Caring for the Thunderbirds Nest:

Advanced Geophysical Site Assessment

Submitted by:

Submitted to:

School of Applied Technology,

Humber College

Discipline: Civil Engineering Technology

Date: April 17th, 2023

Executive Summary

Humber College was retained by Fort William First Nation (FWFN) to undergo research at the Mount McKay Waste Disposal Site in Thunder Bay, Ontario. It is suspected there is a correlation between the decommissioned landfill, and a cluster of leukemia cases arising in the FWFN community. A contamination plume of leachate impacted groundwater has been mapped using various geophysical methods to estimate its coverage and direction of flow. Infiltration of precipitation and surface water runoff is suspected to have caused the impacted groundwater to advance past the collection system, thus allowing the plume to migrate towards the community. Field data collection was performed in October 2022, with four (4) transects being studied, this report primarily focuses on “East-West Line 2”. However, data from the other three (3) transects will be reviewed. A water quality assessment report by Oshki Aki LP, dated March 27, 2018, will be referenced for historical data. Results show a general easternly flow towards FWFN land from the majority of the soil layers. Air quality data is not of concern due to levels below Government of Canada average levels. Pockets of contamination could not be verified as the location of the silty clay layer is encroaching on the transect that was investigated. Further studies are required in order to verify findings prior to a full assessment of the conditions relating to the FWFN leukemia cases.

Table of Contents

List of Figures

1.0 Background

1.1 Closed Waste Disposal Site

The site in question is the Mount McKay Waste Disposal Site in Thunder Bay, Ontario, hereinafter referred to as the Site. The Environmental Compliance Approval (ECA) was originally issued to The Great Lakes Paper Company in the early 1970s; Several changes in ownership and ECA amendments have occurred since then. The Site received solid industrial waste such as wood waste, lime mud, clarifier sludge, and boiler ash from the Resolute Thunder Bay Pulp and Paper Mill (Resolute), and its predecessors, in the early 1970s to 1988. The estimated average landfilling rate of 60,000 m^3 per year is assumed for its 24-year lifespan with an estimated total site capacity of 1,440,000 m^3.

The Site was closed in 1988 due to leachate impacted groundwater reported to be migrating off site onto adjacent FWFN property, due to infiltration of precipitation and surface water runoff.

Resolutes predecessor, in consultation with FWFN, developed and implemented a formal closure plan between the years of 1997 and 1998. Closure included clay capping, re-vegetation, and perimeter ditching. Additionally, a Leachate Collection System (LCS) was installed. The LCS pumps leachate impacted groundwater into the sanitary sewer system for treatment in the City of Thunder Bay's municipal sewage treatment plant.

The site is currently governed by MOECC Approval No. A590111, dated May 27, 2010, Notice No.1, dated November 23, 2012, and Notice No. 2, dated March 24, 2015 (Oshki

Aki LP, 2018). These can be found in Appendix E, from the *2017 Water Quality Assessment, Mount McKay Waste Disposal Site* by Oshki Aki LP

2.0 Body

2.1 Site Setting

The site is bounded by the FWFN Reserve No. 52 to the north and east, Mount McKay to the south, and former Department of National Defense, now known to be FWFN land, on the west with Quarry Road being the access road. The Kaministiquia River runs around to the north and northwest of the Site. Resolute Forest Products plants lay to the northeast and west sides of the Site. Refer to *Figure 1: Site Location Plan* as a visual explanation, a larger version is provided in Appendix D.

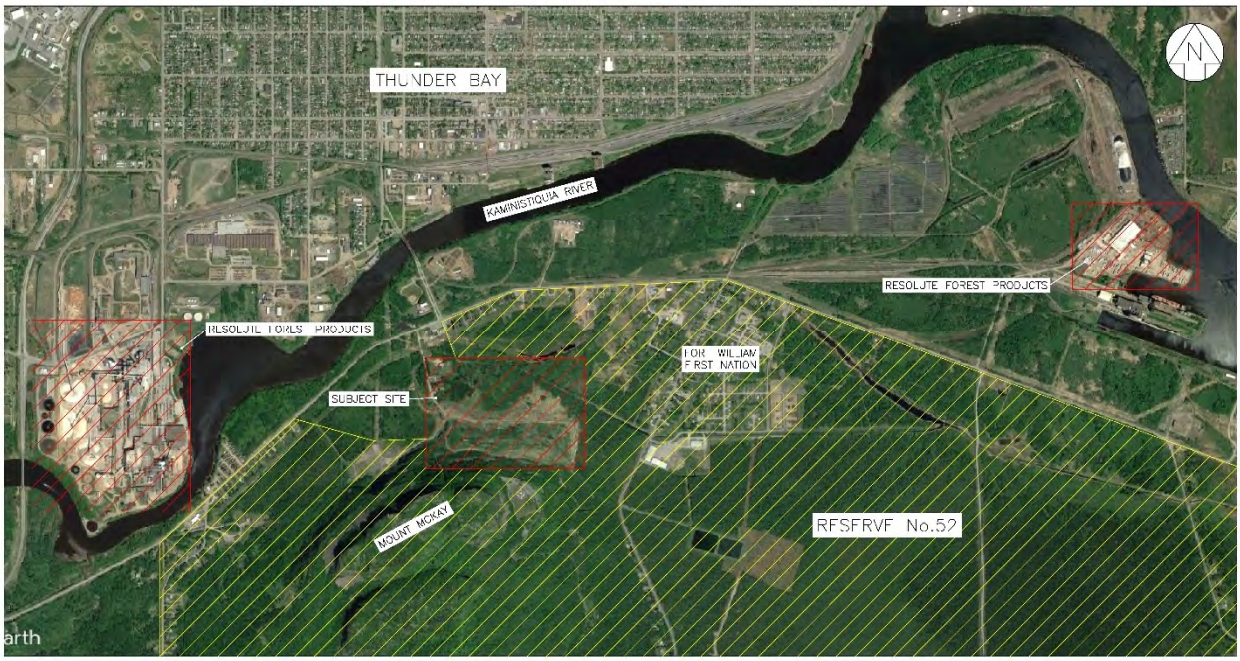

Figure 1: Site Location Plan

The site is relatively flat with a gradual slope (percent of slope unknown) towards the Kaministiquia River. Aside from Mount McKay, the only significant topographical feature of the site is the landfill mound which rises approximately 30 meters along the face of Mount McKay. The total footprint area of the landfill is unknown.

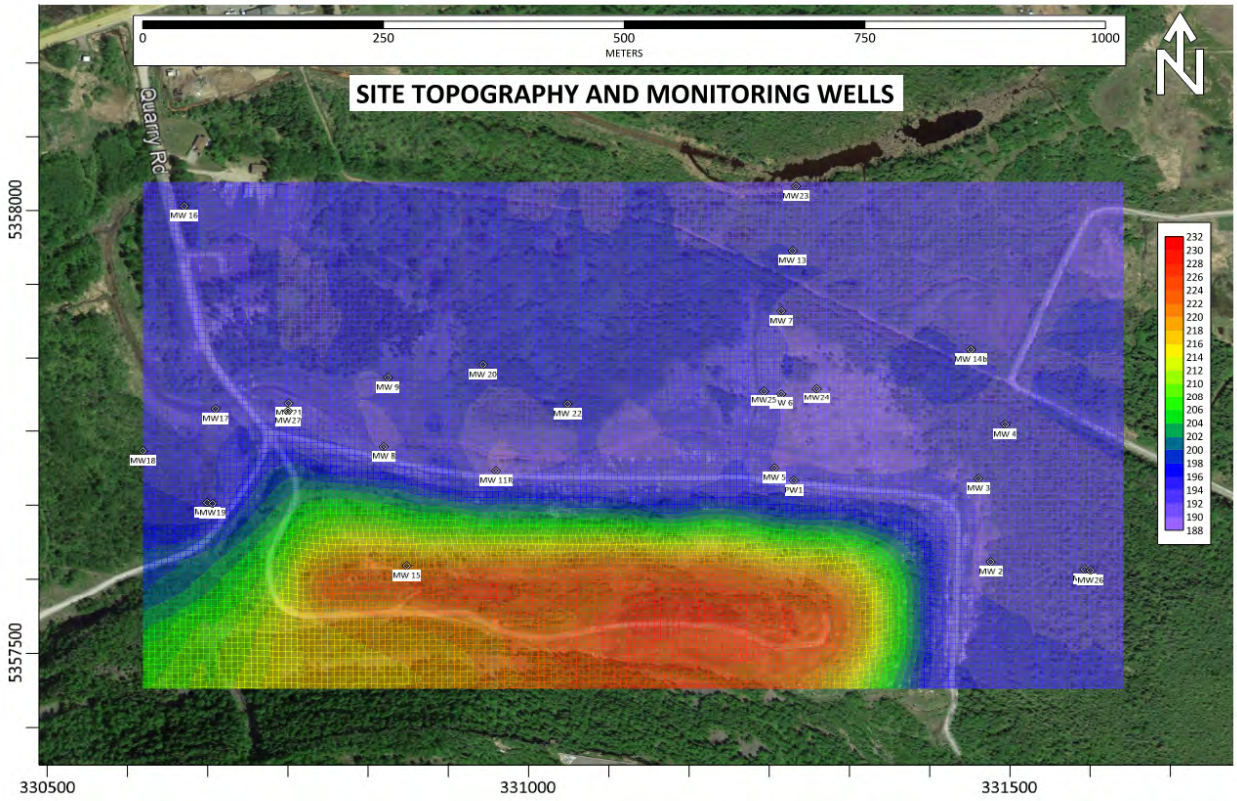

Figure 2: Site Topography and Monitoring Well Locations

There are twenty-seven (27) monitoring wells installed across the Site; See *Figure 2: Site Topography and Monitoring Well Locations for locations*, and *Figure 3: Monitoring Well Coordinates* for coordinates. The monitoring wells were installed between the years of 1991 to 1998, with depths ranging between 5 to 67 meters (Oshki Aki LP,

2018). Borehole logs from the *2017 Water Quality Assessment, Mount McKay Waste Disposal Site* by Oshki Aki LP are provided in Appendix F.

Monitoring Well Coordinates

Monitoring Well	Easting	Northing
MW 1	331577.485	5357594.629
MW 2	331480.123	5357602.944
MW 3	331467.303	5357696.495
MW 4	331495.022	5357757.476
MW 5	331255.602	5357708.275
MW 6	331262.532	5357792.470
MW 7	331262.532	5357886.367
MW 8	330849.524	5357732.182
MW 9	330854.029	5357811.181
MW 10	330666.235	5357669.469
MW 11R	330966.289	5357705.157
MW 12	331226.498	5357567.950
MW 13	331274.312	5357954.624
MW 14	331459.681	5357842.710
MW 15	330873.432	5357598.440
MW 16	330642.328	5358004.864
MW 17	330674.897	5357774.800
MW 18	330599.364	5357727.678
MW 19	330671.779	5357668.430
MW 20	330952.776	5357825.733
MW 21	330750.777	5357781.036
MW 22	331040.436	5357780.344
MW 23	331277.777	5358027.386
MW 24	331299.259	5357798.361
MW 25	331244.515	5357795.589
MW 26	331583.722	5357593.243
MW 27	330750.084	5357772.374

Figure 3: Monitoring Well Coordinates

2.2 Introduction

Humber College was retained by FWFN to undergo research at the Mount McKay Waste Disposal Site, a decommissioned landfill in Thunder Bay, Ontario. It is suspected the contamination is the result of the waste disposal by Resolute, a pulp and paper mill company.

Included in this report will be contour mapping of various soil layers, geoelectrical tomographs, and air quality mapping. Omitted from this report was water quality analysis and ground penetrating radar (GPR) data, which could potentially be included in another study for the Site.

The scope of this report is to perform a site assessment applying various geophysical methods to accurately determine and map the location of the contamination plume.

It is suspected that the contamination plume is linked to a cluster of leukemia cases in FWFN which is potentially stemming from the decommissioned landfill.

The entirety of this project is based off four (4) major transects, East-West Line 1, East-West Line 2, North-South Line 3, and North-South Line 4. This report places a focus on East-West Line 2, with consideration and analysis of the remaining transects. Refer to *Figure 4: East-West Line 2 Topography* for location of the transect in focus. All transects are included in Appendix A.

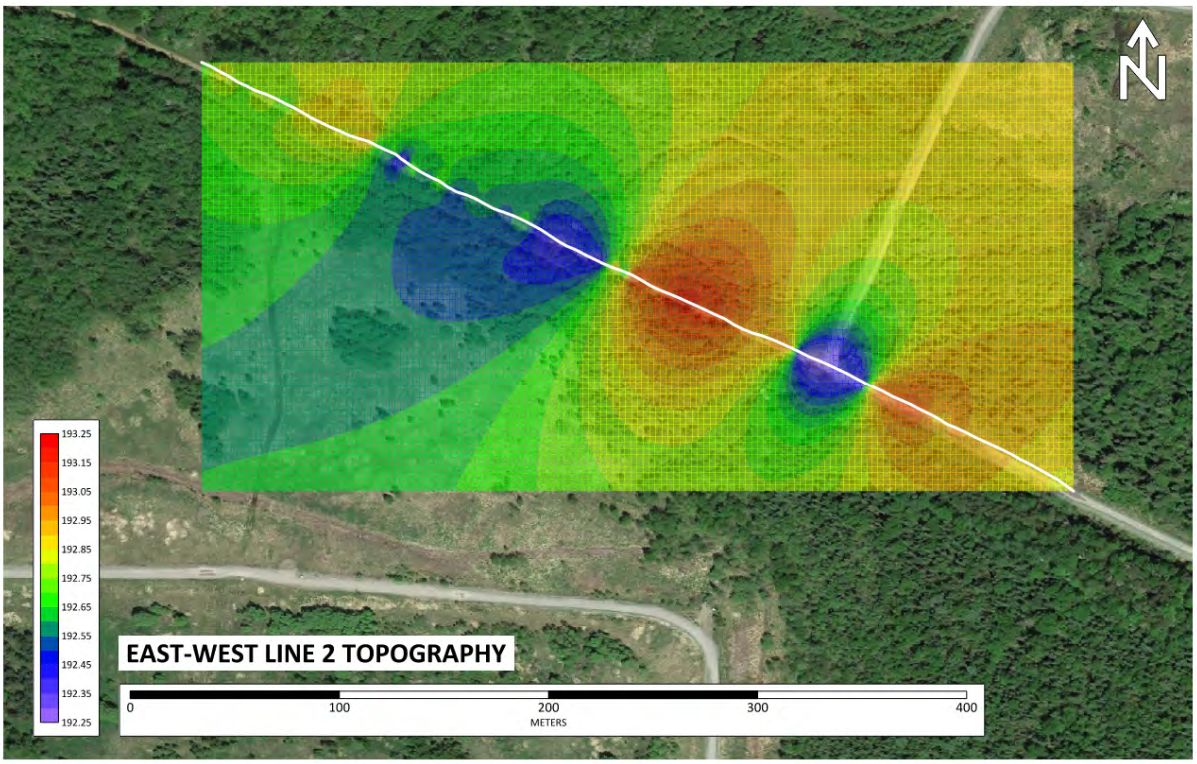

Figure 4: East-West Line 2 Topography

2.3 Methodology

This report covers various methods of data analysis. Included will be contour maps, geoelectrical tomographs, and air quality measurements. These methods were used to locate and map potential groundwater contaminants, establish and verify soils characteristics, and estimate surface and groundwater flow direction.

Contour maps were produced to estimate ground and surface water directional flow, as well as to aid in the analysis of other geophysical data.

Geoelectrical tomographs for each of the transects were generated, while detailed analysis was performed on East-West Line 2. Assessment was done to differentiate areas with resistivity and chargeability, indicating where contaminants are present.

Air quality data sets for the specified transect were studied to estimate the airborne contaminants on the Site.

Water quality and GPR data was collected as a part of the October 2022 field study but will not be analyzed at this time.

Through these methods it is expected to find the estimated location and migration of the contamination plume within the affected Site. Within the consideration of data, cross referencing will be done with previously developed studies to allow further understanding of the information.

3.0 Data Analysis

3.1 Contour Maps

Contour maps were generated for the ten (10) major soil types found while drilling the monitoring wells. These wells range in depth between 5 to 67 meters, installed between the years of 1991 to 1998 (Oshki Aki LP, 2018). KGS Group was obtained by Canadian Pacific Forest Products (the Client) for the Observation Well Installation at the Mount McKay Waste Disposal Site (the Site).

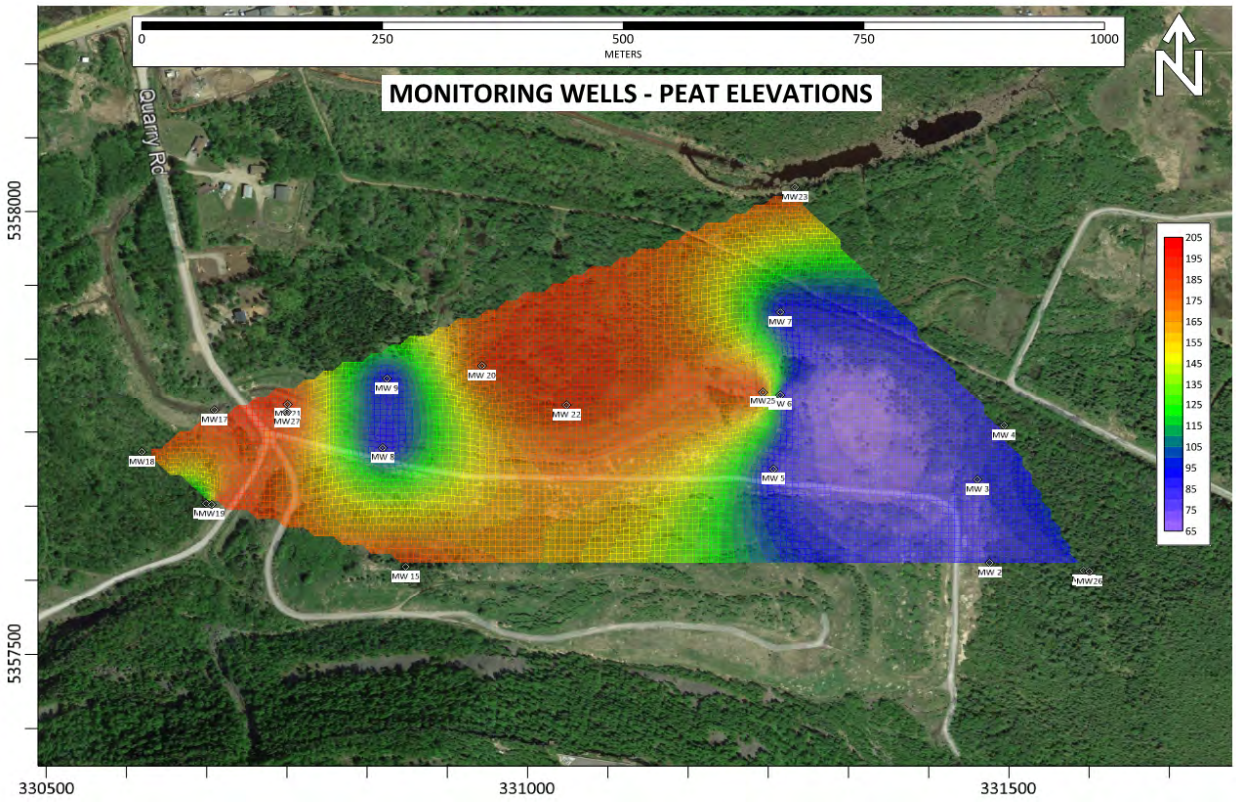

Figure 5: Monitoring Well Peat Elevations

Figure 5: Monitoring Well Peat Elevations shows the elevations for the peat layer related to the respective monitoring wells. The contour map displays a peak in the center, with an eastward slope. A depression can be seen east of the center.

The peat layers are described as dark brown to black, amorphous and non-woody with a fibrous texture. Various logs stated 2 to 4 inches of ice cover, with several having brush cover. Organics were found within several hoes, specifically MW 10 is noted to have some fine sand.

Included in this data set are monitoring wells 1-10, 15, 17-23, 25-27, and PW1.

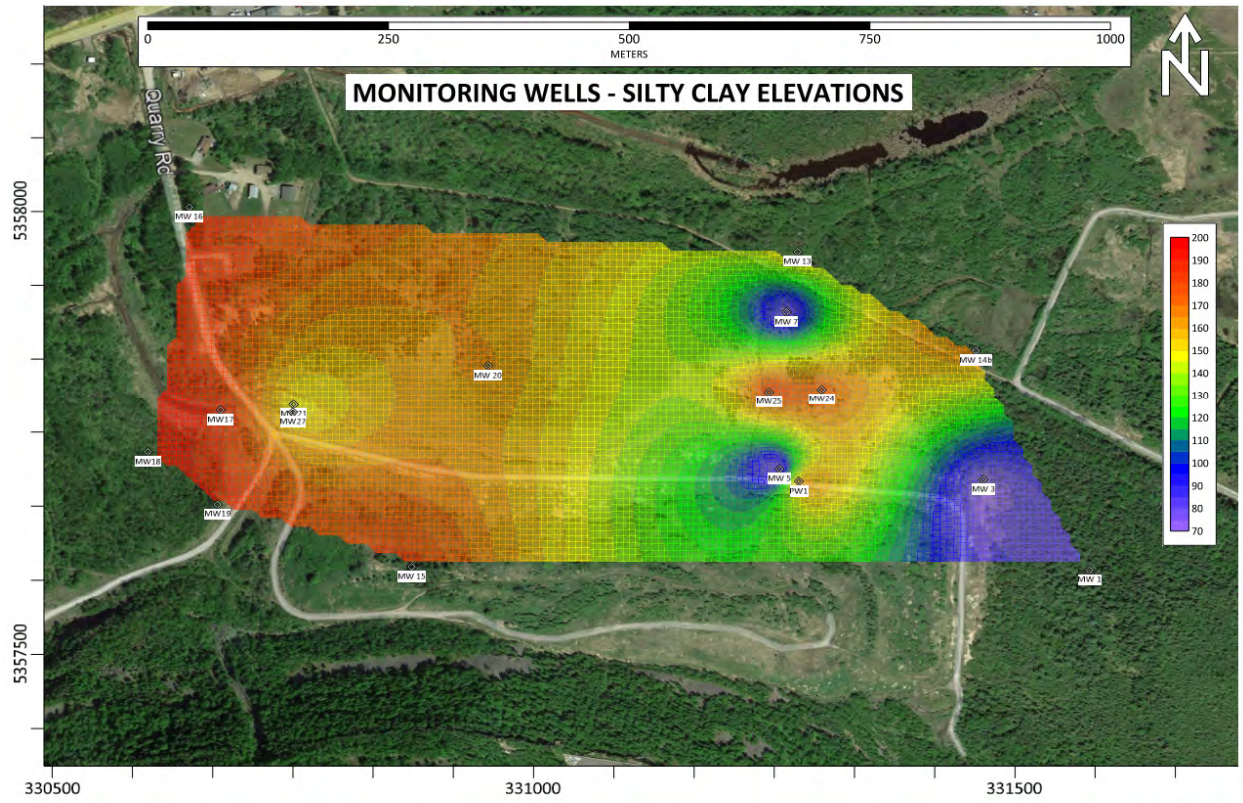

Figure 6: Monitoring Well Silty Clay Elevations

Figure 6: Monitoring Well Silty Clay Elevations shows the elevations for the silty clay layer related to the respective monitoring wells. The contour map displays a peak on the westmost side, gradually sloping east, with a sharp downgrade southwest in the farthest east quarter. Steep depressions can be seen at MW 5 and MW 7.

The silty clay layers are described as grey, brown and green, with low to intermediate plasticity. The density is soft to very soft, with firmness appearing in various holes past 30 feet deep. Occasional sand and peat layers can be seen in several of the holes. MW 15 displayed a high moisture content, nearing the liquid limit. MW 19 was pushing rock pieces at 80 and 82 feet. Layers of wood and organics can be seen in MW 16 and 17. Included in this data set are monitoring wells 1, 3, 5, 7, 13-21, 24, 25, 27, and PW1.

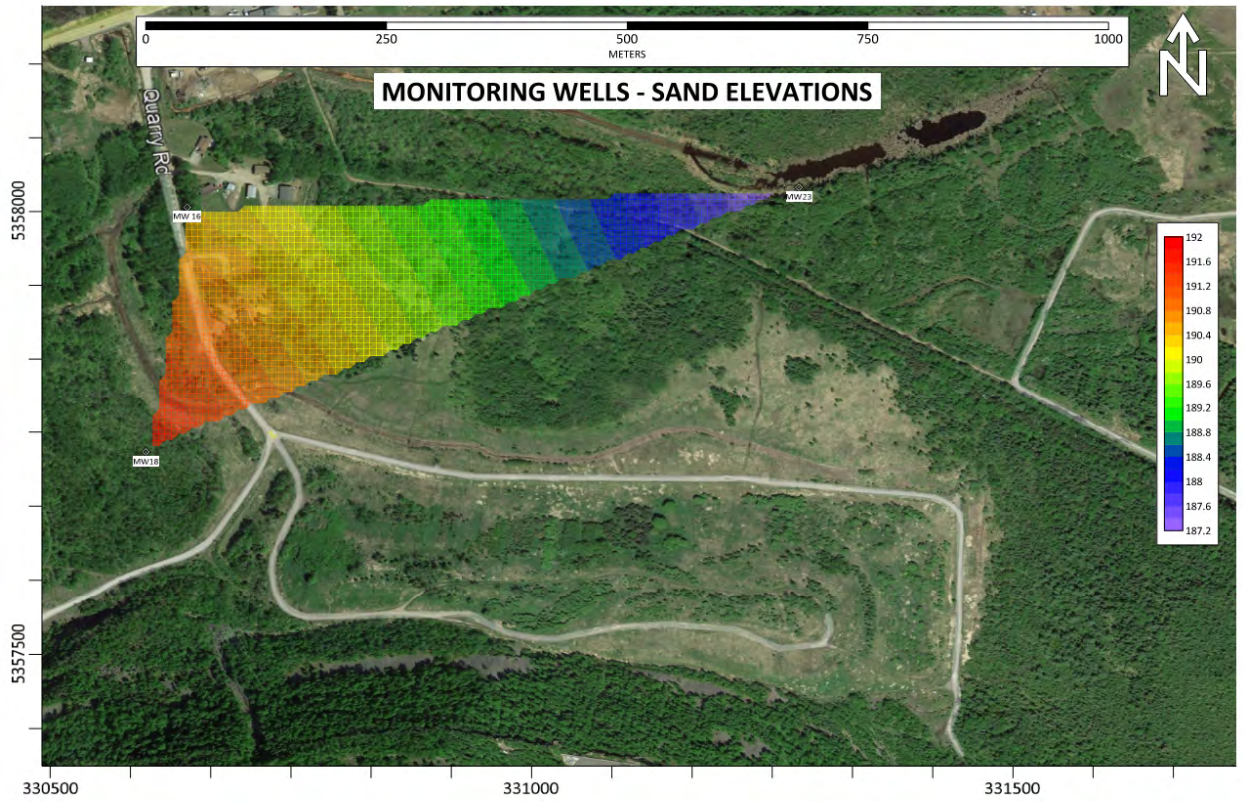

Figure 7: Monitoring Well Sand Elevations

Figure 7: Monitoring Well Sand Elevations shows the elevations for the sand layer related to the respective monitoring wells. The contour map displays an even downward gradient west to northeast.

The sand layer appears to be a brown to grey color, ranging between moist to fully saturated. It is described as loose, medium grained, and poorly graded, with traces of silt and organic materials. Oxidation within the sand can been seen in all boreholes studied.

Included in this data set are monitoring wells 16, 18, 23.

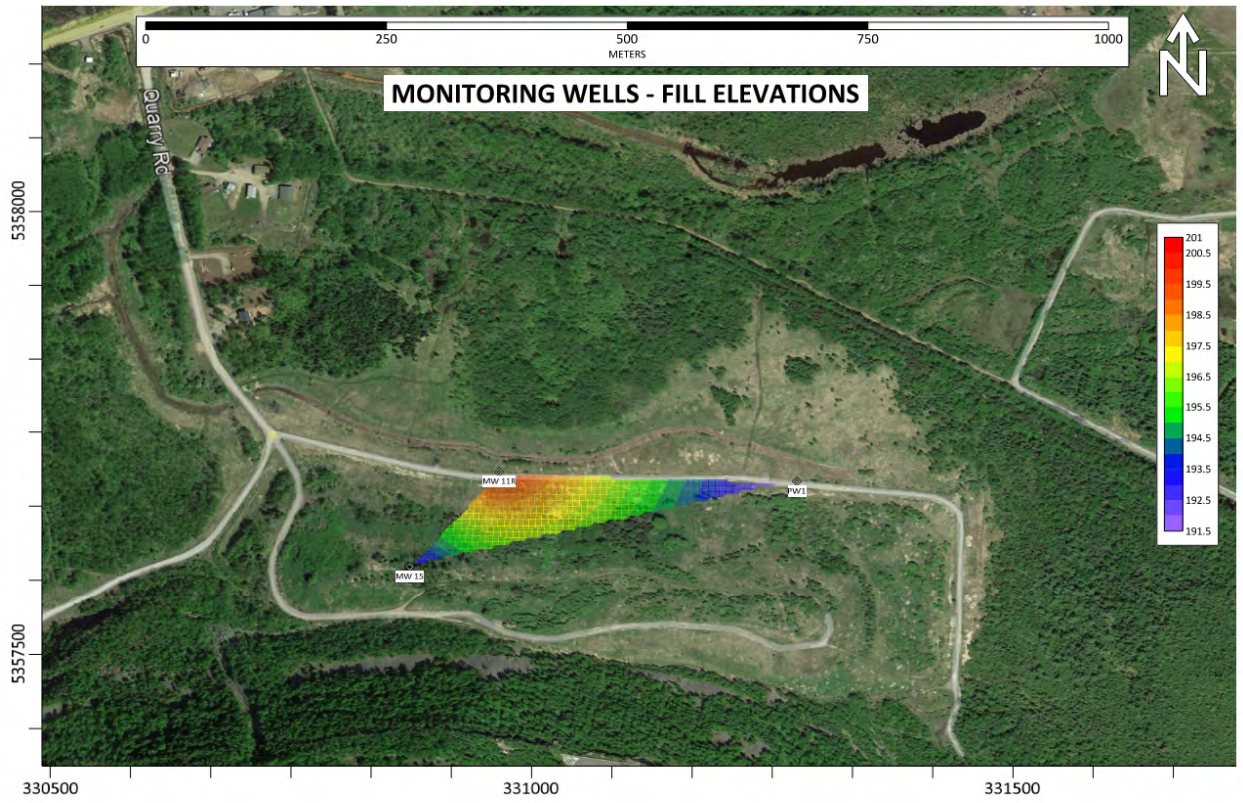

Figure 8: Monitoring Well Fill Elevations

Figure 8: Monitoring Well Fill Elevations shows the elevations for the fill layer related to the respective monitoring wells. The contour map displays a peak in the center at MW 11R, and gradual downward slope east and southwest individually.

The fill layer is mainly composed of wood debris (wood chips, bark), ranging between dry to very wet. Partial to extensive decomposition can be seen, with major decomposition seen specifically in MW 11R. MW 15 is seen to be clayey, sandy, gravelly, moist and dense.

Included in this data set are monitoring wells 11R, 15, and PW1.

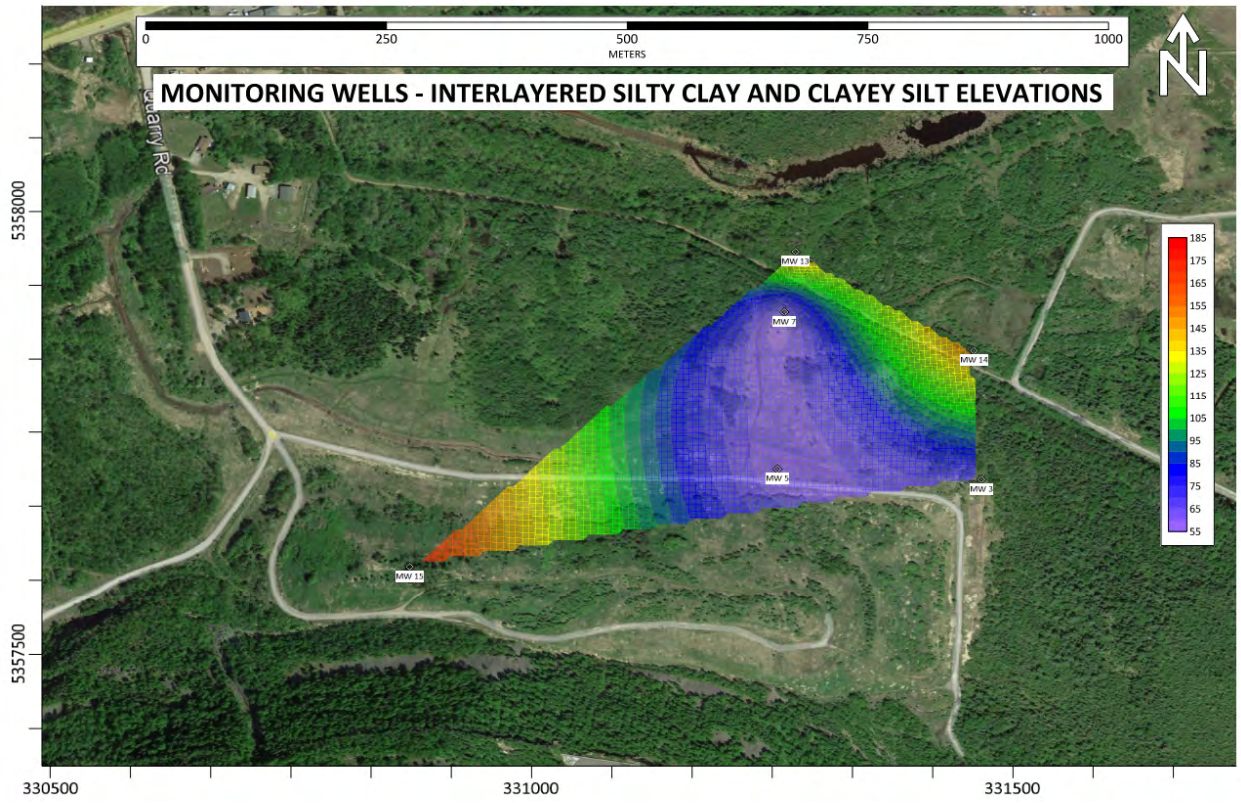

Figure 9: Monitoring Well Interlayered Silty Clay and Clayey Silt Elevations

Figure 9: Monitoring Well Interlayered Silty Clay and Clayey Silt Elevations shows the elevations for the interlayered silty clay and clayey silt layer related to the respective monitoring wells. The contour map displays a high point at MW 15 and on the northeast side, with a gradual downward slope to a large depression in the center of the model. The interlayered silty clay and clayey silt layer shows a grey to brown color, loose with a fine to medium grain. Non to intermediate plasticity can be seen with a soft to firm density. On average it is moist to saturated; MW 15 was found to be wet, nearing it's liquid limit.

Included in this data set are monitoring wells 3, 5, 7, and 13-15.

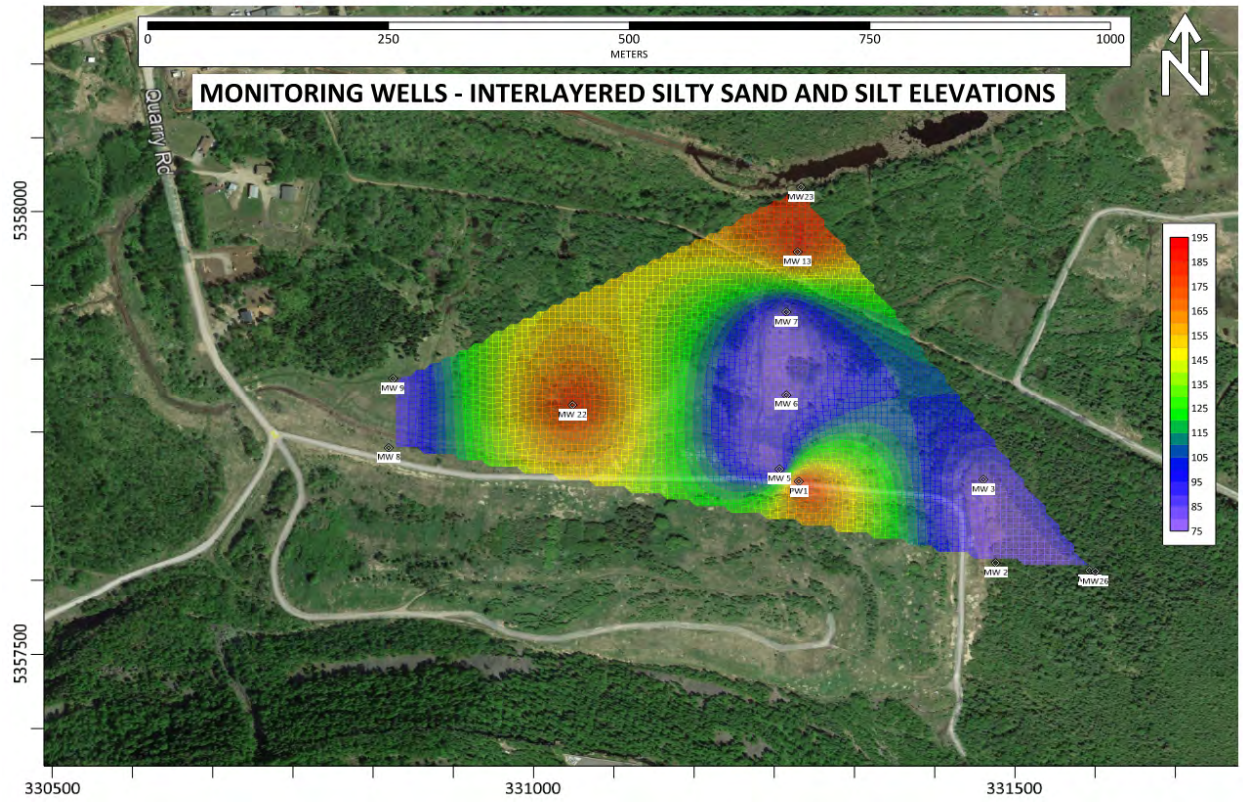

Figure 10: Monitoring Well Interlayered Silty Sand and Silt Elevations

Figure 10: Monitoring Well Interlayered Silty Sand and Silt Elevations shows the elevations for the interlayered silty sand and silt layer related to the respective monitoring wells. High points can be seen at MW 22 and MW 13, as well as PW 1, with a gradual slope downwards towards the low points on the west and southeast sides, as well as slightly east of center.

The interlayered silty sand and silt layer is shown to be rust brown to grey, with a loose to firm density. It is found to be fine to medium grained and ranging between moist to fully saturated. Free water was seen in MW 13, as well as rootlets. Plasticity is non to very low.

Included in this data set are monitoring wells 1-3, 5-9, 13, 22, 23, 26, and PW1.

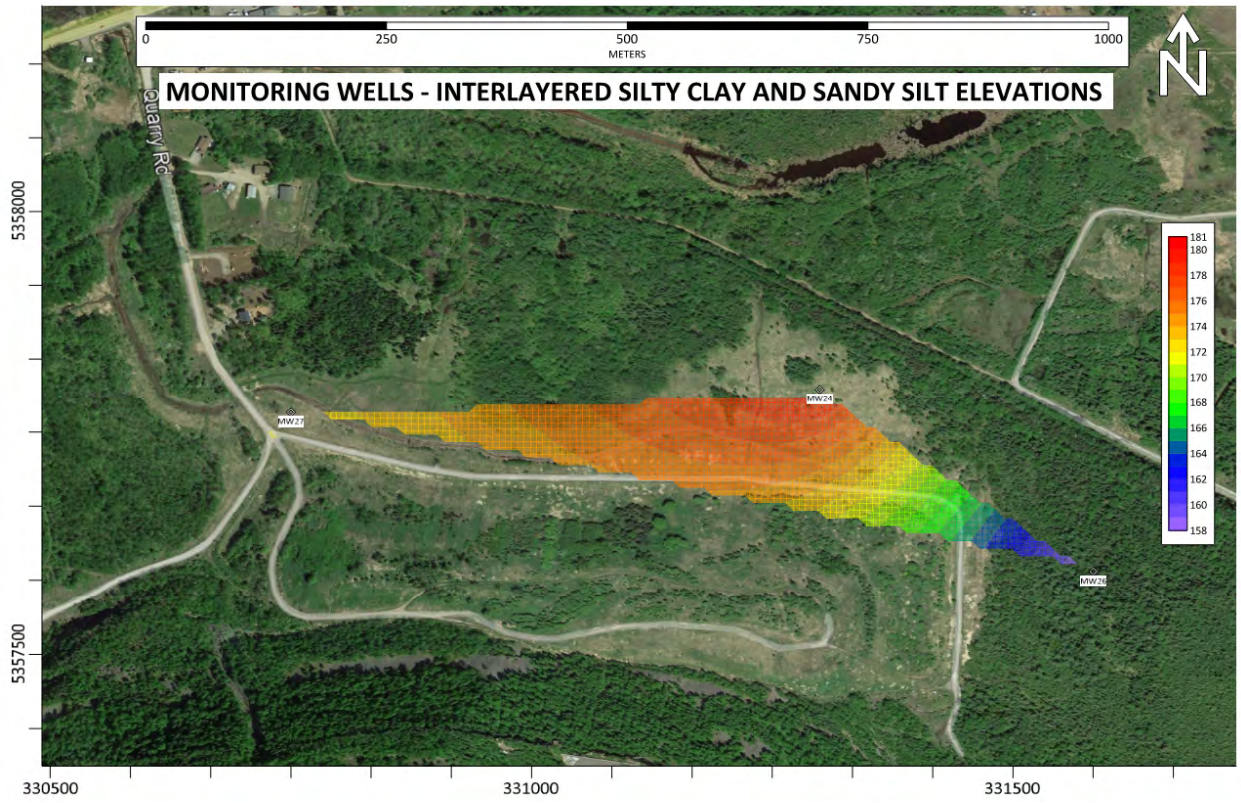

Figure 11: Monitoring Well Interlayered Silty Clay and Sandy Silt Elevations

Figure 11: Monitoring Well Interlayered Silty Clay and Sandy Silt Elevations shows the elevations for the interlayered silty clay and sandy silt layer related to the respective monitoring wells. The contour map displays a highpoint in the center with a gradual downwards slope to the southeast.

The silty clay and sandy silt layer is seen to be brown to dark grey, ranging between firm to loose density and moist to wet consistency. Low to intermediate plasticity was seen.

Included in this data set are monitoring wells 24, 26, and 27.

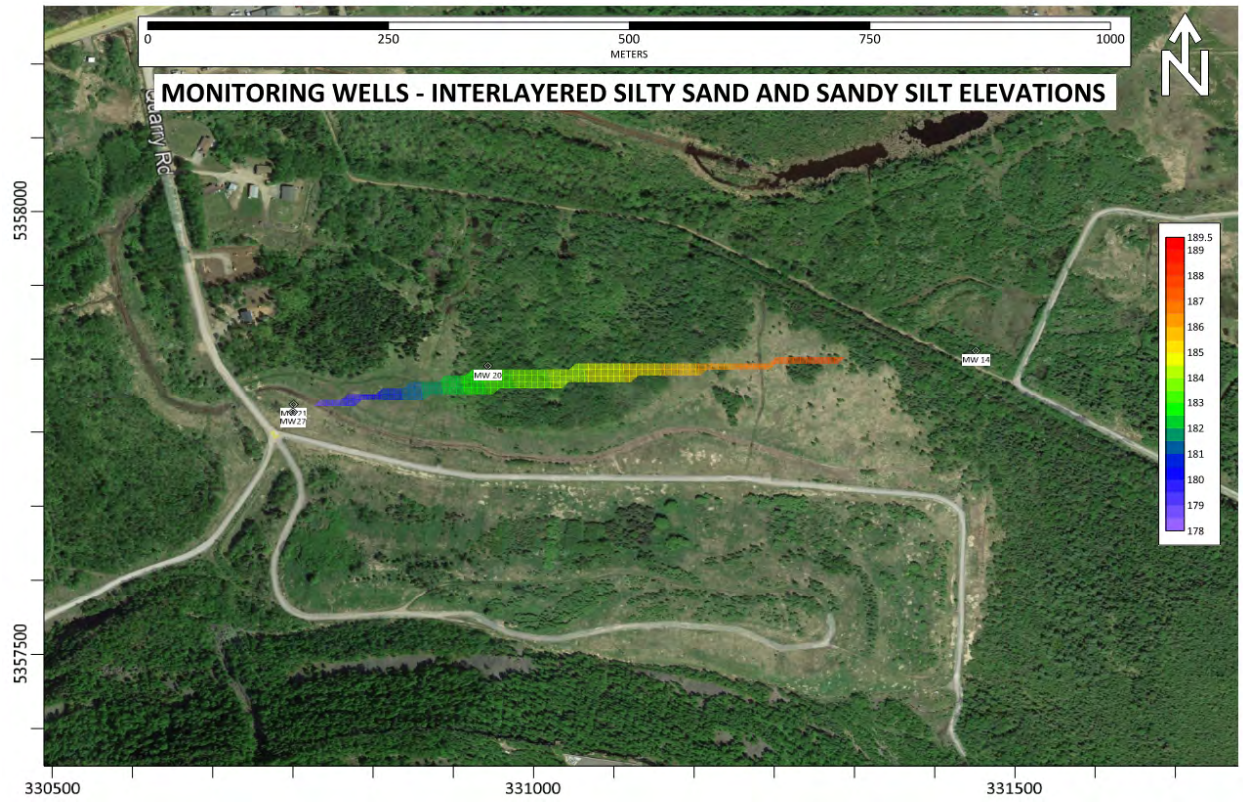

Figure 12: Monitoring Well Interlayered Silty Sand and Sandy Silt Elevations

Figure 12: Monitoring Well Interlayered Silty Sand and Sandy Silt Elevations shows the elevations for the interlayered silty sand and sandy silt layer related to the respective monitoring wells. The contour map displays a gradual downward slope from east to west.

The interlayered silty sand and sandy silt layer appears to be grey to brown, ranging between fine to medium grained and poorly graded. Plasticity is non to very low, with a density ranging between soft to firm. Moisture varies from moist to saturated, free water by dilatancy below 10 feet is seen in MW 14B.

Included in this data set are monitoring wells 14, 20, 21, and 27.

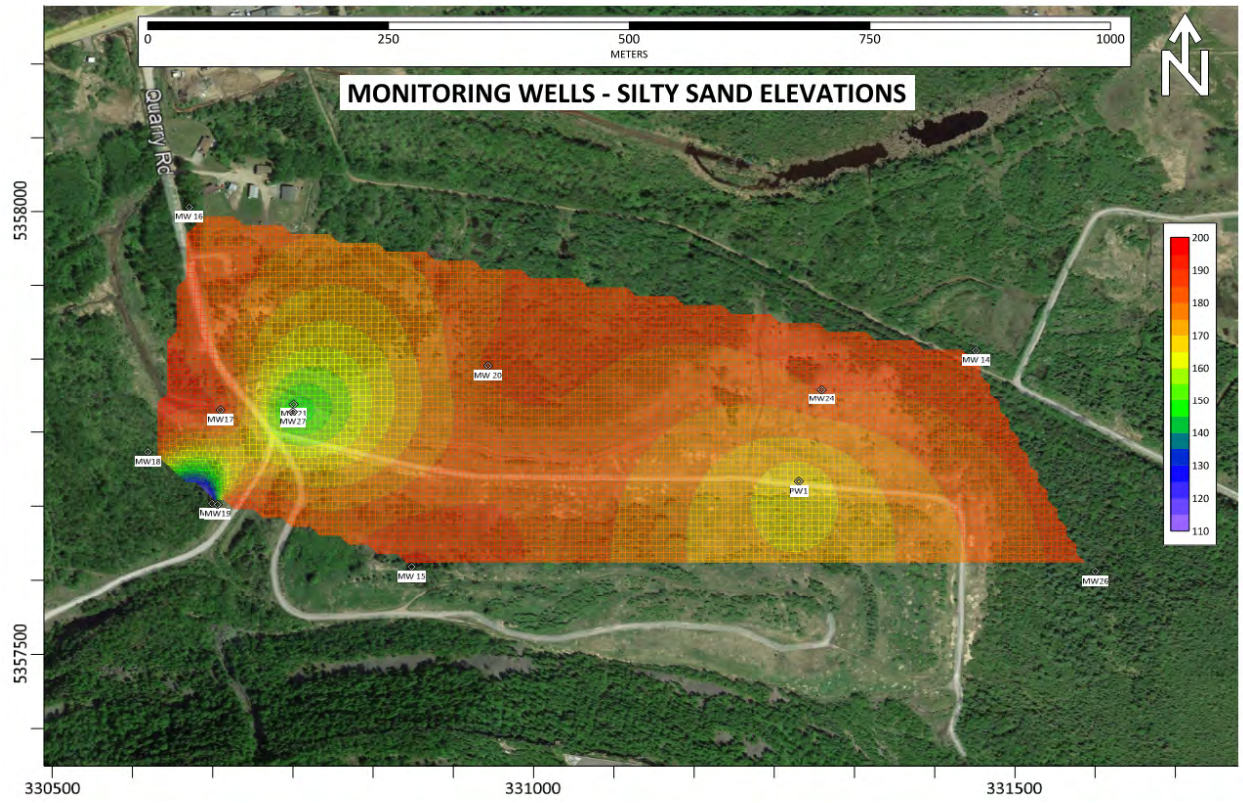

Figure 13: Monitoring Well Silty Sand Elevations

Figure 13: Monitoring Well Silty Sand Elevations shows the elevations for the silty sand layer related to the respective monitoring wells. Overall, this contour map displays a shallow and flat layer with a depression on the southwest side, at MW 19.

The silty sand layer ranges in color from dark grey to rust brown, poorly graded with a density varying between loose to compact. Moisture is consistently saturated. It is fine to coarse grained.

Included in this data set are monitoring wells 10, 14-21, 24, 26, 27, and PW1.

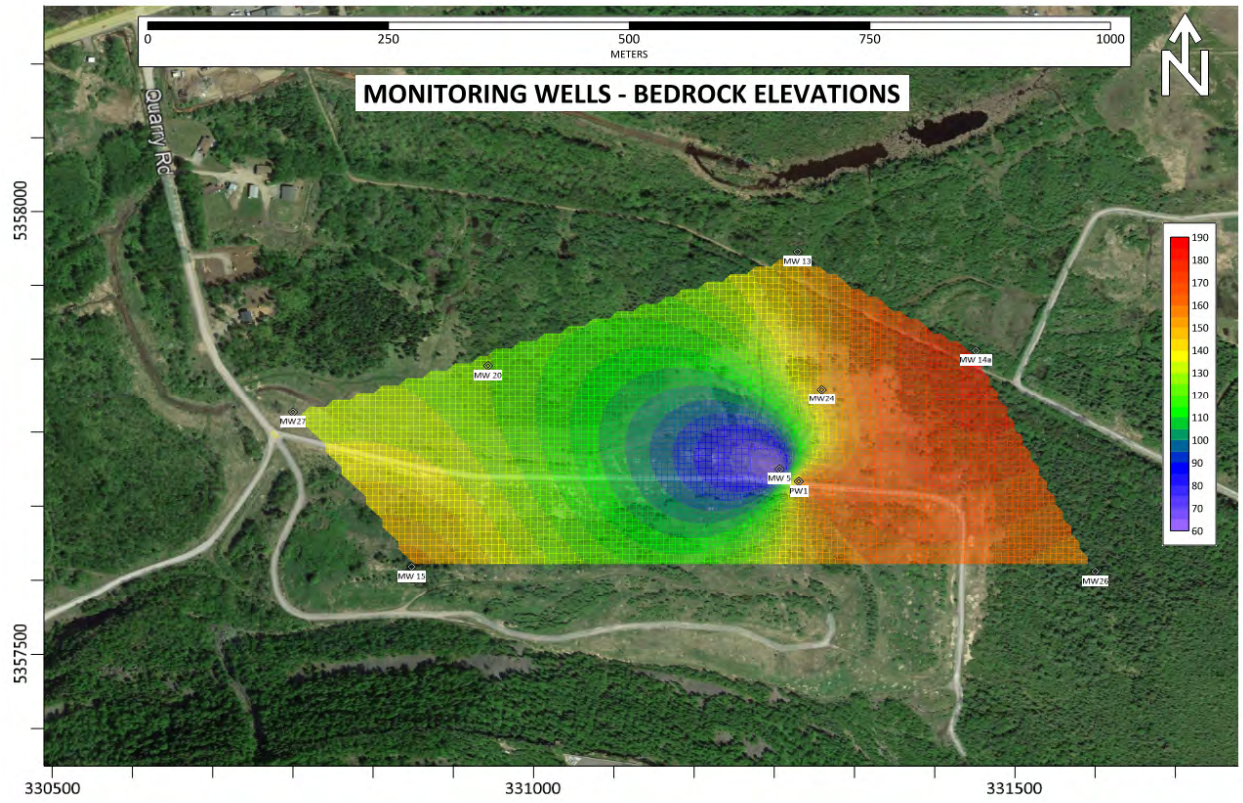

Figure 14: Monitoring Well Bedrock Elevations

Figure 14: Monitoring Well Bedrock Elevations shows the elevations for the bedrock layer related to the respective monitoring wells. A steep depression is shown at the center of the model, with a sharp upward slope to the east and a gradual upward slope to the west.

The bedrock layer ranges in color between dark grey to black. Some fracturing is seen in the shale throughout the holes. Diabase, siltstone, quartz, olivine, and graywacke can been seen throughout. Large volumes of grey, very fine sand can also be seen. Included in this data set are monitoring wells 5, 13-15, 20, 24, 26, 27, and PW1.

3.2 Geoelectrical Tomographs

Geoelectrical tomographs were generated and analyzed to review for potential sections of the contamination plume. East-West Line 2 was focused on, see Appendix B for all tomographs.

This data was collected during the field work section of this study, October 2022. Data collection included the temporary installation of electrodes and injecting a high voltage current along the line. Resistivity values are measured from the underground soil layer, allowing a resistivity map to be generated and processed. Divots were dug around each electrode and a saline solution was used prior to running the circuit to increase conductivity for data collection.

The graphs displayed show induced polarization and resistivity, respectively. Induced polarization, seen in *Figure 15: East-West Line 2 Induced Polarization,* measures chargeability, high chargeability displays a potential concentration of contaminants.

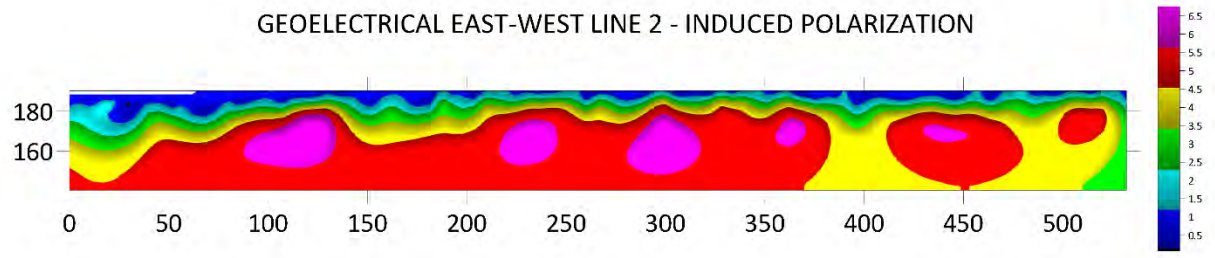

Figure 15: East-West Line 2 Induced Polarization

A low resistivity indicates a potential concentration of contaminants or clay content, this data will be assessed by referencing the clay layer contour map *(Figure 6)*. Refer to *Figure 16: East-West Line 2 Resistivity* for details.

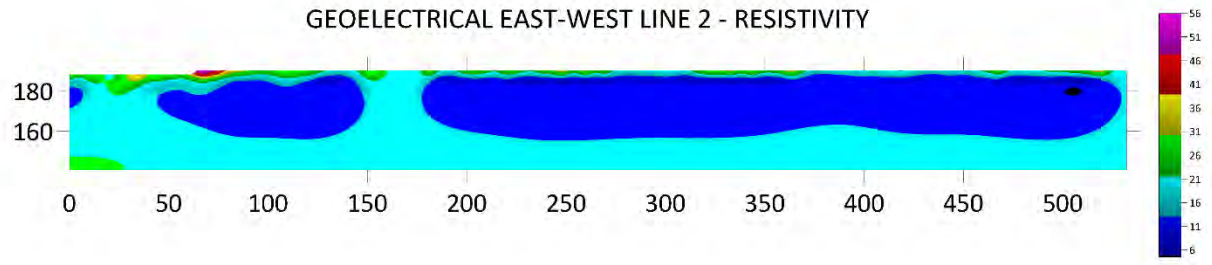

Figure 16: East-West Line 2 Resistivity

3.3 Air Quality Measurements

Air quality data for East-West Line 2 was collected, focusing on the levels of carbon dioxide, methane, and VOCs at each coordinate. The data was collected using an RKI Eagle 2 Multi Gas Detector. The carbon dioxide levels in the transect were found to be consistently at 250 ppm, with only minimal variations observed within the range of 225 ppm to 275 ppm. No discernible levels of methane or VOCs were identified along the transect. A visual representation of the carbon dioxide levels in the East-West Line 2 can be seen in *Figure 17: East-West Line 2 Carbon Dioxide Levels*. This data provides a basic insight into the air quality within this particular transect.

Low level investigation into the other transects shows slightly elevated levels of carbon dioxide, as well as low levels of detectable methane.

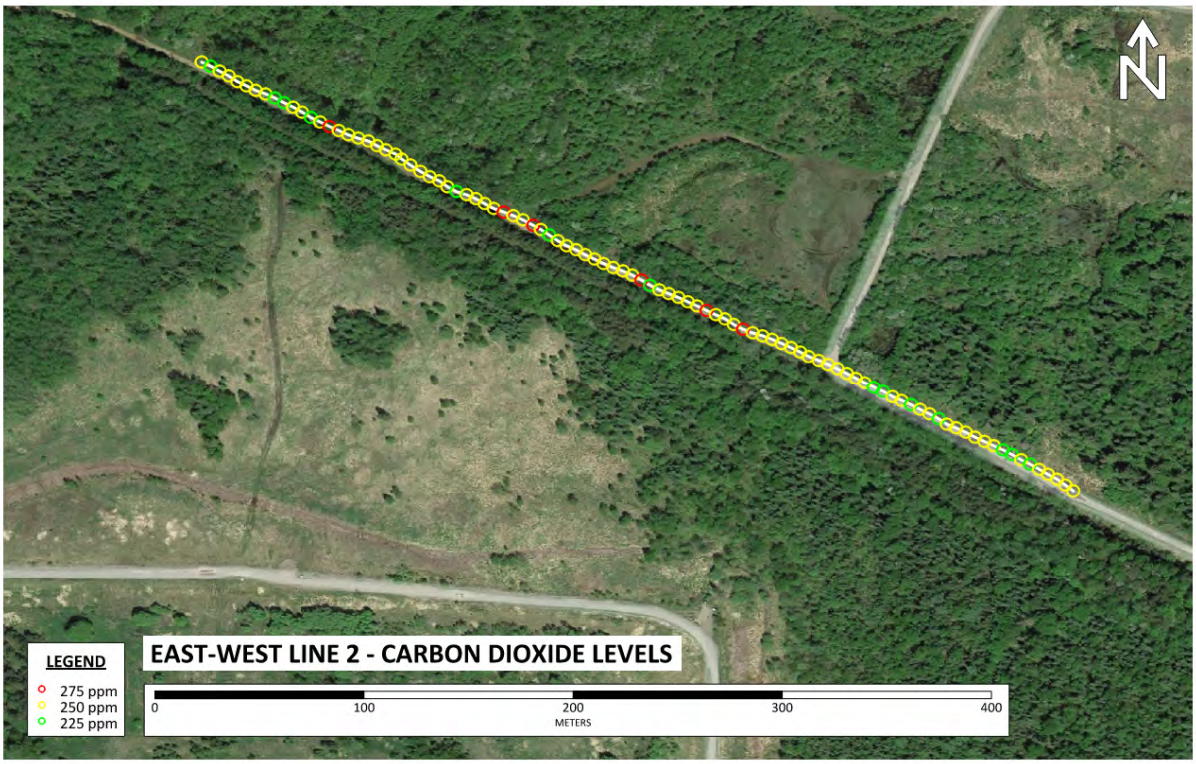

Figure 17: East-West Line 2 Carbon Dioxide Levels

4.0 Results

Many of the material layers are sloping in an easterly or southeasterly direction, guiding groundwater towards FWFN land. The bedrock and interlayered silty sand and sandy silt layer both slopes westerly, but not in such a manner that would cause a sizable effect on the groundwater direction. With this data, there is the assumption that the groundwater flow is being directed towards FWFN land.

In review of the air quality data, carbon dioxide was found to be minimal, but still present, with no detected methane or VOC levels. No baseline levels for carbon monoxide levels in the Thunder Bay and surrounding areas are available for cross referencing. A study by the Government of Canada states that in 2020 the annual average outdoor carbon dioxide concentration sat at approximately 415 ppm in Canada (Canada.ca, 2022). With this data, it is assumed that the range between 225 to 275 ppm for East-West Line 2 is of little to no concern without further investigation.

Figure 15: East-West Line 2 Induced Polarization, shows a large segment of highly charged material. *Figure 16: East-West Line 2 Resistivity*, displays an equally large segment of low resistivity; indicating a concentration of contaminants or clay content. Cross-reference of this data to the clay layer contour map implies that this section of low resistivity could potentially have a high clay content versus contamination.

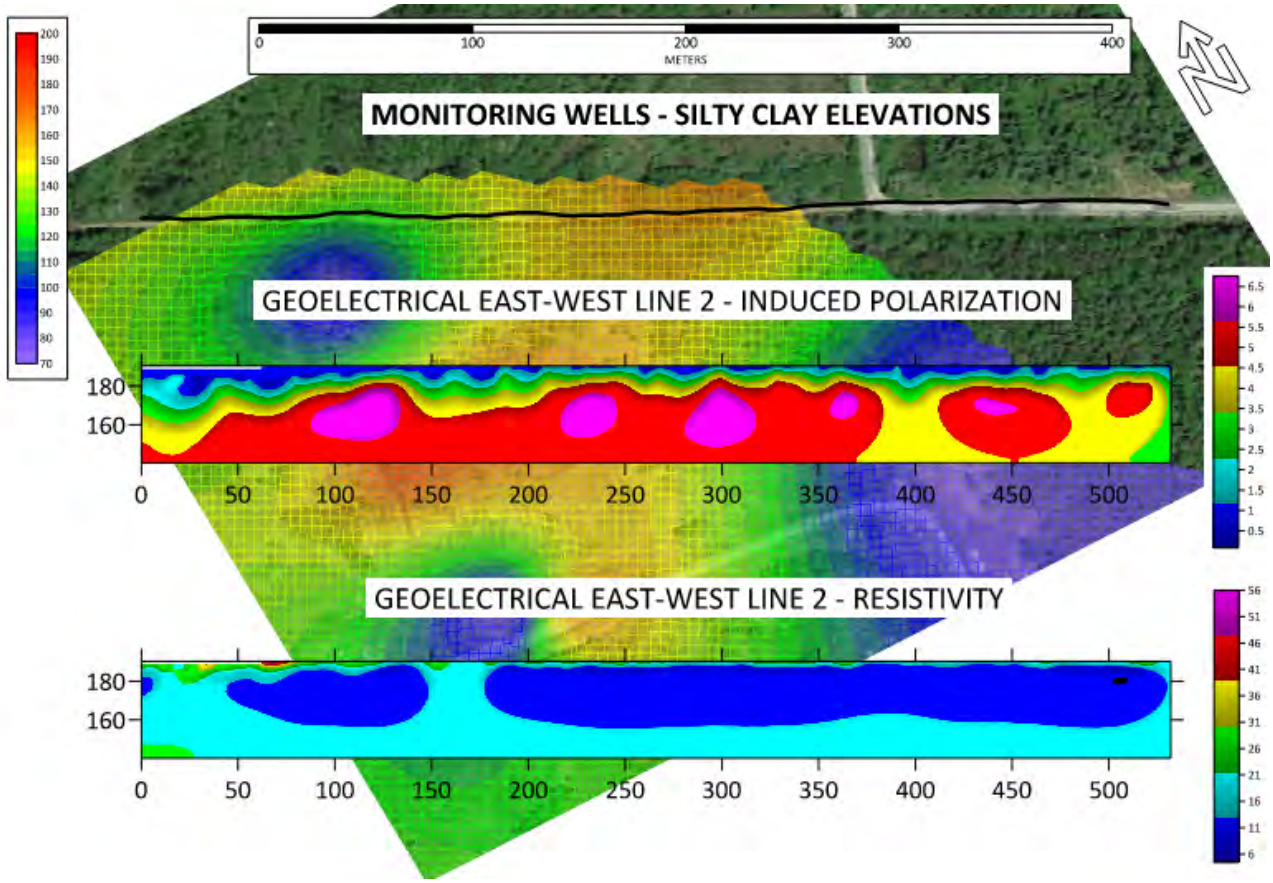

Figure 18: East-West Line 2: Clay Layer Vs Geoelectrical Data

Figure 18: East-West Line 2: Clay Layer vs Geoelectrical Data compares the depth of clay layer to the depth of the chargeability and resistivity pockets. The clay layer ranges between 120 to 170 meters. The potential contaminant sections in question can be seen at a depth of 150 to 180 meters. In comparison of the location of the transect to the estimated clay layer, there is a potential for clay to be the cause of the clusters.

Figure 19: East-West Line 2: Potential Contaminant Delineations highlights the sections in question.

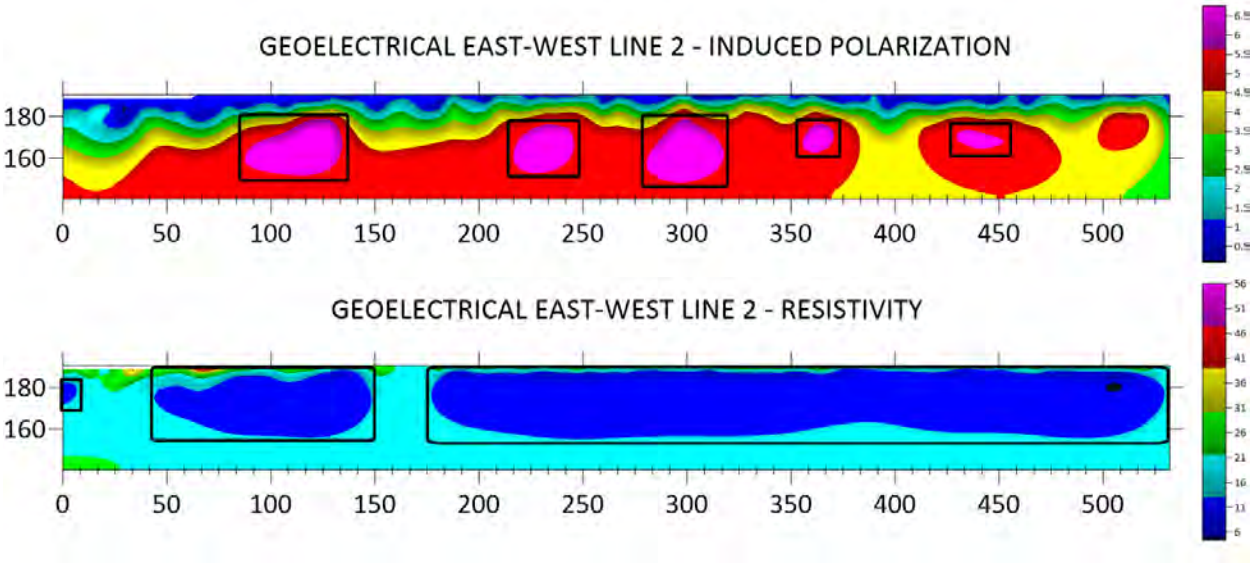

Figure 19: East-West Line 2: Potential Contaminant Delineations

5.0 Conclusion

Results found from the contour mapping display a general easternly and south-easterly slope from several of the material layers, indicating a natural groundwater runoff course towards FWFN land.

Air quality data gathered showed that, for this transect, this level is not of concern unless further testing and comparison is completed.

The geoelectrical tomographs illustrate sections that could be either clay or the contamination plume. Referencing the geoelectrical data to the clay contour maps, the location of the clay potentially shows that the pockets displayed on the tomographs are clay and not contamination. Further testing would be required to consolidate the boundary of the contamination plume and its migration.

6.0 Recommendations

It is recommended to collect water quality analysis samples along East-West Line 2 to support contamination claims against the decommissioned landfill. Benzene should be focused on as there is a direct link between benzene contamination and leukemia cases (Snyder, 2012), allowing a connection to be formed between the Site and the leukemia clusters within the FWFN community.

It is recommended that GPR data that is available to be processed to cross reference with the other geophysical data. This will allow further insight into the pockets of potential contamination seen in the geoelectrical tomographs.

Further fieldwork and data sampling will need to be performed, therefore remediation and land use cannot be discussed in this report prior to further investigation.

7.0 Declaration of Authorship

I, Laura Meneghetti, certify that this report being submitted for evaluation belongs to me and is written in my own words. Any writings, equations, figures, or ideas that belong to other authors and professionals are acknowledged throughout the report, and a bibliography is included.

Laura Meneghetti
Civil Engineering Technology Student
N01459400@humber.ca

8.0 Glossary

FWFN	Fort William First Nation
GPR	Ground Penetrating Radar
VOCs	Volatile Organic Compounds
LCS	Leachate Collection Systems
ECA	Environmental Compliance Approval

9.0 Bibliography

Oshki Aki LP (2018). *2017 Water Quality Assessment, Mount McKay Waste Disposal Site*.

Government of Canada (2022, May 26). *Greenhouse Gas Concentrations*. Canada.ca. Retrieved April 2, 2023, from https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/greenhouse-gas-concentrations.html.

Snyder, R. (2012). Leukemia and Benzene. *International Journal of Environmental Research and Public Health*. https://doi.org/10.3390/ijerph9082875.