2021 Groundwater and Soil Vapour Monitoring Report
Riverside Heavy Dry Waste Site
NE and SE of Section 33-038-27 W4M

PRESENTED TO
City of Red Deer

JUNE 14, 2022
ISSUED FOR USE
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EXECUTIVE SUMMARY

The City of Red Deer (The City) retained Tetra Tech Canada Inc. (Tetra Tech) to conduct the 2021 groundwater and vapour monitoring program at the former landfill located beneath the Riverside Heavy Dry Waste Site (Riverside Heavy site), located at 4240 Northland Drive within the NE and SE portions of Section 33-038-27 W4M, Red Deer, Alberta, hereafter referred to as the site. The objective of the monitoring program is to identify potential environmental concerns related to former operations at the site.

Tetra Tech's scope of work for the 2021 monitoring and sampling program at the Riverside Heavy site included conducting quarterly events of groundwater and vapour monitoring, reviewing and updating previous recommendations for the site, and preparing an annual report.

The groundwater monitoring network at the site consists of three monitoring wells (MW-01 to MW-03). MW-01 and MW-03 are screened within the native sand and clay and MW-02 is screened within siltstone bedrock. The vapour monitoring network consists of one vapour monitoring well (VW-01) located at the west side of the site near the top of the hill between the site and adjacent commercial-industrial developments.

The results of the 2021 monitoring program are consistent with the results of the previous groundwater monitoring programs at the Riverside Heavy site in 2013 and 2019. Key findings of the 2021 monitoring program include the following:

- During the four monitoring events in 2021, methane headspace concentrations at the groundwater monitoring wells (including along the east site perimeter) were relatively low, ranging from less than the instrument detection limit at MW-02 in July to 190 parts per million (ppm) at MW-03 in July. Concentrations of methane at the vapour well were less than the instrument detection limit during most monitoring events in 2021, with the exception of April 2021 where a concentration of 0.1% (1,000 ppm) methane was measured. The methane concentrations measured in the monitoring wells headspace in 2021 are not interpreted to be of concern.
- The groundwater elevations in 2021 indicated that the inferred groundwater flow direction was to the northeast. The average horizontal hydraulic gradient at the site is 0.07 m/m. This is consistent with observations made historically.

In the 2019 groundwater and soil vapour monitoring report, Tetra Tech recommended monitoring the headspace pressures of the ground water monitoring wells. However, during project planning it was determined that measuring the headspace pressure of the groundwater monitoring wells would not provide additional insight to site impacts as historically the screens of all three wells have been partially or fully submerged and would not provide accurate pressure measurements.

The prior monitoring programs identified indications of residual impacts related to the former landfill operations at several groundwater monitoring well locations. The 2019 groundwater monitoring program identified that some leachate indicator parameter concentrations were elevated in the groundwater at the cross-gradient and down-gradient monitoring well locations; however, based on the 2021 monitoring program, the groundwater flow direction is well defined and inferred risks to receptors are limited. Therefore, continuing the groundwater monitoring program is not warranted.

Based on the 2019 results of the soil vapour samples, there was little indication that the soil vapour pathway will pose a hazard to receptors. The 2021 monitoring of subsurface methane concentrations along the eastern portion of the site confirmed that vapour migration is not identified as a significant concern.

Based upon the results of the 2021 groundwater monitoring program, Tetra Tech provides the following recommendations:

- Continuation of a groundwater or vapour monitoring program is not warranted; however, the vapour and groundwater monitoring wells should be maintained for potential future assessments. It is recommended to conduct an annual site check to verify the integrity of the landfill cover, drainage, and the integrity of the monitoring wells.
- Utilize the revised generic mitigative measures (attached in Appendix B) when evaluating applications for development within the setback.
- Ensure that the site is clearly identified within The City's Land Use Bylaw and appropriate administrative requirements are met for the site in accordance with City policies.

Further to the above recommendations, the site remains an historical landfill. It presently appears to be well maintained and capped. The City should review this status on an ongoing basis to ensure that the cover remains intact and drainage remains positive; repairs or maintenance should be undertaken as required to maintain the site.

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LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of The City of Red Deer and their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than The City of Red Deer, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on the Use of this Document attached in the Appendix or Contractual Terms and Conditions executed by both parties.

1.0 INTRODUCTION

The City of Red Deer (The City) retained Tetra Tech Canada Inc. (Tetra Tech) to conduct the 2021 groundwater and soil vapour monitoring program at the former landfill located beneath the Riverside Heavy Dry Waste Site (Riverside Heavy site), located at 4240 Northland Drive within the NE and SE portions of Section 33-038-27 W4M, hereafter referred to as the site.

The scope for 2021 was based on Tetra Tech's 2019 groundwater and soil vapour monitoring and sampling program conducted at the site. Those results were presented and discussed in the 2019 Groundwater and Soil Vapour Monitoring Report – Riverside Heavy Dry Waste Site (Tetra Tech 2020), and key findings and recommendations of that program are summarized in Section 1.1. The objectives and scope for the 2021 monitoring program are presented in Section 1.2.

The field components of the monitoring program were completed under Tetra Tech's detailed work plans encompassing the scope of work outlined in Section 1.2 below. The current report was completed under Tetra Tech's Limitations on the Use of this Document for conducting environmental work. A copy of these conditions is provided in Appendix A.

1.1 2019 Program – Key Findings and Recommendations

The scope of work for the 2019 monitoring program was based on the proposal submitted by Tetra Tech on January 11, 2019 to The City to conduct environmental monitoring services for the pre-1972 landfill sites. The objectives of the overall project were to:

- Confirm and implement the prior recommendations from the risk management plans (RMPs);
- Consult with the regulator on amendments to the program, as required;
- Conduct environmental monitoring and sampling for each of the eight sites, as outlined in the RMP recommendations, while incorporating any approved recommendations;
- Update the hazard quotients for each site; and
- Prepare an environmental monitoring report for each site.

The 2019 program at the Riverside Heavy site included monitoring and sampling of groundwater and soil vapours from existing wells. The program identified that there are indications of residual impacts related to the former landfill operations at several monitoring well locations. The groundwater monitoring program identified that some leachate indicator parameter concentrations were elevated in the groundwater at the cross-gradient and down-gradient monitoring well locations; however, the groundwater flow direction was well defined and inferred risks to receptors were limited. Therefore, continuing the groundwater monitoring and sampling program was not warranted. However, the report identified that buried landfill waste remains beneath the site; therefore, ongoing risk management is required. Key findings included:

- The groundwater elevations in 2019 indicated that the inferred groundwater flow direction was to the northeast under an average horizontal hydraulic gradient of 0.08 m/m.
- Groundwater parameters that exceeded the Tier 1 Guidelines at one or more monitoring wells in 2019 included total dissolved solids (TDS), sodium, chloride, sulphate, and dissolved metals including aluminum, arsenic, barium, iron, manganese, and uranium. The measured concentrations of these parameters were generally

consistent with previous results. Several parameters were interpreted to reflect natural groundwater quality; however, some leachate impact was evident at MW-02 (northeast) and MW-03 (east).

- Concentrations of benzene, toluene, ethylbenzene, xylenes (BTEX), petroleum hydrocarbon (PHC) fractions F1 to F2, adsorbable organic halides (AOX), volatile fatty/carboxylic acids, and volatile organic compounds (VOCs) in 2019 were less than the analytical detection limits at all groundwater monitoring wells with the exception of PHC fraction F2 at MW-03, which was equal to the analytical detection limit (0.10 mg/L), but considerably less than the Tier 1 Guideline (1.1 mg/L).
- Concentrations of BTEX, hydrocarbons, and VOCs in soil vapour samples collected (VW-01 and duplicate) were less than the soil vapour screening criteria.
- Siloxanes were not detected in the soil vapour samples collected.
- The estimated individual and cumulative risks and hazards associated with the soil vapour samples collected in December 2019 did not exceed the corresponding target risk and hazard levels.

Based on these findings, recommendations for the 2021 monitoring program included the following:

- Conduct one additional year of quarterly monitoring at the site, including measuring headspace methane concentrations, headspace pressures, and water levels at all groundwater and soil vapour probes, to confirm methane is not present at significant concentrations, in particular along the eastern portion of the site.
- If preliminary monitoring results indicate either that the eastern groundwater wells are blinded (i.e., the well screen is completely submerged) or identify elevated methane, soil vapour-specific monitoring probes would be recommended for this portion of the site. If concerns with methane are not identified, then the program would be recommended to be stopped.

1.2 Scope of Work

The 2021 monitoring program scope of work included the following activities:

- Conducting quarterly events of groundwater and soil vapour monitoring, including, measuring headspace vapours[1] and groundwater levels within each monitoring well and observing monitoring well integrity.
- Conducting monitoring well repairs, as required.
- Preparing an annual report summarizing the field activities undertaken for the year and interpreting the groundwater and soil vapour monitoring results.

In the 2019 groundwater and soil vapour monitoring report, Tetra Tech recommended monitoring the groundwater monitoring well headspaces for methane as a useful screening tool in the absence of soil vapour wells in other areas of the site. Subsequently, in 2021, headspace monitoring was conducted to measure methane concentrations and not VOCs and combustible vapour concentrations (CVCs), which were measured in 2019.

[1] During project planning it was determined that measuring the headspace pressure of the groundwater monitoring wells would not provide additional insight to site impacts as historically the screens of all three wells have been partially or fully submerged and would not provide accurate pressure measurements.

2.0 BACKGROUND INFORMATION

2.1 General Information

The site is located within the NE and SE portions of Section 33-038-27 W4M, at 4240 Northland Drive in Red Deer, Alberta. A general site location plan is shown on Figure 1. The site is zoned A2 – Environmental Preservation. The site is located on a large hill slope within the Riverside Heavy Industrial Park. Access to the site is from the Red Deer Fire Training Centre located east of site. The north and east boundary of the site is bounded by a Canadian National Railway right-of-way (ROW). South of the site consists of a natural area containing a slough and various shrubs and grasses. The site has mountain bike trails and is vegetated with a variety of natural grasses, shrubs, and trees. A general site plan showing surrounding land use is provided on Figure 2.

Additional information on the site history, historical groundwater monitoring investigations, and site setting can be found in Appendix B.

2.2 Conceptual Site Model Summary

The selection of comparative guidelines is based on the conceptual site model (CSM), which outlines the rationale for the selection of applicable exposure pathways and receptors at the site. This evaluation is based on guidance presented in the Alberta Tier 1 Guidelines (Alberta Environment and Parks [AEP] 2019). The CSM that was developed for the site in the 2019 groundwater and soil vapour monitoring report can be found in Appendix B and includes the following items:

- Description of identified environmental issues including a description of processes or activities undertaken at or near the site and a listing of chemicals of potential concern (COPCs) identified in earlier investigations.
- Description of known and reported historical releases, including locations and status of any subsequent environmental site assessments (ESAs) and remediation.
- Identification of applicable exposure pathways and receptors.

The following table presents a summary of the relevant exposure pathways and receptors identified in the CSM.

Release Mechanism	COPC	Migration/Exposure Pathway	Potential Receptor
Leachate infiltration from buried waste into foundation or through cover	Inorganic parameters and nutrients, metals, PHCs, VOCs, and other indicator parameters (i.e., biochemical oxygen demand [BOD] and chemical oxygen demand [COD]).	Direct soil contact.	Human users of the commercial area; ecological plants and soil invertebrates.
		Groundwater ingestion (drinking water).	Domestic use aquifer (DUA); freshwater aquatic life in a slough (approx. 30 m away) and the Red Deer River.
		Off-site surface migration (wind or water erosion).	Adjacent sites of more sensitive land use.
		Nutrient and energy cycling.	Microbial functioning of the soil.
Landfill gas (LFG) emissions from buried waste	VOCs, methane, BTEX and PHC fractions, and siloxanes.	Vapour inhalation.	Human users of the commercial area.
	Methane	Accumulation to explosive levels in presence of an ignition source.	Enclosed spaces.

As recommended by AEP, the soil vapour results obtained during the 2019 investigation were evaluated using the Canadian Council of Minister of the Environment's (CCME's) document A Protocol for the Derivation of Soil Vapour Quality Guidelines for Protection of Human Exposures Via Inhalation of Vapours (CCME 2014). To determine the appropriate soil vapour guidelines, indoor air risk calculations were undertaken and hazard quotients were calculated. Potential explosive risk was evaluated through relative comparison of the measured concentrations to the lower explosive limit (LEL) for methane (5% gas by volume).

The CSM determined that the most applicable guidelines for groundwater and vapour results for the site were:

- Groundwater concentrations at the site were compared to the Tier 1 Guidelines under commercial/industrial land uses for coarse-grained soils; and
- Soil vapour analytical results were compared to A Protocol for the Derivation of Soil Vapour Quality Guidelines for Protection of Human Exposures Via Inhalation of Vapours under commercial land use for coarse-grained soils.

Cross-sections that were prepared using the wells included in the monitoring program are included in Appendix C (from Tiamat Environmental Consultants Ltd. [Tiamat] 2014a).

2.3 Monitoring Well Network

The groundwater monitoring network at the site consists of three monitoring wells (MW-01 to MW-03). MW-01 and MW-03 are screened within the native sand and clay and MW-02 is screened within siltstone bedrock. All monitoring wells were in good condition in 2021. Monitoring well completion details are summarized in Table 1.

The vapour monitoring network consists of one soil vapour monitoring well (VW-01) located at the west side of the site near the top of the hill. The soil vapour well was in good condition in 2021.

Groundwater and vapour monitoring well locations are shown on Figure 2.

3.0 MONITORING METHODOLOGY

A discussion of the methods used for the groundwater and vapour monitoring fieldwork is presented in the following sections. In 2021, Tetra Tech conducted groundwater and vapour monitoring on April 28, July 12, September 8, and November 23.

3.1 Groundwater Monitoring Wells

Monitoring at the groundwater monitoring wells (51 mm diameter) consisted of measuring methane vapour concentrations in monitoring well headspaces, and static groundwater levels in each monitoring well quarterly (April, July, September, and November).

The methodology for monitoring at the groundwater monitoring wells included the following:

- Observing the integrity of each well and noting drainage and site conditions near the well that may have an effect on monitoring results.
- Measuring the methane headspace concentrations in each well using an RKI Eagle Hydrocarbon Surveyor II (RKI Eagle) calibrated to methane.

- Measuring liquid levels in each monitoring well with an interface probe and recording total depths confirming absence of non-aqueous phase liquids (NAPL) and evaluating the water level relative to the screen to confirm the screen was not blinded.
- Recording of field data on standardized forms as documented in Tetra Tech standard operating practices.

3.2 Soil Vapour Monitoring Wells

Monitoring at the vapour monitoring probe (25 mm diameter) consisted of measuring and recording soil gas pressure, composition (methane, carbon dioxide, oxygen, hydrogen sulphide, and balance) on a percent volumetric basis and groundwater elevation, quarterly (April, July, September, and November).

The soil vapour probe was inspected for visible signs of damage and noting the position of the sampling labcock. Soil gas pressure was recorded using a digital manometer. Once the soil gas pressure measurement was recorded, the soil gas probe was purged of three well volumes, or until readings stabilized. VW-01 is a small diameter soil gas probe (25 mm well), which was purged directly with the GEM LFG analyzer.

After purging, gas composition measurements for methane, carbon dioxide, oxygen, balance gas, and hydrogen sulphide were recorded using the GEM analyzer. Upon recording soil gas concentrations, the probe/well depths and water levels were measured and recorded to confirm the water level within the probe was beneath the screened portion of the soil gas probe (i.e., that the probe was not blinded).

4.0 RESULTS AND DISCUSSION

This section presents the results of the fieldwork conducted in 2021 at Riverside Heavy site and discussions of these results.

4.1 Well Headspace Monitoring

The headspace vapour concentrations for 2021 are presented in Table 1 (groundwater wells) and Table 2 (soil vapour probe). Based on the style of installation, different monitoring methodologies were utilized; however, the instruments utilized were each calibrated to methane. Groundwater methane concentrations were measured using an RKI Eagle, calibrated to methane. The RKI Eagle detection limit ranges from 5 parts per million (ppm) to 100% of the lower explosive limit (LEL). For methane, 500 ppm is equivalent to 1% LEL; 20% LEL is equivalent to 1% Gas.

At the groundwater monitoring wells, the water level was above the top of the monitoring well screen of up-gradient monitoring well MW-01 during all four monitoring events in 2021 and at MW-03 in April 2021, meaning the wells were blinded and headspace vapour measurements are not representative for in-situ soil vapours. The two monitoring wells located down-gradient of the waste footprint were not blinded in 2021 during most monitoring events, with the exception of MW-03 in April. The vapour well (VW-01) was dry during all events in 2021 indicating the well was not blinded with groundwater.

During the four monitoring events in 2021, methane headspace concentrations at the groundwater wells (measured using the RKI Eagle) were relatively low, ranging from less than the instrument detection limit at MW-02 in July to 190 ppm at MW-03 in July. At the vapour well (VW-01), concentrations of methane (measured using the GEM) were less than the instrument detection limit during most monitoring events in 2021, with the exception of April 2021, where a concentration of 0.1% methane was measured. The Guidance Document on Management of Methane Gas Adjacent to Landfills (CH2M Gore & Storrie Limited 1999) recommends for soil vapour adjacent to buildings to not

exceed a methane concentration of 50,000 ppm if the soil gas pressure is less than 0.249 kPa and 5,000 ppm if the soil gas pressure is greater than 5,000 ppm. For the Riverside Heavy site, the methane concentrations at the soil vapour probe and groundwater wells are so low that the soil gas pressures in the groundwater wells is considered irrelevant.

Wellhead pressures at VW-01 were negligible during all monitoring events in 2021. Concentrations of carbon dioxide, oxygen, and balance gas were consistent between the four monitoring events.

4.2 Groundwater Elevations

The measured groundwater levels and calculated groundwater elevations for 2021 are presented in Table 1.

Figure 3 presents the groundwater elevation trends (hydrographs) for the groundwater monitoring wells. These figures show groundwater elevations in 2013, 2019, and 2021. Overall, the groundwater elevations in 2021 were consistent at all monitoring wells with the elevations from 2013 and 2019. Slight seasonal fluctuations were observed in 2021.

In 2021, the average depths to groundwater in the monitoring wells were 4.92 m below grade (mbg) in April, 5.09 mbg in July, 5.09 mbg in September, and 5.35 mbg in November. The contoured elevations for the monitoring wells suggest the groundwater flow was to the northeast in 2021, which is consistent with the historical inferred flow direction. The inferred groundwater flow directions are shown on Figure 4 to Figure 7. The average horizontal gradient in 2021 was 0.07 m/m.

5.0 EVALUATION OF SITE CONDITIONS

5.1 Summary of Site Conditions

A review of the mitigative measures from the 2014 risk management plan (Tiamat 2014b) that was originally completed for the 2019 groundwater and soil vapour monitoring report is included in Appendix B.

As summarized in the 2019 groundwater and soil vapour monitoring report, based on the evaluation of 2019 groundwater quality data and historical groundwater quality data for the site, some leachate impact is evident at MW-02 (northeast) and MW-03 (east) as demonstrated by measured concentrations of typical leachate indicator parameters like ammonia and chloride. However, there is no evidence that there are significant groundwater quality concerns related to the former landfill operations at Riverside Heavy. Groundwater flow conditions at the site in 2021 were consistent with conditions in 2013 and 2019.

Based on the 2019 results of the soil vapour sampling, there was little indication that the soil vapour pathway will pose a hazard to receptors[2]. In 2021, the soil vapour monitoring results at vapour monitoring well VW-01 indicate that concentrations of methane were less than the instrument detection limit during most monitoring events, with the exception of April 2021, where a concentration of 0.1% (1,000 ppm) methane was measured. Methane headspace concentrations at the down-gradient monitoring wells (MW-02 and MW-03) were of a similar order of magnitude in 2021 with the highest concentration measured being 190 ppm at MW-03 in July. Based on the 2021 and prior vapour monitoring results, the measured headspace methane concentrations are not interpreted to be of concern relative to the adjacent commercial buildings.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The results of the 2021 monitoring program are consistent with the results of the previous monitoring programs at the Riverside Heavy site in 2013 and 2019. Key findings of the 2021 monitoring program include the following:

- During the four monitoring events in 2021, methane headspace concentrations at the groundwater monitoring wells (including along the east site perimeter) were relatively low, ranging from less than the instrument detection limit at MW-02 in July to 190 ppm at MW-03 in July. Concentrations of methane at the vapour well were less than the instrument detection limit during most monitoring events in 2021, with the exception of April 2021 where a concentration of 0.1% (1,000 ppm) methane was measured. The methane concentrations measured in the monitoring wells headspace in 2021 are not interpreted to be of concern.
- The groundwater elevations in 2021 indicated that the inferred groundwater flow direction was to the northeast. The average horizontal hydraulic gradient at the site is 0.07 m/m. This is consistent with observations made historically.

In the 2019 groundwater and soil vapour monitoring report, Tetra Tech recommended monitoring the headspace pressures of the groundwater monitoring wells. However, during project planning it was determined that measuring the headspace pressure of the groundwater monitoring wells would not provide additional insight to site impacts as historically the screens of all three wells have been partially or fully submerged and would not provide accurate pressure measurements.

The prior monitoring programs identified indications of residual impacts related to the former landfill operations at several groundwater monitoring well locations. The 2019 groundwater monitoring program identified that some leachate indicator parameter concentrations were elevated in the groundwater at the cross-gradient and down-gradient monitoring well locations; however, based on the 2021 monitoring program, the groundwater flow direction is well defined and inferred risks to receptors are limited. Therefore, continuing the groundwater monitoring program is not warranted.

Based on the 2019 results of the soil vapour samples, there was little indication that the soil vapour pathway will pose a hazard to receptors. The 2021 monitoring of subsurface methane concentrations along the eastern portion of the site confirmed that vapour migration is not identified as a significant concern.

Based upon the results of the 2021 groundwater monitoring program, Tetra Tech provides the following recommendations:

- Continuation of a groundwater or vapour monitoring program is not warranted; however, the vapour and groundwater monitoring wells should be maintained for potential future assessments. It is recommended to conduct an annual site check to verify the integrity of the landfill cover, drainage and the integrity of the monitoring wells.
- Utilize the revised generic mitigative measures (attached in Appendix B) when evaluating applications for development within the setback.
- Ensure that the site is clearly identified within The City's Land Use Bylaw and appropriate administrative requirements are met for the site in accordance with City policies.

Further to the above recommendations, the site remains an historical landfill. It presently appears to be well maintained and capped. The City should review this status on an ongoing basis to ensure that the cover remains intact and drainage remains positive; repairs or maintenance should be undertaken as required to maintain the site.

7.0 CLOSURE

We trust this document meets your present requirements. If you have any questions or comments, please contact Frans Hettinga at our Calgary office.

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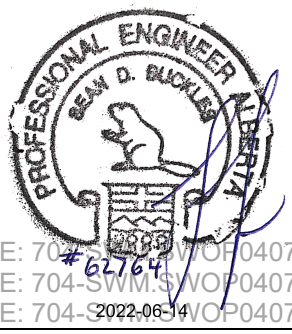

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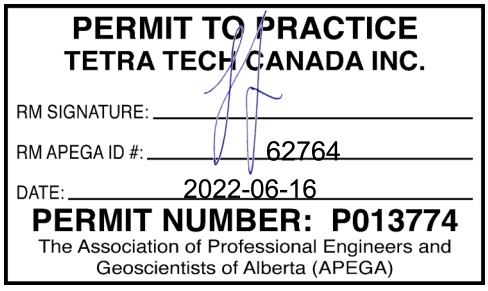

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TABLES

Table 1: Monitoring Results - Groundwater Wells

Monitoring Well		MW-01	MW-02	MW-03
Total Drilled Depth (m)		14.9	6.1	6.1
Top of Screened Interval (mbg)		11.9	3.1	1.5
Bottom of Screened Interval (mbg)		14.9	6.1	6.1
Stick up (m)		0.75	0.74	0.73
Ground Elevation (m)		871.81	848.56	847.73
TPC Elevation (m)		872.56	849.29	848.47
Depth to Groundwater (mBTPC)	Aug-13	9.63	3.99	1.90
	May-19	10.53	4.81	1.96
	Jun-19	10.43	4.44	2.08
	Sep-19	10.49	4.85	2.70
	Dec-19	10.37	4.85	2.43
	Apr-21	10.03	4.81	2.00
	Jul-21	10.12	4.56	2.66
	Sep-21	10.35	4.93	2.86
	Nov-21	10.34	4.96	2.36
Groundwater Elevation (m)	Aug-13	862.93	845.31	846.56
	May-19	862.03	844.48	846.50
	Jun-19	862.13	844.86	846.39
	Sep-19	862.07	844.45	845.77
	Dec-19	862.19	844.45	846.04
	Apr-21	862.39	844.48	846.46
	Jul-21	862.30	844.73	845.81
	Sep-21	862.07	844.37	845.60
	Nov-21	862.08	844.34	846.10
Volatile Organic Compounds* (VOCs) (ppm)	May-19	ND	ND	ND
	Jun-19	ND	ND	ND
	Sep-19	ND	ND	ND
	Dec-19	ND	ND	12
Combustile Vapour Concentrations* (CVCs) (ppm)	May-19	ND	ND	ND
	Jun-19	ND	ND	ND
	Sep-19	ND	ND	65
	Dec-19	5	5	5
Methane Concentrations** (ppm)	Apr-21	10	85	75
	Jul-21	15	0	190
	Sep-21	40	15	65
	Nov-21	130	120	50

Notes:
mbg - Metres below grade.
mBTPC - Metres below top of plastic pipe casing.
ppm - Parts per million
*- Measured using an RKI Eagle II calibrated to hexane (CVCs) and isobutylene (VOCs) and operated in methane elimination mode.
**- Measured using an RKI Eagle II calibrated to methane.
ND- non-detect

Table 2: Monitoring Results - Soil Vapour Well

Parameter	Gas Well								
	VW-01								
	Aug-13	May-19	Jun-19	Sep-19	Dec-19	Apr-21	Jul-21	Sep-21	Nov-21
Pressure (kPa)[1]		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CH_4 (%)	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
CO (ppm)[2]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO_2 (%)	7.0	6.7	6.5	7.0	9.3	7.3	9.2	11.4	11.4
O_2 (%)	14.2	11.9	12.3	12.9	11.1	11.8	10.4	8.6	10.1
Balance (% v/v)	78.8	81.5	81.2	80.1	79.4	80.8	80.4	80.0	78.6
Static Water Level (mbtoc)[3]		Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
Depth to Bottom (m)	7.30	4.60	4.59	4.58	4.71	4.66	4.66	4.46	4.58
Stick up (m)		0.70	0.70	0.79	0.87	0.82	0.84	0.83	0.81

Notes:

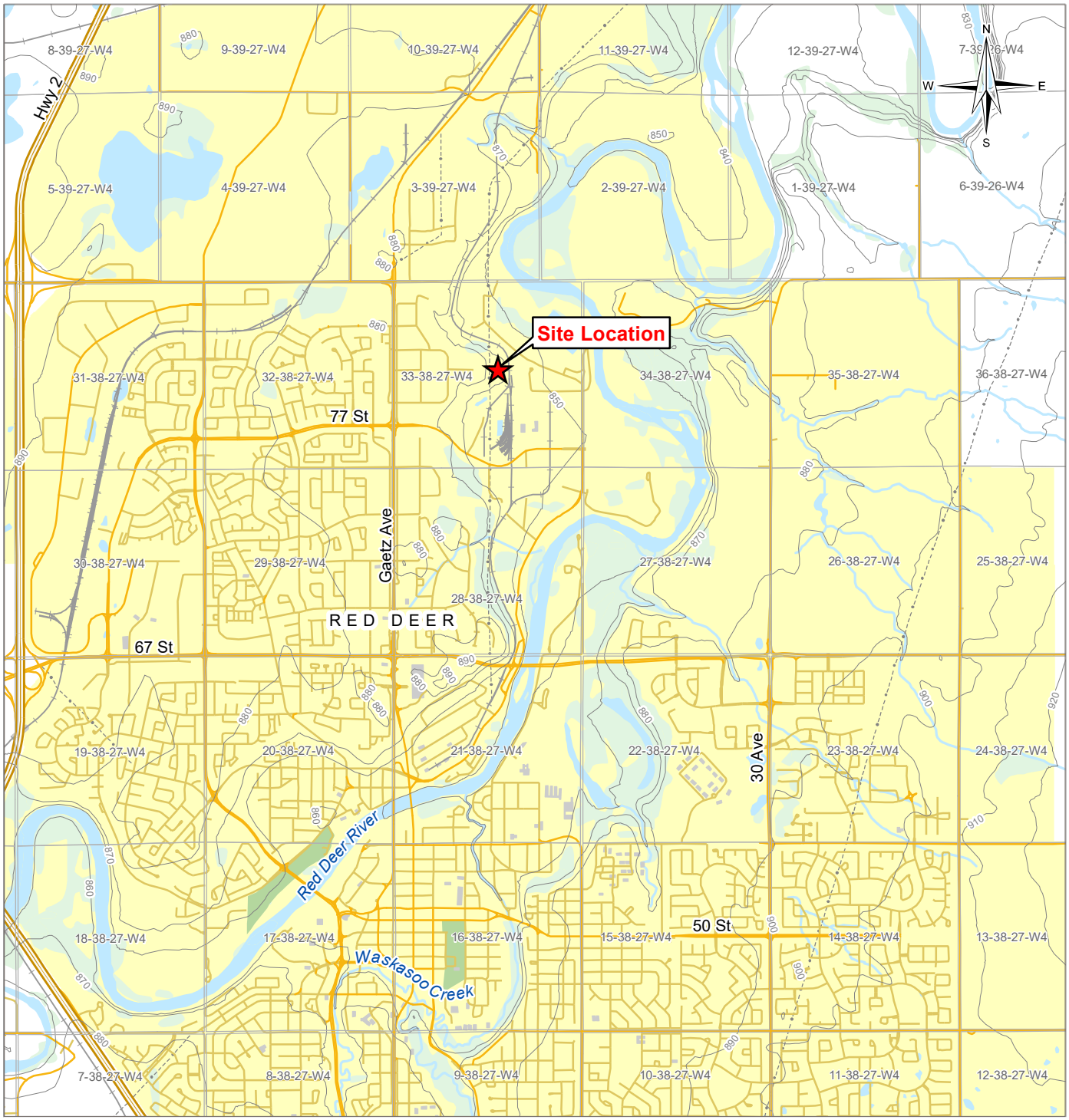
[1] Kpa - Kilopascal.

[2] ppm - Parts per million.

[3] mbtoc - Meters below top of casing.

N/A - Not applicable - well can not be accessed to obtain measurement.

FIGURES



LEGEND

- Site Location
- Highway
- Main Road
- Local Road
- Resource/Recreational Road
- Railway
- Power Line
- Building
- Park
- Residential Area
- Contour (10 m)
- Watercourse
- Waterbody
- Wooded Area
- Urban Area

NOTES
Base data source: CanVec 1:50,000.

STATUS
ISSUED FOR USE

2021 GROUNDWATER AND SOIL VAPOUR MONITORING REPORT RIVERSIDE HEAVY DRY WASTE

Site Location Plan

PROJECTION	DATUM	CLIENT
3TM 114	NAD83	The City of Red Deer

Scale: 1:50,000
1 0.5 0 1
Kilometres

FILE NO.
SWOP04071-02_Figure1_SiteLocation.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-EDM	SL	MRV	RM	0

DATE	PROJECT NO.
June 14, 2022	SWM.SWOP04071-02.006

TETRA TECH

Figure 1

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Q:\Edmonton\GIS\SOLID_WASTE\SWOP\SWOP04071-02\Maps\Task006\SWOP04071-02_Figure2_LandUse.mxd modified 2022-06-14 by stephanie.leusink

LEGEND

- Monitoring Well
- Vapour Well
- Historic Waste Disposal (Provided by Tiamat,
- Municipal Sanitary Waste Area (Provided by Tiamat, 2014)
- Site Boundary
- Lot Boundary

Utilities

- Electrical
- Sanitary
- Storm
- Water

NOTES

Base data source: Imagery provided by ESRI; City of Red Deer (2020)
Roads from City of Red Deer Open Data, 2018
Utilities provided by City of Red Deer. Locations have not been field verified, and should not be used for construction or other intrusive field activities.

STATUS
ISSUED FOR USE

Scale: 1:3,500

80 40 0 80

Metres

PROJECTION	DATUM
3TM 114	NAD83

FILE NO.
SWOP04071-02_Figure2_LandUse.mxd

CLIENT
The City of Red Deer

TETRA TECH

2021 GROUNDWATER AND SOIL VAPOUR MONITORING REPORT RIVERSIDE HEAVY DRY WASTE

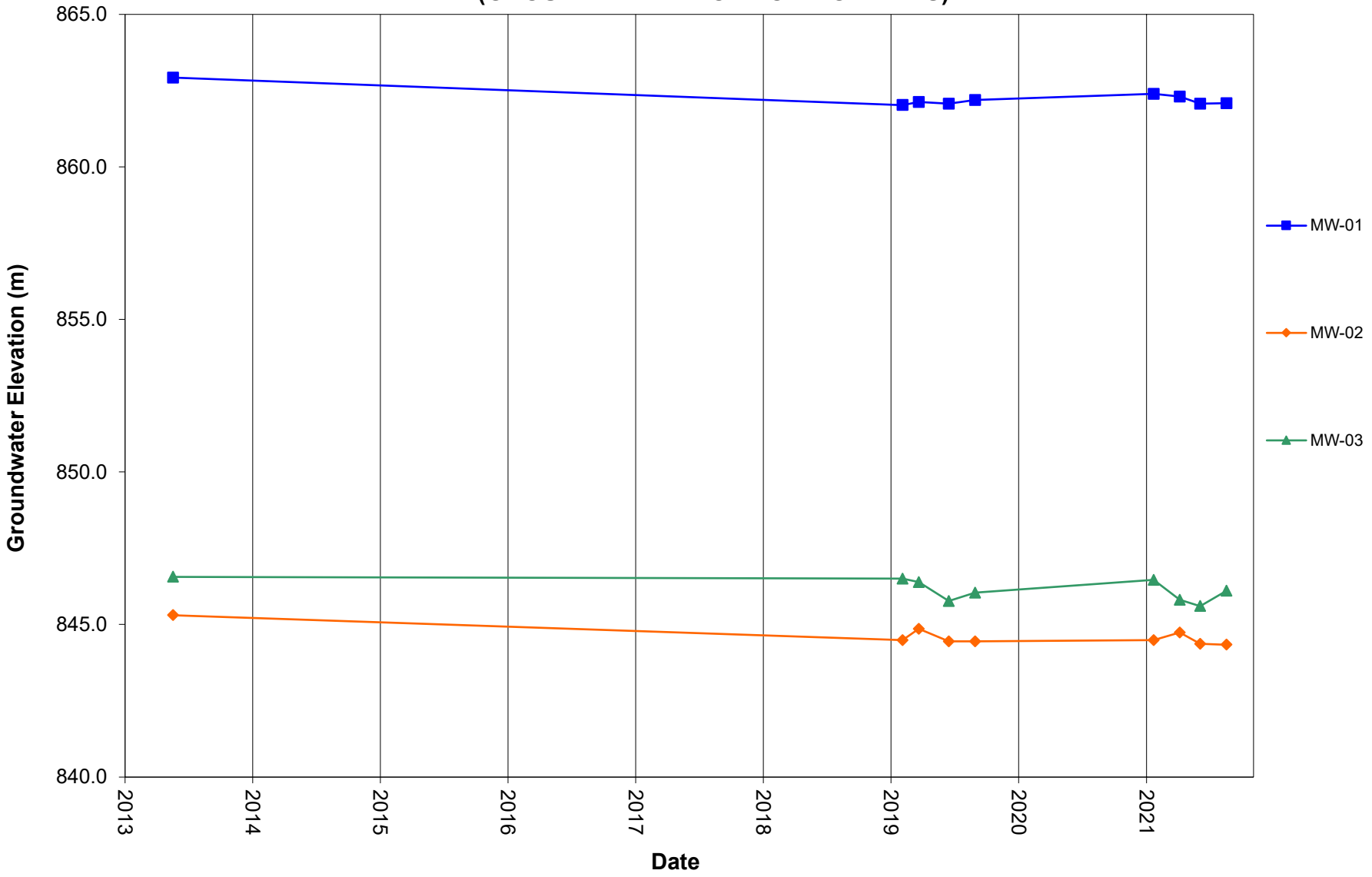
Site Plan and Surrounding Land Use

OFFICE	DWN	CKD	APVD	REV
Tt-EDM	SL	MRV	RM	0

DATE	PROJECT NO.
June 14, 2022	SWM.SWOP04071-02.006

Figure 2

FIGURE 3
HISTORICAL GROUNDWATER ELEVATIONS
(GROUNDWATER MONITORING WELLS)



TETRA TECH

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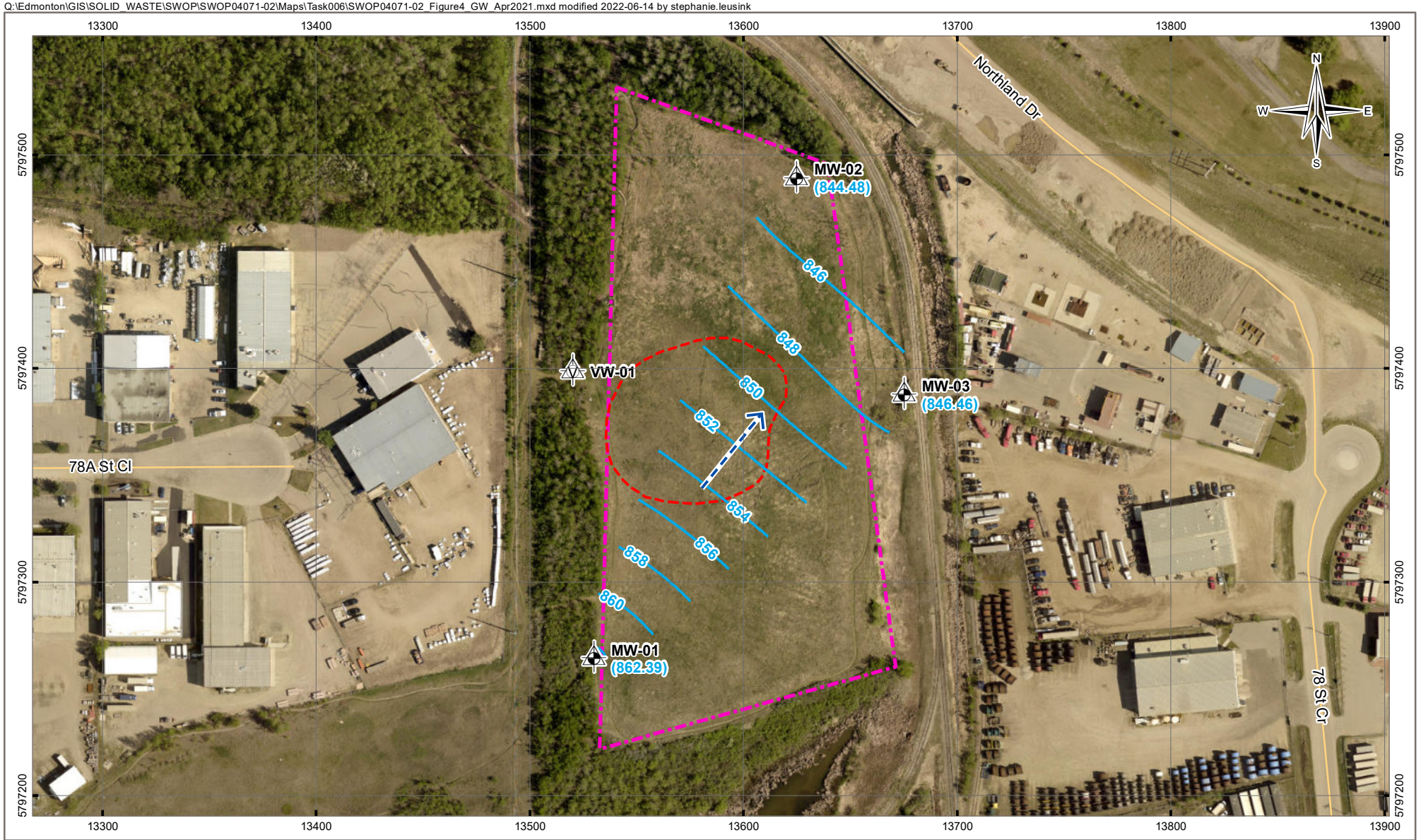


LEGEND

- Monitoring Well
- Vapour Well
- Inferred Groundwater Flow Direction
- Groundwater Elevation Contour (2 masl)
- (8XX.XX) Groundwater Elevation (masl)
- Historic Waste Disposal (Provided by Tiamat, 2014)
- Municipal Sanitary Waste Area (Provided by Tiamat, 2014)
- Road

NOTES
Base data source: Imagery provided by ESRI; City of Red Deer (2020)
Roads from City of Red Deer Open Data, 2018
masl - metres above sea level

STATUS
ISSUED FOR USE

Scale: 1:2,500
50 25 0 50
Metres

PROJECTION	DATUM
3TM 114	NAD83

FILE NO.
SWOP04071-02_Figure4_GW_Apr2021.mxd

CLIENT
The City of Red Deer

TETRA TECH

2021 GROUNDWATER AND SOIL VAPOUR MONITORING REPORT RIVERSIDE HEAVY DRY WASTE

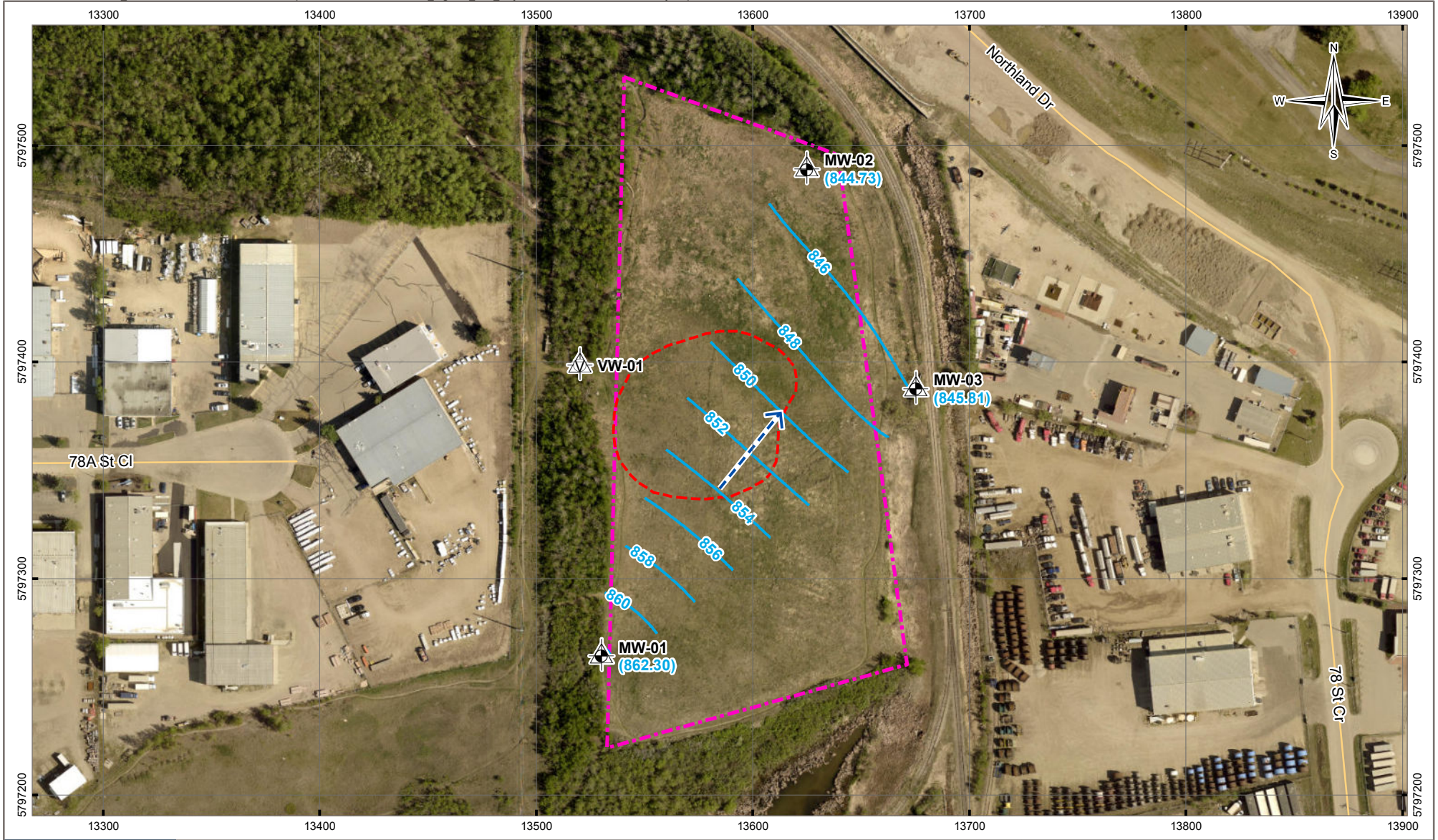
Groundwater Elevation Contours April 2021

OFFICE	DWN	CKD	APVD	REV
Tt-EDM	SL	MRV	RM	0

DATE	PROJECT NO.
June 14, 2022	SWM.SWOP04071-02.006

Figure 4

Q:\Edmonton\GIS\SOLID_WASTE\SWOP\SWOP04071-02\Maps\Task006\SWOP04071-02_Figure5_GW_July2021.mxd modified 6/14/2022 by stephanie.leusink



LEGEND

- Monitoring Well
- Vapour Well
- Inferred Groundwater Flow Direction
- Groundwater Elevation Contour (2 masl)
- (8XX.XX) Groundwater Elevation (masl)
- Historic Waste Disposal (Provided by Tiamat, 2014)
- Municipal Sanitary Waste Area (Provided by Tiamat, 2014)
- Road

NOTES
Base data source: Imagery provided by ESRI; City of Red Deer (2020)
Roads from City of Red Deer Open Data, 2018
masl - metres above sea level

STATUS
ISSUED FOR USE

Scale: 1:2,500
50 25 0 50
Metres

PROJECTION	DATUM
3TM 114	NAD83

FILE NO. SWOP04071-02_Figure5_GW_July2021.mxd

CLIENT The City of Red Deer

TETRA TECH

2021 GROUNDWATER AND SOIL VAPOUR MONITORING REPORT RIVERSIDE HEAVY DRY WASTE

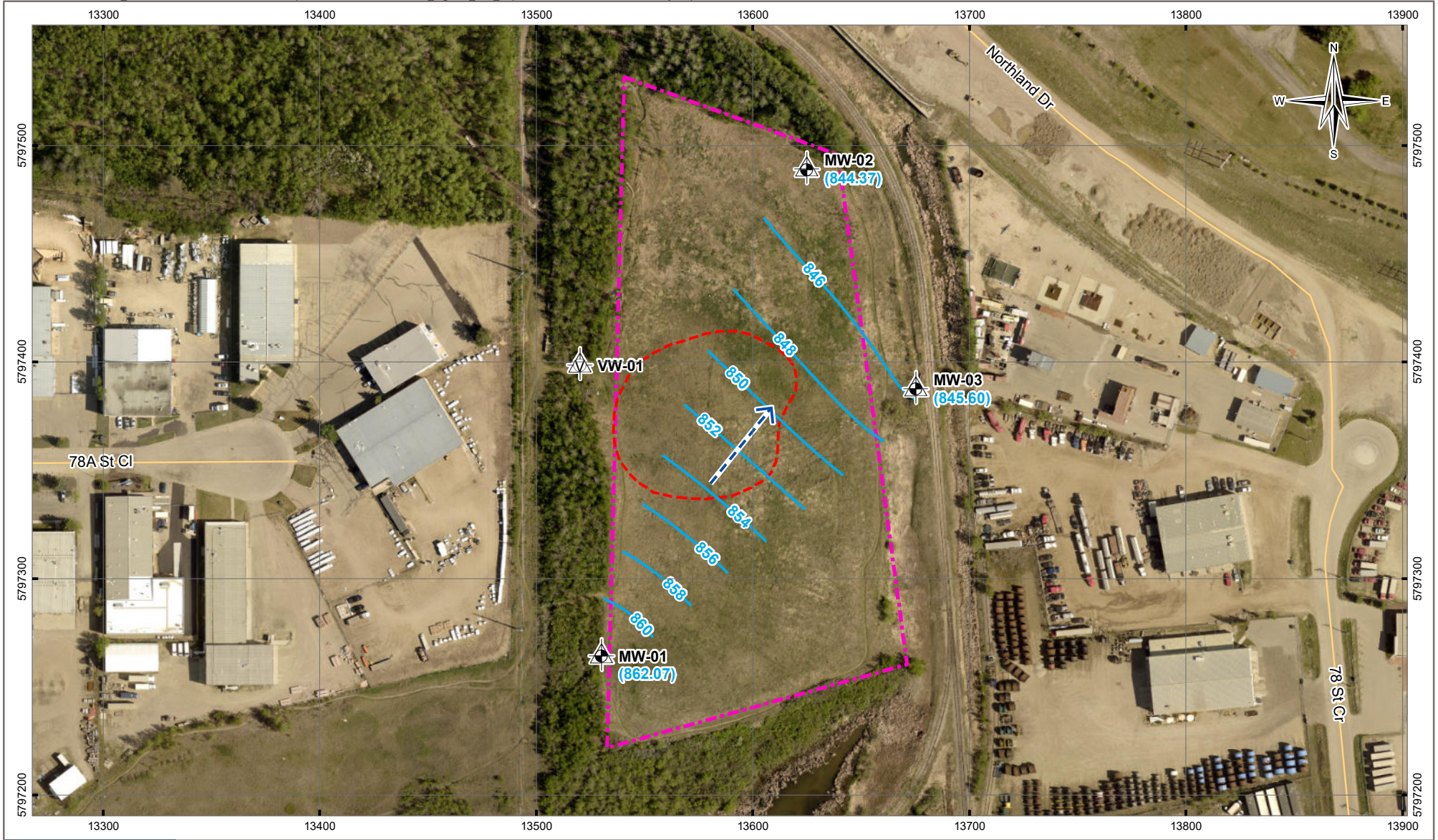
Groundwater Elevation Contours July 2021

OFFICE	DWN	CKD	APVD	REV
Tt-EDM	SL	MRV	RM	0

DATE	PROJECT NO.
June 14, 2022	SWM.SWOP04071-02.006

Figure 5

Q:\Edmonton\GIS\SOLID_WASTE\SWOP\SWOP04071-02\Maps\Task006\SWOP04071-02_Figure6_GW_Sept2021.mxd modified 6/14/2022 by stephanie.leusink



LEGEND

- Monitoring Well
- Vapour Well
- Inferred Groundwater Flow Direction
- Groundwater Elevation Contour (2 masl)
- (8XX.XX) Groundwater Elevation (masl)
- Historic Waste Disposal (Provided by Tiamat, 2014)
- Municipal Sanitary Waste Area (Provided by Tiamat, 2014)
- Road

NOTES
Base data source: Imagery provided by ESRI; City of Red Deer (2020)
Roads from City of Red Deer Open Data, 2018
masl - metres above sea level

STATUS
ISSUED FOR USE

Scale: 1:2,500
50 25 0 50
Metres

PROJECTION	DATUM
3TM 114	NAD83

FILE NO.
SWOP04071-02_Figure6_GW_Sept2021.mxd

CLIENT
The City of Red Deer

TETRA TECH

2021 GROUNDWATER AND SOIL VAPOUR MONITORING REPORT RIVERSIDE HEAVY DRY WASTE

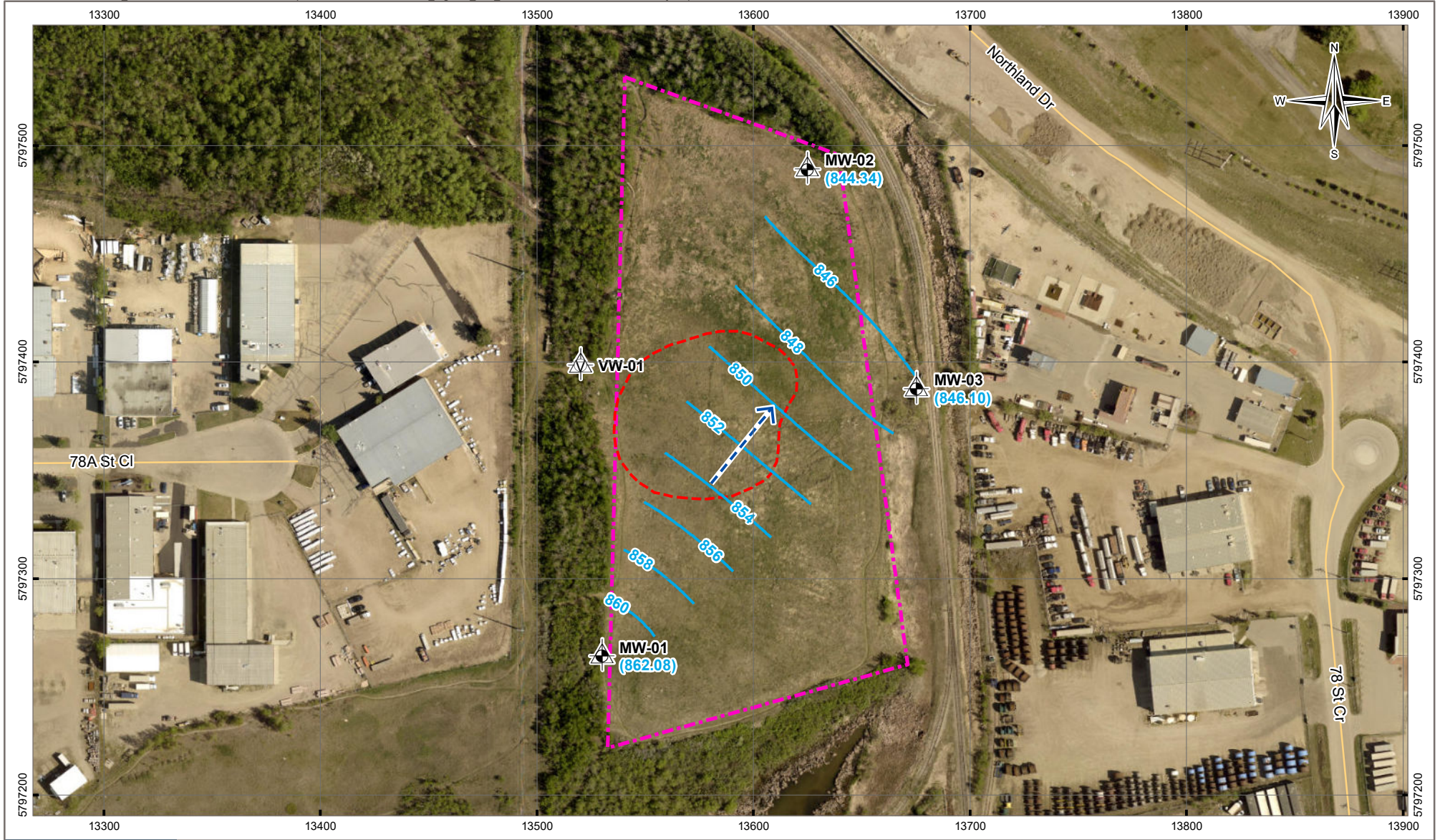
Groundwater Elevation Contours September 2021

OFFICE	DWN	CKD	APVD	REV
Tt-EDM	SL	MRV	RM	0

DATE	PROJECT NO.
June 14, 2022	SWM.SWOP04071-02.006

Figure 6

Q:\Edmonton\GIS\SOLID_WASTE\SWOP\SWOP04071-02\Maps\Task006\SWOP04071-02_Figure7_GW_Nov2021.mxd modified 6/14/2022 by stephanie.leusink



LEGEND

- Monitoring Well
- Vapour Well
- Inferred Groundwater Flow Direction
- Groundwater Elevation Contour (2 masl)
- (8XX.XX) Groundwater Elevation (masl)
- Historic Waste Disposal (Provided by Tiamat, 2014)
- Municipal Sanitary Waste Area (Provided by Tiamat, 2014)
- Road

NOTES
Base data source: Imagery provided by ESRI; City of Red Deer (2020)
Roads from City of Red Deer Open Data, 2018
masl - metres above sea level

STATUS
ISSUED FOR USE

Scale: 1:2,500
50 25 0 50
Metres

PROJECTION	DATUM
3TM 114	NAD83

FILE NO. SWOP04071-02_Figure7_GW_Nov2021.mxd

CLIENT The City of Red Deer

TETRA TECH

2021 GROUNDWATER AND SOIL VAPOUR MONITORING REPORT RIVERSIDE HEAVY DRY WASTE

Groundwater Elevation Contours November 2021

OFFICE	DWN	CKD	APVD	REV
Tt-EDM	SL	MRV	RM	0

DATE June 14, 2022

PROJECT NO. SWM.SWOP04071-02.006

Figure 7

APPENDIX A

TETRA TECH'S LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

GEOENVIRONMENTAL

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

The Professional Document is intended for the sole use of TETRA TECH's Client (the "Client") as specifically identified in the TETRA TECH Services Agreement or other Contractual Agreement entered into with the Client (either of which is termed the "Contract" herein). TETRA TECH does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the Client, unless authorized in writing by TETRA TECH.

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The Professional Document is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of TETRA TECH. Additional copies of the Document, if required, may be obtained upon request.

1.2 ALTERNATIVE DOCUMENT FORMAT

Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Both electronic file and/or hard copy versions of TETRA TECH's Instruments of Professional Service shall not, under any circumstances, be altered by any party except TETRA TECH. TETRA TECH's Instruments of Professional Service will be used only and exactly as submitted by TETRA TECH.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of TETRA TECH.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by third parties other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 NOTIFICATION OF AUTHORITIES

In certain instances, the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the client agrees that notification to such bodies or persons as required may be done by TETRA TECH in its reasonably exercised discretion.

APPENDIX B

SITE HISTORY, HISTORICAL INFORMATION, AND SITE SETTING

1.0 SITE HISTORY

Municipal records indicate that waste disposal at the site occurred between 1991 and 2007 (approximately 16 years). This would indicate that the estimated age of the waste material would be approximately 13 to 29 years old. The findings from the Phase II environmental site assessment (ESA) completed in 2014[1] confirmed that the waste material at the site consisted of construction material (wires, plastics, brick, asphalt, concrete, glass, and wood) and municipal solid waste (MSW). The former landfill is closed and inactive.

Historical waste disposal was identified during the Phase II ESA to be situated beneath the east facing slope of the hill. The waste disposal of asphalt and concrete was used for slope stabilization. The western portion of the site is approximately 30 m higher than the eastern portion.

Results of the Phase II ESA conducted by Tiamat Environmental Consultants Ltd. (Tiamat) indicate that surface material of sod and loam was overlying the buried waste material. The sod and loam varied between 15 cm and 45 cm in depth. The MSW contained fill soil consisting of sand, silt, and clay, located below the sod to a depth of approximately 7.6 m below grade (mbg). Native clay was encountered underlying the MSW in the south and clay fill was underneath in the north, east, and west. Siltstone bedrock was encountered at MW-02 in the north.

The Phase II ESA suggested mild strength constituents from leachate are present in the groundwater. Initial assessments of landfill gas (LFG) showed the concentrations of soil gas constituents to be low with no notable concern for the environmental quality of the subsurface soil vapour.

2.0 HISTORICAL GROUNDWATER MONITORING AND INVESTIGATION SUMMARY

Previous reports prepared by Tiamat for the site include the following:

- Phase I Environmental Site Assessment, Historic Waste Disposal Site, Riverside Heavy Dry Waste Site, The City of Red Deer. September 24, 2013[2].
- Phase II Environmental Site Assessment, Historic Waste Disposal Site, Riverside Heavy Dry Waste Site, The City of Red Deer. February 26, 2014[1].
- Environmental Risk Management Plan, Historic Waste Disposal Sites, Riverside Heavy Dry Waste Site, The City of Red Deer. November 25, 2014[3].

Nine testholes (TH-01 to TH-09) were advanced in July 2013 as part of the Phase II ESA. One vapour well (VW-01) and three monitoring wells (MW-01, MW-02, and MW-03) were installed.

The results of the Phase II ESA conducted by Tiamat in 2014 indicated the following:

- Waste was encountered at several testholes across the site through the fill material.

[1] Tiamat Environmental Consultants Ltd. 2014. Phase II Environmental Site Assessment, Historic Waste Disposal Site, Riverside Heavy Dry Waste, The City of Red Deer. February 26, 2014.
[2] Tiamat Environmental Consultants Ltd. 2013. Phase I Environmental Site Assessment, Historic Waste Disposal Site, Riverside Heavy Dry Waste, The City of Red Deer. September 24, 2013.
[3] Tiamat Environmental Consultants Ltd. 2014. Environmental Risk Management Plan, Historic Waste Disposal Sites, Riverside Heavy Dry Waste, The City of Red Deer. November 24, 2014.

- Groundwater analytical results showed concentrations of routine parameters and metals greater than the referenced Alberta Tier 1 Soil and Groundwater Remediation Guidelines[4].
- Groundwater has been impacted by mild strength leachate constituents.
- Soil vapour analytical results showed trace amounts of volatile organic compounds (VOCs) and siloxanes at VW-01.

The recommendations of the program were as follows, as identified in the Phase II ESA[1]:

- Continue to monitor groundwater elevations and soil vapour data quarterly for one hydrogeological cycle.
- If groundwater conditions on site change, the water quality at the slough should be monitored.
- Collect an additional set of soil vapour and groundwater analytical data, groundwater elevations, and volatile headspace measurements during the winter months to determine seasonal changes in soil vapour concentrations.
- Create a risk management plan (RMP) that outlines the environmental issues of the site and future land use.
- Review any available data to update the RMP.

The recommendations of the RMP completed by Tiamat[3] included the following:

- Information in the preliminary quantitative risk assessment (PQRA) should be updated as new site information is obtained.
- A review of the RMP should be completed when the PQRA information is updated, if there are changes to the chemicals of potential concern (COPCs).
- The RMP should be reviewed and updated at five-year intervals.

3.0 SITE SETTING

The following section presents an overview of the regional and local setting for the site.

3.1 Geology

The following sections summarize the regional and local geology.

3.1.1 Geological Setting and Stratigraphy

The City and site are located within the Red Deer River drainage basin with principal drainage via the Red Deer River located east of the site. The Red Deer River has incised the uplands with gentle slopes to the east and west of the river in the vicinity of the site.

The geology in the river valley is characterized by fluvial surficial sediments deposited by the Red Deer River, overlying shale and sandstone bedrock of the Paskapoo Formation. The uplands at the west of the site comprise

[4] Alberta Environment and Parks. 2019. Alberta Tier 1 Soil and Groundwater Remediation Guidelines. Land Policy Branch, Policy and Planning Division. 198 pp.

undivided ice-contact lacustrine and fluvial deposits, of gravel, sand, silt, clay, and local till. These deposits are described as being up to 25 m thick[5]. The fluvial deposits to the east comprise gravel, sand, with minor silt beds.

Key elements of the geological setting are presented below from Tiamat's 2013 Phase I Report[2]:

"The fertile black soil in the region (Penhold Loam) is of alluvial lacustrine origin. The Penhold Loam is a well-drained fine sandy loam classified as Chernozemic. It is generally stone free and in natural areas, is typically 1.5 m thick, more or less.

The Quaternary deposits consist of drift deposits of clay, silt, gravel and sand. Published information indicates the banks of the Red Deer River comprise of dirty gravel with thickness ranging from 6 to 12 m, more or less.

Terrace gravels hydraulically connected to the Red Deer River are a known resource of groundwater. Surficial soils comprise largely of poorly to moderately sorted sand, silt and gravel with a varying amount of clay. The fluvial sediments generally have obscure bedding planes. Medium to coarse sized gravel with cross-bedded sand have been documented.

The Tertiary bedrock consists of sequences of alternating shales and sandstones of the Paskapoo Formation. The Paskapoo Formation underlies the gravel sediments. This non-marine bedrock is composed of mudstone, siltstone and sandstone. The formation of the Rocky Mountains subjected the Paskapoo Formation to a regional stress-induced fracture pattern."

3.1.2 Local Geology

Based on the Phase II ESA results, Riverside Heavy consisted of fill material up to 7 m, consisting of a mixture of vegetation, clay, sand, and loam, overlying a native clay. Testholes with observed waste encountered debris up to a maximum depth of 10 m in the central portion of the site. Waste material was situated on top of a native clay and sand layer, overlying a siltstone bedrock at the bottom of the slope, located at 4.6 m depth at MW02. Bedrock was not encountered at the testholes on or at the top of the slope.

3.2 Hydrogeology

The following sections summarize the regional and local hydrogeology.

3.2.1 Regional Hydrogeology

The regional hydrogeology is most influenced by the presence of the river sediments situated within the valley along the Red Deer River and a bedrock valley trending north-northeast in the vicinity of the site.

Key elements of the hydrogeological setting are presented below from Tiamat's 2013 Phase I Report[2]:

"A significant buried valley and aquifer resource trending northeastward through the city has been partially mapped and lies in the SE 28-38-27 W4M (Mackenzie Trail and Riverside). This buried valley extends to a depth of 21 m, more or less and may extend to the south into north portions of 21-28-27 W4M." Mapping by the Alberta Geological Survey[6] indicates that the valley is located approximately 1.4 km east of the site; however, the width of the valley is not defined.

[5] Shetsen, I. 1990. Quaternary Geology, Central Alberta. Alberta Research Council.

[6] Andriashek, L. comp. 2018. Thalwegs of Bedrock Valleys, Alberta (GIS data, line features); Alberta Energy Regulator, AER/AGS Digital Data 2018-0001.

"The dominant type of near-surface groundwater in the Paskapoo Formation in the area of assessment is sodium bicarbonate. Notable concentrations of sodium sulphate type groundwater have also been reported. The quality of groundwater for potable use is generally suitable to depths of 300 m on the west side of Red Deer and decreases to 90 m, more or less in the east.

Areas of recharge (downward flow) in unsaturated heterogeneous sediments include most areas above the river and creek valleys, whereas; the river valleys will generally exhibit discharge. The distribution of groundwater in the area can also be influenced by the local geology, topographic relief, areas of artesian flow, springs and reasonable yielding water source wells.

Numerous permanent surface water features within The City of Red Deer and vicinity include Red Deer River, Waskasoo Creek, Gaetz Lakes, Hazlett Lake, Bower Ponds (result of formerly mining gravel resources), various sloughs in the fringe areas of the city and an assortment of other smaller creeks and springs."

The regional groundwater flow is expected to follow the bedrock topography and will be influenced by the varying distribution of sediments in the river valley, which will have been deposited in various historical channels since filled in under varying depositional environments. Further, the river is in hydrologic connection with the adjacent sediments; therefore, seasonal changes in the river stage will affect the local groundwater flow patterns (magnitude and direction). In seasons of higher river flow, bank storage will occur whereas in seasons of lower flow (such as late summer/fall), the storage will be released.

3.2.2 Local Hydrogeology

The site slopes to the east and has greater than 30 m in elevation change from the top to the bottom. A slough exists at the south boundary of the site. The Red Deer River flows northwesterly in the area and is located approximately 700 m east of the site and 600 m north of the site. Shallow groundwater is assumed to flow towards the river.

3.3 Groundwater Resource Usage

A search of the Alberta Water Well Database for groundwater users within a 1 km radius of the site identified 23 groundwater wells, 5 of the wells are listed as domestic use, 1 is listed as domestic and stock use, 10 are listed as industrial use, 2 as "other", and 5 are listed as unknown use[7].

The nearest water well is located approximately 200 m southeast of the site. The well use is listed as "other". The depths of water wells within a 1 km radius of the site range from 9 m to 195 m. The status and use of the surrounding groundwater wells were not confirmed and they were not field verified.

The 2014 RMP presented a proposed site-specific environmental risk management plan as a tool to assist with the review of future subdivision applications on lands lying within the regulated setback distance from the site (300 m). The focus was on potential ingress of soil gas for COPCs with a hazard quotient (HQ) greater than 1.0. Residential land use was considered most sensitive, and exposure ratings for other land uses (e.g. school, public institutions, commercial complexes) were considered to not be greater than residential; however, unique exceptions would have to be reviewed and addressed on a site-specific basis (Tiamat, 2014). Further, underground utility workers and subsurface utility infrastructure were considered relevant to potential exposure.

The RMP applied a 10x factor of safety to the HQs to address uncertainties. HQs from the RMP ranged up to 567 (including the 10x factor of safety). Based on these, the RMP then provided recommended generic mitigative

[7] Alberta Environment and Parks. 2019. Water Well Database. Information obtained http://www.telusgeomatics.com/tgpub/ag_water/.

measures based on the calculated HQs, ranging from passive to active measures, recognizing that the ultimate approach would require a design professional for the proposed development.

Following the 2014 RMP, CCME released the document "*A Protocol for the Derivation of Soil Vapour Quality Guidelines for Protection of Human Exposures Via Inhalation of Vapours"* (CCME 2014), designed to provide guidance for developing site-appropriate soil vapour quality guidelines. The guidelines developed using the methods outlined in the CCME document were used for this current study and are included with the vapour sampling results in Table 4. HQs were calculated using estimated dose (based on concentrations measured at the site) and divided by tolerable daily intake. Soil vapour concentrations from the Phase II ESA conducted in 2013 were not compared to soil vapour quality guidelines, however spot checks of five target compounds with the highest HQs in the 2013 work (benzene, toluene, ethylbenzene, chloromethane, and chloroform) identified that none of the 2013 concentrations would have unacceptable HQs using the updated CCME methodology.

4.0 REVIEW OF MITIGATIVE MEASURES FROM RISK MANAGEMENT PLAN

The following section is a review of the 2014 RMP[3] for the site that was completed by Tiamat. The review of the 2014 RMP was completed for the 2019 groundwater and soil vapour monitoring report[8].

The 2014 RMP was prepared concurrent to RMPs at several other former City landfills, and a common set of mitigative measures was applied based on the HQs. Subsequent to the 2014 RMP and to the release of the CCME Protocol document, The City undertook additional assessment at another former City Landfill[9] (Montfort); as part of that work, their consultant XCG Consulting Limited (XCG) revised the 2014 RMP criteria ranges for each generic mitigative measure category to include a Cancer Risk range to allow comparison of the 2014 RMP ranges with the HQ and Cancer Risks calculated by XCG. From that work, XCG identified the following generic mitigative measures for developments within a 300 m setback of these landfills (based on Tiamat 2014), and these have been adopted for this site:

Passive Measures

1. Passive Measures – Level A: for Cancer Risk of > $1E^{-5}$ and < $5E^{-5}$ and/or HQ >0.2 and <1.

   Compacted clay liner with a minimum thickness of 1m and confirmed maximum hydraulic conductivity of 10^{-6} cm/sec.

2. Passive Measures – Level B: for Cancer Risk of > $5E^{-5}$ and < $5E^{-4}$ and/or HQ >1 and <5.

   Synthetic liner with type of material, thickness and installation details dependent on the design professional.

3. Passive Measures – Level C: for Cancer Risk of > $5E^{-4}$ and < $1E^{-3}$ and/or HQ >5 and <50.

   Passive sub-slab depressurization (SSD) system with a minimum depressurization of 4 Pa to 10 Pa. In some instances (such as a pervious subgrade), the actual depressurization necessary may require an active SSD or alternative active ventilation system.

[8] Tetra Tech Canada Inc. 2020. 2019 Groundwater and Soil Vapour Monitoring Report – Riverside Heavy Dry Waste Site. Prepared for The City of Red Deer. October 2020. Project Number: 704-SWM.SWOP04071-01.007.

[9] XCG Consulting Limited. 2018. Vapour Intrusion Assessment and Environmental Monitoring Report, prepared for the City of Red Deer's Montfort Landfill.

Active Measures

Field verify the presence of the identified chemicals of concern and other potential chemicals in the soil gas state at the development site. If confirmed, determine the most appropriate manner to prevent soil vapour intrusion.

1. Active Measures – Level D: for Cancer Risk of > $1E^{-3}$ and < $2E^{-3}$ and/or HQ values >50 and <100.

   Active SSD must be configured to compensate for depressurization of the building and have adequate negative pressure gradients across the entire footprint of the foundation.

2. Active Measures - Level E: for Cancer Risk of >$2E^{-3}$ and/or HQ values >100.

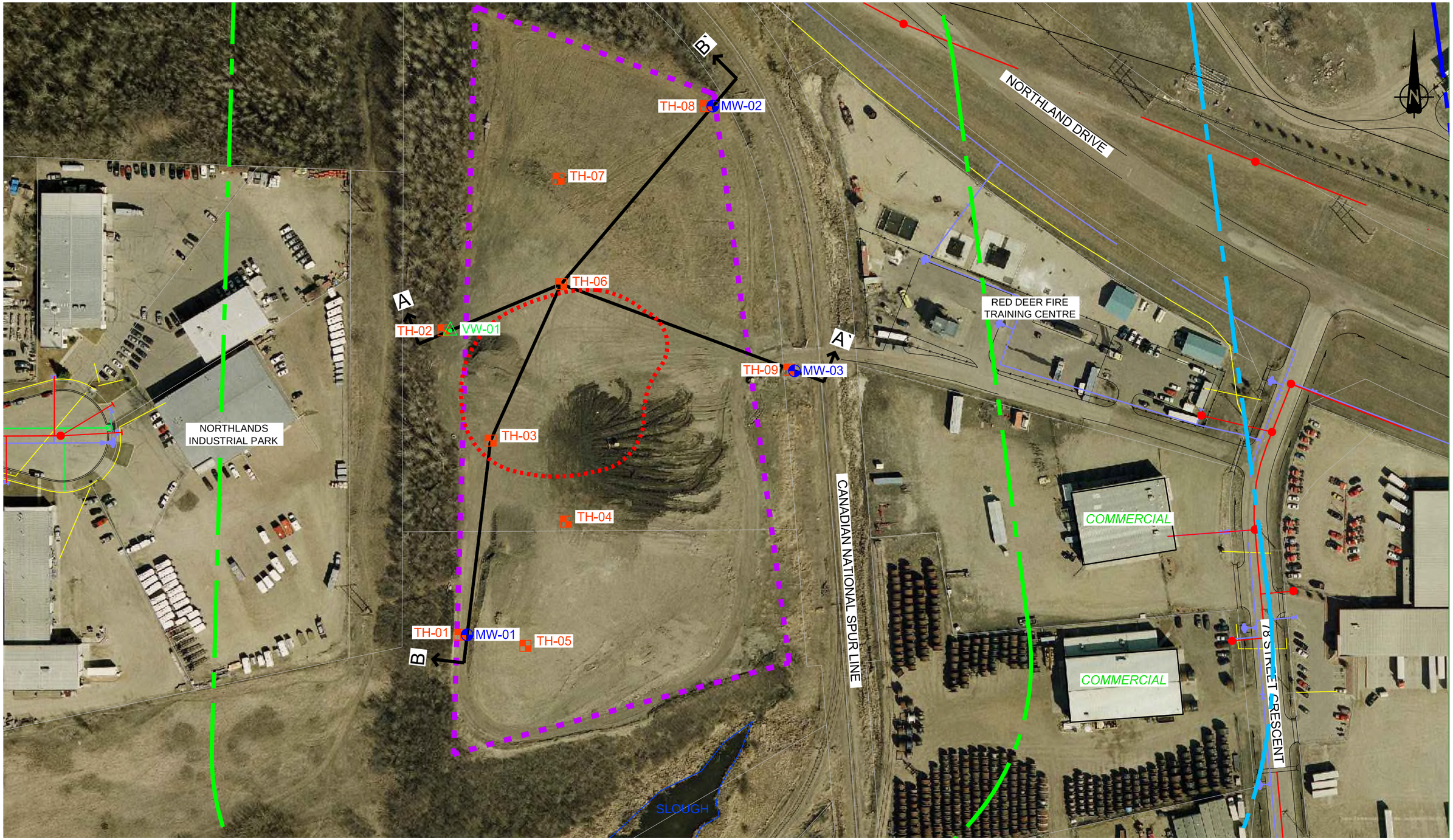
   Installation of geomembrane and active soil vapour extraction with system fault notification alarm.

For consistency with XCG's approach from 2017, we compared individual HQs with the individual target hazard level (0.2). Based on the 2019 program, the greatest individual HQ calculated for the site was 0.0008 (vs the individual target hazard level of 0.2) and the greatest estimated cancer risk was 3.4×10^{-8} (vs target Risk of 1.0×10^{-5}). While development at the site is not currently proposed, for illustrative purposes, based on these HQs and cancer risk levels calculated from the 2019 vapour data, no passive or active measures would be required for the site. It is noted that even if the 10x factor of safety is applied, mitigative measures would still not be required. Similarly, with cumulative risks and HQs the same conclusion can be drawn. The assumptions made in the calculations of HQs and cancer risk above are inherently conservative; therefore, applying a factor of safety is not needed.

Future applications for development within the setback are subject to review by The City. The developer's team would be responsible for reviewing and verifying the available data relative to their proposed development. The mitigative measures presented above are generic and can be used as a general guide for expectations by The City; ultimately, the developer's design engineer would be responsible for developing measures specific to the intended development based on the above or an appropriate equivalent. Protection of workers (e.g., construction and utility) should form part of any development plan.

APPENDIX C

CROSS-SECTIONS (TIAMAT 2014A AND 2014B)



SOURCE
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0 20 40 80m
Scale 1:1500

PHASE II TEST LOCATIONS
MW-## GROUNDWATER MONITORING WELL (3)
TH-## TESTHOLE (9)
VW-## SOIL VAPOUR MONITORING WELL (2)

LEGEND
HISTORIC WASTE DISPOSAL
MUNICIPAL SANITARY WASTE AREA
LOT BOUNDARY
CROSS SECTION LOCATION
ELECTRICAL
SANITARY
STORM
WATER

NOTE:
LOCATION OF BURIED UTILITIES ARE APPROXIMATE, ACTUAL LOCATIONS OF THE SHALLOW UTILITIES AND ANY OTHER UTILITIES SHOULD BE VERIFIED PRIOR TO ANY GROUND DISTURBANCE ACTIVITY.

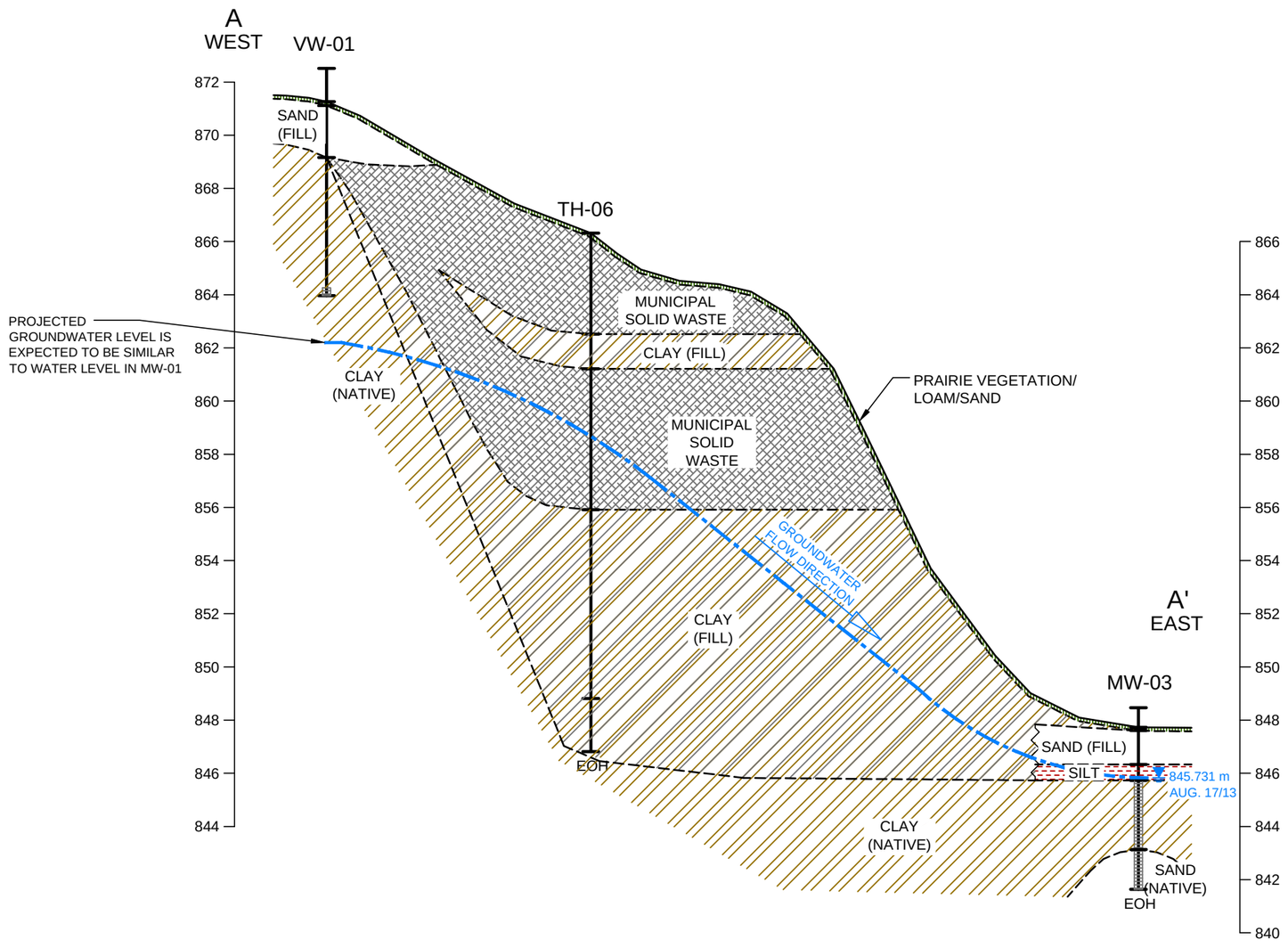
CLIENT: THE CITY OF RED DEER

PROJECT: ENVIRONMENTAL RISK MANAGEMENT PLAN
HISTORIC WASTE DISPOSAL SITE
RIVERSIDE HEAVY DRY WASTE

TITLE: SITE PLAN SHOWING INTERPRETED EXTENT OF WASTE

Tiamat Environmental Consultants Ltd.

SCALE:	DATE:	PROJECT NO.:	FIGURE NO.:
1 : 1500	JUNE 10/14	12-435	FIGURE 2
DRAWN BY: LCH	CHECKED BY: LTM	CAD FILE NO.: ERMP v1.00.dwg	



NOTE:

THE GEOLOGIC AND STRATIGRAPHIC SECTIONS SHOWN ON THIS DRAWING ARE INTERPRETED FROM BOREHOLE LOGS. STRATIGRAPHY IS KNOWN WITH CERTAINTY ONLY AT THE BOREHOLE LOCATIONS. ACTUAL STRATIGRAPHY AND GEOLOGIC CONDITIONS BETWEEN BOREHOLES MAY VARY FROM THAT INDICATED ON THIS DRAWING.

0 2 5 10m
Vertical Scale 1:200

0 10 30 50m
Horizontal Scale 1:1000

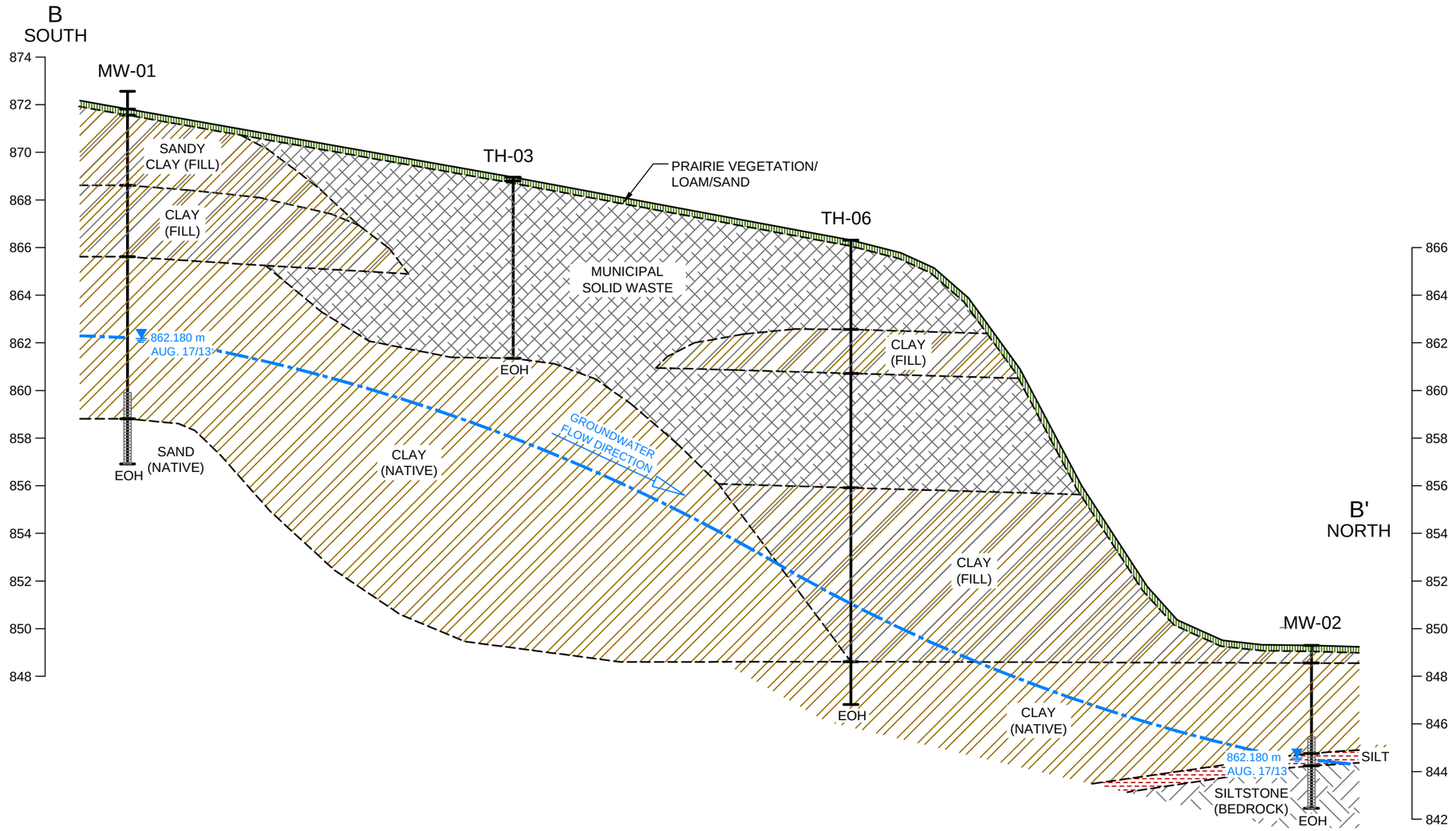
CLIENT: THE CITY OF RED DEER

PROJECT: ENVIRONMENTAL RISK MANAGEMENT PLAN
HISTORIC WASTE DISPOSAL SITE
RIVERSIDE HEAVY DRY WASTE

TITLE: CROSS SECTION A - A`

Tiamat Environmental Consultants Ltd.

SCALE:	DATE:	PROJECT NO.:	FIGURE NO.:
AS SHOWN	June 10/14	12-435	FIGURE 3A
DRAWN BY: LCH	CHECKED BY: LTM	CAD FILE NO.: ERMP Sections v1.00	



NOTE:

THE GEOLOGIC AND STRATIGRAPHIC SECTIONS SHOWN ON THIS DRAWING ARE INTERPRETED FROM BOREHOLE LOGS. STRATIGRAPHY IS KNOWN WITH CERTAINTY ONLY AT THE BOREHOLE LOCATIONS. ACTUAL STRATIGRAPHY AND GEOLOGIC CONDITIONS BETWEEN BOREHOLES MAY VARY FROM THAT INDICATED ON THIS DRAWING.

0 2 5 10m
Vertical Scale 1:200

0 10 30 50m
Horizontal Scale 1:1000

CLIENT: THE CITY OF RED DEER

PROJECT: ENVIRONMENTAL RISK MANAGEMENT PLAN
HISTORIC WASTE DISPOSAL SITE
RIVERSIDE HEAVY DRY WASTE

TITLE: CROSS SECTION B - B`

Tiamat Environmental Consultants Ltd.

SCALE:	DATE:	PROJECT NO.:	FIGURE NO.:
AS SHOWN	June 10/14	12-435	FIGURE 3B
DRAWN BY: LCH	CHECKED BY: LTM	CAD FILE NO.: ERMP Sections v1.00	

APPENDIX D

HISTORICAL ANALYTICAL DATA

Table 1
Soil Vapour and Groundwater Monitoring Well Elevations

Test Location	Well Depth (m)	Elevations				Screen Length (m)
		Ground (m)	Top of Pipe (m)	Screen Interval		
				From	To	
MW-01	14.9	871.813	872.559	856.913	859.913	3.0
MW-02	6.1	848.556	849.294	842.456	845.456	3.0
MW-03	6.1	847.734	848.466	841.634	846.234	4.6
VW-01	7.3	871.261	NA	863.961	864.261	0.3
TH-03	NA	868.951	NA	NA	NA	NA
TH-04	NA	868.686	NA	NA	NA	NA
TH-05	NA	869.951	NA	NA	NA	NA
TH-06	NA	866.315	NA	NA	NA	NA
TH-07	NA	863.026	NA	NA	NA	NA

Notes:

1) Geodetic elevations are determined from multiple datums, ASCM Nos. 36574, 170910 and 124339.
2) MW - Monitoring Well.
3) VW - Soil Vapour Well.
4) TH- Testhole.
5) NA - Not Applicable.

Table 2
Site Monitoring Results

Test Location	Elevation		Groundwater Elevation (m)		Headspace Vapour			
					08/17/2013			
	Ground (m)	Top of Pipe (m)	08/17/2013		Combustible	Volatile	Combustile	Volatile
MW-01	871.813	872.559	862.180		1,100	30		
MW-02	848.556	849.294	844.568		20	1		
MW-03	847.734	848.466	845.831		230	ND		
VW-01	871.261	NA	- -	- -	185	3		

Notes:

1) Measurement of combustible and volatile vapours by RKI Eagle 2.
   Combustible vapour sensor calibrated to hexane and photoionization detector calibrated to isobutylene.
2) NA - Not Applicable.
3) ND - Not Detected, less than the limit of instrument detection.
4) - - No value established.

Table 3A
Analytical Results - Soil - Drill Cuttings (Soil Bag)

Parameter	Detection Limit	Soil Bag			Class II Landfill Acceptance Criteria
		1 of 3	2 of 3	3 of 3	
pH	0.10	8.42	7.90	7.74	2-12.5
Flash Point (°C)	30.0	>75	>75	>75	>61
Paint Filter Test	-	PASS	PASS	PASS	PASS
Total Carbon by Combustion	0.1	3.5	2.8	1.8	- -
Total Organic Carbon	0.10	0.86	1.99	0.84	- -
TCLP Hydrocarbons					
Benzene	0.0050	ND	ND	ND	0.5
Toluene	0.0050	ND	ND	ND	0.5
Ethylbenzene	0.0050	ND	ND	ND	0.5
Xylenes	0.0050	ND	ND	ND	0.5
TCLP Leachable Metals					
Antimony (Sb)	5.0	ND	ND	ND	500
Arsenic (As)	0.20	ND	ND	ND	5
Barium (Ba)	5.0	ND	ND	ND	100
Beryllium (Be)	0.50	ND	ND	ND	5
Boron (B)	5.0	ND	ND	ND	500
Cadmium (Cd)	0.050	ND	ND	ND	1
Chromium (Cr)	0.50	ND	ND	ND	5
Cobalt (Co)	5.0	ND	ND	ND	100
Copper (Cu)	5.0	ND	ND	ND	100
Iron (Fe)	5.0	ND	ND	ND	1,000
Lead (Pb)	0.50	ND	ND	ND	5
Mercury (Hg)	0.010	ND	ND	ND	0.2
Nickel (Ni)	0.50	ND	ND	ND	5
Selenium (Se)	0.20	ND	ND	ND	1
Silver (Ag)	0.50	ND	ND	ND	5
Thallium (Tl)	0.50	ND	ND	ND	5
Uranium (U)	1.0	ND	ND	ND	2
Vanadium (V)	5.0	ND	ND	ND	100
Zinc (Zn)	5.0	ND	ND	ND	500
Zirconium (Zr)	5.0	ND	ND	ND	500

Notes:

1) Class II Landfill Acceptance Criteria - per Table 2, Part 4 Schedule to the Alberta User Guide for Waste Managers 3/95. Applicable waste screening for The City of Red Deer Class II Waste Managment Facility.
2) All units are mg/L unless otherwise stated.
3) ND - Not Detected, less than the limit of method detection.
4) - - No value established.
5) Soil bags were sampled on Friday, June 28, Saturday, June 29 and Wednesday, July 10, 2013.
6) For further information, refer to the specific laboratory report in Appendix A.

Table 3B
Analytical Results - Soil - General Indices and Heavy Metals

Parameter	Unit	Detection Limit	TH-01 @ 13.1 m	TH-03 @ 5.5 m	TH-06 @ 12.8 - 13.4 m	TH-06 @ 17.7 m	TH-08 @ 4.6 m	TH-09 @ 4.6 m	Tier 1 Guideline
			12/07/13			07/13/2013			
Chloride (Cl)	mg/kg	3.7 - 16	ND	29	ND	ND	20	26	- -
Nitrate-N	mg/kg	0.19 - 0.80	ND	ND	ND	ND	ND	ND	- -
Nitrite-N	mg/kg	0.19 - 0.80	ND	ND	ND	ND	ND	ND	- -
Metals									
Antimony (Sb)	mg/kg	0.20	ND	0.36	0.33	0.40	0.68	0.58	40
Arsenic (As)	mg/kg	0.20	1.86	5.85	15.90	6.54	9.24	6.98	26
Barium (Ba)	mg/kg	5.0	54.4	223	93.5	213	728	315	2,000
Beryllium (Be)	mg/kg	1.0	ND	ND	ND	ND	ND	ND	8
Cadmium (Cd)	mg/kg	0.50	ND	ND	ND	ND	ND	ND	22
Chromium (Cr)	mg/kg	0.50	5.76	18.6	19.6	18.6	23.2	30.2	87
Cobalt (Co)	mg/kg	1.0	2.2	7.3	7.6	7.4	6.7	9.9	300
Copper (Cu)	mg/kg	2.0	3.7	16.4	10.2	15.8	17.7	23.0	91
Lead (Pb)	mg/kg	5.0	ND	8.4	7.4	8.7	10.9	11.2	260
Mercury (Hg)	mg/kg	0.050	ND	ND	ND	ND	ND	ND	24
Molybdenum (Mo)	mg/kg	1.0	ND	ND	ND	1.1	7	4.9	40
Nickel (Ni)	mg/kg	2.0	5.7	21.1	22.8	20.2	23.9	32.1	50
Selenium (Se)	mg/kg	0.50	ND	ND	ND	ND	ND	ND	2.9
Silver (Ag)	mg/kg	1.0	ND	ND	ND	ND	ND	ND	40
Thallium (Tl)	mg/kg	0.50	ND	ND	ND	ND	ND	ND	1.0
Tin (Sn)	mg/kg	2.0	ND	ND	ND	ND	ND	ND	300
Uranium (U)	mg/kg	2.0	ND	ND	ND	ND	ND	ND	33
Vanadium (V)	mg/kg	1.0	8.4	29.2	21.9	31.1	30.5	39.1	130
Zinc (Zn)	mg/kg	10	15	58	65	56	67	76	360
Hexavalent Chromium	mg/kg	0.10	ND	ND	ND	ND	ND	ND	1.4
Boron (B), Hot Water Ext.	mg/kg	0.10	0.21	0.12	0.22	0.87	0.42	0.62	2

Notes:

1) Tier 1 Guideline - Alberta Tier 1 Soil and Groundwater Remediation Guidelines, December 2010 and amendments. Coarse-grained criteria for industrial/commercial land use.
2) ND - Not Detected, less than the limit of method detection.
3) - - No value established in the reference criteria.
4) Bold & Shaded - Exceeds the referenced Alberta Tier 1 Guideline.
5) For further laboratory information, refer to the specific laboratory report in Appendix A.

Table 3C
Analytical Results - Soil - VOCs

Parameter	Detection Limit	TH-01 @ 13.1 m	TH-03 @ 5.5 m	TH-06 @ 12.8 - 13.4 m	TH-06 @ 17.7 m	TH-08 @ 4.6 m	TH-09 @ 4.6 m	Tier 1 Guideline
		12/07/13			07/13/2013			
Hydrocarbons								
F1 (C_6-C_{10})	10	ND	ND	ND	ND	ND	ND	270
F2 (C_{10}-C_{16})	25	ND	ND	ND	ND	ND	ND	260
F3 (C_{16}-C_{34})	50	ND	ND	ND	271	ND	ND	1,700
F4 (C_{34}-C_{50})	50	ND	ND	ND	148	ND	ND	3,300
Total Hydrocarbons (C_6-C_{50})	50	ND	ND	ND	419	ND	ND	- -
Volatile Organic Compounds								
Benzene	0.0050	ND	ND	ND	ND	ND	ND	0.078
Bromobenzene	0.010	ND	ND	ND	ND	ND	ND	- -
Bromochloromethane	0.010	ND	ND	ND	ND	ND	ND	- -
Bromodichloromethane	0.010	ND	ND	ND	ND	ND	ND	- -
Bromoform	0.010	ND	ND	ND	ND	ND	ND	- -
Bromomethane	0.10	ND	ND	ND	ND	ND	ND	- -
n-Butylbenzene	0.010	ND	ND	ND	ND	ND	ND	- -
sec-Butylbenzene	0.010	ND	ND	ND	ND	ND	ND	- -
tert-Butylbenzene	0.010	ND	ND	ND	ND	ND	ND	- -
Carbon tetrachloride	0.010	ND	ND	ND	ND	ND	ND	0.0068
Chlorobenzene	0.010	ND	ND	ND	ND	ND	ND	0.22
Dibromochloromethane	0.010	ND	ND	ND	ND	ND	ND	1.5
Chloroethane	0.10	ND	ND	ND	ND	ND	ND	- -
Chloroform	0.010	ND	ND	ND	ND	ND	ND	0.003
Chloromethane	0.10	ND	ND	ND	ND	ND	ND	- -
2-Chlorotoluene	0.010	ND	ND	ND	ND	ND	ND	- -
4-Chlorotoluene	0.010	ND	ND	ND	ND	ND	ND	- -
1,2-Dibromo-3-chloropropane	0.010	ND	ND	ND	ND	ND	ND	- -
1,2-Dibromoethane	0.010	ND	ND	ND	ND	ND	ND	- -
Dibromomethane	0.010	ND	ND	ND	ND	ND	ND	- -
1,2-Dichlorobenzene	0.010	ND	ND	ND	ND	ND	ND	0.18
1,3-Dichlorobenzene	0.010	ND	ND	ND	ND	ND	ND	- -
1,4-Dichlorobenzene	0.010	ND	ND	ND	ND	ND	ND	0.098
Dichlorodifluoromethane	0.010	ND	ND	ND	ND	ND	ND	- -
1,1-Dichloroethane	0.010	ND	ND	ND	ND	ND	ND	- -
1,2-Dichloroethane	0.010	ND	ND	ND	ND	ND	ND	0.033
1,1-Dichloroethene	0.010	ND	ND	ND	ND	ND	ND	0.24
cis-1,2-Dichloroethene	0.010	ND	ND	ND	ND	ND	ND	- -
trans-1,2-Dichloroethene	0.010	ND	ND	ND	ND	ND	ND	- -
Methylene chloride	0.010	ND	ND	ND	ND	ND	0.039	0.095
1,2-Dichloropropane	0.010	ND	ND	ND	ND	ND	ND	- -
1,3-Dichloropropane	0.010	ND	ND	ND	ND	ND	ND	- -
2,2-Dichloropropane	0.010	ND	ND	ND	ND	ND	ND	- -
1,1-Dichloropropene	0.010	ND	ND	ND	ND	ND	ND	- -
cis-1,3-Dichloropropene	0.010	ND	ND	ND	ND	ND	ND	- -
trans-1,3-Dichloropropene	0.010	ND	ND	ND	ND	ND	ND	- -
Ethylbenzene	0.015	ND	ND	ND	ND	ND	ND	0.21
Hexachlorobutadiene	0.010	ND	ND	ND	ND	ND	ND	0.031
Isopropylbenzene	0.010	ND	ND	ND	ND	ND	ND	- -
p-Isopropyltoluene	0.010	ND	ND	ND	ND	ND	ND	- -
n-Propylbenzene	0.010	ND	ND	ND	ND	ND	ND	- -
Styrene	0.050	ND	ND	ND	ND	ND	ND	0.80
1,1,1,2-Tetrachloroethane	0.010	ND	ND	ND	ND	ND	ND	- -
1,1,2,2-Tetrachloroethane	0.050	ND	ND	ND	ND	ND	ND	- -
Tetrachloroethene	0.010	ND	ND	ND	ND	ND	ND	0.77
Toluene	0.050	ND	ND	ND	ND	ND	ND	0.49
1,2,3-Trichlorobenzene	0.010	ND	ND	ND	ND	ND	ND	0.31
1,2,4-Trichlorobenzene	0.010	ND	ND	ND	ND	ND	ND	0.93
1,1,1-Trichloroethane	0.010	ND	ND	ND	ND	ND	ND	- -
1,1,2-Trichloroethane	0.010	ND	ND	ND	ND	ND	ND	- -
Trichloroethene	0.010	ND	ND	ND	ND	ND	ND	0.081
Trichlorofluoromethane	0.010	ND	ND	ND	ND	ND	ND	- -
1,2,3-Trichloropropane	0.020	ND	ND	ND	ND	ND	ND	- -
1,2,4-Trimethylbenzene	0.010	ND	ND	ND	ND	ND	ND	- -
1,3,5-Trimethylbenzene	0.010	ND	ND	ND	ND	ND	ND	- -
Vinyl chloride	0.20	ND	ND	ND	ND	ND	ND	0.0043
Xylenes	0.10	ND	ND	ND	ND	ND	ND	28

Notes:
1) Tier 1 Guideline - Alberta Tier 1 Soil and Groundwater Remediation Guidelines, December 2010 and amendments. Coarse-grained criteria for industrial/commercial land use.
2) ND - Not Detected, less than the limit of method detection.
3) - - No value established in the reference criteria.
4) Bold & Shaded - Exceeds the referenced Alberta Tier 1 Guideline.
5) Units are in mg/kg unless otherwise noted.
6) For further laboratory information, refer to the specific laboratory report in Appendix A.

Table 4A
Groundwater Indices at Time of Sampling

Monitoring Well	pH	Electrical Conductivity (µg/cm)	Temperature (°C)	Dissolved Oxygen (mg/L)	Total Dissolved Solid (mg/L)	Redox (±mV)
MW-01	7.91	1,239	7.6	2.6	1,202.50	-12.5
MW-02	7.50	2,021	7.3	1.83	1,976.00	+33.7
MW-03	6.99	1,909	11.9	0.81	1,644.50	-106.7

Notes:

1) Measurement of groundwater indices by YSI Pro Plus multimeter.
2) Wells sampled on Saturday, August 17, 2013.

Table 4B
Analytic Results - Groundwater - General Water Quality

Parameter	Unit	Detection Limit	MW-01	MW-02	MW-03	Tier 1 Guideline
			08/17/2013			
General Water Quality						
Biochemical Oxygen Demand	mg/L	2.0	3.5	2	4.3	- -
Total Chemical Oxygen Demand	mg/L	5.0 - 50.0	100	310	460	- -
Conductivity	µS/cm	1.0	1,900	3,200	2,700	- -
pH	Unitless	NA	7.71	6.78	7.55	6.5-8.5
Total Organic Carbon (C)	mg/L	0.50 - 2.5	14	20	46	- -
Dissolved Cadmium (Cd)	µg/L	0.0050 - 0.013	0.087	0.12	0.039	- -
Total Cadmium (Cd)	µg/L	0.0050 - 0.013	**0.60**	**5.5**	**5.0**	0.060*
Alkalinity ($CaCO_3$)	mg/L	0.50	570	550	860	- -
Bicarbonate (HCO_3)	mg/L	0.50	690	670	1,100	- -
Carbonate (CO_3)	mg/L	0.50	ND	ND	ND	- -
Hydroxide (OH)	mg/L	0.50	ND	ND	ND	- -
Sulphate (SO_4)	mg/L	1.0 - 5.0	510	690	ND	- -
Chloride (Cl)	mg/L	1.0 - 5.0	4.7	360	360	- -
Total Ammonia (N)	mg/L	0.050 - 0.50	0.64	0.76	**4.6**	1.37*
Total Phosphorus (P)	mg/L	0.030 - 0.15	0.54	6.2	4.8	- -
Total Nitrogen (N)	mg/L	0.050	1.1	4.1	6.4	- -
Total Kjeldahl Nitrogen	mg/L	0.050 - 0.50	0.98	4.1	6.3	- -
Nitrite (NO_2)	mg/L	0.0030	0.010	ND	0.0090	- -
Nitrate (NO_3)	mg/L	0.0030	0.067	0.030	0.11	- -
Nitrate plus Nitrite (N)	mg/L	0.0030	0.077	0.030	0.12	- -
Trace Organics						
Acetic Acid	mg/L	50	ND	ND	ND	- -
Formic Acid	mg/L	50	ND	ND	ND	- -
Propionic Acid	mg/L	50	ND	ND	ND	- -
Adsorbable Organic Halogen	mg/L	0.002 - 0.02	0.05	0.023	0.13	- -

Notes:

1) Tier 1 Guideline - Alberta Tier 1 Soil and Groundwater Remediation Guidelines, December 2010 and amendments. Coarse-grained criteria for commercial/industrial land use.
2) * Surface Water Quality Guidelines for Use in Alberta (AENV, 1999) on aquatic life pathway. Canadian Council of Ministers of the Environment (CCME) guidelines are referenced.
3) ND - Not Detected, less than the limit of method detection.
4) - - No value established in the reference criteria.
5) Bold & Shaded - Exceeds the referenced Alberta Tier 1 and CCME guidelines.
6) For further laboratory information, refer to the specific laboratory report in Appendix A.

Table 4C
Analytic Results - Groundwater - Metals

Parameter	Unit	Detection Limit	MW-01	MW-02	MW-03	Tier 1 Guideline
			08/17/2013			
Total Metals						
Aluminum (Al)	mg/L	0.0030 - 0.0075	**4.3**	**100**	**74**	0.1*
Antimony (Sb)	mg/L	0.00060 - 0.0015	0.00074	ND	ND	0.006
Arsenic (As)	mg/L	0.00020 - 0.00050	**0.011**	**0.066**	**0.069**	0.005
Barium (Ba)	mg/L	0.010	0.320	**3.3**	**3.5**	1
Beryllium (Be)	mg/L	0.0010 - 0.0025	ND	0.0099	0.0072	- -
Boron (B)	mg/L	0.020	0.28	0.11	0.13	1.5
Calcium (Ca)	mg/L	0.30 - 1.5	270	730	1,000	- -
Chromium (Cr)	mg/L	0.0010 - 0.0025	**0.010**	**0.19**	**0.14**	0.001*
Cobalt (Co)	mg/L	0.00030 - 0.00075	0.014	0.12	0.13	- -
Copper (Cu)	mg/L	0.00020 - 0.00050	**0.025**	**0.25**	**0.23**	0.003*
Iron (Fe)	mg/L	0.060 - 0.30	**20**	**330**	**260**	0.3
Lead (Pb)	mg/L	0.00020 - 0.00050	**0.0068**	**0.11**	**0.11**	0.004*
Lithium (Li)	mg/L	0.020	0.093	0.32	0.15	- -
Magnesium (Mg)	mg/L	0.20	62	230	330	- -
Manganese (Mn)	mg/L	0.0040	**1.4**	**13.0**	**15.0**	0.05
Molybdenum (Mo)	mg/L	0.00020 - 0.00050	0.0021	0.012	0.0036	0.073*
Nickel (Ni)	mg/L	0.00050 - 0.0013	0.033	**0.29**	**0.29**	0.11*
Phosphorus (P)	mg/L	0.10	0.68	11	7.2	- -
Potassium (K)	mg/L	0.30	8.4	20	21	- -
Selenium (Se)	mg/L	0.00020 - 0.00050	0.0007	**0.0031**	**0.0014**	0.001
Silicon (Si)	mg/L	0.10	17	94	87	- -
Silver (Ag)	mg/L	0.00010 - 0.00025	ND	**0.001**	**0.0016**	0.0001*
Sodium (Na)	mg/L	0.50	160	230	160	- -
Strontium (Sr)	mg/L	0.020	1.4	3.7	2.5	- -
Sulphur (S)	mg/L	0.20	180	230	7.8	- -
Thallium (Tl)	mg/L	0.00020 - 0.00050	ND	**0.0011**	**0.00087**	0.0008*
Tin (Sn)	mg/L	0.0010 - 0.0025	0.0029	0.0044	ND	- -
Titanium (Ti)	mg/L	0.0010 - 0.0025	0.19	0.96	0.45	- -
Uranium (U)	mg/L	0.00010 - 0.00025	0.012	**0.045**	0.0075	0.02
Vanadium (V)	mg/L	0.0010 - 0.0025	0.018	0.300	0.200	- -
Zinc (Zn)	mg/L	0.0030 - 0.0075	**0.057**	**0.73**	**0.67**	0.03
Dissolved Metals						
Aluminum (Al)	mg/L	0.0030 - 0.0075	0.0044	0.017	0.088	- -
Antimony (Sb)	mg/L	0.00060 - 0.0015	ND	0.002	ND	- -
Arsenic (As)	mg/L	0.00020 - 0.00050	0.0027	0.0061	0.024	- -
Barium (Ba)	mg/L	0.010	0.083	0.081	0.72	- -
Beryllium (Be)	mg/L	0.0010 - 0.0025	ND	ND	ND	- -
Boron (B)	mg/L	0.020	0.27	0.12	0.12	- -
Calcium (Ca)	mg/L	0.30	220	310	210	- -
Chromium (Cr)	mg/L	0.0010 - 0.0025	ND	ND	ND	- -
Cobalt (Co)	mg/L	0.00030 - 0.00075	0.0043	0.0045	0.012	- -
Copper (Cu)	mg/L	0.00020 - 0.00050	0.0023	0.0021	0.0013	- -
Iron (Fe)	mg/L	0.060	0.19	0.24	27	- -
Lead (Pb)	mg/L	0.00020 - 0.00050	ND	ND	ND	- -
Lithium (Li)	mg/L	0.020	0.091	0.130	0.034	- -
Magnesium (Mg)	mg/L	0.20	56	110	120	- -
Manganese (Mn)	mg/L	0.0040	0.7	0.78	3.6	- -
Molybdenum (Mo)	mg/L	0.00020 - .00050	0.0015	0.0059	0.0021	- -
Nickel (Ni)	mg/L	0.00050 - 0.0013	0.011	0.013	0.016	- -
Phosphorus (P)	mg/L	0.10	ND	ND	ND	- -
Potassium (K)	mg/L	0.30	6.9	8.6	9.8	- -
Selenium (Se)	mg/L	0.00020 - 0.00050	0.00028	0.00050	ND	- -
Silicon (Si)	mg/L	0.10	7.4	6.5	15	- -
Silver (Ag)	mg/L	0.00010 - 0.00025	ND	ND	ND	- -
Sodium (Na)	mg/L	0.50	170	250	160	- -
Strontium (Sr)	mg/L	0.020	1.3	2.7	1.4	- -
Sulphur (S)	mg/L	0.20	180	220	3.9	- -
Thallium (Tl)	mg/L	0.00020 - 0.00050	ND	ND	ND	- -
Tin (Sn)	mg/L	0.0010 - 0.0025	ND	ND	ND	- -
Titanium (Ti)	mg/L	0.0010 - 0.0025	ND	ND	ND	- -
Uranium (U)	mg/L	0.00010 - 0.00025	0.011	0.021	0.0014	- -
Vanadium (V)	mg/L	0.0010 - 0.0025	ND	ND	ND	- -
Zinc (Zn)	mg/L	0.0030 - 0.0075	ND	ND	ND	- -

Notes:

1) Tier 1 Guideline - Alberta Tier 1 Soil and Groundwater Remediation Guidelines, December 2010 and amendments. Coarse-grained criteria for commercial/industrial land use.
2) * Surface Water Quality Guidelines for Use in Alberta (AENV, 1999) on aquatic life pathway. Canadian Council of Ministers of the Environment (CCME) guidelines are referenced.
3) ND - Not Detected, less than the limit of method detection.
4) - - No value established in the reference criteria.
5) Bold & Shaded - Exceeds the referenced Alberta Tier 1 and CCME guidelines.
6) For further laboratory information, refer to the specific laboratory report in Appendix A.

Table 4D
Analytical Results - Groundwater - VOCs

Parameter	Unit	Detection Limit	MW-01	MW-02	MW-03	Tier 1 Guideline
			08/17/2013			
Volatiles						
Benzene	mg/L	0.00040	ND	ND	ND	0.005
Toluene	mg/L	0.00040	ND	ND	ND	0.024
Ethylbenzene	mg/L	0.00040	ND	ND	ND	0.0024
Xylenes (Total)	mg/L	0.00080	ND	ND	ND	0.3
F1 (C_6-C_{10})	mg/L	0.10	ND	ND	ND	2.2
F2 (C_{10}-C_{16})	mg/L	0.10	ND	ND	ND	1.1
Total Trihalomethanes	mg/L	0.0020	ND	ND	ND	0.1
Bromodichloromethane	mg/L	0.00050	ND	ND	ND	- -
Bromoform	mg/L	0.00050	ND	ND	ND	- -
Bromomethane	mg/L	0.0020	ND	ND	ND	- -
Carbon tetrachloride	mg/L	0.00050	ND	ND	ND	0.005
Chlorobenzene	mg/L	0.00050	ND	ND	ND	0.0013
Chlorodibromomethane	mg/L	0.0010	ND	ND	ND	- -
Chloroethane	mg/L	0.0010	ND	ND	ND	- -
Chloroform	mg/L	0.00050	ND	ND	ND	0.0018
Chloromethane	mg/L	0.0020	ND	ND	ND	- -
1,2-dibromoethane	mg/L	0.00050	ND	ND	ND	- -
1,2-dichlorobenzene	mg/L	0.00050	ND	ND	ND	0.0007
1,3-dichlorobenzene	mg/L	0.00050	ND	ND	ND	- -
1,4-dichlorobenzene	mg/L	0.00050	ND	ND	ND	0.001
1,1-dichloroethane	mg/L	0.00050	ND	ND	ND	- -
1,2-dichloroethane	mg/L	0.00050	ND	ND	ND	0.005
1,1-dichloroethene	mg/L	0.00050	ND	ND	ND	0.014
cis-1,2-dichloroethene	mg/L	0.00050	ND	ND	ND	- -
trans-1,2-dichloroethene	mg/L	0.00050	ND	ND	ND	- -
Dichloromethane	mg/L	0.0020	ND	ND	ND	0.05
1,2-dichloropropane	mg/L	0.00050	ND	ND	ND	- -
cis-1,3-dichloropropene	mg/L	0.00050	ND	ND	ND	- -
trans-1,3-dichloropropene	mg/L	0.00050	ND	ND	ND	- -
Methyl methacrylate	mg/L	0.00050	ND	ND	ND	0.47
Methyl-tert-butylether (MTBE)	mg/L	0.00050	ND	ND	ND	0.015
Styrene	mg/L	0.00050	ND	ND	ND	0.072
1,1,1,2-tetrachloroethane	mg/L	0.0020	ND	ND	ND	- -
1,1,2,2-tetrachloroethane	mg/L	0.0020	ND	ND	ND	- -
Tetrachloroethene	mg/L	0.00050	ND	ND	ND	0.03
1,2,3-trichlorobenzene	mg/L	0.0010	ND	ND	ND	0.008
1,2,4-trichlorobenzene	mg/L	0.0010	ND	ND	ND	0.015
1,3,5-trichlorobenzene	mg/L	0.00050	ND	ND	ND	0.014
1,1,1-trichloroethane	mg/L	0.00050	ND	ND	ND	- -
1,1,2-trichloroethane	mg/L	0.00050	ND	ND	ND	- -
Trichloroethene	mg/L	0.00050	ND	ND	ND	0.005
Trichlorofluoromethane	mg/L	0.00050	ND	ND	ND	- -
1,2,4-trimethylbenzene	mg/L	0.00050	ND	ND	ND	- -
1,3,5-trimethylbenzene	mg/L	0.00050	ND	ND	ND	- -
Vinyl chloride	mg/L	0.00050	ND	ND	ND	0.002

Notes:

1) Tier 1 Guideline - Alberta Tier 1 Soil and Groundwater Remediation Guidelines, December 2010 and amendments. Coarse-grained criteria for commercial/industrial land use.
2) ND - Not Detected, less than the limit of method detection.
3) - - No value established in the reference criteria.
4) Bold & Shaded - Exceeds the referenced Alberta Tier 1 and CCME guidelines.
5) For further laboratory information, refer to the specific laboratory report in Appendix A.

Table 5A
Summary of Parameters Measured During Sampling of Soil Vapour

Parameter	Well Diameter (mm)	Screen Length (cm)	Well Depth (m)	Headspace Volume (cm^3)	Purge Rate (cm^3/min)	Purge Time (min)	Pressure	
							Ambient (psi)	Vapour Well (psi)
VW-01	25	30	7.3	3,583.4	943.3	9	15.03	15.05

Notes:

1) Measurement of pressure by digital Cole-Parmer absolute pressure gauge.
2) Purge time is elapsed time prior to the collection of a soil vapour sample.
3) Screen set at base of well.
4) Soil vapour sampling was completed Saturday, August 17, 2013.

Table 5B
Analytical Results - Soil Vapour - General Indices

Parameters	Units	Detection Limit	VW-01
Gause Pressure			
pressure after sampling	psig	- -	-5.0
pressure on receipt	psig	- -	-4.6
Fixed Gases			
Oxygen	% v/v	0.3	14.2
Nitrogen	% v/v	0.3	78.8
Carbon Monoxide	% v/v	0.3	ND
Methane	% v/v	0.3	ND
Carbon Dioxide	% v/v	0.3	7.0

Notes:

1) Soil vapour sample collected on Saturday, August 17, 2013.
2) ND - Not Detected, less than the limit of method detection.
3) - - No value established in the detection limit and reference criteria.
4) For further information, the reader should refer to the laboratory report in Appendix A.

Table 5C
Analytical Results - Soil Vapour - VOCs

Parameters	Unit	Detection Limit	VW-01 08/17/13
Hydrocarbon Fractions			
Aliphatic >C_5-C_6	µg/m^3	5.0	7.3
Aliphatic >C_6-C_8	µg/m^3	5.0	34.9
Aliphatic >C_8-C_{10}	µg/m^3	5.0	27.8
Aliphatic >C_{10}-C_{12}	µg/m^3	5.0	39.7
Aliphatic >C_{12}-C_{16}	µg/m^3	5.0	15.2
Aromatic >C_7-C_8 (TEX Excluded)	µg/m^3	5.0	ND
Aromatic >C_8-C_{10}	µg/m^3	5.0	6.7
Aromatic >C_{10}-C_{12}	µg/m^3	5.0	6.1
Aromatic >C_{12}-C_{16}	µg/m^3	5.0	ND
Select Volatile Gases			
Acetylene	ppm	0.26	ND
Ethane	ppm	0.26	ND
Ethylene	ppm	0.26	ND
Methane	ppm	5.1	ND
n-Butane	ppm	0.51	ND
n-Pentane	ppm	0.26	ND
Propane	ppm	0.26	ND
Propene	ppm	0.26	ND
Propyne	ppm	0.51	ND
Volatile Organic Compounds			
Dichlorodifluoromethane (FREON 12)	ppbv	0.20	1.08
1,2-Dichlorotetrafluoroethane	ppbv	0.17	ND
Chloromethane	ppbv	0.30	1.21
Vinyl Chloride	ppbv	0.18	ND
Chloroethane	ppbv	0.30	ND
1,3-Butadiene	ppbv	0.50	ND
Trichlorofluoromethane (FREON 11)	ppbv	0.20	0.40
Ethanol (ethyl alcohol)	ppbv	2.3	21.8
Trichlorotrifluoroethane	ppbv	0.15	ND
2-propanol	ppbv	3.0	3.2
2-Propanone	ppbv	0.80	22.8
Methyl Ethyl Ketone (2-Butanone)	ppbv	5.0	ND
Methyl Isobutyl Ketone	ppbv	3.2	ND
Methyl Butyl Ketone (2-Hexanone)	ppbv	2.0	ND
Methyl t-butyl ether (MTBE)	ppbv	0.20	ND
Ethyl Acetate	ppbv	2.2	ND
1,1-Dichloroethylene	ppbv	0.25	ND
cis-1,2-Dichloroethylene	ppbv	0.19	ND
trans-1,2-Dichloroethylene	ppbv	0.20	ND
Methylene Chloride(Dichloromethane)	ppbv	0.80	ND
Chloroform	ppbv	0.15	0.33
Carbon Tetrachloride	ppbv	0.30	ND
1,1-Dichloroethane	ppbv	0.20	ND
1,2-Dichloroethane	ppbv	0.20	ND
Ethylene Dibromide	ppbv	0.17	ND
1,1,1-Trichloroethane	ppbv	0.30	ND
1,1,2-Trichloroethane	ppbv	0.15	ND
1,1,2,2-Tetrachloroethane	ppbv	0.20	ND
cis-1,3-Dichloropropene	ppbv	0.18	ND
trans-1,3-Dichloropropene	ppbv	0.17	ND
1,2-Dichloropropane	ppbv	0.40	ND
Bromomethane	ppbv	0.18	ND
Bromoform	ppbv	0.20	ND
Bromodichloromethane	ppbv	0.20	ND
Dibromochloromethane	ppbv	0.20	ND
Trichloroethylene	ppbv	0.30	ND
Tetrachloroethylene	ppbv	0.20	ND
Benzene	ppbv	0.18	0.48
Toluene	ppbv	0.20	1.86
Ethylbenzene	ppbv	0.20	0.55
p+m-Xylene	ppbv	0.37	2.53
o-Xylene	ppbv	0.20	0.84
Styrene	ppbv	0.20	ND
4-ethyltoluene	ppbv	2.2	ND
1,3,5-Trimethylbenzene	ppbv	0.50	ND
1,2,4-Trimethylbenzene	ppbv	0.50	ND
Chlorobenzene	ppbv	0.20	ND
Benzyl chloride	ppbv	1.0	ND
1,3-Dichlorobenzene	ppbv	0.40	ND
1,4-Dichlorobenzene	ppbv	0.40	ND
1,2-Dichlorobenzene	ppbv	0.40	ND
1,2,4-Trichlorobenzene	ppbv	2.0	ND
Hexachlorobutadiene	ppbv	3.0	ND
Hexane	ppbv	0.30	3.44
Heptane	ppbv	0.30	0.49
Cyclohexane	ppbv	0.20	0.40
Tetrahydrofuran	ppbv	0.40	3.49
1,4-Dioxane	ppbv	2.0	ND
Xylene (Total)	ppbv	0.60	3.37
Vinyl Bromide	ppbv	0.20	ND
Propene	ppbv	0.30	1.29
2,2,4-Trimethylpentane	ppbv	0.20	0.25
Carbon Disulfide	ppbv	0.50	6.98
Vinyl Acetate	ppbv	0.20	ND

Notes:
1) Results are from sampling performed on Saturday, August 17, 2013.
2) ND - Not Detected, less than the limit of method detection.
3) - - No value established in the detection limit and reference criteria.
4) For further information, the reader should refer to the laboratory report in Appendix A.

Table 5D
Analytical Results - Soil Vapour - Siloxanes

Parameter	Detection Limit		VW-01 08/17/2013	
	mg/m³	ppm	mg/m³	ppm
Trimethylsilyl Fluoride	- -	- -	0.0011	0.0003
Tetramethylsilane	0.0001	0.0001	ND	ND
Methoxytrimethylsilane	0.0019	0.0004	ND	ND
Ethoxytrimethylsilane	0.0018	0.0004	ND	ND
Trimethylsilanol	- -	- -	0.0526	0.0143
Isopropoxytrimethylsilane	0.0008	0.0001	ND	ND
Trimethoxymethyl Silane #	- -	- -	ND	ND
Hexamethyl Disiloxane - L2	- -	- -	0.0006	0.0001
Propoxytrimethylsilane	0.0021	0.0004	ND	ND
1-Methylbutoxytrimethylsilane *	- -	- -	ND	ND
Butoxytrimethylsilane *	- -	- -	ND	ND
Trimethoxyvinyl Silane #	- -	- -	ND	ND
Hexamethyl Cyclotrisiloxane - D3	- -	- -	0.0111	0.0012
Octamethyl Trisiloxane - L3	0.0001	0.0001	ND	ND
Triethoxyvinyl Silane #	- -	- -	ND	ND
Triethoxyethyl Silane #	- -	- -	ND	ND
Octamethyl Cyclotetrasiloxane - D4	- -	- -	0.0090	0.0007
Decamethyl Tetrasiloxane - L4	0.0002	0.0001	ND	ND
Tetraethylsilicate #	- -	- -	ND	ND
Decamethyl Cyclopentasiloxane - D5	- -	- -	0.0236	0.0016
Dodecamethyl Pentasiloxane - L5	0.0018	0.0001	ND	ND
Dodecamethyl Cyclohexasiloxane - D6	- -	- -	0.1655	0.0091
Sum	- -	- -	0.2722	0.0288

Notes:

1) Soil vapour samples collected on Saturday, August 17, 2013.
2) ND - Not Detected, less than the limit of method detection.
3) - - No value established in the detection limit and reference criteria.
4) V=200 mL, where V is volume of air/gas sampled.
5) * - Semiquanititative (response factor set at 5).
6) # - Unstable, poor detectability, commercial standards tested.
7) For further information, the reader should refer to the laboratory report in Appendix A.