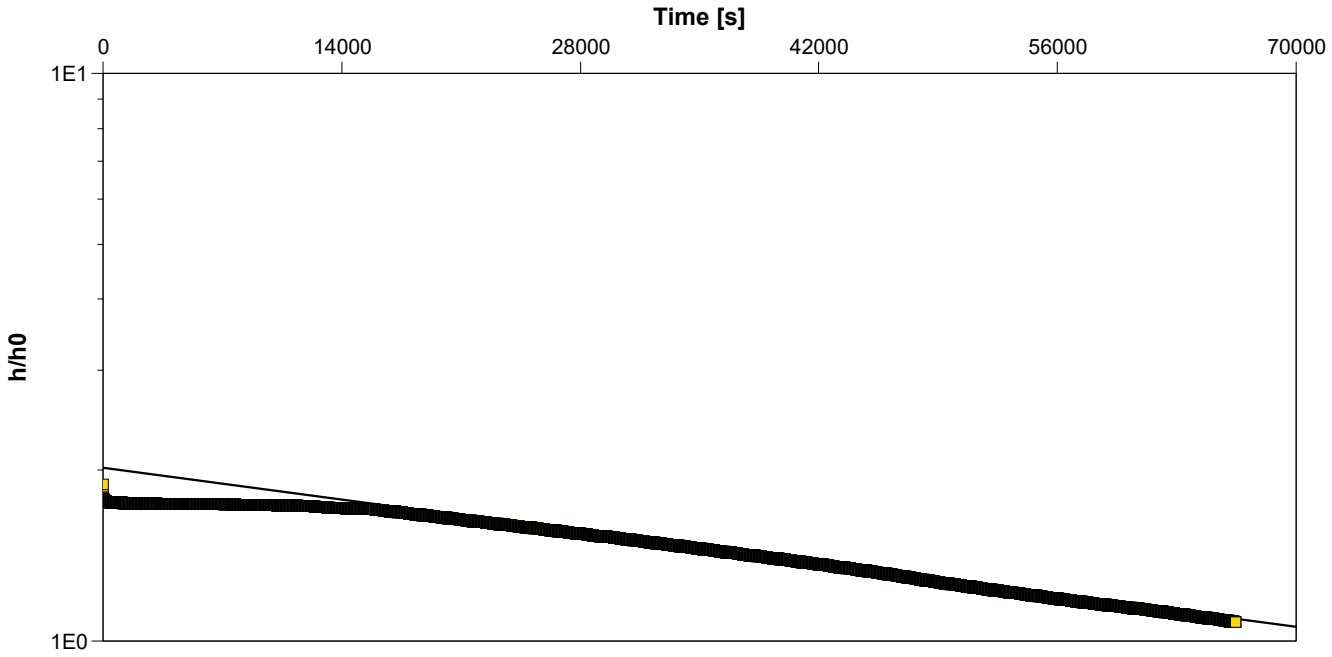


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
M203	1.21×10^{-6}	

BluMetric Environmental Inc. 102-957 Cambrian Heights Drive Sudbury, ON P3C 5S5	**Slug Test Analysis Report**
	Project: WM Richmond - CAZ Investigation
	Number: 180150-02
	Client: Waste Management

Location: Richmond Landfill, Napanee ON	Slug Test: M204 Bail Test	Test Well: M204
Test Conducted by: BM		Test Date: 2018-06-21
Analysis Performed by:	Hvorslev	Analysis Date: 2018-06-22
Aquifer Thickness: 3.63 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
M204	4.83×10^{-9}	

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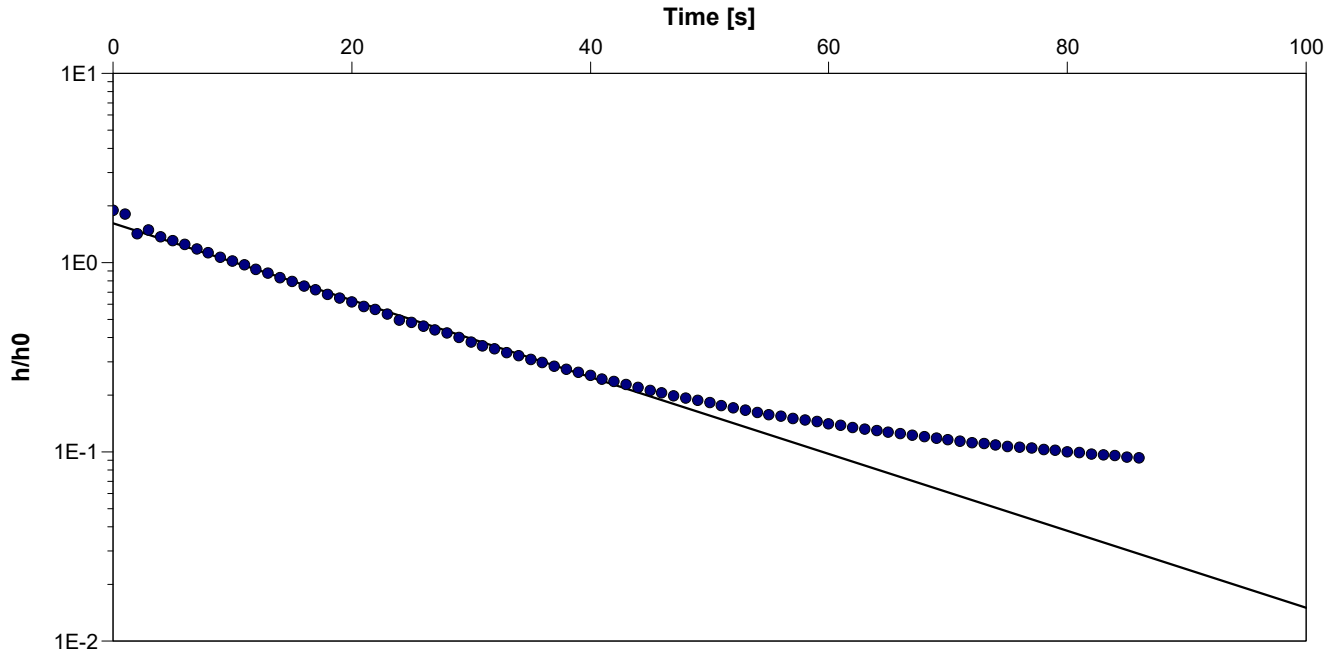
Slug Test Analysis Report

Project: WM Richmond - CAZ Investigation

Number: 180150-02

Client: Waste Management

Location: Richmond Landfill, Napanee ON	Slug Test: M205 Bail Test 1	Test Well: M205
Test Conducted by: BM		Test Date: 2018-06-21
Analysis Performed by:	Hvorslev	Analysis Date: 2018-06-22
Aquifer Thickness: 3.47 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
M205	2.44×10^{-5}	

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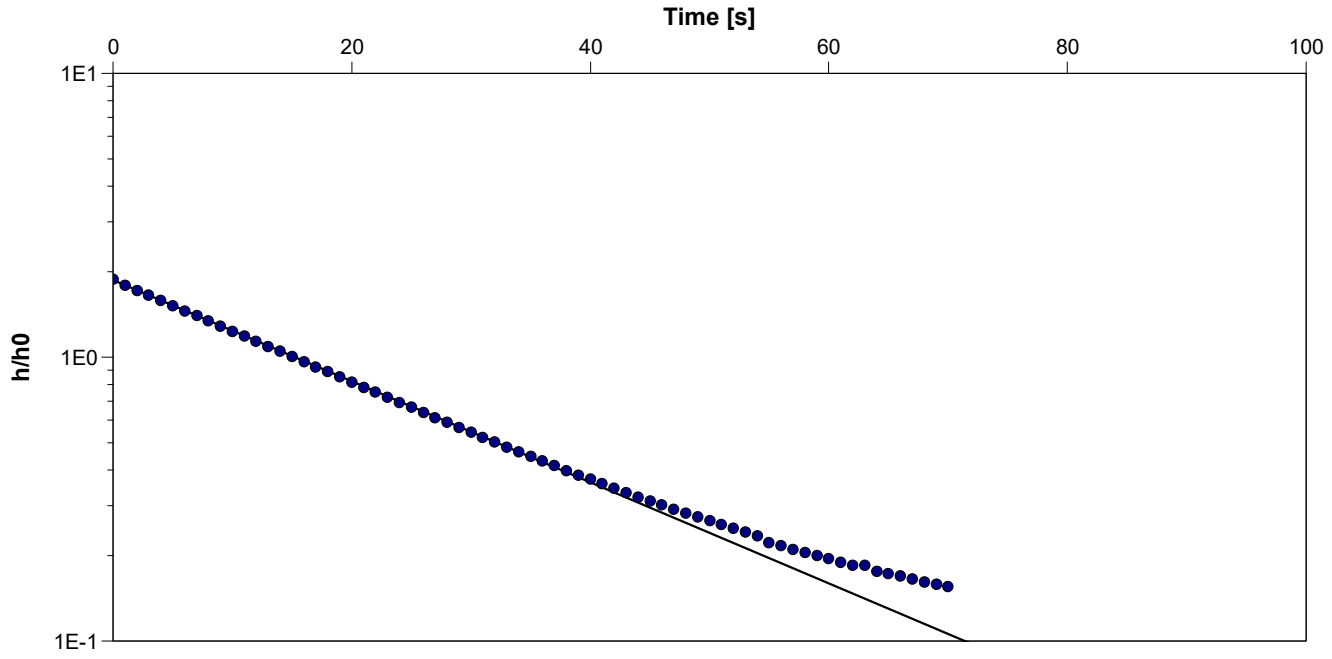
Slug Test Analysis Report

Project: WM Richmond - CAZ Investigation

Number: 180150-02

Client: Waste Management

Location: Richmond Landfill, Napanee ON	Slug Test: M205 Bail Test 2	Test Well: M205
Test Conducted by:		Test Date: 2018-06-21
Analysis Performed by:	Hvorslev	Analysis Date: 2018-06-22
Aquifer Thickness: 3.47 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
M205	2.14×10^{-5}	

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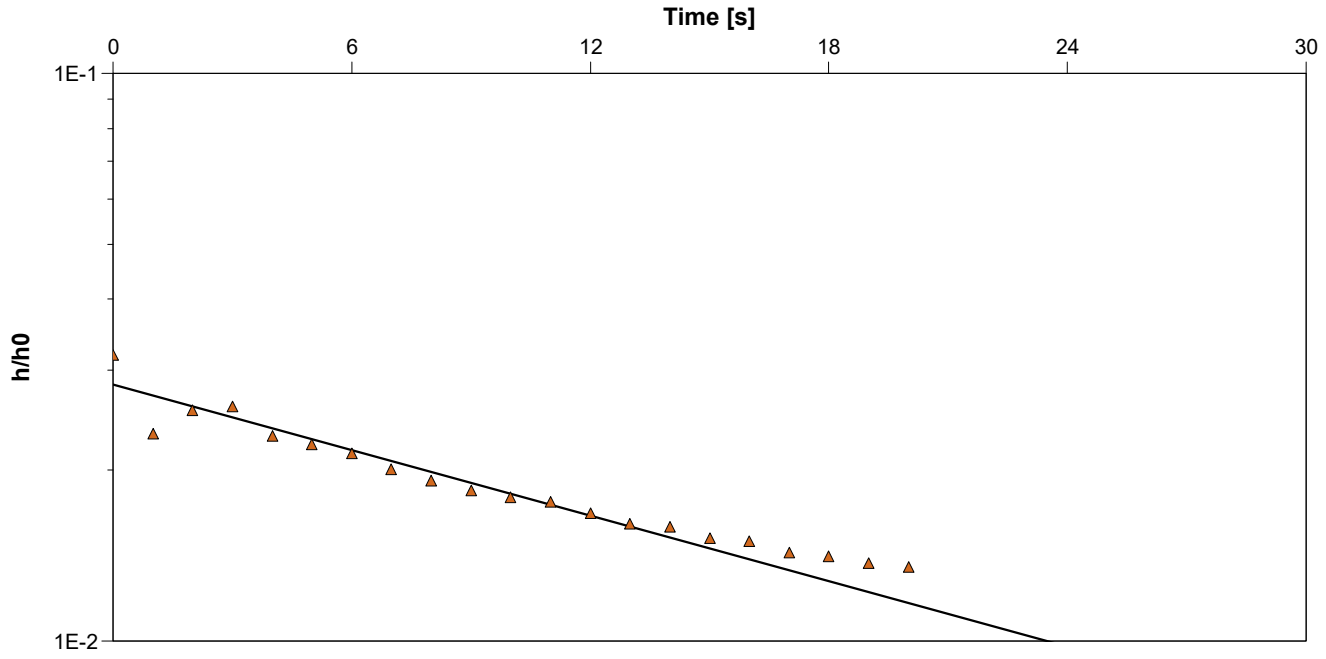
Slug Test Analysis Report

Project: WM Richmond - CAZ Investigation

Number: 180150-02

Client: Waste Management

Location: Richmond Landfill, Napanee ON	Slug Test: M206 Bail Test 1	Test Well: M206
Test Conducted by: BM		Test Date: 2018-06-21
Analysis Performed by:	Hvorslev	Analysis Date: 2018-06-22
Aquifer Thickness: 2.80 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
M206	2.31×10^{-5}	

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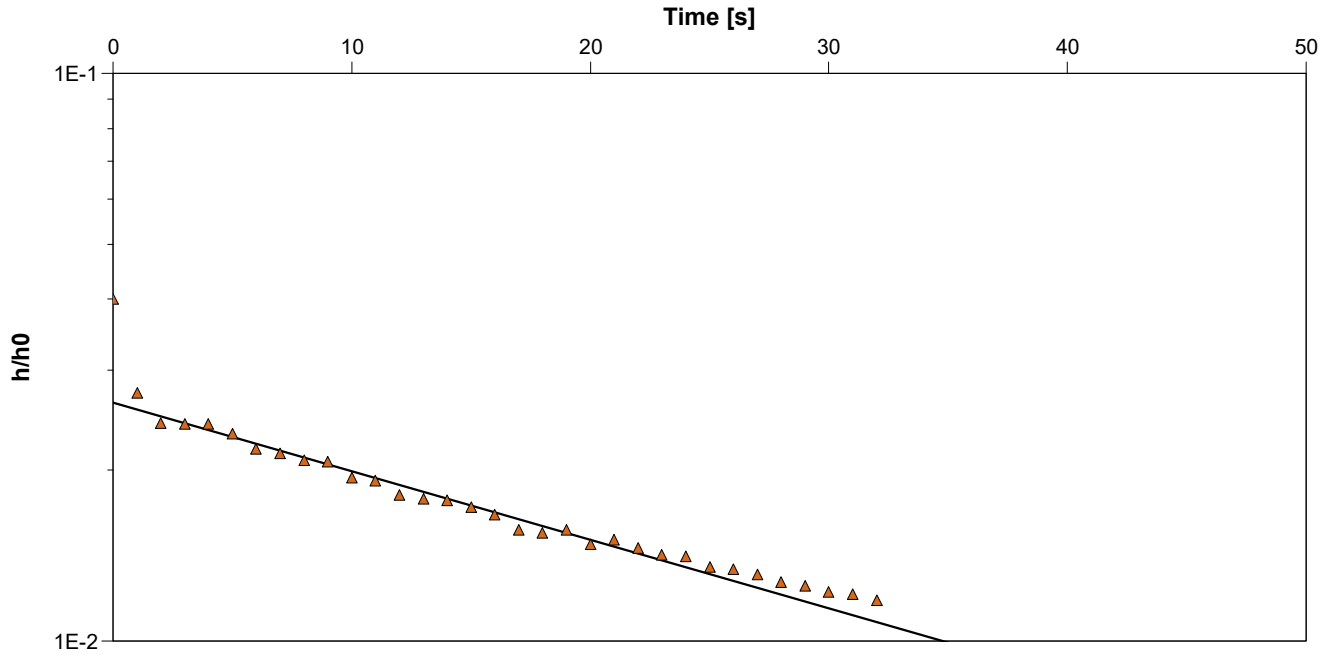
Slug Test Analysis Report

Project: WM Richmond - CAZ Investigation

Number: 180150-02

Client: Waste Management

Location: Richmond Landfill, Napanee ON	Slug Test: M206 Bail Test 2	Test Well: M206
Test Conducted by:		Test Date: 2018-06-22
Analysis Performed by: MC	Hvorslev	Analysis Date: 2018-06-22
Aquifer Thickness: 2.80 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
M206	1.45×10^{-5}	

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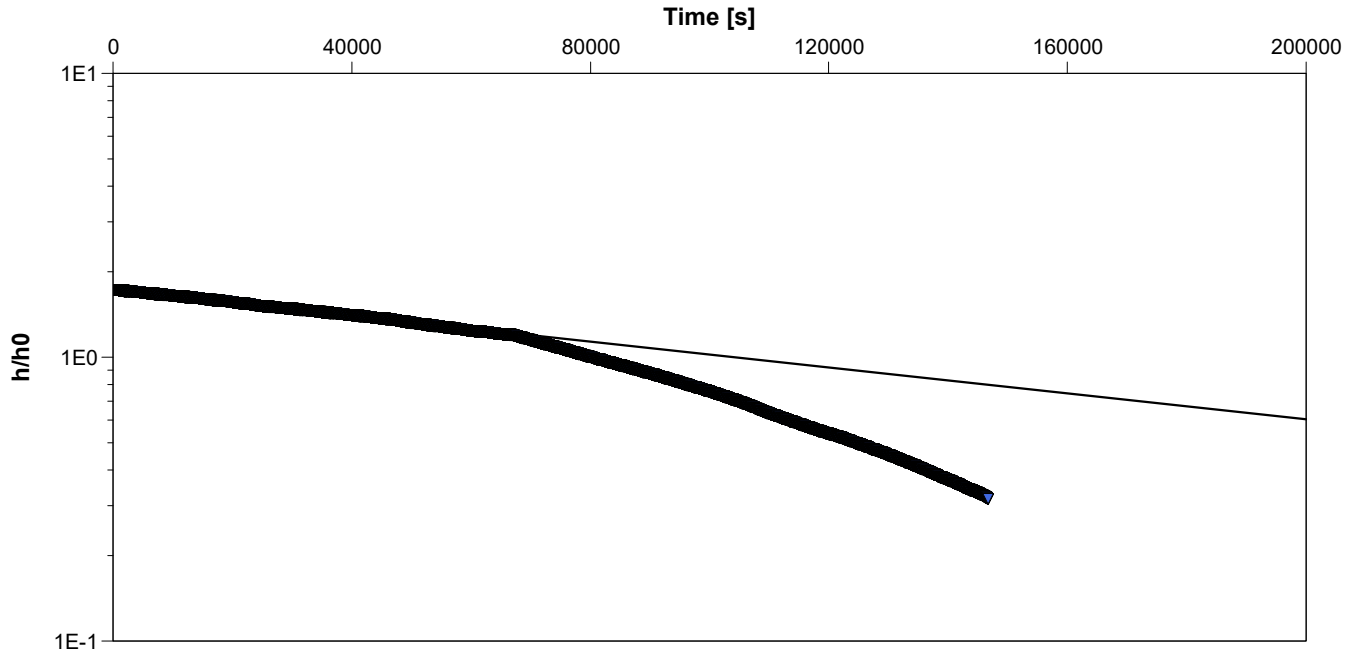
Slug Test Analysis Report

Project: WM Richmond - CAZ Investigation

Number: 180150-02

Client: Waste Management

Location: Richmond Landfill, Napanee ON	Slug Test: M207 Bail Test	Test Well: M207
Test Conducted by: BM		Test Date: 2018-06-22
Analysis Performed by:	Hvorslev	Analysis Date: 2018-06-22
Aquifer Thickness: 2.73 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
M207	2.74×10^{-9}	

BluMetric Environmental Inc.

BluMetric Offices

4-41 de Valcourt Street
Gatineau, Québec
Canada J8T 8G9
Téléphone: 819 243.7555
Télécopieur: 819 243.0167
gatineau@blumetric.ca

3108 Carp Road
PO Box 430
Ottawa, Ontario
Canada K0A 1L0
Tel: 613.839.3053
Fax: 613.839.5376
ottawa@blumetric.ca

825 Milner Avenue
Toronto, Ontario
Canada M1B 3C3
Tel: 877.487.8436
toronto@blumetric.ca

276, Saint-Jacques Street
Suite 818
Montréal, Québec
Canada H2Y 1N3
Téléphone: 514 844.7199
Télécopieur: 514 841.9111
montreal@blumetric.ca

4 Cataraqui Street
The Tower, The Woolen Mill
Kingston, Ontario
Canada K7K 1Z7
Tel: 613.531.2725
Fax: 613.531.1852
kingston@blumetric.ca

4916 – 49th Street
Yellowknife, NT
Canada X1A 1P3
Tel: 867.873.3500
Fax: 867.873.3499
yellowknife@blumetric.ca

171 Victoria Street North
Kitchener, Ontario
Canada N2H 5C5
Tel: 519.742.6685
Fax: 519.742.9810
kitchener@blumetric.ca

102-957 Cambrian Heights Drive
Sudbury, Ontario
Canada P3C 5S5
Tel: 705.525.6075
Fax: 705.525.6077
sudbury@blumetric.ca

1046 Gorham Street
Thunder Bay, Ontario
Canada P7B 5X5
Tel: 807.707.1687
thunderbay@blumetric.ca

www.blumetric.ca