Correctional Services Canada (CSC) – Drumheller Institution No. 530 Landfill Remediation

Environmental Assessment Report
Submitted to the Public Works and Government Services Canada (PWGSC)
Pursuant to the *Canadian Environmental Assessment Act (CEA Act)*

FINAL REPORT

Prepared for:

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Winnipeg, Manitoba

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EXECUTIVE SUMMARY

Background

Correctional Services Canada (CSC) owns the property on which the Drumheller Institution is located. A former landfill, associated with the Institution and containing primarily construction debris, is also present on the site. The landfill has become unstable over time, and some metals have been detected at concentrations exceeding applicable federal water quality guidelines. Remedial work is now required. Since the proposed project involves physical work on a federally-owned property, a screening-level environmental assessment is required under the *Canadian Environmental Assessment Act*.

The Drumheller Institution is located 5 kilometres south-southeast of Drumheller, Alberta. Drumheller is within the Red Deer River valley in the badlands of east-central Alberta, approximately 110 kilometres northeast of Calgary. The institution was opened in 1967 and provides accommodation for medium-security inmates. An inactive landfill is located approximately 500 m southeast of the institution on the edge of a coulee. It covers an area measuring approximately 150 m x 200 m. The former landfill was constructed in a series of trenches, and received waste from the institution for more than 20 years. The waste material in the landfill consists of domestic waste and demolition material such as pipes, concrete, and building materials from renovations at the institution.

A groundwater seep was observed in a steep gully 20 m north of the landfill. The seepage water drains into a creek at the base of the coulee, which in turn discharges into the Red Deer River, approximately 4.5 km downstream of the site.

In 2010, FRANZ conducted a preliminary qualitative slope stability analysis at the Former Landfill Site using existing information on the soil/waste properties and new topographic data acquired during the 2010 site investigation (FRANZ, 2011). Some signs of slope instability were observed at the subject site, as indicated by tension cracks on the table land along the east side of the landfill. An existing deep failure zone was observed at the northeast end of the landfill. Based on the results of this analysis, it was determined that the slope was at its maximum angle of repose and that the landfill posed a significant physical hazard that required remedial action. The objectives of the proposed slope stabilization work, therefore, are to remove the physical hazard to humans, livestock and wildlife by reducing the slope and channelling groundwater away from the slope face (FRANZ, 2011a).

Water seeping from the toe of the landfill on the north side was not in compliance with CCME water quality criteria for cadmium, aluminum, arsenic, copper, iron or zinc. The water ultimately drains into the Red Deer River via an ephemeral creek, potentially posing unacceptable risk to

downstream components. Natural attenuation of metals in the groundwater is already taking place. The objectives of the proposed in-situ passive treatment system are to enhance the existent natural attenuation process of scavenging of inorganic contaminants by iron hydroxide precipitation, and to decrease the likelihood of exposure of ecological receptors and livestock to these contaminants in surface water.

Rationale for the Environmental Assessment

The proposed project is a physical work being conducted on federal government land by a federal government department, therefore a screening-level environmental assessment is required under Section 5 of the *Canadian Environmental Assessment Act* (*CEA Act*). CSC is both the Proponent and the Responsible Authority for the proposed project. The Notice of Commencement for the EA has been entered into the Canadian Environmental Assessment Registry (CEAR), and was assigned reference number 11-01-63723, entitled “Former Landfill Remediation, Drumheller Institution, Alberta”.

Communications

Federal and provincial departments with mandates relevant to the project were contacted to obtain information regarding, for example, use of the land in the vicinity of the site by First Nations people, potential for encountering items of archaeological or paleontological significance, potential occurrence of species at risk, etc. Comments and recommendations made by these departments have been incorporated into this environmental screening report.

Environmental Effects on the Biophysical and Socio-Economic Environment

The potential for adverse effects on each of the identified valued components was examined and mitigative measures proposed to prevent or minimize such effects.

Since the proposed project involves a short-term construction phase (weeks) and a long-term functional phase (indefinite), and since the main purpose of the project is to rehabilitate the former landfill, any residual adverse effects after standard mitigation measures are implemented are expected to be minimal. Further, it is anticipated that the long-term beneficial environmental effects of the project will greatly outweigh any short-term residual adverse effects that may occur.

Effects of the Environment on the Project

The influence of precipitation (rain water) and drainage were considered, and addressed by means of standard mitigation measures and in the proposed project design. Similarly, the potential for adverse effects derived from the contents of the former landfill were addressed by proposed standard mitigation measures.

Accidents and Malfunctions

Proposed, standard mitigation measures of environmental effects include actions to prevent and address any potential accidents or malfunctions, including slope failure and resulting injury to workers or damage to property, fire, and vehicular accidents during equipment transport. Given that the proposed work area is remote, and that any adverse effects of the construction phase of the project would temporarily affect a small land area for a short period of time, any residual adverse effects of accidents and malfunctions on the surrounding area were anticipated to be insignificant.

Cumulative Environmental Effects

No related projects are anticipated in the area. No further remediation activities are planned or expected for the former landfill, and there are no ancillary projects associated with the proposed project. For these reasons, no cumulative effects were assessed.

Post Remediation Monitoring

Performance monitoring and environmental monitoring will be undertaken on a semi-annual basis for a period of at least two years following completion of the remediation works. The monitoring may continue in the long term, but the results of monitoring in the immediate, post-implementation phase will determine the frequency and scope of the longer-term requirements. Performance monitoring should include semi-annual inspections by using 3-D laser surveys to compare elevations at the time of inspection to as-built elevations, and determine whether the slopes (or drainage channels) have remained stable over time. The primary focus of the environmental monitoring program will include annual surface water and sediment sampling at the sampling locations previously established, to monitor the decrease in concentration of any remaining contaminants in surface and groundwater over time.

Conclusion

This report has been prepared by Franz Environmental Inc. (FRANZ) in compliance with the *CEA Act*. The report identifies and addresses potential effects associated with the remediation of the Drumheller Institution No. 530 Landfill.

The comprehensive program of mitigation measures to be undertaken by Correctional Service Canada (CSC, the Proponent) addresses potential effects on valued biophysical and socioeconomic components, including potential residual effects. No significant adverse effects on valued components are anticipated to occur as a result of the proposed project, with the implementation of the mitigation measures described herein.

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LIST OF ABBREVIATIONS

CCME	Canadian Council of Ministers of the Environment
CCME CWS	Canadian Council of Ministers of the Environment - Canada-Wide Standard
CEA Act	Canadian Environmental Assessment Act
CEA Agency	Canadian Environmental Assessment Agency
CEPA	Canadian Environmental Protection Act
CSA	Canadian Standards Association
DFO	Department of Fisheries and Oceans
EA	Environmental Assessment
EIP	Environmental Implementation Plan
EPP	Environmental Protection Plan
ESA	Environmental and Socio-Economic Assessment
FRANZ	Franz Environmental Inc.
ROW	Right-of-Way
VC	Valued Component
VEC	Valued Ecosystem Component
VSC	Valued Socio-Economic Component

1.0 INTRODUCTION

This report has been prepared by Franz Environmental Inc. (FRANZ) to satisfy the Environmental Assessment (EA) requirements outlined by Public Works and Government Services Canada (PWGSC) as specified in contract number EW699-103892, project number R.044325.002. The EA report is in compliance with the *Canadian Environmental Assessment Act* (*CEA Act*). The Notice of Commencement for the EA has been entered into the Canadian Environmental Assessment Registry (CEAR), and was assigned reference number 11-01-63723, entitled "Former Landfill Remediation, Drumheller Institution, Alberta". It pertains to the physical project activities associated with proposed remediation/risk management work for the former landfill at the Correctional Services Canada (CSC) facility in Drumheller, Alberta. The physical work in question includes erosion control and slope improvements to remove physical hazards, as well as in-situ passive remediation to address water quality impacts.

1.1 Canadian Environmental Assessment Act

Section 5(1) of the *Canadian Environmental Assessment Act (CEA Act)* states:

> *"An environmental assessment of a project is required before a federal authority exercises one of the following powers or performs one of the following duties or functions in respect of a project, namely, where a federal authority*
>
> (a) is the proponent of the project and does any act or thing that commits the federal authority to carrying out the project in whole or in part;
>
> (b) makes or authorizes payments or provides a guarantee for a loan or any other form of financial assistance to the proponent for the purpose of enabling the project to be carried out in whole or in part, except where the financial assistance is in the form of any reduction, avoidance, deferral, removal, refund, remission or other form of relief from the payment of any tax, duty or impost imposed under any Act of Parliament, unless that financial assistance is provided for the purpose of enabling an individual project specifically named in the Act, regulation or order that provides the relief to be carried out;
>
> (c) has the administration of federal lands and sells, leases or otherwise disposes of those lands or any interests in those lands, or transfers the administration and control of those lands or interests to Her Majesty in right of a province, for the purpose of enabling the project to be carried out in whole or in part; or
>
> (d) under a provision prescribed pursuant to paragraph 59(f), issues a permit or licence, grants an approval or takes any other action for the purpose of enabling the project to be carried out in whole or in part."

The proposed project is a physical work being conducted on federal government land by a federal government department, therefore a screening-level environmental assessment is required under Sections 5(a) and 5(b) of the *Canadian Environmental Assessment Act* (*CEA Act*).

1.2 Regulations under the *CEA Act*

FRANZ reviewed the following regulations, established under the *CEA Act*, with respect to the proposed project:

1. **The *Inclusion List Regulations*** contain a list of physical activities that are specifically identified for the purpose of the definition of a project under the *CEA Act*. The inclusion list identifies some types of physical activities that have the potential to cause significant negative effects.

2. **The *Law List Regulations*** provide a list of the federal statutory and regulatory approvals that trigger the need for an EA under the *CEA Act*.

3. **The *Exclusion List Regulations*** list certain projects that are generally related to physical works but are not foreseen to have significant environmental effects. These projects do not require an EA under the *CEA Act*, if they fall within these regulations.

4. **The *Comprehensive Study List Regulations*** contain a list of projects that require a comprehensive study. This type of EA is a more in-depth review, which includes all the factors required for a screening, as well as additional factors, and makes provisions for mandatory public participation and follow-up.

It was determined that the above Regulations do not apply to the proposed project.

1.3 Roles and Responsibilities

The *CEA Act* sets out the responsibilities and procedures for environmental assessment of projects involving the federal government. CSC is the proponent of the remediation project, and will fund the work assuming that the project is approved and implemented. CSC will therefore act as lead Responsible Authority (RA) for the EA at the federal level, but has delegated responsibility to PWGSC to conduct the EA. PWGSC will manage the EA process to ensure the successful completion of the project. Final authority for the project will rest with CSC.

As the project proponent, CSC is responsible for registering the EA with the CEA Agency, for conducting federal co-ordination and registering the decision once the EA is complete. CSC is also responsible for ensuring the EA is completed in compliance with the *CEA Act* prior to making any irrevocable decisions with respect to project implementation. CSC has scoped the assessment as a “screening-level” EA under the *CEA Act.*

1.4 Project Contacts

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2.0 PROJECT INFORMATION

This section explains why the project is required, provides a general description of the proposed project work and discusses what activities are necessary to implement it. All work undertaken in the proposed project will utilize best practices and common industry standards.

2.1 Site and Surrounding Area

The Drumheller Institution is situated on the subject site (Site 530-L01), located 5 kilometres south-southeast of Drumheller, Alberta (Figure 1, Appendix A). Drumheller is situated within the Red Deer River valley in the badlands of east-central Alberta, approximately 110 kilometres northeast of Calgary. The institution opened in 1967 and provides accommodation for medium-security inmates. An inactive landfill is located approximately 500 m southeast of the institution on the edge of a coulee. It covers an area measuring approximately 150 m x 200 m. The former landfill was constructed in a series of trenches, and received waste from the institution for more than 20 years, from the mid-1960s until its closure in the late 1980s (UMA 2000). The waste material in the landfill consists of domestic waste and demolition material such as pipes, concrete, and building materials from renovations at the institution. The waste was pushed over the top edge of the slope into the coulee. The landfill was not engineered or built in compliance with landfill construction guidelines. The surface of the landfill has historically been used as a burn area and is occasionally used to store spoil piles from the excavations around the site. The topsoil and subsoil layers were not separated for use as cover before the landfill site was closed.

A groundwater seepage is present in a steep gully 20 m north of the landfill, about 5 to 10 m below the elevation of the top of the landfill (FRANZ, 2011b). The seepage water drains into a creek at the base of the coulee. The water in the creek discharges into the Red Deer River, approximately 4.5 km downstream of the site. The steepness of the landfill slope limits accessibility.

To the immediate west side of the landfill is an unpaved gravel access road connecting the institution and the landfill area. The coulee is located to the immediate east side of the landfill. Grazing pasture land surrounds the landfill on the north and south sides. A photographic log of the site is provided in Appendix B.

2.2 Project Background and History

Several investigations have been completed at the Site and reviewed by FRANZ. The most relevant reports detailing these previous investigations are listed below, and are provided in Appendices C through I.

- Supplemental Investigation and Biological Site Survey for the Drumheller Institution Site No, 530 Landfill, Drumheller, Alberta, by Franz Environmental Inc., January 2012.

- *Data Gap Analysis Slope Remediation Works Drumheller Institution Landfill Site, Drumheller, Alberta*. Prepared by Houle Chevirer Engineering Ltd., January 2012.
- Supplemental Environmental Site Investigation and Data Gap Analysis for the Drumheller Institution Site No. 530, Drumheller, Alberta, by Franz Environmental Inc., October 2011b
- *Update memo – Drumheller Institute Site No 530 Cost Estimate Former Landfill Site 530-L01: Option 4: Completed Landfill Removal and Re-location*. Prepared by Franz Environmental Inc., May 2011c.
- *Environmental Site Investigation and Slope Stability Study for the Drumheller Institution Site No. 530, Drumheller, Alberta*. Prepared by Franz Environmental Inc., March 29, 2011a.
- *Supplemental Phase II Investigation, Site 530-L01, Landfill, Drumheller Institution, Drumheller, Alberta.* Prepared by Franz Environmental Inc., March 2006.
- *Phase II Environmental Site Assessment Drumheller Institution.* Prepared by UMA Engineering Ltd., March 2000.
- *Correctional Services Canada, Environmental Baseline Assessment, Drumheller Medium Security Institution, Site Number 530, Volume 1 of 4: Phase I Environmental Site Assessment.* Prepared by PWGSC, February 10, 1999.

The Environmental Site Investigation and a Slope Stability Study at the former landfill, conducted by FRANZ in 2010-11, recommended that remediation/risk management work be undertaken to address issues related to slope stability. This work would include implementation of erosion control and slope improvement measures to remove physical hazards, as well as in-situ passive remediation to address water quality impacts. CSC now plans to carry out the recommended physical work.

2.3 Project Rationale

2.3.1 Rationale for Slope Stability Work

In 2010, FRANZ conducted a preliminary qualitative slope stability analysis at the Former Landfill Site using existing information on the soil/waste properties and new topographic data acquired during the 2010 site investigations (FRANZ, 2011a). Supplemental investigations and data gap analyses were completed in 2011 by FRANZ (2011b, 2012) and Houle-Chevrier Engineering (2012) to update the existing information.

Some signs of slope instability were observed at the subject site, as indicated by tension cracks on the table lands along the east side of the landfill. The fissures were observed to extend to a depth of at least 1 to 2 metres below ground surface and were about 300 millimetres wide at the ground surface. It was noted that the cracks may extend beyond this depth (FRANZ, 2011a).

An existing deep failure zone was observed at the northeast end of the landfill. In the vicinity of the failure the slope has a height of about 19 metres and is generally inclined at about 40 degrees from the horizontal. The failure zone extends about 4 to 5 metres back from the original crest of the slope and has a width of about 3 to 4 metres at the top of the failure zone. At time of the site reconnaissance, a near vertical failure scarp several metres in depth was observed at the location of the failure. A small frozen spring was observed at the base of failure zone, indicating that the failure may have occurred as a result of concentrated groundwater/surface runoff from the tableland to this portion of the landfill (FRANZ, 2011a).

The factor of safety of a slope is defined as the ratio of the magnitude of the forces which tend to cause the slope to fail to the magnitude of the forces which resist failure. A computed factor of safety of less than 1.0 indicates a slope that is unstable; a factor of safety of 1.0 to 1.3 is considered to represent a slope bordering on failure to marginally stable, respectively; a factor of safety of 1.3 to 1.5 is considered to indicate a slope that is less likely to fail in the long term and provides a degree of confidence against failure ranging from marginal (1.3) to adequate (1.4 and greater) should conditions vary from the assumed conditions. A factor of safety of 1.5, or greater, is considered to indicate adequate long term stability and is the target value for the site. The loss of existing vegetation along the face of the slopes or the placement of fill along the crest of a slope will reduce the factor of safety.

Table 2–1: Summary of Computed Factors of Safety for Existing Slope Conditions

Location of Slope Analysis	Computed Factor of Safety Against Overall Failure of the Slope
North Section	1
Middle Section	1.1
South Section	1.4
Existing Slope Failure	0.8

Excerpted from: Data Gap Analysis, Slope Remediation Work, Drumheller Institution Landfill Site, Drumheller, Alberta, Houle Chevrier Engineering Ltd., January 2012.

Based on the results of this analysis, it was determined that the slope was at its maximum angle of repose and that the landfill posed a significant physical hazard that required remedial action. The objectives of the proposed slope stabilization work, therefore, are to remove the physical hazard to humans, livestock and wildlife by reducing the slope and channeling groundwater away from the slope face (FRANZ, 2011a).

2.3.2 Rationale for Enhancement of Natural Attenuation of Surface Water

Water seeping from the toe of the landfill on the north side was not in compliance with CCME water quality criteria for cadmium, barium, arsenic and iron (FRANZ, 2011b). The water ultimately drains into the Red Deer River via an ephemeral creek, potentially posing unacceptable risk to downstream components (Figure 2, Appendix A). The sample location with the highest exceedances over guidelines was collected at the outflow of a small wetland characterized by hydric, peaty soil and aquatic plant species, where the water table was just beneath the ground surface. This area is assumed to be fed by groundwater from the former landfill.

Typically, water saturating organic soil is anoxic and rich in dissolved iron. Although porewater chemistry is not available for the small wetland, it is evident that water daylighting from the wet soil to a small, flowing creek at SEEP1A contains relatively high concentrations of particulate iron hydroxides. Data in support of this conclusion includes the decrease by two orders of magnitude in total iron between SEEP1A (23 mg/L) and SEEP 1B (0.4 mg/L; located approximately 50 m downstream of SEEP 1A), with only a slight decrease in dissolved iron (0.25 to 0.16 mg/L) over the same distance (FRANZ, 2011b). Field observations corroborate these analytical results; Photo 18 in Appendix B shows the bright orange colour of colloidal iron oxides at the SEEP1A sampling location, and a biofilm (“sheen”-like appearance, with angular edges) of iron-reducing bacteria on the surface. (These bacteria are typically present where oxidized iron is readily available for use as a terminal electron acceptor.)

Natural attenuation of metals in the groundwater is already taking place, as metals sorbed to iron hydroxide particles are being removed from solution when the particulate matter is deposited on the sediments. The process of oxygenating the outflow from the wetland is important from the perspective of removing inorganic constituents that are readily sorbed to iron hydroxides (e.g. arsenic, cadmium). In addition to this process, it is likely that the small wetland removes metals from solution by sorption to the highly organic soil. It is therefore desirable that the wetland be left in place.

The objectives of the proposed enhancement of natural attenuation are to increase the performance of the existing natural attenuation process of scavenging of inorganic contaminants by iron hydroxide precipitation, and to decrease the likelihood of exposure of ecological receptors and livestock to these contaminants in surface water.

2.4 Alternatives to the Project

The following studies were conducted to develop and evaluate possible methods to achieve the desired remedial objectives:

- In 2010, FRANZ was retained by PWGSC on behalf of CSC to complete an Environmental Investigation and Slope Stability Study at the Drumheller Institution. Three options were proposed to mitigate the water quality impacts in the seepage, and two options were proposed to address the slope instability.
- An additional option (supplemental option 4 *entitled Update memo-Drumheller Institute Site 530 Cost Estimate Former landfill Site 530-L01: Option 4: Completed Landfill Removal and Re-location)* was proposed to address both the water quality impact and the slope stability issue simultaneously.
- Houle-Chevrier Engineering completed a *Data Gap Analysis for the Slope Remediation Work, Drumheller Institution Landfill Site in Drumheller, Alberta* to present possible construction options and construction approaches for consideration, and to provide an indication of what additional information is required to select a preferred construction option and to carry out a detailed design of that option for tendering.

2.4.1 Alternatives to Proposed Enhancement of Natural Attenuation

Four conceptual remedial and risk management options were presented in the FRANZ report entitled *Environmental Site Investigation and Slope Stability Study for the Drumheller Institution Site No. 530, Drumheller, Alberta*, dated March 29, 2011 to mitigate potential exposure of human and ecological receptors to site contaminants detected in the seepage at concentrations exceeding CCME FWAL:

- Option 1 – Long-term monitoring;
- Option 2 – Passive in-situ treatment and monitored natural attenuation; and,
- Option 3 – Risk assessment.

The evaluation of these options is presented below.

<u>Option 1: Long-term monitoring</u>

The goal of the long-term monitoring program would be to ensure that present and future risks are negligible and that monitoring could be terminated with confidence, based on findings of no risk and no degradation of the environmental conditions at the site. The program would be developed specifically to:

- Evaluate metal concentrations in groundwater over time
- Inspect and monitor surface water integrity, flow rates, channelling and physical conditions
- Monitor metal concentrations in surface water over time, and
- Ensure the protection of human health and the environment from exposure to chemicals of concern.

Both passive and active monitoring would be undertaken at the property. A site inspection program would be conducted to observe the physical condition of the surface water bodies, including sediments. An active groundwater and surface water monitoring program would be developed upon which future risk management decisions could be based. This plan would effectively provide an early warning system that could be implemented in association with a contingency plan and could provide the decision criteria for termination.

Option 2: Passive in-situ treatment and monitoring natural attenuation

In recent years, a variety of passive treatment systems have been developed that do not require continuous chemical inputs and that take advantage of naturally occurring chemical and biological processes to treat metal impacted waters. The primary passive technologies include constructed wetlands, anoxic limestone drains (ALD), successive alkalinity producing systems (SAPS), limestone ponds, and open limestone channels (OLC).

For the former landfill site, the existing drainage systems at the toe of the landfill could be modified to reduce the surface water/sediment metal loading to the environment by:

- providing a predictable and steady flow path to the discharge points by enhancing the physical drainage systems with weirs, banks or channels to avoid overflow, flooding or hydraulically cross-connecting with other low-lying areas during heavy run-off periods; and,
- enhancing the natural treatment system to trap or remove metals along the flow path.

Prior to implementation, this approach would require that the site be well characterized and that the processes which affect surface water and sediment chemistry be well understood. For this option to be successful, an in-depth evaluation of the chemical, biological and physical characteristics of the site would need to be conducted by means of seasonal monitoring, detailed hydrologic studies and bench-scale treatment tests.

Option 3: Risk assessment

A screening-level risk assessment (SLRA) was considered to determine potential for unacceptable levels of risk to human health and ecological receptors. The outcomes of the risk assessment would subsequently be used to guide the selection of long-term strategies for the site.

The main elements of the risk assessment would include:

- Chemical hazard assessment;
- Receptor identification;
- Exposure pathways and assessment; and

- Qualitative risk characterization and estimates.

A summary of the options to address contamination in seepage water, presented in the FRANZ report entitled *Environmental Site Investigation and Slope Stability Study for the Drumheller Institution Site No. 530, Drumheller, Alberta*, dated March 29, 2011, is provided in Table 2–2 below.

Table 2–2: Remedial Options to Address Contamination in Seepage

OPTIONS	**Option 1 Long Term Monitoring**	**Option 2 Enhancement of Natural Attenuation**	**Option 3 Risk Assessment**
Project Goals	Ensure the protection of human health and environment from exposure to chemicals of concern.		
Operating Principle	Complete detailed monitoring of surface water and sediments, as required. Evaluated data based on trigger criteria and contingency plans	Enhance the natural removal of metals along the surface water flow systems prior to discharge to receiving bodies. Enhancements would include surface water drainage routing and construction of wetlands and filters to reduce chemical concentrations.	A screening-level risk assessment could be completed to determine the potential for unacceptable levels of risk to human health and ecological receptors.
Protection of Human Health and the Environment	Yes	Yes	Yes
Degree of Site Disruption	Low; once a year monitoring round	Moderate; construction of wetland	Low; no on-site work
Confidence Level of Successful Outcome	Moderate to Low; not effective in short term	Moderate; effective over long term	N/A
Estimated Time for Implementation	Long-term (>10 years)	2-3 years	3 months
Long-term Effectiveness	No; impacts naturally attenuate over time	Yes; elevated natural attenuation by wetland	N/A
Ease of Implementation	Low. Requires yearly monitoring visits.	Moderate, studies required	N/A
Estimated Capital Costs	$84,400	$387,500	$94,400
Estimated Operating Costs	$75,000	$75,000	$0
Total Estimated Remedial Costs	$159,400	$462,500	$94,400

No option was put forward as the preferred option at this initial stage of evaluation.

2.4.2 Alternatives to Proposed Slope Stabilization Work

Two options to mitigate the physical hazards represented by the unstable slope conditions were proposed in the FRANZ report entitled *Environmental Site Investigation and Slope Stability Study for the Drumheller Institution Site No. 530, Drumheller, Alberta*, dated March 29, 2011 and are summarized as follows:

- Regrade the slope, and (if required)
- Implement erosion control measures and other slope improvements.

The evaluation of these two options is presented below.

<u>Option 1: Regrade the Slope</u>

This option would involve regrading the slope on the face of the landfill. To increase the stability of the slope to an acceptable factor of safety, the slope angle should be reduced to about 2.5 horizontal to 1 vertical, or flatter. This could be achieved by either removing existing material from the crest of the slope and placing it on the lower portions of the slope ("cut-and-fill" approach) or, alternatively, by importing fill material such as blast rock and placing it on the face of the slopes ("belt" approach). The blast rock fill should consist of well graded, competent, non-argillaceous blast rock material (limestone, dolostone or sandstone, for example), having a maximum size of approximately 400 to 500 millimetres. Alternatively, the slope could be regraded with glacial till in combination with surface erosion protection. The estimated amount of fill materials required to regrade the current slope angle to a 2:1 slope was 9,332 m^3.

Prior to placing the fill material, the existing topsoil would need to be stripped from the area. The fill material would be benched into the existing slopes at regular intervals. Care would be taken during excavation of the benches to ensure that the works not adversely affect the overall stability of the existing landfill waste material. The toe of the stabilizing fill would be keyed into the underlying native soils along the base of the landfill.

Any excavation works along the base of the landfill and on the landfill slopes would be protected from groundwater runoff and rainfall events. Periodic inspections would be performed, and if signs of instability were observed, the excavations would be backfilled immediately.

The final slope angle to which the landfill slopes would be graded would depend on the future use of the landfill area. The final grading could also be influenced by aesthetic requirements for the finished landfill.

To confirm the assumptions on which option 1 was based, an additional investigation was conducted at the former landfill in November 2011. The goal of this investigation was to confirm

the depth to waste, type(s) of waste(s) and concentrations of potential contaminants in native soil and in cover fill material. The following findings were documented:

- Domestic and general construction waste were identified in the former landfill and their extent is well defined. Provisions can be made to segregate and manage the waste(s) encountered during construction if required.
- The site specific health and safety plan developed in support of the RAP will include provisions to contact CSC staff should any tear gas canisters (similar to the one found in August 2011) be encountered during construction.
- Localized areas of impacted soil were identified in three (3) test pits located at the top of the former landfill. Reported concentrations marginally exceed selected CCME CSQGs and the extent of impacted soils is well defined.
- Provisions to segregate and manage impacted soil during construction have been included in the RAP. Off-site disposal of impacted soils segregated during construction is not considered likely based on the types of contamination encountered and reported concentrations, however there will be contingency plans to do so during construction, if necessary.

<u>Option 2: Erosion Control and Other Slope Improvements (if Required)</u>
Final control measures will be implemented as required following re-grading of the slope based upon the method selected and materials used. Depending on the type of material used (i.e. rock or high density glacial till), the stability of the re-graded slopes could be negatively affected by erosion. If native sandy silt soils were used to re-grade the slope, the upper portions of the re-graded slope would have to be covered with vegetation to reduce the potential risk of surficial erosion. This would be achieved by seeding and mulching graded portions of the slope or placing commercially available erosion mats following final grading. Tree roots also help to stabilize slopes. If native soils are used to re-grade the slope, native trees should remain in place where possible or replaced with new trees in areas where removal was required to conduct the necessary grading work.

Other erosion control measures could include the construction of drainage swales or other channels to direct surface water drainage.

2.4.3 Supplementary "Option 4"

In May 2011, PWGSC requested that FRANZ consider another option – full excavation and removal of the fill and waste materials at the former landfill site, which would address both the contaminant impacts and slope stability control. FRANZ completed an additional remedial option plan presented in the report entitled "*Update Memo – Drumheller Institute Site No. 530, Cost Estimate Former landfill Site 530-L01: Option 4: Completed Landfill Removal and Re-location*". The strategy described in the memo is presented below.

Due to the difficulty of site access (and unstable slopes), landfill materials could be recovered by using a truck-mounted or stationary, anchored crane and clam shell attachment for non-metallic debris. The crane would be mounted on the upper bench of the landfill and debris would be transported from the slope and toe of the landfill to the upper bench, where loaders would then move the debris to a temporary staging ground located for sorting/screening. The screening process would be needed to reduce the volume requiring disposal at the landfill. Upon completion of the screening process, native soil materials would be used as needed backfill material for slope stability and other materials would be transported to an off-site treatment facility.

The removal of the landfill would require the following activities:

1. Formulating a removal strategy including techniques, staging areas, sorting/screening and final disposal locations
2. Developing a strategy to ensure that methane gas is properly managed with respect to health and safety and fire protection
3. Excavating (using clam shell-type equipment to remove landfill waste), sorting, loading and disposal
4. Backfilling, compaction and slope re-grading
5. Final geotechnical and environmental inspections.

2.4.4 Selection of Proposed Approach

Passive in-situ treatment was deemed the most appropriate method to address metal impacts in seepage water, based on the expected long-term effectiveness of enhanced natural attenuation. The details of this option were modified, and proposed project work scaled back to reflect additional information gathered during the 2011 site investigation. Pertinent factors included observation of the low flow conditions at the seep and in the creek, and recognition of the importance of aerobic processes in precipitating metals from solution.

With respect to the slope stability work, the options above can be summarized as:

1) Re-grading of the slope combined with erosion control and other slope improvements; and,
2) Full excavation and removal of fill and waste materials.

Option 2 was rejected, as there was insufficient rationale for removing waste materials from one landfill simply to deposit them in another landfill and because the location and extent of hazardous materials previously placed in the landfill has yet to be defined. As such, potential costs to implement this option could not be estimated.

Option 1, re-grading combined with supplemental erosion control, was determined to be the most suitable alternative, as the objective was not to completely remediate the landfill, but rather rehabilitate the surrounding slope to prevent localized failures.

In 2011, an additional data gap analysis was prepared to help evaluate techniques to be used in re-grading the slope (Houle Chevrier Engineering Ltd., 2011). Two techniques were considered: import fill material to the site, or re-use existing, on-site material ("cut-and-fill" approach). The results of the data gap analysis are presented below.

Import Material to Site

- This option would not require significant disturbance of the existing landfill material which has been placed at the site, excluding stripping of the existing topsoil and vegetation, and benching of the slope.
- Additional space at the toe of the landfill would be required to construct the berm along the toe and slopes of the existing landfill. To quantify the space required, assuming the current slopes are at a 1 horizontal to 1 vertical side slope, an additional 1.5 metres of land would be required at the base of the slope for each metre in height difference between the toe (base) and crest (top) of the landfill.
- An available source of suitable material (such as a rock fill or glacial till) would be required within a reasonable distance of the site. Such a source could consist of a quarry in non-argillaceous rock, or possibly a large excavation through glacial till or granular soils.
- If coarse rock fill materials were used on the slope face, it is unlikely that the slope would become re-vegetated, and as such, the visual impact of the landfill would be increased. This could be mitigated somewhat by the use of suitable earth fill material which could be vegetated, if it were available (possibly with the assistance of proprietary vegetated soil systems).
- Construction of an in-situ passive treatment system would likely require controlling and containing the existing surface and groundwater flow (where present) through the landfill material and the stabilizing berm. The use of rock fill material on the face of the landfill would not create preferred drainage paths (as the material as a whole would have a very high permeability) unless the base on which the rock fill material is placed is prepared and shaped to promote drainage towards the desired area. Similarly, a lower permeability earth fill would not allow drainage of groundwater unless drainage measures (such as a perforated pipe drain or granular "French drain") were installed within the berm.

Re-Use of Existing, On-Site Material ("Cut-and-Fill" Approach)

- This option would require significant disturbance of the existing landfill waste material which has been placed at the site and may be of concern from both an environmental and health and safety perspective since the composition and extent of waste that could potentially be encountered within the former landfill is not fully known at this time.
- Excavated landfill material would be placed, in a controlled manner, downgradient of the cut-fill line, and compacted in place. Some sorting of unsuitable/undesirable landfill waste material would be carried out during the construction.
- Less fill material and thus less space would be required at the toe of the slope using a cut and fill approach than if imported material were placed at the base of the slope. Moving material from the top of the slope reduces the volume of fill that needs to be placed at the base of the slope to achieve the desired slope gradation. The final amount of fill and the space required at the toe of the slope would depend on the position of the cut-fill line through the existing landfill material. Where space constraints dictate, the landfill waste could be cut back to the proposed slope gradation (i.e. 2.5 horizontal to 1.0 vertical) at the location of the existing toe of the slope and any excess material could be used at an alternative location, or removed from the site.
- A reduced amount of material would be required to be brought to the site, and reduced traffic through the site would occur, compared with importing material to the site.
- While less fill material would need to be imported to the site using the "cut and fill" option, there may be significant additional costs if excess waste were encountered while excavating in the former landfill. The associated costs to segregate, remove and dispose of excess landfill material from the site could offset some, or all, of the potential cost savings realized from reducing the volume of fill imported to the site;
- It is understood that the existing landfill was constructed without compaction and as such voids may be present within the landfill, and may be holding groundwater. Excavation and placement and compaction of the existing landfill waste may disrupt these drainage patterns. The erosion control measures mentioned previously could be implemented to maintain existing surface water drainage and assist with the control and management of the groundwater at the site.

Based on this data gap analysis, FRANZ determined the optimal design would involve using a modified cut-and-fill approach to address the physical hazard associated with the area of highest instability (northeast section) in the landfill, together with installation of erosion control measures to channel water away from the landfill to stable land. Material would be removed from the steepest, least stable area of the current slope and deposited in the lower portion of the more stable section (southeast) of the landfill. This approach entails the following considerations.

- The cost of importing fill materials would greatly exceed using on-site materials.
- Reducing the area to be disturbed, and placing the "cut" materials in another section of the landfill would mean that the small wetland could be kept in place, undisturbed, rather than filled in.
- Disturbance of landfill materials (and, potentially, associated contaminants) would be minimized.
- Water movement through the regraded area would be limited to natural groundwater flow patterns, as additional surface water flow would be directed away from the area of least stability.

2.5 Regulatory Requirements

Table 2–3, below, presents contact information for relevant agencies.

Table 2–3: Contact Information

Federal/provincial/municipal Government Agency	Contact
Fisheries and Oceans Canada (DFO)	Pacific Fisheries and Oceans Canada Suite 200 - 401 Burrard Street Vancouver, British Columbia, V6C 3S4 Telephone: 604-666-0384 Facsimile: 604-666-1847
Aboriginal Affairs and Northern Development Canada (AANDC)	Shannon Britton Environmental Officer Suite 300 9911 Chiila Boulevard TSUU T'INA, AB T2W 6H6 Telephone: 403 292 5614
Correctional Services Canada	Mark Slacke M.Sc. Environmental Officer/ Agent en environment CSC - Technical Services Telephone : 613.944.5673 Facsimile : 613.996.9421 slackema@csc-scc.gc.ca
Alberta Environment	George Chalut Southeast Region, Land Use Planner Land Use Planning Section Historic Resources Management Branch Alberta Culture and Community Spirit Old St Stephens College 8820 - 112 Street Edmonton, Alberta T6G 2P8 Telephone 780-431-2329 Facsimile 780-422-3106
Town of Drumheller	General Contact Information Town of Drumheller 703 - 2nd Avenue West Drumheller, Alberta T0J 0Y3 Telephone: (403) 823-6300 Facsimile: (403) 823-7739

2.6 Project Scope

The Former Landfill site at the Drumheller Institution will be remediated by: stabilizing the slope to remove physical hazards and reduce the potential risk of slope failure; and enhancing natural features at the site to reduce concentrations of metals in the surface water and groundwater discharged from the former landfill by means of in-situ passive attenuation.

The work program will be conducted over a two-year period (i.e. 2011 and 2012). A cut and fill excavation program will be completed to reduce the slope at the coulee in the vicinity of the former landfill to an angle of 2.5 horizontal to 1 vertical. This will be done by excavating soil from the top of coulee/former landfill area and placing it at the toe (base) of the coulee/former landfill area until the desired angle is achieved. Placed soil will be graded and compacted as required to achieve the proper slope angle. Existing natural features along the surface and base of the coulee will be augmented to naturally attenuate metals in surface and groundwater emanating from the former landfill and discharging into the creek.

It is anticipated that the work program will include implementation of slope stability measures, constructing a natural attenuation zone for surface and groundwater and developing long-term site monitoring requirements. The proposed work is expected to take place in 2012.

Once construction work is completed, the remediated landfill will remain in place indefinitely, i.e. the installation will not be decommissioned. It is envisioned that the site will be inspected periodically by a geotechnical engineer to assess slope stability over time and that a surface and groundwater sampling program will be implemented to assess the performance of the natural attenuation zone.

The anticipated work area is shown in Figure 2, Appendix A and includes the following:

- The former landfill site
- An excavation soil borrow source at the top of the former landfill/slope
- Soil stockpiling areas at the top of the table lands and at the base of the former landfill
- An equipment storage area
- A site office/trailer
- Access routes to move equipment to/from the work areas at the top and bottom of the former landfill
- Access routes to move to/from the former landfill site.

2.7 Project Description

The project will comprise two components:

- Slope Stabilization Work – removing the physical hazard to humans, livestock and wildlife by reducing the slope and directing surface water away from the slope face.

- Enhanced natural attenuation - enhancing the existent natural attenuation process of scavenging of inorganic contaminants by iron hydroxide precipitation, and decreasing the likelihood of exposure of ecological receptors and livestock to these contaminants in surface water.

2.7.1 Project Activities

Installation of the proposed facilities will consist of several steps that will be executed in succession. These steps are expected to include:

- Preparation of site access routes
- Preparation for both the excavation and soil stockpile areas;
- De-grubbing of soil excavation areas (as required);
- Set-up of equipment at both the excavation and soil stockpile areas;
- Installation of surface water control measures (as required) at excavation and stockpile areas;
- Excavation, loading and hauling of soil from top of slope (northeast portion);
- Placing, grading and compacting of soil at base of slope (southern portion);
- Final seeding and grading to restore work areas; and,
- Site clean-up and restoration
- Long-term monitoring and inspection.

A more detailed project description, including engineering specifications, will be developed and appended to the EA report prior to the initiation of the work program.

2.7.2 Project Components

For the purpose of assessing potential environmental effects, the proposed project has been divided into the following components:

1. Site preparation;
2. Transportation of materials and equipment
3. Cut and fill of slope;
4. Excavation and placement of excavated soils;
5. Drainage control measures;
6. Natural attenuation;
7. Resource and materials use.

Details of each component, relevant to the EA report, are described below.

2.7.2.1 Site Preparation

Prior to commencing the cut and fill operation, the following activities may be required:

- Utility clearances and capping,
- Upgrades to access gravel roads and culverts,
- Layout and construction of access routes to get from top of landfill to slope work areas, and
- Designation of soil/fill stockpiling and handling areas.

In the unlikely event that a clay borrow source is required, its location should be identified and established in the hills adjacent to the site, within the boundaries of the CSC property.

At this time, no major improvements or upgrades are anticipated to the local road network situated on the agricultural and table lands in the vicinity of the former landfill. Proposed minor improvements include temporary support of livestock grates and placement of temporary culverts in areas where small creeks or ditches are crossed. In addition, granular A or B fill will be imported, placed and compacted, as required, so that heavy equipment can be driven to the desired work locations in the vicinity of the former landfill.

Excavation and soil stockpiling work sites will be prepared and positioned so that surface water runoff, erosion and sediment/soil runoff are kept to a minimum. Site preparation may include surveying, removal of surface vegetation around the excavation and soil stockpiling sites, de-grubbing, topsoil stripping, storage, and levelling. These activities will be conducted as required.

At the soil excavation site(s), surface vegetation will be removed and some trees trimmed, i.e. those located directly below the proposed work area (see Photos 1 and 2, Appendix B). No clearing of vegetation will be required near the creek banks.

The soil stockpile area will be located near the base of the slope, on level land, between the slope and the creek (see Photos 3 and 4, Appendix B). Soil stockpile locations will be cleared and levelled before soil is stockpiled.

All work will occur on CSC owned lands. The work areas will be cleared and levelled and a berm will be installed around the perimeter of each work site. The ground surface on the work sites and access roads will be made suitable for heavy trucks and loaders.

Noise and dust levels will be measured at the outset of the project at both the excavation and soil stockpile work areas, to provide baseline data against which to compare monitoring data throughout the construction phase. Given the remote location of the site, additional noise buffering measures are not considered necessary.

Fencing will be erected around the excavation and soil stockpile sites to protect wildlife, and the length of time excavations are left open will be minimized.

2.7.2.2 Transportation of Materials and Equipment

It will be necessary to transport equipment to the excavation and soil stockpile work sites at the former landfill located on the Drumheller Institution property. Equipment transportation will be conducted by qualified companies. It is anticipated that the equipment will be delivered to the work areas by means of flatbed transport trucks. Drumheller Institution is accessed via Hwy 9. Once contractors arrive at the entrance of the Institution they will be escorted to the former landfill via an unpaved gravel road.

Officials from the City of Drumheller, CSC and the Alberta Ministry of Transportation will be contacted to review details of the equipment transportation plan being developed for this project. It is estimated that up to ten trucks would be utilized to transport project equipment and materials and that between one and five tandem or tri-axle trucks would be utilized per day to haul excavated soil from the top of the former landfill and place it at the soil stockpile area situated adjacent to the base of the former landfill.

While no load bearing issues are anticipated, a traffic control plan may be necessary during equipment transportation to minimize disruption of traffic flow and ensure no obstruction to emergency response vehicle routes. Traffic control measures could include modifications to signal light patterns, a police escort and/or manual traffic signals. If required, a traffic control plan will be drawn up prior to the commencement of project work.

2.7.2.3 Cut and Fill of Slope

Cut and fill is a process used to stabilize slopes in situations where it is not practical to import and place large quantities of fill materials, or in locations where the subsurface environment can be disturbed without adverse environmental effects.
The “cut” portion of the proposed work program will involve excavation and placement of soils. It is proposed that the work would be completed in the following phases:

1. Remove (cut) soil and fill from the surface of the slopes at the designated locations. The present grade of the slope is shown in Figure 3 and the cross-sections indicating the desired grades after soil/fill material is removed are provided in Figures 4 and 5.
2. Construction of soil and management areas at the top of the former landfill site in close proximity to the slopes being cut, but within boundaries of the landfill. In all likely hood work will progress from the top of the site down the face of the slope (subject to contractor confirmation) and it may be necessary to stockpile material at the top of the landfill before it is spread out;

3. Segregation and removal of waste material from the soil and fill removed from the slope, as required by stakeholder agreement;
4. Segregation and management of contaminated soils are required in the stakeholder agreement;
5. Removal and transportation of waste material and contaminated soils to an approved off-site landfill for disposal (if and when required);
6. Surveying of final grades along the slope using 3-D laser survey (Faro Focus or equivalent); and,
7. Verification sampling of the resulting slope face, as applicable.

Successive rounds of excavation may be required depending on field observations until the desired grades on the slope face are met. Upon completion of the work, an as-built drawing should be signed and stamped by the geotechnical engineer responsible for the slope stability design.

The “fill” portion of the proposed work program will be completed in the following phases:

- Haul “cut” soil and fill to the top of the landfill;
- Temporarily stockpile it at designated locations;
- Allow for inspection of material by the departmental representative (both for environmental and geotechnical purposes);
- Segregate any waste material or impacted soil and dispose of it off-site as directed by the departmental representative;
- Spread remaining soil/fill in 0.3 m lifts at the top of landfill;
- Once all excavated soil/fill has been placed, cap it by placing a 0.3 m layer of silty clay above the final sub grade, place 0.10 m of topsoil above the silty clay and seed the topsoil; and,
- Survey final grades along the slope using 3-D laser survey (Faro Focus or equivalent).

Upon completion of the proposed work, an as-built drawing will be signed and stamped by the geotechnical engineer responsible for the slope stability design.

A schematic of the proposed slope stability set-up is presented in Figure 6, Appendix A.

2.7.2.4 Drainage Control Measures

The proposed work program to control surface water drainage will be completed in the following phases:

- Excavate channels to direct surface water flow away from newly constructed slopes and control erosion;’

- Excavate channels at desired locations from top of landfill across slope and along base of slope to direct surface water away from regraded slope (Figure 6, Appendix A);
- Use excavated soil to create desired grade/slope in each channel and to create berms around channels;
- Line channels with gravel or rip rap to promote surface water flow and avoid erosion;
- Direct flow to existing wetland;
- Surveying of final grades and locations of the drainage channels using 3-D laser survey (Faro Focus or equivalent).

Upon completion of the proposed work, an as-built drawing will be signed and stamped by the geotechnical engineer responsible for the slope stability design to indicate that the channels have been properly constructed as intended.

2.7.2.5 Enhanced Natural Attenuation

As stated previously, the existing wetland is naturally attenuating surface water migration from the landfill. Steps will be put in place to protect it during construction work on the adjacent slope and ensure that the peat and other native soils remain in place so that the natural attenuation process of scavenging of inorganic contaminants by iron hydroxide precipitation continues.

With regard to the proposed slope stabilization construction alternatives, the re-use of the existing site material (Option 2) will allow for the installation of additional drainage measures. These measures will be within the upper part of the landfill to divert surface water towards the wetland area and will provide the most available space for the construction / preservation of the wetland and any drainage measures along the toe of the landfill (Houle Chevrier, 2011).

Directing surface water flow away from the construction work area and through the wetland will control surface water migration from the site and enhance ongoing natural attenuation of dissolved phase metals. Groundwater migration from the site will also continue from the seep into the wetland.

2.7.2.6 Resource and Materials Use

The majority of materials needed to regrade the coulee slope in the vicinity of the former landfill, to construct the natural attenuation zone and to re-vegetate the surface of the reinstated slope will be brought to the work areas and assembled on site, and later disassembled and removed upon completion of the work. Excavations will be temporary, and it is anticipated that native soil will be removed from the top of the coulee and placed at the base of the coulee to stabilize the slope. Water used to wet seeded areas or facilitate the growth of planted vegetation will be obtained from a municipal hydrant in Drumheller and hauled to the work site by a water truck.

Alternately, some water may be obtained from surface water holding ponds at the work site or from the reach of the creek that traverses the site.

Any excess waste segregated from the former landfill that cannot remain on site will be disposed of in accordance with the requirements set out in *Standards for Landfills in Alberta* and *Environmental Code of Practice for Landfills*, if required.

Water will be used during seeding, to water planted trees or surface vegetation and for standard dust control practices to be implemented throughout the construction phase. Any excess water requiring disposal will be tested for compliance and disposed of according to the *CCME Canadian Water Quality Guidelines for the Protection of Aquatic Life* or in conformance with *Alberta Tier 1 Soil and Groundwater Remediation Guidelines*.

2.7.3 Project Schedule

A preliminary schedule specific to the slope stabilization and remediation activities is presented below:

Finalize RAP & Construction Specification	December 31, 2011
Selection of Construction Contractor by PWGSC	May 30, 2012
Completion of Initial Slope Stability Measures (to be confirmed)	August 31, 2012
Construction of Natural Attenuation Zone	September 30, 2012
Submission of “as built” drawings and final site plans	October 31, 2012

The above schedule is subject to contractor availability and weather and will be updated as required.

3.0 CONSULTATION AND COMMUNICATIONS

3.1 Public Consultations

Public consultations were not deemed necessary for the following reasons:

- The site is relatively remote.
- It does not hold any particular significance for First Nations people.
- With the exception of the Red Deer River, which the project is designed to help protect, there are no environmentally sensitive areas within 5 km of the site.
- The project is relatively small in scale.
- The purpose of the project is to improve environmental conditions at the site.

However, the public may obtain access to the Notice of Commencement and any other information regarding this project from the CEA Public Registry website (http://www.ceaa.gc.ca/050/index-eng.cfm). The Registry number is 11-01-63723.

3.2 Provincial cooperation

It was determined that there is no requirement for a provincial-level EA, as the project does not involve a “Mandatory Activity” under Alberta Regulation 111/93 of the Environmental Protection and Enhancement Act, Environmental Assessment (Mandatory and Exempted Activities) Regulation. Further, the proposed project, if approved, will be conducted on federal land, with a federal government department as the proponent.

The project description was shared with the Government of Alberta Ministry of Environment and Water (AEW), to determine which provincial bodies might have a regulatory interest in the project, or have any concerns with regard to the project or requirements for further involvement. AEW’s reply is attached as Appendix J. In brief, it was recommended that a Water Act application be submitted for the proposed project. However, after consultation with federal and provincial authorities, including Rob Simieritsch (by telephone) at AEW, it was subsequently determined that a *Water Act* approval would not be required, as there will be no disturbance to the wetland or other water courses, and erosion controls will be in place AEW undertook to review final plans to reconfirm the no Water Act approval is required. AEW also had the following comments:

- Any contamination issues need to be addressed as a component of the reclamation plan.
- Environmental monitoring should be considered if warranted.
- On Federal lands in Alberta, AEW would encourage the use of Alberta's criteria for soil and groundwater. Meeting these criteria would be required on any provincial lands in the vicinity of the site that could be impacted or on any federal lands at the site that could potentially be transferred to the Province of Alberta.

An environmental monitoring plan, if required, will be developed prior to initiation of earth works.

As the site is on federal lands, the criteria used for soil and groundwater will be the CCME guidelines. There are no plans to transfer lands to the Province of Alberta. AEW also coordinated consultation with other Alberta Government ministries, including:

- The Historic Resources Management Branch (HRMB of Alberta Culture and Community Spirit (ACCS)),
- Alberta Sustainable Resource Development (SRD),
- Alberta Health and Wellness (AHW), and
- Alberta Transportation (AT).

Of these, the HRMB of ACCS has a regulatory interest in this project but does not wish to participate in the federal review. Pursuant to Section 31 of the *Historic Resources Act*, should any archaeological resources, paleontological resources, Aboriginal traditional use sites and/or historic sites be encountered during development activities, the HRMB is to be contacted immediately for further direction. Contact information is given in Appendix J. No other departments had any regulatory requirements or concerns, or any need for further involvement in the project or the EA.

3.3 Federal cooperation

Environment Canada (EC) was consulted as part of the federal coordination process under the *Federal Coordination Regulation* to determine if they have a Section 5 trigger under the CEAA. EC has reviewed the Project Description for the proposed project and determined that EC is not a Responsible Authority (RA) under CEAA for the reasons listed in the response letter that is attached as Appendix J, and this document has been modified in accordance with Environment Canada's comments. Furthermore, EC provided the following specialist advice and expert information or knowledge on the proposal as per subsection 12(3) of the CEAA.

- *Species at Risk.* Section 79(1) and 79(2) of the Species at Risk Act indicated that an assessment of the environmental effects must be conducted and reported to the minister(s) if it is likely to affect a listed wildlife species or its critical habitat, measures must be taken to avoid or lessen those effects and to monitor them. In particular, EC requests that further guidance is required to protect Leopard Frogs and snake hibernacula at this site.
- *Migratory Birds*. EC provides timing restrictions as general guidelines for industry to protect the great majority of migratory birds while realizing the practicalities of development activities on the landscape.
- *Wetlands*. EC advised that one hundred metre setbacks should be utilized where feasible. For those wetlands where avoidance is not possible, the mitigation measures

and monitoring plan, as well as a proposed compensation plan, should be consistent with the principles of the wetland policy.

4.0 SCOPE OF THE ENVIRONMENTAL ASSESSMENT

4.1 Scope of the Project

The scope of the project includes the project's physical activities that are to be considered as relevant under the *CEA Act* environmental screening requirements. The key elements of the physical project are described in Section 2.

4.2 Factors to be considered in the EA Report

The present environmental assessment considered the factors set out in paragraphs 16(1)(a) through (d) of the *CEA Act*.

Subsection 16(1) of the *CEA Act* states:

16. (1) Every screening or comprehensive study of a project and every mediation or assessment by a review panel shall include a consideration of the following factors:

> (a) the environmental effects of the project, including the environmental effects of malfunctions or accidents that may occur in connection with the project and any cumulative environmental effects that are likely to result from the project in combination with other projects or activities that have been or will be carried out;
> (b) the significance of the effects referred to in paragraph (a);
> (c) comments from the public that are received in accordance with this *Act* and the regulations;
> (d) measures that are technically and economically feasible and that would mitigate any significant adverse environmental effects of the project; and
> (e) any other matter relevant to the screening, comprehensive study, mediation or assessment by a review panel, such as the need for the project and alternatives to the project, that the responsible authority or, except in the case of a screening, the Minister after consulting with the responsible authority, may require to be considered.

All of these factors have been considered and are specifically addressed in this EA report.

4.3 Scope of the Factors to be Considered

The EA considered the biophysical and socio-economic elements that could be affected by the physical project within the spatial and temporal boundaries of the project. The specific biophysical and socio-economic elements considered in this study were selected by applying a matrix approach (Section 6) to select from potential valued components discussed in Section 5.

The spatial boundaries associated with the analysis of biophysical and socio-economic elements encompass the work areas described in Section 2 (Figure 2, Appendix A). The study

area encompasses the proposed work area (the landfill, road access, the wetland and the natural attenuation area).

The proposed project is bounded temporally by the beginning date of the construction works, but since the proposed work would remain in place indefinitely, no further temporal boundaries apply. Construction work would take place during a two-week time frame, beginning after receipt of all approvals and permits. PWGSC anticipates receiving the necessary permits and approvals to conduct the work by November 30, 2011. Following construction, performance and environmental monitoring are anticipated to continue for at least two years, as described in Section 8, below.

4.4 Level of Detail Appropriate to the EA Report

The following factors were taken into consideration in determining the appropriate level of detail for this ESA report.

- The proposed project is not considered a large-scale project, as it is not anticipated to result in a large number of environmental effects, or in higher magnitude environmental effects. Most of the physical impact will be localized in the vicinity of the site and during the short period of time the physical work takes place, and monitoring activity afterwards, therefore effects to human or ecological receptors are expected to be minimal.
- The geographic location of the proposed project is relatively remote. No trans-boundary effects will occur as a result of the project. There are no significant unique or sensitive environmental resources or socio-economic conditions in the immediate area.
- Potential for the project to directly or indirectly affect area landowners or residents is essentially negligible. Aboriginal groups in the area do not use the land in question. No potential concerns have been raised by Aboriginal groups, non-governmental or local organizations, or members of the public. The land is owned by CSC.
- The Species at Risk Act requires that any federally-listed species at risk that could be affected by the project be identified in the EA report. It is not anticipated that any listed species would be affected by the project, although some verification may be required (see Section 5.1.12).
- Any mitigation measures employed in the project will conform to established industry standards and practices.

In summary, based on the fact the proposed project will affect a limited area, primarily comprising disturbed land, no significant public concerns are anticipated, and potential impacts to human and ecological receptors are expected to be minimal, the level of detail required in the EA report is not extensive.

5.0 ENVIRONMENTAL OVERVIEW

5.1 Biophysical Overview

Drumheller is located in the Prairies Ecozone which is a part of the Interior Plains of Canada. The relief consists of low-lying valleys and plains sloping eastward. The ecozone, spanning an area of 520,000 square kilometres, is nearly 94% farm land. It contains the majority of the country's productive agricultural cropland, rangeland, and pasture.

More specifically, Drumheller is in south-central Alberta, within the Moist Mixed Grassland Ecoregion, which includes the northern extension of open grasslands in the Interior Plains of Canada.

5.1.1 Climate

The Prairies Ecozone climate is determined by its location being in the centre of North America and by the neighbouring Rocky Mountains, which block moisture-bearing winds from the Pacific. This results in its sub-humid to semi-arid climate. Although dry, arctic air predominates in winter, periodic Chinook winds (strong, warm and dry) blow over the prairies from the Rockies, bringing spring-like conditions to southern Alberta, reducing snow cover and removing moisture from an already dry region.

Water deficit is typical of the Prairies as the Ecozone receives considerably less precipitation than other parts of Canada. High winds predominate in the ecozone. Mean annual wind speed in many places is 18 to 21 km/h. Wind accelerates evaporation, causing much of the dryness. In combination with precipitation and evaporation patterns, wind determines the amount of soil erosion and the resulting land degradation (Ecological Framework of Canada, http://sis.agr.gc.ca, accessed September 20, 2011).

The Moist Mixed Grassland Ecoregion is typically characterized by semiarid conditions and dark brown chernozemic soils. The mean annual temperature is between 2.5°C and 5°C. The mean summer temperature is 15.5°C and the mean winter temperature is -11°C. The mean annual precipitation ranges from 350 to 400 mm.

5.1.2 Vegetation

Native vegetation in the Moist Mixed Grassland Ecoregion is relegated to non-arable pasturelands, dominated by spear grass and wheat grass, and a variety of deciduous shrubs including buckbrush, chokecherry, wolf willow, and saskatoon. Patches of scrubby aspen, willow, cottonwood, and box-elder grow on shaded slopes of valleys and on river terraces to a limited extent, and meadow grasses and sedges cover non-saline depressional sites. Local saline soil areas support alkali grass, i.e. wild barley, red sampire, and sea blite (Ecological Framework of Canada, http://sis.agr.gc.ca, accessed September 20, 2011).

Agricultural crops include spring wheat, other cereal grains, and oilseed crops. During the 2011 site investigation, the site was observed to have 100% natural vegetation coverage, including approximately 75% grasses and 25% shrubs, mostly made up of aspens and poplars. There was no riparian vegetation observed along the creek at the toe of the landfill, as the creek is ephemeral.

Lands surrounding the former landfill are predominantly prairie grassland, some of which has been cultivated.

5.1.3 Soil

Soils in the prairies ecozone have been identified as dark brown chernozemic soils on clay overlaying on a lucustrine deposition. The Mixed Moist Grassland Ecoregion is composed of upper Cretaceous sediments and covered almost entirely by hummocky to kettled glacial till and level to very gently undulating, sandy to clayey lacustrine deposits (Ecological Framework of Canada, http://sis.agr.gc.ca, accessed September 20, 2011). Native soils at the former landfill site, as described in the FRANZ Supplemental Phase II report, are light brown to dark brown, and consist predominantly of fine-grained silty sand and clay.

Contaminants in soils in and around the landfill include arsenic, selenium, thallium, benzene, and toluene (FRANZ, 2006 and 2011).

The former landfill is covered, and contains primarily domestic waste and construction waste materials/debris from the correctional facility. It was reported by CSC that there is no hazardous waste present. The limits of the landfill material, cover fill material and native soils were confirmed by supplemental investigations conducted at the site in November 2011.

Slope stability conditions are described in Section 2.3, above, and constitute the rationale for the proposed slope stability work. Briefly, results of a slope stability study (FRANZ, 2010) showed that soil in the north section of the former landfill and in an existing slope failure were unstable (factor of safety = 1.0 and 0.8, respectively), soil in the middle section was bordering on failure (1.1), and the southern section was adequately stable.

The existing slope failure is located at the northeast end of the landfill. In the vicinity of the failure, the slope is about 19 m high and inclined at approximately 40 degrees from the horizontal. The failure zone extends approximately 4 to 5 m back from the original crest of the slope and is approximately 3 to 4 m wide at the top of the failure zone. A near-vertical failure scarp several meters in depth was observed at the location of the failure. A wetland and small seep are located at the base of the failure zone, indicating that the failure may have occurred as

a result of concentrated runoff to this portion of the landfill. Tension cracks were also observed along the east side of the landfill.

5.1.4 Topography

The institution is at an elevation of approximately 800 masl (metres above sea level). The Red Deer River, at an elevation of 680 masl, is located to the northeast and has cut deep ravines through the topography (Alberta, 2003).

The landfill is relatively flat and surrounded by low rolling hills. The ground surface elevation at the crest of the slope ranges from about 797 to 799 masl. Along the toe of the slope, the ground surface elevation ranges from about 776 to 783 masl. The side slopes of the landfill are generally inclined at about 30 to 45 degrees to the horizontal. Much of the surrounding area to the south and east is dominated by rolling, hilly terrain. The ground surface level is relatively flat and hummocky extending from the toe of the slope to a distance of about 10 to 20 m. Beyond this point the ground surface drops off to the level of the base of the coulee which, is estimated to be at about 50 to 60 metres below the top of the landfill (or at about 720 to 730 masl) (FRANZ, 2010).

5.1.5 Surficial Geology

The landfill site is located in the physiographic division known as the Beiseker Lowlands, adjacent to the Red Deer Badlands. Glacial deposition formed the small mounds and rolling plains which are now present in the area. Specific to the landfill area, the site is underlain by deposits of recessional moraine (glacial till). These deposits were formed in a period of equilibrium between ice advance and marginal melting, during which material was brought up to the stationary margin and deposited, resulting in the formation of hummocky terrain. The glacial till in the Drumheller area is reported to be clayey and silty, with a sand component and bentonite clay. The upper portion of the till tends to be coarser due to the effect of melt water which removed the finer particles. Erosion from melt waters has resulted in numerous steep-walled valleys, such as the Red Deer Valley. The coulee present beneath the current landfill was likely formed by the same process (Stalker, 1973).

5.1.6 Bedrock Geology

The bedrock geological formation of the Prairies Ecozone has been shaped by multiple historical glaciations. Continental glaciation flattened the landscape and left behind a variety of glacial deposits. Ponds and small lakes occupy many of the depressions in moraines. Underlying the surface landforms of the plains are horizontal layers of sedimentary bedrock consisting of various Cretaceous and Tertiary sediments.

The bedrock formations of the Drumheller area were laid down in the Alberta geosyncline during the final phases of the Cretaceous and Tertiary Sea, and represent the vast outpouring of debris

from the mountains that were rising to the west. Much of the rock is poorly consolidated and substantial thickness of loose sand and clay are common. Consolidated, resistant bedrock units form the steep valley walls in the area. The landfill site is underlain by Cretaceous aged bedrock from the Edmonton Formation. The formation consists of grey, green and brown shale, sandstone and coal. The bedrock contains layers of silt, clay and sand. Some of the beds also contain bentonite clay.

5.1.7 Hydrology

To the east of the landfill, the topography drops steeply to the east and south towards the closest surface water body, an ephemeral creek. The creek drains into the Red Deer River located approximately 4.5 km to the northeast, with an approximate elevation of 680 masl (GSC, 1973). During the 2011 investigation, at the base of a coulee, approximately 50 to 60 meters below the landfill, groundwater seepage was observed to intersect with the creek on a steep gully 20 metres north of the landfill. The groundwater seepage appeared to discharge out of a naturally occurring wetland, located at the toe of the north side of the landfill.

The processes of glaciation and subsequent erosion by creeks and rivers have shaped the area. The creek and river valleys are generally deep and wide. The largest river in this area is the Red Deer River, which begins at Red Deer Lakes and Drummond Glacier in Banff National Park. Flowing east and southeast across Alberta, it traverses the Front Range of the Rocky Mountains, the Foothills, the Boreal Forest, the Parkland and the Prairies before joining the South Saskatchewan River, a distance of approximately 744 km.

The annual mean flow rate of the Red Deer River is 62 m^3/s. Its valley is on average 90 m deep and approximately 1.6 km wide. The mean monthly discharge of the Red Deer River at Drumheller is 55 m^3/s. The other rivers and creeks in the area are much smaller, including Ghostpine Creek, Three Hills Creek, Lonepine Creek, Rosebud River and Serviceberry Creek. They are all tributaries of the Red Deer River, and generally flow southeast. Their mean monthly discharge rates range from 1 ~ 18 m^3/s.

5.1.8 Groundwater

In the 2005 Supplemental Phase II ESA, groundwater was encountered at 6.8 to 9.3 m below grade and was inferred to flow east towards the Red Deer River. Potential contaminants in groundwater were identified as nitrate, aluminum, copper, iron, and selenium (FRANZ, 2006).

During the 2011 supplemental investigation, two monitoring wells were sampled for groundwater.

The contaminants of concern (COCs) in a groundwater sample collected from MW99-03,located on top of the former landfill, were iron, selenium, uranium, cadmium, zinc, sodium, nitrate and

sulphate. The sample also exceeded applicable guidelines for total dissolved solids. COCs in MW05-1, collected at the toe of the landfill, were manganese, cadmium, sodium, fluoride and sulphate, and total dissolved solids also exceeded guideline values. No groundwater was recovered from monitoring wells installed in other locations.

5.1.9 Wetlands

During the August 2011 site investigation (FRANZ, 2011b), groundwater was seeping from a naturally occurring depression, which formed a small wetland, covering approximately 100 m^2, located at the toe and 20 m north of the landfill. The water table was just below the ground surface, and the area was characterized by hydric, peat soil, with some common species of aquatic plants present, including willows, cattails and sedges.

5.1.10 Surface Water and Sediment Quality

The water and sediment that the Red Deer River carries create a favourable environment to sustain aquatic plants, plankton, aquatic insects, fish, floodplain vegetation, reptiles, amphibians, birds, and mammals within the watershed. The unnamed, ephemeral creek draining the former landfill is a tributary to the Red Deer River, and as such, presents a potential pathway for transport of site contaminants to this locally important watercourse.

Tables 3 and 4 in the 2011 FRANZ report (FRANZ, 2011b) present sediment and surface water analytical results, respectively. Two sediment samples collected downstream of the landfill (DRUM-SED2 and DRUM-SED3) slightly exceeded CCME interim freshwater sediment quality guidelines (ISQG) for arsenic, based on the results of the 2011 supplemental investigation. A third sample, collected at the point of confluence between the seepage water and the receiving creek water (DRUM-SED4), was in compliance with the CCME ISQG for arsenic. A sediment sample collected from the seepage (DRUM-SED SEEP 1A) contained arsenic at a concentration equivalent to the CCME ISQG (6 mg/kg, vs. ISQG value of 5.9 mg/kg; the difference of 0.1 mg/kg is less than 2% over the ISQG value, and may simply result from the difference in significant digits between the lab report and the guideline). The background sample DRUM-SED-BK1 complied with ISQGs for arsenic, and was collected approximately 300 m upstream of the landfill (FRANZ, 2011b).

Five surface water samples (DRUM-SW2, -SW3, -SW4, -SEEP1A and –SEEP1B) were collected downstream of the landfill, in the seepage and the creek. A background sample (DRUM-SW-BK1) was collected approximately 300 m upstream of the landfill, and sample DRUM-SW1 was collected approximately 50 m upstream of the landfill. DRUM-SW1 exhibited concentrations of cadmium, aluminum, copper and iron above CCME FWAL guidelines; however, these concentrations were below those detected in DRUM-SW-BK1, with the exception of cadmium. Overall, analytical results for DRUM-SW1 and DRUM-SW-BK1 were

very similar, therefore both were considered to be background samples, and the highest concentration from either of these samples was used for comparison purposes.

Of the creek water samples collected downstream of the landfill, DRUM-SW4, located at the intersection of the seepage and the creek, exceeded background concentrations and CCME FWAL for cadmium and iron. Similarly, DRUM-SEEP1A, located immediately downgradient of the wetland in the seepage stream, exceeded background concentrations and CCME FWAL for cadmium and iron, as well as arsenic and barium. This sample was also the only sample to surpass maximum detected background concentrations of silicon and titanium, but both of these were within 2x the maximum background level, and silicon is known to be innocuous, therefore no potential impacts were considered likely to result from these elements.

Lithium, magnesium, manganese, strontium and sulphur exceeded the maximum detected background concentrations in multiple samples. There is no CCME FWAL or agricultural guidelines for any of these elements. The impact associated with lithium, however, was considered negligible, as the measured value was comparable to background. Similarly, magnesium concentrations were within 2x background concentrations. Impacts from strontium were considered negligible, as strontium is an essential nutrient for humans and ecological receptors, in low concentrations. Although there is no CCME FWAL guideline for total sulphur, there is an agricultural guideline for sulphate, which is expected to be the dominant sulphur species present given the oxidizing conditions (as evidenced by the visible presence of iron oxides). Total sulphur values were converted to equivalent sulphate concentrations (FRANZ, 2011b). The resulting values were within 10% of the measured dissolved sulphate concentrations, therefore the CCME agricultural guideline of 1,000 mg SO_4/L was applied. All values were compliant with this guideline.

As presented in Section 2.3.2, above, water seeping from the toe of the landfill on the north side (SEEP1A) surpassed background concentrations and/or CCME water quality criteria for cadmium, barium, arsenic and iron (FRANZ, 2011b). The sample location with the highest exceedances over guidelines (SEEP1A) was collected at the outflow of a small wetland characterized by hydric, peaty soil and aquatic plant species, where the water table was just beneath the ground surface. This area is assumed to be fed by groundwater from the former landfill.

Typically, water saturating organic soil is anoxic and rich in dissolved iron. Although porewater chemistry is not available for the small wetland, it is evident that water daylighting from the wet soil to a small, flowing creek at SEEP1A contains relatively high concentrations of particulate iron hydroxides. Data in support of this conclusion includes the decrease by two orders of magnitude in total iron between SEEP1A (23 mg/L) and SEEP 1B (0.4 mg/L; located

approximately 50 m downstream of SEEP 1A), with only a slight decrease in dissolved iron (0.25 to 0.16 mg/L) over the same distance (FRANZ, 2011b). Field observations corroborate these analytical results; Photo 18 in Appendix B shows the bright orange colour of colloidal iron oxides at the SEEP1A sampling location, and a biofilm ("sheen"-like appearance, with angular edges) of iron-reducing bacteria on the surface. (These bacteria are typically present where oxidized iron is readily available for use as a terminal electron acceptor.)

5.1.11 Fish and Fish Habitat

The creek that receives water from the seepage at the former landfill is ephemeral; it is therefore not considered suitable habitat for fish or other aquatic species. The creek appears to be approximately 50 to 60 m below and 20 m north of the landfill. The creek drains into the Red Deer River located approximately 4.5 km to the northeast. The closest fish habitat in this region is the Red Deer River, which is known for its flat and moderate flows with subtle surface features, though the in-stream physical structure is abundant. It is a shallow river with a good hatchery, comprising a favourable habitat for trout (Red Deer River Watershed Alliance, http://www.rdrwa.ca, 2011).

Some of the sport fish species that inhabit the Red Deer River watershed include Walleye, Northern Pike, Brown Trout, Rainbow Trout, Yellow Perch, Goldeye, And Whitefish, etc. (Red Deer River Watershed Alliance, 2011. http://www.rdrwa.ca).

5.1.12 Wildlife and Wildlife Habitat

Birds frequenting the Drumheller Badlands include Canada Geese, Turkey Vultures, Pileated Woodpeckers, Rock Wrens and Chickadees. The region is a major flyway for Tundra Swans in the spring. Migrating warblers are abundant during the spring and fall in the trees and bushes along the Red Deer River. The Badlands are prime habitat for Mountain Bluebirds and Say's Phoebe. In bush, in the coulees and along the rivers, Catbirds, Rufous-sided Towhees and Yellowthroats are common. The larger trees closer to the Red Deer River provide homes for a variety of woodpeckers, vireos, warblers and Northern Orioles. Golden Eagles, Prairie Falcons, Merlins and Great Horned Owls are present year-round. Saw-whet Owls are present along the river in early spring. Summer visitors include other raptors such as Ferruginous Hawks and the occasional Peregrine Falcon. The valley serves as a flyway for migrating raptors in fall (http://www.camacdonald.com/birding/Hotspots/Badlands.htm).

Intermittent sloughs and ponds in the Mixed Moist Grassland Ecoregion provide habitat for waterfowl, and white-tailed deer, pronghorn antelope, coyote, rabbit, and ground squirrel are common (Ecological Framework of Canada, http://sis.agr.gc.ca, accessed September 20, 2011). Waterfowl hunting is common, and recreation is important around several large reservoirs, including Red Deer River watershed. During the 2011 site investigation, a garter snake was observed in the vicinity of the landfill. Deer, squirrels, and chipmunks were observed

as well. Large portions of the surrounding area are used as grazing land for livestock, (mainly cattle).

5.1.13 Species at Risk

The federal *Species at Risk Act* (*SARA*, 2003) provides for the legal protection of wildlife species and the conservation of their biological diversity. Under *SARA*, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was established as an independent body of experts responsible for identifying and assessing wildlife species considered to be at risk. Once identified by COSEWIC, these species are considered for legal protection and recovery under *SARA*.

The *SARA* Public Registry (http://www.sararegistry.gc.ca/sar/index/default_e.cfm) includes a listing of all species at risk in Canada, including the provinces they are known to inhabit, and their status under *SARA* and/or COSEWIC. Species assessed by Alberta's Endangered Species Conservation Committee (ESCC) and its Scientific Subcommittee (SSC) were listed under Alberta's *Wildlife Act* ("the *Act*", Government of Alberta, 2011) in *Species at Risk Fact Sheets*. The *Act* identifies, protects and recovers species at risk in Alberta. It applies to any wild animal, plant or other species managed by the Government of Alberta on both public and private lands. Some species that are protected in Alberta are also listed under *SARA*. A list of at-risk species in Alberta is available from the Alberta Sustainable Resource Development website (http://www.srd.alberta.ca).

To identify species at risk that could potentially inhabit or use the CSC Drumheller Institution site and/or its environs, both the provincial list and the federal *SARA* list were consulted. The habitat and range for each species at risk listed for the Alberta Prairies Ecozone, Moist Mixed Grassland Ecoregion were compared with the location and conditions of the site to determine whether the species could be present on the site. The species that are listed as "threatened" and/or "endangered" under Alberta provincial and/or federal status are presented in Table 5–1 below, along with notes regarding the likelihood of their occurrence on the site.

Table 5–1: Species at Risk

Common Name	Scientific name	Taxon	Alberta Wildlife Act Status	Federal SARA	COSEWIC	Habitat preference
Piping Plover	*Charadrius melodus*	Birds	Endangered	Endangered	Endangered	NO HABITAT
Ord's Kangaroo Rat	*Dipodomys ordii*	Mammals	Endangered	Endangered	Endangered	NOT IN RANGE
Whooping Crane	*Grus americana*	Birds	Endangered	Endangered	Endangered	NOT IN RANGE
Mountain Plover	*Charadrius montanus*	Birds	Endangered	Endangered	Endangered	NOT IN RANGE
Burrowing Owl	***Athene cunicularia***	**Birds**	**Endangered**	**Endangered**	**Endangered**	**POSSIBLE**
Ferruginous Hawk	***Buteo regalis***	**Birds**	**Endangered**	**Threatened**	**Threatened**	**POSSIBLE**
Tiny Cryptanthe	*Cryptantha minima*	Vascular Plants	Endangered	Endangered	Endangered	NOT IN RANGE
Soapweed	*Yucca glauca*	Vascular Plants	Endangered	Threatened	Threatened	NOT IN RANGE
Western Spiderwort	*Tradescantia occidentalis*	Vascular Plants	Endangered	Threatened	Threatened	NOT IN RANGE
Porsild's Bryum	*Bryum porsildii*	Mosses	Endangered	Threatened	Threatened	NOT IN RANGE
Limber Pine	*Pinus flexilis*	Vascular Plants	Endangered			NOT IN RANGE
Whitebark Pine	*Pinus albicaulis*	Vascular Plants	Endangered	No Status	Endangered	NOT IN RANGE
Banff Springs Snail	*physella johnsoni*	molluscs		Endangered	Endangered	NOT IN RANGE
Dusky Dune Moth	*copablepharon longipenne*	Arthropods		Endangered	Endangered	NOT IN RANGE
Eskimo Curlew	*Mumenius borealis*	Birds		Endangered	Endangered	NO HABITAT (EXTINCT)
Five-Spotted Bogus Yucca Moth	*Prodoxus quinquepunctellus*	Arthropods		Endangered	Endangered	NOT IN RANGE

Common Name	Scientific name	Taxon	Alberta Wildlife Act Status	Federal SARA	COSEWIC	Habitat preference
Gold-Edged Gem	*Schinia avemensis*	Arthropods		Endangered	Endangered	NOT IN RANGE
Greater Sage-Grouse Urophasianus Subspecies	*Centrocercus urophasianus urophasianus*	Birds	Endangered	Endangered	Endangered	NOT IN RANGE
Greater Short-Horned Lizard (a.k.a. Eastern Short-Horned Lizard)	*Phrynosoma hernandesi (a.k.a. Phrynosoma douglassi brevirostre)*	Reptiles	Endangered	Endangered	Endangered	NOT IN RANGE
Half-Moon Hairstreak	*Satyrium semiluna*	Arthropods		Endangered	Endangered	NOT IN RANGE
Non-Pollinating Yucca Moth	*Tegeticula corruptrix*	Arthropods		Endangered	Endangered	NOT IN RANGE
Sage Thrasher	*Oreoscoptes montanus*	Birds		Endangered	Endangered	NOT IN RANGE
Small-Flowered Sand-Verbena	*Tripterocalyx micranthus*	Vascular Plants		Endangered	Endangered	NOT IN RANGE
Swift Fox	*Vulpes velox*	Mammals	Endangered	Endangered	Threatened	NOT IN RANGE
Western Harvest Mouse *Dychei* Subspecies	*Reithrodontomys megalotis dychei*	Mammals		Endangered	Endangered	NOT IN RANGE
Yucca Moth	*Tegeticula yuccasella*	Arthropods		Endangered	Endangered	NOT IN RANGE
Peregrine Falcon	***Falco peregrinus***	**Birds**	**Threatened**	**Threatened**	**Threatened**	**POSSIBLE (migrant only)**
Woodland Caribou (Both Boreal and Sourthern Mountain Population))	*Rangifer tarandus caribou*	Mammals	Threatened	Threatened	Threatened	NOT IN RANGE
Barren Ground Caribou	*Rangifer tarandusgroenlandicus*	Mammals	Threatened	Special Concern	Special Concern	NOT IN RANGE

Common Name	Scientific name	Taxon	Alberta Wildlife Act Status	Federal SARA	COSEWIC	Habitat preference
Trumpeter Swan	*Cygnus buccinator*	Birds	Threatened	No Status	Not at Risk	NO HABITAT
Northern Leopard Frog (Western Borial/Prairie populations)	***Rana pipiens***	**Amphibians**	**Threatened**	Special Concern	Special Concern	**OBSERVED**
St. Mary Sculpin	*Cottus bairdi punctulatus*		Threatened	No Status	No Status	NO HABITAT
Stonecat	*Noturus flavus*	Fishes	Threatened	No Status	No Status	NO HABITAT
Shortjaw Cisco	*Coregonus zenithicus*	Fishes	Threatened	Threatened	Threatened	NO HABITAT
Western Silvery Minnow	*Hybognathus argyritis*	Fishes	Threatened	Threatened	Threatened	NO HABITAT
Lake Sturgeon	*Acipenser fulvescens*	Fishes	Threatened	No Status	Endangered	NO HABITAT
Small-Flowered Sand Verbena	*Trypterocalyx micranthus*	Vascular Plants	Threatened	Endangered	Endangered	NOT IN RANGE
Westslope Cutthroat Trout (Alberta population)	*Oncorhynchus clarkii lewisi*	Fishes	Threatened	No Status	Threatened	NOT IN RANGE
Grizzly Bear (Northwestern Population)	*Ursus arctos*	Mammals	Threatened	No Status	Special Concern	NOT IN RANGE
Bolander's Quillwort	*Isoetes bolanderi*	Vascular Plants		Threatened	Threatened	NOT IN RANGE
Canada Warbler	*Wilsonia canadensis*	Birds		Threatened	Threatened	No habitat
Common Nighthawk	***Chordeiles minor***	**Birds**		**Threatened**	**Threatened**	**POSSIBLE**
Haller's Apple Moss	*Bartramia halleriana*	Mosses		Threatened	Threatened	NOT IN RANGE
Loggerhead Shrike *excubitorides* subspecies	***Lanius ludovicianus excubitorides***	**Birds**		**Threatened**	**Threatened**	**POSSIBLE**
Olive-Sided Flycatcher	*Contopus cooperi*	Birds		Threatened	Threatened	NO HABITAT

Common Name	Scientific name	Taxon	Alberta Wildlife Act Status	Federal SARA	COSEWIC	Habitat preference
Rocky Mountain Sculpin	*Cottus sp. Eastslope populations*	Fishes		Threatened	Threatened	NOT IN RANGE
Slender Mouse Ear Cress	***Halimolobos virgata***	**Vascular Plants**		**Threatened**	**Threatened**	**Known in Area**
Smooth Goosefoot	*Chenopodium subglabrum*	Vascular Plants		Threatened	Threatened	NOT IN RANGE
Sprague's Pipit	***Anthus spragueii***	**Birds**		**Threatened**	**Threatened**	**POSSIBLE**
Verna's Flower Moth	*Schinia verna*	Arthropods		Threatened	Threatened	NOT IN RANGE
Western Blue Flag	*Iris missouriensis*	Vascular Plants		Threatened	Threatened	NOT IN RANGE
Wood Bison	*Bison bison athabascae Mammals*	Mammals	Endangered	Threatened	Threatened	NOT IN RANGE

Of the listed species that could possibly occur at the site, only the Northern Leopard Frog (*Rana pipiens*) was observed at the site (during the 2011 supplemental site investigation), near the creek at the toe of the slope. This species is protected provincially, but not at the federal level.

The Slender Mouse Ear Cress (*Halimolobos virgata*) is known to be present in the area, but its presence on or near the site was not verified at the time of the 2011 site investigations. The investigation took place in late summer and early fall, whereas *H.virgata* blooms in June.

The remaining species that could possibly inhabit the area were the Burrowing Owl (*Athene cunicularia*), Ferruginous Hawk (*Buteo regalis*), Peregrine Falcon (*Falco peregrinus*), Common Nighthawk (*Chordeiles minor*), Loggerhead Shrike, excubitorides subspecies (*Lanius ludovicianus excubitorides*), and Sprague's Pipit (*Anthus spragueii*). The possibility of these species being present on the site was considered marginal. Confirmation of their presence would require investigation in the spring, while birds are present. The residences of Burrowing Owl, which often uses existing prairie dog burrows as a residence, cannot be destroyed under SARA. It is unlikely that such burrows are on site, as the vegetation is too high.

5.1.14 Environmentally Significant Areas

The only environmentally significant area in the immediate vicinity of the proposed project is the Red Deer River and its associated riparian zone, the maximum extent of which is approximately 500 m from the site (http://www.tpr.alberta.ca/parks/heritageinfocentre/environsigareas/default.aspx).

6.0 CULTURAL, SOCIAL AND ECONOMIC OVERVIEW

6.1 Air Quality and Acoustic Environment

There is no industrial activity in the area, and very little traffic in this relatively remote location. The only sources of atmospheric emissions are the Drumheller Institution itself (e.g. heating fuel exhaust, kitchen exhaust, etc.), and any volatile emissions that could be produced by the former landfill.

6.2 Historical Land Use

The Drumheller Institution is a medium-security facility built in 1967, located on the outskirts of Drumheller, Alberta. The institution can accommodate up to 558 inmates. The landfill was reportedly developed approximately 35 years ago in 1976 and closed prior to 1988. The main occupants of the site are institution employees, occasional contractors, and inmates. Limited information regarding the historical land use of the site prior to the construction of the institution is available, but it is assumed the land was used for agricultural purposes. The site is currently used as occasional agricultural grazing area.

The remediation activity will take place within the institution property boundary, primarily limited to the former landfill area. Construction activity will be contained within the CSC-owned lands located within the boundaries of the Drumheller Institution.

6.3 Heritage Resources

Drumheller Valley is located in the heart of the Badlands, which is a key paleontologically sensitive area due to its 70 million years of historical climatic changes from being flat and tropical to its current conditions of semi-arid climate and rolling hills. The Drumheller area is well-known for its richness of dinosaur fossils. Subsequent to the arrival of Ice Age, glaciers covered the region with thick layers of ice. As glaciers melted during the interglacial period, lakes and valleys formed, including the Red Deer River Valley. At the end of the ice age, the newly formed valley became home to a new ecosystem of animals, plants, and humans (native populations).

The Royal Tyrrell Museum, a world-class paleontological museum and research facility, is located in Drumheller.

Alberta Environment was contacted with regard to the potential archaeological or paleontological significance of the proposed work site area. At the time the draft EA report was written, a preliminary assessment had shown that the landfill site is located within an area rated “5p” for high paleontological potential due to the proximity to the watercourse. However, the Royal Tyrrell Museum in Drumheller recommended no further work to characterize the site at this time. No archaeological concerns were identified (Appendix J).

The Historic Resources Management Branch (HRMB of the Alberta Culture and Community Spirit (ACCS)) reviewed the project information for the remediation plan, and has a regulatory interest. Pursuant to Section 31 of the *Historic Resources Act*, the HRMB must be contacted immediately should any archaeological resources, paleontological resources, Aboriginal traditional use sites and/or historic sites be encountered during the remediation activities (Appendix J).

6.4 Social and Cultural Well-Being

The institution is approximately 5 km southeast of the Town of Drumheller. The Royal Tyrrell Museum of Palaeontology opened in the town of Drumheller in 1985 and is a major tourist attraction. The Drumheller portion of the Red Deer River valley, often referred to as Dinosaur Valley, has an approximate width of 2 kilometres (1.2 mi) and an approximate length of 28 kilometres (17 mi). Drumheller is a town of approximately 8,200 people, with agriculture, energy and tourism as its economic base.

Aboriginal Affairs and Northern Development Canada (AANDC) confirmed that there is no known use of the land in the vicinity of the former landfill by First Nations people.

6.5 Human Health, Safety and Security

The primary human health and safety issue currently existing at the site is the potential for slope failure, which represents a significant physical hazard, as described in Section 5.1.2, above.

Local groundwater is not used as drinking water, and it is unlikely that significant concentrations of metals from the landfill are transported downstream to the Red Deer River, as the receiving creek draining the coulee is ephemeral. Nonetheless, some low level of metal contamination may be periodically mobilized with rain water or snow melt, and may contribute to metal loading in the Red Deer River.

Strict security measures are in place to prevent interaction of site visitors or workers with inmates, and to prevent escape of inmates. These include physical barriers, the presence of guards, sign-in and sign-out procedures, and controls over the type of activities that can take place at various locations at different times.

A Health and Safety Plan will be required of the contractor undertaking the proposed physical works.

6.6 Aesthetic Considerations

The landfill is covered, and is therefore visually similar to the surrounding land, except for small areas of burn piles and building materials (bricks) and visible garbage where soil has eroded.

6.7 Infrastructure and Services

The institution is located on the east side of a major highway (Highway 9). The institution compound is connected to the landfill area by an unpaved gravel access road, which is the only entry and exit pathway for the proposed temporary work space area. The road is only used by authorized personnel.

The water supply for the institution is from the municipal drinking water supply system. The sewage system is also connected to the main municipal sewage system, which flows into the municipal waste water treatment plant. Sewage mains, power lines, and utility corridors are located approximately 500 m southwest of the work area, inside the boundaries of the institution compound.

Private and public underground utilities located in the vicinity of the proposed work areas will be identified prior to any construction work taking place. The Drumheller Institution will be contacted to discuss temporary work space requirements within the institution property boundary.

6.8 Employment and Economy

In the short term, i.e. during the construction phase, the local economy will benefit from the proposed facilities, as the project will likely create work for local contractors, and any workers required from other areas could be expected to use local hotels and restaurants. Local construction supply businesses could be sourced for some of the materials and supplies required on an as-needed basis. There is no cost to local community members associated with the proposed facilities.

The land surrounding the former landfill is agricultural, and the site itself is used for by local farmers for pasturing cows. There are no barriers in place to prevent cows from walking on the former landfill, as evidenced by cow dung at the landfill and throughout the area.

7.0 EVALUATION OF ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

7.1 Valued Ecosystem Components

The *CEA Act* identifies two main purposes of an Environmental Assessment (*CEAA*, 2005):

- To minimize or avoid adverse environmental effects before they occur
- To incorporate environmental factors into decision making.

A key stage in reaching these primary objectives is to conduct an environmental assessment to identify environmental and socio-economic components that could be affected by or have an influence on the proposed physical work. While all components of the environment are important, it is not practical to access every potential effect on every component. Assessment must therefore focus on the components that have the greatest relevance in terms of value and sensitivity to the particular circumstances of the development under review, and that have a meaningful potential to be affected by the development.

A widely acceptable approach is to identify Valued Ecosystem Components (VECs), defined under the *Act* as:

"Any part of the environment that is considered important by the proponent, public, scientists, and the government involved in the assessment process. Importance may be determined on the basis of cultural values or scientific concern." (CEAA, 1999)

VECs incorporate elements of the natural environment, such as particular species, assemblages of plant or animals, habitats, environmental features or indicators of environmental health.

Examples of valued socio-economic components (VSCs) are activities or sites of social and cultural importance or of commercial and economic value, infrastructure, recreational or aesthetic features, or indicators of community well-being and quality of life. The proposed project will primarily take place within the institution property boundary, likely limited to the former landfill area.

VECs and VSCs, together, are referred to as Valued Components (VCs). To be considered a VC, the component must be known to occur in the project work area, and there must be a reasonable possibility that it would be affected by or have influence on the project. Based on the Biophysical Overview presented in Section 5, and the cultural, social and economic overview presented in Section 6, the following were selected as VCs relevant to the proposed project:

- Soil and Surficial Geology

- Vegetation
- Surface Water and Sediment Quality
- Groundwater/Hydrogeology
- Fish and Fish Habitat
- Wetlands
- Wildlife
- Air Quality and Acoustic Environment
- Infrastructure and Services
- Human health, safety and security
- Employment and Economy
- Aesthetic Considerations
- Heritage Resources

The remainder of this section presents a discussion of the adverse effects that could plausibly occur to VCs, mitigating measures and the significance of any residual effects.

7.1.1 Effects on Soil and Surface Geology

Soil and surface geology will be affected by excavation work proposed as part of staging and site preparation, cut and fill work (excavation, grading, shaping), and enhancement of natural attenuation. Potential negative impacts include removal of vegetation and stripping of topsoil, resulting in loss of soil due to erosion during the construction phase, and soil compaction can affect infiltration of water, as well as the soil's ability to regenerate.

These effects will be mitigated by the following standard techniques:

- stockpiling native soil removed from the top of the coulee and using it to stabilize the slope elsewhere
- segregation of soil from waste materials
- minimization of the length of time excavations are left open
- backfilling of excavations
- removal of any wastes that may require disposal in a licensed facility
- installation of surface water controls (berms, swales, drains, silt fences) to minimize erosion or slumping due to water movement and excess weight
- site clean-up, restoration and re-vegetation of affected areas, including excavation and soil stockpile work areas, to preconstruction conditions, to the extent practical
- monitoring of restoration activities
- minimizing the time-frame of the construction phase
- designated access routes for trucks and large equipment to minimizing the soil compaction to other areas on site.

No adverse residual effects are anticipated, provided that the above mitigative techniques are employed.

In the longer term, it is expected that the proposed project will have a net positive effect on soil and surface geology, as the main objective of the project is to stabilize the slope to prevent slumping and erosion. This, in turn, will prevent exposure of the material remaining in the landfill, and therefore reduce the risk of exposing potential soil contaminants and debris.

7.1.2 Vegetation (including Species at Risk)

It will be necessary to remove vegetation during staging and site preparation, and, to a lesser extent, prior to excavating the area for the in-situ passive treatment system.

In general, removal of vegetation will be mitigated by the following standard measures:

- Limiting the area of disturbance;
- Avoiding the use of pesticides;
- Re-vegetating exposed soils with local species;
- Cleaning equipment and vehicles, as required, to prevent the spread or introduction of invasive plant species.

There is potential for a federally-protected plant species to be present on the site (*Halimolobus virgata*), therefore a brief site survey was conducted in December, 2011, to ascertain whether this species could be present in the proposed work area. One plant was identified as potentially *H. virgata*, but its identity remains to be confirmed during the blooming period (spring, 2012). If *H. virgata* is present and there is a potential for it to be affected by the proposed project work, a SARA notification would need to be sent to Environment Canada (EC). EC personnel would provide advice and, possibly, suggestions for mitigation measures to protect the plant.

Residual adverse effects on vegetation are expected to be insignificant, provided the above mitigative measures are taken. If the site is colonized by native prairie plants, it will be re-vegetated with a native grass seed mix to discourage introduction and colonization of invasive species.

7.1.3 Surface Water and Sediment Quality

Surface water and sediment quality could be adversely affected by improper disposal of contaminated water, or from improper handling of fuel or hazardous materials during the construction phase. To mitigate these potential effects, the following standard measures will be put in place:

- Any used water requiring disposal will be tested for compliance and disposed of according to the Canadian Council of Ministers of the Environment (CCME) Environmental Quality Guidelines.
- Should used water satisfy applicable CCME guidelines, it will be discharged into the wetland (to avoid creating any surface runoff or erosion issues).
- During construction, a dedicated soil handling area will be created to segregate/handle/manage soils. Silt fences will be placed along the bank of the creek and around the perimeter of the soil handling area. Visual inspections will be conducted each work day to ensure that sediment or sediment laden runoff does not migrate from the work areas into the adjacent creek.
- A fuel storage and handling area will be set up on table lands at the top of the slope at least 100 m from the creek. All refuelling areas will be at least 30 m from any watercourses. Proper containment measures will be used for hazardous materials storage tanks.

Provided that these measures are employed, no adverse residual effects on surface water or sediment quality are anticipated.

7.1.4 Groundwater and Hydrogeology

It is not expected that water table levels will be affected to any appreciable degree by the proposed re-grading of the slope, therefore no mitigative measures are required. With respect to groundwater quality, only positive effects are anticipated, resulting from the enhancement of natural attenuation of landfill-associated inorganic contaminants.

7.1.5 Fish and Fish Habitat

No potential adverse effects to fish or fish habitat were identified. Natural attenuation of landfill-associated inorganic contaminants will be enhanced by the proposed works; therefore the main effect of the proposed project would be beneficial to these VECs.

7.1.6 Wetlands

The wetland is located at the toe of the area of highest instability. If the wetland were to be excavated to reduce the slope, it would be destroyed, as it would if fill were deposited there. To avoid this situation, the proposed project design was modified as follows:

- The slope is proposed to be reduced by re-grading the area upgradient of the wetland, leaving the wetland undisturbed.
- Work that may cause physical disturbance in the wetland, if any, will take into account potentially sensitive timeframes for ecological receptors.

Adverse effects to the wetland are not anticipated, provided that these standard mitigation measures are followed.

7.1.7 Wildlife

In the absence of preventive measures, it is plausible that injury or mortality of wildlife could occur due to interactions with heavy equipment, falling into excavations or walking on unstable ground during construction activities. Further, bird nests and snake hibernacula on the ground could be destroyed by vehicular traffic or during clearing, excavation or filling operations.

To minimize the likelihood of adverse effects on wildlife, the following standard mitigative measures will be taken:

- Fencing will be installed to keep wildlife and livestock away from the construction area.
- Construction activities will not take place during nesting season (spring thaw until approximately the end of July, as indicated by EC).
- Shortly before destructive construction activities (e.g. vegetation or soil disturbance), a qualified biologist will conduct a sweep of the area for birds and their nests (tree-nesting and ground-nesting), plants, snake hibernaculae, and frogs.
- The intended work area will be checked for the presence of prairie dog burrows, and if any such burrows are found, their use by Burrowing Owls will be verified.
- Open excavations will be checked for wildlife prior to backfilling.
- Proper storage and disposal practices for construction site wastes will be observed to avoid attracting wildlife.
- Workers will be instructed not to chase, harass or feed wildlife.

No adverse residual effects to wildlife are anticipated, provided that these conditions are met.

In the longer term, net positive effects to local wildlife would be expected, as the area will be safer for wildlife due to the elimination of slope stability issues and removal of landfill-related contaminants from seepage and surface water that could be consumed by wildlife.

7.2 Valued Socio-Economic Components

7.2.1 Air Quality and Acoustic Environment

Air emissions resulting from proposed project work will consist primarily of diesel emissions from the excavator, transport trucks, and/or other construction machines that run on diesel or gasoline (e.g. grader), and traffic along the unpaved haul and access road. No significant adverse residual effects with respect to emissions or noise levels are anticipated, however, as:

- Baseline data will be obtained prior to project initiation, and noise levels monitored to comply with local bylaws during construction phase.

- Equipment will be kept in good working order with mufflers.
- Construction activities will be restricted to daytime hours (10-12 hrs/ day).
- Construction will take place over a short time frame (3-4 weeks).
- The work area is relatively small, i.e. less than 5 ha.

Similarly increased dust suspension during the construction phase will be addressed by:

- Using water to suppress dust during periods of heavy activity and dry periods.
- Enforcing equipment maintenance schedules.
- Preserving natural vegetation wherever practicable.
- Minimizing or suspending activities that generate large quantities of dust during high winds.
- Completing the construction phase over a short time frame (3-4 weeks).

Provided that the above standard mitigative procedures are followed, no significant adverse effects to air quality or the acoustic environment are anticipated.

7.2.2 Infrastructure and Services

Roads and traffic are the only infrastructure components identified that could plausibly be affected by proposed project components. Specifically, local traffic control measures could be required during transportation of equipment and the movement of vehicles to and from the site. Traffic control may be required at the entrance road to the site off Highway 9, and the configuration and/or construction of roads could be changed.

To address these potential issues, the following standard mitigative measures are proposed:

- A traffic control plan may be necessary to minimize disruption of traffic flow and ensure no obstruction to emergency response vehicle routes.
- Traffic control measures could include modifications to signal light patterns, a police escort and/or manual traffic signals, as required.
- Excavations of the road will be backfilled, and the road surface restored to pre-construction conditions.
- Vehicles and heavy machinery exiting the site onto the highway will be cleaned of site mud and soil to prevent soiling of the highway.

Given the remote location of the site, any potential disruption to traffic patterns would be expected to be minimal. The above measures would further ensure no significant adverse residual effects to traffic or roads.

7.2.3 Human Health, Safety and Security

Construction-related incidents resulting in harm to workers, CSC personnel, members of the public or to property and equipment could occur due to lack of knowledge of site conditions or safety equipment and procedures.

To prevent such incidents, the following standard mitigation measures will apply:

- The construction program will employ best management practices and will meet or exceed the standards, codes, regulations and instructions outlined in:
  - Alberta's Occupational Health and Safety Act (2002);
  - The Canadian Environmental Protection Act (CEPA); and
  - The Canada Labour Code, Canada Occupational Safety and Health Regulations (2002).
- Signage, natural barriers and fencing will be used to restrict public access to work areas.
- Any project work will be conducted in accordance with the contractor's health and safety plan.

Discovery of hazardous materials in landfill during excavation could result in risk to health and safety of workers. Identified wastes will therefore be segregated and placed in an on-site holding area, as required. Following characterization, excess waste will be disposed of at a licensed facility off-site, if required.

Breach of security could occur at the Drumheller Institution if site access is not strictly controlled. To avoid this situation, the contractor will be required to liaise with CSC personnel and Site Commissioners to develop and implement site access and egress measures that will include daily sign in and sign out.

Implementation of the above standard mitigation techniques can be expected to result in no significant adverse effects in terms of human health, safety and security.

Overall, the net effect of the proposed project to human health and safety is expected to be positive, as the risk of harm to individuals and equipment from slope failure and falling down steep slopes will be reduced, as will the potential for interaction with landfill materials exposed by soil erosion.

7.2.4 Employment and Economy

Since agriculture is the main economic activity in the area surrounding the former landfill, it will be important to avoid damage to livestock. There is the potential for harm to livestock from interactions with heavy equipment, from falling into excavations or from walking on unstable

and/or excavated areas during the construction phase of the proposed project. This in turn would entail economic losses for local farmers.

Standard mitigative measures to minimize the risk of this effect include:

- Erecting fencing to prevent animals from entering the proposed work area.
- Making arrangements with affected farmers to pasture livestock elsewhere, or establishing other mutually agreeable alternatives, as appropriate.

Implementation of these measures would ensure no significant adverse effects to employment or the local economy.

Positive effects of the project, in the short-term, would include temporary employment for local workers, local purchasing of supplies and materials, rental of equipment, etc. In the long term, the stabilized slope would be safer for grazing livestock.

7.2.5 Aesthetic Considerations

Some temporary changes to the appearance of the work area would unavoidably occur during the construction phase due to excavation, equipment mobilization, slope stabilizing, work area safety barricades, temporary stockpiling of soil, etc..

However, this phase, as proposed, would take place over a short time frame (3-4 weeks), and the site would be cleaned up and restored, including re-vegetation, once the construction phase is completed. As such, no significant adverse aesthetic effects are anticipated, provided that these mitigative actions are implemented.

The proposed project will have a positive effect with respect to aesthetic considerations in the long term, as at present, erosion processes have exposed and continue to uncover landfill debris. This debris would be covered or removed (depending on its location), and further erosion would be prevented.

Once completed, the slope will be stabilized and new local vegetation will be re-populated along the slope. No emissions, vibrations or odours will be generated during the functional phase of the project, i.e. in perpetuity.

7.2.6 Heritage Resources

Although the site is located within an area rated “5p” by the Royal Tyrrell Museum, meaning that it has high paleontological potential, the proposed work will not disturb bedrock, therefore the likelihood of encountering fossils is minimal. Nonetheless, should fossils be encountered, work activity will stop and the Museum will be contacted, as per the instructions of Museum personnel.

No archaeological items are expected to be encountered, based on the advice of Museum staff. However, should human remains be found, the local police department will be contacted.

The Historic Resources Management Branch (HRMB of the Alberta Culture and Community Spirit (ACCS)) will be contacted immediately should any archaeological resources, paleontological resources, Aboriginal traditional use sites and/or historic sites be encountered during the remediation activities (Appendix J)
Provided the above standard measures are implemented, no significant adverse effects on heritage resources are anticipated.

7.3 Effects of the Environment of the Proposed Project

7.3.1 Soil and Surficial Geology

Although the contents of the landfill are expected to be non-hazardous, no records exist to document their composition. Existing landfill materials, if disturbed, could therefore potentially act as a source of unknown contaminants to clean soil and/or water.

To prevent the spread of any contaminants that may potentially be encountered during excavation:

- Waste materials will be segregated from soil.
- Any waste requiring disposal in a licensed facility will be removed immediately.
- Soil and groundwater quality will be monitored at regular and frequent intervals during excavation.
- Any contaminated soil or water that may be encountered will be disposed of according to environmental protection requirements.

No significant residual adverse effects are anticipated, provided that the above measures are implemented.

7.4 Effects of Accidents or Malfunctions

7.4.1 Health, Safety and Security

The following potential effects of accidents or malfunctions were identified:

- Slope failure could occur due to construction activity, and could result in injury to workers or damage to equipment;
- Vehicular incidents could occur during equipment transport;
- Spills and leaks of hydrocarbons from vehicles and machinery could occur; and,
- Grass fire or other fire ignited due to improper fuel handling, vehicular incident and/or dry conditions.

With respect to slope failure, setback distance would be established on the basis of geotechnical data to keep staff and machinery safely away from slope edges. This information would be incorporated into the contractor's health and safety plan.

To minimize the risk of vehicular incidents, equipment transportation will be conducted by qualified companies only. The risk of fire will be addressed by careful planning to ensure that firefighting equipment and personnel will be available, and that site workers are made aware of emergency measures incorporated into the contractor's health and safety plan.
It is anticipated that no significant residual adverse effects will occur, provided that these standard mitigative measures are implemented.

7.5 Summary of Effects and Mitigation Measures

Table 7-1 presents an assessment of potential effects of each component of the proposed project on VCs, as well as standard design or mitigation measures to address adverse effects. The table also includes potential effects of VCs on the project, as well as accidental effects, positive effects and residual effects.

Table 7–1: Assessment of Potential Effects of the Proposed Project on VCs

Potential Adverse Environmental Effects					Proposed Standard Design or Mitigation Measures	Residual Adverse Effects	Anticipated Long-Term Positive Effects
		Valued Component	**Project Component(s)**	**Potential Effect without Mitigation**			
Effects of Project on the Environment	Biophysical	Soil and Surficial Geology	Staging and Site Preparation Natural attenuation Site clean-up and restoration	Loss of soil due to site clearing and excavation activities.	• Stockpiling native soil removed from the top of the coulee and replacement during restoration phase, or using it to stabilize the slope (Cut & Fill option only). • Excavations will be backfilled.	No significant adverse effects.	• Slope stabilization. • Erosion control. • Minimized risk of exposing landfill debris or contaminants due to future erosion.
			Cut and Fill Surface Water Controls	Soil erosion due to wind and surface water runoff.	• Surface water controls (berms, swales, silt fences) • Length of time excavations are left open will be minimized • Site clean-up, restoration and revegetation of affected areas, including excavation and soil stockpile work areas, to preconstruction conditions, to the extent practical. • Monitoring of restoration activities. • Short time-frame of construction project.		
				Slope failure due to extensive removal of vegetation, native soil and fill.	• Limit extent of cut-and-fill to regrade slope in area most prone to failure (top, north section).	No significant adverse effects.	
		Vegetation, Species at Risk	Staging and Site Preparation Cut and Fill Natural attenuation	Loss of vegetation due to removal, degrubbing, etc. during site preparation, excavation. Destruction of *Halimolobos virgata* (federally listed species at risk).	• Verify identity of potential specimens; if confirmed as H.virgata, file SARA notification with EC and act on any advice from EC regarding mitigation. • Limited area of disturbance. • No herbicides will be used. • Revegetate exposed soils. Seed mixes to be composed of native grass seed mix (if site is inhabited with native prairie plants), and free of weed species to the extent feasible. • Use cleaning stations for equipment and vehicles, where required, to reduce the spread and introduction of invasive species of plants	No significant adverse effects.	N/A
		Surface Water and Sediment Quality	Staging and Site Preparation Cut and Fill Drainage Control Measures Natural attenuation	Impacts to surface water and groundwater from improper disposal of contaminated water.	• Any used water requiring disposal will be tested for compliance and disposed of according to the Canadian Council of Ministers of the Environment (CCME) Environmental Quality Guidelines. • Water discharge areas, if any, will be monitored for erosion.	No significant adverse effects.	Protection of surface water and sediment from transport of site contaminants and eroded soil.
				Impacts to surface water from improper handling of segregate/handle/manage soils.	• During construction, a dedicated soil handling area will be created to segregate/handle/manage soils. Silt fences will be placed along the bank of the creek and around the perimeter of the soil handling area. Visual inspections will be conducted each work day to ensure that sediment or sediment-laden runoff does not migrate from the work areas into the adjacent creek.	No significant adverse effects.	
				Impacts to surface water from improper handling of fuel and hazardous materials.	• A fuel storage and handling area will be set up on table lands at the top of the slope at least 100 m from the creek, to accommodate these activities. All refueling areas will be at least 30 m from any watercourses. Proper containment measures will be used for hazardous materials storage tanks.	No significant adverse effects.	
		Groundwater/Hydrogeology	Natural attenuation Cut and Fill	No adverse effects anticipated.	• n/a	No significant adverse effects.	Removal of landfill-associated inorganic contaminants from seepage water prior to recharge to groundwater.
		Fish and Fish Habitat	Natural attenuation	No adverse effects anticipated.	• n/a	No significant adverse effects.	Protection of fish and fish habitat from inorganic contaminants potentially transported from the former landfill to the Red Deer River by surface water in the

Potential Adverse Environmental Effects					Proposed Standard Design or Mitigation Measures	Residual Adverse Effects	Anticipated Long-Term Positive Effects
		Valued Component	**Project Component(s)**	**Potential Effect without Mitigation**			
							creek.
		Wetlands	Cut-and-Fill Natural attenuation	Excavation of soil or deposition of fill in the wetland would destroy it as habitat, and potentially destroy birds and wildlife inhabiting the wetland.	• Construction activities will be limited to the upgradient area (cut-and-fill), leaving the wetland largely undisturbed. • Work that may cause physical disturbance near the wetland, if any, will take into account potentially sensitive timeframes for ecological receptors.	No significant adverse effects.	N/A
			Natural attenuation	The small wetland upgradient of the proposed in-situ passive treatment system could be affected by reduced water levels if downstream drainage is improved.	• Flow rates will be measured prior to construction, and drainage enhancement will be designed to maintain similar discharge rates.		
		Wildlife	Staging and Site Preparation	Injury to or mortality of wildlife due to interactions with heavy equipment, falling into excavations or walking on unstable ground during construction activities. Disturbance to or destruction of bird nests on the ground.	• Fencing will be installed to keep wildlife and livestock away from the construction area. • Construction activities will not take place during nesting season (spring thaw until approximately the end of June). • Prior to construction, the intended work area will be checked for the presence of prairie dog burrows, and if any such burrows are found, their use by Burrowing Owls will be verified. • Prior to construction, the intended work area will be checked for the presence of snake hibernacula and all reasonable efforts will be made to avoid impacts to any hibernacula found. • Open excavations will be checked for wildlife prior to backfilling. • Proper storage and disposal practices for construction site wastes will be observed to avoid attracting wildlife. • Workers will be instructed not to chase, harass or feed wildlife.	No significant adverse effects.	Area will be safer for wildlife due to elimination of slope stability issue and removal of landfill-related contaminants from seepage and surface water that could be consumed by wildlife.
	Socio-Economic	Air Quality and Acoustic Environment	Transportation of Materials and Equipment Cut and Fill	Air emissions from the project will consist primarily of diesel emissions from the excavator, transport trucks, and/or other construction machines that run on diesel or gasoline (e.g. grader), and traffic along the unpaved haul and access road. Increased noise levels during construction phase.	• Baseline data will be obtained prior to project initiation, and noise levels monitored to comply with local bylaws during construction phase. • Equipment will be kept in good working order with mufflers. • Construction activities will be restricted to daytime hours (10-12 hrs/ day). • Construction will take place over a short time frame (3-4 weeks). • The work area is relatively small, i.e. less than 5 ha.	No significant adverse effects.	N/A
				Increased dust suspension during construction.	• Water will be used as dust suppressant during periods of heavy activity and dry periods. • Equipment maintenance schedules will be enforced. • Natural vegetation will be preserved, where practicable. • Activities generating large quantities of dust will either not be scheduled or minimized during high winds. • Construction will take place over a short time frame (3-4 weeks).	No significant adverse effects.	N/A
		Infrastructure and Services	Transportation of Materials and Equipment	Traffic disruptions during equipment transportation.	• A traffic control plan may be necessary to minimize disruption of traffic flow and ensure no obstruction to emergency response vehicle	No significant adverse effects.	N/A

Potential Adverse Environmental Effects					Proposed Standard Design or Mitigation Measures	Residual Adverse Effects	Anticipated Long-Term Positive Effects
		Valued Component	**Project Component(s)**	**Potential Effect without Mitigation**			
			Cut and Fill		routes. • Traffic control measures could include modifications to signal light patterns, a police escort and/or manual traffic signals. • Vehicles and heavy machinery exiting the site onto the highway will be cleaned of site mud and soil to prevent soiling of the highway.		
				Changes to roads.	• Changed to roads will be kept to the minimum required to carry out the proposed work. • Excavations will be backfilled and the road surface restored to pre-construction conditions.	No significant adverse effects.	N/A
		Human Health, Safety and Security	Transportation of Materials and Equipment Cut and Fill	Construction-related incidents resulting in harm to workers, CSC personnel, members of the public, or to property and equipment could occur due to lack of knowledge of site conditions or safety equipment and procedures.	• The construction program will employ best management practices and will meet or exceed the standards, codes, regulations and instructions outlined in: o Alberta's *Occupational Health and Safety Act* (2002); o The Canadian Environmental Protection Act (CEPA); and o The Canada Labour Code, Canada Occupational Safety and Health Regulations (2002). • Signage, natural barriers and fencing will be used to restrict public access to work areas. • Any project work will be conducted in accordance with the contractor's health and safety plan.	No significant adverse effects.	Reduced risk of harm to individuals and equipment from slope failure and from falling down steep slopes.
				Breach of security could occur at the Drumheller Institution if site access is not strictly controlled.	• Liaise with CSC personnel and Site Commissioners to develop and implement site access and egress measures that will include daily sign in and sign out.	No significant adverse effects.	N/A
			Cut and Fill	Discovery of hazardous materials in landfill during excavation could result in risk to health and safety of workers.	• Identified wastes will be segregated and placed in an on-site holding area as required. Following characterization, excess waste will be disposed of at a licensed facility off-site, if required	No significant adverse effects.	Reduced risk of humans, wildlife and livestock encountering landfill materials exposed due to soil erosion.
		Employment and Economy	Transportation of Materials and Equipment Cut and Fill	Potential for harm to livestock from interactions with heavy equipment, from falling into excavations or from walking on unstable/excavated areas during the construction phase. Consequent economic losses for local farmers.	• Fencing will be erected to prevent animals from entering the proposed work area. • It is anticipated that most work would take place in late fall and/or winter, when livestock would not be grazing in pastureland. • If the work schedule changes, and work is planned for warmer months, arrangements will be made with affected farmers to pasture livestock elsewhere, or other mutually agreeable alternatives, as appropriate.	No significant adverse effects.	Long-term effects include better quality, safer area for grazing livestock. Short-term positive effects include temporary employment for local workers, local purchasing of supplies and materials, rental of equipment, etc.
		Aesthetic Considerations	Staging and Site Preparation Transportation and Materials and Equipment Cut and Fill Resource and Materials Use	Temporary changes to aesthetics in work areas.	• Minimize time period for excavations. • Site clean-up and restoration, including revegetation will be carried out after construction phase.	No significant adverse effects.	Covering of debris currently exposed due to erosion.
		Heritage Resources	Staging and site preparation Cut and Fill Natural attenuation	Artifacts of paleontological significance could be encountered during site clearing and excavation activities, and/or from excavation of borrow source(s).	• Work areas are primarily located in previously disturbed areas (location of manmade landfill). • The proposed work will not disturb bedrock, therefore the likelihood of encountering fossils is minimal. • If any fossils are encountered, work activity will stop and the Royal Tyrell Museum will be contacted, as per the instructions of Museum personnel.	No significant adverse effects.	N/A

Potential Adverse Environmental Effects					Proposed Standard Design or Mitigation Measures	Residual Adverse Effects	Anticipated Long-Term Positive Effects
		Valued Component	**Project Component(s)**	**Potential Effect without Mitigation**			
					• If any archeological resources, palaeontological resources, Aboriginal traditional use sites and/or historic sites are encountered during construction activities, the Historic Resources Management Branch (HRMB of Alberta Culture and Community Spirit (ACCS)) will be contacted immediately. • The local police department will be contacted if human remains are found.		
Effects of the Environment on the Project		Soil and Surficial Geology	Staging and Site Preparation Cut and Fill	Extensive excavation would involve significant disturbance of existing landfill waste material or contaminated soil that could potentially act as source of contaminants to clean soil and/or water.	• Segregation of soil from waste materials. • Removal of any wastes that may require disposal in a licensed facility. • Soil and groundwater quality will be monitored at regular and frequent intervals during excavation. • Any contaminated soil or water that may be encountered will be disposed of according to environmental protection requirements.	No significant adverse effects.	N/A
Effects of Accidents or Malfunctions		Health, Safety and Security	Staging and Site Preparation Transportation of Materials and Equipment Cut and Fill	Slope failure could occur due to construction activity, and could result in injury to workers or damage to equipment.	• Setback distance to keep staff and machinery safely away from slope edges etc. • HASP of contractor. • Emergency plan and evacuation route to get to nearest hospital or medical clinic/facilities at the Drumheller Institution.	No significant adverse effects	N/A
				Vehicular incidents during equipment transport.	• Equipment transportation will be conducted by qualified companies.	No significant adverse effects.	N/A
				Fuel storage and handling practices	• Dedicated fuel storage/handling/transfer area will be set up on-site. Locations will be away from wetland, creek or any other potentially sensitive receptors. • ASTs will comply with CCME and EPA requirements and will have secondary containment. • A spill response plan will be in effect throughout the project. • Spill response measures will include measures to capture spilt fuel on-site (i.e. adsorbent materials) and emergency contacts (i.e. Alberta Environment).	No significant adverse effects anticipated.	N/A
				Grass fire or other fire ignited due to improper fuel handling, vehicular incident and/or dry conditions.	• The location of firefighting equipment and personnel will be determined and made known to site workers as part of the contractor's health and safety plan.	No significant adverse effects.	N/A

7.6 Significance of Residual Effects

Since the proposed project involves a short-term construction phase (weeks) and a long-term functional phase (indefinite), and since the main purpose of the project is to rehabilitate the former landfill, any residual adverse effects after standard mitigation measures are implemented are expected to be minimal. Further, it is anticipated that the long-term beneficial environmental effects of the project will greatly outweigh any short-term residual adverse effects that may occur.

7.7 Cumulative Effects

No related projects are anticipated in the area. No further remediation activities are planned or expected for the former landfill, and there are no ancillary projects associated with the proposed project. For these reasons, no cumulative effects were assessed.

8.0 INSPECTION, MONITORING AND FOLLOW UP

The construction contractor will receive copies of this report.

All potential environmental effects of the proposed project will be addressed through standard mitigation measures, which include inspection and monitoring requirements. All construction activities will be subject to inspection requirements to ensure adherence to applicable procedures and specifications. The contractor will be responsible for the supervision of on-site project inspection activities, for ensuring that the construction procedures implemented on site respect the conditions set out within this EA report, and that ongoing monitoring of potential environmental effects is conducted.

To ensure that all work is carried out in compliance with the provisions of this EA, an Environmental Protection Plan is being developed for the proposed project and will be made available to the contract prior to the initiation of work. The EPP will include more detailed descriptions of actions required in order to ensure that the mitigation measures specified in Table 7-1, above are implemented.

It was determined that a follow-up program, as specified in the *CEA* Act, would not be required, as:

- The project is not contributing to regional issues of concern;
- The project does not involve new or unproven mitigation measures such that the ability to reduce effects is uncertain;
- The project does not constitute a familiar or routine project proposed for a new or unfamiliar environmental and socio-economic setting; and
- There is no uncertainty about the conclusion of the EA.

8.1 Post Remediation Monitoring

The remedial actions outlined in the tasks above will require a commitment to monitoring, both during the implementation phase of the project and after the remediation is complete.

Monitoring during remedial work will include water quality and ambient air (dust) monitoring in the environment around the site. The potential impact of the remediation work on wildlife should also be monitored. A designated health and safety officer will be on site at all times during the implementation, with the primary role of monitoring the health and safety of site workers. The monitoring will include dust monitoring when there is any risk of airborne dust affecting site workers, gas monitoring for accessing closed spaces, and any other occupational monitoring required to ensure a safe work place.

Monitoring after remediation is completed will assess the performance of the remedial measures compared with the original objectives and will allow any necessary maintenance or corrective action to be taken in a timely manner. The site is remote and difficult to access, therefore remedial measures will be designed to minimize the need for maintenance and long-term monitoring.

Two types of post-remediation monitoring are anticipated: performance monitoring and environmental monitoring. These are discussed in the following sections.

8.1.1 Performance Monitoring

Performance monitoring will be required for all of the remediation measures that involve changes to the site, including: excavations of the slopes, placement of removed soil/fill/waste on the top of the former landfill, capping and re-vegetation of the top of the site, potential roadway repairs and surface water quality. The performance of these remedial works will be measured in terms of physical stability, erosion, and re-vegetation. Performance monitoring will be undertaken on a semi-annual basis for a period of at least two years following completion of the remediation works. The monitoring may continue in the long term, but the results of monitoring in the immediate, post-implementation phase will determine the frequency and scope of the longer-term requirements, if any.

Performance monitoring should include semi-annual inspections for all works, by an appropriately qualified geotechnical engineer. The inspections would include the use of 3-D laser surveys to compare elevations at the time of inspection to as-built elevations, and determine whether the slopes (or drainage channels) have remained stable over time. The results of all inspections will be documented in annual reports to PWGSC, including any recommendations for maintenance or corrective actions, should “slope creep” occur.

8.1.2 Environmental Monitoring

Monitoring of environmental quality at the site should continue in conjunction with the performance monitoring of remediation measures. Environmental monitoring will be undertaken during the implementation phase and on a semi-annual basis for a period of at least two years following completion of the proposed remediation works. Surface and ground water quality will be the primary focus of the environmental monitoring program and will include sampling to monitor the decrease in concentration of any remaining contaminants in surface and groundwater over time. Environmental monitoring will continue in the longer term, but the frequency and scope of the work will be reduced.

The field work undertaken during the monitoring events should target collection of sufficient information to fulfil any risk management requirements. These tasks will include:

- Assessing contaminant concentrations in surface and ground water adjacent to and within the site boundaries;
- Assessing geochemistry and other parameters in ground water to evaluate natural attenuation processes; and,
- Updating the site conceptual model to reflect newly-obtained environmental information.

Following the remediation program, surface and ground water quality should be assessed. Special efforts should be made to protect and maintain as many monitoring wells as possible throughout the remedial process. Five to ten of the peripheral monitoring wells should be monitored as part of the environmental monitoring program.

Annual surface water and sediment sampling should continue at the sampling locations established.

9.0 DECLARATION

This environmental assessment report identifies and addresses potential effects associated with the remediation of the Drumheller Institution No. 530 Landfill.

The comprehensive program of mitigation measures to be undertaken by Correctional Service Canada (CSC, the Proponent) addresses potential effects on valued biophysical and socioeconomic components, including potential residual effects. No significant adverse effects on valued components are anticipated to occur as a result of the proposed project, with the implementation of the mitigation measures described herein.

This report has been prepared in general compliance with the requirements of the *Canadian Environmental Assessment Act*. Any inquiries should be directed to the undersigned.

FRANZ ENVIRONMENTAL INC.

Susan Winch, Ph.D.
Senior Environmental Scientist

Mike Grinnell, P.Eng.
Senior Environmental Engineer

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10.0 LIMITATIONS

This report has been prepared exclusively for Public Works and Government Services Canada (PWGSC), on behalf of Correctional Service Canada (CSC). Any other person or entity may not rely upon the report without the express written consent from Franz Environmental Inc. (FRANZ) and PWGSC.

Any use a third party makes of this report, or any reliance on decisions made based on it, is the responsibility of such third parties. FRANZ accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

There is no warranty, expressed or implied, that the work reported herein has uncovered all potential environmental liabilities. The findings of this report were developed in a manner consistent with a level of care and skill normally exercised by members of the environmental science and engineering profession currently practicing under similar conditions in the area. This report was prepared based on the information available to date.

Should new information become available, FRANZ requests that this information be brought to our attention so that we may reassess the conclusions presented herein.

11.0 REFERENCES

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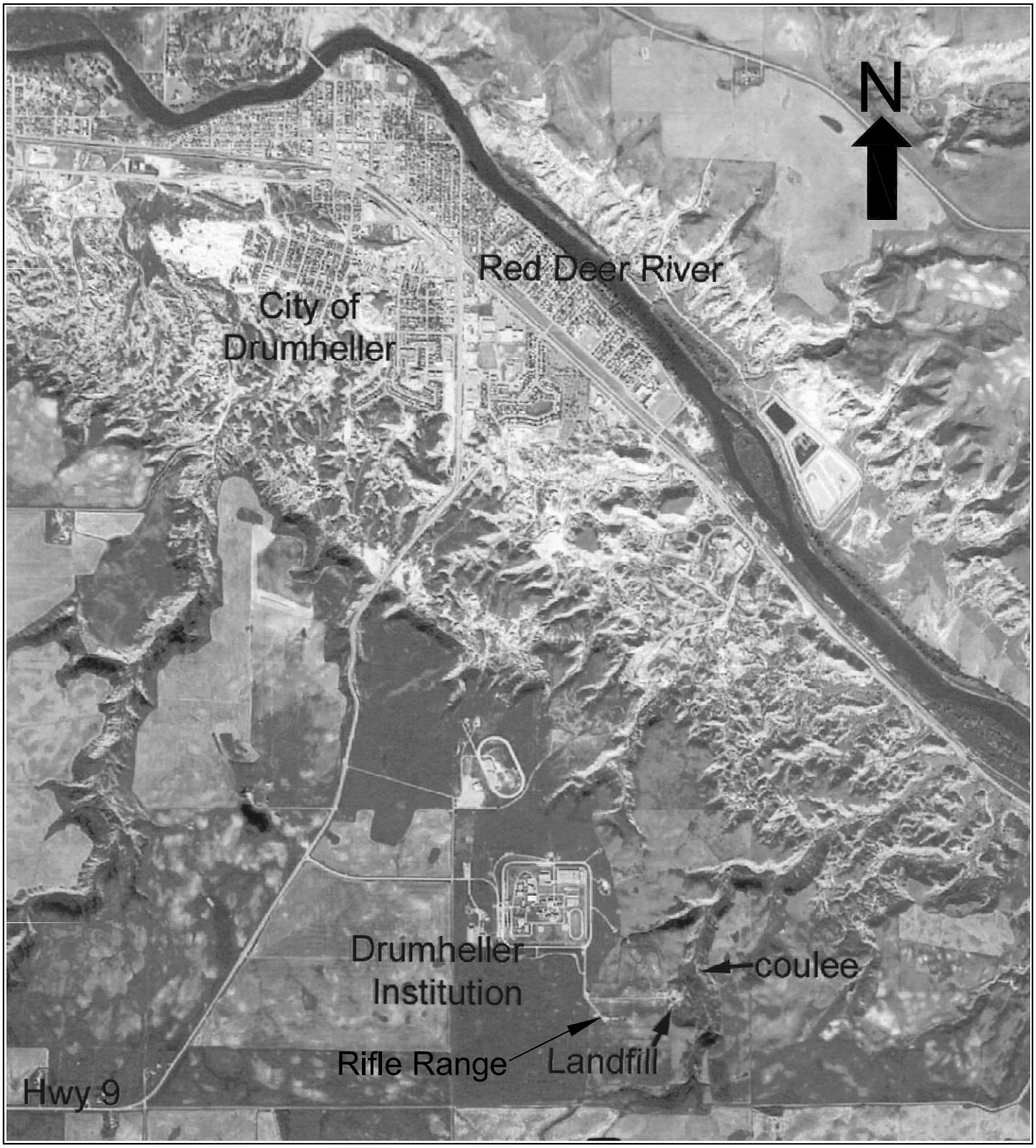
APPENDIX A

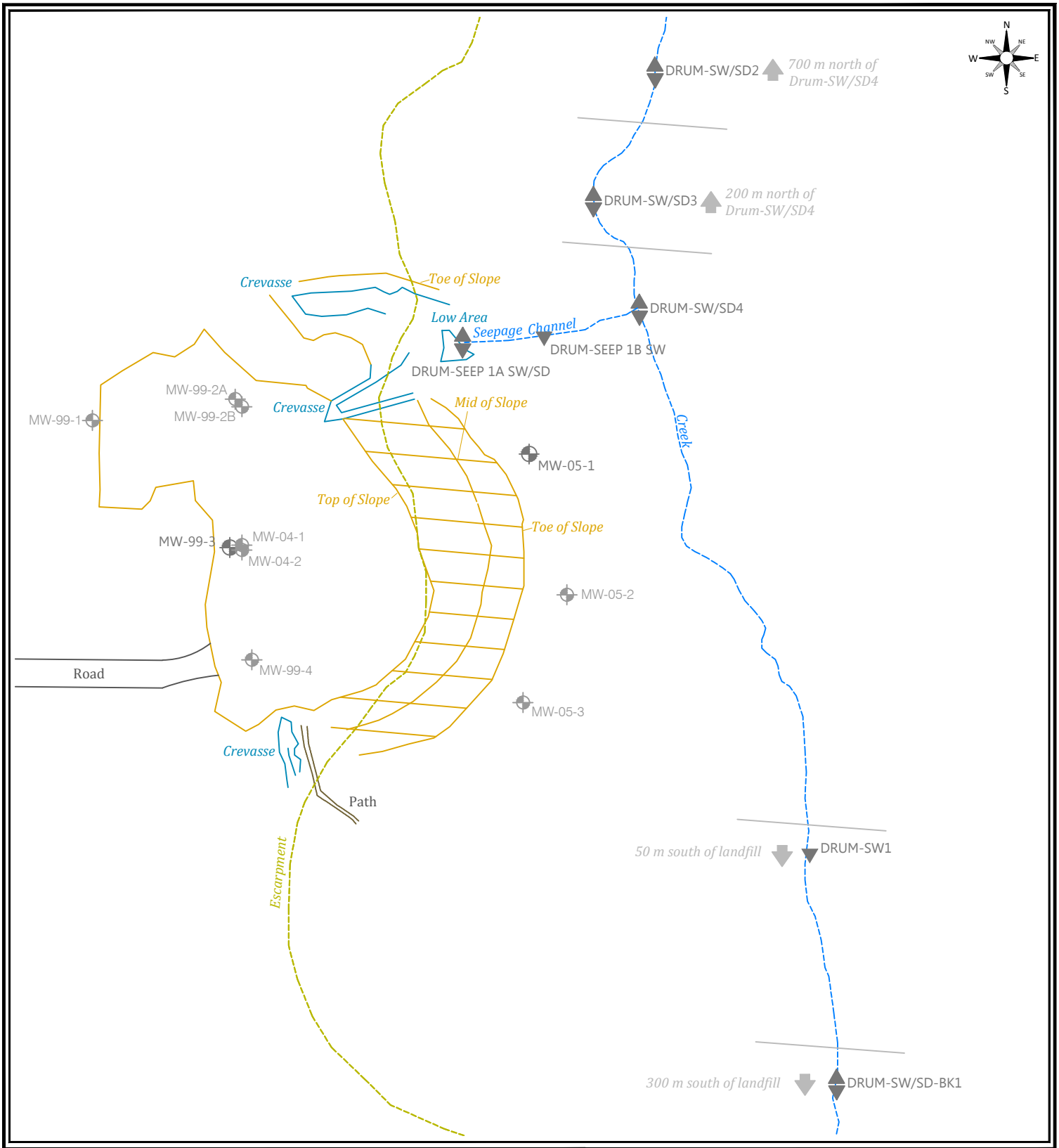
Figures



Reference:
Franz Environmental Inc. 2006. Supplemental Phase II Investigation Site 530-L01, Landfill Drumheller Institution, Alberta

Scale 1:30,000
500 250 0 Metres 500 1000

Title:	SITE LOCATION
Project:	SUPPLEMENTAL ENVIRONMENTAL SITE INVESTIGATION AND DATA GAP ANALYSIS DRUMHELLER INSTITUTION, DRUMHELLER, AB
Client:	PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
FRANZ ENVIRONMENTAL INC. ♦ CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦	Date: OCTOBER 2011
	FIGURE 1



Legend

- Sediment Sample Location
- Surface Water Sample Location
- Monitoring Well with Sufficient Volume for Sampling
- Previously Installed Monitoring Well

Reference: Taggish Engineering Figure - Existing Condition

Title: Sample Locations

FRANZ ENVIRONMENTAL INC.
CONSULTING ENGINEERING TECHNOLOGIES

Project: Supplemental Enviromental Site Investigation and Data Gap Analysis Drumheller Institution, Drumheller, AB

Date: October 2011

Client: Public Works and Government Services Canada

Scale 1:1750

50 40 30 20 10 0 25 50 metres

Figure 2

last saved by: cfernandes

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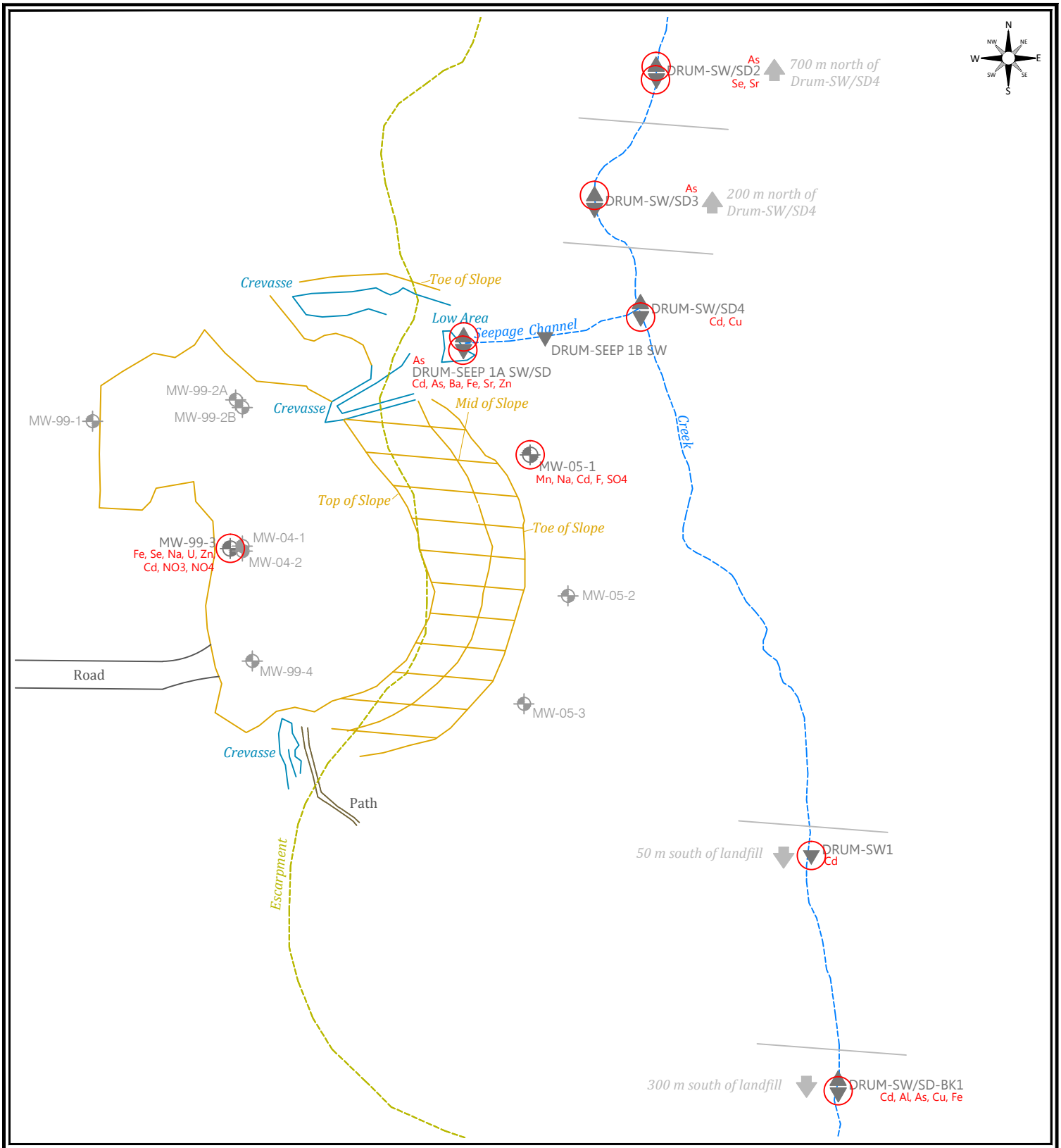

Legend

- Sediment Sample Location
- Surface Water Sample Location
- Monitoring Well with Sufficient Volume for Sampling
- Previously Installed Monitoring Well
- Above Applicable Guidelines (Fe)

Reference: Taggish Engineering Figure - Existing Condition

Title: Analytical Results for Groundwater, Surface Water and Sediment

FRANZ ENVIRONMENTAL INC.
CONSULTING ENGINEERING TECHNOLOGIES

Project: Supplemental Enviromental Site Investigation and Data Gap Analysis Drumheller Institution, Drumheller, AB

Date: October 2011

Client: Public Works and Government Services Canada

Scale 1:1750

50 40 30 20 10 0 25 50 metres

Figure 3

last saved by: cfernandes

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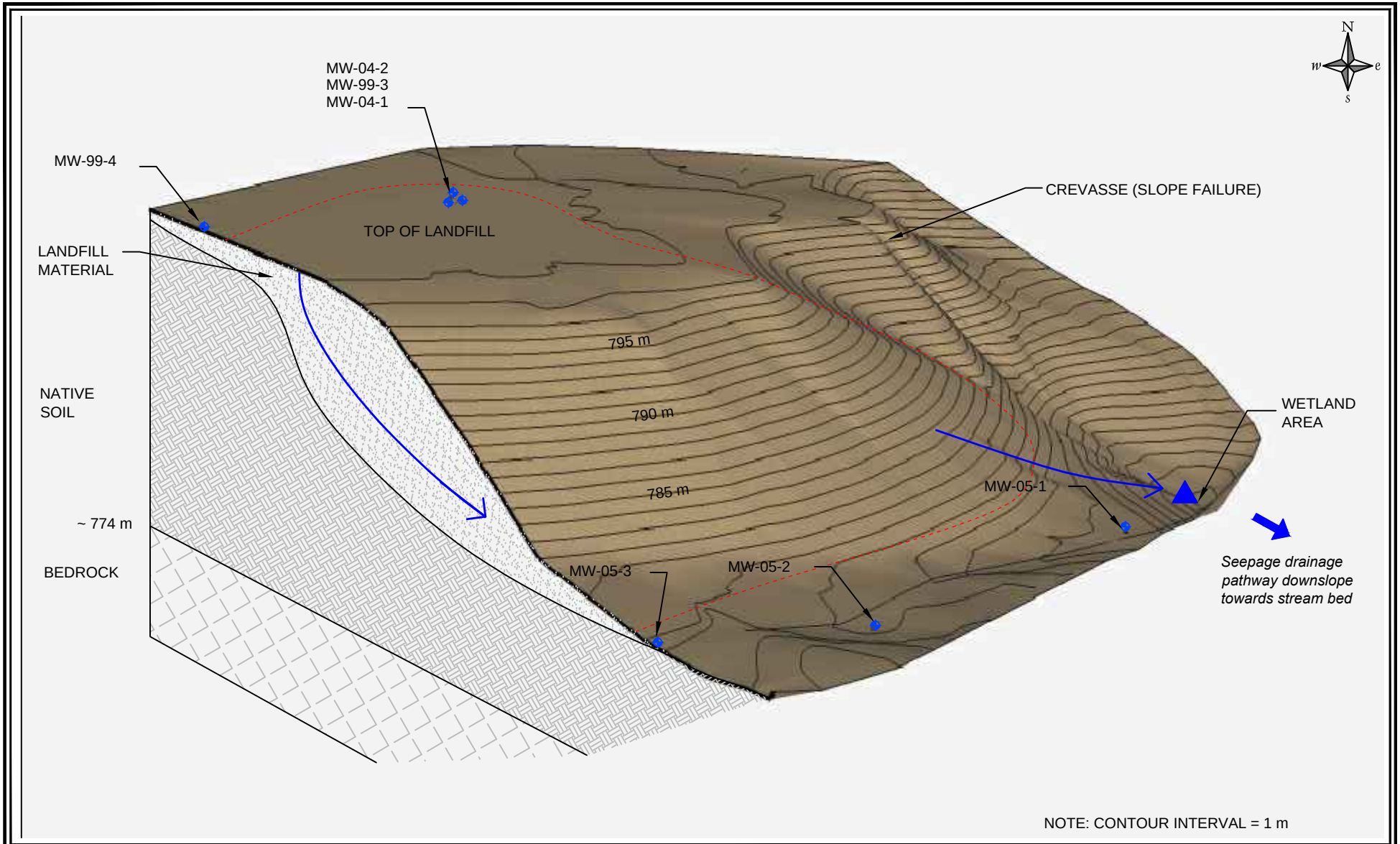

LEGEND

- APPROXIMATE LANDFILL EXTENTS
- CONTOUR LINE
- GROUNDWATER DAYLIGHTING TO SURFACE WATER
- MONITORING WELL
- GROUNDWATER FLOW DIRECTION

Title: UPDATED CONCEPTUAL SITE MODEL - FORMER LANDFILL

FRANZ ENVIRONMENTAL INC.
CONSULTING ENGINEERING TECHNOLOGIES

Project: SUPPLEMENTAL ENVIROMENTAL SITE INVESTIGATION AND DATA GAP ANALYSIS DRUMHELLER INSTITUTION, DRUMHELLER, AB

Date: OCTOBER 2011

Client: Public Works and Government Services Canada

NO SCALE

FIGURE 4

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APPENDIX B

Photographic Logs

FRANZ ENVIRONMENTAL INC.
CONSULTING • ENGINEERING • TECHNOLOGIES

PHOTOGRAPHIC LOG

Environmental Assessment Report **Former Landfill, Drumheller Institution**	**Project No: 2026-1102**
Photo ID 1 **Direction:** NW **Description:** Top of Former Landfill looking NW towards fence line.	

Environmental Assessment Report **Former Landfill, Drumheller Institution**	**Project No: 2026-1102**
Photo ID 2 **Direction:** NW **Description:** View of the Former Landfill looking NW.	

Environmental Assessment Report Former Landfill, Drumheller Institution	Project No: 2026-1102
Photo ID 3	
Direction: SE	
Description: View of Former Landfill looking SE. Note slope failure on the right hand side of photo.	

Environmental Assessment Report Former Landfill, Drumheller Institution	Project No: 2026-1102
Photo ID 4	
Direction: W	
Description: View of MW99-03 on top of Landfill. Well located adjacent to Landfill fence line.	

Environmental Assessment Report Former Landfill, Drumheller Institution	Project No: 2026-1102
Photo ID 5	
Direction: NW	
Description: View of MW05-1. Wetland area is located just beyond trees at the top right hand corner of photo. Slope failure area located in top background of photo.	

Environmental Assessment Report Former Landfill, Drumheller Institution	Project No: 2026-1102
Photo ID 6	
Direction: N	
Description: View of adjacent lands looking north.	

Environmental Assessment Report Former Landfill, Drumheller Institution	Project No: 2026-1102
Photo ID 7 **Direction:** S **Description:** Stream bed at bottom of coulee. View looking south towards background sample location.	

Environmental Assessment Report Former Landfill, Drumheller Institution	Project No: 2026-1102
Photo ID 8 **Direction:** W **Description:** Looking west up at Former Landfill. Standing where seepage meets the stream bed (DRUM-SW/SED-4). Note slope failure on right side of Landfill.	

Environmental Assessment Report Former Landfill, Drumheller Institution	Project No: 2026-1102
Photo ID 9	
Direction: S	
Description: Stream bed at bottom of coulee. Looking south towards Landfill.	

Environmental Assessment Report Former Landfill, Drumheller Institution	Project No: 2026-1102
Photo ID 10	
Direction: W	
Description: View of seepage drainage pathway looking west towards Landfill. Drainage pathway is heavily vegetated.	

Environmental Assessment Report Former Landfill, Drumheller Institution	Project No: 2026-1102
Photo ID 11	
Direction: N/A	
Description: Seepage drainage pathway. Flow is minimal.	

Environmental Assessment Report Former Landfill, Drumheller Institution	Project No: 2026-1102
Photo ID 12	
Direction: SW	
Description: Wetland area located at toe of Landfill. View towards SW up at Landfill. This area is a low lying depression.	

Environmental Assessment Report Former Landfill, Drumheller Institution	Project No: 2026-1102
Photo ID 13	
Direction: W	
Description: Wetland area. View towards the west and the slope failure.	

Environmental Assessment Report Former Landfill, Drumheller Institution	Project No: 2026-1102
Photo ID 14	
Direction: E	
Description: View of wetland area towards E. The seepage drainage pathway exits wetland and flows down slope towards stream bed from here.	

Environmental Assessment Report Former Landfill, Drumheller Institution	Project No: 2026-1102
Photo ID 15	
Direction: E	
Description: Standing at top of the Former Landfill at the slope failure looking E.	

Environmental Assessment Report Former Landfill, Drumheller Institution	Project No: 2026-1102
Photo ID 16	
Direction: N	
Description: View towards the north from top of Landfill.	

Environmental Assessment Report Former Landfill, Drumheller Institution	Project No: 2026-1102
Photo ID 17	
Direction: S	
Description: View south from top of coulee. Former Landfill on right hand side.	

Environmental Assessment Report Former Landfill, Drumheller Institution	Project No: 2026-1102
Photo ID 18	
Direction: N/A	
Description: View of the bright orange colour of colloidal iron oxides at the DRUM-SEEP1A sampling location. Note the biofilm (“sheen”-like appearance, with angular edges) of iron-reducing bacteria on the surface.	

Environmental Assessment Report Former Landfill, Drumheller Institution	Project No: 2026-1102

Photo ID 19	
Direction: N/A	
Description: Canister found during site reconnaissance. Confirmed to be tear gas, but has been decommissioned prior to disposal.	

APPENDIX C

Phase II Environmental Site Assessment Drumheller Institution March 2000, by UMA Engineering Ltd., March 2000.

PHASE II
ENVIRONMENTAL SITE ASSESSMENT
DRUMHELLER INSTITUTION

Solid waste landfill

Prepared for:

Public Works and Government Services Canada

Prepared by:

UMA Engineering Ltd.
Engineers, Planners and Surveyors
17007 – 107 Avenue
Edmonton, Alberta
T5S 1G3

APPEGA PERMIT TO PRACTICE NO. P329

March 2000
2977-213-00-02

R00-53

TABLE OF CONTENTS

UMA ENGINEERING LTD.
THIRD PARTY DISCLAIMER

1.0 INTRODUCTION

UMA Engineering Ltd. (UMA) was retained by Public Works and Government Services Canada (PWGSC) to conduct a Phase II Environmental Site Assessment (ESA) in the area of a closed landfill at the Drumheller Medium Security Institution.

The Drumheller Institution is located approximately 5 kilometers south of the City of Drumheller within the southeast quarter of Section 25, Township 28, Range 20, west of the Fourth meridian.

1.1 PURPOSE

The purpose of the Phase II ESA was to conduct a detailed assessment in the area of the landfill. The landfill was identified during the Phase I ESA completed by PWGSC in February, 1999[1]. It was recommended that an intrusive investigation be conducted in the area of the landfill to characterize the waste and to determine whether leachate was present at the site, and the extent of any possible impact to the area.

1.2 SCOPE

The scope of the Phase II ESA was to include:

- an electromagnetic (EM) survey to define the lateral extent of the landfill and identify any possible leachate plumes;
- excavation of test pits to assess the nature of the waste materials within the landfill;
- Drilling of boreholes to be completed as monitoring wells;
- Collection of soil, groundwater and surface water samples to be submitted for selected laboratory analyses;
- submission of selected soil and water samples to a laboratory for analysis of selected parameters;

[1] Correctional Services Canada, Environmental Baseline Assessment, Drumheller Medium Security Institution, Site No. 530, Volume 1 of 4: Phase I Environmental Site Assessment. February 10, 1999. Public Works and Government Services Canada.

- processing, analysis, and interpretation of the laboratory results, including a comparison of the analytical results to applicable comparative criteria; and,
- completion of a summary report, including conclusions, and recommendations.

A copy of the UMA Group Disclaimer and UMA Engineering Ltd. Supplemental Terms and Conditions are in Appendix E, as these apply to all work conducted and completed by UMA Engineering Ltd.

1.3 BACKGROUND

A Phase I ESA for the Drumheller Medium Security Institution was completed in February, 1999 by PWGSC. Among the specific environmental issues identified through the Phase I ESA process, was a closed landfill located approximately 750 metres south of the perimeter fence. The landfill was reported to have been developed approximately 35 years ago and closed prior to 1988. The landfill was operated in a series of trenches, occupying an area of approximately 150 by 200 metres. Food and non-food wastes were separated prior to disposal in the landfill; however, there was no indicated exclusion of any waste materials prior to disposal. The landfill was not engineered and topsoil and subsoil layers were not separated to be used as cover material at closure. The Phase I ESA recommended a Phase II investigation be conducted to determine whether leachate was being produced at the site.

2.0 PRESENT PROGRAM

2.1 ELECTROMAGNETIC SURVEY

A geophysical survey of the closed landfill area was conducted by Associated Mining Consultants Ltd. of Calgary on October 19 and 20, 1999. The electromagnetic survey included the use of an EM-61 instrument, which detects metals to a depth of approximately 10 metres below ground surface (mBGS), to assess the lateral extent of the landfill. An EM-31, with a depth of investigation of approximately 5 mBGS, and an EM-34, with a depth of investigation of approximately 10 mBGS, were also used to detect the presence of any possible leachate plumes migrating away from the landfill area. The results of the geophysical survey were mapped and presented as a report, included as Appendix B.

2.2 TEST PITTING

Thirteen (13) test pits were excavated in the area of the landfill on November 2, 1999. The excavations were dug to a maximum depth of approximately 5 mBGS, the maximum reach of the backhoe. Each test pit was backfilled and returned to grade with excavated material. The site plan in Appendix A shows the approximate locations of the test pits.

2.3 BOREHOLE DRILLING AND MONITORING WELL INSTALLATION

Five boreholes were drilled and completed as groundwater monitoring wells (MW) on November 3, 1999. Approximate borehole locations are illustrated on the site plan in Appendix A. A truck-mounted auger drill was used to drill the boreholes. Soil samples were collected as grab samples off the auger flights at approximately 0.75 metre intervals, pared and placed in plastic bags. The completion depth of borehole 99-2B was 15.2 mBGS and the completion depth for borehole 99-4 was 10.7 mBGS. The remaining boreholes were drilled to a depth of 9.1 mBGS. The borehole logs are in Appendix C.

The monitoring wells were completed using 50 millimetre threaded PVC pipe and fittings. The annulus around and above the 3-metre slotted interval was backfilled with sand, above which the borehole annulus was backfilled with bentonite chips. The bentonite chips were intended to seal the borehole and prevent the entrance of surface water into the monitoring well. The monitoring wells were labeled MW 99-1 through MW 99-4, with the exception of the location of MW 99-2 where two monitoring wells, labeled MW 99-2A and MW 99-2B, were completed. The two monitoring wells were completed through two vertically separate intervals to be able to determine the vertical difference in water levels. Completion details for the monitoring wells are included on the borehole logs in Appendix C.

2.4 SOIL SAMPLING

Representative sub-surface soil samples from the boreholes were selected for analysis. The selected soil samples were submitted to a laboratory for the following analyses:

- Detailed salinity;
- Trace metals;
- Alberta Tier I PAH (Polycyclic Aromatic Hydrocarbons);
- BTEX (benzene, toluene, ethylbenzene, and xylenes);
- TVH (Total Volatile Hydrocarbons);
- TEH (Total Extractable Hydrocarbons); and,
- Recoverable Hydrocarbons (equivalent to Mineral Oil and Grease).

Copies of the laboratory analytical test results for the soil samples are in Appendix D.

2.5 WATER SAMPLING

A site visit was conducted on November 10, 1999 for the purpose of measuring water levels, purging the monitoring wells, conducting hydraulic conductivity tests, and collecting groundwater and surface water samples. At the time of the site visit, no groundwater was present in the monitoring wells. As such, no testing was completed and no groundwater samples were collected.

Two surface water samples were collected from the creek at the base of the coulee, downslope and to the east of the landfill, and one surface water sample was collected from a spring located on the northeast slope of the landfill site. Sampling locations are shown on the Site Plan in Appendix A. The samples were submitted to a laboratory for the following analyses:

- Salinity;
- Dissolved metals;
- Alberta Tier I PAH (Polycyclic Aromatic Hydrocarbons);
- BTEX (benzene, toluene, ethylbenzene, and xylenes);
- TVH (Total Volatile Hydrocarbons);
- TEH (Total Extractable Hydrocarbons); and,
- Recoverable Hydrocarbons (equivalent to Mineral Oil and Grease).

Copies of the laboratory analytical test results for the surface water samples are in Appendix D.

3.0 RESULTS

3.1 ELECTROMAGNETIC SURVEY

The results of the EM survey identified two areas where metal was indicated to be present below the surface. The largest quantities of buried metal were indicated to be in the northern region of the study area, north of the fenced compound. The results indicated smaller quantities of buried metal near the south slope of the landfill area, south of the fire hydrant.

A survey was also performed outside the indicated perimeter of the landfill. The results of this survey indicated variations in conductivity likely due to variations in soil properties with topography, as the survey moved downslope. Localized ground conductivity variations were also noted, possibly indicating elevated total dissolved solids (TDS), along the perimeter downslope to the northeast and southeast of the landfill site.

The perimeter survey also indicated elevated ground conductivity associated with the spring located along the northeast slope of the landfill area. It was suggested that the elevated conductivity in this area could be naturally occurring or could be the result of mobilized contaminants originating within the landfill. The EM survey report recommended the water from the spring be analysed to determine the cause of the elevated ground conductivity.

3.2 TEST PITTING

Test pitting was used to confirm the results of the EM survey and to review the nature of the landfilled material. At the time of the initial site visit, a crack in the ground, extending north/south across the site, was observed approximately 10 to 20 metres from the eastern slope of the landfill area. No test pits were dug beyond this point. At the time of test pitting, a large pile of scrap wood was located in the south central portion of the landfill area. As such, it was not possible to complete test pits in this area.

Thirteen (13) test pits were excavated in the area of the landfill. Table 3-1 provides a summary of the completion depths and the types of materials encountered in each test pit.

Test Pits 4 through 6, 11, and 12 were excavated in the central area of the site. The depth of the excavations ranged from 4.0 to 5.2 metres below ground surface (mBGS) and the profiles consisted primarily of silty clay fill material. No waste materials were encountered in this area.

Test Pits 7 through 10 were excavated in the southern area of the site. The depth of the excavations ranged from 4.3 to 4.6 mBGS, with the exception of Test Pit 8, which was excavated to a depth of 2.4 mBGS. No waste or fill materials were encountered at the location of Test Pit 8; the excavated material appeared to consist of undisturbed native soil. Asphalt, concrete, wood and cloth waste materials were encountered at a depth of approximately 3.0 mBGS at the location of Test Pit 9. Large quantities of these materials, mixed with scrap metal, copper pipes, rigid plastic, Styrofoam, pop cans, and plastic garbage bags, were encountered at the locations of Test Pits 7 and 10, 4.6 and 4.3 mBGS, respectively. Insulation material and large quantities of stones, up to 10 cm in diameter, were also encountered in Test Pit 10. No waste materials were encountered at the base of Test Pits 7 and 10; however, a concrete slab was encountered at the base of Test Pit 9, at a depth of approximately 4.6 mBGS.

Test Pits 1 through 3, and 13 were excavated to depths ranging from 3.0 to 4.2 mBGS in the northern area of the site. No waste material was encountered at the location of Test Pit 13 and the excavated material consisted primarily of silty clay fill. A metal screen, several small pieces of concrete and cloth were encountered at a depth of approximately 1.0 mBGS at the location of Test Pit 1. No other waste materials were encountered at this location and the excavated material consisted mainly of silty clay fill. Large quantities of metal materials, such as car parts, bed frames, copper pipes, and pop cans, as well as concrete, wood, and cloth were encountered at the locations of Test Pits 2 and 3. A small quantity of food waste was encountered in Test Pit 2.

The Test Pits were returned to grade with the excavated materials, including all waste materials encountered. At the location of Test Pit 3, large quantities of metal were encountered and could not be returned to the excavation. Institution staff indicated the excavated metal and fill materials would be separated and properly disposed of.

3.3 BOREHOLE DRILLING

The unconsolidated sediments encountered in boreholes 99-1, 99-2A, and 99-2B, located on the north side of the landfill, were characterized by interbedded units of sand and silt. The alternating layers of sand and silt encountered at these locations may have consisted of fill materials and extended to a maximum depth of approximately 12.8 metres below ground surface (mBGS) at the location of borehole 99-2B. The sand and silt deposits extended to the full depth of completion for the two boreholes with shallower completion depths (9.1 mBGS), boreholes 99-1 and 99-2A. At the location of borehole 99-2B, these sand and silt units were underlain by clay deposits. A clay layer, also likely fill material, was encountered, at the location of borehole 99-1, in the interval between approximately 2.3 and 3.8 mBGS.

A layer of clay fill material, extending from surface to a depth of approximately 3.0 mBGS, was encountered at the location of borehole 99-3. Clay till was encountered beneath the fill material, to a depth of approximately 6.1 mBGS, overlying mottled clay deposits which extended to the completion depth of 9.1 mBGS.

Fill material from ground surface to a depth of 2.1 mGBS, at the location of borehole 99-4, overlay an organic layer, approximately 0.2 metres in thickness. The organic layer appeared to be the topsoil of the former hill slope. This organic layer was underlain by clay to a depth of 4.6 mBGS overlying a silt unit in the interval between approximately 4.6 and 9.9 mBGS. The silt unit overlay silty clay deposits which extended to the completion depth of 10.7 mBGS.

3.4 SOIL ANALYSIS

3.4.1 Comparative Criteria

The following criteria were selected for comparison to the analytical laboratory results:

- 1997 Canadian Council of Ministers of the Environment (CCME) Recommended Canadian Soil Quality Guidelines: Recommended Guidelines for Residential and Parkland Land Use;

- 1991 CCME Interim Canadian Environmental Quality Criteria for Contaminated Sites: Remediation Criteria for Residential and Parkland Land Use; and,
- 1994 Alberta Tier I Draft Criteria for Contaminated Soil Assessment and Remediation.

As the Drumheller Institution is located on federal lands, the federal CCME criteria were the primary assessment criteria used for comparison to the analytical results. The Alberta Tier I criteria were also included for comparison purposes as they provide assessment criteria for some parameters not included in the CCME criteria. Neither set of criteria are site specific. Rather, they are intended to approximate acceptable concentrations of soil contaminants for all site conditions and land uses.

3.4.2 Soil Sample Analysis Results

The analytical results for the soil samples, and comparative criteria, are presented in Table 3-2.

The reported recoverable hydrocarbons (RH) concentrations reported for the two soil samples collected from Monitoring Well (MW) 99-4 exceeded the Alberta Tier 1 assessment criteria. Recoverable hydrocarbons are equivalent to mineral oil and grease, which are petroleum hydrocarbon based. Of particular note, the soil sample collected from the 2.3 to 3.0 metre interval had a reported RH concentration of 6,600 mg/kg. The Alberta Tier 1 criteria is 1,000 mg/kg; there are no CCME criteria for RH. The soil in this interval was black in colour and was believed to be topsoil material. No smell of hydrocarbons was detected. The RH concentrations for the remaining soil samples ranged from below the detection level of 100 mg/kg to 700 mg/kg. RH concentrations were reported for all soil samples, with the exception of the sample submitted for MW 99-2B.

The soil samples collected from MW 99-2B, MW 99-3 (a duplicate sample for 3.0-3.8 m), and the 2.3 to 3.0 metre sample from MW 99-4 had low TEH concentrations, ranging from 6 to 8 μg/g. These concentrations are marginally above the analytical method detection limit of 5 μg/g. The TEH concentration for the 1.5 to 2.3 metre soil sample from MW 99-4 was 42 μg/g. The remainder of the TEH concentrations were reported as below the analytical method detection limit. No BTEX or TVH

concentrations above the analytical method detection limit were reported for any of the soil samples.

No PAH parameter concentrations above the analytical method detection limits were reported for any of the soil samples.

The chromium concentration for the soil sample collected from MW 99-4 (2.3-3.0 m), at 69.2 mg/kg, was the only metal concentration above CCME criteria. The CCME criteria for chromium is 64 mg/kg. The nickel concentration for the soil samples collected from MW 99-3 (3.0-3.8 m) and MW 99-4 (2.3-3.0 m) and the zinc concentration for MW 99-3 (2.3-3.0 m) exceeded the Alberta Tier I criteria, but were below the CCME criteria for these two parameters. All other metals concentrations for the soil samples were below the assessment criteria.

Several of the trace metals concentrations for the soil samples collected from MW 99-3 and MW 99-4, located in the central and southern area of the landfill were slightly higher than the concentrations reported for the soil samples from MW 99-1 and MW 99-2B, located in the northern portion of the landfill area.

The highest pH value was reported for the soil sample from MW 99-2B. At 8.1 pH units, the pH for this sample marginally exceeds the CCME criteria for pH, but is within the Alberta Tier I acceptable range for pH. The remainder of the pH values ranged from 7.7 to 7.9 pH units. The specific conductance for the soil samples for MW 99-1 (2.3-3.0 m), MW 99-3 (3.0-3.8 m), and MW 99-4 (1.5-2.3 m) were also above the CCME criteria. The values that exceeded the 2 dS/cm criteria ranged from 2.26 to 3.56 dS/cm. No sodium absorption ratios above the criteria were reported for any of the samples.

There are no CCME or Alberta Tier I criteria for the remainder of the salinity parameters. The highest soluble sodium, calcium, magnesium, sulphate, and specific conductance concentrations were associated with the soil sample for MW 99-1. The soil sample for MW 99-3 (3.0-3.8 m) reported the second highest concentration for each of these parameters. The salinity parameter concentrations for the duplicate sample from MW 99-3 (3.0-3.8 m) were significantly lower.

The soluble chloride concentrations reported for the samples collected from MW 99-4, at 40 mg/L for the depth interval from 1.5 to 2.3 metres, and 77 mg/L for the depth interval from 2.3 to 3.0 metres, were high when compared to the other analytical results. The soil sample collected from MW 99-1 also reported a higher chloride concentration, at 34 mg/L. The chloride concentrations for the remaining wells ranged from 9 to 23 mg/L.

3.4.3 Quality Assurance / Quality Control

A duplicate sample was collected from borehole 99-3, in the interval 3.0 to 3.8 metres, for the purpose of QA/QC. Some variation in parameter concentrations were noted between the two samples submitted from this interval. Given that the two samples submitted for analysis from borehole 99-3 (3.0 – 3.8 m) were not collected from a homogeneous sample, the inconsistencies noted are not greater than would be expected from natural variability in soil chemistry. The analytical results for the duplicate soil sample are included in Table 3-2.

3.5 WATER ANALYSIS

3.5.1 Comparative Criteria

The following criteria were selected for comparison to the analytical laboratory results:

- 1996 CCME Guidelines for Canadian Drinking Water Quality Criteria: Raw Water for Drinking Water Supply;
- 1991 CCME Interim Canadian Environmental Quality Criteria for Contaminated Sites: Remediation Criteria for Drinking Water and Interim Assessment Criteria for Water; and,
- July 1998 Alberta Environmental Protection Alberta Surface Water Quality Guidelines (ASWQG): A working compendium.

As indicated previously, the federal CCME criteria were selected because the Drumheller Institution is located on federal lands. As personal communication with residents in the area indicated livestock are watered downstream of the closed landfill, the ASWQG are also included, for comparison purposes only. Both sets of criteria are based on the Guidelines for Canadian Drinking Water Quality. They are intended to

apply to all drinking water supplies, public or private, and are considered to be protective of human health.

3.5.2 Water Sample Analysis Results

The analytical results for the groundwater samples, and comparative criteria, are presented in Table 3-3.

As groundwater was not present in the monitoring wells at the time of the subsequent site visit, one week after completion, no groundwater samples could be collected. Two surface water samples were collected from the creek at the base of the coulee, which is located to the east of the landfill. One sample was collected upstream and one sample was collected downstream of the landfill site. A water sample was also collected from a spring discharge located on the northeast slope of the landfill site.

No BTEX, TVH, TEH, MOG or PAH parameter concentrations above the analytical method detection limit were reported for any of the surface water samples.

The sodium concentrations for the surface water samples ranged from 280 mg/L to 343 mg/L. All the samples exceeded the sodium parameter CCME criteria of 200 mg/L.

The surface water sample collected upstream of the landfill site was intended to represent background conditions. A comparison of the upstream sample with the sample collected downstream of the landfill site, and from the spring on the northeast slope, indicated the downstream and spring samples had slightly higher sulphate, iron, manganese, and strontium concentrations. The spring sample also had a slightly higher calcium concentration and a lower pH than the upstream sample. The sulphate and iron concentration were below applicable assessment criteria and the spring sample pH value was within the acceptable range for pH. The manganese concentration of 0.057 mg/L for the sample collected from the spring marginally exceeded the CCME criteria for manganese of 0.05 mg/L. There are no CCME criteria for strontium or calcium; however, the calcium concentration was well below the ASWQG criteria.

3.5.3 Quality Assurance / Quality Control

A duplicate sample was collected from the spring discharge located on the northeast slope of the landfill site for the purpose of QA/QC. No significant inconsistencies were noted between the results reported for the two samples collected from this location. A field blank, consisting of distilled water, was also collected under field conditions. Analytical results reported for this sample were below or near the analytical method detection limit for most of the parameters. The analytical results for the duplicate sample and the field blank sample are included in Table 3-3.

3.6 OBSERVATIONS

At the time of the collection of the surface water samples, the excavated metal and fill material from Test Pit 3 was observed at the base of the north slope of the landfill site. It did not appear that any materials had been separated prior to the materials being pushed off the side of the slope.

Table 3-1
Drumheller Institution Landfill
Test Pitting Results

Test Pit	Depth (m)	Comments
1	4.1	small quantities of waste materials primarily metal, concrete
2	4.3	some waste materials concrete, wood, metal, domestic waste
3	3.7	large quantities of waste materials concrete, metal, wood, rigid plastic, domestic waste
4	5.2	no waste materials
5	4.6	no waste materials
6	4.9	no waste materials
7	4.6	some waste materials wood, metal, asphalt, rigid plastic, domestic waste
8	2.4	undisturbed native soil
9	4.6	some waste materials concrete, asphalt, wood, domestic waste
10	4.3	large quantities of waste materials concrete, metal, wood, rigid plastic, domestic waste
11	4.9	no waste materials
12	4.0	no waste materials
13	3.0	no waste materials

Table 3-2
Drumheller Institution Landfill
Analytical Results - Soil Samples

PARAMETERS	Units	Criteria: 1997 CCME Recommended	Criteria: 1994 Alberta Tier I	Location: MW 99-1 2.3-3.0 m	MW 99-2B 3.8-4.6 m	MW 99-3 2.3-3.0 m	MW 99-3 3.0-3.8 m	MW 99-3 (Duplicate) 3.0-3.8 m	MW 99-4 1.5-2.3 m	MW 99-4 2.3-3.0 m
Trace Metals										
Arsenic	mg/kg	12	10	5.8	4.4	5.3	6.6	7.0	5.7	7.2
Barium	mg/kg	500*	600	194	175	390	328	476	310	332
Beryllium	mg/kg	4*	5	<1	<1	<1	<1	<1	<1	<1
Cadmium	mg/kg	10	1	<0.5	<0.5	0.9	<0.5	<0.5	0.7	<0.5
Chromium	mg/kg	64	100	34.1	15.0	42.0	47.3	60.0	54.7	89.7
Cobalt	mg/kg	50*	20	9	6	11	12	12	10	11
Copper	mg/kg	63	80	20	8	23	28	29	28	29
Lead	mg/kg	140	50	10	6	13	12	13	35	15
Manganese	mg/kg	-	-	429	245	552	448	454	378	502
Mercury	mg/kg	6.6	0.2	0.02	<0.01	<0.01	0.03	0.01	0.05	0.01
Molybdenum	mg/kg	10*	4	<1	<1	<1	<1	<1	<1	<1
Nickel	mg/kg	100*	40	29	18	35	42	43	33	45
Selenium	mg/kg	3*	2	0.8	0.5	1.4	0.9	0.8	0.8	1.0
Strontium	mg/kg	-	-	68	33	80	84	85	58	50
Thallium	mg/kg	-	1	<1	<1	<1	<1	<1	<1	<1
Vanadium	mg/kg	130	100	32	15	45	45	70	47	75
Zinc	mg/kg	200	120	57.4	37.4	74.1	76.4	84.9	88.6	86.6
Soil Salinity										
pH	pH	6.0-8.0*	6.0-8.5	7.8	8.1	7.9	7.9	7.9	7.8	7.7
Sodium Absorption Ratio	n/a	5*	6.0	3.2	1.4	2.9	3.3	3.9	3.5	3.7
Soluble Calcium	mg/L	-	-	437	69.5	110	398	191	275	120
Soluble Chloride	mg/L	-	-	34	9	23	19	14	40	77
Soluble Magnesium	mg/L	-	-	256	105	57.3	181	106	122	54.2
Soluble Potassium	mg/L	-	-	20.4	9.6	7.4	15.2	11.6	21.0	7.2
Soluble Sodium	mg/L	-	-	338	82	148	318	272	281	195
Soluble Sulphate	mg/L	-	-	2720	677	647	2250	1360	1600	629
Specific Conductance	dS/cm	2*	2	3.50	1.24	1.26	3.16	2.26	2.64	1.55
AB Tier 1-PAHs										
Naphtalene	ug/g	0.6	0.1#	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	ug/g	-	0.1#	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthene	ug/g	-	0.1#	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	ug/g	-	0.1#	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenanthrene/Anthracene	ug/g	5	0.1#	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	ug/g	-	0.1#	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrene	ug/g	-	0.1#	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
B(a) A/Chrysene/B(C)P	ug/g	-	0.1#	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
7,12-Dimethylbenz(a)anthracene	ug/g	-	0.1#	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b/j/k) fluoranthene	ug/g	-	0.1#	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	ug/g	0.7	0.1#	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3-methylcholanthrene	ug/g	-	0.1#	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-cd)pyrene	ug/g	1*	0.1#	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenzo(ah)anthracene	ug/g	-	0.1#	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(ghi) perylene	ug/g	-	0.1#	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenz(ah, ai, aj)pyrene	ug/g	-	0.1#	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Hydrocarbons										
Benzene	ug/g	0.5	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Toluene	ug/g	0.8	1.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ethylbenzene	ug/g	1.2	0.5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Xylenes	ug/g	1.0	1.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
TVH	ug/g	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
TEH	ug/g	-	-	<5	8	<5	<5	8	42	6
Hydrocarbons Recoverable	mg/kg	-	1000	600	<100	300	700	600	1700	9600

NOTE 1: Shaded areas indicate values above comparative criteria.
NOTE 2: Alberta Tier I (1994) - Indicates 1994 Alberta Tier I (Draft) Criteria for Contaminated Soil Assessment and Remediation.
NOTE 3: 1997 CCME Recommended - Indicates 1997 CCME Recommended Canadian Soil Quality Guidelines Recommended Guidelines for Residential / Parkland land use.
NOTE 5: * Indicates no 1997 Guidelines were available. Value represents 1991 CCME Interim Canadian Environmental Quality Criteria for Contaminated Sites: Remediation Criteria for Residential / Parkland land use.
NOTE 6: # Indicates criteria for non-chlorinated PAH, individual

Table 3-3
Drumheller Institution Landfill
Analytical Results - Surface Water Samples

PARAMETERS	Units	Criteria			Location				
		CCME 1996	CCME 1991	ASWQG 1998	SS-1 Upstream	SS-2 Downstream	SS-3 Spring	SS-3 Spring	Field Blank
Dissolved Metals									
Arsenic	mg/L	0.05	0.025	0.025	0.0028	0.0017	0.0006	0.0006	<0.0004
Aluminum	mg/L	-	-	5.0	<0.01	<0.01	<0.01	<0.01	<0.01
Antimony	mg/L	-	-	-	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004
Barium	mg/L	1.0	1.0	-	0.044	0.031	0.024	0.024	<0.003
Beryllium	mg/L	-	-	0.10	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	5.0	5.0	0.50	0.15	0.17	0.19	0.20	<0.05
Cadmium	mg/L	0.005	0.005	0.08	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium	mg/L	0.05	0.05	0.05	<0.005	<0.005	<0.005	<0.005	<0.005
Cobalt	mg/L	-	0.01*	1.0	<0.002	<0.002	<0.002	<0.002	<0.002
Copper	mg/L	1.0	1.0	1**	0.003	0.004	0.002	0.002	0.001
Iron	mg/L	0.3	0.3	-	0.080	0.104	0.190	0.177	<0.005
Lead	mg/L	0.05	0.01	0.1	<0.005	<0.005	<0.005	<0.005	<0.005
Manganese	mg/L	0.05	0.05	-	<0.001	0.002	0.057	0.042	<0.001
Mercury	mg/L	0.001	0.001	0.003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Molybdenum	mg/L	-	0.005*	0.5	<0.005	<0.005	<0.005	<0.005	<0.005
Nickel	mg/L	-	0.01*	1.0	0.003	0.005	0.004	0.004	<0.002
Phosphorus	mg/L	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.1
Selenium	mg/L	0.01	0.01	0.05	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004
Silver	mg/L	0.05	0.005*	-	<0.005	<0.005	<0.005	<0.0005	<0.005
Strontium	mg/L	-	-	-	0.376	0.447	0.664	0.681	<0.005
Thallium	mg/L	-	-	-	<0.05	<0.05	<0.05	<0.05	<0.05
Tin	mg/L	-	0.01*	-	<0.05	<0.05	<0.05	<0.05	<0.05
Titanium	mg/L	-	-	-	0.003	0.010	0.001	0.001	<0.001
Vanadium	mg/L	-	-	0.1	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	mg/L	5.0	5.0	50.0	0.004	0.007	0.008	0.004	0.003
Salinity									
Calcium	mg/L	-	-	1000.0	45.5	37.8	75.9	77.8	<0.5
Chloride	mg/L	250	250	-	4	5	5	3	<1
Conductance	uS/cm	-	-	-	1650	1790	1680	1690	10.3
Magnesium	mg/L	-	-	-	19.0	16.9	21.8	23.1	<0.1
pH	pH	6.5 - 8.5	6.5 - 8.5	-	8.3	8.5	8.0	8.0	7.0
Potassium	mg/L	-	-	-	6.4	6.7	4.6	4.7	2.5
SAR	SAR	-	-	-	10.1	11.7	7.3	8.3	<0.1
Sodium	mg/L	-	200	-	322	345	280	323	<1
Sulfate	mg/L	500	500	1000.0	284	326	338	353	<0.5
AB Tier 1-PAHs in water									
3-methylcholanthrene	ug/L	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01
7,12-Dimethylbenz(a)anthracene	ug/L	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthene	ug/L	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01
B(a) A/Chrysene/B(C)P	ug/L	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	ug/L	-	0.01	-	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b/j/k) fluoranthene	ug/L	-	0.01*	-	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(ghi) perylene	ug/L	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenzo(ah)anthracene	ug/L	-	0.01*	-	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenz(ah, ai, aj)pyrene	ug/L	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	ug/L	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	ug/L	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01
Indenol(1,2,3-cd)pyrene	ug/L	-	0.1*	-	<0.01	<0.01	<0.01	<0.01	<0.01
Naphtalene	ug/L	-	0.2*	-	<0.01	<0.01	<0.01	<0.01	<0.01
Phenanthrene/Anthracene	ug/L	-	0.2*	-	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrene	ug/L	-	0.2*	-	<0.01	<0.01	<0.01	<0.01	<0.01
Hydrocarbons									
Benzene	ug/L	-	5	-	<0.5	<0.5	<0.5	<0.5	<0.5
Toluene	ug/L	-	24	24	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	ug/L	-	2.4	2.4	<0.5	<0.5	<0.5	<0.5	<0.5
Xylenes	ug/L	-	300	-	<0.5	<0.5	<0.5	<0.5	<0.5
Total Volatile Hydrocarbons	ug/L	-	-	-	<100	<100	<100	<100	<100
Total Extractable Hydrocarbons	ug/L	-	-	-	<50	<50	<50	<50	<50
Hydrocarbons Recoverable	mg/L	-	-	-	<1	<1	<1	<1	<1

Manganese

Sodium

NOTE 1: Shaded areas indicate values above comparative criteria.
NOTE 2: CCME / 1996 – Indicates 1996 CCME Guidelines for Canadian Drinking Water Quality Criteria Raw Water for Drinking Water Supply.
NOTE 3: CCME / 1991 - Indicates 1991 CCME Interim Canadian Environmental Quality Criteria for Contaminated Site Remediation Criteria for Water
NOTE 4: ASWQG / 1998 - Indicates Alberta Surface Water Quality Guidelines: A working compendium Alberta Environmental Protection, July 1998
NOTE 5: * Indicates no 1991 Remediation Criteria were available. Value represents 1991 Interim Assessment Criteria for Water
NOTE 6: ** Indicates criteria applies to watering of cattle

4.0 INTERPRETATION

The results of the EM survey identified large quantities of sub-surface metals in the northern and southern areas of the landfill site. No significant metal deposits were indicated to be present in the central portion of the site. Test Pitting confirmed these results, but was limited to a depth of less than 5 metres. It is possible waste materials are present in the central portion of the site at depths greater than 5 metres, based on the nature of the fill material present at the base of the excavations.

The results of the test pitting suggests localized deposits of waste materials consisting primarily of metal, wood, and concrete. No significant segregation of waste materials within the landfill was apparent. Figure 2.0, in Appendix A, illustrates the estimated extent of near-surface waste materials in the area of the closed landfill site.

The trace metals concentrations for the soil samples from MW 99-3 and MW 99-4, located to the east of the fenced compound were generally higher than those for MW 99-1 and MW 99-2B, located on the north side of the landfill. The soil profiles of MW 99-3 and MW 99-4 generally consisted of fill overlying clay till, while the soils in the area of MW 99-1 and MW 99-2B were coarser-grained, consisting of silt and sand. No fill layer was present in this area. The higher metals concentrations for MW 99-3 and MW 99-4 may be the result of impact due to the fill layer, or may reflect natural variability in soil chemistry.

The soil sample submitted for MW 99-1, and to a lesser extent MW 99-3, generally had higher salinity concentrations when compared to other soil samples, including soluble sodium, calcium, magnesium, and sulphate. During project design, MW 99-1 was intended to represent background soil quality. As the soil profiles encountered in boreholes 99-1, 99-2A, and 99-2B varied significantly from boreholes 99-3 and 99-4, a direct comparison of soil quality between these locations was not considered appropriate. However, as no source of contamination has been identified for the elevated salinity parameters encountered at the location of borehole 99-1, these higher concentrations likely represent natural variability in soil quality. Further, significant variation in salinity parameter concentrations between the two samples submitted for MW 99-3 (3.0-3.8 m) suggests variability may be due to the heterogeneous nature of the fill material encountered at this location.

When compared to the other analytical results, the chloride concentrations for the two soil samples collected from MW 99-4 were high. As the soil samples from MW 99-4 were also associated with higher RH and TEH concentrations when compared to other samples, the elevated chloride concentrations may be indicative of hydrocarbon impact in the area.

The results of the EM survey suggested possible impact in the area of the spring along the northeast slope of the site. Slightly higher than background concentrations of sulphate, iron, manganese, and calcium were reported for the surface water sample collected from the spring. The analytical results for the surface water sample collected from the creek, downstream of the landfill, also reported slightly higher concentrations for selected metal and salinity parameters. Although these concentrations are considered low, and are generally within CCME criteria, they may be indicative of low level impact due to landfill leachate.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions are based on the results of the Phase II ESA:

- The majority of near-surface waste material is located in the northern and southern areas of the landfill site. Waste material may be present in the central portion of the site, but at depths greater than approximately 5 metres.
- There is no significant segregation of waste materials within the landfill.
- Impact due to the presence of "heavier-end" hydrocarbons is indicated in the soils in the area of MW 99-4, located in the south portion of the landfill.
- Higher trace metals concentrations for the soil samples submitted from the location of MW 99-3 and MW 99-4 are likely due to the presence of a fill layer in the central portion of the landfill site.
- Higher salinity in the soils in the area of MW 99-1 and MW 99-3 is likely due to natural variability in soil chemistry, but may indicate localized impact.
- Possible impact due to landfill leachate is indicated in the surface water downgradient with respect to the landfill area. At this time, the extent of any possible impact appears to be low.

Based on the results of the Phase II ESA, it is recommended that a follow-up groundwater and surface water sampling program be completed in the spring of 2000, after snow melt and ground thaw has occurred. The analytical parameters should include, but not necessarily be limited to, dissolved metals, detailed salinity, and hydrocarbons. The results obtained from this sampling event will be used to determine if any additional assessment or monitoring work may be required.

6.0 CLOSING

The information and data presented in this report are based on the purpose and scope of the project, and form the basis for any conclusions and recommendations presented herein. Any conclusions and recommendations presented herein do not preclude the existence of environmental concerns other than those which may have been identified.

Work performed by UMA personnel employed sound environmental assessment principles. UMA cannot guarantee the accuracy and reliability of information provided by others. Therefore, UMA does not claim responsibility for undisclosed environmental concerns that may result in costs for environmental clean-up or remediation. UMA staff attempted to seek clarification on information provided and to verify its accuracy. This report is intended for information purposes only.

The contents of this report are governed by the UMA Group Disclaimer and UMA Group Supplemental Terms and Conditions statements, copies of which are included in Appendix E.

Respectfully submitted by:

Melanie E. Siewert, B.Sc.
Environmental Scientist

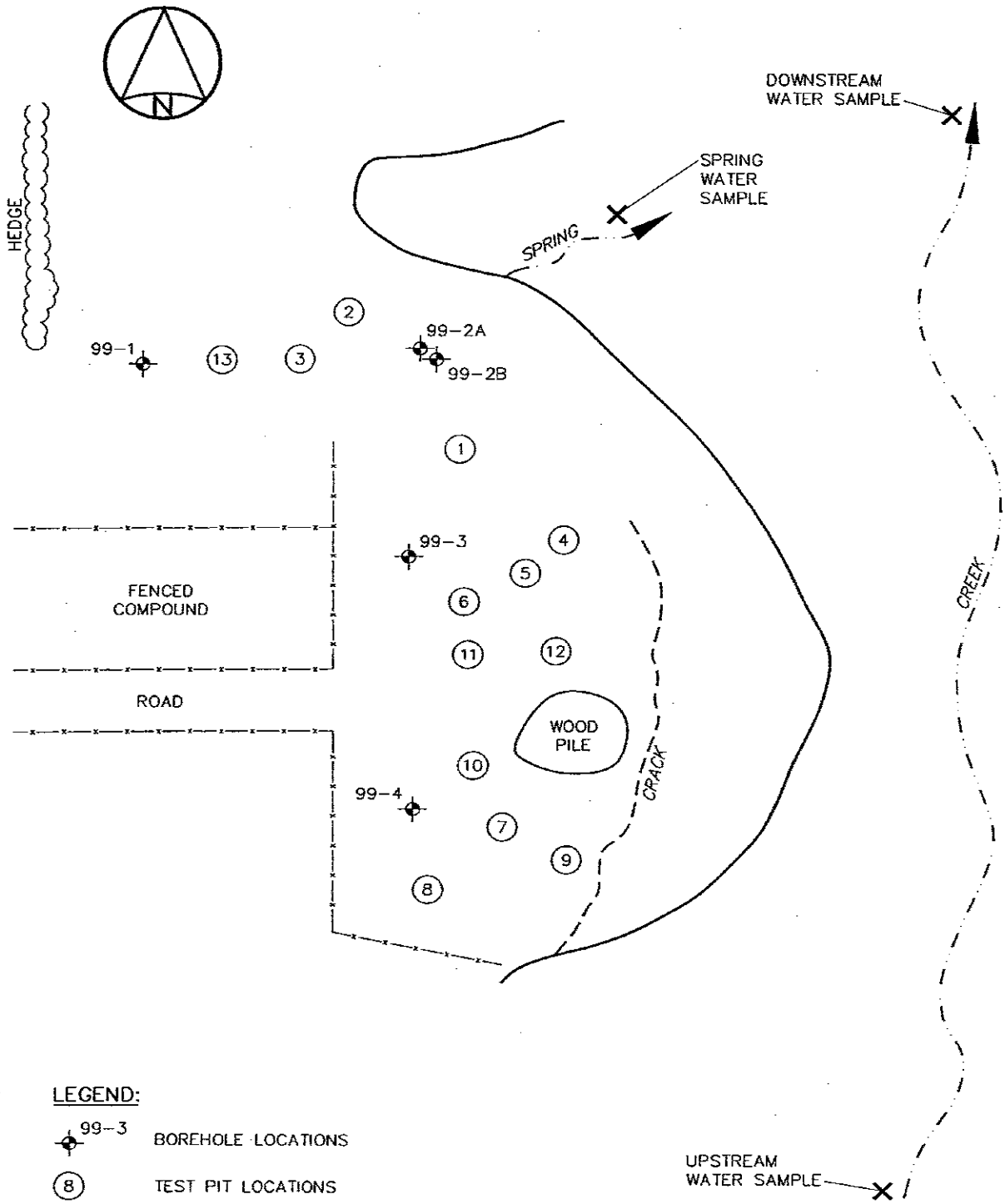
Reviewed by:

PROFESSIONAL GEOLOGIST ALBERTA
Donald E. McClymont
2000 May 03

Don McClymont, P. Geol.
Senior Hydrogeologist

APPENDIX A

SITE PLAN



LEGEND:

99-3 BOREHOLE LOCATIONS

(8) TEST PIT LOCATIONS

× SURFACE WATER SAMPLE LOCATIONS

PHASE II ENVIRONMENTAL SITE ASSESSMENT
DRUMHELLER INSTITUTION
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

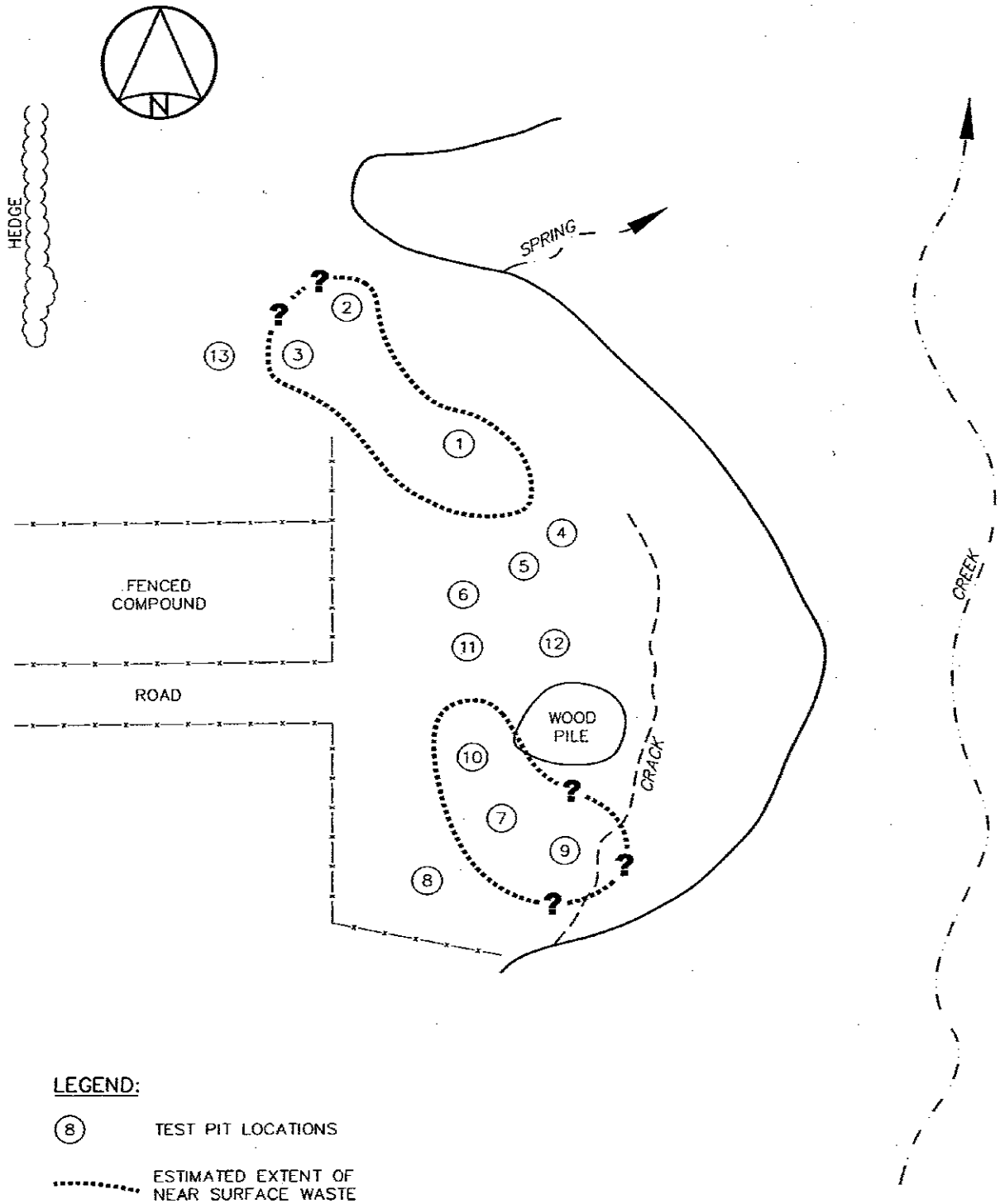
NOT TO SCALE

SITE PLAN

uma

Figure 1.0

2135K001.DWG FEB. 28, 2000 2977-213-00-02



LEGEND:

(8) TEST PIT LOCATIONS

ESTIMATED EXTENT OF NEAR SURFACE WASTE MATERIALS

? ASSUMED EXTENT OF NEAR SURFACE WASTE MATERIALS

NOT TO SCALE

PHASE II ENVIRONMENTAL SITE ASSESSMENT
DRUMHELLER INSTITUTION
PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

NEAR SURFACE WASTE MATERIALS

uma

Figure 2.0

APPENDIX B

ELECTROMAGNETIC SURVEY

AMCL

Associated Mining Consultants Ltd.

#200, 708 - 11th Avenue S.W.
Calgary, Alberta
Canada, T2R 0E4

Tel: 1-403-264-9496
Fax: 1-403-269-7640

File: 99PJ05
October 22, 1999

UMA Engineering Limited
17007 - 107 Avenue
Edmonton, Alberta
T5S 1G3

Attention: Mr. Don McClymont, P.Geol.

Dear Mr. McClymont,

Associated Mining Consultants Ltd. is pleased to submit the following report entitled:

Geophysical Surveys
Drumheller Penitentiary Landfill
Drumheller, Alberta

We would like to express our thanks to UMA Engineering Limited for the opportunity to provide our services in relation to this project.

If you have any questions or require any additional information, please do not hesitate to contact our office.

Yours sincerely
ASSOCIATED MINING CONSULTANTS LTD.

Mark Bowman. P.Geoph.
Senior Geophysicist

Jim Henderson, P.Geoph.
Manager of Geophysical Services

/mh
N:\PROJECTS\GEOPH\CURRENT\PJ05\Report\McClymont.wpd

TABLE OF CONTENTS

1.0 INTRODUCTION

This report presents the results of a geophysical study undertaken at the Drumheller Penitentiary Landfill site near Drumheller, Alberta on October 19 and 20, 1999.

The primary objective of the study was to determine the lateral extent of buried material within the landfill and adjacent region. A secondary objective was the identification of potential contaminant migration from the perimeter of the site.

All work for this project was undertaken in accordance with the Associated Mining Consultants Ltd. (AMCL) proposal AMP1150 dated October 1, 1999.

2.0 METHOD

The objectives of the present study were addressed in two stages as outlined in the following sections.

2.1 EM61 Survey

A time-domain electromagnetic (TDEM) survey employing the Geonics EM61 was conducted to delineate buried metal within, and adjacent to, the present landfill site.

A time-varying electromagnetic (EM) field produced at surface results in currents flowing within subsurface conductors in configurations defined by the laws of electromagnetic induction. Resulting secondary EM fields distort the primary field. The resultant field, measured at the ground surface, differs from the primary field in intensity, phase and direction to an extent dependent on the magnitude and geometry of the subsurface conductor(s).

The Geonics Limited EM61 is a high-powered TDEM metal detector. The decay of secondary currents produced by a pulsed primary field is measured a relatively long time after the primary pulse is terminated. This technique results in a method where results are essentially independent of ground conductivity.

Depth capabilities of the EM61 are dependant upon the size and depth of the buried metal. It is estimated, however, that a single 45 gallon drum can be detected at a depth of 3.5 metres. The use of two vertically displaced receiver coils enables a filtering, of sorts, of near surface anomalies.

The EM61 survey data were collected at approximately 0.2 metre intervals along survey lines spaced 2 to 4 metres apart.

2.2 Ground Conductivity Surveys

A relatively thick fill layer overlies buried metal at the site. A ground conductivity survey, using the fixed frequency electromagnetic (FEM) method, was performed to detect buried metal to depths in the order of 10 metres in regions where little to no anomalous EM61 response was apparent. Lateral and depth resolution of buried metal decreases with depth when employing the FEM method and as such, only large quantities of buried metal can be detected at depth. In addition, the lateral resolution is significantly less than the EM61 method due to instrument dimensions and practical sample interval.

Whereas TDEM methods may resolve conductive materials that underlie near surface conductors, conductive surface materials effectively prevent the detection of deeper conductors by the FEM technique. The FEM method is therefore unable to detect metal that underlies surface metal.

The FEM method generally utilises highly portable instrumentation consisting of a vertical or horizontal magnetic transmitter dipole and a similar receiver dipole. A primary field, produced by passing a time-varying current through the transmitter loop, results in a secondary field dependant on subsurface conditions. The ratio of the primary and secondary fields is directly related to ground conductivity.

Ground conductivity varies with mineral composition (clays are of high electrical conductivity), variations in the volume of total dissolved solids (TDS), presence of buried metal, and, to a lesser extent, thermal state.

Ground conductivity measurements were collected in the immediate vicinity of the present landfill using the Geonics EM31 and EM34 Terrain Conductivity Meters. Measurements were generally acquired at 8 metre intervals along lines spaced 5 and 10 metres apart.

Table 1 illustrates the effective depths of exploration for the instrument operating modes employed. In the vicinity of buried metal, the validity of Table 1 is severely compromised. The effects of large quantities of buried metal may be detected at greater depths than the generally accepted average exploration depths of the individual instrument modes. In addition, depending on coupling geometry, the influence of metal may result in either an increase or a decrease in measured conductivity.

TABLE 1: EM Measurement Modes Recorded

MEASUREMENT MODE		EFFECTIVE DEPTH OF EXPLORATION
EM31 (Hg)	Horizontal co-planar dipole mode at ground level.	2 metres
EM31 (Vg)	Vertical co-planar dipole mode at ground level.	5 metres
EM34 (20H)	Horizontal co-planar dipole mode. 20 metre coil separation.	10 metres

The data obtained by these measurements are values of apparent conductivity in units of milliSiemens per metre (mS/m). Each increase in the effective depth of exploration represents a change in instrument type and/or dipole orientation. The conductivity values thus obtained are not absolute values for each depth point, but are instead variously weighted averages of conductivity from the surface and are thus termed "apparent" conductivities.

The FEM method was also employed to measure ground conductivity in order to identify potential contaminant migration from the landfill perimeter. Perimeter lines were surveyed downslope to the

east, and along the north and south boundaries of the site using the EM31 and EM34 Terrain Conductivity Meters. When outside the influence of buried metal, it was expected that variations in measured ground conductivity would be a direct result of variations in soil type and/or TDS volumes.

3.0 SITE DESCRIPTION

The Drumheller Penitentiary Landfill site is situated to the southeast of the Penitentiary. The present landfill has, for the most part, been graded level. Small areas of surficial debris, mostly in the southern region, and mounds of earth stacked along the eastern boundary are the only features evident at surface. Topography drops off steeply to the east and south. A rill borders the northern extent.

The survey grid was aligned with the eastern perimeter fence of an adjacent scrap yard, with the southeast corner designated as Station 0 East, 0 North.

4.0 RESULTS

Results of the EM61 survey are presented as two colour contour maps (Figures 1a and 1b) illustrating lateral variations in electromagnetic response (mV). The lower coil response (channel 2) identifies all buried and surficial metal occurring within the sphere of effect of that coil. The differential channel response is the weighted difference of the upper and lower coil responses, resulting in a partial filtering of near surface metallic influence. In general, upper coil response (channel 1) is biased towards metallic objects occurring at surface and/or very shallow depth and, as such, is not presented herein.

Resulting anomalous EM61 response is identified as gradations to warmer colours, with specific regions labelled for description in Table 2.

Results of the ground conductivity surveys are presented as colour conductivity contour maps (Figures 2a, 2b, 2c, 3a, 3b and 3c) illustrating lateral variations in apparent ground conductivity for each instrument mode and corresponding depth of exploration. High conductivity zones are identified as gradations to warmer colours, with specific regions labelled for discussion in Tables 3 and 4.

4.1 EM61 Survey

Anomalous response resulting from metallic sources occurs predominantly in the northern and southern regions of the study area (Figures 1a and 1b). Background response is 0mV. Response magnitude is directly proportional to the degree of metal content of the target, and inversely proportional to depth of burial.

TABLE 2: EM61 Anomaly Description

ANOMALY	DESCRIPTION
61a	Channel 2 response only. Metal occurring at surface.
61b	Channel 2 response only. Metal occurring at surface.
61c	Metal apparent at surface. Differential response may indicate buried metal in this area also.
61d	Channel 2 response only. Metal occurring at surface.
61e	Strong anomalous response evident in both channel 2 and differential response indicative of metal buried at 1 metre or greater. Coincident with the location of several earth mounds.

ANOMALY	DESCRIPTION
61f	Anomalous response prominent in channel 2 results. Attributed mostly to metal apparent at surface.
61g	Apparent in channel 2 data; due to metal chainlink fence.
61h	Strong response evident in channel 2 and differential data sets attributed to buried metal extending to depth. Located in northeastern region of study area covered by short grasses.
61i	Anomalous response predominantly in channel 2 data set, less in differential data. Metal likely occurs at a depth of approximately 1 metre.
61j	Located in the central regions of the cleared landfill site, anomalous response attributed to buried metal extending to a depth of greater than 1 metre.
61k	Response attributed to surface and/or near surface metal.
61l	Channel 2 response only; attributed to surface metal.
61m	Metal evident at surface. Differential channel response indicative of buried metal also.
61n	Response attributed to surface features (fire hydrant and associated traffic bumpers).
61o	Coincident with observed surface metals. Response of differential channel indicates extension of metal to depth as confirmed by observations along side of adjacent slope.
61p	Minor scattered anomalous response in channel 2 data only. Indicative of small metallic items buried near surface (<1 metre depth).

4.2 Ground Conductivity Surveys

Results of the EM31 and EM34 surveys conducted to detect buried metal at depth within, and immediately adjacent to the landfill are illustrated by Figures 2a, 2b and 2c and discussed in Table 3. In general, ground conductivity decreases with depth, an indication of finer-grained material occurring near surface.

TABLE 3: Ground Conductivity Anomaly Description - Landfill Site

ANOMALY	DESCRIPTION
31a	Anomalous ground conductivity attributed to metal that occurs at surface.
31b	A slight increase in apparent conductivity within EM31(Hg) and EM31(Vg) data sets. Coincident with EM61 anomaly 61p, attributed to small amounts of metal buried at relatively shallow depth.
31c	Increased apparent conductivity resulting from influence of fire hydrant and associated infrastructure.
34a	Slightly increased EM34 conductivity response along western portion of surveyed area due to influence of adjacent chainlink fence.

Results of the ground conductivity survey performed outside the perimeter of the landfill site to detect possible contaminant migration downslope are illustrated by Figures 3a, 3b and 3c and localised anomalies discussed in Table 4. In general, measured ground conductivity increases as elevation decreases to the east. This suggests an increase in clay material and/or moisture content within the soils within the valley bottom.

Marked increases in measured ground conductivity are evident in both the southeast and northeast corners of the survey line configuration and may correspond to an increase in TDS. Additional localised conductivity anomalies are identified and discussed within Table 4.

TABLE 4: Ground Conductivity Anomaly Description - Perimeter Survey

ANOMALY	DESCRIPTION
31d	Anomalous ground conductivity attributed to metal occurring at surface, and within adjacent slope.
31e	Anomalous ground conductivity resulting from scrap metal on surface.
31f	Large anomalous response due to scrap metal on surface (scrapped vehicle).
31g	Low conductivities within both EM31 and EM34 data sets. May be attributed to a confined region of coarser-grained soils, or to proximity of metal.
31h	Apparent predominantly within the EM31(Vg) data set, increased conductivity is coincident with runoff from adjacent spring. Likely reflects a localised increase in TDS.

ANOMALY	DESCRIPTION
31i	Increased conductivity that may be attributed to increased clay content, buried metal and/or increased TDS.

5.0 CONCLUSIONS

The extent of buried metal in the immediate vicinity of the present landfill site has been identified by TDEM methods (EM61 survey). Results indicate that the largest quantities of buried metal occur in the northern region of the study area. There are also indications that metal is buried within the present dumping location within the southern region of the landfill. A complementary ground conductivity (FEM) survey has not identified additional metal content at depth.

Prior to subsequent investigations employing intrusive methods, it is recommended that "as-built" drawings be consulted to determine if any of the identified anomalies are a result of underground infrastructure, particularly water lines associated with the existing fire hydrant located on site.

Ground conductivity measurements acquired exterior to the landfill perimeter have identified variations in conductivity within the subsurface. Soil properties likely vary with topography. In addition, localised ground conductivity variations, predominantly occurring to the northeast and southeast of the landfill, may indicate increases in TDS. It is therefore recommended that subsequent sampling include the regions proximal to the northeast and southeast corners of the surveyed perimeter lines.

Elevated ground conductivity coincident with runoff from an adjacent spring may also reflect increases in TDS that may be naturally occurring, or resulting from mobilised contaminants originating within the landfill located upslope. It is therefore recommended that the springwater be tested to uniquely determine the cause of the elevated ground conductivity in this region.

APPENDIX C

BOREHOLE LOGS

PROJECT:Drumheller Penitentiary Landfill	DRILLER:Beck	BOREHOLE NO: MW99-1
CLIENT:Public Works & Govt Services Can	DRILLING METHOD:Truck-mounted auger	PROJECT NO: 2977-213-00-02
START DATE: 03/11/99		ELEVATION:

SAMPLE TYPE: DRIVE SAMPLE; SHELBY TUBE; GRAB SAMPLE; AUGER SAMPLE; NO RECOVERY; CORED SAMPLE

BACKFILL TYPE: BENTONITE; PEA GRAVEL; SLOUGH; GROUT; DRILL CUTTINGS; SAND

DEPTH(ft)	PID READINGS (ppm) 20 40 60 80	SAMPLE TYPE	SAMPLE NO	USC	SOIL SYMBOL	Soil Description	Other Data	ELEVATION(m)
0.0–7.0			1, 2, 3	SP		SAND, light brown, some silt, trace clay, trace pebbles, no rootlets, dry		0.0, −1.0, −2.0
7.0–12.0			4, 5	CL		CLAY, light brown, some silt, some sand, trace white pockets, trace coal, trace pebbles, trace red pockets, dry	Sample 4 (2.3 to 3.0 m) submitted for analysis	−3.0
12.0–15.0			6	CL-ML		SILTY CLAY, light to medium brown, increasing silt, trace white pockets, trace pebbles, trace sand lenses (1 cm), damp		−4.0
15.0–20.0			7, 8	ML		SILT, light to medium brown, some clay, no pebbles, damp – at 5.3 metres, mottles light brown to medium brown, increasing mottling		−5.0, −6.0

UMA Engineering Ltd.
Edmonton, Alberta

LOGGED BY: MES
REVIEWED BY: DEM
Fig. No: 1

COMPLETION DEPTH: 30 ft
COMPLETE: 03/11/33

PROJECT:Drumheller Penitentiary Landfill	DRILLER:Beck	BOREHOLE NO: MW99-1
CLIENT:Public Works & Govt Services Can	DRILLING METHOD:Truck-mounted auger	PROJECT NO: 2977-213-00-02
START DATE: 03/11/99		ELEVATION:

SAMPLE TYPE: DRIVE SAMPLE, SHELBY TUBE, GRAB SAMPLE, AUGER SAMPLE, NO RECOVERY, CORED SAMPLE

BACKFILL TYPE: BENTONITE, PEA GRAVEL, SLOUGH, GROUT, DRILL CUTTINGS, SAND

DEPTH(ft)	PID READINGS (ppm) 20 40 60 80	SAMPLE TYPE	SAMPLE NO	USC	SOIL SYMBOL	Soil Description	WELL INSTALLATION	Other Data	ELEVATION(m)
20.0									
21.0			9						
22.0									
23.0									-7.0
24.0			10						
25.0				ML		– at 7.6 metres, increasing clay			
26.0			11						-8.0
27.0									
28.0									
29.0			12						
30.0						END OF HOLE AT 9.14 METRES DRY UPON COMPLETION 0.81M STICK-UP TO TOP OF PVC PIPE			
31.0									
32.0									
33.0									
34.0									
35.0									
36.0									-11.0
37.0									
38.0									
39.0									
40.0									

UMA Engineering Ltd.
Edmonton, Alberta

LOGGED BY: MES	COMPLETION DEPTH: 30 ft
REVIEWED BY: DEM	COMPLETE: 03/11/33
Fig. No: 1	Page 2 of

PROJECT:Drumheller Penitentiary Landfill	DRILLER:Beck	BOREHOLE NO: MW99-2A
CLIENT:Public Works & Govt Services Can	DRILLING METHOD:Truck-mounted auger	PROJECT NO: 2977-213-00-02
START DATE: 03/11/99		ELEVATION:

SAMPLE TYPE: DRIVE SAMPLE, SHELBY TUBE, GRAB SAMPLE, AUGER SAMPLE, NO RECOVERY, CORED SAMPLE

BACKFILL TYPE: BENTONITE, PEA GRAVEL, SLOUGH, GROUT, DRILL CUTTINGS, SAND

DEPTH(ft)	PID READINGS (ppm) 20 40 60 80	SAMPLE TYPE	SAMPLE NO	USC	SOIL SYMBOL	Soil Description	Other Data	ELEVATION(m)
0.0–5.0			1, 2	ML-SP		SANDY SILT, light brown, trace rootlets, no pebbles, dry		0.0, -1.0
5.0–20.0			3, 4, 5, 6, 7, 8	ML		SILT, light brown, trace clay, no pebbles, some white pockets, trace rootlets, dry – at 3.0 metres, no white pockets, no rootlets		-2.0, -3.0, -4.0, -5.0, -6.0

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Edmonton, Alberta

LOGGED BY: MES	COMPLETION DEPTH: 30 ft
REVIEWED BY: DEM	COMPLETE: 03/11/33
Fig. No: 2	Page 1 of 2

PROJECT:Drumheller Penitentiary Landfill	DRILLER:Beck	BOREHOLE NO: MW99-2A
CLIENT:Public Works & Govt Services Can	DRILLING METHOD:Truck-mounted auger	PROJECT NO: 2977-213-00-02
START DATE: 03/11/99		ELEVATION:

SAMPLE TYPE: DRIVE SAMPLE | SHELBY TUBE | GRAB SAMPLE | AUGER SAMPLE | NO RECOVERY | CORED SAMPLE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH(ft)	PID READINGS (ppm) 20 40 60 80	SAMPLE TYPE	SAMPLE NO	USC	SOIL SYMBOL	Soil Description	WELL INSTALLATION	Other Data	ELEVATION(m)
20.0						SAND, light brown, no rootlets, some pebbles, various sizes, damp			
21.0			9						
22.0				SP					
23.0						– at 6.9 metres, clayey silt layer, some mottling			-7.0
24.0			10						
25.0						SAND, light brown, some clay, mottled, damp, increasing clay, increasing mottling			
26.0			11						-8.0
27.0				SP					
28.0									
29.0			12						-9
30.0						END OF HOLE AT 9.14 METRES DRY UPON COMPLETION 0.81 M STICK-UP TO TOP OF PVC PIPE			
31.0									
32.0									
33.0									-10
34.0									
35.0									
36.0									-11.0
37.0									
38.0									
39.0									-12.0
40.0									

UMA Engineering Ltd.
Edmonton, Alberta

LOGGED BY: MES	COMPLETION DEPTH: 30 ft
REVIEWED BY: DEM	COMPLETE: 03/11/33
Fig. No: 2	Page 2 of

PROJECT:Drumheller Penitentiary Landfill	DRILLER:Beck	BOREHOLE NO: MW33-2B
CLIENT:Public Works & Govt Services Can	DRILLING METHOD:Truck-mounted auger	PROJECT NO: 2977-213-00-02
START DATE: 03/11/99		ELEVATION:

SAMPLE TYPE: DRIVE SAMPLE | SHELBY TUBE | GRAB SAMPLE | AUGER SAMPLE | NO RECOVERY | CORED SAMPLE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH(ft)	PID READINGS (ppm) 20 40 60 80	SAMPLE TYPE	SAMPLE NO	USC	SOIL SYMBOL	Soil Description	Other Data	ELEVATION(m)
0.0–12.0			1, 2, 3, 4, 5	ML		SILT, very light brown, trace sand, no clay, no rootlets, no pebbles, very dry – at 1.5 metres, some white pockets and flecs		0.0, −1.0, −2.0, −3.0
12.0–15.0			6	SP		SAND, very light brown, some silt, some mottling	Sample 6 (3.8 to 4.6 m) submitted for analysis	−4.0
15.0–16.0			7	ML-SP		SANDY SILT, some clay, light brown – at 4.6 metres, black varving in direction of hill slope		−5.0
16.0–20.0			8	SP		SAND, very light brown, some silt, some mottling – at 5.5 metres, silt with trace clay, some mottling		−6.0
20.0–23.0			9, 10	SP		SAND, trace silt, increasing moisture, dry to damp – at 6.1 metres, trace white and red flecs, trace pebbles		−7.0

UMA Engineering Ltd.
Edmonton, Alberta

LOGGED BY: MES	COMPLETION DEPTH: 50 ft
REVIEWED BY: DEM	COMPLETE: 03/11/33
Fig. No: 3	Page 1 of 3

PROJECT:Drumheller Penitentiary Landfill	DRILLER:Beck	BOREHOLE NO: MW99-2B
CLIENT:Public Works & Govt Services Can	DRILLING METHOD:Truck-mounted auger	PROJECT NO: 2977-213-00-02
START DATE: 03/11/99		ELEVATION:

SAMPLE TYPE: DRIVE SAMPLE, SHELBY TUBE, GRAB SAMPLE, AUGER SAMPLE, NO RECOVERY, CORED SAMPLE

BACKFILL TYPE: BENTONITE, PEA GRAVEL, SLOUGH, GROUT, DRILL CUTTINGS, SAND

DEPTH(ft)	PID READINGS (ppm) 20 40 60 80	SAMPLE TYPE	SAMPLE NO	USC	SOIL SYMBOL	Soil Description	WELL INSTALLATION	Other Data	ELEVATION(m)
23.0									
24.0			10						
25.0				SP		– at 7.6 metres, some black flecs with trace varving, some mottling			
26.0			11						-8
27.0									
28.0						SILT, some sand, trace clay, mottling light brown to reddish brown,			
29.0			12						-9
30.0				ML		– at 9.1 metres, increasing clay, increasing mottling			
31.0			13						
32.0									
33.0						SILT, reddish light brown, some clay, some mottling, damp			-10
34.0			14						
35.0						– at 10.7 metres, increasing sand, decreasing clay, decreasing mottling, dry to damp			
36.0			15	ML					-11
37.0									
38.0									
39.0			16						-12
40.0						CLAYEY SILT, medium brown, some patches of light brown, some patches of dark grey, some iron staining, coal pockets, occassional white flecs, damp			
41.0			17	ML-CL					
42.0						CLAY, dark grey, some silt, some pebbles, some white flecs, increasing clay, thick, sticky, increasing moisture, damp to moist			-13
43.0									
44.0			18	CL					
45.0						SILTY CLAY, dark grey to almost black, blue-grey sections, light brown pockets,			
46.0			19						-14

UMA Engineering Ltd. Edmonton, Alberta	LOGGED BY: MES	COMPLETION DEPTH: 50 ft
	REVIEWED BY: DEM	COMPLETE: 03/11/33
	Fig. No: 3	Page 2 of

PROJECT:Drumheller Penitentiary Landfill	DRILLER:Beck	BOREHOLE NO: MW99-2B
CLIENT:Public Works & Govt Services Can	DRILLING METHOD:Truck-mounted auger	PROJECT NO: 2977-213-00-02
START DATE: 03/11/99		ELEVATION:

SAMPLE TYPE: DRIVE SAMPLE, SHELBY TUBE, GRAB SAMPLE, AUGER SAMPLE, NO RECOVERY, CORED SAMPLE

BACKFILL TYPE: BENTONITE, PEA GRAVEL, SLOUGH, GROUT, DRILL CUTTINGS, SAND

DEPTH(ft)	PID READINGS (ppm) 20 40 60 80	SAMPLE TYPE	SAMPLE NO	USC	SOIL SYMBOL	Soil Description	WELL INSTALLATION	Other Data	ELEVATION(m)
46.0						pockets of blue shale, occasional coal pockets			
47.0			19						
48.0									
49.0			20						15.0
50.0						END OF HOLE AT 15.24 METRES DRY UPON COMPLETION 0.81 M STICK-UP TO TOP OF PVC PIPE			
51.0									
52.0									16.0
53.0									
54.0									
55.0									
56.0									17.0
57.0									
58.0									
59.0									18.0
60.0									
61.0									
62.0									19.0
63.0									
64.0									
65.0									20.0
66.0									
67.0									
68.0									
69.0									21.0

UMA Engineering Ltd.
Edmonton, Alberta

LOGGED BY: MES	COMPLETION DEPTH: 50 ft
REVIEWED BY: DEM	COMPLETE: 03/11/33
Fig. No: 3	Page 3 of 3

PROJECT:Drumheller Penitentiary Landfill	DRILLER:Beck	BOREHOLE NO: MW99-3
CLIENT:Public Works & Govt Services Can	DRILLING METHOD:Truck-mounted auger	PROJECT NO: 2977-213-00-02
START DATE: 03/11/99		ELEVATION:

SAMPLE TYPE: DRIVE SAMPLE, SHELBY TUBE, GRAB SAMPLE, AUGER SAMPLE, NO RECOVERY, CORED SAMPLE

BACKFILL TYPE: BENTONITE, PEA GRAVEL, SLOUGH, GROUT, DRILL CUTTINGS, SAND

DEPTH(ft)	PID READINGS (ppm) 20 40 60 80	SAMPLE TYPE	SAMPLE NO	USC	SOIL SYMBOL	Soil Description	Other Data	ELEVATION(m)
0.0–5.0			1, 2	FILL		FILL, dark brown to black, sandy, some clay, brick chips, grass, roots, assorted masonry, crushed, dry		0.0, -1.0
5.0–10.0			3, 4	FILL		FILL, dark brown to black, clay, thick, stiff, assorted masonry, dry	Sample 4 (2.3 to 3.0 m) submitted for analysis	-2, -3
10.0–15.0			5, 6	CL		CLAY TILL, dark brown, stiff, heavy, some silt, some pebbles, various sizes, trace pockets of deep red colour, trace white flecs, trace red flecs, trace coal flecs, damp – at 3.8 metres, mottling	Sample 5 (3.0 to 3.8 m) submitted for analysis	-4.0
15.0–20.0			7, 8	CL		CLAY TILL, dark brown, trace silt, trace pockets of red and white, increasing dampness – at 4.6 to 5.2 metres, highly mottled		-5.0, -6

UMA Engineering Ltd.
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LOGGED BY: MES
REVIEWED BY: DEM
Fig. No: 4

COMPLETION DEPTH: 30 ft
COMPLETE: 03/11/33
Page 1 of

PROJECT:Drumheller Penitentiary Landfill	DRILLER:Beck	BOREHOLE NO: MW99-3
CLIENT:Public Works & Govt Services Can	DRILLING METHOD:Truck-mounted auger	PROJECT NO: 2977-213-00-02
START DATE: 03/11/99		ELEVATION:

SAMPLE TYPE: DRIVE SAMPLE, SHELBY TUBE, GRAB SAMPLE, AUGER SAMPLE, NO RECOVERY, CORED SAMPLE

BACKFILL TYPE: BENTONITE, PEA GRAVEL, SLOUGH, GROUT, DRILL CUTTINGS, SAND

DEPTH(ft)	PID READINGS (ppm) 20 40 60 80	SAMPLE TYPE	SAMPLE NO	USC	SOIL SYMBOL	Soil Description	WELL INSTALLATION	Other Data	ELEVATION(m)
20.0						CLAY, dark brown, trace silt, increasing light brown patches from mottling, swirling mottling, no pockets or flecs of colour, few stones, moist, sticky			
21.0			9						
22.0									
23.0									-7.0
24.0			10						
25.0				CL		– at 7.6 metres, decreasing mottling			
26.0			11						-8.0
27.0									
28.0									
29.0			12						-9.0
30.0						END OF HOLE AT 9.14 METRES DRY UPON COMPLETION 0.86 M STICK-UP TO TOP OF PVC PIPE			
31.0									
32.0									
33.0									-10.0
34.0									
35.0									
36.0									-11.0
37.0									
38.0									
39.0									-12.0
40.0									

UMA Engineering Ltd.
Edmonton, Alberta

LOGGED BY: MES	COMPLETION DEPTH: 30 ft
REVIEWED BY: DEM	COMPLETE: 03/11/33
Fig. No: 4	Page 2 of 2

PROJECT:Drumheller Penitentiary Landfill	DRILLER:Beck	BOREHOLE NO: MW99-1
CLIENT:Public Works & Govt Services Can	DRILLING METHOD:Truck-mounted auger	PROJECT NO: 2977-213-00-02
START DATE: 03/11/99		ELEVATION:

SAMPLE TYPE: DRIVE SAMPLE, SHELBY TUBE, GRAB SAMPLE, AUGER SAMPLE, NO RECOVERY, CORED SAMPLE

BACKFILL TYPE: BENTONITE, PEA GRAVEL, SLOUGH, GROUT, DRILL CUTTINGS, SAND

DEPTH(ft)	PID READINGS (ppm) 20 40 60 80	SAMPLE TYPE	SAMPLE NO	USC	SOIL SYMBOL	Soil Description	Other Data	ELEVATION(m)
0.0				FILL		FILL, dark brown to black, sandy, assorted masonry, crushed, brick chips, grass, roots, dry – blue rag brought up with auger		0.0
1.0			1					
2.0						CLAY FILL, dark brown, some darker spots, some stones, some pebbles, assorted masonry, crushed, dry		
3.0								-1.0
4.0			2	FILL				
5.0						– at 1.5 metres, large stones, assorted sizes		
6.0			3				Sample 3 (1.5 to 2.3 m) submitted for analysis	-2
7.0				OR		TOPSOIL, black, organics, silty, dry – no smell of hydrocarbons		
8.0						CLAY, dark brown, thick, stiff, some rootlets, no stones, occasional pebbles, dry to damp		
9.0			4				Sample 4 (2.3 to 3.0 m) submitted for analysis	
10.0						– at 3.0 metres, no rootlets, no pebbles		-3
11.0			5	CL				
12.0								
13.0								-4.0
14.0			6					
15.0						SILT, medium brown, some clay, increasing silt, trace red and white flecs, trace mottling, very faint, damp		
16.0			7					-5.0
17.0								
18.0				ML				
19.0			8					-6
20.0								

UMA Engineering Ltd.
Edmonton, Alberta

LOGGED BY: MES	COMPLETION DEPTH: 35 ft
REVIEWED BY: DEM	COMPLETE: 03/11/33
Fig. No: 5	Page 1 of

PROJECT:Drumheller Penitentiary Landfill	DRILLER:Beck	BOREHOLE NO: MW99-4
CLIENT:Public Works & Govt Services Can	DRILLING METHOD:Truck-mounted auger	PROJECT NO: 2977-213-00-02
START DATE: 03/11/99		ELEVATION:

SAMPLE TYPE: DRIVE SAMPLE, SHELBY TUBE, GRAB SAMPLE, AUGER SAMPLE, NO RECOVERY, CORED SAMPLE

BACKFILL TYPE: BENTONITE, PEA GRAVEL, SLOUGH, GROUT, DRILL CUTTINGS, SAND

DEPTH(ft)	PID READINGS (ppm) 20 40 60 80	SAMPLE TYPE	SAMPLE NO	USC	SOIL SYMBOL	Soil Description	WELL INSTALLATION	Other Data	ELEVATION(m)
20.0						– at 6.1 metres, trace mottling, more defined			
21.0			9						
22.0				ML					
23.0									-7.0
24.0			10						
25.0						SANDY SILT, light to medium brown, trace clay, trace white pockets, some mottling, damp			
26.0			11						-8.0
27.0									
28.0									
29.0			12	ML-SP					-9.0
30.0						– at 9.1 metres, increasing clay			
31.0			13						
32.0									
33.0						SILTY CLAY, occasional sand pockets, some iron staining, some mottling, decreasing mottling, decreasing moisture			-10.0
34.0			14	CL-ML					
35.0						END OF HOLE AT 10.67 METRES DRY UPON COMPLETION 0.81 M STICK-UP TO TOP OF PVC PIPE			
36.0									-11.0
37.0									
38.0									
39.0									-12.0
40.0									

UMA Engineering Ltd. Edmonton, Alberta	LOGGED BY: MES REVIEWED BY: DEM Fig. No: 5	COMPLETION DEPTH: 35 ft COMPLETE: 03/11/33 Page 2 of 2

APPENDIX D

ANALYTICAL TEST RESULTS

ETL Enviro·Test

A DIVISION OF ETL CHEMSPEC ANALYTICAL LIMITED

UMA ENGINEERING LTD.

FILE:			
NOV 2 9 1999			
TO	OK	TO	OK
MS			

monton (Main)
- 67 Avenue
onton, AB
E 0P5
one: (780) 413-5227
(780) 437-2311

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Flr., 10158 - 103 Street
onton, AB
J 0X6
one: (780) 413-5265
(780) 424-4602

lgary
2, 1313 - 44th Ave. N.E.
ary, AB
E 6L5
one: (403) 291-9897
(403) 291-0298

ande Prairie
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de Prairie, AB
V 5W1
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nnipeg
Logan Avenue
nipeg, MB
E 3L5
one: (204) 945-3705
(204) 945-0763

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Barton Street
nder Bay, ON
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one: (807) 623-6463
(807) 623-7598

nada Wide Phone:
00-668-9878

stern Canada Fax:
00-286-7319

CHEMICAL ANALYSIS REPORT

UMA ENGINEERING LTD
17007 107 AVE
EDMONTON AB T5S 1G3

DATE: November 23, 1999

ATTN: MELANIE SIEWERT

Lab Work Order #:	E911714	Sampled By:	MES
Project Reference:	2977-213-00-02	Date Received:	11/12/99
Project P.O.#:	NOT SUBMITTED		

Comments:

APPROVED BY:

Roy Jones
Project Manager

ACCREDITATIONS: STANDARDS COUNCIL OF CANADA (SCC), IN COOPERATION WITH THE CANADIAN ASSOCIATION FOR ENVIRONMENTAL ANALYTICAL LABORATORIES (CAEAL): FOR SPECIFIC TESTS AS REGISTERED BY THE COUNCIL (EDMONTON, CALGARY, SASKATOON, WINNIPEG, THUNDER BAY)
AMERICAN INDUSTRIAL HYGIENE ASSOCIATION (AIHA) FOR INDUSTRIAL HYGIENE ANALYSIS (EDMONTON, WI
STANDARDS COUNCIL OF CANADA IN COOPERATION WITH THE CANADIAN FOOD INSPECTION AGENCY (CFIA FOR FERTILIZER AND FEED TESTING (SASKATOON)

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E911714-01	SS-1 (UPSTREAM)							
Sample Type:WATER								
Collected:11/10/99								
		Hydrocarbons,Recoverable	<1	1	mg/L		11/16/99	MP
		AB Tier1-PAHs in Water						
		Naphthalene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Acenaphthylene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Acenaphthene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Fluorene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Phenanthrene/Anthracene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Fluoranthene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Pyrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		B(a)A/Chrysene/B(c)P	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		7,12-Dimethylbenz(a)anthracene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Benzo(b/j/k)fluoranthene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Benzo(a)pyrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		3-Methylcholanthrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Indeno(1,2,3-cd)pyrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Dibenzo(ah)anthracene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Benzo(ghi)perylene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Dibenz(ah,ai,aj)pyrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		BTEX, TVH and TEH in Water						
		BTEX and TVH in Water						
		Benzene	< 0.5	0.5	ug/L	11/15/99	11/17/99	SCM
		Toluene	< 0.5	0.5	ug/L	11/15/99	11/17/99	SCM
		Ethylbenzene	< 0.5	0.5	ug/L	11/15/99	11/17/99	SCM
		Xylenes	< 0.5	0.5	ug/L	11/15/99	11/17/99	SCM
		Total Volatiles	< 100	100	ug/L	11/15/99	11/17/99	SCM
		Total Extractables (Water)	<50	50	ug/L (ppb)	11/15/99	11/15/99	SCM
		Dissolved Hydride Metals						
		Arsenic (As)	0.0028	0.0004	mg/L		11/18/99	GC
		Mercury (Hg), Dissolved	<0.0002	0.0002	mg/L		11/18/99	GC
		Antimony (Sb)	<0.0004	0.0004	mg/L		11/18/99	GC
		Selenium (Se)	<0.0004	0.0004	mg/L		11/18/99	GC
		Metals, Dissolved						
		Silver (Ag)	<0.005	0.005	mg/L		11/18/99	GC
		Aluminum (Al)	<0.01	0.01	mg/L		11/18/99	GC
		Boron (B)	0.15	0.05	mg/L		11/18/99	GC
		Barium (Ba)	0.044	0.003	mg/L		11/18/99	GC
		Beryllium (Be)	<0.001	0.001	mg/L		11/18/99	GC
		Cadmium (Cd)	<0.001	0.001	mg/L		11/18/99	GC
		Cobalt (Co)	<0.002	0.002	mg/L		11/18/99	GC
		Chromium (Cr)	<0.005	0.005	mg/L		11/18/99	GC
		Copper (Cu)	0.003	0.001	mg/L		11/18/99	GC
		Iron (Fe)	0.080	0.005	mg/L		11/18/99	GC
		Manganese (Mn), Dissolved	<0.001	0.001	mg/L		11/18/99	GC
		Molybdenum (Mo)	<0.005	0.005	mg/L		11/18/99	GC
		Nickel (Ni)	0.003	0.002	mg/L		11/18/99	GC
		Phosphorus (P)	<0.1	0.1	mg/L		11/18/99	GC
		Lead (Pb)	<0.005	0.005	mg/L		11/18/99	GC
		Tin (Sn)	<0.05	0.05	mg/L		11/18/99	GC
		Strontium (Sr)	0.376	0.005	mg/L		11/18/99	GC
		Titanium (Ti)	0.003	0.001	mg/L		11/18/99	GC
		Thallium (Tl)	<0.05	0.05	mg/L		11/18/99	GC
		Vanadium (V)	<0.001	0.001	mg/L		11/18/99	GC
		Zinc (Zn)	0.004	0.001	mg/L		11/18/99	GC
		Salinity for Water						
		Chloride (Cl)	4	1	mg/L		11/15/99	MOF
		Conductance (EC)	1650	0.2	uS/cm		11/16/99	PTT
		Calcium (Ca)	45.5	0.5	mg/L		11/16/99	AZ
		Potassium (K)	6.4	0.1	mg/L		11/16/99	AZ
		Magnesium (Mg)	19.0	0.1	mg/L		11/16/99	AZ
		Sodium (Na)	322	1	mg/L		11/16/99	AZ
		Sulfate (SO4)	284	0.5	mg/L		11/16/99	AZ
		pH in Water	8.3		pH		11/16/99	PTT
		SAR	10.1		SAR		11/19/99	AZ
E911714-02	SS-2 (DOWNSTREAM)							
Sample Type:WATER								
Collected:11/10/99								
		Hydrocarbons,Recoverable	<1	1	mg/L		11/16/99	MP
		AB Tier1-PAHs in Water						
		Naphthalene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Acenaphthylene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E911714-02	SS-2 (DOWNSTREAM)							
Sample Type:WATER								
Collected:11/10/99								
		Acenaphthene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Fluorene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Phenanthrene/Anthracene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Fluoranthene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Pyrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		B(a)A/Chrysene/B(c)P	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		7,12-Dimethylbenz(a)anthracene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Benzo(b/j/k)fluoranthene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Benzo(a)pyrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		3-Methylcholanthrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Indeno(1,2,3-cd)pyrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Dibenzo(ah)anthracene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Benzo(ghi)perylene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Dibenz(ah,ai,aj)pyrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		BTEX, TVH and TEH in Water						
		BTEX and TVH in Water						
		Benzene	< 0.5	0.5	ug/L	11/15/99	11/17/99	SCM
		Toluene	< 0.5	0.5	ug/L	11/15/99	11/17/99	SCM
		Ethylbenzene	< 0.5	0.5	ug/L	11/15/99	11/17/99	SCM
		Xylenes	< 0.5	0.5	ug/L	11/15/99	11/17/99	SCM
		Total Volatiles	< 100	100	ug/L	11/15/99	11/17/99	SCM
		Total Extractables (Water)	<50	50	ug/L (ppb)	11/15/99	11/15/99	SCM
		Dissolved Hydride Metals						
		Arsenic (As)	0.0017	0.0004	mg/L		11/18/99	GC
		Mercury (Hg), Dissolved	<0.0002	0.0002	mg/L		11/18/99	GC
		Antimony (Sb)	<0.0004	0.0004	mg/L		11/18/99	GC
		Selenium (Se)	<0.0004	0.0004	mg/L		11/18/99	GC
		Metals, Dissolved						
		Silver (Ag)	<0.005	0.005	mg/L		11/18/99	GC
		Aluminum (Al)	<0.01	0.01	mg/L		11/18/99	GC
		Boron (B)	0.17	0.05	mg/L		11/18/99	GC
		Barium (Ba)	0.031	0.003	mg/L		11/18/99	GC
		Beryllium (Be)	<0.001	0.001	mg/L		11/18/99	GC
		Cadmium (Cd)	<0.001	0.001	mg/L		11/18/99	GC
		Cobalt (Co)	<0.002	0.002	mg/L		11/18/99	GC
		Chromium (Cr)	<0.005	0.005	mg/L		11/18/99	GC
		Copper (Cu)	0.004	0.001	mg/L		11/18/99	GC
		Iron (Fe)	0.104	0.005	mg/L		11/18/99	GC
		Manganese (Mn), Dissolved	0.002	0.001	mg/L		11/18/99	GC
		Molybdenum (Mo)	<0.005	0.005	mg/L		11/18/99	GC
		Nickel (Ni)	0.005	0.002	mg/L		11/18/99	GC
		Phosphorus (P)	<0.1	0.1	mg/L		11/18/99	GC
		Lead (Pb)	<0.005	0.005	mg/L		11/18/99	GC
		Tin (Sn)	<0.05	0.05	mg/L		11/18/99	GC
		Strontium (Sr)	0.447	0.005	mg/L		11/18/99	GC
		Titanium (Ti)	0.010	0.001	mg/L		11/18/99	GC
		Thallium (Tl)	<0.05	0.05	mg/L		11/18/99	GC
		Vanadium (V)	<0.001	0.001	mg/L		11/18/99	GC
		Zinc (Zn)	0.007	0.001	mg/L		11/18/99	GC
		Salinity for Water						
		Chloride (Cl)	5	1	mg/L		11/15/99	MOR
		Conductance (EC)	1790	0.2	uS/cm		11/16/99	PTT
		Calcium (Ca)	37.8	0.5	mg/L		11/16/99	AZ
		Potassium (K)	6.7	0.1	mg/L		11/16/99	AZ
		Magnesium (Mg)	16.9	0.1	mg/L		11/16/99	AZ
		Sodium (Na)	343	1	mg/L		11/16/99	AZ
		Sulfate (SO4)	326	0.5	mg/L		11/16/99	AZ
		pH in Water	8.5		pH		11/16/99	PTT
		SAR	11.7		SAR		11/19/99	AZ
E911714-03	SS-3 (SPRING)							
Sample Type:WATER								
Collected:11/10/99								
		Hydrocarbons,Recoverable	<1	1	mg/L		11/16/99	MP
		AB Tier1-PAHs in Water						
		Naphthalene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Acenaphthylene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Acenaphthene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Fluorene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Phenanthrene/Anthracene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Fluoranthene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E911714-03	SS-3 (SPRING)							
Sample Type:WATER								
Collected:11/10/99								
		Pyrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		B(a)A/Chrysene/B(c)P	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		7,12-Dimethylbenz(a)anthracene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Benzo(b/j/k)fluoranthene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Benzo(a)pyrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		3-Methylcholanthrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Indeno(1,2,3-cd)pyrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Dibenzo(ah)anthracene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Benzo(ghi)perylene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Dibenz(ah,ai,aj)pyrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		BTEX, TVH and TEH in Water						
		BTEX and TVH in Water						
		Benzene	< 0.5	0.5	ug/L	11/15/99	11/18/99	SCM
		Toluene	< 0.5	0.5	ug/L	11/15/99	11/18/99	SCM
		Ethylbenzene	< 0.5	0.5	ug/L	11/15/99	11/18/99	SCM
		Xylenes	< 0.5	0.5	ug/L	11/15/99	11/18/99	SCM
		Total Volatiles	< 100	100	ug/L	11/15/99	11/18/99	SCM
		Total Extractables (Water)	<50	50	ug/L (ppb)	11/15/99	11/16/99	SCM
		Dissolved Hydride Metals						
		Arsenic (As)	0.0006	0.0004	mg/L		11/18/99	GC
		Mercury (Hg), Dissolved	<0.0002	0.0002	mg/L		11/18/99	GC
		Antimony (Sb)	<0.0004	0.0004	mg/L		11/18/99	GC
		Selenium (Se)	<0.0004	0.0004	mg/L		11/18/99	GC
		Metals, Dissolved						
		Silver (Ag)	<0.005	0.005	mg/L		11/18/99	GC
		Aluminum (Al)	<0.01	0.01	mg/L		11/18/99	GC
		Boron (B)	0.19	0.05	mg/L		11/18/99	GC
		Barium (Ba)	0.024	0.003	mg/L		11/18/99	GC
		Beryllium (Be)	<0.001	0.001	mg/L		11/18/99	GC
		Cadmium (Cd)	<0.001	0.001	mg/L		11/18/99	GC
		Cobalt (Co)	<0.002	0.002	mg/L		11/18/99	GC
		Chromium (Cr)	<0.005	0.005	mg/L		11/18/99	GC
		Copper (Cu)	0.002	0.001	mg/L		11/18/99	GC
		Iron (Fe)	0.190	0.005	mg/L		11/18/99	GC
		Manganese (Mn), Dissolved	0.057	0.001	mg/L		11/18/99	GC
		Molybdenum (Mo)	<0.005	0.005	mg/L		11/18/99	GC
		Nickel (Ni)	0.004	0.002	mg/L		11/18/99	GC
		Phosphorus (P)	<0.1	0.1	mg/L		11/18/99	GC
		Lead (Pb)	<0.005	0.005	mg/L		11/18/99	GC
		Tin (Sn)	<0.05	0.05	mg/L		11/18/99	GC
		Strontium (Sr)	0.664	0.005	mg/L		11/18/99	GC
		Titanium (Ti)	0.001	0.001	mg/L		11/18/99	GC
		Thallium (Tl)	<0.05	0.05	mg/L		11/18/99	GC
		Vanadium (V)	<0.001	0.001	mg/L		11/18/99	GC
		Zinc (Zn)	0.008	0.001	mg/L		11/18/99	GC
		Salinity for Water						
		Chloride (Cl)	5	1	mg/L		11/15/99	MOR
		Conductance (EC)	1680	0.2	uS/cm		11/16/99	PTT
		Calcium (Ca)	75.9	0.5	mg/L		11/16/99	AZ
		Potassium (K)	4.6	0.1	mg/L		11/16/99	AZ
		Magnesium (Mg)	21.8	0.1	mg/L		11/16/99	AZ
		Sodium (Na)	280	1	mg/L		11/16/99	AZ
		Sulfate (SO4)	338	0.5	mg/L		11/16/99	AZ
		pH in Water	8.0		pH		11/16/99	PTT
		SAR	7.3		SAR		11/19/99	AZ
E911714-04	SS-4 (SPRING)							
Sample Type:WATER	(SS-3 DUPLICATE)							
Collected:11/10/99								
		Hydrocarbons,Recoverable	<1	1	mg/L		11/16/99	MP
		AB Tier1-PAHs in Water						
		Naphthalene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Acenaphthylene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Acenaphthene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Fluorene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Phenanthrene/Anthracene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Fluoranthene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Pyrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		B(a)A/Chrysene/B(c)P	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		7,12-Dimethylbenz(a)anthracene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Benzo(b/j/k)fluoranthene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E911714-04	SS-4 (SPRING)							
Sample Type:WATER								
Collected:11/10/99								
		Benzo(a)pyrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		3-Methylcholanthrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Indeno(1,2,3-cd)pyrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Dibenzo(ah)anthracene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Benzo(ghi)perylene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Dibenz(ah,ai,aj)pyrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		BTEX, TVH and TEH in Water						
		BTEX and TVH in Water						
		Benzene	< 0.5	0.5	ug/L	11/15/99	11/18/99	SCM
		Toluene	< 0.5	0.5	ug/L	11/15/99	11/18/99	SCM
		Ethylbenzene	< 0.5	0.5	ug/L	11/15/99	11/18/99	SCM
		Xylenes	< 0.5	0.5	ug/L	11/15/99	11/18/99	SCM
		Total Volatiles	< 100	100	ug/L	11/15/99	11/18/99	SCM
		Total Extractables (Water)	<50	50	ug/L (ppb)	11/15/99	11/16/99	SCM
		Dissolved Hydride Metals						
		Arsenic (As)	0.0006	0.0004	mg/L		11/18/99	GC
		Mercury (Hg), Dissolved	<0.0002	0.0002	mg/L		11/18/99	GC
		Antimony (Sb)	<0.0004	0.0004	mg/L		11/18/99	GC
		Selenium (Se)	<0.0004	0.0004	mg/L		11/18/99	GC
		Metals, Dissolved						
		Silver (Ag)	<0.005	0.005	mg/L		11/18/99	GC
		Aluminum (Al)	<0.01	0.01	mg/L		11/18/99	GC
		Boron (B)	0.20	0.05	mg/L		11/18/99	GC
		Barium (Ba)	0.024	0.003	mg/L		11/18/99	GC
		Beryllium (Be)	<0.001	0.001	mg/L		11/18/99	GC
		Cadmium (Cd)	<0.001	0.001	mg/L		11/18/99	GC
		Cobalt (Co)	<0.002	0.002	mg/L		11/18/99	GC
		Chromium (Cr)	<0.005	0.005	mg/L		11/18/99	GC
		Copper (Cu)	0.002	0.001	mg/L		11/18/99	GC
		Iron (Fe)	0.177	0.005	mg/L		11/18/99	GC
		Manganese (Mn), Dissolved	0.042	0.001	mg/L		11/18/99	GC
		Molybdenum (Mo)	<0.005	0.005	mg/L		11/18/99	GC
		Nickel (Ni)	0.004	0.002	mg/L		11/18/99	GC
		Phosphorus (P)	<0.1	0.1	mg/L		11/18/99	GC
		Lead (Pb)	<0.005	0.005	mg/L		11/18/99	GC
		Tin (Sn)	<0.05	0.05	mg/L		11/18/99	GC
		Strontium (Sr)	0.681	0.005	mg/L		11/18/99	GC
		Titanium (Ti)	0.001	0.001	mg/L		11/18/99	GC
		Thallium (Tl)	<0.05	0.05	mg/L		11/18/99	GC
		Vanadium (V)	<0.001	0.001	mg/L		11/18/99	GC
		Zinc (Zn)	0.004	0.001	mg/L		11/18/99	GC
		Salinity for Water						
		Chloride (Cl)	3	1	mg/L		11/15/99	MOR
		Conductance (EC)	1690	0.2	uS/cm		11/16/99	PTT
		Calcium (Ca)	77.8	0.5	mg/L		11/16/99	AZ
		Potassium (K)	4.7	0.1	mg/L		11/16/99	AZ
		Magnesium (Mg)	23.1	0.1	mg/L		11/16/99	AZ
		Sodium (Na)	323	1	mg/L		11/16/99	AZ
		Sulfate (SO4)	353	0.5	mg/L		11/16/99	AZ
		pH in Water	8.0		pH		11/16/99	PTT
		SAR	8.3		SAR		11/19/99	AZ
E911714-05	SS-5 (SPRING)							
Sample Type:WATER								
Collected:11/10/99	(FIELD BLANK)							
		Hydrocarbons,Recoverable	<1	1	mg/L		11/16/99	MP
		AB Tier1-PAHs in Water						
		Naphthalene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Acenaphthylene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Acenaphthene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Fluorene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Phenanthrene/Anthracene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Fluoranthene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Pyrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		B(a)A/Chrysene/B(c)P	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		7,12-Dimethylbenz(a)anthracene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Benzo(b/j/k)fluoranthene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Benzo(a)pyrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		3-Methylcholanthrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Indeno(1,2,3-cd)pyrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Dibenzo(ah)anthracene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E911714-05	SS-5 (SPRING)							
Sample Type:WATER								
Collected:11/10/99								
		Benzo(ghi)perylene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		Dibenz(ah,ai,aj)pyrene	< 0.01	0.01	ug/L	11/16/99	11/19/99	SRJ
		BTEX, TVH and TEH in Water						
		BTEX and TVH in Water						
		Benzene	< 0.5	0.5	ug/L	11/15/99	11/18/99	SCM
		Toluene	< 0.5	0.5	ug/L	11/15/99	11/18/99	SCM
		Ethylbenzene	< 0.5	0.5	ug/L	11/15/99	11/18/99	SCM
		Xylenes	< 0.5	0.5	ug/L	11/15/99	11/18/99	SCM
		Total Volatiles	< 100	100	ug/L	11/15/99	11/18/99	SCM
		Total Extractables (Water)	<50	50	ug/L (ppb)	11/15/99	11/16/99	SCM
		Dissolved Hydride Metals						
		Arsenic (As)	<0.0004	0.0004	mg/L		11/18/99	GC
		Mercury (Hg), Dissolved	<0.0002	0.0002	mg/L		11/18/99	GC
		Antimony (Sb)	<0.0004	0.0004	mg/L		11/18/99	GC
		Selenium (Se)	<0.0004	0.0004	mg/L		11/18/99	GC
		Metals, Dissolved						
		Silver (Ag)	<0.005	0.005	mg/L		11/18/99	GC
		Aluminum (Al)	<0.01	0.01	mg/L		11/18/99	GC
		Boron (B)	<0.05	0.05	mg/L		11/18/99	GC
		Barium (Ba)	<0.003	0.003	mg/L		11/18/99	GC
		Beryllium (Be)	<0.001	0.001	mg/L		11/18/99	GC
		Cadmium (Cd)	<0.001	0.001	mg/L		11/18/99	GC
		Cobalt (Co)	<0.002	0.002	mg/L		11/18/99	GC
		Chromium (Cr)	<0.005	0.005	mg/L		11/18/99	GC
		Copper (Cu)	0.001	0.001	mg/L		11/18/99	GC
		Iron (Fe)	<0.005	0.005	mg/L		11/18/99	GC
		Manganese (Mn), Dissolved	<0.001	0.001	mg/L		11/18/99	GC
		Molybdenum (Mo)	<0.005	0.005	mg/L		11/18/99	GC
		Nickel (Ni)	<0.002	0.002	mg/L		11/18/99	GC
		Phosphorus (P)	<0.1	0.1	mg/L		11/18/99	GC
		Lead (Pb)	<0.005	0.005	mg/L		11/18/99	GC
		Tin (Sn)	<0.05	0.05	mg/L		11/18/99	GC
		Strontium (Sr)	<0.005	0.005	mg/L		11/18/99	GC
		Titanium (Ti)	<0.001	0.001	mg/L		11/18/99	GC
		Thallium (Tl)	<0.05	0.05	mg/L		11/18/99	GC
		Vanadium (V)	<0.001	0.001	mg/L		11/18/99	GC
		Zinc (Zn)	0.003	0.001	mg/L		11/18/99	GC
		Salinity for Water						
		Chloride (Cl)	<1	1	mg/L		11/15/99	MOR
		Conductance (EC)	10.3	0.2	uS/cm		11/16/99	PTT
		Calcium (Ca)	<0.5	0.5	mg/L		11/16/99	AZ
		Potassium (K)	2.5	0.1	mg/L		11/16/99	AZ
		Magnesium (Mg)	<0.1	0.1	mg/L		11/16/99	AZ
		Sodium (Na)	<1	1	mg/L		11/16/99	AZ
		Sulfate (SO4)	<0.5	0.5	mg/L		11/16/99	AZ
		pH in Water	7.0		pH		11/16/99	PTT
		SAR	<0.1		SAR		11/19/99	AZ

N.D. - NOT DETECTED, LESS THAN THE DETECTION LIMIT

THIS IS THE FINAL PAGE OF THE REPORT

Appendix A Test Methodologies

Arsenic (As) — Laboratory Code: ASD2W1

Preparation Method: Digest with sulphuric acid/persulphate and HCl
Instrumental Method: Continuous hydride atomic absorption spectrophotometry @ 193.7
Method Reference: APHA 3114C

BTEX and TVH in Water — Laboratory Code: BTX2W1

PREPARATION METHOD: Purge and trap extraction

INSTRUMENTAL METHOD: GC/PID for BTEX.
GC/FID for TVH - summation of hydrocarbons from C5 to C10 carbon range and is calculated against a BTEX standard.

METHOD REFERENCE: Modified SW-846 USEPA Method 5030 and 8015/8020.

BTEX QC SUMMARY:

Accuracy	Precision
100%	+/- 10%

NOTE: Accuracy is expressed as the average % recovery and Precision as the relative standard deviation (RSD) of fortifications made using certified standards (BTEX).

TVH QC SUMMARY:

Accuracy	Precision
97%	+/- 17%

NOTE: Accuracy is expressed as the average % recovery and Precision as the relative standard deviation (RSD) of fortifications made using certified standards (BTEX).

Chloride (Cl) — Laboratory Code: CHL1W1

Preparation: Filter through 0.45u filter
Instrumental: Sample analyzed colorimetrically @ 480 nm using ferricyanide method on a Cobas Fara discrete analyzer
Reference: APHA 4500-Cl, E

or

Preparation Method: 0.45μ filtration if turbid
Instrumental Method: Ion Chromatography
Method Reference: APHA 4110 B

Conductance (EC) — Laboratory Code: ECW1W1

Instrumental Method: Conductivity Meter
Method Reference: Conductance APHA 2510B

Mercury (Hg), Dissolved — Laboratory Code: HGD2W1

Preparation Method: Digest with nitric/sulphuric acid and persulphate/permanganate.
Instrumental Method: Analyzed by cold vapor atomic absorption spectrophotometry @ 253.7
Method Reference: Hg APHA 3112 B

Hydrocarbons, Recoverable — Laboratory Code: HOG1W1

Preparation Method: Separatory funnel extraction with 80% to 20% Hexane to MTBE; silica gel addition.
Instrumental Method: Gravimetric analysis
Method Reference: APHA 5520F

ICP Metals Setup — Laboratory Code: ICPDIS

PREPARATION METHOD:

Dissolved: Filter through 0.45u and preserve with nitric acid

Appendix A Test Methodologies

Extractable: Preserve with nitric acid
Total: Preserve with nitric acid; digest with nitric/hydrochloric acid

INSTRUMENTAL METHOD: ICP Spectrophotometry
METHOD REFERENCE: APHA 3120B/3030F, Standard Methods; 18th ed.

Routine Metals — Laboratory Code: ICPRDS

PREPARATION METHOD: Filter through 0.45u and preserve with nitric acid
INSTRUMENTAL METHOD: ICP Spectrophotometry
METHOD REFERENCE: APHA 3120B/3030F, Standard Methods; 18th ed.

Sulfur reported as sulfate. ICP result multiplied by 3 to convert.

Sulfate (SO4) — Laboratory Code: ICPSO4

Preparation Method: 0.45 u filtraton if turbid
Instrumental Method: Ion Chromatography or ICP
Method Reference: S04 Dionex Handbook of Ion Chromatography pg 37.

AB Tier1-PAHs in Water — Laboratory Code: PAH5W1

Preparation Method: Liquid/liquid extraction with DCM

Instrument Method: GC/MSD analysis

Method Reference: Extraction Method: EPA 3510 or EPA 3520 (modified)
Analytical Method: EPA 8270 (modified)

pH in Water — Laboratory Code: PHW1W1

Instrumental Method: pH Meter
Method Reference: APHA 4500-H+ B

SAR — Laboratory Code: SAR

Preparation Method: Saturated Paste Extract
Calculation: SAR = Na/sq.rt.((Ca+Mg)/2) (in meq/L)
Method Reference: Carter CSSS 18.4

Antimony (Sb) — Laboratory Code: SBD2W1

Preparation Method: Digest with sulphuric acid/persulphate and HCl
Instrumental Method: Continuous hydride atomic absorption spectrophotometry @ 217.6
Method Reference: Sb APHA 3114C

Selenium (Se) — Laboratory Code: SED2W1

Preparation Method: Digest with sulphuric acid/persulphate and HCl
Instrumental Method: Continuous hydride atomic absorption spectrophotometry @ 196.0
Method Reference: Se APHA 3114C

Total Extractables (Water) — Laboratory Code: TEH1W1

PREPARATION METHOD: Liquid-liquid extraction with organic solvent

INSTRUMENTAL METHOD: GC/FID - summation of hydrocarbons from C11 to C30 carbon range (excluding benzene, toluene, ethylbenzene, and xylenes) and calculated against diesel standard.

METHOD REFERENCE: Modified SW-846 USEPA Method 3510 and 8000

QC SUMMARY:

Accuracy	Precision
91%	+/- 19%

Appendix A Test Methodologies

NOTE: Accuracy is expressed as the average % recovery and Precision as the relative standard deviation (RSD) of fortifications made using in-house standards (TEH).

Key To Sub-Contracted Laboratory Identification:

Laboratory	Test Code # *	Laboratory	Test Code# *
ETL - Edmonton	1,S	Core Laboratories	C
ETL - Calgary	2	HydroQual	H
ETL -Saskatoon	3	SRC	R
ETL - Thunder Bay	7	Biochem	B
ETL - Winnipeg	8	Bioquest	Q
ETL - Grande Prairie	9	WSH Laboratories	W
ETL - Mobile Services	L	Maxxam	M
Bodycote	E	Alpha Laboratories	A
Norwest Laboratories	N		

* The Test code #/Letter is the last character on the test code.
For Example: NMA1W3 designates that the test was performed in the ETL Saskatoon laboratory.
THIS IS THE LAST PAGE OF THE METHODOLOGY APPENDIX.

ETL EnviroTest

CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM

9936 - 67th Avenue, Edmonton, Alberta T6E 0P5 — Telephone: (780) 413-5220 — Fax: (780) 437-2311
Edmonton Toll Free Line — Telephone: 1-800-668-9878 — Fax: 1-800-286-7319
1313 - 44th Avenue N.E., Calgary, Alberta T2E 6L5 — Telephone: (403) 291-9897 — Fax: (403) 291-0298
9505 - 111th Street, Grande Prairie, Alberta T8V 5W1 — Telephone: (780) 539-5196 — Fax: (780) 513-2191
General Purpose Bldg., 124 Veterinary Road, Saskatoon, Saskatchewan S7N 5E3 — Telephone: (306) 668-8370 — Fax: (306) 668-8383
745 Logan Avenue, Winnipeg, Manitoba R3E 3L5 — Telephone: (204) 945-3705 — Fax: (204) 945-0763
1081 Barton Street, Thunder Bay, Ontario P7B 5N3 — Telephone: (807) 623-6463 — Fax: (807) 623-7598

DATE: Nov 11, 1999 DATE REQUIRED:

SERVICE REQUESTED:

☐ REGULAR ☐ PRIORITY (50% SURCHARGE) ☐ EMERGENCY (100% SURCHARGE)

PRICING: *(Check one)*
AS PER QUOTE #: ☐
AS PER LIST PRICE: ☐

ANALYSIS REQUESTED:

E91171

SAMPLE ID	SAMPLED BY	DATE / TIME SAMPLED	SAMPLE TYPE	SALIN W(D)	ICP DW (ORTHO)	HYDG W(D)	PAHS W(D)	(a,h) anthracene	BTEX	TVH / BTEX W(D)	TEH	HINERAL OIL & GROSE	N/A	N/A	SAMPLE RECEIVED (Y OR N)	SAMPLE BROKEN (Y OR N)	LAB SAMPLE NO.
SS-1 (UPSTREAM)	MES	NOV 10/99	SURFACE WATER	✓	✓	✓		✓		✓	✓	✓	✓				-01
SS-2 (DOWNSTREAM)	"	"	"	✓	✓	✓		✓		✓	✓	✓	✓				-02
SS-3 (SPRING)	"	"	"	✓	✓	✓		✓		✓	✓	✓	✓				-03
SS-4 (SPRING)	"	"	"	✓	✓	✓		✓		✓	✓	✓	✓				-04
SS-5 (SPRING)	"	"	"	✓	✓	✓		✓		✓	✓	✓	✓				-05
			PRESERVED / FILTERED					✓	✓	✓	✓						

✱ RAW WATER ✱
✱ NOT FIELD FILTERED ✱

NOTES & CONDITIONS
1. Quote number must be provided to ensure proper pricing.
2. Turnaround times will vary dependant on complexity of analysis & lab workload at time of submission. Please contact the lab to confirm turnaround times.
3. All hazardous samples submitted must be labeled to comply with WHMIS regulations. This must include the nature of the hazard, as well as a contact name & phone number that the lab can contact for further information.

NOTE: Failure to properly complete all portions of this form may delay analysis.

NOTE: **Shaded areas MUST be completed in full by client for sample processing to occur.**

CLIENT: UMA ENGINEERING
CONTACT: MELANIE SIEWERT
REPORT ADDRESS: 17007-107 AVE
EDMONTON
BILLING ADDRESS: SAME

NO. SAMPLES SUBMITTED: 5
NO. BOTTLES / SAMPLES: 35
PHONE: 486-7028
FAX: 486-7070
P. O. NO.:

RELINQUISHED BY:	DATE: NOV 12/99	RECEIVED BY:	DATE: 11/12/99
	TIME: 21:30	ETL LAB:	TIME: 15:30
RELINQUISHED BY:	DATE:	RECEIVED BY:	DATE:
	TIME:	ETL LAB:	TIME:

SAMPLE CONDITION UPON RECEIPT:

FROZEN: COLD: AMBIENT:

OTHER: *(BREAKAGE, LEAKAGE, ETC.)*

WHITE – Report Copy
PINK – File Copy
YELLOW – Customer C

ETL Enviro·Test

A DIVISION OF ETL CHEMSPEC ANALYTICAL LIMITED

UMA ENGINEERING LTD.

FILE:

DEC 13 1999

TO	OK	TO	OK
MS			

onton (Main)
- 67 Avenue
onton, AB
E 0P5
ne: (780) 413-5227
(780) 437-2311

onton (Downtown)
Flr., 10158 - 103 Street
onton, AB
J 0X6
ne: (780) 413-5265
(780) 424-4602

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ary, AB
E 6L5
ne: (403) 291-9897
(403) 291-0298

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- 111 Street
de Prairie, AB
V 5W1
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(780) 513-2191

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N 5E3
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Logan Avenue
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der Bay, ON
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one: (807) 623-6463
(807) 623-7598

nada Wide Phone:
0-668-9878

estern Canada Fax:
0-286-7319

CHEMICAL ANALYSIS REPORT

UMA ENGINEERING LTD
17007 107 AVE
EDMONTON AB T5S 1G3

DATE: December 8, 1999

ATTN: MELANIE SIEWERT

Lab Work Order #:	E911396(Revised)	**Sampled By:**	MES
Project Reference:	2977-213-00-02	**Date Received:**	11/05/99
Project P.O.#:	DRUMHELLER		

Comments:

APPROVED BY:

Roy Jones
Project Manager

ACCREDITATIONS: STANDARDS COUNCIL OF CANADA (SCC), IN COOPERATION WITH THE CANADIAN ASSOCIATION FOR ENVIRONMENTAL ANALYTICAL LABORATORIES (CAEAL): FOR SPECIFIC TESTS AS REGISTERED BY THE COUNCIL (EDMONTON, CALGARY, SASKATOON, WINNIPEG, THUNDER BAY)
AMERICAN INDUSTRIAL HYGIENE ASSOCIATION (AIHA) FOR INDUSTRIAL HYGIENE ANALYSIS (EDMONTON, WI
STANDARDS COUNCIL OF CANADA IN COOPERATION WITH THE CANADIAN FOOD INSPECTION AGENCY (CFIA FOR FERTILIZER AND FEED TESTING (SASKATOON)

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E911396-01	MW99-1(7.5-10)							
Sample Type:SOIL								
Collected:11/04/99								
		Hydrocarbons, Recoverable	600	100	mg/kg	11/11/99	11/11/99	UK
		AB Tier1-PAHs in Soil						
		Naphthalene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Acenaphthylene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Acenaphthene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Fluorene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Phenanthrene/Anthracene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Fluoranthene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		B(a)A/Chrysene/B(c)P	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		7,12-Dimethylbenz(a)anthracene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Benzo(b/j/k)fluoranthene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Benzo(a)pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		3-Methylcholanthrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Indeno(1,2,3-cd)pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Dibenzo(ah)anthracene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Benzo(ghi)perylene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Dibenz(ah,ai,aj)pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		BTEX, TVH and TEH in Soil						
		BTEX and TVH in Soil						
		Benzene	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Toluene	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Ethylbenzene	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Xylenes	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Total Volatiles	<0.5	0.5	ug/g (ppm)	11/08/99	11/08/99	TDV
		% Moisture	17.6	0	%		11/09/99	md
		Total Extractables (Soil)	<5	5	ug/g (ppm)	11/08/99	11/09/99	TDV
		Detailed Salinity						
		Chloride (Cl)	34	1	mg/L		11/08/99	MOR
		Electrical Conductivity	3.56	0.01	dS m-1		11/08/99	ARA
		Calcium (Ca)	437	0.5	mg/L		11/10/99	AZ
		Potassium (K)	20.4	0.1	mg/L		11/10/99	AZ
		Magnesium (Mg)	256	0.1	mg/L		11/10/99	AZ
		Sodium (Na)	338	1	mg/L		11/10/99	AZ
		Sulfate (SO4)	2720	0.5	mg/L		11/10/99	AZ
		pH	7.8		pH		11/08/99	ARA
		SAR	3.2		SAR		11/11/99	AZ
		% Saturation	67	1	%		11/08/99	ARA
		PITS Metals (ICP)						
		Arsenic (As)	5.8	0.1	mg/kg		11/10/99	GC
		Mercury (Hg)	0.02	0.01	mg/kg		11/10/99	GC
		Barium (Ba)	194	0.5	mg/kg		11/10/99	GC
		Beryllium (Be)	<1	1	mg/kg		11/10/99	GC
		Cadmium (Cd)	<0.5	0.5	mg/kg		11/10/99	GC
		Cobalt (Co)	9	1	mg/kg		11/10/99	GC
		Chromium (Cr)	34.1	0.5	mg/kg		11/10/99	GC
		Copper (Cu)	20	1	mg/kg		11/10/99	GC
		Manganese (Mn)	429	0.1	mg/kg		11/10/99	GC
		Molybdenum (Mo)	<1	1	mg/kg		11/10/99	GC
		Nickel (Ni)	29	2	mg/kg		11/10/99	GC
		Lead (Pb)	10	5	mg/kg		11/10/99	GC
		Strontium (Sr)	68	1	mg/kg		11/10/99	GC
		Thallium (Tl)	<1	1	mg/kg		11/10/99	GC
		Vanadium (V)	32	1	mg/kg		11/10/99	GC
		Zinc (Zn)	57.4	0.5	mg/kg		11/10/99	GC
		Selenium (Se)	0.8	0.1	mg/kg		11/10/99	GC
E911396-02	MW99-2B(12.5-15)							
Sample Type:SOIL								
Collected:11/04/99								
		Hydrocarbons, Recoverable	<100	100	mg/kg	11/11/99	11/11/99	UK
		AB Tier1-PAHs in Soil						
		Naphthalene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Acenaphthylene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Acenaphthene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Fluorene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Phenanthrene/Anthracene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Fluoranthene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		B(a)A/Chrysene/B(c)P	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		7,12-Dimethylbenz(a)anthracene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Benzo(b/j/k)fluoranthene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E911396-02	MW99-2B(12.5-15)							
Sample Type:SOIL								
Collected:11/04/99								
		Benzo(a)pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		3-Methylcholanthrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Indeno(1,2,3-cd)pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Dibenzo(ah)anthracene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Benzo(ghi)perylene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Dibenz(ah,ai,aj)pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		BTEX, TVH and TEH in Soil						
		BTEX and TVH in Soil						
		Benzene	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Toluene	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Ethylbenzene	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Xylenes	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Total Volatiles	<0.5	0.5	ug/g (ppm)	11/08/99	11/08/99	TDV
		% Moisture	4.9	0	%		11/09/99	md
		Total Extractables (Soil)	8	5	ug/g (ppm)	11/08/99	11/09/99	TDV
		Detailed Salinity						
		Chloride (Cl)	9	1	mg/L		11/08/99	MOR
		Electrical Conductivity	1.24	0.01	dS m-1		11/08/99	ARA
		Calcium (Ca)	69.5	0.5	mg/L		11/10/99	AZ
		Potassium (K)	9.6	0.1	mg/L		11/10/99	AZ
		Magnesium (Mg)	105	0.1	mg/L		11/10/99	AZ
		Sodium (Na)	82	1	mg/L		11/10/99	AZ
		Sulfate (SO4)	677	0.5	mg/L		11/10/99	AZ
		pH	8.1		pH		11/08/99	ARA
		SAR	1.4		SAR		11/11/99	AZ
		% Saturation	42	1	%		11/08/99	ARA
		PITS Metals (ICP)						
		Arsenic (As)	4.4	0.1	mg/kg		11/10/99	GC
		Mercury (Hg)	<0.01	0.01	mg/kg		11/10/99	GC
		Barium (Ba)	175	0.5	mg/kg		11/10/99	GC
		Beryllium (Be)	<1	1	mg/kg		11/10/99	GC
		Cadmium (Cd)	<0.5	0.5	mg/kg		11/10/99	GC
		Cobalt (Co)	6	1	mg/kg		11/10/99	GC
		Chromium (Cr)	15.0	0.5	mg/kg		11/10/99	GC
		Copper (Cu)	8	1	mg/kg		11/10/99	GC
		Manganese (Mn)	245	0.1	mg/kg		11/10/99	GC
		Molybdenum (Mo)	<1	1	mg/kg		11/10/99	GC
		Nickel (Ni)	16	2	mg/kg		11/10/99	GC
		Lead (Pb)	6	5	mg/kg		11/10/99	GC
		Strontium (Sr)	33	1	mg/kg		11/10/99	GC
		Thallium (Tl)	<1	1	mg/kg		11/10/99	GC
		Vanadium (V)	15	1	mg/kg		11/10/99	GC
		Zinc (Zn)	37.4	0.5	mg/kg		11/10/99	GC
		Selenium (Se)	0.5	0.1	mg/kg		11/10/99	GC
E911396-03	MW99-3(7.5-10)							
Sample Type:SOIL								
Collected:11/04/99								
		Hydrocarbons, Recoverable	300	100	mg/kg	11/11/99	11/11/99	UK
		AB Tier1-PAHs in Soil						
		Naphthalene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Acenaphthylene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Acenaphthene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Fluorene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Phenanthrene/Anthracene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Fluoranthene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		B(a)A/Chrysene/B(c)P	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		7,12-Dimethylbenz(a)anthracene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Benzo(b/j/k)fluoranthene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Benzo(a)pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		3-Methylcholanthrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Indeno(1,2,3-cd)pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Dibenzo(ah)anthracene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Benzo(ghi)perylene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Dibenz(ah,ai,aj)pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		BTEX, TVH and TEH in Soil						
		BTEX and TVH in Soil						
		Benzene	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Toluene	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Ethylbenzene	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E911396-03	MW99-3(7.5-10)							
Sample Type:SOIL								
Collected:11/04/99								
		BTEX, TVH and TEH in Soil						
		Xylenes	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Total Volatiles	<0.5	0.5	ug/g (ppm)	11/08/99	11/08/99	TDV
		% Moisture	17.4	0	%		11/09/99	md
		Total Extractables (Soil)	<5	5	ug/g (ppm)	11/08/99	11/09/99	TDV
		Detailed Salinity						
		Chloride (Cl)	23	1	mg/L		11/08/99	MOR
		Electrical Conductivity	1.26	0.01	dS m-1		11/08/99	ARA
		Calcium (Ca)	110	0.5	mg/L		11/10/99	AZ
		Potassium (K)	7.4	0.1	mg/L		11/10/99	AZ
		Magnesium (Mg)	57.3	0.1	mg/L		11/10/99	AZ
		Sodium (Na)	148	1	mg/L		11/10/99	AZ
		Sulfate (SO4)	647	0.5	mg/L		11/10/99	AZ
		pH	7.9		pH		11/08/99	ARA
		SAR	2.9		SAR		11/11/99	AZ
		% Saturation	73	1.	%		11/08/99	ARA
		PITS Metals (ICP)						
		Arsenic (As)	5.3	0.1	mg/kg		11/10/99	GC
		Mercury (Hg)	<0.01	0.01	mg/kg		11/10/99	GC
		Barium (Ba)	390	0.5	mg/kg		11/10/99	GC
		Beryllium (Be)	<1	1	mg/kg		11/10/99	GC
		Cadmium (Cd)	0.9	0.5	mg/kg		11/10/99	GC
		Cobalt (Co)	11	1	mg/kg		11/10/99	GC
		Chromium (Cr)	42.0	0.5	mg/kg		11/10/99	GC
		Copper (Cu)	23	1	mg/kg		11/10/99	GC
		Manganese (Mn)	552	0.1	mg/kg		11/10/99	GC
		Molybdenum (Mo)	<1	1	mg/kg		11/10/99	GC
		Nickel (Ni)	35	2	mg/kg		11/10/99	GC
		Lead (Pb)	13	5	mg/kg		11/10/99	GC
		Strontium (Sr)	80	1	mg/kg		11/10/99	GC
		Thallium (Tl)	<1	1	mg/kg		11/10/99	GC
		Vanadium (V)	45	1	mg/kg		11/10/99	GC
		Zinc (Zn)	141	0.5	mg/kg		11/10/99	GC
		Selenium (Se)	1.4	0.1	mg/kg		11/10/99	GC
E911396-04	MW99-3(10-12.5)							
Sample Type:SOIL								
Collected:11/04/99								
		Hydrocarbons, Recoverable	700	100	mg/kg	11/11/99	11/11/99	UK
		AB Tier1-PAHs in Soil						
		Naphthalene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Acenaphthylene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Acenaphthene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Fluorene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Phenanthrene/Anthracene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Fluoranthene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		B(a)A/Chrysene/B(c)P	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		7,12-Dimethylbenz(a)anthracene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Benzo(b/j/k)fluoranthene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Benzo(a)pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		3-Methylcholanthrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Indeno(1,2,3-cd)pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Dibenzo(ah)anthracene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Benzo(ghi)perylene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Dibenz(ah,ai,aj)pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		BTEX, TVH and TEH in Soil						
		BTEX and TVH in Soil						
		Benzene	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Toluene	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Ethylbenzene	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Xylenes	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Total Volatiles	<0.5	0.5	ug/g (ppm)	11/08/99	11/08/99	TDV
		% Moisture	19.4	0	%		11/09/99	md
		Total Extractables (Soil)	<5	5	ug/g (ppm)	11/08/99	11/09/99	TDV
		Detailed Salinity						
		Chloride (Cl)	19	1	mg/L		11/08/99	MOR
		Electrical Conductivity	3.16	0.01	dS m-1		11/08/99	ARA
		Calcium (Ca)	398	0.5	mg/L		11/10/99	AZ
		Potassium (K)	15.2	0.1	mg/L		11/10/99	AZ
		Magnesium (Mg)	181	0.1	mg/L		11/10/99	AZ

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E911396-04	MW99-3(10-12.5)							
Sample Type:SOIL								
Collected:11/04/99								
		Detailed Salinity						
		Sodium (Na)	318	1	mg/L		11/10/99	AZ
		Sulfate (SO4)	2250	0.5	mg/L		11/10/99	AZ
		pH	7.9		pH		11/08/99	ARA
		SAR	3.3		SAR		11/11/99	AZ
		% Saturation	86	1	%		11/08/99	ARA
		PITS Metals (ICP)						
		Arsenic (As)	6.6	0.1	mg/kg		11/10/99	GC
		Mercury (Hg)	0.03	0.01	mg/kg		11/10/99	GC
		Barium (Ba)	328	0.5	mg/kg		11/10/99	GC
		Beryllium (Be)	<1	1	mg/kg		11/10/99	GC
		Cadmium (Cd)	<0.5	0.5	mg/kg		11/10/99	GC
		Cobalt (Co)	12	1	mg/kg		11/10/99	GC
		Chromium (Cr)	47.3	0.5	mg/kg		11/10/99	GC
		Copper (Cu)	28	1	mg/kg		11/10/99	GC
		Manganese (Mn)	448	0.1	mg/kg		11/10/99	GC
		Molybdenum (Mo)	<1	1	mg/kg		11/10/99	GC
		Nickel (Ni)	42	2	mg/kg		11/10/99	GC
		Lead (Pb)	12	5	mg/kg		11/10/99	GC
		Strontium (Sr)	84	1	mg/kg		11/10/99	GC
		Thallium (Tl)	<1	1	mg/kg		11/10/99	GC
		Vanadium (V)	45	1	mg/kg		11/10/99	GC
		Zinc (Zn)	76.4	0.5	mg/kg		11/10/99	GC
		Selenium (Se)	0.9	0.1	mg/kg		11/10/99	GC
E911396-05	MW99-4(5-7.5)							
Sample Type:SOIL								
Collected:11/04/99								
		Hydrocarbons, Recoverable	1700	100	mg/kg	11/11/99	11/11/99	UK
		AB Tier1-PAHs in Soil						
		Naphthalene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Acenaphthylene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Acenaphthene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Fluorene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Phenanthrene/Anthracene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Fluoranthene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		B(a)A/Chrysene/B(c)P	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		7,12-Dimethylbenz(a)anthracene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Benzo(b/j/k)fluoranthene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Benzo(a)pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		3-Methylcholanthrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Indeno(1,2,3-cd)pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Dibenzo(ah)anthracene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Benzo(ghi)perylene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Dibenz(ah,ai,aj)pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		BTEX, TVH and TEH in Soil						
		BTEX and TVH in Soil						
		Benzene	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Toluene	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Ethylbenzene	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Xylenes	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Total Volatiles	<0.5	0.5	ug/g (ppm)	11/08/99	11/08/99	TDV
		% Moisture	22.7	0	%		11/09/99	md
		Total Extractables (Soil)	42	5	ug/g (ppm)	11/08/99	11/09/99	TDV
		Detailed Salinity						
		Chloride (Cl)	40	1	mg/L		11/08/99	MOR
		Electrical Conductivity	2.64	0.01	dS m-1		11/08/99	ARA
		Calcium (Ca)	275	0.5	mg/L		11/10/99	AZ
		Potassium (K)	21.0	0.1	mg/L		11/10/99	AZ
		Magnesium (Mg)	122	0.1	mg/L		11/10/99	AZ
		Sodium (Na)	281	1	mg/L		11/10/99	AZ
		Sulfate (SO4)	1600	0.5	mg/L		11/10/99	AZ
		pH	7.8		pH		11/08/99	ARA
		SAR	3.5		SAR		11/11/99	AZ
		% Saturation	69	1	%		11/08/99	ARA
		PITS Metals (ICP)						
		Arsenic (As)	5.7	0.1	mg/kg		11/12/99	GC
		Mercury (Hg)	0.05	0.01	mg/kg		11/12/99	GC
		Barium (Ba)	310	0.5	mg/kg		11/12/99	GC
		Beryllium (Be)	<1	1	mg/kg		11/12/99	GC

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E911396-05	MW99-4(5-7.5)							
Sample Type:SOIL								
Collected:11/04/99								
		PITS Metals (ICP)						
		Cadmium (Cd)	0.7	0.5	mg/kg		11/12/99	GC
		Cobalt (Co)	10	1	mg/kg		11/12/99	GC
		Chromium (Cr)	54.7	0.5	mg/kg		11/12/99	GC
		Copper (Cu)	28	1	mg/kg		11/12/99	GC
		Manganese (Mn)	378	0.1	mg/kg		11/12/99	GC
		Molybdenum (Mo)	<1	1	mg/kg		11/12/99	GC
		Nickel (Ni)	33	2	mg/kg		11/12/99	GC
		Lead (Pb)	35	5	mg/kg		11/12/99	GC
		Strontium (Sr)	58	1	mg/kg		11/12/99	GC
		Thallium (Tl)	<1	1	mg/kg		11/12/99	GC
		Vanadium (V)	47	1	mg/kg		11/12/99	GC
		Zinc (Zn)	88.6	0.5	mg/kg		11/12/99	GC
		Selenium (Se)	0.8	0.1	mg/kg		11/12/99	GC
E911396-06	MW99-4(7.5-10)							
Sample Type:SOIL								
Collected:11/04/99								
		Hydrocarbons, Recoverable	6600	100	mg/kg	11/11/99	11/11/99	UK
		AB Tier1-PAHs in Soil						
		Naphthalene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Acenaphthylene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Acenaphthene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Fluorene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Phenanthrene/Anthracene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Fluoranthene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		B(a)A/Chrysene/B(c)P	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		7,12-Dimethylbenz(a)anthracene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Benzo(b/j/k)fluoranthene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Benzo(a)pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		3-Methylcholanthrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Indeno(1,2,3-cd)pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Dibenzo(ah)anthracene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Benzo(ghi)perylene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Dibenz(ah,ai,aj)pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		BTEX, TVH and TEH in Soil						
		BTEX and TVH in Soil						
		Benzene	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Toluene	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Ethylbenzene	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Xylenes	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Total Volatiles	<0.5	0.5	ug/g (ppm)	11/08/99	11/08/99	TDV
		% Moisture	22.0	0	%		11/09/99	md
		Total Extractables (Soil)	6	5	ug/g (ppm)	11/08/99	11/09/99	TDV
		Detailed Salinity						
		Chloride (Cl)	77	1	mg/L		11/08/99	MOR
		Electrical Conductivity	1.55	0.01	dS m-1		11/08/99	ARA
		Calcium (Ca)	120	0.5	mg/L		11/10/99	AZ
		Potassium (K)	7.2	0.1	mg/L		11/10/99	AZ
		Magnesium (Mg)	54.2	0.1	mg/L		11/10/99	AZ
		Sodium (Na)	195	1	mg/L		11/10/99	AZ
		Sulfate (SO4)	629	0.5	mg/L		11/10/99	AZ
		pH	7.7		pH		11/08/99	ARA
		SAR	3.7		SAR		11/11/99	AZ
		% Saturation	76	1	%		11/08/99	ARA
		PITS Metals (ICP)						
		Arsenic (As)	7.2	0.1	mg/kg		11/12/99	GC
		Mercury (Hg)	0.01	0.01	mg/kg		11/12/99	GC
		Barium (Ba)	332	0.5	mg/kg		11/12/99	GC
		Beryllium (Be)	<1	1	mg/kg		11/12/99	GC
		Cadmium (Cd)	<0.5	0.5	mg/kg		11/12/99	GC
		Cobalt (Co)	11	1	mg/kg		11/12/99	GC
		Chromium (Cr)	69.2	0.5	mg/kg		11/12/99	GC
		Copper (Cu)	29	1	mg/kg		11/12/99	GC
		Manganese (Mn)	502	0.1	mg/kg		11/12/99	GC
		Molybdenum (Mo)	<1	1	mg/kg		11/12/99	GC
		Nickel (Ni)	46	2	mg/kg		11/12/99	GC
		Lead (Pb)	15	5	mg/kg		11/12/99	GC
		Strontium (Sr)	50	1	mg/kg		11/12/99	GC
		Thallium (Tl)	<1	1	mg/kg		11/12/99	GC
		Vanadium (V)	75	1	mg/kg		11/12/99	GC

ENVIRO-TEST CHEMICAL ANALYSIS REPORT

LAB ID	SAMPLE ID	TEST DESCRIPTION	RESULT	D.L.	UNITS	EXTRACTED	ANALYZED	BY
E911396-06	MW99-4(7.5-10)							
Sample Type:SOIL								
Collected:11/04/99								
		PITS Metals (ICP)						
		Zinc (Zn)	86.6	0.5	mg/kg		11/12/99	GC
		Selenium (Se)	1.0	0.1	mg/kg		11/12/99	GC
E911396-07	MW99-6(10-12.5)							
Sample Type:SOIL								
Collected:11/04/99	(MW99-3 DUPLICATE)							
		Hydrocarbons, Recoverable	600	100	mg/kg	11/11/99	11/11/99	UK
		AB Tier1-PAHs in Soil						
		Naphthalene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Acenaphthylene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Acenaphthene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Fluorene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Phenanthrene/Anthracene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Fluoranthene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		B(a)A/Chrysene/B(c)P	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		7,12-Dimethylbenz(a)anthracene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Benzo(b/j/k)fluoranthene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Benzo(a)pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		3-Methylcholanthrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Indeno(1,2,3-cd)pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Dibenzo(ah)anthracene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Benzo(ghi)perylene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		Dibenz(ah,ai,aj)pyrene	< 0.01	0.01	ug/g	11/08/99	11/10/99	SRJ
		BTEX, TVH and TEH in Soil						
		BTEX and TVH in Soil						
		Benzene	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Toluene	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Ethylbenzene	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Xylenes	<0.01	0.01	ug/g (ppm)	11/08/99	11/08/99	TDV
		Total Volatiles	<0.5	0.5	ug/g (ppm)	11/08/99	11/08/99	TDV
		% Moisture	19.8	0	%		11/09/99	md
		Total Extractables (Soil)	8	5	ug/g (ppm)	11/08/99	11/09/99	TDV
		Detailed Salinity						
		Chloride (Cl)	14	1	mg/L		11/08/99	MOR
		Electrical Conductivity	2.26	0.01	dS m-1		11/08/99	ARA
		Calcium (Ca)	191	0.5	mg/L		11/10/99	AZ
		Potassium (K)	11.6	0.1	mg/L		11/10/99	AZ
		Magnesium (Mg)	106	0.1	mg/L		11/10/99	AZ
		Sodium (Na)	272	1	mg/L		11/10/99	AZ
		Sulfate (SO4)	1360	0.5	mg/L		11/10/99	AZ
		pH	7.9		pH		11/08/99	ARA
		SAR	3.9		SAR		11/11/99	AZ
		% Saturation	88	1	%		11/08/99	ARA
		PITS Metals (ICP)						
		Arsenic (As)	7.0	0.1	mg/kg		11/12/99	GC
		Mercury (Hg)	0.01	0.01	mg/kg		11/12/99	GC
		Barium (Ba)	476	0.5	mg/kg		11/12/99	GC
		Beryllium (Be)	<1	1	mg/kg		11/12/99	GC
		Cadmium (Cd)	<0.5	0.5	mg/kg		11/12/99	GC
		Cobalt (Co)	12	1	mg/kg		11/12/99	GC
		Chromium (Cr)	60.0	0.5	mg/kg		11/12/99	GC
		Copper (Cu)	29	1	mg/kg		11/12/99	GC
		Manganese (Mn)	454	0.1	mg/kg		11/12/99	GC
		Molybdenum (Mo)	<1	1	mg/kg		11/12/99	GC
		Nickel (Ni)	43	2	mg/kg		11/12/99	GC
		Lead (Pb)	13	5	mg/kg		11/12/99	GC
		Strontium (Sr)	85	1	mg/kg		11/12/99	GC
		Thallium (Tl)	<1	1	mg/kg		11/12/99	GC
		Vanadium (V)	70	1	mg/kg		11/12/99	GC
		Zinc (Zn)	84.9	0.5	mg/kg		11/12/99	GC
		Selenium (Se)	0.8	0.1	mg/kg		11/12/99	GC

N.D. - NOT DETECTED, LESS THAN THE DETECTION LIMIT

THIS IS THE FINAL PAGE OF THE REPORT

Appendix A Test Methodologies

Acid Digestion — Laboratory Code: ADS1S1

Preparation: Microwave digestion of sample in a closed vessel with concentrated nitric acid on a wet or dry soil/solids
Reference: E.P.A. SW 846 Method 3051

Arsenic (As) — Laboratory Code: AST2S1

Instrumentation: Continuous hydride by Flameless Atomic Absorption Spectrometry
Reference: US EPA SW 846 ; APHA 3114C

BTEX and TVH in Soil — Laboratory Code: BTX2S1

PREPARATION METHOD: Methanol extraction with headspace analysis.

INSTRUMENTAL METHOD: GC/PID for BTEX.
GC/FID for TVH - summation of hydrocarbons from C5 to C10 carbon range and is calculated against a BTEX standard.
NOTE: Results based upon dry weight.

METHOD REFERENCE: Modified SW-846 USEPA Method 5021 and 8015/8020.

BTEX QC SUMMARY:

Accuracy	Precision
93%	+/- 23%

NOTE: Accuracy is expressed as the average % recovery and Precision as the relative standard deviation (RSD) of fortifications made using certified standards (BTEX).

TVH QC SUMMARY:

Accuracy	Precision
96%	+/- 24%

NOTE: Accuracy is expressed as the average % recovery and Precision as the relative standard deviation (RSD) of fortifications made using certified standards (BTEX).

Chloride (Cl) — Laboratory Code: CHL4S1

Preparation: Filter salinity extract through 0.45u filter
Instrumental: Sample analyzed colorimetrically @ 480 nm using ferricyanide method on a Cobas Fara discrete analyzer
Reference: APHA 4500-Cl, E

or

Preparation Method: 0.45μ filtration if turbid
Instrumental Method: Ion Chromatography
Method Reference: APHA 4110 B

Electrical Conductivity — Laboratory Code: ECS2S1

Preparation Method: Saturated Paste extracts
Instrumental Method: Conductivity meter
Method Reference: Carter CSSS 18.3.1

Mercury (Hg) — Laboratory Code: HGT2S1

Instrumentation: Continuous cold vapour atomic absorption spectrometry
Reference: US EPA SW 846; APHA 3112B

Hydrocarbons, Recoverable — Laboratory Code: HOG1S1

Preparation Method: Samples are air dried and ground.
Preparation Method: Soxhlet extraction of sample with dichloromethane; Addition of silica gel to remove polar extractables.
Instrumental Method: Measurement of oil content in the extract gravimetrically.
Method Reference: Preparation - US EPA SW846 No. 9071

Appendix A Test Methodologies

Analysis - APHA 5520E \ 5520F

Routine Metals **Laboratory Code: ICPRDS**
PREPARATION METHOD: Filter through 0.45u and preserve with nitric acid
INSTRUMENTAL METHOD: ICP Spectrophotometry
METHOD REFERENCE: APHA 3120B/3030F, Standard Methods; 18th ed.

Sulfur reported as sulfate. ICP result multiplied by 3 to convert.

ICP Method Descriptions **Laboratory Code: ICPS__**
Metals by Inductively Coupled Plasma in digests of soils/solids
Metals by Inductively Coupled Plasma-Mass Spec. in digests of soils/solids
METHOD REFERENCE: E.P.A. SW846 Method 6010/200.8 and 3051.
NOTE: Wavelengths selected for analysis are the determination of the laboratory
NOTE: Masses selected for analysis are the determination of the laboratory
*The actual detection limits reported will vary with the digestion extraction ratio.
NOTE: Wavelenghts/mass and detection limits may vary with matrix and sample composition.

Sulfate (SO4) **Laboratory Code: ICPSO4**
Preparation Method: 0.45 u filtraton if turbid
Instrumental Method: Ion Chromatography or ICP
Method Reference: S04 Dionex Handbook of Ion Chromatography pg 37.

% Moisture **Laboratory Code: MOI1S1**
Preparation Method: Sample is oven dried at 105 degrees C
Instrumental Method: Gravimetric analysis

AB Tier1-PAHs in Soil **Laboratory Code: PAH5S1**
Preparation Method: Soxhlet extraction with DCM or by accelerated solvent extraction with DCM/Acetone

Instrument Method: GC/MSD analysis

Method Reference: Extraction Method: EPA 3540 (modified) or EPA 3545 (modified)
Analytical Method: EPA 8270 (modified)

pH **Laboratory Code: PHS3S1**
Preparation Method: Saturated paste extraction.
Instrumental Method: Electrometric Measurement of pH.
Reference Method: Carter CSSC 16.3

SAR **Laboratory Code: SAR**
Preparation Method: Saturated Paste Extract
Calculation: SAR = Na/sq.rt.((Ca+Mg)/2) (in meq/L)
Method Reference: Carter CSSS 18.4

% Saturation **Laboratory Code: SATUR**
Preparation Method: Prepare saturated paste
Instrumental Method: SP = wt. water/dry wt soil*100
Method Reference: Carter CSSS 18.2.2

Sample Preparation **Laboratory Code: SDG1S1**
PREPARATION METHOD: Sample is air dried and ground to pass a 2 mm sieve

Selenium (Se) **Laboratory Code: SET2S1**
Instrumentation: Continuous hydride by Flameless Atomic Absorption Spectrometry

Appendix A Test Methodologies

Reference: US EPA SW 846 ; APHA 3114C

Saturated Paste Extract — Laboratory Code: SPEX

Preparation Method: Saturated paste extracts
Method Reference: Carter CSSS 18.2.2

Total Extractables (Soil) — Laboratory Code: TEH1S1

PREPARATION METHOD: Shake and sonication extraction with organic solvent

INSTRUMENTAL METHOD: GC/FID - summation of hydrocarbons from C11 to C30 carbon range (excluding benzene, toluene, ethylbenzene, and xylenes) and calculated against diesel standard.
NOTE: Results based upon dry weight.

METHOD REFERENCE: Modified SW-846 USEPA Method 3550/3580 and 8000

QC SUMMARY:

Accuracy	Precision
111%	+/- 24%

NOTE: Accuracy is expressed as the average % recovery and Precision as the relative standard deviation (RSD) of fortifications made using in-house standards (TEH).

Hydride Metals Preparation — Laboratory Code: VAP2S1

Preparation: Digestion with permanganate/persulphate, nitric, and sulphuric acid
Addition of hydrochloric acid and cysteine prior to analysis.
Reference: US EPA SW 846, APHA 3114

Mercury Cold Vapor Prep. — Laboratory Code: VHG2S1

Preparation: Digestion with permanganate, nitric, and sulphuric acids.
Reference: US EPA SW 846 / APHA 3112B

Key To Sub-Contracted Laboratory Identification:

Laboratory	Test Code # *	Laboratory	Test Code# *
ETL - Edmonton	1,S	Core Laboratories	C
ETL - Calgary	2	HydroQual	H
ETL -Saskatoon	3	SRC	R
ETL - Thunder Bay	7	Biochem	B
ETL - Winnipeg	8	Bioquest	Q
ETL - Grande Prairie	9	WSH Laboratories	W
ETL - Mobile Services	L	Maxxam	M
Bodycote	E	Alpha Laboratories	A
Norwest Laboratories	N		

* The Test code #/Letter is the last character on the test code.
For Example: NMA1W3 designates that the test was performed in the ETL Saskatoon laboratory.
THIS IS THE LAST PAGE OF THE METHODOLOGY APPENDIX.

ETL EnviroTest — CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM

9936 - 67th Avenue, Edmonton, Alberta T6E 0P5 — Telephone: (780) 413-5220 — Fax: (780) 437-2311
Edmonton Toll Free Line — Telephone: 1-800-668-9878 — Fax: 1-800-286-7319
1313 - 44th Avenue N.E., Calgary, Alberta T2E 6L5 — Telephone: (403) 291-9897 — Fax: (403) 291-0298
9505 - 111th Street, Grande Prairie, Alberta T8V 5W1 — Telephone: (780) 539-5196 — Fax: (780) 513-2191
General Purpose Bldg., 124 Veterinary Road, Saskatoon, Saskatchewan S7N 5E3 — Telephone: (306) 668-8370 — Fax: (306) 668-8383
745 Logan Avenue, Winnipeg, Manitoba R3E 3L5 — Telephone: (204) 945-3705 — Fax: (204) 945-0763
1081 Barton Street, Thunder Bay, Ontario P7B 5N3 — Telephone: (807) 623-6463 — Fax: (807) 623-7598

DATE: Nov 4, 1999 DATE REQUIRED:

SERVICE REQUESTED:

☑ REGULAR ☐ PRIORITY (50% SURCHARGE) ☐ EMERGENCY (100% SURCHARGE)

PRICING: *(Check one)* AS PER QUOTE #: ☐ AS PER LIST PRICE: ☐

ANALYSIS REQUESTED:

SAMPLE ID	SAMPLED BY	DATE / TIME SAMPLED	SAMPLE TYPE	DETAILED SALINITY (SAL45)(J)	TRACE METALS (ICP55)(J)	PAH55 1+dibenzo (a,h) anthracene	BTEX	TVH (BTL731)(J)	TEH	MINERAL OIL & GREASE HOC151	N: 11/12/99, EV: 11/15/99	SAMPLE RECEIVED (Y OR N)	SAMPLE BROKEN (Y OR N)	LAB SAMPLE NO.
MW99-1 (7.5-10)	MES	Nov 4/99	SOIL	X	X	X	X	X	X	X				E911396-01
MW99-2B (12.5-15)	"	"	"	X	X	X	X	X	X	X				-02
MW99-3 (7.5-10)	"	"	"	X	X	X	✓	✓	✓	✓				-03
MW99-3 (10-12.5)	"	"	"	✓	✓	✓	✓	✓	✓	✓				-04
MW99-4 (5-7.5)	"	"	"	✓	✓	✓	✓	✓	✓	✓				-05
MW99-4 (7.5-10)	"	"	"	✓	✓	✓	✓	✓	✓	✓				-06
MW99-6 (10-12.5)	"	"	"	✓	✓	✓	✓	✓	✓	✓				-07
			PRESERVED / FILTERED											

NOTES & CONDITIONS

1. Quote number must be provided to ensure proper pricing.
2. Turnaround times will vary dependant on complexity of analysis & lab workload at time of submission. Please contact the lab to confirm turnaround times.
3. All hazardous samples submitted must be labeled to comply with WHMIS regulations. This must include the nature of the hazard, as well as a contact name & phone number that the lab can contact for further information.

NOTE: Failure to properly complete portions of this form may del analysis.

NOTE: **Shaded areas MUST be completed in full by client for sample processing to occur.**

RELINQUISHED BY: [signature]	DATE: Nov 4/99 TIME: 1500	RECEIVED BY: [signature] ETL LAB:	DATE: 11/05/99 TIME: 13:30
RELINQUISHED BY:	DATE: TIME:	RECEIVED BY: ETL LAB:	DATE: TIME:

CLIENT: MELANIE SIEWERT

CONTACT: UMA ENGINEERING

REPORT ADDRESS: 17007-107 AVE EDMONTON, AB

BILLING ADDRESS: (SAME)

NO. SAMPLES SUBMITTED: 7

NO. BOTTLES / SAMPLES: 28

PHONE: 486-7028

FAX: 486-7070

P. O. NO.: DRUMHELLER

JOB NO.: 2977-213-00-02

SAMPLE CONDITION UPON RECEIPT:

FROZEN: COLD: AMBIENT:

OTHER: *(BREAKAGE, LEAKAGE, ETC.)*

WHITE – Report C
PINK – File Copy
YELLOW – Custome

APPENDIX E

UMA GROUP DISCLAIMER
AND
UMA ENGINEERING LTD. SUPPLEMENTAL TERMS AND CONDITIONS

SERVICES INVOLVING POLLUTANTS AND HAZARDOUS WASTES

DISCLAIMER

This report has been prepared by UMA Engineering Ltd. ("UMA") for the benefit of the Client . The information and data contained herein, including without limitation the results of any sampling and analyses conducted by UMA pursuant to its Agreement with the Client, represent UMA's best professional judgement in light of the knowledge and information available to UMA at the time of preparation. Although every effort has been made to confirm that all such information and data is factual, complete and accurate, UMA makes no guarantees or warranties whatsoever, whether express or implied, with respect to such information or data and UMA accepts no responsibility for any injury, loss or damage arising therefrom or related thereto.

UMA shall not by the act of issuing this report be deemed to have represented thereby that any sampling and analyses conducted by it have been exhaustive or will identify all contamination at the site, and persons relying on the results thereof do so at their own risk.

Except as required by law, this report and the information and data contained herein are to be treated as confidential and, unless otherwise agreed to by UMA and the Client, may be used and relied upon only by the Client, its officers and employees, subject to the limitations set forth in the preceding paragraphs. UMA denies any liability whatsoever to other parties who may obtain access to this report for any injury, loss or damage suffered by such parties arising from their use of, or reliance upon, this report or any of its contents without the express written consent of UMA and the Client.

SERVICES INVOLVING POLLUTANTS AND HAZARDOUS WASTES

UMA ENGINEERING LTD.
SUPPLEMENTAL TERMS AND CONDITIONS

These Supplemental Terms and Conditions govern all environmental services (the "Services") offered by UMA Engineering Ltd. ("Engineer") in Canada which may involve pollutants and/or hazardous wastes. By accepting a proposal from Engineer offering any of the Services (the "Proposal") or authorizing or accepting all or any portion of the Services with respect to a particular project (the "Project"), the client or prospective client ("Client") shall be deemed to have accepted these Supplemental Terms and Conditions in full and to have agreed with Engineer that they shall form part of the resulting agreement between Client and Engineer in respect of the Services (the "Agreement").

1. Project Information

1.1 Client shall provide Engineer with all information in its possession or control relating to the Project and the site at which the Services are to be performed (the "Site") and the property adjacent thereto, including without limitation all information pertaining to hazardous materials which may exist at the Site and details of any underground utilities, services or other hidden obstructions. Engineer shall review such information for accuracy and applicability to the extent reasonably practicable. Client acknowledges that Engineer shall be entitled to rely upon full disclosure by Client of the foregoing information to enable Engineer to properly perform the Services.

1.2 Engineer shall not be responsible for any incorrect advice, judgement, recommendation, finding, decision or conduct based upon any inaccurate or incomplete information supplied by Client and Client shall defend, indemnify and hold Engineer harmless from and against any claim, loss or damage resulting therefrom.

2. Site Access

2.1 Client shall grant or arrange timely and unobstructed access to the Site for all equipment and personnel of Engineer required to perform the Services.

2.2 Engineer will take reasonable precautions to minimize damage to the Site but it is understood by Client that, in the normal course of events, damage to or at the Site, including without limitation damage to underground utilities or services, may occur. The correction of such damage is not part of the Services unless agreed to in writing by Engineer and any such restoration of the Site will only be undertaken by Engineer at additional cost. Client shall defend, indemnify and hold Engineer harmless from and against any loss or liability resulting from damage to or at the Site.

3. Other Consulting Services

3.1 Client shall retain directly, or authorize Engineer as Client's agent to retain, all other consultants required by Engineer to enable it to perform the Services. If requested by Client, Engineer will review accounts submitted by such consultants to Client.

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SERVICES INVOLVING POLLUTANTS AND HAZARDOUS WASTES

4. Investigations and Reports

4.1 Client agrees to disclose to Engineer the reason for the investigation and all potential uses for both the information which will be generated by the investigation and all associated reports prepared by Engineer in respect thereof. The findings of any such investigation will be based solely upon information generated as a result of the specific scope of the investigation authorized by Client. Visual inspections do not constitute a thorough audit of environmental conditions at the Site. Only those items which are capable of being observed and are reasonably obvious to Engineer during such a visit can be reported. Detailed investigation, sampling and analyses would be required to more accurately determine the environmental condition of the Site.

4.2 Engineer agrees to provide a final report upon completion of the Services. The information contained in any report, including without limitation the results of any sampling and analyses conducted by Engineer, will be developed or obtained through the exercise of Engineer's best professional judgment in light of the knowledge and information available to Engineer at the time of preparation. Although every effort will be made to confirm that all such information is factual, complete and accurate, Engineer shall make no guarantees or warranties whatsoever, whether express or implied, with respect to such information and shall accept no responsibility for any loss or damage arising therefrom or related thereto. Engineer shall not by the act of issuing any report be deemed to have represented thereby that any sampling and analysis conducted by it have been exhaustive or will identify all contamination at the Site, and persons relying on the results thereof do so at their own risk.

4.3 Except as required by law, any report and the information contained therein shall be treated as confidential and, unless otherwise agreed to by Engineer and Client, may be used and relied upon only by Client, its officers and employees. Any such use and reliance shall be subject to the limitations and exclusions set forth in 4.1 and 4.2 above.

5. Samples

5.1 Engineer shall be responsible for appropriate disposal of non-hazardous sample material and sample residuals after 30 days following submission of engineering reports unless Client specifically requests otherwise.

5.2 All sample material and sample residuals considered hazardous shall be returned to Client for disposal, at Client's cost. Client may request Engineer to arrange for the appropriate disposal of hazardous sample material and sample residuals, the cost of which will be borne by Client.

6. Fees And Invoicing

Engineer shall invoice Client, and Client shall pay Engineer, for the Services as follows:

6.1 Fees and all other charges and disbursements will be billed to Client as provided in the Proposal or as otherwise mutually agreed to in writing.

6.2 Fees shall be paid within 30 days of being invoiced by Engineer to Client. If any invoice is not paid within such period, Client shall be liable to Engineer for a late charge accruing from the date of such invoice to the date of payment at the lower of 15 percent per annum or the maximum rate allowed by law and Client shall reimburse Engineer for all costs and expenses incurred by Engineer in the collection of such invoice, including reasonable legal expenses.

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SERVICES INVOLVING POLLUTANTS AND HAZARDOUS WASTES

6.3 If Client fails to pay any invoice in full within 30 days after invoice date, Engineer may, at any time, and without waiving any of its other rights or claims against Client, elect to terminate performance of the Services upon 10 days prior written notice to Client. Notwithstanding any such termination of Services, Client shall pay Engineer in full for all Services rendered by Engineer to the date of such termination plus all interest, costs and expenses incurred by Engineer and related thereto.

6.4 In the event that Client requests termination of the Services prior to their completion, it is understood that Engineer shall be allowed a reasonable period of time to complete such analyses and records as are considered necessary by Engineer to place its files in order and/or protect its professional reputation and legal liability.

7. Professional Responsibility And Legal Liability

7.1 Engineer shall render its Services to Client under the Agreement with that degree of care, skill and diligence normally provided in the performance of services in respect of projects of a similar nature to that contemplated hereunder at the time and place that such Services are rendered.

7.2 Client agrees that any claim which it has or hereafter may have against Engineer and its directors, officers, employees, agents or subconsultants in respect of the Services howsoever arising, whether in contract, tort or otherwise, shall be absolutely limited to:

7.2.1 Direct damages arising out of such Services, and Engineer and its directors, officers, employees, agents and subconsultants shall bear no liability whatsoever for any consequential loss, injury or damage incurred by Client, including but not limited to, claims for loss of use, loss of profits, loss of markets or any loss arising from delay;

7.2.2 Claims brought within a period of 2 years from the date of the termination of the Services; and

7.2.3 The amount of Engineer's or the Project professional liability insurance, as the case may be, available to Engineer in respect of any such claim, including the deductible portion thereof. If for any reason such insurance shall not be available or shall not apply to any claim made by Client against Engineer in respect of the Services, then the liability of Engineer and its directors, officers, employees, agents and subconsultants to Client under the Agreement shall be absolutely limited to the lesser of $100,000 or Engineer's fee hereunder.

7.3 Notwithstanding 7.2.3 above, it is understood and agreed that the maximum aggregate liability of Engineer to Client and to third parties for or in respect of any and all claims, actions, proceedings, damages, penalties, fines, losses, costs and expenses whatsoever sustained by or brought or threatened against Engineer or its directors, officers, employees, agents or subconsultants which arise out of or relate to the presence, discharge, release, escape or effect of Pollutants or Hazardous Wastes (the "Pollution Claims"), whether in contract, tort or otherwise, shall be absolutely limited to the amount of Engineer's or the Project professional liability insurance, as the case may be, available to Engineer in respect of the Pollution Claims, including the deductible portion thereof. If for any reason such insurance shall not be available or shall not apply to any of the Pollution Claims, then the maximum aggregate liability of Engineer and its directors, officers, employees, agents and subconsultants to Client under this Agreement with respect to any and all such uninsured Pollution Claims shall be absolutely limited to the lesser of $100,000 or Engineer's fee hereunder. Client hereby agrees to release, defend, indemnify and hold Engineer and its directors, officers, employees, agents and subconsultants harmless, to the fullest extent permitted by law regardless of any negligence, breach of contract or other fault on the part of Engineer or such other persons, from and against any such liability which is in excess of the said limits.

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SERVICES INVOLVING POLLUTANTS AND HAZARDOUS WASTES

7.3.1 Without limiting the generality of the foregoing, such release and indemnity shall extend to claims which arise out of the actual or threatened dispersal, discharge, escape, release or saturation (whether sudden or gradual) of any Pollutants or Hazardous Wastes in or into the atmosphere, or on, onto, upon, in or into surface or subsurface soils, water or water courses, persons, objects or any other tangible matter.

7.3.2 For purposes of this clause 7.3, "Pollutants" and "Hazardous Wastes" shall mean any solid, liquid, gaseous, radiative or thermal irritant or contaminant, including without limitation, smoke, vapour, soot, fumes, acids, alkalis, chemicals, biological materials and any other substances defined as pollutants or hazardous wastes in any federal, provincial or municipal laws.

7.4 In the performance of the Services, every director, officer, employee, agent and subconsultant of Engineer shall have the benefit of all provisions herein and in the Agreement limiting the liability of Engineer as if such provisions were expressed to limit their liability mutatis mutandis; and, in entering into the Agreement, Engineer does so, to the extent of such provisions, both on its own behalf and as agent and trustee for such directors, officers, employees, agents and subconsultants. It is further acknowledged and agreed by Client that any director, officer, employee, agent or subconsultant of Engineer may ratify such agency at any time for the purpose of entitlement to the benefit of such limitations of liability.

7.5 Nothing herein shall relieve Engineer from its obligations to provide the Services, generally in accordance with the standards set forth in 7.1 above, or from any liability to Client or to third parties which is finally determined at law to result from wrongful acts or omissions intentionally committed by Engineer or others for whom it is legally responsible.

8. Force Majeure

8.1 Engineer shall not be responsible for any late provision of, or failure to perform, the Services if there is any failure to provide or delay in providing Engineer with necessary access to properties, documentation, information, materials or personnel, or if due to any act of God, labour disputes, fire, inclement weather, act of governmental authority, failure of transportation, accident or any other cause or event beyond Engineer's control, including without limitation Client's failure to approve or disapprove Engineer's work or Client's delay in doing any of the foregoing. In any of such events, Engineer's time for completion of the Services shall be extended accordingly.

9. Independent Contractor

9.1 In performing the Services, Engineer shall be deemed to be acting solely as an independent contractor, and only to the extent and for the specific purpose expressly set forth herein and in the Agreement. Nothing herein contained or implied shall at any time be construed so as to create the relationship of employer and employee, principal and agent, partners or joint venturers as between Client and Engineer.

10. Entire Agreement

10.1 These Supplemental Terms and Conditions and any other terms and conditions specifically agreed to in writing by Engineer constitute the sole and entire Agreement between Client and Engineer relating to the Services, and supersede all prior agreements between them, whether written or oral, respecting the subject matter hereof, and no other terms, conditions, warranties or guarantees, whether express, implied or statutory, shall form a part hereof. In particular, any and all implied warranties of fitness for a particular purpose, course of dealing or usage of trade are hereby expressly disclaimed and excluded.

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SERVICES INVOLVING POLLUTANTS AND HAZARDOUS WASTES

10.2 If any provisions in Client's purchase order or any other document conflict with or contradict the terms and conditions hereof or include additional terms and conditions not set forth herein, such conflicting or additional provisions shall be of no force and effect and these Supplemental Terms and Conditions shall govern.

10.3 If any provision herein is held invalid or unenforceable, such provision shall thereupon be deemed modified only to the extent necessary to render the same valid or excluded from the Agreement, as the situation may require, and the Agreement shall be enforced and construed as if such provision had been included herein as so modified or had not been included herein, as the case may be.

11. Waiver, Alteration And Modification

11.1 No waiver, alteration or modification of any term or condition contained herein or of any other term or condition of the Agreement shall be binding upon Engineer unless made in writing and signed by an authorized representative of Engineer.

12. Governing Law

12.1 The Agreement shall be deemed to have been made in the Province where the Services are to be performed, and its provisions, interpretation and performance shall be governed by the laws of such Province.

Location on property not shown on map

Wells to 15 m / dry

Two areas of waste to 5 m

Adjacent valley depth not specified

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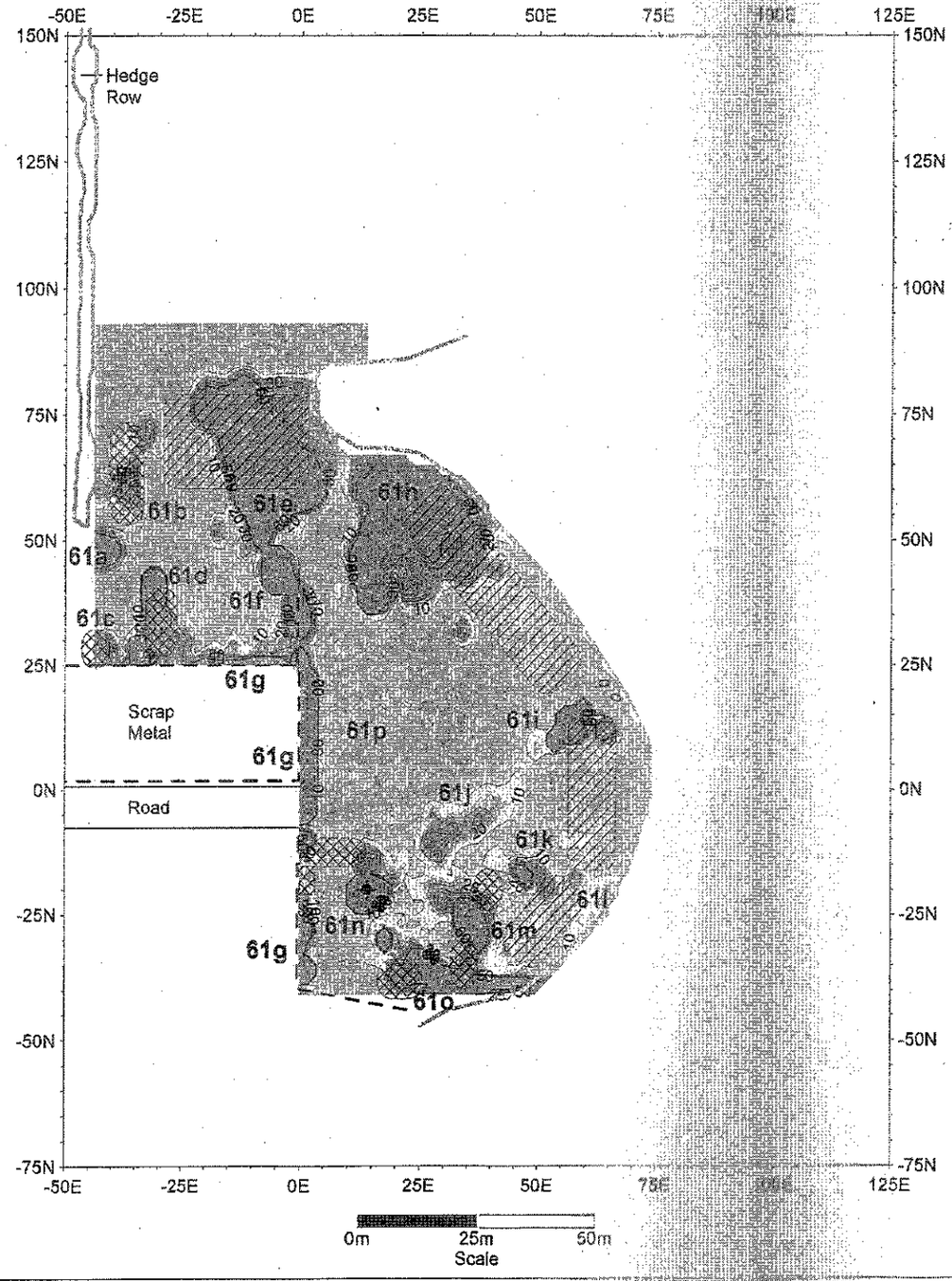
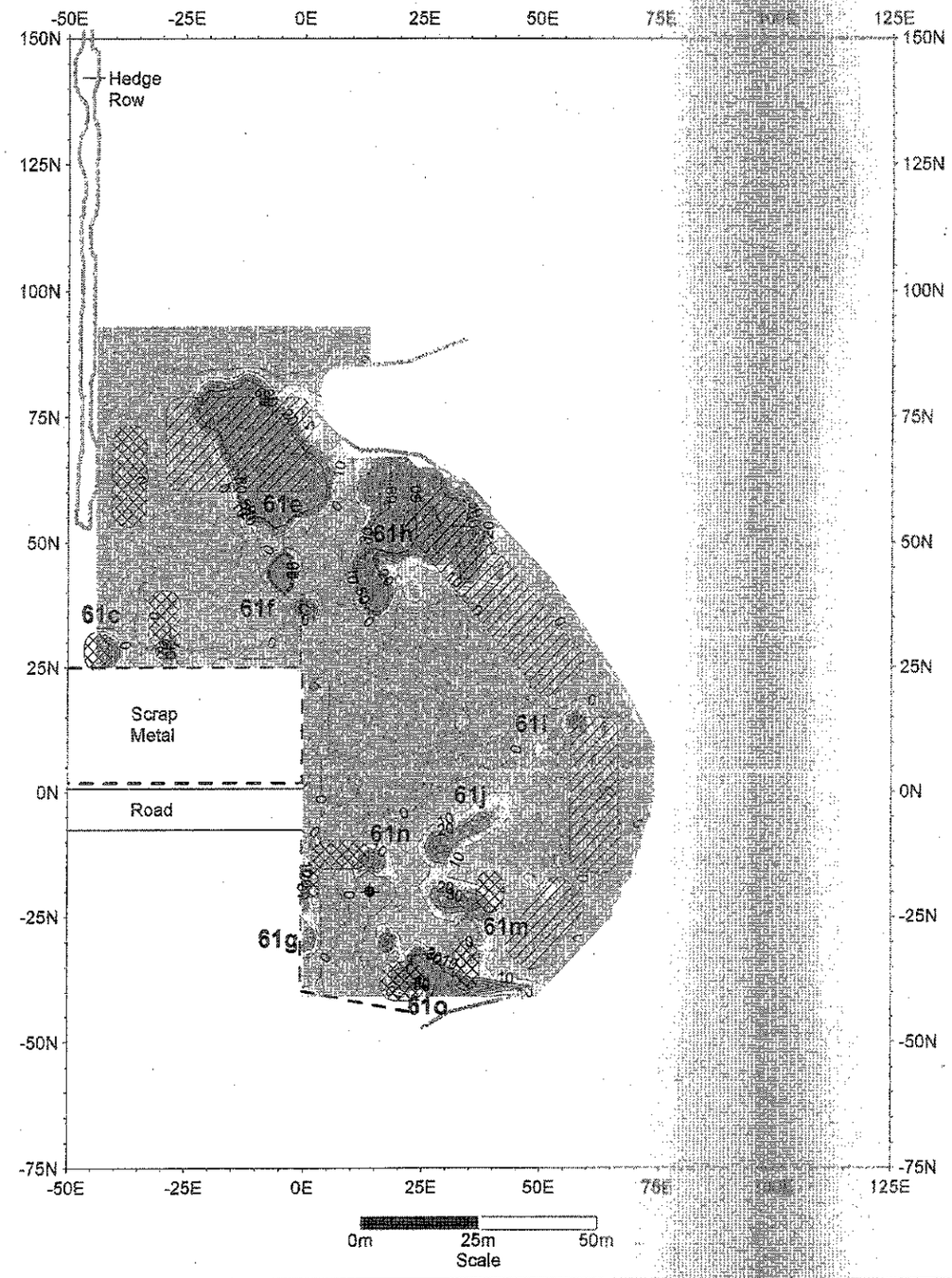


Fence
Top of Slope
Fire Hydrant
Earth Piles (Approximate)
Surface Debris (Approximate)
61a EM61 Anomaly

Drumheller Penitentiary Landfill
Drumheller, Alberta

EM61 Survey
Channel 2 Response
Figure 1a - October 1999

AMCL
Associated Mining Consultants Ltd.
PJ05



Fence
Top of Slope
Fire Hydrant
Earth Piles (Approximate)
Surface Debris (Approximate)
61a EM61 Anomaly

55
45
35
25
16
12
8
4
0
Response (mV)

Drumheller Penitentiary Landfill
Drumheller, Alberta

EM61 Survey
Differential Response
Figure 1b - October 1999

AMCL
Advanced Mining Consultants Ltd.
PJ05

Drumheller Penitentiary Landfill
Drumheller, Alberta

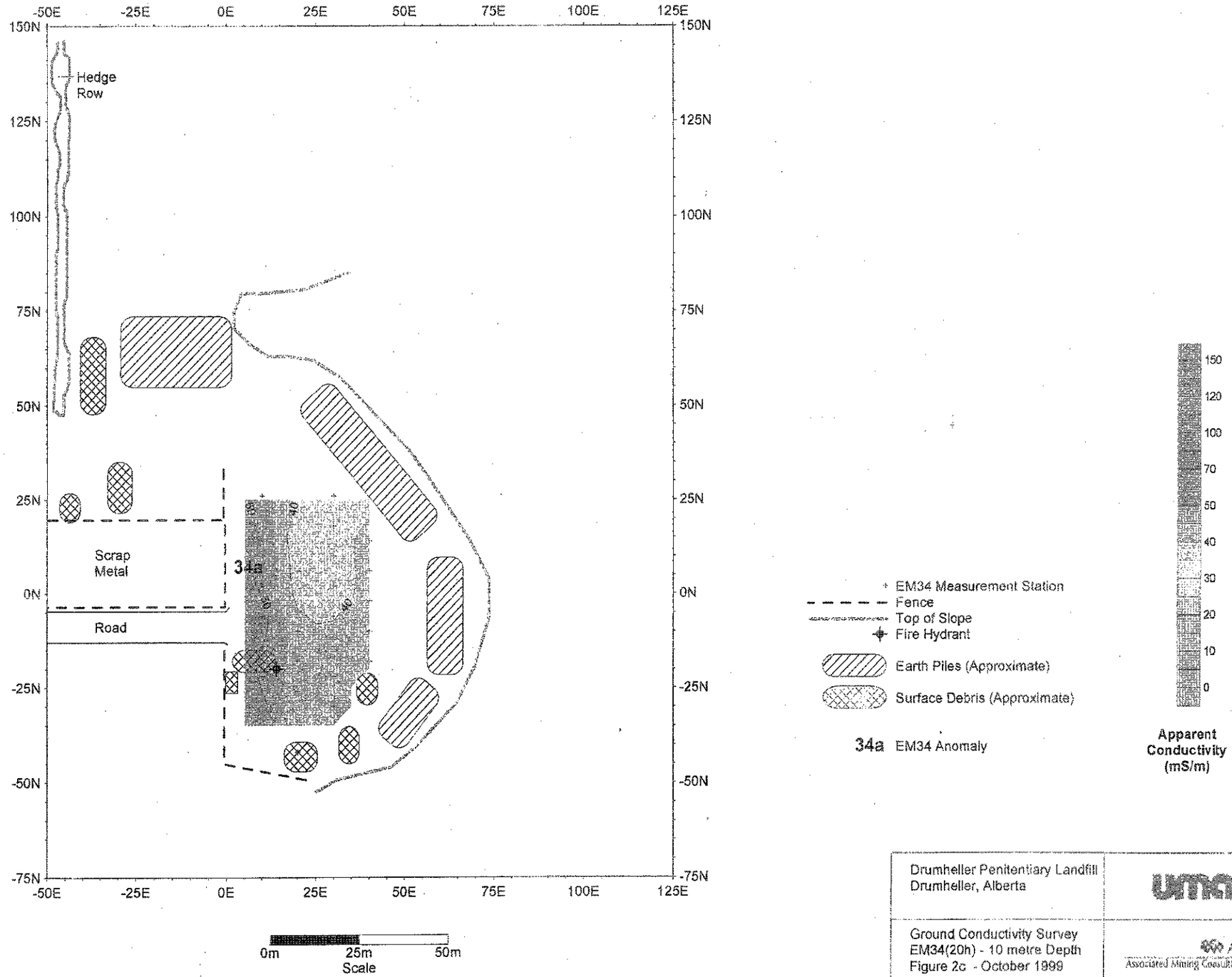
Ground Conductivity Survey
EM31(Hq) - 2 metre Depth
Figure 2a - October 1999

AMCL
Associated Mining Consultants Ltd.
PJ05

Drumheller Penitentiary Landfill
Drumheller, Alberta

Ground Conductivity Survey
EM31(Vg) - 5 metre Depth
Figure 2b - October 1999

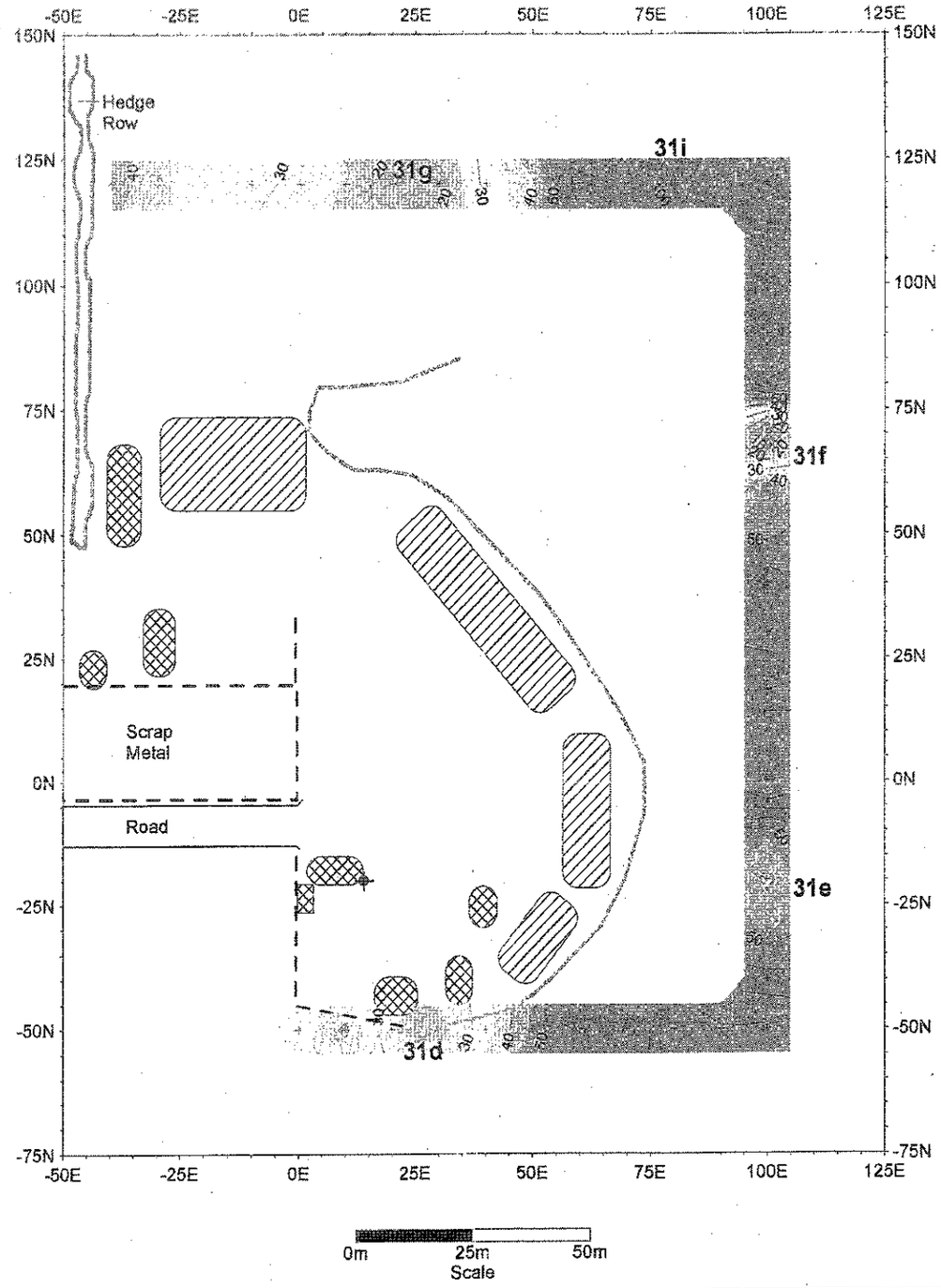
AMCL
Associated Mining Consultants Ltd.



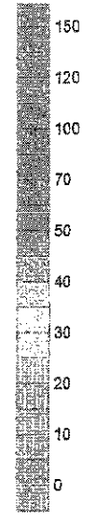
Drumheller Penitentiary Landfill
Drumheller, Alberta

Ground Conductivity Survey
EM34(20h) - 10 metre Depth
Figure 2c - October 1999

AMCL
Associated Mining Consultants Ltd.
P.05



EM31 Measurement Station
Fence
Top of Slope
Fire Hydrant
Earth Piles (Approximate)
Surface Debris (Approximate)
31a EM31 Anomaly

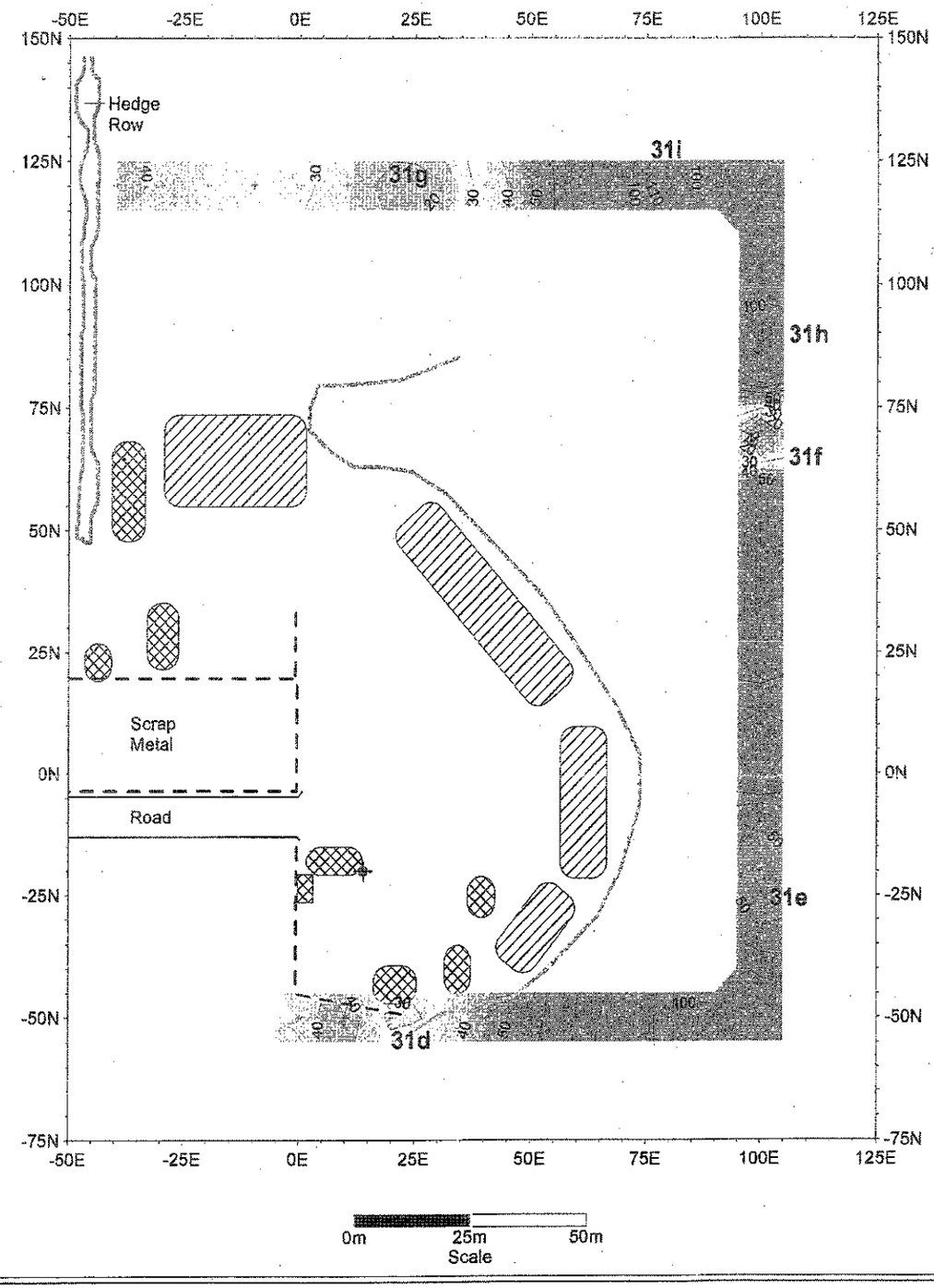


Apparent Conductivity (mS/m)

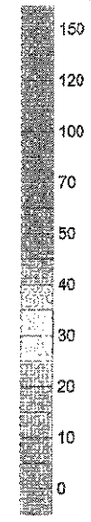
Drumheller Penitentiary Landfill Perimeter
Drumheller, Alberta

Ground Conductivity Survey
EM31(Hg) - 2 metre Depth
Figure 3a - October 1999

AMCL
Associated Mining Consultants Ltd.



EM31 Measurement Station
Fence
Top of Slope
Fire Hydrant
Earth Piles (Approximate)
Surface Debris (Approximate)
31a EM31 Anomaly

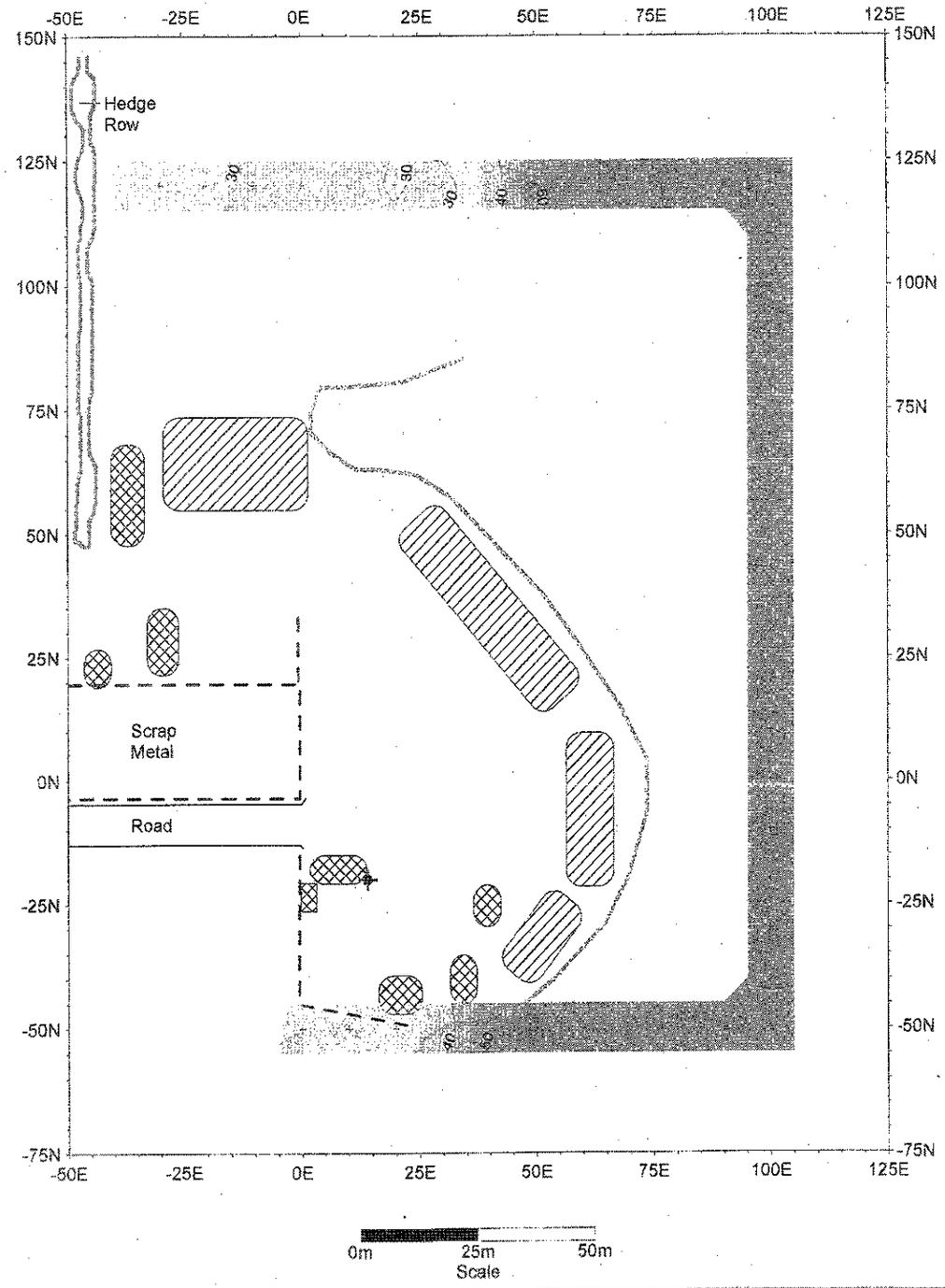


Apparent Conductivity (mS/m)

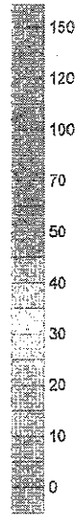
Drumheller Penitentiary Landfill Perimeter
Drumheller, Alberta

Ground Conductivity Survey
EM31(Vg) - 5 metre Depth
Figure 3b - October 1999

AMCL
Associated Mining Consultants Ltd.
PJ05



EM34 Measurement Station
Fence
Top of Slope
Fire Hydrant
Earth Piles (Approximate)
Surface Debris (Approximate)
34a EM34 Anomaly



Apparent Conductivity (mS/m)

Drumheller Penitentiary Landfill Perimeter
Drumheller, Alberta

UMA

Ground Conductivity Survey
EM34(20h) - 10 metre Depth
Figure 3c - October 1999

AMCL
Associated Mining Consultants Ltd.

APPENDIX D

Supplemental Phase II Investigation Site 530-L01, Landfill Drumheller Institution, Drumheller, Alberta, by Franz Environmental Inc., March 2006.

SUPPLEMENTAL PHASE II INVESTIGATION
SITE 530-L01, LANDFILL
DRUMHELLER INSTITUTION
DRUMHELLER, ALBERTA

Prepared for:

Consulting and Audit Canada
112 Kent Street, 11th Floor
Place de Ville, Tower "B"
Ottawa, Ontario
K1A 0S5

Prepared by:

Franz Environmental Inc.
8177 Torbram Road
Brampton, Ontario
L6T 5C5

FEI Project No. 979-0501
March 2006
CAC Project No. 502-0865
CAC Contract No. 502-4017

Vincent Ramcharan, P.Eng.
Darren Coleman, P.Eng.

FRANZ
ENVIRONMENTAL
INC.

♦ CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

March 2006

FEI Project No: 979-0501

Mariame Sakanoko
Research Analyst
Consulting and Audit Canada
112 Kent Street,
Place de Ville, Tower 'B'
Ottawa, Ontario
K1A 0S5

Dear Ms. Sakanoko:

RE: Final Report – Supplemental Phase II Investigation
Site 530-L01, Landfill Drumheller Institution, Drumheller, Alberta
CAC Contract No. 502-4017, CAC Project No. 502-0865

Franz Environmental Inc. is pleased to provide four (4) copies of the above-captioned report. Also provided is a CD containing an electronic copy of the report. It has been our pleasure to assist you with this project and we would welcome the opportunity to be of service in the future. If there are any questions arising from this report, please do not hesitate to contact me at 905 792 1093.

Yours very truly,

FRANZ ENVIRONMENTAL INC.

Darren J. Coleman, P.Eng.
Senior Environmental Engineer

8177 Torbram Road, Brampton, Ontario, L6T 5C5
Phone: 905-792-1093 Fax: 905-792-9751
Offices in Brampton, Ottawa, Montreal, Calgary, Vancouver, Victoria

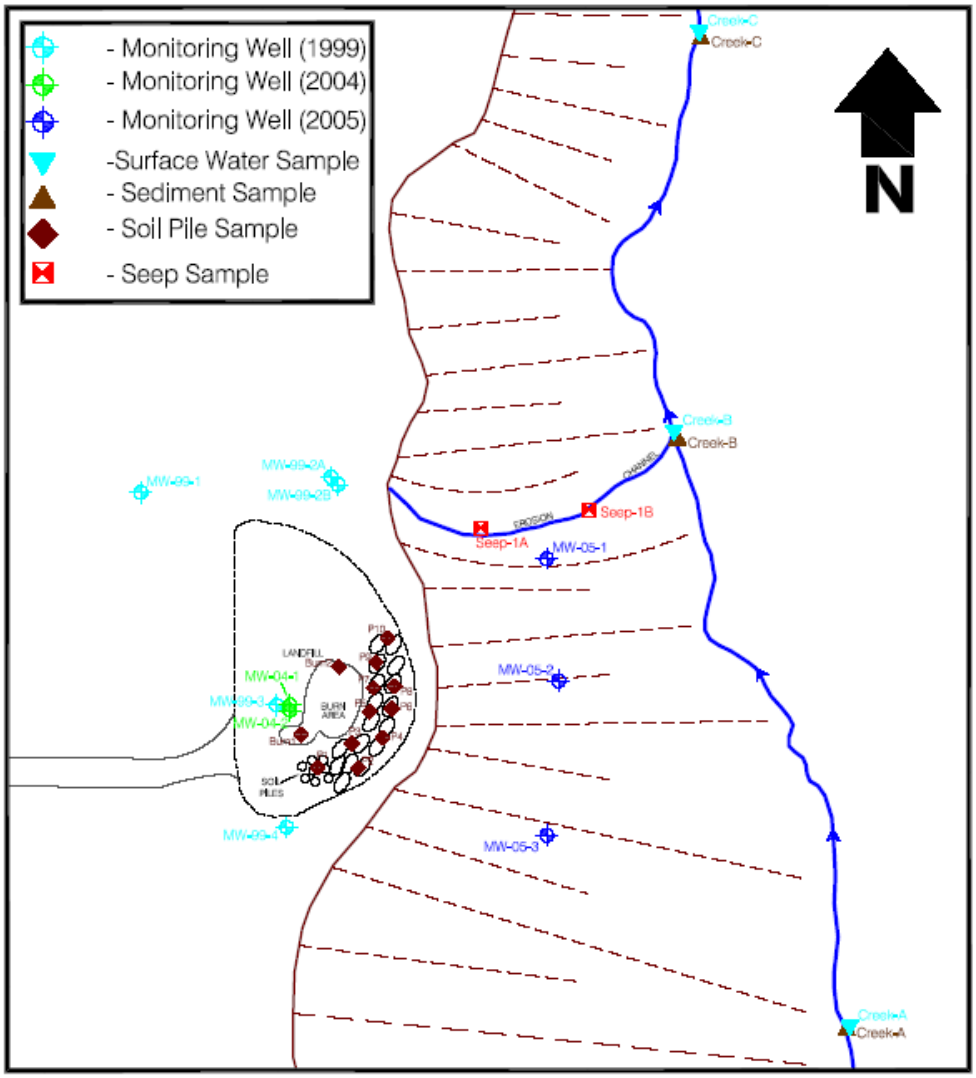
EXECUTIVE SUMMARY

In the summer/early fall of 2005, a Supplemental Phase II Investigation was carried out by Franz Environmental Inc. (FEI) of Site 530-L01 at the Drumheller Institution in Drumheller, Alberta. The investigation was supplemental to investigations carried out by UMA Engineering Ltd. in 2000 and FEI in 2004. This site is an inactive landfill located approximately 500 metres (m) southeast of the Institution complex. The objective of the investigation was to establish if the landfill has affected:

a) local soil and groundwater quality; and
b) surface water and sediment quality in a nearby spring and creek.

The landfill site is illustrated in the graphic below.

Site Plan Showing Landfill and Investigation Locations



As illustrated, the landfill occupies an area of approximately 3 hectares adjacent to a deep ravine or coulee. Spoil piles and a burn area occupy the top of the landfill. A creek runs along the base of the coulee. The creek flows northerly and is approximately 50 to 60 m lower in elevation than landfill grade. A groundwater spring discharges out of the coulee slope, approximately 20 m north of the landfill. The spring discharge location is at about 5 to 10 m below landfill grade.

According to previous investigations, the landfill was reportedly formed by pushing wastes consisting of household waste and demolition debris (pipes and building materials including concrete, brick and steel) over the edge of the coulee.

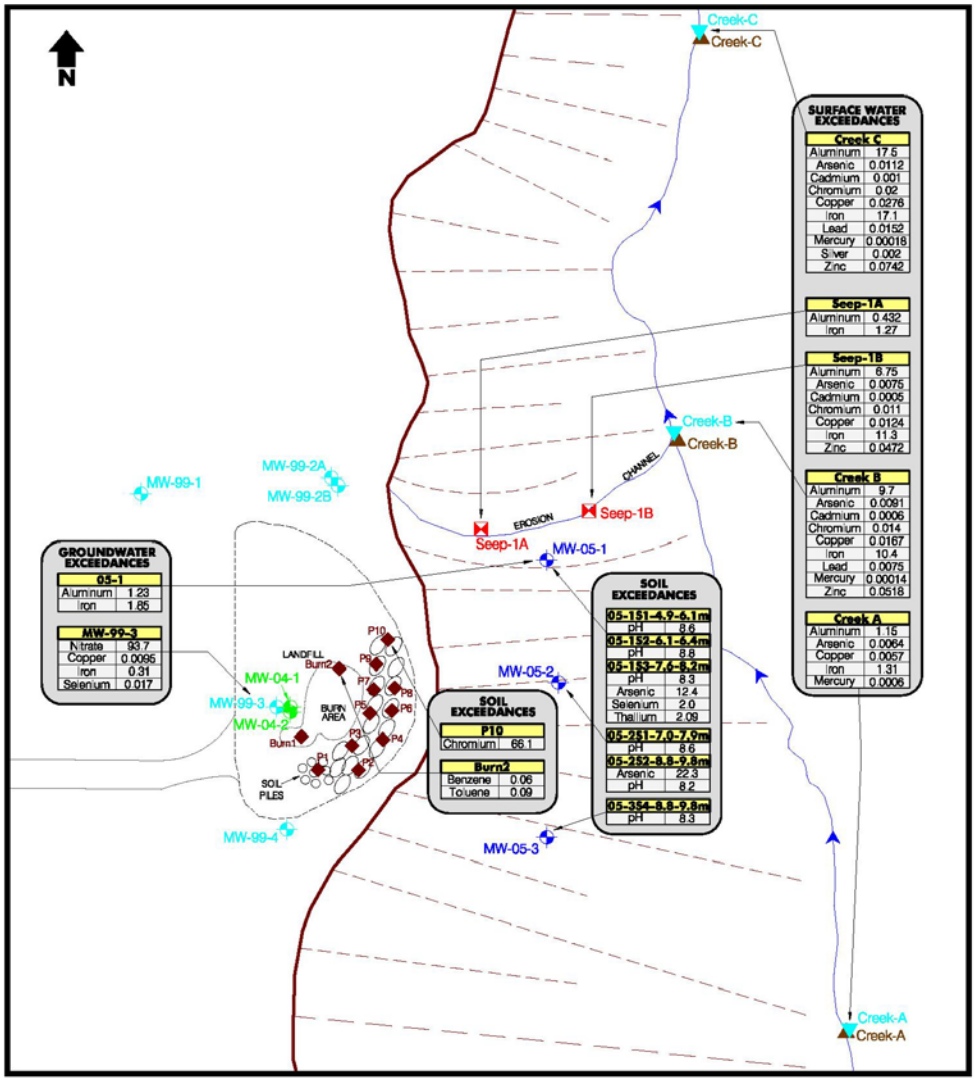
The UMA study included an electromagnetic survey as well as environmental media sampling and chemical testing for metals, petroleum hydrocarbons, polycyclic aromatic hydrocarbons, and salinity via test pits (13), boreholes (5) and surface waters (creek and spring). Groundwater was not assessed, as the monitoring wells were dry. The contaminants of concern (parameters found at concentrations in excess of applicable federal guidelines or CoCs) included pH, electrical conductivity and chromium in soil and manganese in a surface water sample from the spring.

The 2004 FEI study included soil sampling and chemical testing for metals and major ions via two boreholes. The FEI study also called for the assessment of groundwater quality in new and existing wells and the assessment of soil and groundwater quality at the toe of the landfill/coulee. Groundwater was not assessed, as the monitoring wells were dry. The assessment work at the base of the coulee was aborted due to inclement weather conditions and safety concerns related to the movement of equipment and manpower down the steep coulee slope. No contaminants of concern were identified in the soil samples analysed as part of the 2004 study.

This investigation involved well surveying and water level monitoring and sampling of soil and groundwater via existing wells and new boreholes/wells (MW05-01 to MW05-03), burn pit sampling, spoil pile sampling, and surface water and sediment sampling of the spring and creek. In all, there were five surface water/sediment sampling locations; two in the spring and three in the creek (upstream, downstream and down-gradient of landfill). Representative samples of the various environmental media were acquired for laboratory analyses. Burn pit and spoil samples were analysed for benzene, toluene, ethylbenzene and xylenes (BTEX), petroleum hydrocarbon fractions and metals. Surface water and groundwater samples were analysed for metals and major ions. Sediment samples were analysed for metals.

The stratigraphy at the site generally consists of sand and silt layers overlying clay that rests atop bedrock (shale, mudstone, sandstone). In November 2005, groundwater was encountered at 6.8 m to 9.3 m below grade and groundwater flow across the site was inferred as easterly towards the creek.

The chemical results on the environmental media tested in August 2005 as part of this investigation were evaluated against applicable Federal guidelines (CCME Canadian Environmental Quality Guidelines (2004)) to identify contaminants of concern (CoC). Specifically, soil chemical results were evaluated against the residential/parkland land use guidelines, groundwater was assessed against the Freshwater Aquatic Life (FAL) guidelines, sediment was evaluated against the sediment quality guidelines and surface water was assessed against the FAL guidelines. The results of this evaluation are illustrated on the graphic below.



CoCs in the burn pit soils include benzene and toluene. Of the ten spoil piles tested, one was of environmental concern, the CoC in this pile is chromium.

Soils within and in the general area of the landfill are alkaline. The pH in the bulk of the soil samples analysed is above the upper pH limit specified under the CCME guideline. Because no background pH information was available at the time of this study, we could not ascertain whether this alkaline condition is natural or derived from the landfill waste. Arsenic is a CoC in soil at two of the three boreholes drilled at the toe of the landfill. Additional CoCs found in soils at one of these boreholes include selenium and thallium.

Of the ten observation wells at the site, only two produced sufficient groundwater to sample. Both of these wells are within the landfill waste with one on the upper plateau and the other in the landfill toe at the base of the coulee. The potential CoCs in groundwater within the landfill include aluminum, copper, iron, selenium and nitrate. It should be recognized that these parameters were deemed CoCs based on a direct evaluation against the FAL guidelines, which are intended to assess surface water quality. It is expected that natural dilution would occur upon discharge of the groundwater into the down-gradient creek. Typically, the dilution factor for this type of discharge condition used by practitioners is 10. Considering a 10 fold dilution, the potential CoC list is reduced to aluminum and selenium.

There were no CoCs identified in any of the sediment samples analysed.

Aluminum, arsenic, copper, iron and mercury were identified as COCs in all of the surface water samples analysed from the creek, including the upstream sample. The concentrations of all of these metals increase in the downstream direction. Cadmium, chromium, lead and zinc were identified as COCs in the surface water samples obtained from the creek at the downstream and downgradient (of landfill) stations. A similar increasing concentration trend in the downstream direction was also noted for these metals with the highest concentrations apparent in surface water from the downstream location.

In the groundwater spring, the CoCs in surface water include aluminum and iron in both samples and arsenic, cadmium, chromium, copper and zinc in the downstream sample.

The increasing trends in metals concentrations in creek water in the downstream direction noted in August 2005 seems to suggest that the landfill may have contributed to some of the metals contamination in surface water within the creek. Before a judgement can be made in this regard, it is important to consider the following:

- With the exception of aluminum, copper and iron, none of the metals of concern in the surface water were of concern in landfill groundwater.
- Aluminum, copper and iron were metals of concern in all of the surface water samples analysed in August 2005 from the creek.
- Mineral contributions from the natural environment (i.e. background concentrations) have not been determined, thus, an evaluation of the detected concentrations against natural background concentrations has not been completed.

Notwithstanding the above, it is possible that some of the metals may have originated from regions of the landfill not specifically sampled in this investigation or prior investigations. In order to conclusively make this judgement, information collected from the following tasks, combined, is needed.

- Additional seasonal sampling and chemical testing for metals should be carried out at the same surface water sampling stations in this study and at least one additional upstream and downstream location.
- Seasonal sampling and chemical testing for metals in groundwater samples obtained from all monitoring wells located in the landfill toe at the base of the coulee.
- A background concentration study to establish which of the metals identified as CoCs are anthropogenic in origin and/or naturally high in concentration.

The following additional recommendations are provided for consideration:

- The benzene and toluene impacted soil and the remnants of the charcoal and metal pieces at the burn area, along with chromium impacted soil in the single spoil pile, should be removed and disposed at a suitable disposal site.
- A qualified practitioner should be consulted to assess the stability of the landfill slope and establish what engineering controls or mitigative action may be required to protect human safety and minimize/prevent the possibility of a catastrophic slope failure.

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1.0 INTRODUCTION

Franz Environmental Inc. (FEI) was retained by Consulting and Audit Canada (CAC) on behalf of Correctional Service of Canada (CSC) to conduct a Supplemental Phase II investigation of an inactive landfill (Site 530-L01) at the Drumheller Institution, a medium security facility, in Drumheller, Alberta.

FEI attempted this work in the winter of 2004, however the work was aborted due to safety concerns. This site is located on the edge of a coulee, approximately 500 m southeast of the enclosure. The toe of the landfill is located in the coulee and access to the toe is limited by the steep slopes of the coulee. During the field program, FEI concluded it was unsafe to try to lower a drill rig into the coulee until the area was dry and free of snow.

1.1 Project Objectives

The objectives of the work were to ascertain whether the landfill has affected the quality of:

- local surface and subsurface soil and groundwater; and
- local surface water and sediment in a nearby spring and creek.

1.2 Scope of Work

To accomplish the project objectives, the following work tasks were completed:

- review of intrusive investigations completed to date;
- site reconnaissance to assess environmental conditions; and
- intrusive investigation to assess soil, groundwater, surface water and sediment quality in the area of the former landfill.

The above scope of work was outlined, in general, in our proposal entitled “Environmental Site Assessment and Site-specific Risk Assessments at Correctional Institutions, Work Package No. 5, Alberta Region, Solicitation No. CCAB-3-0212 (November 3, 2003)”. The general work scope was refined and amended based on site-specific information provided following contract award. The amended scope was outlined in our work plans dated May 27, 2005 (P1750) and August 19, 2005 (P1750A), and entitled “Supplemental Phase II Investigation Work Plan, Former Landfill (Site 530-L01), Drumheller Institution, Drumheller, Alberta” and “Addendum-Supplemental Phase II Investigation Work Plan, Former Landfill (Site 530-L01), Drumheller Institution, Drumheller, Alberta”, respectively.

2.0 BACKGROUND

2.1 Site Location

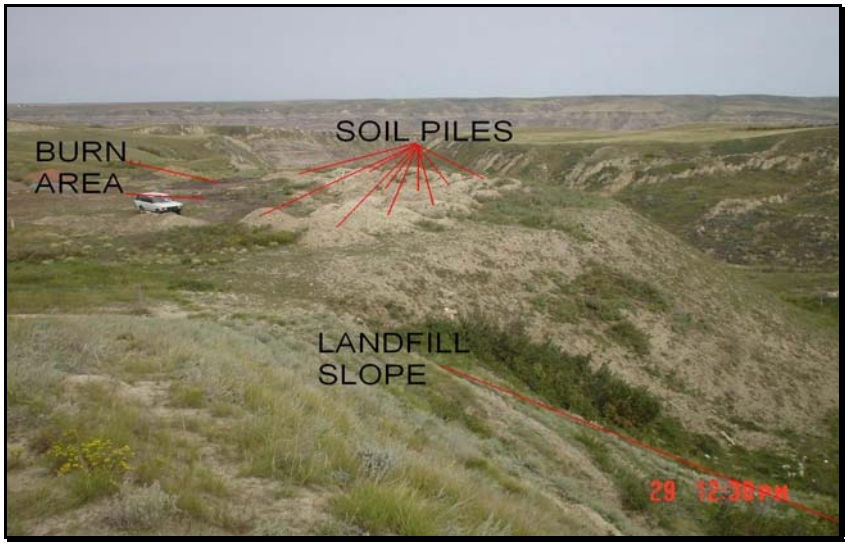
The Drumheller Institution that houses the subject site (Site 530-L01) was opened in 1967 and provides accommodation for medium-security inmates. The institution is located five kilometres south-southeast of Drumheller, Alberta. The site location on institutional lands is shown on Figure 1.

The inactive landfill is located on the edge of a coulee, approximately 500 m southeast of the Institution complex, as shown on Figure 2.

2.2 Site Features and Facilities

The landfill, with dimensions of approximately 150 m by 200 m (3 hectares), was operated in a series of trenches and received waste from the institution for more than 20 years (UMA 2000). The landfill reportedly operated from the mid 1960's until its closure in the late 1980's. Mr. Earl Pratt, Environment and Safety Officer for the Drumheller Institution, advised that the waste material at the landfill consists of domestic waste and demolition material such as pipes, concrete, and building materials from renovations at the institution. The waste was pushed over the edge into the coulee. The landfill was not engineered and topsoil and subsoil layers were not separated for use as cover before the landfill site closed.

The surface of the landfill was used as a burn area and is used to store spoil piles from excavations around the site (see Photograph 1).



Photograph 1 : Site overview, looking northeast

A groundwater spring was found in a steep gully about 20 m north of the landfill, with the spring emanating from the ground about 5 to 10 m below the elevation of the top of the landfill. The creek was estimated to be between 50 and 60 m below the top of the landfill.

There is limited access to the toe of the landfill due to the steepness of the slopes.

2.3 Topography and Drainage

The institution is at an elevation of about 800 masl (metres above sea level) (Alberta 2003). The site topography drops steeply to the east and south towards a creek (see Photograph 2) located east of the landfill. The creek drains into the Red Deer River located approximately 1.5 km to the northeast, with an approximate elevation of 680 masl.

Photograph 2: Creek at bottom of gully, looking west.

2.4 Regional Geology and Hydrogeology

Regional geology consists of bedrock of the upper Cretaceous and Paleocene age. The bedrock includes shale and sandstone and is overlain with glacial till and lacustrine deposits consisting of sand, silt and clay. *(Craig, B.G. 1956).*

Regional groundwater flow is assumed to be towards the Red Deer River.

The drinking water supply for the institution is provided from the City of Drumheller system. No potable use of the groundwater is made in the vicinity of the landfill.

2.5 Previous Investigations

UMA Engineering Limited (UMA) conducted a Phase II Environmental Site assessment in 1999 on the former landfill. The investigation included the excavation of thirteen test pits; drilling of five boreholes; installation of five monitoring wells (MW-99-1 to MW-99-4); and soil and groundwater sampling. Their findings are summarized as follows:

- a crack in the ground extending north/south across the site was observed 10 to 20 m from the top of the eastern slope of the landfill area and no test pits were advanced beyond this point;
- scrap metal, wood, concrete and some domestic wastes were encountered in the test pits which were excavated to depths of up to 4.9 metres below ground (mbg);
- the stratigraphy in the boreholes, which were drilled to depths of up to 15.2 mbg generally consist of interbedded sand and silt units, overlying clay;
- chloride was detected in groundwater at MW-99-4 and MW-99-1; and
- salinity in MW-99-1 and M-99-3 was likely due to natural variability in soil chemistry, but could have also indicated localized impacts.

The following exceedances of Federal Guidelines were noted:

CCME Residential/Parkland Exceedances(1997) in Soil

- pH at MW-99-2B;
- nickel and zinc at MW-99-3; and
- chromium and zinc at MW-99-4.

CCME Exceedances (1991 CCME Interim Criteria for Water) in Surface Water

- sodium in all of the samples from the creek and spring; and
- manganese in the sample from the spring.

Franz Environmental Inc. conducted a Phase II investigation in 2004. The investigation included the drilling of two boreholes each completed with a monitoring well (MW-04-01 and MW-04-2). Investigation work planned for the base of the landfill within the coulee as part of the program was abandoned due to inclement weather and slope safety concerns. The study found no exceedances of the applicable residential/parkland guidelines in soil for the parameters tested.

2.6 Contaminants of Concern

The typical parameters, which may indicate pollution of soil, groundwater, surface water and/or sediment from leachate, released from a domestic waste landfill, could include:

- pH
- electrical conductivity
- dissolved oxygen
- total dissolved solids
- alkalinity
- hardness
- biochemical oxygen demand (BOD)
- chemical oxygen demand (COD)
- nitrogen
- chloride
- sulphate
- metals (aluminum, arsenic, barium, beryllium, boron, cadmium, cobalt, copper, chromium, iron, lead, mercury and zinc)

2.7 Site Assessment Criteria

As outlined in the Bid Solicitation issued by CAC, the soil assessment criteria considered applicable to Correctional Service Canada (CSC) Institutions are the residential/parkland guidelines provided in the *"Canadian Council of Ministers of the Environment (CCME), Environmental Quality Guidelines"* (EQG) publication, updated in 2004.

The surface water and groundwater assessment criteria considered applicable to this CSC institution are the CCME Freshwater Aquatic Life (FAL) guidelines and sediment assessment guidelines.

The drinking water criteria were not considered applicable because the potable water source, for the institution, originates from a municipal treatment system operated by the City of Drumheller and no potable use of the groundwater is known in the vicinity of the site.

3.0 INVESTIGATION METHODOLGOY

3.1 Investigation Work Plan

An intrusive investigation to assess surface and subsurface conditions was carried out by FEI in the late summer/early fall of 2005. The investigation involved the following tasks:

- site reconnaissance and existing monitoring well inventory;
- utility locates and clearances;
- development and implementation of a health and safety plan;
- soil, surface water and sediment sampling;
- site preparation;
- borehole drilling, soil sampling and well installations;
- well development and surveying;
- groundwater gauging and sampling; and
- chemical analysis.

The methods for the above work tasks are outlined in the following sections.

3.2 Methodology

3.2.1 Site Reconnaissance and Existing Monitoring Well Inventory

FEI personnel and Mr. Earl Pratt, Environment and Safety Officer for the Drumheller Institution, conducted a site reconnaissance on July 7, 2005, to:

- determine site features such as existing facilities and buildings, slopes, drainage, water bodies, proximity of onsite contaminant sources to receptors, etc;
- identify areas of potential environmental concern (waste, seepage, staining, erosion, stability and safety conditions etc); and
- locate existing wells.

The results of the site reconnaissance were used to refine the intrusive investigation work plan.

3.2.2 Utility Locates and Clearances

The site was cleared of utility conflicts in the 2004 aborted field program, as such, utility clearances were not deemed necessary and thus not carried out for this investigation.

3.2.3 Health and Safety

Before commencing with site activities, a site-specific health and safety plan (HSP) was developed. The HSP identified and provided mitigative actions for potential physical and chemical hazards associated with the work. The HSP also contained a list of emergency contact numbers and provided protocols to follow in the event of an emergency.

Daily health and safety tailgate meetings were conducted to educate onsite personnel on the apparent risks and appropriate mitigative actions as well as address any health and safety concerns.

The site-specific health and safety plan has been retained on file at FEI.

3.2.4 Soil, Surface Water and Sediment Sampling

On August 29, 2005, the following sample collection work was conducted:

- soil samples (P1 to P10) from the soil piles on top of the landfill;
- soil samples (Burn 1 and Burn 2) from the Burn area (see Photograph 3) on top of the landfill;
- surface water samples, Seep-1A and Seep-1B (see Photograph 4), from the spring on the landfill slope; and
- surface water and sediment samples from three accessible locations in the creek.

The locations of these samples are shown on Figure 3.

The creek sampling locations were selected to investigate conditions upstream (background), adjacent (directly down-gradient of the landfill) and downstream of the landfill and are described as follows:

- upstream (background) of the site (Creek-A);

- adjacent (directly down-gradient) to the site (Creek-B); and
- downstream (Creek-C) of the site.

To minimize the potential for cross contamination, the sampling equipment was cleaned and decontaminated in accordance with standard practise between sampling locations and new disposable gloves, discarded after the collection of each set of samples, were used.

Field duplicates were also collected for QA/QC purposes. The samples were packed in coolers and maintained at a temperature below 4°C and shipped to Maxxam Analytics, under chain of custody, for subsequent analytical testing.

Photograph 3: Burn area.

Photograph 4: Surface water sample Seep 1B

3.2.5 Site Preparation

A bulldozer was utilized to create access for the drilling rig to the toe area of the landfill (Photograph 5) on August 29, 2005. This was carried out to mitigate safety concerns identified in previous investigations and site visits.

Photograph 5: Access to toe of the landfill.

3.2.6 Borehole Drilling, Soil Sampling and Well Installations

The drilling program involved the advancement of 3 boreholes (MW-05-1, MW-05-2 and MW-05-3) each of which was completed with a monitoring well, at the locations shown on Figure 3, provided in Attachment A. Drilling was carried out by Enviro-Core Sampling Ltd. on September 26, 2005. Boreholes with inner diameters (I.D.) of 114 mm were advanced to depths of 9.1 m to 11.5 m below grade, using a track-mounted direct push unit drilling rig (Model 6620DT), shown in photograph 6, equipped with split-spoon samplers.

Photograph 6: Truck-mounted direct push unit used for drilling of boreholes.

Soil samples were collected from the split spoons at regular intervals during borehole drilling and the spoon samples were split, with one half immediately placed in jars for possible laboratory analysis and the other half used for textural and visual classification. Three samples from each borehole were submitted to Maxxam Analytics, for analysis of metals, major ions, nutrients and pH. The jar samples were placed in a cooler regulated to a maximum temperature of 4 °C.

Drilling and soil sampling equipment was decontaminated between drilling and sample locations to prevent cross contamination.

The groundwater monitoring wells installed in the boreholes were constructed of 38 mm I.D. polyvinyl chloride (PVC) piping (piping with #10 slot screens (0.25 mm). The screened intervals, 3 m in length, were placed to intercept the anticipated watertable. The borehole annulus was backfilled from the bottom of the hole to approximately 0.5 m above the top of the well screen, with sand pack material of sufficient particle size to minimize inflow of fine particulate matter from the surrounding formation. A hydrated bentonite seal was placed above the sand pack to about 0.3 to 0.5 m below grade in each borehole. The annulus above the bentonite seal was capped with sand fill. Each monitoring well was completed with approximately 0.3 m of sand and fitted with a lockable aboveground protective casing.

3.2.7 Well Development and Surveying

Well development was conducted on all of the new well installations prior to groundwater sampling using dedicated Waterra sample pumps (low density polyethylene tubing with an

inertial foot valve). Development was carried out until either a minimum of three well volumes (including sand pack) was removed or the well was pumped dry.

On November 3, 2005, the new monitoring wells were surveyed for their horizontal positions, top of casing and grade elevations.

3.2.8 Groundwater Gauging and Sampling

All accessible monitoring wells were monitored for fluid levels in September and November 2005. Water levels were gauged using a Waterra WS-1 water level tape. The probe of the water tape was rinsed with methanol and distilled water between monitoring wells to prevent cross contamination using new disposable gloves replaced between wells.

Before groundwater sample collection each monitoring well was purged using dedicated inertial pumps until a minimum of three well volumes had been removed and the produced groundwater was clear. For low yield wells producing less than three volumes, the well was purged dry before sampling.

Groundwater sampling was conducted on all monitoring wells. The samples were packed in coolers, maintained at a temperature below 4 °C, which were subsequently delivered to Maxxam Analytics in Calgary, Alberta.

3.2.9 Chemical Analysis

The chemical analysis program was designed considering some of the contaminants common to, and representative of, domestic waste landfills.

From each borehole location, three soil samples were analysed for pH, metals, anions, and nutrients.

Soil samples from the soil piles and burn area were analysed for metals, BTEX and petroleum hydrocarbons.

Groundwater samples, from accessible monitoring wells, were analysed for pH, alkalinity, hardness, metals, anions and nutrients.

Surface water samples from the spring and creek were analysed for pH, alkalinity, hardness, metals, anions, nutrients and suspended solids.

Sediment samples from the creek were analysed for metals.

Maxxam Analytics, a CAEAL-accredited laboratory in Calgary, Alberta, was contracted to carry out the above analyses.

For Quality Assurance/Quality Control (QA/QC) purposes, all samples were preserved according to laboratory protocols. Additionally one blind duplicate groundwater sample was collected and analysed to check analytical and sampling methods. The duplicate was collected from monitoring well MW-99-3.

4.0 INVESTIGATION RESULTS

This section presents the results of the intrusive investigation. Borehole logs are presented in Appendix A, site photographs in Appendix B, and laboratory certificates of analysis provided in Appendix C.

4.1 Site Reconnaissance

Based on the site reconnaissance of July 7, 2005, conducted by FEI personnel and Mr. Pratt, the following was noted:

- existing monitoring wells, MW-99-1 to MW-99-4 and MW-04-1, appeared to be in adequate condition to allow monitoring and groundwater sampling;
- additional spoil piles had been deposited at the site since the 2004 visit. Mr. Pratt indicated that these piles originated from trench excavations at the institution;
- construction debris (concrete and asphalt) is evident at or near the surface at various locations;
- buried waste material was exposed on the surface and slope of the landfill;
- the soil cover on the landfill slope does not appear to be compacted and there is visible erosion (see photograph 7);
- the landfill slope was relatively steep with slope angles being approximately 45 degrees;
- charred ground is evident in the burn area from former refuse burning and fire-fighter training according to Mr. Pratt. Wooden pallets are reportedly ignited and extinguished during training exercises.
- iron staining is visible at the seep on the landfill slope.

Photograph 7: Erosion on landfill slope, top right of photo.

4.2 Stratigraphy

As illustrated on the borehole logs (Appendix A), boreholes depths ranged from 9.1 to 11.5 metres below ground surface (mbgs). The stratigraphy generally consisted of sand and silty clay grading to clay, overlying bedrock (shale, mudstone and sandstone). Coal was also encountered in boreholes MW-05-1 and MW-05-2, at depths ranging from 7.9 to 10.3 mbgs. Some refuse was encountered in borehole MW-05-1.

4.3 Groundwater Conditions

The September and November 2005 water levels and watertable surface elevations are presented in Table 1 (Attachment B). As presented, the watertable ranged from 6.81 to 9.30 m below grade in depth on November 3, 2005, with four wells being dry.

Based on the watertable elevations, groundwater flow in November 2005 is inferred as easterly towards the creek.

4.4. Soil Analytical Results

The results of the soil chemical analyses, are presented, along with the CCME residential/parkland (R/P) criteria, in Tables 2 to 4. Parameters with concentrations in non-conformance with the CCME soil guidelines are illustrated on Figure 4.

4.4.1 Boreholes

As presented in Table 2 and as illustrated on Figure 4, the soil at the site appears to be alkaline with values at or above the CCME upper limit of pH 8 in all but one of the nine soil samples analyzed from the three boreholes. The arsenic, selenium and thallium concentrations in one sample from MW-05-1 and the arsenic concentration in one sample from MW-05-2 exceeded the CCME residential/parkland (R/P) criteria. Both of the samples were obtained from native soils at depths of more than 7 m below grade.

4.4.2 Soil Piles and Burn Area

As presented in Tables 3 and 4 and illustrated on Figure 4, the following exceedences of the CCME R/P criteria were apparent in soils:

- chromium in sample P10 from one of the spoil piles; and
- benzene and toluene in sample Burn 2 from the burn area.

Xylene and petroleum hydrocarbons (PHC) F3 and F4 were detected in some samples collected from the spoil piles and burn area, however, no concentrations exceeded the applicable CCME criteria.

4.5 Groundwater Analytical Results

During the sampling event, all of the monitoring wells were dry or did not have sufficient water for sampling, except for monitoring wells MW-99-3 and MW-05-1.

The results of the groundwater chemical analyses are presented along with the CCME Freshwater Aquatic Life (FAL) criteria in Table 5 provided in Attachment B. As presented in Table 5 and as illustrated on Figure 4, the following exceedances of the CCME FAL criteria were apparent in groundwater:

- nitrate, copper, iron and selenium in MW-99-3; and
- aluminum and iron in MW-05-1;

None of the other parameters investigated in the groundwater samples exhibited concentrations in excess of the FAL criteria.

4.6 Surface Water Analytical Results

The results of the chemical analysis of the surface water samples, collected from the creek and seeps, are presented along with the CCME Freshwater Aquatic Life (FAL) criteria in Table 6 provided in Attachment B. As presented in Table 6 and illustrated on Figure 4 the following exceedances of the CCME FAL criteria were apparent in surface water:

- aluminum, arsenic, copper, iron and mercury in all of the creek samples (Creek A, Creek B and Creek C);
- cadmium, chromium, lead and zinc in the Creek B and Creek C samples;
- silver in sample Creek C;
- aluminum and iron in the Seep 1A sample acquired from the spring; and
- aluminum, arsenic, cadmium, chromium, copper, iron and zinc in the Seep 1B sample acquired from the spring.

4.7 Sediment Chemical Results

The results of the sediment samples collected from the creek are presented along with the CCME Interim Sediment Quality Guidelines (ISQG) in Table 7 provided in Attachment B. All metals detected in the sediment samples were present at concentrations below the applicable CCME Interim Sediment Quality Guidelines (ISQG).

4.8 Quality Assurance/Quality Control

Good agreement was obtained between the results of the field duplicate (QC-1) and sample (MW99-3), as presented in Table 6.

5.0 DISCUSSION OF RESULTS AND CONCLUSIONS

5.1 Site Conditions

The landfill slope is relatively steep and the cover material in some areas is fairly loose and unconsolidated. With continued erosion, slope stability may become a safety concern and a slope failure may be inevitable. As a minimum, the site may require a hazard assessment from a qualified geotechnical engineer and some engineering mitigating actions to eliminate/reduce this risk.

5.2 Site Media Quality

Parameters found in non-compliance with CCME criteria in soil, groundwater and surface water are illustrated on Figure 4. The following were noted from our interpretation of the investigation results:

- There is little or no background information available in soil, groundwater, surface water and sediments, for the various parameters tested in this program.

- The pH in soils, from the boreholes, ranged from 7.9 to 8.8 with six of the nine samples analysed exhibiting pH in excess of the applicable CCME upper limit of 8. Since no background pH data were available at the time of this investigation, it is not possible at this time to ascertain if the alkaline pH condition is natural or related to the landfill waste.

- The non-compliant arsenic, selenium and thallium concentrations found in soil samples, from the boreholes, may have originated from the landfill waste material, since there is little or no information available on background soil quality in the area but these are suspected to be of natural origin.

- The non-conforming chromium concentration in soil sample P10, collected from the spoil piles, represents an environmental concern; in addition to the benzene and toluene exceedances in soil at the burn area, which may be attributed to previous fire training activities.

- The non-conforming concentrations of nitrate, aluminum, copper, iron, and selenium found in groundwater from wells MW99-3 and MW-05-1, located on top and downgradient, respectively, of the landfill may be indicative of landfill leachate, since there is little or no information available on background groundwater quality in the area.

- The non-conforming concentrations of aluminum, arsenic, cadmium, chromium, copper, iron and zinc in the seep samples acquired from the spring may be indicative of landfill leachate since the seepage water is presumed to pass through the landfill waste.

- The creek sampling locations were selected to be representative of background and downgradient (existing) site conditions. Since the non-conforming concentrations of aluminum, arsenic, copper, iron and mercury were encountered in all three surface water samples, these metals may be naturally high in the area or may have originated from an alternative upstream source location.

- The non-conforming concentrations of cadmium, chromium, lead, silver and zinc in the surface water samples, Creek B and Creek C were higher than that in the background sample Creek A; these metals concentrations may, therefore, be indicative of landfill leachate.

- Without a background concentration assessment, it cannot be concluded that these apparent pH and metals impacts, in soil, groundwater and surface water, originated from the landfill at this time.

6.0 RECOMMENDATIONS

As evident from the intrusive investigation results, a number of metals (aluminum, arsenic, cadmium, copper, iron, lead, mercury, nickel, selenium, silver, thallium and zinc), one anion (nitrate) and pH were found in soil, groundwater and surface water, at concentrations that did not conform with the CCME guidelines. Additional study should include a background concentration assessment and additional seasonal surface water and groundwater sampling and chemical testing for metals. The additional groundwater sampling should focus on the wells at the landfill toe. Additional surface water sampling should include all sampling stations in this study as well as an additional upstream and downstream station in the creek.

The benzene and toluene impacted soil and the remnants of the charcoal and metal pieces at the burn area, along with chromium impacted soil at the soil pile area, should be removed and disposed of at an approved disposal site;

Since slope stability concerns have arisen, a hazard assessment by a qualified geotechnical engineer is recommended to determine if engineering mitigative actions are necessary to stabilize the slope and eliminate or reduce the safety risk.

7.0 LIMITATIONS

This report has been prepared in accordance with generally accepted environmental practices for the exclusive use of Consulting and Audit Canada (CAC) and Correctional Service Canada (CSC). This report is based on the information obtained while conducting a supplemental Phase II investigation of a landfill and adjacent creek and spring.

The findings and conclusions presented in this report are based exclusively on the chemical parameters addressed in this report at the locations sampled and tested. It should be recognized that conditions between and beyond the sample locations may vary. FEI cannot expressly guarantee that subsurface conditions between and beyond the sample locations do not vary from the results determined at the sample locations. Notwithstanding these limitations, this report is believed to provide a reasonable representation of site conditions as of November 2005.

The contents of this report are based on the information collected during assessment activities, our understanding of the actual site conditions, and our professional opinion according to the information available at the time of preparation of this report. This report gives a professional opinion and, by consequence, no guarantee is attached to the conclusions or expert advice depicted in this report. This report does not provide a legal opinion in regards to Regulations and applicable Laws.

Any use of this report by a third party and any decision made based on the information contained in this report by the third party is the sole responsibility of the third party. FEI will not accept any responsibility for damages resulting from a decision or an action made by a third party based on the information contained in this report.

8.0 REFERENCES

(Alberta 2003) - 1:20000 Base Map NAD83 UTM. Copyright 2003 Government of Alberta.

(CCME 2004) - Canadian Council of Ministers of the Environment (CCME). 2004. Canadian Environmental Quality Guidelines, publication, updated in 2004.

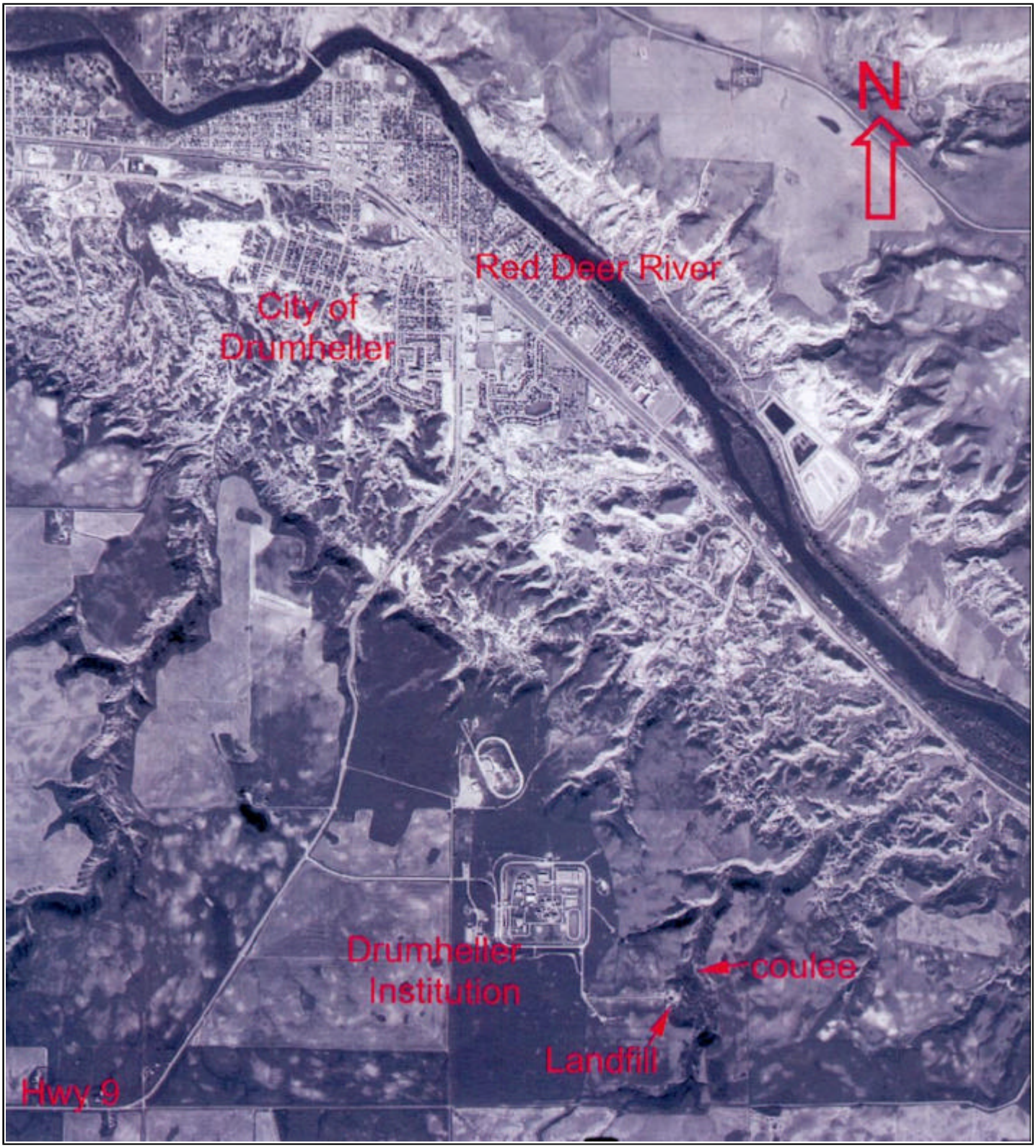
(Craig, B.G. 1956) - Craig, B. G. 1956. Surficial geology of the Drumheller area, Alberta, Canada. Unpublished Ph.D. dissertation. University of Michigan

(UMA 2000) - UMA Engineering Ltd. 2000. Phase II Environmental Site Assessment. Report prepared for Public Works and General Services Canada, March 2000.

Respectfully submitted,

ATTACHMENT A

FIGURES



Scale 1:30,000

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Title:	**SITE LOCATION**
Project:	**SUPPLEMENTAL PHASE II INVESTIGATION, SITE 530-L01 - LANDFILL, DRUMHELLER INSTITUTION, DRUMHELLER, AB**
Client:	**CONSULTING AND AUDIT CANADA**
FRANZ ENVIRONMENTAL INC. ♦ CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦	Date: January 2006
	Updated: Mar. 17, 2006
	FIGURE 1

0979-0501/VR/MZ/Drumheller-SitePlan.dwg

Title: **SITE LOCATION ON INSTITUTION GROUNDS**

Project: **SUPPLEMENTAL PHASE II INVESTIGATION, SITE 530-L01 - LANDFILL, DRUMHELLER INSTITUTION, DRUMHELLER, AB**

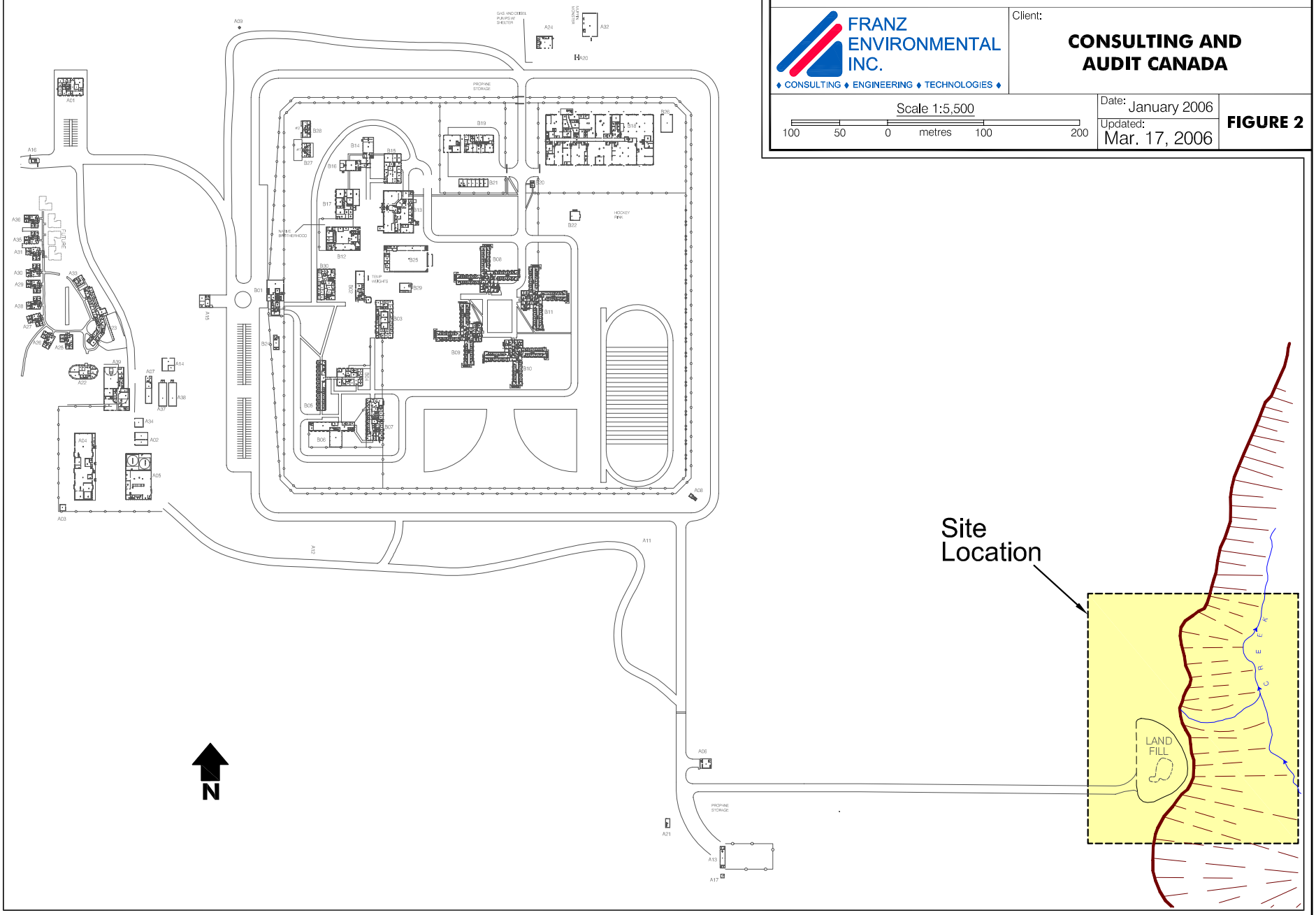
FRANZ ENVIRONMENTAL INC.
♦ CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Client: **CONSULTING AND AUDIT CANADA**

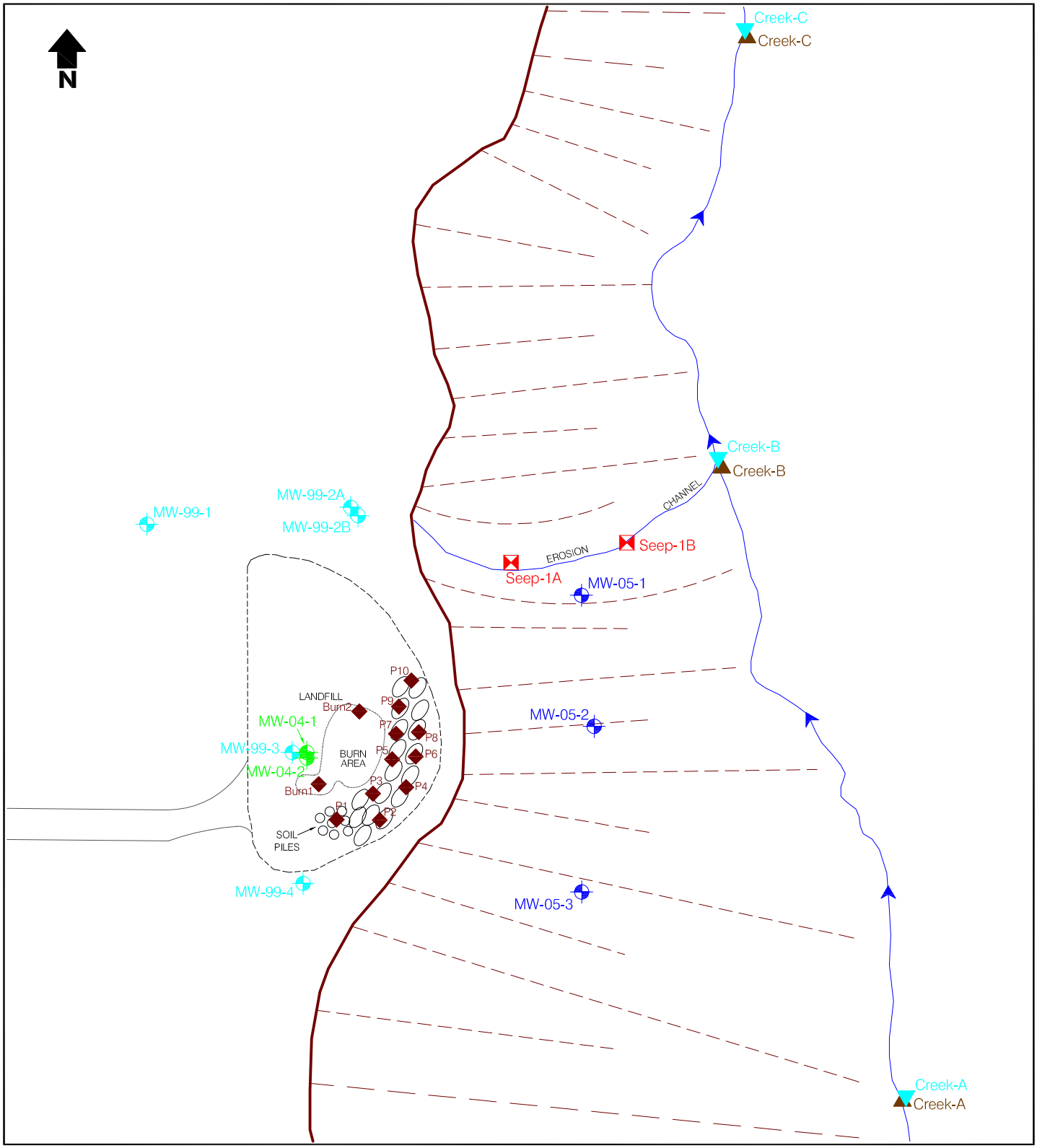
Scale 1:5,500
100 50 0 metres 100 200

Date: January 2006
Updated: Mar. 17, 2006

FIGURE 2



0979-0501/VR/MZ/Drumheller-SitePlan.dwg



LEGEND

- Monitoring Well (1999)
- Monitoring Well (2004)
- Monitoring Well (2005)
- Surface Water Sample
- Sediment Sample
- Soil Pile Sample
- Seep Sample

Scale 1:1500

20 10 0 metres 25 50

Title: **SITE PLAN**

Project: **SUPPLEMENTAL PHASE II INVESTIGATION, SITE 530-L01 - LANDFILL, DRUMHELLER INSTITUTION, DRUMHELLER, AB**

Client: **CONSULTING AND AUDIT CANADA**

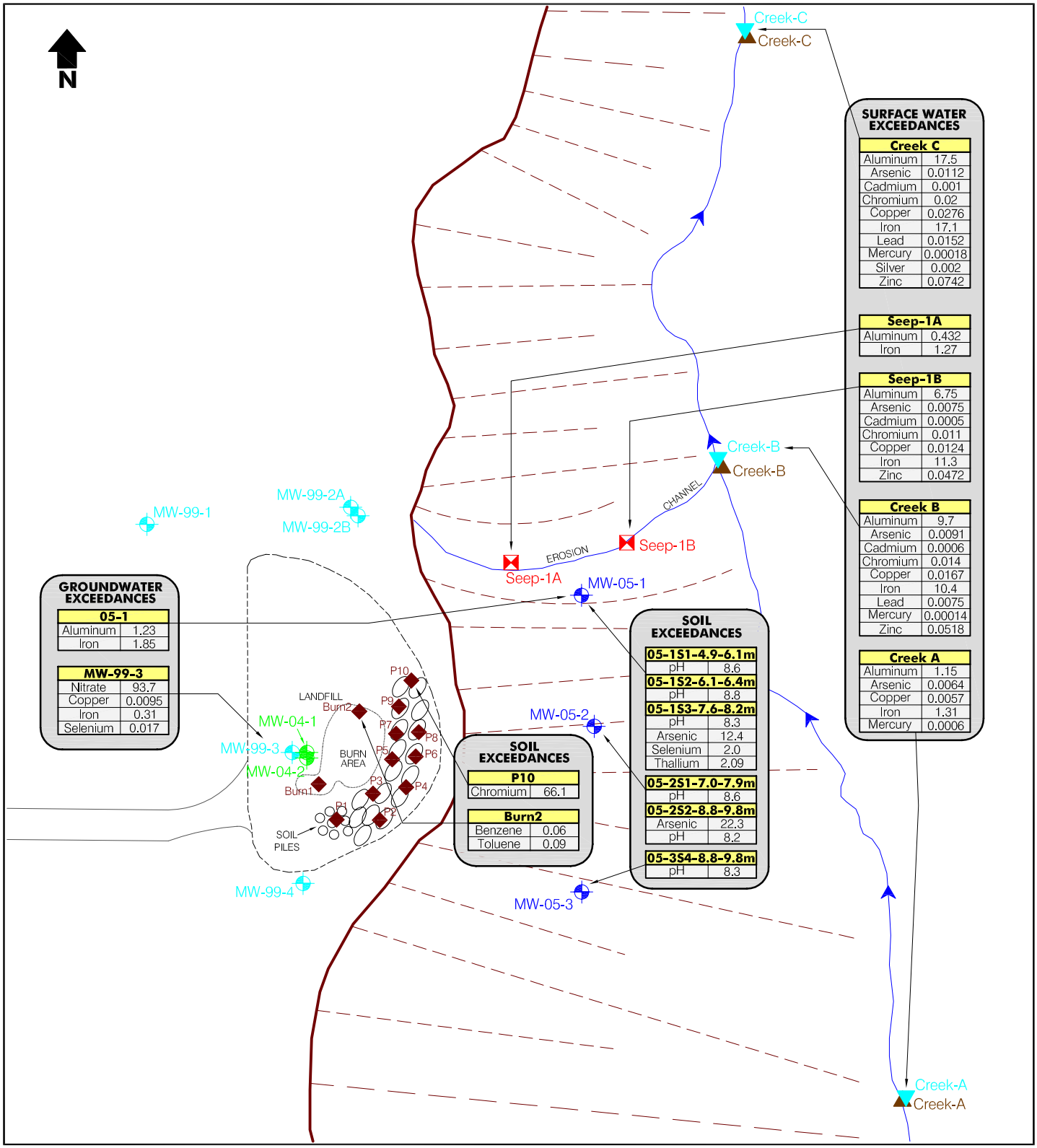
FRANZ ENVIRONMENTAL INC.
♦ CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Date: January 2006

Updated: Mar. 17, 2006

FIGURE 3

0979-0501/VR/MZ/Drumheller-SitePlan.dwg



LEGEND

- Monitoring Well (1999)
- Monitoring Well (2004)
- Monitoring Well (2005)
- Surface Water Sample
- Sediment Sample
- Soil Pile Sample
- Seep Sample

Note:
- All concentrations for water samples are expressed as mg/L
- All concentrations for soil samples are expressed as mg/kg

Scale 1:1500

20 10 0 metres 25 50

Title: **PARAMETER EXCEEDANCES**

Project: **SUPPLEMENTAL PHASE II INVESTIGATION, SITE 530-L01 - LANDFILL, DRUMHELLER INSTITUTION, DRUMHELLER, AB**

Client: **CONSULTING AND AUDIT CANADA**

FRANZ ENVIRONMENTAL INC.
♦ CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Date: January 2006

Updated: Mar. 17, 2006

FIGURE 4

0979-0501/VR/MZ/Drumheller-SitePlan.dwg

ATTACHMENT B

TABLES

TABLE 1
FLUID LEVEL DATA AND WATERTABLE ELEVATIONS
SITE 530 L01 FORMER LANDFILL
DRUMHELLER INSTITUTION, DRUMHELLER ALBERTA

Monitoring Well	TOC Elevation (m)	Grade Elevation (m)	September 26, 2005 - Monitoring Event			November 3, 2005 Monitoring Event		
			Water Level (m)		Watertable Elevation	Water Level (m)		Watertable Elevation
			(wrt TOC)	(wrt grade)	(m)	(wrt TOC)	(wrt grade)	(m)
MW99-1	298.30	297.49	NA	NA	NA	Dry	Dry	Dry
MW99-2A	297.40	296.59	NA	NA	NA	9.90	9.10	287.50
MW99-2B	297.36	296.55	NA	NA	NA			
MW99-3	299.91	299.05	NA	NA	NA	8.50	7.64	291.41
MW99-4	299.88	299.07	NA	NA	NA	Dry	Dry	Dry
MW04-1	300.00	299.15	NA	NA	NA	Dry	Dry	Dry
MW04-2	299.98	299.14	NA	NA	NA	Dry	Dry	Dry
MW05-1	275.90	275.30	7.48	6.88	268.42	7.41	6.81	268.49
MW05-2	279.40	278.70	Dry	Dry	Dry	10.00	9.30	269.40
MW05-3	282.31	281.61	12.15	11.45	270.16	8.20	7.50	274.11

Notes:
1. All elevations referred to aribitrary datum - TOC for MW04-1 assigned an elevation of 300 m.
NA = Not available

TABLE 2
SOIL (BOREHOLE) CHEMICAL RESULTS - INORGANICS
SITE 530 L01 FORMER LANDFILL
DRUMHELLER INSTITUTION, DRUMHELLER ALBERTA
(expressed as mg/kg)

Parameter	CCME Guideline[1] R/P	MW05-1 S1 4.9-6.1 26-Sep-05	MW05-1 S2 6.1-6.4 26-Sep-05	MW05-1 S3 7.6-8.2 26-Sep-05	MW05-2 S1 2.4-3.7 26-Sep-05	MW05-2 S2 7.0-7.9 26-Sep-05	MW05-2 S3 10.1-10.7 26-Sep-05	MW05-3 S2 7.0-7.9 26-Sep-05	MW05-3 S3 7.9-8.8 26-Sep-05	MW05-3 S4 8.8-9.8 26-Sep-05
Ammonia	---	<0.09	0.07	0.1	0.1	<0.2	0.1	<0.1	<0.08	0.08
Bicarbonate	---	77	29	78	<13	66	76	<14	<16	<17
Carbonate	---	<18	<13	<14	<13	<34	<15	<14	<16	<17
Chloride	---	<4	<3	<3	3	<8	<4	<4	<4	<4
Hydroxide	---	<18	<13	<14	<13	<34	<15	<14	<16	<17
Nitrate	---	<0.2	<0.1	<0.1	<0.1	<0.3	<0.1	<0.1	<0.2	<0.2
Nitrite	---	<0.2	<0.1	<0.1	<0.1	<0.3	<0.1	<0.1	<0.2	<0.2
pH	6.0-8.0	**8.6**	**8.8**	**8.3**	**8.6**	**8.2**	7.9	8	8	**8.1**
Phosphate	---	0.04	0.04	0.03	0.13	<0.05	0.23	0.07	0.07	0.13
Saturation	---	88	66	68	64	169	73	70	82	84
Sulphate		112	49	213	472	343	112	176	141	349
TKN		1310	226	3200	1950	125	1600	558	475	614
Aluminum	---	9450	5400	7080	9150	4330	6420	8870	6870	7240
Antimony	20	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic	12	2.8	9.2	**12.4**	3.6	**22.3**	4	2.3	6.1	3.1
Barium	500	76.9	55.6	267	242	120	481	234	237	363
Beryllium	4	0.9	<0.7	1.7	0.9	<0.7	1.9	1.2	<0.7	<0.7
Boron	---	<2	<2	29	<2	<2	4	<2	2	<2
Cadmium	10	0.34	0.25	0.29	0.41	0.15	0.42	0.41	0.37	0.31
Calcium	---	7260	13800	7900	5990	11700	4260	2900	3810	6970
Chromium	64	14	14	9	14	11	11	14	13	15
Cobalt	50	13	13	12	13	15	9	10	14	12
Copper	63	29.9	15.3	14.5	28.8	10.9	23.3	21.8	19.3	16.3
Iron	---	12200	18000	6530	16100	16500	6210	9780	41200	21300
Lead	140	13	8	13	11	7	11	9	14	10
Lithium	---	9.2	5.8	6.1	8.3	4.5	8.3	7.3	7.5	6.5
Magnesium	---	4430	3660	1730	3220	1310	1330	2440	2220	2880
Manganese	---	381	685	40.4	541	537	132	307	1290	566
Mercury	6.6	0.072	0.026	0.244	0.096	<0.02	0.029	<0.02	<0.02	<0.02
Molybdenum	10	0.23	0.25	1.68	0.18	0.3	0.55	0.08	0.36	0.27
Nickel	50	32	32	23	40	40	17	23	34	30
Phosphorus	---	493	508	125	286	454	131	143	426	264
Potassium	---	1270	786	530	1160	711	777	1400	1120	1160
Selenium	1	<1	<1	**2**	<1	<1	1	<1	<1	<1
Silicon	---	535	581	2450	858	534	317	615	542	168
Silver	20	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Sodium	---	2710	2000	3390	2390	2920	5260	3670	3550	3720
Strontium	---	91.2	93	154	80.2	52.4	101	63	83	77.1
Sulphur	---	409	358	5950	436	423	1700	547	615	863
Thallium	1	0.15	0.1	**2.09**	0.23	0.16	0.29	0.29	0.22	0.17
Tin	50	<1	<1	<1	<1	<1	<1	<1	<1	<1
Titanium	---	6	6	216	11	6	19	8	13	14
Uranium	---	1.54	1.08	3.11	1.76	1.08	2.21	1.88	1.69	1.75
Vanadium	130	14.4	18	15.2	14.7	16.3	18.1	10.2	25	13.1
Zinc	200	90.3	84.9	45.9	66	65.3	46.8	56.6	81.1	67.5
Zirconium	---	0.9	0.2	90.9	0.6	0.5	38.4	0.4	2.7	0.5

Notes:
[1] = Canadian Council of Ministers of the Environment (CCME), Canadian Environmental Quality Guidelines (2004) - residential/parkland (R/P) soil guidelines.
--- = Not analysed or no guideline exists
BOLD Value exceeds residential/parkland guideline

TABLE 3
SOIL (SOIL PILES AND BURN AREA) CHEMICAL RESULTS - METALS
SITE 530 L01 FORMER LANDFILL
DRUMHELLER INSTITUTION, DRUMHELLER ALBERTA
(expressed as mg/kg)

Parameter	CCME Guideline[1] R/P	P1 29-Aug-05	P2 29-Aug-05	P3 29-Aug-05	P4 29-Aug-05	P5 29-Aug-05	P6 29-Aug-05
Aluminum	---	7,410	19,900	6,620	10,000	11,000	9,530
Antimony	20	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic	12	3	4.4	0	4.2	4.4	4.1
Barium	500	187	221	208	200	240	235
Beryllium	4	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
Boron	---	2	7	<2	4	3	2
Cadmium	10	0.28	0.29	0.34	0.26	0.28	0.3
Calcium	---	37,400	14,400	26,700	23,700	24,200	25,700
Chromium	64	15.7	27.1	15.4	19.4	30.1	26.6
Cobalt	50	7	9	8	9	8	8
Copper	63	15	20	15.4	20.8	20.4	19.4
Iron	---	14,000	21,200	2,110	18,300	19,300	17,700
Lead	140	4	13.3	6	10.3	10	10
Lithium	---	9.5	17.2	9.4	14.4	14.1	11.8
Magnesium	---	8,890	6,710	8,210	7,800	7,810	8,700
Manganese	---	400	420	413	457	475	399
Mercury	6.6	<0.02	<0.02	0.028	<0.02	0.021	0.034
Molybdenum	10	0.2	0.26	0.03	0.22	0.32	0.23
Nickel	50	21.2	23.9	22.7	25.9	28.7	25.8
Phosphorus	---	365	450	0	474	502	505
Potassium	---	1,170	2,940	978	1,370	1,500	1,250
Selenium	1	<1	<1	<1	<1	<1	<1
Silicon	---	595	1970	591	1120	666	602
Silver	20	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Sodium	---	352	955	949	2340	1370	1070
Strontium	---	62.7	49.7	61.5	68.6	67.8	65.3
Sulphur	---	206	333	687	2120	1870	982
Thallium	1	0.15	0.21	0.15	0.2	0.19	0.2
Tin	50	<1	<1	<1	<1	<1	<1
Titanium	---	8	44.1	5	17.8	13.1	14.9
Uranium	---	1.09	0.89	1.28	1.79	1.51	1.49
Vanadium	130	15.2	36.8	1.5	22	24	20.2
Zinc	200	55	71.7	65.7	66.2	72	74.4
Zirconium	---	<0.1	2.2	<0.1	0.5	2.4	0.9

Notes:
[1] = Canadian Council of Ministers of the Environment (CCME), Canadian Environmental Quality Guidelines (2004) - residential/parkland (R/P) soil guidelines.
--- = Not analysed or no guideline exists
BOLD Value exceeds residential/parkland guideline

TABLE 3
SOIL (SOIL PILES AND BURN AREA) CHEMICAL RESULTS - METALS
SITE 530 L01 FORMER LANDFILL
DRUMHELLER INSTITUTION, DRUMHELLER ALBERTA
(expressed as mg/kg)

Parameter	CCME Guideline[1] R/P	P7 29-Aug-05	P8 29-Aug-05	P9 29-Aug-05	P10 29-Aug-05	BURN1 29-Aug-05	BURN2 29-Aug-05
Aluminum	---	8,080	8,680	6,140	7,860	11,300	8,300
Antimony	20	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic	12	4.3	4.4	0	0	7.2	4.9
Barium	500	214	313	195	220	250	226
Beryllium	4	<0.7	<0.7	<0.7	0.9	0.9	0.7
Boron	---	3	4	<2	3	8	5
Cadmium	10	0.27	0.27	0.28	0.36	0.33	0.35
Calcium	---	25,400	25,000	25,600	25,600	23,500	20,700
Chromium	64	19.2	29.1	25.4	**66.1**	28.4	18
Cobalt	50	8	8	7	8	8	8
Copper	63	17.5	19.4	14.8	17.6	30.7	17
Iron	---	15,600	19,100	8,060	7,090	18,000	16,100
Lead	140	6	8	9	6	12.5	10.6
Lithium	---	10.3	11.3	8.6	9.4	9.4	7.5
Magnesium	---	7,760	7,670	7,210	6,980	7,540	5,970
Manganese	---	398	498	398	889	488	541
Mercury	6.6	0.029	0.023	0.026	0.022	<0.02	<0.02
Molybdenum	10	0.27	0.32	0.04	0.03	0.41	0.33
Nickel	50	21.9	28.3	25.5	47.5	24.8	23.2
Phosphorus	---	462	485	77	30	631	408
Potassium	---	1080	1210	882	1140	2180	1360
Selenium	1	<1	<1	<1	<1	<1	<1
Silicon	---	742	1020	585	589	713	793
Silver	20	<0.3	<0.3	<0.3	<0.30	<0.3	<0.3
Sodium	---	1180	786	935	583	735	563
Strontium	---	60.7	67.3	56.8	59.7	69.8	60.9
Sulphur	---	1340	721	1170	187	847	601
Thallium	1	0.17	0.18	0.14	0.12	0.19	0.14
Tin	50	<1	<1	<1	<1	<1	<1
Titanium	---	21	25	9	6	31.3	12.6
Uranium	---	1.38	1.4	1.28	0.92	1.2	1.34
Vanadium	130	18.8	20.3	3	1.4	25.1	17.8
Zinc	200	63.1	65.7	59.6	64.2	76.5	97
Zirconium	---	0.4	0.7	<0.1	<0.1	0.8	0.6

Notes:
[1] = Canadian Council of Ministers of the Environment (CCME), Canadian Environmental Quality Guidelines (2004) - residential/parkland (R/P) soil guidelines.
--- = Not analysed or no guideline exists
BOLD Value exceeds residential/parkland guideline

TABLE 4
SOIL (SOIL PILES AND BURN AREA) CHEMICAL RESULTS - BTEX AND HYDROCARBONS
SITE 530 L01 FORMER LANDFILL
DRUMHELLER INSTITUTION, DRUMHELLER ALBERTA
(expressed as mg/kg)

Parameter	Date	Benzene	Toluene	Ethylbenzene	Xylene	PHC F1	PHC F2	PHC F3	PHC F4
CCME[1] Guidelines R/P		0.0068	0.08	0.018	2.4	180	250	800	5600
P1	29-Aug-05	< 0.04	<0.04	<0.04	<0.08	<10	<9	<9	<9
P2	29-Aug-05	<0.04	<0.04	<0.04	<0.08	<10	<10	28	<10
P3	29-Aug-05	<0.04	<0.04	<0.04	<0.08	<10	<10	<10	<10
P4	29-Aug-05	<0.04	<0.04	<0.04	<0.08	<10	<10	<10	<10
P5	29-Aug-05	<0.04	<0.04	<0.04	<0.08	<10	<10	<10	<10
P6	29-Aug-05	<0.04	<0.04	<0.04	<0.08	<10	<9	<9	<9
P7	29-Aug-05	<0.04	<0.04	<0.04	<0.08	<10	<10	<10	<10
P8	29-Aug-05	<0.04	<0.04	<0.04	<0.08	<10	<10	355	41
P9	29-Aug-05	<0.04	<0.04	<0.04	<0.08	<10	<10	<10	<10
P10	29-Aug-05	<0.04	<0.04	<0.04	<0.08	<10	<10	<10	<10
BURN1	29-Aug-05	<0.04	<0.04	<0.04	<0.08	<10	<10	<10	<10
BURN2	29-Aug-05	**0.06**	**0.09**	<0.04	0.08	<10	<9	82.3	<9

Notes:
[1] = Canadian Council of Ministers of the Environment (CCME), Canadian Environmental Quality Guidelines (2004) - residential/parkland (R/P) soil guidelines.
--- = Not analysed or no guideline exists
PHC - Petroleum Hydrocarbons
BOLD Value exceeds residential/parkland guideline

Table 5
GROUNDWATER CHEMICAL RESULTS - INORGANICS
SITE 530 L01 FORMER LANDFILL
DRUMHELLER INSTITUTION, DRUMHELLER ALBERTA
(All concentrations expressed as mg/L, unless otherwise noted)

Station ID / Sampling Date / Parameter	CCME Guideline[1] Aquatic Life	MW99-3 29-Aug-05	MW99-3 29-Aug-05 Duplicate	MW05-1 Sept-26-05
pH (units)	5.0-9.0	7.52	---	8.3
Hardness ($CaCO_3$)	---	3400	---	170
Alkalinity (as total $CaCO_3$)	---	<0.5	---	776
Ammonia, Total (N)	---	0.88	0.68	0.7
Conductivity (uS/cm)	---	5880	---	2210
Chloride (Dissolved)	---	100	---	5.8
Nitrate (Dissolved)	13	**93.7**	---	0.081
Nitrite (Dissolved)	0.06	<0.003	---	0.006
Sulphate (Dissolved)	---	3070	---	432
Total Dissolved Solids (TDS)	---	5950	---	1450
Total Kkedahl Nitrogen (TKN)	---	4.63	4.91	13.6
Phosphate, Total (P)	---	0.078	0.075	2.1
Aluminum	0.005 - 0.1[P]	0.018	0.008	**1.23**
Antimony	---	<0.0002	<0.0002	<0.0002
Arsenic	0.005	0.0008	0.0008	0.001
Barium	---	0.0327	0.0315	0.0456
Beryllium	---	<0.0002	<0.0002	<0.0002
Boron	---	0.11	0.11	0.27
Cadmium	0.000017	<0.0002	<0.0002	<0.0002
Calcium	---	678	759	50.1
Chromium	0.0089	0.004	0.006	0.003
Cobalt	---	0.0006	0.0006	0.0012
Copper	0.002-0.004[H]	**0.0095**	**0.0096**	0.0024
Iron	0.3	0.17	**0.31**	**1.85**
Lead	0.001-0.007[H]	0.0006	<0.0003	0.0012
Lithium	---	0.467	0.426	0.198
Magnesium	---	285	301	9.7
Manganese	---	0.006	0.024	0.181
Mercury	0.000026	<0.00005	<0.00005	<0.00005
Molybdenum	0.073	0.0004	0.0004	0.0093
Nickel	0.025-0.15[H]	0.0084	0.0084	0.0043
Phosphorus	---	0.4	<0.1	0.2
Potassium	---	9.1	11.4	4.6
Selenium	0.001	**0.017**	**0.0372**	0.0003
Silicon	---	11.7	10.7	12.4
Silver	0.0001	<0.0001	<0.0001	<0.0001
Sodium	---	673	640	483
Strontium	---	5.64	5.18	0.67
Sulphur	---	1060	982	129
Thallium	0.0008	<0.0002	<0.0002	<0.0002
Tin	---	<0.0001	<0.0001	<0.0001
Titanium	---	<0.0001	0.0005	0.042
Uranium	---	0.189	0.185	0.0015
Vanadium	---	0.005	0.008	0.002
Zinc	0.03	0.009	0.0111	0.0084
Zirconium	---	0.0014	0.0014	0.0035

Notes:
--- = Not analysed or no guideline exists
[P] = guideline is pH dependant
[H] = guideline is hardness dependant
[1] = Canadian Council of Ministers of the Environment (CCME), Canadian Environmental Quality Guidelines (2004) - Chapters 4 Freshwater Aquatic Life (FAL) guidelines.
BOLD = value exceeds or does not comply with FAL Guideline

TABLE 6
SURFACE WATER CHEMICAL RESULTS - INORGANICS
SITE 530 L01 FORMER LANDFILL
DRUMHELLER INSTITUTION, DRUMHELLER ALBERTA
(All concentrations expressed as mg/L, unless otherwise noted)

Station ID / Sampling Date / Parameter	CCME Guideline[1] Aquatic Life	CREEK A	CREEK B	CREEK C	SEEP 1A	SEEP 1B
		29-Aug-05	29-Aug-05	29-Aug-05	29-Aug-05	29-Aug-05
Indicator Parameters						
pH	6.5-9.0	8.66	8.44	8.61	8.2	8.24
Hardness	---	140	200	200	410	260
Alkalinity (Total as CaCO3)	---	40.3	16.4	32.6	<0.5	<0.5
Ammonia, Total (N)	---	0.05	0.06	0.02	0.04	0.01
Conductivity (uS/cm)	---	1750	1840	1840	1710	1870
Chloride (Dissolved)	---	6.1	5.5	5.1	4.3	3.9
Nitrate (Dissolved)	---	0.011	0.016	0.007	0.005	0.049
Nitrite (Dissolved)	---	<0.003	<0.003	<0.003	0.004	0.027
Sulphate (Dissolved)	---	248	350	355	359	399
Total Dissolved Solids (TDS)	---	1150	1220	1220	1140	1210
Total Kkedahl Nitrogen (TKN)	---	0.49	1.98	1.81	0.42	1.81
Phosphate, Total (P)	---	0.079	0.48	0.305	0.044	0.525
Total Suspended Solids (TSS)	---	95.6	51	1010	N/A	N/A
Total Metals						
Aluminum	0.005 - 0.1[P]	**1.15**	**9.7**	**17.5**	**0.432**	**6.75**
Antimony	---	0.0004	0.0004	0.0004	<0.0002	0.0003
Arsenic	0.005	**0.0064**	**0.0091**	**0.0112**	0.0035	**0.0076**
Barium	---	0.0848	0.204	0.31	0.0922	0.164
Beryllium	---	<0.0002	0.0006	0.0012	<0.0002	0.0005
Boron	---	0.21	0.29	0.27	0.2	0.29
Cadmium	0.000017	<0.0002	**0.0006**	**0.001**	<0.0002	**0.0005**
Calcium	---	49.1	69.3	78.2	116	148
Chromium	0.0089	0.006	**0.014**	**0.02**	0.006	**0.011**
Cobalt	---	0.0013	0.0061	0.0084	0.0024	0.0059
Copper	0.002-0.004[H]	**0.0057**	**0.0167**	**0.0276**	0.0036	**0.0124**
Iron	0.3	**1.31**	**10.4**	**17.1**	**1.27**	**11.3**
Lead	0.001-0.007[H]	0.0007	**0.0075**	**0.0152**	0.0004	0.0056
Lithium	---	0.114	0.152	0.157	0.143	0.16
Magnesium	---	21	27	292	37	318
Manganese	---	0.028	0.325	0.492	0.899	0.941
Mercury	0.000026	**0.00006**	**0.00014**	**0.00018**	<0.00005	<0.00005
Molybdenum	0.073	0.0023	0.0023	0.0019	0.0009	0.0015
Nickel	0.025-0.15[H]	0.0111	0.0275	0.0374	0.0175	0.031
Phosphorus	---	0.3	0.3	0.4	<0.1	0.5
Potassium	---	8.6	10.1	11.6	6.5	6.8
Selenium	0.001	0.0002	0.0003	0.0004	<0.0002	0.0002
Silicon	---	9.47	24.9	50.4	9.64	19.8
Silver	0.0001	<0.0001	<0.0001	**0.0002**	<0.0001	<0.0001
Sodium	---	0.328	0.256	0.338	0.268	0.354
Strontium	---	0.5	0.72	0.78	0.96	1.05
Sulphur	---	81.7	122	120	123	148
Thallium	0.0008	<0.0002	0.0002	<0.0002	<0.0002	<0.0002
Tin	---	<0.001	<0.001	<0.001	<0.001	<0.001
Titanium	---	0.025	0.153	0.204	0.019	0.121
Uranium	---	0.0054	0.0088	0.0097	0.0033	0.01
Vanadium	---	0.006	0.019	0.033	0.001	0.013
Zinc	0.03	0.0159	**0.0518**	**0.0742**	0.0127	**0.0472**
Zirconium	---	0.0033	0.0059	0.0067	0.0011	0.0037
Dissolved Metals						
Calcium	---	33.2	50.6	49.6	108	67.6
Iron	0.3	0.03	0.07	0.02	0.01	0.02
Magnesium	---	14.1	18.2	18.7	34.2	22.5
Manganese	---	<0.004	0.065	0.018	0.8	0.084
Potassium	---	6.6	5.4	5.6	5.4	4.8
Sodium	---	385	386	373	245	325

Notes:
--- = Not analysed or no guideline exists
[P] = guideline is pH dependant
[H] = guideline is hardness dependant
[1] = Canadian Council of Ministers of the Environment (CCME), Canadian Environmental Quality Guidelines (2004) - Chapters 4 Freshwater Aquatic Life (FAL) guidelines.
BOLD = value exceeds or does not comply with FAL Guideline

TABLE 7
SEDIMENT CHEMICAL RESULTS - METALS
SITE 530-L01 FORMER LANDFILL
DRUMHELLER INSTITUTION, DRUMHELLER ALBERTA
(All Concentrations expressed as mg/kg)

Parameter	CCME Guideline[1] Sediment (ISQG)	Creek A 28-Aug-05	Creek B 28-Aug-05	Creek C 28-Aug-05
Aluminum	---	6910	3290	4150
Antimony	---	<0.1	<0.1	<0.1
Arsenic	5.9	4.6	3.5	3.3
Barium	---	281	262	287
Beryllium	---	0.9	<0.7	0.8
Boron	---	3	3	4
Cadmium	0.6	0.36	0.17	0.36
Calcium	---	8630	14100	12200
Chromium	37.3	15	7	13
Cobalt	---	8	4	6
Copper	35.7	21.2	8.3	15.5
Iron	---	9400	6970	41700
Lead	35	10	5	11
Lithium	---	6.6	3.9	3.9
Magnesium	---	3290	4230	2540
Manganese	---	253	242	2280
Mercury	0.17	0.046	<0.02	0.046
Molybdenum	---	0.15	0.22	0.31
Nickel	---	25	12	20
Phosphorus	---	273	405	509
Potassium	---	975	500	490
Selenium	---	<1	<1	<1
Silicon	---	2730	487	623
Silver	---	<0.3	<0.3	<0.3
Sodium	---	2660	593	1120
Strontium	---	69.3	40.4	82.1
Sulphur	---	482	436	483
Thallium	---	0.18	0.1	0.11
Tin	---	<1	<1	<1
Titanium	---	4	42	10
Uranium	---	1.81	0.88	1.57
Vanadium	---	12.2	9.7	17.9
Zinc	123	55.2	33.1	50.7
Zirconium	---	0.7	3.4	1.5

Notes:
--- = Not analysed or no guideline exists
[1] = Canadian Council of Ministers of the Environment (CCME), Canadian Environmental Quality Guidelines (2004) - Sediment Quality Guidelines (ISQG)
BOLD Value exceeds ISQG

APPENDIX A

BOREHOLE LOGS

Project No: 0979-0501
Project: Supplemental Phase II Investigation
Location: Site 530 - L01, Former Landfill, Drumheller Institution, AB
Date Drilled: 26 September 2005
Stick Up: 0.60 m
TOC Elevation: 275.9 m
Water Level Elevation: 268.49 m (3 November 2005)
Water Level: 7.41 mbtoc (3 November 2005)

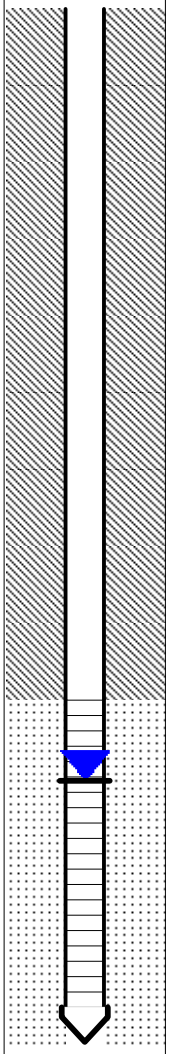
WELL ID: MW05-1

Bottom of Well Depth: 9.70 mbtoc
Drilled By: Enviro Core Sampling Ltd.
Drilling Method: Geoprobe Direct-push
Logged By: D. Thomson
Log Prepared By: R. Jerez
Checked By: V. Ramcharan

Depth (m)	Symbol	Description	Elevation (m)	Sample ID	Well Material	Well Installation Diagram	Well Construction Details
0		Ground Surface	275.3				
		Fill silty clay and pebbles, and garbage	273.776				
1							
		Silty Clay Gypsum crystals in fractures and root holes	272.557				
2							
		Clay Dry and fractured. Rust colour in fractures	271.642				
3							
		not logged; soil jammed in sample tube	270.423				
4							
		Mudstone Grey, dry and fractured	269.204	05-1 S1 16-20'			
5							
		Sandstone and Mudstone Interbedded with fine grained grey sandstone, and dark grey mudstone, slightly moist	268.594	05-1 S2 20-21'			
6							
		Sandstone grey, fine grained, slightly moist. Chert nodule at 7.0 mbgs	267.528				
7							
		Mudstone Carbonaceous, light brown, dry					
8							
		Coal Fractured, interbedded with carbonaceous mudstone and shale, wet	266.156	05-1 S3 25-27'			
9							
		End of Borehole					
10							

3.8-cm Sch. 40 Threaded PVC Riser

3.8-cm Sch. 40 Slotted PVC Screen (250 µm)



Bentonite

Seal

Sand

Backfill

Note: Any decisions/actions made by a third party based on this log are the sole responsibility of the third party. Franz Environmental Inc. accepts no liability for third party decisions/actions made based on this log.

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FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES

Project No: 0979-0501
Project: Supplemental Phase II Investigation
Location: Site 530 - L01, Former Landfill, Drumheller Institution, AB
Date Drilled: 26 September 2005
Stick Up: 0.70 m
TOC Elevation: 279.40 m
Water Level Elevation: 269.40 m (3 November 2005)
Water Level: 10.00 mbtoc (3 November 2005)

WELL ID: MW05-2

Bottom of Well Depth: 11.05 mbtoc
Drilled By: Enviro Core Sampling Ltd.
Drilling Method: Geoprobe Direct-push
Logged By: D. Thomson
Log Prepared By: R. Jerez
Checked By: V. Ramcharan

Depth (m)	Symbol	Description	Elevation (m)	Sample ID	Well Material	Well Installation Diagram	Well Construction Details
0		Ground Surface	278.7				
		Silty Clay Light brown, dry, gypsum crystals in fractures and root holes.	276.871				
1							
2		***Clayey Silt*** Rust cloured, slightly moist	276.262				
		Clay Rust coloured, dry to moist, fractured and friable, trace of coal		05-2 S1 8-12'	3.8-cm Sch. 40 Threaded PVC Riser		Bentonite Seal
3							
4							
5			273.518				
		Water at 5.2 m	272.756				
6		***Shale*** Carbonaceous, dark brown, slightly moist	272.299				
		Sandstone grey, fine grained, slightly moist. Rust coloured bands		05-2 S2 23-26'	3.8-cm Sch. 40 Slotted PVC Screen (250 µm)		Sand Backfill
7							
8			270.166				
		Shale Carbonaceous, weathered, moist					
9							
10			268.489				
		Coal Wet		05-2 S3 33-35'			
		Shale Carbonaceous, moist	267.727				
11		End of Borehole					

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FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES

Project No: 0979-0501
Project: Supplemental Phase II Investigation
Location: Site 530 - L01, Former Landfill, Drumheller Institution, AB
Date Drilled: 26 September 2005
Stick Up: 0.70 m
TOC Elevation: 282.31 m
Water Level Elevation: 274.11 m (3 November 2005)
Water Level: 8.2 mbtoc (3 November 2005)

WELL ID: MW05-3

Bottom of Well Depth: 12.20 mtboc
Drilled By: Enviro Core Sampling Ltd.
Drilling Method: Geoprobe Direct-push
Logged By: D. Thomson
Log Prepared By: R. Jerez
Checked By: V. Ramcharan

Depth (m)	Symbol	Description	Elevation (m)	Sample ID	Well Material	Well Installation Diagram	Well Construction Details
0		Ground Surface	281.61				
		Sand Fine grained, light brown, dry, some silt.			3.8-cm Sch. 40 Threaded PVC Riser		Bentonite Seal
5		***Clay***	276.733 / 276.428				
		Sand Grey with some rust coloured layers, moist.					
7				05-3 S2 23-26'			
8		***Mudstone***	273.685				
		Clayey Sand Rust coloured, wet.		05-3 S3 26-29'	3.8-cm Sch. 40 Slotted PVC Screen (250 µm)		Sand Backfill
9				05-3 S4 29-32'			
10		***Shale*** Carbonaceous	271.856 / 271.552				
		Sandstone Grey with rust coloured layers. Moist to wet					
11		***Clay*** Blue grey	270.332 / 270.104				
12		End of Borehole					

Note: Any decisions/actions made by a third party based on this log are the sole responsibility of the third party. Franz Environmental Inc. accepts no liability for third party decisions/actions made based on this log.

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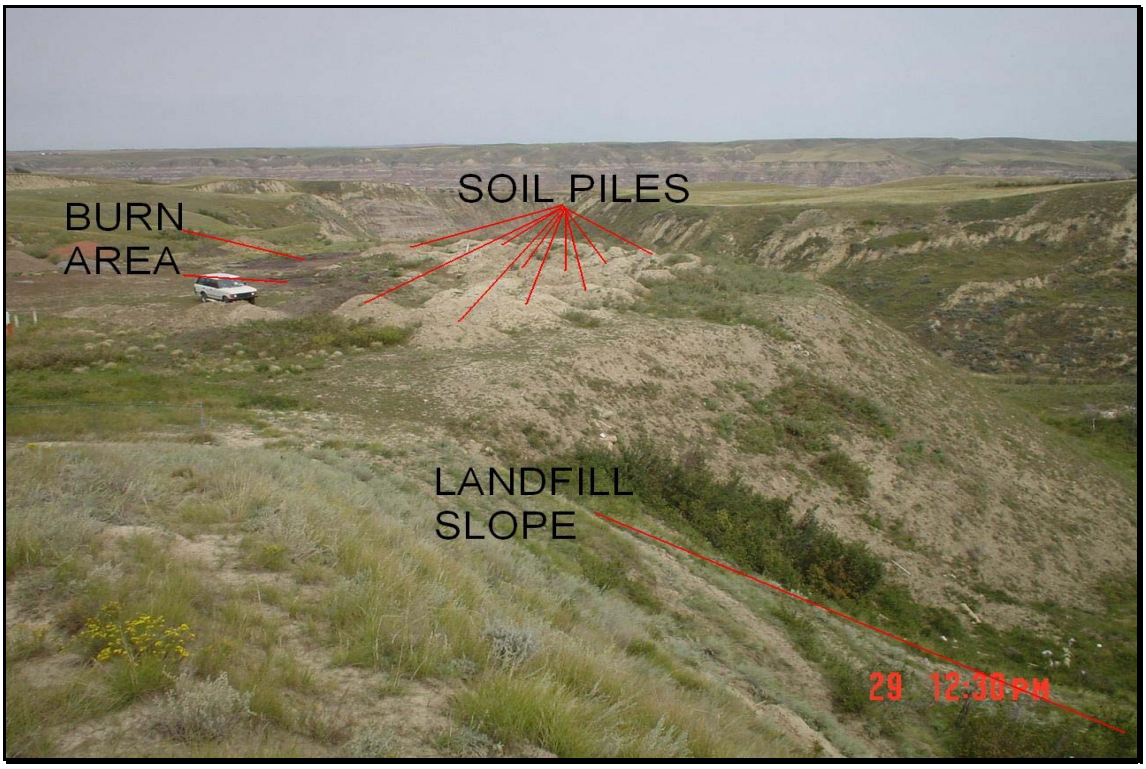
APPENDIX B

SITE PHOTOGRAPHS



Photograph 1 – Site Overview

Photograph 2 – View after sloping work at landfill.

Photograph 3 – Burn areas.

Photograph 4 – Soil Piles on top of the landfill.

Photograph 5 – Creek east of landfill, looking west.

Photograph 6 - Looking down the landfill slope.

Photograph 7 – Visible erosion of landfill slope.

Photograph 8 - Seep on east side of landfill. Note iron staining in water.

Photograph 9 - Truck-mounted direct push unit used for borehole drilling.

Photograph 10 – Drilling of borehole 05-3

Photograph 11 – Monitoring well 05-2.

Photograph 12 – Seep location.

Photograph 13 – Surface water sample from Seep 1B.

Photograph 14 – Surface water sample Creek C.

APPENDIX C

CERTIFICATES OF CHEMICAL ANALYSES

Maxxam Analytics Inc

Attention: DAVID THOMSON
FRANZ ENVIRONMENTAL INC.
6731 SILVERVIEW ROAD NW
CALGARY, AB T3B 3L5

Report Date: 2005/10/06
Invoice #: C137747

Your Project #: 979-0501, DRUMHELLER
Site: DRUMHELLER

ANALYTICAL REPORT

MAXXAM JOB #: A539430, Received: 2005/09/27, 11:00

Sample Matrix: Soil, # Samples Received: 9

Analyses	Number of Tests	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
3050 Acid Digestion	9	2005/09/29	2005/09/29	CAL SOP# 1119, E1060R7	
Carbonate and Bicarbonate (Soluble)	9	N/A	2005/09/30	CAL SOP# 0022	TITRATION
Chloride (soluble)	9	N/A	2005/09/30	CAL SOP-0016 CALSOP-0186	Ion Chromatography
Drying and Grinding	9	N/A	2005/09/28	CAL SOP# 0015	
Environmental Sample Disposal Fee	9	2005/09/29	2005/09/29		
Mercury	9	N/A	2005/09/30	CAL SOP# 0125	CVAA
Elements by ICPMS	9	N/A	2005/09/29	CAL SOP# 0068	EPA 3050/ICP-MS
ICP Scan - Full	9	N/A	2005/09/30	CAL SOP# 0068	EPA 3050/ICP
Ammonia-N (Soluble)	9	N/A	2005/09/30	CAL SOP# 0104	COLORIMETRIC
Nitrite-N (Soluble)	9	N/A	2005/09/30	CAL SOP# 0090, CAL SOP#0016	IC-EXTRACTION
Nitrate-N (Soluble)	9	N/A	2005/09/30	CAL SOP# 0090, CAL SOP#0016	IC-EXTRACTION
pH (Soluble)	9	N/A	2005/09/30	CAL SOP# 0017	PHELE
Phosphate-P (Soluble)	9	N/A	2005/09/30	CAL SOP-0016, CAL SOP# 0109,	Extr'n/Colorimetric
Ca,Mg,Na,K,SO4 (Soluble)	9	N/A	2005/09/30	CAL SOP# 0068, CAL SOP#0016	ICP-EXTRACTION
Soluble Paste	9	N/A	2005/09/30	CAL SOP# 0016	EXTRACTION
Total Kjeldahl Nitrogen	9	N/A	2005/09/29	CAL SOP-0198	Colorimetric

../2

Maxxam Analytics Inc

Invoice #: C137747

Sample Matrix: Water, # Samples Received: 1

Analyses	Number of Tests	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity, carbonate and bicarbonate	1	N/A	2005/09/28	CAL SOP-0071, EDM SOP-0027	Titration
Chloride (IC)	1	N/A	2005/09/29	CAL SOP# 0089	
Environmental Sample Disposal Fee	1	2005/09/28	2005/09/28		
Conductivity	1	N/A	2005/09/28	CAL SOP-0073, CAL SOP-0071, EDM SOP-0029	Electrode
Hardness	1	N/A	2005/09/28	CAL WI# 000013	
Mercury (Dissolved)	1	N/A	2005/09/29	CAL SOP# 0070	CVAA
Arsenic by Hydride AA - Dissolved	1	2005/09/30	2005/09/30	CAL SOP# 0067	
Antimony by Hydride AA (Dissolved)	1	N/A	2005/09/30	CAL SOP# 0067	AA
Selenium by Hydride AA -Dissolved	1	2005/09/30	2005/09/30	SOP-0067	
ICP Scan - Dissolved	1	N/A	2005/09/29	CAL SOP# 0068	ICP
Elements by ICPMS - Dissolved	1	N/A	2005/09/30	CAL SOP# 0068	ICP-MS
Ion Balance	1	N/A	2005/09/28	CAL WI# 0013	
Sum of cations, anions	1	N/A	2005/09/28	CAL WI# 0013	
Ammonia-N	1	N/A	2005/09/28	CAL SOP-0104, EDM SOP-0040	Colorimetric
Nitrate + Nitrite-N (calculated)	1	2005/09/28	2005/09/28	CAL WI# 0013	
Nitrogen, (Nitrite, Nitrate) by IC	1	N/A	2005/09/29	CAL SOP# 0090,	IC
pH (Alkalinity titrator)	1	N/A	2005/09/28	CAL SOP-0071, EDM SOP-0028, EDM SOP-0166	Titrator
Sulphate (SO4)	1	N/A	2005/09/29	CAL SOP# 0089	IC
Total Dissolved Solids (Calculated)	1	N/A	2005/09/28	CAL SOP-0086, EDM SOP-0037	Calculation
Total Kjeldahl Nitrogen	1	N/A	2005/09/29	CAL SOP-0105, EDM SOP-0041	Colorimetric
Phosphate-P (Total)	1	N/A	2005/09/29	CAL SOP-0197	Colorimetric

UNIT CONVERSION FOR SOIL ANALYSIS

MAXXAM Analytics Inc.

RON VENZI

RV1/sg
encl.

Maxxam Analytics Inc

Maxxam Job#: A539430
Report Date: 2005/12/14

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: DCJ

RESULTS OF CHEMICAL ANALYSES OF SOIL

Maxxam ID		934288	934311	934288	934288	934288	934288	934288	934288	934288
Sampling Date		2005/09/26	2005/09/26	2005/09/26	2005/09/26	2005/09/26	2005/09/26	2005/09/26	2005/09/26	2005/09/26
COC Number		67064	67064	67064	67064	67064	67064	67064	67064	67064
Parameters	**Units**	05-1 S1 @ 16-20'	05-1 S2 @ 20-21'	05-1 S3 @ 25-27'	05-2 S1 @ 8-12'	05-2 S2 @ 23-26'	05-2 S3 @ 33-35'	05-3 S2 @ 23-26'	05-3 S1 @ 26-29'	05-3 S4 @ 29-32'
Soluble Ammonia (N)	mg/kg	<0.09	0.07	0.1	0.1	<0.2	0.1	<0.1	<0.08	0.08
Soluble Bicarbonate (HCO3)	mg/kg	77	29	78	<13	66	76	<14	<16	<17
Soluble Carbonate (CO3)	mg/kg	<18	<13	<14	<13	<34	<15	<14	<16	<17
Soluble Chloride (Cl)	mg/kg	<4	<3	<3	3	<8	<4	<4	<4	<4
Soluble Hydroxide (OH)	mg/kg	<18	<13	<14	<13	<34	<15	<14	<16	<17
Soluble Nitrate (N)	mg/kg	<0.2	<0.1	<0.1	<0.1	<0.3	<0.1	<0.1	<0.2	<0.2
Soluble Nitrite (N)	mg/kg	<0.2	<0.1	<0.1	<0.1	<0.3	<0.1	<0.1	<0.2	<0.2
Soluble Phosphate (P)	mg/kg	0.04	0.04	0.03	0.13	<0.05	0.23	0.07	0.07	0.13
Soluble Sulphate (SO4)	mg/kg	112	49	213	472	343	112	176	141	349
Saturation %	%	88	66	68	64	169	73	70	82	84

Maxxam Analytics Inc

Your Project #: 979-0501, DRUMHELLER
Site: DRUMHELLER
Your C.O.C. #: 125183

Attention: ANDREW HOWTON
FRANZ ENVIRONMENTAL INC.
6731 SILVERVIEW ROAD NW
CALGARY, AB
T3B 3L5

Report Date: 2006/01/17

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: A534894
Received: 2005/08/30, 14:30

Sample Matrix: Soil
Samples Received: 15

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
BTEX (MSD)	12	2005/09/08	2005/09/08	CAL SOP# 0048	GC/MS-PURGE & TRAI
Chloride (soluble)	3	N/A	2005/09/13	CAL SOP-0016 CALSOP-0186	Ion Chromatography
CCME Hydrocarbons (F2-F4 in soil)	12	2005/09/08	2005/09/08		CCME PHC-CWS
CCME Hydrocarbons-SilicaGel (F4 in soil)	12	2005/09/08	2005/09/08	CAL SOP 0065	BASED ON CCME (AM
Mercury	10	N/A	2005/09/06	CAL SOP# 0125	CVAA
Mercury	3	N/A	2005/09/12	CAL SOP# 0125	CVAA
Mercury	2	N/A	2005/09/13	CAL SOP# 0125	CVAA
Elements by ICPMS	10	N/A	2005/09/07	CAL SOP# 0068	EPA 3050/ICP-MS
Elements by ICPMS	2	N/A	2005/09/09	CAL SOP# 0068	EPA 3050/ICP-MS
Elements by ICPMS	3	N/A	2005/09/13	CAL SOP# 0068	EPA 3050/ICP-MS
ICP Scan - Full	10	N/A	2005/09/06	CAL SOP# 0068	EPA 3050/ICP
ICP Scan - Full	5	N/A	2005/09/12	CAL SOP# 0068	EPA 3050/ICP
Moisture (ccme)	12	2005/09/13	2005/09/13	CAL SOP# 0028	GRAVIMETRIC
Ammonia-N (Soluble)	3	N/A	2005/09/13	CAL SOP# 0104	COLORIMETRIC
Nitrite-N (Soluble)	3	N/A	2005/09/13	CAL SOP# 0090, CAL SOP#0016	IC-EXTRACTION
Nitrate-N (Soluble)	3	N/A	2005/09/13	CAL SOP# 0090, CAL SOP#0016	IC-EXTRACTION
F1 (CCME Hydrocarbons C6-C10)	12	2005/09/07	2005/09/09	CAL SOP# 0066	CCME
pH (Soluble)	3	N/A	2005/09/13	CAL SOP# 0017	PHELE
Phosphate-P (Soluble)	3	N/A	2005/09/13	CAL SOP-0016, CAL SOP# 0109,	Extr'n/Colorimetric
Ca,Mg,Na,K,SO4 (Soluble)	3	N/A	2005/09/13	CAL SOP# 0068, CAL SOP#0016	ICP-EXTRACTION
Soluble Paste	3	N/A	2005/09/13	CAL SOP# 0016	EXTRACTION
Total Kjeldahl Nitrogen	3	N/A	2005/09/13	CAL SOP-0198	Colorimetric

Sample Matrix: Water
Samples Received: 7

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity, carbonate and bicarbonate	6	N/A	2005/09/08	CAL SOP-0071, EDM SOP-0027	Titration

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Maxxam Analytics Inc

Your Project #: 979-0501, DRUMHELLER
Site: DRUMHELLER
Your C.O.C. #: 125183

Attention: ANDREW HOWTON
FRANZ ENVIRONMENTAL INC.
6731 SILVERVIEW ROAD NW
CALGARY, AB
T3B 3L5

Report Date: 2006/01/17

CERTIFICATE OF ANALYSIS

Sample Matrix: Water
Samples Received: 7

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Chloride (IC)	6	N/A	2005/09/12	CAL SOP# 0089	
Conductivity	6	N/A	2005/09/08	CAL SOP-0073, CAL SOP-0071, EDM SOP-0029	Electrode
Hardness	6	N/A	2005/09/08	CAL WI# 000013	
Mercury (Dissolved)	2	N/A	2005/09/02	CAL SOP# 0070	CVAA
Mercury (Total)	5	N/A	2005/09/02	CAL SOP# 0070	CVAA
Arsenic by Hydride AA - Dissolved	2	2005/09/02	2005/09/02	CAL SOP# 0067	
Arsenic by Hydride AA - Total	5	2005/09/02	2005/09/02	CAL SOP# 0067	
Antimony by Hydride AA (Dissolved)	2	N/A	2005/09/02	CAL SOP# 0067	AA
Antimony by Hydride AA (Total)	5	N/A	2005/09/02	CAL SOP# 0067	
Selenium by Hydride AA -Dissolved	2	2005/09/02	2005/09/02	SOP-0067	
Selenium by Hydride AA - Total	5	2005/09/02	2005/09/02	SOP-0067	
ICP Scan - Dissolved	2	N/A	2005/09/06	CAL SOP# 0068	ICP
Elements by ICPMS - Dissolved	2	N/A	2005/09/06	CAL SOP# 0068	ICP-MS
Elements by ICPMS - Total	5	N/A	2005/09/02	CAL SOP# 0068	EPA3005/ICP-MS
ICP Scan - Full, total	5	N/A	2005/09/06	CAL SOP# 0068	EPA 3005/ICP
Ion Balance	6	N/A	2005/09/08	CAL WI# 0013	
Ammonia-N	7	N/A	2005/09/06	CAL SOP-0104, EDM SOP-0040	Colorimetric
Nitrate + Nitrite-N (calculated)	6	2005/09/09	2005/09/09	CAL WI# 0013	
Nitrogen, (Nitrite, Nitrate) by IC	6	N/A	2005/09/09	CAL SOP# 0090,	IC
pH (Alkalinity titrator)	6	N/A	2005/09/08	CAL SOP-0071, EDM SOP-0028, EDM SOP-0166	Titrator
Metals by ICP, Major cations, Fe and Mn	6	N/A	2005/09/09	CAL SOP# 0068,EDM SOP# 0025	ICP
Sulphate (SO4)	6	N/A	2005/09/12	CAL SOP# 0089	IC
Total Dissolved Solids (Calculated)	6	N/A	2005/09/08	CAL SOP-0086, EDM SOP-0037	Calculation
Total Kjeldahl Nitrogen	7	N/A	2005/09/06	CAL SOP-0105, EDM SOP-0041	Colorimetric
Phosphate-P (Total)	7	N/A	2005/09/07	CAL SOP-0197	Colorimetric
Total Suspended Solids (NFR)	3	N/A	2005/09/09	CAL SOP-0088, EDM SOP-0039	Gravimetric

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Maxxam Analytics Inc

Your Project #: 979-0501, DRUMHELLER
Site: DRUMHELLER
Your C.O.C. #: 125183

Attention: ANDREW HOWTON
FRANZ ENVIRONMENTAL INC.
6731 SILVERVIEW ROAD NW
CALGARY, AB
T3B 3L5

Report Date: 2006/01/17

CERTIFICATE OF ANALYSIS

-3-

Validated by : _____
LILI ZHOU

Total cover pages: 3

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

CCMEHC MECHANICAL EXTRACTION LESS SIEVE (SOIL)

Maxxam ID		908274		908276		
Sampling Date		2005/08/29		2005/08/29		
COC Number		125183		125183		
	Units	**P1**	**RDL**	**P2**	**RDL**	**QC Batch**
Physical Properties						
Moisture	%	15	1	24	1	892772
Ext. Pet. Hydrocarbon						
F2 (C10-C16 Hydrocarbons)	mg/kg	<9	9	<10	10	888756
F3 (C16-C34 Hydrocarbons)	mg/kg	<9	9	28	10	888756
F4 (C34-C50 Hydrocarbons)	mg/kg	<9	9	<10	10	888756
Reached Baseline at C50	mg/kg	YES	N/A	YES	N/A	888756
OIL & GREASE						
F4SG (Heavy Hydrocarbons-SilicaGel)	mg/kg	<500	500	<500	500	888758
Ext. Pet. Hydrocarbon						
F1 (C06-C10) - BTEX	mg/kg	<13	13	<15	15	888076
Volatiles						
Purgeable (MeOH) Benzene	mg/kg	<0.038	0.038	<0.043	0.043	888075
Purgeable (MeOH) Toluene	mg/kg	<0.038	0.038	<0.043	0.043	888075
Purgeable (MeOH) Ethylbenzene	mg/kg	<0.038	0.038	<0.043	0.043	888075
Purgeable (MeOH) m & p-Xylene	mg/kg	<0.076	0.076	<0.086	0.086	888075
Purgeable (MeOH) o-Xylene	mg/kg	<0.038	0.038	<0.043	0.043	888075
Purgeable (MeOH) Xylenes (Total)	mg/kg	<0.076	0.076	<0.086	0.086	888075
Surrogate Recovery (%)						
Purgeable (MeOH) D8-TOLUENE (sur.)	%	102	N/A	101	N/A	888075

N/A = Not Applicable
RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

CCMEHC MECHANICAL EXTRACTION LESS SIEVE (SOIL)

Maxxam ID		908277		908278		
Sampling Date		2005/08/29		2005/08/29		
COC Number		125183		125183		
	Units	**P3**	**RDL**	**P4**	**RDL**	**QC Batch**
Physical Properties						
Moisture	%	17	1	21	1	892772
Ext. Pet. Hydrocarbon						
F2 (C10-C16 Hydrocarbons)	mg/kg	<10	10	<10	10	888756
F3 (C16-C34 Hydrocarbons)	mg/kg	<10	10	<10	10	888756
F4 (C34-C50 Hydrocarbons)	mg/kg	<10	10	<10	10	888756
Reached Baseline at C50	mg/kg	YES	N/A	YES	N/A	888756
OIL & GREASE						
F4SG (Heavy Hydrocarbons-SilicaGel)	mg/kg	<500	500	<500	500	888758
Ext. Pet. Hydrocarbon						
F1 (C06-C10) - BTEX	mg/kg	<14	14	<15	15	888076
Volatiles						
Purgeable (MeOH) Benzene	mg/kg	<0.041	0.041	<0.043	0.043	888075
Purgeable (MeOH) Toluene	mg/kg	<0.041	0.041	<0.043	0.043	888075
Purgeable (MeOH) Ethylbenzene	mg/kg	<0.041	0.041	<0.043	0.043	888075
Purgeable (MeOH) m & p-Xylene	mg/kg	<0.082	0.082	<0.087	0.087	888075
Purgeable (MeOH) o-Xylene	mg/kg	<0.041	0.041	<0.043	0.043	888075
Purgeable (MeOH) Xylenes (Total)	mg/kg	<0.082	0.082	<0.087	0.087	888075
Surrogate Recovery (%)						
Purgeable (MeOH) D8-TOLUENE (sur.)	%	101	N/A	102	N/A	888075

N/A = Not Applicable
RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

CCMEHC MECHANICAL EXTRACTION LESS SIEVE (SOIL)

Maxxam ID		908280		908281		
Sampling Date		2005/08/29		2005/08/29		
COC Number		125183		125183		
	Units	**P5**	**RDL**	**P6**	**RDL**	**QC Batch**
Physical Properties						
Moisture	%	20	1	13	1	892772
Ext. Pet. Hydrocarbon						
F2 (C10-C16 Hydrocarbons)	mg/kg	<10	10	<9	9	888756
F3 (C16-C34 Hydrocarbons)	mg/kg	<10	10	<9	9	888756
F4 (C34-C50 Hydrocarbons)	mg/kg	<10	10	<9	9	888756
Reached Baseline at C50	mg/kg	YES	N/A	YES	N/A	888756
OIL & GREASE						
F4SG (Heavy Hydrocarbons-SilicaGel)	mg/kg	<500	500	<500	500	888758
Ext. Pet. Hydrocarbon						
F1 (C06-C10) - BTEX	mg/kg	<14	14	<13	13	888076
Volatiles						
Purgeable (MeOH) Benzene	mg/kg	<0.042	0.042	<0.037	0.037	888075
Purgeable (MeOH) Toluene	mg/kg	<0.042	0.042	<0.037	0.037	888075
Purgeable (MeOH) Ethylbenzene	mg/kg	<0.042	0.042	<0.037	0.037	888075
Purgeable (MeOH) m & p-Xylene	mg/kg	<0.085	0.085	<0.074	0.074	888075
Purgeable (MeOH) o-Xylene	mg/kg	<0.042	0.042	<0.037	0.037	888075
Purgeable (MeOH) Xylenes (Total)	mg/kg	<0.085	0.085	<0.074	0.074	888075
Surrogate Recovery (%)						
Purgeable (MeOH) D8-TOLUENE (sur.)	%	101	N/A	103	N/A	888075

N/A = Not Applicable
RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

CCMEHC MECHANICAL EXTRACTION LESS SIEVE (SOIL)

Maxxam ID		908282		908283		
Sampling Date		2005/08/29		2005/08/29		
COC Number		125183		125183		
	Units	**P7**	**RDL**	**P8**	**RDL**	**QC Batch**
Physical Properties						
Moisture	%	17	1	15	1	892772
Ext. Pet. Hydrocarbon						
F2 (C10-C16 Hydrocarbons)	mg/kg	<10	10	<10	10	888756
F3 (C16-C34 Hydrocarbons)	mg/kg	<10	10	355	10	888756
F4 (C34-C50 Hydrocarbons)	mg/kg	<10	10	41	10	888756
Reached Baseline at C50	mg/kg	YES	N/A	YES	N/A	888756
OIL & GREASE						
F4SG (Heavy Hydrocarbons-SilicaGel)	mg/kg	<500	500	<500	500	888758
Ext. Pet. Hydrocarbon						
F1 (C06-C10) - BTEX	mg/kg	<13	13	<13	13	888076
Volatiles						
Purgeable (MeOH) Benzene	mg/kg	<0.039	0.039	<0.039	0.039	888075
Purgeable (MeOH) Toluene	mg/kg	<0.039	0.039	<0.039	0.039	888075
Purgeable (MeOH) Ethylbenzene	mg/kg	<0.039	0.039	<0.039	0.039	888075
Purgeable (MeOH) m & p-Xylene	mg/kg	<0.078	0.078	<0.079	0.079	888075
Purgeable (MeOH) o-Xylene	mg/kg	<0.039	0.039	<0.039	0.039	888075
Purgeable (MeOH) Xylenes (Total)	mg/kg	<0.078	0.078	<0.079	0.079	888075
Surrogate Recovery (%)						
Purgeable (MeOH) D8-TOLUENE (sur.)	%	100	N/A	102	N/A	888075

N/A = Not Applicable
RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

CCMEHC MECHANICAL EXTRACTION LESS SIEVE (SOIL)

Maxxam ID		908284	908285		908303		
Sampling Date		2005/08/29	2005/08/29		2005/08/29		
COC Number		125183	125183		125183		
	Units	**P9**	**P10**	**RDL**	**BURN 1**	**RDL**	**QC Batch**
Physical Properties							
Moisture	%	19	16	1	16	1	892772
Ext. Pet. Hydrocarbon							
F2 (C10-C16 Hydrocarbons)	mg/kg	<10	<10	10	<10	10	888756
F3 (C16-C34 Hydrocarbons)	mg/kg	<10	<10	10	<10	10	888756
F4 (C34-C50 Hydrocarbons)	mg/kg	<10	<10	10	<10	10	888756
Reached Baseline at C50	mg/kg	YES	YES	N/A	YES	N/A	888756
OIL & GREASE							
F4SG (Heavy Hydrocarbons-SilicaGel)	mg/kg	<500	<500	500	<500	500	888758
Ext. Pet. Hydrocarbon							
F1 (C06-C10) - BTEX	mg/kg	<14	<14	14	<13	13	888076
Volatiles							
Purgeable (MeOH) Benzene	mg/kg	<0.040	<0.040	0.040	<0.039	0.039	888075
Purgeable (MeOH) Toluene	mg/kg	<0.040	<0.040	0.040	<0.039	0.039	888075
Purgeable (MeOH) Ethylbenzene	mg/kg	<0.040	<0.040	0.040	<0.039	0.039	888075
Purgeable (MeOH) m & p-Xylene	mg/kg	<0.080	<0.080	0.080	<0.079	0.079	888075
Purgeable (MeOH) o-Xylene	mg/kg	<0.040	<0.040	0.040	<0.039	0.039	888075
Purgeable (MeOH) Xylenes (Total)	mg/kg	<0.080	<0.080	0.080	<0.079	0.079	888075
Surrogate Recovery (%)							
Purgeable (MeOH) D8-TOLUENE (sur.)	%	101	101	N/A	101	N/A	888075

N/A = Not Applicable
RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

CCMEHC MECHANICAL EXTRACTION LESS SIEVE (SOIL)

Maxxam ID		908304		
Sampling Date		2005/08/29		
COC Number		125183		
	Units	**BURN 2**	**RDL**	**QC Batch**
Physical Properties				
Moisture	%	15	1	892772
Ext. Pet. Hydrocarbon				
F2 (C10-C16 Hydrocarbons)	mg/kg	<9	9	888756
F3 (C16-C34 Hydrocarbons)	mg/kg	82	9	888756
F4 (C34-C50 Hydrocarbons)	mg/kg	<9	9	888756
Reached Baseline at C50	mg/kg	YES	N/A	888756
OIL & GREASE				
F4SG (Heavy Hydrocarbons-SilicaGel)	mg/kg	<500	500	888758
Ext. Pet. Hydrocarbon				
F1 (C06-C10) - BTEX	mg/kg	<14	14	888076
Volatiles				
Purgeable (MeOH) Benzene	mg/kg	0.061	0.040	888075
Purgeable (MeOH) Toluene	mg/kg	0.085	0.040	888075
Purgeable (MeOH) Ethylbenzene	mg/kg	<0.040	0.040	888075
Purgeable (MeOH) m & p-Xylene	mg/kg	0.082	0.079	888075
Purgeable (MeOH) o-Xylene	mg/kg	<0.040	0.040	888075
Purgeable (MeOH) Xylenes (Total)	mg/kg	0.082	0.079	888075
Surrogate Recovery (%)				
Purgeable (MeOH) D8-TOLUENE (sur.)	%	102	N/A	888075

N/A = Not Applicable
RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

33 DISSOLVED ELEMENT SCAN (MET33D)

Maxxam ID		908323	908333		
Sampling Date		2005/08/29	2005/08/29		
COC Number		125183	125183		
	Units	**QC-1**	**W WELL**	**RDL**	**QC Batch**
Elements					
Dissolved Arsenic (As)	mg/L	0.0008	0.0008	0.0002	880659
Dissolved Selenium (Se)	mg/L	0.0372	0.0170	0.0002	880661
Dissolved Aluminum (Al)	mg/L	0.008	0.018	0.001	880710
Dissolved Antimony (Sb)	mg/L	<0.0002	<0.0002	0.0002	881375
Dissolved Barium (Ba)	mg/L	0.0315	0.0327	0.0002	880710
Dissolved Beryllium (Be)	mg/L	<0.0002	<0.0002	0.0002	880710
Dissolved Boron (B)	mg/L	0.11	0.11	0.01	880710
Dissolved Cadmium (Cd)	mg/L	<0.0002	<0.0002	0.0002	880710
Dissolved Calcium (Ca)	mg/L	759	N/A	0.3	881148
Dissolved Chromium (Cr)	mg/L	0.006	0.004	0.001	880710
Dissolved Cobalt (Co)	mg/L	0.0006	0.0006	0.0003	880710
Dissolved Copper (Cu)	mg/L	0.0096	0.0095	0.0002	880710
Dissolved Iron (Fe)	mg/L	0.31	N/A	0.01	881148
Dissolved Lead (Pb)	mg/L	<0.0003	0.0006	0.0003	880710
Dissolved Lithium (Li)	mg/L	0.426	0.467	0.004	881148
Dissolved Magnesium (Mg)	mg/L	301	N/A	0.2	881148
Dissolved Manganese (Mn)	mg/L	0.024	N/A	0.004	881148
Dissolved Mercury (Hg)	ug/L	<0.05	<0.05	0.05	882041
Dissolved Molybdenum (Mo)	mg/L	0.0004	0.0004	0.0002	880710
Dissolved Nickel (Ni)	mg/L	0.0084	0.0084	0.0005	880710
Dissolved Phosphorus (P)	mg/L	<0.1	0.4	0.1	881148
Dissolved Potassium (K)	mg/L	11.4	N/A	0.3	881148
Dissolved Silicon (Si)	mg/L	10.7	11.7	0.04	881148
Dissolved Silver (Ag)	mg/L	<0.0001	<0.0001	0.0001	880710
Dissolved Sodium (Na)	mg/L	640	N/A	0.5	881148
Dissolved Strontium (Sr)	mg/L	5.18	5.64	0.02	881148
Dissolved Sulphur (S)	mg/L	982	1060	0.2	881148
Dissolved Thallium (Tl)	mg/L	<0.0002	<0.0002	0.0002	880710
Dissolved Tin (Sn)	mg/L	<0.001	<0.001	0.001	880710
Dissolved Titanium (Ti)	mg/L	0.005	<0.001	0.001	880710
Dissolved Uranium (U)	mg/L	0.185	0.189	0.0004	880710
Dissolved Vanadium (V)	mg/L	0.008	0.005	0.001	880710

N/A = Not Applicable
RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

33 DISSOLVED ELEMENT SCAN (MET33D)

Maxxam ID		908323	908333		
Sampling Date		2005/08/29	2005/08/29		
COC Number		125183	125183		
	Units	**QC-1**	**W WELL**	**RDL**	**QC Batch**
Dissolved Zinc (Zn)	mg/L	0.0111	0.0090	0.0006	880710
Dissolved Zirconium (Zr)	mg/L	0.0014	0.0014	0.0002	880710

RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

33 ELEMENT SCAN (MET33-S)

Maxxam ID		908274	908276	908277	908278		
Sampling Date		2005/08/29	2005/08/29	2005/08/29	2005/08/29		
COC Number		125183	125183	125183	125183		
	Units	**P1**	**P2**	**P3**	**P4**	**RDL**	**QC Batch**
Elements							
Total Aluminum (Al)	mg/kg	7410	19900	6620	10000	10	884668
Total Antimony (Sb)	mg/kg	<0.1	<0.1	<0.1	<0.1	0.1	883050
Total Arsenic (As)	mg/kg	3.0	4.4	<0.5	4.2	0.5	883050
Total Barium (Ba)	mg/kg	187	221	208	200	0.7	884668
Total Beryllium (Be)	mg/kg	<0.7	<0.7	<0.7	<0.7	0.7	884668
Total Boron (B)	mg/kg	2	7	<2	4	2	884668
Total Cadmium (Cd)	mg/kg	0.28	0.29	0.34	0.26	0.02	883050
Total Calcium (Ca)	mg/kg	37400	14400	26700	23700	30	884668
Total Chromium (Cr)	mg/kg	16	27	15	19	1	884668
Total Cobalt (Co)	mg/kg	7	9	8	9	1	884668
Total Copper (Cu)	mg/kg	15.0	20.0	15.4	20.8	0.4	884668
Total Iron (Fe)	mg/kg	14000	21200	2110	18300	1	884668
Total Lead (Pb)	mg/kg	4	13	6	10	3	884668
Total Lithium (Li)	mg/kg	9.5	17.2	9.4	14.4	0.4	884668
Total Magnesium (Mg)	mg/kg	8890	6710	8210	7800	20	884668
Total Manganese (Mn)	mg/kg	400	420	413	457	0.4	884668
Acid Extr. (Closed) Mercury (Hg)	ug/kg	<20	<20	28	<20	20	882907
Total Molybdenum (Mo)	mg/kg	0.20	0.26	0.03	0.22	0.02	883050
Total Nickel (Ni)	mg/kg	21	24	23	26	2	884668
Total Phosphorus (P)	mg/kg	365	450	<10	474	10	884668
Total Potassium (K)	mg/kg	1170	2940	978	1370	30	884668
Total Selenium (Se)	mg/kg	<1	<1	<1	<1	1	883050
Total Silicon (Si)	mg/kg	595	1970	591	1120	4	884668
Total Silver (Ag)	mg/kg	<0.3	<0.3	<0.3	<0.3	0.3	884668
Total Sodium (Na)	mg/kg	352	955	949	2340	50	884668
Total Strontium (Sr)	mg/kg	62.7	49.7	61.5	68.6	0.4	884668
Total Sulphur (S)	mg/kg	206	333	687	2120	20	884668
Total Thallium (Tl)	mg/kg	0.15	0.21	0.15	0.20	0.02	883050
Total Tin (Sn)	mg/kg	<1	<1	<1	<1	1	883050
Total Titanium (Ti)	mg/kg	8	44	5	18	1	884668
Total Uranium (U)	mg/kg	1.09	0.89	1.28	1.79	0.04	883050
Total Vanadium (V)	mg/kg	15.2	36.8	1.5	22.0	0.6	884668
Total Zinc (Zn)	mg/kg	55.0	71.7	65.7	66.2	0.3	884668

RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

33 ELEMENT SCAN (MET33-S)

Maxxam ID		908274	908276	908277	908278		
Sampling Date		2005/08/29	2005/08/29	2005/08/29	2005/08/29		
COC Number		125183	125183	125183	125183		
	Units	**P1**	**P2**	**P3**	**P4**	**RDL**	**QC Batch**
Total Zirconium (Zr)	mg/kg	<0.1	2.2	<0.1	0.5	0.1	883050

RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

33 ELEMENT SCAN (MET33-S)

Maxxam ID		908280	908281	908282	908283		
Sampling Date		2005/08/29	2005/08/29	2005/08/29	2005/08/29		
COC Number		125183	125183	125183	125183		
	Units	**P5**	**P6**	**P7**	**P8**	**RDL**	**QC Batch**
Elements							
Total Aluminum (Al)	mg/kg	11000	9530	8080	8680	10	884668
Total Antimony (Sb)	mg/kg	<0.1	<0.1	<0.1	<0.1	0.1	883050
Total Arsenic (As)	mg/kg	4.4	4.1	4.3	4.4	0.5	883050
Total Barium (Ba)	mg/kg	240	235	214	313	0.7	884668
Total Beryllium (Be)	mg/kg	<0.7	<0.7	<0.7	<0.7	0.7	884668
Total Boron (B)	mg/kg	3	2	3	4	2	884668
Total Cadmium (Cd)	mg/kg	0.28	0.30	0.27	0.27	0.02	883050
Total Calcium (Ca)	mg/kg	24200	25700	25400	25000	30	884668
Total Chromium (Cr)	mg/kg	30	27	19	29	1	884668
Total Cobalt (Co)	mg/kg	8	8	8	8	1	884668
Total Copper (Cu)	mg/kg	20.4	19.4	17.5	19.4	0.4	884668
Total Iron (Fe)	mg/kg	19300	17700	15600	19100	1	884668
Total Lead (Pb)	mg/kg	10	10	6	8	3	884668
Total Lithium (Li)	mg/kg	14.1	11.8	10.3	11.3	0.4	884668
Total Magnesium (Mg)	mg/kg	7810	8700	7760	7670	20	884668
Total Manganese (Mn)	mg/kg	475	399	398	489	0.4	884668
Acid Extr. (Closed) Mercury (Hg)	ug/kg	21	34	29	23	20	882907
Total Molybdenum (Mo)	mg/kg	0.32	0.23	0.27	0.32	0.02	883050
Total Nickel (Ni)	mg/kg	29	26	22	28	2	884668
Total Phosphorus (P)	mg/kg	502	505	462	485	10	884668
Total Potassium (K)	mg/kg	1500	1250	1080	1210	30	884668
Total Selenium (Se)	mg/kg	<1	<1	<1	<1	1	883050
Total Silicon (Si)	mg/kg	666	602	742	1020	4	884668
Total Silver (Ag)	mg/kg	<0.3	<0.3	<0.3	<0.3	0.3	884668
Total Sodium (Na)	mg/kg	1370	1070	1180	786	50	884668
Total Strontium (Sr)	mg/kg	67.8	65.3	60.7	67.3	0.4	884668
Total Sulphur (S)	mg/kg	1870	982	1340	721	20	884668
Total Thallium (Tl)	mg/kg	0.19	0.20	0.17	0.18	0.02	883050
Total Tin (Sn)	mg/kg	<1	<1	<1	<1	1	883050
Total Titanium (Ti)	mg/kg	13	15	21	25	1	884668
Total Uranium (U)	mg/kg	1.51	1.49	1.38	1.40	0.04	883050
Total Vanadium (V)	mg/kg	24.0	20.2	18.8	20.3	0.6	884668
Total Zinc (Zn)	mg/kg	72.0	74.4	63.1	65.7	0.3	884668

RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

33 ELEMENT SCAN (MET33-S)

Maxxam ID		908280	908281	908282	908283		
Sampling Date		2005/08/29	2005/08/29	2005/08/29	2005/08/29		
COC Number		125183	125183	125183	125183		
	Units	**P5**	**P6**	**P7**	**P8**	**RDL**	**QC Batch**
Total Zirconium (Zr)	mg/kg	2.4	0.9	0.4	0.7	0.1	883050

RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

33 ELEMENT SCAN (MET33-S)

Maxxam ID		908284	908285		908300		
Sampling Date		2005/08/29	2005/08/29		2005/08/29		
COC Number		125183	125183		125183		
	Units	**P9**	**P10**	**QC Batch**	**CREEK A**	**RDL**	**QC Batch**
Elements							
Total Aluminum (Al)	mg/kg	6140	7860	884668	6910	10	891390
Total Antimony (Sb)	mg/kg	<0.1	<0.1	883050	<0.1	0.1	891433
Total Arsenic (As)	mg/kg	<0.5	<0.5	883050	4.6	0.5	891433
Total Barium (Ba)	mg/kg	195	220	884668	281	0.7	891390
Total Beryllium (Be)	mg/kg	<0.7	0.9	884668	0.9	0.7	891390
Total Boron (B)	mg/kg	<2	3	884668	3	2	891390
Total Cadmium (Cd)	mg/kg	0.28	0.36	883050	0.36	0.02	891433
Total Calcium (Ca)	mg/kg	25600	25600	884668	8630	30	891390
Total Chromium (Cr)	mg/kg	25	66	884668	15	1	891390
Total Cobalt (Co)	mg/kg	7	8	884668	8	1	891390
Total Copper (Cu)	mg/kg	14.8	17.6	884668	21.2	0.4	891390
Total Iron (Fe)	mg/kg	8060	7090	884668	9400	1	891390
Total Lead (Pb)	mg/kg	9	6	884668	10	3	891390
Total Lithium (Li)	mg/kg	8.6	9.4	884668	6.6	0.4	891390
Total Magnesium (Mg)	mg/kg	7210	6980	884668	3290	20	891390
Total Manganese (Mn)	mg/kg	398	889	884668	253	0.4	891390
Acid Extr. (Closed) Mercury (Hg)	ug/kg	26	22	882907	46	20	891007
Total Molybdenum (Mo)	mg/kg	0.04	0.03	883050	0.15	0.02	891433
Total Nickel (Ni)	mg/kg	25	48	884668	25	2	891390
Total Phosphorus (P)	mg/kg	77	30	884668	273	10	891390
Total Potassium (K)	mg/kg	882	1140	884668	975	30	891390
Total Selenium (Se)	mg/kg	<1	<1	883050	<1	1	891433
Total Silicon (Si)	mg/kg	585	589	884668	2730	4	891390
Total Silver (Ag)	mg/kg	<0.3	<0.3	884668	<0.3	0.3	891390
Total Sodium (Na)	mg/kg	935	583	884668	2660	50	891390
Total Strontium (Sr)	mg/kg	56.8	59.7	884668	69.3	0.4	891390
Total Sulphur (S)	mg/kg	1170	187	884668	482	20	891390
Total Thallium (Tl)	mg/kg	0.14	0.12	883050	0.18	0.02	891433
Total Tin (Sn)	mg/kg	<1	<1	883050	<1	1	891433
Total Titanium (Ti)	mg/kg	9	6	884668	4	1	891390
Total Uranium (U)	mg/kg	1.28	0.92	883050	1.81	0.04	891433
Total Vanadium (V)	mg/kg	3.0	1.4	884668	12.2	0.6	891390
Total Zinc (Zn)	mg/kg	59.6	64.2	884668	55.2	0.3	891390

RDL = Reportable Detection Limit

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

33 ELEMENT SCAN (MET33-S)

Maxxam ID		908284	908285		908300		
Sampling Date		2005/08/29	2005/08/29		2005/08/29		
COC Number		125183	125183		125183		
	Units	**P9**	**P10**	**QC Batch**	**CREEK A**	**RDL**	**QC Batch**
Total Zirconium (Zr)	mg/kg	<0.1	<0.1	883050	0.7	0.1	891433

RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

33 ELEMENT SCAN (MET33-S)

Maxxam ID		908301	908302		908303		
Sampling Date		2005/08/29	2005/08/29		2005/08/29		
COC Number		125183	125183		125183		
	Units	**CREEK B**	**CREEK C**	**QC Batch**	**BURN 1**	**RDL**	**QC Batch**
Elements							
Total Aluminum (Al)	mg/kg	3290	4150	891390	11300	10	891390
Total Antimony (Sb)	mg/kg	<0.1	<0.1	891433	<0.1	0.1	890250
Total Arsenic (As)	mg/kg	3.5	3.3	891433	7.2	0.5	890250
Total Barium (Ba)	mg/kg	262	287	891390	250	0.7	891390
Total Beryllium (Be)	mg/kg	<0.7	0.8	891390	0.9	0.7	891390
Total Boron (B)	mg/kg	3	4	891390	8	2	891390
Total Cadmium (Cd)	mg/kg	0.17	0.36	891433	0.33	0.02	890250
Total Calcium (Ca)	mg/kg	14100	12200	891390	23500	30	891390
Total Chromium (Cr)	mg/kg	7	13	891390	28	1	891390
Total Cobalt (Co)	mg/kg	4	6	891390	8	1	891390
Total Copper (Cu)	mg/kg	8.3	15.5	891390	30.7	0.4	891390
Total Iron (Fe)	mg/kg	6970	41700	891390	18000	1	891390
Total Lead (Pb)	mg/kg	5	11	891390	13	3	891390
Total Lithium (Li)	mg/kg	3.9	3.9	891390	9.4	0.4	891390
Total Magnesium (Mg)	mg/kg	4230	2540	891390	7540	20	891390
Total Manganese (Mn)	mg/kg	242	2280	891390	488	0.4	891390
Acid Extr. (Closed) Mercury (Hg)	ug/kg	<20	46	891007	<20	20	892371
Total Molybdenum (Mo)	mg/kg	0.22	0.31	891433	0.41	0.02	890250
Total Nickel (Ni)	mg/kg	12	20	891390	25	2	891390
Total Phosphorus (P)	mg/kg	405	509	891390	631	10	891390
Total Potassium (K)	mg/kg	500	490	891390	2180	30	891390
Total Selenium (Se)	mg/kg	<1	<1	891433	<1	1	890250
Total Silicon (Si)	mg/kg	487	623	891390	713	4	891390
Total Silver (Ag)	mg/kg	<0.3	<0.3	891390	<0.3	0.3	891390
Total Sodium (Na)	mg/kg	593	1120	891390	735	50	891390
Total Strontium (Sr)	mg/kg	40.4	82.1	891390	69.8	0.4	891390
Total Sulphur (S)	mg/kg	436	483	891390	847	20	891390
Total Thallium (Tl)	mg/kg	0.10	0.11	891433	0.19	0.02	890250
Total Tin (Sn)	mg/kg	<1	<1	891433	<1	1	890250
Total Titanium (Ti)	mg/kg	42	10	891390	31	1	891390
Total Uranium (U)	mg/kg	0.88	1.57	891433	1.20	0.04	890250
Total Vanadium (V)	mg/kg	9.7	17.9	891390	25.1	0.6	891390
Total Zinc (Zn)	mg/kg	33.1	50.7	891390	76.5	0.3	891390

RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

33 ELEMENT SCAN (MET33-S)

Maxxam ID		908301	908302		908303		
Sampling Date		2005/08/29	2005/08/29		2005/08/29		
COC Number		125183	125183		125183		
	Units	**CREEK B**	**CREEK C**	**QC Batch**	**BURN 1**	**RDL**	**QC Batch**
Total Zirconium (Zr)	mg/kg	3.4	1.5	891433	0.8	0.1	890250

RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

33 ELEMENT SCAN (MET33-S)

Maxxam ID		908304		
Sampling Date		2005/08/29		
COC Number		125183		
	Units	**BURN 2**	**RDL**	**QC Batch**
Elements				
Total Aluminum (Al)	mg/kg	8300	10	891390
Total Antimony (Sb)	mg/kg	<0.1	0.1	890250
Total Arsenic (As)	mg/kg	4.9	0.5	890250
Total Barium (Ba)	mg/kg	226	0.7	891390
Total Beryllium (Be)	mg/kg	0.7	0.7	891390
Total Boron (B)	mg/kg	5	2	891390
Total Cadmium (Cd)	mg/kg	0.35	0.02	890250
Total Calcium (Ca)	mg/kg	20700	30	891390
Total Chromium (Cr)	mg/kg	18	1	891390
Total Cobalt (Co)	mg/kg	8	1	891390
Total Copper (Cu)	mg/kg	17.0	0.4	891390
Total Iron (Fe)	mg/kg	16100	1	891390
Total Lead (Pb)	mg/kg	11	3	891390
Total Lithium (Li)	mg/kg	7.5	0.4	891390
Total Magnesium (Mg)	mg/kg	5970	20	891390
Total Manganese (Mn)	mg/kg	541	0.4	891390
Acid Extr. (Closed) Mercury (Hg)	ug/kg	<20	20	892371
Total Molybdenum (Mo)	mg/kg	0.33	0.02	890250
Total Nickel (Ni)	mg/kg	23	2	891390
Total Phosphorus (P)	mg/kg	408	10	891390
Total Potassium (K)	mg/kg	1360	30	891390
Total Selenium (Se)	mg/kg	<1	1	890250
Total Silicon (Si)	mg/kg	793	4	891390
Total Silver (Ag)	mg/kg	<0.3	0.3	891390
Total Sodium (Na)	mg/kg	563	50	891390
Total Strontium (Sr)	mg/kg	60.9	0.4	891390
Total Sulphur (S)	mg/kg	601	20	891390
Total Thallium (Tl)	mg/kg	0.14	0.02	890250
Total Tin (Sn)	mg/kg	<1	1	890250
Total Titanium (Ti)	mg/kg	13	1	891390
Total Uranium (U)	mg/kg	1.34	0.04	890250
Total Vanadium (V)	mg/kg	17.8	0.6	891390
Total Zinc (Zn)	mg/kg	97.0	0.3	891390

RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

33 ELEMENT SCAN (MET33-S)

Maxxam ID		908304		
Sampling Date		2005/08/29		
COC Number		125183		
	Units	**BURN 2**	**RDL**	**QC Batch**
Total Zirconium (Zr)	mg/kg	0.6	0.1	890250

RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

33 TOTAL ELEMENT SCAN (MET33T)

Maxxam ID		908312	908317	908318	908319	908320		
Sampling Date		2005/08/29	2005/08/29	2005/08/29	2005/08/29	2005/08/29		
COC Number		125183	125183	125183	125183	125183		
	Units	**CREEK A**	**CREEK B**	**CREEK C**	**SEEP 1A**	**SEEP 1B**	**RDL**	**QC Batch**
Elements								
Total Arsenic (As)	mg/L	0.0064	0.0091	0.0112	0.0035	0.0076	0.0002	880664
Total Selenium (Se)	mg/L	0.0002	0.0003	0.0004	<0.0002	0.0002	0.0002	880668
Total Aluminum (Al)	mg/L	1.15	9.70	17.5	0.432	6.75	0.001	880794
Total Antimony (Sb)	mg/L	0.0004	0.0004	0.0004	<0.0002	0.0003	0.0002	881377
Total Barium (Ba)	mg/L	0.0848	0.204	0.310	0.0922	0.164	0.0002	880794
Total Beryllium (Be)	mg/L	<0.0002	0.0006	0.0012	<0.0002	0.0005	0.0002	880794
Total Boron (B)	mg/L	0.21	0.29	0.27	0.20	0.29	0.01	880794
Total Cadmium (Cd)	mg/L	<0.0002	0.0006	0.0010	<0.0002	0.0005	0.0002	880794
Total Calcium (Ca)	mg/L	49.1	69.3	78.2	116	148	0.3	881144
Total Chromium (Cr)	mg/L	0.006	0.014	0.020	0.006	0.011	0.001	880794
Total Cobalt (Co)	mg/L	0.0013	0.0061	0.0084	0.0024	0.0059	0.0003	880794
Total Copper (Cu)	mg/L	0.0057	0.0167	0.0276	0.0036	0.0124	0.0002	880794
Total Iron (Fe)	mg/L	1.31	10.4	17.1	1.27	11.3	0.01	881144
Total Lead (Pb)	mg/L	0.0007	0.0075	0.0152	0.0004	0.0056	0.0003	880794
Total Lithium (Li)	mg/L	0.114	0.152	0.157	0.143	0.160	0.004	881144
Total Magnesium (Mg)	mg/L	21.0	27.0	29.2	37.0	31.8	0.2	881144
Total Manganese (Mn)	mg/L	0.028	0.352	0.492	0.899	0.941	0.004	881144
Total Mercury (Hg)	ug/L	0.06	0.14	0.18	<0.05	<0.05	0.05	882043
Total Molybdenum (Mo)	mg/L	0.0023	0.0023	0.0019	0.0009	0.0015	0.0002	880794
Total Nickel (Ni)	mg/L	0.0111	0.0275	0.0374	0.0175	0.0310	0.0005	880794
Total Phosphorus (P)	mg/L	0.3	0.3	0.4	<0.1	0.5	0.1	881144
Total Potassium (K)	mg/L	8.6	10.1	11.6	6.5	6.8	0.3	881144
Total Silicon (Si)	mg/L	9.47	24.9	50.4	9.64	19.8	0.04	881144
Total Silver (Ag)	mg/L	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	0.0001	880794
Total Sodium (Na)	mg/L	328	356	338	268	354	0.5	881144
Total Strontium (Sr)	mg/L	0.50	0.72	0.78	0.96	1.05	0.02	881144
Total Sulphur (S)	mg/L	81.7	122	120	123	148	0.2	881144
Total Thallium (Tl)	mg/L	<0.0002	0.0002	0.0004	<0.0002	<0.0002	0.0002	880794
Total Tin (Sn)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	880794
Total Titanium (Ti)	mg/L	0.025	0.153	0.204	0.019	0.121	0.001	880794
Total Uranium (U)	mg/L	0.0054	0.0088	0.0097	0.0033	0.0100	0.0004	880794
Total Vanadium (V)	mg/L	0.006	0.019	0.033	0.001	0.013	0.001	880794
Total Zinc (Zn)	mg/L	0.0159	0.0518	0.0742	0.0127	0.0472	0.0006	880794

RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

33 TOTAL ELEMENT SCAN (MET33T)

Maxxam ID		908312	908317	908318	908319	908320		
Sampling Date		2005/08/29	2005/08/29	2005/08/29	2005/08/29	2005/08/29		
COC Number		125183	125183	125183	125183	125183		
	Units	**CREEK A**	**CREEK B**	**CREEK C**	**SEEP 1A**	**SEEP 1B**	**RDL**	**QC Batch**
Total Zirconium (Zr)	mg/L	0.0033	0.0059	0.0067	0.0011	0.0037	0.0002	880794

RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

ROUTINE WATER (WATER)

Maxxam ID		908312	908317	908318	908319		
Sampling Date		2005/08/29	2005/08/29	2005/08/29	2005/08/29		
COC Number		125183	125183	125183	125183		
	Units	**CREEK A**	**CREEK B**	**CREEK C**	**SEEP 1A**	**RDL**	**QC Batch**
Calculated Parameters							
Hardness (CaCO3)	mg/L	140	200	200	410	0.5	888796
Ion Balance	N/A	0.96	1.00	0.96	0.93	0.01	888797
Misc. Inorganics							
Conductivity	uS/cm	1750	1840	1840	1710	1	889216
pH	N/A	8.66	8.44	8.61	8.20	0.01	889218
Total Dissolved Solids	mg/L	1150	1220	1220	1140	10	888802
Anions							
Alkalinity (PP as CaCO3)	mg/L	40.3	16.4	32.6	<0.5	0.5	888722
Alkalinity (Total as CaCO3)	mg/L	762	679	682	644	0.5	888722
Bicarbonate (HCO3)	mg/L	831	788	753	786	0.5	888722
Carbonate (CO3)	mg/L	48.4	19.7	39.1	<0.5	0.5	888722
Dissolved Chloride (Cl)	mg/L	6.1	5.5	5.1	4.3	0.5	891311
Hydroxide (OH)	mg/L	<0.5	<0.5	<0.5	<0.5	0.5	888722
Dissolved Sulphate (SO4)	mg/L	248	350	355	359	0.5	891313
Nutrients							
Dissolved Nitrate (N)	mg/L	0.011	0.016	0.007	0.005	0.003	890296
Nitrate plus Nitrite (N)	mg/L	0.011	0.016	0.007	0.009	0.003	889754
Dissolved Nitrite (N)	mg/L	<0.003	<0.003	<0.003	0.004	0.003	890296
Cations							
Dissolved Calcium (Ca)	mg/L	33.2	50.6	49.6	108	0.3	893125
Dissolved Magnesium (Mg)	mg/L	14.1	18.2	18.7	34.2	0.2	893125
Dissolved Potassium (K)	mg/L	6.6	5.4	5.6	5.4	0.3	893125
Dissolved Sodium (Na)	mg/L	385	386	373	245	0.5	893125
Dissolved Iron (Fe)	mg/L	0.03	0.07	0.02	0.01	0.01	893125
Dissolved Manganese (Mn)	mg/L	<0.004	0.065	0.018	0.800	0.004	893125

RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

ROUTINE WATER (WATER)

Maxxam ID		908320		908333		
Sampling Date		2005/08/29		2005/08/29		
COC Number		125183		125183		
	Units	**SEEP 1B**	**QC Batch**	**W WELL**	**RDL**	**QC Batch**
Calculated Parameters						
Hardness (CaCO3)	mg/L	260	888796	3400	0.5	888796
Ion Balance	N/A	0.91	888797	1.08	0.01	888797
Misc. Inorganics						
Conductivity	uS/cm	1870	889216	5880	1	889216
pH	N/A	8.24	889218	7.52	0.01	889218
Total Dissolved Solids	mg/L	1210	888802	5950	10	888802
Anions						
Alkalinity (PP as CaCO3)	mg/L	<0.5	888722	<0.5	0.5	888722
Alkalinity (Total as CaCO3)	mg/L	647	888722	864	0.5	888722
Bicarbonate (HCO3)	mg/L	790	888722	1050	0.5	888722
Carbonate (CO3)	mg/L	<0.5	888722	<0.5	0.5	888722
Dissolved Chloride (Cl)	mg/L	3.9	891311	100	0.5	891311
Hydroxide (OH)	mg/L	<0.5	888722	<0.5	0.5	888722
Dissolved Sulphate (SO4)	mg/L	399	891313	3070	0.5	891313
Nutrients						
Dissolved Nitrate (N)	mg/L	0.049	890296	93.7	0.003	890296
Nitrate plus Nitrite (N)	mg/L	0.076	889754	93.7	0.003	889754
Dissolved Nitrite (N)	mg/L	0.027	890296	<0.003	0.003	890296
Cations						
Dissolved Calcium (Ca)	mg/L	67.6	893125	678	0.3	889900
Dissolved Magnesium (Mg)	mg/L	22.5	893125	285	0.2	889900
Dissolved Potassium (K)	mg/L	4.8	893125	9.1	0.3	889900
Dissolved Sodium (Na)	mg/L	325	893125	673	0.5	889900
Dissolved Iron (Fe)	mg/L	0.02	893125	0.17	0.01	889900
Dissolved Manganese (Mn)	mg/L	0.084	893125	0.006	0.004	889900

RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

RESULTS OF CHEMICAL ANALYSES OF SOIL

Maxxam ID		908300	908301	908302		
Sampling Date		2005/08/29	2005/08/29	2005/08/29		
COC Number		125183	125183	125183		
	Units	**CREEK A**	**CREEK B**	**CREEK C**	**RDL**	**QC Batch**
Misc. Inorganics						
Total Kjeldahl Nitrogen	mg/kg	1010	506	848	3	892764
Soluble Parameters						
Soluble Ammonia (N)	mg/L	0.4	0.3	0.5	0.1	892762
Soluble Chloride (Cl)	mg/L	24	13	16	5	892621
Soluble Nitrate (N)	mg/L	1.6	0.6	1.7	0.2	893102
Soluble Nitrite (N)	mg/L	<0.2	<0.2	<0.2	0.2	893258
Soluble pH	N/A	8.60	8.20	8.30	0.01	892755
Soluble Phosphate (P)	mg/L	0.49	0.98	0.93	0.03	893230
Saturation %	%	75.0	34.0	42.0	N/A	892743
Soluble Calcium (Ca)	mg/L	N/A	N/A	33	2	892396
Soluble Magnesium (Mg)	mg/L	N/A	N/A	10	1	892396
Soluble Sodium (Na)	mg/L	N/A	N/A	355	3	892396
Soluble Potassium (K)	mg/L	N/A	N/A	7	1	892396
Soluble Sulphate (SO4)	mg/L	988	551	640	5	892396

N/A = Not Applicable
RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		908312	908317	908318	908319	908320		
Sampling Date		2005/08/29	2005/08/29	2005/08/29	2005/08/29	2005/08/29		
COC Number		125183	125183	125183	125183	125183		
	Units	**CREEK A**	**CREEK B**	**CREEK C**	**SEEP 1A**	**SEEP 1B**	**RDL**	**QC Batch**
Misc. Inorganics								
Total Suspended Solids	mg/L	96	51	1010	N/A	N/A	1	890275
Nutrients								
Total Ammonia (N)	mg/L	0.05	0.06	0.02	0.04	0.01	0.01	883700
Total Kjeldahl Nitrogen	mg/L	0.49	1.98	1.61	0.42	1.81	0.05	884840
Total Phosphate (P)	mg/L	0.079	0.480	0.305	0.044	0.525	0.003	886998

N/A = Not Applicable
RDL = Reportable Detection Limit

Maxxam ID		908323	908333		
Sampling Date		2005/08/29	2005/08/29		
COC Number		125183	125183		
	Units	**QC-1**	**W WELL**	**RDL**	**QC Batch**
Nutrients					
Total Ammonia (N)	mg/L	0.68	0.88	0.01	883700
Total Kjeldahl Nitrogen	mg/L	4.91	4.63	0.05	884840
Total Phosphate (P)	mg/L	0.075	0.078	0.003	886998

RDL = Reportable Detection Limit

Maxxam Analytics Inc

Maxxam Job #: A534894
Report Date: 2006/01/17

FRANZ ENVIRONMENTAL INC.
Client Project #: 979-0501, DRUMHELLER
Site Reference: DRUMHELLER
Sampler Initials: AH

CCMEHC MECHANICAL EXTRACTION LESS SIEVE (SOIL) Comments

Sample 908284-02 CCME Hydrocarbons (F2-F4 in soil): Sample was not homogeneous

Sample 908284-02 CCME Hydrocarbons-SilicaGel (F4 in soil): Sample was not homogeneous

33 DISSOLVED ELEMENT SCAN (MET33D) Comments

Sample 908323-01 Antimony by Hydride AA (Dissolved): Sb run on ICP-MS.

Sample 908333-01 Antimony by Hydride AA (Dissolved): Sb run on ICP-MS.

33 TOTAL ELEMENT SCAN (MET33T) Comments

Sample 908312-01 Antimony by Hydride AA (Total): Sb run on ICP-MS

Sample 908317-01 Antimony by Hydride AA (Total): Sb run on ICP-MS

Sample 908318-01 Antimony by Hydride AA (Total): Sb run on ICP-MS

Sample 908319-01 Antimony by Hydride AA (Total): Sb run on ICP-MS

Sample 908320-01 Antimony by Hydride AA (Total): Sb run on ICP-MS

RESULTS OF CHEMICAL ANALYSES OF SOIL Comments

Sample 908301-01 Ca,Mg,Na,K,SO4 (Soluble): Sulphate result taken from IC

Results relate only to the items tested.

Maxxam Analytics Inc

FRANZ ENVIRONMENTAL INC.
Attention: ANDREW HOWTON
Client Project #: 979-0501, DRUMHELLER
P.O. #:
Site Reference: DRUMHELLER

Quality Assurance Report

Maxxam Job Number: CA534894

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
880659 LK	Calibration Check	Dissolved Arsenic (As)	2005/09/02		95	%	75 - 123
	MATRIX SPIKE	Dissolved Arsenic (As)	2005/09/02		86	%	70 - 130
	QC STANDARD	Dissolved Arsenic (As)	2005/09/02		103	%	83 - 117
	BLANK	Dissolved Arsenic (As)	2005/09/02	<0.0002		mg/L	
	RPD	Dissolved Arsenic (As)	2005/09/02	0		%	20
880661 LK	Calibration Check	Dissolved Selenium (Se)	2005/09/02		103	%	77 - 123
	MATRIX SPIKE	Dissolved Selenium (Se)	2005/09/02		79	%	72 - 131
	QC STANDARD	Dissolved Selenium (Se)	2005/09/02		86	%	74 - 119
	BLANK	Dissolved Selenium (Se)	2005/09/02	<0.0002		mg/L	
	RPD	Dissolved Selenium (Se)	2005/09/02	NC		%	20
880664 LK	Calibration Check	Total Arsenic (As)	2005/09/02		95	%	75 - 123
	MATRIX SPIKE	Total Arsenic (As)	2005/09/02		108	%	70 - 130
	QC STANDARD	Total Arsenic (As)	2005/09/02		90	%	83 - 117
	BLANK	Total Arsenic (As)	2005/09/02	<0.0002		mg/L	
	RPD	Total Arsenic (As)	2005/09/02	NC		%	N/A
880668 LK	Calibration Check	Total Selenium (Se)	2005/09/02		103	%	77 - 123
	MATRIX SPIKE	Total Selenium (Se)	2005/09/02		87	%	72 - 131
	QC STANDARD	Total Selenium (Se)	2005/09/02		94	%	74 - 119
	BLANK	Total Selenium (Se)	2005/09/02	<0.0002		mg/L	
	RPD	Total Selenium (Se)	2005/09/02	NC		%	N/A
880710 SB1	Calibration Check	Dissolved Aluminum (Al)	2005/09/06		96	%	85 - 113
		Dissolved Barium (Ba)	2005/09/06		94	%	85 - 109
		Dissolved Beryllium (Be)	2005/09/06		97	%	78 - 116
		Dissolved Boron (B)	2005/09/06		96	%	67 - 125
		Dissolved Cadmium (Cd)	2005/09/06		94	%	84 - 110
		Dissolved Chromium (Cr)	2005/09/06		96	%	83 - 108
		Dissolved Cobalt (Co)	2005/09/06		97	%	83 - 110
		Dissolved Copper (Cu)	2005/09/06		94	%	83 - 113
		Dissolved Lead (Pb)	2005/09/06		94	%	82 - 107
		Dissolved Molybdenum (Mo)	2005/09/06		92	%	85 - 109
		Dissolved Nickel (Ni)	2005/09/06		97	%	81 - 111
		Dissolved Silver (Ag)	2005/09/06		92	%	85 - 109
		Dissolved Thallium (Tl)	2005/09/06		95	%	78 - 108
		Dissolved Tin (Sn)	2005/09/06		94	%	79 - 110
		Dissolved Titanium (Ti)	2005/09/06		101	%	84 - 114
		Dissolved Uranium (U)	2005/09/06		95	%	82 - 110
		Dissolved Vanadium (V)	2005/09/06		96	%	85 - 111
		Dissolved Zinc (Zn)	2005/09/06		96	%	80 - 117
		Dissolved Zirconium (Zr)	2005/09/06		97	%	80 - 140
	MATRIX SPIKE	Dissolved Aluminum (Al)	2005/09/06		95	%	80 - 120
		Dissolved Barium (Ba)	2005/09/06		98	%	80 - 120
		Dissolved Beryllium (Be)	2005/09/06		95	%	80 - 120
		Dissolved Boron (B)	2005/09/06		103	%	80 - 120
		Dissolved Cadmium (Cd)	2005/09/06		90	%	80 - 120
		Dissolved Chromium (Cr)	2005/09/06		95	%	80 - 120
		Dissolved Cobalt (Co)	2005/09/06		93	%	73 - 109
		Dissolved Copper (Cu)	2005/09/06		91	%	80 - 120
		Dissolved Lead (Pb)	2005/09/06		89	%	80 - 120
		Dissolved Molybdenum (Mo)	2005/09/06		93	%	80 - 120
		Dissolved Nickel (Ni)	2005/09/06		90	%	73 - 115
		Dissolved Silver (Ag)	2005/09/06		85	%	80 - 120
		Dissolved Thallium (Tl)	2005/09/06		92	%	80 - 120
		Dissolved Tin (Sn)	2005/09/06		92	%	80 - 120
		Dissolved Titanium (Ti)	2005/09/06		98	%	80 - 120
		Dissolved Uranium (U)	2005/09/06		92	%	80 - 120
		Dissolved Vanadium (V)	2005/09/06		94	%	80 - 120

Maxxam Analytics Inc

FRANZ ENVIRONMENTAL INC.
Attention: ANDREW HOWTON
Client Project #: 979-0501, DRUMHELLER
P.O. #:
Site Reference: DRUMHELLER

Quality Assurance Report (Continued)

Maxxam Job Number: CA534894

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
880710 SB1	MATRIX SPIKE	Dissolved Zinc (Zn)	2005/09/06		95	%	80 - 120
		Dissolved Zirconium (Zr)	2005/09/06		91	%	70 - 140
	SPIKE	Dissolved Aluminum (Al)	2005/09/06		100	%	80 - 120
		Dissolved Barium (Ba)	2005/09/06		94	%	88 - 112
		Dissolved Beryllium (Be)	2005/09/06		103	%	87 - 113
		Dissolved Cadmium (Cd)	2005/09/06		101	%	90 - 110
		Dissolved Chromium (Cr)	2005/09/06		100	%	88 - 112
		Dissolved Cobalt (Co)	2005/09/06		99	%	88 - 112
		Dissolved Copper (Cu)	2005/09/06		92	%	86 - 114
		Dissolved Lead (Pb)	2005/09/06		95	%	84 - 116
		Dissolved Molybdenum (Mo)	2005/09/06		94	%	86 - 114
		Dissolved Nickel (Ni)	2005/09/06		95	%	88 - 112
		Dissolved Silver (Ag)	2005/09/06		92	%	87 - 113
		Dissolved Thallium (Tl)	2005/09/06		96	%	87 - 113
		Dissolved Uranium (U)	2005/09/06		95	%	87 - 113
		Dissolved Vanadium (V)	2005/09/06		98	%	88 - 112
	BLANK	Dissolved Aluminum (Al)	2005/09/06	<0.001		mg/L	
		Dissolved Barium (Ba)	2005/09/06	<0.0002		mg/L	
		Dissolved Beryllium (Be)	2005/09/06	<0.0002		mg/L	
		Dissolved Boron (B)	2005/09/06	<0.01		mg/L	
		Dissolved Cadmium (Cd)	2005/09/06	<0.0002		mg/L	
		Dissolved Chromium (Cr)	2005/09/06	<0.001		mg/L	
		Dissolved Cobalt (Co)	2005/09/06	<0.0003		mg/L	
		Dissolved Copper (Cu)	2005/09/06	<0.0002		mg/L	
		Dissolved Lead (Pb)	2005/09/06	<0.0003		mg/L	
		Dissolved Molybdenum (Mo)	2005/09/06	<0.0002		mg/L	
		Dissolved Nickel (Ni)	2005/09/06	<0.0005		mg/L	
		Dissolved Silver (Ag)	2005/09/06	<0.0001		mg/L	
		Dissolved Thallium (Tl)	2005/09/06	<0.0002		mg/L	
		Dissolved Tin (Sn)	2005/09/06	<0.001		mg/L	
		Dissolved Titanium (Ti)	2005/09/06	<0.001		mg/L	
		Dissolved Uranium (U)	2005/09/06	<0.0004		mg/L	
		Dissolved Vanadium (V)	2005/09/06	<0.001		mg/L	
		Dissolved Zinc (Zn)	2005/09/06	<0.0006		mg/L	
		Dissolved Zirconium (Zr)	2005/09/06	<0.0002		mg/L	
	RPD	Dissolved Aluminum (Al)	2005/09/06	11.6		%	20
		Dissolved Barium (Ba)	2005/09/06	0.3		%	20
		Dissolved Beryllium (Be)	2005/09/06	NC		%	20
		Dissolved Boron (B)	2005/09/06	NC		%	20
		Dissolved Cadmium (Cd)	2005/09/06	NC		%	20
		Dissolved Chromium (Cr)	2005/09/06	NC		%	20
		Dissolved Cobalt (Co)	2005/09/06	NC		%	20
		Dissolved Copper (Cu)	2005/09/06	5.8		%	20
		Dissolved Lead (Pb)	2005/09/06	0.4		%	20
		Dissolved Molybdenum (Mo)	2005/09/06	14.7		%	20
		Dissolved Nickel (Ni)	2005/09/06	NC		%	20
		Dissolved Silver (Ag)	2005/09/06	NC		%	20
		Dissolved Thallium (Tl)	2005/09/06	NC		%	20
		Dissolved Tin (Sn)	2005/09/06	NC		%	20
		Dissolved Titanium (Ti)	2005/09/06	18.7		%	20
		Dissolved Uranium (U)	2005/09/06	NC		%	20
		Dissolved Vanadium (V)	2005/09/06	NC		%	20
		Dissolved Zinc (Zn)	2005/09/06	7.0		%	20
		Dissolved Zirconium (Zr)	2005/09/06	NC		%	20
880794 MJ1	Calibration Check	Total Aluminum (Al)	2005/09/02		110	%	80 - 120
		Total Barium (Ba)	2005/09/02		98	%	80 - 120

Maxxam Analytics Inc

FRANZ ENVIRONMENTAL INC.
Attention: ANDREW HOWTON
Client Project #: 979-0501, DRUMHELLER
P.O. #:
Site Reference: DRUMHELLER

Quality Assurance Report (Continued)

Maxxam Job Number: CA534894

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
880794 MJ1	Calibration Check	Total Beryllium (Be)	2005/09/02		108	%	80 - 120
		Total Boron (B)	2005/09/02		109	%	67 - 130
		Total Cadmium (Cd)	2005/09/02		96	%	80 - 120
		Total Chromium (Cr)	2005/09/02		90	%	80 - 120
		Total Cobalt (Co)	2005/09/02		93	%	80 - 120
		Total Copper (Cu)	2005/09/02		92	%	80 - 120
		Total Lead (Pb)	2005/09/02		92	%	80 - 120
		Total Molybdenum (Mo)	2005/09/02		91	%	80 - 120
		Total Nickel (Ni)	2005/09/02		100	%	80 - 120
		Total Silver (Ag)	2005/09/02		90	%	80 - 120
		Total Thallium (Tl)	2005/09/02		92	%	80 - 120
		Total Tin (Sn)	2005/09/02		93	%	80 - 120
		Total Titanium (Ti)	2005/09/02		109	%	80 - 120
		Total Uranium (U)	2005/09/02		88	%	80 - 120
		Total Vanadium (V)	2005/09/02		100	%	80 - 120
		Total Zinc (Zn)	2005/09/02		94	%	80 - 120
		Total Zirconium (Zr)	2005/09/02		98	%	80 - 140
	MATRIX SPIKE	Total Aluminum (Al)	2005/09/02		96	%	80 - 120
		Total Barium (Ba)	2005/09/02		94	%	80 - 120
		Total Beryllium (Be)	2005/09/02		86	%	80 - 120
		Total Boron (B)	2005/09/02		88	%	67 - 130
		Total Cadmium (Cd)	2005/09/02		87	%	80 - 120
		Total Chromium (Cr)	2005/09/02		109	%	80 - 120
		Total Cobalt (Co)	2005/09/02		91	%	80 - 120
		Total Copper (Cu)	2005/09/02		89	%	80 - 120
		Total Lead (Pb)	2005/09/02		92	%	80 - 120
		Total Molybdenum (Mo)	2005/09/02		88	%	80 - 120
		Total Nickel (Ni)	2005/09/02		88	%	80 - 120
		Total Silver (Ag)	2005/09/02		85	%	80 - 120
		Total Thallium (Tl)	2005/09/02		84	%	80 - 120
		Total Tin (Sn)	2005/09/02		90	%	80 - 120
		Total Titanium (Ti)	2005/09/02		102	%	80 - 120
		Total Uranium (U)	2005/09/02		95	%	80 - 120
		Total Vanadium (V)	2005/09/02		103	%	80 - 120
		Total Zinc (Zn)	2005/09/02		100	%	80 - 120
		Total Zirconium (Zr)	2005/09/02		92	%	80 - 140
	BLANK	Total Aluminum (Al)	2005/09/02	<0.001		mg/L	
		Total Barium (Ba)	2005/09/02	<0.0002		mg/L	
		Total Beryllium (Be)	2005/09/02	<0.0002		mg/L	
		Total Boron (B)	2005/09/02	<0.01		mg/L	
		Total Cadmium (Cd)	2005/09/02	<0.0002		mg/L	
		Total Chromium (Cr)	2005/09/02	<0.001		mg/L	
		Total Cobalt (Co)	2005/09/02	<0.0003		mg/L	
		Total Copper (Cu)	2005/09/02	<0.0002		mg/L	
		Total Lead (Pb)	2005/09/02	<0.0003		mg/L	
		Total Molybdenum (Mo)	2005/09/02	<0.0002		mg/L	
		Total Nickel (Ni)	2005/09/02	<0.0005		mg/L	
		Total Silver (Ag)	2005/09/02	<0.0001		mg/L	
		Total Thallium (Tl)	2005/09/02	<0.0002		mg/L	
		Total Tin (Sn)	2005/09/02	<0.001		mg/L	
		Total Titanium (Ti)	2005/09/02	<0.001		mg/L	
		Total Uranium (U)	2005/09/02	<0.0004		mg/L	
		Total Vanadium (V)	2005/09/02	<0.001		mg/L	
		Total Zinc (Zn)	2005/09/02	<0.0006		mg/L	
		Total Zirconium (Zr)	2005/09/02	<0.0002		mg/L	
	RPD	Total Aluminum (Al)	2005/09/02	0.4		%	20

Maxxam Analytics Inc

FRANZ ENVIRONMENTAL INC.
Attention: ANDREW HOWTON
Client Project #: 979-0501, DRUMHELLER
P.O. #:
Site Reference: DRUMHELLER

Quality Assurance Report (Continued)

Maxxam Job Number: CA534894

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
880794 MJ1	RPD	Total Barium (Ba)	2005/09/02	5.1		%	20
		Total Beryllium (Be)	2005/09/02	NC		%	20
		Total Boron (B)	2005/09/02	NC		%	20
		Total Chromium (Cr)	2005/09/02	0.9		%	20
		Total Cobalt (Co)	2005/09/02	NC		%	20
		Total Copper (Cu)	2005/09/02	NC		%	20
		Total Lead (Pb)	2005/09/02	NC		%	20
		Total Molybdenum (Mo)	2005/09/02	NC		%	20
		Total Nickel (Ni)	2005/09/02	0		%	20
		Total Silver (Ag)	2005/09/02	NC		%	20
		Total Thallium (Tl)	2005/09/02	NC		%	20
		Total Tin (Sn)	2005/09/02	NC		%	20
		Total Titanium (Ti)	2005/09/02	3.8		%	20
		Total Uranium (U)	2005/09/02	NC		%	20
		Total Vanadium (V)	2005/09/02	NC		%	20
		Total Zinc (Zn)	2005/09/02	10.6		%	20
		Total Zirconium (Zr)	2005/09/02	NC		%	20
881144 ED	Calibration Check	Total Calcium (Ca)	2005/09/06		95	%	80 - 120
		Total Iron (Fe)	2005/09/06		99	%	80 - 120
		Total Lithium (Li)	2005/09/06		96	%	80 - 120
		Total Magnesium (Mg)	2005/09/06		98	%	80 - 120
		Total Manganese (Mn)	2005/09/06		99	%	80 - 120
		Total Phosphorus (P)	2005/09/06		97	%	80 - 120
		Total Potassium (K)	2005/09/06		97	%	80 - 120
		Total Silicon (Si)	2005/09/06		93	%	80 - 120
		Total Sodium (Na)	2005/09/06		97	%	80 - 120
		Total Strontium (Sr)	2005/09/06		99	%	80 - 120
	MATRIX SPIKE	Total Calcium (Ca)	2005/09/06		100	%	80 - 120
		Total Iron (Fe)	2005/09/06		101	%	80 - 120
		Total Lithium (Li)	2005/09/06		96	%	80 - 120
		Total Magnesium (Mg)	2005/09/06		97	%	80 - 120
		Total Manganese (Mn)	2005/09/06		104	%	80 - 120
		Total Phosphorus (P)	2005/09/06		97	%	80 - 120
		Total Potassium (K)	2005/09/06		96	%	80 - 120
		Total Silicon (Si)	2005/09/06		96	%	80 - 120
		Total Sodium (Na)	2005/09/06		95	%	80 - 120
		Total Strontium (Sr)	2005/09/06		99	%	80 - 120
	SPIKE	Total Sulphur (S)	2005/09/06		95	%	80 - 120
	BLANK	Total Calcium (Ca)	2005/09/06	<0.3		mg/L	
		Total Iron (Fe)	2005/09/06	<0.01		mg/L	
		Total Lithium (Li)	2005/09/06	<0.004		mg/L	
		Total Magnesium (Mg)	2005/09/06	<0.2		mg/L	
		Total Manganese (Mn)	2005/09/06	<0.004		mg/L	
		Total Phosphorus (P)	2005/09/06	<0.1		mg/L	
		Total Potassium (K)	2005/09/06	<0.3		mg/L	
		Total Silicon (Si)	2005/09/06	<0.04		mg/L	
		Total Sodium (Na)	2005/09/06	<0.5		mg/L	
		Total Strontium (Sr)	2005/09/06	<0.02		mg/L	
		Total Sulphur (S)	2005/09/06	<0.2		mg/L	
	RPD	Total Calcium (Ca)	2005/09/06	3.3		%	20
		Total Iron (Fe)	2005/09/06	NC		%	20
		Total Lithium (Li)	2005/09/06	3.3		%	20
		Total Magnesium (Mg)	2005/09/06	2.8		%	20
		Total Manganese (Mn)	2005/09/06	NC		%	20
		Total Phosphorus (P)	2005/09/06	NC		%	20
		Total Potassium (K)	2005/09/06	2.6		%	20

Maxxam Analytics Inc

FRANZ ENVIRONMENTAL INC.
Attention: ANDREW HOWTON
Client Project #: 979-0501, DRUMHELLER
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Site Reference: DRUMHELLER

Quality Assurance Report (Continued)

Maxxam Job Number: CA534894

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
881144 ED	RPD	Total Silicon (Si)	2005/09/06	1.0		%	20
		Total Sodium (Na)	2005/09/06	4.5		%	20
		Total Strontium (Sr)	2005/09/06	1.9		%	20
		Total Sulphur (S)	2005/09/06	2.5		%	20
881148 ED	Calibration Check	Dissolved Calcium (Ca)	2005/09/06		98	%	89 - 110
		Dissolved Iron (Fe)	2005/09/06		98	%	87 - 113
		Dissolved Lithium (Li)	2005/09/06		100	%	88 - 109
		Dissolved Magnesium (Mg)	2005/09/06		103	%	91 - 106
		Dissolved Manganese (Mn)	2005/09/06		99	%	92 - 110
		Dissolved Phosphorus (P)	2005/09/06		100	%	88 - 105
		Dissolved Potassium (K)	2005/09/06		98	%	90 - 113
		Dissolved Silicon (Si)	2005/09/06		100	%	92 - 107
		Dissolved Sodium (Na)	2005/09/06		99	%	92 - 114
		Dissolved Strontium (Sr)	2005/09/06		100	%	91 - 108
	MATRIX SPIKE	Dissolved Calcium (Ca)	2005/09/06		100	%	80 - 120
		Dissolved Iron (Fe)	2005/09/06		97	%	80 - 120
		Dissolved Lithium (Li)	2005/09/06		104	%	80 - 120
		Dissolved Magnesium (Mg)	2005/09/06		103	%	80 - 120
		Dissolved Manganese (Mn)	2005/09/06		100	%	80 - 120
		Dissolved Phosphorus (P)	2005/09/06		106	%	80 - 120
		Dissolved Potassium (K)	2005/09/06		99	%	80 - 120
		Dissolved Silicon (Si)	2005/09/06		101	%	80 - 120
		Dissolved Sodium (Na)	2005/09/06		103	%	80 - 120
		Dissolved Strontium (Sr)	2005/09/06		101	%	80 - 120
	QC STANDARD	Dissolved Calcium (Ca)	2005/09/06		97	%	90 - 110
		Dissolved Magnesium (Mg)	2005/09/06		102	%	90 - 110
		Dissolved Sodium (Na)	2005/09/06		107	%	90 - 110
	SPIKE	Dissolved Sulphur (S)	2005/09/06		97	%	80 - 120
	BLANK	Dissolved Calcium (Ca)	2005/09/06	<0.3		mg/L	
		Dissolved Iron (Fe)	2005/09/06	<0.01		mg/L	
		Dissolved Lithium (Li)	2005/09/06	<0.004		mg/L	
		Dissolved Magnesium (Mg)	2005/09/06	<0.2		mg/L	
		Dissolved Manganese (Mn)	2005/09/06	<0.004		mg/L	
		Dissolved Phosphorus (P)	2005/09/06	<0.1		mg/L	
		Dissolved Potassium (K)	2005/09/06	<0.3		mg/L	
		Dissolved Silicon (Si)	2005/09/06	<0.04		mg/L	
		Dissolved Sodium (Na)	2005/09/06	<0.5		mg/L	
		Dissolved Strontium (Sr)	2005/09/06	<0.02		mg/L	
		Dissolved Sulphur (S)	2005/09/06	<0.2		mg/L	
	RPD	Dissolved Calcium (Ca)	2005/09/06	0.5		%	20
		Dissolved Iron (Fe)	2005/09/06	NC		%	20
		Dissolved Lithium (Li)	2005/09/06	NC		%	20
		Dissolved Magnesium (Mg)	2005/09/06	4.4		%	20
		Dissolved Manganese (Mn)	2005/09/06	NC		%	20
		Dissolved Phosphorus (P)	2005/09/06	NC		%	20
		Dissolved Potassium (K)	2005/09/06	2.6		%	20
		Dissolved Silicon (Si)	2005/09/06	3.4		%	20
		Dissolved Sodium (Na)	2005/09/06	5.2		%	20
		Dissolved Strontium (Sr)	2005/09/06	3.6		%	20
		Dissolved Sulphur (S)	2005/09/06	3.6		%	20
881375 SB1	Calibration Check	Dissolved Antimony (Sb)	2005/09/02		87	%	68 - 133
	QC STANDARD	Dissolved Antimony (Sb)	2005/09/02		104	%	74 - 117
	BLANK	Dissolved Antimony (Sb)	2005/09/02	<0.0002		mg/L	
881377 LK	Calibration Check	Total Antimony (Sb)	2005/09/02		94	%	68 - 133
	MATRIX SPIKE	Total Antimony (Sb)	2005/09/02		87	%	68 - 127
	BLANK	Total Antimony (Sb)	2005/09/02	<0.0002		mg/L	

Maxxam Analytics Inc

FRANZ ENVIRONMENTAL INC.
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Client Project #: 979-0501, DRUMHELLER
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Quality Assurance Report (Continued)

Maxxam Job Number: CA534894

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
881377 LK	RPD	Total Antimony (Sb)	2005/09/02	NC		%	N/A
882041 JL2	Calibration Check	Dissolved Mercury (Hg)	2005/09/02		98	%	69 - 132
	MATRIX SPIKE	Dissolved Mercury (Hg)	2005/09/02		102	%	66 - 133
	BLANK	Dissolved Mercury (Hg)	2005/09/02	<0.05		ug/L	
	RPD	Dissolved Mercury (Hg)	2005/09/02	NC		%	20
882043 JL2	Calibration Check	Total Mercury (Hg)	2005/09/02		90	%	69 - 132
	MATRIX SPIKE	Total Mercury (Hg)	2005/09/02		95	%	66 - 133
	BLANK	Total Mercury (Hg)	2005/09/02	<0.05		ug/L	
	RPD	Total Mercury (Hg)	2005/09/02	NC		%	20
882907 JL2	Calibration Check	Acid Extr. (Closed) Mercury (Hg)	2005/09/06		103	%	69 - 132
	MATRIX SPIKE	Acid Extr. (Closed) Mercury (Hg)	2005/09/06		105	%	60 - 140
	QC STANDARD	Acid Extr. (Closed) Mercury (Hg)	2005/09/06		78	%	66 - 133
	BLANK	Acid Extr. (Closed) Mercury (Hg)	2005/09/06	<20		ug/kg	
	RPD	Acid Extr. (Closed) Mercury (Hg)	2005/09/06	NC		%	40
883050 SB1	Calibration Check	Total Antimony (Sb)	2005/09/07		91	%	74 - 117
		Total Arsenic (As)	2005/09/07		98	%	77 - 113
		Total Cadmium (Cd)	2005/09/07		98	%	84 - 110
		Total Molybdenum (Mo)	2005/09/07		95	%	85 - 109
		Total Selenium (Se)	2005/09/07		93	%	74 - 119
		Total Thallium (Tl)	2005/09/07		97	%	78 - 108
		Total Tin (Sn)	2005/09/07		109	%	79 - 110
		Total Uranium (U)	2005/09/07		96	%	82 - 110
		Total Zirconium (Zr)	2005/09/07		98	%	80 - 140
	QC STANDARD	Total Arsenic (As)	2005/09/07		82	%	60 - 139
		Total Cadmium (Cd)	2005/09/07		91	%	60 - 140
		Total Selenium (Se)	2005/09/07		96	%	60 - 140
	BLANK	Total Antimony (Sb)	2005/09/07	<0.1		mg/kg	
		Total Arsenic (As)	2005/09/07	<0.5		mg/kg	
		Total Cadmium (Cd)	2005/09/07	<0.02		mg/kg	
		Total Molybdenum (Mo)	2005/09/07	<0.02		mg/kg	
		Total Selenium (Se)	2005/09/07	<1		mg/kg	
		Total Thallium (Tl)	2005/09/07	<0.02		mg/kg	
		Total Tin (Sn)	2005/09/07	<1		mg/kg	
		Total Uranium (U)	2005/09/07	<0.04		mg/kg	
		Total Zirconium (Zr)	2005/09/07	<0.1		mg/kg	
	RPD [908274-01]	Total Antimony (Sb)	2005/09/07	NC		%	40
		Total Arsenic (As)	2005/09/07	7.2		%	40
		Total Cadmium (Cd)	2005/09/07	8.7		%	40
		Total Molybdenum (Mo)	2005/09/07	3.3		%	40
		Total Selenium (Se)	2005/09/07	NC		%	40
		Total Thallium (Tl)	2005/09/07	0.7		%	40
		Total Tin (Sn)	2005/09/07	NC		%	40
		Total Uranium (U)	2005/09/07	3.1		%	40
		Total Zirconium (Zr)	2005/09/07	NC		%	40
883700 LLE	Calibration Check	Total Ammonia (N)	2005/09/06		102	%	88 - 120
	MATRIX SPIKE	Total Ammonia (N)	2005/09/06		101	%	83 - 118
	BLANK	Total Ammonia (N)	2005/09/06	0.02, RDL=0.01		mg/L	
	RPD	Total Ammonia (N)	2005/09/06	NC		%	20
884668 ED	Calibration Check	Total Aluminum (Al)	2005/09/06		92	%	86 - 106
		Total Barium (Ba)	2005/09/06		94	%	89 - 105
		Total Beryllium (Be)	2005/09/06		95	%	89 - 105
		Total Boron (B)	2005/09/06		95	%	90 - 107
		Total Calcium (Ca)	2005/09/06		100	%	89 - 110
		Total Chromium (Cr)	2005/09/06		98	%	84 - 106
		Total Cobalt (Co)	2005/09/06		97	%	88 - 104
		Total Copper (Cu)	2005/09/06		97	%	91 - 105

Maxxam Analytics Inc

FRANZ ENVIRONMENTAL INC.
Attention: ANDREW HOWTON
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Quality Assurance Report (Continued)

Maxxam Job Number: CA534894

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
884668 ED	Calibration Check	Total Iron (Fe)	2005/09/06		97	%	87 - 113
		Total Lead (Pb)	2005/09/06		95	%	88 - 105
		Total Lithium (Li)	2005/09/06		93	%	88 - 109
		Total Magnesium (Mg)	2005/09/06		96	%	91 - 106
		Total Manganese (Mn)	2005/09/06		101	%	92 - 110
		Total Nickel (Ni)	2005/09/06		94	%	91 - 103
		Total Phosphorus (P)	2005/09/06		98	%	88 - 105
		Total Potassium (K)	2005/09/06		90	%	90 - 113
		Total Silicon (Si)	2005/09/06		97	%	92 - 107
		Total Silver (Ag)	2005/09/06		95	%	90 - 109
		Total Sodium (Na)	2005/09/06		96	%	92 - 114
		Total Strontium (Sr)	2005/09/06		96	%	91 - 108
		Total Titanium (Ti)	2005/09/06		97	%	93 - 107
		Total Vanadium (V)	2005/09/06		95	%	91 - 106
		Total Zinc (Zn)	2005/09/06		95	%	89 - 110
	MATRIX SPIKE	Total Barium (Ba)	2005/09/06		103	%	60 - 140
		Total Beryllium (Be)	2005/09/06		97	%	60 - 140
		Total Chromium (Cr)	2005/09/06		99	%	60 - 140
		Total Cobalt (Co)	2005/09/06		103	%	60 - 140
		Total Copper (Cu)	2005/09/06		100	%	60 - 140
		Total Iron (Fe)	2005/09/06		126	%	60 - 140
		Total Lead (Pb)	2005/09/06		99	%	60 - 140
		Total Magnesium (Mg)	2005/09/06		137	%	60 - 140
		Total Nickel (Ni)	2005/09/06		110	%	60 - 140
		Total Potassium (K)	2005/09/06		88	%	60 - 140
		Total Zinc (Zn)	2005/09/06		103	%	60 - 140
	QC STANDARD	Total Barium (Ba)	2005/09/06		89	%	60 - 140
		Total Beryllium (Be)	2005/09/06		96	%	60 - 132
		Total Calcium (Ca)	2005/09/06		93	%	60 - 140
		Total Chromium (Cr)	2005/09/06		94	%	60 - 140
		Total Cobalt (Co)	2005/09/06		97	%	60 - 136
		Total Copper (Cu)	2005/09/06		97	%	60 - 140
		Total Iron (Fe)	2005/09/06		105	%	60 - 140
		Total Lead (Pb)	2005/09/06		97	%	60 - 140
		Total Magnesium (Mg)	2005/09/06		96	%	60 - 137
		Total Nickel (Ni)	2005/09/06		98	%	60 - 131
		Total Potassium (K)	2005/09/06		90	%	60 - 128
		Total Zinc (Zn)	2005/09/06		95	%	60 - 139
	SPIKE	Total Sulphur (S)	2005/09/06		93	%	80 - 120
	BLANK	Total Aluminum (Al)	2005/09/06	<10		mg/kg	
		Total Barium (Ba)	2005/09/06	<0.7		mg/kg	
		Total Beryllium (Be)	2005/09/06	<0.7		mg/kg	
		Total Boron (B)	2005/09/06	<2		mg/kg	
		Total Calcium (Ca)	2005/09/06	<30		mg/kg	
		Total Chromium (Cr)	2005/09/06	<1		mg/kg	
		Total Cobalt (Co)	2005/09/06	<1		mg/kg	
		Total Copper (Cu)	2005/09/06	<0.4		mg/kg	
		Total Iron (Fe)	2005/09/06	<1		mg/kg	
		Total Lead (Pb)	2005/09/06	<3		mg/kg	
		Total Lithium (Li)	2005/09/06	<0.4		mg/kg	
		Total Magnesium (Mg)	2005/09/06	<20		mg/kg	
		Total Manganese (Mn)	2005/09/06	<0.4		mg/kg	
		Total Nickel (Ni)	2005/09/06	<2		mg/kg	
		Total Phosphorus (P)	2005/09/06	<10		mg/kg	
		Total Potassium (K)	2005/09/06	<30		mg/kg	
		Total Silicon (Si)	2005/09/06	<4		mg/kg	

Maxxam Analytics Inc

FRANZ ENVIRONMENTAL INC.
Attention: ANDREW HOWTON
Client Project #: 979-0501, DRUMHELLER
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Quality Assurance Report (Continued)

Maxxam Job Number: CA534894

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
884668 ED	BLANK	Total Silver (Ag)	2005/09/06	<0.3		mg/kg	
		Total Sodium (Na)	2005/09/06	<50		mg/kg	
		Total Strontium (Sr)	2005/09/06	<0.4		mg/kg	
		Total Sulphur (S)	2005/09/06	<20		mg/kg	
		Total Titanium (Ti)	2005/09/06	<1		mg/kg	
		Total Vanadium (V)	2005/09/06	<0.6		mg/kg	
		Total Zinc (Zn)	2005/09/06	<0.3		mg/kg	
	RPD	Total Aluminum (Al)	2005/09/06	11.6		%	40
		Total Barium (Ba)	2005/09/06	12.4		%	40
		Total Beryllium (Be)	2005/09/06	NC		%	40
		Total Boron (B)	2005/09/06	NC		%	40
		Total Calcium (Ca)	2005/09/06	2.5		%	40
		Total Chromium (Cr)	2005/09/06	24.2		%	40
		Total Cobalt (Co)	2005/09/06	NC		%	40
		Total Copper (Cu)	2005/09/06	29.3		%	40
		Total Iron (Fe)	2005/09/06	0.4		%	40
		Total Lead (Pb)	2005/09/06	NC		%	40
		Total Lithium (Li)	2005/09/06	12.4		%	40
		Total Magnesium (Mg)	2005/09/06	5.6		%	40
		Total Manganese (Mn)	2005/09/06	3.9		%	40
		Total Nickel (Ni)	2005/09/06	26.1		%	40
		Total Phosphorus (P)	2005/09/06	9.7		%	40
		Total Potassium (K)	2005/09/06	19.6		%	40
		Total Silicon (Si)	2005/09/06	38.9		%	40
		Total Silver (Ag)	2005/09/06	NC		%	40
		Total Sodium (Na)	2005/09/06	10.6		%	40
		Total Strontium (Sr)	2005/09/06	8.2		%	40
		Total Sulphur (S)	2005/09/06	31.0		%	40
		Total Titanium (Ti)	2005/09/06	13.0		%	40
		Total Vanadium (V)	2005/09/06	9.5		%	40
		Total Zinc (Zn)	2005/09/06	31.2		%	40
884840 LLE	Calibration Check	Total Kjeldahl Nitrogen	2005/09/06		90	%	80 - 120
	MATRIX SPIKE	Total Kjeldahl Nitrogen	2005/09/06		94	%	78 - 123
	BLANK	Total Kjeldahl Nitrogen	2005/09/06	<0.05		mg/L	
	RPD	Total Kjeldahl Nitrogen	2005/09/06	3.6		%	20
886998 HA	Calibration Check	Total Phosphate (P)	2005/09/07		98	%	87 - 113
	MATRIX SPIKE	Total Phosphate (P)	2005/09/07		96	%	88 - 114
	BLANK	Total Phosphate (P)	2005/09/07	<0.003		mg/L	
	RPD	Total Phosphate (P)	2005/09/07	NC		%	20
888075 OJ	Calibration Check	Purgeable (MeOH) D8-TOLUENE (sur.)	2005/09/08		101	%	80 - 117
		Purgeable (MeOH) Benzene	2005/09/08		107	%	85 - 115
		Purgeable (MeOH) Toluene	2005/09/08		106	%	85 - 115
		Purgeable (MeOH) Ethylbenzene	2005/09/08		103	%	85 - 115
		Purgeable (MeOH) m & p-Xylene	2005/09/08		107	%	85 - 115
		Purgeable (MeOH) o-Xylene	2005/09/08		106	%	85 - 115
	SPIKE	Purgeable (MeOH) D8-TOLUENE (sur.)	2005/09/08		103	%	80 - 117
		Purgeable (MeOH) Benzene	2005/09/08		119	%	75 - 125
		Purgeable (MeOH) Toluene	2005/09/08		121	%	75 - 125
		Purgeable (MeOH) Ethylbenzene	2005/09/08		122	%	75 - 125
		Purgeable (MeOH) m & p-Xylene	2005/09/08		121	%	75 - 125
		Purgeable (MeOH) o-Xylene	2005/09/08		119	%	75 - 125
	BLANK	Purgeable (MeOH) D8-TOLUENE (sur.)	2005/09/08		102	%	80 - 117
		Purgeable (MeOH) Benzene	2005/09/08	<0.035		mg/kg	
		Purgeable (MeOH) Toluene	2005/09/08	<0.035		mg/kg	
		Purgeable (MeOH) Ethylbenzene	2005/09/08	<0.035		mg/kg	
		Purgeable (MeOH) m & p-Xylene	2005/09/08	<0.070		mg/kg	

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FRANZ ENVIRONMENTAL INC.
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Client Project #: 979-0501, DRUMHELLER
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Quality Assurance Report (Continued)

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QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
888075 OJ	BLANK	Purgeable (MeOH) o-Xylene	2005/09/08	<0.035		mg/kg	
		Purgeable (MeOH) Xylenes (Total)	2005/09/08	<0.070		mg/kg	
	RPD [908274-02]	Purgeable (MeOH) Benzene	2005/09/08	NC		%	40
		Purgeable (MeOH) Toluene	2005/09/08	NC		%	40
		Purgeable (MeOH) Ethylbenzene	2005/09/08	NC		%	40
		Purgeable (MeOH) m & p-Xylene	2005/09/08	NC		%	40
		Purgeable (MeOH) o-Xylene	2005/09/08	NC		%	40
		Purgeable (MeOH) Xylenes (Total)	2005/09/08	NC		%	40
888076 JC2	Calibration Check	F1 (C06-C10) - BTEX	2005/09/09		91	%	N/A
	QC STANDARD	F1 (C06-C10) - BTEX	2005/09/09		114	%	80 - 120
	SPIKE	F1 (C06-C10) - BTEX	2005/09/09		95	%	N/A
	BLANK	F1 (C06-C10) - BTEX	2005/09/09	<12		mg/kg	
	RPD [908274-02]	F1 (C06-C10) - BTEX	2005/09/09	NC		%	40
888722 CK	Calibration Check	Alkalinity (Total as CaCO3)	2005/09/08		102	%	92 - 106
	RPD	Alkalinity (PP as CaCO3)	2005/09/08	NC		%	20
		Alkalinity (Total as CaCO3)	2005/09/08	2.3		%	20
		Bicarbonate (HCO3)	2005/09/08	2.1		%	20
		Carbonate (CO3)	2005/09/08	NC		%	20
		Hydroxide (OH)	2005/09/08	NC		%	20
888756 VM	Calibration Check	F2 (C10-C16 Hydrocarbons)	2005/09/08		97	%	85 - 115
		F3 (C16-C34 Hydrocarbons)	2005/09/08		106	%	85 - 115
		F4 (C34-C50 Hydrocarbons)	2005/09/08		105	%	85 - 115
	QC STANDARD	F2 (C10-C16 Hydrocarbons)	2005/09/08		73	%	50 - 120
		F3 (C16-C34 Hydrocarbons)	2005/09/08		91	%	80 - 120
		F4 (C34-C50 Hydrocarbons)	2005/09/08		107	%	80 - 120
	SPIKE	F2 (C10-C16 Hydrocarbons)	2005/09/08		105	%	80 - 120
		F3 (C16-C34 Hydrocarbons)	2005/09/08		107	%	80 - 120
		F4 (C34-C50 Hydrocarbons)	2005/09/08		104	%	80 - 120
	BLANK	F2 (C10-C16 Hydrocarbons)	2005/09/08	<8		mg/kg	
		F3 (C16-C34 Hydrocarbons)	2005/09/08	<8		mg/kg	
		F4 (C34-C50 Hydrocarbons)	2005/09/08	<8		mg/kg	
		Reached Baseline at C50	2005/09/08	YES		mg/kg	
	RPD [908282-02]	F2 (C10-C16 Hydrocarbons)	2005/09/08	NC		%	50
		F3 (C16-C34 Hydrocarbons)	2005/09/08	NC		%	50
		F4 (C34-C50 Hydrocarbons)	2005/09/08	NC		%	50
		Reached Baseline at C50	2005/09/08	NC		%	50
888758 AA2	BLANK	F4SG (Heavy Hydrocarbons-SilicaGel)	2005/09/08	<500		mg/kg	
	RPD [908282-02]	F4SG (Heavy Hydrocarbons-SilicaGel)	2005/09/08	NC		%	50
889216 CK	Calibration Check	Conductivity	2005/09/08		101	%	92 - 110
	SPIKE	Conductivity	2005/09/08		100	%	80 - 120
	BLANK	Conductivity	2005/09/08	1, RDL=1		uS/cm	
	RPD	Conductivity	2005/09/08	1.1		%	20
889218 CK	Calibration Check	pH	2005/09/08		100	%	99 - 101
	RPD	pH	2005/09/08	0.07		%	5
889900 SW	Calibration Check	Dissolved Calcium (Ca)	2005/09/09		91	%	89 - 110
		Dissolved Magnesium (Mg)	2005/09/09		103	%	91 - 106
		Dissolved Potassium (K)	2005/09/09		107	%	90 - 113
		Dissolved Sodium (Na)	2005/09/09		107	%	92 - 114
		Dissolved Iron (Fe)	2005/09/09		96	%	87 - 113
		Dissolved Manganese (Mn)	2005/09/09		96	%	92 - 110
	MATRIX SPIKE	Dissolved Calcium (Ca)	2005/09/09		98	%	80 - 120
		Dissolved Magnesium (Mg)	2005/09/09		101	%	80 - 120
		Dissolved Potassium (K)	2005/09/09		98	%	80 - 120
		Dissolved Sodium (Na)	2005/09/09		103	%	80 - 120
		Dissolved Iron (Fe)	2005/09/09		96	%	80 - 120
		Dissolved Manganese (Mn)	2005/09/09		97	%	80 - 120

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Quality Assurance Report (Continued)

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QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
889900 SW	QC STANDARD	Dissolved Calcium (Ca)	2005/09/09		97	%	90 - 110
		Dissolved Magnesium (Mg)	2005/09/09		106	%	90 - 110
		Dissolved Sodium (Na)	2005/09/09		106	%	90 - 110
	BLANK	Dissolved Calcium (Ca)	2005/09/09	<0.3		mg/L	
		Dissolved Magnesium (Mg)	2005/09/09	<0.2		mg/L	
		Dissolved Potassium (K)	2005/09/09	<0.3		mg/L	
		Dissolved Sodium (Na)	2005/09/09	<0.5		mg/L	
		Dissolved Iron (Fe)	2005/09/09	<0.01		mg/L	
		Dissolved Manganese (Mn)	2005/09/09	<0.004		mg/L	
	RPD	Dissolved Calcium (Ca)	2005/09/09	1.5		%	20
		Dissolved Magnesium (Mg)	2005/09/09	2.7		%	20
		Dissolved Potassium (K)	2005/09/09	2.5		%	20
		Dissolved Sodium (Na)	2005/09/09	3.4		%	20
		Dissolved Iron (Fe)	2005/09/09	NC		%	20
		Dissolved Manganese (Mn)	2005/09/09	0.5		%	20
890250 SB1	Calibration Check	Total Antimony (Sb)	2005/09/09		93	%	74 - 117
		Total Arsenic (As)	2005/09/09		102	%	77 - 113
		Total Cadmium (Cd)	2005/09/09		101	%	84 - 110
		Total Molybdenum (Mo)	2005/09/09		98	%	85 - 109
		Total Selenium (Se)	2005/09/09		98	%	74 - 119
		Total Thallium (Tl)	2005/09/09		100	%	78 - 108
		Total Tin (Sn)	2005/09/09		98	%	79 - 110
		Total Uranium (U)	2005/09/09		99	%	82 - 110
		Total Zirconium (Zr)	2005/09/09		98	%	80 - 140
	MATRIX SPIKE [908303-01]	Total Arsenic (As)	2005/09/09		108	%	60 - 140
		Total Cadmium (Cd)	2005/09/09		108	%	60 - 140
		Total Selenium (Se)	2005/09/09		110	%	60 - 140
	QC STANDARD	Total Arsenic (As)	2005/09/09		87	%	60 - 139
		Total Cadmium (Cd)	2005/09/09		95	%	60 - 140
		Total Selenium (Se)	2005/09/09		90	%	60 - 140
	BLANK	Total Antimony (Sb)	2005/09/09	<0.1		mg/kg	
		Total Arsenic (As)	2005/09/09	<0.5		mg/kg	
		Total Cadmium (Cd)	2005/09/09	<0.02		mg/kg	
		Total Molybdenum (Mo)	2005/09/09	<0.02		mg/kg	
		Total Selenium (Se)	2005/09/09	<1		mg/kg	
		Total Thallium (Tl)	2005/09/09	<0.02		mg/kg	
		Total Tin (Sn)	2005/09/09	<1		mg/kg	
		Total Uranium (U)	2005/09/09	<0.04		mg/kg	
		Total Zirconium (Zr)	2005/09/09	<0.1		mg/kg	
	RPD [908303-01]	Total Antimony (Sb)	2005/09/09	NC		%	40
		Total Arsenic (As)	2005/09/09	7.5		%	40
		Total Cadmium (Cd)	2005/09/09	11.5		%	40
		Total Molybdenum (Mo)	2005/09/09	2.5		%	40
		Total Selenium (Se)	2005/09/09	NC		%	40
		Total Thallium (Tl)	2005/09/09	7.2		%	40
		Total Tin (Sn)	2005/09/09	NC		%	40
		Total Uranium (U)	2005/09/09	1.2		%	40
		Total Zirconium (Zr)	2005/09/09	9.6		%	40
890275 KW	Calibration Check	Total Suspended Solids	2005/09/09		103	%	76 - 112
	BLANK	Total Suspended Solids	2005/09/09	<1		mg/L	
	RPD [908312-01]	Total Suspended Solids	2005/09/09	11.0		%	20
890296 JU1	Calibration Check	Dissolved Nitrate (N)	2005/09/09		102	%	92 - 111
		Dissolved Nitrite (N)	2005/09/09		101	%	91 - 110
	MATRIX SPIKE	Dissolved Nitrate (N)	2005/09/09		101	%	81 - 121
		Dissolved Nitrite (N)	2005/09/09		99	%	87 - 117

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Quality Assurance Report (Continued)

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QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
890296 JU1	BLANK	Dissolved Nitrate (N)	2005/09/09	<0.003		mg/L	
		Dissolved Nitrite (N)	2005/09/09	<0.003		mg/L	
	RPD	Dissolved Nitrate (N)	2005/09/09	0		%	20
		Dissolved Nitrite (N)	2005/09/09	NC		%	20
891007 NJ1	Calibration Check	Acid Extr. (Closed) Mercury (Hg)	2005/09/12		97	%	69 - 132
	MATRIX SPIKE [908300-01]	Acid Extr. (Closed) Mercury (Hg)	2005/09/12		89	%	60 - 140
	QC STANDARD	Acid Extr. (Closed) Mercury (Hg)	2005/09/12		75	%	66 - 133
	BLANK	Acid Extr. (Closed) Mercury (Hg)	2005/09/12	<20		ug/kg	
	RPD [908300-01]	Acid Extr. (Closed) Mercury (Hg)	2005/09/12	NC		%	40
891311 BL3	Calibration Check	Dissolved Chloride (Cl)	2005/09/12		103	%	80 - 120
	MATRIX SPIKE	Dissolved Chloride (Cl)	2005/09/12		102	%	80 - 120
	BLANK	Dissolved Chloride (Cl)	2005/09/12	<0.5		mg/L	
	RPD	Dissolved Chloride (Cl)	2005/09/12	0.4		%	20
891313 BL3	Calibration Check	Dissolved Sulphate (SO4)	2005/09/12		108	%	80 - 120
	MATRIX SPIKE	Dissolved Sulphate (SO4)	2005/09/12		94	%	80 - 120
	BLANK	Dissolved Sulphate (SO4)	2005/09/12	<0.5		mg/L	
	RPD	Dissolved Sulphate (SO4)	2005/09/12	0.2		%	20
891390 SW	Calibration Check	Total Aluminum (Al)	2005/09/12		93	%	86 - 106
		Total Barium (Ba)	2005/09/12		97	%	89 - 105
		Total Beryllium (Be)	2005/09/12		96	%	89 - 105
		Total Boron (B)	2005/09/12		95	%	90 - 107
		Total Calcium (Ca)	2005/09/12		102	%	89 - 110
		Total Chromium (Cr)	2005/09/12		100	%	84 - 106
		Total Cobalt (Co)	2005/09/12		98	%	88 - 104
		Total Copper (Cu)	2005/09/12		103	%	91 - 105
		Total Iron (Fe)	2005/09/12		97	%	87 - 113
		Total Lead (Pb)	2005/09/12		93	%	88 - 105
		Total Lithium (Li)	2005/09/12		88	%	88 - 109
		Total Magnesium (Mg)	2005/09/12		96	%	91 - 106
		Total Manganese (Mn)	2005/09/12		101	%	92 - 110
		Total Nickel (Ni)	2005/09/12		95	%	91 - 103
		Total Phosphorus (P)	2005/09/12		94	%	88 - 105
		Total Potassium (K)	2005/09/12		102	%	90 - 113
		Total Silicon (Si)	2005/09/12		96	%	92 - 107
		Total Silver (Ag)	2005/09/12		95	%	90 - 109
		Total Sodium (Na)	2005/09/12		102	%	92 - 114
		Total Strontium (Sr)	2005/09/12		95	%	91 - 108
		Total Titanium (Ti)	2005/09/12		98	%	93 - 107
		Total Vanadium (V)	2005/09/12		97	%	91 - 106
		Total Zinc (Zn)	2005/09/12		97	%	89 - 110
	MATRIX SPIKE [908303-01]	Total Barium (Ba)	2005/09/12		96	%	60 - 140
		Total Beryllium (Be)	2005/09/12		109	%	60 - 140
		Total Calcium (Ca)	2005/09/12		108	%	60 - 140
		Total Chromium (Cr)	2005/09/12		103	%	60 - 140
		Total Cobalt (Co)	2005/09/12		109	%	60 - 140
		Total Copper (Cu)	2005/09/12		102	%	60 - 140
		Total Iron (Fe)	2005/09/12		98	%	60 - 140
		Total Lead (Pb)	2005/09/12		103	%	60 - 140
		Total Magnesium (Mg)	2005/09/12		102	%	60 - 140
		Total Nickel (Ni)	2005/09/12		109	%	60 - 140
		Total Potassium (K)	2005/09/12		85	%	60 - 140
		Total Zinc (Zn)	2005/09/12		107	%	60 - 140
	QC STANDARD	Total Barium (Ba)	2005/09/12		90	%	60 - 140
		Total Beryllium (Be)	2005/09/12		98	%	60 - 132

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Quality Assurance Report (Continued)

Maxxam Job Number: CA534894

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
891390 SW	QC STANDARD	Total Calcium (Ca)	2005/09/12		97	%	60 - 140
		Total Chromium (Cr)	2005/09/12		98	%	60 - 140
		Total Cobalt (Co)	2005/09/12		99	%	60 - 136
		Total Copper (Cu)	2005/09/12		94	%	60 - 140
		Total Iron (Fe)	2005/09/12		105	%	60 - 140
		Total Lead (Pb)	2005/09/12		94	%	60 - 140
		Total Magnesium (Mg)	2005/09/12		96	%	60 - 137
		Total Nickel (Ni)	2005/09/12		100	%	60 - 131
		Total Potassium (K)	2005/09/12		79	%	60 - 128
		Total Zinc (Zn)	2005/09/12		99	%	60 - 139
	SPIKE	Total Sulphur (S)	2005/09/12		97	%	80 - 120
	BLANK	Total Aluminum (Al)	2005/09/12	<10		mg/kg	
		Total Barium (Ba)	2005/09/12	<0.7		mg/kg	
		Total Beryllium (Be)	2005/09/12	<0.7		mg/kg	
		Total Boron (B)	2005/09/12	<2		mg/kg	
		Total Calcium (Ca)	2005/09/12	<30		mg/kg	
		Total Chromium (Cr)	2005/09/12	<1		mg/kg	
		Total Cobalt (Co)	2005/09/12	<1		mg/kg	
		Total Copper (Cu)	2005/09/12	<0.4		mg/kg	
		Total Iron (Fe)	2005/09/12	<1		mg/kg	
		Total Lead (Pb)	2005/09/12	<3		mg/kg	
		Total Lithium (Li)	2005/09/12	<0.4		mg/kg	
		Total Magnesium (Mg)	2005/09/12	<20		mg/kg	
		Total Manganese (Mn)	2005/09/12	<0.4		mg/kg	
		Total Nickel (Ni)	2005/09/12	<2		mg/kg	
		Total Phosphorus (P)	2005/09/12	<10		mg/kg	
		Total Potassium (K)	2005/09/12	<30		mg/kg	
		Total Silicon (Si)	2005/09/12	<4		mg/kg	
		Total Silver (Ag)	2005/09/12	<0.3		mg/kg	
		Total Sodium (Na)	2005/09/12	<50		mg/kg	
		Total Strontium (Sr)	2005/09/12	<0.4		mg/kg	
		Total Sulphur (S)	2005/09/12	<20		mg/kg	
		Total Titanium (Ti)	2005/09/12	<1		mg/kg	
		Total Vanadium (V)	2005/09/12	<0.6		mg/kg	
		Total Zinc (Zn)	2005/09/12	<0.3		mg/kg	
	RPD [908300-01]	Total Aluminum (Al)	2005/09/12	2.0		%	40
		Total Barium (Ba)	2005/09/12	6.9		%	40
		Total Beryllium (Be)	2005/09/12	NC		%	40
		Total Boron (B)	2005/09/12	NC		%	40
		Total Calcium (Ca)	2005/09/12	1.8		%	40
		Total Chromium (Cr)	2005/09/12	4.7		%	40
		Total Cobalt (Co)	2005/09/12	11.4		%	40
		Total Copper (Cu)	2005/09/12	2.4		%	40
		Total Iron (Fe)	2005/09/12	18.5		%	40
		Total Lead (Pb)	2005/09/12	NC		%	40
		Total Lithium (Li)	2005/09/12	12.7		%	40
		Total Magnesium (Mg)	2005/09/12	9.2		%	40
		Total Manganese (Mn)	2005/09/12	2.0		%	40
		Total Nickel (Ni)	2005/09/12	5.3		%	40
		Total Phosphorus (P)	2005/09/12	2.9		%	40
		Total Potassium (K)	2005/09/12	9.8		%	40
		Total Silicon (Si)	2005/09/12	33.2		%	40
		Total Silver (Ag)	2005/09/12	NC		%	40
		Total Sodium (Na)	2005/09/12	17.7		%	40
		Total Strontium (Sr)	2005/09/12	7.3		%	40
		Total Sulphur (S)	2005/09/12	8.1		%	40

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Quality Assurance Report (Continued)

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QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
891390 SW	RPD [908300-01]	Total Titanium (Ti)	2005/09/12	NC		%	40
		Total Vanadium (V)	2005/09/12	17.2		%	40
		Total Zinc (Zn)	2005/09/12	0.7		%	40
		Total Aluminum (Al)	2005/09/12	1.3		%	40
		Total Barium (Ba)	2005/09/12	0.02		%	40
		Total Beryllium (Be)	2005/09/12	NC		%	40
		Total Boron (B)	2005/09/12	NC		%	40
		Total Calcium (Ca)	2005/09/12	2.1		%	40
		Total Chromium (Cr)	2005/09/12	2.5		%	40
		Total Cobalt (Co)	2005/09/12	8.4		%	40
		Total Copper (Cu)	2005/09/12	10.2		%	40
		Total Iron (Fe)	2005/09/12	0.1		%	40
		Total Lead (Pb)	2005/09/12	NC		%	40
		Total Lithium (Li)	2005/09/12	2.0		%	40
		Total Magnesium (Mg)	2005/09/12	1.7		%	40
		Total Manganese (Mn)	2005/09/12	3.4		%	40
		Total Nickel (Ni)	2005/09/12	0.3		%	40
		Total Phosphorus (P)	2005/09/12	7.8		%	40
		Total Potassium (K)	2005/09/12	1.2		%	40
		Total Silicon (Si)	2005/09/12	37.4		%	40
		Total Silver (Ag)	2005/09/12	NC		%	40
		Total Sodium (Na)	2005/09/12	8.9		%	40
		Total Strontium (Sr)	2005/09/12	3.5		%	40
		Total Sulphur (S)	2005/09/12	11.2		%	40
		Total Titanium (Ti)	2005/09/12	31.0		%	40
		Total Vanadium (V)	2005/09/12	4.9		%	40
		Total Zinc (Zn)	2005/09/12	3.3		%	40
891433 SB1	Calibration Check	Total Antimony (Sb)	2005/09/13		89	%	74 - 117
		Total Arsenic (As)	2005/09/13		92	%	77 - 113
		Total Cadmium (Cd)	2005/09/13		92	%	84 - 110
		Total Molybdenum (Mo)	2005/09/13		92	%	85 - 109
		Total Selenium (Se)	2005/09/13		91	%	74 - 119
		Total Thallium (Tl)	2005/09/13		99	%	78 - 108
		Total Tin (Sn)	2005/09/13		95	%	79 - 110
		Total Uranium (U)	2005/09/13		105	%	82 - 110
		Total Zirconium (Zr)	2005/09/13		89	%	80 - 140
	MATRIX SPIKE [908300-01]	Total Arsenic (As)	2005/09/13		91	%	60 - 140
		Total Cadmium (Cd)	2005/09/13		98	%	60 - 140
		Total Selenium (Se)	2005/09/13		98	%	60 - 140
	QC STANDARD	Total Arsenic (As)	2005/09/13		80	%	60 - 139
		Total Cadmium (Cd)	2005/09/13		82	%	60 - 140
		Total Selenium (Se)	2005/09/13		82	%	60 - 140
	BLANK	Total Antimony (Sb)	2005/09/13	<0.1		mg/kg	
		Total Arsenic (As)	2005/09/13	<0.5		mg/kg	
		Total Cadmium (Cd)	2005/09/13	<0.02		mg/kg	
		Total Molybdenum (Mo)	2005/09/13	<0.02		mg/kg	
		Total Selenium (Se)	2005/09/13	<1		mg/kg	
		Total Thallium (Tl)	2005/09/13	<0.02		mg/kg	
		Total Tin (Sn)	2005/09/13	<1		mg/kg	
		Total Uranium (U)	2005/09/13	<0.04		mg/kg	
		Total Zirconium (Zr)	2005/09/13	<0.1		mg/kg	
	RPD [908300-01]	Total Antimony (Sb)	2005/09/13	NC		%	40
		Total Arsenic (As)	2005/09/13	16.3		%	40
		Total Cadmium (Cd)	2005/09/13	3.0		%	40
		Total Molybdenum (Mo)	2005/09/13	36.0		%	40

Maxxam Analytics Inc

FRANZ ENVIRONMENTAL INC.
Attention: ANDREW HOWTON
Client Project #: 979-0501, DRUMHELLER
P.O. #:
Site Reference: DRUMHELLER

Quality Assurance Report (Continued)

Maxxam Job Number: CA534894

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
891433 SB1	RPD [908300-01]	Total Selenium (Se)	2005/09/13	NC		%	40
		Total Thallium (Tl)	2005/09/13	18.9		%	40
		Total Tin (Sn)	2005/09/13	NC		%	40
		Total Uranium (U)	2005/09/13	3.9		%	40
		Total Zirconium (Zr)	2005/09/13	15.6		%	40
892371 NJ1	Calibration Check	Acid Extr. (Closed) Mercury (Hg)	2005/09/13		89	%	69 - 132
	MATRIX SPIKE [908303-01]	Acid Extr. (Closed) Mercury (Hg)	2005/09/13		87	%	66 - 133
	QC STANDARD	Acid Extr. (Closed) Mercury (Hg)	2005/09/13		88	%	66 - 133
	BLANK	Acid Extr. (Closed) Mercury (Hg)	2005/09/13	<20		ug/kg	
	RPD [908303-01]	Acid Extr. (Closed) Mercury (Hg)	2005/09/13	NC		%	40
892396 SP3	Calibration Check	Soluble Calcium (Ca)	2005/09/13		104	%	89 - 110
		Soluble Magnesium (Mg)	2005/09/13		99	%	91 - 106
		Soluble Sodium (Na)	2005/09/13		98	%	92 - 114
		Soluble Potassium (K)	2005/09/13		99	%	90 - 113
		Soluble Sulphate (SO4)	2005/09/13		102	%	86 - 110
	QC STANDARD	Soluble Calcium (Ca)	2005/09/13		95	%	85 - 115
		Soluble Magnesium (Mg)	2005/09/13		93	%	86 - 112
		Soluble Sodium (Na)	2005/09/13		96	%	88 - 112
		Soluble Potassium (K)	2005/09/13		95	%	80 - 135
		Soluble Sulphate (SO4)	2005/09/13		92	%	87 - 116
	BLANK	Soluble Calcium (Ca)	2005/09/13	<2		mg/L	
		Soluble Magnesium (Mg)	2005/09/13	<1		mg/L	
		Soluble Sodium (Na)	2005/09/13	4, RDL=3		mg/L	
		Soluble Potassium (K)	2005/09/13	<1		mg/L	
		Soluble Sulphate (SO4)	2005/09/13	<5		mg/L	
	RPD [908300-01]	Soluble Sulphate (SO4)	2005/09/13	0.7		%	40
		Soluble Calcium (Ca)	2005/09/13	0.5		%	40
		Soluble Magnesium (Mg)	2005/09/13	0.2		%	40
		Soluble Sodium (Na)	2005/09/13	0.1		%	40
		Soluble Potassium (K)	2005/09/13	0.8		%	40
892621 RC	Calibration Check	Soluble Chloride (Cl)	2005/09/13		99	%	93 - 108
	MATRIX SPIKE [908300-01]	Soluble Chloride (Cl)	2005/09/13		98	%	90 - 108
	QC STANDARD	Soluble Chloride (Cl)	2005/09/13		99	%	50 - 150
	BLANK	Soluble Chloride (Cl)	2005/09/13	<5		mg/L	
	RPD [908300-01]	Soluble Chloride (Cl)	2005/09/13	NC		%	40
892743 TL1	QC STANDARD	Saturation %	2005/09/13		98	%	84 - 116
	RPD [908300-01]	Saturation %	2005/09/13	1.3		%	12
892755 TL1	Calibration Check	Soluble pH	2005/09/13		100	%	99 - 101
	QC STANDARD	Soluble pH	2005/09/13		99	%	95 - 105
	RPD [908300-01]	Soluble pH	2005/09/13	0		%	5
892762 LLE	Calibration Check	Soluble Ammonia (N)	2005/09/13		102	%	88 - 120
	QC STANDARD	Soluble Ammonia (N)	2005/09/13		80	%	50 - 150
	BLANK	Soluble Ammonia (N)	2005/09/13	<0.1		mg/L	
	RPD [908300-01]	Soluble Ammonia (N)	2005/09/13	NC		%	N/A
892764 LLE	Calibration Check	Total Kjeldahl Nitrogen	2005/09/13		90	%	80 - 120
	QC STANDARD	Total Kjeldahl Nitrogen	2005/09/13		87	%	60 - 121
	BLANK	Total Kjeldahl Nitrogen	2005/09/13	<3		mg/kg	
	RPD [908302-01]	Total Kjeldahl Nitrogen	2005/09/13	11.1		%	40
892772 JL3	RPD [908284-01]	Moisture	2005/09/13	10.2		%	20
893102 JU1	Calibration Check	Soluble Nitrate (N)	2005/09/13		101	%	92 - 111
	MATRIX SPIKE [908300-01]	Soluble Nitrate (N)	2005/09/13		101	%	81 - 121
	QC STANDARD	Soluble Nitrate (N)	2005/09/13		89	%	50 - 150
	BLANK	Soluble Nitrate (N)	2005/09/13	0.3, RDL=0.2		mg/L	

Maxxam Analytics Inc

FRANZ ENVIRONMENTAL INC.
Attention: ANDREW HOWTON
Client Project #: 979-0501, DRUMHELLER
P.O. #:
Site Reference: DRUMHELLER

Quality Assurance Report (Continued)

Maxxam Job Number: CA534894

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
893102 JU1	RPD [908300-01]	Soluble Nitrate (N)	2005/09/13	2.5		%	40
893125 SW	Calibration Check	Dissolved Calcium (Ca)	2005/09/13		101	%	89 - 110
		Dissolved Magnesium (Mg)	2005/09/13		99	%	91 - 106
		Dissolved Potassium (K)	2005/09/13		100	%	90 - 113
		Dissolved Sodium (Na)	2005/09/13		102	%	92 - 114
		Dissolved Iron (Fe)	2005/09/13		96	%	87 - 113
		Dissolved Manganese (Mn)	2005/09/13		102	%	92 - 110
	MATRIX SPIKE [908319-01]	Dissolved Calcium (Ca)	2005/09/13		103	%	80 - 120
		Dissolved Magnesium (Mg)	2005/09/13		98	%	80 - 120
		Dissolved Potassium (K)	2005/09/13		98	%	80 - 120
		Dissolved Sodium (Na)	2005/09/13		104	%	80 - 120
		Dissolved Iron (Fe)	2005/09/13		92	%	80 - 120
		Dissolved Manganese (Mn)	2005/09/13		101	%	80 - 120
	QC STANDARD	Dissolved Calcium (Ca)	2005/09/13		102	%	90 - 110
		Dissolved Magnesium (Mg)	2005/09/13		96	%	90 - 110
		Dissolved Sodium (Na)	2005/09/13		99	%	90 - 110
	BLANK	Dissolved Calcium (Ca)	2005/09/13	<0.3		mg/L	
		Dissolved Magnesium (Mg)	2005/09/13	<0.2		mg/L	
		Dissolved Potassium (K)	2005/09/13	<0.3		mg/L	
		Dissolved Sodium (Na)	2005/09/13	<0.5		mg/L	
		Dissolved Iron (Fe)	2005/09/13	<0.01		mg/L	
		Dissolved Manganese (Mn)	2005/09/13	<0.004		mg/L	
	RPD [908319-01]	Dissolved Calcium (Ca)	2005/09/13	5.7		%	20
		Dissolved Magnesium (Mg)	2005/09/13	2.3		%	20
		Dissolved Potassium (K)	2005/09/13	1.5		%	20
		Dissolved Sodium (Na)	2005/09/13	0.3		%	20
		Dissolved Iron (Fe)	2005/09/13	NC		%	20
		Dissolved Manganese (Mn)	2005/09/13	4.4		%	20
893230 LLE	Calibration Check	Soluble Phosphate (P)	2005/09/13		97	%	N/A
	BLANK	Soluble Phosphate (P)	2005/09/13	<0.03		mg/L	
	RPD [908300-01]	Soluble Phosphate (P)	2005/09/13	2.8		%	40
893258 JU1	Calibration Check	Soluble Nitrite (N)	2005/09/13		100	%	91 - 110
	MATRIX SPIKE [908300-01]	Soluble Nitrite (N)	2005/09/13		100	%	87 - 117
	BLANK	Soluble Nitrite (N)	2005/09/13	<0.2		mg/L	
	RPD [908300-01]	Soluble Nitrite (N)	2005/09/13	NC		%	40

N/A = Not Applicable
NC = Non-calculable
RPD = Relative Percent Difference

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APPENDIX E

Environmental Site Investigation and Slope Stability Study for the Drumheller Institution Site No. 530, Drumheller, Alberta, by Franz Environmental Inc., March 2011

Environmental Site Investigation and Slope Stability Study for the Drumheller Institution Site No. 530, Drumheller, Alberta

Contract No: WE699-103892-004-NCS

FINAL REPORT

Prepared for:
Public Works and Government Services Canada
Environmental Services-Western Region
10025 Jasper Avenue, Fifth Floor
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FRANZ Project No. 2026-1001
March 29, 2011

Stephen Livingstone, M.Sc., P.Geo.
Tryfan Jones, M.Sc.

EXECUTIVE SUMMARY

Franz Environmental Inc. (FRANZ) was retained by Public Works and Government Services Canada (PWGSC) on behalf of Correctional Services Canada (CSC) to complete an Environmental Investigation (EI) and preliminary qualitative Slope Stability Study at the Drumheller Institution Site No.530 in Drumheller, Alberta. The two sites investigated were:

a. The Rifle Range Site (530-C04).
b. The Former Landfill Site (530-L01).

The full scope of work set out in the work plan by FRANZ and based on the SOW, was not completed due to limitations encountered from weather conditions. Because of the sub zero temperatures reached prior to the commencement of the field program, surface media were frozen. Surface water and sediments could not be sampled and groundwater samples were limited.

A total of fourteen (14) test pits were advanced by FRANZ personnel at the Rifle Range during the field program from December 13 to 19, 2010. Soil samples were collected and submitted for laboratory analysis metals and a leachate test. The Rifle Range (530-C04) was confirmed an area of environmental concern (AEC). All 19 soil samples submitted for metals reported concentrations in excess of Environmental Quality Guidelines for agricultural land use with fine-grained soil and non-potable groundwater guidelines. The preliminary estimated areal extent of metal contamination is the order of 3500 m^2. A depth of 0.4 m was assumed, resulting in an initial expected volume of contamination on the order of 1400 m^3. One groundwater sample was collected from a previously installed monitoring well at the Former Landfill Site (530-L01). The sample was submitted for laboratory analysis of metals (dissolved) and VOCs. Boron, copper and uranium had detectable concentrations that were above CCME FWAL guidelines. Molybdenum reported concentrations that were just above the CCME Agricultural guidelines. In addition, historical testing on site reported concentrations of aluminum and selenium in groundwater above CCME FWAL guidelines.

The final NCSCS worksheet score for the Rifle Range Site was 53.2, making the Site a Class 2 – Medium Priority for Action. The Site received a score of 17.3 (out of a possible 33) for contaminant characteristics; 15.9 (out of a possible 33) for Migration Potential; and 20 (out of a possible 34) for Exposure. The final NCSCS worksheet score for Former Landfill Site (530-L01) with revised information obtained in this investigation was 65.6, making the Site a Class 2 – Medium Priority for Action. The Site received a score of 21.5 for contaminant characteristics (out of a possible 33); 22.7 (out of a possible 33) for Migration Potential; and 21.4 (out of a possible 34) for Exposure.

A preliminary qualitative slope stability analysis was completed at the Former Landfill Site using existing information on the soil/waste properties and newly acquired topographic data during a site visit.

The purpose of the investigation was to establish the preliminary 'Limit of Hazard Lands' for the site. This limit constitutes a safe setback for the landfill site with respect to slope stability. As a result of the slope stability analysis, it is recommended that no construction equipment or stockpiling of material be permitted within 30 metres of the north section of the landfill, 25 metres of the mid section of the landfill and 7 metres of the south section of the landfill or at the crest of the slope until the landfill slope remediation measures are carried out.

Conceptual Remedial and Risk Management Options are presented which outlines the strategies that can be used to mitigate exposure of contaminants to potential human and ecological receptors.

The buried waste debris is likely the main source of the metal impacts to the environment at the Former Landfill. It is our opinion that the remediation/risk management priority should be based on the removal of physical hazards (slope stability) and the containment and control of metals in the surface water pathways at the Former Landfill (i.e., surface water drainage from landfill) discharging to the Red River.

The long-term strategy for the Former Landfill should be based on the following goals, in order of priority:

- Removal of Physical Hazards;
    a. Re-grade the Slope; and (if required)
    b. Erosion Control and Slope Improvements
- Containment and control, including long term monitoring or in-situ passive treatment systems;
- Risk management through the completion of a preliminary quantitative risk assessment; and
- Site monitoring and inspections.

At the Rifle Range the remediation/risk management priority should be to remove/control the contaminant source of metals in soils (i.e. residual bullets and bullet fragments). The following three options were presented:

- Option 1: *Ex-Situ* Removal of Impacted Soils – excavation of impacted soils with disposal at a land treatment facility.

- Option 2: In-Situ Management – mechanical screening of soils.
- Option 3: In-Situ Treatment – physical separation of contaminants by soil washing and chemical separation.

As long as the Rifle Range continues in use as a rifle range and there are no operable pathways to surface water receptors ex-situ remediation and off-site treatment, as well as in-situ treatment are not recommended since the gun butt berm soils would become re-contaminated by the shooting activity after soil remediation. However, once the Rifle Range is permanently closed, these would become viable options. In the interim, in-situ management is recommended for partial removal of the source and homogenizing of soils.

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1.0 INTRODUCTION

Franz Environmental Inc. (FRANZ) was retained by Public Works and Government Services Canada (PWGSC) on behalf of Correctional Services Canada (CSC) to complete an Environmental Investigation (EI) and preliminary Slope Stability Study at the Drumheller Institution Site No.530 in Drumheller, Alberta. The project was completed under PWGSC Contract No. EW699-103892-004-NCS. PWGSC Project number R.044325.001.

This report describes the Environmental Investigation and preliminary Slope Stability Study and was prepared in accordance with the PWGSC Statement of Work (SOW) dated November 2010 and additional details and discussion regarding the scope of work with the PWGSC Project Manager (PM) on November 5, 2010 and the FRANZ work plan dated November 10, 2010.

CSC retained PWGSC Environmental Services Branch – Western Region to assist in co-coordinating the program on its behalf. All contract administration and project management for CSC was conducted by PWGSC.

Throughout this report the Drumheller Institution will be referred to as “the Site”.

1.1 Project Objectives

The objectives of this EI and slope stability study, as stated in the SOW and clarified with the PWGSC PM (November 5, 2010), are as follows:

<u>Rifle Range Site 530-C04:</u>

1. Complete a detailed intrusive investigation to identify and if possible, delineate the horizontal and vertical extent of metal impacts to soils. This includes the completion of a background soil quality assessment.
2. Develop a Remedial Options Analysis (ROA) (minimum of two options should be provided).
3. Classify the site according to the National Classification System for Contaminated Sites (NCSCS, CCME, 2010).

<u>Former Landfill Site 530-L01:</u>

1. Collect surface water and groundwater samples at the Former Landfill for pH, general chemistry and metals.
2. Complete an assessment of the background concentrations to determine if the metal parameters which were previously found to exceed the CCME guidelines in the samples collected from the Former Landfill are indicative of background concentrations or a result of the site activities.
3. Complete a preliminary slope stability assessment which may include critical surface calculations, profiles normal to the slope contour and survey levelling if deemed by the

consultant to be required to determine if engineered mitigative actions are necessary to stabilize the slope and eliminate/reduce the safety risk at the former landfill.

4. Further characterize the sites by development of a thorough knowledge of subsurface geology, hydrology and hydrogeology in the areas including soil permeability and groundwater flow gradients by developing a 3-D conceptual model.
5. Develop a Remedial Options Analysis (ROA) including (minimum of two options should be provided).
6. Classify the site according to the National Classification System for Contaminated Sites (NCSCS, CCME, 2008).

The work plan for this study was based on the SOW and on the previous reports provided by PWGSC.

1.2 Scope of Work

FRANZ completed the following tasks to fulfill the objectives identified in Section 1.1:

- Completed a document review and data gap analysis;
- Designed a supplemental field investigation and laboratory analytical program to address data gaps. The work plan addressed any gaps in information required to further refine the remedial options in sufficient detail to provide information required to prepare a specification for remediation activities;
- Developed a Site-Specific Health & Safety Plan prior to the field program;
- Executed the approved field and laboratory analytical program;
- Interpreted the data from previous and current investigations to develop a 3-Dimensional Conceptual Site Model, indicating the spatial location of contaminated media, potential pathways for contaminant migration, and potential receptors;
- Developed at least two remedial options to screen using qualitative screening criteria;
- Classified the site using the NCSCS (2008);
- Documented supplemental investigation findings and remedial options as a sub section in a report.

2.0 BACKGROUND INFORMATION

2.1 Site Description

The Drumheller Institution was opened in 1967 to house medium-security inmates. The Institution is located five kilometres south-southeast of Drumheller, Alberta (See Figure 1, Appendix A). The legal description of the property is South East ¼ of Section 25; Township 28; Range 20; West of the Fourth Meridian.

The main portion of the Institution is enclosed within a perimeter fence. The main living units and activities are located along with various recreational facilities. The rifle range and associated building, smoke house and old incinerator building are located on a low hill approximately 750 meters south east of the perimeter fence. This area is along a short unpaved road and is housed within its own perimeter fence. The inactive landfill is located approximately 500 m southeast of the Institution on the edge of a coulee, as shown on Figure 2, Appendix A.

The drinking water supply for the Institution is supplied by the City of Drumheller. No potable use of groundwater is made on site. The site is relatively flat and surrounded by low rolling hills. Much of the surrounding area to the south and east is dominated by the rolling hill terrain. Surface water drainage at the site ultimately drains towards the Red River. The Red Deer River is located to the north east and has cut deep ravines through the topography. Surrounding lands are predominantly prairie grassland, some of which has been cultivated.

2.2 Previous Investigations

Several investigations have been completed at the Site and reviewed by FRANZ. The most relevant reports detailing these previous investigations are listed below.

- *Correctional Services Canada, Environmental Baseline Assessment, Drumheller Medium Security Institution, Site Number 530, Volume 1 of 4: Phase I Environmental Site Assessment. Prepared by PWGSC, dated February 10, 1999.*
- *Supplemental Phase II Investigation, Site 530-L01, Landfill, Drumheller Institution, Drumheller, Alberta. Prepared by Franz Environmental Inc., dated March 2006.*

The previous investigations conducted at the site have identified two specific areas of environmental concern (AEC) to be discussed within this report: the Rifle Range and the Former Landfill.

<u>The Rifle Range (530-C04)</u>
The rifle range has reportedly been maintained southeast of the compound since approximately 1973. The Institution uses the Rifle Range on a weekly basis for staff training exercises. The

soil in the berm has never been replaced, however it is not known if material has been added to the berm or the berm size increased. The range is less than 150 metres from a steep ravine to the east. It appears that surface runoff from the site would flow in this direction.

The Former Landfill (530-L01)

The inactive landfill is located approximately 500 m southeast of the Institution on the edge of a coulee. A creek, which drains into the Red River, is present at the base of the coulee, approximately 50 to 60 m below the landfill and a groundwater spring was previously observed in a steep gully 20 m north of the landfill. The landfill is approximately 150 m by 200 m and operated from the mid 1960s until the late 1980s. It was reported that the material disposed of in the landfill includes domestic waste and demolition material generated during the renovations at the Institution. The landfill is not engineered and it is reported that wastes were historically pushed over the edge of the coulee. The surface of the landfill has historically been used as a burn area and is occasionally used to store spoil piles from the excavations around the site. Previous investigations identified elevated concentrations of metals in groundwater and surface water (collected from the creek and groundwater spring) with elevated concentrations of metals, PHCs and pH also identified in soil samples collected along the walls of the coulee and spoil piles.

2.2.1 Summary of PWGSC – Western Region Phase I ESA

The results of the PWGSC Phase I ESA were based on a records review, interviews, aerial photos and a site visit that was conducted on November 12, 1998.

The following potential contamination issues were identified during the Phase I ESA by PWGSC:

- Fuel Storage Tanks;
- Solid Wastes in the large landfill south of the perimeter fence; and
- Lead in Firearms Range Soils.

The PWGSC Phase I ESA concluded with the following recommendations to address the fore mentioned contamination issues:

- Confirm that no contamination exists at the former UST site by completing a Phase II ESA;
- Initiate a Phase II investigation to determine whether leachate is being produced from the landfill site; and
- A Phase II site investigation of the firearms range should be initiated to determine total volume of contamination at the site and potential impacts to surrounding area.

Documented recommendations for other issues that may prevent or lower the potential for future site contamination were made in relation to hazardous wastes, storage tanks, solid wastes, asbestos, PCB's, halocarbons, and lead paint.

2.2.2 Summary of FRANZ Supplemental Phase II ESA

FRANZ completed a Supplemental Phase II investigation in 2005 at the Drumheller Institution. This work was supplemental to investigations completed by UMA Engineering Ltd. in 2000 and FRANZ in 2004. The site investigated was the inactive Landfill located 500 metres southeast of the Institution complex. The objective was to establish impacts to soil, groundwater, surface water and sediments.

The investigation involved well surveying and water level monitoring, soil sampling and groundwater sampling from existing wells and new boreholes (MW05-1 – MW05-3), burn pit sampling, spoil pile (excavated material from the Institution temporarily stockpiled at the site) sampling, and surface water and sediment sampling from the spring and creek. Soils were analyzed for benzene, toluene, ethylbenzene, and xylenes (BTEX), petroleum hydrocarbons (PHCs) and metals. Surface water, groundwater, and sediments were analyzed for metals.

Contaminants of concern (COCs) identified in soils at the burn pit include benzene and toluene. Chromium was reported in the spoil pile. Soils within the general area of the landfill are alkaline. Arsenic was identified in two of the three boreholes and selenium and thallium was identified in one of the boreholes.

Only two wells (MW99-3 and MW05-1) on site were able to produce sufficient sample volumes, one on the upper plateau and one at the toe of the landfill. Aluminum and selenium were reported in groundwater above FWAL CCME guidelines.

Aluminum, cadmium, chromium, lead, zinc, arsenic, copper, iron and total mercury were identified as contaminants of concern (COCs) in all surface water samples collected from the creek. In the groundwater spring, the same COCs were reported with the exception of total mercury. The specification of the mercury was not completed. There were no COCs identified in any of the sediment samples analyzed.

FRANZ recommended further sampling to accurately delineate and assess the contamination present on the site. Specifically, FRANZ suggested the following:

- Additional seasonal sampling and chemical testing for metals should be carried out at the same surface water locations and at least one additional upstream and downstream locations;
- Seasonal sampling and chemical testing for metals in groundwater obtained from all monitoring wells located in the landfill toe and at the base of the coulee; and

- A background concentration study to establish which of the metals identified as COCs is anthropogenic in origin and/or naturally high in concentration.

FRANZ also recommended the following additional recommendations:

- The benzene and toluene impacted soil and the remnants of the charcoal and metal pieces at the burn area, along with chromium impacted soil in the single spoil pile, should be removed and disposed at a suitable disposal site.
- A qualified practitioner should be consulted to assess the stability of the landfill slope and establish what engineering controls or mitigative action may be required to protect human safety and minimize/prevent the possibility of a catastrophic slope failure.

3.0 REGULATORY GUIDELINES

Federal environmental guidelines are generally used on sites owned and operated by the federal government; however, where federal criteria do not exist, FRANZ will reference Alberta Environment guidelines.

3.1 Soil

The soil analytical results were compared to the CCME Canadian Environmental Quality Guidelines (EQGs), specifically the *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health* (CSQGs). These guidelines are applied to most federal contaminated sites. The guidelines are numerical limits intended to maintain, improve or protect environmental quality and human health at contaminated sites. They are derived using toxicological data and aesthetic considerations.

The *CSQGs* (CCME, 1999) are a subsection of the Canadian Environmental Quality Guidelines, and are derived to approximate a no- to low- effect level (or threshold level) based only on scientific data, including toxicology, fate, and behaviour. The guidelines are based on direct contact, ingestion, and inhalation toxicity data, as well as check mechanisms to ensure that the guidelines are protective of receptors exposed indirectly to contaminants. Fact sheets are provided for 31 compounds. In this report, the benzene, toluene, ethylbenzene and xylenes fact sheets were used as sources of comparative criteria.

As a preliminary and conservative determination of protection of human health and the environment at the site, FRANZ has applied the Tier 1 levels to all analytical results. The appropriate levels are presented with the laboratory analytical data in tables.

The standards or guidelines adopted for this evaluation are presented as follows:

Canadian Soil Quality Guidelines (CSQG) for the Protection of Environmental and Human Health (CCME, 1999, with updates) for agricultural land use, including fact sheets for benzene, toluene, ethylbenzene, and xylenes. Fine-grained soils and non-potable groundwater are stipulated.

Leachate soil results were compared against the *Alberta Government's Waste Control Regulation 192/96 - Schedule 1*. This criterion defines which solid hazardous wastes can be disposed of in Alberta's Class I, II and III landfills. Environmental guidelines from *Table A – Chemical Constituents and Leachate Limits in Alberta* from the document title Final Report – Alberta's Hazardous Waste Regulatory Framework prepared by the Hazardous Waste Technical Committee for the Waste Management Stakeholder Group, dated November 2006 were used.

3.2 Groundwater

Canadian Water Quality Guidelines are intended to protect freshwater and marine life from anthropogenic stressors such as chemical inputs or changes to physical conditions. The guidelines that apply to freshwater habitat are called the Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life, hereafter referred to as CCME FWAL.

As the groundwater on site is not used for potable purposes on site, the CCME Canadian Environmental Quality Guidelines, specifically the *CCME FWAL,* may be appropriate as groundwater is expected to daylight to surface water at the groundwater seeps on the slope of the Landfill, ultimately discharging to the surface water in the creek.

In the absence of CCME FWAL guidelines, the CCME Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses will be used.

4.0 INVESTIGATIVE METHODOLOGY

An environmental investigation was completed at the Drumheller Institution from December 13 to 19, 2010. The program consisted of the following:

- Completing a health and safety plan prior to the field work;
- Locating underground utilities prior to the field work;
- Advancing fourteen (14) test pits in the vicinity of the Rifle Range;
- Collection of soil samples (19) from said test pits;
- Collection of groundwater from at the Former Landfill area;
- Completion of an assessment of background soil conditions;
- Completion a slope stability assessment of the Former Landfill; and
- Submission of samples for laboratory analysis.

The full scope of work set out in the work plan by FRANZ, based on the SOW, was not completed due to limitations encountered from weather conditions. Because of the sub zero temperatures reached prior to the commencement of the field program, surface media were frozen. Surface water and sediments could not be sampled. Groundwater samples were limited. In addition, due to snow cover, FRANZ field assessor had limited view of surface features at the Rifle Range and Former Landfill.

The field investigation procedures are described below.

4.1 Health & Safety Plan

Before commencing with site activities, a site-specific health and safety plan (HASP) was prepared. The HASP identified and provided mitigative actions for potential physical and chemical hazards associated with the work involved in the site investigation. The HASP also contained a listing of emergency contact numbers and provided protocols to follow in the event of an emergency. A copy of the plan was presented to PWGSC and the CSC site representative for their review and agreement. A copy of the HASP has been retained on file at FRANZ, and is presented in Appendix C.

4.2 Rifle Range Site 530-C04

4.2.1 Approach

The field work undertaken during the investigation was aimed at collecting sufficient information to determine the horizontal and vertical impacts to soil from metals, completion of the Environmental Investigation, NCSCS and development of conceptual Remedial Options. These tasks included:

- Obtaining information on the frequency of use, number of shots and historical use;

- Completion of a general topographic survey between the target and the gun butt/bermed area;
- Completion of a site reconnaissance to observe:
  - Bullet pockets in butt/berm area
  - Strafed soil conditions near berm area
  - Bullet fall-out in open range
  - Map all surface water ditches and discharge points
- Confirming the physical and chemical properties of the soil;
- Characterizing the soil contamination by collecting soil samples at appropriate locations to assess the type, form, concentrations, and horizontal and vertical extent of contamination; and
- Preparing the site conceptual model to reflect the environmental knowledge attained.

4.2.2 Utility Locates

Upon arrival at the site, FRANZ discussed underground utilities with the CSC staff. The nature of the work would not have posed a threat to underground utilities as it consisted of maximum 0.30 metre hand dug pits. Due diligence was followed visually, based on site features.

4.2.3 Test Pitting and Soil Sampling

Prior to the excavation of the test pits, a sampling plan was completed based on the previous Phase I ESA completed by PWGSC and the Supplemental Phase II investigation completed by FRANZ. Figure 3 in Appendix A indicates the location of the Rifle Range in relation to other site features, as well as test pit locations.

The soil sampling program included advancing 14 test pits to address the rifle range. A northern and southern transect along the rifle range provided a course sample grid across the site. Anecdotal evidence suggested that more bullets were buried in the area around the shooting targets. This area was targeted accordingly. Soil samples were collected and selected samples were submitted for laboratory analysis.

A total of nineteen (19) soil samples were collected and submitted for metals analysis. Three background samples were submitted for metals analysis and one composite sample was submitted for a Basic Class II Landfill leachate test for waste characterization. The FRANZ field assessor took representative soils samples in the absence of lead shot fragments. Soils were collected and manually screened for shot fragments and other ordnances. If bullets/shot fragments were present, they were removed prior to placing soils in the sample jars.

Four field duplicate samples were also submitted for metals for quality assurance and quality control (QA/QC) purposes.

Manual test pitting and soil sampling was completed using a stainless steel trowel. All test pits were to be excavated to the maximum depth of 30 cm, however due to weather conditions (i.e. surface was frozen) a number of test pits were excavated to a maximum depth of 5 - 20 cm below grade. Samples were collected from the test pit wall and homogenized prior to filling the laboratory supplied sample jars.

Soil samples were collected from each test pit and placed into glass jars. Discrete soil samples and blind duplicates were collected as grab samples using disposable nitrile gloves for each sample. Subsurface conditions encountered in the test pits were logged at the time of excavation. Soil descriptions including approximate grain size, colour, moisture content, stratigraphy, metal debris present (i.e., bullets), and the nature and extent of apparent contamination was recorded for each unit. A selection of site photos is presented in Appendix D.

4.2.4 Surface Water and Sediment Sampling

Surface water samples were to be collected along the stream banks, pooled water areas (ponds) adjacent to the rifle range and at locations in which surface water contamination by metals is likely. Where available, sediment samples were to be collected at the corresponding surface water sample locations. However, due to the weather conditions at the time of the site visit, surface water or sediments (if present) were not available for sampling as surface conditions were frozen.

4.2.5 Quality Assurance and Quality Control

Field personnel employed FRANZ'S QA/QC protocols, including techniques for soil sampling, sample storage, shipping and handling, as well as collection of duplicates.

4.2.5.1 Field

Soil samples collected for potential laboratory analysis were placed in laboratory-prepared 120 mL glass jars fitted with screw-tight Teflon-lined lids. Sample numbers were clearly marked on the containers, as well as on the lids. The soil jars were filled to capacity with minimum headspace and stored in coolers with cold packs to moderate temperature fluctuations during transport to the laboratory. To prevent cross contamination, samples were collected with fresh nitrile gloves. Where samples were impossible to obtain by hand, the FRANZ field assessor employed a stainless steel trowel.

The samples were transported to the project laboratory, Maxxam Analytics in Calgary, Alberta, accompanied by a Chain of Custody form. The analytical results can be found in Tables 1 through 3 (Appendix B), and the laboratory reports and chain of custody forms can be found in Appendix E.

4.2.5.2 Laboratory

To assess the reliability of the laboratory data, duplicate samples were taken for approximately every five samples collected by FRANZ. As a result, four blind field duplicates were collected in the soil sampling program at the rifle range.

FRANZ personnel generated the duplicate samples by alternately placing approximately 10 percent of the sample volume into the primary sample container and then placing the same amount into the duplicate container. The field staff continued placing aliquots of approximately 10 percent of the container volume into each container until both containers were filled.

Analytical data quality was assessed by submission of the following:

- Soil samples B1-1 (primary) and B1-1 DUP (duplicate), B3-1 (primary) and B3-1 DUP (duplicate), B6-2 (primary) and B6-1 DUP (duplicate) and B7-1 (primary) and B7-2 DUP (duplicate) were all analyzed for metals.

For each set of duplicates, the relative percent difference (RPD) was calculated using the following formula:

$$RPD = \frac{|X_1 - X_2|}{X_{average}} \times 100$$

where, X_1 and X_2 are the duplicate concentrations and X_{average} is the mean of these two values. The duplicate results were evaluated using criteria developed by Zeiner (1994), which draws from several data validation guidelines developed by the United States Environmental Protection Agency (USEPA). According to these criteria, the RPD for duplicate samples should be less than 20% for aqueous samples, and less than 40% for solid samples. RPDs can be calculated only when the compound is detected in both the original and the duplicate sample at a concentration above the method detection limit. Alternative criteria are used to evaluate duplicate pairs where one or both of the results is less than five times the detection or quantitation limit, or where one or both of the results is less than the detection or quantitation limit (i.e., nd or ‘not-detected’). A full description of the criteria is provided in Table 4-1, below.

Table 4-1: Criteria for the Evaluation of Duplicate Sample Results

Result A	Result B	Criteria for Acceptable Precision	
		Aqueous (water)	Solid (soil)
Organic			
nd	nd	acceptable precision, no evaluation required	
nd	positive	result B - 0.5 x QL < QL	result B - 0.5 x QL < 2 x QL
positive and > 5 x QL	positive and > 5 x QL	RPD < 20%	RPD < 40%
positive and < or = 5 x QL	positive	|result B - result A| < QL	|result B - result A| < 2 x QL
Inorganic			
nd	nd	acceptable precision, no evaluation required	
nd	positive	result B - IDL < LRL	result B - IDL < 2 x LRL
positive and > 5 x LRL	positive and > 5 x LRL	RPD < 20%	RPD < 40%
positive and < or = 5 x LRL	positive	|result B - result A| < QL	|result B - result A| < 2 x QL

Source: Zeiner, S.T., 1994

Notes:
nd – not detected
QL – quantitation limit
RPD – relative percent difference, $\frac{|X_1 - X_2|}{X_{average}} \times 100$
IDL – instrument detection limit
LRL – laboratory reporting limit

4.3 Former Landfill Site 530-L01

4.3.1 Approach

The field work undertaken during this investigation at the Former Landfill Site was aimed at collecting sufficient information to supplement the existing information for the site. In addition, this information was used to complete the NCSCS and development of a conceptual Remedial Options. The tasks completed included:

- Sampling and assessing contaminant concentrations in groundwater;
- Complete a preliminary slope stability study, and
- Prepare a site conceptual model of the hydrology, geology and hydrogeology to reflect the contaminant pathways.

4.3.2 Monitoring of Existing Wells

The FRANZ field assessor was to monitor ten previously installed monitoring wells to assess the presence of groundwater. During the site visit, only one well had sufficient water for sampling. The remaining groundwater wells were dry.

4.3.3 Groundwater Sampling

At the time of the site visit, only one groundwater well (MW05-01) had sufficient volumes for sampling. The purpose of groundwater sampling was to obtain information that could be used to determine the presence and possible extent of groundwater impacts and determine the

potential for trans-boundary migration of COCs. Prior to the collection of the groundwater sample, water levels were measured with reference to a datum.

Following water level monitoring, and prior to sampling, each interval was purged of standing water until pH, conductivity, turbidity, redox and temperature was stabilized. This ensured that the sample was representative of aquifer conditions.

The groundwater sample was submitted to the laboratory for analysis of VOCs and Dissolved metals. A duplicate sample was also collected. Analytical results can be found in Table 3 and 4 (Appendix B).

4.3.4 Hydraulic Conductivity Testing

Hydraulic conductivity testing was to be conducted on 2 existing wells to determine spatial hydraulic conductivity at the site. In-situ, single well rising head slug tests was to be conducted on all monitoring wells. Hydraulic conductivity testing was not completed due to the insufficient volumes and dry well conditions during the time of the site visit. This information was to be used in the conceptual model.

4.3.5 Surface Water and Sediment Sampling

It was proposed that surface water and sediment samples would be collected at corresponding locations along the stream banks, pooled water areas and at locations where metal contamination was likely. However, due to weather conditions during the site visit, sampling was not possible as surface waters, seepage faces and sediments were frozen.

4.3.6 Quality Assurance and Quality Control

Field personnel employed FRANZ'S QA/QC protocols, including techniques for groundwater sampling, sample storage, and shipping and handling.

The groundwater sample collected for potential laboratory analysis was placed in laboratory-prepared containers. Each sample for VOCs and metals was collected in a laboratory supplied bottle. Sample numbers were clearly marked on the containers. Samples were collected with no headspace for VOCs analysis. The sample was stored in a cooler with cold packs to moderate temperature fluctuations during transport to the laboratory.

Analytical data quality was assessed by submission of the following:

- Groundwater sample MW05-01 (primary) and MW05-01 DUP (duplicate) was analyzed for Dissolved metals and VOCs.

The samples were transported to the project laboratory, Maxxam Analytics in Calgary, Alberta, accompanied by a Chain of Custody form. The analytical results can be found in Tables 4 and

5 (Appendix B), and the laboratory reports and chain of custody forms can be found in Appendix E.

4.4 Laboratory Analytical Program

Soil samples and the groundwater sample were screened for visual and olfactory indicators of impacts. Samples were sent to Maxxam Analytics in Calgary, Alberta for chemical analysis for various target compounds previously identified. Maxxam is certified by the Canadian Association for Laboratory Accreditation, Inc. (CALA) and has an internal QA/QC protocol. The laboratory QA/QC documentation is provided with the analytical report and was reviewed by FRANZ as part of the QA/QC protocol. The laboratory results and chain of custody forms are presented in Appendix E.

4.5 National Classification System for Contaminated Sites

FRANZ completed the 2008 National Classification System for Contaminated Sites (NCSCS) worksheets for both the Rifle Range Site and the Former Landfill Site. The source NCSCS spreadsheets are available at the CCME's website, http://www.ccme.ca/ourwork/soil.html?category_id=68. Changes were made based on new observations and additional data obtained during the Phase III ESA.

The NCSCS was developed as a tool to aid in the evaluation of contaminated sites and to identify low, medium and high risk conditions. There is also a category for sites with insufficient information to make a judgement. The NCSCS is a screening tool, and is not designed to provide either a qualitative or quantitative risk assessment. Instead, it allows sites to be ranked and assigned a priority. The three risk elements on which the NCSCS is based include the source of contamination (i.e., contaminant characteristics), exposure pathways, and receptors. A site presents a potential health risk when the exposure pathways are operable, i.e., where contaminants can reach receptor(s) through one or more pathways (CCME, 2008).

The NCSCS evaluation form/worksheets were completed for the site and are provided in Appendix F. The evaluation form provides the detailed rationale of each score for all categories.

5.0 INVESTIGATION RESULTS AND DISCUSSION

An Environmental Investigation was completed at the Drumheller Institution from December 13 to 19, 2010. The EI included the collection of nineteen (19) soil samples, including three background samples and one composite leachate test, to delineate the contaminants of concern in the Rifle Range Site. One groundwater sample was collected to assess the Former Landfill Site. In addition, a preliminary qualitative Slope Stability Study was completed and is presented below in Section 5.6.

Conceptual Site Models are presented in Figures 7 to 9, Appendix A. Photographs of the investigation are presented in Appendix D. The investigation results are tabulated in Appendix B; the laboratory data is presented in Appendix E.

5.1 Topography

The site is relatively flat and surrounded by low rolling hills. Much of the surrounding area to the south and east is dominated by the rolling hill terrain. The Red Deer River is located to the north east and has cut deep ravines through the topography. Surrounding lands are predominantly prairie grassland, some of which has been cultivated.

5.2 Surficial Geology

Soils in the area have been identified as dark brown chernozemic soils on clay placed on a lucustrine deposition (PWGSC, 1999). This type of soil is beneficial for agricultural purposes. The surficial geology of the Drumheller area is discussed in the Geological Survey of Canada Memoir 370 title “Surficial Geology of the Drumheller Area” dated 1973. The geology is summarized as follows:

The landfill site is located in the physiographic division known as the Beiseker Lowlands adjacent to the Red Deer Badlands. Glacial deposition formed the small mounds and rolling plains which are now present in the area. Specific to the landfill area, the site is underlain by deposits of recessional moraine (glacial till). These deposits were formed in a period of equilibrium between ice advance and marginal melting, during which material was brought up to the stationary margin and deposited, resulting in the formation of hummocky terrain. The glacial till in the Drumheller area is reported to be clayey and silty, with a sand component and bentonite clay. The upper portion of the till tends to be coarser due to the effect of melt water which removed the finer particles.

Erosion from melt waters have resulted in numerous steep walled valleys, such as the Red Deer Valley. The coulee present below the current landfill was likely formed through the same process. Native soils, as described in the FRANZ Supplemental Phase II report, are light brown to dark brown, sandy silt with trace clay, silt with some clay, silty clay, clay with some silt, clay till with trace to some silt and some pebbles and clay.

Soils encountered on site consisted of silty sand and clay. As such, the FRANZ field assessor has determined that the soil texture at the site is characterized as fine-grained.

5.3 Bedrock Geology

The bedrock formations of the Drumheller area were laid down in the Alberta geosycline during the final phases of the Cretaceous and Tertiary Sea, and represent the vast outpouring of debris from the mountains that were rising to the west. Much of the rock is poorly consolidated and substantial thickness of loose sand and clay are common. Consolidated resistant bedrock units form the steep valley walls in the area. The landfill site is underlain by Cretaceous aged bedrock from the Edmonton Formation. The formation consists of grey, green and brown shale, sandstone and coal. The bedrock contains layers of silt, clay and sand. Some of the beds also contain bentonite clay.

5.4 Hydrology and Hydrogeology

There was no surface water visible on the site at the time of the site visit, due to frozen surface conditions.

At the Former Landfill Site, no groundwater seepage was observed from the face of the slope. A creek is present at the base of the coulee (observed to be frozen at the time of the site visit), approximately 50 to 60 meters below the landfill and a groundwater spring was previously identified on a steep gully 20 metres north of the landfill. The creek at the base of the coulee flows, when not frozen, in the general direction north-northeast into the Red Deer River. The elevation of the Red Deer River is approximately 680 metres ASL (GSC, 1973).

5.5 Analytical Test Results

Based on the contaminants of concern previously identified, soil samples collected from the Rifle Range were analyzed for metals, leachable metals, and leachable BTEX. The one groundwater sample collected from the Former Landfill Site was analyzed for VOCs, metals and organics. The results are presented in Tables 1 through 5 (Appendix B) and on Figures 5 and 6 (Appendix A).

5.5.1 Background Soil Results

Three background soil samples were collected in the vicinity of the Former Landfill site. Background samples were collected from native, undisturbed ground at a sufficient distance from the landfill footprint. One sample (BK3) was collected from a flat lying area approximately 100 metres south southwest of the soil piles. BK1 and BK2 samples were collected from the bank of the coulee 30 metres east of the landfill. See Figure 4 (Appendix A) for background sample locations.

All three samples were analyzed for metals. BK1 and BK2 reported metal concentrations that were below applicable EQGs. BK3 reported copper concentrations of 110 ug/g, above the EQG

of 63 ug/g. All remaining parameters were below the EQGs. Analytical results for background samples are presented in Table 1 (Appendix A), and the laboratory reports can be found in Appendix E.

5.5.2 Analysis of Duplicates

FRANZ quantitatively assessed the analytical quality of the data through assessing the relative percent difference (RPD) between each sample and its corresponding duplicate.

Four duplicates for nineteen soil samples were submitted for metals analysis. B1-1 DUP exhibited concentrations of lead above the acceptable limit, as did B6-1 DUP. B7-1 DUP exhibited concentrations of antimony, arsenic, lead and tin above the acceptable limit.

The high RPDs highlight the difficulty in obtaining true soil duplicates. While every effort was made in the field to obtain good-quality duplicates, sampling requirements prohibit any additional soil handling or mixing than that outlined in the field procedures section (4.2.5) (above). In addition, the nature of the contamination at a rifle range is expected to be very difficult to homogenize: small, discrete particles of metal materials might not be detected during field homogenization but could cause large differences in concentrations between primary and duplicate samples.

While RPD results may be unacceptable, the conclusions that would be drawn from using either the primary or duplicate sample chemical results would be the same. There is agreement between sampling results as to whether samples exceed or samples do not exceed the standards. FRANZ considers that the high RPDs obtained in the field program underline the contingent nature of soil sampling and the need to estimate the extent of soil contamination conservatively.

One duplicate was submitted for analysis of groundwater. The duplicate evaluation criteria were satisfied and the sampling procedures and laboratory analytical precision are considered acceptable.

A summary of the analytical results for the original and duplicate samples is included in the soil analytical results in Table 1, 3 and 4 (Appendix B).

5.5.3 Rifle Range Site 530-C04 – Results and Evaluation

Nineteen soils samples, including four duplicates, were collected from fourteen test pits at the rifle range. All samples collected, with the exception of one (B6-2), exhibited concentrations of at least one metal parameter above the applicable EQGs.

A northern and southern transect were used for sampling in a grid pattern across the Rifle Range. The area sampled was roughly 50 metres by 70 metres in size. Four test pits were excavated on the open range, four test pits excavated around the targets, and six test pits were excavated on the soil butt/berm. Please refer to Figure 3 (Appendix B) for sample locations.

Twelve samples (B1-1, B2-1, B3-1, B4-1, B5-1, B5-2, B6-1, B7-1, B8-1, B11-1, B12-1 and B13-1) exhibited concentrations of antimony that were above the EQG of 20 ug/g. The maximum concentration exhibited was reported from sample B11-1 at 1,300 ug/g, 65x the EQG.

Samples B7-1, B11-1, B12-1 and B13-1 reported concentrations of arsenic above the EQG of 12 ug/g. B11-1 reported the maximum exceedance with a concentration of 140 ug/g, 11x the EQG.

Two samples, B2-1 and B5-1, exhibited concentrations of copper that were above the EQG of 63 ug/g at 120 ug/g and 200 ug/g, respectively.

All samples, with the exception of B6-2, reported concentrations of lead above the applicable EQG of 70 ug/g. A wide range of concentrations were reported from 140 ug/g (B10-1) to 42,000 ug/g (B11-1). Six test pits reported concentrations that were greater than 5,000 ug/g, namely B2, B5, B7, B11, B12 and B13.

Selected analytical results for soil samples exhibiting high exceedances of lead are presented in Table 5-1, below and are presented more fully in the attached Table 1 (Appendix B) and on Figure 5 (Appendix A).

Table 5-1: Selected Analytical Results for Lead

Station ID	Average Background Concentration	CCME[1] Agricultural	B2	B2	B5	B7	B11	B12	B13
Field label			B2-1	B2-2	B5-1	B7-1	B11-1	B12-1	B13-1
Date			14/Dec/10	14/Dec/10	14/Dec/10	14/Dec/10	14/Dec/10	14/Dec/10	14/Dec/10
Depth (cm)			0-5	20-30	0 – 0.5	0-5	0-5	0-5	0-5
Antimony	<1	20	43	<40	210	910	1300	210	430
Arsenic	5	12	7	8	9	29	140	47	48
Barium	230	750	200	210	200	160	150	170	210
Beryllium	0.5	4	0.8	0.9	0.9	0.4	0.4	0.5	0.5
Cadmium	0.5	1.4	0.6	0.7	0.5	0.4	0.4	0.5	0.5
Chromium	14.3	64	23	23	23	19	21	23	22
Cobalt	7.3	40	10	10	10	7	7	9	9
Copper	45	63	120	57	200	37	26	24	25
Lead	8.6	70	4700	9400	16000	32000	42000	6700	14000
Mercury	<0.05	NC	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Molybdenum	0.6	5	0.7	0.7	0.8	0.6	0.7	1.0	0.8
Nickel	19.3	50	27	28	25	19	19	21	24
Selenium	<0.5	1	<0.5	<0.5	<0.5	0.6	0.6	0.8	<0.5
Silver	<1	20	<1	<1	<1	<1	1	<1	<1
Tin	<1	5	6	9	11	14	76	3	6
Uranium	1	23	1	1	<1	<1	<1	<1	<1
Zinc	59.3	200	70	68	73	63	73	91	79

More detailed results and sources of regulatory criteria can be found in Appendix E.

Six samples collected from five test pits reported concentrations of tin above the EQGs. The maximum concentration (76 ug/g) was reported in test pit B11 and was >15x the EQG of 5 ug/g. One composite sample was submitted for a leachate test for metals and BTEX. The sample reported leachable lead concentrations (270 mg/L) above the Alberta Waste Control Regulation of 5 mg/L. All remaining leachable metals and BTEX parameters were below EQGs or reported non-detect concentrations. Please refer to Table 2 (Appendix B) for analytical results.

Analytical results confirm the Rifle Range as an Area of Environmental Concern (AEC) with high concentrations of metal impacts to soils at the site. The source of contamination in the rifle range is lead from shotgun pellets and other ordnances. During the investigation, FRANZ's field assessor took representative soils samples in the absence of lead shot fragments.

The highest concentrations of all metals were surficially distributed around the shooting targets, specifically between the targets and the soil butt berm, and just behind the face of the soil butt berm. The four test pits located in these locations exhibited the highest concentrations of lead, antimony, arsenic and copper. Comparing between the northern and southern transects, the southern transect did exhibit very high concentrations of lead in four of the seven test pits. These high concentrations were concentrated around the shooting targets and just behind the face of the soil butt berm. The northern transect, similar to the southern transect, had metals distributed in the same fashion, however, concentrations of metals were lower.

Based on the analytical results obtained from the Rifle Range, the preliminary inferred contaminated area is on the order of 3500 m^2. Due to the weather conditions, it was very difficult to excavate the test pits to depths. The maximum depth reached was 0.3 m. Given that the high concentrations of metals were reported at depths of 0.3 metres, FRANZ considers 0.4 metres as a reasonable estimate of impacted soil depth as vertical delineation was not obtained. Using a maximum estimated vertical extent of contamination of 0.4 metres, the initial estimated volume of metal impacted soils at the site is on the order of 1400 m^3.

As the composite leachate test was in exceedance of the Alberta Government's Waste Control Regulation for leachable lead. The soils, if removed from the site, would not be accepted at a Class II or III landfill for disposal. The materials would be considered hazardous materials and disposal at a Class I Industrial Waste facility would be needed.

5.5.4 Former Landfill Site 530-L01 – Results and Evaluation

One groundwater sample, plus one duplicate was collected from MW05-01 and submitted for metals (dissolved) and VOCs analysis. MW05-01 is located east of the Landfill on the bank of the coulee. Concentrations of barium were detected; however, CCME guidelines do not exist at this time for comparison. Boron, copper and uranium had detectable concentrations that were above CCME FWAL guidelines. The maximum exceedance factor of all of exceeded metals

was reported for uranium at 15x the EQG. Molybdenum reported concentrations that were just above the CCME Agricultural guidelines. In addition, historical testing on site reported concentrations of aluminum and selenium in groundwater above CCME FWAL guidelines. All VOCs concentrations were reported as non-detect. Analytical results are presented in Tables 4 and 5, Appendix B.

Groundwater and surface water were not fully assessed during this investigation due to weather conditions. A background soil quality assessment was completed for the Former Landfill and resulted in the conclusion that background soils are not representative of metal impacted soils reported during previous environmental investigations.

Although one groundwater sample was collected and concentrations for metals and VOCs were reported as non-detect or below environmental guidelines, FRANZ believes that additional spring monitoring to groundwater wells and surface water is warranted for a more complete characterization of the site.

5.6 Preliminary Slope Stability Study

A preliminary qualitative slope stability analysis was completed at the Former Landfill Site using existing information on the soil/waste properties and newly acquired topographic data during a site visit.

The purpose of the investigation was to understand the stability of the landfill slops and establish the 'Limit of Hazard Lands' for the site. This limit constitutes a safe setback for the landfill site with respect to slope stability. The Limit of Hazard Lands was determined based on the Natural Hazard Policies set forth in Section 3.1 of the Provincial Policy Statements of the Planning Act of Ontario. Current regulations restrict development within the Limit of Hazard Lands. Based on our desk study, site reconnaissance and stability analysis recommendations are provided on remedial measures for the stabilization of the slopes (where required).

It is understood that the landfill was in operation from the mid 1960's until the late 1980's. However, more recent filling may also have taken place. The waste material placed in the landfill is understood to include domestic waste and demolition material generated during various phases of construction work at the institute. It is understood that the landfill was formed by pushing waste material over the edge of the coulee. As such, the waste was not subject to compaction during placement.

5.6.1 Description of Site and Slopes

A site reconnaissance was carried out on December 14 and 15, 2010. During the site reconnaissance the ground surface elevations and condition of the slopes across the site were observed. The ground surface elevations were measured in the vicinity of the landfill using

global positioning system (GPS) survey equipment supplied and operated by Tagish Engineering Ltd. Where possible, the exposed ground conditions were observed and recorded.

At the time of our inspection, the landfill site and surrounding areas were generally snow covered. Portions of the slopes are lightly vegetated with tall grasses and shrubs. The ground surface elevation at the crest of the slope ranges from about 797 to 799 metres ASL. Along the toe of the slope the ground surface elevation ranges from about 776 to 783 metres ASL. The side slopes of the landfill are generally inclined at about 30 to 45 degrees to the horizontal. Figure 11, Appendix A depicts a view of the Landfill.

Some signs of slope instability were observed at the subject site, as indicated by tension cracks on the table land along the east side of the landfill. The fissures were observed to extend to a depth of at least 1 to 2 metres below ground surface and were about 300 millimetres wide at the ground surface. It should be noted that the cracks may extend beyond this depth. Photographs of the cracks are provided on Figures 12A and 12B, Appendix A.

An existing deep failure zone was observed at the northeast end of the landfill. In the vicinity of the failure the slope has a height of about 19 metres and is generally inclined at about 40 degrees from the horizontal. The failure zone extends about 4 to 5 metres back from the original crest of the slope and has a width of about 3 to 4 metres at the top of the failure zone. At time of the site reconnaissance a near vertical failure scarp which is several metres in depth was observed at the location of the failure. A small frozen spring was observed at the base of failure zone which indicates that the failure may have occurred as a result of concentrated groundwater / surface runoff from the tableland to this portion of the landfill. Photographs of the failure zone are provided on Figures 13A and 13B.

An access road has been constructed along the southern end of the landfill. The road appears to be partly on the landfill waste and partly excavated through the native slopes to the south of the landfill. From the toe of the slope the ground surface level is relatively flat / hummocky for a distance of about 10 to 20 metres. Beyond this point the ground surface drops off to the level of the base of the coulee which is estimated to be at about 50 to 60 metres below the top of the landfill (or at about 720 to 730 metres ASL).

No groundwater seepage was observed from the face of the slopes. A creek is present at the base of the coulee, approximately 50 to 60 metres below the landfill and a groundwater spring was previously observed on a steep gully 20 metres north of the landfill. The creek at the base of the coulee flows in a general north-northeast direction into the Red Deer River.

5.6.2 Design Soil Profile / Landfill Cross Section

As previously stated, the limits of the landfill material, possible fill material and native soils at the site are poorly defined. Based on the available information, approximate cross sections for the landfill are shown on Figures 15A to 15C (Appendix A) inclusive. The cross sections are drawn on an approximate east west axis between the northern, middle and southern portions of the landfill. Specifically, Figures 15A through 15C show the assumed soil conditions between MW 99-1 to MW 05-1, MW 99-3 to MW 05-2, and MW 99-4 to MW 05-1, respectively.

It should be noted that ground conditions between the boreholes have been interpolated based on the available information.

5.6.3 Subsurface Conditions and Soil Strength Parameters

The soil conditions and soil strength parameters used in the stability analysis were based on the results of the boreholes which were previously advanced at each of the sites and the results of the laboratory testing on samples of the native soil and landfill waste recovered during our site reconnaissance.

For the purpose of this analysis, the native soils were modeled using interbedded layers of clay, silty clay, silt, silty sand and sand with some silt. The landfill waste was modeled as silty clay with some sand and some gravel. The shear strength properties of the soil used in the analysis are summarized in the following Table 5-2:

Table 5-2: Summary of Soil Strength Parameters Used in Slope Stability Analysis

Soil Type	Effective Angle of Internal Friction, φ (degrees)	Effective Cohesion, c' (kilopascals)	Unit Weight, γ (kN/m^3)
Landfill Waste (silty clay some sand and gravel)	35	0	18
Native Soil (Interbedded clay, silty clay, silt, and silty sand)	37	2	18
Bedrock	Infinite	Infinite	N/A

The depth to bedrock surface was assumed to be constant beneath the landfill and was based on the elevation noted in each of the boreholes advanced by Franz Environmental along the toe of the slope.

It should be noted that the slope stability analysis was carried out using soil parameters, groundwater conditions and slope profiles that attempt to model the slope in question but do not exactly represent the actual conditions. For the purposes of this study, a computed factor of safety of less than 1.0 indicates a slope that is unstable; a factor of safety of 1.0 to 1.3 is considered to represent a slope bordering on failure to marginally stable, respectively; a factor of safety of 1.3 to 1.5 is considered to indicate a slope that is less likely to fail in the long term and provides a degree of confidence against failure ranging from marginal (1.3) to adequate (1.4 and greater) should conditions vary from the assumed conditions. A factor of safety of 1.5, or greater, is considered to indicate adequate long term stability and is considered to be the target value for the site. The factor of safety of a slope is defined as the ratio of the magnitude of the forces which tend to cause the slope to fail to the magnitude of the forces which resist failure. The loss of existing vegetation along the face of the slopes or the placement of fill along the crest of a slope will reduce the factor of safety.

The results of slope stability analyses are highly dependent on the assumed groundwater conditions. As such, in order to calibrate the soil and groundwater conditions for the analysis, the model parameters were also based in part on “back calculations” of the failed portion of the slope at the north end of the landfill. Using the probable initial landfill profile (pre-failure) for the analysis at this area, the soil strength parameters and groundwater level was varied until the analysis indicated a factor of safety which, when adjusted to account for three dimensional effects, is about or slightly less than 1.0, (i.e., at the point of failure). Good agreement was also observed between the shape of the predicted failure surface and that observed during our site reconnaissance. These strength parameters were then applied to the other areas of the site. The strength parameters for the stabilizing berm material are based on assumed values which are considered to be broadly representative of the site materials. A similar depth to groundwater was then applied to the other cross sections. This represents a more realistic “worst case” scenario as far as the slope stability is concerned than assuming the groundwater level to be at the surface of the slope profile.

5.6.4 Results of Slope Stability Analyses

The slope stability analyses were carried out using SLIDE, a state of the art, two dimensional limit equilibrium slope stability program. The stability analyses were carried out for the cross sections shown in Figures 15A to 15C, inclusive and also at the location of the existing slope failure (to calibrate the soil strength properties as described previously).

The following Table 5-3 provides the results of the stability analyses which were carried out for each of the slopes:

Table 5-3: Summary of Computed Factor of Safety for Existing Slope Conditions

Location of Slope Analysis	Computed Factor of Safety Against Overall Failure of the Slope
North Section between MW 99-1 and MW 05-1	1.0
Middle Section between MW 99-3 and MW 05-2	1.1
South Section between MW 99-4 and MW 05-3	1.4
Existing Slope Failure	0.8

The results of the analyses and the corresponding minimum factor of safety against overall rotational failure are provided on Figures 16A to 16C (Appendix A), inclusive.

As previously stated, tension cracks were observed along the crest of the slope on the east side of the landfill. Tension cracks are an indication that movement of the slope has occurred and therefore should be considered as a potential hazard. Based on the results of the analysis the distance from the crest of the slope to a point where the factor of safety is greater than 1.5 metres for each of the cross-sections is as follows:

Table 5-4: Summary of Required Distance from Crest of Slope

Location of Slope Analysis	Required Set Back Distance from Crest of Slope for FOS > 1.5
North Section between MW 99-1 and MW 05-1	30 metres
Middle Section between MW 99-3 and MW 05-2	25 metres
South Section between MW 99-4 and MW 05-3	7 metres

It is recommended that no construction equipment or stockpiling of material be permitted within the distances provided in Table 5-4 of the crest of the slope until the landfill slope remediation measures described in Section 6.0 of this report are carried out. No active water courses which could cause erosion were observed at the toe of the landfill waste material, and as such, an erosion allowance is not deemed necessary at this time.

Groundwater runoff should be directed away from the slope face in a concentrated fashion. This can be achieved by re-grading the ground slope in the vicinity of the crest and with the installation of shallow surface drains which should outlet to a suitable discharge point.

Furthermore, in accordance with the Ministry of Natural Resources Ontario (MNR) Technical Guide “Understanding Natural Hazards” dated 2001, a six (6) metre wide access allowance beyond the stable slope allowances described in Table 3 is required to allow for access by equipment to repair a possible failed slope. The MNR technical guide also requires an allowance for erosion caused by waterways. The “limit of hazard land” is defined as the sum of these three (3) setbacks. However, the slope access and erosion allowances are not considered applicable to the landfill slopes at this site. As such, based on the results in Table 5-4, the geotechnical limit of development, or limit of hazard lands for the landfill has been determined and plotted on Figure 17, Appendix A.

6.0 REMEDIATION AND RISK MANAGEMENT OPTIONS

6.1 Areas of Environmental Concern (AEC)

The results of the chemical distribution and impacts evaluation (Section 5), the spatial analysis and contaminant transport model, and the slope stability assessment (Section 5.7) indicate that at selected areas, risk management or remediation may be required to reduce the physical safety hazards and mitigate exposure to chemicals of concern present at concentrations greater than the Environmental Quality Guidelines (EQG).

This Remedial and Risk Management Options chapter outlines the strategies that can be used to mitigate potential physical risks and exposure of human and ecological receptors to contaminants.

6.1.1 Contaminant Impacts

At the Rifle Range Site, there are known and discrete metal impacted soils associated with on-site activities that are continually occurring. Elevated metals (particularly lead, antimony, arsenic, copper and tin) exist on site and are somewhat heterogeneous in terms of spatial distribution around the shooting targets and the soil butt berm. Higher concentrations of metals are concentrated around the targets and soil berm.

Within the Former Landfill study area, there are known and discrete impacted soils associated with up-gradient waste burial and filling activities. Elevated metals in soils, as well as, elevated metals in groundwater and surface water exist on site and are heterogeneous in terms of spatial distribution and concentrations. Isolated BTEX impacts to soils were detected on the plateau of the Landfill within the burn pit. These impacts are likely associated with the historical burning activities of various materials at the site. Based on the spatial analysis, the source area for each of the COC's remains consistent with each parameter tested. It is our opinion that the soil, groundwater, and surface water chemistry reflect the environmental impacts associated with waste disposal and land filling activities on site. Our evaluation indicates that the buried and exposed debris imparts a slow release of contaminants into the environment. In addition, contaminants originating from the source areas (landfill) are present in the surface water in the creek at the toe of the landfill. A summary of the contaminant impacts is provided in the Table 6-1 below:

Table 6-1: Contaminant Impacts at the Rifle Range and Former Landfill Sites

Area Identification	AEC	Identified Contaminant	Impacted Media
Rifle Range	Yes	Higher priority - metals	Soils
Former Landfill	Yes	Moderate priority – metals and BTEX	Soil, groundwater and surface water
		Higher priority- slope stability hazard	

6.1.2 Former Landfill Slope Stability

Based on the preliminary qualitative slope stability assessment of the Former Landfill, it appears that the slope is at its maximum angle of repose and that the landfill poses a significant current and potential physical hazard. Remedial work is proposed for this area below in Section 6.5.

6.2 Approach and Evaluation Criteria

It is our opinion that the remediation/risk management priorities should be based on the removal of chemical and physical hazards (i.e., ammunition/ordnances and slope stabilization) and the containment and control of metals in soils and through the surface water pathway (i.e., Landfill drainage) ultimately discharging to the Red River.

The Rifle Range's on-site activity (i.e. shooting range) is the main source of metal impacts to soils in that area. At the Former Landfill, the buried and exposed debris is the main source of the metal impacts to the environment. Essentially contaminants found at discrete locations and close to the source areas (i.e., metals) would need to be addressed.

The long-term strategy for the study area(s) should be based on the following goals, in order of priority:

- Containment and control, including risk management, passive treatment systems and monitoring of surface water drainage systems;
- Risk management/remediation of impacted soils/sediments; and
- Site monitoring and inspections.

Evaluation Criteria

For the analysis of remedial and risk management strategies, a set of criteria for the evaluation of the options include:

- Overall protection of human health and the environment;
- Removal of hazards;
- Long term effectiveness;
- Ease of implementation;
- Maximal level of confidence in remediation results;

- Minimal remediation time;
- Minimal site disruption; and
- Cost effectiveness.

It should be noted that our responses to the criteria have been established based on our professional opinion and available information. A more detailed analysis would be required in a specific Remedial/Risk Management Plan.

6.3 Rifle Range Site

Metals in soils were identified at the Rifle Range Site. These impacts are directly related to on-site activities, specifically the target shooting by the Institution staff. As long as the Rifle Range continues in use as a rifle range, remediation of soils is not an appropriate option because the gun butt berm soils would continually become re-contaminated by the shooting activity. However, once the Rifle Range is permanently closed, full remediation is recommended.

Three options to mitigate impacts have been proposed and are summarized as follows:

- Removal of Impacted Soils
- In-Situ Management
- In-Situ Treatment

Prior to In-Situ Treatment, supplemental investigative work would need to be completed for the delineation of the full extent of impacted soils.

6.3.1 Option #1: Removal of Impacted Soils

This remedial strategy involves excavation of contaminated soil followed by transportation of the soil to an off-site treatment facility. Soil would be excavated from the contaminated area, transported off-site, and treated within at an appropriate licensed landfill.

Ex-situ remediation is the fastest and most comprehensive way of removing contaminated soil from the site. However, off-site disposal would likely require special permitting for disposal and transporting the soil as it would be considered hazardous wastes. In addition, an increase in transportation costs, as well as disposal fees, would be incurred. The closest Class I Industrial Waste landfill would be in Calgary, Alberta, approximately 130 km from Drumheller via Hwy 9.

As previously stated, as long as the Rifle Range continues in use as a rifle range and there are no operable pathways to surface water receptors, the high costs of removal and transportation to a licensed disposal facility and backfilling is not a recommended remedial option because the gun butt berm soils would become re-contaminated by the shooting activity after soil remediation. However, once the Rifle Range is permanently closed, this would become a viable option.

6.3.2 Option #2: In-Situ Management (Mechanical Soil Screening)

This remedial option involves a periodic screening of the soils in and around the target area, as well as the gun butt berm to avoid excessive build-up of bullet fragments and reduce the concentrations significantly in discrete areas. Screening is a process of physical separation of material according to grain size performed by passing it across a stationary or vibrating screen allowing the undersized fraction (bullets) to pass through. Mechanical screening assists in the homogenizing of soils, distributing metal concentrations throughout the screened area.

The impacted soil would be screened while on site and left on the site, which would eliminate any transportation or disposal costs. This would not likely be time consuming as the tonnage of soil to be screened is low.

Precautions must be taken during the screening process as contaminants in dust can become airborne, increasing its mobility and area of impact. Screening is most appropriate for removing oversized materials in soils that are dominantly sand size or larger with low fines content. Wet screening is then necessary, using water to transform the soils into slurry either by milling the soil or using a high pressured jet to break clay fragments. As the soils on site are predominantly fine grained, wet screening may be needed in addition to the mechanical screening.

6.3.3 Option #3: In-Situ Treatment (Soil Washing and Chemical Separation)

If more aggressive methods are required to remediate the impacted soils due to potential mobility issues of metals leaching to groundwater receptors then in-situ treatment could be employed. This remedial technique achieves physical separation of contaminants from soil by agitating soils in water to liberate and recover the metal fraction from the soil matrix. The water may be amended with chemicals that serve as surfactants, to dissolve certain contaminants or to displace toxic cations. Chemical separation is often used in addition to soil washing to enhance the efficiency and recovery of the metals. The four processes commonly used are acid extraction, chelation, ammonia and chloride extraction.

Though simple in concept, soil washing generally requires several pieces of specialized equipment which can be costly. Provisions must also be made for the recovery, neutralization, regeneration or disposal of the treatment solutions and secondary treatment (rinsing) of the uncontaminated soil fractions prior to re-use.

A summary of the options available for the Rifle Range is provided in Table 6-2 below:

Table 6-2: Remedial Options for the Rifle Range Site

OPTIONS	Option 1 Removal of Impacted Soils	Option 2 In-Situ Management	Option 3 In-Situ Treatment
Project Goals	Ensure the protection of human health and environment from exposure to chemicals of concern.		
Operating Principle	Excavate and removal of impacted soils and disposal off-site at a licensed disposal facility.	Periodic mechanical screening of soils to avoid excessive build-up of bullet fragments to reduce ricochet and distribute metal concentrations throughout.	Soil washing with additional chemical treatment to physically separate contaminants from soil.
Protection of Human Health and the Environment	Yes; Impacted soils removed from site, no impacts to human health or environment	Yes; Impacted soils remain on site, impacts To human health and environment reduced	Yes; If successful, majority of impacts to soils removed, no impacts to human health or environment
Degree of Site Disruption	High to Moderate; large excavation and removal from site	Moderate; soils remain on site	Moderate to High; soils remain on site, more intricate
Confidence Level of a Successful Outcome	High; proven effective and permanent	Moderate; effective, not permanent	Moderate to Low; effective depending on a number of variables
Estimated Time for Implementation	2 weeks for excavation and reinstatement	2 weeks for screening and reinstatement	2 weeks for washing and reinstatement
Long-term Effectiveness	Yes; removes all impacts	No; reduces impacts, does not remove	Likely; if successful removes majority of impacts
Ease of Implementation	High	High	Moderate – more intricate
Estimated Capital Costs	$685,600	$93,280	$273,150
Estimated Operating Costs	$0	$0	$0
Total Estimated Remedial Costs	$685,600	$93,280	$273,150

6.4 Former Landfill Site

The historical metal loading and current slow release of metals associated with the metallic and non-metallic debris deposited on site have resulted in impacted soils, groundwater and surface waters on the slope and down-gradient of the Landfill. Additionally, an isolated BTEX impact was identified in shallow soils in the burn area on the plateau of the Landfill. Downgradient impacts will likely continue for some time due to the presence of scattered and landfilled waste debris. Contaminant loading from the landfill and the associated downgradient impacts could be

managed through the implementation of an in-situ remediation and surface water management system. The employment of a Site Specific Risk Assessment, could be used to guide the long-term strategies for the site. Three possible management options are proposed as follows:

- Long-term Monitoring
- Passive In-Situ Treatment and Monitored Natural Attenuation
- Risk Assessment

6.4.1 Option #1: Long Term Monitoring

The goal of the long-term monitoring program would be to ensure that present and future risks are negligible and that monitoring could be terminated with confidence, based on findings of no risk and no reduction of the environmental conditions at the site. The program would be developed specifically to:

- Evaluate and analyze for metals in groundwater over time;
- Inspect and monitor surface water integrity, flow rates, channelling and physical conditions;
- Monitor, evaluate and analyze for metals in surface waters over time; and
- Ensure the protection of human health and environment from exposure to chemicals of concern.

Both passive and active monitoring would be undertaken at the property. A site inspection program would be conducted to observe the physical condition of the surface water bodies, including sediments. An active groundwater and surface water monitoring program would be developed upon which future risk management decisions could be based. This plan would effectively provide an early warning system that could be implemented in association with a Contingency Plan and could provide the decision criteria for termination. As an outcome of Option 1, a passive in-Situ treatment evaluation may be warranted.

6.4.2 Option #2: Passive In-Situ Treatment and Monitoring Natural Attenuation

In recent years, a variety of passive treatment systems have been developed that do not require continuous chemical inputs and that take advantage of naturally occurring chemical and biological processes to treat metal impacted waters. The primary passive technologies include constructed wetlands, anoxic limestone drains (ALD), successive alkalinity producing systems (SAPS), limestone ponds, and open limestone channels (OLC).

For the Landfill site, the existing drainage systems at the toe of the Landfill could be modified to reduce the surface water/sediment metal loading to the environment by:

- providing a predictable and steady flow path to the discharge points by enhancing the physical drainage systems with weirs, banks or channels to avoid overflow, flooding or

hydraulically cross-connecting with other low-lying areas during heavy run-off periods ; and

- enhancing the natural treatment system to trap or remove metals along the flow path.

Enhanced wetlands are characterized by water-saturated soils or sediments with supporting vegetation adapted to reducing conditions in their rhizosphere. Often they consist of shallow excavations filled with flooded gravel, soil, and organic matter to support wetland plants such as *Typha*, *Juncus*, and *Scirpus* sp. Treatment depends on dynamic biogeochemical interactions as contaminated water travels through the constructed wetland.

Selection of an appropriate passive system is based on water chemistry, flow rate, local topography and site characteristics. Mechanisms of metal retention within wetlands, listed in their order of importance, include: 1) formation and precipitation of metal hydroxides, 2) formation of metal sulfides, 3) organic complexation reactions, 4) exchange with other cations on negatively-charged sites, and 5) direct uptake by living plants. Other mechanisms include neutralization by carbonates, attachment to substrate materials, adsorption and exchange of metals onto algal mats, and microbial dissimilatory reduction of iron hydroxides and sulfate.

The way in which a wetland is constructed ultimately affects how water treatment occurs. Two construction styles currently predominate: 1) "aerobic" wetlands consisting of *Typha* and other wetland vegetation planted in shallow (<30 cm), relatively impermeable sediments comprised of soil, clay or mine spoil, and 2) "anaerobic" wetlands consisting of *Typha* and other wetland vegetation planted into deep (>30 cm), permeable sediments comprised of soil, peat moss, spent mushroom compost, sawdust, straw/manure, hay bales, or a variety of other organic mixtures, which are often underlain or admixed with limestone. In aerobic wetlands, treatment is dominated by processes in the shallow surface layer. In anaerobic wetlands, treatment involves major interactions within the substrate.

Prior to implementation, this approach requires that the site be well characterized and that the processes which affect surface water and sediment chemistry be well understood. For this option to be successful, an in-depth evaluation of the chemical, biological and physical characteristics of the site should be conducted through seasonal monitoring, detailed hydrology studies and bench-scale treatment tests.

6.4.3 Option #3: Risk Assessment

A preliminary qualitative risk assessment (PQRA) or higher level SSRA could be completed to determine the absence/presence of risks to human health and the environment. The outcomes of the screening level risk assessment will be used to guide the long-term strategies for the site. The main elements of the risk assessment would include:

- Chemical hazard assessment;

- Receptor identification;
- Exposure pathways and assessment; and
- Qualitative risk characterization and estimates.

A summary of the options available for the Former Landfill is provided in Table 6-3 below:

Table 6-3: Remedial Options for the Former Landfill Site

OPTIONS	Option 1 Long Term Monitoring	Option 2 Passive In-Situ Treatment	Option 3 Risk Assessment
Project Goals	Ensure the protection of human health and environment from exposure to chemicals of concern.		
Operating Principle	Complete detailed monitoring of surface water and sediments, as required. Evaluated data based on trigger criteria and contingency plans	Enhance the natural removal of metals along the surface water flow systems prior to discharge to receiving bodies. Enhancements could include surface water drainage routing and construction of wetlands and filters to reduce chemical concentrations.	A preliminary qualitative risk assessment could be completed to determine the absence/presence of risks to human health and the environment.
Protection of Human Health and the Environment	Yes	Yes	Yes
Degree of Site Disruption	Low; once a year monitoring round	Moderate; construction of wetland	Low; no on-site work
Confidence Level of Successful Outcome	Moderate to Low; not effective in short term	Moderate; effective over long term	N/A
Estimated Time for Implementation	Long-term (>10 years)	2-3 years	3 months
Long-term Effectiveness	No; impacts naturally attenuate over time	Yes; elevated natural attenuation by wetland	N/A
Ease of Implementation	High	Moderate, studies required	N/A
Estimated Capital Costs	$84,400	$387,500	$94,400
Estimated Operating Costs	$75,000	$75,000	$0
Total Estimated Remedial Costs	$159,400	$462,500	$94,400

6.5 Slope Stability at the Former Landfill Site

The geotechnical slope stability of the Former Landfill was identified as a physical hazard. Two options to mitigate these physical hazards have been proposed and are summarized as follows:

- Re-grade the Slope and (if required)
- Erosion Control and Other Slope Improvements

6.5.1 Slope Stability - Re-grade the Slope

This remedial option involves the re-grading of the slope on the face of the Landfill. To increase the stability of the slopes to an acceptable factor of safety, the slope angle should be reduced to about 2.5 horizontal to 1 vertical, or flatter. This could be achieved by either removing existing material from the crest of the slope and placing it on the lower portions of the slope or, alternatively, by importing fill material such as blast rock fill and placing it on the face of the slopes. The blast rock fill should consist of well graded competent non-argillaceous blast rock material (limestone, dolostone or sandstone, for example) having a maximum size of about 400 to 500 millimetres. Alternatively, the slopes could be regarded with glacial till in combination with surface erosion protection (see 6.5.2 below additional requirements). The estimated amount of fill materials required to re-grade the current slope angle to a 2:1 slope is 9,332 m^3.

Prior to placing the fill material the existing topsoil should be stripped from the area. This should be carried out in relatively small areas as the placement of fill proceeds. The blast rock fill material should be benched into the existing slopes at regular intervals. The benches should be about 1.0 metres deep and could be installed at 5 metre vertical spacing up the slope face. Care should be taken during excavation of the benches to insure that the works do not adversely affect the overall stability of the existing landfill waste material. The toe of the stabilizing fill should be keyed into the underlying native soils along the base of the landfill. The trench for the key should be about 0.3 to 0.5 metres in depth.

Any excavation works along the base of the landfill and on the landfill slopes should not be left open without backfilling for prolonged periods of time (i.e. greater than 1 working day), and should be protected from groundwater runoff and rainfall events. Periodic inspections should be carried out while excavations are open to insure that the temporary slopes are stable. If signs of instability are observed the excavations should be backfill immediately.

The final slope angle to which the landfill slopes will be graded may also depend on the future use of the landfill area. If for instance it is proposed to cap the landfill using a clay fill and topsoil the minimum side slopes on which equipment could traffic is about 3 horizontal to 1 vertical. If however it is proposed to cap the landfill using geosynthetic liners it may be necessary to re-grade the slopes to about 4 horizontal to 1 vertical (or flatter) to prevent slippage of the capping materials. The final grading may also be influenced by the aesthetic requirements for the finished landfill.

6.5.2 Slope Stability - Erosion Control and Other Slope Improvements

Depending on the type of material used (i.e. rock or high density glacial till); the stability of slopes can be negatively affected by erosion. If rock is not used for the slope stability, to reduce surficial erosion of the slopes, the upper portions of the slope should remain covered with vegetation or where vegetation does not exist, the areas should be seeded and mulched or protected with commercially available erosion mats. Tree roots also help to stabilize slopes and, as such, it is recommended that trees not be removed from the slopes. Where possible, the placement of blast rock material should be such that the trees can remain.

The Slope Stability Study undertaken during this assessment was preliminary. If the proposed stabilization measures are to be finalized, a number of additional measures should be taken. An additional site visit could be warranted and scheduled during the design phase or during the construction phase. If a landfill clay cap is constructed, details should be provided prior to implementation. Proof rolling or an alternate method should be conducted to identify any soft/wet problematic areas of the landfill. And lastly, monitoring using methods such as slope inclinometer, pneumatic piezometer, or slope stability radar could be carried out once construction is completed.

6.6 Summary of Remedial Costs

Based on the discussion provided above, a summary of the options and Class D costs are provided in Table G-1, Table G-2 and Table G-3 in Appendix G.

Cost estimates are based on preliminary volumes of impacted media. Cost estimates are provided based on FRANZ's previous projects and discussions with remediation contractors. Also included is an indication of the long-term monitoring requirements. The estimated costs are based on industry standards and current contractor rates in Alberta. The remediation costs can vary with the selected contractor, remedial approach and time of remediation (i.e. season and year of remediation).

7.0 NATIONAL CONTAMINATED SITES CLASSIFICATION SUMMARY

FRANZ completed the CCME National Classification System for Contaminated Sites (NCSCS) worksheet (2008) for the Rifle Range Site and Former Landfill Site using the NCSCS spreadsheet available from the CCME website.

The NCSCS was developed as a tool to aid in the evaluation of contaminated sites and to identify low, medium, and high risk conditions. There is also a category for sites with insufficient information to make a judgement. The NCSCS is a screening tool, and is not designed to provide either a qualitative or quantitative risk assessment. Instead, it allows sites to be classified and assigned a priority. The three risk elements on which a NCSCS is based include: source (i.e., contaminant characteristics), exposure pathways, and receptors. A site presents a potential health risk when the exposure pathways are operable, i.e., where contaminants can reach receptor(s) through one or more pathway (CCME, 2008d).

FRANZ completed the worksheets using analytical data and site reconnaissance information collected during the 2010 investigation, as well as previous investigations. The final scores and a breakdown by risk elements are presented in Table 7-1, below.

Table 7-1: NCSCS Scores

Area of Potential Environmental Concern	Worksheet Scores			Final Score (Class)
	Contaminant Characteristics (out of 33)	Migration Potential (out of 33)	Exposure (out of 34)	
Rifle Range Site	17.3	15.9	20	53.2 (2)
Former Landfill Site	21.5	22.7	21.4	65.6 (2)

Both the Rifle Range and Former Landfill Sites received scores that would classify them as a Class 2 – Medium Priority for Action sites.

Copies of the NCSCS worksheets are included in Appendix F.

8.0 CONCLUSION AND RECOMMENDATIONS

1. Franz Environmental Inc. (FRANZ) was retained by Public Works and Government Services Canada (PWGSC) on behalf of Correctional Services Canada (CSC) to complete an Environmental Investigation (EI) and Slope Stability Study at the Drumheller Institution Site No.530 in Drumheller, Alberta. The two sites investigated were:
    a. The Rifle Range Site (530-L01)
    b. The Former Landfill Site.(530-C04)

2. The full scope of work set out in the work plan by FRANZ and based on the SOW, was not completed due to limitations encountered from weather conditions. Because of the sub zero temperatures reached prior to the commencement of the field program, surface media were frozen. Surface water and sediments were not able to be sampled and groundwater samples were limited.
3. A total of fourteen (14) test pits were advanced by FRANZ personnel at the Rifle Range during the field program from December 13 to 19, 2010. Soil samples were collected and submitted for laboratory analysis metals and a leachate test. The soil analytical results were compared to the CCME Environmental Quality Guidelines for agricultural land use with fine-grained soil and non-potable groundwater. A composite leachate test was compared against the Alberta Environmental Protection and Enhancement Act's Waste Control Regulation criterion.
4. The Rifle Range was confirmed as an area of environmental concern (AEC). All 19 soil samples submitted for metals reported concentrations in excess of selected guidelines. A preliminary estimated areal extent of metal contamination on the order of 3500 m^2 was inferred. A depth of 0.4 m was assumed, resulting in an initial expected volume of contamination on the order of 1400 m^3.
5. One groundwater sample was collected from a previously installed monitoring well at the Former Landfill site. The sample was submitted for laboratory analysis of metals (dissolved) and VOCs. Boron, copper and uranium had detectable concentrations that were above CCME FWAL guidelines. Molybdenum reported concentrations that were just above the CCME Agricultural guidelines. In addition, historical testing on site reported concentrations of aluminum and selenium in groundwater above CCME FWAL guidelines.
6. The final NCSCS worksheet score for the Rifle Range Site was 53.2, making the Site a Class 2 – Medium Priority for Action. The Site received a score of 17.3 (out of a possible 33) for contaminant characteristics; 15.9 (out of a possible 33) for Migration Potential; and 20 (out of a possible 34) for Exposure.
7. The final NCSCS worksheet score for Former Landfill Site with revised information obtained in this investigation was 65.6, making the Site a Class 2 – Medium Priority for Action. The Site received a score of 21.5 for contaminant characteristics (out of a possible 33); 22.7 (out of a possible 33) for Migration Potential; and 21.4 (out of a possible 34) for Exposure.

8. A preliminary qualitative slope stability analysis was completed at the Former Landfill Site using existing information on the soil/waste properties and newly acquired topographic data during a site visit. The purpose of the investigation was to establish the 'Limit of Hazard Lands' for the site. This limit constitutes a safe setback for the landfill site with respect to slope stability.
9. As a result of the preliminary slope stability analysis, it is recommended that no construction equipment or stockpiling of material be permitted within 30 metres of the north section of the landfill, 25 metres of the mid section of the landfill and 7 metres of the south section of the landfill or at the crest of the slope until the landfill slope remediation measures are carried out.

Conceptual Remedial and Risk Management Options are presented which outline the strategies that can be used to mitigate exposure of contaminants to potential human and ecological receptors.

The buried waste debris is likely the main source of the metal impacts to the environment at the Former Landfill. It is our opinion that the remediation/risk management priority should be based on the removal of physical hazards (slope stability) and the containment and control of metals in the surface water pathways at the Former Landfill (i.e., Surface water drainage from landfill) discharging to the Red River.

The long-term strategy for the Former Landfill should be based on the following goals, in order of priority:

- Removal of Physical Hazards;
    a. Re-grade the Slope; and (if required)
    b. Erosion Control and Slope Improvements
- Containment and control, including long term monitoring and in-situ passive treatment systems;
- Risk management through the completion of a preliminary quantitative risk assessment; and
- Site monitoring and inspections.

At the Rifle Range the remediation/risk management priority should be to remove the contaminant source of metals in soils (i.e. bullets). The following three options were presented:

- Option 1: *Ex-Situ* Removal of Impacted Soils – excavation of impacted soils with disposal at a land treatment facility.

- Option 2: In-Situ Management – mechanical screening of soils.
- Option 3: In-Situ Treatment – physical separation of contaminants by soil washing and chemical separation.

As long as the Rifle Range continues in use as a rifle range, with no operable pathways to surface water receptors ex-situ remediation and off-site treatment, as well as in-situ treatment are a recommended remedial options because the gun butt berm soils would become re-contaminated by the shooting activity after soil remediation. However, once the Rifle Range is permanently closed, these would become viable options. In the interim, in-situ management is recommended for partial removal of the metal source and homogenizing of soils.

9.0 LIMITATIONS

This report has been prepared exclusively for PWGSC and CSC. Any other person or entity may not rely upon the report without the express written consent from Franz Environmental Inc., PWGSC, and CSC.

Any use that a third party makes of this report, or any reliance on decisions made based on it, is the responsibility of such third parties. Franz Environmental Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Some of the information presented in this report was provided through existing documents and interviews. Although attempts were made, whenever possible, to obtain a minimum of two confirmatory sources of information, Franz Environmental Inc., in certain instances, has been required to assume that the information provided is accurate.

The conclusions presented represent the best judgment of the assessors based on current environmental standards and on the site conditions observed on December 10 to 18, 2010. Due to the nature of the investigation and the limited data available, the assessors cannot warrant against undiscovered environmental liabilities.

Should additional information become available, Franz Environmental Inc. requests that this information be brought to our attention so that we may re-assess the conclusions presented herein.

There is no warranty, expressed or implied that the work reported herein has uncovered all potential environmental liabilities, nor does the report preclude the possibility of contamination outside of the areas of investigation. The findings of this report were developed in a manner consistent with a level of care and skill normally exercised by members of the environmental science and engineering profession currently practicing under similar conditions in the area.

A potential remains for the presence of unknown, unidentified, or unforeseen surface and sub-surface contamination. Any evidence of such potential site contamination would require appropriate surface and sub-surface exploration and testing.

If new information is developed in future work (which may include excavations, borings, or other studies), Franz Environmental Inc. should be requested to re-evaluate the conclusions of this report, and to provide amendments as required.

10.0 REFERENCES

Alberta Government, Environmental Protection and Enhancement Act, Waste Control Regulation 192/96, Schedule 1. 2000.

Franz Environmental Inc., Supplemental Phase II Investigation, Site 530-L01, Landfill Drumheller Institution, Drumheller Alberta, dated March 2006.

Canadian Council of Ministers of the Environment. 1999. *Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses*.

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Canadian Council of Ministers of the Environment. 2007. *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health.*

Canadian Council of Ministers of the Environment. 2008e. *National Classification System for Contaminated Sites Guidance Document.*

Geological Survey of Canada (GSC). Memoir 370, Surficial Geology of the Drumheller Area, dated 1973.

Google Maps (2010). Drumheller Health Centre, viewed December 9, 2010, http://maps.google.ca/maps?hl=en&tab=wl.

UMA Engineering Ltd. Phase II Environmental Site Assessment, Drumheller Institution, March 2000.

Zeiner, S.*T., Realistic Criteria for the Evaluation of Field Duplicate Sample Results,* Proceedings of Superfund XV, November 29-December 1, 1994, Sheraton Washington Hotel, Washington, D.C.

11.0 CLOSURE

We trust that this information is satisfactory for your present requirements. Should you have any questions or require additional information, please do not hesitate to contact the undersigned.

Sincerely,

Franz Environmental Inc.

Stephen Livingstone, M.Sc., P.Geo
Vice President

For

Tryfan Jones, M.Sc.
Environmental Scientist

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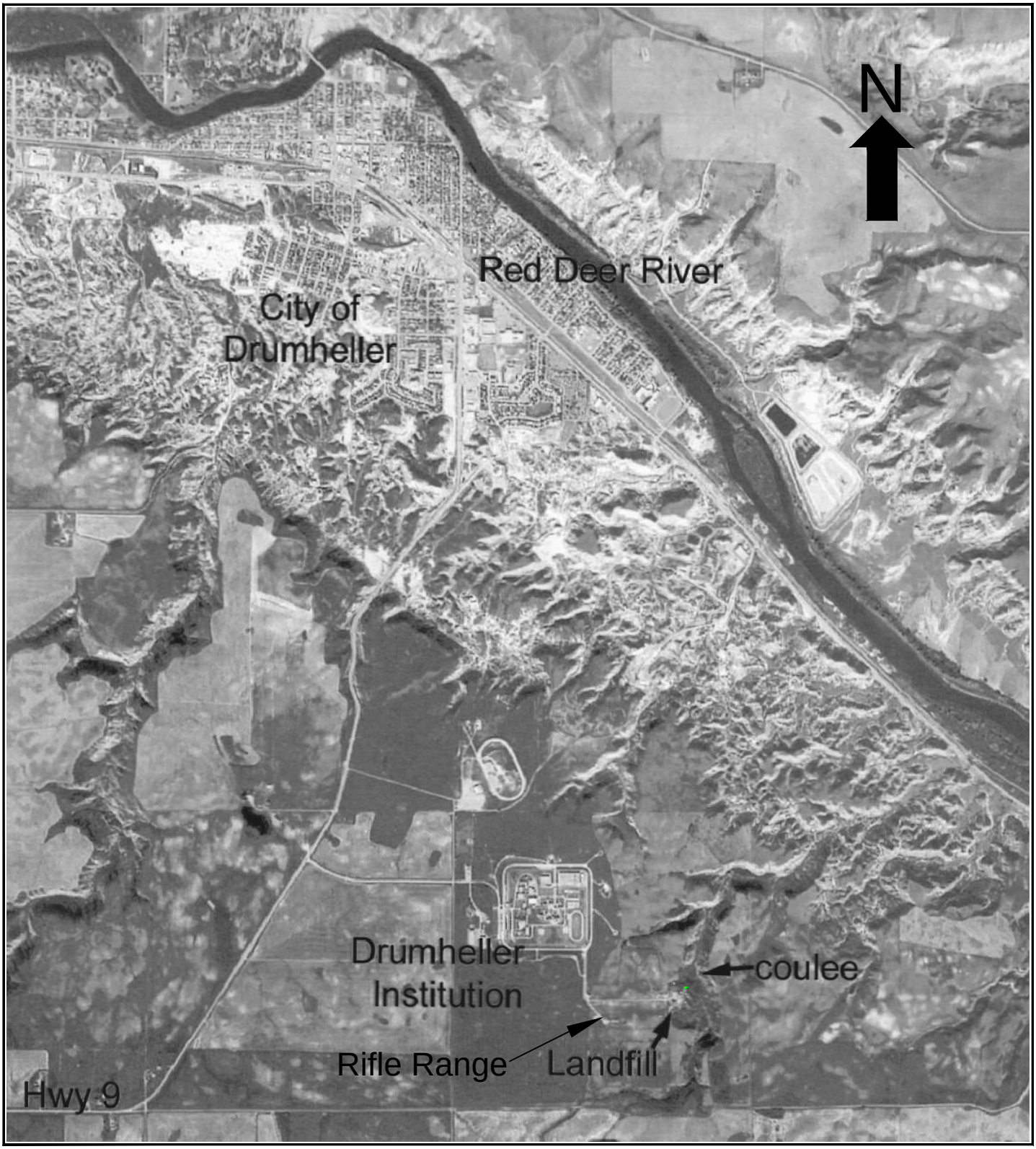
APPENDIX A

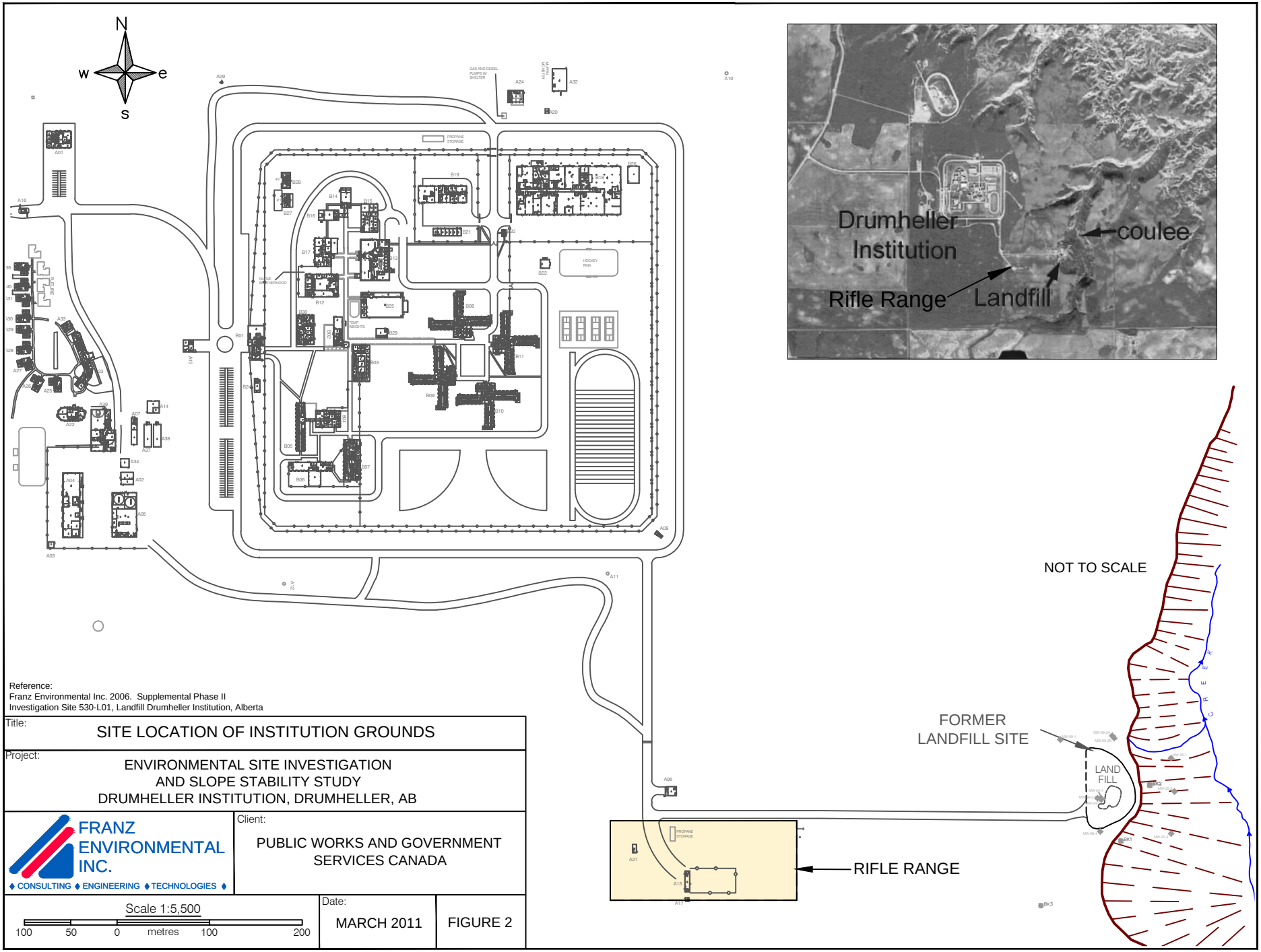
Figures



Reference:
Franz Environmental Inc. 2006. Supplemental Phase II Investigation Site 530-L01, Landfill Drumheller Institution, Alberta

Scale 1:30,000
500 250 0 Metres 500 1000

Title:	SITE LOCATION
Project:	ENVIRONMENTAL SITE INVESTIGATION AND SLOPE STABILITY STUDY DRUMHELLER INSTITUTION, DRUMHELLER, AB
Client:	PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
	FRANZ ENVIRONMENTAL INC. ♦ CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦
Date:	MARCH 2011
	FIGURE 1



Reference:
Franz Environmental Inc. 2006. Supplemental Phase II Investigation Site 530-L01, Landfill Drumheller Institution, Alberta

Title: SITE LOCATION OF INSTITUTION GROUNDS

Project: ENVIRONMENTAL SITE INVESTIGATION AND SLOPE STABILITY STUDY DRUMHELLER INSTITUTION, DRUMHELLER, AB

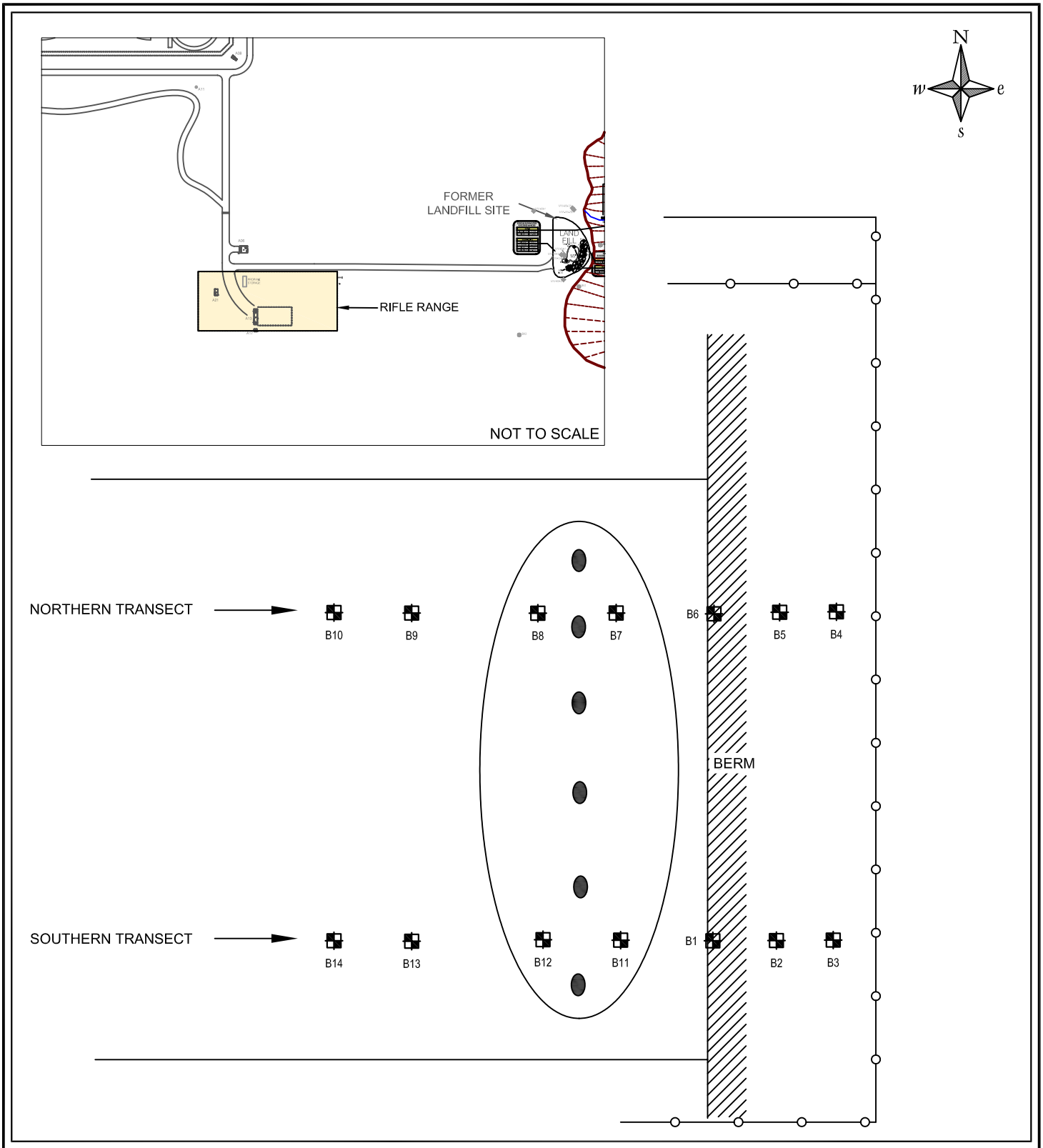
FRANZ ENVIRONMENTAL INC.
♦ CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Client: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

Scale 1:5,500
100 50 0 metres 100 200

Date: MARCH 2011

FIGURE 2

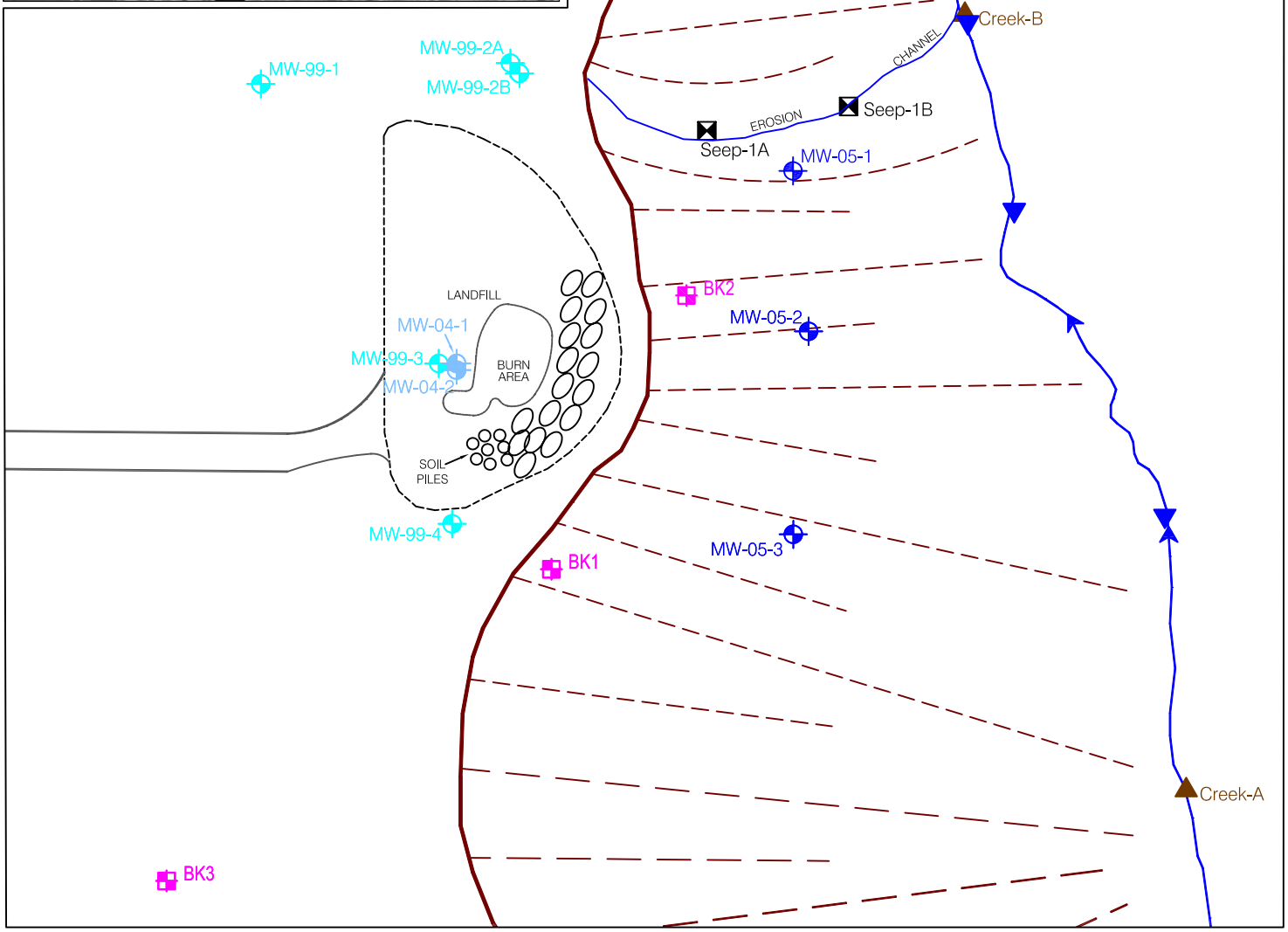


LEGEND

- Testpit Location (2010)
- Target
- Fence Line
- Berm
- Anecdotal Evidence of High Impact Area

NOT TO SCALE

Title:	RIFLE RANGE (530-C04) SITE PLAN & SAMPLE LOCATIONS
Project:	ENVIRONMENTAL SITE INVESTIGATION AND SLOPE STABILITY STUDY DRUMHELLER INSTITUTION, DRUMHELLER, AB
Client:	PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
FRANZ ENVIRONMENTAL INC. ♦ CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦	Date: MARCH 2011
	FIGURE 3



LEGEND

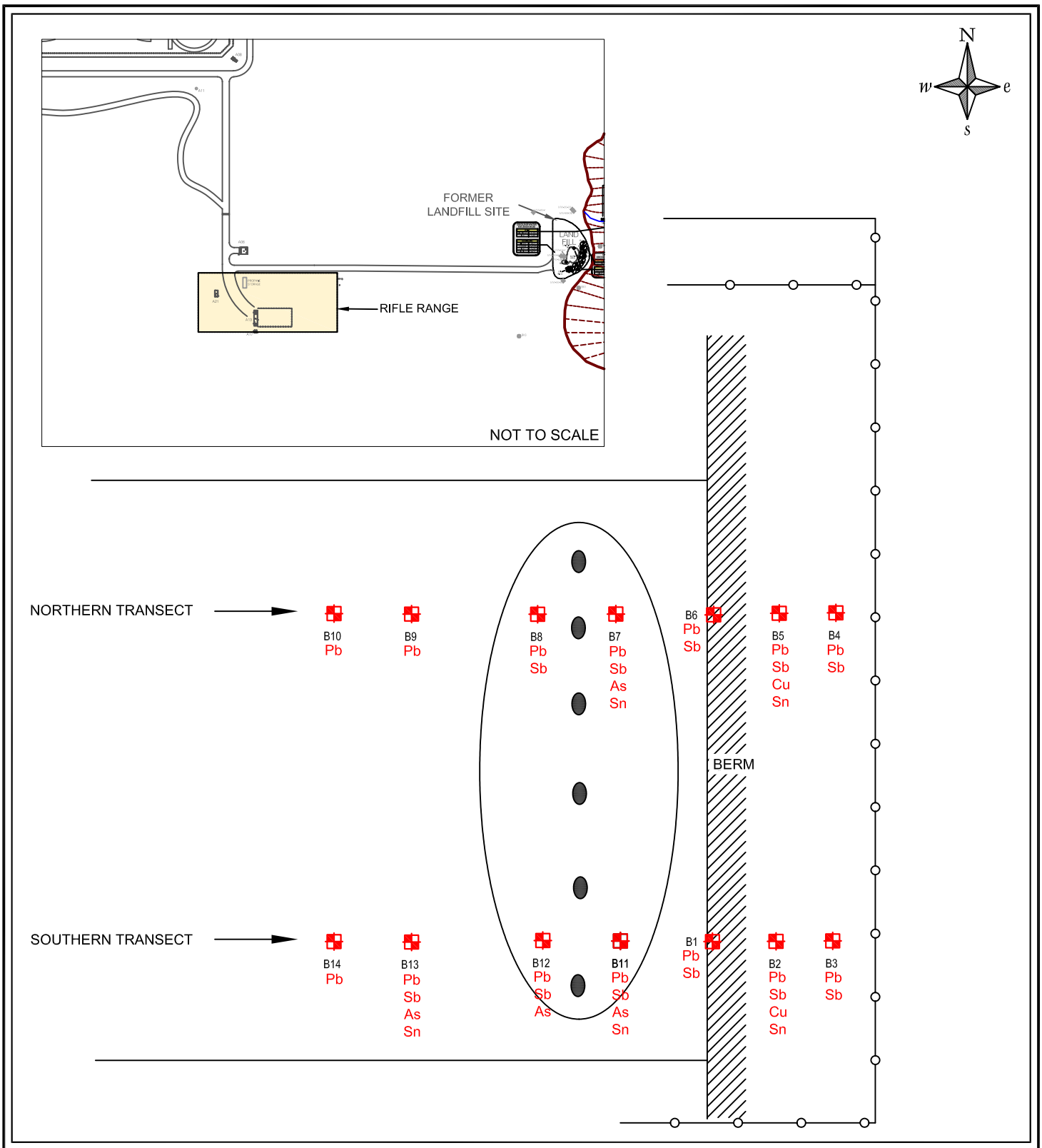
- Monitoring Well (UMA, 1999)
- Monitoring Well (Franz, 2004)
- Monitoring Well (Franz, 2005)
- Background Soil Sample (Franz, 2011)

Scale 1:1500

20 10 0 metres 25 50

References:
For a list of historical reports, please see report

Title:	FORMER LANDFILL (530-L01) SITE PLAN
Project:	ENVIRONMENTAL SITE INVESTIGATION AND SLOPE STABILITY STUDY DRUMHELLER INSTITUTION, DRUMHELLER, AB
Client:	PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
	FRANZ ENVIRONMENTAL INC. ♦ CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦
Date:	MARCH 2011
	FIGURE 4



LEGEND

NOT TO SCALE

- Testpit Location (2010) - Exceeded Recommended Guidelines
- Target
- Fence Line
- Berm
- Anecdotal Evidence of High Impact Area

Title: RIFLE RANGE (530-C04) - ANALYTICAL RESULTS FOR METALS

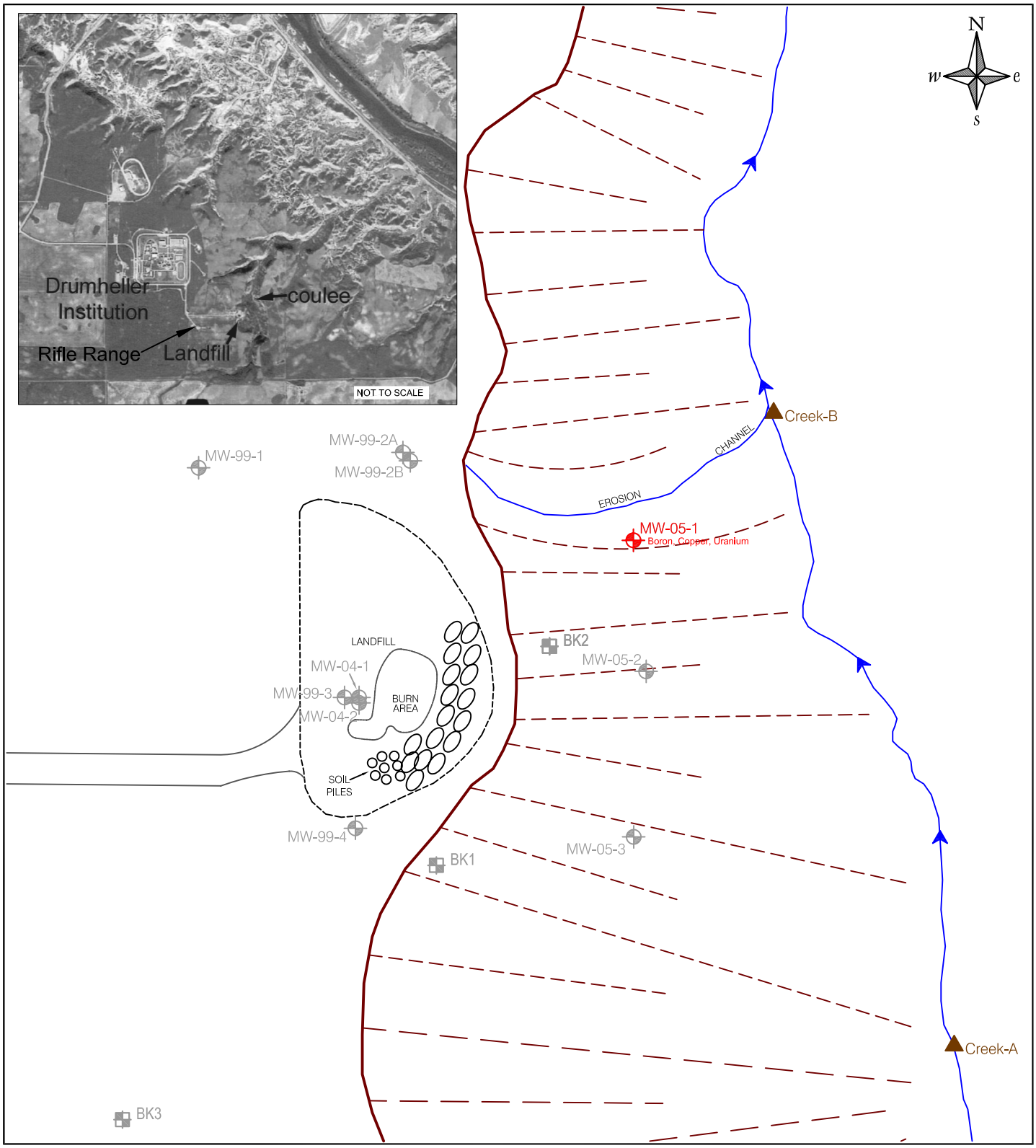
Project: ENVIRONMENTAL SITE INVESTIGATION AND SLOPE STABILITY STUDY DRUMHELLER INSTITUTION, DRUMHELLER, AB

Client: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

FRANZ ENVIRONMENTAL INC.
♦ CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Date: MARCH 2011

FIGURE 5



LEGEND

- Monitoring Well - Exceeded Recommended Guidelines

Not Tested

- Monitoring Well (UMA, 1999)
- Monitoring Well (Franz, 2004)
- Monitoring Well (Franz, 2005)
- Background Soil Sample (Franz, 2011)

References:
For a list of historical reports, please see report

Scale 1:1500

20 10 0 metres 25 50

Title: FORMER LANDFILL (530-L01) - ANALYTICAL RESULTS FOR METALS & VOCS IN GROUNDWATER

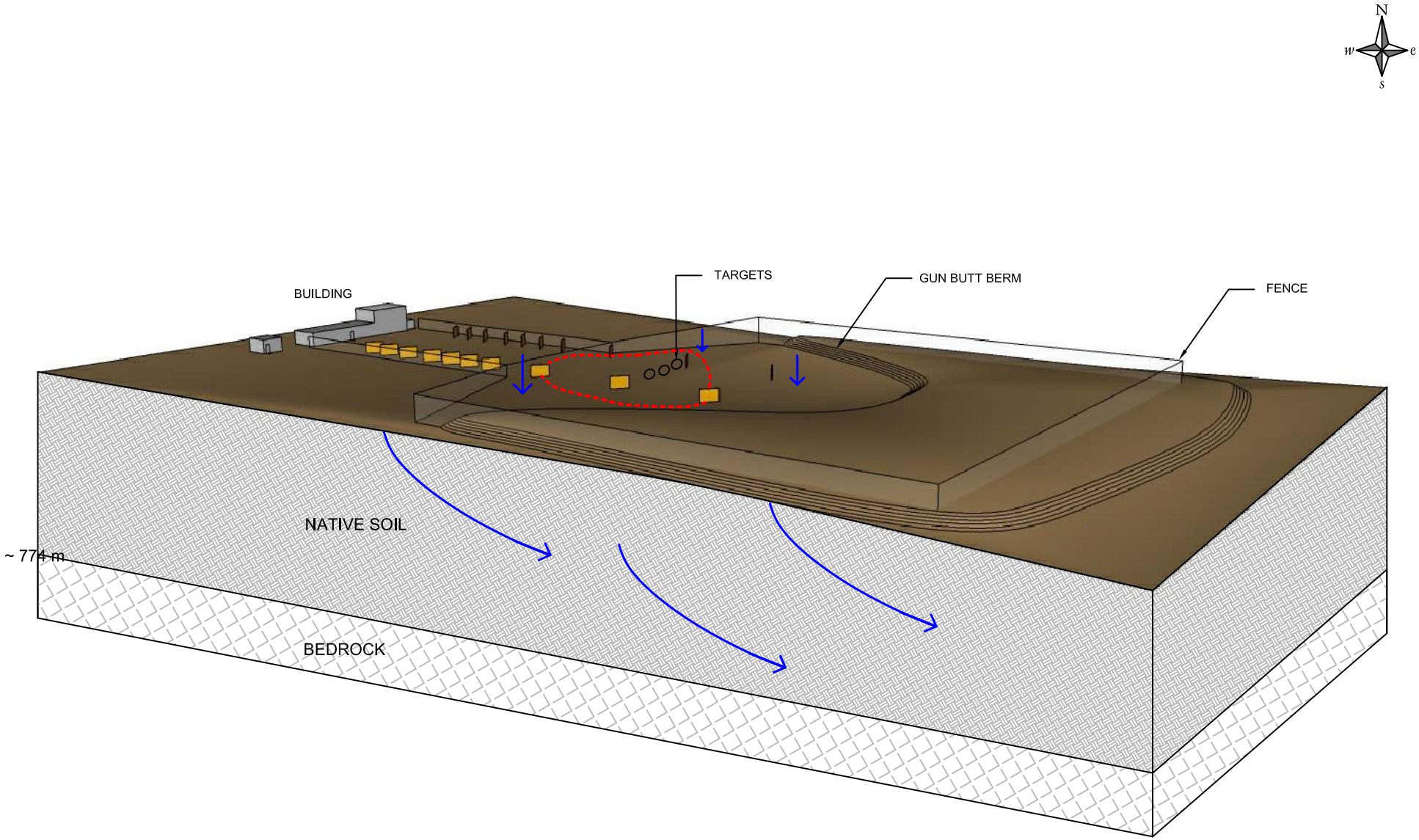
Project: ENVIRONMENTAL SITE INVESTIGATION AND SLOPE STABILITY STUDY DRUMHELLER INSTITUTION, DRUMHELLER, AB

Client: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

FRANZ ENVIRONMENTAL INC.
♦ CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Date: MARCH 2011

FIGURE 6



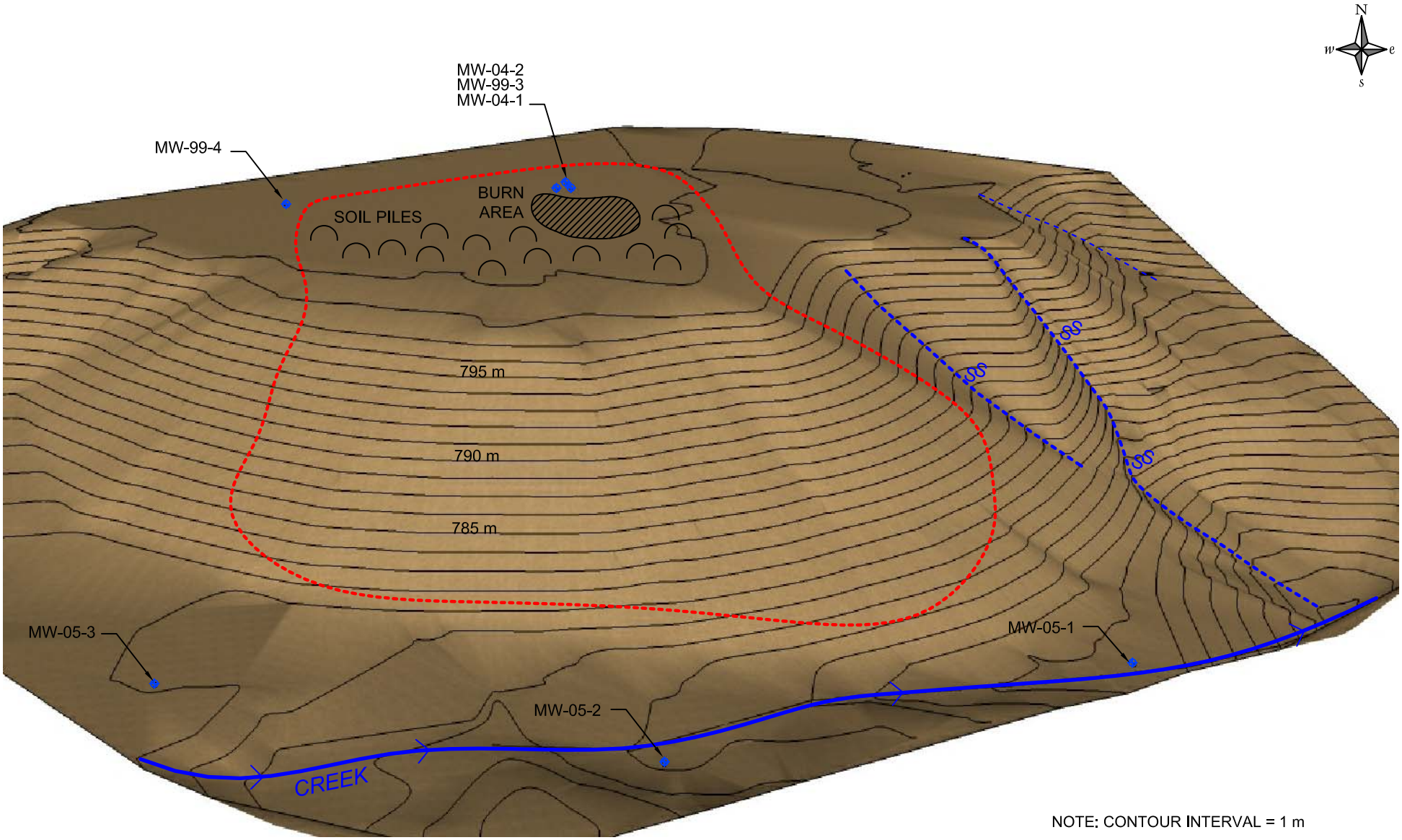
LEGEND

→ ANTICIPATED WATER INFILTRATION AND FLOW PATTERNS

(- - -) APPROXIMATE AREA OF IMPACTED SOILS

Title: CONCEPTUAL SITE MODEL - RIFLE RANGE (530-C04)	
FRANZ ENVIRONMENTAL INC. ♦ CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦	Project: ENVIRONMENTAL SITE INVESTIGATION & SLOPE STABILITY DRUMHELLER INSTITUTION
Date: MARCH 2011	Client: Public Works and Government Services Canada
NO SCALE	FIGURE 7

Z:\Projects\2010\2026-1001 Drumheller Institution\Figures\conceptual model\drumheller concept.dwg (layout)



LEGEND

- APPROXIMATE LANDFILL EXTENTS
- SOIL PILES
- BURN AREA
- CONTOUR LINE
- GROUNDWATER SEEPAGE
- MONITORING WELL
- INTERMITTENT SURFACE DRAINAGE
- CREEK
- FLOW DIRECTION

Title: CONCEPTUAL SITE MODEL 1 - FORMER LANDFILL (530-L01)

FRANZ ENVIRONMENTAL INC.
♦ CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Project: ENVIRONMENTAL SITE INVESTIGATION & SLOPE STABILITY DRUMHELLER INSTITUTION

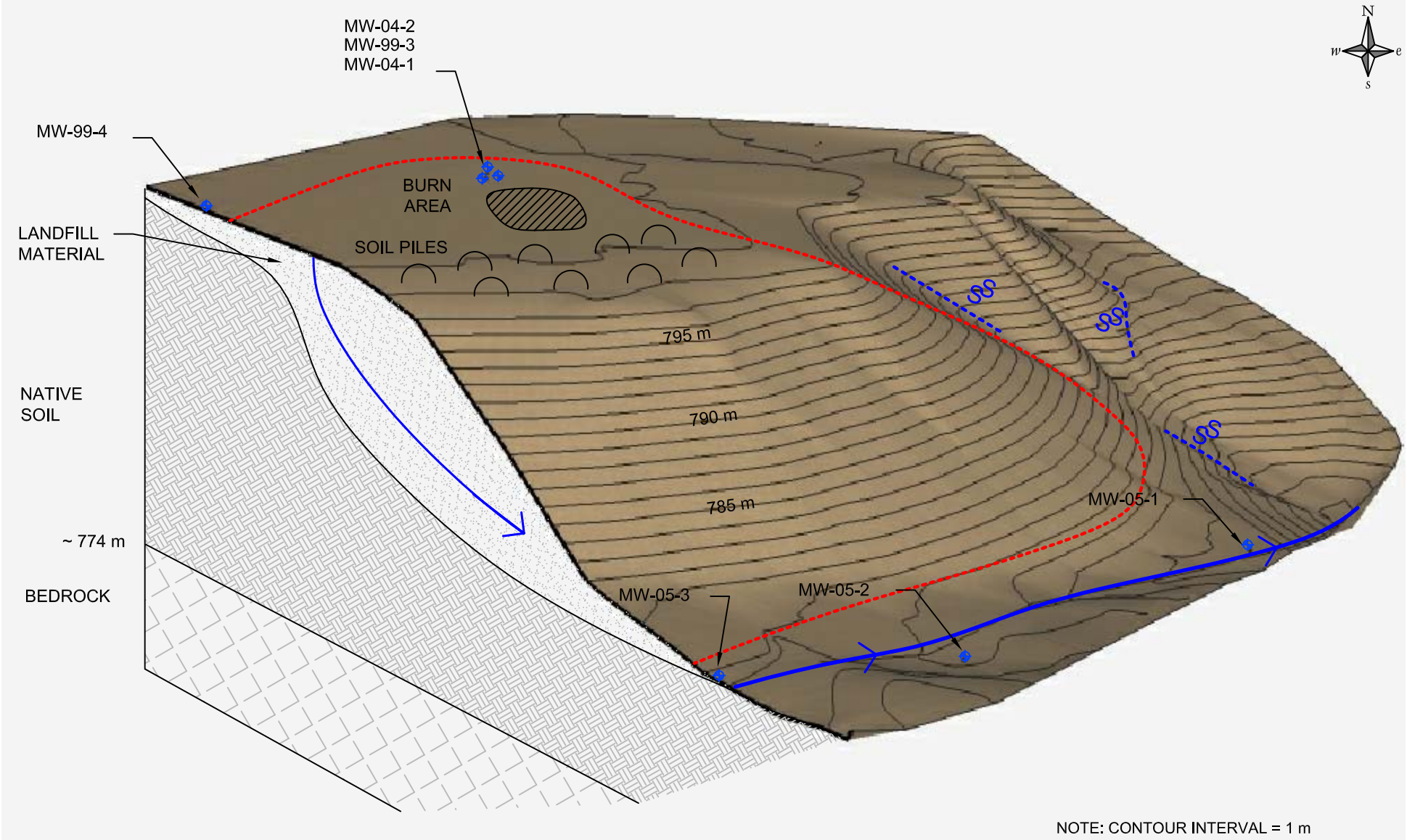
Date: MARCH 2011

Client: Public Works and Government Services Canada

NO SCALE

FIGURE 8

Z:\Projects\2010\2026-1001 Drumheller Institution\Figures\conceptual model\drumheller concept.dwg (layout)



NOTE: CONTOUR INTERVAL = 1 m

LEGEND

- APPROXIMATE LANDFILL EXTENTS
- SOIL PILES
- BURN AREA
- CONTOUR LINE
- GROUNDWATER SEEPAGE
- MONITORING WELL
- INTERMITTENT SURFACE DRAINAGE
- CREEK
- FLOW DIRECTION

Title: CONCEPTUAL SITE MODEL 2 - FORMER LANDFILL (530-L01)

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES

Project: ENVIRONMENTAL SITE INVESTIGATION & SLOPE STABILITY DRUMHELLER INSTITUTION

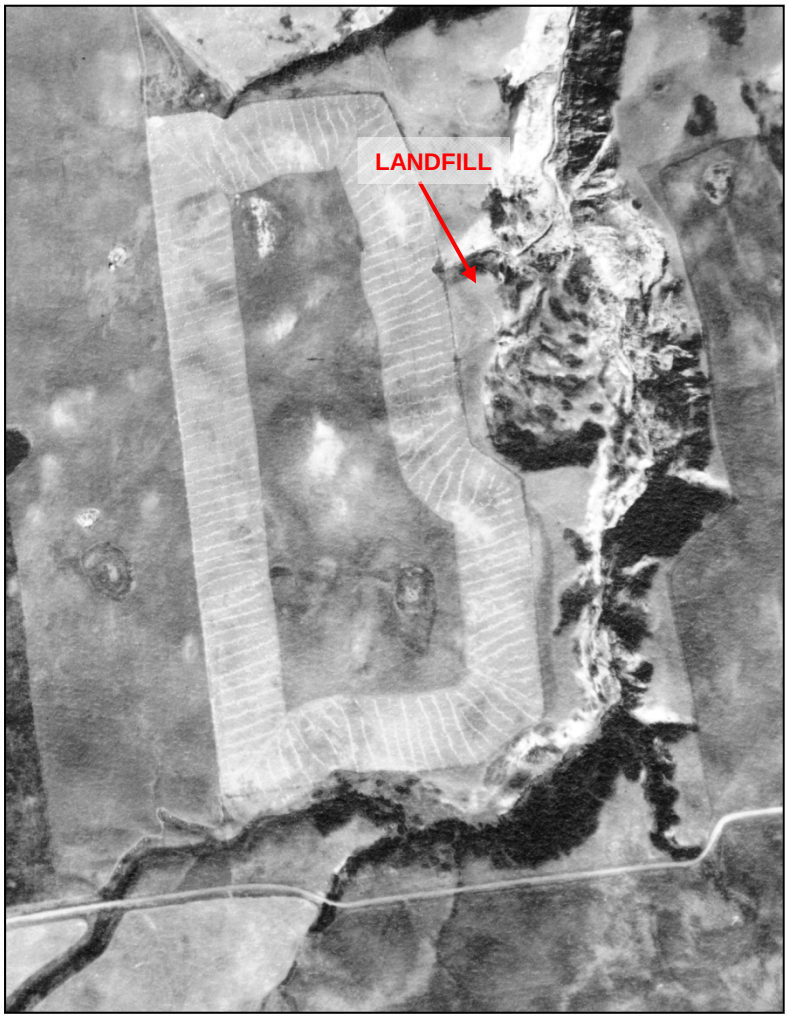
Date: MARCH 2011

Client: Public Works and Government Services Canada

NO SCALE

FIGURE 9

Z:\Projects\2010\2026-1001 Drumheller Institution\Figures\conceptual model\drumheller concept.dwg (layout)

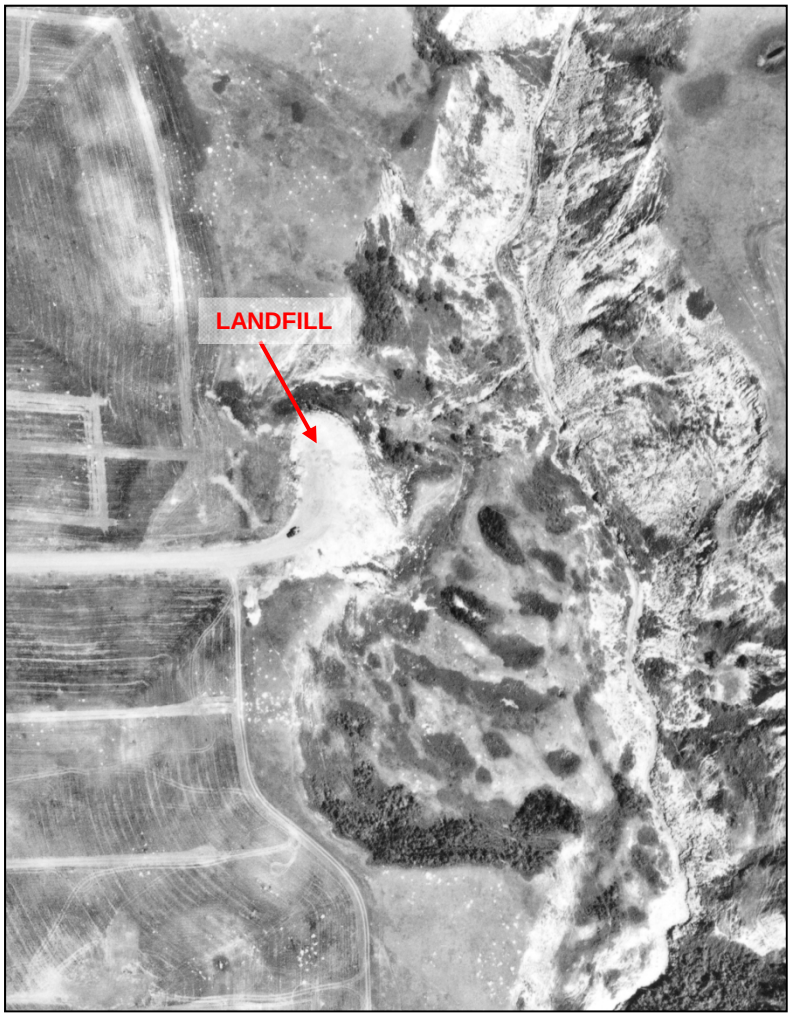


AERIAL PHOTOGRAPH CIRCA 1948

FRANZ ENVIRONMENTAL INC.
CONSULTING ENGINEERING TECHNOLOGIES

AERIAL PHOTOGRAPH OF LANDFILL

FIGURE 10A

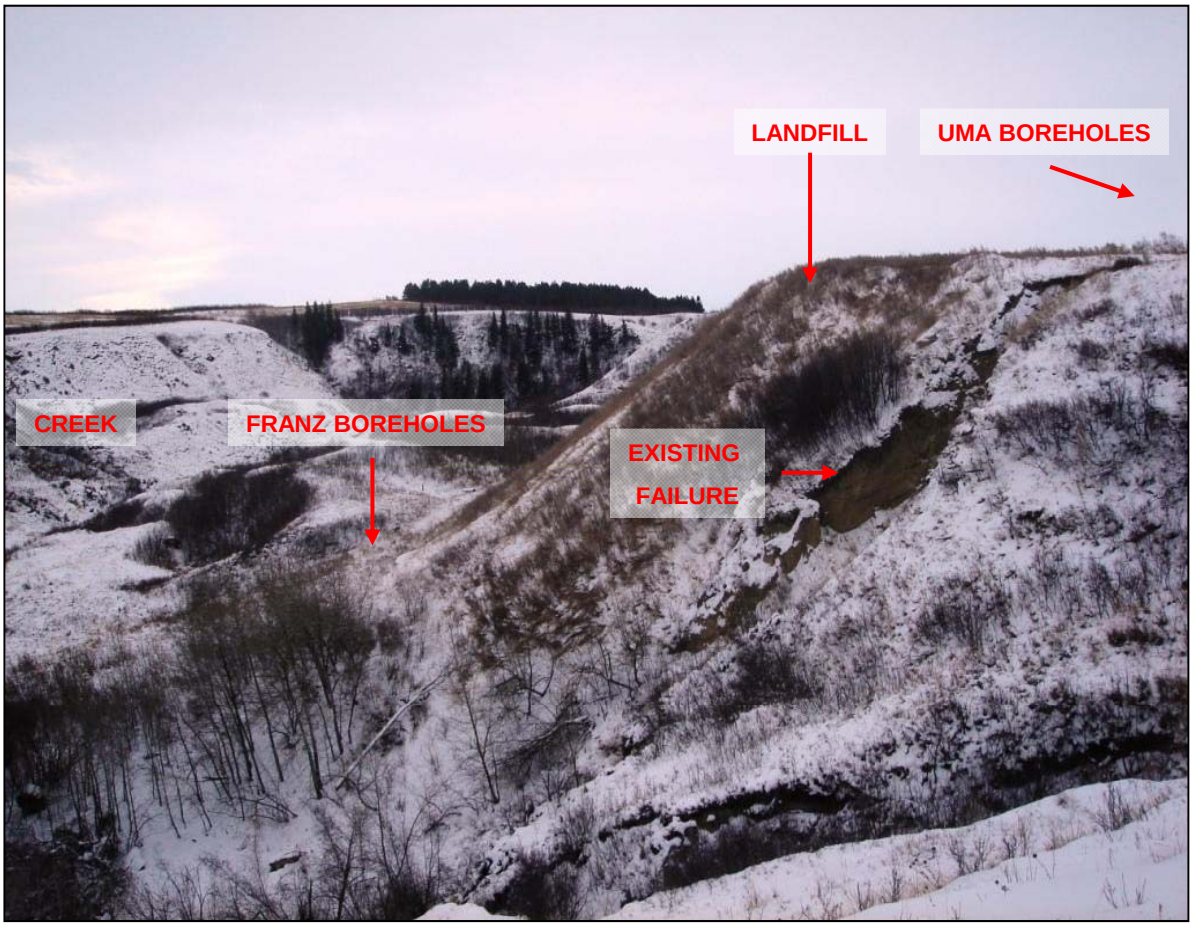


AERIAL PHOTOGRAPH CIRCA 1969

FRANZ ENVIRONMENTAL INC.
◆ CONSULTING ◆ ENGINEERING ◆ TECHNOLOGIES ◆

AERIAL PHOTOGRAPH OF LANDFILL

FIGURE 10B

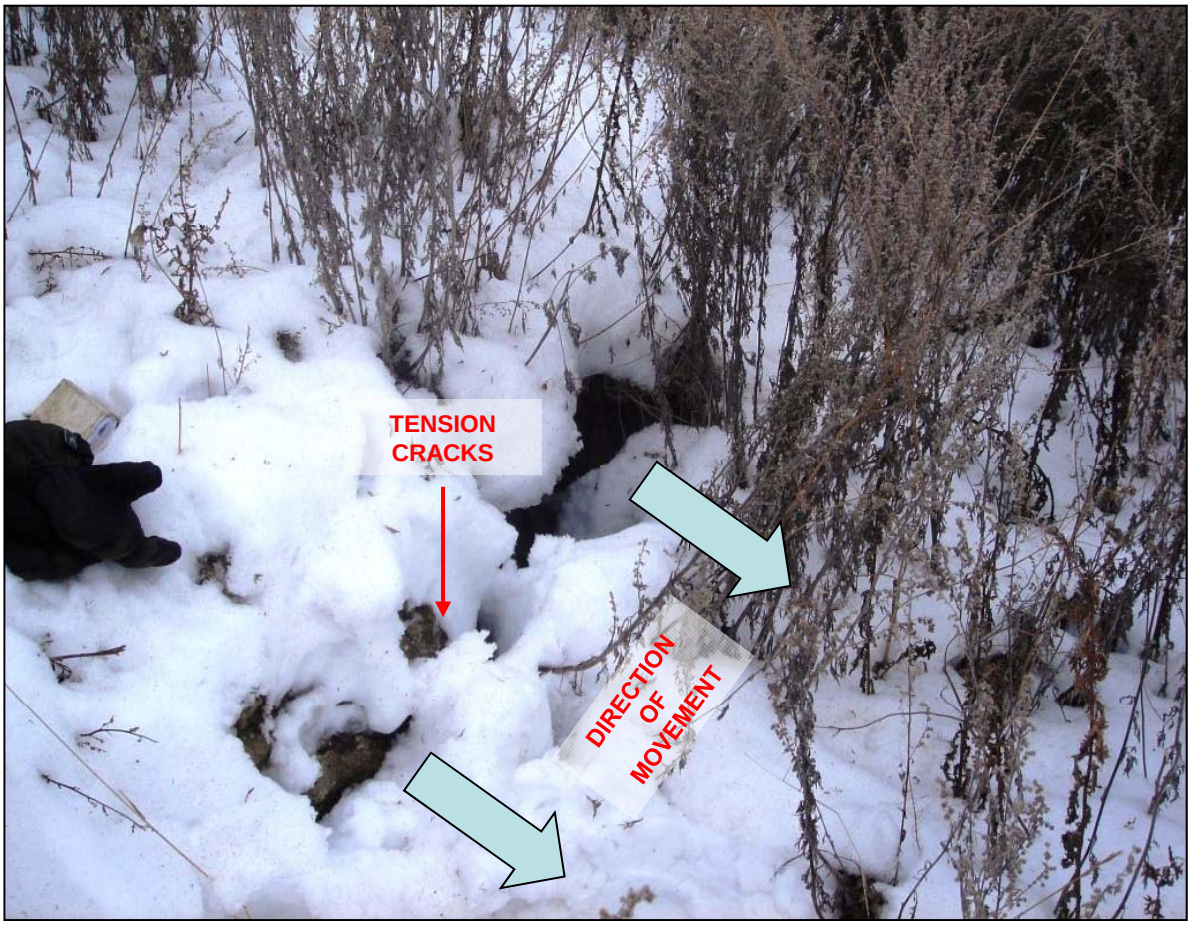


VIEW TO SOUTH OF LANDFILL TAKEN FROM
ADJACENT SLOPE TO NORTH

FRANZ ENVIRONMENTAL INC.
◆ CONSULTING ◆ ENGINEERING ◆ TECHNOLOGIES ◆

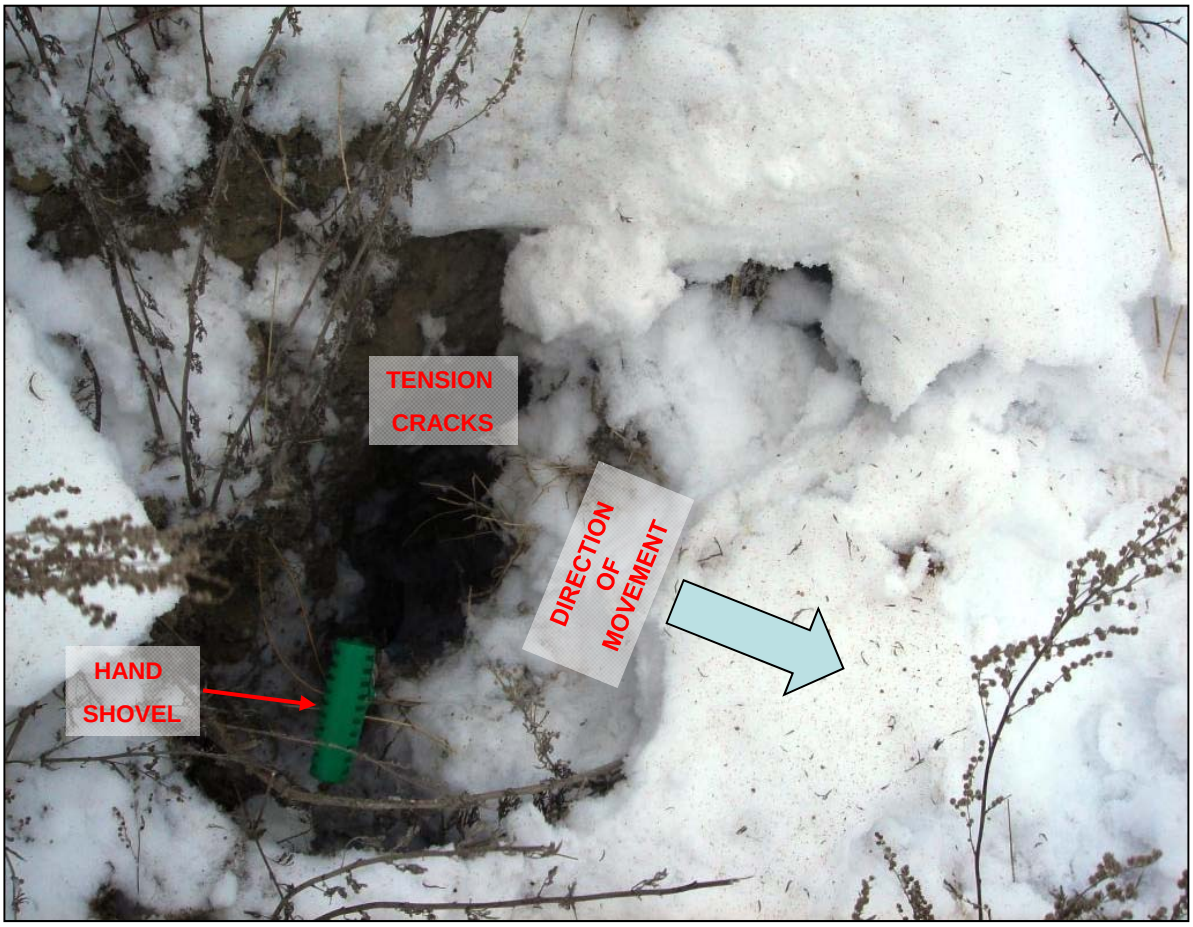
VIEW OF LANDFILL

FIGURE 11



VIEW OF TENSION CRACK ALONG CREST OF SLOPE

FRANZ ENVIRONMENTAL INC. ◆ CONSULTING ◆ ENGINEERING ◆ TECHNOLOGIES ◆	PHOTOGRAPH OF TENSION CRACK	FIGURE 12A



VIEW OF TENSION CRACK ALONG CREST OF SLOPE

Note: Hand shovel placed in tension crack, depth exceeding 1 – 2 metres.

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◆ CONSULTING ◆ ENGINEERING ◆ TECHNOLOGIES ◆

PHOTOGRAPH OF TENSION CRACK

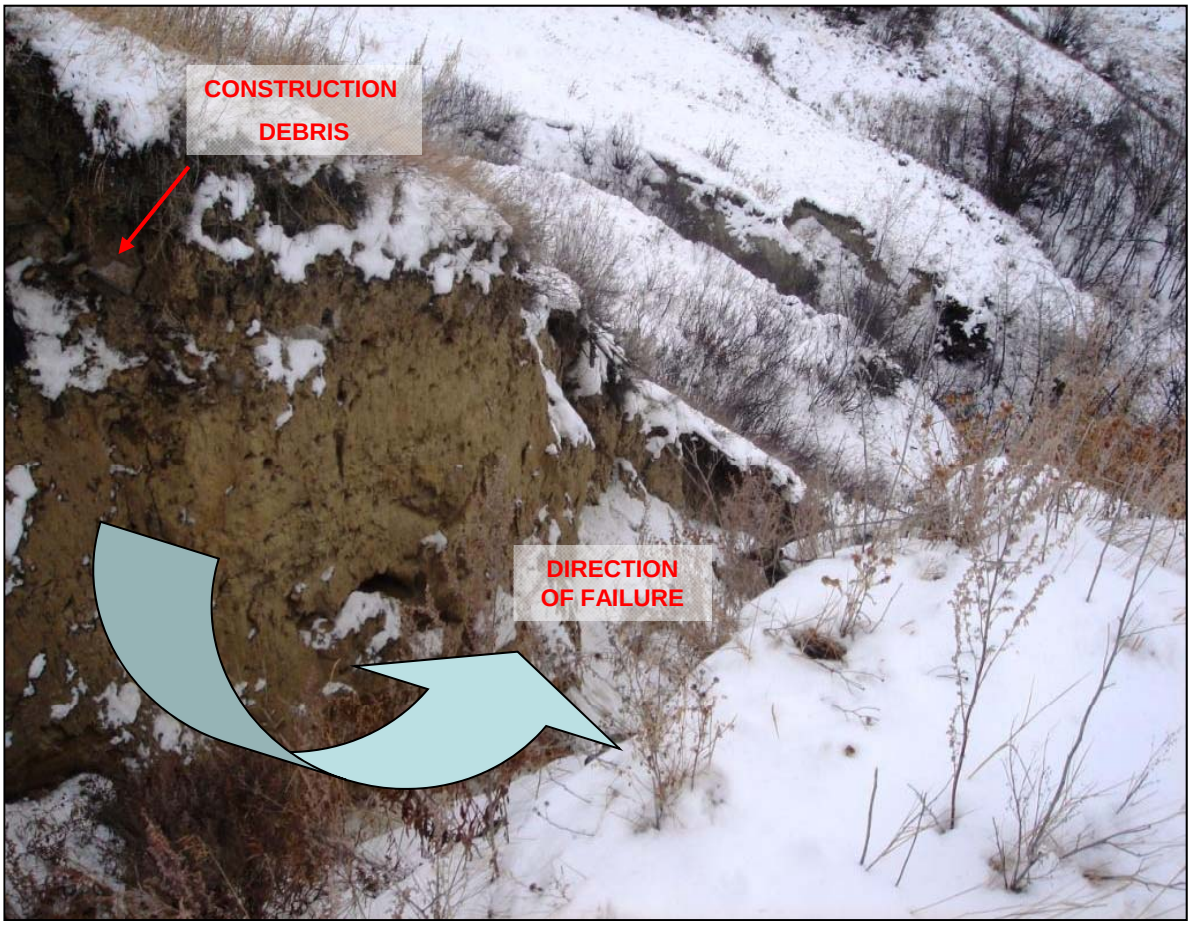
FIGURE 12B

VIEW OF TO EAST FROM CREST OF SLOPE

FRANZ ENVIRONMENTAL INC.
◆ CONSULTING ◆ ENGINEERING ◆ TECHNOLOGIES ◆

PHOTOGRAPH OF EXISTING FAILURE

FIGURE 13A



VIEW OF FILL MATERIAL IN EXISTING FAILURE

Note: Exposed construction debris on north face of failure scarp.

FRANZ ENVIRONMENTAL INC. ♦ CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦	PHOTOGRAPH OF EXISTING FAILURE	FIGURE13B

VIEW OF EXPOSED SOIL WEST SIDE OF ACCESS RAMP

Note: Interbedded layers of sand and silty sand

FRANZ ENVIRONMENTAL INC. ♦ CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦	PHOTOGRAPH OF NATIVE SOILS	FIGURE 14A

VIEW OF EXPOSED SOIL WEST SIDE OF ACCESS RAMP

Note: Interbedded layers of sand and silty sand

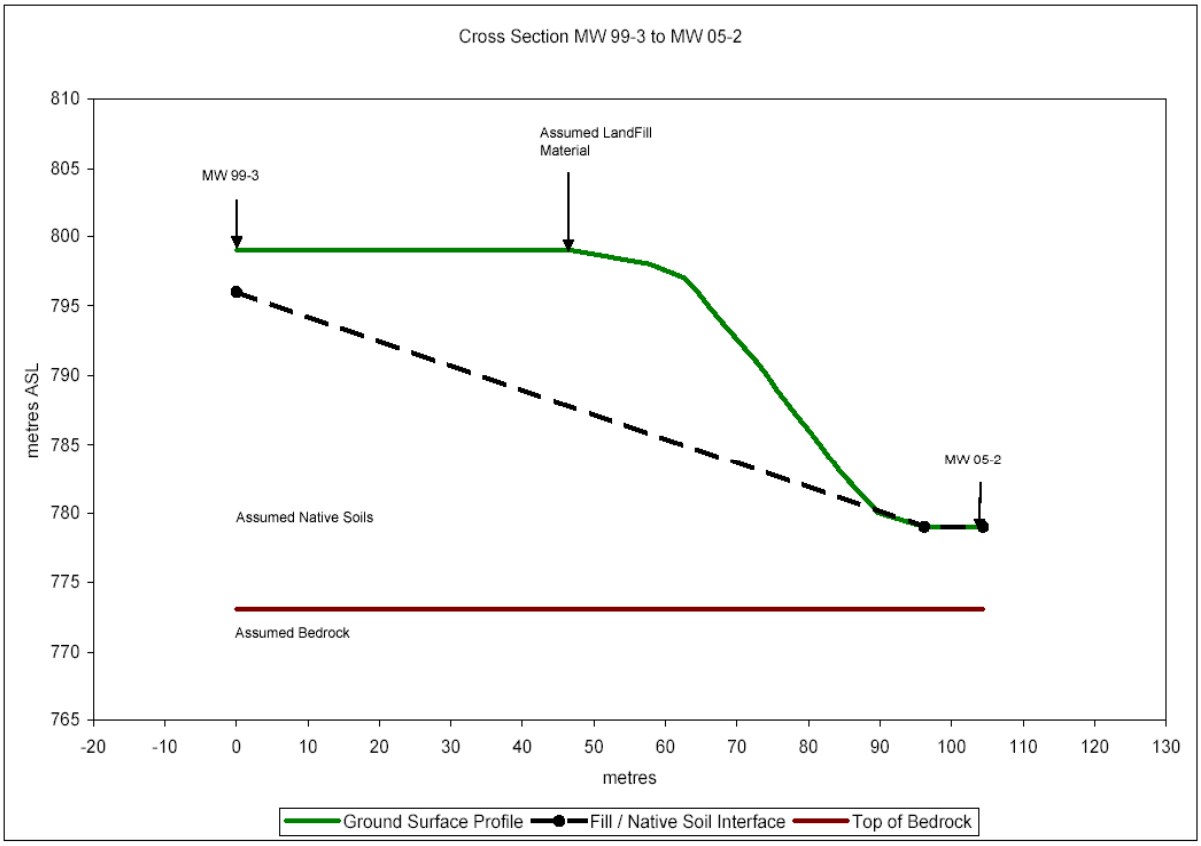
FRANZ ENVIRONMENTAL INC. ◆ CONSULTING ◆ ENGINEERING ◆ TECHNOLOGIES ◆	PHOTOGRAPH OF NATIVE SOIL	FIGURE 14B

Note: Cross section developed using UMA Environmental Ltd. and Franz Environmental Inc. boreholes and Tagish Engineering Ltd. survey data

FRANZ ENVIRONMENTAL INC.
◆ CONSULTING ◆ ENGINEERING ◆ TECHNOLOGIES ◆

LANDFILL CROSS SECTION, NORTH

FIGURE 15A

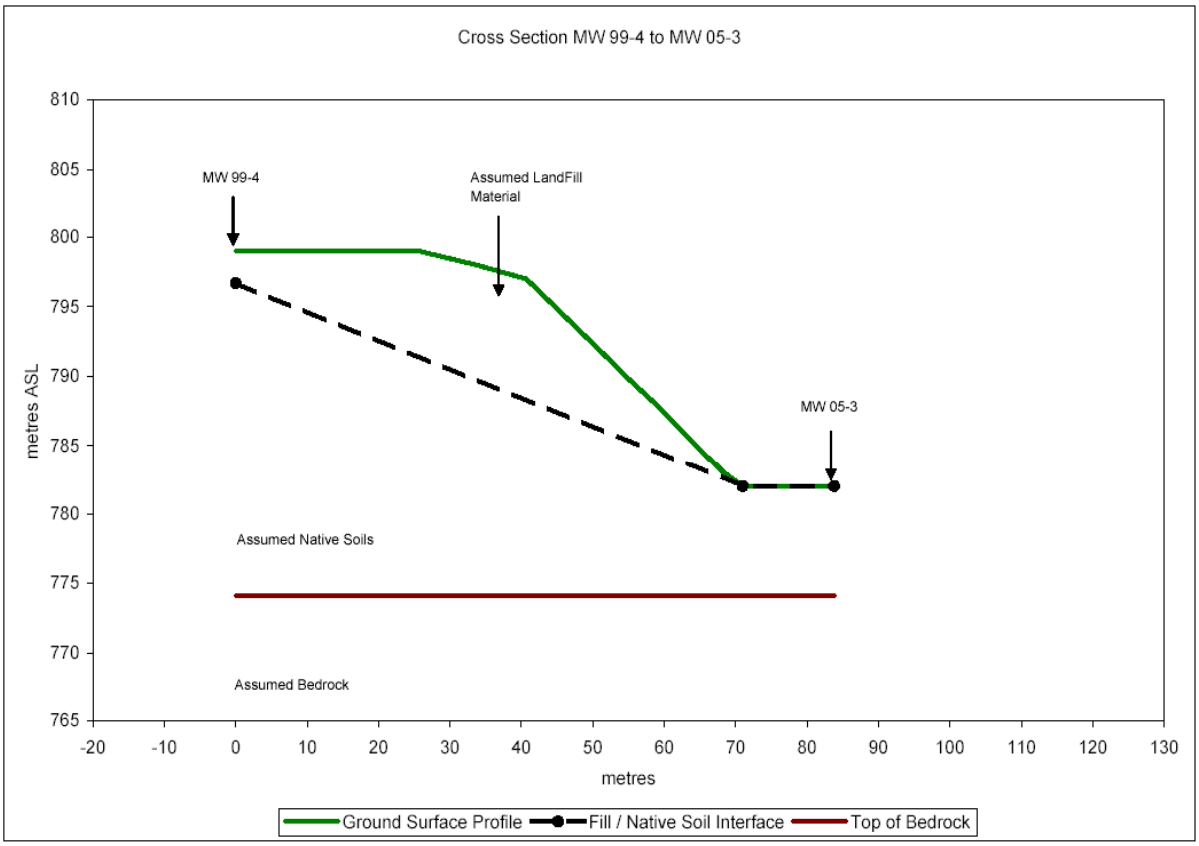


Note: Cross section developed using UMA Environmental Ltd. and Franz Environmental Inc. boreholes and Tagish Engineering Ltd. survey data

FRANZ ENVIRONMENTAL INC.
◆ CONSULTING ◆ ENGINEERING ◆ TECHNOLOGIES ◆

LANDFILL CROSS SECTION, MID

FIGURE 15B

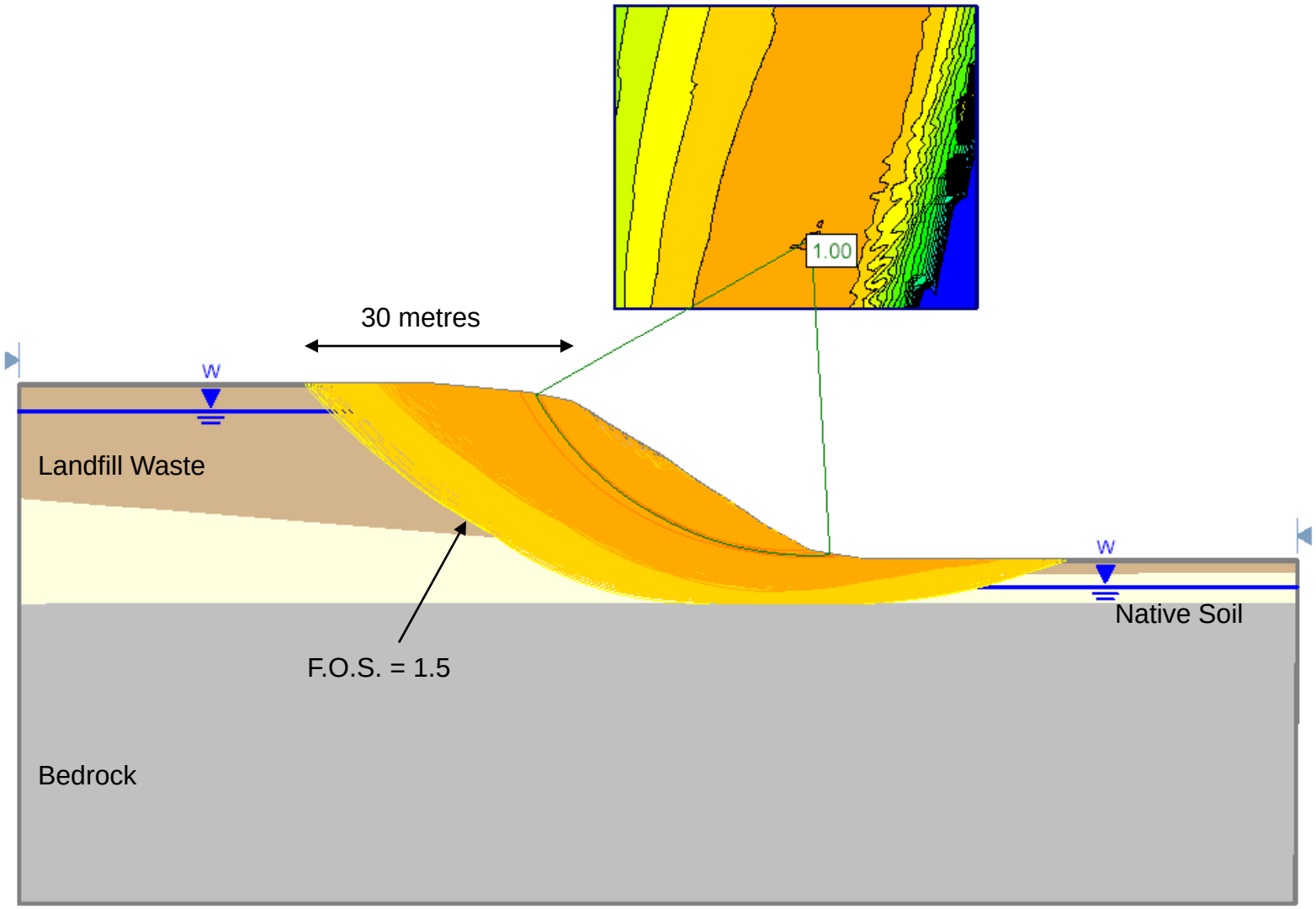


Note: Cross section developed using UMA Environmental Ltd. and Franz Environmental Inc. boreholes and Tagish Engineering Ltd. survey data

FRANZ ENVIRONMENTAL INC.
◆ CONSULTING ◆ ENGINEERING ◆ TECHNOLOGIES ◆

LANDFILL CROSS SECTION, SOUTH

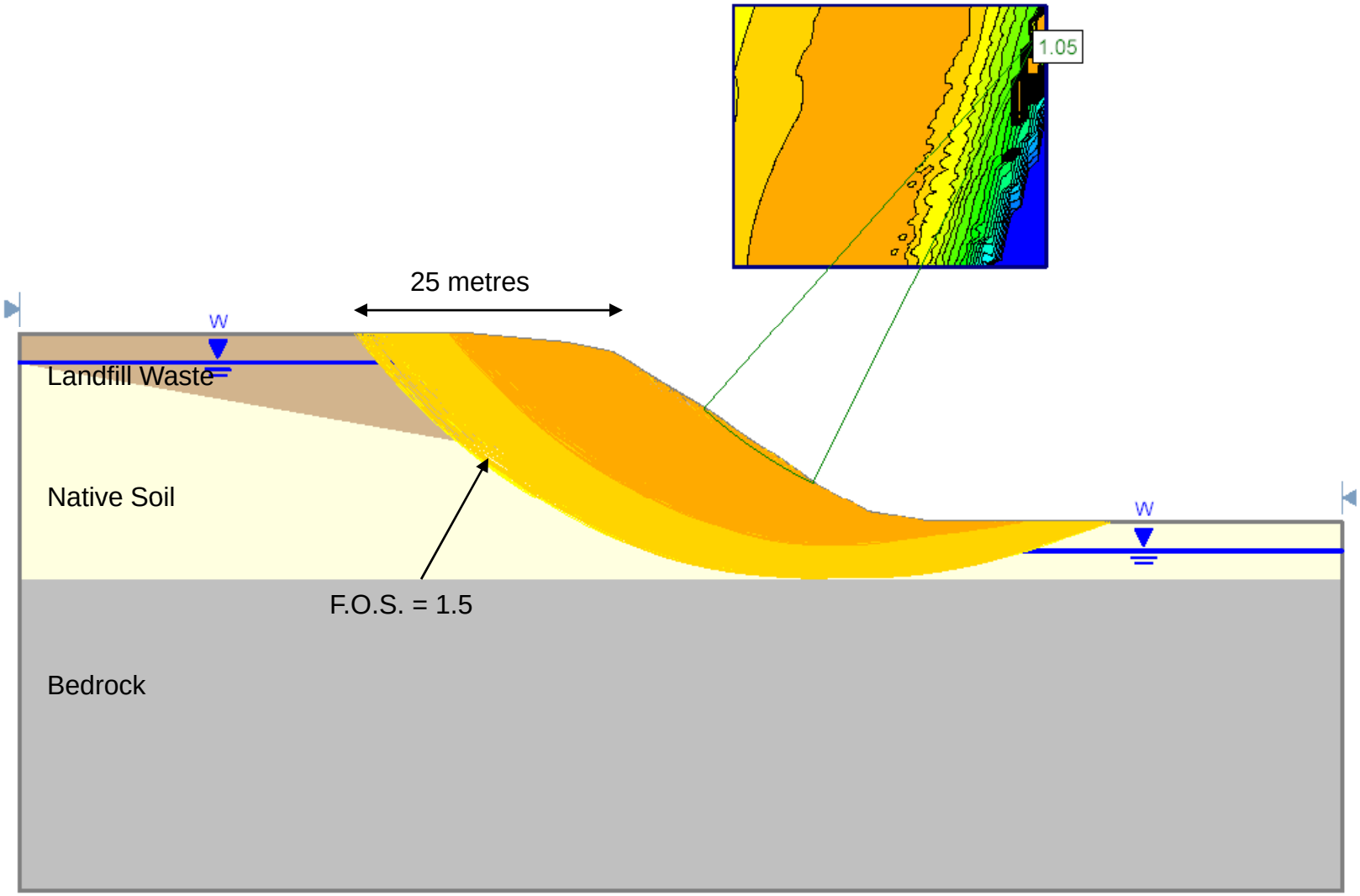
FIGURE 15C



FRANZ ENVIRONMENTAL INC.
◆ CONSULTING ◆ ENGINEERING ◆ TECHNOLOGIES ◆

SLOPE STABILITY ANALYSIS, NORTHERN SECTION

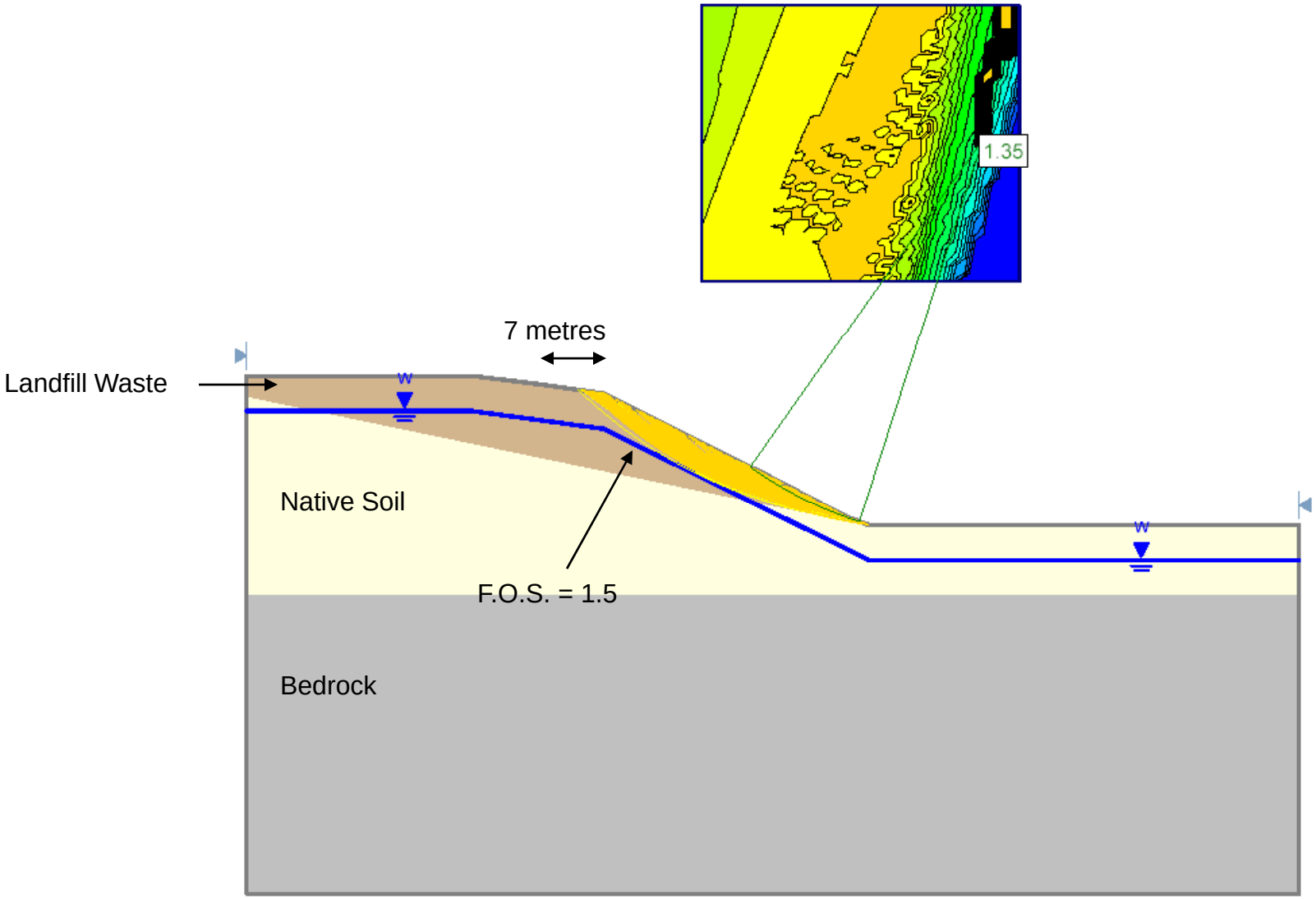
FIGURE 16A



FRANZ ENVIRONMENTAL INC.
◆ CONSULTING ◆ ENGINEERING ◆ TECHNOLOGIES ◆

SLOPE STABILITY ANALYSIS, MID SECTION

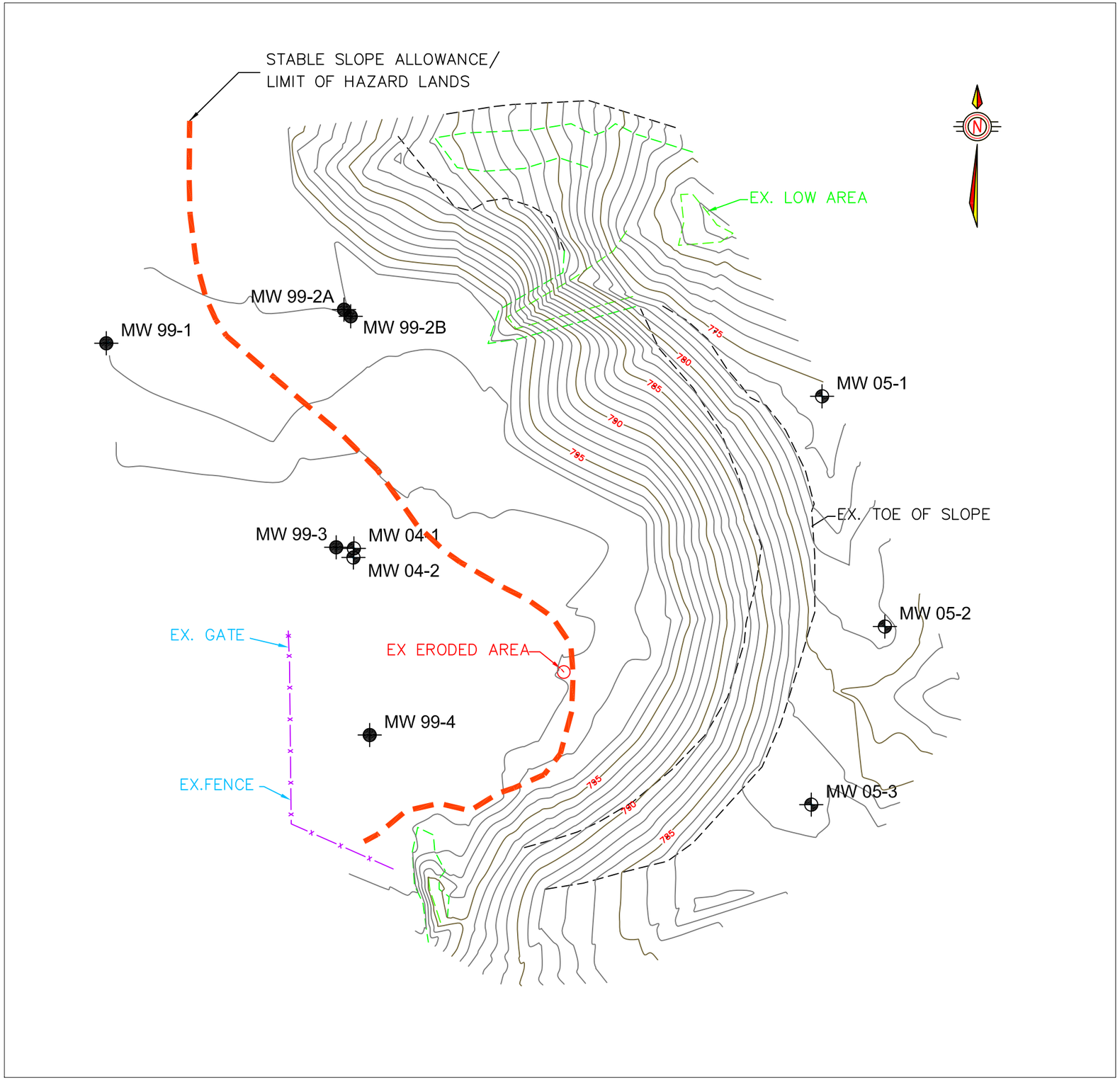
FIGURE 16B



FRANZ ENVIRONMENTAL INC.
◆ CONSULTING ◆ ENGINEERING ◆ TECHNOLOGIES ◆

SLOPE STABILITY ANALYSIS, SOUTHERN SECTION

FIGURE 16C



LEGEND

MW 05-1 APPROXIMATE BOREHOLE LOCATION IN PLAN, PREVIOUS INVESTIGATION BY FRANZ ENVIRONMENTAL INC.

MW 99-1 APPROXIMATE BOREHOLE LOCATION IN PLAN, PREVIOUS INVESTIGATION BY UMA ENGINEERING LTD.

PLAN PREPARED BY HOULE CHEVRIER ENGINEERING LTD. USING TOPOGRAPHIC DATA SUPPLIED BY TAGISH ENGINEERING LTD.

Client PWGSC		Location DRUMHELLER ALBERTA	Revision 0
Drawn by D.J.R	Approved by A.F.C	Project No. 10-611	Scale 1:1000
FRANZ ENVIRONMENTAL INC. • CONSULTING • ENGINEERING • TECHNOLOGIES •		Title LIMIT OF HAZARD LANDS	
		Date MARCH 2011	FIGURE 17

APPENDIX B

Analytical Tables

TABLE 1 - ANALYTICAL RESULTS FOR METALS IN SOILS AT
DRUMHELLER INSTITUTION

Station ID	CCME[1] Agricultural	Background			TRIP BLANK	B1					B1	B2	B2	B3				
Field label		BACKGROUND SOIL 1	BACKGROUND SOIL 2	BACKGROUND SOIL 3	TRIP BLANK	B1-1	B1-1 DUP	Duplicate Evaluation			B1-2	B2-1	B2-2	B3-1	B3-1 DUP	Duplicate Evaluation		
Date		14/Dec/10	14/Dec/10	14/Dec/10	17/Dec/10	14/Dec/10	14/Dec/10	Scenario**	Value	Acceptable	14/Dec/10	14/Dec/10	14/Dec/10	14/Dec/10	14/Dec/10	Scenario**	Value	Acceptable
Depth (cm)		0-5	0-5	0-5		0-5	0-5				20-30	0-5	20-30	0-5	0-5			
Antimony	20	<1	<1	<1	<1	22	19	D	3	Y	19	43	<40	32	22	C	37	Y
Arsenic	12	5	5	5	<1	7	6	D	1	Y	6	7	8	6	6	D	0	Y
Barium	750	220	250	220	<10	180	210	D	30	Y	200	200	210	180	220	C	20	Y
Beryllium	4	<0.4	0.5	0.6	<0.4	0.6	0.8	C	28.5	Y	0.9	0.8	0.9	0.8	0.8	D	0.0	Y
Cadmium	1.4	0.5	0.5	0.5	<0.1	0.5	0.6	C	9.0	Y	0.6	0.6	0.7	0.5	0.6	C	9.0	Y
Chromium	64	11	13	19	<1	18	23	D	4	Y	25	23	23	22	24	C	8.6	Y
Cobalt	40	6	8	8	<1	8	10	D	2	Y	10	10	10	9	10	C	10	Y
Copper	63	12	13	110	<5	49	42	D	7	Y	32	120	57	57	45	C	23.5	Y
Lead	70	7	8	11	<1	2100	1100	C	62.5	N	690	4700	9400	1800	1400	C	25	Y
Mercury	NC	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	A	N/A	Y	<0.05	<0.05	<0.05	<0.05	<0.05	A	N/A	Y
Molybdenum	5	0.6	0.6	0.7	<0.4	0.8	0.7	D	0.1	Y	0.7	0.7	0.7	0.6	0.7	D	0.1	Y
Nickel	50	17	20	21	<1	21	26	D	1	Y	27	27	28	24	28	C	15.3	Y
Selenium	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	A	N/A	Y	<0.5	<0.5	<0.5	<0.5	<0.5	A	N/A	Y
Silver	20	<1	<1	<1	<1	<1	<1	A	N/A	Y	<1	<1	<1	<1	<1	A	N/A	Y
Tin	5	<1	<1	<1	<1	2	1	D	1	Y	<1	6	9	2	1	D	1	Y
Uranium	23	1	<1	1	<1	<1	<1	A	N/A	Y	<1	1	1	<1	<1	A	N/A	Y
Zinc	200	45	47	86	<10	62	65	D	3	Y	60	70	68	59	68	C	14	Y

Notes:

1= CCME (2007), Canadian Soil Quality Guidelines, Update 7.0, Table 2. Canadian Soil Quality Guidelines, Agricultural Land Use.

**= Scenario A is used when both results are ND, Scenario B is used when result A is ND and result B is a positive number, Scenario C is used when Result A and result B are positive and > 5x the MDL , Scenario D is used when result A is positive and < or equal to 5x the MDL and result B is positive.

NC = No Criteria/Not Calculated

RDL = Reportable Detection Limit

20 = Guidelines used.

20 = Denotes exceedances for Agricultural Land Use.

TABLE 1 - ANALYTICAL RESULTS FOR METALS IN SOILS AT
DRUMHELLER INSTITUTION

Station ID	CCME[1] Agricultural	B4	B4	B5	B5	B6	B6					B7				
Field label		B4-1	B4-2	B5-1	B5-2	B6-1	B6-2	B6-2 DUP	Duplicate Evaluation			B7-1	B7-2 DUP	Duplicate Evaluation		
Date		14/Dec/10	14/Dec/10	14/Dec/10	14/Dec/10	14/Dec/10	14/Dec/10	14/Dec/10	Scenario**	Value	Acceptable	14/Dec/10	14/Dec/10	Scenario**	Value	Acceptable
Depth (cm)		0-5	20-30	0 – 0.5	20-30	0-5	20-30	20-30				0-5	20-30			
Antimony	20	27	4	210	28	26	<1	6	B	5.5	N	910	48	C	179	N
Arsenic	12	6	6	9	11	9	5	7	D	2	Y	29	17	C	52	N
Barium	750	180	240	200	170	200	220	200	C	9	Y	160	190	C	17	Y
Beryllium	4	0.8	0.9	0.9	0.7	0.8	0.7	0.7	D	0.0	Y	0.4	0.8	D	0.4	Y
Cadmium	1.4	0.5	0.6	0.5	0.5	0.5	0.7	0.6	C	15.0	Y	0.4	0.5	D	0.1	Y
Chromium	64	23	22	23	19	22	19	22	C	14.6	Y	19	23	C	19	Y
Cobalt	40	9	10	10	8	9	10	9	C	10	Y	7	9	C	25	Y
Copper	63	30	26	200	30	34	19	20	D	1	Y	37	40	C	8	Y
Lead	70	1700	360	16000	740	1600	52	260	C	133	N	32000	2000	C	176	N
Mercury	NC	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	A	N/A	Y	<0.05	<0.05	A	N/A	Y
Molybdenum	5	0.6	0.6	0.8	0.8	0.8	0.6	0.8	D	0.2	Y	0.6	0.6	D	0.0	Y
Nickel	50	23	25	25	22	25	26	25	C	4	Y	19	23	C	18	Y
Selenium	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	A	N/A	Y	0.6	<0.5	B	0.05	Y
Silver	20	<1	<1	<1	<1	<1	<1	<1	A	N/A	Y	<1	<1	A	N/A	Y
Tin	5	<1	<1	11	<1	2	<1	<1	A	N/A	Y	14	<1	B	13.5	N
Uranium	23	<1	<1	<1	<1	1	1	<1	B	0.5	Y	<1	<1	A	N/A	Y
Zinc	200	56	55	73	50	76	58	57	C	1.7	Y	63	66	C	4.6	Y

Notes:

CCME (2007), Canadian Soil Quality Guidelines, Update 7.0, Table 2. Canadian Soil Quality Guidelines, Agricultural Land Use.

Scenario A is used when both results are ND, Scenario B is used when result A is ND and result B is a positive number, Scenario C is used when Result A and result B are positive and > 5x the MDL , Scenario D is used when result A is positive and < or equal to 5x the MDL and result B is positive.

No Criteria/Not Calculated
Reportable Detection Limit
Guidelines used.
Denotes exceedances for Agricultural Land Use.

TABLE 1 - ANALYTICAL RESULTS FOR METALS IN SOILS AT
DRUMHELLER INSTITUTION

Station ID	**CCME[1] Agricultural**	**B8**	**B9**	**B10**	**B11**	**B12**	**B13**	**B14**
Field label		**B8-1**	**B9-1**	**B10-1**	**B11-1**	**B12-1**	**B13-1**	**B14-1**
Date		14/Dec/10	14/Dec/10	14/Dec/10	14/Dec/10	14/Dec/10	14/Dec/10	14/Dec/10
Depth (cm)		0-5	0-5	0-5	0-5	0-5	0-5	0-5
Antimony	20	32	10	3	1300	210	430	16
Arsenic	12	12	8	6	140	47	48	9
Barium	750	180	190	170	150	170	210	190
Beryllium	4	0.5	0.8	0.6	0.4	0.5	0.5	0.4
Cadmium	1.4	0.5	0.6	0.5	0.4	0.5	0.5	0.4
Chromium	64	33	38	44	21	23	22	16
Cobalt	40	9	9	8	7	9	9	7
Copper	63	23	27	18	26	24	25	25
Lead	70	1600	400	140	42000	6700	14000	1900
Mercury	NC	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Molybdenum	5	1.2	1.0	1.1	0.7	1.0	0.8	0.9
Nickel	50	27	30	30	19	21	24	19
Selenium	1	0.8	0.5	<0.5	0.6	0.8	<0.5	<0.5
Silver	20	<1	<1	<1	1	<1	<1	<1
Tin	5	2	<1	<1	76	3	6	<1
Uranium	23	<1	<1	<1	<1	<1	<1	<1
Zinc	200	66	69	55	73	91	79	54

Notes:

CCME (2007), Canadian Soil Quality Guidelines, Update 7.0, Table 2. Canadian Soil Quality Guidelines, Agricultural Land Use.

Scenario A is used when both results are ND, Scenario B is used when result A is ND and result B is a positive number, Scenario C is used when Result A and result B are positive and > 5x the MDL , Scenario D is used when result A is positive and < or equal to 5x the MDL and result B is positive.

No Criteria/Not Calculated
Reportable Detection Limit
Guidelines used.
Denotes exceedances for Agricultural Land Use.

TABLE 2 - ANALYTICAL RESULTS FOR COMPOSITE LEACHATE TEST IN SOIL AT DRUMHELLER INSTITUTION

BASIC CLASS II LANDFILL PACKAGE (LEACHATE)	Alberta Waste Control Regulations[1] (mg/L)	COMPOSITE LEACHATE TEST
Station ID		
Date		14/Dec/10
Lab report ID		B0C2712
Sample depth (cm)		0-30
Leachable Metals (mg/L)		
Leachable Antimony (Sb)	500	1
Leachable Arsenic (As)	5	0.9
Leachable Barium (Ba)	100	1
Leachable Beryllium (Be)	5	<0.5
Leachable Boron (B)	500	<1
Leachable Cadmium (Cd)	1	<0.1
Leachable Chromium (Cr)	5	<0.5
Leachable Cobalt (Co)	100	<1
Leachable Copper (Cu)	100	<1
Leachable Iron (Fe)	1000	<1
Leachable Lead (Pb)	5	270 (1)
Leachable Mercury (Hg)	0.2	<0.02
Leachable Nickel (Ni)	5	<0.5
Leachable Selenium (Se)	1	<0.1
Leachable Silver (Ag)	5	<0.5
Leachable Thallium (Tl)	5	<0.5
Leachable Uranium (U)	2	<0.2
Leachable Vanadium (V)	100	<1
Leachable Zinc (Zn)	500	<1
Leachable Zirconium (Zr)	500	<1
Volatiles (mg/L)		
Leachable (ZH) Benzene	500	<11
Leachable (ZH) Toluene	500	<10
Leachable (ZH) Ethylbenzene	500	<10
Leachable (ZH) o-Xylene	NS	<10
Leachable (ZH) m & p-Xylene	NS	<20
Leachable (ZH) Xylenes (Total)	500	<20

Notes

All units in mg/L unless otherwise stated.

1 = Alberta Waste Control Regulation, Table A - Chemical Constituents and Leachate Limits in Alberta

(1) = Detection limits raised due to dilution to bring analyte within the calibrated range

Red cells indicates parameter exceeds Alberta Waste Control Regulations.

TABLE 3 - ANALYTICAL RESULTS FOR METALS IN GROUNDWATER AT DRUMHELLER INSTITUTION

Sample ID	CCME FWAL[1]	CCME Agr[2]	MW05-01*	MW05-01 DUP*	Duplicate Evaluation			TRIP BLANK 101213	FIELD BLANK
Date			15/Dec/10	15/Dec/10	Scenario**	Value	Acceptable	15/Dec/10	15/Dec/10
Screen depth (m)			6.0-9.0	6.0-9.0					
Hardness (CaCO3)	-	-	140000	130000	C	7	Y	<500	<500
Dissolved Antimony	-	-	<0.2	<0.2	A	N/A	Y	<0.2	<0.2
Dissolved Arsenic	5	0.1	<0.2	<0.2	A	N/A	Y	<0.2	<0.2
Dissolved Barium	-	-	20	20	D	0	Y	<10	<10
Dissolved Beryllium	-	0.1	<1	<1	A	N/A	Y	<1	<1
Dissolved Boron	29	0.5	300	330	C	9	Y	<20	<20
Dissolved Cadmium (ug/L)	0.0016	5.1	<0.005	0.020	B	0.002	Y	<0.005	<0.005
Dissolved Chromium	-	-	<1	<1	A	N/A	Y	<1	<1
Dissolved Cobalt	-	0.05	<0.3	<0.3	A	N/A	Y	<0.3	<0.3
Dissolved Copper	1.1	0.2	1.4	1.4	C	0.0	Y	<0.2	<0.2
Dissolved Lead	32.2	0.2	<0.2	<0.2	A	N/A	Y	<0.2	<0.2
Dissolved Molybdenum	73	0.01	0.4	0.4	D	0.0	Y	<0.2	<0.2
Dissolved Nickel	23.5	0.2	<0.5	1.2	B	0.0	Y	<0.5	<0.5
Dissolved Selenium	1	0.02	<0.2	0.2	B	0.1	Y	<0.2	<0.2
Dissolved Silver	0.1	-	<0.1	<0.1	A	N/A	Y	<0.1	<0.1
Dissolved Thallium	0.8	-	<0.2	<0.2	A	N/A	Y	<0.2	<0.2
Dissolved Titanium	-	-	<1	<1	A	N/A	Y	<1	<1
Dissolved Uranium	15	0.01	1.0	1.0	D	0.0	Y	<0.1	<0.1
Dissolved Zinc	30	0.1 - 0.5	<3	<3	A	N/A	Y	<3	<3

Notes

All units in mg/L.

1 = CCME (2007) Summary Table, Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life (FWAL) Update 7.0.

2 = CCME (1999) Summary Table, Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses, Irrigation Water.

* = Sample was field filtered.

** = Scenario A is used when both results are ND, Scenario B is used when result A is ND and result B is a positive number, Scenario C is used when Result A and result B are positive and > 5x the MDL , Scenario D is used when result A is positive and < or equal to 5x the MDL and result B is positive.

- = Indicates that there is no applicable regulation or analyses were not performed

1 = Indicates parameter exceeds CCME FWAL guideline.

1 = Indicates parameter exceeds CCME Agr. guideline.

TABLE 4 -
ANALYTICAL RESULTS FOR VOCs IN GROUNDWATER AT
DRUMHELLER INSTITUTION

Sample ID	CCME FWAL[1]	CCME Agr[2]	MW05-01	MW05-01 DUP	Duplicate Evaluation			TRIP BLANK 101213	FIELD BLANK
Date			15/Dec/10	15/Dec/10	Scenario**	Value	Acceptable	15/Dec/10	15/Dec/10
Screen depth (m)			6.0-9.0	6.0-9.0					
Carbon tetrachloride	-	-	<0.5	<0.5	A	N/A	Y	<0.5	<0.5
Chlorobenzene	-	-	<0.5	<0.5	A	N/A	Y	<0.5	<0.5
Chloroform	-	-	<0.5	<0.5	A	N/A	Y	<0.5	<0.5
1,2-dichlorobenzene	-	-	<0.5	<0.5	A	N/A	Y	<0.5	<0.5
1,3-dichlorobenzene	0.15	-	<0.5	<0.5	A	N/A	Y	<0.5	<0.5
1,4-dichlorobenzene	0.026	-	<0.5	<0.5	A	N/A	Y	<0.5	<0.5
1,2-dichloroethane	0.1	-	<0.5	<0.5	A	N/A	Y	<0.5	<0.5
1,1-dichloroethene	-	-	<0.5	<0.5	A	N/A	Y	<0.5	<0.5
Dichloromethane	-	-	<2	<2	A	N/A	Y	<2	<2
Tetrachloroethene	-	-	<0.5	<0.5	A	N/A	Y	<0.5	<0.5
Trichloroethene	-	-	<0.5	<0.5	A	N/A	Y	<0.5	<0.5
Vinyl chloride	-	-	<0.5	<0.5	A	N/A	Y	<0.5	<0.5

Notes

All units in mg/L.

1 = CCME (2007) Summary Table, Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life (FWAL) Update 7.0.

2 = CCME (1999) Summary Table, Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses, Irrigation Water.

** = Scenario A is used when both results are ND, Scenario B is used when result A is ND and result B is a positive number, Scenario C is used when Result A and result B are positive and > 5x the MDL , Scenario D is used when result A is positive and < or equal to 5x the MDL and result B is positive.

- = Indicates that there is no applicable regulation or analyses were not performed

1 = Indicates parameter exceeds guideline.

APPENDIX C

Health and Safety Plan

Drumheller Institution - SITE SAFETY PLAN

SAFETY POLICY STATEMENT

All operations will comply with all applicable Provincial guidelines and other specified safety protocols and/or operating procedure specified by the site owner and/or operator. Operations will be conducted in a safe and professional manner. No site work will be undertaken prior to the safety meeting, which will be conducted on the site prior to commencement of work.

Site Name	Drumheller Institution – Drumheller, Alberta
Site Location	The Drumheller Institution is situated on the southern outskirts of the City of Drumheller and is approximately four kilometres southeast of the downtown area.
Site Description	Two APECs have been identified. APEC 1 is an outside rifle range with a berm and shooting lane. APEC 2 is an inactive landfill located approx 500 m southeast of the Institution that was in operation from the mid 1960s to mid 1980s
Owner/Operator	Correction Services Canada

LOCAL EMERGENCY AND PROJECT TELEPHONE NUMBERS

EMERGENCY NUMBERS	Name	Telephone Number
Hospital	Drumheller Community Health Complex	(403) 823-6500
Ambulance	EMS	911
Police	RCMP	911
Fire		911
UTILITY EMERGENCY NUMBERS		
Alberta One Call	Cable Locations / Clearance	1-800-242-3447
Direct Energy	Emergencies	1-866-420-3174
PROJECT PERSONNEL NUMBERS		
Site Health and Safety Officer	Tryfan Jones	Office: (604) 632-9941 Cell: (778) 668-1227
Project Manager	Stephen Livingstone	Office: (613) 721-0555 Cell: (613) 791-8515 Home (613) 274-0554
Site Contacts	Larry Greene	Office: 403-823-5101 ext 6070
Client Contacts	PWGSC: Joan La Rue-van Es	(204) 984-4510

EMERGENCY ROUTES

See attached route to Health Care Centre

PERSONAL PROTECTIVE EQUIPMENT

Hard hat	❑	Visible vest	☒
Safety boots	☒	Safety glasses	☒
Hip waders	☒	Hearing Protection	❑

SAFETY EQUIPMENT

First aid kit	☒	Fire extinguisher	❑

POTENTIAL CONTAMINANTS OF CONCERN

Metals, PHCs and possible volatile organic compounds

Hazard	Dermal contact and/or inhalation
Mitigation	Wear the appropriate protective equipment and avoid skin contact or inhalation.

SCOPE OF WORK AND HEALTH AND SAFETY RESPONSIBILITY

Scope of Work

1. Complete a daily Tool Box checklist.
2. Collecting soil, sediment, surface water and sediment samples
3. Soils will be collected by hand excavations and no drilling or heavy equipment
4. Site surveying and slope stability assessment
5. Collect all necessary information to complete the National Classification System for Contaminated Sites (NCSCS) for each APEC.
6. Develop a Remedial Action Plan for the rifle range and landfill site as required.

Responsibilities

The Site Health and Safety Officer (SHSO) will implement the Plan. He/She has the authority to stop work or prohibit any personnel from working on the site at any time for not complying with any aspect of the Plan.

The SHSO is directly responsible for implementing the Plan for themselves, the field engineer and survey crew.

Each person on the site has responsibility for their own health and safety, as well as, assisting others in carrying out the Plan. Any person observed to be in violation of the Plan should be assisted in complying with the Plan, or reported to the Site Health and Safety Officer.

Any site personnel may shut down field activities if there is a real or perceived immediate danger to life or health.

SITE HAZARDS AND MITGATION

TYPE OF HAZARD	DESCRIPTION OF HAZARD	MITIGATION	YES	NO
Overhead Hazards	Overhead power lines, not expected	Locate and ensure equipment maintains safe distance from all overhead hazards	❑	☒
Underground Hazards	Water line and underground power lines		❑	☒
Equipment Hazards	No heavy equipment used on site, company trucks or other vehicles will be present		❑	☒
Drilling Hazards	No drilling or heavy equipment excavation		❑	☒
Excavation Hazards	Not expected- shallow test pits by hand		❑	☒
Machinery Hazards	No expected machine hazards		❑	☒
Heat Exposure	Not expected		❑	☒
Cold Exposure	Cold temperatures or raining/snowing	Dress appropriately	☒	❑
Electrical Hazards	Not expected	Conduct utility locates prior to drilling boreholes	❑	☒
Oxygen Deficiency	Not expected		❑	☒
Noise Hazards	No mechanical equipment		❑	☒
Ionizing Radiation	Not expected		❑	☒
Non-Ionizing Radiation	Not expected		❑	☒
Fire/Explosion Hazards	Not expected		❑	☒
Biological Hazards	Nutrients, bacterial, fecal	Wear appropriate PPE, nitrile gloves	☒	❑
Chemical Hazards	Petroleum Hydrocarbons, Metals, possible VOCs	Wear appropriate PPE, nitrile gloves	☒	❑
Water Hazards	Sampling will be completed on creeks and other surface water bodies	Buddy system, only sampling from the shoreline of creeks, no boat operations	☒	❑
Holes/Ditches	Not expected	Walk slowly and steadily	☒	❑
Steep Grades	Possible debris, piping, steep terrain	Walk slowly and steadily	☒	❑
Slippery Surfaces	Snow/wet surfaces	Walk slowly and steadily	☒	❑
Uneven Terrain	Rain and slick surfaces (i.e., mud)	Walk slowly and steadily	☒	❑
Unstable Surfaces	Landfill area may have unstable surfaces but are unknown	Walk slowly and steadily	☒	❑
Elevated Work Surfaces	Not expected		❑	☒
Shoring/Scaffolding	Not expected		❑	☒

Public Risk	Workers moving around site	Watch for CSC personnel entering the work site and warm of dangers.	☒	❑
Vehicular	Moving traffic and excavator	Watch for traffic at all times (site is open-access), wear PPE (high-vis. vest), avoid excavating in high traffic areas	☒	❑
Fire Arms	Correctional Facility personnel may be carrying firearms. Will be sampling adjacent to the Firing Range	Immediately STOP and OBEY any directions given by Correctional Facility personnel. Only approach Firing Range with Correctional Services Supervision and when it is inactive.	☒	❑
Tools and Equipment	Tools (knives, screw drivers, saws, etc.) and Equipment (cell phones, GPS) can be stolen and or utilized by inmates.	Complete daily the tool box checklist and ensure no tools are missing. Report any missing tools to Correctional Facility personnel IMMEDIATELY. Leave all cell phones units locked in the vehicle. Only use GPS once under supervision of Correctional Facility personnel.	☒	❑

POTENTIAL WASTE GENERATION

Waste Generation (Types and Quantities Expected) **Drill cuttings**

TYPE	QUANTITY	TYPE	QUANTITY	TYPE	QUANTITY
N/A	N/A	N/A	N/A	N/A	N/A

Other (describe)

CHARACTERISTICS EXPECTED

Waste Generation (Types and Quantities Expected)

TYPE	QUANTITY	TYPE	QUANTITY
Corrosive	N/A		
Reactive	N/A		
Toxic	N/A		

UNDERGROUND AND OVERHEAD UTILITIES AND INSTALLATIONS

Utility locate undertaken	❑ Yes	☒ No	Information attached	❑ Yes	☒ No
Private locate undertaken	❑ Yes	☒ No	Information attached	❑ Yes	☒ No

SITE SAFETY PLAN REVIEWED BY

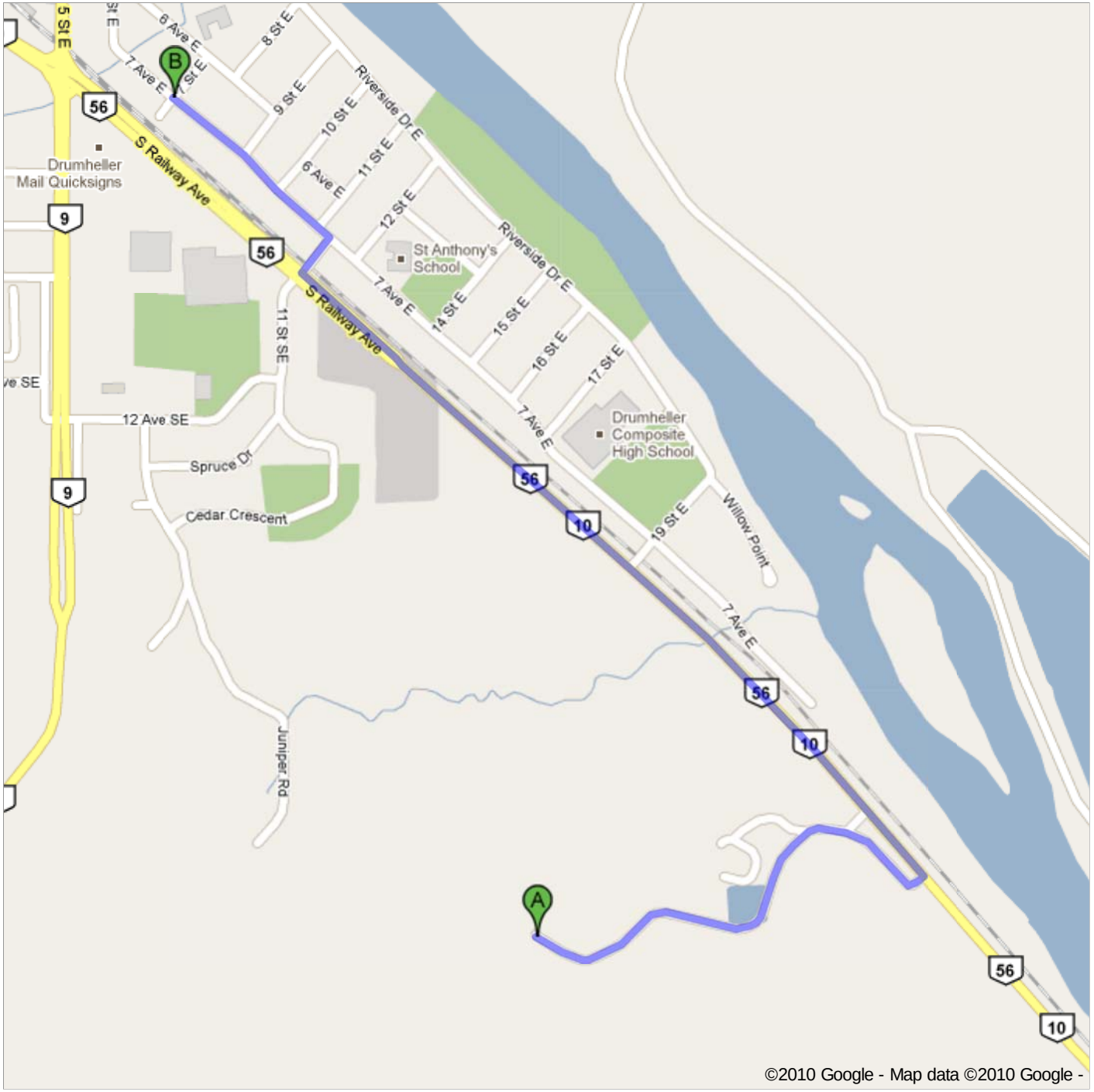
Project Manager	Date
Senior Review	Date

SIGNATURES OF AGREEMENT

By signing below, I have read and understood the safety policy statement and site hazards and mitigation as outlined above

FRANZ Representative	Date
Site Owner/Operator Representative	Date
Contractor	Date
Contractor Representative	Date
Contractor Representative	Date
Contractor Representative	Date

Directions to Drumheller Health Centre
7 Street East, Drumheller, AB T0J 0Y5 - (403) 823-6500
3.1 km – about **5 mins**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Drumheller Composite High School
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15 St E
16 St E
17 St E
19 St E
11 St SE
12 Ave SE
Spruce Dr
Cedar Crescent
Juniper Rd
Willow Point
©2010 Google - Map data ©2010 Google -

Drumheller, AB T0J 0Y7

	1. Head **southeast** toward **AB-10 W/AB-56 N** About 2 mins	go 950 m total 950 m
	2. Turn left at **AB-10 W/AB-56 N** About 2 mins	go 1.7 km total 2.6 km
	3. Take the 2nd right onto **11 St SE**	go 85 m total 2.7 km
	4. Turn left at **7 Ave E** About 1 min	go 400 m total 3.1 km

Drumheller Health Centre
7 Street East, Drumheller, AB T0J 0Y5 - (403) 823-6500

These directions are for planning purposes only. You may find that construction projects, traffic, weather, or other events may cause conditions to differ from the map results, and you should plan your route accordingly. You must obey all signs or notices regarding your route.

Directions weren't right? Please find your route on www.google.ca and click "Report a problem" at the bottom left.

APPENDIX D

Site Photos

FRANZ ENVIRONMENTAL INC.
CONSULTING • ENGINEERING • TECHNOLOGIES

PHOTOGRAPHIC LOG

Environmental Investigation and Slope Stability Study, Drumheller Institution	**Project No: 2026-1001**
Photo ID 1	
Description: Photo taken from the rifle range building, looking down the range in an easterly direction towards the grey rectangle targets.	

Environmental Investigation and Slope Stability Study, Drumheller Institution	**Project No: 2026-1001**
Photo ID 2	
Description: Photo taken from top of berm looking in a westerly direction down the rifle range. Twelve targets visible on firing range, with range building furthest away from photographer.	

Environmental Investigation and Slope Stability Study, Drumheller Institution	Project No: 2026-1001
Photo ID 3	
Description: Photo taken of northern sample transect. Southern transect visible on right. Location of sample points represented by orange flags. Targets visible in foreground. Berm represented by raised earth towards rear fence.	

Environmental Investigation and Slope Stability Study, Drumheller Institution	Project No: 2026-1001
Photo ID 4	
Description: Photo taken of southern sample transect. Northern transect visible on left. Location of sample points represented by orange flags. Targets visible in foreground. Berm represented by raised earth towards top of picture.	

Environmental Investigation and Slope Stability Study, Drumheller Institution	Project No: 2026-1001
Photo ID 5	
Description: Photo taken of southern sample transect along berm. Location of sample points represented by orange flags. Targets visible in foreground. Berm represented by raised earth towards top of picture.	

Environmental Investigation and Slope Stability Study, Drumheller Institution	Project No: 2026-1001
Photo ID 6	 
Description: Photo's taken from top of berm. Left picture: North facing. Right picture: South facing.	

Environmental Investigation and Slope Stability Study, Drumheller Institution	Project No: 2026-1001
Photo ID 7	
Description: Photograph taken from the top of the landfill, looking in a westerly direction. Wind turbine, water tower and watch tower visible from left to right.	

Environmental Investigation and Slope Stability Study, Drumheller Institution	Project No: 2026-1001
Photo ID 8	
Description North westerly facing photograph. Landfill visible as hill in background. Red groundwater stick-up MW-05-3 visible in foreground.	

Environmental Investigation and Slope Stability Study, Drumheller Institution	Project No: 2026-1001
Photo ID 9	
Description: North facing photograph. Coulee visible in background. Red groundwater stick-up MW-05-1 visible in foreground.	

Environmental Investigation and Slope Stability Study, Drumheller Institution	Project No: 2026-1001
Photo ID 10	
Description: Westerly facing photograph. Eroded face of landfill visible in centre. Collapsed landfill material resting on slope.	

Environmental Investigation and Slope Stability Study, Drumheller Institution	Project No: 2026-1001

Photo ID 11

Description: Easterly facing photograph through area of collasped landfill material.

Environmental Investigation and Slope Stability Study, Drumheller Institution	Project No: 2026-1001

Photo ID 12

Description: North facing photo of Erosion channel, formed on north east side of landfill.

APPENDIX E

Laboratory Reports and Chain of Custody Forms

Maxxam

Success Through Science®

Your P.O. #: 2026-1001
Your Project #: DRUMHELLER INSTITUTION
Site: DRUMHELLER, AB
Your C.O.C. #: A037660

Attention: STEVE LIVINGSTONE
FRANZ ENVIRONMENTAL INC.
329 CHURCHILL AVE NORTH
SUITE 2000
OTTAWA, ON
CANADA K1Z5B8

Report Date: 2010/12/24

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B0C2661
Received: 2010/12/17, 9:11

Sample Matrix: Soil
Samples Received: 4

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Boron (Hot Water Soluble)	4	2010/12/22	2010/12/22	AB SOP-00042	EPA 200.7
Hexavalent Chromium	4	2010/12/23	2010/12/23	CAL SOP-00056	SM 3500-Cr B
Elements by ICPMS - Soils	4	2010/12/22	2010/12/22	AB SOP-00043	EPA 200.8
Moisture	4	N/A	2010/12/20	CAL SOP-00023	McKeague MSSMA 2.411

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

PARMINDER VIRK,
Email: PVirk@maxxam.ca
Phone# (403) 291-3077

==========
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total cover pages: 1

Maxxam

Success Through Science®

Maxxam Job #: B0C2661
Report Date: 2010/12/24

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: DRUMHELLER, AB
Your P.O. #: 2026-1001
Sampler Initials: TJ

REGULATED METALS (CCME/AT1) - SOILS

Maxxam ID		Z11422		Z11427		Z11428		Z11429		
Sampling Date		2010/12/14		2010/12/14		2010/12/14		2010/12/14		
	Units	**B3-1 DUP**	**RDL**	**B1-1 DUP**	**RDL**	**B7-2 DUP**	**RDL**	**B6-2 DUP**	**RDL**	**QC Batch**
Elements										
Soluble (Hot water) Boron (B)	mg/kg	0.6	0.1	0.6	0.1	0.6	0.1	0.5	0.1	4526618
Hex. Chromium (Cr 6+)	mg/kg	<0.15	0.15	<0.15	0.15	<0.15	0.15	<0.15	0.15	4527327
Total Antimony (Sb)	mg/kg	22(1)	10	19	1	48(1)	10	6	1	4526218
Total Arsenic (As)	mg/kg	6	1	6	1	17	1	7	1	4526218
Total Barium (Ba)	mg/kg	220	10	210	10	190	10	200	10	4526218
Total Beryllium (Be)	mg/kg	0.8	0.4	0.8	0.4	0.8	0.4	0.7	0.4	4526218
Total Cadmium (Cd)	mg/kg	0.6	0.1	0.6	0.1	0.5	0.1	0.6	0.1	4526218
Total Chromium (Cr)	mg/kg	24	1	23	1	23	1	22	1	4526218
Total Cobalt (Co)	mg/kg	10	1	10	1	9	1	9	1	4526218
Total Copper (Cu)	mg/kg	45	5	42	5	40	5	20	5	4526218
Total Lead (Pb)	mg/kg	1400(1)	10	1100(1)	10	2000(1)	10	260(1)	2	4526218
Total Mercury (Hg)	mg/kg	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	4526218
Total Molybdenum (Mo)	mg/kg	0.7	0.4	0.7	0.4	0.6	0.4	0.8	0.4	4526218
Total Nickel (Ni)	mg/kg	28	1	26	1	23	1	25	1	4526218
Total Selenium (Se)	mg/kg	<0.5	0.5	<0.5	0.5	<0.5	0.5	<0.5	0.5	4526218
Total Silver (Ag)	mg/kg	<1	1	<1	1	<1	1	<1	1	4526218
Total Thallium (Tl)	mg/kg	<0.3	0.3	<0.3	0.3	<0.3	0.3	<0.3	0.3	4526218
Total Tin (Sn)	mg/kg	1	1	1	1	<1	1	<1	1	4526218
Total Uranium (U)	mg/kg	<1	1	<1	1	<1	1	<1	1	4526218
Total Vanadium (V)	mg/kg	43	1	44	1	44	1	39	1	4526218
Total Zinc (Zn)	mg/kg	68	10	65	10	66	10	57	10	4526218

RDL = Reportable Detection Limit
(1) - Detection limits raised due to dilution to bring analyte within the calibrated range.

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Maxxam Job #: B0C2661
Report Date: 2010/12/24

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: DRUMHELLER, AB
Your P.O. #: 2026-1001
Sampler Initials: TJ

RESULTS OF CHEMICAL ANALYSES OF SOIL

Maxxam ID		Z11422	Z11427	Z11428	Z11429		
Sampling Date		2010/12/14	2010/12/14	2010/12/14	2010/12/14		
	Units	**B3-1 DUP**	**B1-1 DUP**	**B7-2 DUP**	**B6-2 DUP**	**RDL**	**QC Batch**
Physical Properties							
Moisture	%	13	13	20	17	0.3	4518154
RDL = Reportable Detection Limit							

Maxxam Job #: B0C2661
Report Date: 2010/12/24

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: DRUMHELLER, AB
Your P.O. #: 2026-1001
Sampler Initials: TJ

Package 1	5.7°C

Each temperature is the average of up to three cooler temperatures taken at receipt

General Comments

Maxxam

Success Through Science®

Maxxam Job #: B0C2661
Report Date: 2010/12/24

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: DRUMHELLER, AB
Your P.O. #: 2026-1001
Sampler Initials: TJ

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
4518154	Moisture	2010/12/20							3.9	20		
4526218	Total Antimony (Sb)	2010/12/22	81	75 - 125	95	75 - 125	<1	mg/kg	NC	35		
4526218	Total Arsenic (As)	2010/12/22	85	75 - 125	91	81 - 103	<1	mg/kg	8.9	35	100	50 - 150
4526218	Total Barium (Ba)	2010/12/22	NC	75 - 125	87	75 - 125	<10	mg/kg	1.2	35	101	69 - 131
4526218	Total Beryllium (Be)	2010/12/22	97	75 - 125	93	75 - 116	<0.4	mg/kg	NC	35		
4526218	Total Cadmium (Cd)	2010/12/22	89	75 - 125	91	75 - 125	<0.1	mg/kg	0.4	35		
4526218	Total Chromium (Cr)	2010/12/22	106	75 - 125	109	75 - 125	<1	mg/kg	2.2	35	94	41 - 159
4526218	Total Cobalt (Co)	2010/12/22	100	75 - 125	104	75 - 125	<1	mg/kg	0.05	35	92	75 - 125
4526218	Total Copper (Cu)	2010/12/22	87	75 - 125	98	75 - 125	<5	mg/kg	NC	35	94	72 - 127
4526218	Total Lead (Pb)	2010/12/22	103	75 - 125	102	85 - 112	<1	mg/kg	0.4	35	94	54 - 146
4526218	Total Mercury (Hg)	2010/12/22	97	75 - 125	105	75 - 125	<0.05	mg/kg	NC	35	86	75 - 125
4526218	Total Molybdenum (Mo)	2010/12/22	99	75 - 125	100	75 - 125	<0.4	mg/kg	NC	35		
4526218	Total Nickel (Ni)	2010/12/22	NC	75 - 125	100	75 - 125	<1	mg/kg	6.2	35	107	61 - 139
4526218	Total Selenium (Se)	2010/12/22	79	75 - 125	86	75 - 125	<0.5	mg/kg	NC	35		
4526218	Total Silver (Ag)	2010/12/22	90	75 - 125	95	75 - 125	<1	mg/kg	NC	35		
4526218	Total Tin (Sn)	2010/12/22	89	75 - 125	90	75 - 125	<1	mg/kg	NC	35		
4526218	Total Uranium (U)	2010/12/22	98	75 - 125	96	75 - 125	<1	mg/kg	NC	35		
4526218	Total Vanadium (V)	2010/12/22	NC	75 - 125	112	75 - 125	<1	mg/kg	3.9	35	102	50 - 150
4526218	Total Zinc (Zn)	2010/12/22	NC	75 - 125	92	75 - 125	<10	mg/kg	4.3	35	94	72 - 128
4526218	Total Thallium (Tl)	2010/12/22			97	75 - 125	<0.3	mg/kg	NC	35		
4526618	Soluble (Hot water) Boron (B)	2010/12/22	114	75 - 125	96	80 - 120	<0.1	mg/kg	8.2	35		
4527327	Hex. Chromium (Cr 6+)	2010/12/23	94	75 - 125	95	90 - 110	<0.15	mg/kg	NC	35		

N/A = Not Applicable
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

Validation Signature Page

Maxxam Job #: B0C2661

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Junzhi Gao

JANET GAO, Senior Analyst, Organics Department

RON VENZI, Scientific Specialist

==========

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Maxxam

Calgary: 4000 19st St. NE, T2E 6P8. Ph: (403) 291-3077, Fax: (403) 735-2240, Toll free: (800) 386-7247
Edmonton: 9331 - 48 Street, T6B 2R4. Ph: (780) 577-7100, Fax: (780) 450-4187, Toll free: (877) 465-8889
www.maxxamanalytics.com

Chain of Custody

A037660

Page: 1 of 1

	Invoice To: C/O Report Address ☒	Report To: Same as Invoice ☒	Report Distribution (E-Mail):	REGULATORY GUIDELINES:
Company:	Franz Environmental Ottawa		slivingstone@franzenvironmental.com	☐ AT1
Contact:	Steve Livingstone		tjones@franzbc.com	☒ CCME
Address:	329 Churchill Ave, North-Suite 200			☐ Regulated Drinking Water
	Prov: Ontario PC: K1Z5B8	Prov: PC:		☒ Other: ALBERTA
Contact #s:	Ph: 613 721 0555 Cell:	Ph: Cell:		

All samples are held for 60 calendar days after sample receipt, unless specified otherwise.

PO #: 2026-1001
Project # / Name: Drumheller Institution
Site Location: Drumheller, AB
Quote #:
Sampled By: TJ

SERVICE REQUESTED: ☐ RUSH (Contact lab to reserve) Date Required: ☒ REGULAR (5 to 7 Days)

See reverse for package specifics

	Sample ID	Depth (unit)	Matrix GW / SW Soil	Date/Time Sampled YY/MM/DD 24:00	SOIL: BTEX F1-F4	Sieve (75 micron)	Regulated Metals (CCME / AT1)	Salinity 4	Assessment ICP Metals	Basic Class II Landfill	WATER: ☐VOCs ☐BTEX F1	☐BTEX F1-F4 ☐BTEX F1-F2	☐ Routine Water ☐ Turb ☐ F	☐ TOC ☐ DOC	Regulated Metals (CCME / AT1) Total	Dissolved	Mercury ☐ Total ☐ Dissolved	Other Analysis	HOLD - Do not Analyze	# of Containers Submitted
1	B3-1 DUP		SOIL	10/12/14			X													1
2	B1-1 DUP		↓	↓			X													1
3	B7-2 DUP		↓	↓			X													1
4	B6-2 DUP		↓	↓			X													1
5																				
6																				
7																				
8																				
9																				
10																				
11																				
12																				

Please indicate Filtered, Preserved or Both (F, P, F/P) → F/P

Relinquished By (Signature/Print):	Date (YY/MM/DD):	Time (24:00):
THWJ	10/12/16	
Relinquished By (Signature/Print):	Date (YY/MM/DD):	Time (24:00):

Special Instructions:

# of Jars Used & Not Submitted

LAB USE ONLY

Received By: RECEIVED DEC 17 2010 Date: Time: Maxxam Job #: CBOC2661

Lab Comments: 0911 Demain

Custody Seal	Temperature	Ice
X	5.6	✓

Maxxam

Success Through Science®

Your P.O. #: 2026-1001
Your Project #: DRUMHELLER INSTITUTION
Site: DRUMHELLER, AB
Your C.O.C. #: A037653

Attention: STEVE LIVINGSTONE
FRANZ ENVIRONMENTAL INC.
329 CHURCHILL AVE NORTH
SUITE 2000
OTTAWA, ON
CANADA K1Z5B8

Report Date: 2010/12/24

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B0C2706
Received: 2010/12/17, 9:11

Sample Matrix: Soil
Samples Received: 4

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Boron (Hot Water Soluble)	4	2010/12/23	2010/12/23	AB SOP-00042	EPA 200.7
Hexavalent Chromium	4	2010/12/23	2010/12/23	CAL SOP-00056	SM 3500-Cr B
Elements by ICPMS - Soils	4	2010/12/22	2010/12/23	AB SOP-00043	EPA 200.8
Moisture	4	N/A	2010/12/21	CAL SOP-00023	McKeague MSSMA 2.411

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

PARMINDER VIRK,
Email: PVirk@maxxam.ca
Phone# (403) 291-3077

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Total cover pages: 1

Maxxam

Success Through Science®

Maxxam Job #: B0C2706
Report Date: 2010/12/24

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: DRUMHELLER, AB
Your P.O. #: 2026-1001
Sampler Initials: TJ

REGULATED METALS (CCME/AT1) - SOILS

Maxxam ID		Z11780	Z11781	Z11782	Z11783		
Sampling Date		2010/12/14	2010/12/14	2010/12/14	2010/12/17		
	Units	**BACKGROUND SOIL 1**	**BACKGROUND SOIL 2**	**BACKGROUND SOIL 3**	**TRIP BLANK 101213**	**RDL**	**QC Batch**
Elements							
Soluble (Hot water) Boron (B)	mg/kg	0.2	0.3	1.0	<0.1	0.1	4528614
Hex. Chromium (Cr 6+)	mg/kg	<0.15	<0.15	<0.15	<0.15	0.15	4527327
Total Antimony (Sb)	mg/kg	<1	<1	<1	<1	1	4526475
Total Arsenic (As)	mg/kg	5	5	5	<1	1	4526475
Total Barium (Ba)	mg/kg	220	250	220	<10	10	4526475
Total Beryllium (Be)	mg/kg	<0.4	0.5	0.6	<0.4	0.4	4526475
Total Cadmium (Cd)	mg/kg	0.5	0.5	0.5	<0.1	0.1	4526475
Total Chromium (Cr)	mg/kg	11	13	19	<1	1	4526475
Total Cobalt (Co)	mg/kg	6	8	8	<1	1	4526475
Total Copper (Cu)	mg/kg	12	13	110	<5	5	4526475
Total Lead (Pb)	mg/kg	7	8	11	<1	1	4526475
Total Mercury (Hg)	mg/kg	<0.05	<0.05	<0.05	<0.05	0.05	4526475
Total Molybdenum (Mo)	mg/kg	0.6	0.6	0.7	<0.4	0.4	4526475
Total Nickel (Ni)	mg/kg	17	20	21	<1	1	4526475
Total Selenium (Se)	mg/kg	<0.5	<0.5	<0.5	<0.5	0.5	4526475
Total Silver (Ag)	mg/kg	<1	<1	<1	<1	1	4526475
Total Thallium (Tl)	mg/kg	<0.3	<0.3	<0.3	<0.3	0.3	4526475
Total Tin (Sn)	mg/kg	<1	<1	<1	<1	1	4526475
Total Uranium (U)	mg/kg	1	<1	1	<1	1	4526475
Total Vanadium (V)	mg/kg	17	22	35	<1	1	4526475
Total Zinc (Zn)	mg/kg	45	47	86	<10	10	4526475
RDL = Reportable Detection Limit							

Maxxam

Success Through Science®

Maxxam Job #: B0C2706
Report Date: 2010/12/24

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: DRUMHELLER, AB
Your P.O. #: 2026-1001
Sampler Initials: TJ

RESULTS OF CHEMICAL ANALYSES OF SOIL

Maxxam ID		Z11780	Z11781	Z11782	Z11783		
Sampling Date		2010/12/14	2010/12/14	2010/12/14	2010/12/17		
	Units	**BACKGROUND SOIL 1**	**BACKGROUND SOIL 2**	**BACKGROUND SOIL 3**	**TRIP BLANK 101213**	**RDL**	**QC Batch**
Physical Properties							
Moisture	%	4.1	3.5	32	<0.3	0.3	4520773
RDL = Reportable Detection Limit							

Maxxam Job #: B0C2706
Report Date: 2010/12/24

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: DRUMHELLER, AB
Your P.O. #: 2026-1001
Sampler Initials: TJ

Package 1	5.7°C

Each temperature is the average of up to three cooler temperatures taken at receipt

General Comments

Maxxam

Success Through Science®

Maxxam Job #: B0C2706
Report Date: 2010/12/24

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: DRUMHELLER, AB
Your P.O. #: 2026-1001
Sampler Initials: TJ

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
4520773	Moisture	2010/12/21							10.8	20		
4526475	Total Antimony (Sb)	2010/12/23	88	75 - 125	96	75 - 125	<1	mg/kg	NC	35		
4526475	Total Arsenic (As)	2010/12/23	89	75 - 125	89	75 - 125	<1	mg/kg	NC	35	97	50 - 150
4526475	Total Barium (Ba)	2010/12/23	NC	75 - 125	85	75 - 125	<10	mg/kg	4.1	35	93	69 - 131
4526475	Total Beryllium (Be)	2010/12/23	111	75 - 125	94	75 - 125	<0.4	mg/kg	NC	35		
4526475	Total Cadmium (Cd)	2010/12/23	94	75 - 125	90	75 - 125	<0.1	mg/kg	0.07	35		
4526475	Total Chromium (Cr)	2010/12/23	NC	75 - 125	109	75 - 125	<1	mg/kg	14.0	35	99	41 - 159
4526475	Total Cobalt (Co)	2010/12/23	105	75 - 125	108	75 - 125	<1	mg/kg	2.1	35	96	75 - 125
4526475	Total Copper (Cu)	2010/12/23	90	75 - 125	94	75 - 125	<5	mg/kg	NC	35	87	72 - 127
4526475	Total Lead (Pb)	2010/12/23	94	75 - 125	99	75 - 125	<1	mg/kg	8.2	35	90	54 - 146
4526475	Total Mercury (Hg)	2010/12/23	97	75 - 125	100	N/A	<0.05	mg/kg	NC	35	83	75 - 125
4526475	Total Molybdenum (Mo)	2010/12/23	101	75 - 125	95	75 - 125	<0.4	mg/kg	NC	35		
4526475	Total Nickel (Ni)	2010/12/23	90	75 - 125	96	75 - 125	<1	mg/kg	10.3	35	98	61 - 139
4526475	Total Selenium (Se)	2010/12/23	84	75 - 125	85	75 - 125	<0.5	mg/kg	NC	35		
4526475	Total Silver (Ag)	2010/12/23	85	75 - 125	76	75 - 125	<1	mg/kg	NC	35		
4526475	Total Thallium (Tl)	2010/12/23	97	75 - 125	99	75 - 125	<0.3	mg/kg	NC	35		
4526475	Total Tin (Sn)	2010/12/23	90	75 - 125	87	75 - 125	<1	mg/kg	NC	35		
4526475	Total Uranium (U)	2010/12/23	102	75 - 125	97	75 - 125	<1	mg/kg	NC	35		
4526475	Total Vanadium (V)	2010/12/23	NC	75 - 125	117	75 - 125	<1	mg/kg	3.6	35	113	50 - 150
4526475	Total Zinc (Zn)	2010/12/23	NC	75 - 125	90	75 - 125	<10	mg/kg	NC	35	91	72 - 128
4527327	Hex. Chromium (Cr 6+)	2010/12/23	94	75 - 125	95	90 - 110	<0.15	mg/kg	NC	35		
4528614	Soluble (Hot water) Boron (B)	2010/12/23	99	75 - 125	87	80 - 120	<0.1	mg/kg	NC	35		

N/A = Not Applicable
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

Validation Signature Page

Maxxam Job #: B0C2706

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Junzhi Gao

JANET GAO, Senior Analyst, Organics Department

RON VENZI, Scientific Specialist

==========

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam

Calgary: 4000 19st St. NE, T2E 6P8. Ph: (403) 291-3077, Fax: (403) 735-2240, Toll free: (800) 386-7247
Edmonton: 9331 - 48 Street, T6B 2R4. Ph: (780) 577-7100, Fax: (780) 450-4187, Toll free: (877) 465-8889
www.maxxamanalytics.com

Chain of Custody

A037653

Page: 1 of 1

	Invoice To: C/O Report Address ☒	Report To: Same as Invoice ☒	Report Distribution (E-Mail):	REGULATORY GUIDELINES:
Company:	Franz Environmental Ottawa		slivingstone@franzenvironmental.com tjones@franzec.com	☐ AT1 ☒ CCME ☐ Regulated Drinking Water ☒ Other: ALBERTA
Contact:	Steve Livingstone			
Address:	324 Churchill Ave, North-Suite 200			
	Prov: Ontario PC: K1Z5B8	Prov: PC:		
Contact #s:	Ph: 613 7210555 Cell:	Ph: Cell:		

All samples are held for 60 calendar days after sample receipt, unless specified otherwise.

PO #: 2026-1001
Project # / Name: Drumheller Institution
Site Location: Drumheller, AB
Quote #:
Sampled By: TJ

SERVICE REQUESTED: ☐ RUSH (Contact lab to reserve) Date Required: ☒ REGULAR (5 to 7 Days)

See reverse for package specifics

	Sample ID	Depth (unit)	Matrix GW / SW Soil	Date/Time Sampled YY/MM/DD 24:00	SOIL: BTEX F1-F4	Sieve (75 micron)	Regulated Metals (CCME / AT1)	Salinity 4	Assessment ICP Metals	Basic Class II Landfill	WATER: ☐VOCs ☐BTEX F1 ☐BTEX F1-F2 ☐BTEX F1-F4 ☐ Routine Water ☐ Turb ☐ F ☐ TOC ☐ DOC	Regulated Metals (CCME / AT1) Total	Dissolved	Mercury ☐ Total ☐ Dissolved	Other Analysis	HOLD - Do not Analyze	# of Containers Submitted
1	Background Soil 1		Soil	10/12/14			X										1
2	Background Soil 2		↓	↓			X										1
3	Background Soil 3		↓	↓			X										1
4	Trip blank 101213						X										3
5																	
6																	
7																	
8																	
9																	
10																	
11																	
12																	

Please indicate Filtered, Preserved or Both (F, P, F/P) → F/P

Relinquished By (Signature/Print):	Date (YY/MM/DD):	Time (24:00):
TJ	10/12/16	
Relinquished By (Signature/Print):	Date (YY/MM/DD):	Time (24:00):

Special Instructions:

# of Jars Used & Not Submitted

LAB USE ONLY

Received By: RECEIVED DEC 17 2010 Date: Time: Maxxam Job #: CBOC2706

Lab Comments: 0911 Kamani

Custody Seal	Temperature	Ice
X	5.6	✓

Maxxam

Success Through Science®

Your P.O. #: 2026-1001
Your Project #: DRUMHELLER INSTITUTION
Site: DRUMHELLER, AB
Your C.O.C. #: A037662

Attention: STEVE LIVINGSTONE
FRANZ ENVIRONMENTAL INC.
329 CHURCHILL AVE NORTH
SUITE 2000
OTTAWA, ON
CANADA K1Z5B8

Report Date: 2010/12/24

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B0C2712
Received: 2010/12/17, 9:11

Sample Matrix: Leachate
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
BTEX in Leachates by HS GC/MS	1	2010/12/21	2010/12/22	CAL SOP-00190	EPA 1311/8260C
ICPMS Metals on TCLP Leachate	1	2010/12/22	2010/12/23	AB SOP-00043	EPA 200.8

Sample Matrix: Soil
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Flash Point	1	N/A	2010/12/20	CAL SOP-00175	ASTM D93-07, 3828-05
Free Liquid (Paint filter)	1	N/A	2010/12/20	AB SOP-00047	EPA SW846/9095B
pH (1:1 extract, solid waste)	1	2010/12/22	2010/12/22	AB SOP-00006	SSMA 16.3

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

PARMINDER VIRK,
Email: PVirk@maxxam.ca
Phone# (403) 291-3077

==========
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total cover pages: 1

Maxxam

Success Through Science®

Maxxam Job #: B0C2712
Report Date: 2010/12/24

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: DRUMHELLER, AB
Your P.O. #: 2026-1001
Sampler Initials: TJ

BASIC CLASS II LANDFILL PACKAGE (LEACHATE)

Maxxam ID		Z11831		
Sampling Date		2010/12/14		
	Units	**COMPOSITE LEACHATE TEST**	**RDL**	**QC Batch**
Elements				
Leachable Antimony (Sb)	mg/L	1	1	4527301
Leachable Arsenic (As)	mg/L	0.9	0.5	4527301
Leachable Barium (Ba)	mg/L	1	1	4527301
Leachable Beryllium (Be)	mg/L	<0.5	0.5	4527301
Leachable Boron (B)	mg/L	<1	1	4527301
Leachable Cadmium (Cd)	mg/L	<0.1	0.1	4527301
Leachable Chromium (Cr)	mg/L	<0.5	0.5	4527301
Leachable Cobalt (Co)	mg/L	<1	1	4527301
Leachable Copper (Cu)	mg/L	<1	1	4527301
Leachable Iron (Fe)	mg/L	<1	1	4527301
Leachable Lead (Pb)	mg/L	270(1)	30	4527301
Leachable Mercury (Hg)	mg/L	<0.02	0.02	4527301
Leachable Nickel (Ni)	mg/L	<0.5	0.5	4527301
Leachable Selenium (Se)	mg/L	<0.1	0.1	4527301
Leachable Silver (Ag)	mg/L	<0.5	0.5	4527301
Leachable Thallium (Tl)	mg/L	<0.5	0.5	4527301
Leachable Uranium (U)	mg/L	<0.2	0.2	4527301
Leachable Vanadium (V)	mg/L	<1	1	4527301
Leachable Zinc (Zn)	mg/L	<1	1	4527301
Leachable Zirconium (Zr)	mg/L	<1	1	4527301
Volatiles				
Leachable (ZH) Benzene	ug/L	<10	10	4521822
Leachable (ZH) Toluene	ug/L	<10	10	4521822
Leachable (ZH) Ethylbenzene	ug/L	<10	10	4521822
Leachable (ZH) o-Xylene	ug/L	<10	10	4521822
Leachable (ZH) m & p-Xylene	ug/L	<20	20	4521822
Leachable (ZH) Xylenes (Total)	ug/L	<20	20	4521822
Surrogate Recovery (%)				
Leachable (ZH) 4-BROMOFLUOROBENZENE (sur.)	%	82	N/A	4521822
Leachable (ZH) D4-1,2-DICHLOROETHANE (sur.)	%	109	N/A	4521822
Leachable (ZH) D8-TOLUENE (sur.)	%	101	N/A	4521822

N/A = Not Applicable
RDL = Reportable Detection Limit
(1) - Detection limits raised due to dilution to bring analyte within the calibrated range.

Maxxam

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Maxxam Job #: B0C2712
Report Date: 2010/12/24

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: DRUMHELLER, AB
Your P.O. #: 2026-1001
Sampler Initials: TJ

BASIC CLASS II LANDFILL PACKAGE (SOIL)

Maxxam ID		Z11831		
Sampling Date		2010/12/14		
	Units	**COMPOSITE LEACHATE TEST**	**RDL**	**QC Batch**
Soluble Parameters				
Soluble (1:1) pH	N/A	7.14	N/A	4523572
Physical Properties				
Closed Cup Flash point	deg. C	>61	N/A	4518330
Free Liquid	N/A	PASS	N/A	4518331

N/A = Not Applicable
RDL = Reportable Detection Limit

Maxxam Job #: B0C2712
Report Date: 2010/12/24

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: DRUMHELLER, AB
Your P.O. #: 2026-1001
Sampler Initials: TJ

Package 1	5.7°C

Each temperature is the average of up to three cooler temperatures taken at receipt

General Comments

Maxxam

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Maxxam Job #: B0C2712
Report Date: 2010/12/24

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: DRUMHELLER, AB
Your P.O. #: 2026-1001
Sampler Initials: TJ

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
4518330	Closed Cup Flash point	2010/12/20							NC	35		
4521822	Leachable (ZH) 4-BROMOFLUOROBENZENE (sur.)	2010/12/22			107	60 - 140	85	%				
4521822	Leachable (ZH) D4-1,2-DICHLOROETHANE (sur.)	2010/12/22			106	60 - 140	105	%				
4521822	Leachable (ZH) D8-TOLUENE (sur.)	2010/12/22			98	60 - 140	100	%				
4521822	Leachable (ZH) Benzene	2010/12/22			78	70 - 130	<10	ug/L	NC	50		
4521822	Leachable (ZH) Toluene	2010/12/22			77	70 - 130	<10	ug/L	NC	50		
4521822	Leachable (ZH) Ethylbenzene	2010/12/22			80	70 - 130	<10	ug/L	NC	50		
4521822	Leachable (ZH) o-Xylene	2010/12/22			81	70 - 130	<10	ug/L	NC	50		
4521822	Leachable (ZH) m & p-Xylene	2010/12/22			82	70 - 130	<20	ug/L	NC	50		
4521822	Leachable (ZH) Xylenes (Total)	2010/12/22					<20	ug/L	NC	50		
4523572	Soluble (1:1) pH	2010/12/22			100	97 - 102			0.9	5	101	91 - 109
4527301	Leachable Antimony (Sb)	2010/12/23	109	75 - 125	95	80 - 120	<1	mg/L	NC	35		
4527301	Leachable Arsenic (As)	2010/12/23	102	75 - 125	90	83 - 104	<0.5	mg/L	NC	35		
4527301	Leachable Barium (Ba)	2010/12/23	95	75 - 125	90	80 - 119	<1	mg/L	NC	35		
4527301	Leachable Beryllium (Be)	2010/12/23	101	75 - 125	88	80 - 120	<0.5	mg/L	NC	35		
4527301	Leachable Boron (B)	2010/12/23	101	75 - 125	85	80 - 120	<1	mg/L	NC	35		
4527301	Leachable Cadmium (Cd)	2010/12/23	102	75 - 125	96	80 - 114	<0.1	mg/L	NC	35		
4527301	Leachable Chromium (Cr)	2010/12/23	104	75 - 125	92	80 - 115	<0.5	mg/L	NC	35		
4527301	Leachable Cobalt (Co)	2010/12/23	102	75 - 125	93	80 - 120	<1	mg/L	NC	35		
4527301	Leachable Copper (Cu)	2010/12/23	96	75 - 125	92	80 - 116	<1	mg/L	NC	35		
4527301	Leachable Iron (Fe)	2010/12/23	NC	75 - 125	92	80 - 120	<1	mg/L	NC	35		
4527301	Leachable Lead (Pb)	2010/12/23	95	75 - 125	95	80 - 116	<0.5	mg/L	NC	35		
4527301	Leachable Mercury (Hg)	2010/12/23	93	75 - 125	92	80 - 120	<0.02	mg/L	NC	35		
4527301	Leachable Nickel (Ni)	2010/12/23	98	75 - 125	92	80 - 116	<0.5	mg/L	NC	35		
4527301	Leachable Selenium (Se)	2010/12/23	102	75 - 125	94	80 - 117	<0.1	mg/L	NC	35		
4527301	Leachable Silver (Ag)	2010/12/23	91	75 - 125	94	80 - 119	<0.5	mg/L	NC	35		
4527301	Leachable Thallium (Tl)	2010/12/23	99	75 - 125	97	80 - 116	<0.5	mg/L	NC	35		
4527301	Leachable Uranium (U)	2010/12/23	105	75 - 125	96	80 - 120	<0.2	mg/L	NC	35		
4527301	Leachable Vanadium (V)	2010/12/23	112	75 - 125	95	80 - 120	<1	mg/L	NC	35		

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Maxxam Job #: B0C2712
Report Date: 2010/12/24

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: DRUMHELLER, AB
Your P.O. #: 2026-1001
Sampler Initials: TJ

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
4527301	Leachable Zinc (Zn)	2010/12/23	94	75 - 125	99	80 - 120	<1	mg/L	NC	35		
4527301	Leachable Zirconium (Zr)	2010/12/23	115	75 - 125	86	80 - 120	<1	mg/L	NC	35		

N/A = Not Applicable
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

Validation Signature Page

Maxxam Job #: B0C2712

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

JENNIFER LO, Senior Analyst, Organics Department

RON VENZI, Scientific Specialist

==========

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www.maxxamanalytics.com

Chain of Custody

A037662

Page: 1 of 1

	Invoice To: C/O Report Address ☒	Report To: Same as Invoice ☒	Report Distribution (E-Mail):	REGULATORY GUIDELINES:
Company:	Franz Environmental Ottawa		slivingstone@franzenvironmental.com tjones@franzbc.com	☐ AT1 ☒ CCME ☐ Regulated Drinking Water ☒ Other: ALBERTA
Contact:	Steve Livingstone			
Address:	329 Churchill Ave, North. Suite 200			
	Prov: Ontario PC: K1Z5B8	Prov: PC:		
Contact #s:	613 Ph: 721-0555 Cell:	Ph: Cell:		

All samples are held for 60 calendar days after sample receipt, unless specified otherwise.

PO #: 2026-1001
Project # / Name: Drumheller Institution
Site Location: Drumheller, AB
Quote #:
Sampled By: TJ

SERVICE REQUESTED: ☐ RUSH (Contact lab to reserve) Date Required: ☒ REGULAR (5 to 7 Days)

See reverse for package specifics

	Sample ID	Depth (unit)	Matrix GW / SW Soil	Date/Time Sampled YY/MM/DD 24:00	SOIL: BTEX F1-F4	Sieve (75 micron)	Regulated Metals (CCME / AT1)	Salinity 4	Assessment ICP Metals	Basic Class II Landfill	WATER: ☐ BTEX F1 ☐ VOCs	☐ BTEX F1-F2 ☐ BTEX F1-F4	☐ Routine Water ☐ Turb ☐ F	☐ TOC ☐ DOC	Regulated Metals (CCME / AT1) Total	Dissolved	Mercury ☐ Total ☐ Dissolved	Other Analysis	HOLD - Do not Analyze	# of Containers Submitted
1	Composite lechate test		Soil	10/12/14						X										4
2																				
3																				
4																				
5																				
6																				
7																				
8																				
9																				
10																				
11																				
12																				

Please indicate Filtered, Preserved or Both (F, P, F/P) → F/P

Relinquished By (Signature/Print): TJ / TJ	Date (YY/MM/DD): 10/12/16	Time (24:00):	
Relinquished By (Signature/Print):	Date (YY/MM/DD):	Time (24:00):	
Special Instructions: composite lechate test ; landfill package and [illegible] BTEX		# of Jars Used & Not Submitted	

LAB USE ONLY

Received By: RECEIVED DEC 17 2010	Date:	Time:	Maxxam Job #: C8OC2712
Lab Comments: 0911 [illegible]	Custody Seal: X	Temperature: 5,6,6	Ice: ✓

Maxxam

Success Through Science®

Your P.O. #: 2026-1001
Your Project #: DRUMHELLER INSTITUTION
Site: DRUMHELLER, AB
Your C.O.C. #: A037654

Attention: STEVE LIVINGSTONE
FRANZ ENVIRONMENTAL INC.
329 CHURCHILL AVE NORTH
SUITE 2000
OTTAWA, ON
CANADA K1Z5B8

Report Date: 2010/12/24

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B0C2719
Received: 2010/12/17, 9:11

Sample Matrix: Soil
Samples Received: 11

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Boron (Hot Water Soluble)	11	2010/12/22	2010/12/22	AB SOP-00042	EPA 200.7
Hexavalent Chromium	11	2010/12/23	2010/12/23	CAL SOP-00056	SM 3500-Cr B
Elements by ICPMS - Soils	11	2010/12/22	2010/12/23	AB SOP-00043	EPA 200.8
Moisture	11	N/A	2010/12/21	CAL SOP-00023	McKeague MSSMA 2.411

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

PARMINDER VIRK,
Email: PVirk@maxxam.ca
Phone# (403) 291-3077

==========
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Total cover pages: 1

Maxxam

Success Through Science®

Maxxam Job #: B0C2719
Report Date: 2010/12/24

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: DRUMHELLER, AB
Your P.O. #: 2026-1001
Sampler Initials: TJ

REGULATED METALS (CCME/AT1) - SOILS

Maxxam ID		Z11887		Z11899		Z11900		Z11901		Z11905	Z11906		
Sampling Date		2010/12/14		2010/12/14		2010/12/14		2010/12/14		2010/12/14	2010/12/14		
	Units	**B1-1 @ 0-5CM**	**RDL**	**B1-2 @ 20-30CM**	**RDL**	**B2-1 @ 0-5CM**	**RDL**	**B2-2 @ 20-30CM**	**RDL**	**B3-1 @ 0-5CM**	**B4-1 @ 0-5CM**	**RDL**	**QC Batch**
Elements													
Soluble (Hot water) Boron (B)	mg/kg	1.1(1)	0.2	0.5	0.1	0.6	0.1	0.5	0.1	0.5	0.5	0.1	4526618
Hex. Chromium (Cr 6+)	mg/kg	<0.15	0.15	<0.15	0.15	<0.15	0.15	<0.15	0.15	<0.15	<0.15	0.15	4527344
Total Antimony (Sb)	mg/kg	22	1	19	1	43(2)	2	<40(2)	40	32(2)	27(2)	10	4526475
Total Arsenic (As)	mg/kg	7	1	6	1	7	1	8	1	6	6	1	4526475
Total Barium (Ba)	mg/kg	180	10	200	10	200	10	210	10	180	180	10	4526475
Total Beryllium (Be)	mg/kg	0.6	0.4	0.9	0.4	0.8	0.4	0.9	0.4	0.8	0.8	0.4	4526475
Total Cadmium (Cd)	mg/kg	0.5	0.1	0.6	0.1	0.6	0.1	0.7	0.1	0.5	0.5	0.1	4526475
Total Chromium (Cr)	mg/kg	18	1	25	1	23	1	23	1	22	23	1	4526475
Total Cobalt (Co)	mg/kg	8	1	10	1	10	1	10	1	9	9	1	4526475
Total Copper (Cu)	mg/kg	49	5	32	5	120	5	57	5	57	30	5	4526475
Total Lead (Pb)	mg/kg	2100(2)	20	690(2)	4	4700(2)	40	9400(2)	40	1800(2)	1700(2)	10	4526475
Total Mercury (Hg)	mg/kg	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	<0.05	0.05	4526475
Total Molybdenum (Mo)	mg/kg	0.8	0.4	0.7	0.4	0.7	0.4	0.7	0.4	0.6	0.6	0.4	4526475
Total Nickel (Ni)	mg/kg	21	1	27	1	27	1	28	1	24	23	1	4526475
Total Selenium (Se)	mg/kg	<0.5	0.5	<0.5	0.5	<0.5	0.5	<0.5	0.5	<0.5	<0.5	0.5	4526475
Total Silver (Ag)	mg/kg	<1	1	<1	1	<1	1	<1	1	<1	<1	1	4526475
Total Thallium (Tl)	mg/kg	<0.3	0.3	<0.3	0.3	<0.3	0.3	<0.3	0.3	<0.3	<0.3	0.3	4526475
Total Tin (Sn)	mg/kg	2	1	<1	1	6	1	9	1	2	<1	1	4526475
Total Uranium (U)	mg/kg	<1	1	<1	1	1	1	1	1	<1	<1	1	4526475
Total Vanadium (V)	mg/kg	32	1	48	1	33	1	33	1	42	45	1	4526475
Total Zinc (Zn)	mg/kg	62	10	60	10	70	10	68	10	59	56	10	4526475

RDL = Reportable Detection Limit
(1) - Detection limits raised due to insufficient sample volume.
(2) - Detection limits raised due to dilution to bring analyte within the calibrated range.

Maxxam

Success Through Science®

Maxxam Job #: B0C2719
Report Date: 2010/12/24

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: DRUMHELLER, AB
Your P.O. #: 2026-1001
Sampler Initials: TJ

REGULATED METALS (CCME/AT1) - SOILS

Maxxam ID		Z11907		Z11908		Z11909		Z11910		Z11911		
Sampling Date		2010/12/14		2010/12/14		2010/12/14		2010/12/14		2010/12/14		
	Units	**B4-2 @ 20-30CM**	**RDL**	**B5-1 @ 0-5CM**	**RDL**	**B5-2 @ 20-30CM**	**RDL**	**B6-1 @ 0-5CM**	**RDL**	**B6-2 @ 20-30CM**	**RDL**	**QC Batch**
Elements												
Soluble (Hot water) Boron (B)	mg/kg	0.3	0.1	0.8	0.1	0.6	0.1	0.7	0.1	0.5	0.1	4526618
Hex. Chromium (Cr 6+)	mg/kg	<0.15	0.15	<0.15	0.15	<0.15	0.15	<0.15	0.15	<0.15	0.15	4527344
Total Antimony (Sb)	mg/kg	4	1	210(1)	20	28(1)	2	26(1)	10	<1	1	4526475
Total Arsenic (As)	mg/kg	6	1	9	1	11	1	9	1	5	1	4526475
Total Barium (Ba)	mg/kg	240	10	200	10	170	10	200	10	220	10	4526475
Total Beryllium (Be)	mg/kg	0.9	0.4	0.9	0.4	0.7	0.4	0.8	0.4	0.7	0.4	4526475
Total Cadmium (Cd)	mg/kg	0.6	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.7	0.1	4526475
Total Chromium (Cr)	mg/kg	22	1	23	1	19	1	22	1	19	1	4526475
Total Cobalt (Co)	mg/kg	10	1	10	1	8	1	9	1	10	1	4526475
Total Copper (Cu)	mg/kg	26	5	200	5	30	5	34	5	19	5	4526475
Total Lead (Pb)	mg/kg	360(1)	2	16000(1)	100	740(1)	4	1600(1)	10	52	1	4526475
Total Mercury (Hg)	mg/kg	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	4526475
Total Molybdenum (Mo)	mg/kg	0.6	0.4	0.8	0.4	0.8	0.4	0.8	0.4	0.6	0.4	4526475
Total Nickel (Ni)	mg/kg	25	1	25	1	22	1	25	1	26	1	4526475
Total Selenium (Se)	mg/kg	<0.5	0.5	<0.5	0.5	<0.5	0.5	<0.5	0.5	<0.5	0.5	4526475
Total Silver (Ag)	mg/kg	<1	1	<1	1	<1	1	<1	1	<1	1	4526475
Total Thallium (Tl)	mg/kg	<0.3	0.3	<0.3	0.3	<0.3	0.3	<0.3	0.3	<0.3	0.3	4526475
Total Tin (Sn)	mg/kg	<1	1	11	1	<1	1	2	1	<1	1	4526475
Total Uranium (U)	mg/kg	<1	1	<1	1	<1	1	1	1	1	1	4526475
Total Vanadium (V)	mg/kg	37	1	45	1	35	1	38	1	27	1	4526475
Total Zinc (Zn)	mg/kg	55	10	73	10	50	10	76	10	58	10	4526475

RDL = Reportable Detection Limit
(1) - Detection limits raised due to dilution to bring analyte within the calibrated range.

Maxxam

Success Through Science®

Maxxam Job #: B0C2719
Report Date: 2010/12/24

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: DRUMHELLER, AB
Your P.O. #: 2026-1001
Sampler Initials: TJ

RESULTS OF CHEMICAL ANALYSES OF SOIL

Maxxam ID		Z11887	Z11899	Z11900	Z11901	Z11905		
Sampling Date		2010/12/14	2010/12/14	2010/12/14	2010/12/14	2010/12/14		
	Units	**B1-1 @ 0-5CM**	**B1-2 @ 20-30CM**	**B2-1 @ 0-5CM**	**B2-2 @ 20-30CM**	**B3-1 @ 0-5CM**	**RDL**	**QC Batch**
Physical Properties								
Moisture	%	28	17	29	19	11	0.3	4522121
RDL = Reportable Detection Limit								

Maxxam ID		Z11906	Z11907	Z11908	Z11909	Z11910	Z11911		
Sampling Date		2010/12/14	2010/12/14	2010/12/14	2010/12/14	2010/12/14	2010/12/14		
	Units	**B4-1 @ 0-5CM**	**B4-2 @ 20-30CM**	**B5-1 @ 0-5CM**	**B5-2 @ 20-30CM**	**B6-1 @ 0-5CM**	**B6-2 @ 20-30CM**	**RDL**	**QC Batch**
Physical Properties									
Moisture	%	13	16	13	14	25	21	0.3	4522121
RDL = Reportable Detection Limit									

Maxxam Job #: B0C2719
Report Date: 2010/12/24

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: DRUMHELLER, AB
Your P.O. #: 2026-1001
Sampler Initials: TJ

Package 1	5.7°C

Each temperature is the average of up to three cooler temperatures taken at receipt

General Comments

Maxxam

Success Through Science®

Maxxam Job #: B0C2719
Report Date: 2010/12/24

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: DRUMHELLER, AB
Your P.O. #: 2026-1001
Sampler Initials: TJ

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
4522121	Moisture	2010/12/21							12.1	20		
4526475	Total Antimony (Sb)	2010/12/23	88	75 - 125	96	75 - 125	<1	mg/kg	NC	35		
4526475	Total Arsenic (As)	2010/12/23	89	75 - 125	89	75 - 125	<1	mg/kg	NC	35	97	50 - 150
4526475	Total Barium (Ba)	2010/12/23	NC	75 - 125	85	75 - 125	<10	mg/kg	4.1	35	93	69 - 131
4526475	Total Beryllium (Be)	2010/12/23	111	75 - 125	94	75 - 125	<0.4	mg/kg	NC	35		
4526475	Total Cadmium (Cd)	2010/12/23	94	75 - 125	90	75 - 125	<0.1	mg/kg	0.07	35		
4526475	Total Chromium (Cr)	2010/12/23	NC	75 - 125	109	75 - 125	<1	mg/kg	14.0	35	99	41 - 159
4526475	Total Cobalt (Co)	2010/12/23	105	75 - 125	108	75 - 125	<1	mg/kg	2.1	35	96	75 - 125
4526475	Total Copper (Cu)	2010/12/23	90	75 - 125	94	75 - 125	<5	mg/kg	NC	35	87	72 - 127
4526475	Total Lead (Pb)	2010/12/23	94	75 - 125	99	75 - 125	<1	mg/kg	8.2	35	90	54 - 146
4526475	Total Mercury (Hg)	2010/12/23	97	75 - 125	100	N/A	<0.05	mg/kg	NC	35	83	75 - 125
4526475	Total Molybdenum (Mo)	2010/12/23	101	75 - 125	95	75 - 125	<0.4	mg/kg	NC	35		
4526475	Total Nickel (Ni)	2010/12/23	90	75 - 125	96	75 - 125	<1	mg/kg	10.3	35	98	61 - 139
4526475	Total Selenium (Se)	2010/12/23	84	75 - 125	85	75 - 125	<0.5	mg/kg	NC	35		
4526475	Total Silver (Ag)	2010/12/23	85	75 - 125	76	75 - 125	<1	mg/kg	NC	35		
4526475	Total Thallium (Tl)	2010/12/23	97	75 - 125	99	75 - 125	<0.3	mg/kg	NC	35		
4526475	Total Tin (Sn)	2010/12/23	90	75 - 125	87	75 - 125	<1	mg/kg	NC	35		
4526475	Total Uranium (U)	2010/12/23	102	75 - 125	97	75 - 125	<1	mg/kg	NC	35		
4526475	Total Vanadium (V)	2010/12/23	NC	75 - 125	117	75 - 125	<1	mg/kg	3.6	35	113	50 - 150
4526475	Total Zinc (Zn)	2010/12/23	NC	75 - 125	90	75 - 125	<10	mg/kg	NC	35	91	72 - 128
4526618	Soluble (Hot water) Boron (B)	2010/12/22	114	75 - 125	96	80 - 120	<0.1	mg/kg	8.2	35		
4527344	Hex. Chromium (Cr 6+)	2010/12/23	85	75 - 125	94	90 - 110	<0.15	mg/kg	NC	35		

N/A = Not Applicable
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

Validation Signature Page

Maxxam Job #: B0C2719

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Junzhi Gao

JANET GAO, Senior Analyst, Organics Department

RON VENZI, Scientific Specialist

==========

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam

Calgary: 4000 19st St. NE, T2E 6P8. Ph: (403) 291-3077, Fax: (403) 735-2240, Toll free: (800) 386-7247
Edmonton: 9331 - 48 Street, T6B 2R4. Ph: (780) 577-7100, Fax: (780) 450-4187, Toll free: (877) 465-8889
www.maxxamanalytics.com

Chain of Custody

A037654

Page: 1 of 1

	Invoice To: C/O Report Address ☒	Report To: Same as Invoice ☒	Report Distribution (E-Mail):
Company:	Franz Environmental Ottawa		slivingstone@franzenvironmental.com
Contact:	Steve Livingstone		tjones@franzlt.com
Address:	329 Churchill Ave, North-Suite 200		
	Prov: Ontario PC: K2S 0B8	Prov: PC:	
Contact #s:	Ph: 613 721 0555 Cell:	Ph: Cell:	

REGULATORY GUIDELINES:
- ☐ AT1
- ☒ CCME
- ☐ Regulated Drinking Water
- ☒ Other: ALBERTA

All samples are held for 60 calendar days after sample receipt, unless specified otherwise.

PO #:	2026-1001
Project # / Name:	Drumheller Institute
Site Location:	Drumheller, AB
Quote #:	
Sampled By:	TJ

SERVICE REQUESTED: ☐ RUSH (Contact lab to reserve) Date Required: ☒ REGULAR (5 to 7 Days)

See reverse for package specifics

	Sample ID	Depth (unit)	Matrix GW / SW Soil	Date/Time Sampled YY/MM/DD 24:00	SOIL: BTEX F1-F4	Sieve (75 micron)	Regulated Metals (CCME / AT1)	Salinity 4	Assessment ICP Metals	Basic Class II Landfill	WATER: ☐BTEX F1 ☐VOCs	☐BTEX F1-F2 ☐BTEX F1-F4	☐ Routine Water ☐ Turb ☐ F	☐ TOC ☐ DOC	Regulated Metals (CCME / AT1) Total	Dissolved	Mercury	☐ Total ☐ Dissolved	HOLD - Do not Analyze	# of Containers Submitted
1	B1-1	0-5cm	Soil	10/12/14			X													1
2	B1-2	20-30cm					X													1
3	B2-1	0-5cm					X													1
4	B2-2	20-30cm					X													1
5	B3-1	0-5cm					X													1
6	B4-1	0-5cm					X													1
7	B4-2	20-30cm					X													1
8	B5-1	0-5cm					X													1
9	B5-2	20-30cm					X													1
10	B6-1	0-5cm					X													1
11	B6-2	20-30cm					X													1
12																				

Other Analysis

Please indicate Filtered, Preserved or Both (F, P, F/P) → F/P

Relinquished By (Signature/Print): [signature] / THWS	Date (YY/MM/DD): 10/12/16	Time (24:00):
Relinquished By (Signature/Print):	Date (YY/MM/DD):	Time (24:00):
Special Instructions: Samples taken from barn		# of Jars Used & Not Submitted

LAB USE ONLY

Received By: RECEIVED DEC 17 2010	Date:	Time:	Maxxam Job #: C606279
Lab Comments: 0911 [signature]			Custody Seal: X; Temperature: 5,6,6; Ice: ✓

Maxxam

Success Through Science®

Your P.O. #: 2026-1001
Your Project #: DRUMHELLER INSTITUTION
Site: ALBERTA
Your C.O.C. #: A037659

Attention: STEVE LIVINGSTONE
FRANZ ENVIRONMENTAL INC.
329 CHURCHILL AVE NORTH
SUITE 2000
OTTAWA, ON
CANADA K1Z5B8

Report Date: 2010/12/23

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B0C2880
Received: 2010/12/17, 9:11

Sample Matrix: Water
Samples Received: 6

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity (pp, total), CO3,HCO3,OH	4	N/A	2010/12/20	AB SOP-00005	SM 2320-B
Cadmium - low level CCME - Dissolved	4	N/A	2010/12/23	AB SOP-00043	EPA 200.8
Chloride by Automated Colourimetry	3	N/A	2010/12/20	AB SOP-00020	EPA 325.2
Chloride by Automated Colourimetry	1	N/A	2010/12/22	AB SOP-00020	EPA 325.2
Conductivity	3	N/A	2010/12/20	AB SOP-00005	SM 2510-B
Conductivity	1	N/A	2010/12/22	AB SOP-00005	SM 2510-B
Hardness	4	N/A	2010/12/20	CAL WI-00053	AEMM, Method 423
Elements by ICP - Dissolved	2	N/A	2010/12/19	AB SOP-00042	EPA 200.7
Elements by ICP - Dissolved	1	N/A	2010/12/22	AB SOP-00042	EPA 200.7
Elements by ICP - Dissolved	1	N/A	2010/12/23	AB SOP-00042	EPA 200.7
Elements by ICPMS - Dissolved	4	N/A	2010/12/22	AB SOP-00043	EPA 200.8
Ion Balance	4	N/A	2010/12/20	CAL WI-00053	SM 1030E
Sum of cations, anions	4	N/A	2010/12/20	CAL WI-00053	SM 1030E
Nitrate and Nitrite	4	N/A	2010/12/21		CAL SOP-00060
Nitrate + Nitrite-N (calculated)	4	N/A	2010/12/21	AB SOP-00023	SM 4110-B
Nitrogen, (Nitrite, Nitrate) by IC	4	N/A	2010/12/19	AB SOP-00023	SM 4110-B
pH (Alkalinity titrator)	3	N/A	2010/12/20	AB SOP-00005	SM 4500-H B
pH (Alkalinity titrator)	1	N/A	2010/12/22	AB SOP-00005	SM 4500-H B
Sulphate by Automated Colourimetry	3	N/A	2010/12/20	AB SOP-00018	EPA 375.4
Sulphate by Automated Colourimetry	1	N/A	2010/12/22	AB SOP-00018	EPA 375.4
Total Dissolved Solids (Calculated)	4	N/A	2010/12/21		SM 1030 E
Total Trihalomethanes Calculation	4	N/A	2010/12/22	CAL SOP-00104	EPA 8260 C
VOCs in Water by P&T GC/MS (Std List)	4	N/A	2010/12/21	CAL SOP-00104	EPA 8260 C

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

PARMINDER VIRK,
Email: PVirk@maxxam.ca
Phone# (403) 291-3077

==========
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section

Maxxam Job #: B0C2880
Report Date: 2010/12/23

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: ALBERTA
Your P.O. #: 2026-1001
Sampler Initials: TJ

5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total cover pages: 2

Maxxam

Success Through Science®

Maxxam Job #: B0C2880
Report Date: 2010/12/23

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: ALBERTA
Your P.O. #: 2026-1001
Sampler Initials: TJ

ROUTINE WATER & DISS. REGULATED METALS (WATER)

Maxxam ID		Z13440		Z13441			Z13454			Z13455		
Sampling Date		2010/12/15		2010/12/15								
	Units	**MW-05-01**	**QC Batch**	**MW-05-01 DUP**	**RDL**	**QC Batch**	**TRIP BLANK 101213**	**RDL**	**QC Batch**	**FIELD BLANK**	**RDL**	**QC Batch**
Calculated Parameters												
Anion Sum	meq/L	24	4516744	24	N/A	4516744	0.021	N/A	4516744	0.87	N/A	4516744
Cation Sum	meq/L	21	4516744	21	N/A	4516744	0.000	N/A	4516744	0.000	N/A	4516744
Hardness (CaCO3)	mg/L	140	4516743	130	0.5	4516743	<0.5	0.5	4516743	<0.5	0.5	4516743
Ion Balance	N/A	0.89	4516762	0.91	0.01	4516762	NC	0.01	4516762	NC	0.01	4516762
Dissolved Nitrate (NO3)	mg/L	<0.01	4516763	<0.01	0.01	4516763	<0.01	0.01	4516763	<0.01	0.01	4516763
Nitrate plus Nitrite (N)	mg/L	<0.003	4516731	<0.003	0.003	4516731	<0.003	0.003	4516731	<0.003	0.003	4516731
Dissolved Nitrite (NO2)	mg/L	<0.01	4516763	<0.01	0.01	4516763	<0.01	0.01	4516763	<0.01	0.01	4516763
Total Dissolved Solids	mg/L	1300	4516621	1300	10	4516621	<10	10	4516621	40	10	4516621
Misc. Inorganics												
Conductivity	uS/cm	2200	4518646	2200	1	4518646	<1	1	4518646	430	1	4524074
pH	N/A	7.92	4518647	7.96	N/A	4518647	6.21	N/A	4518647	3.01	N/A	4524075
Low Level Elements												
Dissolved Cadmium (Cd)	ug/L	<0.005	4516612	0.020	0.005	4516612	<0.005	0.005	4516612	<0.005	0.005	4516612
Anions												
Alkalinity (PP as CaCO3)	mg/L	<0.5	4518634	<0.5	0.5	4518634	<0.5	0.5	4518634	<0.5	0.5	4518634
Alkalinity (Total as CaCO3)	mg/L	740	4518634	740	0.5	4518634	1.0	0.5	4518634	<0.5	0.5	4518634
Bicarbonate (HCO3)	mg/L	900	4518634	900	0.5	4518634	1.3	0.5	4518634	<0.5	0.5	4518634
Carbonate (CO3)	mg/L	<0.5	4518634	<0.5	0.5	4518634	<0.5	0.5	4518634	<0.5	0.5	4518634
Hydroxide (OH)	mg/L	<0.5	4518634	<0.5	0.5	4518634	<0.5	0.5	4518634	<0.5	0.5	4518634
Dissolved Sulphate (SO4)	mg/L	410(1)	4519643	420(1)	5	4519643	<1	1	4519643	37(1)	2	4524879
Dissolved Chloride (Cl)	mg/L	6	4519633	4	1	4519633	<1	1	4519633	4	1	4524833
Nutrients												
Dissolved Nitrite (N)	mg/L	<0.003	4516954	<0.003	0.003	4516954	<0.003	0.003	4516954	<0.003	0.003	4516954
Dissolved Nitrate (N)	mg/L	<0.003	4516954	<0.003	0.003	4516954	<0.003	0.003	4516954	<0.003	0.003	4516954

N/A = Not Applicable
NC = Non-calculable
RDL = Reportable Detection Limit
(1) - Detection limits raised due to dilution to bring analyte within the calibrated range.

Maxxam

Success Through Science®

Maxxam Job #: B0C2880
Report Date: 2010/12/23

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: ALBERTA
Your P.O. #: 2026-1001
Sampler Initials: TJ

ROUTINE WATER & DISS. REGULATED METALS (WATER)

Maxxam ID		Z13440		Z13441			Z13454			Z13455		
Sampling Date		2010/12/15		2010/12/15								
	Units	**MW-05-01**	**QC Batch**	**MW-05-01 DUP**	**RDL**	**QC Batch**	**TRIP BLANK 101213**	**RDL**	**QC Batch**	**FIELD BLANK**	**RDL**	**QC Batch**
Elements												
Dissolved Aluminum (Al)	mg/L	0.005	4519268	0.002	0.001	4519268	<0.001	0.001	4519268	<0.001	0.001	4519268
Dissolved Antimony (Sb)	mg/L	<0.0002	4519268	<0.0002	0.0002	4519268	<0.0002	0.0002	4519268	<0.0002	0.0002	4519268
Dissolved Arsenic (As)	mg/L	<0.0002	4519268	<0.0002	0.0002	4519268	<0.0002	0.0002	4519268	<0.0002	0.0002	4519268
Dissolved Barium (Ba)	mg/L	0.02	4527556	0.02	0.01	4524316	<0.01	0.01	4516984	<0.01	0.01	4516984
Dissolved Beryllium (Be)	mg/L	<0.001	4519268	<0.001	0.001	4519268	<0.001	0.001	4519268	<0.001	0.001	4519268
Dissolved Boron (B)	mg/L	0.30	4527556	0.33	0.02	4524316	<0.02	0.02	4516984	<0.02	0.02	4516984
Dissolved Calcium (Ca)	mg/L	44	4527556	41	0.3	4524316	<0.3	0.3	4516984	<0.3	0.3	4516984
Dissolved Chromium (Cr)	mg/L	<0.001	4519268	<0.001	0.001	4519268	<0.001	0.001	4519268	<0.001	0.001	4519268
Dissolved Cobalt (Co)	mg/L	<0.0003	4519268	<0.0003	0.0003	4519268	<0.0003	0.0003	4519268	<0.0003	0.0003	4519268
Dissolved Copper (Cu)	mg/L	0.0014	4519268	0.0014	0.0002	4519268	<0.0002	0.0002	4519268	<0.0002	0.0002	4519268
Dissolved Iron (Fe)	mg/L	0.11	4527556	0.14	0.06	4524316	<0.06	0.06	4516984	<0.06	0.06	4516984
Dissolved Lead (Pb)	mg/L	<0.0002	4519268	<0.0002	0.0002	4519268	<0.0002	0.0002	4519268	<0.0002	0.0002	4519268
Dissolved Lithium (Li)	mg/L	0.19	4527556	0.20	0.02	4524316	<0.02	0.02	4516984	<0.02	0.02	4516984
Dissolved Magnesium (Mg)	mg/L	7.5	4527556	7.5	0.2	4524316	<0.2	0.2	4516984	<0.2	0.2	4516984
Dissolved Manganese (Mn)	mg/L	0.091	4527556	0.085	0.004	4524316	<0.004	0.004	4516984	<0.004	0.004	4516984
Dissolved Molybdenum (Mo)	mg/L	0.0004	4519268	0.0004	0.0002	4519268	<0.0002	0.0002	4519268	<0.0002	0.0002	4519268
Dissolved Nickel (Ni)	mg/L	<0.0005	4519268	0.0012	0.0005	4519268	<0.0005	0.0005	4519268	<0.0005	0.0005	4519268
Dissolved Phosphorus (P)	mg/L	0.1	4527556	0.1	0.1	4524316	<0.1	0.1	4516984	<0.1	0.1	4516984
Dissolved Potassium (K)	mg/L	3.0	4527556	2.9	0.3	4524316	<0.3	0.3	4516984	<0.3	0.3	4516984
Dissolved Selenium (Se)	mg/L	<0.0002	4519268	0.0002	0.0002	4519268	<0.0002	0.0002	4519268	<0.0002	0.0002	4519268
Dissolved Silicon (Si)	mg/L	6.0	4527556	6.3	0.1	4524316	<0.1	0.1	4516984	<0.1	0.1	4516984
Dissolved Silver (Ag)	mg/L	<0.0001	4519268	<0.0001	0.0001	4519268	<0.0001	0.0001	4519268	<0.0001	0.0001	4519268
Dissolved Sodium (Na)	mg/L	410	4527556	430	0.5	4524316	<0.5	0.5	4516984	<0.5	0.5	4516984
Dissolved Strontium (Sr)	mg/L	0.54	4527556	0.55	0.02	4524316	<0.02	0.02	4516984	<0.02	0.02	4516984
Dissolved Sulphur (S)	mg/L	130	4527556	130	0.2	4524316	<0.2	0.2	4516984	<0.2	0.2	4516984
Dissolved Thallium (Tl)	mg/L	<0.0002	4519268	<0.0002	0.0002	4519268	<0.0002	0.0002	4519268	<0.0002	0.0002	4519268
Dissolved Tin (Sn)	mg/L	<0.001	4519268	<0.001	0.001	4519268	<0.001	0.001	4519268	<0.001	0.001	4519268
Dissolved Titanium (Ti)	mg/L	<0.001	4519268	<0.001	0.001	4519268	<0.001	0.001	4519268	<0.001	0.001	4519268
Dissolved Uranium (U)	mg/L	0.0010	4519268	0.0010	0.0001	4519268	<0.0001	0.0001	4519268	<0.0001	0.0001	4519268
Dissolved Vanadium (V)	mg/L	<0.001	4519268	<0.001	0.001	4519268	<0.001	0.001	4519268	<0.001	0.001	4519268
Dissolved Zinc (Zn)	mg/L	<0.003	4519268	0.008	0.003	4519268	<0.003	0.003	4519268	<0.003	0.003	4519268

RDL = Reportable Detection Limit

Maxxam

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Maxxam Job #: B0C2880
Report Date: 2010/12/23

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: ALBERTA
Your P.O. #: 2026-1001
Sampler Initials: TJ

VOLATILE ORGANICS BY GC-MS (WATER)

Maxxam ID		Z13442	Z13444	Z13454	Z13455		
Sampling Date		2010/12/16	2010/12/16				
	Units	**MW05-01**	**MW-05-01 DUP**	**TRIP BLANK 101213**	**FIELD BLANK**	**RDL**	**QC Batch**
Volatiles							
Total Trihalomethanes	ug/L	<2	<2	<2	<2	2	4516828
Benzene	ug/L	<0.4	<0.4	<0.4	<0.4	0.4	4520509
Bromodichloromethane	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
Bromoform	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
Bromomethane	ug/L	<2	<2	<2	<2	2	4520509
Carbon tetrachloride	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
Chlorobenzene	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
Chlorodibromomethane	ug/L	<1	<1	<1	<1	1	4520509
Chloroethane	ug/L	<1	<1	<1	<1	1	4520509
Chloroform	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
Chloromethane	ug/L	<2	<2	<2	<2	2	4520509
1,2-dibromoethane	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
1,2-dichlorobenzene	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
1,3-dichlorobenzene	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
1,4-dichlorobenzene	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
1,1-dichloroethane	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
1,2-dichloroethane	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
1,1-dichloroethene	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
cis-1,2-dichloroethene	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
trans-1,2-dichloroethene	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
Dichloromethane	ug/L	<2	<2	<2	<2	2	4520509
1,2-dichloropropane	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
cis-1,3-dichloropropene	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
trans-1,3-dichloropropene	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
Ethylbenzene	ug/L	<0.4	<0.4	<0.4	<0.4	0.4	4520509
Methyl methacrylate	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
Methyl-tert-butylether (MTBE)	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
Styrene	ug/L	<0.5	<0.5(1)	<0.5	<0.5	0.5	4520509
1,1,1,2-tetrachloroethane	ug/L	<2	<2	<2	<2	2	4520509
1,1,2,2-tetrachloroethane	ug/L	<2	<2	<2	<2	2	4520509
Tetrachloroethene	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
Toluene	ug/L	<0.4	<0.4	<0.4	<0.4	0.4	4520509
1,2,3-trichlorobenzene	ug/L	<1	<1(2)	<1	<1	1	4520509

RDL = Reportable Detection Limit
(1) - Matrix Spike exceeds acceptance limit, recovery: 43.55%, limit 70-130%.
(2) - Matrix Spike exceeds acceptance limit, recovery: 66.92%, limit 70-130%.

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Maxxam Job #: B0C2880
Report Date: 2010/12/23

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: ALBERTA
Your P.O. #: 2026-1001
Sampler Initials: TJ

VOLATILE ORGANICS BY GC-MS (WATER)

Maxxam ID		Z13442	Z13444	Z13454	Z13455		
Sampling Date		2010/12/16	2010/12/16				
	Units	**MW05-01**	**MW-05-01 DUP**	**TRIP BLANK 101213**	**FIELD BLANK**	**RDL**	**QC Batch**
1,2,4-trichlorobenzene	ug/L	<1	<1	<1	<1	1	4520509
1,3,5-trichlorobenzene	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
1,1,1-trichloroethane	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
1,1,2-trichloroethane	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
Trichloroethene	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
Trichlorofluoromethane	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
1,2,4-trimethylbenzene	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
1,3,5-trimethylbenzene	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
Vinyl chloride	ug/L	<0.5	<0.5	<0.5	<0.5	0.5	4520509
Xylenes (Total)	ug/L	<0.8	<0.8	<0.8	<0.8	0.8	4520509
m & p-Xylene	ug/L	<0.8	<0.8	<0.8	<0.8	0.8	4520509
o-Xylene	ug/L	<0.4	<0.4	<0.4	<0.4	0.4	4520509
Surrogate Recovery (%)							
4-BROMOFLUOROBENZENE (sur.)	%	91	86	93	91	N/A	4520509
D4-1,2-DICHLOROETHANE (sur.)	%	94	99	98	92	N/A	4520509
D8-TOLUENE (sur.)	%	103	102	107	105	N/A	4520509

N/A = Not Applicable
RDL = Reportable Detection Limit

Maxxam Job #: B0C2880
Report Date: 2010/12/23

FRANZ ENVIRONMENTAL INC.
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Sampler Initials: TJ

Package 1	3.3°C

Each temperature is the average of up to three cooler temperatures taken at receipt

General Comments

Sample Z13440-01: Cation anion balance investigated, data quality confirmed.

VOLATILE ORGANICS BY GC-MS (WATER) Comments

Sample Z13442-01 VOCs in Water by P&T GC/MS (Std List): Sample was run by GC/MS/Headspace as per CAL SOP-00227.

Sample Z13444-01 VOCs in Water by P&T GC/MS (Std List): Sample was run by GC/MS/Headspace as per CAL SOP-00227.

Sample Z13454-02 VOCs in Water by P&T GC/MS (Std List): Sample was run by GC/MS/Headspace as per CAL SOP-00227.

Sample Z13455-02 VOCs in Water by P&T GC/MS (Std List): Sample was run by GC/MS/Headspace as per CAL SOP-00227.

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Maxxam Job #: B0C2880
Report Date: 2010/12/23

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: ALBERTA
Your P.O. #: 2026-1001
Sampler Initials: TJ

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
4516954	Dissolved Nitrite (N)	2010/12/19	98	80 - 120	99	80 - 120	<0.003	mg/L	NC	20
4516954	Dissolved Nitrate (N)	2010/12/19	98	80 - 120	98	82 - 116	<0.003	mg/L	NC	20
4516984	Dissolved Barium (Ba)	2010/12/19	89	80 - 120	88	80 - 119	<0.01	mg/L		
4516984	Dissolved Boron (B)	2010/12/19	104	80 - 120	101	80 - 113	<0.02	mg/L		
4516984	Dissolved Calcium (Ca)	2010/12/19	104	80 - 120	99	87 - 116	<0.3	mg/L	NC	20
4516984	Dissolved Iron (Fe)	2010/12/19	95	80 - 120	91	80 - 101	<0.06	mg/L	NC	20
4516984	Dissolved Lithium (Li)	2010/12/19	96	80 - 120	97	81 - 116	<0.02	mg/L		
4516984	Dissolved Magnesium (Mg)	2010/12/19	106	80 - 120	104	82 - 115	<0.2	mg/L	NC	20
4516984	Dissolved Manganese (Mn)	2010/12/19	101	80 - 120	97	80 - 120	<0.004	mg/L		
4516984	Dissolved Phosphorus (P)	2010/12/19	109	80 - 120	108	86 - 112	<0.1	mg/L		
4516984	Dissolved Potassium (K)	2010/12/19	100	80 - 120	99	81 - 115	<0.3	mg/L	NC	20
4516984	Dissolved Silicon (Si)	2010/12/19	94	80 - 120	91	80 - 120	<0.1	mg/L		
4516984	Dissolved Sodium (Na)	2010/12/19	94	80 - 120	95	80 - 120	<0.5	mg/L	NC	20
4516984	Dissolved Strontium (Sr)	2010/12/19	92	80 - 120	91	80 - 115	<0.02	mg/L		
4516984	Dissolved Sulphur (S)	2010/12/19					<0.2	mg/L		
4518634	Alkalinity (Total as CaCO3)	2010/12/20			98	80 - 120	0.7, RDL=0.5	mg/L	1.2	20
4518634	Alkalinity (PP as CaCO3)	2010/12/20					<0.5	mg/L	NC	20
4518634	Bicarbonate (HCO3)	2010/12/20					0.8, RDL=0.5	mg/L	1.2	20
4518634	Carbonate (CO3)	2010/12/20					<0.5	mg/L	NC	20
4518634	Hydroxide (OH)	2010/12/20					<0.5	mg/L	NC	20
4518646	Conductivity	2010/12/20			100	93 - 106	<1	uS/cm	0.3	20
4518647	pH	2010/12/20			100	97 - 102			0.04	5
4519268	Dissolved Aluminum (Al)	2010/12/22	NC	80 - 120	109	80 - 120	<0.001	mg/L	4.1	20
4519268	Dissolved Antimony (Sb)	2010/12/22	100	80 - 120	101	80 - 120	<0.0002	mg/L	NC	20
4519268	Dissolved Arsenic (As)	2010/12/22	93	80 - 120	101	85 - 109	<0.0002	mg/L	NC	20
4519268	Dissolved Beryllium (Be)	2010/12/21	118	80 - 120	104	80 - 118	<0.001	mg/L		
4519268	Dissolved Chromium (Cr)	2010/12/22	96	80 - 120	105	80 - 120	<0.001	mg/L	NC	20
4519268	Dissolved Cobalt (Co)	2010/12/21	98	80 - 120	106	80 - 120	<0.0003	mg/L		
4519268	Dissolved Copper (Cu)	2010/12/22	93	80 - 120	105	80 - 120	<0.0002	mg/L	NC	20
4519268	Dissolved Lead (Pb)	2010/12/22	101	80 - 120	103	85 - 113	<0.0002	mg/L	NC	20
4519268	Dissolved Molybdenum (Mo)	2010/12/21	109	80 - 120	103	80 - 120	<0.0002	mg/L		
4519268	Dissolved Nickel (Ni)	2010/12/22	95	80 - 120	105	82 - 120	<0.0005	mg/L	NC	20
4519268	Dissolved Selenium (Se)	2010/12/22	98	80 - 120	106	81 - 120	<0.0002	mg/L	NC	20
4519268	Dissolved Silver (Ag)	2010/12/22	85	80 - 120	90	80 - 120	<0.0001	mg/L	NC	20
4519268	Dissolved Thallium (Tl)	2010/12/21	103	80 - 120	105	80 - 120	<0.0002	mg/L		
4519268	Dissolved Tin (Sn)	2010/12/21	84	80 - 120	94	80 - 120	0.001, RDL=0.001	mg/L		
4519268	Dissolved Titanium (Ti)	2010/12/21	87	80 - 120	104	80 - 120	<0.001	mg/L		
4519268	Dissolved Uranium (U)	2010/12/22	101	80 - 120	107	80 - 120	<0.0001	mg/L	10.9	20
4519268	Dissolved Vanadium (V)	2010/12/21	NC	80 - 120	102	80 - 120	<0.001	mg/L		

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Your P.O. #: 2026-1001
Sampler Initials: TJ

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
4519268	Dissolved Zinc (Zn)	2010/12/22	87	80 - 120	106	80 - 120	<0.003	mg/L	NC	20
4519633	Dissolved Chloride (Cl)	2010/12/20	NC	80 - 120	98	92 - 113	<1	mg/L	1.5	20
4519643	Dissolved Sulphate (SO4)	2010/12/20	NC	80 - 120	108	91 - 116	<1	mg/L	1.2	20
4520509	4-BROMOFLUOROBENZENE (sur.)	2010/12/21	113	70 - 130	112	70 - 130	92	%		
4520509	D4-1,2-DICHLOROETHANE (sur.)	2010/12/21	97	70 - 130	90	70 - 130	93	%		
4520509	D8-TOLUENE (sur.)	2010/12/21	103	70 - 130	106	70 - 130	105	%		
4520509	Benzene	2010/12/21	97	70 - 130	109	70 - 130	<0.4	ug/L	NC	40
4520509	Bromodichloromethane	2010/12/21	106	70 - 130	109	70 - 130	<0.5	ug/L	NC	40
4520509	Bromoform	2010/12/21	109	70 - 130	107	70 - 130	<0.5	ug/L	NC	40
4520509	Bromomethane	2010/12/21	95	70 - 130	106	70 - 130	<2	ug/L	NC	40
4520509	Carbon tetrachloride	2010/12/21	99	70 - 130	111	70 - 130	<0.5	ug/L	NC	40
4520509	Chlorobenzene	2010/12/21	101	70 - 130	119	70 - 130	<0.5	ug/L	NC	40
4520509	Chlorodibromomethane	2010/12/21	104	70 - 130	109	70 - 130	<1	ug/L	NC	40
4520509	Chloroethane	2010/12/21	96	70 - 130	109	70 - 130	<1	ug/L	NC	40
4520509	Chloroform	2010/12/21	104	70 - 130	111	70 - 130	<0.5	ug/L	NC	40
4520509	Chloromethane	2010/12/21	129	70 - 130	144(1)	70 - 130	<2	ug/L	NC	40
4520509	1,2-dibromoethane	2010/12/21	105	70 - 130	110	70 - 130	<0.5	ug/L	NC	40
4520509	1,2-dichlorobenzene	2010/12/21	94	70 - 130	112	70 - 130	<0.5	ug/L	NC	40
4520509	1,3-dichlorobenzene	2010/12/21	93	70 - 130	117	70 - 130	<0.5	ug/L	NC	40
4520509	1,4-dichlorobenzene	2010/12/21	94	70 - 130	109	70 - 130	<0.5	ug/L	NC	40
4520509	1,1-dichloroethane	2010/12/21	90	70 - 130	114	70 - 130	<0.5	ug/L	NC	40
4520509	1,2-dichloroethane	2010/12/21	106	70 - 130	109	70 - 130	<0.5	ug/L	NC	40
4520509	1,1-dichloroethene	2010/12/21	96	70 - 130	108	70 - 130	<0.5	ug/L	NC	40
4520509	cis-1,2-dichloroethene	2010/12/21	101	70 - 130	111	70 - 130	<0.5	ug/L	NC	40
4520509	trans-1,2-dichloroethene	2010/12/21	111	70 - 130	124	70 - 130	<0.5	ug/L	NC	40
4520509	Dichloromethane	2010/12/21	103	70 - 130	106	70 - 130	<2	ug/L	NC	40
4520509	1,2-dichloropropane	2010/12/21	102	70 - 130	112	70 - 130	<0.5	ug/L	NC	40
4520509	cis-1,3-dichloropropene	2010/12/21	103	70 - 130	106	70 - 130	<0.5	ug/L	NC	40
4520509	trans-1,3-dichloropropene	2010/12/21	116	70 - 130	120	70 - 130	<0.5	ug/L	NC	40
4520509	Ethylbenzene	2010/12/21	97	70 - 130	114	70 - 130	<0.4	ug/L	NC	40
4520509	Methyl methacrylate	2010/12/21	103	70 - 130	109	70 - 130	<0.5	ug/L	NC	40
4520509	Methyl-tert-butylether(MTBE)	2010/12/21	110	70 - 130	122	70 - 130	<0.5	ug/L	NC	40
4520509	1,1,1,2-tetrachloroethane	2010/12/21	111	70 - 130	116	70 - 130	<2	ug/L	NC	40
4520509	1,1,2,2-tetrachloroethane	2010/12/21	115	70 - 130	113	70 - 130	<2	ug/L	NC	40
4520509	Tetrachloroethene	2010/12/21	99	70 - 130	113	70 - 130	<0.5	ug/L	NC	40
4520509	Toluene	2010/12/21	97	70 - 130	117	70 - 130	<0.4	ug/L	NC	40
4520509	1,2,4-trichlorobenzene	2010/12/21	71	70 - 130	106	70 - 130	<1	ug/L	NC	40
4520509	1,3,5-trichlorobenzene	2010/12/21	77	70 - 130	115	70 - 130	<0.5	ug/L	NC	40
4520509	1,1,1-trichloroethane	2010/12/21	99	70 - 130	112	70 - 130	<0.5	ug/L	NC	40

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Maxxam Job #: B0C2880
Report Date: 2010/12/23

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: ALBERTA
Your P.O. #: 2026-1001
Sampler Initials: TJ

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
4520509	1,1,2-trichloroethane	2010/12/21	103	70 - 130	100	70 - 130	<0.5	ug/L	NC	40
4520509	Trichloroethene	2010/12/21	101	70 - 130	114	70 - 130	<0.5	ug/L	NC	40
4520509	Trichlorofluoromethane	2010/12/21	101	70 - 130	114	70 - 130	<0.5	ug/L	NC	40
4520509	1,2,4-trimethylbenzene	2010/12/21	80	70 - 130	107	70 - 130	<0.5	ug/L	NC	40
4520509	1,3,5-trimethylbenzene	2010/12/21	83	70 - 130	111	70 - 130	<0.5	ug/L	NC	40
4520509	Vinyl chloride	2010/12/21	114	70 - 130	130(1)	70 - 130	<0.5	ug/L	NC	40
4520509	m & p-Xylene	2010/12/21	90	70 - 130	112	70 - 130	<0.8	ug/L	NC	40
4520509	o-Xylene	2010/12/21	90	70 - 130	109	70 - 130	<0.4	ug/L	NC	40
4520509	Styrene	2010/12/21			101	70 - 130	<0.5	ug/L	NC	40
4520509	1,2,3-trichlorobenzene	2010/12/21			98	70 - 130	<1	ug/L	NC	40
4520509	Xylenes (Total)	2010/12/21					<0.8	ug/L	NC	40
4524074	Conductivity	2010/12/22			100	92 - 106	<1	uS/cm	2.4	20
4524075	pH	2010/12/22			100	97 - 102			0.6	5
4524316	Dissolved Barium (Ba)	2010/12/22	86	80 - 120	90	80 - 119	<0.01	mg/L	0.6	20
4524316	Dissolved Boron (B)	2010/12/22	100	80 - 120	101	80 - 113	<0.02	mg/L	NC	20
4524316	Dissolved Calcium (Ca)	2010/12/22	NC	80 - 120	100	87 - 116	<0.3	mg/L	1.3	20
4524316	Dissolved Iron (Fe)	2010/12/22	90	80 - 120	94	80 - 101	<0.06	mg/L	NC	20
4524316	Dissolved Lithium (Li)	2010/12/22	99	80 - 120	100	81 - 116	<0.02	mg/L	NC	20
4524316	Dissolved Magnesium (Mg)	2010/12/22	NC	80 - 120	103	82 - 115	<0.2	mg/L	0.1	20
4524316	Dissolved Manganese (Mn)	2010/12/22	95	80 - 120	99	80 - 120	<0.004	mg/L	0.7	20
4524316	Dissolved Phosphorus (P)	2010/12/22	101	80 - 120	101	86 - 112	<0.1	mg/L	NC	20
4524316	Dissolved Potassium (K)	2010/12/22	97	80 - 120	97	81 - 115	<0.3	mg/L	1.2	20
4524316	Dissolved Silicon (Si)	2010/12/22	93	80 - 120	95	80 - 120	<0.1	mg/L	0.3	20
4524316	Dissolved Sodium (Na)	2010/12/22	98	80 - 120	100	80 - 120	<0.5	mg/L	0.5	20
4524316	Dissolved Strontium (Sr)	2010/12/22	88	80 - 120	94	80 - 115	<0.02	mg/L	0.1	20
4524316	Dissolved Sulphur (S)	2010/12/22					<0.2	mg/L	0.6	20
4524833	Dissolved Chloride (Cl)	2010/12/22	NC	80 - 120	110	92 - 113	<1	mg/L	2.2	20
4524879	Dissolved Sulphate (SO4)	2010/12/22	NC	80 - 120	107	91 - 116	<1	mg/L	2.7	20
4527556	Dissolved Barium (Ba)	2010/12/23	84	80 - 120	90	80 - 119	<0.01	mg/L		
4527556	Dissolved Boron (B)	2010/12/23	98	80 - 120	106	80 - 113	<0.02	mg/L		
4527556	Dissolved Calcium (Ca)	2010/12/23	NC	80 - 120	113	87 - 116	<0.3	mg/L	1.9	20
4527556	Dissolved Iron (Fe)	2010/12/23	91	80 - 120	100	80 - 101	<0.06	mg/L		
4527556	Dissolved Lithium (Li)	2010/12/23	92	80 - 120	100	81 - 116	<0.02	mg/L		
4527556	Dissolved Magnesium (Mg)	2010/12/23	NC	80 - 120	111	82 - 115	<0.2	mg/L	2.6	20
4527556	Dissolved Manganese (Mn)	2010/12/23	98	80 - 120	109	80 - 120	<0.004	mg/L		
4527556	Dissolved Phosphorus (P)	2010/12/23	113	80 - 120	109	86 - 112	<0.1	mg/L		
4527556	Dissolved Potassium (K)	2010/12/23	91	80 - 120	101	81 - 115	0.4, RDL=0.3	mg/L	1.0	20
4527556	Dissolved Silicon (Si)	2010/12/23	NC	80 - 120	101	80 - 120	<0.1	mg/L		
4527556	Dissolved Sodium (Na)	2010/12/23	NC	80 - 120	102	80 - 120	<0.5	mg/L	1.3	20

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Maxxam Job #: B0C2880
Report Date: 2010/12/23

FRANZ ENVIRONMENTAL INC.
Client Project #: DRUMHELLER INSTITUTION
Site Reference: ALBERTA
Your P.O. #: 2026-1001
Sampler Initials: TJ

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
4527556	Dissolved Strontium (Sr)	2010/12/23	86	80 - 120	95	80 - 115	<0.02	mg/L		
4527556	Dissolved Sulphur (S)	2010/12/23					<0.2	mg/L		

N/A = Not Applicable
RDL = Reportable Detection Limit
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.
(1) - Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

Validation Signature Page

Maxxam Job #: B0C2880

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

JENNIFER LO, Senior Analyst, Organics Department

LILI ZHOU, Senior analyst, Inorganic department.

==========

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

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Chain of Custody

A037659

Page: 1 of 1

	Invoice To: C/O Report Address ☒	Report To: Same as Invoice ☒	Report Distribution (E-Mail):
Company:	Franz Environmental Ottawa		slivingstone@franzenvironmental.com
Contact:	Steve Livingstone		tjones@franzbc.com
Address:	329 Churchill Ave, North - Suite 200		
	Prov: Ontario PC: K1Z 5B9	Prov: PC:	
Contact #s:	Ph: 613 721 0555 Cell:	Ph: Cell:	

REGULATORY GUIDELINES:
- ☐ AT1
- ☒ CCME
- ☐ Regulated Drinking Water
- ☒ Other: ALBERTA

All samples are held for 60 calendar days after sample receipt, unless specified otherwise.

PO #:	2026-1001
Project # / Name:	Drumheller Institution
Site Location:	Alberta
Quote #:	
Sampled By:	TJ

SERVICE REQUESTED: ☐ RUSH (Contact lab to reserve) Date Required: ☒ REGULAR (5 to 7 Days)

See reverse for package specifics

	Sample ID	Depth (unit)	Matrix GW / SW Soil	Date/Time Sampled YY/MM/DD 24:00	SOIL: BTEX F1-F4	Sieve (75 micron)	Regulated Metals (CCME / AT1)	Salinity 4	Assessment ICP Metals	Basic Class II Landfill	WATER: ☐BTEX F1 ☒VOCs	☐BTEX F1-F2 ☐BTEX F1-F4	☒ Routine Water ☐ Turb ☐ F	☐ TOC ☐ DOC	Regulated Metals (CCME / AT1): Total	Dissolved	Mercury	☐ Total ☐ Dissolved	HOLD - Do not Analyze	# of Containers Submitted
1	MW-05-01		GW	10/12/15									X			X				3
2	MW-05-01 DUP		GW	10/12/15									X			X				3
3	MW-05-01		GW	10/12/16							X									3
4	MW-05-01 DUP		GW	10/12/16							X									3
5	Trip blank 101213 (101213)										X		X			X				5
6	~~Trip blank~~																			
7	Field blank										X		X			X				6
8																				
9																				
10																				
11																				
12																				

Please indicate Filtered, Preserved or Both (F, P, F/P) → F/P

Relinquished By (Signature/Print): / THWJ	Date (YY/MM/DD): 10/12/16	Time (24:00):
Relinquished By (Signature/Print):	Date (YY/MM/DD):	Time (24:00):
Special Instructions: NO_2, NO_3, N+N Filtered	# of Jars Used & Not Submitted	

LAB USE ONLY

Received By: RECEIVED DEC 17 2010	Date:	Time:	Maxxam Job #:
Lab Comments: 0911	Custody Seal: X	Temperature: 2, 3, 5	Ice: ✓

AB FCD-00331 Rev3 2010/05

Maxxam Analytics International Corporation o/a Maxxam Analytics

APPENDIX F

National Classification System for Contaminated Sites Worksheets

CCME National Classification System for Contaminated Sites (2008, 2010 v 1.2)
Pre-Screening Checklist

Question	Response (yes / no)	Comment
1. Are **Radioactive material**, **Bacterial contamination** or **Biological hazards** likely to be present at the site?	No	If yes, do not proceed through the NCSCS. Contact applicable regulatory agency immediately.
2. Are there **no contamination exceedances** (known or suspected)? Determination of exceedances may be based on: 1) CCME environmental quality guidelines; 2) equivalent provincial guidelines/standards if no CCME guideline exists for a specific chemical in a relevant medium; or 3) toxicity benchmarks derived from the literature for chemicals not covered by CCME or provincial guidelines/standards.	No	If yes (i.e., there are no exceedances), do not proceed through the NCSCS.
3. Have **partial/incompleted or no environmental site investigations** been conducted for the Site?	No	If yes, do not proceed through the NCSCS.
4. Is there direct and signficant evidence of **impacts to humans** at the site, or off-site due to migration of contaminants from the site?	No	If yes, automatically rate the site as Class 1, a priority for remediation or risk management, regardless of the total score obtained should one be calculated (e.g., for comparison with other Class 1 sites).
5. Is there direct and significant evidence of **impacts to ecological receptors** at the site, or off-site due to migration of contaminants from the site?	No	Some low levels of impact to ecological receptors are considered acceptable, particularly on commercial and industrial land uses. However, if ecological effects are considered to be severe, the site may be categorized as Class 1, regardless of the numerical total NCSCS score. For the purpose of application of the NCSCS, effects that would be considered severe include observed effects on survival, growth or reproduction which could threaten the viability of a population of ecological receptors at the site. Other evidence that qualifies as severe adverse effects may be determined based on professional judgement and in consultation with the relevant jurisdiction.
6. Are there indicators of significant **adverse effects in the exposure zone** (i.e., the zone in which receptors may come into contact with contaminants)? Some examples are as follows: -Hydrocarbon sheen or NAPL in the exposure zone -Severely stressed biota or devoid of biota; -Presence of material at ground surface or sediment with suspected high concentration of contaminants such as ore tailings, sandblasting grit, slag, and coal tar.	No	If yes, automatically rate the site as Class 1, a priority for remediation or risk management, regardless of the total score obtained should one be calculated (e.g., for comparison with other Class 1 sites).
7. Do measured concentrations of volatiles or unexploded ordnances represent an **explosion hazard**?	No	If yes, automatically rate the site as Class 1, a priority for remediation or risk management, and do not continue until the safety risks have been addressed. Consult your jurisdiction's occupational health and safety guidance or legislation on exposive hazards and measurement of lower explosive limits.

If none of the above applies, proceed with the NCSCS scoring.

CCME National Classification System for Contaminated Sites (2008, 2010 v 1.2)
Summary of Site Conditions

Subject Site:	**Drumheller Institution**	
Civic Address: *(or other description of location)*	Drumheller Institution, 5km south-southeast of Drumheller, Alberta	
Site Common Name : *(if applicable)*	Rifle Range Site - Drumheller Institution	
Site Owner or Custodian: *(Organization and Contact Person)*	Correctional Services Canada (CSC)	
Legal description *or* metes and bounds:	South East ¼ of Section 25; Township 28; Range 20; West of the Fourth Meridian	
Approximate Site area:		
PID(s) : *(or Parcel Identification Numbers [PIN] if untitled Crown land)*		
Centre of site: *(provide latitude/longitude or UTM coordinates)*	Latitude: Longitude:	___51___ degrees ___25___ min __13.39____ secs __112____ degrees __41___ min ___17.30___ secs
	UTM Coordinate:	Northing _____ Easting _____
Site Land Use:	Current:	A Rifle Range for employees target practice.
	Proposed:	Remain the same
Site Plan	**To delineate the bounds of the Site a site plan MUST be attached. The plan must be drawn to scale indicating the boundaries in relation to well-defined reference points and/or legal descriptions. Delineation of the contamination should also be indicated on the site plan.**	
Provide a brief description of the Site:	The Drumheller Institution was opened in 1967 to house medium-security inmates. The Institution is located five kilometres south-southeast of Drumheller, Alberta. The firearms range has reportedly been maintained southeast of the compound since approximately 1973 and was used for staff training exercises. The soil in the berm has never been replaced, however it is not known if material has been added to the berm or the berm size increased. The range is less than 150 metres from a steep ravine to the east. It appears that surface runoff from the site would flow in this direction.	

CCME National Classification System for Contaminated Sites (2008, 2010 v 1.2)
Summary of Site Conditions

Affected media and Contaminants of Potential Concern (COPC):	Soil: Metals: antimony, arsenic, copper, lead and tin and leachable lead Source: ESI and Slope Stability Analysis, Franz, 2010.

Please fill in the "letter" that best describes the level of information available for the site being assessed

Site Letter Grade **D**

If letter grade is F, do not continue, you must have a minimum of a Phase I Environmental Site Assessment or equivalent.

Scoring Completed By:	Julie Dittburner
Date Scoring Completed:	22-Feb-11

CCME National Classification System for Contaminated Sites (2008, 2010 v 1.2)
User's Guide - Instructions

1) Please review the following overview of contents. The revised CCME National Classification System for Contaminated Sites (NCSCS) consists of a pre-screening checklist, summary of site conditions, summary score sheet, and three instruction/worksheet pages for the user to fill out: Contaminant Characteristics, Migration Potential and Exposure. For ease of printing, the method of evaluation for scoring each section of the worksheet is provided in a separate Instructions tab. Reference material is also provided to assist with the evaluation. A brief description of each sheet is as follows:

Pre-Screening Checklist - Used to determine if the Site can either be considered a Class 1 site (to be remediated immediately) or more information must be collected before the Site can be ranked, or other hazards exist at the Site that must be addressed first before the Site can be ranked using the revised NCSCS.

Site Description Sheet - Summarizes Site information. It also indicates the level of information available (Site Letter Grade) for the site to conduct the NCSCS scoring evaluation. The known/potential contaminants of concern and affected media will also be summarized here.

Contaminant Characteristics Instructions & Worksheet - Prompts the user for information related to the contaminants of potential concern (COPC) found at the site.

Migration Potential Instructions & Worksheet - Prompts the user for information related to physical transport processes which may move contamination to neighboring sites or re-distribute contamination within a site. Migration potential includes many of the exposure pathways, but is not limited to exposure pathways. Migration potential does not require clearly defined receptors.

Exposure Instructions & Worksheet - Prompts the user for information related to exposure pathways and receptors which may be located on the site.

Summary Score Sheet - Generates a total site score by adding up the scores generated on each of the three worksheets and provides the corresponding Site Classification. It also provides an estimate of certainty in the score provided (Certainty Percentage).

Reference Material - Additional information which may be useful to refer to when conducting the evaluation.
- Contaminant Hazard Ranking
- Examples of Persistent Substances
- Examples of Substances in the Various Chemical Classes
- Chemical-specific Properties
- Range of Values of Hydraulic Conductivity and Permeability

The worksheet titles and sub headings are as follows.

I. Contaminant Characteristics

1. Residency Media
2. Chemical Hazard
3. Contaminant Exceedance Factor
4. Contaminant Quantity
5. Modifying Factors

II. Migration Potential

1. Groundwater Movement
2. Surface water Movement
3. Soil
4. Vapour
5. Sediment Movement
6. Modifying Factors

III. Exposure

1. Human Receptors
   - A. Known Impact
   - B Potential
     - a. Land Use
     - b. Accessibility
     - c. Exposure Route
2. Human Modifying Factors
3. Ecological Receptors
   - A. Known Impact
   - B. Potential
     - a. Terrestrial
     - b. Aquatic
4. Ecological Modifying Factors
   - a. Species at Risk
   - b. Aesthetics
5. Other Receptors
   - a. Permafrost

CCME National Classification System for Contaminated Sites (2008, 2010 v 1.2)
User's Guide - Instructions

2) This is an electronic form which will prompt the user for information. Based on the answers provided, a score is calculated for the contaminated site in question. In most cases, the user will be asked to select amongst two or more choices in a drop down checklist. To access the drop down checklist, move the mouse towards the right side of the "action box". If a drop down is available, an arrow will appear, which must be selected to access the drop down choices. An "action box" requires input from the user. All action boxes have an amber background. action box

3) When assigning scores for each factor, it is highly recommended to give a rationale (a column has been provided for this purpose in Worksheets I, II and III). Information that would be useful in justifying the scores assigned may include: a statement of any assumptions, a description of site-specific information, and references for any data sources (e.g., site visit, personal interview, site assessment reports, or other documents consulted).

4) The Site Letter Grade is related to the level of information available for the Site (as defined by the User) and provides an indication of completeness of information based on the level of investigation and remediation work that has been carried out at the site. More detailed descriptions of the various categories are provided below.

Site Letter Grade:	*Detailed Descriptions:*
F	***Pre Phase I ESA –*** No environmental investigations have been conducted or there are only partial or incomplete Phase I ESA for the Site. It is not recommended to continue through the NCSCS when insufficient data are available. In these cases, it will generally be necessary to conduct a Phase I ESA or other site investigation tasks in order to complete the NCSCS scoring.
E	***Phase I ESA –*** A preliminary desk-top type study has been conducted, involving non-intrusive data collection to determine whether there is a potential for the Site to be contaminated and to provide information to direct any intrusive investigations. Data collected may include a review of available information on current site conditions and history of the property, a site inspection and interviews with personnel familiar with the Site. [Note: This stage is similar to "Phase I: Site Information Assessment" as described in Guidance Document on the Management of Contaminated Sites in Canada (CCME 1997).]
D	***Limited Phase II ESA –*** An initial intrusive investigation and assessment of the property has been conducted, generally focusing on potential sources of contamination, to determine whether there is contamination present above the relevant screening guidelines or criteria, and to broadly define soil and groundwater conditions; samples have been collected and analyzed to identify, characterize and quantify contamination that may be present in air, soil, groundwater, surface water or building materials. [Note: This stage is similar to "Phase II: Reconnaissance Testing Program" as described in Guidance Document on the Management of Contaminated Sites in Canada (CCME 1997).]
C	***Detailed Phase II ESA –*** Further intrusive investigations have been conducted to characterize and delineate the contamination, to obtain detailed information on the soil and groundwater conditions, to identify the contaminant pathways, and to provide other information required to develop a remediation plan. [Note: This stage is similar to "Phase III: Detailed Testing Program" as described in Guidance Document on the Management of Contaminated Sites in Canada (CCME 1997).]
B	***Risk Assessment with or without Remedial Plan or Risk Management Strategy –*** A risk assessment has been completed, and if the risk was found to be unacceptable, a site-specific remedial action plan has been designed to mitigate environmental and health concerns associated with the Site, or a risk management strategy has been developed.
A	***Confirmation Sampling –*** Remedial work, monitoring, and/or compliance testing have been conducted and confirmatory sampling demonstrates whether contamination has been removed or stabilized effectively and whether cleanup or risk management objectives have been attained.

5) A few terms are used throughout which require definition, they are as follows:

Known - refers to scores that are assigned based on documented scientific and/or technical observations

Potential - refers to scores that are assigned when something is not known, though it may be suspected

Allowed Potential - If, in a given category, known and potential scores are provided by the user, the checklist will typically default to the "known" score. If a "known" score is provided, the "allowed potential" score will equal zero. Exceptions can be found within the Modifying Factors categories in each worksheet where there are often several independent questions. Therefore, "known" and "potential" scores are allowed to contribute to the total modifying factor score.

Raw - refers to score totals which have not been adjusted down to the total maximum score for the given category. In most cases the possible total raw score is greater than the maximum allowed

CCME National Classification System for Contaminated Sites (2008, 2010 v 1.2)
User's Guide - Instructions

Note: For some questions in the worksheets, the option selected will determine whether a "known" or "potential" score is assigned. In these cases, if "Do Not Know" is selected, a score will automatically be listed as "potential", whereas all of the other options in the list will provide a "known" score.

6) Certainty Percentage: The ratio of “Known” to “Potential” responses reflects the relative certainty, or confidence, of the resulting final score and the classification. The NCSCS system defines this ratio as the “Certainty Percentage”. The Certainty Percentage is generated from the number of sections assigned scores based on “known” information divided by the total number of sections. A high percentage indicates that more is known about the Site, and therefore there is more confidence in the ranking, whereas a low percentage suggests that the ranking should be treated with caution.

7) Site Classification Categories: Sites should not be ranked relative to one another. Sites must be classifed on their individual characteristics in order to determine the appropriate classification (Class 1, 2, 3, or N) according to their priority for action, or Class INS (Insufficient Information) for sites that require further information before they can be classifed. The classification groupings are as follows:

Class 1 - High Priority for Action (Total NCSCS Score greater than 70)

The available information indicates that action (e.g., futher site characterization, risk management, remediation, etc.) is required to address existing concerns. Typically, Class 1 sites indicate high concern for several factors, and measured or observed impacts have been documented.

Class 2 - Medium Priority for Action (Total NCSCS Score between 50 and 69.9)

The available information indicates that there is high potential for adverse impacts, although the threat to human health and the environment is generally not imminent. There will tend not to be indication of off-site contamination, however, the potential for this was rated high and therefore some action is likely required.

Class 3 - Low Priority for Action (Total NCSCS Score between 37 and 49.9)

The available information indicates that this site is currently not a high concern. However, additional investigation may be carried out to confirm the site classification, and some degree of action may be required.

Class N - Not a Priority for Action (Total NCSCS Score less than 37)

The available information indicates there is probably no significant environmental impact or human health threats. There is likely no need for action unless new information becomes available indicating greater concerns, in which case the site should be re-examined.

Class INS - Insufficient Information (>15% of Responses are "Do Not Know")

There is insufficient information to classify the site. In this event, additional information is required to address data gaps.

8) Additional Complementary Tools to the NCSCS

The CCME Soil Quality Index (SoQI) is a complementary tool that focuses more on evaluating the relative hazard, by comparing contaminant concentrations with their respective soil quality guidelines. The SoQI uses three factors for its calculations, namely: 1) scope (% of contaminants that do not meet their respective guidelines), 2) frequency (% of individual tests of contaminants that do not meet their respective guidelines), and 3) amplitude (the amount by which the contaminants do not meet their respective guidelines). The soil quality index can be used to compare different contaminated sites with similar types of contamination as well as to see if the jurisdictional requirements have been met after remediation of a particular site.

The NCSCS was not developed for and is not readily applicable for the assessment of sites with a significant marine or aquatic component. Environmental conditions at marine and aquatic sites are best measured in the bed sediments as they act as long-term reservoirs of chemicals to the aquatic environment and to organisms living in or having direct contact with sediments. The CCME Sediment Quality Index (SeQI) provides a convenient means of summarizing sediment quality data and can complement the NCSCS. The SeQI provides a mathematical framework for assessing sediment quality conditions by comparing contaminant concentrations with their respective sediment quality guidelines.

CCME National Classification System (2008, 2010 v 1.2)

(I) Contaminant Characteristics

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method of Evaluation	Notes
1. Residency Media (replaces physical state)				
Which of the following residency media are known (or strongly suspected) to have one or more exceedances of the applicable CCME guidelines? **yes** = has an exceedance or strongly suspected to have an exceedance **no** = does not have an exceedance or strongly suspected not to have an exceedance		The ESI and Slope Stability Analysis, Franz, 2010 reported the following exceedances: Soil: antimony, arsenic, copper, lead, tin, leachable lead GW, SW and sediments: not assessed at this time	The overall score is calculated by adding the individual scores from each residency media (having one or more exceedance of the most conservative media specific and land-use appropriate CCME guideline). Summary tables of the Canadian Environmental Quality Guidelines for soil, water (aquatic life, non-potable groundwater environments, and agricultural water uses) and sediment are available on the CCME website at http://www.ccme.ca/publications/cegg_rcqe.html?category_id=124 . For potable groundwater environments, guidelines for Canadian Drinking Water Quality (for comparison with groundwater monitoring data) are available on the Health Canada website at http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/doc_sup-appui/sum_guide-res_recom/index_e.html.	An increasing number of residency media containing chemical exceedances often equates to a greater potential risk due to an increase in the number of potential exposure pathways.
A. Soil	Yes			
Yes No Do Not Know				
B. Groundwater	Do Not Know			
Yes No Do Not Know				
C. Surface water	Do Not Know			
Yes No Do Not Know				
D. Sediment	Do Not Know			
Yes No Do Not Know				
"Known" -score	2			
"Potential" - score	3			
2. Chemical Hazard				
What is the relative degree of chemical hazard of the contaminant in the list of hazard rankings proposed by the Federal Contaminated Sites Action Plan (FCSAP)?	High	Results of chemical analysis of environmental media are provided within the Phase II ESI's. Contaminant hazards with HIGH hazard rankings include the following: Soil: antimony, arseinc, and lead	The relative degree of chemical hazard should be selected based on the most hazardous contaminant known or suspected to be present at the site. The degree of hazard has been defined by the Federal Contaminated Sites Action Plan (FCSAP) and a list of substances with their associated hazard (Low, Medium and High) has been provided as a separate sheet in this file. *See Attached Reference Material for Contaminant Hazard Rankings.*	Hazard as defined in the revised NCS pertains to the physical properties of a chemical which can cause harm. Properties can include toxic potency, propensity to biomagnify, persistence in the environment, etc. Although there is some overlap between hazard and contaminant exceedance factor below, it will not be possible to derive contaminant exceedance factors for many substances which have a designated chemical hazard designation, but don't have a CCME guideline. The purpose of this category is to avoid missing a measure of toxic potential.
High Medium Low Do Not Know				
"Known" -score	8			
"Potential" - score	---			
3. Contaminant Exceedence Factor				
What is the ratio between the measured contaminant concentration and the applicable CCME guidelines (or other "standards")?	High (>100x)	Results of chemical analysis of environmental media are provided within the Phase II ESI. The greatest exceedance of contaminant concentration above CCME guidelines was observed as the following: HIGH (> 100x): lead in soil concentration of 42,000 ug/g and CCME EQG is 70 ug/g (600x EQG). Antimony (65x), arsenic (11x) and tin (15x) were ranked as medium and copper (3x) was ranked as low ratios.	Ranking of contaminant "exceedance" is determined by comparing contaminant concentrations with the *most conservative media-specific and land-use appropriate CCME* environmental quality guidelines. **Ranking should be based on contaminant with greatest exceedance of CCME guidelines.** Ranking of contaminant hazard as high, medium and low is as follows: High = One or more measured contaminant concentration is greater than 100 X appropriate CCME guidelines Medium = One or more measured contaminant concentration is 10 - 99.99 X appropriate CCME guidelines Low = One or more measured contaminant concentration is 1 - 9.99 X appropriate CCME guidelines Mobile NAPL = Contaminant is a non-aqueous phase liquid (i.e., due to its low solubility, it does not dissolve in water, but remains as a separate liquid) and is present at a sufficiently high saturation (i.e., greater than residual NAPL saturation) such that there is significant potential for mobility either downwards or laterally. Other standards may include local background concentration or published toxicity benchmarks. Results of toxicity testing with site samples can be used as an alternative. This approach is only relevant for contaminants that do not biomagnify in the food web, since toxicity tests would not indicate potential effects at higher trophic levels. High = lethality observed. Medium = no lethality, but sub lethal effects observed. Low = neither lethal nor sub lethal effects observed.	In the event that elevated levels of a material with no associated CCME guidelines are present, check provincial and USEPA environmental criteria. Hazard Quotients (sometimes referred to as a screening quotient in risk assessments) refer to the ratio of measured concentration to the concentration believed to be the threshold for toxicity. A similar calculation is used here to determine the contaminant exceedance factor (CEF). Concentrations greater than one times the applicable CCME guideline (i.e., CEF=>1) indicate that risks are possible. Mobile NAPL has the highest associated score (8) because of its highly concentrated nature and potential for increase in the size of the impacted zone.
Mobile NAPL High (>100x) Medium (10x to 100x) Low (1x to 10x) Do Not Know				
"Known" -score	6			
"Potential" - score	---			

CCME National Classification System (2008, 2010 v 1.2)

(I) Contaminant Characteristics

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method of Evaluation	Notes
4. Contaminant Quantity (known or strongly suspected)				
What is the known or strongly suspected quantity of all contaminants? >10 hectare (ha) or 5000 m^3 2 to 10 ha or 1000 to 5000 m^3 <2 ha or 1000 m^3 Do Not Know	<2 ha or 1000 m3	Impacts are defined within Rifle range area	Measure or estimate the area or quantity of total contamination (i.e, all contaminants known or strongly suspected to be present on the site). The "Area of Contamination" is defined as the area or volume of contaminated media (soil, sediment, groundwater, surface water) exceeding appropriate environmental criteria.	A larger quantity of a potentially toxic substance can result in a larger frequency of exposure as well as a greater probability of migration, therefore, larger quantities of these substances earn a higher score.
"Known" -score	2			
"Potential" - score	---			
5. Modifying Factors				
Does the chemical fall in the class of persistent chemicals based on its behavior in the environment? Yes No Do Not Know	No	No chemicals reported on site are classified as persistent chemicals.	Persistent chemicals, e.g., PCBs, chlorinated pesticides etc. either do not degrade or take longer to degrade, and therefore may be available to cause effects for a longer period of time. Canadian Environmental Protection Act (CEPA) classifies a chemical as persistent when it has at least one of the following characteristics: (a) in air, (i) its half-life is equal to or greater than 2 days, or (ii) it is subject to atmospheric transport from its source to a remote area; (b) in water, its half-life is equal to or greater than 182 days; (c) in sediments, its half-life is equal to or greater than 365 days; or (d) in soil, its half-life is equal to or greater than 182 days. This list does not include metals or metalloids, which in their elemental form do not degrade. However metals and metalloids form chemical species in the environment, many of which are not readily bioavailable.	*Examples of Persistent Substances are provided in attached Reference Materials*
Are there contaminants present that could cause damage to utilities and infrastructure, either now or in the future, given their location? Yes No Do Not Know	No	There are utilities present on site, however, the chemicals reported will not react with infrastructure.		Some contaminants may react or absorb into underground utilities and infrastructure. For example, organic solvents may degrade some plastics, and salts could cause corrosion of metal.
How many different contaminant classes have representative CCME guideline exceedances? one two to four five or more Do Not Know	one	Results of the ESI indicate the following with respect to Contaminant Classes: 1) Inorganic Substances	For the purposes of the revised NCS ranking system, the following chemicals represent distinct chemical "classes": inorganic substances (including metals), volatile petroleum hydrocarbons, light extractable petroleum hydrocarbons, heavy extractable petroleum hydrocarbons, PAHs, phenolic substances, chlorinated hydrocarbons, halogenated methanes, phthalate esters, pesticides.	*Refer to the Reference Material sheet for a list of example substances that fall under the various chemical classes.*
"Known" - Score	0			
"Potential" - Score	---			

Contaminant Characteristic Total

Raw Total Scores- "Known"	18
Raw Total Scores- "Potential"	3
Raw Combined Total Scores	21
Total Score (Raw Combined / 40 * 33)	**17.3**

(II) Migration Potential (Evaluation of contaminant migration pathways)

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method Of Evaluation	Notes
1. Groundwater Movement				
A. Known COPC exceedances and an operable groundwater pathway within and/or beyond the property boundary.				
i) For **potable groundwater environments**, 1) groundwater concentrations exceed background concentrations and 1X the Guideline for Canadian Drinking Water Quality (GCDWQ) or 2) there is known contact of contaminants with groundwater, based on physical evidence of groundwater contamination. For **non-potable environments** (typically urban environments with municipal services), 1) groundwater concentrations exceed 1X the applicable non potable guidelines or modified generic guidelines (which exclude ingestion of drinking water pathway) or 2) there is known contact of contaminants with groundwater, based on physical evidence of groundwater impacts.	12	Groundwater was not been assessed at the site.	Review chemical data and evaluate groundwater quality. The evaluation method concentrates on 1) a potable or non-potable groundwater environment; 2) the groundwater flow system and its potential to be an exposure pathway to known or potential receptors An aquifer is defined as a geologic unit that yields groundwater in usable quantities and drinking water quality. The aquifer can currently be used as a potable water supply or could have the potential for use in the future. Non-potable groundwater environments are defined as areas that are serviced with a reliable alternative water supply (most commonly provided in urban areas). The evaluation of a non-potable environment will be based on a site specific basis. Physical evidence includes significant sheens, liquid phase contamination, or contaminant saturated soils. Seeps and springs are considered part of the groundwater pathway. In Arctic environments, the potability and evaluation of the seasonal active layer (above the permafrost) as a groundwater exposure pathway will be considered on a site-specific basis.	The 1992 NCS rationale evaluated the off-site migration as a regulatory issue. The exposure assessment and classification of hazards should be evaluated regardless of the property boundaries. Someone experienced must provide a thorough description of the sources researched to determine the presence/absence of a groundwater supply source in the vicinity of the contaminated site. This information must be documented in the NCS Site Classification Worksheet including contact names, phone numbers, e-mail correspondence and/or reference maps/reports and other resources such as internet links. Note that for potable groundwater that also daylights into a nearby surface water body, the more stringent guidelines for both drinking water and protection of aquatic life should be considered. **Selected References** Potable Environments Guidelines for Canadian Drinking Water Quality www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/doc_sup-appui/sum_guide-res_recom/index_e.html Non-Potable Environments Canadian Water Quality Guidelines for Protection of Aquatic Life. CCME. 1999 www.ccme.ca Compilation and Review of Canadian Remediation Guidelines, Standards and Regulations. Science Applications International Corporation (SAIC Canada), report to Environment Canada, January 4, 2002.
ii) Same as (i) except the information is not known but strongly suspected based on indirect observations.	9			
iii) Meets GCDWQ for **potable environments**; meets non-potable criteria or modified generic criteria (excludes ingestion of drinking water pathway) for **non-potable environments** **or** Absence of groundwater exposure pathway (i.e., there is no aquifer (see definition at right) at the site or there is an adequate isolating layer between the aquifer and the contamination, and within 5 km of the site there are no aquatic receiving environments and the groundwater does not daylight).	0			
	Go to Potential			
Score	---			
NOTE: If a score is assigned here for Known COPC Exceedances, then you can skip Part B (Potential for groundwater pathway) and go to Section 2 (Surface Water Pathway)				
B. Potential for groundwater pathway.				
a. Relative Mobility High Moderate Low Insignificant Do Not Know	Low	Metals generally have low mobilty	Organics Koc (L/kg) — Metals with higher mobility at acidic conditions — Metals with higher mobility at alkaline conditions Koc < 500 (i.e., log Koc < 2.7) — pH < 5 — pH > 8.5 Koc = 500 to 5000 (i.e., log Koc = 2.7 to 3.7) — pH = 5 to 6 — pH = 7.5 to 8.5 Koc = 5,000 to 100,000 (i.e., log Koc = 3.7 to 5) — pH > 6 — pH < 7.5 Koc > 100,000 (i.e., log Koc > 5)	Reference: US EPA Soil Screening Guidance (Part 5 - Table 39) If a score of zero is assigned for relative mobility, it is still recommended that the following sections on potential for groundwater pathway be evaluated and scored. Although the Koc of an individual contaminant may suggest that it will be relatively immobile, it is possible that, with complex mixtures, there could be enhanced mobility due to co-solvent effects. Therefore, the Koc cannot be relied on solely as a measure of mobility. An evaluation of other factors such as containment, thickness of confining layer, hydraulic conductivities and precipitation infiltration rate are still useful in predicting potential for groundwater migration, even if a contaminant is expected to have insignificant mobility based on its chemistry alone.
Score	1			
b. Presence of engineered sub-surface containment? No containment Partial containment Full containment Do Not Know	No containment	Sub surface containment is not present on site.	Review the existing engineered systems or natural attenuation processes for the site and determine if full or partial containment is achieved. Full containment is defined as an engineered system or natural attenuation processes, monitored as being effective, which provide for full capture and/or treatment of contaminants. All chemicals of concern must be contained for "Full Containment" scoring. Natural attenuation must have sufficient data, and reports cited with monitoring data to support steady state conditions and the attenuation processes. If there is no containment or insufficient natural attenuation process, this category is evaluated as high. If there is less than full containment or if uncertain, then evaluate as medium. In Arctic environments, permafrost will be evaluated, as appropriate, based on detailed evaluations, effectiveness and reliability to contain/control contaminant migration.	Someone experienced must provide a thorough description of the sources researched to determine the containment of the source at the contaminated site. This information must documented in the NCS Site Classification Worksheet including contact names, phone numbers, e-mail correspondence and/or reference maps, geotechnical reports or natural attenuation studies and other resources such as internet links. **Selected Resources:** United States Environmental Protection Agency (USEPA) 1998. Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater. EPA/600/R-98/128. Environment Canada – Ontario Region – Natural Attenuation Technical Assistance Bulletins (TABS) Number 19 –21.
Score	3			
c. Thickness of confining layer over aquifer of concern o groundwater exposure pathway 3 m or less including no confining layer or discontinuous confining layer 3 to 10 m > 10 m Do Not Know	3 m or less		The term "confining layer" refers to geologic material with little or no permeability or hydraulic conductivity (such as unfractured clay); water does not pass through this layer or the rate of movement is extremely slow. Measure the thickness and extent of materials that will impede the migration of contaminants to the groundwater exposure pathway. The evaluation of this category is based on: 1) The presence and thickness of saturated subsurface materials that impede the vertical migration of contaminants to lower aquifer units which can or are used as drinking water sources or 2) The presence and thickness of unsaturated subsurface materials that impede the vertical migration of contaminants from the source location to the saturated zone (e.g., water table aquifer, first hydrostratigraphic unit or other groundwater pathway).	
Score	1			
d. Hydraulic conductivity of confining layer $>10^{-4}$ cm/s or no confining layer 10^{-4} to 10^{-6} cm/s $<10^{-6}$ cm/s Do Not Know	10-4 to 10-6 cm/s	Soils present at the site are silty sands and clay.	Determine the nature of geologic materials and estimate hydraulic conductivity from published material (or use "Range of Values of Hydraulic Conductivity and Permeability" figure in the Reference Material sheet). Unfractured clays should be scored low. Silts should be scored medium. Sand, gravel should be scored high. The evaluation of this category is based on: 1) The presence and hydraulic conductivity ("K") of saturated subsurface materials that impede the vertical migration of contaminants to lower aquifer units which can or are used as a drinking water source, groundwater exposure pathway or 2) The presence and permeability ("k") of unsaturated subsurface materials that impede the vertical migration of contaminants from the source location to the saturated water table aquifer, first hydrostratigraphic unit or other groundwater pathway.	
Score	0.5			

(II) Migration Potential (Evaluation of contaminant migration pathways)

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method Of Evaluation	Notes
B. Potential for groundwater pathway.				
e. Precipitation infiltration rate (Annual precipitation factor x surface soil relative permeability factor) High Moderate Low Very Low None Do Not Know	Low	Environment Canada Climate Normals indicate Red Deer, Alberta (nearest weather station) to have an average annual precipitation of 522 mm. Surface soils are a mix of silty sand and clay leading to a classification of loam and a permmeability factor of 0.15. =0.5 x 0.3 = 0.15	Precipitation Refer to Environment Canada precipitation records for relevant areas. Divide annual precipitation by 1000 and round to nearest tenth (e.g., 667 mm = 0.7 score). Permeability For surface soil relative permeability (i.e., infiltration) assume: gravel (1), sand (0.6), loam (0.3) and pavement or clay (0). Multiply the surface soil relative permeability factor with precipitation factor to obtain the score for precipitation infiltration rate.	
Score	0.4			
f. Hydraulic conductivity of aquifer $>10^{-2}$ cm/s 10^{-2} to 10^{-4} cm/s $<10^{-4}$ cm/s Do Not Know	<10-4 cm/s	The geological materials in the area consist of shale and sandstone. The hydraulic conductivity those materials range from 10-6 to 10-7.	Determine the nature of geologic materials and estimate hydraulic conductivity of all aquifers of concern from published material (refer to "Range of Values of Hydraulic Conductivity and Permeability" in the Reference Material sheet).	
Score	0			
Potential groundwater pathway total	5.9			
Allowed Potential score	5.9	Note: If a "known" score is provided, the "potential" score is disallowed.		
Groundwater pathway total	**5.9**			
2. Surface Water Movement				
A. Demonstrated migration of COPC in surface water above background conditions				
Known concentrations of surface water: i) Concentrations exceed background concentrations and exceed CCME CWQG for protection of aquatic life, irrigation, livestock water, and/or recreation (whichever uses are applicable at the site) by >1 X; or There is known contact of contaminants with surface water based on site observations. or In the absence of CWQG, chemicals have been proven to be toxic based on site specific testing (e.g. toxicity testing; or other indicator testing of exposure).	12	Surface water was not assessed.	Collect all available information on quality of surface water near to site. Evaluate available data against Canadian Water Quality Guidelines (select appropriate guidelines based on local water us e.g., recreation, irrigation, aquatic life, livestock watering, etc.). The evaluation method concentrates on the surface water flow system and its potential to be an exposure pathway. Contamination is present on the surface (above ground) and has the potential to impact surface water bodies. Surface water is defined as a water body that supports one of the following uses: recreation, irrigation, livestock watering, aquatic life.	General Notes: Someone experienced must provide a thorough description of the sources researched to classify the surface water body in the vicinity of the contaminated site. This information must be documented in the NCS Site Classification Worksheet including contact names, phone numbers, e-mail correspondence and/or reference maps/reports and other resource such as internet links. Selected References: CCME. 1999. Canadian Water Quality Guidelines for the Protection of Aquatic Life www.ccme.ca CCME. 1999. Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses (Irrigation and Livestock Water) www.ccme.ca Health and Welfare Canada. 1992. Guidelines for Canadian Recreational Water Quality.
ii) Same as (i) except the information is not known but strongly suspected based on indirect observations.	8			
iii) Meets CWQG or absence of surface water exposure pathway (i.e., Distance to nearest surface water is > 5 km.)	0			
Score	Go to Potential ---			
NOTE: If a score is assigned here for Demonstrated Migration in Surface Water, then you can skip Part B (Potential for migration of COPCs in surface water) and go to Section 3 (Surface Soils)				
B. Potential for migration of COPCs in surface water				
a. Presence of containmen No containmen Partial containmen Full containmen Do Not Know	No containment	No containment is present on site.	Review the existing engineered systems and relate these structures to site conditions and proximity to surface water and determine if full containment is achieved: score low if there is full containment such as capping, berms, dikes; score medium if there is partial containment such as natural barriers, trees, ditches, sedimentation ponds; score high if there are no intervening barriers between the site and nearby surface water. Full containment must include containment of all chemicals.	
Score	5			
b. Distance to Surface Water 0 to <100 m 100 - 300 m >300 m Do Not Know	100 - 300 m	No standing water is present on site. The nearest surface water is a creek approximatly 300 metres east of the site.	Review available mapping and survey data to determine distance to nearest surface water bodies.	
Score	2			

(II) Migration Potential (Evaluation of contaminant migration pathways)

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method Of Evaluation	Notes
c. Topography Contaminants above ground level and slope is stee Contaminants at or below ground level and slope is stee Contaminants above ground level and slope is intermedia Contaminants at or below ground level and slope is intermedia Contaminants above ground level and slope is fl Contaminants at or below ground level and slope is fl Do Not Know	Above and intermed Score 1.5	The rifle range is located on a rolling hill with an intermittent slope. Contaminants are at the surface.	Review engineering documents on the topography of the site and the slope of surrounding terrain. Steep slope = >50% Intermediate slope = between 5 and 50% Flat slope = < 5% Note: Type of fill placement (e.g., trench, above ground, etc.).	
d. Run-off potential High (rainfall run-off score > 0.6) Moderate (0.4 < rainfall run-off score <0.6) Low (0.2 < rainfall run-off score <0.4) Very Low (0 < rainfall run-off score < 0.2) None (rainfall run-off score = 0) Do Not Know	Very Low Score 0.2	Environment Canada Climate Normals indicate Red Deer, Alberta (nearest weather station) to have an average annual precipitation of 522 mm. Surface soils are a mix of silty sand and clay leading to a classification of loam and a permmeability factor of 0.15. =0.5 x 0.3 = 0.15	Rainfall Refer to Environment Canada precipitation records for relevant areas. Divide rainfall by 1000 and round to nearest tenth (e.g., 667 mm = 0.7 score). The former definition of "annual rainfall" did not include the precipitation as snow. This minor adjustment has been made. The second modification was the inclusion of permeability of surface materials as an evaluation factor. Permeability For infiltration assume: gravel (0), sand (0.3), loam (0.6) and pavement or clay (1). Multiply the infiltration factor with precipitation factor to obtain rainfall run off score.	Selected Sources: Environment Canada web page linkwww.msc.ec.gc.ca Snow to rainfall conversion apply ratio of 15 (snow):1(water)
e. Flood potentia 1 in 2 years 1 in 10 years 1 in 50 years Not in floodplair Do Not Know	1 in 50 years Score 0.2	Drumheller Institution is located just outside the "Flood Fringe" according to the Alberta Governments Flood Hazards Mapping Application.	Review published data such as flood plain mapping or flood potential (e.g., spring or mountain run-off) and Conservation Authority records to evaluate flood potential of nearby water courses both up and down gradient. Rate zero if site not in flood plain.	
Potential surface water pathway total Allowed Potential score **Surface water pathway total**	8.9 8.9 **8.9**	Note: If a "known" score is provided, the "potential" score is disallowed.		
3. Surface Soils (potential for dust, dermal and ingestion exposure)				
A. Demonstrated concentrations of COPC in surface soils (top 1.5 m)				
COPCs measured in surface soils exceed the CCME soil quality guideline. Strongly suspected that soils exceed guidelines COPCs in surface soils does not exceed the CCME soil quality guideline or is not present (i.e., bedrock).	12 9 0 12 Score 12	As documented in the Franz 2010 ESI and slope stability analysis, the following contaminants were documented to exceed CCME criteria in soil at the Rifle Range Site: antimony, arsenic, copper, lead and tin	Collect all available information on quality of surface soils (i.e., top 1.5 metres) at the site. Evaluate available data against Canadian Soil Quality Guidelines. Select appropriate guidelines based on current (or proposed future) land use (i.e, agricultural, residential/parkland, commercial, or industrial), and soil texture if applicable (i.e., coarse or fine).	Selected References: CCME. 1999. Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health www.ccme.ca
NOTE: If a score is assigned here for Demonstrated Concentrations in Surface Soils, then you can skip Part B (Potential for a surface soils migration pathway) and go to Section 4 (Vapour)				
B. Potential for a surface soils (top 1.5 m) migration pathway				
a. Are the soils in question covered? Exposed Vegetatec Landscaped Paved Do Not Know	Do Not Know Score 4	Scored as known	Consult engineering or risk assessment reports for the site. Alternatively, review photographs or perform a site visit. Landscaped surface soils must include a minimum of 0.5 m of topsoil.	The possibility of contaminants in blowing snow have not been included in the revised NC as it is difficult to assess what constitutes an unacceptable concentration and secondly, spills to snow or ice are most efficiently mitigated while freezing conditions remain.
b. For what proportion of the year does the site remain covered t snow? 0 to 10% of the yea 10 to 30% of the yea More than 30% of the yea Do Not Know	Do Not Know Score 3	Scored as known	Consult climatic information for the site. The increments represent the full span from soils which are always wet or covered with snow (and therefore less likely to generate dust) to those soils which are predominantly dry and not covered by snow (and therefore are more likely to generate dust).	
Potential surface soil pathway total Allowed Potential score **Soil pathway total**	7 --- **12**	**Note: If a "known" score is provided, the "potential" score is disallowed.**		

(II) Migration Potential (Evaluation of contaminant migration pathways)

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method Of Evaluation	Notes
4. Vapour				
A. Demonstrated COPCs in vapour.				
Vapour has been measured (indoor or outdoor) in concentrations exceeding risk based concentrations.	12		Consult previous investigations, including human health risk assessments, for reports of vapours detected.	
Strongly suspected (based on observations and/or modelling)	9			
Vapour has not been measured and volatile hydrocarbons have not been found in site soils or groundwater.	0			
	Go to Potential			
Score	---			
NOTE: If a score is assigned here for Demonstrated COPCs in Vapour, then you can skip Part B (Potential for COPCs in vapour) and go to Section 5 (Sediment)				
B. Potential for COPCs in vapour				
a. Relative Volatility based on Henry's Law Constant, H (dimensionless) High (H' > 1.0E-1) Moderate (H' = 1.0E-1 to 1.0E-3 Low (H' < 1.0E-3) Not Volatile Do Not Know		The Henry's Law Constants (dimensionless) is not available in the reference materials for the exceeding chemical. Inorganics have low volatility.	Reference: US EPA Soil Screening Guidance (Part 5 - Table 36) *Provided in Attached Reference Materials*	If the Henry's Law Constant for a substance indicates that it is not volatile, and a score of zero is assigned here for relative volatility, then the other three questions in this section on Potential for COPCs will be automatically assigned scores of zero and you can skip to section 5.
	Not Volatile			
Score	0			
b. What is the soil grain size? Fine Coarse Do Not Know		Results of test pit excavation indicate these soils are primarily fine grained.	Review soil permeability data in engineering reports. The greater the permeability of soils, the greater the possible movement of vapours. Fine-grained soils are defined as those which contain greater than 50% by mass particles less than 75 µm mean diameter (D50 < 75 µm). Coarse-grained soils are defined as those which contain greater than 50% by mass particles greater than 75 µm mean diameter (D50 > 75 µm).	
	Fine			
Score	0			
c. Is the depth to the source less than 10m? Yes No Do Not Know		Source is within 10m of the surface. Impacts reported from surface samples.	Review groundwater depths below grade for the site.	
	Yes			
Score	0			
d. Are there any preferential pathways? Yes No Do Not Know		Bedrock was not observed on site.	Visit the site during dry summer conditions and/or review available photographs. Where bedrock is present, fractures would likely act as preferential pathyways.	Preferential pathways refer to areas where vapour migration is more likely to occur becau there is lower resistance to flow than in the surrounding materials. For example, underground conduits such as sewer and utility lines, drains, or septic systems may serve as preferential pathways. Features of the building itself that may also be preferential pathways include earthen floors, expansion joints, wall cracks, or foundation perforations for subsurface features such as utility pipes, sumps, and drains.
	No			
Score	0			
Potential vapour pathway total	0			
Allowed Potential score	0	Note: If a "known" score is provided, the "potential" score is disallowed.		
Vapour pathway total	**0**			
5. Sediment Movement				
A. Demonstrated migration of sediments containing COPCs				
There is evidence to suggest that sediments originally deposited to the site (exceeding the CCME sediment quality guidelines) have migrated.	12	Sediments were not assessed.	Review sediment assessment reports. Evidence of migration of contaminants in sediments must be reported by someone experienced in this area.	Usually not considered a significant concern in lakes/marine environments, but could be very important in rivers where transport downstream could be significant.
Strongly suspected (based on observations and/or modelling)	9			
Sediments have been contained and there is no indication that sediments will migrate in future. **or** Absence of sediment exposure pathway (i.e., within 5 km of the site there are no aquatic receiving environments, and therefore no sediments).	0			
	Go to Potential			
Score	---			
NOTE: If a score is assigned here for Demonstrated Migration of Sediments, then you can skip Part B (Potential for Sediment Migration) and go to Section 6 (Modifying Factors)				

CCME National Classification System (2008, 2010 v 1.2)

(II) Migration Potential (Evaluation of contaminant migration pathways)

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method Of Evaluation	Notes
B. Potential for sediment migration				
a. Are the sediments having COPC exceedances capped with sediments having no exceedances ("clean sediments")?	Do Not Know		Review existing sediment assessments. If sediment coring has been completed, it may indicate th historically contaminated sediments have been covered over by newer "clean" sediments. This assessment will require that cores collected demonstrate a low concentration near the top and higher concentration with sediment depth.	
Yes No Do Not Know	2			
b. For lakes and marine habitats, are the contaminated sediments in shallow water and therefore likely to be affected by tidal action, wave action or propeller wash?	No	Lake and marine habitats are not present on site.	Review existing sediment assessments. If the sediments present at the site are in a river, select "no" for this question.	
Yes No Do Not Know	0			
c. For rivers, are the contaminated sediments in an area prone t sediment scouring?	No	No, surface water creeks are low flowing.	Review existing sediment assessments. It is important that the assessment is made under worst case flows (high yearly flows). Under high yearly flows, areas which are commonly depositional m	
Yes No Do Not Know	0			
Potential sediment pathway total	2			
Allowed Potential score	2	Note: If a "known" score is provided, the "potential" score is disallowed.		
Sediment pathway total	**2**			
6. Modifying Factors				
Are there subsurface utility conduits in the area affected b contamination?	Do Not Know	There are subsurface utilities present on site. Metal impacts on these utilities are unknown.	Consult existing engineering reports. Subsurface utilities can act as conduits for contaminant migration.	
Yes No Do Not Know				
Known	---			
Potentia	2			

Migration Potential Total		
Raw "known" total	12	
Raw "potential" tota	18.8	
Raw combined tota	30.8	Note: If "Known" and "Potential" scores are provided, the checklist defaults to known. Therefore,
Total (max 33)	**15.9**	the total "Potential" Score may not reflect the sum of the individual "Potential" scores.

(III) Exposure (Demonstrates the presence of an exposure pathway and receptors)

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method Of Evaluation	Notes
1. Human				
A. Known exposure				
Documented adverse impact or high quantified exposure which has or will result in an adverse effect, injury or harm or impairment of the safety to humans as a result of the contaminated site. (Class 1 Site*) Same as above, but "Strongly Suspected" based on observations or indirect evidence. No quantified or suspected exposures/impacts in humans. Score	22 10 0 Go to Potential ---		*Where adverse effects on humans are documented, the site should be automatically designated as a Class 1 site (i.e., action required). There is no need to proceed through the NCS in this case. However, a scoring guideline (22) is provided in case a numerical score for the site is still desired (e.g., for comparison with other Class 1 sites). This category can be based on the outcomes of risk assessments and applies to studies which have reported Hazard Quotients >1 for noncarcinogenic chemicals and incremental cancer risks that exceed acceptable levels defined by the jurisdiction for carcinogenic chemicals (for most jurisdictions this is typically either >10^{-5} or >10^{-6}). Known impacts can also be evaluated based on blood testing (e.g. blood lead >10 ug/dL) or other health based testing. This category can be based on the outcomes of risk assessments and applies to studies which have reported Hazard Quotients of less than 0.2 for non-carcinogenic chemicals and incremental lifetime cancer risks for carcinogenic chemicals that are within acceptable levels as defined by the jurisdiction (for most jurisdictions this is less than either 10^{-6} or 10^{-5}).	Known adverse impact includes domestic and traditional food sources. Adverse effects based on food chain transfer to humans and/or animals can be scored in this category. However, the weight of evidence must show a direct link of a contaminated food source/supply and subsequent ingestion/transfer to humans. Any associated adverse effects to the environment are scored separately later in this worksheet. Someone experienced must provide a thorough description of the sources researched to evaluate and determine the quantified exposure/impact (adverse effect) in the vicinity of the contaminated site. **Selected References:** Health Canada – Federal Contaminated Site Risk Assessment in Canada Parts 1 and 2 Guidance on Human Heath Screening Level Risk Assessments (www.hc-sc.gc.ca/ewh-semt/pubs/contamsite/index_e.html) United States Environmental Protection Agency, Integrated Risk Information System (IRIS) http://toxnet.nml.nih.gov
NOTE: If a score is assigned here for Known Exposure, then you can skip Part B (Potential for Human Exposure) and go to Section 2 (Human Exposure Modifying Factors)				
B. Potential for human exposure				
a) Land use (provides an indication of potential human exposure scenarios) Agricultural Residential / Parkland Commercial Industrial Do Not Know Score	Agricultural 3	Drumheller Institution is located on agricultural lands.	Review zoning and land use maps over the distances indicated. If the proposed future land use is more "sensitive" than the current land use, evaluate this factor assuming the proposed future use is in place. Agricultural land use is defined as uses of land where the activities are related to the productive capability of the land or facility (e.g., greenhouse) and are agricultural in nature, or activities related to the feeding and housing of animals as livestock. Residential/Parkland land uses are defined as uses of land on which dwelling on a permanent, temporary, or seasonal basis is the activity (residential), as well as uses on which the activities are recreational in nature and require the natural or human designed capability of the land to sustain that activity (parkland). Commercial/Industrial land uses are defined as land on which the activities are related to the buying, selling, or trading of merchandise or services (commercial), as well as land uses which are related to the production, manufacture, or storage of materials (industrial).	This is the main "receptor" factor used in site scoring. A higher score implies a greater exposure and/or exposure of more sensitive human receptors (e.g., children).
b. Indicate the level of accessibility to the contaminated portion of the si (e.g., the potential for coming in contact with contamination) Limited barriers to prevent site access; contamination not covered Moderate access or no intervening barriers, contaminants are covered. Remote locations in which contaminants not covered. Controlled access or remote location and contaminants are covered Do Not Know Score	Controlled or remote 0	The site is located within a controlled environment. Limited access to site available as area is fenced off.	Review location and structures and contaminants at the site and determine if there are intervening barriers between the site and humans. A low rating should be assigned to a (covered) site surrounded by a fence or in a remote location, whereas a high score should be assigned to a site that has no cover, fence, natural barriers or buffer.	
B. Potential for human exposure				
c) Potential for intake of contaminated soil, water, sediment or foods for operable or potentially operable pathways, as identified in Worksheet II (Migration Potential). i) direct contact Is dermal contact with contaminated surface water, groundwater, sediments or soils anticipated? Yes No Do Not Know Score	Yes 3	Surface soils exceed CCME criteria for several metals .	If soils or potable groundwater are present exceeding their respective CCME guidelines, dermal contact is assumed. Exposure to surface water, non-potable groundwater or sediments exceeding their respective CCME guidelines will depend on the site. Select "Yes" if dermal exposure to surface water, non-potable groundwater or sediments is expected. For instance, dermal contact with sediments would not be expected in an active port. Only soils in the top 1.5 m are defined by CCME (2003) as surface soils. If contaminated soils are only located deeper than 1.5 m, direct contact with soils is not anticipated to be an operable contaminant exposure pathway.	Exposure via the skin is generally believed to be a minor exposure route. However for some organic contaminants, skin exposure can play a very important component of overall exposure. Dermal exposure can occur while swimming in contaminated waters, bathing with contaminated surface water/groundwater and digging in contaminated dirt, etc.
ii) inhalation (i.e., inhalation of dust, vapour) Vapour - Are there inhabitable buildings on the site within 30 m of soils or groundwater with volatile contamination as determined in Worksheet II (Migration Potential)? Yes No Do Not Know Score	Yes 3	One inhabitable building is located on site.	If inhabitable buildings are on the site within 30 m of soils or groundwater exceeding their respective guidelines for volatile chemicals, there is a potential of risk to human health (Health Canada, 2004). Review site investigations for location of soil samples (having exceedances of volatile substances) relative to buildings. Refer to (II) Migration Potential worksheet, 4B.a) *Potential for COPCs in Vapour* for a definition of volatility.	Exposure via the lungs (inhalation) can be a very important exposure pathway. Inhalation can be via both particulates (dust) and gas (vapours). Vapours can be a problem where buildings have been built on former industrial sites or where volatile contaminants have migrated below buildings resulting in the potential for vapour intrusion. Assesses the potential for humans to be exposed to vapours originating from site soils. The closer the receptor is to a source of volatile chemicals in soil, the greater the potential of exposure. Also, coarser-grained soil will convey vapour much more efficiently in the soil than finer grained material such as clays and silts. General Notes; Someone experienced must provide a thorough description of the sources researched to determine the presence/absence of a vapour migration and/or dust generation in the vicinity of the contaminated site. This information must be documented in the NCS Site Classification Worksheet including contact names, phone numbers, e-mail correspondence and/or reference maps/reports and other resource such as internet links. Selected References; Canadian Council of Ministers of the Environment (CCME). 2006. Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines. PN 1332 www.ccme.ca Golder, 2004. Soil Vapour Intrusion Guidance for Health Canada Screening Level Risk Assessment (SLRA) Submitted to Health Canada, Burnaby, BC
Dust - If there is contaminated surface soil (e.g. top 1.5 m) , indicate whether the soil is fine or coarse textured. If it is known that surface soil is not contaminated, enter a score of zero. Fine Coarse Surface soil is not contaminated or absent (bedrock) Do Not Know Texture Score inhalation total	Fine 3 6	Soils are fine grained.	Consult grain size data for the site. If soils (containing exceedances of the CCME soil quality guidelines) predominantly consist of fine material (having a median grain size of 75 microns; as defined by CCME (2006)) then these soils are more likely to generate dusts.	

(III) Exposure (Demonstrates the presence of an exposure pathway and receptors)

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method Of Evaluation	Notes
B. Potential for human exposure				
iii) Ingestion (i.e., ingestion of food items, water and soils [for children]), including traditional foods. Drinking Water: Choose a score based on the proximity to a drinking water supply, to indicate the potential for contamination (present or future). 0 to 100 m 100 to 300 m 300 m to 1 km 1 to 5 km No drinking water present Do Not Know	No drinking water preser	A creek is present approx. 300 m to the east. However, drinking water on site is provided by the Muncipality of Drumheller.	Review available site data to determine if drinking water (groundwater, surface water, private, commercial or municipal supply) is known or suspected to be contaminated above Guidelines for Canadian Drinking Water Quality. If drinking water supply is known to be contaminated, some immediate action (e.g., provision of alternate drinking water supply) should be initiated to reduce or eliminate exposure. The evaluation of significant potential for exceedances of the water supply in the future may be based on the capture zones of the drinking water wells; contaminant travel times; computer modelling of flow and contaminant transport.	**Selected References:** Guidelines for Canadian Drinking Water Quality www.hc-sc.gc.ca/hecs-sesc/water/publications/drinking_water_quality_guidelines/toc.htm Drinking water can be an extremely important exposure pathway to humans. If site groundwater or surface water is not used for drinking, then this pathway is considered to be inoperable. Consider both wild foods such as salmon, venison, caribou, as well as agricultural sources of food items if the contaminated site is on or adjacent to agricultural land uses.
Score	0			
Is an alternative water supply readily available? Yes No Do Not Know	No	There are no other water supplies nearby.		
Score	1			
Is human ingestion of contaminated soils possible? Yes No Do Not Know	Yes	Contaminated surface soils could be ingested while at the site, however, it is unlikley.	If contaminated soils are located within the top 1.5 m, it is assumed that ingestion of soils is an operable exposure pathway. Exposure to soils deeper than 1.5 m is possible, but less likely, and the duration is shorter. Refer to human health risk assessment reports for the site in question.	
Score	3			
Are food items consumed by people, such as plants, domestic animals or wildlife harvested from the contaminated land and its surroundings? Yes No Do Not Know	No	Hunting and scavaging does not occur at the site. Limited access to the area.	Use human health risk assessment reports (or others) to determine if there is significant reliance on traditional food sources associated with the site. Is the food item in question going to spend a large proportion of its time at the site (e.g., large mammals may spend a very small amount of time at a small contaminated site)? Human health risk assessment reports for the site in question will also provide information on potential bioaccumulation of the COPC in question.	
Score	0			
Ingestion total	4			
Human Health Total "Potential" Score	16	Note if a "Known" Human Health score is provided, the "Potential" score is disallowed.		
Allowed "Potential" Score	16			
2. Human Exposure Modifying Factors				
a) Strong reliance of local people on natural resources for survival (i.e., food, water, shelter, etc.) Yes No Do Not Know	No	Hunting for subsistence does not occur at the site. Limited access to the area. Area is fenced.		
Known	0			
Potential	---			
Raw Human "known" total	0			
Raw Human "potential" total	16			
Raw Human Exposure Total Score	16			
Human Health Total (max 22)	**16.0**			
3. Ecological				
A. Known exposure				
Documented adverse impact or high quantified exposure which has or will result in an adverse effect, injury or harm or impairment of the safety to terrestrial or aquatic organisms as a result of the contaminated site.	18		Some low levels of impact to ecological receptors are considered acceptable, particularly on commercial and industrial land uses. However, if ecological effects are deemed to be severe, the site may be categorized as class one (i.e., a priority for remediation or risk management), regardless of a numerical total NCS score. For the purpose of application of the NCS, effects that would be considered severe include observed effects on survival, growth or reproduction which could threaten the viability of a population of ecological receptors at the site. Other evidence that qualifies as severe adverse effects may be determined based on professional judgement and in consultation with the relevant jurisdiction. If ecological effects are determined to be severe and an automatic Class 1 is assigned, there is no need to proceed through the NCS. However, a scoring guideline (18) is provided in case a numerical score for the site is still desired (e.g., for comparison with other Class 1 sites). This category can be based on the outcomes of risk assessments and applies to studies which have reported Hazard Quotients >1. Alternatively, known impacts can also be evaluated based on a weight of evidence assessment involving a combination of site observations, tissue testing, toxicity testing and quantitative community assessments. Scoring of adverse effects on individual rare or endangered species will be completed on a case-by-case basis with full scientific justification.	CCME, 1999: Canadian Water Quality Guidelines for the Protection of Aquatic Life www.ccme.ca CCME, 1999: Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses www.ccme.ca Sensitive receptors- review: Canadian Council on Ecological Areas www.ccea.org Ecological effects should be evaluated at a population or community level, as opposed to at the level of individuals. For example, population-level effects could include reduced reproduction, growth or survival in a species. Community-level effects could include reduced species diversity or relative abundances. Further discussion of ecological assessment endpoints is provided in *A Framework for Ecological Risk Assessment: General Guidance* (CCME 1996). Notes: Someone experienced must provide a thorough description of the sources researched to classify the environmental receptors in the vicinity of the contaminated site. This information must be documented in the NCS Site Classification Worksheet including contact names, phone numbers, e-mail correspondence and/or reference maps/reports and other resource such as internet links.
Same as above, but "Strongly Suspected" based on observations or indirect evidence.	12		This category can be based on the outcomes of risk assessments and applies to studies which have reported Hazard Quotients of less than 1 and no other observable or measurable sign of impacts. Alternatively, it can be based on a combination of other lines of evidence showing no adverse effects, such as site observations, tissue testing, toxicity testing and quantitative community assessments.	
No quantified or suspected exposures/impacts in terrestrial or aquatic organisms	0			
	Go to Potential			
Score	---			
NOTE: If a score is assigned here for Known Exposure, then you can skip Part B (Potential for Ecological Exposure) and go to Section 4 (Ecological Exposure Modifying Factors)				

(III) Exposure (Demonstrates the presence of an exposure pathway and receptors)

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method Of Evaluation	Notes
B. Potential for ecological exposure (for the contaminated portion of the site)				
a) Terrestrial i) Land use Agricultural (or Wild lands) Residential/Parkland Commercial Industrial Do Not Know	Agricultural (or Wild lands Score 3	Drumheller Institution is located on agricultural lands.	Review zoning and land use maps. If the proposed future land use is more "sensitive" than the current land use, evaluate this factor assuming the proposed future use is in place (indicate in the worksheet that future land use is the consideration). Agricultural land use is defined as uses of land where the activities are related to the productive capability of the land or facility (e.g., greenhouse) and are agricultural in nature, or activities related to the feeding and housing of animals as livestock. Wild lands are grouped with agricultural land due to the similarities in receptors that would be expected to occur there (e.g., herbivorous mammals and birds) and the similar need for a high level of protection to ensure ecological functioning. Residential/Parkland land uses are defined as uses of land on which dwelling on a permanent, temporary, or seasonal basis is the activity (residential), as well as uses on which the activities are recreational in nature and require the natural or human designed capability of the land to sustain that activity (parkland). Commercial/Industrial land uses are defined as land on which the activities are related to the buying, selling, or trading of merchandise or services (commercial), as well as land uses which are related to the production, manufacture, or storage of materials (industrial).	
ii) Uptake potential Direct Contact - Are plants and/or soil invertebrates likely exposed to contaminated soils at the site? Yes No Do Not Know	Yes Score 1	Surface soils exceed CCME criteria for several metals.	If contaminated soils are located within the top 1.5 m, it is assumed that direct contact of soils with plants and soil invertebrates is an operable exposure pathway. Exposure to soils deeper than 1.5 m is possible, but less likely.	
iii) Ingestion (i.e., wildlife or domestic animals ingesting contaminated food items, soils or water) Are terrestrial animals likely to be ingesting contaminated water at the site? Yes No Do Not Know	Do Not Know Score 0.5	The nearest surface water to the site is approximately 300 metres to the east. Surface water has not be assessed at this time.	Refer to an Ecological Risk Assessment for the site. If there is contaminated surface water at the site, assume that terrestrial organisms will ingest it.	
Are terrestrial animals likely to be ingesting contaminated soils at the site? Yes No Do Not Know	Yes Score 1	Surface soils exceed CCME criteria for several metals. Terrestrial animals may ingest soil through consumption of plants or subsurface invertebrates.	Refer to an Ecological Risk Assessment report. Most animals will co-ingest some soil while eating plant matter or soil invertebrates.	
Can the contamination identified bioaccumulate? Yes No Do Not Know	No Score 0	Chemicals that were reported on site will not bioaccumulate.	Bioaccumulation of contaminants within food items is considered possible if: 1) The Log(Kow) of the contaminant is greater than 4 (as per the chemical characteristics work sheet) and concentrations in soils exceed the most conservative CCME soil quality guideline for the intended land use, or 2) The contaminant in collected tissue samples exceeds the Canadian Tissue Residue Guidelines.	
Distance to sensitive terrestrial ecological area 0 to 300 m 300 m to 1 km 1 to 5 km > 5 km Do Not Know	1 to 5 km Score 1	Midland Park is approximately 4 km northwest of the site. (www.ccea.org)	It is considered that within 300 m of a site, there is a concern for contamination. Therefore an environmental receptor located within this area of the site will be subject to further evaluations. It is also considered that any environmental receptor located greater than 5 km will not be a concern for evaluation. Review Conservation Authority mapping and literature including Canadian Council on Ecological Areas link:www.ccea.org	Environmental receptors include: local, regional or provincial species of interest or significance; arctic environments (on a site specific basis); nature preserves, habitats for species at risk, sensitive forests, natural parks or forests.
Raw Terrestrial Total Potential	6.5	Note if a "Known" Ecological Effects score is provided, the "Potential" score is disallowed.		
Allowed Terrestrial Total Potential	6.5			
B. Potential for ecological exposure (for the contaminated portion of the site)				
b) Aquatic i) Classification of aquatic environment Sensitive Typical Not Applicable (no aquatic environment present) Do Not Know	Typical Score 1	The nearest surface water to the site is approximately 300 metres to the east - this creek would be considered typical for the area.	"Sensitive aquatic environments" include those in or adjacent to shellfish or fish harvesting areas, marine parks, ecological reserves and fish migration paths. Also includes those areas deemed to have ecological significance such as for fish food resources, spawning areas or having rare or endangered species. "Typical aquatic environments" include those in areas other than those listed above.	
ii) Uptake potential Does groundwater daylighting to an aquatic environment exceed the CCME water quality guidelines for the protection of aquatic life at the point of contact? Yes No (or Not Applicable) Do Not Know	Do Not Know Score 0.5		Groundwater concentrations of contaminants at the point of contact with an aquatic receiving environment can be estimated in three ways: 1) by comparing collected nearshore groundwater concentrations to the CCME water quality guidelines (this will be a conservative comparison, as contaminant concentrations in groundwater often decrease between nearshore wells and the point of discharge). 2) by conducting groundwater modeling to estimate the concentration of groundwater immediately before discharge. 3) by installing water samplers, "peepers", in the sediments in the area of daylighting groundwater.	
Distance from the contaminated site to an important surface water resource 0 to 300 m 300 m to 1 km 1 to 5 km > 5 km Do Not Know	1 to 5 km Score 1	Red River is approximately 2.2 km to the east of Drumheller Institution.	It is considered that within 300 m of a site, there is a concern for contamination. Therefore an environmental receptor or important water resource located within this area of the site will be subject further evaluation. It is also considered that any environmental receptor located greater than 5 km away will not be a concern for evaluation. Review Conservation Authority mapping and literature including Canadian Council on Ecological Areas linkwww.ccea.org	Environmental receptors include: local, regional or provincial species of interest or significance, sensitive wetlands and fens and other aquatic environments
Are aquatic species (i.e., forage fish, invertebrates or plants) that are consumed by predatory fish or wildlife consumers, such as mammals and birds, likely to accumulate contaminants in their tissues? Yes No		Chemicals that were reported on site will not bioaccumulate.	Bioaccumulation of food items is possible if: 1) The Log(Kow) of the contaminant is greater than 4 (as per the chemical characteristics work sheet) and concentrations in sediments exceed the CCME ISQGs. 2) The contaminant in collected tissue samples exceeds the CCME tissue quality guidelines.	

(III) Exposure (Demonstrates the presence of an exposure pathway and receptors)

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method Of Evaluation	Notes
Do Not Know	No			
Score	0			
Raw Aquatic Total Potential	2.5	Note if a "Known" Ecological Effects score is provided, the "Potential" score is disallowed.		
Allowed Aquatic Total Potential	2.5			

(III) Exposure (Demonstrates the presence of an exposure pathway and receptors)

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method Of Evaluation	Notes
4. Ecological Exposure Modifying Factors				
a) Known occurrence of a species at risk. Is there a potential for a species at risk to be present at the site? Yes No Do Not Know	Yes	Several species at risk are reported to potentially inhabit the area (Alberta Governments Species at Risk fact sheets - http://www.srd.alberta.ca/BiodiversityStewardship/SpeciesAtRisk/SpeciesSummaries/SpeciesAtRiskFactSheets.aspx).	Consult any ecological risk assessment reports. If information is not present, utilize on-line databases such as Eco Explorer. Regional, Provincial (Environment Ministries), or Federal staff (Fisheries and Oceans or Environment Canada) should be able to provide some guidance.	Species at risk include those that are extirpated, endangered, threatened, or of special concern. For a list of species at risk, consult Schedule 1 of the federal Species at Risk Act (http://www.sararegistry.gc.ca/species/schedules_e.cfm?id=1). Many provincial governments may also provide regionally applicable lists of species at risk. For example, in British Columbia, consult: BCMWLAP. 2005. Endangered Species and Ecosystems in British Columbia. Provincial red and blue lists. Ministry of Sustainable Resource Management and Water, Land and Air Protection (http://srmwww.gov.bc.ca/atrisk/red-blue.htm)
Score	2 ---			
b) Potential impact of aesthetics (e.g., enrichment of a lake or tainting of food flavor).		There was no visual observation of impact to the receiving water bodies		
Is there evidence of aesthetic impact to receiving water bodies?	No		Documentation may consist of environmental investigation reports, press articles, petitions or other records.	This Item will require some level of documentation by user, including contact names, addresses, phone numbers, e-mail addresses. Evidence of changes must be documented, please attach copy of report containing relevant information.
Yes No Do Not Know	0 ---			
Is there evidence of olfactory impact (i.e., unpleasant smell)?	No		Examples of olfactory change can include the smell of a COPC or an increase in the rate of decay in an aquatic habitat.	
Yes No Do Not Know	0 ---			
Is there evidence of increase in plant growth in the lake or water body?	No	There was no evidence of increased plant growth documented.	A distinct increase of plant growth in an aquatic environment may suggest enrichment. Nutrients e.g., nitrogen or phosphorous releases to an aquatic body can act as a fertilizer.	
Yes No Do Not Know	0 ---			
Is there evidence that fish or meat taken from or adjacent to the site smells or tastes different?	No	There is no documentation of changes to fish taste or smell.	Some contaminants can result in a distinctive change in the way food gathered from the site tastes or smells.	
Yes No Do Not Know	0 ---			
Ecological Modifying Factors Total - Known	**2**			
Ecological Modifying Factors Total - Potential	**---**			
Raw Ecological Total - Known	2			
Raw Ecological Total - Potential	9			
Raw Ecological Total	11			
Ecological Total (Max 18)	**11.0**			
5. Other Potential Contaminant Receptors				
a) Exposure of permafrost (leading to erosion and structural concerns)				Plants and lichens provide a natural insulating layer which will help prevent thawing of the permafrost during the summ Plants and lichens may also absorb less solar radiation. Solar radiation is turned into heat which can also cause underlying permafrost to melt.
Are there improvements (roads, buildings) at the site dependant upon the permafrost for structural integrity?	No		Consult engineering reports, site plans or air photos of the site. When permafrost melts, the stability the soil decreases, leading to erosion. Human structures, such as roads and/or buildings are often dependent on the stability that the permafrost provides.	
Yes No Do Not Know	0 ---			
Is there a physical pathway which can transport soils released by damaged permafrost to a nearby aquatic environment?	No	No evidence of soil transport observed.	Melting permafrost leads to a decreased stability of underlying soils. Wind or surface run-off erosion can carry soils into nearby aquatic habitats. The increased soil loadings into a river can cause an increase in total dissolved solids and a resulting decrease in aquatic habitat quality. In addition, the erosion can bring contaminants from soils to aquatic environments.	
Yes No Do Not Know	0 ---			
Other Potential Receptors Total - Known	**0**			
Other Potential Receptors Total - Potential	**0**			

Exposure Total	
Raw Human Health + Ecological Total - Known	2
Raw Human Health + Ecological Total - Potential	25
Raw Total	27
Exposure Total (max 34)	**20.0**

Only includes "Allowed potential" - if a "Known" score was supplied under a given category then the "Potential" score was not included.

CCME National Classification System (2008, 2010 v 1.2)
Score Summary

Scores from individual worksheets are tallied in this worksheet.
Refer to this sheet after filling out the revised NCS completely.

I. Contaminant Characteristics	Known	Potential
1. Residency Media	2	3
2. Chemical Hazard	8	---
3. Contaminant Exceedance Factor	6	---
4. Contaminant Quantity	2	---
5. Modifying Factors	0	---
Raw Total Score	18	3
Raw Total Score (Known + Potential)	21	
Adjusted Total Score (Raw Total / 40 *33)	**17.3**	(max 33)

II. Migration Potential	Known	Potential
1. Groundwater Movement	---	5.9
2. Surface Water Movement	---	8.9
3. Soil	12	---
4. Vapour	---	0
5. Sediment Movement	---	2
6. Modifying Factors	---	2
Raw Total Score	12	18.8
Raw Total Score (Known + Potential)	30.8	
Adjusted Total Score (Raw Total / 64 * 33)	**15.9**	(max 33)

III. Exposure	Known	Potential
1. Human Receptors		
A. Known Impact	---	
B Potential		
a. Land Use		3
b. Accessibility		0
c. Exposure Route		
i. Direct Contact		3
ii. Inhalation		6
iii. Ingestion		4
2. Human Receptors Modifying Factors	0	---
Raw Total Human Score	0	16
Raw Total Human Score (Known + Potential)	16	
Adjusted Total Human Score	16.0	(maximum 22)
3. Ecological Receptors		
A. Known Impact	---	
B. Potential		
a. Terrestrial		6.5
b. Aquatic		2.5
4. Ecological Receptors Modifying Factors	2	---
Raw Total Ecological Score	2	9
Raw Total Ecological Score (Known + Potential)	11	
Adjusted Total Ecological Score	11.0	(maximum 18)
5. Other Receptors	0	0
Total Other Receptors Score (Known + Potential)	0	
Total Exposure Score (Human + Ecological + Other)	**27.0**	
Adjusted Total Exposure Score (Total Exposure / 46 * 34)	**20.0**	(max 34)

Site Score

Drumheller Institution

Site Letter Grade	**D**
Certainty Percentage	**56%**
% Responses that are "Do Not Know"	**12%**
Total NCSCS Score for site	**53.2**
Site Classification Category	**2**

Site Classification Categories*:

Class 1 - High Priority for Action (Total NCS Score >70)
Class 2 - Medium Priority for Action (Total NCS Score 50 - 69.9)
Class 3 - Low Priority for Action (Total NCS Score 37 - 49.9)
Class N - Not a Priority for Action (Total NCS Score <37)
Class INS - Insufficient Information (>15% of responses are "Do Not Know")

* NOTE: The term "action" in the above categories does not necessarily refer to remediation, but could also include risk assessment, risk management or further site characterization and data collection.

CCME National Classification System for Contaminated Sites (2008, 2010 v 1.2)
Pre-Screening Checklist

Question	Response (yes / no)	Comment
1. Are **Radioactive material**, **Bacterial contamination** or **Biological hazards** likely to be present at the site?	No	If yes, do not proceed through the NCSCS. Contact applicable regulatory agency immediately.
2. Are there **no contamination exceedances** (known or suspected)? Determination of exceedances may be based on: 1) CCME environmental quality guidelines; 2) equivalent provincial guidelines/standards if no CCME guideline exists for a specific chemical in a relevant medium; or 3) toxicity benchmarks derived from the literature for chemicals not covered by CCME or provincial guidelines/standards.	No	If yes (i.e., there are no exceedances), do not proceed through the NCSCS.
3. Have **partial/incompleted or no environmental site investigations** been conducted for the Site?	No	If yes, do not proceed through the NCSCS.
4. Is there direct and signficant evidence of **impacts to humans** at the site, or off-site due to migration of contaminants from the site?	No	If yes, automatically rate the site as Class 1, a priority for remediation or risk management, regardless of the total score obtained should one be calculated (e.g., for comparison with other Class 1 sites).
5. Is there direct and significant evidence of **impacts to ecological receptors** at the site, or off-site due to migration of contaminants from the site?	No	Some low levels of impact to ecological receptors are considered acceptable, particularly on commercial and industrial land uses. However, if ecological effects are considered to be severe, the site may be categorized as Class 1, regardless of the numerical total NCSCS score. For the purpose of application of the NCSCS, effects that would be considered severe include observed effects on survival, growth or reproduction which could threaten the viability of a population of ecological receptors at the site. Other evidence that qualifies as severe adverse effects may be determined based on professional judgement and in consultation with the relevant jurisdiction.
6. Are there indicators of significant **adverse effects in the exposure zone** (i.e., the zone in which receptors may come into contact with contaminants)? Some examples are as follows: -Hydrocarbon sheen or NAPL in the exposure zone -Severely stressed biota or devoid of biota; -Presence of material at ground surface or sediment with suspected high concentration of contaminants such as ore tailings, sandblasting grit, slag, and coal tar.	No	If yes, automatically rate the site as Class 1, a priority for remediation or risk management, regardless of the total score obtained should one be calculated (e.g., for comparison with other Class 1 sites).
7. Do measured concentrations of volatiles or unexploded ordnances represent an **explosion hazard**?	No	If yes, automatically rate the site as Class 1, a priority for remediation or risk management, and do not continue until the safety risks have been addressed. Consult your jurisdiction's occupational health and safety guidance or legislation on exposive hazards and measurement of lower explosive limits.

If none of the above applies, proceed with the NCSCS scoring.

CCME National Classification System for Contaminated Sites (2008, 2010 v 1.2)
Summary of Site Conditions

Subject Site:	**Drumheller Institution**	
Civic Address: *(or other description of location)*	Drumheller Institution, 5km south-southeast of Drumheller, Alberta	
Site Common Name : *(if applicable)*	Former Landfill Site - Drumheller Institution	
Site Owner or Custodian: *(Organization and Contact Person)*	Correctional Services Canada (CSC)	
Legal description *or* metes and bounds:	South East ¼ of Section 25; Township 28; Range 20; West of the Fourth Meridian	
Approximate Site area:	~ 3 ha	
PID(s) : *(or Parcel Identification Numbers [PIN] if untitled Crown land)*		
Centre of site: *(provide latitude/longitude or UTM coordinates)*	Latitude: Longitude:	___51___ degrees ___25___ min ___17.40___ secs ___112___ degrees __4___ min ___00.33___ secs
	UTM Coordinate:	Northing _____ Easting _____
Site Land Use:	Current:	Fomer Landfill, presently inactive.
	Proposed:	Same
Site Plan	**To delineate the bounds of the Site a site plan MUST be attached. The plan must be drawn to scale indicating the boundaries in relation to well-defined reference points and/or legal descriptions. Delineation of the contamination should also be indicated on the site plan.**	
Provide a brief description of the Site:	The Drumheller Institution was opened in 1967 to house medium-security inmates. The Institution is located five kilometres south-southeast of Drumheller, Alberta. The inactive landfill is located approximately 500 m southeast of the Institution on the edge of a coulee. A creek is present at the base of the coulee, approximately 50 to 60 m below the landfill and a groundwater spring was previously observed in a steep gully 20 m north of the landfill. The landfill is approximately 150 m by 200 m and operated from the mid 1960s until the late 1980s. It was reported that the material disposed of in the landfill includes domestic waste and demolition material generated during the renovations at the Institution. The landfill is not engineered and it is reported that wastes were historically pushed over the edge of the coulee. The surface of the landfill has historically been used as a burn area and is occasionally used to store spoil piles from the excavations around the site.	

CCME National Classification System for Contaminated Sites (2008, 2010 v 1.2)
Summary of Site Conditions

Affected media and Contaminants of Potential Concern (COPC):	Soil: BTEX: benzene, toluene & Metals: arsenic, selenium, thallium, chromium, nickle, zinc GW: Metals: aluminum, selenium, manganese SW: Metals: aluminum, arsenic, copper, iron, mercury Sediments: No exceedances reported Sources: UMA Engineering Ltd., Phase II ESI, 2000 and Supplemental Phase II ESI, Franz, 2006

Please fill in the "letter" that best describes the level of information available for the site being assessed

Site Letter Grade **D**

If letter grade is F, do not continue, you must have a minimum of a Phase I Environmental Site Assessment or equivalent.

Scoring Completed By:	Julie Dittburner
Date Scoring Completed:	22-Feb-11

CCME National Classification System for Contaminated Sites (2008, 2010 v 1.2)
User's Guide - Instructions

1) Please review the following overview of contents. The revised CCME National Classification System for Contaminated Sites (NCSCS) consists of a pre-screening checklist, summary of site conditions, summary score sheet, and three instruction/worksheet pages for the user to fill out: Contaminant Characteristics, Migration Potential and Exposure. For ease of printing, the method of evaluation for scoring each section of the worksheet is provided in a separate Instructions tab. Reference material is also provided to assist with the evaluation. A brief description of each sheet is as follows:

Pre-Screening Checklist - Used to determine if the Site can either be considered a Class 1 site (to be remediated immediately) or more information must be collected before the Site can be ranked, or other hazards exist at the Site that must be addressed first before the Site can be ranked using the revised NCSCS.

Site Description Sheet - Summarizes Site information. It also indicates the level of information available (Site Letter Grade) for the site to conduct the NCSCS scoring evaluation. The known/potential contaminants of concern and affected media will also be summarized here.

Contaminant Characteristics Instructions & Worksheet - Prompts the user for information related to the contaminants of potential concern (COPC) found at the site.

Migration Potential Instructions & Worksheet - Prompts the user for information related to physical transport processes which may move contamination to neighboring sites or re-distribute contamination within a site. Migration potential includes many of the exposure pathways, but is not limited to exposure pathways. Migration potential does not require clearly defined receptors.

Exposure Instructions & Worksheet - Prompts the user for information related to exposure pathways and receptors which may be located on the site.

Summary Score Sheet - Generates a total site score by adding up the scores generated on each of the three worksheets and provides the corresponding Site Classification. It also provides an estimate of certainty in the score provided (Certainty Percentage).

Reference Material - Additional information which may be useful to refer to when conducting the evaluation.
- Contaminant Hazard Ranking
- Examples of Persistent Substances
- Examples of Substances in the Various Chemical Classes
- Chemical-specific Properties
- Range of Values of Hydraulic Conductivity and Permeability

The worksheet titles and sub headings are as follows.

I. Contaminant Characteristics

1. Residency Media
2. Chemical Hazard
3. Contaminant Exceedance Factor
4. Contaminant Quantity
5. Modifying Factors

II. Migration Potential

1. Groundwater Movement
2. Surface water Movement
3. Soil
4. Vapour
5. Sediment Movement
6. Modifying Factors

III. Exposure

1. Human Receptors
   - A. Known Impact
   - B Potential
     - a. Land Use
     - b. Accessibility
     - c. Exposure Route
2. Human Modifying Factors
3. Ecological Receptors
   - A. Known Impact
   - B. Potential
     - a. Terrestrial
     - b. Aquatic
4. Ecological Modifying Factors
   - a. Species at Risk
   - b. Aesthetics
5. Other Receptors
   - a. Permafrost

CCME National Classification System for Contaminated Sites (2008, 2010 v 1.2)
User's Guide - Instructions

2) This is an electronic form which will prompt the user for information. Based on the answers provided, a score is calculated for the contaminated site in question. In most cases, the user will be asked to select amongst two or more choices in a drop down checklist. To access the drop down checklist, move the mouse towards the right side of the "action box". If a drop down is available, an arrow will appear, which must be selected to access the drop down choices. An "action box" requires input from the user. All action boxes have an amber background. action box

3) When assigning scores for each factor, it is highly recommended to give a rationale (a column has been provided for this purpose in Worksheets I, II and III). Information that would be useful in justifying the scores assigned may include: a statement of any assumptions, a description of site-specific information, and references for any data sources (e.g., site visit, personal interview, site assessment reports, or other documents consulted).

4) The Site Letter Grade is related to the level of information available for the Site (as defined by the User) and provides an indication of completeness of information based on the level of investigation and remediation work that has been carried out at the site. More detailed descriptions of the various categories are provided below.

Site Letter Grade:	*Detailed Descriptions:*
F	***Pre Phase I ESA –*** No environmental investigations have been conducted or there are only partial or incomplete Phase I ESA for the Site. It is not recommended to continue through the NCSCS when insufficient data are available. In these cases, it will generally be necessary to conduct a Phase I ESA or other site investigation tasks in order to complete the NCSCS scoring.
E	***Phase I ESA –*** A preliminary desk-top type study has been conducted, involving non-intrusive data collection to determine whether there is a potential for the Site to be contaminated and to provide information to direct any intrusive investigations. Data collected may include a review of available information on current site conditions and history of the property, a site inspection and interviews with personnel familiar with the Site. [Note: This stage is similar to "Phase I: Site Information Assessment" as described in Guidance Document on the Management of Contaminated Sites in Canada (CCME 1997).]
D	***Limited Phase II ESA –*** An initial intrusive investigation and assessment of the property has been conducted, generally focusing on potential sources of contamination, to determine whether there is contamination present above the relevant screening guidelines or criteria, and to broadly define soil and groundwater conditions; samples have been collected and analyzed to identify, characterize and quantify contamination that may be present in air, soil, groundwater, surface water or building materials. [Note: This stage is similar to "Phase II: Reconnaissance Testing Program" as described in Guidance Document on the Management of Contaminated Sites in Canada (CCME 1997).]
C	***Detailed Phase II ESA –*** Further intrusive investigations have been conducted to characterize and delineate the contamination, to obtain detailed information on the soil and groundwater conditions, to identify the contaminant pathways, and to provide other information required to develop a remediation plan. [Note: This stage is similar to "Phase III: Detailed Testing Program" as described in Guidance Document on the Management of Contaminated Sites in Canada (CCME 1997).]
B	***Risk Assessment with or without Remedial Plan or Risk Management Strategy –*** A risk assessment has been completed, and if the risk was found to be unacceptable, a site-specific remedial action plan has been designed to mitigate environmental and health concerns associated with the Site, or a risk management strategy has been developed.
A	***Confirmation Sampling –*** Remedial work, monitoring, and/or compliance testing have been conducted and confirmatory sampling demonstrates whether contamination has been removed or stabilized effectively and whether cleanup or risk management objectives have been attained.

5) A few terms are used throughout which require definition, they are as follows:

Known - refers to scores that are assigned based on documented scientific and/or technical observations

Potential - refers to scores that are assigned when something is not known, though it may be suspected

Allowed Potential - If, in a given category, known and potential scores are provided by the user, the checklist will typically default to the "known" score. If a "known" score is provided, the "allowed potential" score will equal zero. Exceptions can be found within the Modifying Factors categories in each worksheet where there are often several independent questions. Therefore, "known" and "potential" scores are allowed to contribute to the total modifying factor score.

Raw - refers to score totals which have not been adjusted down to the total maximum score for the given category. In most cases the possible total raw score is greater than the maximum allowed

CCME National Classification System for Contaminated Sites (2008, 2010 v 1.2)
User's Guide - Instructions

Note: For some questions in the worksheets, the option selected will determine whether a "known" or "potential" score is assigned. In these cases, if "Do Not Know" is selected, a score will automatically be listed as "potential", whereas all of the other options in the list will provide a "known" score.

6) Certainty Percentage: The ratio of “Known” to “Potential” responses reflects the relative certainty, or confidence, of the resulting final score and the classification. The NCSCS system defines this ratio as the “Certainty Percentage”. The Certainty Percentage is generated from the number of sections assigned scores based on “known” information divided by the total number of sections. A high percentage indicates that more is known about the Site, and therefore there is more confidence in the ranking, whereas a low percentage suggests that the ranking should be treated with caution.

7) Site Classification Categories: Sites should not be ranked relative to one another. Sites must be classifed on their individual characteristics in order to determine the appropriate classification (Class 1, 2, 3, or N) according to their priority for action, or Class INS (Insufficient Information) for sites that require further information before they can be classifed. The classification groupings are as follows:

Class 1 - High Priority for Action (Total NCSCS Score greater than 70)

The available information indicates that action (e.g., futher site characterization, risk management, remediation, etc.) is required to address existing concerns. Typically, Class 1 sites indicate high concern for several factors, and measured or observed impacts have been documented.

Class 2 - Medium Priority for Action (Total NCSCS Score between 50 and 69.9)

The available information indicates that there is high potential for adverse impacts, although the threat to human health and the environment is generally not imminent. There will tend not to be indication of off-site contamination, however, the potential for this was rated high and therefore some action is likely required.

Class 3 - Low Priority for Action (Total NCSCS Score between 37 and 49.9)

The available information indicates that this site is currently not a high concern. However, additional investigation may be carried out to confirm the site classification, and some degree of action may be required.

Class N - Not a Priority for Action (Total NCSCS Score less than 37)

The available information indicates there is probably no significant environmental impact or human health threats. There is likely no need for action unless new information becomes available indicating greater concerns, in which case the site should be re-examined.

Class INS - Insufficient Information (>15% of Responses are "Do Not Know")

There is insufficient information to classify the site. In this event, additional information is required to address data gaps.

8) Additional Complementary Tools to the NCSCS

The CCME Soil Quality Index (SoQI) is a complementary tool that focuses more on evaluating the relative hazard, by comparing contaminant concentrations with their respective soil quality guidelines. The SoQI uses three factors for its calculations, namely: 1) scope (% of contaminants that do not meet their respective guidelines), 2) frequency (% of individual tests of contaminants that do not meet their respective guidelines), and 3) amplitude (the amount by which the contaminants do not meet their respective guidelines). The soil quality index can be used to compare different contaminated sites with similar types of contamination as well as to see if the jurisdictional requirements have been met after remediation of a particular site.

The NCSCS was not developed for and is not readily applicable for the assessment of sites with a significant marine or aquatic component. Environmental conditions at marine and aquatic sites are best measured in the bed sediments as they act as long-term reservoirs of chemicals to the aquatic environment and to organisms living in or having direct contact with sediments. The CCME Sediment Quality Index (SeQI) provides a convenient means of summarizing sediment quality data and can complement the NCSCS. The SeQI provides a mathematical framework for assessing sediment quality conditions by comparing contaminant concentrations with their respective sediment quality guidelines.

CCME National Classification System (2008, 2010 v 1.2)

(I) Contaminant Characteristics

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method of Evaluation	Notes
1. Residency Media (replaces physical state)				
Which of the following residency media are known (or strongly suspected) to have one or more exceedances of the applicable CCME guidelines? **yes** = has an exceedance or strongly suspected to have an exceedance **no** = does not have an exceedance or strongly suspected not to have an exceedance A. Soil	Yes	Findings of the Phase II ESA by UMA Enginnerring reported contamination in the following media : Soil: chromium, nickel, zinc SW: manganese The supplemental Phase II ESI by Franz, 2006 reported: Soil: benzene, toluene, arsenic, selenium, thallium, chromium GW: aluminum, selenium SW: aluminum, arsenic, copper, iron, mercury Sediments: no exceedances reported	The overall score is calculated by adding the individual scores from each residency media (having one or more exceedance of the most conservative media specific and land-use appropriate CCME guideline). Summary tables of the Canadian Environmental Quality Guidelines for soil, water (aquatic life, non-potable groundwater environments, and agricultural water uses) and sediment are available on the CCME website at http://www.ccme.ca/publications/cegg_rcqe.html?category_id=124 . For potable groundwater environments, guidelines for Canadian Drinking Water Quality (for comparison with groundwater monitoring data) are available on the Health Canada website at http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/doc_sup-appui/sum_guide-res_recom/index_e.html.	An increasing number of residency media containing chemical exceedances often equates to a greater potential risk due to an increase in the number of potential exposure pathways.
Yes No Do Not Know				
B. Groundwater	Yes			
Yes No Do Not Know				
C. Surface water	Yes			
Yes No Do Not Know				
D. Sediment	No			
Yes No Do Not Know				
"Known" -score	6			
"Potential" - score	---			
2. Chemical Hazard				
What is the relative degree of chemical hazard of the contaminant in the list of hazard rankings proposed by the Federal Contaminated Sites Action Plan (FCSAP)?	High	Results of chemical analysis of environmental media are provided within the Phase II ESI's. Contaminant hazards with HIGH hazard rankings include the following: Soil: arseinc and lead GW: mercury	The relative degree of chemical hazard should be selected based on the most hazardous contaminant known or suspected to be present at the site. The degree of hazard has been defined by the Federal Contaminated Sites Action Plan (FCSAP) and a list of substances with their associated hazard (Low, Medium and High) has been provided as a separate sheet in this file. *See Attached Reference Material for Contaminant Hazard Rankings.*	Hazard as defined in the revised NCS pertains to the physical properties of a chemical which can cause harm. Properties can include toxic potency, propensity to biomagnify, persistence in the environment, etc. Although there is some overlap between hazard and contaminant exceedance factor below, it will not be possible to derive contaminant exceedance factors for many substances which have a designated chemical hazard designation, but don't have a CCME guideline. The purpose of this category is to avoid missing a measure of toxic potential.
High Medium Low Do Not Know				
"Known" -score	8			
"Potential" - score	---			
3. Contaminant Exceedence Factor				
What is the ratio between the measured contaminant concentration and the applicable CCME guidelines (or other "standards")?	High (>100x)	Results of chemical analysis of environmental media are provided within the Phase II ESA. The greatest exceedance of contaminant concentration above CCME guidelines was observed as the following: HIGH (> 100x): aluminum in SW CCME FAL is 0.1 ug/L and concentration is 17.5 ug/L (175x EQG). All other exceedance factors are medium and low.	Ranking of contaminant "exceedance" is determined by comparing contaminant concentrations with the *most conservative media-specific and land-use appropriate CCME* environmental quality guidelines. **Ranking should be based on contaminant with greatest exceedance of CCME guidelines.** Ranking of contaminant hazard as high, medium and low is as follows: High = One or more measured contaminant concentration is greater than 100 X appropriate CCME guidelines Medium = One or more measured contaminant concentration is 10 - 99.99 X appropriate CCME guidelines Low = One or more measured contaminant concentration is 1 - 9.99 X appropriate CCME guidelines Mobile NAPL = Contaminant is a non-aqueous phase liquid (i.e., due to its low solubility, it does not dissolve in water, but remains as a separate liquid) and is present at a sufficiently high saturation (i.e., greater than residual NAPL saturation) such that there is significant potential for mobility either downwards or laterally. Other standards may include local background concentration or published toxicity benchmarks. Results of toxicity testing with site samples can be used as an alternative. This approach is only relevant for contaminants that do not biomagnify in the food web, since toxicity tests would not indicate potential effects at higher trophic levels. High = lethality observed. Medium = no lethality, but sub lethal effects observed. Low = neither lethal nor sub lethal effects observed.	In the event that elevated levels of a material with no associated CCME guidelines are present, check provincial and USEPA environmental criteria. Hazard Quotients (sometimes referred to as a screening quotient in risk assessments) refer to the ratio of measured concentration to the concentration believed to be the threshold for toxicity. A similar calculation is used here to determine the contaminant exceedance factor (CEF). Concentrations greater than one times the applicable CCME guideline (i.e., CEF=>1) indicate that risks are possible. Mobile NAPL has the highest associated score (8) because of its highly concentrated nature and potential for increase in the size of the impacted zone.
Mobile NAPL High (>100x) Medium (10x to 100x) Low (1x to 10x) Do Not Know				
"Known" -score	6			
"Potential" - score	---			

CCME National Classification System (2008, 2010 v 1.2)

(I) Contaminant Characteristics

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method of Evaluation	Notes
4. Contaminant Quantity (known or strongly suspected)				
What is the known or strongly suspected quantity of all contaminants? >10 hectare (ha) or 5000 m^3 2 to 10 ha or 1000 to 5000 m^3 <2 ha or 1000 m^3 Do Not Know	<2 ha or 1000 m3	Former landfill covers an approximate area of 3 ha.	Measure or estimate the area or quantity of total contamination (i.e, all contaminants known or strongly suspected to be present on the site). The "Area of Contamination" is defined as the area or volume of contaminated media (soil, sediment, groundwater, surface water) exceeding appropriate environmental criteria.	A larger quantity of a potentially toxic substance can result in a larger frequency of exposure as well as a greater probability of migration, therefore, larger quantities of these substances earn a higher score.
"Known" -score	2			
"Potential" - score	---			
5. Modifying Factors				
Does the chemical fall in the class of persistent chemicals based on its behavior in the environment? Yes No Do Not Know	Yes	Mercury was reported in surface water and is considered a persistent chemical as per reference materials.	Persistent chemicals, e.g., PCBs, chlorinated pesticides etc. either do not degrade or take longer to degrade, and therefore may be available to cause effects for a longer period of time. Canadian Environmental Protection Act (CEPA) classifies a chemical as persistent when it has at least one of the following characteristics: (a) in air, (i) its half-life is equal to or greater than 2 days, or (ii) it is subject to atmospheric transport from its source to a remote area; (b) in water, its half-life is equal to or greater than 182 days; (c) in sediments, its half-life is equal to or greater than 365 days; or (d) in soil, its half-life is equal to or greater than 182 days. This list does not include metals or metalloids, which in their elemental form do not degrade. However metals and metalloids form chemical species in the environment, many of which are not readily bioavailable.	*Examples of Persistent Substances are provided in attached Reference Materials*
Are there contaminants present that could cause damage to utilities and infrastructure, either now or in the future, given their location? Yes No Do Not Know	No	There are no utilities present on the site.		Some contaminants may react or absorb into underground utilities and infrastructure. For example, organic solvents may degrade some plastics, and salts could cause corrosion of metal.
How many different contaminant classes have representative CCME guideline exceedances? one two to four five or more Do Not Know	two to four	Results of the Phase II ESI's indicate the following with respect to Contaminant Classes: 1) Inorganic Substances 2) Volatile Petroleum Hydrocarbons	For the purposes of the revised NCS ranking system, the following chemicals represent distinct chemical "classes": inorganic substances (including metals), volatile petroleum hydrocarbons, light extractable petroleum hydrocarbons, heavy extractable petroleum hydrocarbons, PAHs, phenolic substances, chlorinated hydrocarbons, halogenated methanes, phthalate esters, pesticides.	*Refer to the Reference Material sheet for a list of example substances that fall under the various chemical classes.*
"Known" - Score	4			
"Potential" - Score	---			

Contaminant Characteristic Total

Raw Total Scores- "Known"	26
Raw Total Scores- "Potential"	0
Raw Combined Total Scores	26
Total Score (Raw Combined / 40 * 33)	**21.5**

(II) Migration Potential (Evaluation of contaminant migration pathways)

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method Of Evaluation	Notes
1. Groundwater Movement				
A. Known COPC exceedances and an operable groundwater pathway within and/or beyond the property boundary.				
i) For **potable groundwater environments**, 1) groundwater concentrations exceed background concentrations and 1X the Guideline for Canadian Drinking Water Quality (GCDWQ) or 2) there is known contact of contaminants with groundwater, based on physical evidence of groundwater contamination. For **non-potable environments** (typically urban environments with municipal services), 1) groundwater concentrations exceed 1X the applicable non potable guidelines or modified generic guidelines (which exclude ingestion of drinking water pathway) or 2) there is known contact of contaminants with groundwater, based on physical evidence of groundwater impacts. ii) Same as (i) except the information is not known but strongly suspected based on indirect observations. iii) Meets GCDWQ for **potable environments**; meets non-potable criteria or modified generic criteria (excludes ingestion of drinking water pathway) for **non-potable environments** **or** Absence of groundwater exposure pathway (i.e., there is no aquifer (see definition at right) at the site or there is an adequate isolating layer between the aquifer and the contamination, and within 5 km of the site there are no aquatic receiving environments and the groundwater does not daylight). Score	12 9 0 12 12	The Phase II ESI by UMA Engineering Ltd. reported manganese in groundwater. In addition, the supplemental Phase II ESI by Franz, 2006 reported groundwater exceedances for aluminum and selenium.	Review chemical data and evaluate groundwater quality. The evaluation method concentrates on 1) a potable or non-potable groundwater environment; 2) the groundwater flow system and its potential to be an exposure pathway to known or potential receptors An aquifer is defined as a geologic unit that yields groundwater in usable quantities and drinking water quality. The aquifer can currently be used as a potable water supply or could have the potential for use in the future. Non-potable groundwater environments are defined as areas that are serviced with a reliable alternative water supply (most commonly provided in urban areas). The evaluation of a non-potable environment will be based on a site specific basis. Physical evidence includes significant sheens, liquid phase contamination, or contaminant saturated soils. Seeps and springs are considered part of the groundwater pathway. In Arctic environments, the potability and evaluation of the seasonal active layer (above the permafrost) as a groundwater exposure pathway will be considered on a site-specific basis.	The 1992 NCS rationale evaluated the off-site migration as a regulatory issue. The exposure assessment and classification of hazards should be evaluated regardless of the property boundaries. Someone experienced must provide a thorough description of the sources researched to determine the presence/absence of a groundwater supply source in the vicinity of the contaminated site. This information must be documented in the NCS Site Classification Worksheet including contact names, phone numbers, e-mail correspondence and/or reference maps/reports and other resources such as internet links. Note that for potable groundwater that also daylights into a nearby surface water body, the more stringent guidelines for both drinking water and protection of aquatic life should be considered. **Selected References** Potable Environments Guidelines for Canadian Drinking Water Quality www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/doc_sup-appui/sum_guide-res_recom/index_e.html Non-Potable Environments Canadian Water Quality Guidelines for Protection of Aquatic Life. CCME. 1999 www.ccme.ca Compilation and Review of Canadian Remediation Guidelines, Standards and Regulations. Science Applications International Corporation (SAIC Canada), report to Environment Canada, January 4, 2002.
NOTE: If a score is assigned here for Known COPC Exceedances, then you can skip Part B (Potential for groundwater pathway) and go to Section 2 (Surface Water Pathway)				
B. Potential for groundwater pathway.				
a. Relative Mobility High Moderate Low Insignificant Do Not Know Score	Do Not Know 2	Scored as known	Organics Koc (L/kg) — Metals with higher mobility at acidic conditions — Metals with higher mobility at alkaline conditions Koc < 500 (i.e., log Koc < 2.7) — pH < 5 — pH > 8.5 Koc = 500 to 5000 (i.e., log Koc = 2.7 to 3.7) — pH = 5 to 6 — pH = 7.5 to 8.5 Koc = 5,000 to 100,000 (i.e., log Koc = 3.7 to 5) — pH > 6 — pH < 7.5 Koc > 100,000 (i.e., log Koc > 5)	Reference: US EPA Soil Screening Guidance (Part 5 - Table 39) If a score of zero is assigned for relative mobility, it is still recommended that the following sections on potential for groundwater pathway be evaluated and scored. Although the Koc of an individual contaminant may suggest that it will be relatively immobile, it is possible that, with complex mixtures, there could be enhanced mobility due to co-solvent effects. Therefore, the Koc cannot be relied on solely as a measure of mobility. An evaluation of other factors such as containment, thickness of confining layer, hydraulic conductivities and precipitation infiltration rate are still useful in predicting potential for groundwater migration, even if a contaminant is expected to have insignificant mobility based on its chemistry alone.
b. Presence of engineered sub-surface containment? No containment Partial containment Full containment Do Not Know Score	Do Not Know 1.5	Scored as known	Review the existing engineered systems or natural attenuation processes for the site and determine if full or partial containment is achieved. Full containment is defined as an engineered system or natural attenuation processes, monitored as being effective, which provide for full capture and/or treatment of contaminants. All chemicals of concern must be contained for "Full Containment" scoring. Natural attenuation must have sufficient data, and reports cited with monitoring data to support steady state conditions and the attenuation processes. If there is no containment or insufficient natural attenuation process, this category is evaluated as high. If there is less than full containment or if uncertain, then evaluate as medium. In Arctic environments, permafrost will be evaluated, as appropriate, based on detailed evaluations, effectiveness and reliability to contain/control contaminant migration.	Someone experienced must provide a thorough description of the sources researched to determine the containment of the source at the contaminated site. This information must documented in the NCS Site Classification Worksheet including contact names, phone numbers, e-mail correspondence and/or reference maps, geotechnical reports or natural attenuation studies and other resources such as internet links. **Selected Resources:** United States Environmental Protection Agency (USEPA) 1998. Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater. EPA/600/R-98/128. Environment Canada – Ontario Region – Natural Attenuation Technical Assistance Bulletins (TABS) Number 19 –21.
c. Thickness of confining layer over aquifer of concern o groundwater exposure pathway 3 m or less including no confining layer or discontinuous confining layer 3 to 10 m > 10 m Do Not Know Score	Do Not Know 0.5	Scored as known	The term "confining layer" refers to geologic material with little or no permeability or hydraulic conductivity (such as unfractured clay); water does not pass through this layer or the rate of movement is extremely slow. Measure the thickness and extent of materials that will impede the migration of contaminants to the groundwater exposure pathway. The evaluation of this category is based on: 1) The presence and thickness of saturated subsurface materials that impede the vertical migration of contaminants to lower aquifer units which can or are used as drinking water sources or 2) The presence and thickness of unsaturated subsurface materials that impede the vertical migration of contaminants from the source location to the saturated zone (e.g., water table aquifer, first hydrostratigraphic unit or other groundwater pathway).	
d. Hydraulic conductivity of confining layer $>10^{-4}$ cm/s or no confining layer 10^{-4} to 10^{-6} cm/s $<10^{-6}$ cm/s Do Not Know Score	Do Not Know 0.5	Scored as known	Determine the nature of geologic materials and estimate hydraulic conductivity from published material (or use "Range of Values of Hydraulic Conductivity and Permeability" figure in the Reference Material sheet). Unfractured clays should be scored low. Silts should be scored medium. Sand, gravel should be scored high. The evaluation of this category is based on: 1) The presence and hydraulic conductivity ("K") of saturated subsurface materials that impede the vertical migration of contaminants to lower aquifer units which can or are used as a drinking water source, groundwater exposure pathway or 2) The presence and permeability ("k") of unsaturated subsurface materials that impede the vertical migration of contaminants from the source location to the saturated water table aquifer, first hydrostratigraphic unit or other groundwater pathway.	

(II) Migration Potential (Evaluation of contaminant migration pathways)

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method Of Evaluation	Notes
B. Potential for groundwater pathway.				
e. Precipitation infiltration rate (Annual precipitation factor x surface soil relative permeability factor) High Moderate Low Very Low None Do Not Know	Low Score 0.4	Environment Canada Climate Normals indicate Red Deer, Alberta (nearest weather station) to have an average annual precipitation of 522 mm. Surface soils are a mix of silty sand and clay leading to a classification of loam and a permmeability factor of 0.15. =0.5 x 0.3 = 0.15	Precipitation Refer to Environment Canada precipitation records for relevant areas. Divide annual precipitation by 1000 and round to nearest tenth (e.g., 667 mm = 0.7 score). Permeability For surface soil relative permeability (i.e., infiltration) assume: gravel (1), sand (0.6), loam (0.3) and pavement or clay (0). Multiply the surface soil relative permeability factor with precipitation factor to obtain the score for precipitation infiltration rate.	
f. Hydraulic conductivity of aquifer $>10^{-2}$ cm/s 10^{-2} to 10^{-4} cm/s $<10^{-4}$ cm/s Do Not Know	Do Not Know Score 1	Scored as known	Determine the nature of geologic materials and estimate hydraulic conductivity of all aquifers of concern from published material (refer to "Range of Values of Hydraulic Conductivity and Permeability" in the Reference Material sheet).	
Potential groundwater pathway total Allowed Potential score **Groundwater pathway total**	5.9 --- **12**	Note: If a "known" score is provided, the "potential" score is disallowed.		
2. Surface Water Movement				
A. Demonstrated migration of COPC in surface water above background conditions				
Known concentrations of surface water: i) Concentrations exceed background concentrations and exceed CCME CWQG for protection of aquatic life, irrigation, livestock water, and/or recreation (whichever uses are applicable at the site) by >1 X; or There is known contact of contaminants with surface water based on site observations. or In the absence of CWQG, chemicals have been proven to be toxic based on site specific testing (e.g. toxicity testing; or other indicator testing of exposure).	12	The supplemental Phase II ESI by Franz, 2006 reported exceedances of CCME EQGs in surface water for aluminum, arsenic, copper, iron, mercury.	Collect all available information on quality of surface water near to site. Evaluate available data against Canadian Water Quality Guidelines (select appropriate guidelines based on local water uses e.g., recreation, irrigation, aquatic life, livestock watering, etc.). The evaluation method concentrates on the surface water flow system and its potential to be an exposure pathway. Contamination is present on the surface (above ground) and has the potential to impact surface water bodies. Surface water is defined as a water body that supports one of the following uses: recreation, irrigation, livestock watering, aquatic life.	General Notes: Someone experienced must provide a thorough description of the sources researched to classify the surface water body in the vicinity of the contaminated site. This information must be documented in the NCS Site Classification Worksheet including contact names, phone numbers, e-mail correspondence and/or reference maps/reports and other resources such as internet links. Selected References: CCME. 1999. Canadian Water Quality Guidelines for the Protection of Aquatic Life www.ccme.ca CCME. 1999. Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses (Irrigation and Livestock Water) www.ccme.ca Health and Welfare Canada. 1992. Guidelines for Canadian Recreational Water Quality.
ii) Same as (i) except the information is not known but strongly suspected based on indirect observations.	8			
iii) Meets CWQG or absence of surface water exposure pathway (i.e., Distance to nearest surface water is > 5 km.)	0			
	12 Score 12			
NOTE: If a score is assigned here for Demonstrated Migration in Surface Water, then you can skip Part B (Potential for migration of COPCs in surface water) and go to Section 3 (Surface Soils)				
B. Potential for migration of COPCs in surface water				
a. Presence of containmen No containmen Partial containmen Full containmen Do Not Know	Do Not Know Score 3	Scored as known	Review the existing engineered systems and relate these structures to site conditions and proximity to surface water and determine if full containment is achieved: score low if there is full containment such as capping, berms, dikes; score medium if there is partial containment such as natural barriers, trees, ditches, sedimentation ponds; score high if there are no intervening barriers between the site and nearby surface water. Full containment must include containment of all chemicals.	
b. Distance to Surface Water 0 to <100 m 100 - 300 m >300 m Do Not Know	Do Not Know Score 2	Scored as known	Review available mapping and survey data to determine distance to nearest surface water bodies.	

(II) Migration Potential (Evaluation of contaminant migration pathways)

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method Of Evaluation	Notes
c. Topography Contaminants above ground level and slope is stee Contaminants at or below ground level and slope is stee Contaminants above ground level and slope is intermedia Contaminants at or below ground level and slope is intermedia Contaminants above ground level and slope is fl Contaminants at or below ground level and slope is fl Do Not Know	Do Not Know	Scored as known	Review engineering documents on the topography of the site and the slope of surrounding terrain. Steep slope = >50% Intermediate slope = between 5 and 50% Flat slope = < 5% Note: Type of fill placement (e.g., trench, above ground, etc.).	
Score	1			
d. Run-off potential High (rainfall run-off score > 0.6) Moderate (0.4 < rainfall run-off score <0.6) Low (0.2 < rainfall run-off score <0.4) Very Low (0 < rainfall run-off score < 0.2) None (rainfall run-off score = 0) Do Not Know	Do Not Know	Scored as known	Rainfall Refer to Environment Canada precipitation records for relevant areas. Divide rainfall by 1000 and round to nearest tenth (e.g., 667 mm = 0.7 score). The former definition of "annual rainfall" did not include the precipitation as snow. This minor adjustment has been made. The second modification was the inclusion of permeability of surface materials as an evaluation factor. Permeability For infiltration assume: gravel (0), sand (0.3), loam (0.6) and pavement or clay (1). Multiply the infiltration factor with precipitation factor to obtain rainfall run off score.	Selected Sources: Environment Canada web page linkwww.msc.ec.gc.ca Snow to rainfall conversion apply ratio of 15 (snow):1(water)
Score	0.4			
e. Flood potentia 1 in 2 years 1 in 10 years 1 in 50 years Not in floodplair Do Not Know	Do Not Know	Scored as known	Review published data such as flood plain mapping or flood potential (e.g., spring or mountain run-off) and Conservation Authority records to evaluate flood potential of nearby water courses both up and down gradient. Rate zero if site not in flood plain.	
Score	0.5			
Potential surface water pathway total	6.9			
Allowed Potential score	---	Note: If a "known" score is provided, the "potential" score is disallowed.		
Surface water pathway total	**12**			
3. Surface Soils (potential for dust, dermal and ingestion exposure)				
A. Demonstrated concentrations of COPC in surface soils (top 1.5 m)				
COPCs measured in surface soils exceed the CCME soil quality guideline.	12	As documented in the Phase II ESI by UMA Engineering and the supplemental Phase II ESI by Franz, the following contaminants were documented to exceed CCME criteria in soil at the Form Landfill Site: benzene, toluene, arsenic, selenium, thallium, chromium, chromium, nickel, and zinc.	Collect all available information on quality of surface soils (i.e., top 1.5 metres) at the site. Evaluate available data against Canadian Soil Quality Guidelines. Select appropriate guidelines based on current (or proposed future) land use (i.e, agricultural, residential/parkland, commercial, or industrial), and soil texture if applicable (i.e., coarse or fine).	Selected References: CCME. 1999. Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health www.ccme.ca
Strongly suspected that soils exceed guidelines	9			
COPCs in surface soils does not exceed the CCME soil quality guideline or is not present (i.e., bedrock).	0			
	12			
Score	12			
NOTE: If a score is assigned here for Demonstrated Concentrations in Surface Soils, then you can skip Part B (Potential for a surface soils migration pathway) and go to Section 4 (Vapour)				
B. Potential for a surface soils (top 1.5 m) migration pathway				
a. Are the soils in question covered? Exposed Vegetatec Landscaped Paved Do Not Know	Do Not Know	Scored as known	Consult engineering or risk assessment reports for the site. Alternatively, review photographs or perform a site visit. Landscaped surface soils must include a minimum of 0.5 m of topsoil.	The possibility of contaminants in blowing snow have not been included in the revised NC as it is difficult to assess what constitutes an unacceptable concentration and secondly, spills to snow or ice are most efficiently mitigated while freezing conditions remain.
Score	4			
b. For what proportion of the year does the site remain covered t snow? 0 to 10% of the yea 10 to 30% of the yea More than 30% of the yea Do Not Know	Do Not Know	Scored as known	Consult climatic information for the site. The increments represent the full span from soils which are always wet or covered with snow (and therefore less likely to generate dust) to those soils which are predominantly dry and not covered by snow (and therefore are more likely to generate dust).	
Score	3			
Potential surface soil pathway total	7			
Allowed Potential score	---	**Note: If a "known" score is provided, the "potential" score is disallowed.**		
Soil pathway total	**12**			

(II) Migration Potential (Evaluation of contaminant migration pathways)

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method Of Evaluation	Notes
4. Vapour				
A. Demonstrated COPCs in vapour.				
Vapour has been measured (indoor or outdoor) in concentrations exceeding risk based concentrations. Strongly suspected (based on observations and/or modelling) Vapour has not been measured and volatile hydrocarbons have not been found in site soils or groundwater. Score	12 9 0 Go to Potential ---		Consult previous investigations, including human health risk assessments, for reports of vapours detected.	
NOTE: If a score is assigned here for Demonstrated COPCs in Vapour, then you can skip Part B (Potential for COPCs in vapour) and go to Section 5 (Sediment)				
B. Potential for COPCs in vapour				
a. Relative Volatility based on Henry's Law Constant, H (dimensionless) High (H' > 1.0E-1) Moderate (H' = 1.0E-1 to 1.0E-3 Low (H' < 1.0E-3) Not Volatile Do Not Know Score	High 4	The Henry's Law Constants (dimensionless) in the reference materials for benzene is 2.28E-01 a for toluene is 2.72E-01. Therefore, the volativity is rated as high.	Reference: US EPA Soil Screening Guidance (Part 5 - Table 36) *Provided in Attached Reference Materials*	If the Henry's Law Constant for a substance indicates that it is not volatile, and a score of zero is assigned here for relative volatility, then the other three questions in this section on Potential for COPCs will be automatically assigned scores of zero and you can skip to section 5.
b. What is the soil grain size? Fine Coarse Do Not Know Score	Fine 2	Results of test pit excavation and grain size analysis indicate these soils are primarily fine grained.	Review soil permeability data in engineering reports. The greater the permeability of soils, the greater the possible movement of vapours. Fine-grained soils are defined as those which contain greater than 50% by mass particles less than 75 µm mean diameter (D50 < 75 µm). Coarse-grained soils are defined as those which contain greater than 50% by mass particles greater than 75 µm mean diameter (D50 > 75 µm).	
c. Is the depth to the source less than 10m? Yes No Do Not Know Score	Yes 2	The maximum depth to groundwater is 9.0 mbgs.	Review groundwater depths below grade for the site.	
d. Are there any preferential pathways? Yes No Do Not Know Score	No 0	Bedrock was not observed on site.	Visit the site during dry summer conditions and/or review available photographs. Where bedrock is present, fractures would likely act as preferential pathyways.	Preferential pathways refer to areas where vapour migration is more likely to occur becau there is lower resistance to flow than in the surrounding materials. For example, underground conduits such as sewer and utility lines, drains, or septic systems may serve as preferential pathways. Features of the building itself that may also be preferential pathways include earthen floors, expansion joints, wall cracks, or foundation perforations for subsurface features such as utility pipes, sumps, and drains.
Potential vapour pathway total	8			
Allowed Potential score	8	Note: If a "known" score is provided, the "potential" score is disallowed.		
Vapour pathway total	**8**			
5. Sediment Movement				
A. Demonstrated migration of sediments containing COPCs				
There is evidence to suggest that sediments originally deposited to the site (exceeding the CCME sediment quality guidelines) have migrated. Strongly suspected (based on observations and/or modelling) Sediments have been contained and there is no indication that sediments will migrate in future. **or** Absence of sediment exposure pathway (i.e., within 5 km of the site there are no aquatic receiving environments, and therefore no sediments). Score	12 9 0 0 0	Results of the supplemental Phase II ESI by Franz, 2006 reported concentrations in sediments be below CCME EQGs.	Review sediment assessment reports. Evidence of migration of contaminants in sediments must be reported by someone experienced in this area.	Usually not considered a significant concern in lakes/marine environments, but could be very important in rivers where transport downstream could be significant.
NOTE: If a score is assigned here for Demonstrated Migration of Sediments, then you can skip Part B (Potential for Sediment Migration) and go to Section 6 (Modifying Factors)				

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(II) Migration Potential (Evaluation of contaminant migration pathways)

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method Of Evaluation	Notes
B. Potential for sediment migration		Scored as known		
a. Are the sediments having COPC exceedances capped with sediments having no exceedances ("clean sediments")?	Do Not Know		Review existing sediment assessments. If sediment coring has been completed, it may indicate th historically contaminated sediments have been covered over by newer "clean" sediments. This assessment will require that cores collected demonstrate a low concentration near the top and higher concentration with sediment depth.	
Yes				
No				
Do Not Know	2			
b. For lakes and marine habitats, are the contaminated sediments in shallow water and therefore likely to be affected by tidal action, wave action or propeller wash?	Do Not Know		Review existing sediment assessments. If the sediments present at the site are in a river, select "no" for this question.	
Yes				
No				
Do Not Know	2			
c. For rivers, are the contaminated sediments in an area prone t sediment scouring?	Do Not Know		Review existing sediment assessments. It is important that the assessment is made under worst case flows (high yearly flows). Under high yearly flows, areas which are commonly depositional m	
Yes				
No				
Do Not Know	2			
Potential sediment pathway total	6			
Allowed Potential score	---	Note: If a "known" score is provided, the "potential" score is disallowed.		
Sediment pathway total	**0**			
6. Modifying Factors				
Are there subsurface utility conduits in the area affected b contamination?	No	There are no subsurface utilities on site.	Consult existing engineering reports. Subsurface utilities can act as conduits for contaminant migration.	
Yes				
No				
Do Not Know				
Known	0			
Potentia	0			

Migration Potential Total		
Raw "known" total	36	
Raw "potential" tota	8.0	
Raw combined tota	44.0	Note: If "Known" and "Potential" scores are provided, the checklist defaults to known. Therefore,
Total (max 33)	**22.7**	the total "Potential" Score may not reflect the sum of the individual "Potential" scores.

(III) Exposure (Demonstrates the presence of an exposure pathway and receptors)

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method Of Evaluation	Notes
1. Human				
A. Known exposure				
Documented adverse impact or high quantified exposure which has or will result in an adverse effect, injury or harm or impairment of the safety to humans as a result of the contaminated site. (Class 1 Site*) Same as above, but "Strongly Suspected" based on observations or indirect evidence. No quantified or suspected exposures/impacts in humans. Score	22 10 0 Go to Potential ---		*Where adverse effects on humans are documented, the site should be automatically designated as Class 1 site (i.e., action required). There is no need to proceed through the NCS in this case. However, a scoring guideline (22) is provided in case a numerical score for the site is still desired (e.g., for comparison with other Class 1 sites). This category can be based on the outcomes of risk assessments and applies to studies which have reported Hazard Quotients >1 for noncarcinogenic chemicals and incremental cancer risks that exceed acceptable levels defined by the jurisdiction for carcinogenic chemicals (for most jurisdictions this is typically either $>10^{-5}$ or $>10^{-6}$). Known impacts can also be evaluated based on blood testing (e.g. blood lead >10 ug/dL) or other health based testing. This category can be based on the outcomes of risk assessments and applies to studies which have reported Hazard Quotients of less than 0.2 for non-carcinogenic chemicals and incremental lifetime cancer risks for carcinogenic chemicals that are within acceptable levels as defined by the jurisdiction (for most jurisdictions this is less than either 10^{-6} or 10^{-5}).	Known adverse impact includes domestic and traditional food sources. Adverse effects based on food chain transfer to humans and/or animals can be scored in this category. However, the weight of evidence must show a direct link of a contaminated food source/supply and subsequent ingestion/transfer to humans. Any associated adverse effects to the environment are scored separately later in this worksheet. Someone experienced must provide a thorough description of the sources researched to evaluate and determine the quantified exposure/impact (adverse effect) in the vicinity of the contaminated site. **Selected References:** Health Canada – Federal Contaminated Site Risk Assessment in Canada Parts 1 and 2 Guidance on Human Heath Screening Level Risk Assessments (www.hc-sc.gc.ca/ewh-semt/pubs/contamsite/index_e.html) United States Environmental Protection Agency, Integrated Risk Information System (IRIS) http://toxnet.nml.nih.gov
NOTE: If a score is assigned here for Known Exposure, then you can skip Part B (Potential for Human Exposure) and go to Section 2 (Human Exposure Modifying Factors)				
B. Potential for human exposure				
a) Land use (provides an indication of potential human exposure scenarios) Agricultural Residential / Parkland Commercial Industrial Do Not Know Score	Agricultural 3	Drumheller Institution is located on agricultural lands.	Review zoning and land use maps over the distances indicated. If the proposed future land use is more "sensitive" than the current land use, evaluate this factor assuming the proposed future use is in place. Agricultural land use is defined as uses of land where the activities are related to the productive capability of the land or facility (e.g., greenhouse) and are agricultural in nature, or activities related to the feeding and housing of animals as livestock. Residential/Parkland land uses are defined as uses of land on which dwelling on a permanent, temporary, or seasonal basis is the activity (residential), as well as uses on which the activities are recreational in nature and require the natural or human designed capability of the land to sustain that activity (parkland). Commercial/Industrial land uses are defined as land on which the activities are related to the buying, selling, or trading of merchandise or services (commercial), as well as land uses which are related to the production, manufacture, or storage of materials (industrial).	This is the main "receptor" factor used in site scoring. A higher score implies a greater exposure and/or exposure of more sensitive human receptors (e.g., children).
b. Indicate the level of accessibility to the contaminated portion of the si (e.g., the potential for coming in contact with contamination) Limited barriers to prevent site access; contamination not covered Moderate access or no intervening barriers, contaminants are covered. Remote locations in which contaminants not covered. Controlled access or remote location and contaminants are covered Do Not Know Score	Controlled or remote 0	The site is located within a controlled environment. Limited access to site available.	Review location and structures and contaminants at the site and determine if there are intervening barriers between the site and humans. A low rating should be assigned to a (covered) site surrounded by a fence or in a remote location, whereas a high score should be assigned to a site that has no cover, fence, natural barriers or buffer.	
B. Potential for human exposure				
c) Potential for intake of contaminated soil, water, sediment or foods for operable or potentially operable pathways, as identified in Worksheet II (Migration Potential). i) direct contact Is dermal contact with contaminated surface water, groundwater, sediments or soils anticipated? Yes No Do Not Know Score	Yes 3	Surface soils exceed CCME criteria for several metals and BTEX .	If soils or potable groundwater are present exceeding their respective CCME guidelines, dermal contact is assumed. Exposure to surface water, non-potable groundwater or sediments exceeding their respective CCME guidelines will depend on the site. Select "Yes" if dermal exposure to surface water, non-potable groundwater or sediments is expected. For instance, dermal contact with sediments would not be expected in an active port. Only soils in the top 1.5 m are defined by CCME (2003) as surface soils. If contaminated soils are only located deeper than 1.5 m, direct contact with soils is not anticipated to be an operable contaminant exposure pathway.	Exposure via the skin is generally believed to be a minor exposure route. However for some organic contaminants, skin exposure can play a very important component of overall exposure. Dermal exposure can occur while swimming in contaminated waters, bathing with contaminated surface water/groundwater and digging in contaminated dirt, etc.
ii) inhalation (i.e., inhalation of dust, vapour) Vapour - Are there inhabitable buildings on the site within 30 m of soils or groundwater with volatile contamination as determined in Worksheet II (Migration Potential)? Yes No Do Not Know Score	No 0	Inhabitable buildings are not located within 30 m of the site.	If inhabitable buildings are on the site within 30 m of soils or groundwater exceeding their respective guidelines for volatile chemicals, there is a potential of risk to human health (Health Canada, 2004). Review site investigations for location of soil samples (having exceedances of volatile substances) relative to buildings. Refer to (II) Migration Potential worksheet, 4B.a) *Potential for COPCs in Vapour* for a definition of volatility.	Exposure via the lungs (inhalation) can be a very important exposure pathway. Inhalation can be via both particulates (dust) and gas (vapours). Vapours can be a problem where buildings have been built on former industrial sites or where volatile contaminants have migrated below buildings resulting in the potential for vapour intrusion. Assesses the potential for humans to be exposed to vapours originating from site soils. The closer the receptor is to a source of volatile chemicals in soil, the greater the potential of exposure. Also, coarser-grained soil will convey vapour much more efficiently in the soil than finer grained material such as clays and silts. General Notes; Someone experienced must provide a thorough description of the sources researched to determine the presence/absence of a vapour migration and/or dust generation in the vicinity of the contaminated site. This information must be documented in the NCS Site Classification Worksheet including contact names, phone numbers, e-mail correspondence and/or reference maps/reports and other resource such as internet links. Selected References; Canadian Council of Ministers of the Environment (CCME). 2006. Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines. PN 1332 www.ccme.ca Golder, 2004. Soil Vapour Intrusion Guidance for Health Canada Screening Level Risk Assessment (SLRA) Submitted to Health Canada, Burnaby, BC
Dust - If there is contaminated surface soil (e.g. top 1.5 m) , indicate whether the soil is fine or coarse textured. If it is known that surface soil is not contaminated, enter a score of zero. Fine Coarse Surface soil is not contaminated or absent (bedrock) Do Not Know Texture Score inhalation total	Fine 3 3	Soils are fine grained on site.	Consult grain size data for the site. If soils (containing exceedances of the CCME soil quality guidelines) predominantly consist of fine material (having a median grain size of 75 microns; as defined by CCME (2006)) then these soils are more likely to generate dusts.	

CCME National Classification System (2008, 2010 v 1.2)

(III) Exposure (Demonstrates the presence of an exposure pathway and receptors)

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method Of Evaluation	Notes
B. Potential for human exposure				
iii) Ingestion (i.e., ingestion of food items, water and soils [for children]), including traditional foods. Drinking Water: Choose a score based on the proximity to a drinking water supply, to indicate the potential for contamination (present or future). 0 to 100 m 100 to 300 m 300 m to 1 km 1 to 5 km No drinking water present Do Not Know	No drinking water preser	A creek is present at the base of the coulee, approximately 50 to 60 m below the landfill and a groundwater spring was previously observed in a steep gully 20 m north of the landfill. However, drinking water is provided by the Municipality of Drumheller.	Review available site data to determine if drinking water (groundwater, surface water, private, commercial or municipal supply) is known or suspected to be contaminated above Guidelines for Canadian Drinking Water Quality. If drinking water supply is known to be contaminated, some immediate action (e.g., provision of alternate drinking water supply) should be initiated to reduce or eliminate exposure. The evaluation of significant potential for exceedances of the water supply in the future may be based on the capture zones of the drinking water wells; contaminant travel times; computer modelling of flow and contaminant transport.	**Selected References:** Guidelines for Canadian Drinking Water Quality www.hc-sc.gc.ca/hecs-sesc/water/publications/drinking_water_quality_guidelines/toc.htm Drinking water can be an extremely important exposure pathway to humans. If site groundwater or surface water is not used for drinking, then this pathway is considered to be inoperable. Consider both wild foods such as salmon, venison, caribou, as well as agricultural sources of food items if the contaminated site is on or adjacent to agricultural land uses.
Score	0			
Is an alternative water supply readily available? Yes No Do Not Know	No	There are no other water supplies nearby.		
Score	1			
Is human ingestion of contaminated soils possible? Yes No Do Not Know	Yes	Contaminated surface soils could be ingested while at the site, however, it is unlikley.	If contaminated soils are located within the top 1.5 m, it is assumed that ingestion of soils is an operable exposure pathway. Exposure to soils deeper than 1.5 m is possible, but less likely, and the duration is shorter. Refer to human health risk assessment reports for the site in question.	
Score	3			
Are food items consumed by people, such as plants, domestic animals or wildlife harvested from the contaminated land and its surroundings? Yes No Do Not Know	No	Hunting and scavaging does not occur at the site. Limited access to the area.	Use human health risk assessment reports (or others) to determine if there is significant reliance on traditional food sources associated with the site. Is the food item in question going to spend a large proportion of its time at the site (e.g., large mammals may spend a very small amount of time at a small contaminated site)? Human health risk assessment reports for the site in question will also provide information on potential bioaccumulation of the COPC in question.	
Score	0			
Ingestion total	4			
Human Health Total "Potential" Score	13	Note if a "Known" Human Health score is provided, the "Potential" score is disallowed.		
Allowed "Potential" Score	13			
2. Human Exposure Modifying Factors				
a) Strong reliance of local people on natural resources for survival (i.e., food, water, shelter, etc.) Yes No Do Not Know	No	Hunting for subsistence does not occur at the site. Limited access to the area		
Known	0			
Potential	---			
Raw Human "known" total	---			
Raw Human "potential" total	13			
Raw Human Exposure Total Score	13			
Human Health Total (max 22)	**13.0**			
3. Ecological				
A. Known exposure				
Documented adverse impact or high quantified exposure which has or will result in an adverse effect, injury or harm or impairment of the safety to terrestrial or aquatic organisms as a result of the contaminated site.	18		Some low levels of impact to ecological receptors are considered acceptable, particularly on commercial and industrial land uses. However, if ecological effects are deemed to be severe, the site may be categorized as class one (i.e., a priority for remediation or risk management), regardless of a numerical total NCS score. For the purpose of application of the NCS, effects that would be considered severe include observed effects on survival, growth or reproduction which could threaten the viability of a population of ecological receptors at the site. Other evidence that qualifies as severe adverse effects may be determined based on professional judgement and in consultation with the relevant jurisdiction. If ecological effects are determined to be severe and an automatic Class 1 is assigned, there is no need to proceed through the NCS. However, a scoring guideline (18) is provided in case a numerical score for the site is still desired (e.g., for comparison with other Class 1 sites). This category can be based on the outcomes of risk assessments and applies to studies which have reported Hazard Quotients >1. Alternatively, known impacts can also be evaluated based on a weight of evidence assessment involving a combination of site observations, tissue testing, toxicity testing and quantitative community assessments. Scoring of adverse effects on individual rare or endangered species will be completed on a case-by-case basis with full scientific justification.	CCME, 1999: Canadian Water Quality Guidelines for the Protection of Aquatic Life www.ccme.ca CCME, 1999: Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses www.ccme.ca Sensitive receptors- review: Canadian Council on Ecological Areas www.ccea.org Ecological effects should be evaluated at a population or community level, as opposed to at the level of individuals. For example, population-level effects could include reduced reproduction, growth or survival in a species. Community-level effects could include reduced species diversity or relative abundances. Further discussion of ecological assessment endpoints is provided in *A Framework for Ecological Risk Assessment: General Guidance* (CCME 1996). Notes: Someone experienced must provide a thorough description of the sources researched to classify the environmental receptors in the vicinity of the contaminated site. This information must be documented in the NCS Site Classification Worksheet including contact names, phone numbers, e-mail correspondence and/or reference maps/reports and other resource such as internet links.
Same as above, but "Strongly Suspected" based on observations or indirect evidence.	12			
No quantified or suspected exposures/impacts in terrestrial or aquatic organisms	0		This category can be based on the outcomes of risk assessments and applies to studies which have reported Hazard Quotients of less than 1 and no other observable or measurable sign of impacts. Alternatively, it can be based on a combination of other lines of evidence showing no adverse effects, such as site observations, tissue testing, toxicity testing and quantitative community assessments.	
	Go to Potential			
Score	---			
NOTE: If a score is assigned here for Known Exposure, then you can skip Part B (Potential for Ecological Exposure) and go to Section 4 (Ecological Exposure Modifying Factors)				

(III) Exposure (Demonstrates the presence of an exposure pathway and receptors)

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method Of Evaluation	Notes
B. Potential for ecological exposure (for the contaminated portion of the site)				
a) Terrestrial i) Land use Agricultural (or Wild lands) Residential/Parkland Commercial Industrial Do Not Know	Agricultural (or Wild lands Score 3	Drumheller Institution is located on agricultural lands.	Review zoning and land use maps. If the proposed future land use is more "sensitive" than the current land use, evaluate this factor assuming the proposed future use is in place (indicate in the worksheet that future land use is the consideration). Agricultural land use is defined as uses of land where the activities are related to the productive capability of the land or facility (e.g., greenhouse) and are agricultural in nature, or activities related to the feeding and housing of animals as livestock. Wild lands are grouped with agricultural land due to the similarities in receptors that would be expected to occur there (e.g., herbivorous mammals and birds) and the similar need for a high level of protection to ensure ecological functioning. Residential/Parkland land uses are defined as uses of land on which dwelling on a permanent, temporary, or seasonal basis is the activity (residential), as well as uses on which the activities are recreational in nature and require the natural or human designed capability of the land to sustain that activity (parkland). Commercial/Industrial land uses are defined as land on which the activities are related to the buying, selling, or trading of merchandise or services (commercial), as well as land uses which are related to the production, manufacture, or storage of materials (industrial).	
ii) Uptake potential Direct Contact - Are plants and/or soil invertebrates likely exposed to contaminated soils at the site? Yes No Do Not Know	Yes Score 1	Surface soils exceed CCME criteria for several metals and BTEX.	If contaminated soils are located within the top 1.5 m, it is assumed that direct contact of soils with plants and soil invertebrates is an operable exposure pathway. Exposure to soils deeper than 1.5 m is possible, but less likely.	
iii) Ingestion (i.e., wildlife or domestic animals ingesting contaminated food items, soils or water) Are terrestrial animals likely to be ingesting contaminated water at the site? Yes No Do Not Know	Yes Score 1	Surface water was above applicable EQGs.	Refer to an Ecological Risk Assessment for the site. If there is contaminated surface water at the site, assume that terrestrial organisms will ingest it.	
Are terrestrial animals likely to be ingesting contaminated soils at the site? Yes No Do Not Know	Yes Score 1	Surface soils exceed CCME criteria for several metals and BTEX. Terrestrial animals may ingest soil through consumption of plants or subsurface invertebrates.	Refer to an Ecological Risk Assessment report. Most animals will co-ingest some soil while eating plant matter or soil invertebrates.	
Can the contamination identified bioaccumulate? Yes No Do Not Know	Yes Score 1	Mercury detected in surface water and may bioaccumulate.	Bioaccumulation of contaminants within food items is considered possible if: 1) The Log(Kow) of the contaminant is greater than 4 (as per the chemical characteristics work sheet) and concentrations in soils exceed the most conservative CCME soil quality guideline for the intended land use, or 2) The contaminant in collected tissue samples exceeds the Canadian Tissue Residue Guidelines.	
Distance to sensitive terrestrial ecological area 0 to 300 m 300 m to 1 km 1 to 5 km > 5 km Do Not Know	1 to 5 km Score 1	Midland Park is approximately 4 km northwest of the site. (www.ccea.org)	It is considered that within 300 m of a site, there is a concern for contamination. Therefore an environmental receptor located within this area of the site will be subject to further evaluations. It is also considered that any environmental receptor located greater than 5 km will not be a concern for evaluation. Review Conservation Authority mapping and literature including Canadian Council on Ecological Areas link:www.ccea.org	Environmental receptors include: local, regional or provincial species of interest or significance; arctic environments (on a site specific basis); nature preserves, habitats for species at risk, sensitive forests, natural parks or forests.
Raw Terrestrial Total Potential	8	Note if a "Known" Ecological Effects score is provided, the "Potential" score is disallowed.		
Allowed Terrestrial Total Potential	8			
B. Potential for ecological exposure (for the contaminated portion of the site)				
b) Aquatic i) Classification of aquatic environment Sensitive Typical Not Applicable (no aquatic environment present) Do Not Know	Typical Score 1	Creek on site is considered to be a typical aqutic environment and has a low flow rate.	"Sensitive aquatic environments" include those in or adjacent to shellfish or fish harvesting areas, marine parks, ecological reserves and fish migration paths. Also includes those areas deemed to have ecological significance such as for fish food resources, spawning areas or having rare or endangered species. "Typical aquatic environments" include those in areas other than those listed above.	
ii) Uptake potential Does groundwater daylighting to an aquatic environment exceed the CCME water quality guidelines for the protection of aquatic life at the point of contact? Yes No (or Not Applicable) Do Not Know	Yes Score 1	Springs along the bank of the gully discharge to surface water at elevated metal concentrations	Groundwater concentrations of contaminants at the point of contact with an aquatic receiving environment can be estimated in three ways: 1) by comparing collected nearshore groundwater concentrations to the CCME water quality guidelines (this will be a conservative comparison, as contaminant concentrations in groundwater often decrease between nearshore wells and the point of discharge). 2) by conducting groundwater modeling to estimate the concentration of groundwater immediately before discharge. 3) by installing water samplers, "peepers", in the sediments in the area of daylighting groundwater.	
Distance from the contaminated site to an important surface water resource 0 to 300 m 300 m to 1 km 1 to 5 km > 5 km Do Not Know	300 m to 1 km Score 2	The Red River is proximal to the site.	It is considered that within 300 m of a site, there is a concern for contamination. Therefore an environmental receptor or important water resource located within this area of the site will be subject further evaluation. It is also considered that any environmental receptor located greater than 5 km away will not be a concern for evaluation. Review Conservation Authority mapping and literature including Canadian Council on Ecological Areas linkwww.ccea.org	Environmental receptors include: local, regional or provincial species of interest or significance, sensitive wetlands and fens and other aquatic environments
Are aquatic species (i.e., forage fish, invertebrates or plants) that are consumed by predatory fish or wildlife consumers, such as mammals and birds, likely to accumulate contaminants in their tissues? Yes No		Mecury present in surface water and may bioaccumulate.	Bioaccumulation of food items is possible if: 1) The Log(Kow) of the contaminant is greater than 4 (as per the chemical characteristics work sheet) and concentrations in sediments exceed the CCME ISQGs. 2) The contaminant in collected tissue samples exceeds the CCME tissue quality guidelines.	

(III) Exposure (Demonstrates the presence of an exposure pathway and receptors)

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method Of Evaluation	Notes
Do Not Know	Yes			
Score	1			
Raw Aquatic Total Potential	5	Note if a "Known" Ecological Effects score is provided, the "Potential" score is disallowed.		
Allowed Aquatic Total Potential	5			

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(III) Exposure (Demonstrates the presence of an exposure pathway and receptors)

Drumheller Institution

Definition	Score	Rationale for Score (document any assumptions, reports, or site-specific information; provide references)	Method Of Evaluation	Notes
4. Ecological Exposure Modifying Factors				
a) Known occurrence of a species at risk. Is there a potential for a species at risk to be present at the site? Yes No Do Not Know	Yes	Several species at risk are reported to potentially inhabit the area (Alberta Governments Species at Risk fact sheets - http://www.srd.alberta.ca/BiodiversityStewardship/SpeciesAtRisk/SpeciesSummaries/SpeciesAtRiskFactSheets.aspx).	Consult any ecological risk assessment reports. If information is not present, utilize on-line databases such as Eco Explorer. Regional, Provincial (Environment Ministries), or Federal staff (Fisheries and Oceans or Environment Canada) should be able to provide some guidance.	Species at risk include those that are extirpated, endangered, threatened, or of special concern. For a list of species at risk, consult Schedule 1 of the federal Species at Risk Act (http://www.sararegistry.gc.ca/species/schedules_e.cfm?id=1). Many provincial governments may also provide regionally applicable lists of species at risk. For example, in British Columbia, consult: BCMWLAP. 2005. Endangered Species and Ecosystems in British Columbia. Provincial red and blue lists. Ministry of Sustainable Resource Management and Water, Land and Air Protection (http://srmwww.gov.bc.ca/atrisk/red-blue.htm)
	2			
Score	---			
b) Potential impact of aesthetics (e.g., enrichment of a lake or tainting of food flavor).		There was no visual observation of impact to the receiving water bodies		
Is there evidence of aesthetic impact to receiving water bodies?	No		Documentation may consist of environmental investigation reports, press articles, petitions or other records.	This Item will require some level of documentation by user, including contact names, addresses, phone numbers, e-mail addresses. Evidence of changes must be documented, please attach copy of report containing relevant information.
Yes No Do Not Know	0 ---			
Is there evidence of olfactory impact (i.e., unpleasant smell)?	No		Examples of olfactory change can include the smell of a COPC or an increase in the rate of decay in an aquatic habitat.	
Yes No Do Not Know	0 ---			
Is there evidence of increase in plant growth in the lake or water body?	No	There was no evidence of increased plant growth documented.	A distinct increase of plant growth in an aquatic environment may suggest enrichment. Nutrients e.g., nitrogen or phosphorous releases to an aquatic body can act as a fertilizer.	
Yes No Do Not Know	0 ---			
Is there evidence that fish or meat taken from or adjacent to the site smells or tastes different?	Do Not Know	There is no documentation of changes to fish taste or smell.	Some contaminants can result in a distinctive change in the way food gathered from the site tastes or smells.	
Yes No Do Not Know	--- 1			
Ecological Modifying Factors Total - Known	**2**			
Ecological Modifying Factors Total - Potential	**1**			
Raw Ecological Total - Known	2			
Raw Ecological Total - Potential	14			
Raw Ecological Total	16			
Ecological Total (Max 18)	**16.0**			
5. Other Potential Contaminant Receptors				
a) Exposure of permafrost (leading to erosion and structural concerns)				Plants and lichens provide a natural insulating layer which will help prevent thawing of the permafrost during the summ Plants and lichens may also absorb less solar radiation. Solar radiation is turned into heat which can also cause underlying permafrost to melt.
Are there improvements (roads, buildings) at the site dependant upon the permafrost for structural integrity?	No		Consult engineering reports, site plans or air photos of the site. When permafrost melts, the stability the soil decreases, leading to erosion. Human structures, such as roads and/or buildings are often dependent on the stability that the permafrost provides.	
Yes No Do Not Know	0 ---			
Is there a physical pathway which can transport soils released by damaged permafrost to a nearby aquatic environment?	No	No evidence of soil transport observed.	Melting permafrost leads to a decreased stability of underlying soils. Wind or surface run-off erosion can carry soils into nearby aquatic habitats. The increased soil loadings into a river can cause an increase in total dissolved solids and a resulting decrease in aquatic habitat quality. In addition, the erosion can bring contaminants from soils to aquatic environments.	
Yes No Do Not Know	0 ---			
Other Potential Receptors Total - Known	**0**			
Other Potential Receptors Total - Potential	**0**			

Exposure Total	
Raw Human Health + Ecological Total - Known	2
Raw Human Health + Ecological Total - Potential	27
Raw Total	29
Exposure Total (max 34)	**21.4**

Only includes "Allowed potential" - if a "Known" score was supplied under a given category then the "Potential" score was not included.

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Score Summary

Scores from individual worksheets are tallied in this worksheet.
Refer to this sheet after filling out the revised NCS completely.

I. Contaminant Characteristics	Known	Potential
1. Residency Media	6	---
2. Chemical Hazard	8	---
3. Contaminant Exceedance Factor	6	---
4. Contaminant Quantity	2	---
5. Modifying Factors	4	---
Raw Total Score	26	0
Raw Total Score (Known + Potential)	26	
Adjusted Total Score (Raw Total / 40 *33)	**21.5**	(max 33)

II. Migration Potential	Known	Potential
1. Groundwater Movement	12	---
2. Surface Water Movement	12	---
3. Soil	12	---
4. Vapour	---	8
5. Sediment Movement	0	---
6. Modifying Factors	0	0
Raw Total Score	36	8
Raw Total Score (Known + Potential)	44	
Adjusted Total Score (Raw Total / 64 * 33)	**22.7**	(max 33)

III. Exposure	Known	Potential
1. Human Receptors		
A. Known Impact	---	
B Potential		
a. Land Use		3
b. Accessibility		0
c. Exposure Route		
i. Direct Contact		3
ii. Inhalation		3
iii. Ingestion		4
2. Human Receptors Modifying Factors	0	---
Raw Total Human Score	---	13
Raw Total Human Score (Known + Potential)	13	
Adjusted Total Human Score	13.0	(maximum 22)
3. Ecological Receptors		
A. Known Impact	---	
B. Potential		
a. Terrestrial		8
b. Aquatic		5
4. Ecological Receptors Modifying Factors	2	1
Raw Total Ecological Score	2	14
Raw Total Ecological Score (Known + Potential)	16	
Adjusted Total Ecological Score	16.0	(maximum 18)
5. Other Receptors	0	0
Total Other Receptors Score (Known + Potential)	0	
Total Exposure Score (Human + Ecological + Other)	**29.0**	
Adjusted Total Exposure Score (Total Exposure / 46 * 34)	**21.4**	(max 34)

Site Score

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Site Letter Grade	**D**
Certainty Percentage	**81%**
% Responses that are "Do Not Know"	**0%**
Total NCSCS Score for site	**65.6**
Site Classification Category	**2**

Site Classification Categories*:

Class 1 - High Priority for Action (Total NCS Score >70)
Class 2 - Medium Priority for Action (Total NCS Score 50 - 69.9)
Class 3 - Low Priority for Action (Total NCS Score 37 - 49.9)
Class N - Not a Priority for Action (Total NCS Score <37)
Class INS - Insufficient Information (>15% of responses are "Do Not Know")

* NOTE: The term "action" in the above categories does not necessarily refer to remediation, but could also include risk assessment, risk management or further site characterization and data collection.

CCME National Classification System (2008, 2010 v 1.2)

Contaminant Hazard Ranking

(Based on the Proposed Hazard Ranking developed for the FCSAP Contaminated Sites Classification System)

This information is used in Sheet I (Contaminant Characteristics), section 2 (Chemical Hazard).

Chemical/Parameter	Hazard	CEPA	Carcinogenicity	Notes
Acetaldehyde	H	*	PHC	
Acetone	L			
Acrolein	H	*		
Acrylonitrile	H	*	PHC	
Alachlor	M			
Aldicarb	H			
Aldrin	H			
Allyl Alcohol	H			
Aluminum	L			
Ammonia	L	*		
Antimony	H			
Arsenic	H	*		
Atrazine	M			
Azinphos-Methyl	H			
Barium	L			
Bendiocarb	H			
Benzene	H	*	CHC	BTEX
Benzidine	H	*	CHC	
Beryllium	H		CHC	
Biphenyl, 1,1-	M			
2,3,4,5-Bis(2-Butylene)tetrahydro-2-furfural	H			
Bis(Chloromethyl)Ether	H	*	CHC	
Bis(2-Chloroethyl)Ether	H		CHC	
Bis(2-Chloroisopropyl)Ether	H			
Bis(2-Ethylhexyl)Phthalate	H	*		PH
Boron	L			
Bromacil	M			
Bromate	M			
Bromochlorodifluoromethane	M	*		HM
Bromochloromethane	H	*		HM
Bromodichloromethane	H			HM
Bromoform (Tribromomethane)	H		PHC	HM
Bromomethane	M			HM
Bromotrifluoromethane	M	*		HM
Bromoxynil	H			
Butadiene, 1,3-	H	*	CHC	
Cadmium	H	*	CHC	
Carbofuran	M			
Carbon Tetrachloride (Tetrachloromethane)	H		PHC	HM
Captafol	M			
Chloramines	M	*		
Chloride	L			

Chemical/Parameter	Hazard	CEPA	Carcinogenicity	Notes
Chloroaniline, P-	H			
Chlorobenzene (mono)	M			
Chlorobenzilate	M			
Chlorodimeform	M			
Chloroform	H		PHC	HM
Chloromethane	M			
Chloromethyl Methyl Ether	M	*		
(4-Chlorophenyl)Cyclopropylmethanone, O-((4-Nitrophenyl)Methyl)Oxime	H			
Chlorinated Benzenes				
Monochlorobenzene	M			
Dichlorobenzene, 1,2- (O-DCB)	M			
Dichlorobenzene, 1,3- (M-DCB)	M			
Dichlorobenzene, 1,4- (P-DCB)	H			
Trichlorobenzene, 1,2,3-	M			
Trichlorobenzene, 1,2,4-	M			
Trichlorobenzene, 1,3,5-	M			
Tetrachlorobenzene, 1,2,3,4-	M			
Tetrachlorobenzene, 1,2,3,5-	M			
Tetrachlorobenzene, 1,2,4,5-	M			
Pentachlorobenzene	M			
Hexachlorobenzene	H			
Chlorinated Ethanes				
Dichloroethane, 1,1-	M			
Dichloroethane, 1,2- (Ethylene Dichloride (EDC))	H		PHC	
Trichloroethane, 1,1,1-	H	*		
Trichloroethane, 1,1,2-	M			
Tetrachloroethane, 1,1,1,2-	M			
Tetrachloroethane, 1,1,2,2-	M			
Chlorinated Ethenes				
Monochloroethene (Vinyl Chloride)	H	*	CHC	
Dichloroeth(yl)ene, 1,1-	H			
Dichloroeth(yl)ene, 1,2- (cis or trans)	M			
Trichloroeth(yl)ene (TCE)	H	*		
Tetrachloroeth(yl)ene (PCE)	H	*		
Chlorinated Phenols		*		
Monochlorophenols	M			
Chlorophenol, 2-	M			
Dichlorophenols				
Dichlorophenol, 2,4-	M			
Trichlorophenols				
Trichlorophenol, 2,4,5-	H			
Trichlorophenol, 2,4,6-	H		PHC	
Tetrachlorophenols				
Tetrachlorophenol, 2,3,4,6-	H			
Pentachlorophenol (PCP)	H			
Chloromethane	M			HM
Chlorophenol, 2-	M			CP
Chlorothalonil	H			

Chemical/Parameter	Hazard	CEPA	Carcinogenicity	Notes
Chlorpyrifos	H			
Chromium (Total)	M	*		
Chromium (III)	L	*		
Chromium (VI)	H	*	CHC	
Coal Tar	H		CHC	Refer to PAHs
Cobalt	L			
Copper	L			
Creosote	M	*		Refer to PAHs
Crocidolite	L			
Cyanide (Free)	H			
Cyanazine	M			
Dibenzofuran	H	*		DF
Dibromoethane, 1,2- (Ethylene Dibromide (EDB))	H		PHC	
1,2-Dibromo-3-Chloropropane	H		PHC	
Dibromochloromethane	M	*		HM
Dibromotetrafluoroethane	M			
Dichlorobenzene, 1,2- (O-DCB)	M			CB
Dichlorobenzene, 1,3- (M-DCB)	M			CB
Dichlorobenzene, 1,4- (P-DCB)	H			CB
Dichlorobenzidine, 3,3'-	H		PHC	
DDD	H			
DDE	H			
DDT	H		PHC	
Deltamethrin	M			
Diazinon	M			
Dicamba	H			
Dichloroethane, 1,1-	H			CEA
Dichloroethane, 1,2- (EDC)	H		PHC	CEA
Dichloroeth(yl)ene, 1,1-	H			CEE
Dichloroeth(yl)ene, Cis-1,2-	M			CEE
Dichloroeth(yl)ene, Trans-1,2-	M			CEE
Dichloromethane (Methylene Chloride)	H		PHC	HM
Dichlorophenol, 2,4-	M			CP
Dichloropropane, 1,2-	H			
Dichloropropene, 1,3-	H		PHC	
Diclofop-Methyl	H			
Didecyl Dimethyl Ammonium Chloride	H			
Dieldrin	H			
Dimethoate	H			
Diethyl Phthalate	M			PH
Diethylene Glycol	L			GL
Dimethyl Phthalate	M			PH
Dimethylphenol, 2,4-	L			
Dinitrophenol, 2,4-	M			
Dinitrotoluene, 2,4-	H			
Dinoseb	H			
Di-n-octyl Phthalate	H			
Dioxane, 1,4-	H		PHC	
Dioxins/Furans	H			
Diquat	M			

Chemical/Parameter	Hazard	CEPA	Carcinogenicity	Notes
Diuron	M			
Endosulfan	H			
Endrin	H			
Ethylbenzene	M			BTEX
Ethylene Dibromide (EDB)	H		PHC	
Ethylene Glycol	L			GL
Ethylene Oxide	H		CHC	
Fluoroacetamide	M			
Fluorides	L	*		
Glycols				
Ethylene Glycol	L			
Diethylene Glycol	L			
Propylene Glycol	L			
Glyphosate	M			
Halogenated Methanes				
Bromochlorodifluoromethane	M	*		
Bromochloromethane	M	*		
Bromodichloromethane	H		PHC	
Bromomethane	M			
Bromotrifluoromethane	M	*		
Chloroform	M		PHC	HM
Chloromethane	M			
Dibromochloromethane	M			
Dichloromethane (Methylene Chloride)	H		PHC	
Methyl Bromide	M	*		
Tetrachloromethane (Carbon Tetrachloride)	H			
Tribromomethane (Bromoform)	H			
Trihalomethanes (THM)	M			
Heptachlor	H			
Heptachlor Epoxide	H			
Hexachlorobenzene	H		PHC	
Hexachlorobutadiene	H			
Hexachlorocyclohexane, Gamma	H		PHC	
Hexachloroethane	H		PHC	
Hydrobromofluorocarbons (HBFCS)	M	*		
Hydrochlorofluorocarbons (HCFCS)	M	*		
3-Iodo-2-propynyl Butyl Carbamate	H			
Iron	L			
Lead	H	*		neurotoxins / teratogens
Lead Arsenate	H			
Leptophos	H			
Lindane	H			
Linuron	H			
Lithium	L			
Malathion	M			
Manganese	L			

Chemical/Parameter	Hazard	CEPA	Carcinogenicity	Notes
Mercury	H	*		
Methamidophos	H			
Methoxylchlor	H			
Methyl Bromide (Bromomethane)	M	*		
2-Methyl-4-chloro-phenoxy Acetic Acid	M			
Methyl Ethyl Ketone	L			
Methyl Isobutyl Ketone	L			
Methyl Mercury	H			
Methyl-Parathion	H			
Methyl Tert Butyl Ether (MTBE)	M			
Metolachlor	M			
Metribuzin	H			
Molybdenum	L			
Monochloramine	M			
Monocrotophos	H			
Nickel	H	*		CEPA - inhalation
Nitrilotriacetic Acid	H		PHC	
Nitrate	L			
Nitrite	M			
Nonylphenol + Ethoxylates	H	*		
Organotins				
Tributyltin	H			
Tricyclohexyltin	H			
Triphenyltin	H			
Parathion	H			
Paraquat (as Dichloride)	H			
Pentachlorobenzene	M			CB
Pentachlorophenol (PCP)	H			CP
Petroleum Hydrocarbons				Ranking based upon fraction of toxic and mobile components in product. Lighter compounds such as benzene are more toxic and mobile.
Petroleum Hydrocarbons (Gasoline)	H			
Petroleum Hydrocarbons (Kerosene incl. Jet Fuels)	H			
Petroleum Hydrocarbons (Diesel incl Heating Oil)	M			
Petroleum Hydrocarbons (Heavy Oils)	L			
Petroleum Hydrocarbons (CCME F1)	H			
Petroleum Hydrocarbons (CCME F2)	M			
Petroleum Hydrocarbons (CCME F3)	L			
Petroleum Hydrocarbons (CCME F4)	L			
Phenol	L			
Phenoxy Herbicides	M			
Phorate	H			
Phosphamidon	H			
Phthalate Esters				
Bis(2-Ethylhexyl)Phthalate	H	*		
Diethyl Phthalate	H			
Dimethyl Phthalate	H			
Di-n-octyl Phthalate	H			
Polybrominated Biphenyls (PBB)	H	*		
Polychlorinated Biphenyls (PCB)	H			

Chemical/Parameter	Hazard	CEPA	Carcinogenicity	Notes
Polychlorinated Terphenyls	H	*		
Polycyclic Aromatic Hydrocarbons	H	*	PHC	
Acenaphthene	M			
Acenaphthylene	M			
Acridine	H			
Anthracene	M			
Benzo(a)anthracene	H		PHC	
Benzo(a)pyrene	H		PHC	
Benzo(b)fluoranthene	H		PHC	
Benzo(g,h,i)perylene	H			
Benzo(k)fluoranthene	H		PHC	
Chrysene	M			
Dibenzo(a,h)anthracene	H		PHC	
Fluoranthene	M			
Fluorene	M			
Indeno(1,2,3-c,d)pyrene	H		PHC	
Methylnaphthalenes	M			
Naphthalene	M			
Phenanthrene	M			
Pyrene	M			
Quinoline	H			
Propylene Glycol	L			GL
Radium	H			
Radon	H			
Selenium	M			
Silver	L			
Simazine	M			
Sodium	L			
Strontium-90	H			
Strychnine	H			
Styrene	H			
Sulphate	L			
Sulphide	L			
2,3,7,8-Tetrachlorodibenzo-p-dioxins (TCDD)	H	*		DF
Tebuthiuron	H			
Tetrachloroeth(yl)ene (PCE)	H	*		CEE
Tetraethyl Lead	H			
Tetrachlorobenzene, 1,2,3,4-	H			CB
Tetrachlorobenzene, 1,2,3,5-	H			CB
Tetrachlorobenzene, 1,2,4,5-	H			CB
Tetrachloroethane, 1,1,1,2-	M			CEA
Tetrachloroethane, 1,1,2,2-	M			CEA
Tetrachlorophenol, 2,3,4,6-	H			CP
Tetramethyl Lead	H	*		
Thallium	M			
Thiophene	M			
Tin	L			
Toluene	M			BTEX
Toxaphene	H			

Chemical/Parameter	Hazard	CEPA	Carcinogenicity	Notes
Triallate	M			
Tribromomethane (Bromoform)	H			HM
Tributyltetradecylphosphonium Chloride	H	*		
Trichlorobenzene, 1,2,3-	H			CB
Trichlorobenzene, 1,2,4-	H			CB
Trichlorobenzene, 1,3,5-	H			CB
Trichloroethane, 1,1,1-	H	*		CEA
Trichloroethane, 1,1,2-	M			CEA
Trichloroeth(yl)ene (TCE)	H	*		CEE
Tricyclohexyltin Hydroxide	H			
Trichlorophenol, 2,4,5-	H			CP
Trichlorophenol, 2,4,6-	H		PHC	CP
Trifluralin	H			
Trihalomethanes (THM)	M			
Tris(2,3-Dibromopropyl)phosphate	H			
Tritium	L			
Uranium (Non-radioactive) / (Radioactive)	M/H			
Vanadium	M			
Vinyl Chloride	H	*	CHC	CEE
Xylenes	M			BTEX
Zinc	L			

H = High Hazard
M = Medium Hazard
L = Low Hazard
Hazard ratings based on a number of factors including potential human and ecological health effects.

PHC = Potential Human Carcinogen
CHC = Confirmed Human Carcinogen

BTEX = benzene, toluene, ethylbenzene, and xylenes
CB = chlorobenzenes
CEA = chlorinated ethanes
CEE = chlorinated ethenes
CP = chlorophenols
DF = dioxins and furans
GL = glycols
HM = halomethanes
PAH = polycyclic aromatic hydrocarbons
PH = phthalate esters

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Reference Material (Information to assist in scoring)

Examples of Persistent Substances

This information is used in Sheet I (Chemical Characteristics), section 5 (Modifying Factors).

aldrin	dieldrin	PCBs
benzo(a)pyrene	hexachlorobenzene	PCDDs/PCDFs (dioxins and furans)
chlordane	methylmercury	toxaphene
DDT	mirex	alkylated lead
DDE	octachlorostyrene	

Examples of Substances in the Various Chemical Classes

This information is used in Sheet I (Chemical Characteristics), section 5 (Modifying Factors).

Chemical Class	Examples *
inorganic substances (including metals)	arsenic, barium, cadmium, hexavalent chromium, copper, cyanide, fluoride, lead, mercury, nickel, selenium, sulphur, zinc; brines or salts
volatile petroleum hydrocarbons	benzene, toluene, ethylbenzene, xylenes, PHC F1
light extractable petroleum hydrocarbons	PHC F2
heavy extractable petroleum hydrocarbons	PHC F3
PAHs	Benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenz(a,h0anthracene, indeno(1,2,3-c,d)pyrene, naphthalene, phenanthrene, pyrene
phenolic substances	phenol, pentachlorophenol, chlorophenols, nonchlorinated phenols (e.g., 2,4-dinitrophenol, cresol, etc.)
chlorinated hydrocarbons	PCBs, tetrachloroethylene, trichloroethylene, dioxins and furans, trichlorobenzene, tetrachlorobenzene, pentachlorobenzene, hexachlorobenzene
halogenated methanes	carbon tetrachloride, chloroform, dichloromethane
phthalate esters	di-isononyl phthalate (DINP), di-isodecyl phthalate (DIDP), di-2-ethylhexyl phthalate (DEHP)
pesticides	DDT, hexachlorocyclohexane

* Note: Specific chemicals that belong to the various classes are not limited to those listed in this table. These lists are not exhaustive and are meant just to provide examples of substances that are typically encountered.

Chemical-specific Properties
(Adapted from USEPA Soil Screening Criteria)

The information on Koc is used in Sheet II (Migration Potential), section 1,B,a (Relative Mobility).
The information on the dimensionless Henry's law constant is used in Sheet II (Migration Potential), section 4,B,a (Relative Volatility).
The information on log Kow is used in Sheet III (Exposure), section 3,B,a,iii (Potential for Ecological Exposure - terrestrial ingestion), and section 3,B,b,ii (Potential for Ecological Exposure - aquatic uptake potential).

CAS No.	Compound	Solubility in Water @ 20-25°C (mg/L)	Henry's Law Constant (atm-m3/mol)	Dimensionless Henry's law constant (HLC [atm-m3/mol] * 41) (25 °C).	log Kow	Log Koc (L/kg)
83-32-9	Acenaphthene	4.24E+00	1.55E-04	6.36E-03	3.92	3.85
67-64-1	Acetone	1.00E+06	3.88E-05	1.59E-03	-0.24	-0.24
309-00-2	Aldrin	1.80E-01	1.70E-04	6.97E-03	6.5	6.39
120-12-7	Anthracene	4.34E-02	6.50E-05	2.67E-03	4.55	4.47
56-55-3	Benz(a)anthracene	9.40E-03	3.35E-06	1.37E-04	5.7	5.6
71-43-2	Benzene	1.75E+03	5.55E-03	2.28E-01	2.13	1.77
205-99-2	Benzo(b)fluoranthene	1.50E-03	1.11E-04	4.55E-03	6.2	6.09
207-08-9	Benzo(k)fluoranthene	8.00E-04	8.29E-07	3.40E-05	6.2	6.09
65-85-0	Benzoic acid	3.50E+03	1.54E-06	6.31E-05	1.86	—
50-32-8	Benzo(a)pyrene	1.62E-03	1.13E-06	4.63E-05	6.11	6.01
111-44-4	Bis(2-chloroethyl)ether	1.72E+04	1.80E-05	7.38E-04	1.21	1.19
117-81-7	Bis(2-ethylhexyl)phthalate	3.40E-01	1.02E-07	4.18E-06	7.3	7.18
75-27-4	Bromodichloromethane	6.74E+03	1.60E-03	6.56E-02	2.1	1.74
75-25-2	Bromoform	3.10E+03	5.35E-04	2.19E-02	2.35	1.94
71-36-3	Butanol	7.40E+04	8.81E-06	3.61E-04	0.85	0.84
85-68-7	Butyl benzyl phthalate	2.69E+00	1.26E-06	5.17E-05	4.84	4.76
86-74-8	Carbazole	7.48E+00	1.53E-08	6.26E-07	3.59	3.53
75-15-0	Carbon disulfide	1.19E+03	3.03E-02	1.24E+00	2	1.66
56-23-5	Carbon tetrachloride	7.93E+02	3.04E-02	1.25E+00	2.73	2.24
57-74-9	Chlordane	5.60E-02	4.86E-05	1.99E-03	6.32	5.08
106-47-8	*p-Chloroaniline*	5.30E+03	3.31E-07	1.36E-05	1.85	1.82
108-90-7	Chlorobenzene	4.72E+02	3.70E-03	1.52E-01	2.86	2.34
124-48-1	Chlorodibromomethane	2.60E+03	7.83E-04	3.21E-02	2.17	1.8
67-66-3	Chloroform	7.92E+03	3.67E-03	1.50E-01	1.92	1.6
95-57-8	2-Chlorophenol	2.20E+04	3.91E-04	1.60E-02	2.15	—
218-01-9	Chrysene	1.60E-03	9.46E-05	3.88E-03	5.7	5.6
72-54-8	DDD	9.00E-02	4.00E-06	1.64E-04	6.1	6
72-55-9	DDE	1.20E-01	2.10E-05	8.61E-04	6.76	6.65
50-29-3	DDT	2.50E-02	8.10E-06	3.32E-04	6.53	6.42
53-70-3	Dibenz(a,h)anthracene	2.49E-03	1.47E-08	6.03E-07	6.69	6.58
84-74-2	Di-n-butyl phthalate	1.12E+01	9.38E-10	3.85E-08	4.61	4.53
95-50-1	1,2-Dichlorobenzene	1.56E+02	1.90E-03	7.79E-02	3.43	2.79

CAS No.	Compound	Solubility in Water @ 20-25°C (mg/L)	Henry's Law Constant (atm-m3/mol)	Dimensionless Henry's law constant (HLC [atm-m3/mol] * 41) (25 °C).	log Kow	Log Koc (L/kg)
106-46-7	1,4-Dichlorobenzene	7.38E+01	2.43E-03	9.96E-02	3.42	2.79
91-94-1	3,3-Dichlorobenzidine	3.11E+00	4.00E-09	1.64E-07	3.51	2.86
75-34-3	1,1-Dichloroethane	5.06E+03	5.62E-03	2.30E-01	1.79	1.5
107-06-2	1,2-Dichloroethane	8.52E+03	9.79E-04	4.01E-02	1.47	1.24
75-35-4	1,1-Dichloroethylene	2.25E+03	2.61E-02	1.07E+00	2.13	1.77
156-59-2	cis-1,2-Dichloroethylene	3.50E+03	4.08E-03	1.67E-01	1.86	1.55
156-60-5	trans-1,2-Dichloroethylene	6.30E+03	9.38E-03	3.85E-01	2.07	1.72
120-83-2	2,4-Dichlorophenol	4.50E+03	3.16E-06	1.30E-04	3.08	—
78-87-5	1,2-Dichloropropane	2.80E+03	2.80E-03	1.15E-01	1.97	1.64
542-75-6	1,3-Dichloropropene	2.80E+03	1.77E-02	7.26E-01	2	1.66
60-57-1	Dieldrin	1.95E-01	1.51E-05	6.19E-04	5.37	4.33
84-66-2	Diethylphthalate	1.08E+03	4.50E-07	1.85E-05	2.5	2.46
105-67-9	2,4-Dimethylphenol	7.87E+03	2.00E-06	8.20E-05	2.36	2.32
51-28-5	2,4-Dinitrophenol	2.79E+03	4.43E-07	1.82E-05	1.55	—
121-14-2	2,4-Dinitrotoluene	2.70E+02	9.26E-08	3.80E-06	2.01	1.98
606-20-2	2,6-Dinitrotoluene	1.82E+02	7.47E-07	3.06E-05	1.87	1.84
117-84-0	Di-n-octyl phthalate	2.00E-02	6.68E-05	2.74E-03	8.06	7.92
115-29-7	Endosulfan	5.10E-01	1.12E-05	4.59E-04	4.1	3.33
72-20-8	Endrin	2.50E-01	7.52E-06	3.08E-04	5.06	4.09
100-41-4	Ethylbenzene	1.69E+02	7.88E-03	3.23E-01	3.14	2.56
206-44-0	Fluoranthene	2.06E-01	1.61E-05	6.60E-04	5.12	5.03
86-73-7	Fluorene	1.98E+00	6.36E-05	2.61E-03	4.21	4.14
76-44-8	Heptachlor	1.80E-01	1.09E-03	4.47E-02	6.26	6.15
1024-57-3	Heptachlor epoxide	2.00E-01	9.50E-06	3.90E-04	5	4.92
118-74-1	Hexachlorobenzene	6.20E+00	1.32E-03	5.41E-02	5.89	4.74
87-68-3	Hexachloro-1,3-butadiene	3.23E+00	8.15E-03	3.34E-01	4.81	4.73
319-84-6	a-HCH (a-BHC)	2.00E+00	1.06E-05	4.35E-04	3.8	3.09
319-85-7	b-HCH (b-BHC)	2.40E-01	7.43E-07	3.05E-05	3.81	3.1
58-89-9	g -HCH (Lindane)	6.80E+00	1.40E-05	5.74E-04	3.73	3.03
77-47-4	Hexachlorocyclopentadiene	1.80E+00	2.70E-02	1.11E+00	5.39	5.3
67-72-1	Hexachloroethane	5.00E+01	3.89E-03	1.59E-01	4	3.25
193-39-5	Indeno(1,2,3-cd)pyrene	2.20E-05	1.60E-06	6.56E-05	6.65	6.54
78-59-1	Isophorone	1.20E+04	6.64E-06	2.72E-04	1.7	1.67
7439-97-6	Mercury	—	1.14E-02	4.67E-01	—	—
72-43-5	Methoxychlor	4.50E-02	1.58E-05	6.48E-04	5.08	4.99
74-83-9	Methyl bromide	1.52E+04	6.24E-03	2.56E-01	1.19	1.02
75-09-2	Methylene chloride	1.30E+04	2.19E-03	8.98E-02	1.25	1.07
95-48-7	2-Methylphenol	2.60E+04	1.20E-06	4.92E-05	1.99	1.96
91-20-3	Naphthalene	3.10E+01	4.83E-04	1.98E-02	3.36	3.3
98-95-3	Nitrobenzene	2.09E+03	2.40E-05	9.84E-04	1.84	1.81

CAS No.	Compound	Solubility in Water @ 20-25°C (mg/L)	Henry's Law Constant (atm-m3/mol)	Dimensionless Henry's law constant (HLC [atm-m3/mol] * 41) (25 °C).	log Kow	Log Koc (L/kg)
86-30-6	N-Nitrosodiphenylamine	3.51E+01	5.00E-06	2.05E-04	3.16	3.11
621-64-7	N-Nitrosodi-n-propylamine	9.89E+03	2.25E-06	9.23E-05	1.4	1.38
1336-36-3	PCBs	—	—	—	5.58	5.49
87-86-5	Pentachlorophenol	1.95E+03	2.44E-08	1.00E-06	5.09	—
108-95-2	Phenol	8.28E+04	3.97E-07	1.63E-05	1.48	1.46
129-00-0	Pyrene	1.35E-01	1.10E-05	4.51E-04	5.11	5.02
100-42-5	Styrene	3.10E+02	2.75E-03	1.13E-01	2.94	2.89
79-34-5	1,1,2,2-Tetrachloroethane	2.97E+03	3.45E-04	1.41E-02	2.39	1.97
127-18-4	Tetrachloroethylene	2.00E+02	1.84E-02	7.54E-01	2.67	2.19
108-88-3	Toluene	5.26E+02	6.64E-03	2.72E-01	2.75	2.26
8001-35-2	Toxaphene	7.40E-01	6.00E-06	2.46E-04	5.5	5.41
120-82-1	1,2,4-Trichlorobenzene	3.00E+02	1.42E-03	5.82E-02	4.01	3.25
71-55-6	1,1,1-Trichloroethane	1.33E+03	1.72E-02	7.05E-01	2.48	2.04
79-00-5	1,1,2-Trichloroethane	4.42E+03	9.13E-04	3.74E-02	2.05	1.7
79-01-6	Trichloroethylene	1.10E+03	1.03E-02	4.22E-01	2.71	2.22
95-95-4	2,4,5-Trichlorophenol	1.20E+03	4.33E-06	1.78E-04	3.9	—
88-06-2	2,4,6-Trichlorophenol	8.00E+02	7.79E-06	3.19E-04	3.7	—
108-05-4	Vinyl acetate	2.00E+04	5.11E-04	2.10E-02	0.73	0.72
75-01-4	Vinyl chloride	2.76E+03	2.70E-02	1.11E+00	1.5	1.27
108-38-3	m-Xylene	1.61E+02	7.34E-03	3.01E-01	3.2	2.61
95-47-6	o-Xylene	1.78E+02	5.19E-03	2.13E-01	3.13	2.56
106-42-3	p-Xylene	1.85E+02	7.66E-03	3.14E-01	3.17	2.59

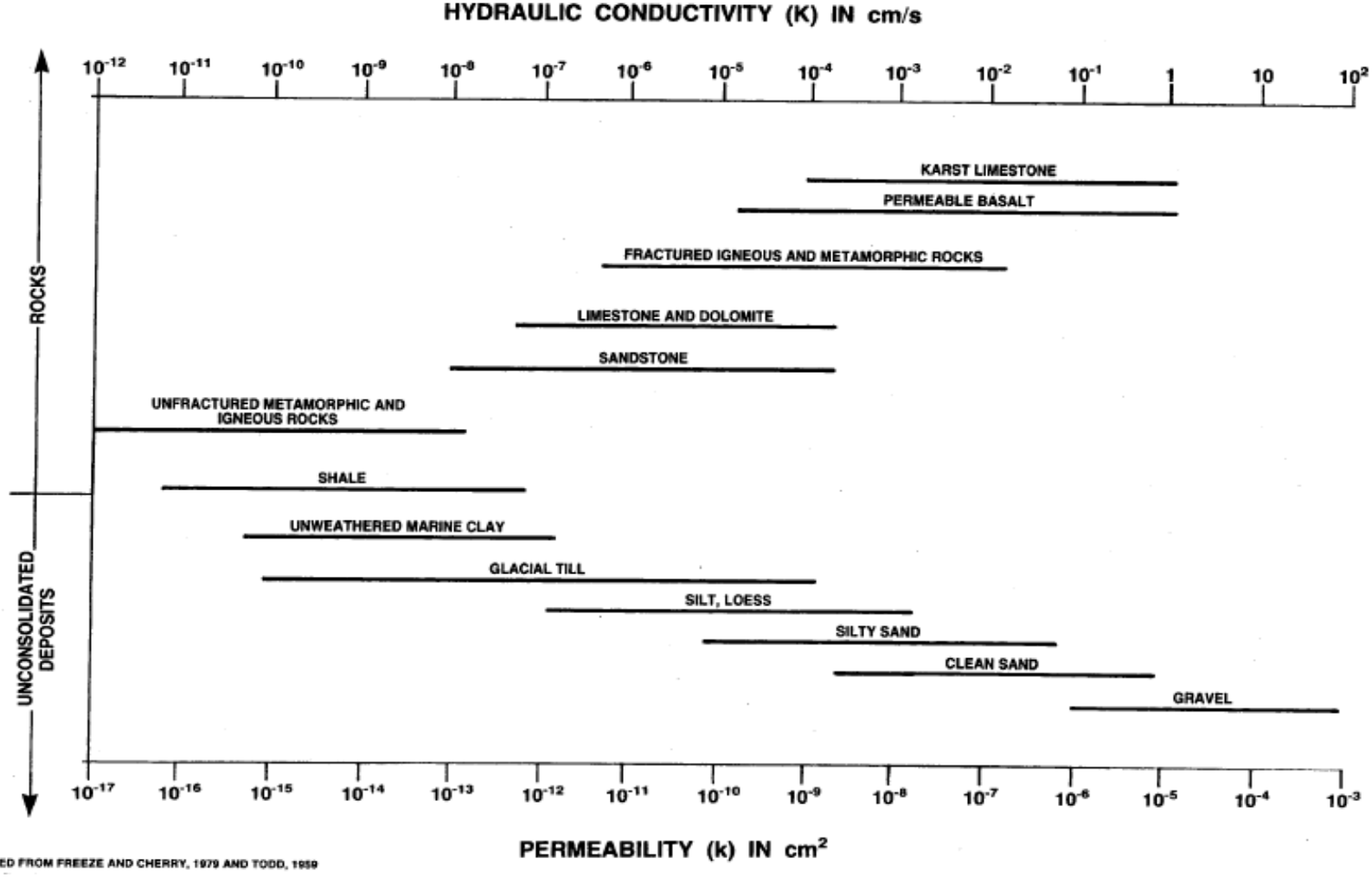
Source: United States Environmental Protection Agency. 1996. Soil Screening Guidance: Technical Background Document. EPA/540/R-95/128 (http://www.epa.gov/superfund/resources/soil/toc.htm#p5)

CAS = Chemical Abstracts Service

Kow = Octanol/water partition coefficient

RANGE OF VALUES OF HYDRAULIC CONDUCTIVITY AND PERMEABILITY

The information on Koc is used in Sheet II (Migration Potential), section 1,B,f (Hydraulic Conductivity)



MODIFIED FROM FREEZE AND CHERRY, 1979 AND TODD, 1959

APPENDIX G

Remedial Cost Estimates

Table G-1
Opinion of Probable Costs
Rifle Range Site 530-C04

Rifle Range Site 530-C04												
Drumheller Institution Remedial Options/Opinion of Probable Cost	**Option 1 - Removal of Impacted Soils**				**Option 2 - In-Situ Management (mechanical screening)**				**Option 3 - In-Situ Treatment (soil washing)**			
Category	*Quantity*	*Unit price*	*Units*	*Sub-Total*	*Quantity*	*Unit price*	*Units*	*Sub-Total*	*Quantity*	*Unit price*	*Units*	*Sub-Total*
Capital Costs- Work Elements												
Equipment and Labour (Contractor Fees)												
Contractor - Equipment (excavator, loader/dozer and labour)	6	$4,500	per day	$27,000	1	$10,000	lump sum	$10,000	9	$4,500	per day	$40,500
Contractor - Backfill (haul and place)	3,080	$10	per metric tonne	$30,800								
Contractor - Impacted Soil hauling	3,080	$15	per metric tonne	$46,200								
Contractor - Landfill Disposal (Clean Harbour, Ryley, AB)	3,080	$175	per metric tonne	$539,000								
Contractor - Soil Washing									3,080	$55	per metric tonne	$169,400
Contractor - gathering and stockpiling soil					3080	$5	per metric tonne	$15,400				
Contractor - mechanical screening of soil					3080	$6	per metric tonne	$18,480				
Contractor - backfilling					3080	$5	per metric tonne	$15,400				
Project Supervision and Management (Professional Fees)												
Project Design and Management Fees - On-Site Supervision, reporting	1	$30,000	lump sum	$30,000	1	$25,000	lump sum	$25,000	1	$40,000	lump sum	$40,000
Site Supervision - Mob and Demob	1	$2,000	per week	$2,000	2	$2,000	per week	$4,000	2	$2,000	per week	$4,000
Site Supervision - Meals/Accomodation	7	$250	per day	$1,750	8	$250	per day	$2,000	14	$250	per day	$3,500
Site Supervision - Equipment and Supplies	1	$3,000	per week	$3,000	1	$3,000	per week	$3,000	2	$3,000	per week	$6,000
Laboratory - Confimatory sampling (rush)	30	$195	per sample	$5,850					50	$195	per sample	$9,750
Capital Costs - subtotal -A				***$685,600***				***$93,280***				***$273,150***
Operating Costs - Work Elements												
None												
Operating Costs -subtotal -B				***$0***				***$0***				***$0***
Total Estimated Cost (A+B)				***$685,600***				***$93,280***				***$273,150***

Notes:
- volume estimates are preliminary
- 1 cubic m = 2.2 tonnes
- Does not include the costs for dewatering of excavation
- assumes 100% of soils require disposal
- does not include QA/QC
- assumes soils hazardous and disposal at a Class I landfill.

Notes:
- volume estimates are preliminary
- 1 cubic m = 2.2 tonnes
- contractor site work includes stripping upper soils at ~1,000 m3/day (1 day) and screening of soils at a rate of 300-400 m3/day (5 days), and backfilling (2 days)
- Does not include the costs for dewatering of excavation
- does not include QA/QC
- does not include any further monitoring
"- only includes costs for one round of mechanical screening of soils

Notes:
- volume estimates are preliminary
- 1 cubic m = 2.2 tonnes
- contractor site work includes stripping upper soils at ~1,000 m3/day (1.5 days) and treatment of impacted soils at a rate of 300-400 m3/day (5 days), temporary storage (5 days) and backfilling (2 days).
- does not include cost for dewatering of excavation.
- does not include QA/QC.
- does not include additional costs for chemical separation if needed.
- assumes soils non-hazardous and disposal at a Class II landfill.

Table G-2
Opinion of Probable Costs
Former Landfill Site 530-L01

Former Landfill Site 530-L01												
Drumheller Institution Remedial Options/Opinion of Probable Cost	**Option 1 - Long Term Monitoring**				**Option 2 - Passive In-Situ Treatment and Monitored Natural Attenuation**				**Option 3 - Risk Assessment**			
Category	*Quantity*	*Unit price*	*Units*	*Sub-Total*	*Quantity*	*Unit price*	*Units*	*Sub-Total*	*Quantity*	*Unit price*	*Units*	*Sub-Total*
Capital Costs - Work Elements												
Materials												
Wetland construction materials- 1 area					1	$80,000	lump sum	$80,000				
Equipment and Labour (Contractor Fees)												
Channel portal drainage and creek					1	$50,000	lump sum	$50,000				
Wetland construction - 1 area					1	$100,000	lump sum	$100,000				
Contractor - Drilling including Mob and Demob, Labour and Well Installation (5)	1	$17,500	lump sum	$17,500	1	$17,500	lump sum	$17,500	1	$17,500	lump sum	$17,500
Project Supervision and Management (Professional Fees)												
Project Design and Management	1	50,000	lump sum	$50,000	1	$50,000	lump sum	$50,000				
Development of SSRA (human and eco)									1	$60,000	lump	$60,000
Bench Scale Treatment -pilot tesing for wetland					1	$30,000	lump sum	$30,000				
Project Supervision - Wetland Installation					1	$20,000	lump sum	$20,000				
Professional Fees and Disbusments (on-site overview, project management, mob and demob, meals)					1	$40,000	lump sum	$40,000				
Monitoring (Mob and Demob, meals, equipment)	1	$7,000	lump	$7,000					1	$7,000	lump	$7,000
Monitoring (jr professional fees)	4	$900	per day	$3,600					4	$900	per day	$3,600
Laboratory Sampling (GW and SW)	12	$400	per sample	$4,800					12	$400	per sample	$4,800
Laboratory Sampling (soil)	6	$250	per sample	$1,500					6	$250	per sample	$1,500
Estimated Capital Costs - subtotal A				***$84,400***				***$387,500***				**$94,400**
Operating Costs												
Monitoring for 5 years (site visit, laboratory, data evaluation and reporting)	5	$15,000	year	$75,000	5	$15,000	year	$75,000				
Operating Costs -subtotal -B				***$75,000***				***$75,000***				**$0**
Total Estimated Cost (A+B)				***$159,400***				***$462,500***				**$94,400**

Notes
- Infers an additional site visit is required to eliminate data gaps
- assumes drilling 5 wells for additional sampling
- does not include QAQC
- only includes cost for 1 sampling round each year
- does not account for costs of inflation over a 10 yr period

Notes
- assumes drilling 5 wells for additional sampling
- does not include QAQC
- does not account for costs of inflation over a 10 yr period

Notes
- Infers an additional site visit is required to eliminate data gaps
- does not include costs for any risk management actions
- assumes that additional wells are required for GW sampling
- does not include QAQC

Table G-3
Opinion of Probable Costs
Former Landfill Site 530-L01

Former Landfill Site 530-L01								
Drumheller Institution Remedial Options/Opinion of Probable Cost	**Option 1 - Re-Grade the Slope**				**Supplemental - Erosion Control and Improvements**			
Category	*Quantity*	*Unit price*	*Units*	*Sub-Total*	*Quantity*	*Unit price*	*Units*	*Sub-Total*
Capital Costs - Work Elements								
Materials								
Imported material (erosion mats, seeds, trees, blast rock)					1	$45,000	lump sum	$45,000
Equipment and Labour (Contractor Fees)								
Contractor - Equipment (excavator, loader/dozer and labour)	40	$4,500	per day	$180,000	3	$4,500	per day	$13,500
Contractor - Import Materials (haul and place)	20,530	$15	per metric tonne	$307,950				
Project Supervision and Management (Professional Fees)								
Project Design and Management Fees - project management, specs	1	$40,000	lump sum	$40,000	1	$20,000	lump sum	$20,000
Site Supervision - on-site supervision	40	$1,000	per day	$40,000				
Site Supervision - Mob and Demob	1	$2,000	lump sum	$2,000	1	$2,000	lump sum	$2,000
Site Supervision - Meals/Accomodation	40	$250	per day	$10,000	4	$250	per day	$1,000
Site Supervision - Equipment and Supplies	1	$3,000	lump sum	$3,000	1	$2,000	lump sum	$2,000
Reporting	1	$6,000	lump sum	$6,000				
Estimated Capital Costs - subtotal A				***$588,950***				***$83,500***
Operating Costs								
Monitoring for 5 years (site visit, data evaluation and reporting)	5	$5,000	per year	$25,000				
Monitoring for 2 years (site visit, data evaluation and reporting)					2	$5,000	per year	$10,000
Operating Costs -subtotal -B				***$25,000***				***$10,000***
Total Estimated Cost (A+B)				***$613,950***				***$93,500***

Notes
- volume estimates are preliminary
- 1 cubic m = 2.2 tonnes

- cost does not include removing existing material from the crest of the slope and placing it on the lower portions of the slope, just importing fill materials
- assumes imported fill materials similar to native soils, not blast rock
- contractor site work assumes placement and compaction of soils at a rate of ~513 m3/day (40 days)

Notes
- placement of blast rock assumed to take 3 days

APPENDIX F

Update Memo – Drumheller Institute site No 530 Cost Estimate Former Landfill Site 530-L01: Option 4: Completed Landfill Removal and Re-location by Franz Environmental Inc., May 2011.

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES

5 May 2011

Joan La Ru-van Es (PWGSC- Winnipeg)
Environment Canada
#150, 123 Main Street
Winnipeg (Manitoba) R3C 4W2

Dear Ms. La Ru-van Es

Re: UPDATE MEMO – Drumheller Institute Site No 530
Cost Estimate Former Landfill Site 530-L01:
Option 4: Completed Landfill Removal and Re-location

1.0 INTRODUCTION

Three remedial options to ensure that the metal loading and release of contaminants from the landfill were being addressed were presented in the Franz's report titled "Environmental Site Investigation and Slope Stability Study for the Drumheller Institution Site No. 530, Drumheller, Alberta" (dated March 29, 2011). The three options were;

Option 1- long term monitoring
Option 2- Passive in-situ treatment and
Option 3 –Risk Assessment

Coupled with the contaminant impacts, the geotechnical slope stability study indicated that re-grading and erosion control methods would be required to prevent possible slope failure.

Considering the potential costs associated with both the contaminant impacts and slope stability control, PWGSC requested that Franz consider a fourth option, namely the full excavation and removal of the fill and waste materials at the former Landfill site. This memo presents a summary of Option 4 to remove the landfill materials and re-locate these materials to a licensed landfill site.

2.0 BACKGROUND

It is understood that the landfill was in operation from the mid 1960's until the late 1980's. However, more recent filling may also have taken place.

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The waste material placed in the landfill is understood to include domestic waste and demolition material generated during various phases of construction work at the institute. It is understood that the landfill was formed by pushing waste material over the edge of the coulee. As such, the waste was not subject to compaction during placement.

Within the Former Landfill study area, there are known and discrete impacted soils associated with up-gradient waste burial and filling activities. Elevated metals in soils, as well as, elevated metals in groundwater and surface water exist on site and are heterogeneous in terms of spatial distribution and concentrations. Isolated BTEX impacts to soils were detected on the plateau of the Landfill within the burn pit. In addition, contaminants originating from the source areas (landfill) are present in the surface water in the creek at the toe of the landfill.

3.0 LANDFILL WASTE AND PROBABLE WASTE

Based on the available borehole and test pit information, the landfill waste is variable in colour, composition and consistency. The fill material is described as dark brown to black and dark brown, sandy clay, and clay. The fill was observed to contain fragments of brick, grass, roots, assorted masonry, stones, pebbles, rags, metal, concrete, wood, domestic waste, rigid plastic, and asphalt. The depth to the base of the fill material ranges from about 2.3 to 7.0 metres at the location of the boreholes as noted on the borehole logs. However, greater depths of possible fill material (in excess of about 12.8 metres) are noted in the text of the UMA report. The possible fill material is described as sand with some pebbles to clay with some silt and some sand.

The extent of the waste materials within the Former Landfill is unknown. Further investigation to fully characterize the extents, both vertically and horizontally, of the wastes and impacted soils is needed for a more accurate assessment of volumes.

From previous studies, the footprint of the Former Landfill covers an approximate area of 150 m by 200 m. Assuming an average depth 5 m depth of waste/fill, the estimated volume is on the order of 150,000 m^3. It must be noted that from the top of the landfill to the toe there is a 22 metre drop in elevation, thus there is uncertainty regarding the potential volume of landfill debris within this elevation drop. It should also be assumed that some of this volume (i.e. the soils and other fill) could be re-used as backfill material.

4.0 STRATEGY

Due to the difficult site access (and unstable slopes), landfill materials could be recovered by using a truck mounted or stationary anchored crane and clam-shell attachment for non-metallic debris. The crane would be mounted on the upper bench of the landfill and debris would be transported from the slope and toe of the landfill to the upper bench, where loaders would then move the debris to a temporary staging ground located for sorting/screening. The screening process is to reduce the

volume requiring disposal at the landfill and provided much needed backfill material for slope stability. This remedial strategy involves transportation of materials to an off-site treatment facility.

The removal of the landfill would require the following activities:

1. Formulating a removal strategy including techniques, staging areas, sorting/screening and final disposal locations
2. Strategy to ensure that methane gas is not issue for health and safety and fire protection
3. Excavation using a clam-shell technique to remove the waste, sorting, loading and disposal
4. Backfill techniques, compaction and slope regarding.
5. Final geotechnical and environmental inspections.

5.0 COST ESTIMATE

A summary of the Class D costs are provided in Table G-4 with a list of assumptions. As provided the estimated costs are on the order of $16M.

APPENDIX G

Supplemental Environmental Site Investigation and Data Gap Analysis for the Drumheller Institution Site No. 530, Drumheller, Alberta, by Franz Environmental Inc., October 2011

Supplemental Environmental Site Investigation and Data Gap Analysis for the Drumheller Institution Site No. 530, Drumheller, Alberta

Contract No: EW699-103892-004-NCS

FINAL REPORT

Prepared for:
Public Works and Government Services Canada
Environmental Services-Western Region
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Project No. 2026-1011
December 5, 2011

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EXECUTIVE SUMMARY

Franz Environmental Inc. (FRANZ) was retained by Public Works and Government Services Canada (PWGSC) on behalf of Correctional Services Canada (CSC) to complete a Supplemental Environmental Site Investigation and Data Gap Analysis for the Drumheller Institution Site No.530 in Drumheller, Alberta. This work was completed as a sub-task for the remediation planning of the Former Landfill Site No. 530. The project was completed under PWGSC Contract No. EW699-103892-004-NCS. PWGSC Project number R.044325.002.

A supplemental environmental site investigation was carried out at the Drumheller Institution on August 19, 2011. The field work undertaken during this investigation was aimed at addressing data gaps previously identified and collecting additional information to enhance the existing information for the Former Landfill. Additionally, this information was used in the development of the remedial action plan.

Based on the contaminants of concern previously identified, groundwater samples collected from the site were analyzed for VOCs, metals and organics. Surface water and sediment samples were submitted for metals analysis.

Concentrations in groundwater of dissolved manganese and sodium were reported above the Alberta Tier 1 guidelines, concentrations of dissolved sulphate were reported above FCSAP FIGQGs and concentrations of dissolved cadmium and fluoride were reported above FCSAP FIGQGs and Alberta Tier 1 guidelines in MW05-1. Concentrations of dissolved iron, selenium, uranium, zinc, nitrate, cadmium and sulphate in groundwater were reported above both FCSAP FIGQGs and Alberta Tier 1 guidelines in MW99-03.

Surface water samples were collected from the stream bed at the bottom of the coulee. A sample collected upstream of the Former Landfill was reported to exceed CCME FWAL guidelines and background levels for cadmium. Downstream of the Former Landfill, cadmium, iron, selenium and strontium were reported above CCME FWAL guidelines and background levels. DRUM-SEEP1A was collected at the originating point of the seepage spring located in the wetland area just north of the landfill. This sample reported surface water concentrations for cadmium, arsenic, barium, iron, strontium and zinc that were above CCME FWAL guidelines or background levels. DRUM-SEEP1B was collected from the seepage spring approximately 15 meters downstream from SEEP1A. All metal concentrations in this sample were reported below CCME FWAL guidelines. Furthermore, metal concentrations reported in DRUM-SEEP1B were significantly lower than those concentrations reported in DRUM-SEEP1A.

All sediment samples were collected at corresponding surface water locations. DRUM-SED2, DRUM-SED3 and DRUM-SED SEEP1A reported concentrations of arsenic above CCME ISQG guidelines.

Analytical data reported a decrease of total iron by two orders of magnitude between upstream SEEP1A and downstream SEEP 1B. It is believed that the groundwater originating from the former landfill is daylighting into the wetland area. Typically, water saturated organic soil underlying the wetland area is anoxic and rich with dissolved iron. Reducing dissolved irons (Fe^{2+}) from groundwater immediately were oxidized and precipitated as iron hydroxide upon discharge to the wetland area when they reach the surface aerobic condition. This chemical oxidation process was confirmed by the field observation to be of a bright orange colour of colloidal iron oxides on the sediment surface. This process is favored under aerobic condition with a continue supply of oxygen and water. Subsequently, inorganic constituents of the groundwater are readily sorbed onto the colloidal iron oxide matrix passively. In addition, “sheen-like” biofilm of iron-reducing bacteria was also observed, indicative of active biotic consumption of oxidized iron.

Based on field observations and the results from the chemical analysis, it is likely that the natural attenuation process is dominated through sorption by the colloidal iron oxide matrix. Continuous supply of oxygen and water facilitates the formation of the colloidal iron oxide, which is believed to be the foundation of the sorption base in this environment in the long-term.

Three possible management options that were proposed in the report titled *Environmental Site Investigation and Slope Stability Study for Drumheller Institution Site No. 530, Drumheller, Alberta,* prepared by FRANZ and dated March 2011 are as follows:

- Long-Term Monitoring
- Passive In-Situ Treatment and Monitored Natural Attenuation
- Risk Assessment

After review of the risk management and/or remediation options, the passive in-situ treatment was deemed the most appropriate method to address metal impacts in seepage water. FRANZ is recommending a modified in-situ passive treatment that may consist of an attenuation strip and recharge zone. The objectives of the in-situ passive treatment system are to enhance the existent natural attenuation process of scavenging of inorganic contaminants by iron hydroxide precipitation, and to decrease the likelihood of exposure of ecological receptors and livestock to these contaminants in surface water.

To achieve these objectives, the natural in-situ passive treatment system may consist of a small drainage channel, back-filled with gravel or other permeable material, and a collection pit/recharge area at the bottom of the drainage channel. This approach will channel the outflow from the wetland along a predictable subsurface pathway, while maintaining well-oxygenated conditions conducive to precipitation of iron hydroxides and associated inorganic contaminants. Once treated, the drainage water would recharge to groundwater from the collection pit.

It is unknown whether the long-tem accumulation of colloidal iron oxide will eventually cause fouling and to what extent. Therefore, long-term monitoring may be required to study the drainage water flow condition.

For more details of design, monitoring, and inspection requirements of the proposed natural in-situ passive treatment system please refer to the Remedial Action Plan being prepared for the site by FRANZ in early 2012.

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1.0 INTRODUCTION

Franz Environmental Inc. (FRANZ) was retained by Public Works and Government Services Canada (PWGSC) on behalf of Correctional Services Canada (CSC) to complete a Supplemental Environmental Site Investigation and Data Gap Analysis for the Drumheller Institution Site No.530 in Drumheller, Alberta. This work was completed as a sub-task for the remediation planning of the Former Landfill Site No. 530. The project was completed under PWGSC Contract No. EW699-103892-004-NCS. PWGSC Project number R.044325.002.

This report describes the Supplemental Environmental Site Investigation and Data Gap Analysis and was prepared in accordance with the *Terms of Reference, Landfill Remediation, Correctional Services of Canada, Drumheller Institution Site No 530, Drumheller, Alberta* prepared by Public Works & Government Services Canada (PWGSC), Environmental Services, *W*estern Region, dated July, 2011 ("TOR").

CSC retained PWGSC Environmental Services Branch – Western Region to assist in co-coordinating the program on its behalf. All contract administration and project management for CSC was conducted by PWGSC.

Throughout this report the Drumheller Institution will be referred to as "the site".

1.1 Project Objectives

The objectives of this data gap analysis and supplemental environmental site investigation are stated below. It should be noted that the slope stability data gap analysis has been provided under a separate cover.

1. Collect surface water, sediment and groundwater samples at the Former Landfill and submit for pH, general chemistry, volatile organic compounds (VOCs), and metal analysis;
2. Complete a data gap analyses to ascertain surface water management requirements; and
3. Design a Remedial Action Plan (RAP) using previous data and information from the current data gap analyses (to be submitted under separate cover).

The work plan for this study was based on the TOR and on the previous reports provided by PWGSC.

1.2 Scope of Work

FRANZ completed the following tasks to fulfil the objectives identified in Section 1.1:

- Completed a document review and data gap analysis;
- Designed a supplemental field investigation and laboratory analytical program to address data gaps. The work plan addressed any gaps in information required to further refine the remedial options in sufficient detail to provide information required to prepare a specification for remediation activities;
- Developed a Site-Specific Health & Safety Plan prior to the field program;
- Executed the approved field and laboratory analytical program;
- Interpreted data from previous and current investigation to develop and prepare a draft and final remedial action plan (under separate cover); and
- Documented data gaps and supplemental investigation findings as a standalone report.

2.0 BACKGROUND INFORMATION

2.1 Site Description

The Drumheller Institution was opened in 1967 to house medium-security inmates. The Institution is located five kilometres south-southeast of Drumheller, Alberta (See Figure 1, Appendix A). The legal description of the property is South East ¼ of Section 25; Township 28; Range 20; West of the Fourth Meridian. The main portion of the Institution is enclosed within a perimeter fence. The main living units and activities are located along with various recreational facilities. The inactive landfill is located approximately 500 m southeast of the Institution on the edge of a coulee, as shown on Figure 1, Appendix A.

The drinking water supply for the Institution is supplied by the City of Drumheller. No potable use of groundwater is made at the site. The site is relatively flat and surrounded by low rolling hills. Much of the surrounding areas to the south and east are dominated by the rolling hill terrain. Surface water drainage at the site ultimately drains towards the Red Deer River. The Red Deer River is located to the northeast and has cut deep ravines through the topography. Surrounding lands are predominantly prairie grassland, some of which has been cultivated.

The inactive landfill site covers an area measuring approximately 150 m x 200 m. It consists of a series of trenches, and received waste from the institution for more than 20 years (UMA 2000) from the mid-1960s until its closure in the late 1980s. The waste material at the landfill consists of domestic waste and demolition material such as pipes, concrete, and building materials from renovations at the institution. During the current environmental site investigation, waste canisters, confirmed by CSC to have previously contained tear gas, were observed (see Photo 19, Appendix C). The waste was pushed over the top edge of the slope into the coulee. The landfill was not engineered or built in compliance with landfill construction guidelines. The surface of the landfill has historically been used as a burn area and is occasionally used to store spoil piles from the excavations around the site. The topsoil and subsoil layers were not separated for use as cover before the landfill site was closed.

Groundwater seepage was observed in a steep gully on the north side of the landfill. At the toe of the landfill a depression was observed containing peaty materials with grasses, sedges and cat tails, similar to a small wetland (see Photo 14, Appendix C). The surface sediments observed had a visible surface film that appeared reddish in color (see Photo 18). It was observed during the site reconnaissance that the seepage water originated from this depression and then flowed down slope into the creek/stream located at the base of the coulee, approximately 50 to 60 m below the landfill. The water in the creek eventually discharges into the Red Deer River at a distance of approximately 4.5 km downstream. At the time of the site visit, the stream bed was dry. Additionally, while on site, the CSC commissionaire stated that

the stream was ephemeral. Approximately 500 metres downstream from the former landfill, the stream bed merged together with an incoming flowing water body. This incoming stream was very shallow and clear, however the origin is unknown. To the immediate west side of the landfill is an unpaved gravel access road connecting the institution and the landfill area. The coulee is located to the immediate east side of the landfill. Grazing pasture land surrounds the landfill on the north and south sides. A creek located at the bottom of the coulee drains into the Red Deer River located approximately 4 km to the northeast.

2.2 Previous Investigations and Data Gap Analysis

Several investigations have been completed for the Site and reviewed by FRANZ. The most relevant reports detailing these previous investigations are listed below.

- *Correctional Services Canada, Environmental Baseline Assessment, Drumheller Medium Security Institution, Site Number 530, Volume 1 of 4: Phase I Environmental Site Assessment. Prepared by PWGSC, dated February 10, 1999.*
- *Phase II Environmental Site Assessment Drumheller Institution. Prepared by UMA Engineering Ltd., dated March 2000.*
- *Supplemental Phase II Investigation, Site 530-L01, Landfill, Drumheller Institution, Drumheller, Alberta. Prepared by Franz Environmental Inc., dated March 2006.*
- *Environmental Site Investigation and Slope Stability Study for Drumheller Institution Site No. 530, Drumheller, Alberta. Prepared by Franz Environmental Inc., dated March 2011.*
- *Update memo – Drumheller Institute Site No 530 Cost Estimate Former Landfill Site 530-L01: Option 4: Completed Landfill Removal and Re-location*. *Prepared by Franz Environmental Inc., dated May 2011.*

A summary of identified information gaps and key findings of the previous reports reviewed are presented in Table 2–1, below.

The data gaps that were identified and incorporated into the work plan for this supplemental investigation include the following:

- Further site reconnaissance to identify seepage spring location and origin;
- Additional surface water and sediment sampling from the seepage spring just north of the Landfill and stream bed at bottom of coulee for better understanding of the contaminants of concern (COCs) and distribution on site; and
- Monitoring well inspection, water level monitoring and groundwater sampling to update groundwater analytical results at the top and toe of the Landfill.

Table 2–1: Summary Of Identified Information Gaps and Key Findings of the Previous Reports Reviewed

Previous Report	Key Findings	Data Gaps/Comments
"Supplemental Phase II Investigation, Site 530-L01, Landfill, Drumheller Institution, Drumheller, Alberta. Prepared by Franz Environmental Inc., dated March 2006."	As reported by FRANZ, 2006: "FRANZ completed a Supplemental Phase II investigation in 2005 at the Drumheller Institution. This work was supplemental to investigations completed by UMA Engineering Ltd. in 2000 and FRANZ in 2004. The site investigated was the inactive Landfill located 500 metres southeast of the Institution complex. The objective was to establish impacts to soil, groundwater, surface water and sediments. The investigation involved well surveying and water level monitoring, soil sampling and groundwater sampling from existing wells and new boreholes (MW05-1 – MW05-3), burn pit sampling, spoil pile (excavated material from the Institution temporarily stockpiled at the site) sampling, and surface water and sediment sampling from the spring and creek. Soils were analyzed for benzene, toluene, ethylbenzene, and xylenes (BTEX), petroleum hydrocarbons (PHCs) and metals. Surface water, groundwater, and sediments were analyzed for metals. Contaminants of concern (COCs) identified in soils at the burn pit include benzene and toluene. Chromium was reported in the spoil pile. Soils within the general area of the landfill are alkaline. Arsenic was identified in two of the three boreholes and selenium and thallium was identified in one of the boreholes. Only two wells (MW99-3 and MW05-1) on site were able to produce sufficient sample volumes, one on the upper plateau and one at the toe of the landfill. Aluminum and selenium were reported in groundwater above FWAL CCME guidelines. Aluminum, cadmium, chromium, lead, zinc, arsenic, copper, iron and total mercury were identified as contaminants of concern (COCs) in all surface water samples collected from the creek. In the groundwater spring (seepage), the same COCs were reported with the exception of total mercury. The specification of the mercury was not completed. There were no COCs identified in any of the sediment samples analyzed.	- Limited SW, Sediments and GW samples collected to accurately delineate and assess the contamination present on the site. - Ten monitoring wells are present on-site; however only 2 wells have had sufficient volumes for sampling. Since groundwater samples were not collected from the remaining monitoring wells, it is not known if the groundwater impacts are isolated. - Location, drainage pathway and origin of groundwater seep needs to be confirmed.

Previous Report	Key Findings	Data Gaps/Comments
	FRANZ recommended further sampling to accurately delineate and assess the contamination present on the site. Specifically, FRANZ suggested the following: • Additional seasonal sampling and chemical testing for metals should be carried out at the same surface water locations and at least one additional upstream and downstream locations; • Seasonal sampling and chemical testing for metals in groundwater obtained from all monitoring wells located in the landfill toe and at the base of the coulee; and • A background concentration study to establish which of the metals identified as COCs is anthropogenic in origin and/or naturally high in concentration. FRANZ also recommended the following additional recommendations: • The benzene and toluene impacted soil and the remnants of the charcoal and metal pieces at the burn area, along with chromium impacted soil in the single spoil pile, should be removed and disposed at a suitable disposal site. • A qualified practitioner should be consulted to assess the stability of the landfill slope and establish what engineering controls or mitigative action may be required to protect human safety and minimize/prevent the possibility of a catastrophic slope failure.”	

Previous Report	Key Findings	Data Gaps/Comments
"Environmental Site Investigation and Slope Stability Study, Drumheller Institution, Drumheller, Alberta. Prepared by Franz Environmental Inc., dated March 2011."	As reported by FRANZ in March 2011 for the Former Landfill site: "FRANZ completed an Environmental Investigation (EI) and preliminary qualitative Slope Stability Study at the Drumheller Institution during the winter of 2010/11. The full scope of work set out in the work plan by FRANZ and based on the SOW was not completed due to limitations encountered from weather conditions. Because of the sub zero temperatures reached prior to the commencement of the field program, surface media were frozen. Surface water and sediments could not be sampled and groundwater samples were limited. One groundwater sample was collected from a previously installed monitoring well at the Former Landfill Site (530-L01). Boron, copper and uranium had detectable concentrations that were above CCME FWAL guidelines. Molybdenum reported concentrations that were just above the CCME Agricultural guidelines. In addition, historical testing on site reported concentrations of aluminum and selenium in groundwater above CCME FWAL guidelines. A preliminary qualitative slope stability analysis was completed at the Former Landfill Site using existing information on the soil/waste properties and newly acquired topographic data during a site visit. The purpose of the investigation was to establish the preliminary 'Limit of Hazard Lands' for the site. This limit constitutes a safe setback for the landfill site with respect to slope stability. As a result of the slope stability analysis, it was recommended that no construction equipment or stockpiling of material be permitted within 30 metres of the north section of the landfill, 25 metres of the mid section of the landfill and 7 metres of the south section of the landfill or at the crest of the slope until the landfill slope remediation measures are carried out. Conceptual Remedial and Risk Management Options were presented which outlines the strategies that can be used to mitigate exposure of contaminants to potential human and ecological receptors. The buried waste debris is likely the main source of the metal impacts to the environment at the Former Landfill. It was FRANZ's opinion that the remediation/risk management priority should be based on the removal of physical	- Analytical data for the Former Landfill is limited due to site conditions for surface water, sediments and groundwater therefore delineation and assessment of the contamination present has not been accurately assessed. - Ten monitoring wells are present on-site; however during the site investigation only 1 well have had sufficient volume for sampling. Additional monitoring well sampling is needed to accurately assess GW impacts. - Origin, drainage pathway of seepage has still not been confirmed. Site reconnaisance and additional sample collection from the groundwater seepage is warranted. - The specific contents (i.e. types of wastes) and location of wastes within the landfill has not been confirmed. This could have an impact on the slope stability.

Previous Report	Key Findings	Data Gaps/Comments
	hazards (slope stability) and the containment and control of metals in the surface water pathways at the Former Landfill (i.e., surface water drainage from landfill) discharging to the Red River. It was recommended that the long-term strategy for the Former Landfill should be based on the following goals, in order of priority: 1. Removal of Physical Hazards; a. Re-grade the Slope; and (if required) b. Erosion Control and Slope Improvements 2. Containment and control, including long term monitoring or in-situ passive treatment systems; 3. Risk management through the completion of a preliminary quantitative risk assessment; and 4. Site monitoring and inspections.”	

3.0 REGULATORY GUIDELINES

Federal environmental guidelines are generally used on sites owned and operated by the federal government; however, where federal criteria do not exist, FRANZ will reference Alberta Environment guidelines.

3.1 Groundwater

In May 2010, the Federal Contaminated Sites Action Plan (FCSAP) released the *Federal Interim Groundwater Quality Guidelines* (FIGQG) for federal contaminated sites. The guidelines were released based on the observed need for federal custodians and others to apply appropriate groundwater guidelines at federal sites. Previously, a mixture of provincial standards, federal surface water guidelines, and drinking water quality guidelines were applied to groundwater at federal sites. The FIGQGs remove the need for this patchwork of regulations, which were not consistently applied at federal sites.

The FIGQGs follow a tiered framework, consistent with the Canadian Soil Quality Guidelines development through the Canadian Council of Minister of the Environment (CCME). The three tiers are:

- Tier 1: direct application of the generic numerical guidelines; specifically, application of the lowest guideline for any pathway;
- Tier 2: allows for the development of site-specific remediation objectives through the consideration of site-specific conditions, by modifying (within limits) the numerical guidelines based on site-specific conditions and focusing on exposure pathways and receptors that are applicable to the site; and
- Tier 3: use of site-specific risk assessment to develop Site-Specific Remediation Objectives.

The FIGQG are based on the consideration of several potential receptors and exposure pathways. The receptor and exposure pathways were evaluated by FRANZ as being active for the site include:

- Direct contact of soil organisms with contaminated groundwater; and
- Groundwater transport to surface water at least 10 m from the contamination and subsequent ingestion by wildlife.

Table 1: Federal Interim Groundwater Quality Guidelines, Generic Guidelines for Agricultural Land Use for fine-grained soils were selected for comparison to the analytical results of the groundwater samples collected at the landfill.

In the absence of FIGQG's, the Alberta Tier 1 Soil and Groundwater Remediation Guidelines, (December 2010) - Table B-2. Alberta Tier 1 Soil Remediation Guidelines, Agriculture Use, fine-grained soils were used.

3.2 Surface Water

The CCME Canadian Water Quality Guidelines (CCME, 2005) are intended to provide protection of freshwater and marine life from anthropogenic stressors such as chemical inputs or changes to physical components (e.g., pH, temperature, and debris). The guidelines that apply to freshwater habitat are called the Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life, hereafter referred to as CCME FWAL. Guideline values are meant to protect all forms of aquatic life and all aspects of the aquatic life cycles, including the most sensitive life stage of the most sensitive species over the long term. Ambient water quality guidelines developed for the protection of aquatic life provide the science-based benchmark for a nationally consistent level of protection for aquatic life in Canada.

The CCME FWAL is intended to protect the designated uses of aquatic ecosystems throughout the country. Nevertheless, it is possible that the guidelines are over- or under-protective at sites with unique conditions. For example, the most sensitive species that occurs at a site may be more or less sensitive than the most sensitive species represented in the toxicological data set that was used to derive the guidelines. Similarly, a substance may be more or less toxic in site water (i.e., due to factors such as pH, water hardness, complexing agents, etc.) than it is under the range of conditions that is represented in the toxicological data set. In some cases, natural background concentrations of a substance may exceed the guideline without any apparent effect on biota (i.e., if the substance is not present in a bioavailable form). Under these circumstances, it might be necessary to modify the WQGs to account for conditions that occur at the site.

Surface water samples were compared to *Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life* (FWAL), 2007 Update. In the absence of CCME FWAL guidelines, the CCME Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses will be used.

3.3 Sediments

Sediment quality guidelines are scientifically-derived values that synthesize information regarding the relationships between sediment concentrations of chemicals and potential adverse biological effects resulting from exposure to these chemicals. For each parameter, the CCME has established two numerical limits: the lesser limit is termed the "Interim Sediment Quality Guideline" (ISQG) value, and the greater limit is called the "Probable Effect Level" (PEL). Sediment chemical concentrations below ISQG values are not expected to be associated with any adverse biological effects, while concentrations above PEL values are

expected to be cause adverse biological effects. Chemical concentrations between the ISQG and PELs represent the range in which effects are occasionally observed.

Sediment quality was compared to the CCME guidelines *Canadian Sediment Quality Guidelines for the Protection of Aquatic Life* summary tables, (ISQG and PEL), Update 2002.

4.0 INVESTIGATIVE METHODOLOGY

A supplemental environmental site investigation was completed at the Drumheller Institution to address data gaps on August 19, 2011. The field program consisted of the following:

- Completing a health and safety plan prior to the field work;
- Collection of groundwater samples from previously installed monitoring wells at the site;
- Collection of surface water and sediment samples from the existing seepage along the slope of the coulee and from the stream bed at the base of the coulee, including background samples; and
- Submission of samples for laboratory analysis.

The field investigation procedures are described below.

The field work undertaken during this supplemental site investigation at the site was aimed at addressing data gaps previously identified (Section 2.2) and collecting additional information to enhance the existing information for the site. Additionally, this information was used in the development of the remedial action plan.

4.1 Health & Safety Plan

Before commencing with site activities, a site-specific health and safety plan (HASP) was prepared. The HASP identified and provided mitigative actions for potential physical and chemical hazards associated with the work involved in the site investigation. The HASP also contained a listing of emergency contact numbers and provided protocols to follow in the event of an emergency. A copy of the HASP has been retained on file at FRANZ.

4.2 Utility Locates

Upon arrival at the site, FRANZ discussed underground utilities with the CSC staff. It was confirmed that underground utilities were not present at the site. Due diligence was followed visually, based on site features.

4.3 Groundwater Monitoring and Sampling of Existing Wells

Groundwater monitoring and sampling was conducted on August 19, 2011. Water level elevations were measured from the top of the riser pipe in each monitoring well using a water level meter. The FRANZ field assessor monitored all ten previously installed monitoring wells to assess the presence of groundwater however; only two wells (MW05-1 and MW99-03) had sufficient water volumes for sampling. The remaining groundwater wells were dry. The presence of dry wells has consistently shown that the water table is relatively deep beneath the site.

Prior to the collection of the groundwater samples, water levels were measured with reference to a datum. Each monitoring well was then purged of three well volumes or was purged until dry. During purging, a Horiba U-22 water quality meter was calibrated and used to measure in-situ field parameters including temperature, conductivity, dissolved oxygen, turbidity, pH and oxidation-reduction potential. Sampling took place when these parameters stabilized. Samples were collected from the monitoring wells using dedicated polyethylene tubing and an inertial lift pump (foot valve). Water samples submitted for total metals analyses were field-filtered using a 45 µm screen size.

Groundwater samples were submitted to the laboratory for analysis of VOCs and dissolved metals. Due to low water volumes, a duplicate sample was not collected. Analytical results can be found in Table 1 and 2 (Appendix B). Monitoring well logs are included in Appendix D.

4.4 Surface Water and Sediment Sampling

Surface Water

Surface water samples were collected at one location upstream of the site, three locations downstream of the Former Landfill, and two locations within the seepage spring (see Figure 2, Appendix A). One background surface water sample (DRUM-BK1) was collected approximately 300 m upstream of the Former Landfill in a small ponded area of the stream bed at the base of the coulee. DRUM-SW1 was collected approximately 50 m upstream of the Landfill in another ponded area of the stream bed. DRUM-SW2 was collected approximately 700 m downstream of the Former Landfill from the stream bed. This water was flowing and clear. DRUM-SW3 was collected approximately 200 m downstream of the Former Landfill from a small pool of water within the stream bed. DRUM-SW4 was collected at the intersect of the seepage with the stream bed at the bottom of the coulee. DRUM-SEEP1A was collected from the outfall of the seepage from the small wetland area. DRUM-SEEP1B was collected half way down the seepage pathway from the wetland to the stream bed, approximately 20 m down slope.

Laboratory-prepared bottles and clean nitrile gloves were used to collect the surface water samples. Bottles were fully submerged to fill. Where samples were collected in flowing water the FRANZ field assessor stood downstream of the sample location. Sample numbers were clearly marked on the containers. The surface water samples were stored in a cooler with cold packs to moderate temperature fluctuations during transport to the laboratory.

Sediments

Sediment samples were collected at the corresponding locations as DRUM-BK1, DRUM-SW2, DRUM-SW3, DRUM-SW4 and DRUM-SEEP1A. Laboratory-prepared jars, a clean trowel and clean nitrile gloves were used to collect the samples. Pebbles and gravel in the stream were temporarily removed from each sample location so that the sample could be collected in the first layer of sediment (depth range 0 – 0.20 m).

Sediments were collected as grab samples. Sample depths, sediment materials and coordinates of sampling locations were recorded. All sediment samples were placed into new laboratory supplied jars and tightly sealed, then stored in laboratory-supplied coolers with ice packs from the time of collection until analyzed in the laboratory. Sediments were collected off a stainless steel trowel. The trowel was decontaminated between samples using alconox and water. Fresh nitrile gloves were used for each sample to eliminate cross contamination.

Both surface water and sediment samples were submitted to the laboratory for analysis of metals. Duplicate samples were not collected due to low flowing, murky water conditions. The increased sediment loading would reduce the homogeneity of the potential duplicate samples, reducing the likelihood of obtaining acceptable results. Analytical results can be found in Table 3 and 4 (Appendix B). Sediment logs are included in Appendix D.

4.5 Quality Assurance and Quality Control

Field personnel employed FRANZ'S QA/QC protocols, including techniques for soil sampling, sample storage, shipping and handling, as well as collection of duplicates.

Field

The groundwater and surface water samples collected for laboratory analysis were placed in laboratory prepared containers. Each sample for VOC analyses were collected in three 40 mL glass vials with Teflon septa and preserved with sodium bisulphate. Each sample for dissolved metal analysis was field filtered and collected in a 120 mL plastic bottle and preserved with nitric acid. Total metals were also collected in a 120 mL bottle and preserved with nitric acid but not field filtered. Each sample for general chemistry was collected in 500 mL plastic containers. Samples were collected with no headspace for VOC analysis and with minimal headspace for the remaining analysis. Samples were stored in coolers with cold packs to moderate temperature fluctuations during transport to the laboratory.

Sediment samples collected for potential laboratory analysis were placed in laboratory-prepared 120 mL glass jars fitted with screw-tight Teflon-lined lids. Sample numbers were clearly marked on the containers, as well as on the lids. The soil jars were filled to capacity with minimum headspace and stored in coolers with cold packs to moderate temperature fluctuations during transport to the laboratory. To prevent cross contamination, samples were collected with fresh nitrile gloves. Where samples were impossible to obtain by hand, the FRANZ field assessor employed a stainless steel trowel.

The samples were transported to the project laboratory, Maxxam Analytics in Calgary, Alberta, accompanied by a Chain of Custody form. The analytical results can be found in Tables 1

through 4 (Appendix B), and the laboratory reports and chain of custody forms can be found in Appendix E.

Laboratory

FRANZ did not collect duplicate samples during the supplemental site investigation due to limited groundwater sample volume and unfavourable site conditions. A trip blank, a sample of analyte free media (supplied by the laboratory) taken to the site and returned to the laboratory unopened, was supplied for QAQC of groundwater samples. The purpose of the trip blank is to identify any potential cross contamination that may occur from other samples, ambient conditions, or other sources that samples may be exposed. Analysis of the trip blank was acceptable, as all parameters were non-detect.

4.6 Laboratory Analytical Program

Groundwater, surface water and sediment samples were screened for visual and olfactory indicators of impacts such as sheen or odours. No visual or olfactory indicators of impacts were observed during the site visit. Samples were sent to Maxxam Analytics in Calgary, Alberta for chemical analysis for various target compounds previously identified. Maxxam is certified by the Canadian Association for Laboratory Accreditation, Inc. (CALA) and has an internal QA/QC protocol. The laboratory QA/QC documentation is provided with the analytical report and was reviewed by FRANZ as part of the QA/QC protocol. The laboratory results and chain of custody forms are presented in Appendix E.

5.0 INVESTIGATION RESULTS AND DISCUSSION

5.1 Analytical Test Results

Based on the contaminants of concern previously identified on site, groundwater samples collected were analyzed for VOCs, metals and organics. Surface water and sediment samples were submitted for metal analysis. The results are presented in Tables 1 through 4 (Appendix B) and on Figure 3 (Appendix A).

5.1.1 Background Results

Ideally, to be representative of site conditions, background sampling location should have surface water with corresponding sediments. Additionally, for statistical purposes, three or more background samples should be collected. Such background samples should be collected from an un-impacted wetland environment and/or an un-impacted stream bed environment representative (similar physical, chemical and biological properties) of the wetland area on site. However, a wetland area in general nor with similar site features for comparison, was found on or near the site. Therefore, the next best option for background samples collection was the stream bed located at the bottom of the coulee upstream from the Former Landfill. Due to the dry conditions during the site visit, no visible surface water was observed in the stream bed 450 m to 700 m upstream of the Landfill. The FRANZ field assessor felt that the conditions further upstream of 700 m are no longer representative of the site conditions. Therefore, a limited number of background samples were available for collection.

At the Former Landfill, it is assumed that concentrations reported in the background sample are naturally occurring in the region. When concentrations are greater than those reported in the background sample and environmental quality guidelines (CCME FWAL and CCME ISQG) the sample will be considered an exceedance.

The background sediment sample did not exceed CCME ISQG guidelines. The surface water sample, collected at the same location as the sediment sample, exhibited concentrations of cadmium, aluminum, arsenic, copper and iron above CCME FWAL guidelines. Analytical results for background samples are presented in Table 3 and 4 (Appendix A), and the laboratory reports can be found in Appendix E.

5.1.2 Groundwater Results

One groundwater sample was collected from both MW05-1 and MW99-03 and submitted for metals (dissolved) and VOCs analysis.

MW05-01 is located east of the site on the bank of the coulee. In MW05-01, concentrations of dissolved manganese and sodium were reported above the Alberta Tier 1 guidelines, concentrations of dissolved sulphate was reported above FCSAP FIGQGs and concentrations

of dissolved cadmium and fluoride were reported above both CCME and Alberta Tier 1 guidelines. The maximum exceedance factor of all of exceeded metals in MW05-1 was reported for cadmium at 8x the FCSAP FIGQG guideline. All VOCs concentrations were reported as non-detect.

MW99-03 is located on the top of the landfill, approximately 15 metres to the SW from the entrance gate into the landfill. Concentrations of dissolved iron, selenium, uranium, zinc, nitrate, cadmium and sulphate were reported above both FCSAP FIGQGs and Alberta Tier 1 guidelines. Dissolved sodium was also reported to exceed the Alberta Tier 1 guideline. The highest exceedance factor was reported for selenium at 60x the guideline. Cadmium also reported a relatively high exceedance factor at 40x the guideline. The remaining parameters reported lower concentrations that had between 1 - 10 exceedance factors. All VOCs concentrations were reported as non-detect.

In summary, the contaminants of concern reported in groundwater at the Former Landfill include iron, manganese, selenium, sodium, uranium, zinc, nitrate, cadmium, fluoride and sulphate. Analytical results are presented in Tables 1 and 2, Appendix B.

5.1.3 Surface Water Results

Six surface water samples, plus one background sample, were collected during the supplemental investigation and submitted for metal analysis (total).

DRUM-SW1 was collected approximately 50 m upstream from the site and exhibited concentrations of cadmium, aluminum, arsenic, copper and iron above CCME FWAL guidelines. All parameters, with the exception of cadmium (11x CCME guideline) reported concentrations that were below background levels; therefore FRANZ considers these non-exceeding. In addition, concentrations of antimony and barium were reported just above the background levels in DRUM-SW1. As SW1 concentrations are within 1x the background levels, antimony and barium are not considered contaminants of concern.

DRUM-SW2 was collected the furthest downstream from the site and reported concentrations of selenium above CCME FWAL guidelines. Lithium and strontium reported concentrations that were 1x and 2x greater than the background levels. As lithium is within 1 x the background levels, it is not considered to be an exceedance however; strontium is exceeding. At SW2, cadmium, aluminum and iron reported concentrations that were above CCME FWAL guidelines, but below background levels, therefore these are not considered exceedances.

DRUM-SW3 reported concentrations of aluminum and iron above CCME FWAL guidelines; however both are well below background levels. As aluminum and iron are within background levels, they are not considered to be an exceedance. Lithium and strontium concentrations

were reported above background levels at DRUM-SW3. However, both concentrations are within background levels (1x the exceedance factor) and are not considered to be exceedances.

DRUM-SW4 was collected at the intersection point of seepage spring and the stream bed. Concentrations of cadmium, aluminum, copper and iron were reported above CCME FWAL guidelines. Cadmium and iron exhibited concentrations above background levels. The exceedance factors for cadmium and iron were 16x and 14x the EQGs, respectively. Aluminum reported concentrations below background levels, therefore is not reported contaminant of concern at SW4. Lithium, strontium and zinc reported concentrations that were within 1 times background levels at DRUM-SW4, therefore these parameters are not considered contaminants of concern.

DRUM-SEEP1A was collected at the originating point of the apparent seepage spring on the east side of the wetland area. This sample reported exceedances for cadmium, aluminum, arsenic, copper, iron and zinc. Aluminum and copper reported concentrations below background levels and not considered to be exceeded. Cadmium, arsenic, iron and zinc reported concentrations above background levels and considered to be exceedances. The highest exceedance factor reported was for iron at 77x the CCME FWAL guideline. Furthermore, barium and strontium reported concentrations that were 2x the background levels. These are both considered to be exceedances of guidelines.

DRUM-SEEP1B was collected approximately 15 meters down slope and downstream within the seepage spring from SEEP1A. This sample reported concentrations of cadmium, aluminum and iron exceeding CCME FWAL guidelines. However, these concentrations were significantly lower than those reported in the background sample, as well as from SEEP1A. For example, the concentration of lead in SEEP1B was 57x lower than in SEEP1A. As a result, these parameters are not considered to be an exceedance. In addition, concentrations of lithium and strontium were reported within 1x of background levels. Due to the exceedance factor, these are not considered to be contaminants of concern at SEEP1B.

In summary, the contaminants of concern reported in surface water at the Former Landfill include cadmium, arsenic, barium, iron, selenium, strontium, and zinc. Analytical results are presented in Table 3, Appendix B.

5.1.4 Sediment Results

Four sediment samples and one background sample were collected from the stream bed at the bottom of the coulee and submitted for metals analysis. All sediment samples were collected at corresponding surface water sampling locations. DRUM-SED2 (7 ug/g), DRUM-SED3 (7 ug/g) and DRUM-SED SEEP1A (6 ug/g) all reported concentrations of arsenic above CCME ISQG guideline of 5.9 ug/g. Arsenic did not exceed guidelines at the background sample.

The contaminant of concern reported in sediments at the Former Landfill is arsenic. Analytical results are presented in Table 4, Appendix B.

5.2 Evaluation and Discussion

Elevated metals concentrations are naturally occurring in surface water at the site. This is evident from the analysis of the background sample collected 300 m upstream where concentrations of cadmium, aluminum, arsenic, copper and iron were present above CCME FWAL guidelines.

Water seeping from a wetland type area at the toe of the landfill was not in compliance with CCME FWAL guidelines for cadmium, aluminum, arsenic, copper, iron or zinc (see Table 3; Figure 3). The sample location (DRUM-SEEP1A) with the highest exceedances over guidelines was collected at the outflow of the small wetland characterized by hydric, peaty soil and aquatic plant species, where the water table appeared to be just beneath the ground surface. This area is assumed to be fed by groundwater from the former landfill day lighting into the wetland area.

Analytical data reported a decrease of total iron by two orders of magnitude between upstream SEEP1A and downstream SEEP 1B. It is believed that the groundwater originated from the former landfill is daylighting into the wetland area. Typically, water saturated organic soil underlying the wetland area is anoxic and rich with dissolved iron. Reducing dissolved irons (Fe^{2+}) from groundwater were immediately oxidized and precipitated as iron hydroxide upon discharge to wetland area when they reach the surface aerobic condition. This chemical oxidation process was confirmed by the field observation of bright orange colour of colloidal iron oxides on the sediment surface. This process is favored under aerobic condition with a continue supply of oxygen and water (see Table 3; and Photo 18). Field observations corroborate these analytical results. Subsequently, inorganic constituents of the groundwater are readily sorbed onto the colloidal iron oxide matrix passively. In addition, “sheen-like” biofilm of iron-reducing bacteria was also observed, indicative of active biotic consumption of oxidized iron.

Based field observations and the results from the chemical analysis, it is likely that the natural attenuation process is dominated through sorption by the colloidal iron oxide matrix. Continuous supply of oxygen and water facilitate the formation of the colloidal iron oxide, which is believed to be the foundation of the sorption base in this environment over long-term.

6.0 REMEDIATION AND RISK MANAGEMENT OPTIONS

Risk management and/or remediation are required to reduce and mitigate exposure to chemicals of concern present at concentrations greater than the Environmental Quality Guidelines (EQG).

6.1 Contaminant Impacts

Within the Former Landfill study area, there are known impacted soils associated with up-gradient waste burial and filling activities. Elevated metal concentrations in soils and sediments, as well as, elevated metals in groundwater and surface water exist on site and are heterogeneous in terms of spatial distribution and concentrations. Based on the spatial analysis, the source area for each of the COC's remains consistent with each parameter tested. It is our opinion that the sediment, groundwater, and surface water chemistry reflect the environmental impacts associated with waste disposal and land filling activities on site. Our evaluation indicates that the buried and exposed debris imparts a slow release of contaminants into the environment. In addition, contaminants originating from the source area (landfill) are present in the surface water in the stream bed at the base of the coulee, as well as the groundwater seepage spring originating from the wetland at the toe of the landfill.

The historical metal loading and current slow release of metals associated with the metallic and non-metallic debris deposited on site have resulted in impacted soils, groundwater and surface waters on the slope and down-gradient of the Landfill. Additionally, an isolated BTEX impact was identified in shallow soils in the burn area on the plateau of the Landfill. Downgradient impacts will likely continue for some time due to the presence of scattered and landfilled waste. Contaminant loading from the landfill and the associated downgradient impacts could be managed through the implementation of an in-situ remediation and surface water management system. The employment of a Site Specific Risk Assessment could be used to guide the long-term strategies for the site.

Three possible management options that were proposed in the report titled *Environmental Site Investigation and Slope Stability Study for Drumheller Institution Site No. 530, Drumheller, Alberta,* prepared by FRANZ and dated March 2011 are as follows:

- Long-Term Monitoring
- Passive In-Situ Treatment and Monitored Natural Attenuation
- Risk Assessment

6.2 Selection of Proposed Approach

After careful review of the risk management and/or remediation options, the passive in-situ treatment was deemed the most appropriate method to address metal impacts in seepage water, based on the expected long-term effectiveness of enhanced natural attenuation.

Based on the data of this report, the details of this option were modified and proposed project work scaled back to reflect additional information gathered. Pertinent factors include:

1. Observation of the low flow conditions at the seep and in the creek;
2. Importance of aerobic processes in precipitating metals from solution; and
3. Observed attenuation of metal impacted surface waters currently ongoing in the natural environment.

As a result, FRANZ is recommending a modified in-situ passive treatment that may consist of an attenuation strip and recharge zone.

The objectives of the in-situ passive treatment system will be to enhance the existent natural attenuation process of scavenging of inorganic contaminants by iron hydroxide precipitation, and to decrease the likelihood of exposure of ecological receptors and livestock to these contaminants in surface water.

To achieve these objectives, the natural in-situ passive treatment system may consist of a small drainage channel, back-filled with gravel or other permeable material, and a collection pit/recharge area at the bottom of the drainage channel. This approach will channel the outflow from the wetland along a predictable subsurface pathway, while maintaining well-oxygenated conditions conducive to precipitation of iron hydroxides and associated inorganic contaminants. Once treated, the drainage water would recharge to groundwater from the collection pit. It is unknown whether the long-tem accumulation of colloidal iron oxide will eventually cause fouling and to what extent. Therefore, long-term monitoring may be required to study the drainage water flow condition.

Disturbed areas will be revegetated once the passive treatment system is in place, and the banks of the drainage will be planted with local riparian vegetation.

For more details of design, monitoring, and inspection requirements of the proposed natural in-situ passive treatment system please refer to the Remedial Action Plan being prepared for the site by FRANZ in early 2012.

7.0 CONCLUSIONS AND RECOMMENDATIONS

1. FRANZ was retained by PWGSC on behalf of CSC to complete a Supplemental Environmental Site Investigation and Data Gap Analysis for the Drumheller Institution Site No.530 in Drumheller, Alberta. This work was completed as a sub-task for the remediation planning of the Former Landfill Site No. 530.

2. A supplemental environmental site investigation was carried out at the Drumheller Institution on August 19, 2011. The field work undertaken during this supplemental site investigation was aimed at addressing data gaps identified and collecting additional information to enhance the existing information for the site. Additionally, this information will be used in the development of the remedial action plan.

3. Based on the contaminants of concern previously identified groundwater samples collected from the site were analyzed for VOCs, metals and organics. Surface water and sediment samples were submitted for metals analysis.

4. Concentrations of dissolved manganese and sodium were reported in groundwater above the Alberta Tier 1 guidelines, concentrations of dissolved sulphate was reported above FCSAP FIGQGs and concentrations of dissolved cadmium and fluoride were reported above both CCME and Alberta Tier 1 guidelines in MW05-1. Concentrations of dissolved iron, selenium, uranium, zinc, nitrate, cadmium and sulphate were reported above both FCSAP FIGQGs and Alberta Tier 1 guidelines in MW99-03.

5. The highest exceedance factor reported for MW05-1 was for cadmium at 8x the FCSAP FIGQG. In MW99-03, selenium reported an exceedance factor of 60x the FCSAP FIGQG and cadmium reported an exceedance for of 40x the guideline.

6. Contaminants of concern reported in the surface water samples (SW1 through SW4) collected from the stream bed at the bottom of the coulee were cadmium, iron, selenium and strontium. In DRUM-SW1, cadmium reported an exceedance factor of 11x the CCME FWAL guideline. Similarly for DRUM-SW4, cadmium reported an exceedance factor of 16x the guideline and iron 14x the CCME FWAL guideline.

7. DRUM-SEEP1A was collected at the originating point of the seepage spring. The contaminants of concern reported for SEEP1A were cadmium, arsenic, barium, iron, strontium and zinc. DRUM-SEEP1B was collected from the seepage spring approximately 15 meters downstream from SEEP1A. This sample did not report concentrations exceeding CCME FWAL guidelines however; did report concentrations that were significantly less than those from DRUM-SEEP1A. The highest exceedance factor reported for either samples collected from the seepage spring was reported for iron at 77x the CCME FWAL guideline for SEEP1A.

8. Sediment samples were collected at corresponding surface water locations. DRUM-SED2, DRUM-SED3 and DRUM-SED SEEP1A reported concentrations of arsenic above CCME ISQG guidelines.

9. Natural attenuation of metals in the surface water is already taking place along the flow paths, as metals sorbed to iron hydroxide particles are being removed from solution when the particulate matter is deposited on the sediments. The process of oxygenating the outflow from the wetland is important from the perspective of removing inorganic constituents that are readily sorbed to iron hydroxides (e.g. arsenic, cadmium, zinc). In addition to this process, it is likely that the small wetland removes metals from solution by sorption to the highly organic soil.

10. Three possible management options that were proposed in the report titled *Environmental Site Investigation and Slope Stability Study for Drumheller Institution Site No. 530, Drumheller, Alberta,* prepared by FRANZ and dated March 2011 are as follows:

    - Long-Term Monitoring
    - Passive In-Situ Treatment and Monitored Natural Attenuation
    - Risk Assessment

11. After review of the risk management and/or remediation options, the passive in-situ treatment was deemed the most appropriate method to address metal impacts in seepage water. FRANZ is recommending a modified in-situ passive treatment that may consist of an attenuation strip and recharge zone. The objectives of the in-situ passive treatment system are to enhance the existent natural attenuation process of scavenging of inorganic contaminants by iron hydroxide precipitation, and to decrease the likelihood of exposure of ecological receptors and livestock to these contaminants in surface water.

12. To achieve these objectives, the natural in-situ passive treatment system may consist of a small drainage channel, back-filled with gravel or other permeable material, and a collection pit/recharge area at the bottom of the drainage channel. This approach will channel the outflow from the wetland along a predictable subsurface pathway, while maintaining well-oxygenated conditions conducive to precipitation of iron hydroxides and associated inorganic contaminants. Once treated, the drainage water would recharge to groundwater from the collection pit.

8.0 LIMITATIONS

This report has been prepared exclusively for PWGSC and CSC. Any other person or entity may not rely upon the report without the express written consent from Franz Environmental Inc., PWGSC, and CSC.

Any use that a third party makes of this report, or any reliance on decisions made based on it, is the responsibility of such third parties. Franz Environmental Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Some of the information presented in this report was provided through existing documents and interviews. Although attempts were made, whenever possible, to obtain a minimum of two confirmatory sources of information, Franz Environmental Inc., in certain instances, has been required to assume that the information provided is accurate.

The conclusions presented represent the best judgment of the assessors based on current environmental standards and on the site conditions observed on August 19, 2011. Due to the nature of the investigation and the limited data available, the assessors cannot warrant against undiscovered environmental liabilities.

Should additional information become available, Franz Environmental Inc. requests that this information be brought to our attention so that we may re-assess the conclusions presented herein.

There is no warranty, expressed or implied that the work reported herein has uncovered all potential environmental liabilities, nor does the report preclude the possibility of contamination outside of the areas of investigation. The findings of this report were developed in a manner consistent with a level of care and skill normally exercised by members of the environmental science and engineering profession currently practicing under similar conditions in the area.

A potential remains for the presence of unknown, unidentified, or unforeseen surface and sub-surface contamination. Any evidence of such potential site contamination would require appropriate surface and sub-surface exploration and testing.

If new information is developed in future work (which may include excavations, borings, or other studies), Franz Environmental Inc. should be requested to re-evaluate the conclusions of this report, and to provide amendments as required.

9.0 REFERENCES

Alberta Government, Alberta Tier 1 Soil and Groundwater Remediation Guidelines. December 2010.

Franz Environmental Inc., Supplemental Phase II Investigation, Site 530-L01, Landfill Drumheller Institution, Drumheller Alberta, dated March 2006.

Franz Environmental Inc., Environmental Site Investigation and Slope Stability Study for Drumheller Institution Site No. 530, Drumheller, Alberta, dated March 2011.

Canadian Council of Ministers of the Environment. 1999. *Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses*.

Canadian Council of Ministers of the Environment. 1999. *Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life.*

Canadian Council of Ministers of the Environment. 2007. *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health.*

Canadian Council of Ministers of the Environment. *Federal Interim Groundwater Quality Guidelines for Contaminated Sites.* May 2010.

UMA Engineering Ltd. Phase II Environmental Site Assessment, Drumheller Institution, March 2000.

10.0 CLOSURE

We trust that this information is satisfactory for your present requirements. Should you have any questions or require additional information, please do not hesitate to contact the undersigned.

Sincerely,

Franz Environmental Inc.

Steve Livingstone, M.Sc., P.Geo.
Vice President

Julie Dittburner, B.Sc., Dipl. Tech.
Junior Environmental Scientist

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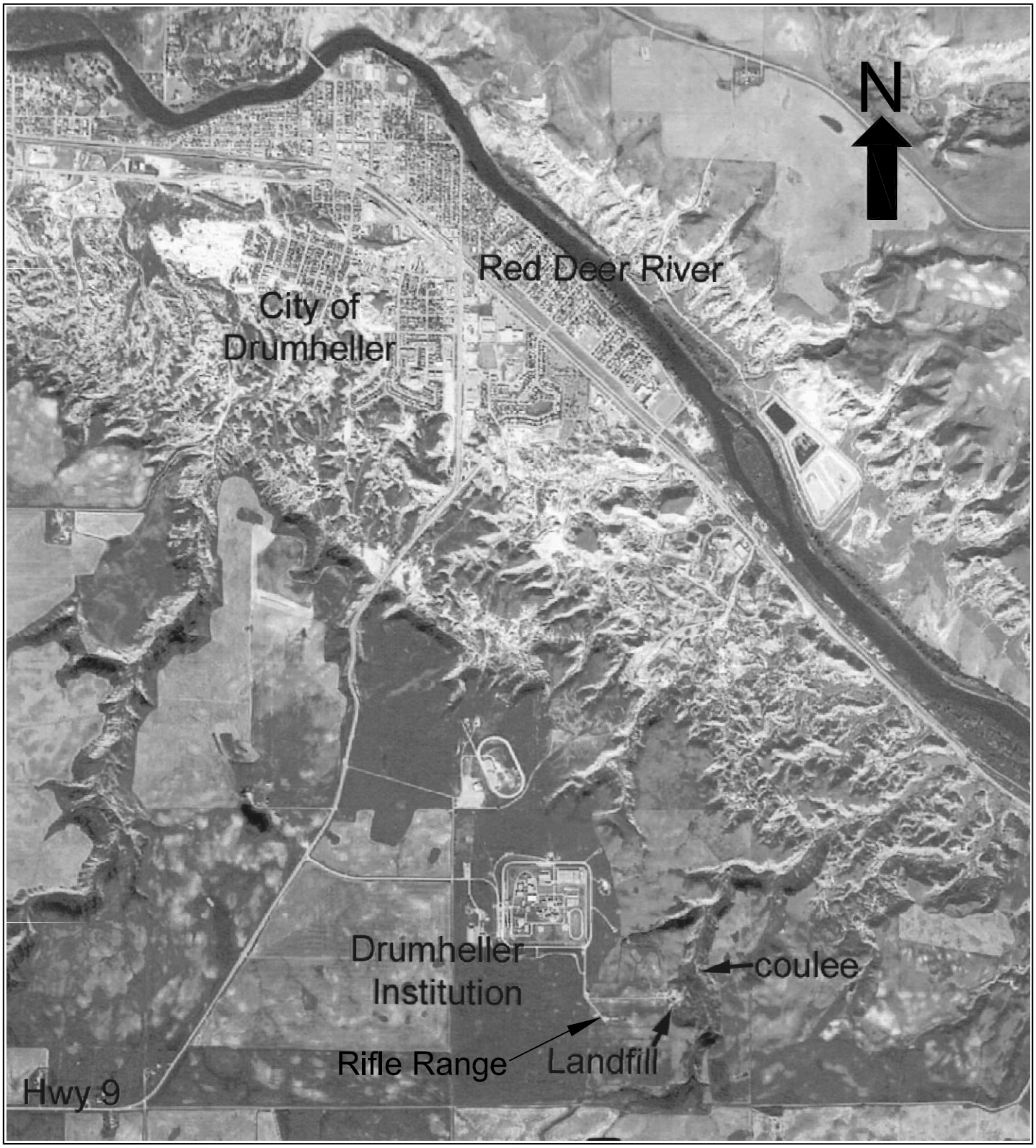
APPENDIX A

Figures



Reference:
Franz Environmental Inc. 2006. Supplemental Phase II Investigation Site 530-L01, Landfill Drumheller Institution, Alberta

Scale 1:30,000
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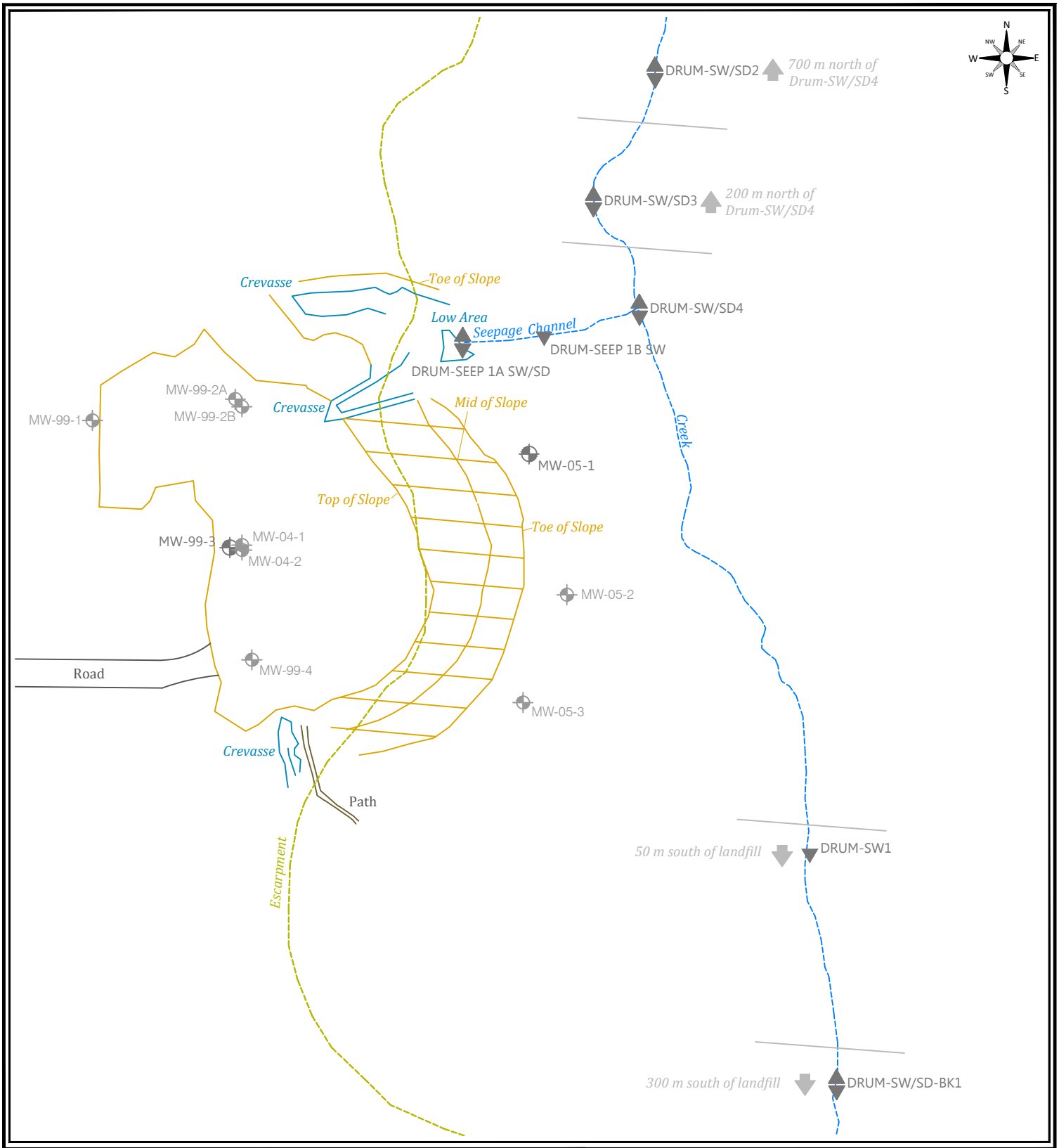
Title:	SITE LOCATION
Project:	SUPPLEMENTAL ENVIRONMENTAL SITE INVESTIGATION AND DATA GAP ANALYSIS DRUMHELLER INSTITUTION, DRUMHELLER, AB
Client:	PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
FRANZ ENVIRONMENTAL INC. ♦ CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦	Date: OCTOBER 2011
	FIGURE 1



Legend

- Sediment Sample Location
- Surface Water Sample Location
- Monitoring Well with Sufficient Volume for Sampling
- Previously Installed Monitoring Well

Reference: Taggish Engineering Figure - Existing Condition

Title: Sample Locations

FRANZ ENVIRONMENTAL INC.
CONSULTING ENGINEERING TECHNOLOGIES

Project: Supplemental Enviromental Site Investigation and Data Gap Analysis Drumheller Institution, Drumheller, AB

Date: October 2011

Client: Public Works and Government Services Canada

Scale 1:1750

50 40 30 20 10 0 25 50 metres

Figure 2

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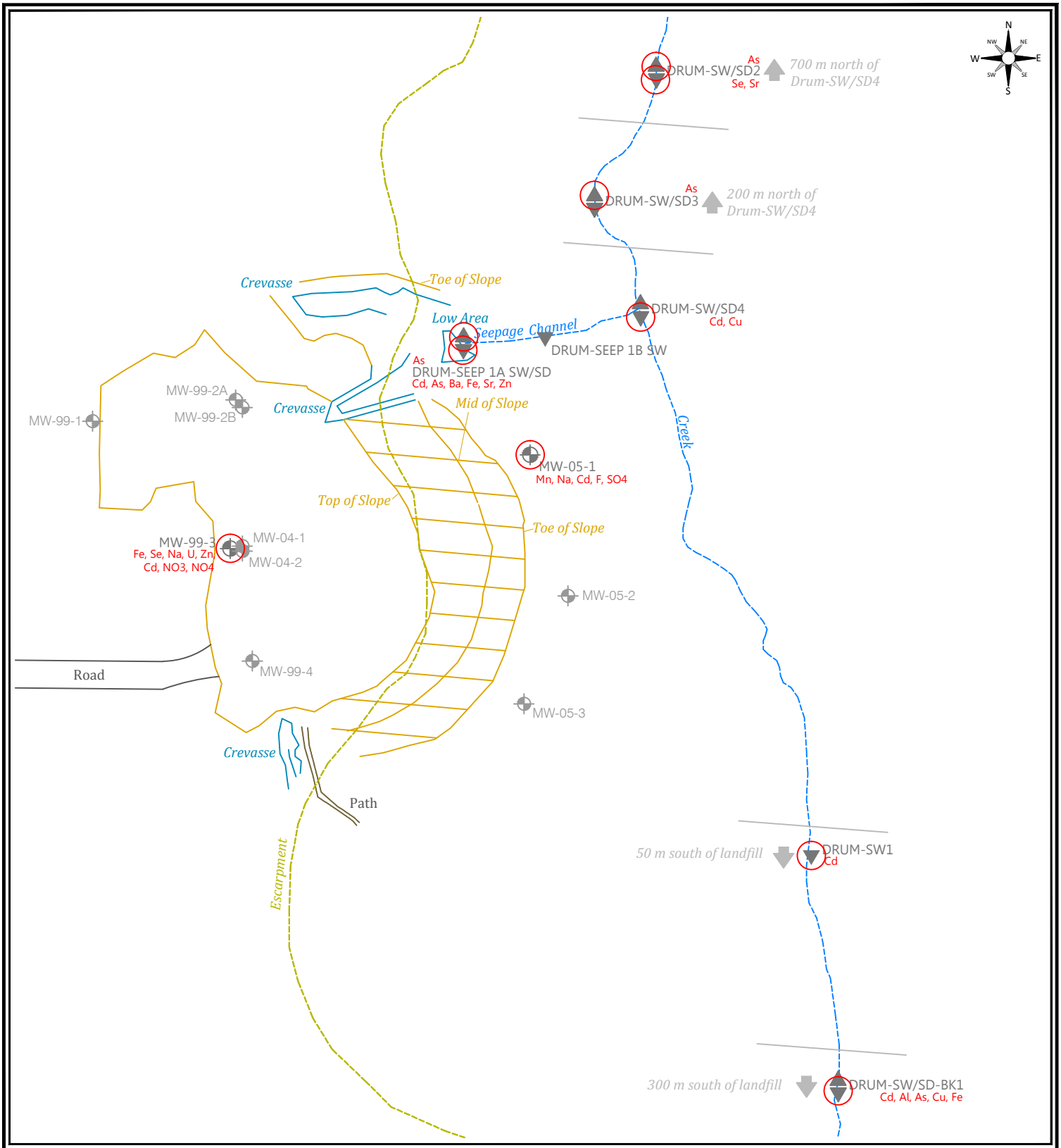

Legend

- Sediment Sample Location
- Surface Water Sample Location
- Monitoring Well with Sufficient Volume for Sampling
- Previously Installed Monitoring Well
- Above Applicable Guidelines (Fe)

Reference: Taggish Engineering Figure - Existing Condition

Title: Analytical Results for Groundwater, Surface Water and Sediment

FRANZ ENVIRONMENTAL INC.
CONSULTING ENGINEERING TECHNOLOGIES

Project: Supplemental Enviromental Site Investigation and Data Gap Analysis Drumheller Institution, Drumheller, AB

Date: October 2011

Client: Public Works and Government Services Canada

Scale 1:1750

50 40 30 20 10 0 25 50 metres

Figure 3

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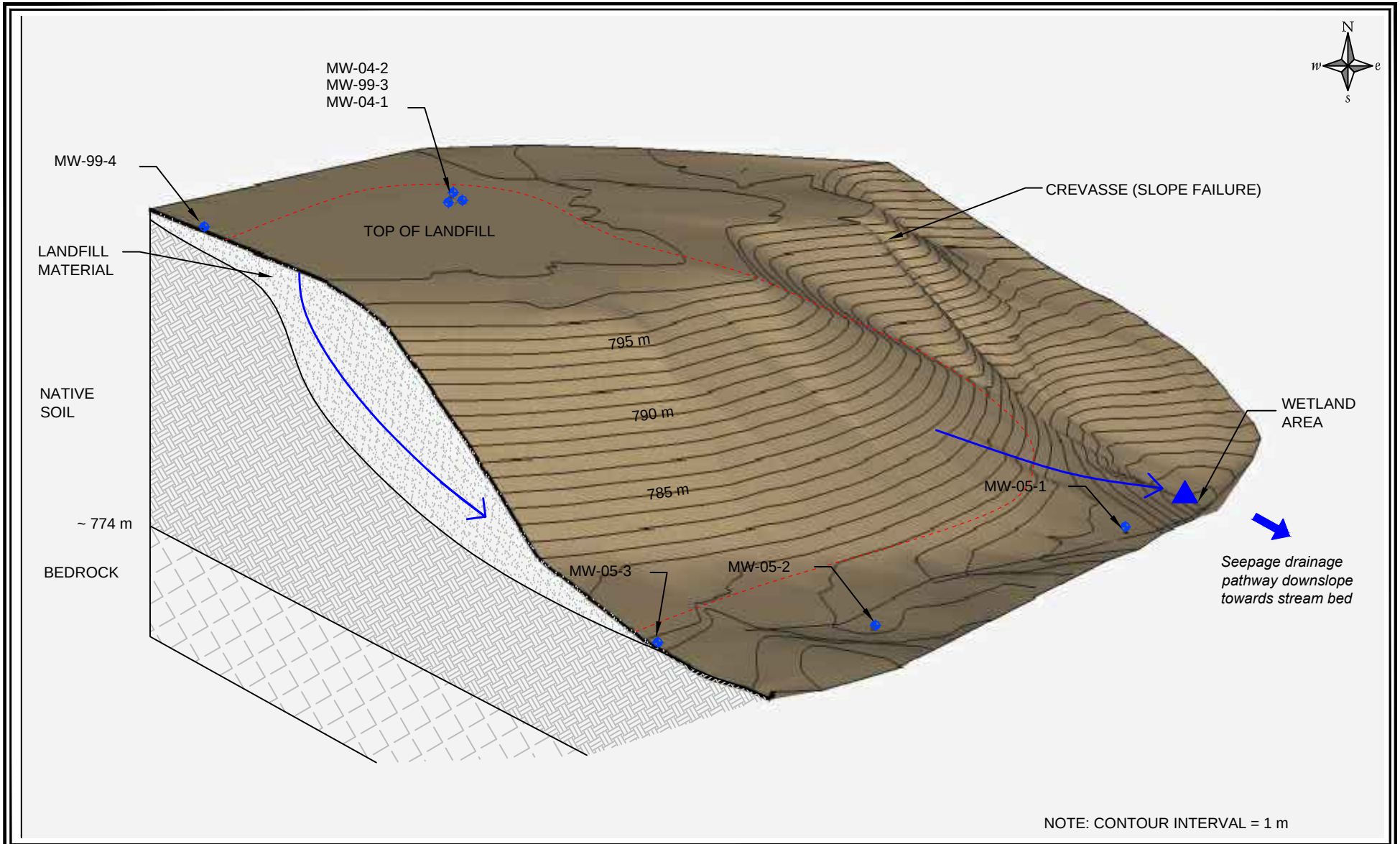

LEGEND

- APPROXIMATE LANDFILL EXTENTS
- CONTOUR LINE
- GROUNDWATER DAYLIGHTING TO SURFACE WATER
- MONITORING WELL
- GROUNDWATER FLOW DIRECTION

Title: UPDATED CONCEPTUAL SITE MODEL - FORMER LANDFILL

FRANZ ENVIRONMENTAL INC.
CONSULTING ENGINEERING TECHNOLOGIES

Project: SUPPLEMENTAL ENVIROMENTAL SITE INVESTIGATION AND DATA GAP ANALYSIS DRUMHELLER INSTITUTION, DRUMHELLER, AB

Date: OCTOBER 2011

Client: Public Works and Government Services Canada

NO SCALE

FIGURE 4

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APPENDIX B

Analytical Tables

Table 1: Groundwater Analytical Results - VOCs

PARAMETER	Federal Interim Guidelines Table 1[1]	Alberta[2] Tier 1	RDL	Drumheller Institution No. 530		
Sample Number				MW99-03	MW05-1	TRIP BLANK
Sampling Date				19/08/2011	19/08/2011	19/08/2011
Volatiles (ug/L)						
Total Trihalomethanes	nc	nc	2	<2	<2	<2
Benzene	88	5	0.4	<0.4	<0.4	<0.4
Bromodichloromethane	6700	nc	0.5	<0.5	<0.5	<0.5
Bromoform	5200	nc	0.5	<0.5	<0.5	<0.5
Bromomethane	16	nc	2	<2	<2	<2
Carbon tetrachloride	5	5	0.5	<0.5	<0.5	<0.5
Chlorobenzene	1.3	1.3	0.5	<0.5	<0.5	<0.5
Chlorodibromomethane	nc	nc	1	<1	<1	<1
Chloroethane	nc	nc	1	<1	<1	<1
Chloroform	1.8	1.8	0.5	<0.5	<0.5	<0.5
Chloromethane	nc	nc	2	5	<2	<2
1,2-dibromoethane	nc	nc	0.5	<0.5	<0.5	<0.5
1,2-dichlorobenzene	0.7	0.7	0.5	<0.5	<0.5	<0.5
1,3-dichlorobenzene	42	nc	0.5	<0.5	<0.5	<0.5
1,4-dichlorobenzene	26	1	0.5	<0.5	<0.5	<0.5
1,1-dichloroethane	56000	nc	0.5	<0.5	<0.5	<0.5
1,2-dichloroethane	5	5	0.5	<0.5	<0.5	<0.5
1,1-dichloroethene	680	14	0.5	<0.5	<0.5	<0.5
cis-1,2-dichloroethene	12000	nc	0.5	<0.5	<0.5	<0.5
trans-1,2-dichloroethene	12000	nc	0.5	<0.5	<0.5	<0.5
Dichloromethane	50	50	2	<2	<2	<2
1,2-dichloropropane	58	nc	0.5	<0.5	<0.5	<0.5
cis-1,3-dichloropropene	24	nc	0.5	<0.5	<0.5	<0.5
trans-1,3-dichloropropene	24	nc	0.5	<0.5	<0.5	<0.5
Ethylbenzene	3200	2.4	0.4	<0.4	<0.4	<0.4
Methyl methacrylate	1700	nc	0.5	<0.5	<0.5	<0.5
Methyl-tert-butylether (MTBE)	5000	nc	0.5	<0.5	<0.5	<0.5
Styrene	nc	nc	0.5	<0.5	<0.5	<0.5
1,1,1,2-tetrachloroethane	38	nc	2	<2	<2	<2
1,1,2,2-tetrachloroethane	140	nc	2	<2	<2	<2
Tetrachloroethene	110	30	0.5	<0.5	<0.5	<0.5
Toluene	4900	24	0.4	<0.4	<0.4	<0.4
1,2,3-trichlorobenzene	8	8	1	<1	<1	<1
1,2,4-trichlorobenzene	24	15	1	<1	<1	<1
1,3,5-trichlorobenzene	380	14	0.5	<0.5	<0.5	<0.5
1,1,1-trichloroethane	18000	nc	0.5	<0.5	<0.5	<0.5
1,1,2-trichloroethane	9400	nc	0.5	<0.5	<0.5	<0.5
Trichloroethene	50	5	0.5	<0.5	<0.5	<0.5
Trichlorofluoromethane	nc	nc	0.5	<0.5	<0.5	<0.5
1,2,4-trimethylbenzene	nc	nc	0.5	<0.5	<0.5	<0.5
1,3,5-trimethylbenzene	nc	nc	0.5	<0.5	<0.5	<0.5
Vinyl chloride	18	2	0.5	<0.5	<0.5	<0.5
Xylenes (Total)	13000	300	0.8	<0.8	<0.8	<0.8
m & p-Xylene	nc	nc	0.8	<0.8	<0.8	<0.8
o-Xylene	nc	nc	0.4	<0.4	<0.4	<0.4

Notes:

1 = Federal Interim Groundwater Quality Guidelines, (2010); Table 1 - Generic Guidelines for Agricultural Land Use for fine-grained soils

2 = Alberta Tier 1 Soil and Groundwater Remediation Guidelines, (December 2010) - Table B-2. Alberta Tier 1 Soil Remediation Guidelines, Agriculture Use, fine-grained soils.

- = Not analyzed

nc = No Criteria

NA = Not applicable

20 = Denotes exceedance of Federal Interim Groundwater Quality Guidelines, (2010); Table 1

20 = Denotes exceedance of Alberta Tier 1, (2010)

Table 2: Groundwater Analytical Results - Metals

PARAMETER	Federal Interim Guidelines Table 1[1]	Alberta[2] Tier 1	Lowest RDL	Drumheller Institution No. 530	
Sample ID				MW99-03	MW05-1
Sampling Date				19/08/2011	19/08/2011
Elements (mg/L)					
Dissolved Aluminum (Al)	5	5	0.001	1.4	0.015
Dissolved Antimony (Sb)	1.6	0.006	0.0006	<0.006	<0.0006
Dissolved Arsenic (As)	0.005	0.005	0.0002	0.003	<0.0002
Dissolved Barium (Ba)	0.5	1	0.01	0.02	0.02
Dissolved Beryllium (Be)	0.0053	nc	0.001	<0.01	<0.001
Dissolved Boron (B)	0.5	0.5	0.02	0.25	0.31
Dissolved Calcium (Ca)	nc	nc	0.3	490	47
Dissolved Chromium (Cr)	0.0089	0.05	0.001	<0.01	<0.001
Dissolved Cobalt (Co)	0.05	nc	0.0003	<0.003	<0.0003
Dissolved Copper (Cu)	0.5	0.5	0.0002	0.016	0.0009
Dissolved Iron (Fe)	0.3	0.3	0.06	0.38	<0.06
Dissolved Lead (Pb)	0.1	0.1	0.0002	0.007	<0.0002
Dissolved Lithium (Li)	nc	nc	0.02	0.35	0.21
Dissolved Magnesium (Mg)	nc	nc	0.2	220	8.4
Dissolved Manganese (Mn)	0.2	0.05	0.004	<0.004	0.096
Dissolved Molybdenum (Mo)	0.073	nc	0.0002	<0.002	0.0002
Dissolved Nickel (Ni)	1	1	0.0005	0.007	<0.0005
Dissolved Phosphorus (P)	nc	nc	0.1	<0.1	<0.1
Dissolved Potassium (K)	nc	nc	0.3	8.2	3.0
Dissolved Selenium (Se)	0.001	0.001	0.0002	0.060	<0.0002
Dissolved Silicon (Si)	nc	nc	0.1	9.3	6.9
Dissolved Silver (Ag)	0.0001	0.05	0.0001	<0.001	<0.0001
Dissolved Sodium (Na)	nc	200	0.5	490	470
Dissolved Strontium (Sr)	nc	nc	0.02	3.5	0.56
Dissolved Sulphur (S)	nc	nc	0.2	840 (1)	150
Dissolved Thallium (Tl)	0.0008	nc	0.0002	<0.002	<0.0002
Dissolved Tin (Sn)	nc	nc	0.001	<0.01	<0.001
Dissolved Titanium (Ti)	0.1	nc	0.001	0.02	<0.001
Dissolved Uranium (U)	0.01	0.01	0.0001	0.11	0.0008
Dissolved Vanadium (V)	0.1	nc	0.001	<0.01	<0.001
Dissolved Zinc (Zn)	0.01	0.03	0.003	0.10	0.008
Nutrients (mg/L)					
Dissolved Nitrite (N)	0.06	nc	0.003	<0.003	0.009
Dissolved Nitrate (N)	13	nc	0.003	33 (1)	0.052
Calculated Parameters (mg/L)					
Anion Sum (meq/L)	nc	nc	N/A	69	24
Cation Sum (meq/L)	nc	nc	N/A	64	23
Hardness (CaCO3)	nc	nc	0.5	2100	150
Ion Balance (N/A)	nc	nc	0.01	0.92	0.96
Dissolved Nitrate (NO3)	13	13	0.01	150	0.23
Nitrate plus Nitrite (N)	100	100	0.003	33	0.061
Dissolved Nitrite (NO2)	0.06	0.06	0.01	<0.01	0.03
Total Dissolved Solids	3000	500	10	4300	1400
Misc. Inorganics					
Conductivity (uS/cm)	nc	nc	1	5200	2300
Turbidity (NTU)	nc	nc	0.1	>1000 (1)	180
pH	6.5 - 8.7	6.5 - 8.5	N/A	7.85	8.16
Low Level Elements (ug/L)					
Dissolved Cadmium (Cd)	0.017	0.08	0.005	0.68	0.15
Anions (mg/L)					
Alkalinity (PP as CaCO3)	nc	nc	0.5	<0.5	<0.5
Alkalinity (Total as CaCO3)	nc	nc	0.5	690	740
Bicarbonate (HCO3)	nc	nc	0.5	850	900
Carbonate (CO3)	nc	nc	0.5	<0.5	<0.5
Hydroxide (OH)	nc	nc	0.5	<0.5	<0.5
Dissolved Fluoride (F)	0.12	0.12	0.05	0.11	0.20
Dissolved Sulphate (SO4)	100	500	5	2500 (1)	450 (1)
Dissolved Chloride (Cl)	100	nc	1	36 (1)	5

Notes:

1 =	Federal Interim Groundwater Quality Guidelines, (2010); Table 1 - Generic Guidelines for Agricultural Land Use for fine-grained soils
2 =	Alberta Tier 1 Soil and Groundwater Remediation Guidelines, (December 2010) - Table B-2. Alberta Tier 1 Soil Remediation Guidelines, Agriculture Use, fine-grained soils.
(1)=	Detection limits raised due to dilution to bring analyte within the calibrated range.
- =	Not analyzed
nc =	No Criteria
NA =	Not applicable
20 =	Denotes exceedance of Federal Interim Groundwater Quality Guidelines, (2010)
20 =	Denotes exceedance of Alberta Tier 1, (2010)
20 =	Denotes exceedance of FIGQG & Alberta Tier 1

Table 3: Surface Water Analytical Results - Metals

PARAMETER	Background	CCME FWAL [1]	CCME AGRI [2]	Lowest RDL	Drumheller Institution No. 530					
					Upstream	Downstream			Seepage	
Sample ID					DRUM-SW1	DRUM-SW2	DRUM-SW3	DRUM-SW4	DRUM-SEEP1A	DRUM-SEEP1B
Sampling Date					19/08/2011	19/08/2011	19/08/2011	19/08/2011	19/08/2011	19/08/2011
Elements (mg/L)										
Total Cadmium (Cd) (ug/L)	**0.093**	0.017	0.08	0.005	0.19	0.086	0.016	0.27	0.27	0.035
Total Aluminum (Al) *	**3.3**	0.1	5	0.001	2.0	1.4	0.15	1.7	3.2 (1)	0.14
Total Antimony (Sb)	**0.0008**	nc	nc	0.0006	0.0010	0.0006	<0.0006	<0.0006	<0.0006	<0.0006
Total Arsenic (As)	**0.0068**	0.005	0.025	0.0002	0.0065	0.0022	0.0012	0.0030	0.015	0.0011
Total Barium (Ba)	**0.11**	nc	nc	0.01	0.12	0.06	0.03	0.11	0.25	0.04
Total Beryllium (Be)	<0.001	nc	0.1	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Total Boron (B)	0.18	**1.5**	5	0.02	0.14	0.15	0.23	0.24	0.18	0.23
Total Calcium (Ca)	27	**nc**	1000	0.3	29	91	28	94	110	73
Total Chromium (Cr) **	0.003	**0.0089**	0.05	0.001	0.002	0.002	<0.001	0.003	0.005	<0.001
Total Cobalt (Co)	0.0026	**nc**	1	0.0003	0.0023	0.0024	<0.0003	0.0038	0.0054	0.0004
Total Copper (Cu) ***	**0.017**	0.003-0.004	1	0.0002	0.0079	0.0070	0.0013	0.0089	0.010	0.0021
Total Iron (Fe)	**3.3**	0.3	nc	0.06	2.4	1.7	0.33	4.2	23	0.40
Total Lead (Pb) ***	0.0036	**0.004-0.007**	0.1	0.0002	0.0029	0.0022	<0.0002	0.0051	0.0058	0.0003
Total Lithium (Li)	**0.16**	nc	nc	0.02	0.14	0.18	0.18	0.19	0.13	0.18
Total Magnesium (Mg)	17	**nc**	nc	0.2	16	32	20	27	31	23
Total Manganese (Mn)	0.065	**nc**	nc	0.004	0.073	0.055	<0.004	0.44	1.6	0.11
Total Molybdenum (Mo)	0.0023	**0.073**	0.5	0.0002	0.0031	0.0030	0.0012	0.0012	0.0009	0.0011
Total Nickel (Ni) ***	0.013	**0.11-0.15**	1	0.0005	0.014	0.012	0.0022	0.012	0.014	0.0029
Total Phosphorus (P)	<0.1	**nc**	nc	0.1	<0.1	<0.1	<0.1	0.3	0.4	<0.1
Total Potassium (K)	7.4	**nc**	nc	0.3	8.6	7.7	5.0	5.4	6.4	4.9
Total Selenium (Se)	0.0005	**0.001**	0.05	0.0002	0.0007	0.0014	<0.0002	0.0003	0.0003	<0.0002
Total Silicon (Si)	11	**nc**	nc	0.1	6.9	6.4	9.3	11	17	8.3
Total Silver (Ag)	<0.0001	**0.0001**	nc	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total Sodium (Na)	350	**nc**	nc	0.5	310	330	330	340	240	320
Total Strontium (Sr)	**0.41**	nc	nc	0.02	0.38	1.1	0.50	0.76	0.82	0.71
Total Sulphur (S)	69	**nc**	nc	0.2	73	210	120	120	75	120
Total Thallium (Tl)	<0.0002	**0.0008**	nc	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Total Tin (Sn)	<0.001	**nc**	nc	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Total Titanium (Ti)	0.049	**nc**	nc	0.001	0.037	0.033	0.005	0.047	0.079	0.005
Total Uranium (U)	0.0035	**0.015**	0.2	0.0001	0.0044	0.013	0.0061	0.0068	0.0031	0.0061
Total Vanadium (V)	0.010	**nc**	0.1	0.001	0.009	0.006	0.002	0.008	0.010	0.002
Total Zinc (Zn)	**0.018**	0.03	50	0.003	0.013	0.010	<0.003	0.022	0.034	<0.003
Calculated Parameters (mg/L)										
Anion Sum (meq/L)	19	nc	nc	N/A	17	23	19	19	16	19
Cation Sum (meq/L)	16	nc	nc	N/A	15	21	17	18	15	18
Hardness (CaCO3)	120	nc	nc	0.5	120	340	150	180	270	240
Ion Balance (N/A)	0.89	nc	nc	0.01	0.90	0.93	0.89	0.93	0.94	0.95
Dissolved Nitrate (NO3)	0.04	nc	nc	0.01	<0.01	3.3	<0.01	<0.01	0.05	0.08
Nitrate plus Nitrite (N)	0.010	nc	100	0.003	<0.003	0.75	<0.003	<0.003	0.012	0.017
Dissolved Nitrite (NO2)	<0.01	nc	nc	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Dissolved Solids	1000	nc	3000	10	920	1400	1100	1100	910	1100
Misc. Inorganics										
Conductivity (uS/cm)	1700	nc	nc	1	1500	2100	1800	1800	1500	1800
Turbidity (NTU)	150	nc	nc	0.1	110	130	8.9	310	600	28
pH	8.59	nc	nc	N/A	8.63	8.48	8.65	8.40	8.26	8.35
Anions (mg/L)										
Alkalinity (PP as CaCO3)	26	nc	nc	0.5	22	9.0	26	9.8	<0.5	6.6
Alkalinity (Total as CaCO3)	710	nc	nc	0.5	600	330	560	570	580	590
Bicarbonate (HCO3)	800	nc	nc	0.5	670	390	610	670	710	710
Carbonate (CO3)	31	nc	nc	0.5	26	11.0	32	12	<0.5	7.9
Hydroxide (OH)	<0.5	nc	nc	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dissolved Flouride (F)	210 (1)	nc	nc	2	230 (1)	670 (1)	360 (1)	360 (1)	230 (1)	340 (1)
Dissolved Sulphate (SO4)	0.27	nc	nc	0.05	0.29	0.33	0.18	0.18	0.22	0.15
Dissolved Chloride (Cl)	4	nc	nc	1	5	77.0	4	4	5	4
Nutrients (mg/L)										
Dissolved Nitrite (N)	<0.003	nc	nc	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Dissolved Nitrate (N)	0.010	nc	nc	0.003	<0.003	0.75	<0.003	<0.003	0.012	0.017
Dissolved Calcium (Ca)	24	nc	nc	0.3	26	87	28	39	68	60
Dissolved Iron (Fe)	0.20	nc	nc	0.06	0.25	0.35	0.20	<0.06	0.25	0.16
Dissolved Magnesium (Mg)	14	nc	nc	0.2	14	31	19	20	24	21
Dissolved Manganese (Mn)	<0.004	nc	nc	0.004	0.005	0.007	<0.004	0.006	0.017	0.035
Dissolved Potassium (K)	6.3	nc	nc	0.3	7.6	7.5	4.7	4.7	5.3	4.6
Dissolved Sodium (Na)	320	nc	nc	0.5	290	330	310	320	230	300

Notes:

1 = CCME (2007) Summary Table, Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life (FWAL) Update 7.1.

2 = CCME (1999) Summary Table, Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses, Livestock.

20 = Bold denotes guideline used

(1)= Detection limits raised due to dilution to bring analyte within the calibrated range.

* = Guideline is pH dependent, pH > 6.5 for all samples.

** = Guideline selected based on chromium (III).

*** = Guideline based on hardness, hardness range of samples is 120 to 340 mg/L CaCO3.

- = Not analyzed

nc = No Criteria

NA = Not applicable

20 = Denotes exceedance of CCME FWAL guideline or background concentrations

20 = Concentration is exceeding but within background levels. See Section 5.1.3 in Supplemental Environmental Site Investigation and Data Gap Analysis dated October 2011 for rationale. Not considered to be an exceedance.

Table 4: Sediment Analytical Results - Metals

PARAMETER	CCME ISQG[1]	Lowest RDL	Drumheller Institution No. 530				
Sample ID			**DRUM-SED-BK1**	**DRUM-SED2**	**DRUM-SED3**	**DRUM-SED4**	**DRUM-SED SEEP 1A**
Sampling Date			19/08/2011	19/08/2011	19/08/2011	19/08/2011	19/08/2011
Elements (ug/g)							
Soluble (Hot water) Boron (B)	nc	0.1	0.4	0.3	0.6	0.6	0.9
Hex. Chromium (Cr 6+)	nc	0.15	2.7 (1)	<0.15	<0.15	<0.15	<0.15
Total Antimony (Sb)	nc	1	<1	<1	<1	<1	<1
Total Arsenic (As)	5.9	1	4	7	7	5	6
Total Barium (Ba)	nc	10	200	240	300	240	240
Total Beryllium (Be)	nc	0.4	0.5	<0.4	0.4	0.4	<0.4
Total Cadmium (Cd)	0.6	0.1	0.5	0.2	0.4	0.2	0.3
Total Chromium (Cr)	37.3	1	15	9	9	15	12
Total Cobalt (Co)	nc	1	7	10	9	6	6
Total Copper (Cu)	35.7	5	32	15	20	13	12
Total Lead (Pb)	35	1	12	8	10	7	8
Total Mercury (Hg)	0.17	0.05	0.06	<0.05	0.05	<0.05	0.07
Total Molybdenum (Mo)	nc	0.4	0.5	0.8	0.8	0.6	<0.4
Total Nickel (Ni)	nc	1	25	23	22	22	16
Total Selenium (Se)	nc	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Silver (Ag)	nc	1	<1	<1	<1	<1	<1
Total Thallium (Tl)	nc	0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Total Tin (Sn)	nc	1	<1	<1	<1	<1	<1
Total Uranium (U)	nc	1	2	1	2	1	<1
Total Vanadium (V)	nc	1	22	16	16	16	17
Total Zinc (Zn)	123	10	62	52	49	44	46
Physical Properties							
Moisture (%)	nc	0.3	46	30	35	27	23

Notes:

1 = CCME (2007) Summary Table, Canadian Sediment Quality Guidelines for the Protection of Aquatic Life, Interim freshwater sediment quality guidelines (ISQG), Table 1. Update 2002.

(1)= Detection limits raised due to matrix interference.

- = Not analyzed

nc = No Criteria

NA = Not applicable

20 = Denotes exceedance of CCME ISQG

APPENDIX C

Site Photos

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PHOTOGRAPHIC LOG

Supplemental Environmental Site Investigation and Data Gap Analysis, Former Landfill, Drumheller Institution	**Project No: 2026-1101**
Photo ID 1	
Direction: NW	
Description: Top of Former Landfill looking NW towards fence line.	

Supplemental Environmental Site Investigation and Data Gap Analysis, Former Landfill, Drumheller Institution	**Project No: 2026-1101**
Photo ID 2	
Direction: NW	
Description: View of the Former Landfill looking NW.	

Supplemental Environmental Site Investigation and Data Gap Analysis, Former Landfill, Drumheller Institution	Project No: 2026-1101
Photo ID 3	
Direction: SE	
Description: View of Former Landfill looking SE. Note slope failure on the right hand side of photo.	

Supplemental Environmental Site Investigation and Data Gap Analysis, Former Landfill, Drumheller Institution	Project No: 2026-1101
Photo ID 4	
Direction: W	
Description: View of MW99-03 on top of Landfill. Well located adjacent to Landfill fence line.	

Supplemental Environmental Site Investigation and Data Gap Analysis, Former Landfill, Drumheller Institution	Project No: 2026-1101
Photo ID 5 **Direction:** NW **Description:** View of MW05-1. Wetland area is located just beyond trees at the top right hand corner of photo. Slope failure area located in top background of photo.	

Supplemental Environmental Site Investigation and Data Gap Analysis, Former Landfill, Drumheller Institution	Project No: 2026-1101
Photo ID 6 **Direction:** N **Description:** View of adjacent lands looking north.	

Supplemental Environmental Site Investigation and Data Gap Analysis, Former Landfill, Drumheller Institution	Project No: 2026-1101
Photo ID 7	
Direction: S	
Description: Stream bed at bottom of coulee. View looking south towards background sample location.	

Supplemental Environmental Site Investigation and Data Gap Analysis, Former Landfill, Drumheller Institution	Project No: 2026-1101
Photo ID 8	
Direction: W	
Description: Looking west up at Former Landfill. Standing where seepage meets the stream bed (DRUM-SW/SED-4). Note slope failure on right side of Landfill.	

Supplemental Environmental Site Investigation and Data Gap Analysis, Former Landfill, Drumheller Institution	Project No: 2026-1101
Photo ID 9	
Direction: S	
Description: Stream bed at bottom of coulee. Looking south towards Landfill.	

Supplemental Environmental Site Investigation and Data Gap Analysis, Former Landfill, Drumheller Institution	Project No: 2026-1101
Photo ID 10	
Direction: W	
Description: View of seepage drainage pathway looking west towards Landfill. Drainage pathway is heavily vegetated.	

Supplemental Environmental Site Investigation and Data Gap Analysis, Former Landfill, Drumheller Institution	Project No: 2026-1101
Photo ID 11	
Direction: N/A	
Description: Seepage drainage pathway. Flow is minimal.	

Supplemental Environmental Site Investigation and Data Gap Analysis, Former Landfill, Drumheller Institution	Project No: 2026-1101
Photo ID 12	
Direction: SW	
Description: Wetland area located at toe of Landfill. View towards SW up at Landfill. This area is a low lying depression.	

Supplemental Environmental Site Investigation and Data Gap Analysis, Former Landfill, Drumheller Institution	Project No: 2026-1101
Photo ID 13	
Direction: W	
Description: Wetland area. View towards the west and the slope failure.	

Supplemental Environmental Site Investigation and Data Gap Analysis, Former Landfill, Drumheller Institution	Project No: 2026-1101
Photo ID 14	
Direction: E	
Description: View of wetland area towards E. The seepage drainage pathway exits wetland and flows down slope towards stream bed from here.	

Supplemental Environmental Site Investigation and Data Gap Analysis, Former Landfill, Drumheller Institution	Project No: 2026-1101
Photo ID 15	
Direction: E	
Description: Standing at top of the Former Landfill at the slope failure looking E.	

Supplemental Environmental Site Investigation and Data Gap Analysis, Former Landfill, Drumheller Institution	Project No: 2026-1101
Photo ID 16	
Direction: N	
Description: View towards the north from top of Landfill.	

Supplemental Environmental Site Investigation and Data Gap Analysis, Former Landfill, Drumheller Institution	Project No: 2026-1101
Photo ID 17	
Direction: S	
Description: View south from top of coulee. Former Landfill on right hand side.	

Supplemental Environmental Site Investigation and Data Gap Analysis, Former Landfill, Drumheller Institution	Project No: 2026-1101
Photo ID 18	
Direction: N/A	
Description: View of the bright orange colour of colloidal iron oxides at the DRUM-SEEP1A sampling location. Note the biofilm (“sheen”-like appearance, with angular edges) of iron-reducing bacteria on the surface.	

Supplemental Environmental Site Investigation and Data Gap Analysis, Former Landfill, Drumheller Institution	Project No: 2026-1101

Photo ID 19

Direction: N/A

Description: Canister found during site reconnaissance. Confirmed to be tear gas, but has been decommissioned prior to disposal.

APPENDIX D

Sediment and Monitoring Well Logs

Sediment Logs

PARAMETER	Drumheller Institution - Former Landfill				
Sampling No.	**DRUM-SED-BK1**	**DRUM-SED2**	**DRUM-SED3**	**DRUM-SED4**	**DRUM-SEEP1A**
Sampling Date	**8/19/2011**	**8/19/2011**	**8/19/2011**	**8/19/2011**	**8/19/2011**
Measured Data	metals	metals	metals	metals	metals
H2O depth (m)	0.15	0.02	0.05	0.02	0.4
Sheen (Y/N)	N	N	N	N	N
Comments	SANDY SILT - light brown, no gravel, no cobbles, no sheen, no odours, no benthos	SAND and SILT- brown, some organics, fine, no gravel, no sheen, no odours, no benthos	SILT and SAND - light brown, some gravel, some clay,fine to coarse, no odour, no sheen, no benthos	SILTY SAND - brown, fine, some organics, no odour, no sheen, no benthos	SAND and ORGANICS - brown with red precipitate layer, fine to medium, some silt and clay, no sheen, slight organic odour, no visible benthos.

Monitoring Well Logs

PARAMETER	Drumheller Institution No. 530	
Sample Number	**MW99-03**	**MW05-1**
Sampling Date	19/08/2011	19/08/2011
Field Parameters		
Temperature (^{o}C)	11.95	6.5
Salinity	2.8	1.15
TDS (NTU)	1261.7	1139.4
Conductivity (us/cm)	394.3	1448
Dissolved Oxygen (ug/L)	10.91	5.74
pH	7.11	7.34

APPENDIX E

Laboratory Reports and Chain of Custody Forms

Maxxam

Success Through Science®

Your Project #: 2026-1101
Site Location: DRUMHELLER, AB
Your C.O.C. #: A033994

Attention: JULIE DITTBURNER
FRANZ ENVIRONMENTAL INC.
329 CHURCHILL AVE NORTH
SUITE 2000
OTTAWA, ON
CANADA K1Z5B8

Report Date: 2011/08/29

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B177703
Received: 2011/08/20, 10:55

Sample Matrix: Water
Samples Received: 10

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity @25C (pp, total), CO3,HCO3,OH	9	N/A	2011/08/24	AB SOP-00005	SM 2320-B
Cadmium - low level CCME - Dissolved	2	N/A	2011/08/27	AB SOP-00043	EPA 200.8
Cadmium - low level CCME (Total)	7	2011/08/22	2011/08/27	AB SOP-00043	EPA 200.8
Chloride by Automated Colourimetry	9	N/A	2011/08/23	AB SOP-00020	EPA 325.2
Conductivity @25C	9	N/A	2011/08/24	AB SOP-00005	SM 2510-B
Fluoride	8	N/A	2011/08/23	AB SOP-00005	SM 4500-F C
Fluoride	1	N/A	2011/08/25	AB SOP-00005	SM 4500-F C
Hardness	9	N/A	2011/08/27	AB WI-00065	SM 2340B
Elements by ICP - Dissolved	9	N/A	2011/08/26	AB SOP-00042	EPA 200.7
Elements by ICP - Total	7	2011/08/25	2011/08/26	AB SOP-00042	EPA 200.7
Elements by ICPMS - Dissolved	2	N/A	2011/08/26	AB SOP-00043	EPA 200.8
Elements by ICPMS - Total	7	2011/08/25	2011/08/27	AB SOP-00043	EPA 200.8
Ion Balance	9	N/A	2011/08/23	AB WI-00065	SM 1030E
Sum of cations, anions	9	N/A	2011/08/27	AB WI-00065	SM 1030E
Nitrate and Nitrite	9	N/A	2011/08/24		CAL SOP-00060
Nitrate + Nitrite-N (calculated)	9	N/A	2011/08/24	AB SOP-00023	SM 4110-B
Nitrogen, (Nitrite, Nitrate) by IC	9	N/A	2011/08/24	AB SOP-00023	SM 4110-B
pH @25°C (Alkalinity titrator)	9	N/A	2011/08/24	AB SOP-00005	SM 4500-H+B
Sulphate by Automated Colourimetry	9	N/A	2011/08/23	AB SOP-00018	EPA 375.4
Total Dissolved Solids (Calculated)	9	N/A	2011/08/27	AB WI-00065	SM 1030E
Total Trihalomethanes Calculation	3	N/A	2011/08/24	CAL SOP-00104	EPA 8260 C
Turbidity	9	N/A	2011/08/24	CAL SOP-00081	SM 2130B
VOCs in Water by P&T GC/MS (Std List)	3	N/A	2011/08/23	CAL SOP-00104	EPA 8260 C

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Parminder Virk, Project Manager
Email: PVirk@maxxam.ca
Phone# (403) 291-3077

==========
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section

Maxxam Job #: B177703
Report Date: 2011/08/29

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1101
Site Location: DRUMHELLER, AB
Sampler Initials: JD

5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total cover pages: 2

Maxxam

Success Through Science®

Maxxam Job #: B177703
Report Date: 2011/08/29

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1101
Site Location: DRUMHELLER, AB
Sampler Initials: JD

ROUTINE WATER (WATER)

Maxxam ID		BH9415	BH9416		BH9417	BH9418	BH9419		BH9420	BH9421		
Sampling Date		2011/08/19	2011/08/19		2011/08/19	2011/08/19	2011/08/19		2011/08/19	2011/08/19		
	Units	**DRUM-SW-BK1**	**DRUM-SW1**	**RDL**	**DRUM-SW2**	**DRUM-SW3**	**DRUM-SW4**	**RDL**	**DRUM-SEEP1A**	**DRUM-SEEP1B**	**RDL**	**QC Batch**
Calculated Parameters												
Anion Sum	meq/L	19	17	N/A	23	19	19	N/A	16	19	N/A	5112651
Cation Sum	meq/L	16	15	N/A	21	17	18	N/A	15	18	N/A	5112651
Hardness (CaCO3)	mg/L	120	120	0.5	340	150	180	0.5	270	240	0.5	5112649
Ion Balance	N/A	0.89	0.90	0.01	0.93	0.89	0.93	0.01	0.94	0.95	0.01	5112650
Dissolved Nitrate (NO3)	mg/L	0.04	<0.01	0.01	3.3	<0.01	<0.01	0.01	0.05	0.08	0.01	5112652
Nitrate plus Nitrite (N)	mg/L	0.010	<0.003	0.003	0.75	<0.003	<0.003	0.003	0.012	0.017	0.003	5112653
Dissolved Nitrite (NO2)	mg/L	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.01	5112652
Total Dissolved Solids	mg/L	1000	920	10	1400	1100	1100	10	910	1100	10	5112654
Misc. Inorganics												
Conductivity	uS/cm	1700	1500	1	2100	1800	1800	1	1500	1800	1	5118975
pH	N/A	8.59	8.63	N/A	8.48	8.65	8.40	N/A	8.26	8.35	N/A	5118976
Anions												
Alkalinity (PP as CaCO3)	mg/L	26	22	0.5	9.0	26	9.8	0.5	<0.5	6.6	0.5	5118842
Alkalinity (Total as CaCO3)	mg/L	710	600	0.5	330	560	570	0.5	580	590	0.5	5118842
Bicarbonate (HCO3)	mg/L	800	670	0.5	390	610	670	0.5	710	710	0.5	5118842
Carbonate (CO3)	mg/L	31	26	0.5	11	32	12	0.5	<0.5	7.9	0.5	5118842
Hydroxide (OH)	mg/L	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	0.5	5118842
Dissolved Sulphate (SO4)	mg/L	210(1)	230(1)	2	670(1)	360(1)	360(1)	5	230(1)	340(1)	2	5114193
Dissolved Chloride (Cl)	mg/L	4	5	1	77	4	4	1	5	4	1	5114191
Nutrients												
Dissolved Nitrite (N)	mg/L	<0.003	<0.003	0.003	<0.003	<0.003	<0.003	0.003	<0.003	<0.003	0.003	5115808
Dissolved Nitrate (N)	mg/L	0.010	<0.003	0.003	0.75	<0.003	<0.003	0.003	0.012	0.017	0.003	5115808
Elements												
Dissolved Calcium (Ca)	mg/L	24	26	0.3	87	28	39	0.3	68	60	0.3	5126238
Dissolved Iron (Fe)	mg/L	0.20	0.25	0.06	0.35	0.20	<0.06	0.06	0.25	0.16	0.06	5126238
Dissolved Magnesium (Mg)	mg/L	14	14	0.2	31	19	20	0.2	24	21	0.2	5126238
Dissolved Manganese (Mn)	mg/L	<0.004	0.005	0.004	0.007	<0.004	0.006	0.004	0.017	0.035	0.004	5126238
Dissolved Potassium (K)	mg/L	6.3	7.6	0.3	7.5	4.7	4.7	0.3	5.3	4.6	0.3	5126238
Dissolved Sodium (Na)	mg/L	320	290	0.5	330	310	320	0.5	230	300	0.5	5126238

N/A = Not Applicable
RDL = Reportable Detection Limit
(1) - Detection limits raised due to dilution to bring analyte within the calibrated range.

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Maxxam Job #: B177703
Report Date: 2011/08/29

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1101
Site Location: DRUMHELLER, AB
Sampler Initials: JD

ROUTINE WATER & DISS. REGULATED METALS (WATER)

Maxxam ID		BH9413		BH9414		
Sampling Date		2011/08/19		2011/08/19		
	Units	**MW99-03**	**RDL**	**MW05-1**	**RDL**	**QC Batch**
Calculated Parameters						
Anion Sum	meq/L	69	N/A	24	N/A	5112651
Cation Sum	meq/L	64	N/A	23	N/A	5112651
Hardness (CaCO3)	mg/L	2100	0.5	150	0.5	5112649
Ion Balance	N/A	0.92	0.01	0.96	0.01	5112650
Dissolved Nitrate (NO3)	mg/L	150	0.3	0.23	0.01	5112652
Nitrate plus Nitrite (N)	mg/L	33	0.06	0.061	0.003	5112653
Dissolved Nitrite (NO2)	mg/L	<0.01	0.01	0.03	0.01	5112652
Total Dissolved Solids	mg/L	4300	10	1400	10	5112654
Misc. Inorganics						
Conductivity	uS/cm	5200	1	2300	1	5118975
pH	N/A	7.85	N/A	8.16	N/A	5118976
Low Level Elements						
Dissolved Cadmium (Cd)	ug/L	0.68	0.05	0.15	0.005	5113154
Anions						
Alkalinity (PP as CaCO3)	mg/L	<0.5	0.5	<0.5	0.5	5118842
Alkalinity (Total as CaCO3)	mg/L	690	0.5	740	0.5	5118842
Bicarbonate (HCO3)	mg/L	850	0.5	900	0.5	5118842
Carbonate (CO3)	mg/L	<0.5	0.5	<0.5	0.5	5118842
Hydroxide (OH)	mg/L	<0.5	0.5	<0.5	0.5	5118842
Dissolved Sulphate (SO4)	mg/L	2500(1)	20	450(1)	5	5114193
Dissolved Chloride (Cl)	mg/L	36(1)	2	5	1	5114191
Nutrients						
Dissolved Nitrite (N)	mg/L	<0.003	0.003	0.009	0.003	5115808
Dissolved Nitrate (N)	mg/L	33(1)	0.06	0.052	0.003	5115808

N/A = Not Applicable
RDL = Reportable Detection Limit
(1) - Detection limits raised due to dilution to bring analyte within the calibrated range.

Maxxam

Success Through Science®

Maxxam Job #: B177703
Report Date: 2011/08/29

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1101
Site Location: DRUMHELLER, AB
Sampler Initials: JD

ROUTINE WATER & DISS. REGULATED METALS (WATER)

Maxxam ID		BH9413		BH9414		
Sampling Date		2011/08/19		2011/08/19		
	Units	**MW99-03**	**RDL**	**MW05-1**	**RDL**	**QC Batch**
Elements						
Dissolved Aluminum (Al)	mg/L	1.4	0.01	0.015	0.001	5127620
Dissolved Antimony (Sb)	mg/L	<0.006	0.006	<0.0006	0.0006	5127620
Dissolved Arsenic (As)	mg/L	0.003	0.002	<0.0002	0.0002	5127620
Dissolved Barium (Ba)	mg/L	0.02	0.01	0.02	0.01	5126238
Dissolved Beryllium (Be)	mg/L	<0.01	0.01	<0.001	0.001	5127620
Dissolved Boron (B)	mg/L	0.25	0.02	0.31	0.02	5126238
Dissolved Calcium (Ca)	mg/L	490	0.3	47	0.3	5126238
Dissolved Chromium (Cr)	mg/L	<0.01	0.01	<0.001	0.001	5127620
Dissolved Cobalt (Co)	mg/L	<0.003	0.003	<0.0003	0.0003	5127620
Dissolved Copper (Cu)	mg/L	0.016	0.002	0.0009	0.0002	5127620
Dissolved Iron (Fe)	mg/L	0.38	0.06	<0.06	0.06	5126238
Dissolved Lead (Pb)	mg/L	0.007	0.002	<0.0002	0.0002	5127620
Dissolved Lithium (Li)	mg/L	0.35	0.02	0.21	0.02	5126238
Dissolved Magnesium (Mg)	mg/L	220	0.2	8.4	0.2	5126238
Dissolved Manganese (Mn)	mg/L	<0.004	0.004	0.096	0.004	5126238
Dissolved Molybdenum (Mo)	mg/L	<0.002	0.002	0.0002	0.0002	5127620
Dissolved Nickel (Ni)	mg/L	0.007	0.005	<0.0005	0.0005	5127620
Dissolved Phosphorus (P)	mg/L	<0.1	0.1	<0.1	0.1	5126238
Dissolved Potassium (K)	mg/L	8.2	0.3	3.0	0.3	5126238
Dissolved Selenium (Se)	mg/L	0.060	0.002	<0.0002	0.0002	5127620
Dissolved Silicon (Si)	mg/L	9.3	0.1	6.9	0.1	5126238
Dissolved Silver (Ag)	mg/L	<0.001	0.001	<0.0001	0.0001	5127620
Dissolved Sodium (Na)	mg/L	490	0.5	470	0.5	5126238
Dissolved Strontium (Sr)	mg/L	3.5	0.02	0.56	0.02	5126238
Dissolved Sulphur (S)	mg/L	840(1)	1	150	0.2	5126238
Dissolved Thallium (Tl)	mg/L	<0.002	0.002	<0.0002	0.0002	5127620
Dissolved Tin (Sn)	mg/L	<0.01	0.01	<0.001	0.001	5127620
Dissolved Titanium (Ti)	mg/L	0.02	0.01	<0.001	0.001	5127620
Dissolved Uranium (U)	mg/L	0.11	0.001	0.0008	0.0001	5127620
Dissolved Vanadium (V)	mg/L	<0.01	0.01	<0.001	0.001	5127620
Dissolved Zinc (Zn)	mg/L	0.10	0.03	0.008	0.003	5127620

RDL = Reportable Detection Limit
(1) - Detection limits raised due to dilution to bring analyte within the calibrated range.

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Maxxam Job #: B177703
Report Date: 2011/08/29

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1101
Site Location: DRUMHELLER, AB
Sampler Initials: JD

REGULATED METALS (CCME/AT1) - TOTAL

Maxxam ID		BH9415		BH9416	BH9417		
Sampling Date		2011/08/19		2011/08/19	2011/08/19		
	Units	**DRUM-SW-BK1**	**RDL**	**DRUM-SW1**	**DRUM-SW2**	**RDL**	**QC Batch**
Low Level Elements							
Total Cadmium (Cd)	ug/L	0.093	0.005	0.19	0.086	0.005	5111976
Elements							
Total Aluminum (Al)	mg/L	3.3(1)	0.003	2.0	1.4	0.001	5127572
Total Antimony (Sb)	mg/L	0.0008	0.0006	0.0010	0.0006	0.0006	5127572
Total Arsenic (As)	mg/L	0.0068	0.0002	0.0065	0.0022	0.0002	5127572
Total Barium (Ba)	mg/L	0.11	0.01	0.12	0.06	0.01	5126214
Total Beryllium (Be)	mg/L	<0.001	0.001	<0.001	<0.001	0.001	5127572
Total Boron (B)	mg/L	0.18	0.02	0.14	0.15	0.02	5126214
Total Calcium (Ca)	mg/L	27	0.3	29	91	0.3	5126214
Total Chromium (Cr)	mg/L	0.003	0.001	0.002	0.002	0.001	5127572
Total Cobalt (Co)	mg/L	0.0026	0.0003	0.0023	0.0024	0.0003	5127572
Total Copper (Cu)	mg/L	0.017	0.0002	0.0079	0.0070	0.0002	5127572
Total Iron (Fe)	mg/L	3.3	0.06	2.4	1.7	0.06	5126214
Total Lead (Pb)	mg/L	0.0036	0.0002	0.0029	0.0022	0.0002	5127572
Total Lithium (Li)	mg/L	0.16	0.02	0.14	0.18	0.02	5126214
Total Magnesium (Mg)	mg/L	17	0.2	16	32	0.2	5126214
Total Manganese (Mn)	mg/L	0.065	0.004	0.073	0.055	0.004	5126214
Total Molybdenum (Mo)	mg/L	0.0023	0.0002	0.0031	0.0030	0.0002	5127572
Total Nickel (Ni)	mg/L	0.013	0.0005	0.014	0.012	0.0005	5127572
Total Phosphorus (P)	mg/L	<0.1	0.1	<0.1	<0.1	0.1	5126214
Total Potassium (K)	mg/L	7.4	0.3	8.6	7.7	0.3	5126214
Total Selenium (Se)	mg/L	0.0005	0.0002	0.0007	0.0014	0.0002	5127572
Total Silicon (Si)	mg/L	11	0.1	6.9	6.4	0.1	5126214
Total Silver (Ag)	mg/L	<0.0001	0.0001	<0.0001	<0.0001	0.0001	5127572
Total Sodium (Na)	mg/L	350	0.5	310	330	0.5	5126214
Total Strontium (Sr)	mg/L	0.41	0.02	0.38	1.1	0.02	5126214
Total Sulphur (S)	mg/L	69	0.2	73	210	0.2	5126214
Total Thallium (Tl)	mg/L	<0.0002	0.0002	<0.0002	<0.0002	0.0002	5127572
Total Tin (Sn)	mg/L	<0.001	0.001	<0.001	<0.001	0.001	5127572
Total Titanium (Ti)	mg/L	0.049	0.001	0.037	0.033	0.001	5127572
Total Uranium (U)	mg/L	0.0035	0.0001	0.0044	0.013	0.0001	5127572
Total Vanadium (V)	mg/L	0.010	0.001	0.009	0.006	0.001	5127572
Total Zinc (Zn)	mg/L	0.018	0.003	0.013	0.010	0.003	5127572

RDL = Reportable Detection Limit
(1) - Detection limits raised due to dilution to bring analyte within the calibrated range.

Maxxam

Success Through Science®

Maxxam Job #: B177703
Report Date: 2011/08/29

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1101
Site Location: DRUMHELLER, AB
Sampler Initials: JD

REGULATED METALS (CCME/AT1) - TOTAL

Maxxam ID		BH9418	BH9419		BH9420		BH9421		
Sampling Date		2011/08/19	2011/08/19		2011/08/19		2011/08/19		
	Units	**DRUM-SW3**	**DRUM-SW4**	**RDL**	**DRUM-SEEP1A**	**RDL**	**DRUM-SEEP1B**	**RDL**	**QC Batch**
Low Level Elements									
Total Cadmium (Cd)	ug/L	0.016	0.27	0.005	0.27	0.005	0.035	0.005	5111976
Elements									
Total Aluminum (Al)	mg/L	0.15	1.7	0.001	3.2(1)	0.003	0.14	0.001	5127572
Total Antimony (Sb)	mg/L	<0.0006	<0.0006	0.0006	<0.0006	0.0006	<0.0006	0.0006	5127572
Total Arsenic (As)	mg/L	0.0012	0.0030	0.0002	0.015	0.0002	0.0011	0.0002	5127572
Total Barium (Ba)	mg/L	0.03	0.11	0.01	0.25	0.01	0.04	0.01	5126214
Total Beryllium (Be)	mg/L	<0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	5127572
Total Boron (B)	mg/L	0.23	0.24	0.02	0.18	0.02	0.23	0.02	5126214
Total Calcium (Ca)	mg/L	28	94	0.3	110	0.3	73	0.3	5126214
Total Chromium (Cr)	mg/L	<0.001	0.003	0.001	0.005	0.001	<0.001	0.001	5127572
Total Cobalt (Co)	mg/L	<0.0003	0.0038	0.0003	0.0054	0.0003	0.0004	0.0003	5127572
Total Copper (Cu)	mg/L	0.0013	0.0089	0.0002	0.010	0.0002	0.0021	0.0002	5127572
Total Iron (Fe)	mg/L	0.33	4.2	0.06	23	0.06	0.40	0.06	5126214
Total Lead (Pb)	mg/L	<0.0002	0.0051	0.0002	0.0058	0.0002	0.0003	0.0002	5127572
Total Lithium (Li)	mg/L	0.18	0.19	0.02	0.13	0.02	0.18	0.02	5126214
Total Magnesium (Mg)	mg/L	20	27	0.2	31	0.2	23	0.2	5126214
Total Manganese (Mn)	mg/L	<0.004	0.44	0.004	1.6	0.004	0.11	0.004	5126214
Total Molybdenum (Mo)	mg/L	0.0012	0.0012	0.0002	0.0009	0.0002	0.0011	0.0002	5127572
Total Nickel (Ni)	mg/L	0.0022	0.012	0.0005	0.014	0.0005	0.0029	0.0005	5127572
Total Phosphorus (P)	mg/L	<0.1	0.3	0.1	0.4	0.1	<0.1	0.1	5126214
Total Potassium (K)	mg/L	5.0	5.4	0.3	6.4	0.3	4.9	0.3	5126214
Total Selenium (Se)	mg/L	<0.0002	0.0003	0.0002	0.0003	0.0002	<0.0002	0.0002	5127572
Total Silicon (Si)	mg/L	9.3	11	0.1	17	0.1	8.3	0.1	5126214
Total Silver (Ag)	mg/L	<0.0001	<0.0001	0.0001	<0.0001	0.0001	<0.0001	0.0001	5127572
Total Sodium (Na)	mg/L	330	340	0.5	240	0.5	320	0.5	5126214
Total Strontium (Sr)	mg/L	0.50	0.76	0.02	0.82	0.02	0.71	0.02	5126214
Total Sulphur (S)	mg/L	120	120	0.2	75	0.2	120	0.2	5126214
Total Thallium (Tl)	mg/L	<0.0002	<0.0002	0.0002	<0.0002	0.0002	<0.0002	0.0002	5127572
Total Tin (Sn)	mg/L	<0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	5127572
Total Titanium (Ti)	mg/L	0.005	0.047	0.001	0.079	0.001	0.005	0.001	5127572
Total Uranium (U)	mg/L	0.0061	0.0068	0.0001	0.0031	0.0001	0.0061	0.0001	5127572
Total Vanadium (V)	mg/L	0.002	0.008	0.001	0.010	0.001	0.002	0.001	5127572
Total Zinc (Zn)	mg/L	<0.003	0.022	0.003	0.034	0.003	<0.003	0.003	5127572

RDL = Reportable Detection Limit
(1) - Detection limits raised due to dilution to bring analyte within the calibrated range.

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Sampler Initials: JD

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		BH9413	BH9414	BH9415	BH9416		
Sampling Date		2011/08/19	2011/08/19	2011/08/19	2011/08/19		
	Units	**MW99-03**	**MW05-1**	**DRUM-SW-BK1**	**DRUM-SW1**	**RDL**	**QC Batch**
Anions							
Dissolved Fluoride (F)	mg/L	0.11	0.20	0.27	0.29	0.05	5114829
Physical Properties							
Turbidity	NTU	>1000(1)	180	150	110	0.1	5116980

RDL = Reportable Detection Limit
(1) - Sample contains sediment

Maxxam ID		BH9417	BH9418	BH9419	BH9420		BH9421		
Sampling Date		2011/08/19	2011/08/19	2011/08/19	2011/08/19		2011/08/19		
	Units	**DRUM-SW2**	**DRUM-SW3**	**DRUM-SW4**	**DRUM-SEEP1A**	**QC Batch**	**DRUM-SEEP1B**	**RDL**	**QC Batch**
Anions									
Dissolved Fluoride (F)	mg/L	0.33	0.18	0.18	0.22	5114829	0.15	0.05	5122032
Physical Properties									
Turbidity	NTU	130	8.9	310	600	5116980	28	0.1	5116980

RDL = Reportable Detection Limit

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VOLATILE ORGANICS BY GC-MS (WATER)

Maxxam ID		BH9413	BH9414	BH9599		
Sampling Date		2011/08/19	2011/08/19	2011/08/17		
	Units	**MW99-03**	**MW05-1**	**TRIP BLANK**	**RDL**	**QC Batch**
Volatiles						
Total Trihalomethanes	ug/L	<2	<2	<2	2	5112655
Benzene	ug/L	<0.4	<0.4	<0.4	0.4	5114821
Bromodichloromethane	ug/L	<0.5	<0.5	<0.5	0.5	5114821
Bromoform	ug/L	<0.5	<0.5	<0.5	0.5	5114821
Bromomethane	ug/L	<2	<2	<2	2	5114821
Carbon tetrachloride	ug/L	<0.5	<0.5	<0.5	0.5	5114821
Chlorobenzene	ug/L	<0.5	<0.5	<0.5	0.5	5114821
Chlorodibromomethane	ug/L	<1	<1	<1	1	5114821
Chloroethane	ug/L	<1	<1	<1	1	5114821
Chloroform	ug/L	<0.5	<0.5	<0.5	0.5	5114821
Chloromethane	ug/L	5	<2	<2	2	5114821
1,2-dibromoethane	ug/L	<0.5	<0.5	<0.5	0.5	5114821
1,2-dichlorobenzene	ug/L	<0.5	<0.5	<0.5	0.5	5114821
1,3-dichlorobenzene	ug/L	<0.5	<0.5	<0.5	0.5	5114821
1,4-dichlorobenzene	ug/L	<0.5	<0.5	<0.5	0.5	5114821
1,1-dichloroethane	ug/L	<0.5	<0.5	<0.5	0.5	5114821
1,2-dichloroethane	ug/L	<0.5	<0.5	<0.5	0.5	5114821
1,1-dichloroethene	ug/L	<0.5	<0.5	<0.5	0.5	5114821
cis-1,2-dichloroethene	ug/L	<0.5	<0.5	<0.5	0.5	5114821
trans-1,2-dichloroethene	ug/L	<0.5	<0.5	<0.5	0.5	5114821
Dichloromethane	ug/L	<2	<2	<2	2	5114821
1,2-dichloropropane	ug/L	<0.5	<0.5	<0.5	0.5	5114821
cis-1,3-dichloropropene	ug/L	<0.5	<0.5	<0.5	0.5	5114821
trans-1,3-dichloropropene	ug/L	<0.5	<0.5	<0.5	0.5	5114821
Ethylbenzene	ug/L	<0.4	<0.4	<0.4	0.4	5114821
Methyl methacrylate	ug/L	<0.5	<0.5	<0.5	0.5	5114821
Methyl-tert-butylether (MTBE)	ug/L	<0.5	<0.5	<0.5	0.5	5114821
Styrene	ug/L	<0.5	<0.5	<0.5	0.5	5114821
1,1,1,2-tetrachloroethane	ug/L	<2	<2	<2	2	5114821
1,1,2,2-tetrachloroethane	ug/L	<2	<2	<2	2	5114821
Tetrachloroethene	ug/L	<0.5	<0.5	<0.5	0.5	5114821
Toluene	ug/L	<0.4	<0.4	<0.4	0.4	5114821
1,2,3-trichlorobenzene	ug/L	<1	<1	<1	1	5114821
1,2,4-trichlorobenzene	ug/L	<1	<1	<1	1	5114821
1,3,5-trichlorobenzene	ug/L	<0.5	<0.5	<0.5	0.5	5114821
1,1,1-trichloroethane	ug/L	<0.5	<0.5	<0.5	0.5	5114821
RDL = Reportable Detection Limit						

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VOLATILE ORGANICS BY GC-MS (WATER)

Maxxam ID		BH9413	BH9414	BH9599		
Sampling Date		2011/08/19	2011/08/19	2011/08/17		
	Units	**MW99-03**	**MW05-1**	**TRIP BLANK**	**RDL**	**QC Batch**
1,1,2-trichloroethane	ug/L	<0.5	<0.5	<0.5	0.5	5114821
Trichloroethene	ug/L	<0.5	<0.5	<0.5	0.5	5114821
Trichlorofluoromethane	ug/L	<0.5	<0.5	<0.5	0.5	5114821
1,2,4-trimethylbenzene	ug/L	<0.5	<0.5	<0.5	0.5	5114821
1,3,5-trimethylbenzene	ug/L	<0.5	<0.5	<0.5	0.5	5114821
Vinyl chloride	ug/L	<0.5	<0.5	<0.5	0.5	5114821
Xylenes (Total)	ug/L	<0.8	<0.8	<0.8	0.8	5114821
m & p-Xylene	ug/L	<0.8	<0.8	<0.8	0.8	5114821
o-Xylene	ug/L	<0.4	<0.4	<0.4	0.4	5114821
Surrogate Recovery (%)						
4-BROMOFLUOROBENZENE (sur.)	%	82	79	78	N/A	5114821
D4-1,2-DICHLOROETHANE (sur.)	%	124	111	112	N/A	5114821
D8-TOLUENE (sur.)	%	98	97	96	N/A	5114821

N/A = Not Applicable
RDL = Reportable Detection Limit

Package 1	6.9°C
Package 2	5.3°C

Each temperature is the average of up to three cooler temperatures taken at receipt

General Comments

Sample BH9415-01: Cation anion balance investigated, data quality confirmed.

Sample BH9418-01: Cation anion balance investigated, data quality confirmed.

ROUTINE WATER & DISS. REGULATED METALS (WATER) Comments

Sample BH9413-01 Elements by ICPMS - Dissolved: Due to the sample matrix, sample required dilution. Detection limit was adjusted accordingly

VOLATILE ORGANICS BY GC-MS (WATER) Comments

Sample BH9413-02 VOCs in Water by P&T GC/MS (Std List): Sample was run by GC/MS/Headspace as per CAL SOP-00227.

Sample BH9414-02 VOCs in Water by P&T GC/MS (Std List): Sample was run by GC/MS/Headspace as per CAL SOP-00227.

Sample BH9599-01 VOCs in Water by P&T GC/MS (Std List): Sample was run by GC/MS/Headspace as per CAL SOP-00227.

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FRANZ ENVIRONMENTAL INC.
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QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
5114191	Dissolved Chloride (Cl)	2011/08/23	NC	80 - 120	103	92 - 113	<1	mg/L	0.01	20
5114193	Dissolved Sulphate (SO4)	2011/08/23	NC	80 - 120	106	91 - 116	<1	mg/L	0.1	20
5114821	4-BROMOFLUOROBENZENE (sur.)	2011/08/23	107	70 - 130	101	70 - 130	82	%		
5114821	D4-1,2-DICHLOROETHANE (sur.)	2011/08/23	109	70 - 130	108	70 - 130	99	%		
5114821	D8-TOLUENE (sur.)	2011/08/23	98	70 - 130	103	70 - 130	99	%		
5114821	Benzene	2011/08/23	109	70 - 130	124	70 - 130	<0.4	ug/L		
5114821	Bromodichloromethane	2011/08/23	111	70 - 130	109	70 - 130	<0.5	ug/L		
5114821	Bromoform	2011/08/23	101	70 - 130	113	70 - 130	<0.5	ug/L		
5114821	Bromomethane	2011/08/23	116	70 - 130	123	70 - 130	<2	ug/L		
5114821	Carbon tetrachloride	2011/08/23	96	70 - 130	102	70 - 130	<0.5	ug/L		
5114821	Chlorobenzene	2011/08/23	81	70 - 130	93	70 - 130	<0.5	ug/L		
5114821	Chlorodibromomethane	2011/08/23	114	70 - 130	128	70 - 130	<1	ug/L		
5114821	Chloroethane	2011/08/23	112	70 - 130	122	70 - 130	<1	ug/L		
5114821	Chloroform	2011/08/23	112	70 - 130	123	70 - 130	<0.5	ug/L		
5114821	Chloromethane	2011/08/23	75	70 - 130	82	70 - 130	<2	ug/L		
5114821	1,2-dibromoethane	2011/08/23	107	70 - 130	123	70 - 130	<0.5	ug/L	NC	40
5114821	1,2-dichlorobenzene	2011/08/23	91	70 - 130	108	70 - 130	<0.5	ug/L		
5114821	1,3-dichlorobenzene	2011/08/23	94	70 - 130	112	70 - 130	<0.5	ug/L		
5114821	1,4-dichlorobenzene	2011/08/23	94	70 - 130	106	70 - 130	<0.5	ug/L		
5114821	1,1-dichloroethane	2011/08/23	117	70 - 130	129	70 - 130	<0.5	ug/L		
5114821	1,2-dichloroethane	2011/08/23	107	70 - 130	121	70 - 130	<0.5	ug/L	NC	40
5114821	1,1-dichloroethene	2011/08/23	116	70 - 130	95	70 - 130	<0.5	ug/L		
5114821	cis-1,2-dichloroethene	2011/08/23	107	70 - 130	123	70 - 130	<0.5	ug/L		
5114821	trans-1,2-dichloroethene	2011/08/23	114	70 - 130	118	70 - 130	<0.5	ug/L		
5114821	Dichloromethane	2011/08/23	114	70 - 130	124	70 - 130	<2	ug/L		
5114821	1,2-dichloropropane	2011/08/23	115	70 - 130	116	70 - 130	<0.5	ug/L		
5114821	cis-1,3-dichloropropene	2011/08/23	107	70 - 130	111	70 - 130	<0.5	ug/L		
5114821	trans-1,3-dichloropropene	2011/08/23	99	70 - 130	106	70 - 130	<0.5	ug/L		
5114821	Ethylbenzene	2011/08/23	81	70 - 130	100	70 - 130	<0.4	ug/L		
5114821	Methyl methacrylate	2011/08/23	80	70 - 130	107	70 - 130	<0.5	ug/L		
5114821	Methyl-tert-butylether(MTBE)	2011/08/23	113	70 - 130	95	70 - 130	<0.5	ug/L		
5114821	Styrene	2011/08/23	89	70 - 130	110	70 - 130	<0.5	ug/L		
5114821	1,1,1,2-tetrachloroethane	2011/08/23	97	70 - 130	111	70 - 130	<2	ug/L		
5114821	1,1,2,2-tetrachloroethane	2011/08/23	110	70 - 130	124	70 - 130	<2	ug/L		
5114821	Tetrachloroethene	2011/08/23	102	70 - 130	103	70 - 130	<0.5	ug/L		
5114821	Toluene	2011/08/23	93	70 - 130	112	70 - 130	<0.4	ug/L		
5114821	1,1,1-trichloroethane	2011/08/23	108	70 - 130	117	70 - 130	<0.5	ug/L		
5114821	1,1,2-trichloroethane	2011/08/23	112	70 - 130	122	70 - 130	<0.5	ug/L		
5114821	Trichloroethene	2011/08/23	108	70 - 130	125	70 - 130	<0.5	ug/L		
5114821	Trichlorofluoromethane	2011/08/23	112	70 - 130	124	70 - 130	<0.5	ug/L		

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Sampler Initials: JD

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
5114821	1,2,4-trimethylbenzene	2011/08/23	83	70 - 130	107	70 - 130	<0.5	ug/L		
5114821	1,3,5-trimethylbenzene	2011/08/23	78	70 - 130	110	70 - 130	<0.5	ug/L		
5114821	Vinyl chloride	2011/08/23	120	70 - 130	129	70 - 130	<0.5	ug/L		
5114821	m & p-Xylene	2011/08/23	82	70 - 130	106	70 - 130	<0.8	ug/L		
5114821	o-Xylene	2011/08/23	92	70 - 130	116	70 - 130	<0.4	ug/L		
5114821	1,2,3-trichlorobenzene	2011/08/23			81	70 - 130	<1	ug/L		
5114821	1,2,4-trichlorobenzene	2011/08/23			80	70 - 130	<1	ug/L		
5114821	1,3,5-trichlorobenzene	2011/08/23			80	70 - 130	<0.5	ug/L		
5114821	Xylenes (Total)	2011/08/23					<0.8	ug/L		
5114829	Dissolved Fluoride (F)	2011/08/23	98	80 - 120	103	86 - 117	<0.05	mg/L	NC	20
5115808	Dissolved Nitrite (N)	2011/08/24	94	80 - 120	98	80 - 120	<0.003	mg/L	NC	20
5115808	Dissolved Nitrate (N)	2011/08/24	99	80 - 120	99	80 - 120	<0.003	mg/L	2.1	20
5116980	Turbidity	2011/08/24			96	93 - 99	<0.1	NTU	NC	20
5118842	Alkalinity (Total as CaCO3)	2011/08/24			98	80 - 120	0.6, RDL=0.5	mg/L	1	20
5118842	Alkalinity (PP as CaCO3)	2011/08/24					<0.5	mg/L	NC	20
5118842	Bicarbonate (HCO3)	2011/08/24					0.7, RDL=0.5	mg/L	1	20
5118842	Carbonate (CO3)	2011/08/24					<0.5	mg/L	NC	20
5118842	Hydroxide (OH)	2011/08/24					<0.5	mg/L	NC	20
5118975	Conductivity	2011/08/24			101	92 - 106	1, RDL=1	uS/cm	0.8	20
5118976	pH	2011/08/24			100	97 - 102			0.8	5
5122032	Dissolved Fluoride (F)	2011/08/25	105	80 - 120	101	86 - 117	<0.05	mg/L	NC	20
5126214	Total Barium (Ba)	2011/08/26	84	80 - 120	91	80 - 120	<0.01	mg/L	NC	20
5126214	Total Boron (B)	2011/08/26	95	80 - 120	103	80 - 120	<0.02	mg/L	5.9	20
5126214	Total Calcium (Ca)	2011/08/26	NC	80 - 120	102	80 - 120	<0.3	mg/L	2.6	20
5126214	Total Iron (Fe)	2011/08/26	105	80 - 120	104	80 - 120	<0.06	mg/L	4.0	20
5126214	Total Lithium (Li)	2011/08/26	86	80 - 120	93	80 - 120	<0.02	mg/L	6.0	20
5126214	Total Magnesium (Mg)	2011/08/26	NC	80 - 120	98	80 - 120	<0.2	mg/L	4.8	20
5126214	Total Manganese (Mn)	2011/08/26	92	80 - 120	98	89 - 110	<0.004	mg/L	NC	20
5126214	Total Phosphorus (P)	2011/08/26	92	80 - 120	98	80 - 120	<0.1	mg/L	NC	20
5126214	Total Potassium (K)	2011/08/26	91	80 - 120	96	80 - 120	<0.3	mg/L	5.9	20
5126214	Total Silicon (Si)	2011/08/26	NC	80 - 120	107	80 - 120	<0.1	mg/L	3.0	20
5126214	Total Sodium (Na)	2011/08/26	NC	80 - 120	94	85 - 119	<0.5	mg/L	5.9	20
5126214	Total Strontium (Sr)	2011/08/26	87	80 - 120	96	80 - 120	<0.02	mg/L	5.4	20
5126214	Total Sulphur (S)	2011/08/26					<0.2	mg/L	4.0	20
5126238	Dissolved Barium (Ba)	2011/08/26	105	80 - 120	98	85 - 104	<0.01	mg/L	NC	20
5126238	Dissolved Boron (B)	2011/08/26	108	80 - 120	101	75 - 125	<0.02	mg/L	0.9	20
5126238	Dissolved Calcium (Ca)	2011/08/26	108	80 - 120	103	80 - 120	<0.3	mg/L	0.2	20
5126238	Dissolved Iron (Fe)	2011/08/26	116	80 - 120	107	80 - 120	<0.06	mg/L	NC	20
5126238	Dissolved Lithium (Li)	2011/08/26	107	80 - 120	100	80 - 116	<0.02	mg/L	1.0	20
5126238	Dissolved Magnesium (Mg)	2011/08/26	108	80 - 120	104	91 - 113	<0.2	mg/L	0.5	20

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QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
5126238	Dissolved Manganese (Mn)	2011/08/26	105	80 - 120	99	89 - 111	<0.004	mg/L	0.4	20
5126238	Dissolved Phosphorus (P)	2011/08/26	114	80 - 120	101	89 - 109	<0.1	mg/L	NC	20
5126238	Dissolved Potassium (K)	2011/08/26	110	80 - 120	101	80 - 120	<0.3	mg/L	0.01	20
5126238	Dissolved Silicon (Si)	2011/08/26	97	80 - 120	93	80 - 120	<0.1	mg/L	0.3	20
5126238	Dissolved Sodium (Na)	2011/08/26	NC	80 - 120	99	84 - 110	<0.5	mg/L	0.2	20
5126238	Dissolved Strontium (Sr)	2011/08/26	105	80 - 120	99	85 - 106	<0.02	mg/L	0.3	20
5126238	Dissolved Sulphur (S)	2011/08/26					<0.2	mg/L	0.9	20
5127572	Total Aluminum (Al)	2011/08/27	NC	80 - 120	105	80 - 120	<0.001	mg/L	1.3	20
5127572	Total Antimony (Sb)	2011/08/27	109	80 - 120	107	80 - 120	<0.0006	mg/L	NC	20
5127572	Total Arsenic (As)	2011/08/27	89	80 - 120	90	80 - 120	<0.0002	mg/L	0.7	20
5127572	Total Beryllium (Be)	2011/08/27	100	80 - 120	99	80 - 120	<0.001	mg/L	NC	20
5127572	Total Chromium (Cr)	2011/08/27	95	80 - 120	97	80 - 120	<0.001	mg/L	NC	20
5127572	Total Cobalt (Co)	2011/08/27	96	80 - 120	99	80 - 120	<0.0003	mg/L	NC	20
5127572	Total Copper (Cu)	2011/08/27	92	80 - 120	98	80 - 120	<0.0002	mg/L	2.0	20
5127572	Total Lead (Pb)	2011/08/27	93	80 - 120	100	80 - 120	<0.0002	mg/L	NC	20
5127572	Total Molybdenum (Mo)	2011/08/27	108	80 - 120	102	80 - 120	<0.0002	mg/L	1.2	20
5127572	Total Nickel (Ni)	2011/08/27	95	80 - 120	101	80 - 120	<0.0005	mg/L	NC	20
5127572	Total Selenium (Se)	2011/08/27	85	80 - 120	87	80 - 120	<0.0002	mg/L	NC	20
5127572	Total Silver (Ag)	2011/08/27	93	80 - 120	99	80 - 120	<0.0001	mg/L	NC	20
5127572	Total Thallium (Tl)	2011/08/27	89	80 - 120	95	80 - 120	<0.0002	mg/L	NC	20
5127572	Total Tin (Sn)	2011/08/27	101	80 - 120	99	80 - 120	<0.001	mg/L	NC	20
5127572	Total Titanium (Ti)	2011/08/27	100	80 - 120	99	80 - 120	<0.001	mg/L	NC	20
5127572	Total Uranium (U)	2011/08/27	86	80 - 120	88	80 - 120	<0.0001	mg/L	0.1	20
5127572	Total Vanadium (V)	2011/08/27	102	80 - 120	100	80 - 120	<0.001	mg/L	NC	20
5127572	Total Zinc (Zn)	2011/08/27	86	80 - 120	93	80 - 120	<0.003	mg/L	NC	20
5127620	Dissolved Aluminum (Al)	2011/08/26	NC	80 - 120	89	80 - 120	<0.001	mg/L	2.1	20
5127620	Dissolved Antimony (Sb)	2011/08/26	110	80 - 120	97	80 - 120	<0.0006	mg/L	NC	20
5127620	Dissolved Arsenic (As)	2011/08/26	94	80 - 120	93	80 - 120	<0.0002	mg/L	NC	20
5127620	Dissolved Beryllium (Be)	2011/08/26	86	80 - 120	91	80 - 120	<0.001	mg/L	NC	20
5127620	Dissolved Chromium (Cr)	2011/08/26	85	80 - 120	95	80 - 120	<0.001	mg/L	NC	20
5127620	Dissolved Cobalt (Co)	2011/08/26	93	80 - 120	96	80 - 120	<0.0003	mg/L	NC	20
5127620	Dissolved Copper (Cu)	2011/08/26	92	80 - 120	97	80 - 120	<0.0002	mg/L	NC	20
5127620	Dissolved Lead (Pb)	2011/08/26	91	80 - 120	96	80 - 120	<0.0002	mg/L	NC	20
5127620	Dissolved Molybdenum (Mo)	2011/08/26	NC	80 - 120	98	80 - 120	<0.0002	mg/L	0.6	20
5127620	Dissolved Nickel (Ni)	2011/08/26	NC	80 - 120	97	80 - 120	<0.0005	mg/L	1.6	20
5127620	Dissolved Silver (Ag)	2011/08/26	95	80 - 120	98	80 - 120	<0.0001	mg/L	NC	20
5127620	Dissolved Thallium (Tl)	2011/08/26	94	80 - 120	96	80 - 120	<0.0002	mg/L	NC	20
5127620	Dissolved Tin (Sn)	2011/08/26	95	80 - 120	97	80 - 120	<0.001	mg/L	NC	20
5127620	Dissolved Titanium (Ti)	2011/08/26	NC	80 - 120	94	80 - 120	<0.001	mg/L	NC	20
5127620	Dissolved Uranium (U)	2011/08/26	89	80 - 120	98	80 - 120	<0.0001	mg/L	4.5	20

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Maxxam Job #: B177703
Report Date: 2011/08/29

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1101
Site Location: DRUMHELLER, AB
Sampler Initials: JD

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
5127620	Dissolved Vanadium (V)	2011/08/26	91	80 - 120	98	80 - 120	<0.001	mg/L	NC	20
5127620	Dissolved Zinc (Zn)	2011/08/26	93	80 - 120	96	80 - 120	<0.003	mg/L	NC	20
5127620	Dissolved Selenium (Se)	2011/08/26			95	80 - 120	<0.0002	mg/L	2.1	20

N/A = Not Applicable
RDL = Reportable Detection Limit
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

Validation Signature Page

Maxxam Job #: B177703

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Ghayasuddin Khan, M.Sc., B.Ed., P.Chem, Senior Analyst, Water Lab

Janet Gao, Senior Analyst, Organics Department

==========

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Maxxam

Calgary: 4000 19st St. NE, T2E 6P8. Ph: (403) 291-3077, Fax: (403) 735-2240, Toll free: (800) 386-7247
Edmonton: 9331 - 46 Street, T6B 2R4. Ph: (780) 577-7100, Fax: (780) 450-4187, Toll free: (877) 465-8889
www.maxxamanalytics.com

Chain of Custody

A033994

Page: 1 of 1

	Invoice To: C/O Report Address ☐	Report To: Same as Invoice ☒	Report Distribution (E-Mail):
Company:	Franz Environmental		jdittburner@franzenvironmental.com mgrinnell@ " "
Contact:	Julie Dittburner		
Address:	329 Churchill Ave N, Ottawa		
	Prov: ON PC: K1Z 5B8	Prov: PC:	
Contact #s:	Ph: 613-721-0555 Cell: 613-794-7449	Ph: Cell:	

REGULATORY GUIDELINES:
- ☐ AT1
- ☒ CCME
- ☐ Regulated Drinking Water
- ☐ Other:

All samples are held for 60 calendar days after sample receipt, unless specified otherwise.

PO #:
Project # / Name: 2020-1101
Site Location: Drumheller, AB
Quote #:
Sampled By: J. Dittburner

SERVICE REQUESTED: ☐ RUSH (Contact lab to reserve) Date Required: ☒ REGULAR (5 to 7 Days)

See reverse for package specifics

	Sample ID	Depth (unit)	Matrix GW / SW Soil	Date/Time Sampled YY/MM/DD 24:00	SOIL: BTEX F1-F4	Sieve (75 micron)	Regulated Metals (CCME / AT1)	Salinity 4	Assessment ICP Metals	Basic Class II Landfill	WATER: ☐BTEX F1 ☒VOCs	☐BTEX F1-F2 ☐BTEX F1-F4	☒Routine Water ☒Turb ☒F	☐TOC ☐DOC	Regulated Metals (CCME / AT1): Total	Dissolved	Mercury	☐Total ☐Dissolved	Other Analysis: general chemistry	HOLD - Do not Analyze	# of Containers Submitted
1	MW99-03		GW	11/08/19							X		X			X			X		6
2	MW05-1		↓								X		X			X			X		6
3	DRUM-SW-BK1		SW										X		X				X		3
4	DRUM-SW1												X		X				X		3
5	DRUM-SW2												X		X				X		3
6	DRUM-SW3												X		X				X		3
7	DRUM-SW4												X		X				X		3
8	DRUM-Seep1A												X		X				X		3
9	DRUM-Seep1B												X		X				X		3
10																					
11																					
12																					

Please indicate Filtered, Preserved or Both (F, P, F/P) → F/P

Relinquished By (Signature/Print):	Date (YY/MM/DD):	Time (24:00):
J. Dittburner / J. Dittburner	11/08/19	20:10
Relinquished By (Signature/Print):	Date (YY/MM/DD):	Time (24:00):

Special Instructions:

# of Jars Used & Not Submitted

LAB USE ONLY

RECEIVED AUG 20 2019

Received By:	Date:	Time:	Maxxam Job #: B177703
DK		10:55	

Lab Comments:	Custody Seal	Temperature	Ice
	✓	6.8/6.8/7.1 7.0/5.5/3.4	Y

Maxxam

Success Through Science®

Your Project #: 2026-1101
Site Location: DRUMHELLER, AB
Your C.O.C. #: A033993

Attention: JULIE DITTBURNER
FRANZ ENVIRONMENTAL INC.
329 CHURCHILL AVE NORTH
SUITE 2000
OTTAWA, ON
CANADA K1Z5B8

Report Date: 2011/08/27

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B177711
Received: 2011/08/20, 10:55

Sample Matrix: Soil
Samples Received: 5

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Boron (Hot Water Soluble)	5	2011/08/26	2011/08/27	AB SOP-00042	EPA 200.7
Hexavalent Chromium	5	2011/08/22	2011/08/23	CAL SOP-00056	SM 3500-Cr B
Elements by ICPMS - Soils	5	2011/08/25	2011/08/26	AB SOP-00043	EPA 200.8
Moisture	5	N/A	2011/08/22	CAL SOP-00023	McKeague MSSMA 2.411

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Parminder Virk, Project Manager
Email: PVirk@maxxam.ca
Phone# (403) 291-3077

==========
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Total cover pages: 1

Maxxam

Success Through Science®

Maxxam Job #: B177711
Report Date: 2011/08/27

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1101
Site Location: DRUMHELLER, AB
Sampler Initials: JD

REGULATED METALS (CCME/AT1) - SOILS

Maxxam ID		BH9481		BH9483	BH9484	BH9485	BH9486		
Sampling Date		2011/08/19		2011/08/19	2011/08/19	2011/08/19	2011/08/19		
	Units	**DRUM-SED-BK1**	**RDL**	**DRUM-SED2**	**DRUM-SED3**	**DRUM-SED4**	**DRUM-SED SEEP 1A**	**RDL**	**QC Batch**
Elements									
Soluble (Hot water) Boron (B)	mg/kg	0.4	0.1	0.3	0.6	0.6	0.9	0.1	5129553
Hex. Chromium (Cr 6+)	mg/kg	2.7(1)	1.5	<0.15	<0.15	<0.15	<0.15	0.15	5114625
Total Antimony (Sb)	mg/kg	<1	1	<1	<1	<1	<1	1	5128183
Total Arsenic (As)	mg/kg	4	1	7	7	5	6	1	5128183
Total Barium (Ba)	mg/kg	200	10	240	300	240	240	10	5128183
Total Beryllium (Be)	mg/kg	0.5	0.4	<0.4	0.4	0.4	<0.4	0.4	5128183
Total Cadmium (Cd)	mg/kg	0.5	0.1	0.2	0.4	0.2	0.3	0.1	5128183
Total Chromium (Cr)	mg/kg	15	1	9	9	15	12	1	5128183
Total Cobalt (Co)	mg/kg	7	1	10	9	6	6	1	5128183
Total Copper (Cu)	mg/kg	32	5	15	20	13	12	5	5128183
Total Lead (Pb)	mg/kg	12	1	8	10	7	8	1	5128183
Total Mercury (Hg)	mg/kg	0.06	0.05	<0.05	0.05	<0.05	0.07	0.05	5128183
Total Molybdenum (Mo)	mg/kg	0.5	0.4	0.8	0.8	0.6	<0.4	0.4	5128183
Total Nickel (Ni)	mg/kg	25	1	23	22	22	16	1	5128183
Total Selenium (Se)	mg/kg	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	0.5	5128183
Total Silver (Ag)	mg/kg	<1	1	<1	<1	<1	<1	1	5128183
Total Thallium (Tl)	mg/kg	<0.3	0.3	<0.3	<0.3	<0.3	<0.3	0.3	5128183
Total Tin (Sn)	mg/kg	<1	1	<1	<1	<1	<1	1	5128183
Total Uranium (U)	mg/kg	2	1	1	2	1	<1	1	5128183
Total Vanadium (V)	mg/kg	22	1	16	16	16	17	1	5128183
Total Zinc (Zn)	mg/kg	62	10	52	49	44	46	10	5128183

RDL = Reportable Detection Limit
(1) - Detection limits raised due to matrix interference.

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Maxxam Job #: B177711
Report Date: 2011/08/27

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1101
Site Location: DRUMHELLER, AB
Sampler Initials: JD

RESULTS OF CHEMICAL ANALYSES OF SOIL

Maxxam ID		BH9481	BH9483	BH9484	BH9485	BH9486		
Sampling Date		2011/08/19	2011/08/19	2011/08/19	2011/08/19	2011/08/19		
	Units	**DRUM-SED-BK1**	**DRUM-SED2**	**DRUM-SED3**	**DRUM-SED4**	**DRUM-SED SEEP 1A**	**RDL**	**QC Batch**
Physical Properties								
Moisture	%	46	30	35	27	23	0.3	5113852
RDL = Reportable Detection Limit								

Maxxam Job #: B177711
Report Date: 2011/08/27

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1101
Site Location: DRUMHELLER, AB
Sampler Initials: JD

Package 1	6.9°C
Package 2	5.3°C

Each temperature is the average of up to three cooler temperatures taken at receipt

General Comments

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Maxxam Job #: B177711
Report Date: 2011/08/27

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1101
Site Location: DRUMHELLER, AB
Sampler Initials: JD

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
5113852	Moisture	2011/08/22							1.7	20		
5114625	Hex. Chromium (Cr 6+)	2011/08/23	89	75 - 125	96	90 - 110	<0.15	mg/kg	NC	35		
5128183	Total Antimony (Sb)	2011/08/26	101	75 - 125	111	75 - 125	<1	mg/kg	NC	35		
5128183	Total Arsenic (As)	2011/08/26	89	75 - 125	91	75 - 125	<1	mg/kg	4.8	35	104	50 - 150
5128183	Total Barium (Ba)	2011/08/26	NC	75 - 125	91	75 - 125	<10	mg/kg	6.6	35	107	69 - 131
5128183	Total Beryllium (Be)	2011/08/26	94	75 - 125	99	75 - 125	<0.4	mg/kg	NC	35		
5128183	Total Cadmium (Cd)	2011/08/26	93	75 - 125	94	75 - 125	<0.1	mg/kg	NC	35		
5128183	Total Chromium (Cr)	2011/08/26	92	75 - 125	95	75 - 125	<1	mg/kg	8.2	35	101	41 - 159
5128183	Total Cobalt (Co)	2011/08/26	92	75 - 125	96	75 - 125	<1	mg/kg	4.0	35	99	75 - 125
5128183	Total Copper (Cu)	2011/08/26	84	75 - 125	94	75 - 125	<5	mg/kg	NC	35	92	72 - 127
5128183	Total Lead (Pb)	2011/08/26	92	75 - 125	100	75 - 125	<1	mg/kg	7.4	35	97	54 - 146
5128183	Total Mercury (Hg)	2011/08/26	89	75 - 125	100	75 - 125	0.08, RDL=0.05	mg/kg	NC	35		
5128183	Total Molybdenum (Mo)	2011/08/26	101	75 - 125	96	75 - 125	<0.4	mg/kg	NC	35		
5128183	Total Nickel (Ni)	2011/08/26	88	75 - 125	95	75 - 125	<1	mg/kg	5.2	35	102	61 - 139
5128183	Total Selenium (Se)	2011/08/26	88	75 - 125	93	75 - 125	<0.5	mg/kg	NC	35		
5128183	Total Silver (Ag)	2011/08/26	93	75 - 125	96	75 - 125	<1	mg/kg	NC	35		
5128183	Total Thallium (Tl)	2011/08/26	88	75 - 125	95	75 - 125	<0.3	mg/kg	NC	35		
5128183	Total Tin (Sn)	2011/08/26	99	75 - 125	95	75 - 125	<1	mg/kg	NC	35		
5128183	Total Uranium (U)	2011/08/26	91	75 - 125	96	75 - 125	<1	mg/kg	NC	35		
5128183	Total Vanadium (V)	2011/08/26	96	75 - 125	97	75 - 125	<1	mg/kg	7.9	35	117	50 - 150
5128183	Total Zinc (Zn)	2011/08/26	NC	75 - 125	93	75 - 125	<10	mg/kg	NC	35	91	72 - 128
5129553	Soluble (Hot water) Boron (B)	2011/08/27	87	75 - 125	85	75 - 125	<0.1	mg/kg	NC	35		

N/A = Not Applicable
RDL = Reportable Detection Limit
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

Validation Signature Page

Maxxam Job #: B177711

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

_____
Ghayasuddin Khan, M.Sc., B.Ed., P.Chem, Senior Analyst, Water Lab

_____
Janet Gao, Senior Analyst, Organics Department

==========

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www.maxxamanalytics.com

Chain of Custody

A033993

Page: 1 of 1

	Invoice To: C/O Report Address ☐
Company:	Franz Environmental
Contact:	Julie Dittburner
Address:	329 Churchill Ave N, Ottawa
	Prov: ON PC: K1Z 5B8
Contact #s:	Ph: 613-721-0555 Cell: 613-714-7447

Report To: Same as Invoice ☒
Prov: PC:
Ph: Cell:

Report Distribution (E-Mail):
jdittburner@franzenvironmental.com
mgrinnell@ " "

REGULATORY GUIDELINES:
☐ AT1
☒ CCME
☐ Regulated Drinking Water
☐ Other:

All samples are held for 60 calendar days after sample receipt, unless specified otherwise.

PO #:
Project # / Name: 2026-1101
Site Location: Drumheller, AB
Quote #:
Sampled By: J. Dittburner

SERVICE REQUESTED: ☐ RUSH (Contact lab to reserve) Date Required: ☒ REGULAR (5 to 7 Days)

See reverse for package specifics

	Sample ID	Depth (unit)	Matrix GW / SW Soil	Date/Time Sampled YY/MM/DD 24:00	SOIL: BTEX F1-F4	Sieve (75 micron)	Regulated Metals (CCME / AT1)	Salinity 4	Assessment ICP Metals	Basic Class II Landfill	general chemistry	WATER: ☐VOCs ☐BTEX F1	☐BTEX F1-F4 ☐BTEX F1-F2	☐ Routine Water ☐ Turb ☐ F	☐ TOC ☐ DOC	Total	Regulated Metals (CCME / AT1) Dissolved	Mercury	☐ Total ☐ Dissolved	Other Analysis	HOLD - Do not Analyze	# of Containers Submitted
1	DRUM-SED-BK1		Soil	11/08/19			X				X											2
2	DRUM-SED2						X				X											2
3	DRUM-SED3						X															1
4	DRUM-SED4						X				X											2
5	DRUM-SEDSeep1A						X															1
6																						
7																						
8																						
9																						
10																						
11																						
12																						

Please indicate Filtered, Preserved or Both (F, P, F/P) → F/P

Relinquished By (Signature/Print):	Date (YY/MM/DD):	Time (24:00):
J. Dittburner	11/08/19	20:00
Relinquished By (Signature/Print):	Date (YY/MM/DD):	Time (24:00):

Special Instructions:

# of Jars Used & Not Submitted

LAB USE ONLY

Received By: RECEIVED AUG 20 2011 Date: Time: Maxxam Job #: B177711

Lab Comments: 10:55

Custody Seal	Temperature	Ice
N	6.8/6.8/7.1 7.0/5.5/3.4	Y

AB FCD-00331 Rev3.2010/05

Maxxam Analytics International Corporation o/a Maxxam Analytics

APPENDIX H

Data Gap Analysis - Slope Remediation Works Drumheller Institution Landfill Site, Drumheller, Alberta, by Houle Chevrier Engineering Ltd., January 2012

Houle Chevrier Engineering Ltd.
180 Wescar Lane
R.R. 2
Carp, Ontario, K0A 1L0
Tel: (613) 836-1422
Fax: (613) 836-9731
www.hceng.ca

DATA GAP ANALYSIS

SLOPE REMEDIATION WORK
DRUMHELLER INSTITUTION
LANDFILL SITE
DRUMHELLER, ALBERTA

Submitted to:

Franz Environmental Inc.
329 Churchill Avenue North
Suite 200
Ottawa, Ontario
K1Z 5B8

DISTRIBUTION:

4 copies - Franz Environmental Inc.
2 copies - Houle Chevrier Engineering Ltd.

January 2012 10-611

Houle Chevrier Engineering Ltd.
180 Wescar Lane
R.R. 2
Carp, Ontario, K0A 1L0
Tel: (613) 836-1422
Fax: (613) 836-9731
www.hceng.ca

January 13, 2012 Our ref: 10-611

Franz Environmental Inc.
329 Churchill Avenue North
Suite 200
Ottawa, Ontario
K1Z 5B8

Attention: Mr. Mike Grinnell, P.Eng.

RE: DATA GAP ANALYSIS
SLOPE REMEDIATION WORK
DRUMHELLER INSTITUTION
LANDFILL SITE
DRUMHELLER, ALBERTA

Dear Sir:

This data gap analysis has been prepared for the proposed landfill remediation work at the Drumheller Institution in Drumheller, Alberta. The purpose of the analysis is to summarize the existing pertinent information for the proposed work which has been made available to Houle Chevrier Engineering Ltd.; to present possible construction options and construction approaches for consideration; and to provide an indication of what additional information is required to select a preferred construction option and to carry out a detailed design of that option for tendering.

It should be noted that this project involves both an environmental and geotechnical component for the proposed work. This data gap analysis has been prepared from a geotechnical perspective only. A Supplemental Environmental Site Investigation and Data Gap Analysis report is being prepared for the site by Franz Environmental Inc. Where construction options are provided, the environmental aspects of the options including (but not limited to) the chemical testing necessary to assess the suitability of the proposed works, are considered to be outside of our scope of work and should be considered by others.

PROJECT DESCRIPTION

Plans are being prepared to remediate the landfill site located within the grounds of the Drumheller Institution, a correctional facility operated by Correctional Services Canada in Drumheller, Alberta (see Key Plan, Figure 1).

The landfill site is located about 500 metres southeast of the Drumheller Institution on the table lands above an existing coulee. The landfill covers an area of about 150 by 200 metres in plan view and was in operation from the mid 1960's until the late 1980's. However, more recent filling may also have taken place.

The waste material placed in the landfill is understood to include a mixture of domestic waste and demolition material generated during various phases of construction work at the institute. It is understood that the landfill was formed by pushing waste material over the edge of the coulee. As such, the waste was not subject to compaction during placement. Native soils were excavated from nearby areas and used as cover material for the landfill waste. From the toe (base) of the landfill slope the ground surface is relatively flat / hummocky, with deep cuts at various locations. The width of the level portion at the base of the landfill is highly variable, being greatest at the south end of the landfill and narrowest near the north end. Near the north end of the landfill the ground is wet possibly due to the presence of springs or the confluence of existing drainage features. This portion of the slope is vegetated with dense shrubs and young trees.

Beyond the area along the toe of the landfill the ground surface drops off to the level of the base of the coulee which is estimated to be about 50 to 60 metres below the top of the landfill. The side slopes down to the base of the coulee are relatively steep and unvegetated which would indicate that these lower natural slopes are undergoing erosion and possible slope instability. An existing stream runs down the face of the lower slope from the wetland area to the base of the coulee at the north end of the landfill.

The site is accessed from Highway 9 via Institution Road Southeast, which is an asphaltic concrete surfaced roadway to the correctional facility. The landfill is located along a gravel surfaced access road which passes over an existing livestock grate. Within the site, a ramp had previously been constructed at the south end of the landfill to provide access to the base of the

landfill. However, it would appear that the ramp was constructed using earth fill and has eroded somewhat.

Consideration is now being given to remediating the landfill from both an environmental and geotechnical perspective by:

- Containing and controlling the movement of chemical parameters from the landfill waste; and
- Improving the stability of the landfill.

It is understood that to achieve the environmental objectives, an engineered wetland may be constructed at the toe (base) of the landfill, or the existing wetland could be preserved while an earthworks program is under consideration to improve the stability of the landfill.

EXISTING INFORMATION

It is understood that a number of reports have been prepared to date regarding the landfill. Houle Chevrier Engineering Ltd. is aware of the following reports which are listed in order of publication (oldest first):

- Phase II Environmental Site Assessment, Drumheller Institution, UMA Engineering Limited, dated March 2000 (UMA 2000);

- Supplemental Phase II Investigation, Site 530-L01, Landfill, Drumheller Institution, Prepared by Franz Environmental Inc., dated March 2006 (Franz 2006);

- Environmental Site Investigation and Slope Stability Study for the Drumheller Institution Site No. 530, Drumheller, Alberta, prepared by Franz Environmental Inc., dated March 2011 (Franz 2011).

In summary, the focus of the UMA 2000 and Franz 2006 reports is the environmental aspects of the landfill while the Franz 2011 report considers both the environmental and geotechnical stability of the landfill. Additional reports for the site may exist which Houle Chevrier

Engineering Ltd. are not aware of, or have not been made available to Houle Chevrier Engineering Ltd.

As part of the Franz 2011 report, a topographic survey of the existing slopes was carried out by Tagish Engineering Ltd. The survey was carried out to measure the slope profiles which was used for the purpose of assessing the stability of the existing landfill slopes and was generally limited to the extent of the landfill only.

POSSIBLE CONSTRUCTION OPTIONS FOR CONSIDERATION

Environmental Works

It is understood that consideration is being given to constructing an engineered wetland or to preserving the existing wetland located at the north end of the existing landfill in the vicinity of an existing drainage feature. The details of the proposed environmental works were not available to Houle Chevrier Engineering Ltd. (HCEL) and are not considered to be within HCEL's scope of work for this assignment, other than to assist in the development of a cohesive approach to the environmental and geotechnical elements of the works. It is not known by HCEL if further construction options to achieve the environmental objectives at the site are currently under consideration.

Slope Stabilization Works

A number of possible slope stabilization measures were proposed in the Franz 2011 report. Broadly speaking, these options consist of;

- Option 1: Importing material to the site in order to create a berm on the existing landfill slope face and along the toe of the landfill; or

- Option 2: Excavating a portion of the existing landfill material from the crest (top) of the slope and placing this material along the lower portions of the slope to flatten the overall slope gradient.

The objective in both cases is to improve the stability of the landfill by means of regrading the existing slope to a stable angle, which from a geotechnical perspective, is consistent with a 2.5

horizontal to 1.0 vertical slope (or flatter). Simplified schematic cross-sections showing the different construction options are shown on Figures 2 and 3 following the text of this data gap analysis.

Additional construction guidelines were also provided in the Franz 2011 report to improve the stability of the slope by controlling ground and surface water drainage. These measures could be implemented under either construction option.

As previously stated, the construction will be carried out over a two (2) year period, with the initial construction phase planned to take place during the summer months of 2012.

RECENTLY OBTAINED INFORMATION

The following information has been gathered during the preparation of this data gap analysis:

- The initial topographic survey has been amended to include additional information on the lands at the base of the landfill. The amended topographic survey plan is provided in Attachment A, following the text of this data gap analysis;

- The composition, and moisture density characteristics of the landfill material and native soils have been assessed. Gradation curves, Atterberg Limits and graphs of the variation of dry density with water content are provided in Attachment B, following the text of this data gap analysis. The native soils are noted to be predominantly silts and sands which would be prone to erosion by surface water runoff;

- Sixteen (16) additional test pits were advanced on the landfill by Franz Environmental Inc. to depths of between about 3 to 6 metres below ground surface. A copy of the test pit logs are provided in Attachment C, following the text of this data gap analysis. Where encountered the thickness of the fill material in the test pits ranges from about 2 to greater than 6 metres below ground surface. General random waste material consisting of plastic, metal, wiring, concrete, brick, plastic, paper, glass, wood and wood chippings, organic material and cobbles and boulders was encountered in the fill material which was excavated using a Hitachi 160 track mounted excavator. The fill material was estimated to contain up to about 20 percent (by volume) of waste material. No groundwater was noted. Some sorting of the

fill material to remove organic and any large fragments of the waste material would be required for any material which will be re-used on site. Unsuitable material could be stockpiled in a designed area on site or removed for offsite disposal.

- Supplier(s) for suitable construction materials to the site have been contacted and likely costs for import and placement of suitable material (rock fill or sand and earth fill) to the site have been obtained. The cost for granular fill ranges from about $43 to about $65 per cubic metre and up to $99 per cubic metre for rip rap. Cost surcharges may be applicable for winter work. For illustrative purposes, assuming that a total budget of $500,000 is available for material import and placement (only) about 7,700 to 11,600 cubic metres of material could be placed (excluding the use of rip rap). This is not considered sufficient quantity of material to construct a berm around the perimeter of the existing landfill (Option 1). To reduce costs this approach could be adopted at selected area(s) within the site. However, this would mean that portions of the site would not be remediated to achieve a factor of safety of greater than 1.5. This is discussed further in the 'Additional Considerations' section of this report;

- Cost estimates for excavation, placement and compaction of on-site material (i.e., cost per cubic metre) have been obtained. The cost per cubic metre ranges from about $9 to $21 per cubic metre. Cost surcharges may be applicable for winter work. For illustrative purposes assuming a total budget of $500,000 is available for material excavation and placement (only) about 24,000 to 55,600 cubic metres of material could be moved within the site. While this may be sufficient to cut back the slopes across the site to achieve a factor of safety of greater than 1.5, the material removed from the site would have to be placed at the base of the slope which could have environmental impacts. To minimize the amount of fill material moved at the site this approach could be adopted at selected area(s) within the site. However, this would mean that portions of the site would not be remediated to achieve a factor of safety of greater than 1.5. Similarly the required slope gradient of 2.5 horizontal to 1 vertical could be relaxed somewhat. This is discussed further in the 'Additional Considerations' section of this report;

- It is understood that the proposed environmental remediation works for the site have been narrowed to include preservation / modification of the existing wetland at the base of the

landfill (refer to Franz Environmental Supplemental Enviromental site Investigation and Data Gap analysis for further details).

REQUIRED ADDITIONAL INFORMATION

The following additional information should be gathered for a more complete assessment of the construction options (from a geotechnical perspective), to allow for detailed design of the preferred option to proceed and to establish the likely cost of the works (or phases of the works):

- Verification of the capacity of the existing livestock grate located along the existing access road to the site to support construction traffic loads;

- Verification of the nature of the materials within the landfill, in particular with reference to the presence of possible unexploded ordnances (refer to Figure 4) and other health and safety related impacts which may be encountered as a result of exposure to material within the landfill;

- Consult with the correctional facility with regard to limitations on accessing the site by construction workers and equipment. For instance, if the number of visits to and from the site are to be restricted, this may preclude the importation of material to the site for use as a berm.

PREFERRED CONSTRUCTION OPTION

In order to proceed with the design of the remediation works at the site the preferred construction option should be selected. To assist with the selection of the preferred stabilization measures the following points are presented for consideration (from a geotechnical perspective):

Option 1: Import Material to Site

- This option would not require significant disturbance or movement of the existing landfill material which has been placed at the site, excluding stripping of the existing topsoil and vegetation, and benching of the slopes;

- Additional space at the toe of the landfill will be required to construct the berm along the toe and slopes of the existing landfill. To quantify the likely space required, assuming the current slopes are at a 1 horizontal to 1 vertical side slope, an additional 1.5 metres of land at the base of the slope would be required for each metre in height difference between the toe (base) and crest (top) of the landfill. This would impact upon the existing wetland area at the north end of the landfill, which is not considered preferable from an environmental perspective (refer to Franz Environmental Supplemental Site Investigation and Data Gap Analysis report).

- An available source of suitable material (such as rock fill, sand or glacial till) would be required within a reasonable distance of the site. Such a source could consist of a quarry in non-argillaceous rock, or possibly a large excavation through glacial till or granular soils. Based on discussions with local contractors such materials are locally available;

- If coarse rock fill material is used on the slope face it is unlikely that the slope will become vegetated and as such the visual impact of the landfill on the surrounding areas will be increased. This can be mitigated somewhat by the use of suitable earth fill material which could be vegetated, if it is available (possibly with the assistance of proprietary vegetated soil systems);

- Construction of a wetland would likely require controlling and containing the existing surface and groundwater flow (where present) through the landfill material and the stabilizing berm. The use of rock fill material on the face of the landfill would not create preferred drainage paths (as the material as a whole would have a very high permeability) unless the base on which the rock fill material is placed is prepared and shaped to promote drainage towards the desired area. Similarly, a lower permeability earth fill would not allow drainage of groundwater unless drainage measures (such as a perforated pipe drain or granular “french drain”) were installed within the berm.

Option 2: Re-Use of Existing on Site Material

- Less space would be required at the toe of the slope for the stabilization measures. The amount of land space required would depend on the position of the cut and fill line through

the existing landfill material as indicated on Figure 3. Where space constraints dictate, the landfill waste could be cut back to the proposed slope gradation (i.e. 2.5 horizontal to 1.0 vertical) at the location of the existing toe of the slope and any excess material generated could be placed at a suitable location on top of the landfill, used at an alternative location for grading works at the site, or removed from the site.

- This option would reduce the potential for the existing wetland to be disturbed by the construction works;

- This option would require significant disturbance of the existing landfill waste material which has been placed at the site which may be of concern from an environmental and health and safety perspective;

- Excavated landfill material could be placed in a controlled manner and compacted in place at the top or base of the landfill. Some sorting of unsuitable / undesirable landfill waste material such as large fragments of debris and organic material could be carried out during the construction;

- There may be a significant cost implication to remove and dispose of excess landfill material from the site or landfill material which contains unacceptable quantities of chemical contaminants;

- A reduced amount of material would be required to be brought to the site, and this would reduce the volume of traffic through the site compared with Option 1;

- It is understood that the existing landfill was constructed without compaction and as such voids may be present within the landfill which are holding groundwater within the landfill. Excavation and placement and compaction of the existing landfill waste may disrupt these drainage paths. This could be mitigated by means of engineered drainage measures which could assist with the control and management of the groundwater at the site.

ADDITIONAL CONSIDERATIONS

Irrespective of the selected construction option (or the phasing of the construction), it is considered likely that the following will also be required to complete the remediation works:

- Improvement of the existing gravel access road between the correctional facility and the landfill to support the construction traffic;

- Construction of a temporary access road(s) suitable for movement of construction plant and materials from the crest of the slope to the base of the slope. These roads could be left in place after the remediation works are completed to allow future access. The contractor should be made responsible for the design of this portion of the works as the access must be suitable for the construction equipment used at the site;

- Stripping of topsoil and clearing of vegetated areas on the slope and at the toe of the slope. The contractor should be made responsible for establishing site clearing to allow access for the construction equipment;

- Improvement of existing drainage measures and/or implementation of additional drainage measures.

With regard to the proposed slope stabilization construction alternatives, from a geotechnical perspective, it is likely that re-use of the existing site material (Option 2) will be preferable over importing material to the site given the higher costs for importation of suitable material, and the increased land space that would be required to complete the works under the alternative. This approach will allow for the installation of additional drainage measures within the upper part of the landfill to divert surface water towards the wetland area and will provide the most available space for the construction / preservation of the wetland and any drainage measures along the toe of the landfill. Nevertheless, it may still be necessary to import an amount of material to the site, for the reasons outlined above, and also to make up any imbalance in available materials. However, this approach has the potential to encounter delays during construction due to the presence of unknown materials within the landfill waste.

As previously stated the native slopes below the existing landfill are showing signs of erosion and instability, as indeed are the higher native slopes in the coulee surrounding the landfill. These native soils which have high sand and silt content are prone to mass wastage (particularly when the slopes are un-vegetated) which can be triggered by a heavy rainfall event. As such, the criteria for establishing a 'stable slope' within an area which is prone to ongoing instability should be viewed pragmatically. In general terms a 'stable slope' is typically considered to be one in which the Factor of Safety (FOS) against a failure is greater than 1.5. Combined with the installation of additional drainage measures across the site consideration could be given to carrying out slope regrading works only in the northern portion of the site where an existing failure has occurred. In this area the slope could be regraded to a 2 horizontal to 1 vertical slope which may not be sufficient to provide a FOS of greater than 1.5, but could be considered adequate given conditions in which the landfill is present. Furthermore, this approach could be adopted in the areas of greatest concern only; (that is, at the northern section of the landfill where an existing failure zone is present and where it is considered desirable to maintain the existing wetland at the toe of the landfill).

Notwithstanding the points outlined above, the selection of the preferred construction option is considered to be the sole responsibility of the site owner and should be selected after careful consideration of the project objectives from the owner's perspective, and in combination with discussions with the design team. To assist with this procedure a summary of the salient points discussed previously in this data gap analysis are provided on the following table:

Option 1: Import Material to Site	Key Points
	• Most costly option per cubic metre of fill; • Greatest land space required; • Existing wetland will be filled in; • Disturbance to existing waste will be minimized.

Option 2: Re-use Existing Fill Material	Key Points
	• Less costly option per cubic metre of fill; • Required land space at toe can be adjusted; • Existing wetland can be maintained; • Greatest disturbance to existing fill material.

We trust that this data gap analysis report is sufficient for your requirements. If you have any questions concerning this information or if we can be of further assistance to you on this project, please do not hesitate to call.

Yours truly,

HOULE CHEVRIER ENGINEERING LTD.

Daire Cummins, M.Sc., D.I.C.

Andrew Chevrier, M.Eng., P.Eng.
Principal

LICENSED PROFESSIONAL ENGINEER
13 Jan. 2012
A.F. CHEVRIER
7974504
PROVINCE OF ONTARIO

Figures 1 to 4, inclusive
Attachments A and B

KEY PLAN	FIGURE 1

N.T.S

Houle Chevrier Engineering

Date: January 2012

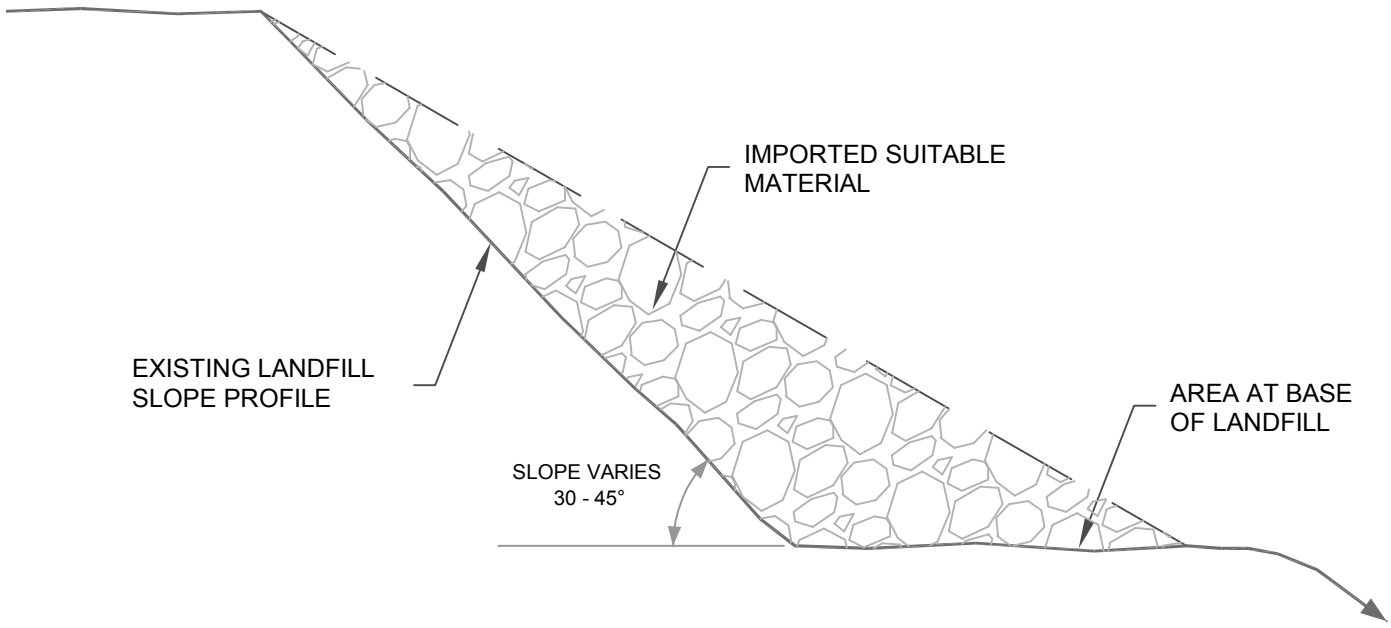
Project: 10-611

Houle Chevrier Engineering
R.R. 2 180 Wescar Lane
Carp, Ontario
KOA 1L0
info@hceng.ca
(613) 836-1422
Fax: 836-9731

SCHEMATIC OF SLOPE REMEDIATION OPTION 1
DRUMHELLER, AB.

FIGURE 2

PROJECT: 10-611
DATE: January 2012



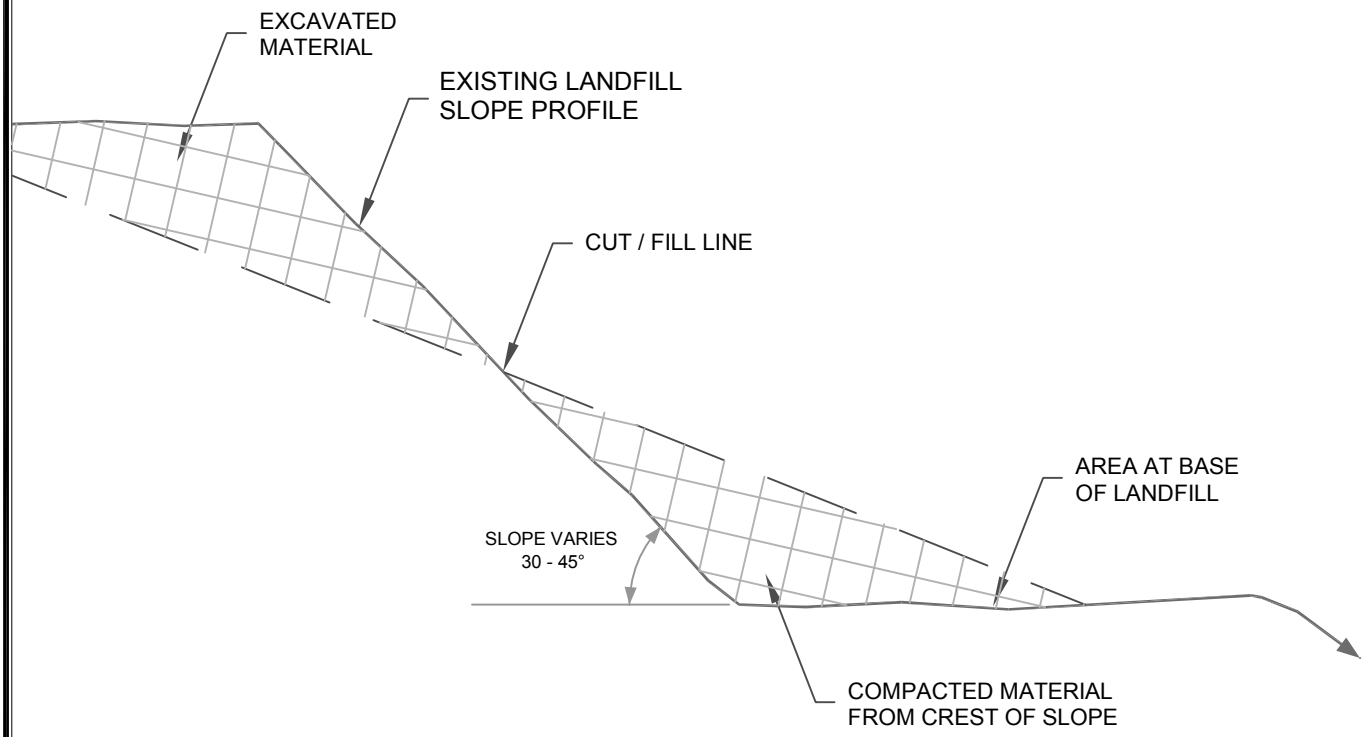
Not to Scale

Houle Chevrier Engineering
R.R. 2 180 Wescar Lane
Carp, Ontario
KOA 1L0
info@hceng.ca
(613) 836-1422
Fax: 836-9731

SCHEMATIC OF SLOPE REMEDIATION OPTION 2
DRUMHELLER, AB.

FIGURE 3

PROJECT: 10-611
DATE: January 2012



NOTE:

HORIZONTAL LOCATION OF CUT / FILL LINE COULD BE VARIED TO SUIT EXISTING FEATURES AND MATERIAL QUANTITIES.

Not to Scale

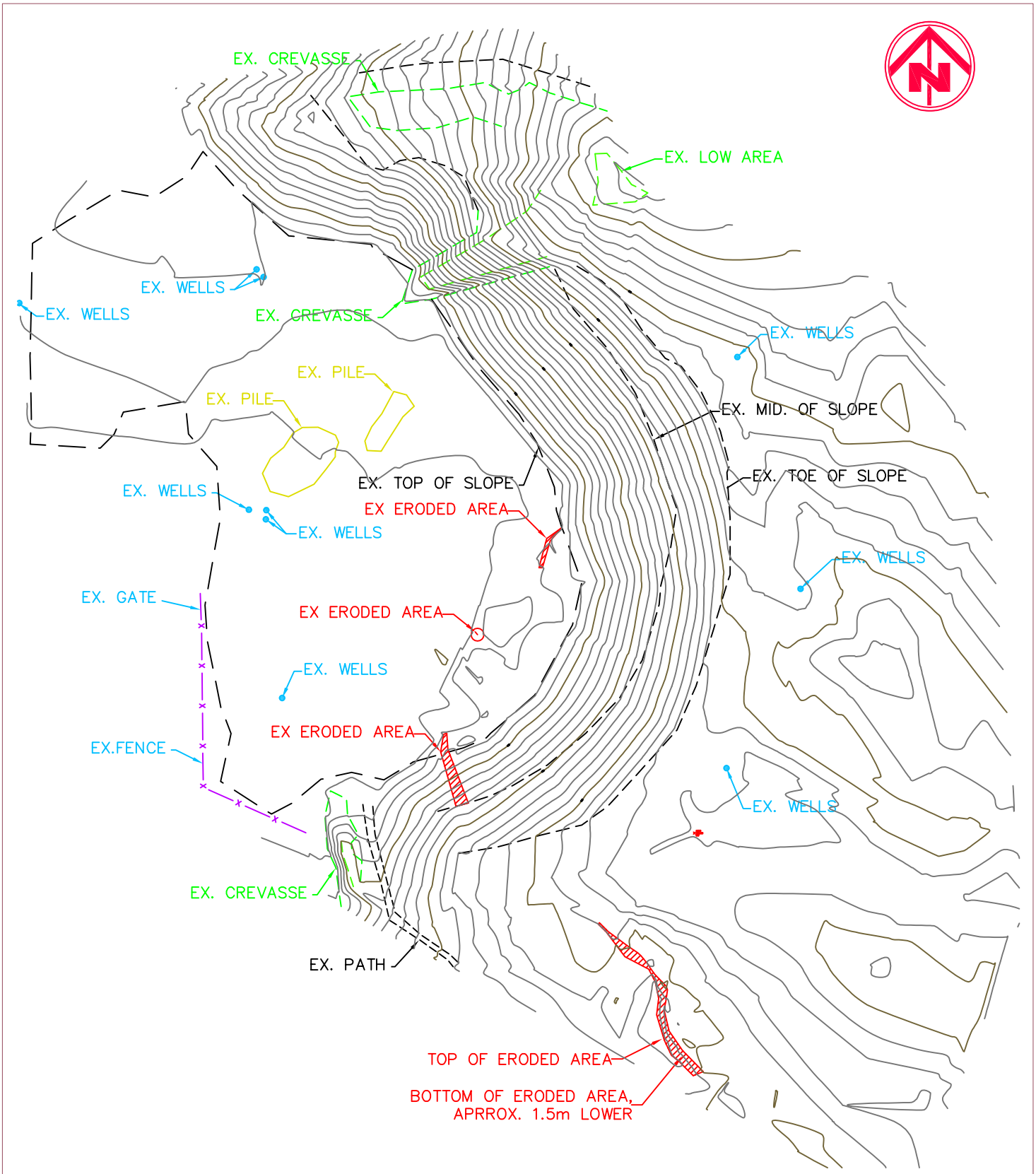
VIEW OF ORDNANCE AT BASE OF NORTH SECTION OF LANDFILL

Note: Item was recovered from the landfill and retained by personnel of the correctional facility

Houle Chevrier Engineering	PHOTOGRAPH OF LANDFILL WASTE	FIGURE 4

ATTACHMENT A

AMENDED TOPOGRAPHIC SURVEY
TAGISH ENGINEERING LTD.



TAGISH ENGINEERING LTD.
Consulting Engineers

G4, 5550 - 45 St.
RED DEER, AB T4N 1L1

Ph: (403) 346-7710
Fax: (403) 341-4909
E-mail: admin@tagish-engineering.com

Client
DRUMHELLER PENITENTIARY

Project
DRUMHELLER LANDFILL SURVEY

Drawing
EXISTING CONDITIONS

Drawn:	MCW	Scale:	1:1000	Drawing No. 1
Designed:	LS	Date:	10/11/11	
Checked:	LS	File No.:	ACAD-FEI01_DGN02_2011.dwg	
Approved:		Project No.:	FEI-01	1

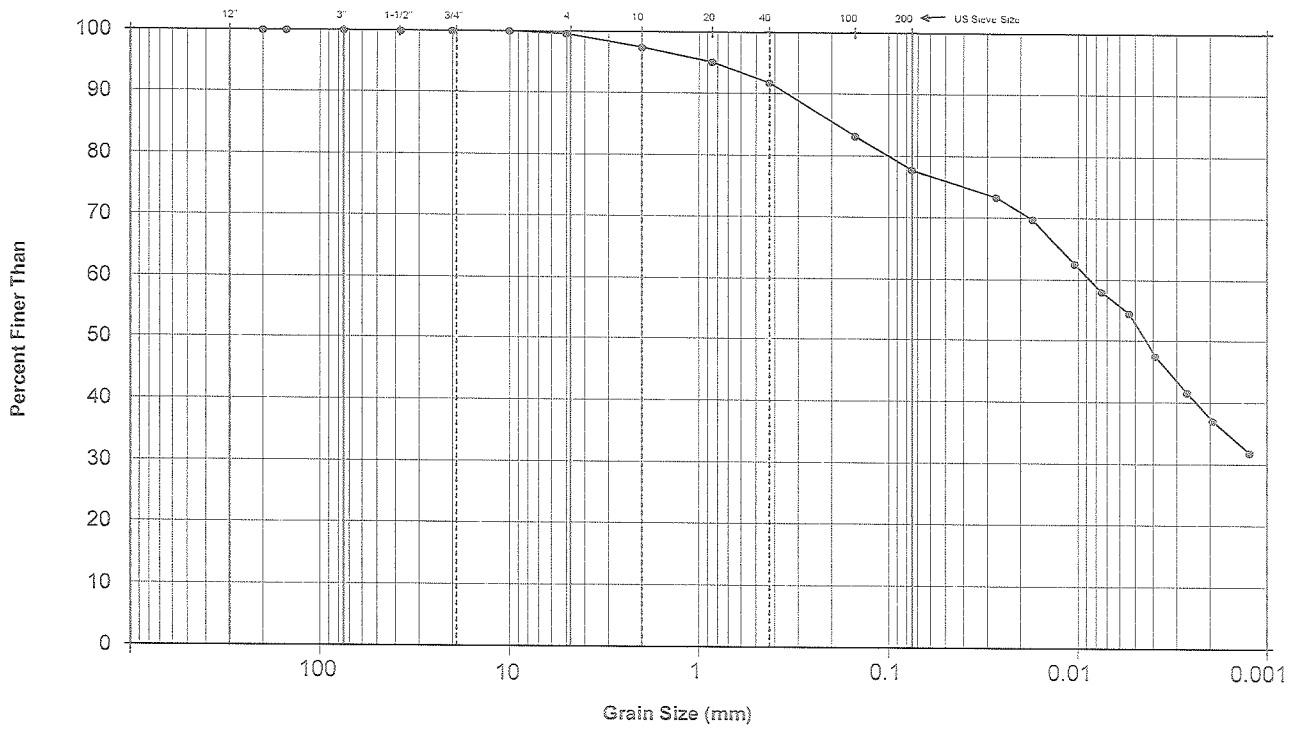
ATTACHMENT B

RESULTS OF LABORATORY TESTING
ON NATIVE SOILS AND LANDFILL WASTE
BY OTHERS

Golder Associates

PARTICLE SIZE ANALYSIS OF SOIL
(ASTM D422)

Project No.:	11-1359-0012	Lab No.:	1095002
Project Title:	Drumheller Landfill		
Borehole:	-	Sample No.:	Fill Material
Depth:	0.2-0.4 m		
Date Tested:	29-Sep-11	By:	CG/AR



Boulder Size	Cobble Size	Gravel Size		Sand Size			Silt and Clay Size
		Coarse	Fine	Coarse	Medium	Fine	

Diameter of Sieve (mm)	Percent Passing (%)
200.0	100.0
150.0	100.0
75.0	100.0
37.5	100.0
20.0	100.0
10.0	100.0
5.00	99.6
2.0	97.5
0.850	95.1
0.425	91.8
0.150	83.3
0.075	77.8
0.027	73.4
0.017	69.8
0.010	62.6
0.007	58.1
0.005	54.6
0.004	47.5
0.003	41.6
0.002	37.1
0.001	31.9

Comments:

Reviewed: Derek Hudson

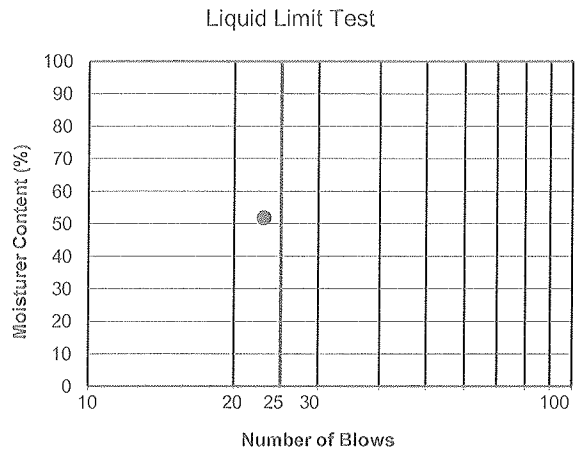
Golder Associates

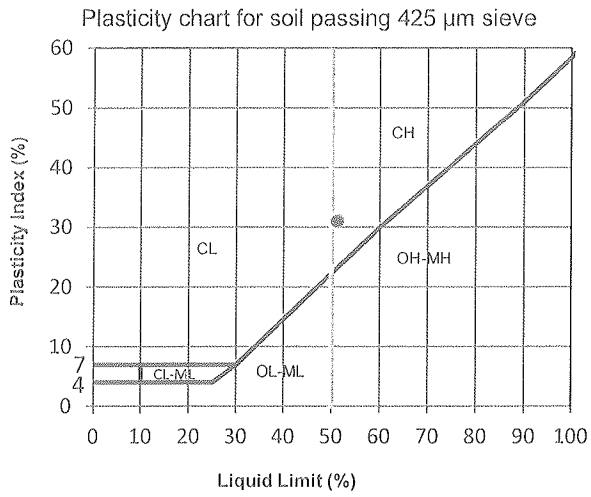
Atterberg Limits (ASTM D 4318)

Project No.:	11-1359-0012	Phase:	
Short Title:	Drumheller Landfill	Lab No.:	1095002
Tested By:	CG	Date:	29-Sep-11

Borehole: Fill Material Sample No.: Depth: 0.2-0.4 m

Liquid Limit Determination:			Natural Moisture Content :		
Number of Blows	23		Natural Moisture Content - as received (%)		16.1%
Blow Correction Factor	0.99		Plastic Limit Determination:		
Mass of wet sample + tare (g)	47.26		Mass of wet sample + tare (g)	19.64	21.81
Mass of dry sample + tare (g)	37.21		Mass of dry sample + tare (g)	17.99	20.01
Mass of tare (g)	17.81		Mass of tare (g)	9.66	10.97
Weight of Water (g)	10.05		Weight of Water (g)	1.65	1.80
Weight of dry soil (g)	19.4		Weight of dry soil (g)	8.33	9.04
Moisture content (%)	51.8%		Moisture content (%)	19.8%	19.9%
Liquid Limit	51.29		Average Moisture Content (%)		19.86





Liquid Limit = 51 %
Plastic Limit = 20 %
Plasticity Index = 31

Comments:

Reviewed: Derek Hudson

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Date: 2011.09.29 15:09:40 -06'00'

Laboratory Compaction Characteristics of Soil using Standard Effort

(ASTM D698)

Project No.:	11-1359-0012	Phase:	
Short Title:	Drumheller Landfill	Lab No.:	1059001
Tested By:	FC/BA	Test Date:	26-Sep-11

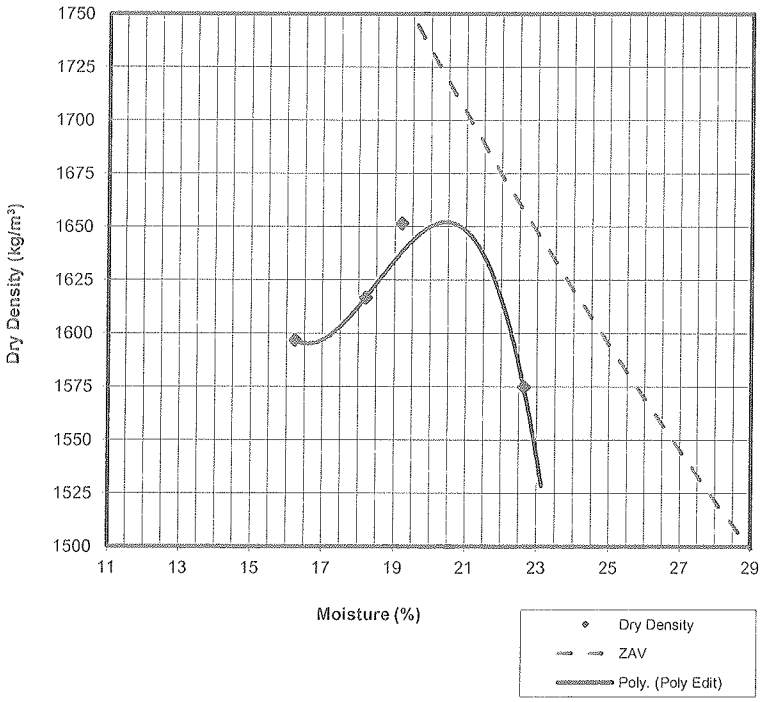
Borehole:	-	Date Sampled:	-
Sample No.:	-	Sample Source:	North Test Pit
Sampled By:	Client	Sample Description:	Brown clay

MOISTURE DENSITY RELATIONSHIP

Trial No.	1	2	3	4	5	6
Mold No.						
Wt of sample wet + mold (g)	6211.90	6263.90	6318.20	6283.10		
Wt. Of mold (g)	4460.00	4460.00	4460.00	4460.00		
Wt. Of sample wet (g)	1751.90	1803.90	1858.20	1823.10		
Volume of Mold (cm^3)	944.00	944.00	944.00	944.00		
Wet Density (kg/m^3)	1855.83	1910.91	1968.43	1931.25		
Dry Density (kg/m^3)	1597	1617	1652	1575		

MOISTURE CONTENT

Tare No.						
Wt of sample wet + tare (g)	476.48	516.21	406.49	472.59		
Wt of sample dry + tare (g)	417.84	452.95	349.92	398.81		
Wt. Water	58.64	63.26	56.57	73.78		
Tare mass (g)	56.34	105.22	55.02	72.71		
Wt. Dry soil (g)	361.50	347.73	294.90	326.10		
Moisture content (%)	16.22	18.19	19.18	22.62		



Maximum Dry Density

Max. Dry Density 1650 kg/m^3

Optimum Moisture 20.5 %

Method A

Rock Correction (if required)

% Oversize _____ %

Max. Dry Density _____ kg/m^3 @ _____

Remarks: _____

Natural Moisture Content = 13.7 %

Reviewed: Derek Hudson

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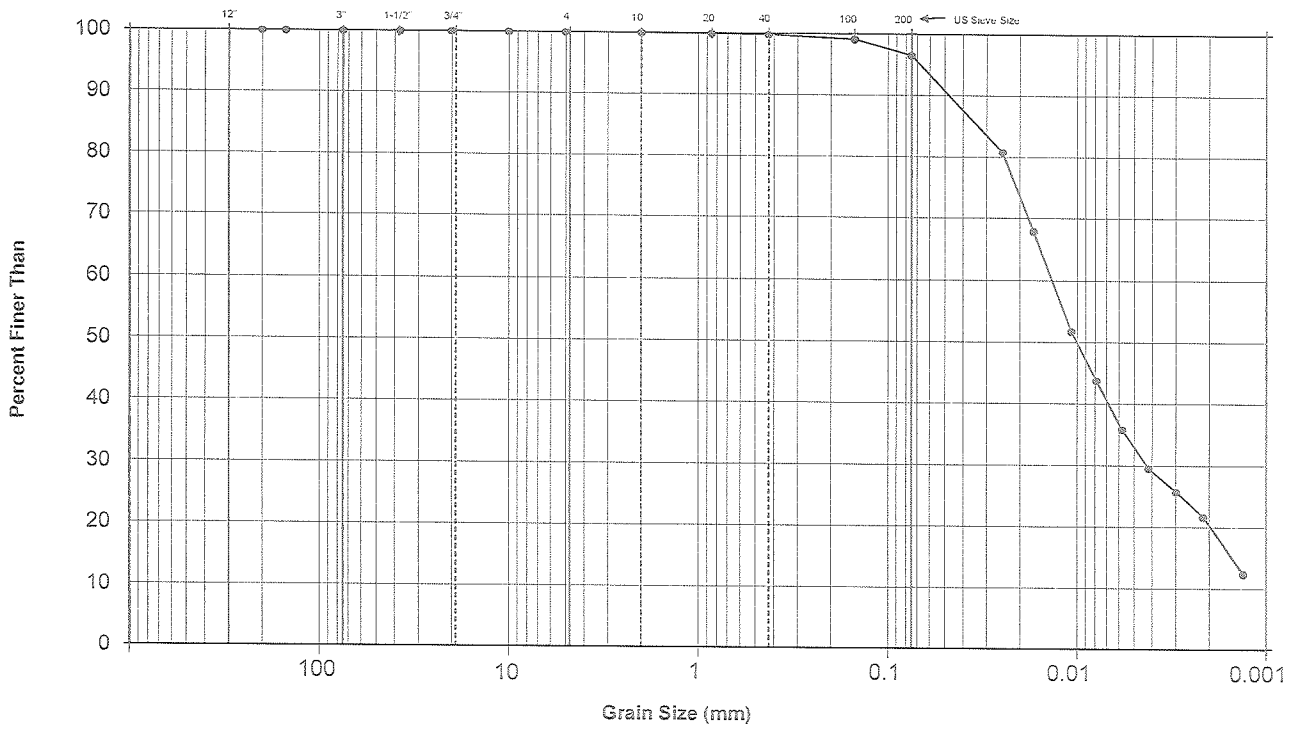
Golder Associates

PARTICLE SIZE ANALYSIS OF SOIL
(ASTM D422)

Project No.:	11-1359-0012	Lab No.:	1059001
Project Title:	Drumheller Landfill		
Borehole:	-	Sample No.:	North Test Pit
Depth:	0.9-1.2 m		
Date Tested:	26-Sep-11	By:	CG/AR



Boulder Size	Cobble Size	Coarse	Fine	Coarse	Medium	Fine	Silt and Clay Size
		Gravel Size		Sand Size			

Diameter of Sieve (mm)	Percent Passing (%)
200.0	100.0
150.0	100.0
75.0	100.0
37.5	100.0
20.0	100.0
10.0	100.0
5.00	100.0
2.0	100.0
0.850	99.9
0.425	99.8
0.150	99.1
0.075	96.5
0.025	80.8
0.017	68.0
0.011	51.9
0.008	43.8
0.006	35.8
0.004	29.6
0.003	25.8
0.002	21.7
0.001	12.4

Comments:

Reviewed: Derek Hudson

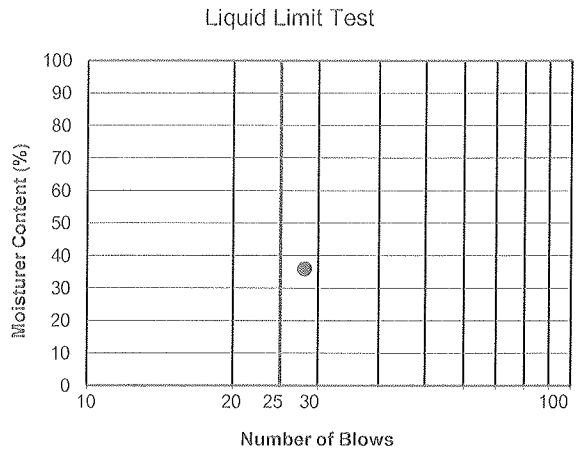
Golder Associates

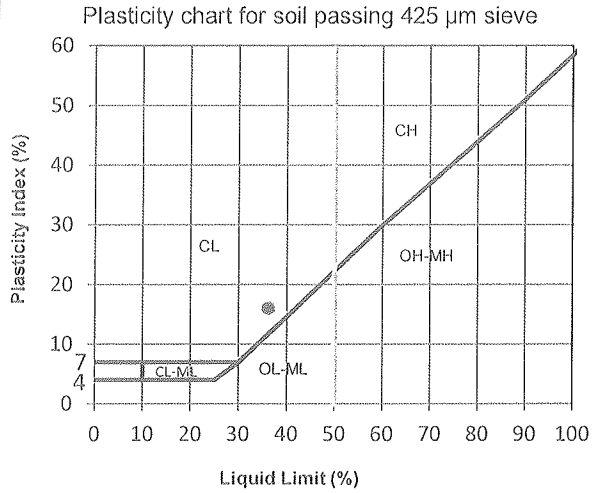
Atterberg Limits (ASTM D 4318)

Project No.:	11-1359-0012	Phase:	
Short Title:	Drumheller Landfill	Lab No.:	1059001
Tested By:	CG	Date:	26-Sep-11

Borehole: - Sample No.: North test pit Depth: 0.9-1.2 m

Liquid Limit Determination:			Natural Moisture Content :		
Number of Blows	28		Natural Moisture Content - as received (%)		15.4%
Blow Correction Factor	1.01		**Plastic Limit Determination:**		
Mass of wet sample + tare (g)	52.87		Mass of wet sample + tare (g)	18.56	18.77
Mass of dry sample + tare (g)	44.98		Mass of dry sample + tare (g)	17.22	17.40
Mass of tare (g)	23.05		Mass of tare (g)	10.67	10.67
Weight of Water (g)	7.89		Weight of Water (g)	1.34	1.37
Weight of dry soil (g)	21.93		Weight of dry soil (g)	6.55	6.73
Moisture content (%)	36.0%		Moisture content (%)	20.5%	20.4%
Liquid Limit	36.48		Average Moisture Content (%)		20.41





Liquid Limit = 36 %
Plastic Limit = 20 %
Plasticity Index = 16

Comments:

Reviewed: Derek Hudson

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Laboratory Compaction Characteristics of Soil using Standard Effort

(ASTM D698)

Project No.:	11-1359-0012	Phase:	
Short Title:	Drumheller Landfill	Lab No.:	1095002
Tested By:	FC/BA	Test Date:	26-Sep-11

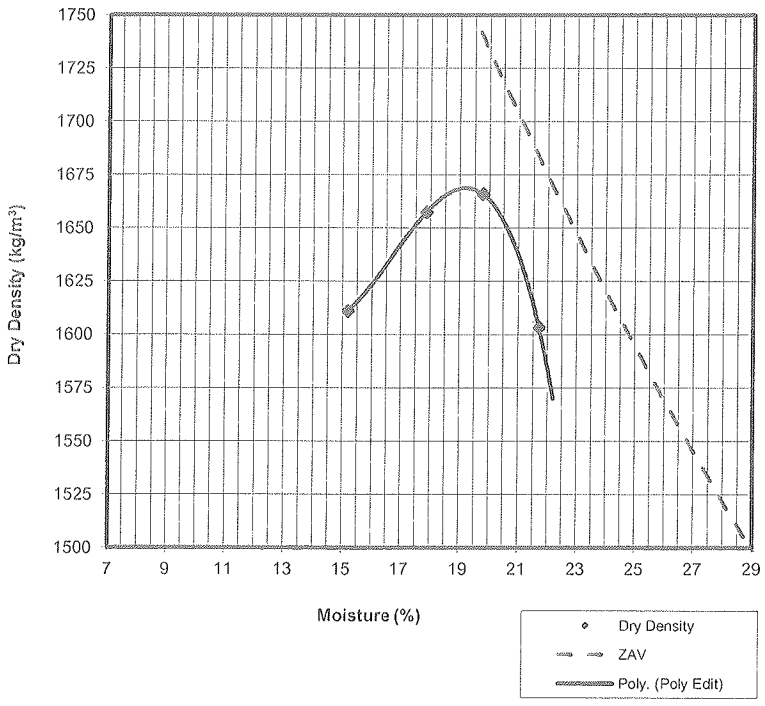
Borehole:	-	Date Sampled:	-
Sample No.:	-	Sample Source:	Fill Material
Sampled By:	Client	Sample Description:	Brown silty clay with some gravel

MOISTURE DENSITY RELATIONSHIP

Trial No.	1	2	3	4	5	6
Mold No.						
Wt of sample wet + mold (g)	6211.60	6303.90	6343.50	6301.90		
Wt. Of mold (g)	4460.00	4460.00	4460.00	4460.00		
Wt. Of sample wet (g)	1751.60	1843.90	1883.50	1841.90		
Volume of Mold (cm^3)	944.00	944.00	944.00	944.00		
Wet Density (kg/m^3)	1855.51	1953.28	1995.23	1951.17		
Dry Density (kg/m^3)	1611	1657	1666	1603		

MOISTURE CONTENT

Tare No.						
Wt of sample wet + tare (g)	438.46	597.49	445.14	493.85		
Wt of sample dry + tare (g)	388.22	522.49	383.06	415.80		
Wt. Water	50.24	75.00	62.08	78.05		
Tare mass (g)	57.11	102.25	68.94	56.04		
Wt. Dry soil (g)	331.11	420.24	314.12	359.76		
Moisture content (%)	15.17	17.85	19.76	21.70		



Maximum Dry Density

Max. Dry Density 1668 kg/m^3

Optimum Moisture 19.3 %

Method A

Rock Correction (if required)

% Oversize 12 %

Max. Dry Density 1746 kg/m^3 @ 17.2%

Remarks:

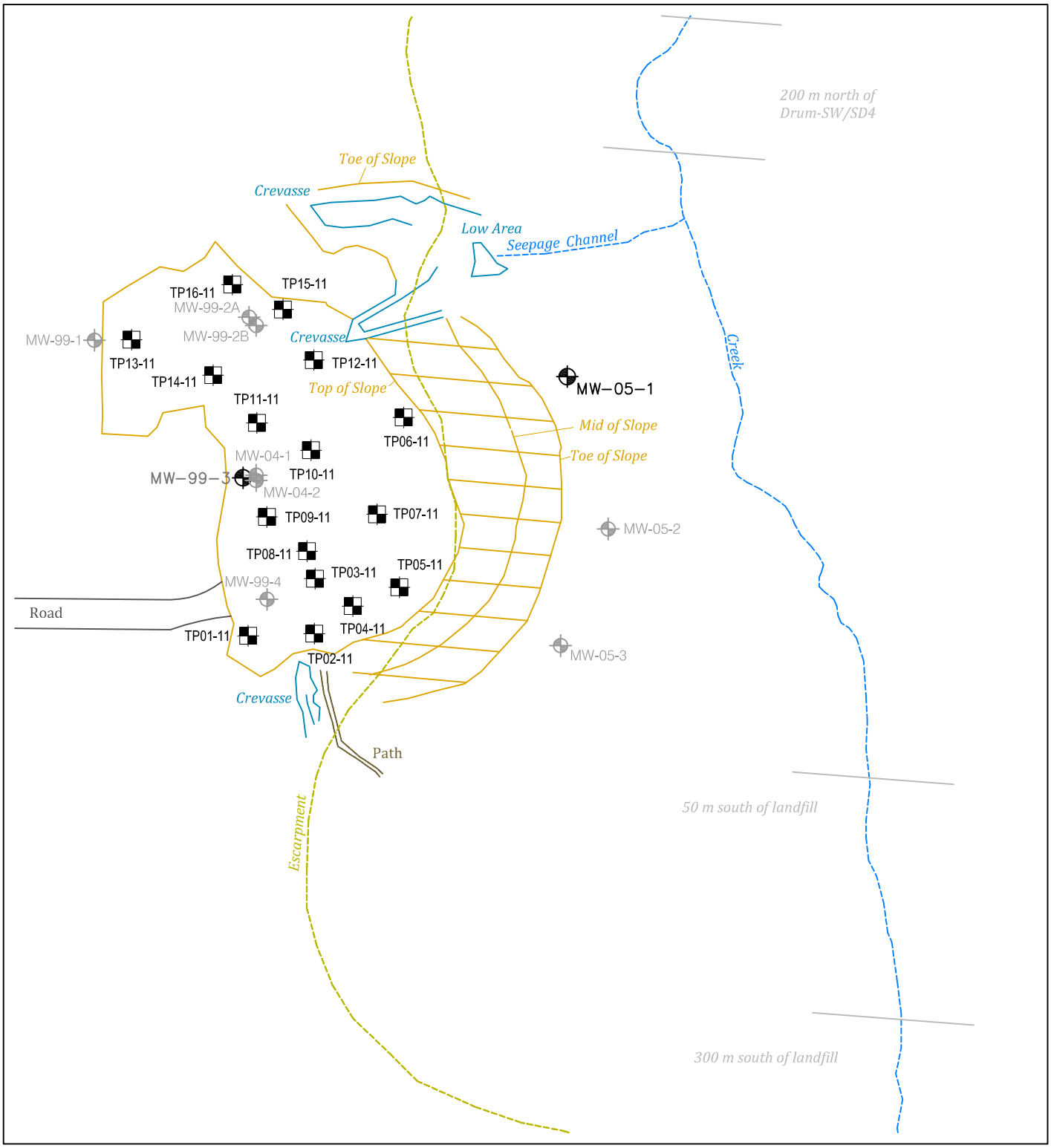
Natural Moisture Content = 14.0 %

Reviewed: Derek Hudson

Digitally signed by Derek Hudson
DN: cn=Derek Hudson
Date: 2011.09.29 15:48:21 -06'00'

ATTACHMENT C

RECORD OF TEST PIT SHEETS
BY FRANZ ENVIRONMENTAL INC.



LEGEND

- Monitoring Well with Sufficient Volume for Sampling
- Previously Installed Monitoring Well
- Test Pit

Scale 1:1,600

32 24 16 0 16 32
metres

Title: STATION LOCATIONS

Project: LANDFILL INTRUSIVE INVESTIGATION AND BIOLOGICAL SITE SURVEY, DRUMHELLER INSTITUTION, DRUMHELLER, AB

Client: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

FRANZ ENVIRONMENTAL INC.
CONSULTING ENGINEERING TECHNOLOGIES

Date: DECEMBER 2011

FIGURE 2

2026-1101/CAD/NR/Analytical_19122011.dwg

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP01-11

Project No: 2026-1101

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			
Depth (ft / m)	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	Well Completion Details
0		Ground Surface	0.0				
		Silty clay with some sand, brown, fine, dense, dry.Native material					
				TP1-11-03	SS		

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP02-11

Project No: 2026-1101

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			
Depth (ft / m)	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	Well Completion Details
0 ft / 0 m		Ground Surface	0.0				
		Silty Clay with some sand, brown, fine, dense, dry.	2.0				
		Silty Clay with some sand, brown to dark brown, fine, dense, dry. Fill material: Some fiberous cloth like material, some red rusty colored sandy shale liki material. Loosley packed.	3.0				
		Sandy clay with some silt, brown with some darker brown organic looking material, dense, fine, dry.	4.0	TP2-11-04	SS		
		Silty Clay with some sand, brown with some darker brown organic looking material, fine, dense, dry.		TP2-11-07	SS		

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP03-11

Project No: 2026-1101

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			
Depth (ft / m)	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	Well Completion Details
		Ground Surface	0.0				
		Silty clay with some sand, brown, fine, dense, dry.	2.0				
		Silty clay with some sand, brown orange, black.Dense and soft, fine, dry. Fill material present: some plastic, pieces of metal, piping, wire, concrete.loose.	3.0				
		Silty clay with some silt gravel and cobbles, light brown, fine, dense,dry. Fill material: Metal, wood, ceramic material, some brick material. loose.	4.0	TP3-11-07	SS		
		Silty clay with some sand and gravel. Light brown, fine, dense, dry. Fill material: wood, glass, foam ceramic material.Loose	5.5				
		Silty clay with some sand, light brown, dense, fine, dry.					

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP04-11

Project No: 2026-1101

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			
Depth (ft / m)	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	Well Completion Details
		Ground Surface	0.0				
		Asphalt, dark brown/black, hard, dense, dry	0.5				
		Silty clay with some sand, light brown, dense, fine, dry. Fill material: Asphalt	2.0				
		Silty clay with some gravel, light brown with darker brown organic patches, dense, fine, dry. Fill material present: Asphalt, wood, plastic pipe, paper		TP4-11-07	SS		

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP05-11

Project No: 2026-1101

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			
Depth (ft / m)	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	Well Completion Details
0 ft / 0 m		Ground Surface	0.0				
		Fill material: Asphalt, dark brown/black, hard, dense, dry.	0.5				
3 ft / 1 m		Clay fill with some silt and gravel, light brown, dense, fine, dry		TP5-11-02	SS		
6 ft / 2 m		Sandy clay with some silt and gravel.light brown. loose, fine, dry.Fill material present: plastic, wood, paper, brick, concrete, wire, ceramic material.Loose.	2.0				
10 ft / 3 m							
13 ft / 4 m							
16 ft / 5 m							
20 ft / 6 m							
23 ft / 7 m							
25 ft							

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP06-11

Project No: 2026-1101

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			
Depth (ft / m)	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	Well Completion Details
0 ft / 0 m		Ground Surface	0.0				
		Fill material:hard clay with some sand and silt with small brick fragments.Dark brown, fine, loose, dry.	3.0				
		Fill Material: Clay, silt, pieces of metal, glass and concrete. Light brown, fine, loose, dry.	4.0				
		Clay with some silt and gravel.Dense, fine, loose dry.Fill material: wood, rusty metal, concrete, oxidized clay rusty color with some cobbles and boulders.Loose.		TP6-11-07	SS		

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP07-11

Project No: 2026-1101

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			
Depth (ft / m)	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	Well Completion Details
		Ground Surface	0.0				
		Clay, few cobbles. Dark brown, hard compact, fine, dense, dry. Fill material: brick, concrete.	1.0				
		Clay, few cobbles. Dark brown, hard compact, fine dense, dry. Fill material: brick, concrete.	2.0				
		Clay with some silt and gravel.Light to dark brown , fine, dense, dry.Fill material: Plastic, metal, wood.	3.0				
		Silty clay, light brown, some darker brown clay bands. fine, dense, dry. Fill material: wood pieces	4.0	TP7-11-05	SS		
		Silty clay, light brown.fine, dense, dry. Native material.					

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP08-11

Project No: 2026-1101

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			
Depth (ft / m)	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	Well Completion Details
0 ft / 0 m		Ground Surface	0.0				
		Fill material: Light brown with some dark brown bands of silty clay with some crumbly grey clay.					
				TP8-11-05	SS		
			5.0				
		Silty clay, light brown, fine, dense, dry. Native material.					

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP09-11

Project No: 2026-1101

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			
Depth (ft / m)	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	Well Completion Details
0 ft / 0 m		Ground Surface	0.0				
		Fill material: silty clay with some cobbles, light brown with red shale, hard clay, dark brown, fine, dense, dry.	2.0				
		Fill material:Silty clay with some cobbles, light brown with red shale, fine, dense, dry.	4.0				
		Mainly silty clay, light brown, fine, dense, dry. Some fill material: red shale and dark brown hard clay.	5.0				
		Silty clay, light brown, fine, dense, dry.Native material.		TP9-11-07	SS		

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP10-11

Project No: 2026-1101

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			
Depth (ft / m)	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	Well Completion Details
		Ground Surface	0.0				
		Fill material:Clay, silt, gravel, dark brown, fine, dense, very compact, dry.		TP10-11-02	SS		
			2.0				
		Silty clay and gravel, light brown, fine, dense, dry. Native material.					

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP11-11

Project No: 2026-1101

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			
Depth (ft / m)	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	Well Completion Details
		Ground Surface	0.0				
		Fill material:Clay, silt, gravel, dark brown, fine, dense, wood chippings, red shale pieces.	1.0				
		Fill material:thick band of hard dark clay, silt, gravel, fine, dense, plastic, styrofoam, glass, wire, wood chippings, ceramic.	2.0	TP11-11-03	SS		
		Silty clay with some sand, brown, fine, dense, dry.Native material					

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP12-11

Project No: 2026-1101

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			
Depth (ft / m)	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	Well Completion Details
0 ft / 0 m		Ground Surface	0.0				
		Silty clay and gravel, light brown, fine, dense, dry. Fill material:Large pieces of concrete building rubble of boulder size (>300 mm), metal sheets and poles, plastic. Loose.					
				TP12-11-04	SS		
			3.0				
		silty clay, light brown, fine, dense, dry. Native.					

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP13-11

Project No: 2026-1101

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			
Depth (ft / m)	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	Well Completion Details
		Ground Surface	0.0				
		Silty clay, dark brown, organic rich, stiff, fine, dense, dry. Native material.locally termed 'Gumbo' top soil.	0.5				
		Silty clay, light brown, fine, dense, dry. Native material.		TP13-11-04	SS		

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP14-11

Project No: 2026-1101

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			
Depth (ft / m)	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	Well Completion Details
0 ft / 0 m		Ground Surface	0.0				
		Silty clay, dark brown, fine, loose, dry. Native.					
				TP14-11-04	SS		
13 ft / 4 m							

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP15-11

Project No: 2026-1101

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			
Depth (ft / m)	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	Well Completion Details
0 ft / 0 m		Ground Surface	0.0				
		Silty clay with some sand, light brown, fine, loose, dry. Fill material: Concrete building waste, concrete slabs, concrete, metal wire, metal mesh, wood, glass.Loose.	2.0				
		Silty clay with some sand, light brown, fine, dense, dry. Native material.		TP15-11-04	SS		
				TP15-11-05	SS		

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP16-11

Project No: 2026-1101

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			
Depth (ft / m)	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	Well Completion Details
0 ft / 0 m		Ground Surface	0.0				
		Silty clay with some sand, gravel, some cobbles, brown, fine, loose, dry. Fill material: Red shale, large (> 300 mm diameter) concrete pieces.		TP16-11-02	SS		
			2.0				
		Clay with some silt and sand, gravel, some cobbles, brown, fine, high plasticity, dry. Fill material: Red shale, large (>300 mm diameter) concrete pieces.Loose					
				TP16-11-07	SS		

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

APPENDIX I

Supplemental Investigation and Biological Site Survey for the Drumheller Institution No. 530 Landfill, Drumheller, Alberta, by Franz Environmental Inc., January 2012

Supplemental Investigation and Biological Site Survey
Correctional Services Canada (CSC) –
Drumheller Institution No. 530 Landfill
Drumheller, Alberta

Contract No: EW699-103892-004-NCS

DRAFT REPORT

Prepared for:
Public Works and Government Services Canada
Environmental Services-Western Region
10025 Jasper Avenue, Fifth Floor
Edmonton, Alberta T5J 1S6

Prepared by:
Franz Environmental Inc
329 Churchill Avenue N, Suite 200,
Ottawa, Ontario K1Z 5B8
Tel (613) 721-0555 Fax (613) 721-0029

Project No. 2026-1103
January 30, 2012

Stephen Livingstone, M.Sc., P.Geo.
Mike Grinnell, P.Eng.
Tryfan Jones, M.Sc.

EXECUTIVE SUMMARY

Franz Environmental Inc. (FRANZ) was retained by Public Works and Government Services Canada (PWGSC) on behalf of Correctional Services Canada (CSC) to complete a Supplemental Investigation and Biological Survey of the former landfill located at the Drumheller Institution Site No.530 in Drumheller, Alberta. This work was completed as a sub-task for the remediation planning of the Former Landfill Site No. 530. The project was completed under PWGSC Contract No. EW699-103892-004-NCS. PWGSC Project number R.044325.002.

The primary objective of this investigation was to collect additional information in the vicinity of the former landfill ("the site"). The proposed remedial action plan (RAP) and draft Environmental Assessment (EA), pursuant to the Canadian Environmental Assessment Act (CEAA) completed at the site by Franz in 2011 identified three main unknowns. In order to complete the current conceptual RAP of a cut and fill approach using native soil at the site and vicinity additional information needed to be obtained to ascertain the following:

- the contents of the former landfill (i.e. type and extent of waste(s) and the potential for tear gas canisters similar to those encountered in August 2011 to be present at the site);
- potential impacted soil located at the top of the landfill (PAH or PHC impacted soil if present should not be excavated or spread during construction); and,
- the potential presence of the federally protected plant species *Halimolobos virgata.* in the proposed construction work area(s).

A landfill intrusive investigation and biological site survey was carried out at the Drumheller Institution from November 28 to 30, 2011 to collect information to address these unknowns. Sixteen (16) test pits were excavated to a maximum of 6 m. A total of 76 soil samples were collect at varying depths to characterise the native soils and imported fill and assess the types and extent of waste present in the former landfill. Twenty-two 22 soil samples were submitted for analysis of metals (including duplicate samples), 18 soil samples (including duplicate samples) were submitted for analysis of both PAH and PHC parameters and 3 soil samples were submitted for grain size analysis.

Waste and fill material (e.g. red shale, plastic, iron mesh, piping, concrete bricks and slabs, wood, glass) was encountered in ten (10) of the test pits excavated at the site. The horizontal and vertical extent of the waste is well defined and has a greater depth and density further east and north from the top of the landfill (towards the edge of the slope). No tear gas canisters (similar to the one encountered in August 2011) or other hazardous wastes were encountered during this investigation.

Three of the submitted soil samples - TP5-11-02, TP6-11-07 and TP13-11-04 exceeded selected CCME standards for one or more of the parameters tested. Sample TP5-11-02 reported concentrations of benzene and ethylbenzene above CCME CSQGs. Sample TP6-11-07 reported concentrations of tin above selected CCME CSQGs. Sample TP13-11-04 reported concentrations of selenium above selected CCME CSQGs. All other samples satisfied the available CCME CSQGs for the metals, BTEX, F1-F4 PHCs and PAHs parameters analyzed.

Using a combination of line transects and quadrant sampling, the Former Landfill and vicinity was surveyed for the presence or absence of *Halimolobos virgata.* The survey identified a single plant that could potentially be *Halimolobos virgata* at the top the former landfill. Definitive identification will require flower and leaf traits which will be visible next spring.

Based on the information collected during this supplemental investigation, the conceptual remedial action plan (RAP) developed for the site can proceed as intended. The three data gaps previously identified can be address within the RAP developed for the site as follows:

- Contents of former landfill –domestic and general construction waste were identified in the former landfill and their extent is well defined. Provisions can be made to segregate and manage the waste(s) encountered during construction if required. The site specific health and safety plan developed in support of the RAP will include provisions to contact CSC staff should any tear gas canisters (similar to the one found in August 2011) be encountered during construction.
- Potential Impacted Soil by the Landfill – localized areas of impacted soil were identified in three (3) test pits located at the top of the former Landfill. Reported concentrations marginally exceed selected CCME CSQGs and the extent of impacted soils is well defined. Provisions to segregate and manage impacted soil during construction will be included in the RAP. Off-site disposal of impacted soils segregated during construction is not considered likely based on the types of contamination encountered and reported concentrations, however there will be contingency plans to do during construction.
- Potential federally-protected plant species – one plant specimen that could potentially be *Halimolobus virgata* was identified at the top of the former landfill. The plant will be positively identified in the spring of 2012. Should the plant prove to be *Halimolobus virgata* it will be transplanted to another location at the Drumhheller Institution away from proposed construction activities.

A detailed RAP for the site and the associated technical specifications required to implement it will be submitted to PWGSC under separate cover.

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LIST OF APPENDICES

1.0 INTRODUCTION

Franz Environmental Inc. (FRANZ) was retained by Public Works and Government Services Canada (PWGSC) on behalf of Correctional Services Canada (CSC) to complete a supplemental intrusive investigation and a biological site survey of the former landfill located at the Drumheller Institution Site No.530 in Drumheller, Alberta. This work was completed as a sub-task to collect additional data during remedial planning of the Former Landfill Site No. 530. The project was completed under PWGSC Contract No. EW699-103892-004-NCS. PWGSC Project number R.044325.002.

This report describes the supplemental intrusive site investigation and biological site survey and was prepared in accordance with the *Terms of Reference, Landfill Remediation, Correctional Services of Canada, Drumheller Institution Site No 530, Drumheller, Alberta* prepared by Public Works & Government Services Canada (PWGSC), Environmental Services, *W*estern Region, dated July, 2011 ("TOR") and FRANZ's proposal *Landfill Intrusive Investigation and Biological Site Survey Former Landfill Site No. 530 Drumheller Institution, Drumheller, Alberta* dated November 3, 2011.

CSC retained PWGSC Environmental Services Branch – Western Region to assist in co-coordinating the program on its behalf. All contract administration and project management for CSC was conducted by PWGSC.

Throughout this report the former landfill at the Drumheller Institution will be referred to as "the site".

1.1 Project Objectives

The primary objective of this investigation was to collect additional information at the site as indentified by the proposed remedial action plan (RAP) and draft Environmental Assessment (EA), pursuant to the Canadian Environmental Assessment Act (CEAA) completed to support the conceptual RAP by Franz in 2011. Three main unknowns were identified in order to complete the current conceptual RAP of a cut and fill approach using native soil at the site and vicinity.

The unknowns and the objectives to obtain additional information addressing the data gaps associated with each are stated below.

- Contents of former landfill – complete a test pitting program to determine the depth, spatial distribution and waste types associated with the landfill materials.
- Potential Impacted soil within former landfill - collect soil samples at the former landfill and submit them for laboratory analysis of polycyclic aromatic hydrocarbons (PAHs), petroleum hydrocarbons (PHCs) and metals to indentify if any impacted soils are present and delineate the spatial distribution of impacted soils (if encountered).

- Potential presence of federally-protected plant species - complete a biological site survey to assess the potential presence of the federally-protected plant species *Halimolobus virgata* in proposed work area(s) during construction.

1.2 Scope of Work

FRANZ completed the following tasks to fulfill the objectives identified above:

- Conducted a supplemental field investigation and laboratory analytical program to further investigate subsurface conditions at the former landfill and vicinity;
- Completed a biological survey at the site to identify the presence/absence of the plant species *Halimolobus virgata*;
- Developed a Site-Specific Health & Safety Plan prior to implementing the field program;
- Interpreted data from previous and current investigation(s) to ascertain if the conceptual RAP could proceed as intended or if modifications were required; and,
- Documented the findings of the supplemental investigation and biological survey in a standalone report.

The work plan for this study was based on the TOR, previous reports provided by PWGSC, recent investigations conducted by FRANZ at the site in 2011 and FRANZ's proposal dated November 3, 2011. The work plan was designed with the view to address the three (3) main data gaps identified above. Information collected from the supplemental investigation was to be obtained in sufficient detail to further refine/finalize the RAP and prepare a technical specification to implement recommended remedial activities at the site.

Both the RAP and associated technical specification developed for the site will be submitted to PWGSC under separate cover from this report.

2.0 BACKGROUND INFORMATION

2.1 Site Description

The Drumheller Institution was opened in 1967 to house medium-security inmates. The Institution is located five kilometres south-southeast of Drumheller, Alberta (See Figure 1, Appendix A). The legal description of the property is South East ¼ of Section 25; Township 28; Range 20; West of the Fourth Meridian. The main portion of the Institution is enclosed within a perimeter fence. The main living units and activities are located along with various recreational facilities. The inactive landfill is located approximately 500 m southeast of the Institution on the edge of a coulee, as shown on Figure 1, Appendix A.

The drinking water supply for the Institution is supplied by the City of Drumheller. No potable use of groundwater is made at the site. The site is relatively flat and surrounded by low rolling hills. Much of the surrounding areas to the south and east are dominated by the rolling hill terrain. Surface water drainage at the site ultimately drains towards the Red Deer River. The Red Deer River is located to the northeast and has cut deep ravines through the topography. Surrounding lands are predominantly prairie grassland, some of which has been cultivated.

The inactive landfill site covers an area measuring approximately 150 m x 200 m. It consists of a series of trenches, and received waste from the institution for more than 20 years from the mid-1960s until its closure in the late 1980s (UMA 2000). The waste material at the landfill consists of domestic waste and demolition material such as pipes, concrete, and building materials from renovations at the institution. The waste was pushed over the top edge of the slope into the coulee. The landfill was not engineered or built in compliance with landfill construction guidelines. The surface of the landfill has historically been used as a burn area and is occasionally used to store spoil piles from the excavations around the site. The topsoil and subsoil layers were not separated for use as cover before the landfill site was closed.

To the immediate west side of the landfill is an unpaved gravel access road connecting the institution and the landfill area. The coulee is located to the immediate east side of the landfill. Grazing pasture land surrounds the landfill on the north and south sides. A creek located at the bottom of the coulee drains into the Red Deer River located approximately 4 km to the northeast.

2.2 Previous Investigations

Several investigations have been completed for the Site and reviewed by FRANZ. The most relevant reports detailing these previous investigations are listed below.

- *Correctional Services Canada, Environmental Baseline Assessment, Drumheller Medium Security Institution, Site Number 530, Volume 1 of 4: Phase I Environmental Site Assessment. Prepared by PWGSC, dated February 10, 1999.*
- *Phase II Environmental Site Assessment Drumheller Institution. Prepared by UMA Engineering Ltd., dated March 2000.*
- *Supplemental Phase II Investigation, Site 530-L01, Landfill, Drumheller Institution, Drumheller, Alberta. Prepared by Franz Environmental Inc., dated March 2006.*
- *Environmental Site Investigation and Slope Stability Study for Drumheller Institution Site No. 530, Drumheller, Alberta. Prepared by Franz Environmental Inc., dated March 2011.*
- *Update memo – Drumheller Institute Site No 530 Cost Estimate Former Landfill Site 530-L01: Option 4: Completed Landfill Removal and Re-location*. *Prepared by Franz Environmental Inc., dated May 2011.*
- *Environmental Assessment - Correctional Services Canada (CSC) Drumheller Institution No. 530 Landfill Remediation, Environmental Assessment Report Submitted to Public Works and Government Services Canada (PWGSC) Pursuant to the Canadian Environmental Assessment Act (CEA Act). Prepared by Franz Environmental Inc.*, dated October 2011
- *Supplemental Environmental Site Investigation and Data Gap Analysis for the Drumheller Institution. Prepared by Franz Environmental Inc., dated November 30 2011.*
- *Data Gap Analyses – Slope Remediation Work, Drumheller Institution Landfill Site, Drumheller Alberta. Prepared by Houle Chevrier Engineering Ltd*., dated January 13, 2012.

These investigations resulted in the development of a conceptual RAP comprised of excavating native soil to re-grade the slope(s) in selected locations (those at most risk off failing) and placing it at the top of the former Landfill (cut and fill approach) and the constructing drainage channels/swales to control surface water runoff following and direct it to the native wetland located adjacent to the site. Based on the results of the above referenced reports, three main unknowns needed further investigation to plan and develop the preferred approach and finalize the RAP:

- Contents of former landfill – although indicated to be comprised of domestic and general construction waste, former tear gas canisters were found at the landfill during the September 2011 test pitting program (Franz, 2011 – see Photo 19, Appendix C). In addition, the type, location and extent of waste(s) potentially encountered during excavation/construction to implement the selected “cut and fill” approach needed to be ascertained (i.e. would planned construction work disturb buried waste(s)).
- Potential Impacted Soil by the Landfill – soils at the top of the Landfill slope maybe impacted by petroleum hydrocarbons and PAHs based on historical activities conducted at the site. The location(s), extent(s) and volume(s) of impacted soil potentially

encountered during construction/excavation also needed to be ascertained (i.e. identify any impacted soils that could not be used to re-grade the slope(s)).

- Potential federally-protected plant species – since the EA completed for the site identified that the plant species *Halimolobus virgata* could potentially be present in proposed construction work areas a survey was required to ascertain if the plant was present at the site and if so at what locations (i.e. would planned construction work potentially damaged habitat of this federally protected plant species).

Once these unknowns were quantified and information obtained to address identified data gaps the RAP could be modified as needed and finalized. Technical specifications could also be developed for the construction work required to implement the final RAP.

3.0 REGULATORY GUIDELINES

3.1 Soil Restoration Standards

Federal environmental guidelines are generally used on sites owned and operated by the federal government; however, where federal criteria do not exist, FRANZ will reference Alberta Environment guidelines.

The soil analytical results were compared to the Canadian Council of Minister of the Environment (CCME) Soil Guidelines, specifically the Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (CSQGs) and the Canada-Wide Standards for Petroleum Hydrocarbons in Soil (CWS-PHC). These guidelines are applied to most federal contaminated land sites. The guidelines are numerical limits intended to maintain, improve or protect environmental quality and human health at contaminated sites.

The CSQGs (CCME, 1999) are a subset of the Canadian Environmental Quality Guidelines and are derived to approximate a threshold level based only on scientific data, including toxicology, fate, and behaviour. The guidelines are based on direct contact, ingestion, and inhalation toxicity data as well as check mechanisms to ensure that the guidelines are protective of receptors exposed indirectly to contaminants.

The CWS-PHC (CCME, 2008a) presents standards for petroleum hydrocarbons in soil. These numerical standards are based on the assessment and consistent management of risks posed to humans, plants, animals and environmental processes under four common land uses (agricultural, residential/parkland, commercial and industrial). Under Tier 1 of the CWS-PHC, specific numerical levels are presented for the four land uses, two soil textures (coarse and fine) and the four defined petroleum hydrocarbon fractions (F1 (nC6-nC10); F2 (nC10-nC16); F3 (nC16-nC34); F4 (nC34+)) for various exposure pathways, including vapour inhalation, drinking water and eco soil contact.

The CWS-PHC also include the option to generate Tier 2 levels where site-specific information indicates that site conditions exist that modify human or ecological exposure to PHC contamination. Such conditions may alter risks significantly relative to the generic conditions used to derive Tier 1 levels. A third tier in the CWSPHC involves developing site-specific cleanup levels and management options using general and site-specific information in conducting a risk assessment.

As a preliminary and conservative determination of protection of human health and the environment at the site, FRANZ has applied Tier 1 levels to all analytical results. The appropriate levels are presented with the laboratory analytical data in tables. The rationale for

the selection of the appropriate criteria is based on an agricultural land use classification within a fine soil type matrix.

The following guidelines will be applied to analytical data:

- *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health* (CSQG*;* CCME, 2007).
- *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health – Polycyclic Aromatic Hydrocarbons* (CSQG – PAHs; CCME, 2010).
- *Canada-Wide Standards (CWS) for Petroleum Hydrocarbons (PHC) in Soil* (CCME, 2008a) - Tier 1.

3.2 Plant Species Protection

Halimolobos virgata (H. virgata) is an annual or biennial mustard that tends to flower in the spring in dry prairie areas. It has been observed at only a handful of sites in Alberta, all in the southeast region of the province, but has a range that includes Saskatchewan, Montana, Idaho, Wyoming, Utah, Colorado, Nevada and California. *H. virgata* is listed as “May be at Risk in Alberta” according to the Alberta Sustainable Resources Development (Macdonald 2005). The closest recorded observation of *H. virgata* to Drumheller was a single individual in 1914 located in Rosedale, AB, a few kilometres SE of Drumheller (Macdonald 2005). Moss and Packer (2000) described the species as follows:

> *Halimolobos virgata:* Stems, 1 or more. 10-40 cm tall stems, simple or branched, pubescent with a mixture of longer, straight, simple or forked hairs and shorter, branched hairs. Slender pedicels 7-11 mm long; fruit a glabrous, erect or nearly so, linear, terete, silique 1.5-4.0 cm long, 1 mm wide. Found in dry prairies.

4.0 INVESTIGATIVE METHODOLOGY

An Intrusive Investigation and Biological Site Survey were completed at the Drumheller Institution to address the data gaps/unknowns as identified in Section 2.2 of this report. The field program consisted of the following:

- Completing a health and safety plan prior to the field work;
- Carrying out utility clearances;
- Excavating sixteen (16) test pits within identified areas of potential environmental concern using a Hitachi 160 excavator. Test pits were excavated to a maximum depth of 6 m;
- Collecting soil and fill samples at 0.5 to 1.0 m intervals from each test pit to investigate subsurface conditions and assess potential waste(s) located within the former landfill (where encountered);
- Submitting selected soil samples for laboratory chemical analysis of PAHs, PHCs and metals;
- Interviewing personnel familiar with historical activities conducted at the former landfill site; and,
- Documenting encountered conditions and using obtained information to update the conceptual RAP prepared for the site and develop Technical Specification(s) to implement it.

The field work undertaken during the Landfill Intrusive Investigation and Biological Site Survey was conducted in accordance with the TOR and FRANZ's proposal dated November 3, 2011. The field investigation procedures are described in more detail in Section 4.1 to 4.6 below.

4.1 Health & Safety Plan

Before commencing with site activities, a site-specific health and safety plan (HASP) was prepared. The HASP identified and provided mitigative actions for potential physical and chemical hazards associated with the work involved in the site investigation. The HASP also contained a listing of emergency contact numbers and provided protocols to follow in the event of an emergency. A copy of the HASP has been retained on file at FRANZ.

4.2 Utility Locates

Upon arrival at the site, FRANZ discussed underground utilities with the CSC staff. It was confirmed that underground utilities were not present at the site. A working fire hydrant was located on site. The approximate location of underground piping associated with the fire hydrant was determined by CSC staff and appropriate measures taken to adjust test pit locations accordingly. Due diligence was followed visually, based on site features.

4.3 Test Pitting and Soil/Waste Sampling

Sixteen (16) test pits were excavated to a maximum depth of 6 m on November 29th and 30th 2011. Excavation of the test pits was completed by Quadrock Trucking and Excavation (Quadrock) of Drumheller, Alberta using a Hitachi 160 excavator. Samples were collected from the test pit wall and homogenized prior to insertion into laboratory supplied sample jars.

Subsurface conditions encountered in the test pits were logged and photographed at the time of excavation. Soil samples were screened for visual and olfactory indicators of impacts such as staining or odours. No visual or olfactory indicators of impacts were observed during the site visit. Soil descriptions including approximate grain size, colour, moisture content, stratigraphy, debris present and nature and extent of apparent contamination was recorded for each unit. An estimation of the percentage of waste (e.g. metal, wood, concrete) as a proportion of the total fill volume was made in each test pit to ascertain waste type and distribution.

The location and rational for the test pits are provided below. Test pit locations are shown in Figure 2, Appendix A:

Table 4–1: Proposed Test Pit Locations

Location	# of TPs or Samples	Rational
A- Buried materials	3	Determine the absence/presence of buried waste materials
B- Soil Piles	3	Determine surficial impacts and buried waste
C- Burned area	4	Determine surficial impacts and buried waste
D- Buried materials	6	Determine the absence/presence of buried waste materials

The method adapted to excavate and sample from each test pit was consistent between test pit locations. The following represents the level of consistency maintained between each test pit:

- Each test pit was excavated from ground surface to a depth of approximately 6 m;
- Subsurface materials encountered during test pitting were inspected, described and photographed; and,
- Representative soil and fill samples were be collected at 0.5 to 1.0 m intervals in each test pit.

Seventy six (76) soil samples were collected from the sixteen (16) test pits located within and around areas of potential environmental concern (Figure 2). Samples were taken at regular depth intervals to characterise the distribution of native soil and imported fill in the vicinity of the former landfill and ascertain the types and distribution of waste material mixed in with the fill.

In test pits were imported fill was encountered a visual inspection was carried out to identify the presence/absence of waste(s). If waste material was encountered, a visual inspection was

carried out to further characterize the materials present (i.e. construction debris, scrap metal etc.) and the depths encountered within the test pit.

Twenty-two (22) soil samples were submitted for analysis of metals (including duplicate samples) and eighteen (18) soil samples (including duplicate samples) were submitted for analysis of both PAH's and PHC's. Three (3) soil samples representative of the three most prominent soil type matrices at the site (based on visual observations) were submitted for grain size analysis.

Additional information on soil and waste sampling during test pitting can be found in the photographic log and test pit logs which are provided in Appendix C and D of this report.

4.4 Interviews

The operator (Clayton Schrock of Quadrock) of the excavator used for the intrusive test pitting investigation was involved in the construction and operation of the former landfill construction. Subsequently, Mr. Schrock was interviewed to extract information on the construction and historical operation of the former landfill. This information was used to improve the conceptual understanding of the types and placement of waste within the former landfill.

4.5 Quality Assurance and Quality Control

A quality assurance and quality control (QA/QC) program was implemented during soil sampling activities to minimize and allow for identification of any potential problems arising from sample collection, handling, shipping and analysis. As part of the QA/QC program, sampling protocols included minimizing sample handling, submitting field QA/QC samples using dedicated non-contaminating sampling equipment, using sample specific identification and labelling procedures and submitting samples to the laboratory within analytical method hold times using dedicated chain of custody records. Field QC samples included at least one (1) blind field duplicate soil sample for every ten (10) analysed samples. .Laboratory QA/QC measures included analysis of laboratory blank, spiked blank, duplicate and matrix spike samples.

The results of the QA/QC program are discussed in Section 5.3 of this report.

4.6 Laboratory Analytical Program

Representative soil samples were submitted to Maxxam Analytics in Calgary, Alberta for chemical analysis for various target compounds previously identified. Maxxam is certified by the Canadian Association for Laboratory Accreditation, Inc. (CALA) and has an internal QA/QC protocol. The laboratory QA/QC documentation provided with the laboratory certificates of analyses was reviewed by FRANZ as part of the QA/QC protocol. The laboratory certificates of analyses and chain of custody forms are presented in Appendix E.

4.7 Biological Site Survey

The objective of the biological site survey is to determine the presence or absence of *Halimolobos virgata* at the former landfill site. The site survey was conducted on November 28, 2011 by Mr. Tan Bao, a Ph.D. student in botany from the University of Alberta. The survey focussed on the area of the former Landfill and vicinity where construction to stabilize the slope of the former landfill would need to occur.

The work area, as well as a 25 m by 50 m margin around the work area, was censured using a series of line transects and GPS located quadrants. The line transects were designed to survey as extensive a portion of the work area as possible. The quadrants were then used to sample the vegetation in detail. A total of one hundred 1 m by 1 m quadrants were sampled.

Additional details on the biological survey methodology can be found in Mr. Boa's report, a copy of which is provided in Appendix F.

5.0 INVESTIGATION RESULTS AND DISCUSSION

5.1 Soil Analytical Results

Analytical results for soil samples submitted for PHC analyses along with selected CCME CSQG and CWS PHCS are presented in Table 1, Appendix B. As shown in the table, all of the submitted samples satisfy the selected standards for the parameters tested with one exception. Sample TP5-11-02 collected from 0-1 m below ground surface (m bgs) within an area of fill which included asphalt had reported concentrations of benzene and ethylbenzene above CCME CSQG guideline values of 0.0068 mg/kg and 0.018 mg/kg respectively..

Analytical results for soil samples submitted for PAH analyses along with selected CCME CSQG are presented in Table 2, Appendix B. As shown in the table, all of the submitted samples satisfy the selected standards for the parameters tested.

Analytical results for soil samples submitted for metals analyses along with selected CCME CSQG Guidelines are presented in Table 3, Appendix B. As shown in the table, all of the submitted samples satisfy the selected standards for the parameters tested with two exceptions. Sample TP13-11-04 collected from soil strata dominated by native, undisturbed silty clay material reported concentrations of selenium above the CCME CSQG value of 1 mg/kg. Sample TP6-11-07 collected at 5 m bgs and comprised of clay with some silt and gravel reported concentrations of tin above the CCME CSQG of 5 mg/kg.

Laboratory certificates of analyses for the above mentioned soil samples can be found in Appendix E. The locations of soil samples that exceed selected CCME CSQG or CWS PHCS are shown in Figure 3 in Appendix A.

5.2 Grain Size Analytical Results

Analytical results for soil samples submitted for grain size analyses are presented in Table 4. As shown in the tables, the samples range from a low of 29% of particles greater than 0.075 mm (sample TP9-11-07 collected from native silty clay) to 70% of particles greater than 0.075 mm (sample TP10-11-02 collected from fill material that included compact clay).

Based on the results of the grain size analyses, silty clay soils at the site and vicinity are considered fine grained and as a result the standards for fine grained soils from the CCME CSQC and the CWS PHCS were selected for the site.

Grain size curves for the above mentioned soil samples are provided in Appendix E.

5.3 Quality Assurance/Quality Control

The results of field duplicate soil and ground water analyses are summarized in Tables 1 to 3, respectively. The results of other QA/QC analyses and the relative percent difference (RPD) calculations for laboratory duplicate analyses are provided in the Laboratory Certificates of Analysis (Appendix E).

Relative percent difference (RPD) calculations (where calculated) for field duplicate soil and ground water samples are summarized in Tables 1 to 3, respectively. Note that consistent with laboratory practices, meaningful RPD values for field duplicate analyses were calculated only where detected concentrations in both the sample and its duplicate were greater than five (5) times the laboratory reportable detection limit (RDL). With the exception of a few instances, results of field and laboratory duplicate analyses generally agreed with their respective analytical pairs, and laboratory and field RPD values (where calculated) were generally within acceptance criteria and alert limits with the exception noted below.

Sample TP-1-11-03 and its field duplicate (TP1-DUP1) reported an unacceptable RPD for nickel. The calculated RPD was 44.8% vs. industry standards of 40% or less. The difference in concentrations between the sample and its duplicate pair and the resulting RPD are attributed to sample heterogeneity, particularly between native soil and fill materials.

Overall, laboratory and field QC results confirm that sample handling and analytical protocols were acceptable, and the results were reproducible.

5.4 Historical Landfilling Activities

The information provided by Clayton Schrock regarding historical activities at the site can be summarized as follows:

- Trucks entered the landfill via the currently used access road and dumped material over the edge of what was then an original ‘native’ coulee slope.
- Mr. Shrock can only recall building and/or demolition waste, for example bed frames and concrete, being deposited on-site. He recalls that organic waste such as food waste was deposited elsewhere within the Institution’s compound.
- Loose material, such as scrap metal, conduits and old beds, were also dumped over the slope, he recalls the material ‘rolling down the slope’.
- A temporary road was engineered roughly half way (60-70 ft) down from the top of the slope to aid the excavator in moving material across the slope face.
- Following dumping of waste material, the slope was then covered by clay extracted from two clay hills, located in the valley at the base of the coulees.
- Site workers were instructed to cover up the unsightly areas of the landfill with sufficient volumes of extracted clay, so that the loose waste material would no longer be visible.

- Mr. Shrock is of the opinion that the locations where loose material (as defined above) was dumped and covered with imported clay fill from the valley may correspond to areas of failure (i.e. sloughed portions) presently observed on the slopes.

The information provided during the interview generally corresponds to conditions encountered during test pitting (see Section 5.5 below). A visual interpretation of historical landfilling practices, based on the anecdotal information obtained from Mr. Schrock is presented in Figure 4, Appendix A.

5.5 Distribution and Types of Waste in Former Landfill

Thirteen (13) of the test pits excavated at the site encountered fill material. Fill encountered during test pitting was comprised primarily of silty clay and/or compact fill. Some sand and/or gravel were also encountered in the fill material. Fill material was not encountered in test pits TP1, TP 13 and TP-14 located at the western portion of the former landfill away from the edge of the slope.

Waste material (e.g. plastic, iron mesh, piping, concrete bricks and slabs, wood, glass), was encountered in ten (10) of the thirteen (13) test pits were imported fill was present. Imported fill encountered by test pits TP8, TP9 and TP10 located near the central portion of the landfill were free of waste. Waste was encountered in test pits TP2, TP3, TP4, TP5, TP6, TP7, TP11, TP12, TP15 and TP16 (refer to Figure 2 for test pit locations). The depth and density of waste materials increases towards the eastern and northern limits of the former landfill (towards the edge of the slope). A summary of the type and distribution of waste and fill material encountered by excavated test pit's TP1 through TP16 is provided in Table 5. A spatial representation of fill and waste material within the former landfill is depicted in two cross sections thru the landfill presented in Figure 5, Appendix A.

The tear gas canister encountered at the site in August 2011 appears to be an isolated occurrence. No tear gas canisters or other potentially hazardous waste materials were encountered during test pitting. The waste material encountered during test pitting can be segregated and managed during futures slope construction activities.

5.6 Biological Site Survey

The results of the biological site survey are documented in the report prepared by Mr. Boa that is provided in Appendix F and are summarized below:

1) No individuals of *Halimolobos virgata* (*H. virgata)* were observed on the line transects.
2) A single individual plant was observed in quadrant 92 that was putatively identified as *H. virgata* (refer to Figure 4, Appendix F). Six quadrants were placed immediately adjacent to quadrant 92 to identify other individuals however; none were found. Quadrant 92

rests on top of the landfill site, as opposed to the natural undisturbed area surrounding the former landfill. Quadrant 92 was located between two piles of construction material (rocks). *H. Virgata* was not identified in any other quadrant.

3) Definitive identification will require flower and leaf traits which were not observable.

4) The University of Alberta Vascular Plant Herbarium was consulted on Dec. 1, 2011 to see if any additional records of *H. virgata* existed in the vicinity of Drumheller. There were no specimens on record.

6.0 DISCUSSION

As mentioned in Section 1.2 of this report, the additional information collected during this investigation was used to evaluate the three main unknowns as indentified in the conceptual remedial action plan (RAP) and draft Environmental Assessment (EA) previously completed for the site by Franz in 2011. A final RAP for the site and the Technical Specifications required to implement it will be submitted to PWGSC under separate cover.

The following sections discuss each potential data gap, the results obtained by the current investigation and the resulting effect on the conceptual RAP previously developed for the site.

6.1 Potential Waste in Former Landfill

Waste material was encountered mixed within imported fill in ten (10) of the thirteen (13) test pits excavated at the site. The extent and distribution of the waste is well defined (refer to Table 5 and Figure 5). Native soil, fill and waste material excavated from the face of the slope will be brought to the top of the landfill and spread out. Based on current activities at the site, nominal compaction will be required at the top of the landfill. Provisions will be made to segregate and manage waste material encountered during excavation and regrading of the slope using conventional equipment such as a sifter. Provisions will also be in place to import fill (either from a soil and gravel pit near the site or a temporary borrow pit established in a coulee near the site) if necessary to cover the waste(s) and suitably compact material placed at the top of the former landfill.

No tear gas canisters or other potentially hazardous waste materials were encountered during test pitting. Provisions to contact CSC staff in the event any additional tear gas canisters are encountered will be included in any health and safety plans developed for construction work implemented at the site.

Based on the above, the conceptual RAP can proceed at the site. If imported fill is required, there will be a corresponding effect to overall project costs since it is more costly to import and place fill at the site than to re-use native soil. As such, both the final RAP and technical specifications submitted to PWGSC will include provisions and associated cost implications based on the estimated volume of waste that could potential not be re-usable and the type of fill material required (i.e. off-site pit vs. local borrow source) in its place.

6.2 Potentially Impacted Soil by top of Former Landfill

Based on soil analytical results for submitted soil samples, soil located within the former landfill is not impacted by PAHs. Impacted soil was encountered in localized areas at the site. Soil with concentrations of benzene and ethylbenzene slightly above selected CCME CSQGs was encountered in test pit TP5. Soil with concentrations of selenium above selected CCME

CSQGs was encountered in test pit TP13 and soil with concentrations of tin above selected CCME CSQGs was encountered in test pit TP6.

The locations on impacted soil are well defined and are not widespread across the site. In addition, reported concentrations for benzene and ethylbenze marginally exceed selected CCME CSQG while selenium and tin are not parameters with considerable health concerns. As such provisions to segregate impacted soil, and if required dispose of it off-site, can be included in the soil management plan (SMP) included within the RAP and technical specifications.

As such the impacted soil indentified at the site does not change the conceptual RAP previously developed.

6.3 Federally Protected *Halimolobos virgata*

Mr. Tan Boa, a Ph.D. student in botany failed to positively identify any *Halimolobos virgata (H. virgata)* during the biological survey he conducted at the site. While Mr. Boa did observe a single plant located at the top of the former landfill that could potentially be *H. virgata*, there are no records of any actual specimens of *H. virgata* being encountered in the vicinity of Drumheller on file at the University of Alberta Vascular Plant Herbarium. Definitive identification of this plant will require flower and leaf traits which will be observable in the spring of 2012. .In the event that this single plant is positively identified as *H. virgata* next spring it could be transplanted to another location at the Drumhheller Institution away from proposed construction activities and further protected by CSC staff working at the institution.

The conceptual RAP can proceed as planned provided that the above provisions are in place to address the presence of a single plant that could potentially be *H. virgata*.

6.4 Overall Impact on the Conceptual RAP

As discussed in Sections 6.1 to 6.3 above, the three main unknowns previously identified at the site have been quantified and can be addressed during future construction. The conceptual RAP will be finalized and technical specifications developed, both of which will be submitted to PWGSC under separate cover.

7.0 CONCLUSIONS AND RECOMMENDATIONS

1. FRANZ was retained by PWGSC on behalf of CSC to complete a Supplemental Environmental Site Investigation and Data Gap Analysis for the Drumheller Institution Site No.530 in Drumheller, Alberta. This work was completed as a sub-task for the remediation planning of the Former Landfill Site No. 530.

2. The field work undertaken during this supplemental site investigation was aimed at addressing three unknowns previously identified at the site and collecting additional information to address associated data gaps.

3. A total of sixteen (16) test pits were excavated to a depth of up to 6 m on November 29 and 30, 2011 to collect soil and fill samples to characterize subsurface conditions and assess the extent of waste(s) potentially located at the site. Based on the potential contaminants of concern previously identified at the site twenty-two (22) soil samples were submitted for analysis of metals (including duplicate samples) and eighteen (18) soil samples (including duplicate samples) were submitted for analysis of both PAH's and PHC's.

4. Waste material (e.g. plastic, iron mesh, piping, concrete bricks and slabs, wood, glass), was encountered in ten (10) of the test pits excavated at the site. The horizontal and lateral extent of waste within the proposed construction area(s) are well defined and the RAP developed for the site will include provisions to segregate waste during excavation and/or use imported fill to cover it and or achieve suitable compaction (if required) during the cut and fill work.

5. Tear gas canisters, similar to the one identified at the site in August 2011 were not encountered during test pitting. No other types of hazardous waste were encountered during test pitting. None the less the site specific health and safety plan developed for future construction work will include provisions to contact CSC staff should any tear gas canisters be encountered during construction.

6. Soil with concentrations of benzene and ethylbenzene slightly above selected CCME CSQGs was encountered in test pit TP5. Soil with concentrations of selenium above selected CCME CSQGs was encountered in test pit TP13 and soil with concentrations of tin above selected CCME CSQGs was encountered in test pit TP6. The location and extent of impacted soil are localized and concentrations are such that impacted soil can be managed during construction. The SMP developed for the RAP will also include provisions to segregate and dispose impacted soil off-site (if required).

7. No indentified specimens of the federally protected plant species *Halimolobus virgata (H. virgata)* were identified during the biological survey conducted at the site. One plant that could potentially be *H. virgata* was identified at the top of the former landfill. Should this

plant prove to be *H. virgata* it can be transplanted prior to construction and protected over time by CSC staff working at the Drumheller Institution.

8. The conceptual RAP developed for the site can proceed at the site. The final RAP and technical specifications developed to implement it will include provision to manage identified areas of impacted soil, segregate waste materials, import fill (if required) and transplant one plant specimen should it prove to be *H. virgata*.
9. Both the final RAP and technical specifications developed for the site will be submitted to PWGSC under separate cover from this report.

8.0 LIMITATIONS

This report has been prepared exclusively for PWGSC and CSC. Any other person or entity may not rely upon the report without the express written consent from Franz Environmental Inc., PWGSC, and CSC.

Any use that a third party makes of this report, or any reliance on decisions made based on it, is the responsibility of such third parties. Franz Environmental Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Some of the information presented in this report was provided through existing documents and interviews. Although attempts were made, whenever possible, to obtain a minimum of two confirmatory sources of information, Franz Environmental Inc., in certain instances, has been required to assume that the information provided is accurate.

The conclusions presented represent the best judgment of the assessors based on current environmental standards and on the site conditions observed on August 19, 2011. Due to the nature of the investigation and the limited data available, the assessors cannot warrant against undiscovered environmental liabilities.

Should additional information become available, Franz Environmental Inc. requests that this information be brought to our attention so that we may re-assess the conclusions presented herein.

There is no warranty, expressed or implied that the work reported herein has uncovered all potential environmental liabilities, nor does the report preclude the possibility of contamination outside of the areas of investigation. The findings of this report were developed in a manner consistent with a level of care and skill normally exercised by members of the environmental science and engineering profession currently practicing under similar conditions in the area.

A potential remains for the presence of unknown, unidentified, or unforeseen surface and sub-surface contamination. Any evidence of such potential site contamination would require appropriate surface and sub-surface exploration and testing.

If new information is developed in future work (which may include excavations, borings, or other studies), Franz Environmental Inc. should be requested to re-evaluate the conclusions of this report, and to provide amendments as required.

9.0 REFERENCES

Franz Environmental Inc., Supplemental Phase II Investigation, Site 530-L01, Landfill Drumheller Institution, Drumheller Alberta, dated March 2006.

Franz Environmental Inc., Environmental Site Investigation and Slope Stability Study for Drumheller Institution Site No. 530, Drumheller, Alberta, dated March 2011.

Canadian Council of Ministers of the Environment. 2007. *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health.*

UMA Engineering Ltd. Phase II Environmental Site Assessment, Drumheller Institution, March 2000.

10.0 CLOSURE

We trust that this information is satisfactory for your present requirements. Should you have any questions or require additional information, please do not hesitate to contact the undersigned.

Sincerely,

Franz Environmental Inc.

DRAFT

Steve Livingstone, M.Sc., P.Geo.
Vice President

DRAFT

Mike Grinnell, P.Eng.
Senior Environmental Engineer

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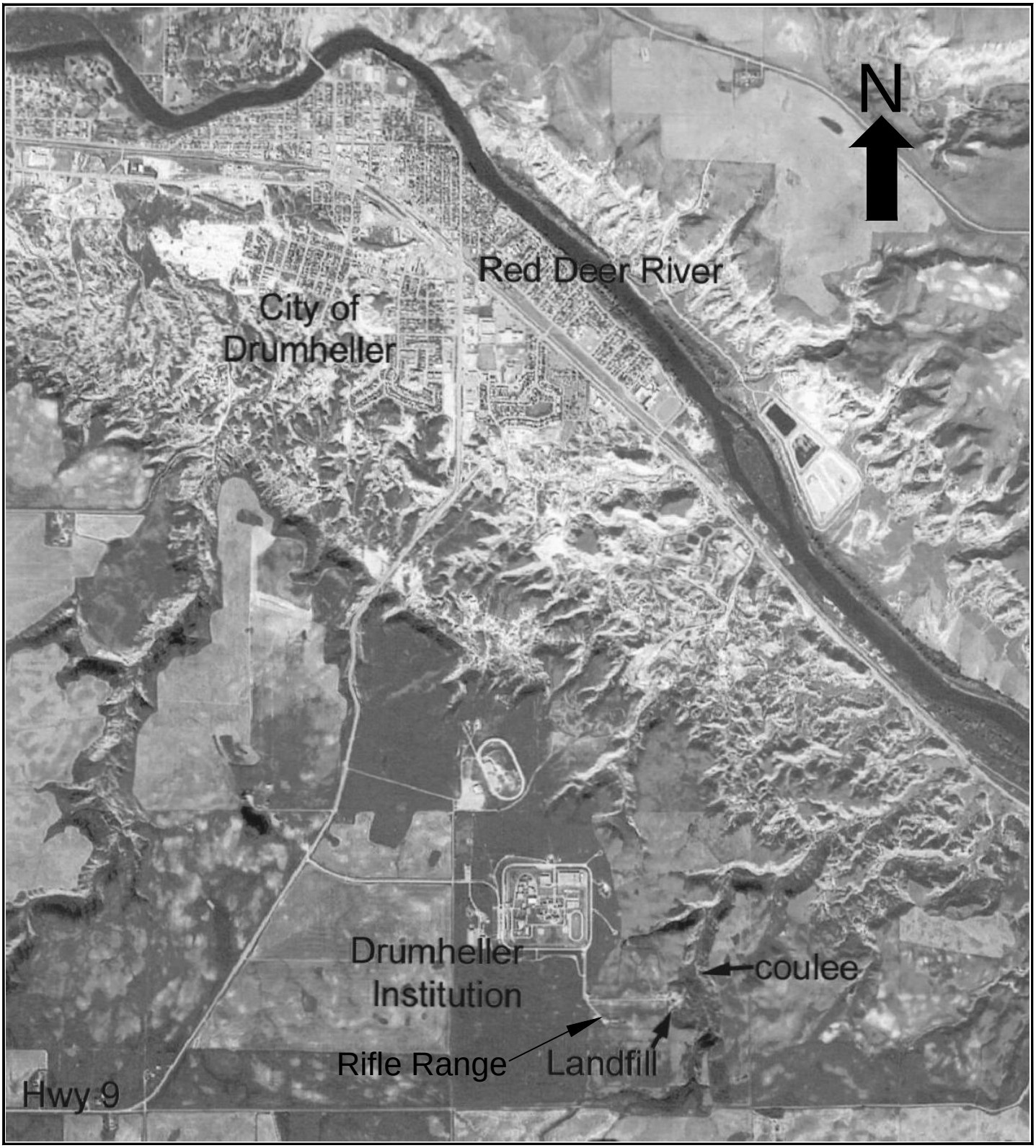
APPENDIX A

Figures



Title: SITE LOCATION

Project: LANDFILL INTRUSIVE INVESTIGATION AND BIOLOGICAL SITE SURVEY DRUMHELLER INSTITUTION, DRUMHELLER, AB

Client: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

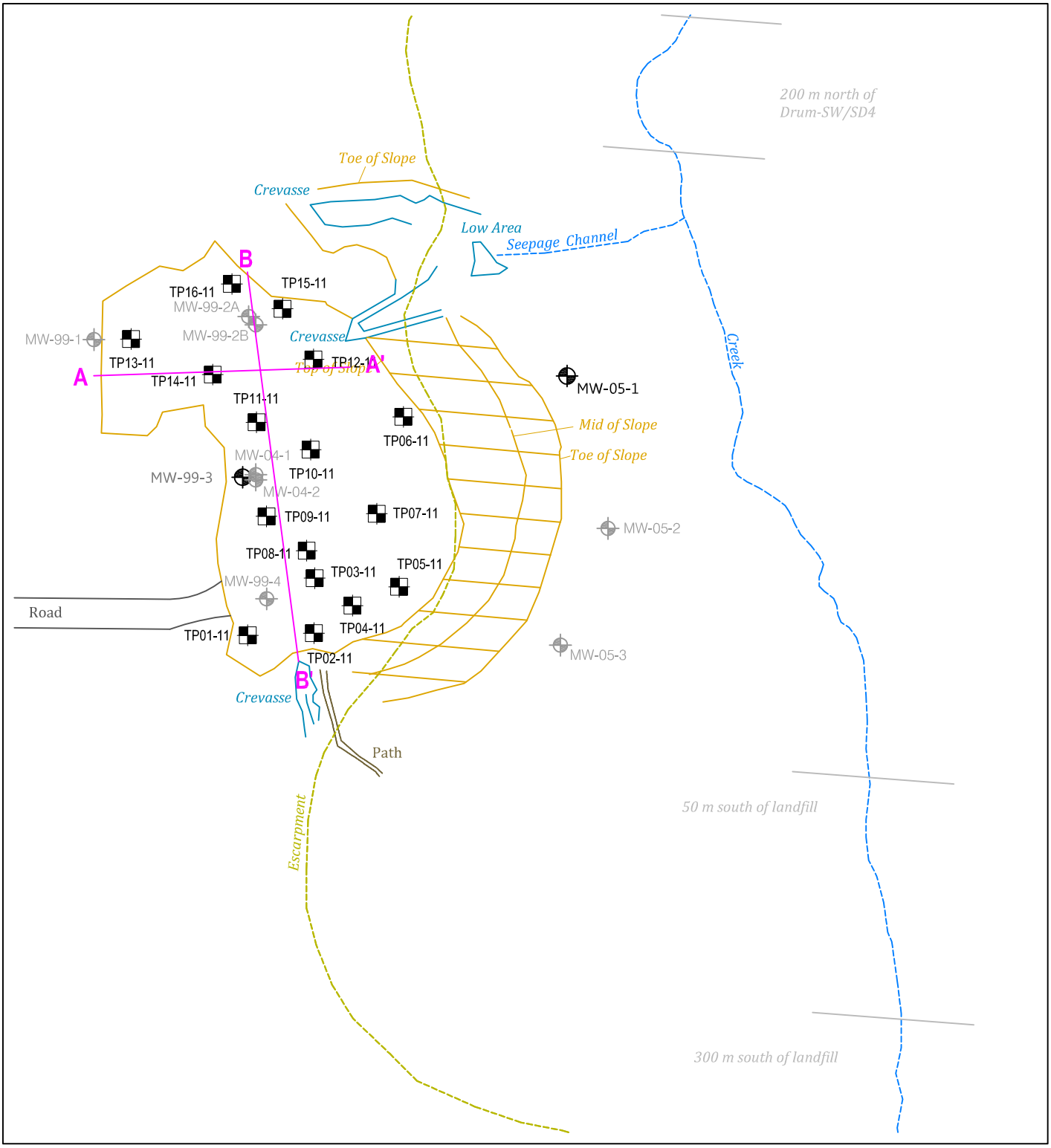
FRANZ ENVIRONMENTAL INC.
♦ CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Date: DECEMBER 2011

FIGURE 1

Scale 1:30,000
500 250 0 Metres 500 1000

Reference:
Franz Environmental Inc. 2006. Supplemental Phase II Investigation Site 530-L01, Landfill Drumheller Institution, Alberta



LEGEND

- Monitoring Well with Sufficient Volume for Sampling
- Previously Installed Monitoring Well
- Test Pit
- A——A Cross Section Line

Scale 1:1,600

32 24 16 0 16 32
metres

Title: STATION LOCATIONS

Project: LANDFILL INTRUSIVE INVESTIGATION AND BIOLOGICAL SITE SURVEY, DRUMHELLER INSTITUTION, DRUMHELLER, AB

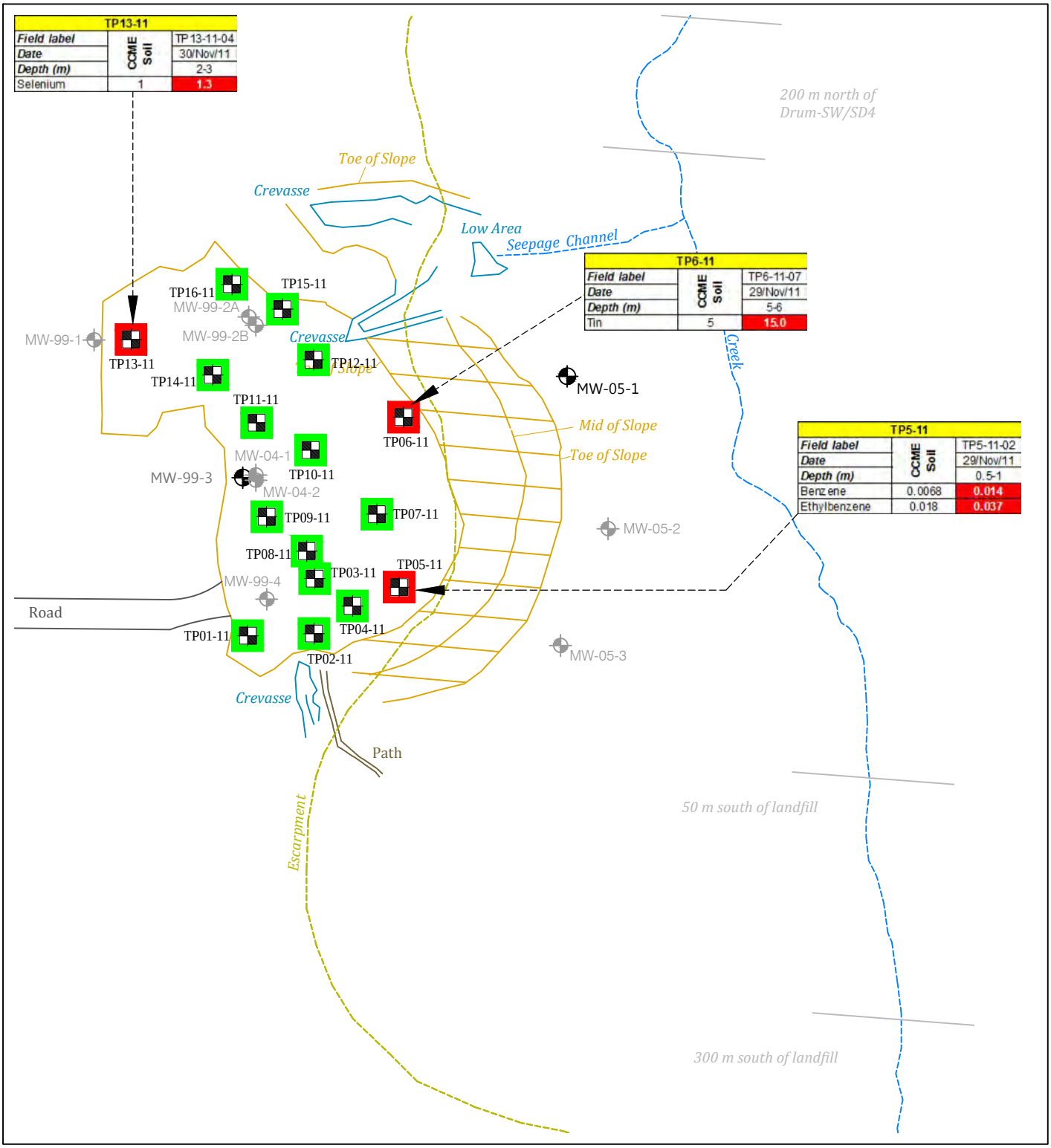
Client: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

FRANZ ENVIRONMENTAL INC.
CONSULTING ENGINEERING TECHNOLOGIES

Date: DECEMBER 2011

FIGURE 2

2026-1101/CAD/NR/Analytical_19122011.dwg



LEGEND

- Monitoring Well with Sufficient Volume for Sampling
- Previously Installed Monitoring Well
- Test Pit
- One or More Analytical Results are Greater than the Applicable Standards
- All Analytical Results is Less than the Applicable Standards

Scale 1:1,600

32 24 16 0 16 32

metres

ote eported on entration in g/g nless indicated otherwise

title

SOIL ANALYTICAL RESULTS

roject

LANDFILL INTRUSIVE INVESTIGATION AND BIOLOGICAL SITE SURVEY, DRUMHELLER INSTITUTION, DRUMHELLER, AB

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PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

FRANZ ENVIRONMENTAL INC.

CONSULTING ENGINEERING TECHNOLOGIES

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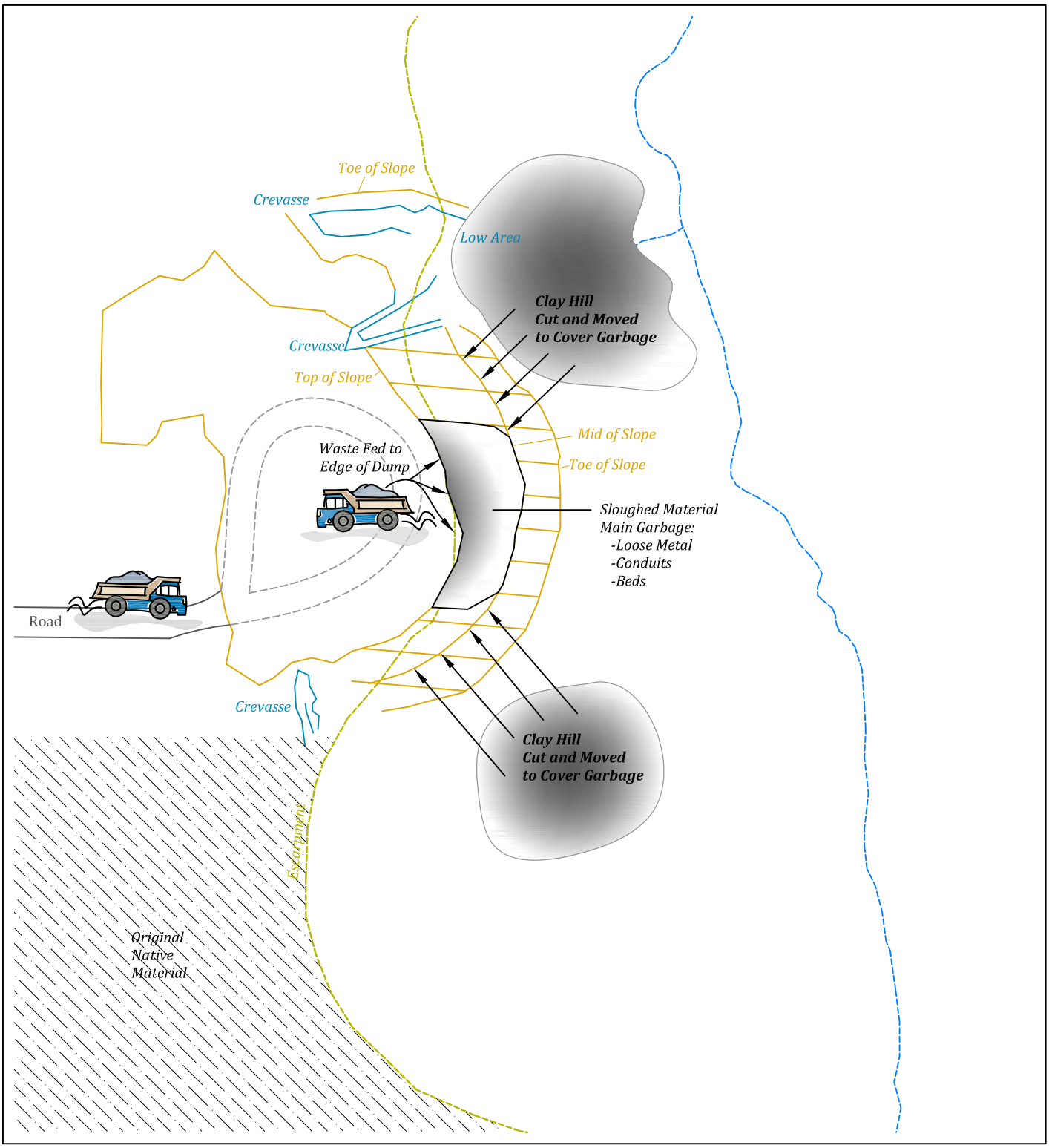
DECEMBER 2011

FIGURE 3

2026-1101/CAD/NR/Analytical_19122011.dwg



Scale 1:1,600

32 24 16 0 16 32

metres

Title: ANECDOTAL EVIDENCE ON HISTORICAL WASTE PLACEMENT

Project: LANDFILL INTRUSIVE INVESTIGATION AND BIOLOGICAL SITE SURVEY, DRUMHELLER INSTITUTION, DRUMHELLER, AB

Client: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

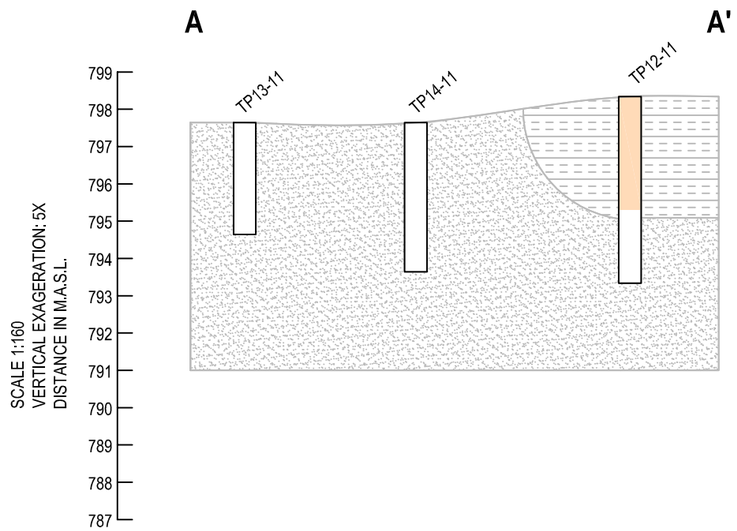
FRANZ ENVIRONMENTAL INC.

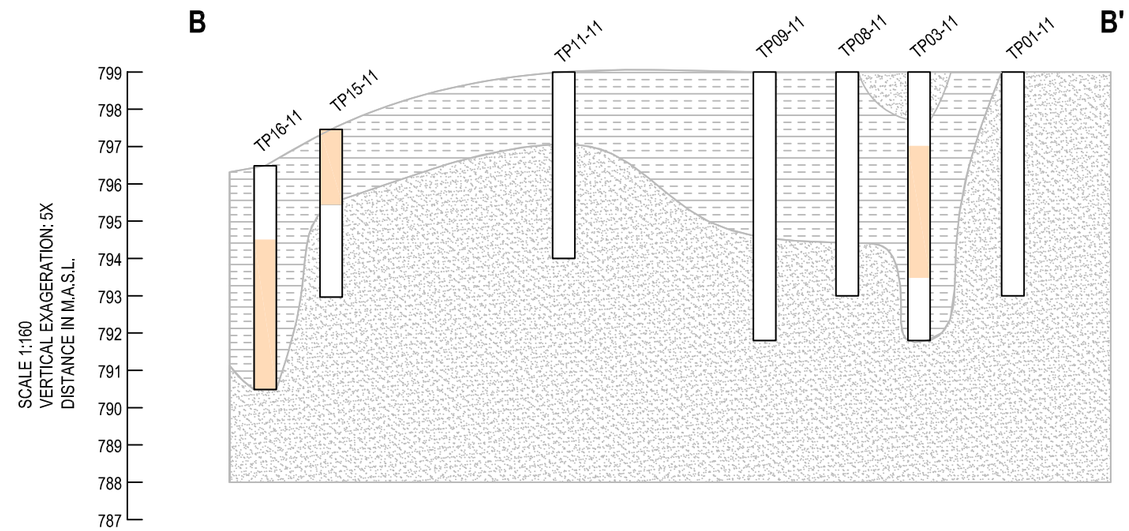
♦ CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Date: DECEMBER 2011

FIGURE 4

2026-1101/CAD/NR/Analytical_19122011.dwg





TP13 and TP14
-Silty clay. Native material.

-Sieve analysis (% >0.075 mm) of native material from TP9 (not included in cross section): 29.0%.

TP12
-Waste material present: concrete building material >300 mm, metal sheets and poles, plastic.

-Fill material matrix of silty clay and gravel.

-Volume of waste as a percentage of total fill volume within 0-3 m below ground level (bgl): 5-10%

-Sieve analysis (% >0.075 mm), loose fill material of silty clay : 48.0 % at 0-3 m bgl.

TP16
-Waste material present: red shale, large concrete building material >300 mm.

-Fill material matrix of silty clay, sand, gravel and some cobbles.

-Volume of waste as a percentage of total fill volume within 0-2 m bgl: 5-10%

-Volume of waste as a percentage of total fill volume within 2-6 m bgl: 15-20%

-Larger pieces of concrete waste, greater in number and density towards the floor (6 m bgl) of the test pit.

TP15
-Waste material present: concrete building waste, metal wire, metal mesh, wood, glass.

-Fill material matrix of clay and some sand.

-Volume of waste as a percentage of total fill volume, within 0-2 m bgl: 10-15%

TP11
-Waste material present: wood chippings, red shale, plastic, Styrofoam, ceramic pieces.

-Fill material matrix of clay, silt, gravel.

-Volume of waste as a percentage of total fill volume, within 0-2 m bgl: 1-5%.

TP09
-Fill material present comprises of disturbed native material (e.g. silty clay) and very compact red shale.

-Sieve analysis (% >0.075 mm), native material (silty clay): 29.0 % at 5-6 m bgl.

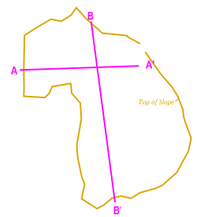
TP08
-Dense compact fill material comprising of disturbed native material and clay.

TP03
-Waste material present: plastic and metal pieces, piping, wire, concrete, ceramic, wood, glass, foam.

-Fill material matrix of silty clay with some sand.

-Volume of waste as a percentage of total fill volume, within 0-5.5 m bgl: 20-25%

TP01
-Silty clay. Native material.



LEGEND

- Silty Clay
- Fill
- Gross Waste
- A——A Cross Section Line
- Testpit

Scale 1:800
16 8 0 8 16
metres

Title: DRUMHELLER LANDFILL WASTE CROSS SECTION

Project: LANDFILL INTRUSION INVESTIGATION AND BIOLOGICAL SITE SURVEY, DRUMHELLER INSTITUTION, DRUMHELLER, AB

Client: PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

FRANZ ENVIRONMENTAL INC.
♦ CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Date: DECEMBER 2011

FIGURE 5

2026-1101/CAD/CB/cross section.dwg

APPENDIX B

Tables

Parameter		RDL	Canadian Federal				TP1-11-03	TP1-DUP1	Relative Percent Difference (%)	TP2-11-04	TP2-11-07	TP3-11-07	TP4-11-05	TP5-11-02	TP6-11-07	TP7-11-05	TP8-11-04	TP8-DUP2	Relative Percent Difference (%)	TP9-11-07	TP10-11-02	TP11-11-03	TP12-11-04	TP15-11-03	TP15-11-04	TP16-11-02
Sampling Date			CCME[1] Agricultural		CWS for PHC [2] in Soil (Tier 1)		29/Nov/11	29/Nov/11		29/Nov/11	29/Nov/11	29/Nov/11	29/Nov/11	29/Nov/11	29/Nov/11	29/Nov/11	30/Nov/11	30/Nov/11		30/Nov/11	30/Nov/11	30/Nov/11	30/Nov/11	30/Nov/11	30/Nov/11	30/Nov/11
Depth (m)			Surface (<1.5m)	Subsoil (>1.5m)	Surface (<3m)	Subsoil (>3m)	1-2	1-2		2-3	5-6	5-6	3-4	0.5-1	5-6	3-4	2-3	2-3		5-6	0.5-1	1-2	2-3	1-2	2-3	0.5-1
BTEX mg/kg	Benzene	0.005	**0.0068**	**0.0068**	---	---	<0.0050	<0.0050	0.0	<0.0050	<0.0050	<0.0050	<0.0050	0.014	<0.0050	<0.0050	<0.0050	<0.0050	0.0	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Toluene	0.02	**0.08**	**0.08**	---	---	<0.020	<0.020	0.0	<0.020	<0.020	<0.020	0.042	0.077	<0.020	<0.020	<0.020	<0.020	0.0	<0.020	<0.020	<0.020	<0.020	0.075	<0.020	<0.020
	Ethylbenzene	0.01	**0.018**	**0.018**	---	---	<0.010	<0.010	0.0	<0.010	<0.010	<0.010	<0.010	0.037	<0.010	<0.010	<0.010	<0.010	0.0	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
	Total Xylenes	0.04	**2.4**	**2.4**	**---**	**---**	<0.040	<0.040	0.0	<0.040	<0.040	<0.040	<0.040	0.17	<0.040	<0.040	<0.040	<0.040	0.0	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
PHC mg/kg	C6-C10 Hydrocarbons (F1)	12	---	---	**210**	**170**	<12	<12	0.0	<12	<12	<12	<12	<12	<12	<12	<12	<12	0.0	<12	<12	<12	<12	<12	<12	<12
	C10-C16 Hydrocarbons (F2)	10	---	---	**150**	**230**	<10	<10	0.0	<10	<10	<10	<10	13	<10	<10	<10	<10	0.0	<10	<10	<10	<10	<10	<10	<10
	C16-C34 Hydrocarbons (F3)	10	---	---	**1300**	**3500**	<10	<10	0.0	<10	<10	<10	53	63	<10	<10	<10	<10	0.0	<10	<10	<10	<10	<10	<10	<10
	C34-C50 Hydrocarbons (F4)	10	---	---	**5600**	**10000**	<10	<10	0.0	<10	<10	<10	66	<10	<10	<10	<10	<10	0.0	<10	<10	<10	<10	<10	<10	<10

Notes:

All units in mg/kg, unless stated otherwise.

1 Canadian Council of Ministers of the Environment, Canadian Soil Quality Guidelines, (Using Agricultural, fine-grained soil). Table 2 and 3: Soil quality guidelines and check values.

2 Canadian Council of Ministers of the Environment Canadian-Wide Standards for Petroleum Hydrocarbons in Soil, Table 1: Summary of Tier 1 Levels (mk/kg soil) surface/sub soil, (2008). (Using Agricultrual, fine-grained soil, non-potable groundwater)

--- = No criterion/guideline established

RDL = Reportable Detection Limit

RDP = Relative Percent Difference

ND = Analytical results are below laboratory MDL

20 Denotes chemical exceedances of selected CWS or CCME criterion

20 Denotes unacceptable Relative Percent Difference

Field label	CCME[1] Agricultural	Lowest RDL	TP1-11-03	TP1-DUP1	Relative Percent Difference (%)	TP2-11-04	TP2-11-07	TP3-11-07	TP4-11-05	TP5-11-02	TP6-11-07	TP7-11-05	TP8-11-04	TP8-DUP2	Relative Percent Difference (%)	TP9-11-07
Date			29/Nov/11	29/Nov/11		29/Nov/11	29/Nov/11	29/Nov/11	29/Nov/11	29/Nov/11	29/Nov/11	29/Nov/11	30/Nov/11	30/Nov/11		30/Nov/11
Depth (m)			1-2	1-2		2-3	5-6	5-6	3-4	0.5-1	5-6	3-4	2-3	2-3		5-6
Elements (mg/kg)																
Benzo(a)anthracene	0.1	0.005	<0.0050	<0.0050	0.0	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0	<0.0050
Benzo(a)pyrene	20	0.005	<0.0050	<0.0050	0.0	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0	<0.0050
Benzo(b,j)fluoranthene	0.1	0.005	<0.0050	<0.0050	0.0	<0.0050	<0.0050	<0.0050	<0.012	<0.0050	0.0076	<0.0050	0.0056	0.0055	1.8	<0.0050
Benzo(k)fluoranthene	0.1	0.005	<0.0050	<0.0050	0.0	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0	<0.0050
Dibenz(a,h)anthracene	0.1	0.005	<0.0050	<0.0050	0.0	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0	<0.0050
Indeno(1,2,3-cd)pyrene	0.1	0.005	<0.0050	<0.0050	0.0	<0.0050	<0.0050	<0.0050	0.0076	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0	<0.0050
Naphthalene	0.013	0.005	<0.0050	<0.0050	0.0	<0.0050	<0.0050	<0.0050	<0.0050	0.0080	<0.0050	<0.0050	<0.0050	<0.0050	0.0	<0.0050
Phenanthrene	0.046	0.005	<0.0050	<0.0050	0.0	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0	<0.0050
Pyrene	0.1	0.005	<0.0050	<0.0050	0.0	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0	<0.0050

Field label	CCME[1] Agricultural	Lowest RDL	TP10-11-02	TP11-11-03	TP12-11-04	TP15-11-03	TP15-11-04	TP16-11-02
Date			30/Nov/11	30/Nov/11	30/Nov/11	30/Nov/11	30/Nov/11	30/Nov/11
Depth (m)			0.5-1	1-2	2-3	1-2	2-3	0.5-1
Elements (mg/kg)								
Benzo(a)anthracene	0.1	0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(a)pyrene	20	0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(b,j)fluoranthene	0.1	0.005	0.0087	<0.0050	0.0086	0.011	<0.0050	<0.0087
Benzo(k)fluoranthene	0.1	0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Dibenz(a,h)anthracene	0.1	0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Indeno(1,2,3-cd)pyrene	0.1	0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Naphthalene	0.013	0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Phenanthrene	0.046	0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Pyrene	0.1	0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050

Notes:
All units in mg/kg, unless stated otherwise.
1= CCME (2007), Canadian Soil Quality Guidelines, Polycyclic Aromatic Hydrocarbons, 2010, Table 1: Soil Quality Guidelines for Carcinogenic and Other PAHs, Agricultural Land Use.
NC = No Criteria/Not Calculated
RDL = Reportable Detection Limit
RPD = Relative Percent Difference
20 = Denotes exceedances for Agricultural Land Use.
20 = Denotes unacceptable RPD

Field label	CCME[1] Agricultural	Lowest RDL	TP1-11-03	TP1-DUP1	Relative Percent Difference (%)	TP2-11-04	TP2-11-07	TP3-11-07	TP4-11-05	TP5-11-02	TP6-11-03	TP6-11-07	TP7-11-05	TP8-11-04	TP8-DUP2	Relative Percent Difference (%)	TP9-11-07	TP10-11-02
Date			29/Nov/11	29/Nov/11		29/Nov/11	29/Nov/11	29/Nov/11	29/Nov/11	29/Nov/11	29/Nov/11	29/Nov/11	29/Nov/11	30/Nov/11	30/Nov/11		30/Nov/11	30/Nov/11
Depth (m)			1-2	1-2		2-3	5-6	5-6	3-4	0.5-1	1-2	5-6	3-4	2-3	2-3		5-6	0.5-1
Elements (mg/kg)																		
Antimony (Sb)	20	1.0	<1.0	<1.0	0.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	<1.0	0.0	<1.0	<1.0
Arsenic (As)	12	1.0	6.2	5.8	6.7	5.8	6.2	7.7	6.3	8.6	4.9	6.1	6.3	5.9	5.8	1.7	7.2	6.4
Barium (Ba)	750	10	190	240	23.3	220	240	220	190	280	270	230	220	270	240	11.8	160	200
Beryllium (Be)	4	0.40	0.68	0.66	3.0	0.58	0.68	0.49	0.41	0.61	0.60	0.47	0.48	0.62	0.55	12.0	<0.40	0.41
Cadmium (Cd)	1.4	0.10	0.38	0.35	8.2	0.38	0.40	0.32	0.30	0.37	0.39	0.43	0.34	0.34	0.33	3.0	0.28	0.24
Chromium (Cr)	64	1.0	22	19	14.6	18	22	16	13	19	14	17	17	12	15	22.2	11	8.6
Cobalt (Co)	40	1.0	9.7	8.9	8.6	8.2	9.5	7.9	7.2	7.7	6.6	7.8	7.9	6.4	7.0	9.0	6.2	5.2
Copper (Cu)	63	5.0	27	24	11.8	30	24	22	17	24	26	40	27	24	20	18.2	15	16
Lead (Pb)	70	1.0	11	10	9.5	13	11	12	8.8	10	13	24	9.9	11	12	8.7	9.0	7.1
Mercury (Hg)	6.6	0.050	0.099	0.089	10.6	0.074	0.055	0.069	0.055	<0.050	0.061	0.081	<0.050	<0.050	<0.050	0.0	<0.050	<0.050
Molybdenum (Mo)	5	0.40	0.54	0.60	10.5	0.73	0.52	0.62	0.70	1.3	0.83	1.3	0.77	1.1	0.92	17.8	0.91	1.1
Nickel (Ni)	50	1.0	41	26	44.8	24	27	24	20	22	18	23	22	18	20	10.5	18	15
Selenium (Se)	1	0.50	<0.50	<0.50	0.0	<0.50	0.75	<0.50	<0.50	<0.50	<0.50	<0.50	0.51	<0.50	<0.50	0.0	<0.50	<0.50
Silver (Ag)	20	1.0	<1.0	<1.0	0.0	3.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.0	<1.0	<1.0
Tin (Sn)	5	1.00	<1.0	<1.0	0.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	15	<1.0	<1.0	<1.0	0.0	<1.0	<1.0
Uranium (U)	23	1.0	<1.0	<1.0	0.0	1.1	<1.0	<1.0	<1.0	1.2	1.9	1.1	<1.0	1.2	1.2	0.0	1.7	<1.0
Zinc (Zn)	200	10.0	69	61	12.3	96	80	62	55	63	50	130	64	53	57	7.3	50	33

Field label	CCME[1] Agricultural	Lowest RDL	TP10-11-04	TP11-11-03	TP12-11-04	TP13-11-04	TP14-11-04	TP15-11-03	TP15-11-05	TP16-11-07
Date			30/Nov/11	30/Nov/11	30/Nov/11	30/Nov/11	30/Nov/11	30/Nov/11	30/Nov/11	30/Nov/11
Depth (m)			2-3	1-2	2-3	2-3	2-3	1-2	3-4	5-6
Elements (mg/kg)										
Antimony (Sb)	20	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Arsenic (As)	12	1.0	5.6	5.8	5.1	5.3	5.7	6.8	4.9	6.4
Barium (Ba)	750	10	190	200	190	190	210	190	240	220
Beryllium (Be)	4	0.40	0.47	0.60	0.50	0.49	0.70	0.49	<0.40	0.51
Cadmium (Cd)	1.4	0.10	0.33	0.34	0.36	0.27	0.34	0.24	0.30	0.39
Chromium (Cr)	64	1.0	13	18	13	16	20	11	10	14
Cobalt (Co)	40	1.0	6.9	8.2	6.7	7.4	8.4	7.5	5.8	7.3
Copper (Cu)	63	5.0	29	20	21	17	20	18	15	18
Lead (Pb)	70	1.0	9.0	10	19	8.7	11	7.6	8.0	9.8
Mercury (Hg)	6.6	0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Molybdenum (Mo)	5	0.40	0.72	0.70	0.80	0.77	0.52	0.72	0.89	0.65
Nickel (Ni)	50	1.0	19	23	17	21	24	18	16	19
Selenium (Se)	1	0.50	<0.50	<0.50	<0.50	1.3	<0.50	<0.50	<0.50	<0.50
Silver (Ag)	20	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Tin (Sn)	5	1.00	<1.0	<1.0	1.5	<1.0	<1.0	<1.0	<1.0	<1.0
Uranium (U)	23	1.0	1.1	1.0	<1.0	1.3	<1.0	1.1	<1.0	<1.0
Zinc (Zn)	200	10.0	61	65	160	53	74	44	52	76

Notes:
All units in mg/kg, unless stated otherwise.
1 = CCME (2007), Canadian Soil Quality Guidelines, Update 7.0, Table 2. Canadian Soil Quality Guidelines, fine grained soil, Agricultural Land Use.
NC = No Criteria/Not Calculated
RPD = Relative Percent Difference
RDL = Reportable Detection Limit
20 = Denotes exceedances for Agricultural Land Use.
20 = Denotes unacceptable RPD

	Units	TP9-11-07	TP10-11-02	TP12-11-04	RDL
Physical Properties					
Sieve - Pan	%	71	30	52	0.2
Sieve - #200 (>0.075mm)	%	29	70	48	0.2
Soil Texture	%	FINE	COARSE	FINE	0.2

Notes:

RDL = Reportable Detection Limit

Table 5. Visual Comparison of Test Pit Material.

Test Pit Location	% Native Material Within Test Pit	Waste Description Within Test Pit	Fill Material Matrix Description Within Test Pit	Estimated Proportion of Waste to Fill (%) Within Test Pit	Sieve analysis (% >0.075 mm)
TP1	100% (Silty Clay with some sand) between 0-6 m bgs	None	None	0	None
TP2	30% (silty clay with some sand) between 4-6 m bgs	Fiberous cloth, rusty red shale material	Silty clay with some sand	1-5% at 0-4 m bgs	None
TP3	8% (silty clay) between 5.5-6 m bgs	plastic and metal pieces, piping, wire, concrete, ceramic, wood, glass, foam	silty clay with some sand	20-25% at 2-2.5 m bgs	None
TP4	None	Asphalt, wood, plastic pipe, paper.	Asphalt, silty clay, sand and gravel	60-80% at 0-0.5 m bgs. 5-10% at 0.5-6 m bgs	None
TP5	None	Asphalt, paper, wood, plastic, concrete, wire	Silt, clay, sand gravel	30-50% at 0-0.5 m bgs. 5-10% at 0.5-6 m bgs	None
TP6	None	Metal, glass concrete	Clay, silt, sand, gravel.	1-5% at 0-6 m bgs	None
TP7	30% (silty clay) between 4-6 m bgs	Brick, concrete, plastic, metal, wood	Silty clay	1-5% at 0-4 m bgs	none
TP8	17% (silty clay) between 5-6 m bgs	None	Dense compact fill material comprising of disturbed native material and clay.	0	None
TP9	17% (silty clay) between 5-6 m bgs	None	Disturbed native material (e.g. silty clay) and very compact red shale	0	29.0 % at 5-6 m bgs
TP10	60% (silty clay and gravel)	None	Disturbed native material (e.g. clay, silt gravel), very compact	0	70.0% at 0-1 m bgs
TP11	60% (silty clay with sand) between 3-5 m bgs	wood chippings, red shale, plastic, Styrofoam, ceramic pieces	clay, silt, gravel	1-5% at 0-2 m bgs	None
TP12	40% (silty clay) between 3-5 m bgs	concrete building material >300 mm, metal sheets and poles, plastic	silty clay, sand, gravel and some cobbles	20-25% at 0-3 m bgs	48.0 % at 0-3 m bgs
TP13	100% (Silty clay)	None	None	0	None
TP14	100% (Silty clay)	None	None	0	None
TP15	56% Native (silty clay with some sand)	concrete building waste, metal wire, metal mesh, wood, glass	Clay and some sand	10-15% at 0-2 m bgs	None
TP16	None	red shale, large concrete building material >300 mm	silty clay, sand, gravel and some cobbles	5-10% at 0-2 m bgs. 15-20% at 2-6 m bgs.	None

Note: m bgs = metres below ground surface

APPENDIX C

Site Photos

FRANZ ENVIRONMENTAL INC.
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PHOTOGRAPHIC LOG

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

Photo No. 1

Date: November 29, 2011

Direction Photo taken: N/A

Description:

TP1: View of test pit walls and floor from surface. Test pit excavated to 6 m bgs.

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

Photo No. 2

Date: November 29, 2011

Direction Photo taken: N/A

Description:

TP1: Native soil sample with white (possibly alkali), fine material layered in bands.

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PHOTOGRAPHIC LOG

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

Photo No. 3

Date: November 29, 2011

Direction Photo taken: N/A

Description:

TP2: Test pit walls and floor (6 m bgs)

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

Photo No. 4

Date: November 29, 2011

Direction Photo taken: N/A

Description:

TP3: Metal sheet painted yellow visible at a depth of 2-3 m bgs.

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PHOTOGRAPHIC LOG

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

Photo No. 5

Date: November 29, 2011

Direction Photo taken: S

Description:

TP3: Material excavated from test pit 3. Waste pictured is irregular shaped (rock, concrete etc.).

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

Photo No. 6

Date: November 29, 2011

Direction Photo taken: N/A

Description:

TP3: In situ waste.

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PHOTOGRAPHIC LOG

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

Photo No. 7

Date: November 29, 2011

Direction Photo taken: N/A

Description:

TP4: In situ waste.

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

Photo No. 8

Date: November 29, 2011

Direction Photo taken: N/A

Description:

TP4: View of test pit walls and floor from surface. Test pit excavated to 6 m bgs.

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PHOTOGRAPHIC LOG

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

Photo No. 9

Date: November 29, 2011

Direction Photo taken: SW

Description:

TP5: View of top of landfill looking towards the south. Native undisturbed land is visible in background adjacent and beyond metal shed.

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

Photo No. 10

Date: November 29, 2011

Direction Photo taken: N/A

Description:

TP5: In situ waste.

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PHOTOGRAPHIC LOG

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

Photo No. 11

Date: November 29, 2011

Direction Photo taken: N/A

Description:

TP5: Clay fill material visible as a darker band. Clay fill extends approximately from 0.5 to 2.0 m bgs.

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

Photo No. 12

Date: November 29, 2011

Direction Photo taken: N/A

Description:

TP5: Metal waste removed from test pit (indicated by red arrow).

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PHOTOGRAPHIC LOG

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

Photo No. 13

Date: November 29, 2011

Direction Photo taken: N/A

Description:

TP6: Test pit wall (note visible waste fragments).

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

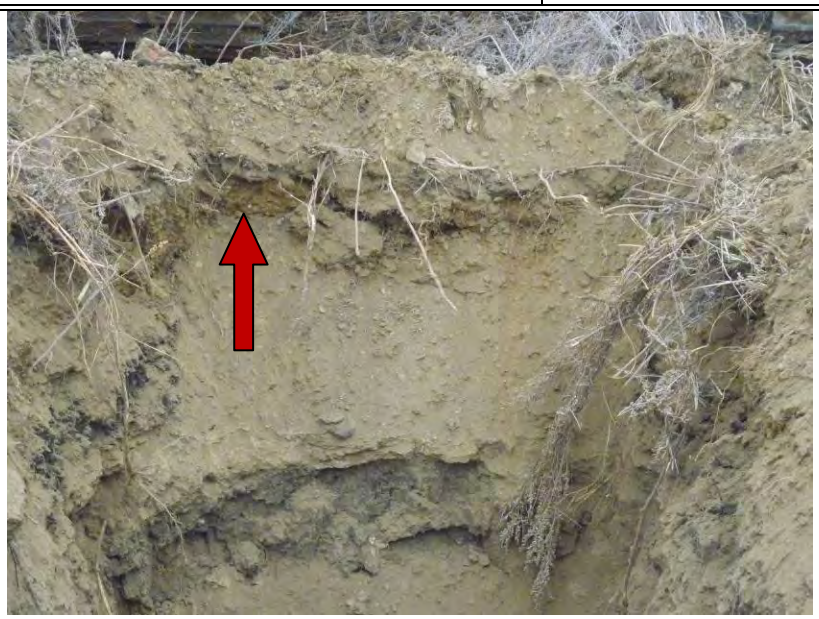
Photo No. 14

Date: November 29, 2011

Direction Photo taken: N/A

Description:

TP6: Rust colored band visible below humic level. Possible red shale or brick fill type material.



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PHOTOGRAPHIC LOG

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

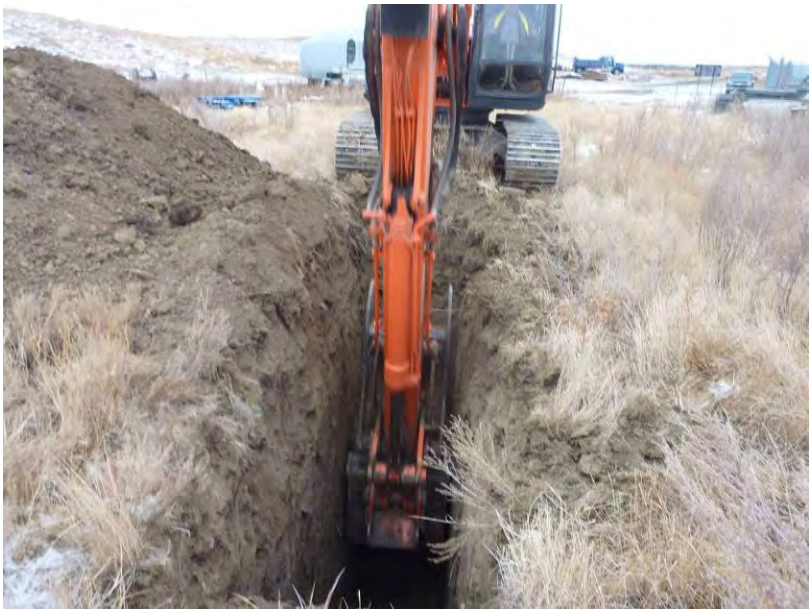
Photo No. 15

Date: November 29, 2011

Direction Photo taken: W

Description:

View of excavation of TP7.



Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

Photo No. 16

Date: November 29, 2011

Direction Photo taken: N/A

Description:

TP7: Metal and wood present in excavated material.

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PHOTOGRAPHIC LOG

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

Photo No. 17

Date: November 29, 2011

Direction Photo taken: N/A

Description:

TP7: View of walls and floor from surface. Test pit extends to 6 m bgs. Note the plastic waste visible at 2-3 m bgs.

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

Photo No. 18

Date: November 30, 2011

Direction Photo taken: W

Description:

TP9: Red shale type material visible in situ.

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PHOTOGRAPHIC LOG

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

Photo No. 19

Date: November 30, 2011

Direction Photo taken: N/A

Description:

TP9: Red shale type material visible in situ.

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

Photo No. 20

Date: November 30, 2011

Direction Photo taken: N/A

Description:

TP11: Excavated fill materials.

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PHOTOGRAPHIC LOG

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

Photo No. 21

Date: November 30, 2011

Direction Photo taken: N/A

Description:

TP12: Building and metal waste present in excavated materials.

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

Photo No. 22

Date: November 30, 2011

Direction Photo taken: N/A

Description:

TP12: In situ fill material. Waste materials visible.

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PHOTOGRAPHIC LOG

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

Photo No. 23

Date: November 30, 2011

Direction Photo taken: N/A

Description:

TP12: View of plastic material and boulder size concrete wastes within fill on wall of test pit.

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1103

Photo No. 24

Date: November 30, 2011

Direction Photo taken: N/A

Description:

TP12: View of excavations side and floor at approximately 5 m bgs. In situ waste visible in test pit.

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PHOTOGRAPHIC LOG

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1101

Photo No. 25

Date: November 30, 2011

Direction Photo taken: N/A

Description:

TP13: "Gumbo" topsoil visible at surface of test pit.

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1101

Photo No. 26

Date: November 30, 2011

Direction Photo taken: N/A

Description:

TP14: Excavated native material.

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PHOTOGRAPHIC LOG

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1101

Photo No. 27

Date: November 30, 2011

Direction Photo taken: N/A

Description:

TP15: Pieces of concrete waste visible in test pit.

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1101

Photo No. 28

Date: November 30, 2011

Direction Photo taken: N/A

Description:

TP15: Metal wire mesh excavated from test pit.

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PHOTOGRAPHIC LOG

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1101

Photo No. 29

Date: November 30, 2011

Direction Photo taken: N/A

Description:

TP16: Red shale type material encountered at 0-1.0 m bgs.

Client Name: Public Works and Government Services Canada	Site Location: Drumheller Institution, Drumheller Alberta	Project No. 2026-1101

Photo No. 30

Date: November 30, 2011

Direction Photo taken: N/A

Description:

TP16: Large piece of concrete (>300 mm) encountered between 2.0 and 6.0 m bgs.

APPENDIX D

Test Pit Logs

FRANZ ENVIRONMENTAL INC.
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Test-pit Log: TP01-11

Project No: 2026-1103

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			LABORATORY ANALYSIS			
Depth	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	PAH	BTEX	Metals	Sieve (75 micron)
		Ground Surface	0.0							
		Silty clay with some sand, brown, fine, dense, dry.Native material		TP1-11-01	SS					
				TP1-11-02	SS	0				
				TP1-11-03	SS		x/DUP1	x/DUP1	x/DUP1	
				TP1-11-04	SS	0				
				TP1-11-05	SS					
				TP1-11-06	SS					
				TP1-11-07	SS	0				

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
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Test-pit Log: TP02-11

Project No: 2026-1103

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			LABORATORY ANALYSIS			
Depth	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	PAH	BTEX	Metals	Sieve (75 micron)
		Ground Surface	0.0							
		Silty Clay with some sand, brown, fine, dense, dry.		TP2-11-01	SS					
				TP2-11-02	SS	0				
				TP2-11-03	SS					
			2.0							
		Silty Clay with some sand, brown to dark brown, fine, dense, dry. Fill material: Some fiberous cloth like material, some red rusty colored sandy shale liki material. Loosley packed.		TP2-11-04	SS	0	x	x	x	
			3.0							
		Sandy clay with some silt, brown with some darker brown organic looking material, dense, fine, dry.		TP2-11-05	SS					
			4.0							
		Silty Clay with some sand, brown with some darker brown organic looking material, fine, dense, dry.		TP2-11-06	SS					
				TP2-11-07	SS	0	x	x	x	

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
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Test-pit Log: TP03-11

Project No: 2026-1103

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			LABORATORY ANALYSIS			
Depth	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	PAH	BTEX	Metals	Sieve (75 micron)
		Ground Surface	0.0							
		Silty clay with some sand, brown, fine, dense, dry.		TP3-11-01	SS					
				TP3-11-02	SS	0				
				TP3-11-03	SS					
			2.0							
		Silty clay with some sand, brown orange, black.Dense and soft, fine, dry. Fill material present: some plastic, pieces of metal, piping, wire, concrete.loose.		TP3-11-04	SS	0				
			3.0							
		Silty clay with some silt gravel and cobbles, light brown, fine, dense,dry. Fill material: Metal, wood, ceramic material, some brick material. loose.		TP3-11-05	SS					
			4.0							
				TP3-11-06	SS					
		Silty clay with some sand and gravel. Light brown, fine, dense, dry. Fill material: wood, glass, foam ceramic material.Loose								
			5.5	TP3-11-07	SS	0	x	x	x	
		Silty clay with some sand, light brown, dense, fine, dry.								

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
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Test-pit Log: TP04-11

Project No: 2026-1103

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			LABORATORY ANALYSIS			
Depth	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	PAH	BTEX	Metals	Sieve (75 micron)
		Ground Surface	0.0							
		Asphalt, dark brown/black, hard, dense, dry	0.5	TP4-11-01	SS					
		Silty clay with some sand, light brown, dense, fine, dry. Fill material: Asphalt		TP4-11-02	SS	0				
				TP4-11-03	SS					
			2.0							
		Silty clay with some gravel, light brown with darker brown organic patches, dense, fine, dry. Fill material present: Asphalt, wood, plastic pipe, paper		TP4-11-04	SS	0				
				TP4-11-05	SS		x	x	x	
				TP4-11-06	SS					
				TP4-11-07	SS	0				

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
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Test-pit Log: TP05-11

Project No: 2026-1103

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			LABORATORY ANALYSIS			
Depth	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	PAH	BTEX	Metals	Sieve (75 micron)
		Ground Surface	0.0							
		Fill material: Asphalt, dark brown/black, hard, dense, dry.	0.5	TP5-11-01	SS					
		Clay fill with some silt and gravel, light brown, dense, fine, dry	2.0	TP5-11-02	SS	0	x	x	x	
				TP5-11-03	SS					
		Sandy clay with some silt and gravel.light brown. loose, fine, dry.Fill material present: plastic, wood, paper, brick, concrete, wire, ceramic material.Loose.		TP5-11-04	SS	0				
				TP5-11-05	SS					
				TP5-11-06	SS					
				TP5-11-07	SS	0				

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
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Test-pit Log: TP06-11

Project No: 2026-1103

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			LABORATORY ANALYSIS			
Depth	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	PAH	BTEX	Metals	Sieve (75 micron)
		Ground Surface	0.0							
		Fill material:hard clay with some sand and silt with small brick fragments.Dark brown, fine, loose, dry.		TP6-11-01	SS					
				TP6-11-02	SS	0				
				TP6-11-03	SS				x	
				TP6-11-04	SS	0				
			3.0							
		Fill Material: Clay, silt, pieces of metal, glass and concrete. Light brown, fine, loose, dry.		TP6-11-05	SS					
			4.0							
		Clay with some silt and gravel.Dense, fine, loose dry.Fill material: wood, rusty metal, concrete, oxidized clay rusty color with some cobbles and boulders.Loose.		TP6-11-06	SS					
				TP6-11-07	SS	0	x	x	x	

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
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Test-pit Log: TP07-11

Project No: 2026-1103

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			LABORATORY ANALYSIS			
Depth	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	PAH	BTEX	Metals	Sieve (75 micron)
		Ground Surface	0.0							
		Clay, few cobbles. Dark brown, hard compact, fine, dense, dry. Fill material: brick, concrete.	1.0	TP7-11-01	SS	0	x	x	x	
				TP7-11-02	SS					
		Clay, few cobbles. Dark brown, hard compact, fine dense, dry. Fill material: brick, concrete.	2.0	TP7-11-03	SS					
		Clay with some silt and gravel.Light to dark brown , fine, dense, dry.Fill material: Plastic, metal, wood.	3.0	TP7-11-04	SS	0				
		Silty clay, light brown, some darker brown clay bands. fine, dense, dry. Fill material: wood pieces	4.0	TP7-11-05	SS					
		Silty clay, light brown.fine, dense, dry. Native material.		TP7-11-06	SS					
				TP7-11-07	SS	0				

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

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Test-pit Log: TP08-11

Project No: 2026-1103

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			LABORATORY ANALYSIS			
Depth	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	PAH	BTEX	Metals	Sieve (75 micron)
		Ground Surface	0.0							
		Fill material: Light brown with some dark brown bands of silty clay with some crumbly grey clay.		TP8-11-01	SS					
				TP8-11-02	SS	0				
				TP8-11-03	SS					
				TP8-11-04	SS	0	x/DUP2	x/DUP2	x/DUP2	
				TP8-11-05	SS					
				TP8-11-06	SS					
			5.0							
		Silty clay, light brown, fine, dense, dry. Native material.		TP8-11-07	SS	0				

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
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Test-pit Log: TP09-11

Project No: 2026-1103

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			LABORATORY ANALYSIS			
Depth	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	PAH	BTEX	Metals	Sieve (75 micron)
		Ground Surface	0.0							
		Fill material: silty clay with some cobbles, light brown with red shale, hard clay, dark brown, fine, dense, dry.		TP9-11-01	SS					
				TP9-11-02	SS	0				
			2.0	TP9-11-03	SS					
		Fill material:Silty clay with some cobbles, light brown with red shale, fine, dense, dry.		TP9-11-04	SS	0				
			4.0	TP9-11-05	SS					
		Mainly silty clay, light brown, fine, dense, dry. Some fill material: red shale and dark brown hard clay.	5.0	TP9-11-06	SS					
		Silty clay, light brown, fine, dense, dry.Native material.		TP9-11-07	SS	0	x	x	x	x

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP10-11

Project No: 2026-1103

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			LABORATORY ANALYSIS			
Depth	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	PAH	BTEX	Metals	Sieve (75 micron)
		Ground Surface	0.0							
		Fill material:Clay, silt, gravel, dark brown, fine, dense, very compact, dry.		TP10-11-01	SS					
				TP10-11-02	SS	0	x	x	x	x
				TP10-11-03	SS					
			2.0							
		Silty clay and gravel, light brown, fine, dense, dry. Native material.		TP10-11-04	SS	0			x	
				TP10-11-05	SS					
				TP10-11-06	SS					
				TP10-11-07	SS	0				

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP11-11

Project No: 2026-1103

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			LABORATORY ANALYSIS			
Depth	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	PAH	BTEX	Metals	Sieve (75 micron)
		Ground Surface	0.0							
		Fill material:Clay, silt, gravel, dark brown, fine, dense, wood chippings, red shale pieces.		TP11-11-01	SS					
			1.0	TP11-11-02	SS	0				
		Fill material:thick band of hard dark clay, silt, gravel, fine, dense, plastic, styrofoam, glass, wire, wood chippings, ceramic.	2.0	TP11-11-03	SS		x	x	x	
		Silty clay with some sand, brown, fine, dense, dry.Native material		TP11-11-04	SS	0				
				TP11-11-05	SS					
				TP11-11-06	SS	0				

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP12-11

Project No: 2026-1103

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			LABORATORY ANALYSIS			
Depth	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	PAH	BTEX	Metals	Sieve (75 micron)
		Ground Surface	0.0							
		Silty clay and gravel, light brown, fine, dense, dry. Fill material:Large pieces of concrete building rubble of boulder size (>300 mm), metal sheets and poles, plastic. Loose.		TP12-11-01	SS					
				TP12-11-02	SS	0				
				TP12-11-03	SS					
				TP12-11-04	SS	0	x	x	x	x
				TP12-11-05	SS					
			4.0							
		silty clay, light brown, fine, dense, dry. Native.		TP12-11-06	SS	0				

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP13-11

Project No: 2026-1103

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			LABORATORY ANALYSIS			
Depth	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	PAH	BTEX	Metals	Sieve (75 micron)
		Ground Surface	0.0							
		Silty clay, dark brown, organic rich, stiff, fine, dense, dry. Native material.locally termed 'Gumbo' top soil.	0.5	TP13-11-01	SS					
				TP13-11-02	SS	0				
		Silty clay, light brown, fine, dense, dry. Native material.		TP13-11-03	SS					
				TP13-11-04	SS	0			x	

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP14-11

Project No: 2026-1103

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			LABORATORY ANALYSIS			
Depth	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	PAH	BTEX	Metals	Sieve (75 micron)
		Ground Surface	0.0							
		Silty clay, dark brown, fine, loose, dry. Native.		TP14-11-01	SS					
				TP14-11-02	SS	0				
				TP14-11-03	SS					
				TP14-11-04	SS				x	
				TP14-11-05	SS	0				

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP15-11

Project No: 2026-1103

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			LABORATORY ANALYSIS			
Depth	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	PAH	BTEX	Metals	Sieve (75 micron)
		Ground Surface	0.0							
		Silty clay with some sand, light brown, fine, loose, dry. Fill material: Concrete building waste, concrete slabs, concrete, metal wire, metal mesh, wood, glass.Loose.		TP15-11-01	SS					
				TP15-11-02	SS	0				
				TP15-11-03	SS		x	x	x	
			2.0							
		Silty clay with some sand, light brown, fine, dense, dry. Native material.		TP15-11-04	SS	0	x	x		
				TP15-11-05	SS				x	
				TP15-11-06	SS	0				

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

FRANZ ENVIRONMENTAL INC.
CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Test-pit Log: TP16-11

Project No: 2026-1103

Project: Drumheller Institution Site No. 530

Client: Public Works and Government Services Canada

Site Location: Drumheller, Alberta

Logged by: THWJ

Checked By:

SUBSURFACE PROFILE				SAMPLE			LABORATORY ANALYSIS			
Depth	Symbol	Description	Depth (mbgs)	Number	Type	Screening Result	PAH	BTEX	Metals	Sieve (75 micron)
		Ground Surface	0.0							
		Silty clay with some sand, gravel, some cobbles, brown, fine, loose, dry. Fill material: Red shale, large (> 300 mm diameter) concrete pieces.		TP16-11-01	SS					
				TP16-11-02	SS	0	x	x		
				TP16-11-03	SS					
			2.0							
		Clay with some silt and sand, gravel, some cobbles, brown, fine, high plasticity, dry. Fill material: Red shale, large (>300 mm diameter) concrete pieces.Loose		TP16-11-04	SS	0				
				TP16-11-05	SS					
				TP16-11-06	SS					
				TP16-11-07	SS	0			x	

Excavated By: Hitachi 160 Track Excavator

Excavation Method: Test Pit

Excavation Date: 29 - 30 Nov, 2011

APPENDIX E

Laboratory Certificates of Analyses and Chain of Custody Forms

Maxxam

Success Through Science®

Your P.O. #: 2026-1101
Your Project #: 2026-1103
Site Location: DRUMHELLER INSTITUTE, ALBERTA
PO # 2026-1101
Your C.O.C. #: A065208, A065210

Attention: STEVE LIVINGSTONE
FRANZ ENVIRONMENTAL INC.
329 CHURCHILL AVE NORTH
SUITE 2000
OTTAWA, ON
CANADA K1Z5B8

Report Date: 2012/01/06
This report supersedes all previous reports with the same Maxxam job number

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B1B7081
Received: 2011/12/02, 12:24

Sample Matrix: Soil
Samples Received: 24

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Boron (Hot Water Soluble)	17	2011/12/06	2011/12/06	AB SOP-00042	EPA 200.7
Boron (Hot Water Soluble)	1	2011/12/06	2011/12/07	AB SOP-00042	EPA 200.7
Boron (Hot Water Soluble)	4	2011/12/07	2011/12/07	AB SOP-00042	EPA 200.7
BTEX/F1 by HS GC/MS (MeOH extract) (1)	18	2011/12/02	2011/12/07	AB SOP-00039	CCME, EPA 8260C
Hexavalent Chromium	22	2011/12/06	2011/12/06	CAL SOP-00056	SM 3500-Cr B
CCME Hydrocarbons (F2-F4 in soil)	18	2011/12/02	2011/12/04	AB SOP-00040 AB SOP-00036	CCME PHC-CWS
Elements by ICPMS - Soils	20	2011/12/05	2011/12/06	AB SOP-00043	EPA 200.8
Elements by ICPMS - Soils	1	2011/12/06	2011/12/06	AB SOP-00043	EPA 200.8
Elements by ICPMS - Soils	1	2011/12/06	2011/12/08	AB SOP-00043	EPA 200.8
Moisture	18	N/A	2011/12/02	CAL SOP-00023	McKeague MSSMA 2.411
Moisture	6	N/A	2011/12/05	CAL SOP-00023	McKeague MSSMA 2.411
Benzo[a]pyrene Equivalency	18	N/A	2011/12/07	AB SOP-00003	EPA 8270D
Polycyclic Aromatic Hydrocarbons in soil	18	2011/12/02	2011/12/06	AB SOP-00003 AB SOP-00036	EPA 3540C/8270D
Particle Size by Sieve (75 micron)	3	N/A	2011/12/05	AB SOP-00022	SSMA 55.4

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

(1) This test was performed by Maxxam Edmonton Environmental

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Parminder Virk, Project Manager
Email: PVirk@maxxam.ca
Phone# (403) 291-3077

==========

Total cover pages: 1

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Maxxam Job #: B1B7081
Report Date: 2012/01/06

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Location: DRUMHELLER INSTITUTE, ALBERTA
Your P.O. #: 2026-1101
Sampler Initials: TJ

AT1 BTEX AND F1-F4 IN SOIL (SOIL)

Maxxam ID		CG7761	CG7762	CG7763	CG7764	CG7765	CG7766	CG7767	CG7769	CG7770		
Sampling Date		2011/11/29	2011/11/29	2011/11/29	2011/11/29	2011/11/29	2011/11/29	2011/11/29	2011/11/29	2011/11/29		
	Units	**TP1-11-03**	**TP1-DUP1**	**TP2-11-04**	**TP2-11-07**	**TP3-11-07**	**TP4-11-05**	**TP5-11-02**	**TP6-11-07**	**TP7-11-05**	**RDL**	**QC Batch**
Physical Properties												
Moisture	%	22	21	16	20	17	11	15	20	18	0.30	5417047
Ext. Pet. Hydrocarbon												
F2 (C10-C16 Hydrocarbons)	mg/kg	<10	<10	<10	<10	<10	<10	13	<10	<10	10	5417151
F3 (C16-C34 Hydrocarbons)	mg/kg	<10	<10	<10	<10	<10	53	63	<10	<10	10	5417151
F4 (C34-C50 Hydrocarbons)	mg/kg	<10	<10	<10	<10	<10	66	<10	<10	<10	10	5417151
Reached Baseline at C50	mg/kg	YES	YES	YES	YES	YES	YES	YES	YES	YES	N/A	5417151
Surrogate Recovery (%)												
O-TERPHENYL (sur.)	%	73	78	76	72	79	77	76	78	77	N/A	5417151
Volatiles												
Benzene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.014	<0.0050	<0.0050	0.0050	5419613
Toluene	mg/kg	<0.020	<0.020	<0.020	<0.020	<0.020	0.042	0.077	<0.020	<0.020	0.020	5419613
Ethylbenzene	mg/kg	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.037	<0.010	<0.010	0.010	5419613
Xylenes (Total)	mg/kg	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	0.17	<0.040	<0.040	0.040	5419613
m & p-Xylene	mg/kg	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	0.12	<0.040	<0.040	0.040	5419613
o-Xylene	mg/kg	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	0.042	<0.020	<0.020	0.020	5419613
F1 (C6-C10) - BTEX	mg/kg	<12	<12	<12	<12	<12	<12	<12	<12	<12	12	5419613
(C6-C10)	mg/kg	<12	<12	<12	<12	<12	<12	<12	<12	<12	12	5419613
Surrogate Recovery (%)												
1,4-Difluorobenzene (sur.)	%	115	114	109	112	110	107	108	111	112	N/A	5419613
4-BROMOFLUOROBENZENE (sur.)	%	100	100	99	100	97	99	98	99	101	N/A	5419613
D10-ETHYLBENZENE (sur.)	%	108	109	110	106	107	104	102	109	111	N/A	5419613
D4-1,2-DICHLOROETHANE (sur.)	%	99	101	101	102	102	100	99	101	102	N/A	5419613

N/A = Not Applicable
RDL = Reportable Detection Limit

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Maxxam Job #: B1B7081
Report Date: 2012/01/06

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Location: DRUMHELLER INSTITUTE, ALBERTA
Your P.O. #: 2026-1101
Sampler Initials: TJ

AT1 BTEX AND F1-F4 IN SOIL (SOIL)

Maxxam ID		CG7771	CG7774	CG7775	CG7776	CG7778	CG7779	CG7782	CG7783	CG7785		
Sampling Date		2011/11/30	2011/11/30	2011/11/30	2011/11/30	2011/11/30	2011/11/30	2011/11/30	2011/11/30	2011/11/30		
	Units	**TP8-11-04**	**TP8-DUP2**	**TP9-11-07**	**TP10-11-02**	**TP11-11-03**	**TP12-11-04**	**TP15-11-03**	**TP15-11-04**	**TP16-11-02**	**RDL**	**QC Batch**
Physical Properties												
Moisture	%	11	11	11	11	13	11	N/A	11	14	0.30	5417047
Ext. Pet. Hydrocarbon												
F2 (C10-C16 Hydrocarbons)	mg/kg	<10	<10	<10	<10	<10	<10	<10	<10	<10	10	5417151
F3 (C16-C34 Hydrocarbons)	mg/kg	<10	<10	<10	<10	<10	<10	<10	<10	<10	10	5417151
F4 (C34-C50 Hydrocarbons)	mg/kg	<10	<10	<10	<10	<10	<10	<10	<10	<10	10	5417151
Reached Baseline at C50	mg/kg	YES	YES	YES	YES	YES	YES	YES	YES	YES	N/A	5417151
Surrogate Recovery (%)												
O-TERPHENYL (sur.)	%	85	85	88	86	84	85	87	87	76	N/A	5417151
Volatiles												
Benzene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	5419613
Toluene	mg/kg	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	0.075	<0.020	<0.020	0.020	5419613
Ethylbenzene	mg/kg	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.010	5419613
Xylenes (Total)	mg/kg	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	0.040	5419613
m & p-Xylene	mg/kg	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	0.040	5419613
o-Xylene	mg/kg	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	0.020	5419613
F1 (C6-C10) - BTEX	mg/kg	<12	<12	<12	<12	<12	<12	<12	<12	<12	12	5419613
(C6-C10)	mg/kg	<12	<12	<12	<12	<12	<12	<12	<12	<12	12	5419613
Surrogate Recovery (%)												
1,4-Difluorobenzene (sur.)	%	105	107	109	107	106	108	109	108	108	N/A	5419613
4-BROMOFLUOROBENZENE (sur.)	%	98	99	100	100	100	99	100	101	97	N/A	5419613
D10-ETHYLBENZENE (sur.)	%	105	103	111	110	113	112	112	111	109	N/A	5419613
D4-1,2-DICHLOROETHANE (sur.)	%	102	101	100	100	98	100	104	101	99	N/A	5419613

N/A = Not Applicable
RDL = Reportable Detection Limit

Maxxam

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Maxxam Job #: B1B7081
Report Date: 2012/01/06

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Location: DRUMHELLER INSTITUTE, ALBERTA
Your P.O. #: 2026-1101
Sampler Initials: TJ

REGULATED METALS (CCME/AT1) - SOILS

Maxxam ID		CG7761		CG7762	CG7763	CG7764	CG7765	CG7766	CG7767	CG7768	CG7769		
Sampling Date		2011/11/29		2011/11/29	2011/11/29	2011/11/29	2011/11/29	2011/11/29	2011/11/29	2011/11/29	2011/11/29		
	Units	**TP1-11-03**	**QC Batch**	**TP1-DUP1**	**TP2-11-04**	**TP2-11-07**	**TP3-11-07**	**TP4-11-05**	**TP5-11-02**	**TP6-11-03**	**TP6-11-07**	**RDL**	**QC Batch**
Elements													
Soluble (Hot water) Boron (B)	mg/kg	0.38	5427660	0.12	0.33	0.64	0.96	0.24	0.97	<0.10	0.72	0.10	5423104
Hex. Chromium (Cr 6+)	mg/kg	<0.15	5422917	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	0.15	5422917
Total Antimony (Sb)	mg/kg	<1.0	5432079	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	5423430
Total Arsenic (As)	mg/kg	6.2	5432079	5.8	5.8	6.2	7.7	6.3	8.6	4.9	6.1	1.0	5423430
Total Barium (Ba)	mg/kg	190	5432079	240	220	240	220	190	280	270	230	10	5423430
Total Beryllium (Be)	mg/kg	0.68	5432079	0.66	0.58	0.68	0.49	0.41	0.61	0.60	0.47	0.40	5423430
Total Cadmium (Cd)	mg/kg	0.38	5432079	0.35	0.38	0.40	0.32	0.30	0.37	0.39	0.43	0.10	5423430
Total Chromium (Cr)	mg/kg	22	5432079	19	18	22	16	13	19	14	17	1.0	5423430
Total Cobalt (Co)	mg/kg	9.7	5432079	8.9	8.2	9.5	7.9	7.2	7.7	6.6	7.8	1.0	5423430
Total Copper (Cu)	mg/kg	27	5432079	24	30	24	22	17	24	26	40	5.0	5423430
Total Lead (Pb)	mg/kg	11	5432079	10	13	11	12	8.8	10	13	24	1.0	5423430
Total Mercury (Hg)	mg/kg	0.099	5432079	0.089	0.074	0.055	0.069	0.055	<0.050	0.061	0.081	0.050	5423430
Total Molybdenum (Mo)	mg/kg	0.54	5432079	0.60	0.73	0.52	0.62	0.70	1.3	0.83	1.3	0.40	5423430
Total Nickel (Ni)	mg/kg	41	5432079	26	24	27	24	20	22	18	23	1.0	5423430
Total Selenium (Se)	mg/kg	<0.50	5432079	<0.50	<0.50	0.75	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	5423430
Total Silver (Ag)	mg/kg	<1.0	5432079	<1.0	3.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	5423430
Total Thallium (Tl)	mg/kg	<0.30	5432079	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	0.30	5423430
Total Tin (Sn)	mg/kg	<1.0	5432079	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	15	1.0	5423430
Total Uranium (U)	mg/kg	<1.0	5432079	<1.0	1.1	<1.0	<1.0	<1.0	1.2	1.9	1.1	1.0	5423430
Total Vanadium (V)	mg/kg	32	5432079	31	29	36	24	21	32	22	22	1.0	5423430
Total Zinc (Zn)	mg/kg	69	5432079	61	96	80	62	55	63	50	130	10	5423430
RDL = Reportable Detection Limit													

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Maxxam Job #: B1B7081
Report Date: 2012/01/06

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Location: DRUMHELLER INSTITUTE, ALBERTA
Your P.O. #: 2026-1101
Sampler Initials: TJ

REGULATED METALS (CCME/AT1) - SOILS

Maxxam ID		CG7770	CG7771		CG7774	CG7775	CG7776	CG7777	CG7778		CG7779		
Sampling Date		2011/11/29	2011/11/30		2011/11/30	2011/11/30	2011/11/30	2011/11/30	2011/11/30		2011/11/30		
	Units	**TP7-11-05**	**TP8-11-04**	**QC Batch**	**TP8-DUP2**	**TP9-11-07**	**TP10-11-02**	**TP10-11-04**	**TP11-11-03**	**RDL**	**TP12-11-04**	**RDL**	**QC Batch**
Elements													
Soluble (Hot water) Boron (B)	mg/kg	<0.10	2.1	5423104	2.0	<0.10	1.2	0.16	0.43	0.10	1.9	0.10	5423104
Hex. Chromium (Cr 6+)	mg/kg	<0.15	<0.15	5422917	<0.15	<0.15	<0.15	<0.15	<0.15	0.15	<0.30(1)	0.30	5423465
Total Antimony (Sb)	mg/kg	<1.0	1.0	5423430	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	<1.0	1.0	5423430
Total Arsenic (As)	mg/kg	6.3	5.9	5423430	5.8	7.2	6.4	5.6	5.8	1.0	5.1	1.0	5423430
Total Barium (Ba)	mg/kg	220	270	5423430	240	160	200	190	200	10	190	10	5423430
Total Beryllium (Be)	mg/kg	0.48	0.62	5423430	0.55	<0.40	0.41	0.47	0.60	0.40	0.50	0.40	5423430
Total Cadmium (Cd)	mg/kg	0.34	0.34	5423430	0.33	0.28	0.24	0.33	0.34	0.10	0.36	0.10	5423430
Total Chromium (Cr)	mg/kg	17	12	5423430	15	11	8.6	13	18	1.0	13	1.0	5423430
Total Cobalt (Co)	mg/kg	7.9	6.4	5423430	7.0	6.2	5.2	6.9	8.2	1.0	6.7	1.0	5423430
Total Copper (Cu)	mg/kg	27	24	5423430	20	15	16	29	20	5.0	21	5.0	5423430
Total Lead (Pb)	mg/kg	9.9	11	5423430	12	9.0	7.1	9.0	10	1.0	19	1.0	5423430
Total Mercury (Hg)	mg/kg	<0.050	<0.050	5423430	<0.050	<0.050	<0.050	<0.050	<0.050	0.050	<0.050	0.050	5423430
Total Molybdenum (Mo)	mg/kg	0.77	1.1	5423430	0.92	0.91	1.1	0.72	0.70	0.40	0.80	0.40	5423430
Total Nickel (Ni)	mg/kg	22	18	5423430	20	18	15	19	23	1.0	17	1.0	5423430
Total Selenium (Se)	mg/kg	0.51	<0.50	5423430	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	<0.50	0.50	5423430
Total Silver (Ag)	mg/kg	<1.0	<1.0	5423430	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	<1.0	1.0	5423430
Total Thallium (Tl)	mg/kg	<0.30	<0.30	5423430	<0.30	<0.30	<0.30	<0.30	<0.30	0.30	<0.30	0.30	5423430
Total Tin (Sn)	mg/kg	<1.0	<1.0	5423430	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	1.5	1.0	5423430
Total Uranium (U)	mg/kg	<1.0	1.2	5423430	1.2	1.7	<1.0	1.1	1.0	1.0	<1.0	1.0	5423430
Total Vanadium (V)	mg/kg	29	20	5423430	23	18	15	19	30	1.0	20	1.0	5423430
Total Zinc (Zn)	mg/kg	64	53	5423430	57	50	33	61	65	10	160	10	5423430

RDL = Reportable Detection Limit
(1) - Detection limits raised due to matrix interference

Maxxam

Success Through Science®

Maxxam Job #: B1B7081
Report Date: 2012/01/06

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Location: DRUMHELLER INSTITUTE, ALBERTA
Your P.O. #: 2026-1101
Sampler Initials: TJ

REGULATED METALS (CCME/AT1) - SOILS

Maxxam ID		CG7780		CG7781	CG7782	CG7784		CG7786		
Sampling Date		2011/11/30		2011/11/30	2011/11/30	2011/11/30		2011/11/30		
	Units	**TP13-11-04**	**QC Batch**	**TP14-11-04**	**TP15-11-03**	**TP15-11-05**	**QC Batch**	**TP16-11-07**	**RDL**	**QC Batch**
Elements										
Soluble (Hot water) Boron (B)	mg/kg	0.58	5423104	0.77	0.36	<0.10	5427660	2.4	0.10	5427660
Hex. Chromium (Cr 6+)	mg/kg	<0.15	5423465	<0.15	<0.15	<0.15	5423465	<0.15	0.15	5423465
Total Antimony (Sb)	mg/kg	<1.0	5423430	<1.0	<1.0	<1.0	5423430	<1.0	1.0	5423832
Total Arsenic (As)	mg/kg	5.3	5423430	5.7	6.8	4.9	5423430	6.4	1.0	5423832
Total Barium (Ba)	mg/kg	190	5423430	210	190	240	5423430	220	10	5423832
Total Beryllium (Be)	mg/kg	0.49	5423430	0.70	0.49	<0.40	5423430	0.51	0.40	5423832
Total Cadmium (Cd)	mg/kg	0.27	5423430	0.34	0.24	0.30	5423430	0.39	0.10	5423832
Total Chromium (Cr)	mg/kg	16	5423430	20	11	10	5423430	14	1.0	5423832
Total Cobalt (Co)	mg/kg	7.4	5423430	8.4	7.5	5.8	5423430	7.3	1.0	5423832
Total Copper (Cu)	mg/kg	17	5423430	20	18	15	5423430	18	5.0	5423832
Total Lead (Pb)	mg/kg	8.7	5423430	11	7.6	8.0	5423430	9.8	1.0	5423832
Total Mercury (Hg)	mg/kg	<0.050	5423430	<0.050	<0.050	<0.050	5423430	<0.050	0.050	5423832
Total Molybdenum (Mo)	mg/kg	0.77	5423430	0.52	0.72	0.89	5423430	0.65	0.40	5423832
Total Nickel (Ni)	mg/kg	21	5423430	24	18	16	5423430	19	1.0	5423832
Total Selenium (Se)	mg/kg	1.3	5423430	<0.50	<0.50	<0.50	5423430	<0.50	0.50	5423832
Total Silver (Ag)	mg/kg	<1.0	5423430	<1.0	<1.0	<1.0	5423430	<1.0	1.0	5423832
Total Thallium (Tl)	mg/kg	<0.30	5423430	<0.30	<0.30	<0.30	5423430	<0.30	0.30	5423832
Total Tin (Sn)	mg/kg	<1.0	5423430	<1.0	<1.0	<1.0	5423430	<1.0	1.0	5423832
Total Uranium (U)	mg/kg	1.3	5423430	<1.0	1.1	<1.0	5423430	<1.0	1.0	5423832
Total Vanadium (V)	mg/kg	25	5423430	34	18	16	5423430	24	1.0	5423832
Total Zinc (Zn)	mg/kg	53	5423430	74	44	52	5423430	76	10	5423832
RDL = Reportable Detection Limit										

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Client Project #: 2026-1103
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Your P.O. #: 2026-1101
Sampler Initials: TJ

RESULTS OF CHEMICAL ANALYSES OF SOIL

Maxxam ID		CG7768	CG7775	CG7776	CG7777	CG7779	CG7780		
Sampling Date		2011/11/29	2011/11/30	2011/11/30	2011/11/30	2011/11/30	2011/11/30		
	Units	**TP6-11-03**	**TP9-11-07**	**TP10-11-02**	**TP10-11-04**	**TP12-11-04**	**TP13-11-04**	**RDL**	**QC Batch**
Physical Properties									
Moisture	%	14	N/A	N/A	21	N/A	14	0.30	5422192
Sieve - Pan	%	N/A	71	30	N/A	52	N/A	0.20	5410245
Sieve - #200 (>0.075mm)	%	N/A	29	70	N/A	48	N/A	0.20	5410245
Grain Size	%	N/A	FINE	COARSE	N/A	FINE	N/A	0.20	5410245

N/A = Not Applicable
RDL = Reportable Detection Limit

Maxxam ID		CG7781		CG7782		CG7784	CG7786		
Sampling Date		2011/11/30		2011/11/30		2011/11/30	2011/11/30		
	Units	**TP14-11-04**	**QC Batch**	**TP15-11-03**	**QC Batch**	**TP15-11-05**	**TP16-11-07**	**RDL**	**QC Batch**
Physical Properties									
Moisture	%	13	5422192	12	5417047	12	19	0.30	5422192

RDL = Reportable Detection Limit

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FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
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Your P.O. #: 2026-1101
Sampler Initials: TJ

SEMIVOLATILE ORGANICS BY GC-MS (SOIL)

Maxxam ID		CG7761	CG7762	CG7763	CG7764	CG7765		CG7766		CG7767		
Sampling Date		2011/11/29	2011/11/29	2011/11/29	2011/11/29	2011/11/29		2011/11/29		2011/11/29		
	Units	**TP1-11-03**	**TP1-DUP1**	**TP2-11-04**	**TP2-11-07**	**TP3-11-07**	**RDL**	**TP4-11-05**	**RDL**	**TP5-11-02**	**RDL**	**QC Batch**
Polycyclic Aromatics												
Acenaphthene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Benzo[a]pyrene equivalency	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	<0.10	0.10	<0.10	0.10	5416495
Acenaphthylene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Acridine	mg/kg	<0.010	<0.010	<0.010	<0.010	<0.010	0.010	<0.010	0.010	<0.010	0.010	5417150
Anthracene	mg/kg	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	0.0040	<0.0040	0.0040	<0.0040	0.0040	5417150
Benzo(a)anthracene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Benzo(b&j)fluoranthene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.012(1)	0.012	<0.0050	0.0050	5417150
Benzo(k)fluoranthene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Benzo(g,h,i)perylene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	0.013	0.0050	<0.0050	0.0050	5417150
Benzo(c)phenanthrene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Benzo(a)pyrene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Benzo[e]pyrene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	0.011	0.0050	<0.0050	0.0050	5417150
Chrysene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Dibenz(a,h)anthracene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Fluoranthene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Fluorene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Indeno(1,2,3-cd)pyrene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	0.0076	0.0050	<0.0050	0.0050	5417150
2-Methylnaphthalene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	0.011	0.0050	5417150
Naphthalene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	0.0080	0.0050	5417150
Phenanthrene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Perylene	mg/kg	<0.0050	<0.0050	0.0054	<0.0050	<0.0050	0.0050	0.019	0.0050	<0.0050	0.0050	5417150
Pyrene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Quinoline	mg/kg	<0.010	<0.010	<0.010	<0.010	<0.010	0.010	<0.010	0.010	<0.010	0.010	5417150
Surrogate Recovery (%)												
D10-ANTHRACENE (sur.)	%	97	98	98	98	95	N/A	98	N/A	97	N/A	5417150
D12-BENZO(A)PYRENE (sur.)	%	103	106	107	108	106	N/A	109	N/A	103	N/A	5417150
D8-ACENAPHTHYLENE (sur.)	%	102	105	106	106	106	N/A	105	N/A	104	N/A	5417150
TERPHENYL-D14 (sur.)	%	97	99	99	99	99	N/A	98	N/A	97	N/A	5417150

N/A = Not Applicable
RDL = Reportable Detection Limit
(1) - Detection limits raised due to matrix interference.

Maxxam

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Maxxam Job #: B1B7081
Report Date: 2012/01/06

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Location: DRUMHELLER INSTITUTE, ALBERTA
Your P.O. #: 2026-1101
Sampler Initials: TJ

SEMIVOLATILE ORGANICS BY GC-MS (SOIL)

Maxxam ID		CG7769	CG7770	CG7771	CG7774	CG7775	CG7776		
Sampling Date		2011/11/29	2011/11/29	2011/11/30	2011/11/30	2011/11/30	2011/11/30		
	Units	**TP6-11-07**	**TP7-11-05**	**TP8-11-04**	**TP8-DUP2**	**TP9-11-07**	**TP10-11-02**	**RDL**	**QC Batch**
Polycyclic Aromatics									
Acenaphthene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	5417150
Benzo[a]pyrene equivalency	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	5416495
Acenaphthylene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	5417150
Acridine	mg/kg	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.010	5417150
Anthracene	mg/kg	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	0.0040	5417150
Benzo(a)anthracene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	5417150
Benzo(b&j)fluoranthene	mg/kg	0.0076	<0.0050	0.0056	0.0055	<0.0050	0.0087	0.0050	5417150
Benzo(k)fluoranthene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	5417150
Benzo(g,h,i)perylene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	5417150
Benzo(c)phenanthrene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	5417150
Benzo(a)pyrene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	5417150
Benzo[e]pyrene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	5417150
Chrysene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	5417150
Dibenz(a,h)anthracene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	5417150
Fluoranthene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	5417150
Fluorene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	5417150
Indeno(1,2,3-cd)pyrene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	5417150
2-Methylnaphthalene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	5417150
Naphthalene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	5417150
Phenanthrene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	5417150
Perylene	mg/kg	0.0091	<0.0050	0.0083	0.0070	<0.0050	0.018	0.0050	5417150
Pyrene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	5417150
Quinoline	mg/kg	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.010	5417150
Surrogate Recovery (%)									
D10-ANTHRACENE (sur.)	%	99	100	101	99	97	100	N/A	5417150
D12-BENZO(A)PYRENE (sur.)	%	110	111	112	110	107	112	N/A	5417150
D8-ACENAPHTHYLENE (sur.)	%	105	108	109	107	104	112	N/A	5417150
TERPHENYL-D14 (sur.)	%	100	102	102	100	98	102	N/A	5417150

N/A = Not Applicable
RDL = Reportable Detection Limit

Maxxam

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Maxxam Job #: B1B7081
Report Date: 2012/01/06

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Location: DRUMHELLER INSTITUTE, ALBERTA
Your P.O. #: 2026-1101
Sampler Initials: TJ

SEMIVOLATILE ORGANICS BY GC-MS (SOIL)

Maxxam ID		CG7778	CG7779	CG7782	CG7783		CG7785		
Sampling Date		2011/11/30	2011/11/30	2011/11/30	2011/11/30		2011/11/30		
	Units	**TP11-11-03**	**TP12-11-04**	**TP15-11-03**	**TP15-11-04**	**RDL**	**TP16-11-02**	**RDL**	**QC Batch**
Polycyclic Aromatics									
Acenaphthene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Benzo[a]pyrene equivalency	mg/kg	<0.10	<0.10	<0.10	<0.10	0.10	<0.10	0.10	5416495
Acenaphthylene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Acridine	mg/kg	<0.010	<0.010	<0.010	<0.010	0.010	<0.010	0.010	5417150
Anthracene	mg/kg	<0.0040	<0.0040	<0.0040	<0.0040	0.0040	<0.0040	0.0040	5417150
Benzo(a)anthracene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Benzo(b&j)fluoranthene	mg/kg	<0.0050	0.0086	0.011	<0.0050	0.0050	<0.0087 (1)	0.0087	5417150
Benzo(k)fluoranthene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Benzo(g,h,i)perylene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	0.0081	0.0050	5417150
Benzo(c)phenanthrene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Benzo(a)pyrene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Benzo[e]pyrene	mg/kg	<0.0050	<0.0050	0.0055	<0.0050	0.0050	0.0065	0.0050	5417150
Chrysene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Dibenz(a,h)anthracene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Fluoranthene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	0.0054	0.0050	5417150
Fluorene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Indeno(1,2,3-cd)pyrene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
2-Methylnaphthalene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Naphthalene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Phenanthrene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Perylene	mg/kg	<0.0050	0.023	0.023	0.010	0.0050	0.0069	0.0050	5417150
Pyrene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	<0.0050	0.0050	5417150
Quinoline	mg/kg	<0.010	<0.010	<0.010	<0.010	0.010	<0.010	0.010	5417150
Surrogate Recovery (%)									
D10-ANTHRACENE (sur.)	%	99	95	105	101	N/A	101	N/A	5417150
D12-BENZO(A)PYRENE (sur.)	%	109	108	116	111	N/A	113	N/A	5417150
D8-ACENAPHTHYLENE (sur.)	%	109	104	110	108	N/A	107	N/A	5417150
TERPHENYL-D14 (sur.)	%	99	99	106	101	N/A	101	N/A	5417150

N/A = Not Applicable
RDL = Reportable Detection Limit
(1) - Detection limits raised due to matrix interference.

Maxxam Job #: B1B7081
Report Date: 2012/01/06

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Location: DRUMHELLER INSTITUTE, ALBERTA
Your P.O. #: 2026-1101
Sampler Initials: TJ

Package 1	9.5°C
Package 2	8.8°C

Each temperature is the average of up to three cooler temperatures taken at receipt

General Comments

This report is being re-issued with change in the project number as requested by the client.

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Maxxam Job #: B1B7081
Report Date: 2012/01/06

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Location: DRUMHELLER INSTITUTE, ALBERTA
Your P.O. #: 2026-1101
Sampler Initials: TJ

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
5410245	Sieve - Pan	2011/12/05							2.5	35	100	96 - 104
5410245	Sieve - #200 (>0.075mm)	2011/12/05							0.5	35	100	90 - 110
5417047	Moisture	2011/12/02							0.9	20		
5417150	D10-ANTHRACENE (sur.)	2011/12/06	95	50 - 130	99	50 - 130	101	%				
5417150	D12-BENZO(A)PYRENE (sur.)	2011/12/06	103	50 - 130	109	50 - 130	107	%				
5417150	D8-ACENAPHTHYLENE (sur.)	2011/12/06	101	50 - 130	105	50 - 130	109	%				
5417150	TERPHENYL-D14 (sur.)	2011/12/06	94	50 - 130	102	50 - 130	101	%				
5417150	Acenaphthene	2011/12/06	98	50 - 130	99	50 - 130	<0.0050	mg/kg	NC	50		
5417150	Acenaphthylene	2011/12/06	105	50 - 130	105	50 - 130	<0.0050	mg/kg	NC	50		
5417150	Acridine	2011/12/06	82	50 - 130	84	50 - 130	<0.010	mg/kg	NC	50		
5417150	Anthracene	2011/12/06	93	50 - 130	95	50 - 130	<0.0040	mg/kg	NC	50		
5417150	Benzo(a)anthracene	2011/12/06	100	50 - 130	103	50 - 130	<0.0050	mg/kg	NC	50		
5417150	Benzo(b&j)fluoranthene	2011/12/06	101	50 - 130	105	50 - 130	<0.0050	mg/kg	NC	50		
5417150	Benzo(k)fluoranthene	2011/12/06	79	50 - 130	80	50 - 130	<0.0050	mg/kg	NC	50		
5417150	Benzo(g,h,i)perylene	2011/12/06	112	50 - 130	104	50 - 130	<0.0050	mg/kg	NC	50		
5417150	Benzo(c)phenanthrene	2011/12/06	89	50 - 130	93	50 - 130	<0.0050	mg/kg	NC	50		
5417150	Benzo(a)pyrene	2011/12/06	91	50 - 130	94	50 - 130	<0.0050	mg/kg	NC	50		
5417150	Benzo[e]pyrene	2011/12/06	93	50 - 130	95	50 - 130	<0.0050	mg/kg	NC	50		
5417150	Chrysene	2011/12/06	106	50 - 130	108	50 - 130	<0.0050	mg/kg	NC	50		
5417150	Dibenz(a,h)anthracene	2011/12/06	113	50 - 130	104	50 - 130	<0.0050	mg/kg	NC	50		
5417150	Fluoranthene	2011/12/06	99	50 - 130	101	50 - 130	<0.0050	mg/kg	NC	50		
5417150	Fluorene	2011/12/06	97	50 - 130	98	50 - 130	<0.0050	mg/kg	NC	50		
5417150	Indeno(1,2,3-cd)pyrene	2011/12/06	114	50 - 130	105	50 - 130	<0.0050	mg/kg	NC	50		
5417150	2-Methylnaphthalene	2011/12/06	107	50 - 130	106	50 - 130	<0.0050	mg/kg	NC	50		
5417150	Naphthalene	2011/12/06	93	50 - 130	94	50 - 130	<0.0050	mg/kg	NC	50		
5417150	Phenanthrene	2011/12/06	101	50 - 130	102	50 - 130	<0.0050	mg/kg	NC	50		
5417150	Perylene	2011/12/06	108	50 - 130	106	50 - 130	<0.0050	mg/kg	NC	50		
5417150	Pyrene	2011/12/06	101	50 - 130	98	50 - 130	<0.0050	mg/kg	NC	50		
5417150	Quinoline	2011/12/06	95	50 - 130	93	50 - 130	<0.010	mg/kg	NC	50		
5417151	O-TERPHENYL (sur.)	2011/12/04	76	50 - 130	84	50 - 130	76	%				
5417151	F2 (C10-C16 Hydrocarbons)	2011/12/04	76	50 - 130	81	70 - 130	<10	mg/kg	NC	50		
5417151	F3 (C16-C34 Hydrocarbons)	2011/12/04	75	50 - 130	79	70 - 130	<10	mg/kg	NC	50		
5417151	F4 (C34-C50 Hydrocarbons)	2011/12/04	78	50 - 130	81	70 - 130	<10	mg/kg	NC	50		
5419613	1,4-Difluorobenzene (sur.)	2011/12/07	112	60 - 140	101	60 - 140	99	%				
5419613	4-BROMOFLUOROBENZENE (sur.)	2011/12/07	101	60 - 140	99	60 - 140	101	%				
5419613	D10-ETHYLBENZENE (sur.)	2011/12/07	109	60 - 130	105	60 - 130	108	%				
5419613	D4-1,2-DICHLOROETHANE (sur.)	2011/12/07	102	60 - 140	100	60 - 140	101	%				
5419613	Benzene	2011/12/07	108	60 - 140	103	60 - 140	<0.0050	mg/kg	NC	50		
5419613	Toluene	2011/12/07	109	60 - 140	100	60 - 140	<0.020	mg/kg	NC	50		

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Maxxam Job #: B1B7081
Report Date: 2012/01/06

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Location: DRUMHELLER INSTITUTE, ALBERTA
Your P.O. #: 2026-1101
Sampler Initials: TJ

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
5419613	Ethylbenzene	2011/12/07	111	60 - 140	100	60 - 140	<0.010	mg/kg	NC	50		
5419613	m & p-Xylene	2011/12/07	111	60 - 140	102	60 - 140	<0.040	mg/kg	NC	50		
5419613	o-Xylene	2011/12/07	110	60 - 140	101	60 - 140	<0.020	mg/kg	NC	50		
5419613	(C6-C10)	2011/12/07	115	60 - 140	115	60 - 140	<12	mg/kg	NC	50		
5419613	Xylenes (Total)	2011/12/07					<0.040	mg/kg	NC	50		
5419613	F1 (C6-C10) - BTEX	2011/12/07					<12	mg/kg	NC	50		
5422192	Moisture	2011/12/05							2.6	20		
5422917	Hex. Chromium (Cr 6+)	2011/12/06	100	75 - 125	102	90 - 110	<0.15	mg/kg	NC	35		
5423104	Soluble (Hot water) Boron (B)	2011/12/06	99	75 - 125	90	75 - 125	<0.10	mg/kg	4.2	35		
5423430	Total Antimony (Sb)	2011/12/06	79	75 - 125	100	75 - 125	<1.0	mg/kg	NC	35		
5423430	Total Arsenic (As)	2011/12/06	79	75 - 125	87	75 - 125	<1.0	mg/kg	0.7	35	95	50 - 150
5423430	Total Barium (Ba)	2011/12/06	NC	75 - 125	97	75 - 125	<10	mg/kg	1.7	35	93	69 - 131
5423430	Total Beryllium (Be)	2011/12/06	99	75 - 125	93	75 - 125	<0.40	mg/kg	NC	35		
5423430	Total Cadmium (Cd)	2011/12/06	86	75 - 125	94	75 - 125	<0.10	mg/kg	NC	35		
5423430	Total Chromium (Cr)	2011/12/06	85	75 - 125	91	75 - 125	<1.0	mg/kg	0.8	35	87	41 - 159
5423430	Total Cobalt (Co)	2011/12/06	81	75 - 125	91	75 - 125	<1.0	mg/kg	0.9	35	86	75 - 125
5423430	Total Copper (Cu)	2011/12/06	75	75 - 125	90	75 - 125	<5.0	mg/kg	NC	35	84	72 - 127
5423430	Total Lead (Pb)	2011/12/06	84	75 - 125	95	75 - 125	<1.0	mg/kg	0.5	35	90	54 - 146
5423430	Total Mercury (Hg)	2011/12/06	88	75 - 125	102	75 - 125	0.057, RDL=0.050	mg/kg	NC	35		
5423430	Total Molybdenum (Mo)	2011/12/06	87	75 - 125	94	75 - 125	<0.40	mg/kg	NC	35		
5423430	Total Nickel (Ni)	2011/12/06	NC	75 - 125	90	75 - 125	<1.0	mg/kg	0.5	35	101	61 - 139
5423430	Total Selenium (Se)	2011/12/06	83	75 - 125	94	75 - 125	<0.50	mg/kg	NC	35		
5423430	Total Silver (Ag)	2011/12/06	83	75 - 125	92	75 - 125	<1.0	mg/kg	NC	35		
5423430	Total Thallium (Tl)	2011/12/06	80	75 - 125	90	75 - 125	<0.30	mg/kg	NC	35		
5423430	Total Tin (Sn)	2011/12/06	88	75 - 125	96	75 - 125	<1.0	mg/kg	NC	35		
5423430	Total Uranium (U)	2011/12/06	82	75 - 125	94	75 - 125	<1.0	mg/kg	NC	35		
5423430	Total Vanadium (V)	2011/12/06	NC	75 - 125	94	75 - 125	<1.0	mg/kg	1.2	35	99	50 - 150
5423430	Total Zinc (Zn)	2011/12/06	NC	75 - 125	91	75 - 125	<10	mg/kg	0.8	35	94	72 - 128
5423465	Hex. Chromium (Cr 6+)	2011/12/06	98	75 - 125	101	90 - 110	<0.15	mg/kg	NC	35		
5423832	Total Antimony (Sb)	2011/12/06	91	75 - 125	99	75 - 125	<1.0	mg/kg	NC	35		
5423832	Total Arsenic (As)	2011/12/06	90	75 - 125	89	75 - 125	<1.0	mg/kg	1.9	35	104	50 - 150
5423832	Total Barium (Ba)	2011/12/06	NC	75 - 125	97	75 - 125	<10	mg/kg	9.2	35	101	69 - 131
5423832	Total Beryllium (Be)	2011/12/06	81	75 - 125	79	75 - 125	<0.40	mg/kg	NC	35		
5423832	Total Cadmium (Cd)	2011/12/06	96	75 - 125	92	75 - 125	<0.10	mg/kg	NC	35		
5423832	Total Chromium (Cr)	2011/12/06	91	75 - 125	93	75 - 125	<1.0	mg/kg	28.2	35	94	41 - 159
5423832	Total Cobalt (Co)	2011/12/06	90	75 - 125	91	75 - 125	<1.0	mg/kg	7.9	35	94	75 - 125
5423832	Total Copper (Cu)	2011/12/06	87	75 - 125	91	75 - 125	<5.0	mg/kg	NC	35	93	72 - 127
5423832	Total Lead (Pb)	2011/12/06	93	75 - 125	93	75 - 125	<1.0	mg/kg	1.7	35	95	54 - 146
5423832	Total Mercury (Hg)	2011/12/06	99	75 - 125	98	75 - 125	<0.050	mg/kg	NC	35		

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Maxxam Job #: B1B7081
Report Date: 2012/01/06

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Location: DRUMHELLER INSTITUTE, ALBERTA
Your P.O. #: 2026-1101
Sampler Initials: TJ

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
5423832	Total Molybdenum (Mo)	2011/12/06	98	75 - 125	93	75 - 125	<0.40	mg/kg	NC	35		
5423832	Total Nickel (Ni)	2011/12/06	87	75 - 125	93	75 - 125	1.7, RDL=1.0	mg/kg	13.1	35	104	61 - 139
5423832	Total Selenium (Se)	2011/12/06	94	75 - 125	95	75 - 125	<0.50	mg/kg	NC	35		
5423832	Total Silver (Ag)	2011/12/06	94	75 - 125	91	75 - 125	<1.0	mg/kg	NC	35		
5423832	Total Thallium (Tl)	2011/12/06	89	75 - 125	88	75 - 125	<0.30	mg/kg	NC	35		
5423832	Total Tin (Sn)	2011/12/06	99	75 - 125	95	75 - 125	<1.0	mg/kg	NC	35		
5423832	Total Uranium (U)	2011/12/06	92	75 - 125	95	75 - 125	<1.0	mg/kg	NC	35		
5423832	Total Vanadium (V)	2011/12/06	97	75 - 125	94	75 - 125	<1.0	mg/kg	5.3	35	109	50 - 150
5423832	Total Zinc (Zn)	2011/12/06	NC	75 - 125	94	75 - 125	<10	mg/kg	6.3	35	102	72 - 128
5427660	Soluble (Hot water) Boron (B)	2011/12/07	100	75 - 125	93	75 - 125	<0.10	mg/kg	15.2	35		
5432079	Total Antimony (Sb)	2011/12/08	93	75 - 125	120	75 - 125	<1.0	mg/kg	NC	35		
5432079	Total Arsenic (As)	2011/12/08	92	75 - 125	101	75 - 125	<1.0	mg/kg	2.5	35	118	50 - 150
5432079	Total Barium (Ba)	2011/12/08	NC	75 - 125	109	75 - 125	<10	mg/kg	2.6	35	112	69 - 131
5432079	Total Beryllium (Be)	2011/12/08	80	75 - 125	97	75 - 125	<0.40	mg/kg	NC	35		
5432079	Total Cadmium (Cd)	2011/12/08	95	75 - 125	104	75 - 125	<0.10	mg/kg	NC	35		
5432079	Total Chromium (Cr)	2011/12/08	92	75 - 125	102	75 - 125	<1.0	mg/kg	3.3	35	108	41 - 159
5432079	Total Cobalt (Co)	2011/12/08	87	75 - 125	95	75 - 125	<1.0	mg/kg	6.9	35	99	75 - 125
5432079	Total Copper (Cu)	2011/12/08	83	75 - 125	95	75 - 125	<5.0	mg/kg	NC	35	100	72 - 127
5432079	Total Lead (Pb)	2011/12/08	87	75 - 125	100	75 - 125	<1.0	mg/kg	2.4	35	100	54 - 146
5432079	Total Mercury (Hg)	2011/12/08	90	75 - 125	100	75 - 125	<0.050	mg/kg	NC	35		
5432079	Total Molybdenum (Mo)	2011/12/08	97	75 - 125	101	75 - 125	<0.40	mg/kg	NC	35		
5432079	Total Nickel (Ni)	2011/12/08	NC	75 - 125	100	75 - 125	<1.0	mg/kg	3.6	35	111	61 - 139
5432079	Total Selenium (Se)	2011/12/08	89	75 - 125	101	75 - 125	<0.50	mg/kg	NC	35		
5432079	Total Silver (Ag)	2011/12/08	90	75 - 125	100	75 - 125	<1.0	mg/kg	NC	35		
5432079	Total Thallium (Tl)	2011/12/08	81	75 - 125	94	75 - 125	<0.30	mg/kg	NC	35		
5432079	Total Tin (Sn)	2011/12/08	102	75 - 125	105	75 - 125	<1.0	mg/kg	NC	35		
5432079	Total Uranium (U)	2011/12/08	83	75 - 125	89	75 - 125	<1.0	mg/kg	NC	35		

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Maxxam Job #: B1B7081
Report Date: 2012/01/06

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Location: DRUMHELLER INSTITUTE, ALBERTA
Your P.O. #: 2026-1101
Sampler Initials: TJ

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
5432079	Total Vanadium (V)	2011/12/08	NC	75 - 125	101	75 - 125	<1.0	mg/kg	5.2	35	120	50 - 150
5432079	Total Zinc (Zn)	2011/12/08	NC	75 - 125	97	75 - 125	<10	mg/kg	0.07	35	105	72 - 128

N/A = Not Applicable
RDL = Reportable Detection Limit
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

Validation Signature Page

Maxxam Job #: B1B7081

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Janet Gao, Senior Analyst, Organics Department

Lili Zhou, Senior analyst, Inorganic department.

Daniel Reslan, Volatiles Supervisor

==========

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam

Calgary: 4000 19st St. NE, T2E 6P8. Ph: (403) 291-3077, Fax: (403) 735-2240, Toll free: (800) 386-7247
Edmonton: 9331 - 48 Street, T6B 2R4. Ph: (780) 577-7100, Fax: (780) 450-4187, Toll free: (877) 465-8889
www.maxxamanalytics.com

Chain of Custody

A065208

Page: 1 of 2

	Invoice To: C/O Report Address ☐	Report To: Same as Invoice ☒	Report Distribution (E-Mail):
Company:	Franz Environmental Inc.		slivingstone@franzenvironmental.com
Contact:	Stephen Livingstone		
Address:	324 Churchill Ave. North - Suite 200		
	Prov: Ottawa, Ontario PC:	Prov: PC:	
Contact #s:	Ph: 613 721 0655 Cell:	Ph: Cell:	

REGULATORY GUIDELINES:
- ☐ AT1
- ☒ CCME
- ☐ Regulated Drinking Water
- ☐ Other:

All samples are held for 60 calendar days after sample receipt, unless specified otherwise.

PO #: 2026-1101
Project # / Name: Landfill Intensive Investigation
Site Location: Drumheller Institute, Alberta
Quote #:
Sampled By: Troy Fun Jones

SERVICE REQUESTED: ☐ RUSH (Contact lab to reserve) Date Required: ☐ REGULAR (5 to 7 Days)

See reverse for package specifics

	Sample ID	Depth (unit)	Matrix GW / SW Soil	Date/Time Sampled YY/MM/DD 24:00	SOIL: BTEX F1-F4	Sieve (75 micron)	Regulated Metals (CCME / AT1)	Salinity 4	Assessment ICP Metals	Basic Class II Landfill	PAH	WATER: ☐VOCs ☐BTEX F1	☐BTEX F1-F4 ☐BTEX F1-F2	☐Routine Water ☐Turb ☐F	☐TOC ☐DOC	Regulated Metals (CCME / AT1) Total	Dissolved	Mercury ☐Total ☐Dissolved	Other Analysis	HOLD - Do not Analyze	# of Containers Submitted
1	TP1-11-03			11/11/29	X				X		X										4
2	TP1-DUP1				X				X		X										4
3	TP2-11-04				X				X		X										4
4	TP2-11-07				X				X		X										4
5	TP3-11-07				X				X		X										4
6	TP4-11-05				X				X		X										4
7	TP5-11-02				X				X		X										4
8	TP6-11-03								X												1
9	TP6-11-07				X				X		X										4
10	TP7-11-05				X				X		X										4
11	TP8-11-04			11/11/30	X				X		X										4
12	TP8-DUP2				X				X		X										4

Please indicate Filtered, Preserved or Both (F, P, F/P) → F/P

Relinquished By (Signature/Print):	Date (YY/MM/DD):	Time (24:00):
THW Jones	11/12/02	0845
Relinquished By (Signature/Print):	Date (YY/MM/DD):	Time (24:00):

Special Instructions: Sample jar boxes damaged, careful when removing.

# of Jars Used & Not Submitted

LAB USE ONLY

Received By:	Date:	Time:	Maxxam Job #: B187081
Ash White	02/12/11	12:24	

Custody Seal	Temperature	Ice

Lab Comments:

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Calgary: 4000 19st St. NE, T2E 6P8. Ph: (403) 291-3077, Fax: (403) 735-2240, Toll free: (800) 386-7247
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Chain of Custody

A065210

Page: 2 of 2

	Invoice To: C/O Report Address ☐	Report To: Same as Invoice ☒	Report Distribution (E-Mail):
Company:	Franz Environmental Inc		slivingstone@franzenvironmental.com
Contact:	Stephen Livingstone		
Address:	32nd Churchill Av. North - Suite 200		
	Prov: Ottawa, Ontario PC:	Prov: PC:	
Contact #s:	Ph: 613 721 0555 Cell:	Ph: Cell:	

REGULATORY GUIDELINES:
- ☐ AT1
- ☒ CCME
- ☐ Regulated Drinking Water
- ☐ Other:

All samples are held for 60 calendar days after sample receipt, unless specified otherwise.

PO #: 2026-1101
Project # / Name: Landfill intrusive investigation
Site Location: Drumheller Irish Hill Alberta
Quote #:
Sampled By: Trystan Jones

SERVICE REQUESTED: ☐ RUSH (Contact lab to reserve) Date Required: ☒ REGULAR (5 to 7 Days)

See reverse for package specifics

	Sample ID	Depth (unit)	Matrix GW / SW Soil	Date/Time Sampled YY/MM/DD 24:00	SOIL: BTEX F1-F4	Sieve (75 micron)	Regulated Metals (CCME / AT1)	Salinity 4	Assessment ICP Metals	Basic Class II Landfill	PAH	WATER: ☐ VOCs ☐ BTEX F1 ☐ BTEX F1-F2	☐ BTEX F1-F4 ☐ Routine Water	☐ Turb ☐ F ☐ TOC	☐ DOC	Regulated Metals (CCME / AT1) Total	Dissolved	Mercury	☐ Total ☐ Dissolved	Other Analysis	HOLD - Do not Analyze	# of Containers Submitted
1	TP9-11-07			11/11/30	X	X			X		X											4
2	TP10-11-02				X	X			X		X											4
3	TP10-11-04								X													1
4	TP11-11-03				X				X		X											4
5	TP12-11-04				X	X			X		X											4
6	TP13-11-04								X													1
7	TP14-11-04								X													1
8	TP15-11-03				X				X		X											4
9	TP15-11-04				X						X											3
10	TP15-11-05								X													1
11	TP16-11-02				X						X											3
12	TP16-11-07								X													1
	Please indicate Filtered, Preserved or Both (F, P, F/P)																					F/P

Relinquished By (Signature/Print):	Date (YY/MM/DD):	Time (24:00):
THW JONES	11/12/02	0845
Relinquished By (Signature/Print):	Date (YY/MM/DD):	Time (24:00):

Special Instructions: Sample jar boxes damaged, careful when removing.

# of Jars Used & Not Submitted

LAB USE ONLY

Received By:	Date:	Time:	Maxxam Job #: B187081
Ash White ACW	02/12/11	12:24	

Lab Comments:	Custody Seal	Temperature	Ice
	Y		Y

AB FCD-00331 Rev3 2010/05

Maxxam Analytics International Corporation o/a Maxxam Analytics

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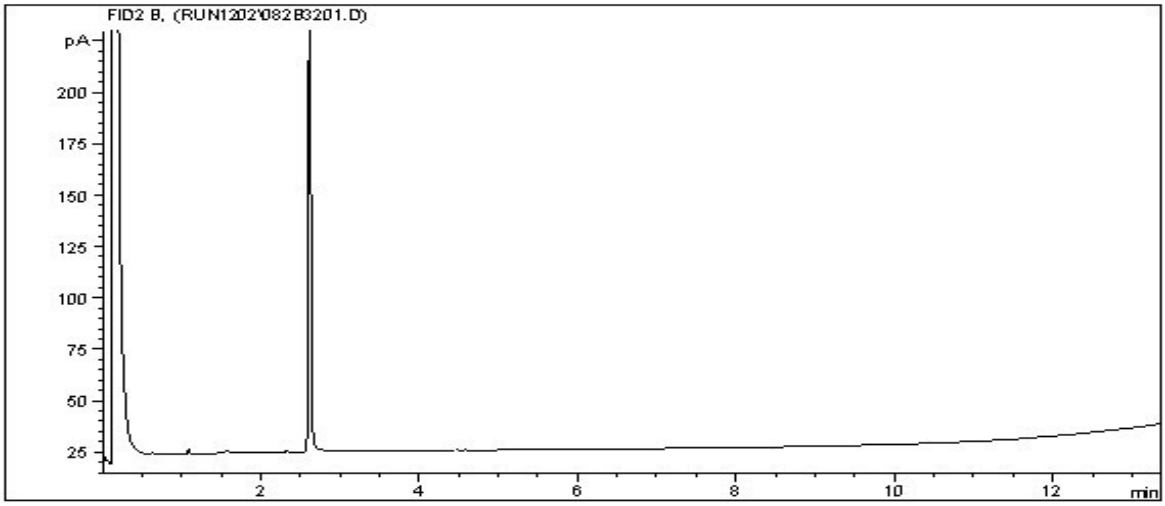
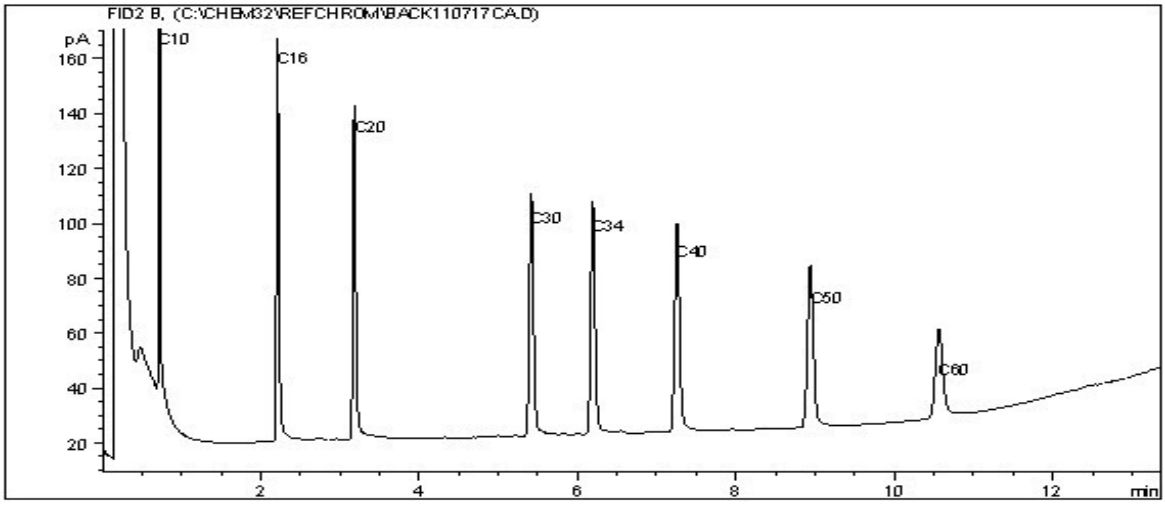
Report Date: 2012/01/06
Maxxam Job #: B1B7081
Maxxam Sample: CG7761

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Reference: DRUMHELLER INSTITUTE, ALBERTA
Client ID: TP1-11-03

CCME Hydrocarbons (F2-F4 in soil) Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40
Kerosene:	C7 - C16	Crude Oils:	C3 - C60+

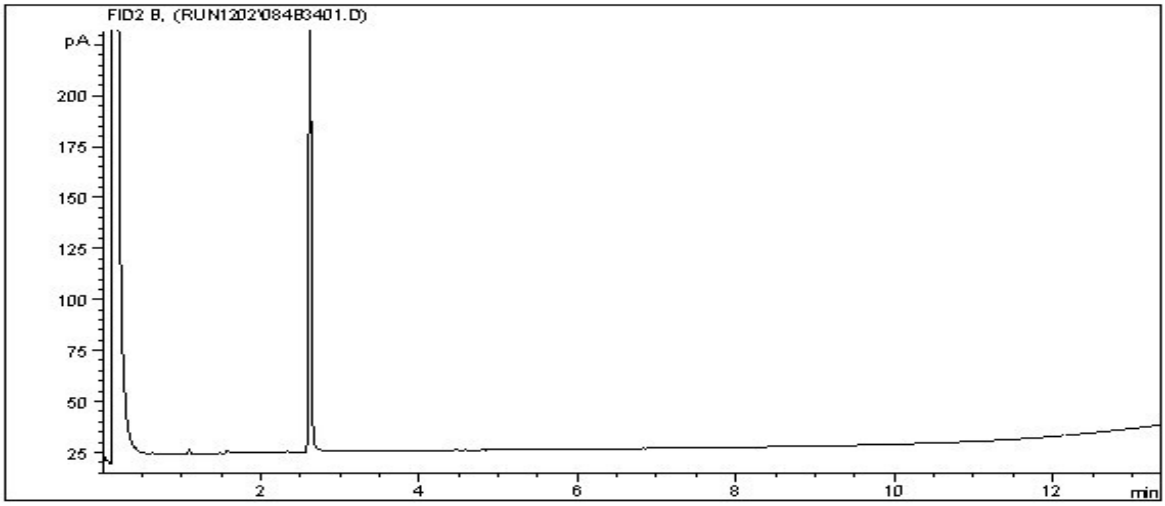
Page 1 of 1

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

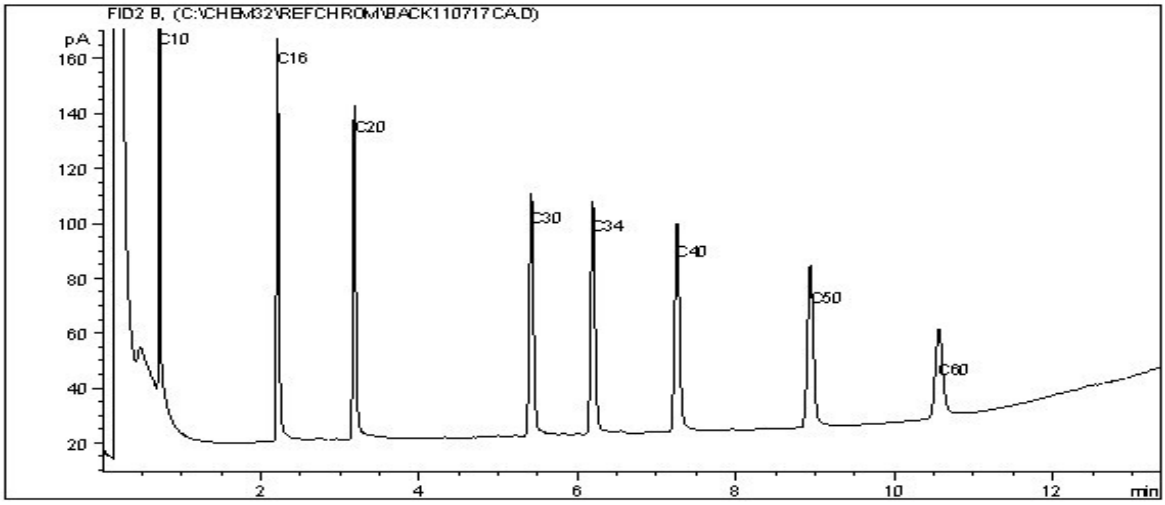
Report Date: 2012/01/06
Maxxam Job #: B1B7081
Maxxam Sample: CG7761 Lab-Dup

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Reference: DRUMHELLER INSTITUTE, ALBERTA
Client ID: TP1-11-03

CCME Hydrocarbons (F2-F4 in soil) Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40
Kerosene:	C7 - C16	Crude Oils:	C3 - C60+

Page 1 of 1

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

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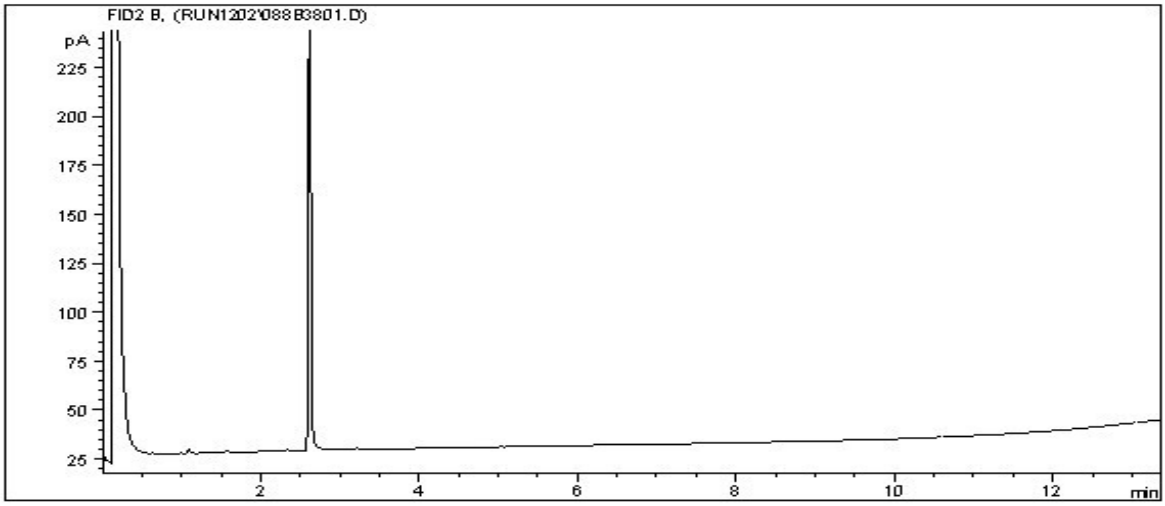
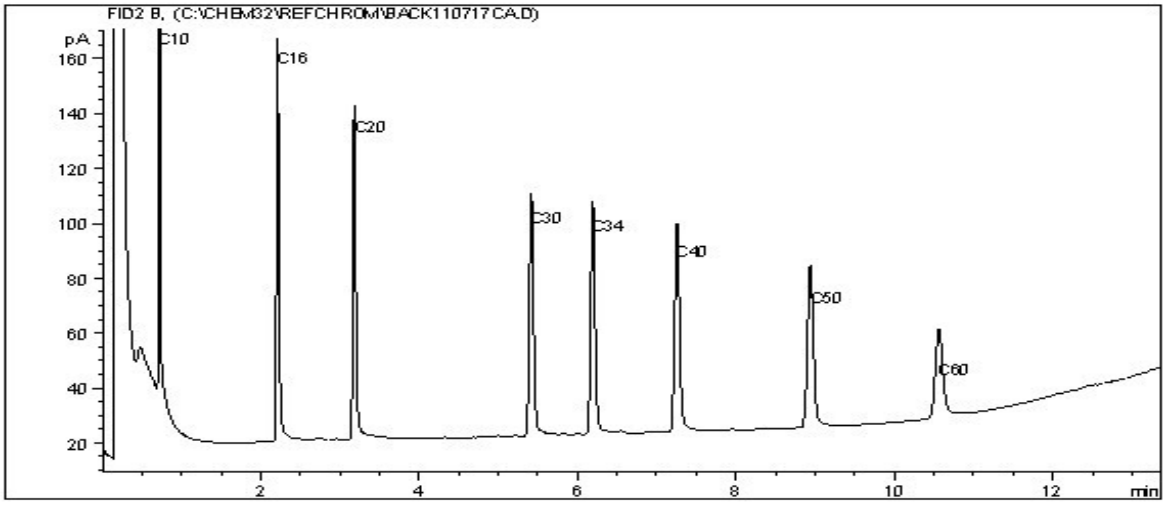
Report Date: 2012/01/06
Maxxam Job #: B1B7081
Maxxam Sample: CG7762

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Reference: DRUMHELLER INSTITUTE, ALBERTA
Client ID: TP1-DUP1

CCME Hydrocarbons (F2-F4 in soil) Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40
Kerosene:	C7 - C16	Crude Oils:	C3 - C60+

Page 1 of 1

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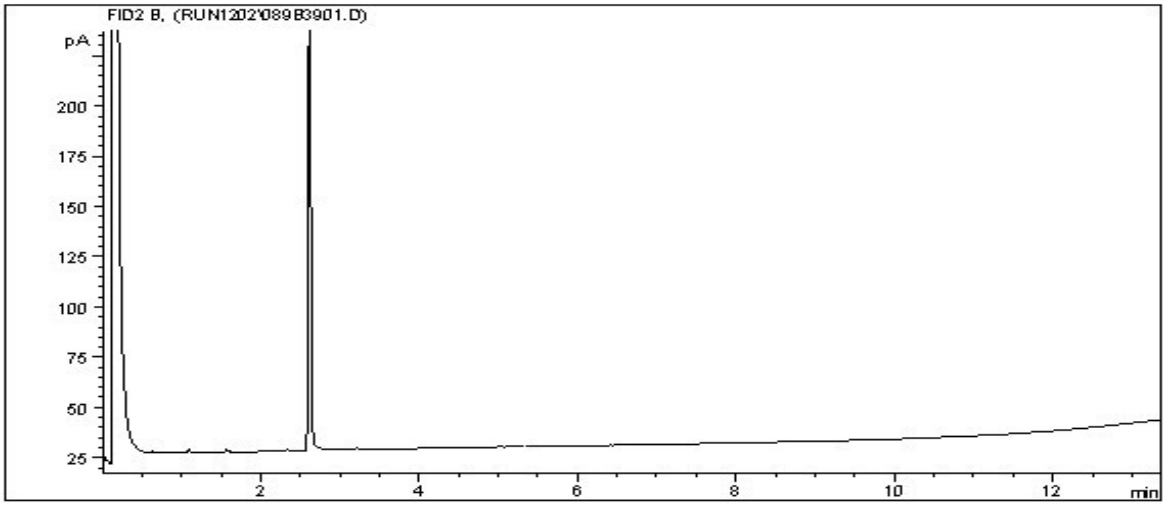
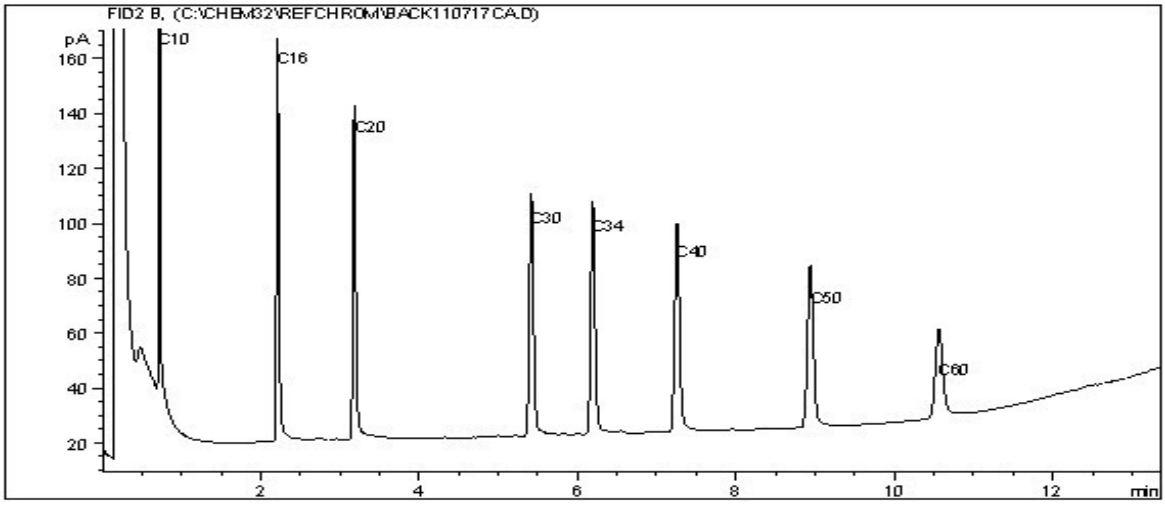
Report Date: 2012/01/06
Maxxam Job #: B1B7081
Maxxam Sample: CG7763

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Reference: DRUMHELLER INSTITUTE, ALBERTA
Client ID: TP2-11-04

CCME Hydrocarbons (F2-F4 in soil) Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40
Kerosene:	C7 - C16	Crude Oils:	C3 - C60+

Page 1 of 1

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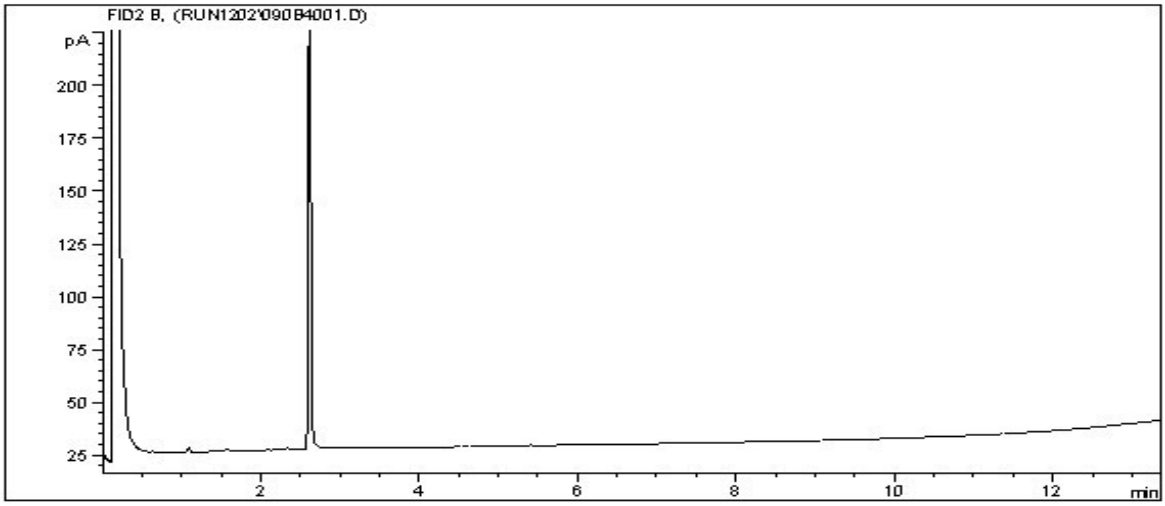
Success Through Science®

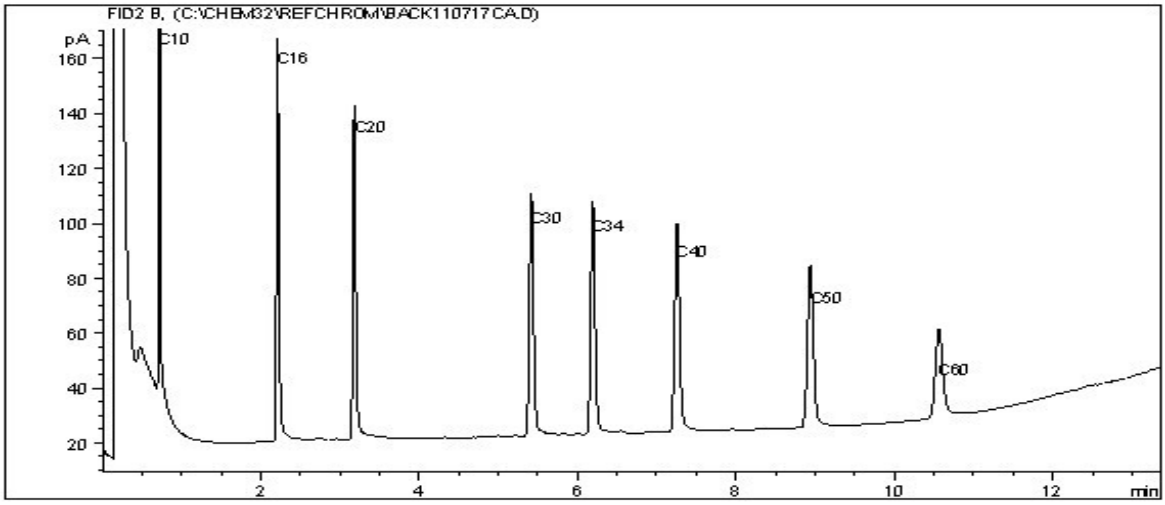
Report Date: 2012/01/06
Maxxam Job #: B1B7081
Maxxam Sample: CG7764

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Reference: DRUMHELLER INSTITUTE, ALBERTA
Client ID: TP2-11-07

CCME Hydrocarbons (F2-F4 in soil) Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40
Kerosene:	C7 - C16	Crude Oils:	C3 - C60+

Page 1 of 1

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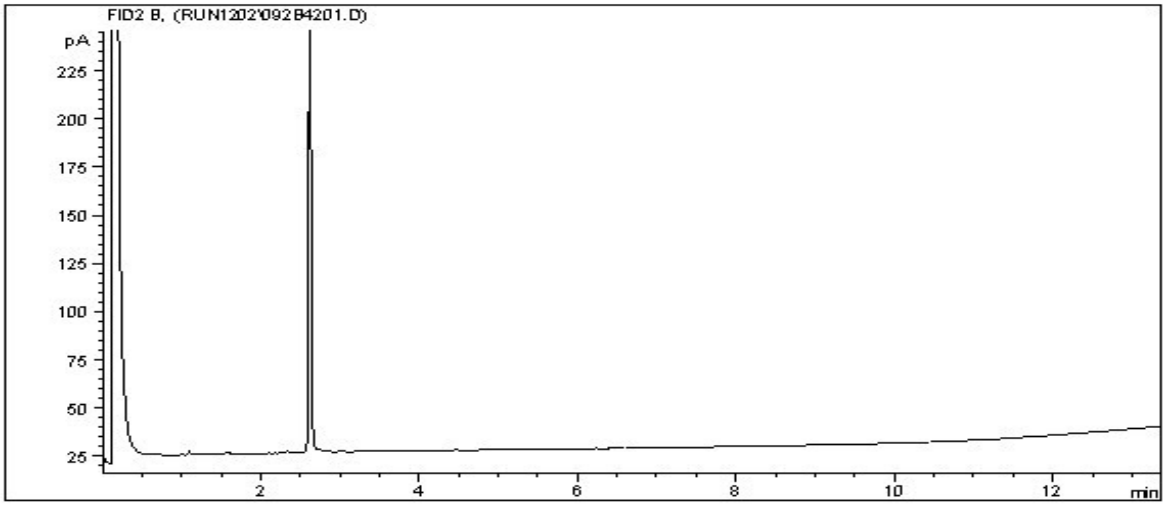
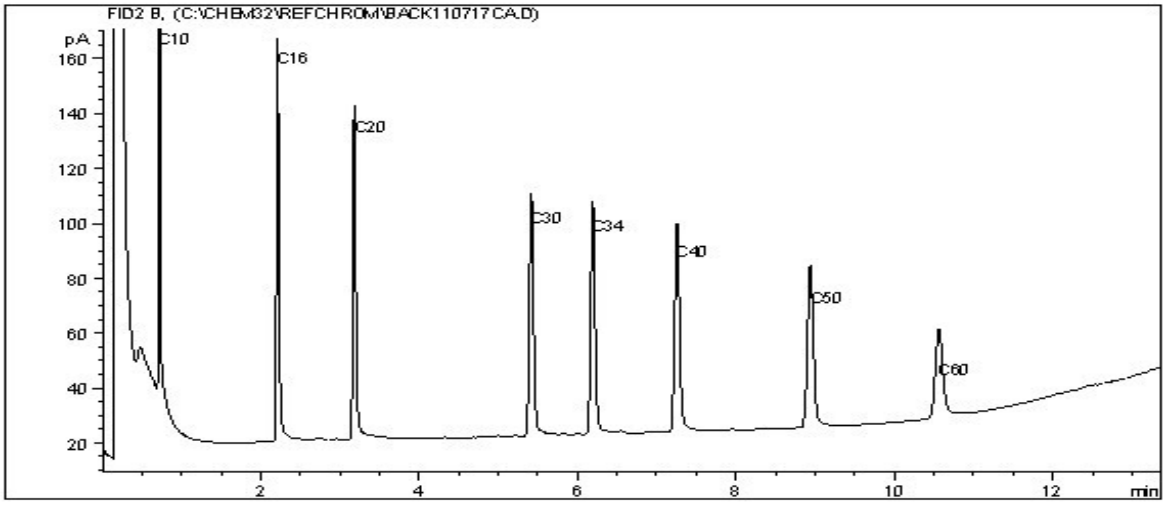
Report Date: 2012/01/06
Maxxam Job #: B1B7081
Maxxam Sample: CG7765

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Reference: DRUMHELLER INSTITUTE, ALBERTA
Client ID: TP3-11-07

CCME Hydrocarbons (F2-F4 in soil) Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40
Kerosene:	C7 - C16	Crude Oils:	C3 - C60+

Page 1 of 1

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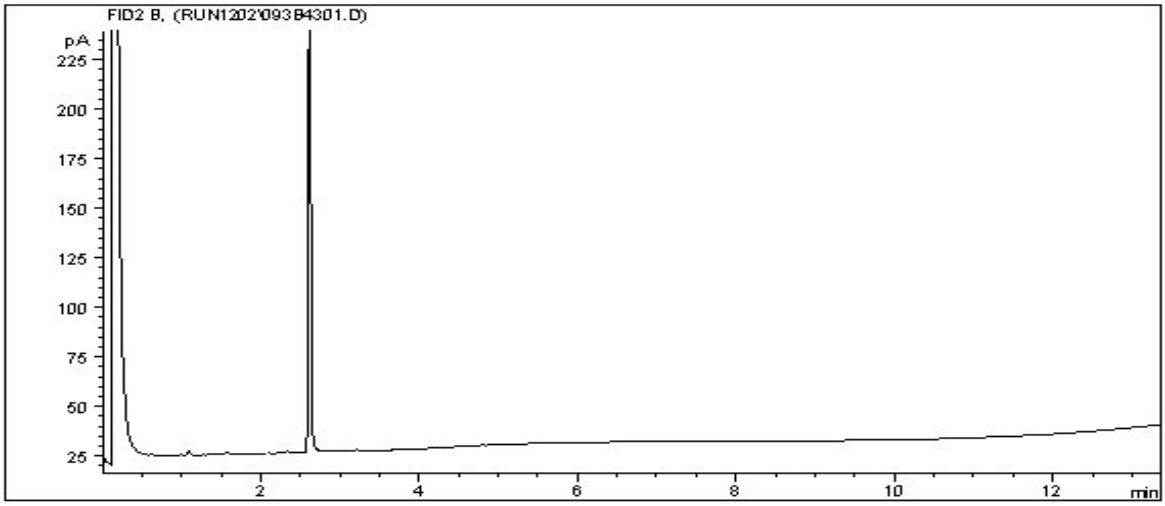
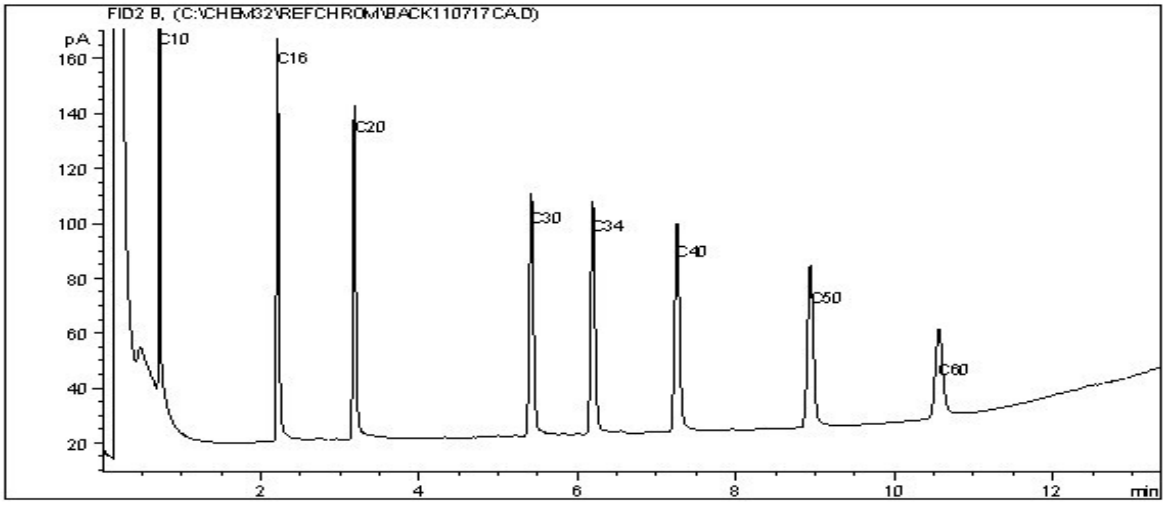
Report Date: 2012/01/06
Maxxam Job #: B1B7081
Maxxam Sample: CG7766

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Reference: DRUMHELLER INSTITUTE, ALBERTA
Client ID: TP4-11-05

CCME Hydrocarbons (F2-F4 in soil) Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40
Kerosene:	C7 - C16	Crude Oils:	C3 - C60+

Page 1 of 1

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

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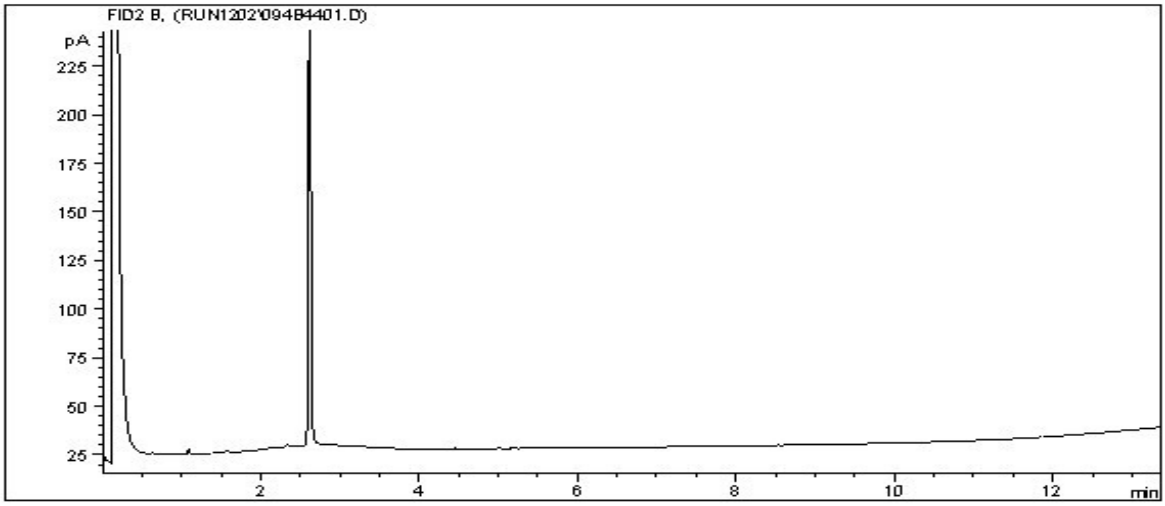
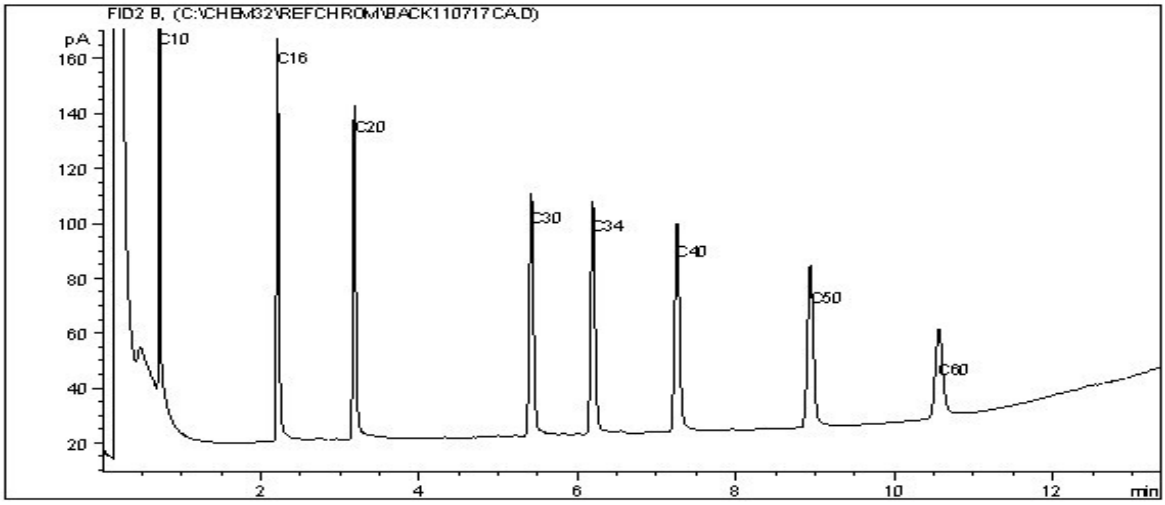
Report Date: 2012/01/06
Maxxam Job #: B1B7081
Maxxam Sample: CG7767

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Reference: DRUMHELLER INSTITUTE, ALBERTA
Client ID: TP5-11-02

CCME Hydrocarbons (F2-F4 in soil) Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40
Kerosene:	C7 - C16	Crude Oils:	C3 - C60+

Page 1 of 1

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

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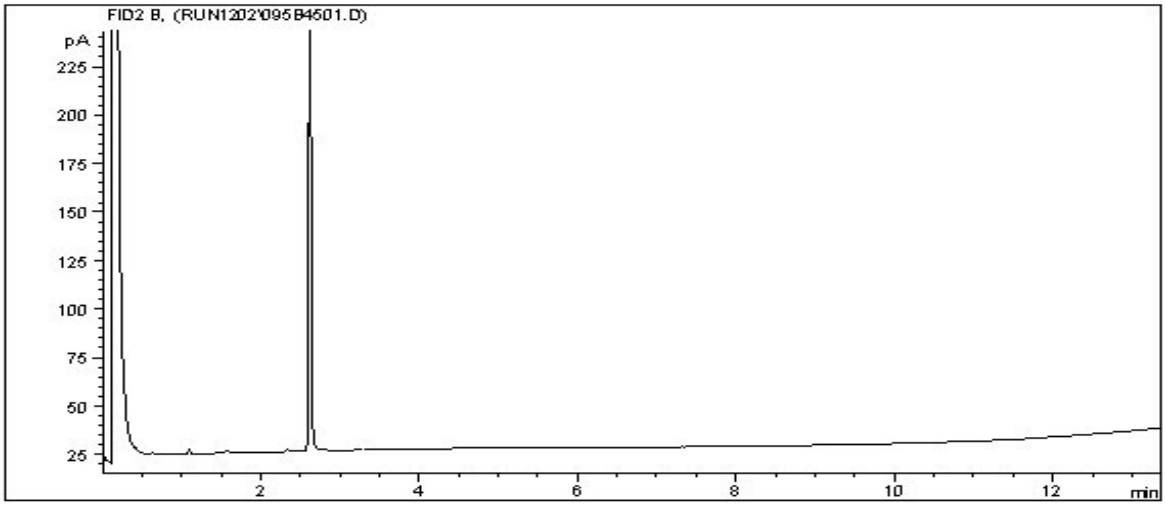
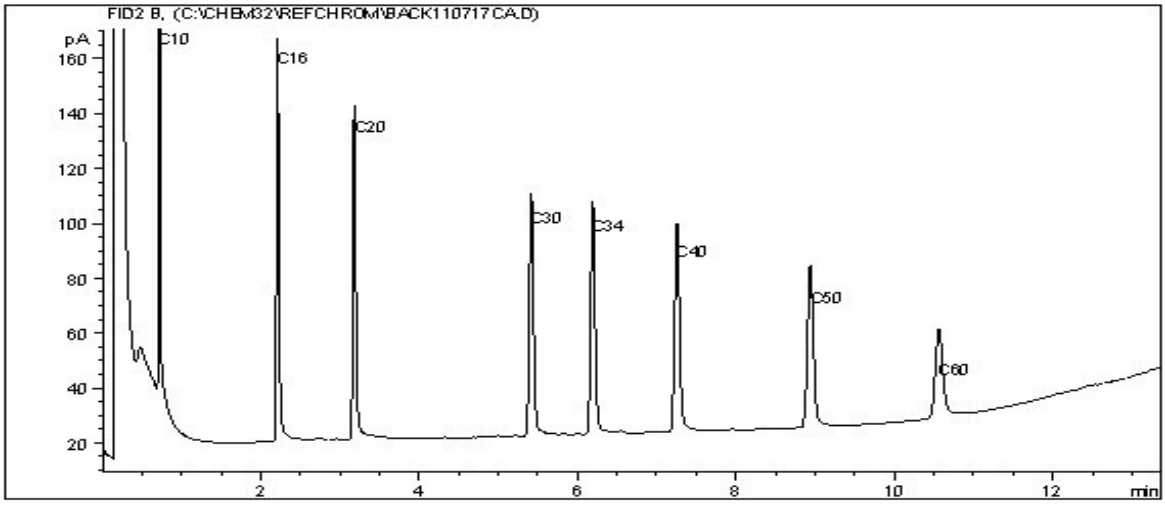
Report Date: 2012/01/06
Maxxam Job #: B1B7081
Maxxam Sample: CG7769

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Reference: DRUMHELLER INSTITUTE, ALBERTA
Client ID: TP6-11-07

CCME Hydrocarbons (F2-F4 in soil) Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40
Kerosene:	C7 - C16	Crude Oils:	C3 - C60+

Page 1 of 1

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

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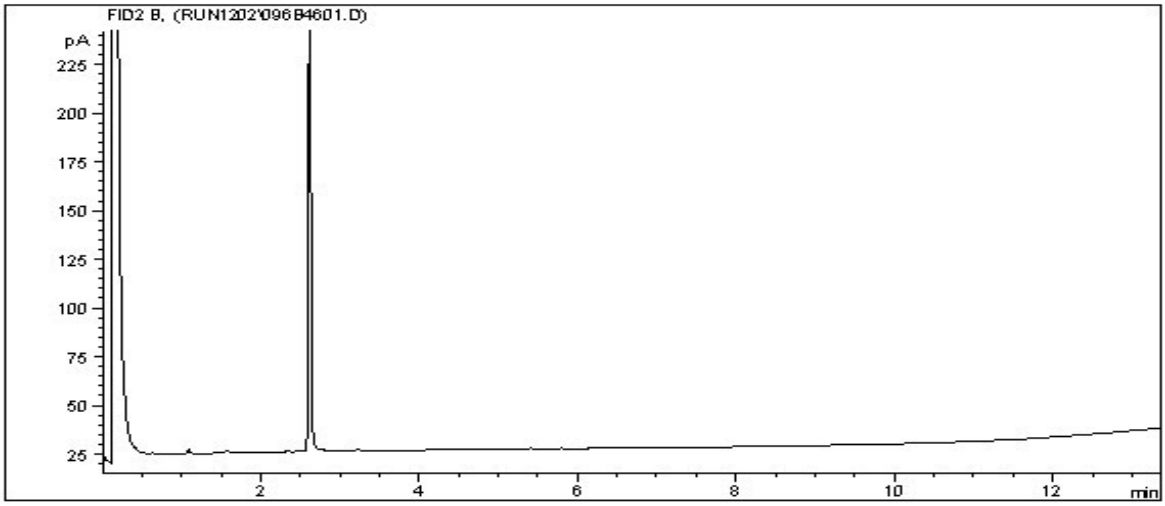
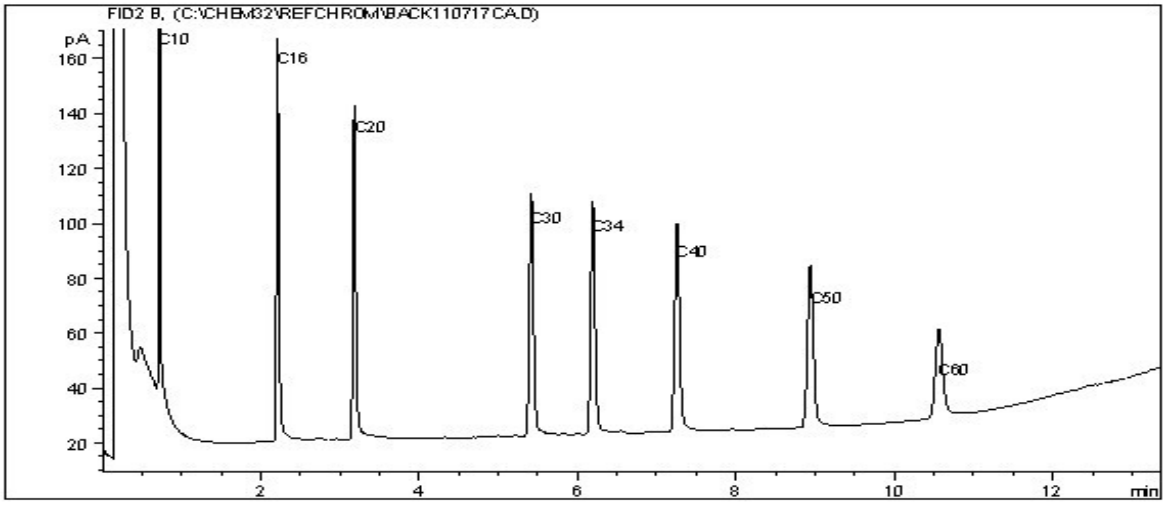
Report Date: 2012/01/06
Maxxam Job #: B1B7081
Maxxam Sample: CG7770

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Reference: DRUMHELLER INSTITUTE, ALBERTA
Client ID: TP7-11-05

CCME Hydrocarbons (F2-F4 in soil) Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40
Kerosene:	C7 - C16	Crude Oils:	C3 - C60+

Page 1 of 1

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

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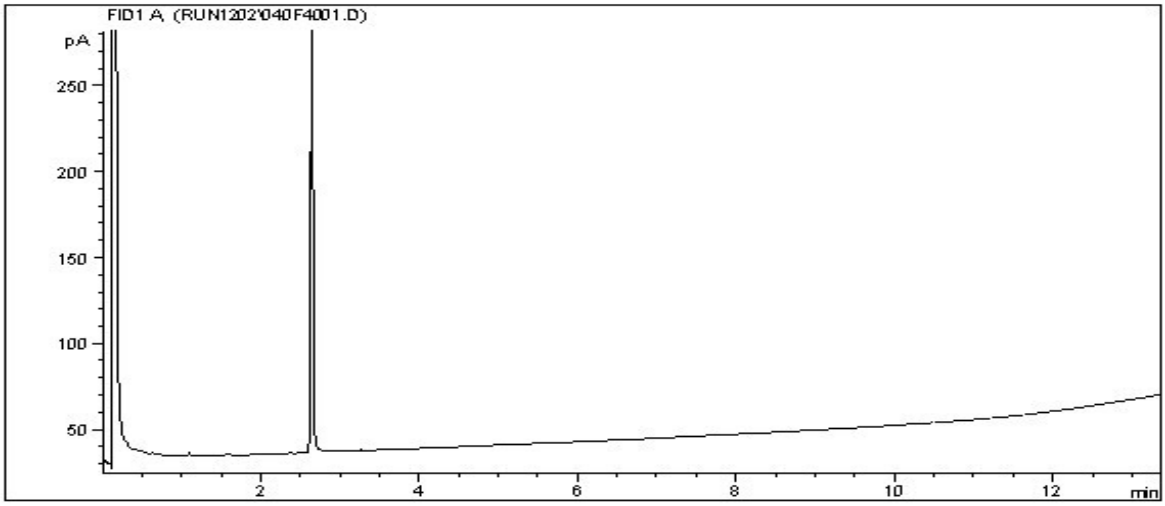
Success Through Science®

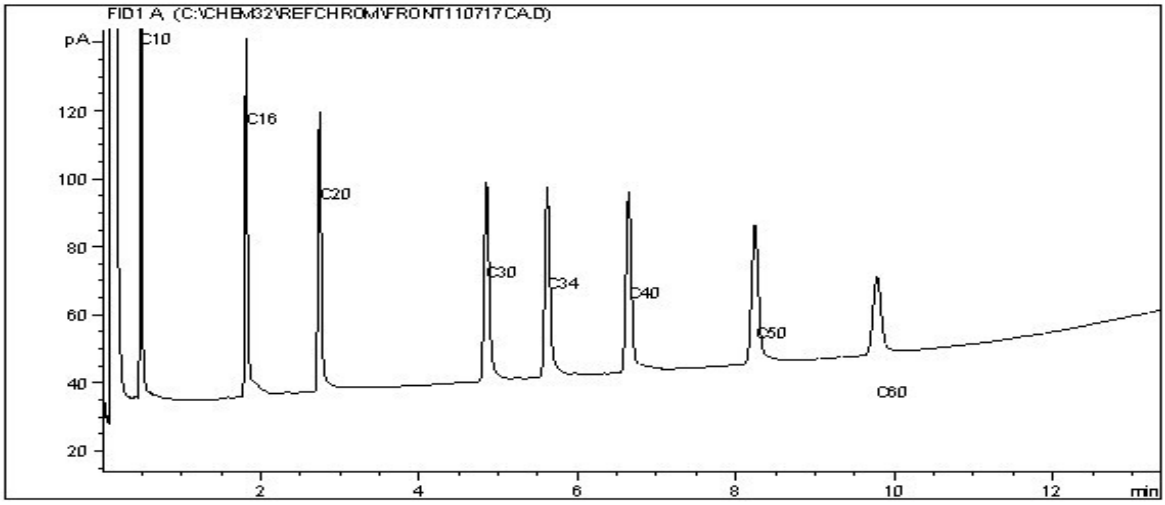
Report Date: 2012/01/06
Maxxam Job #: B1B7081
Maxxam Sample: CG7771

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Reference: DRUMHELLER INSTITUTE, ALBERTA
Client ID: TP8-11-04

CCME Hydrocarbons (F2-F4 in soil) Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40
Kerosene:	C7 - C16	Crude Oils:	C3 - C60+

Page 1 of 1

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

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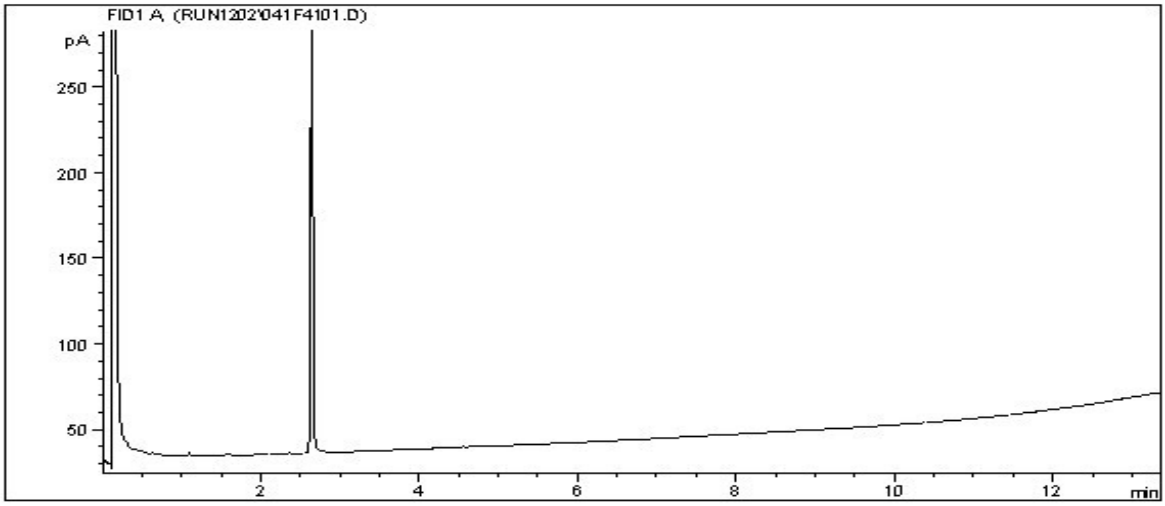
Success Through Science®

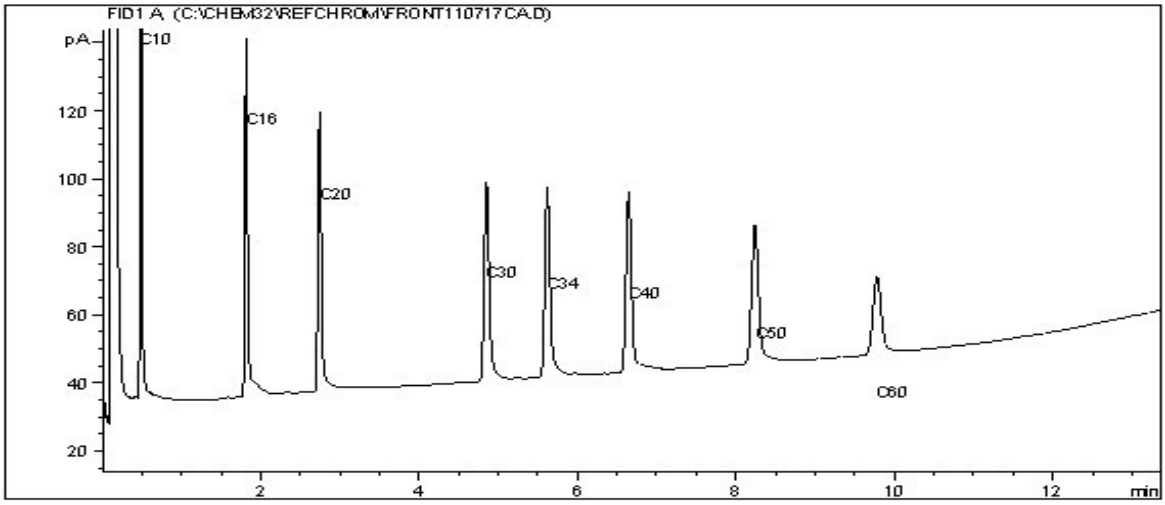
Report Date: 2012/01/06
Maxxam Job #: B1B7081
Maxxam Sample: CG7774

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Reference: DRUMHELLER INSTITUTE, ALBERTA
Client ID: TP8-DUP2

CCME Hydrocarbons (F2-F4 in soil) Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40
Kerosene:	C7 - C16	Crude Oils:	C3 - C60+

Page 1 of 1

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

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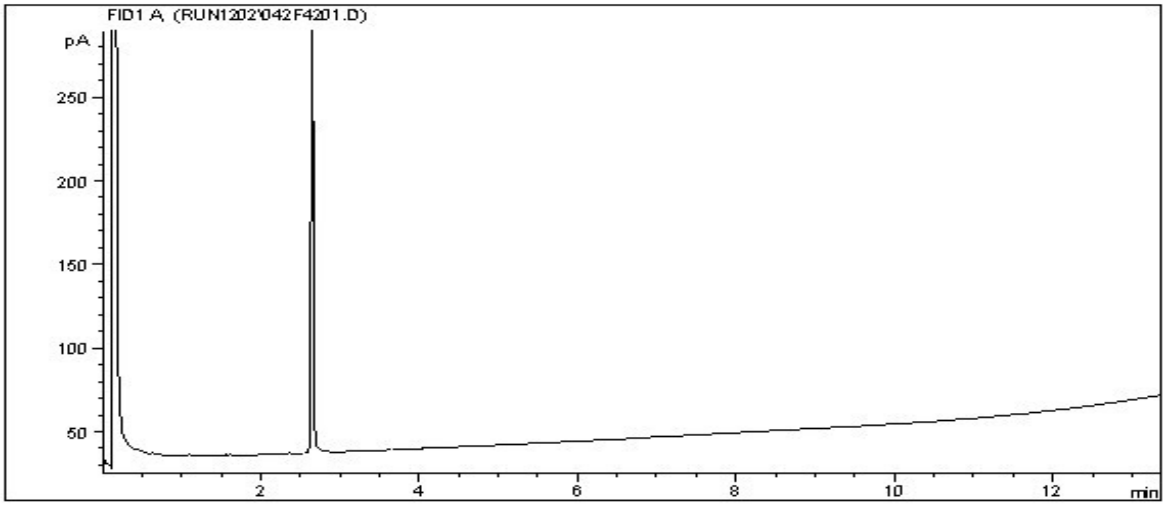
Success Through Science®

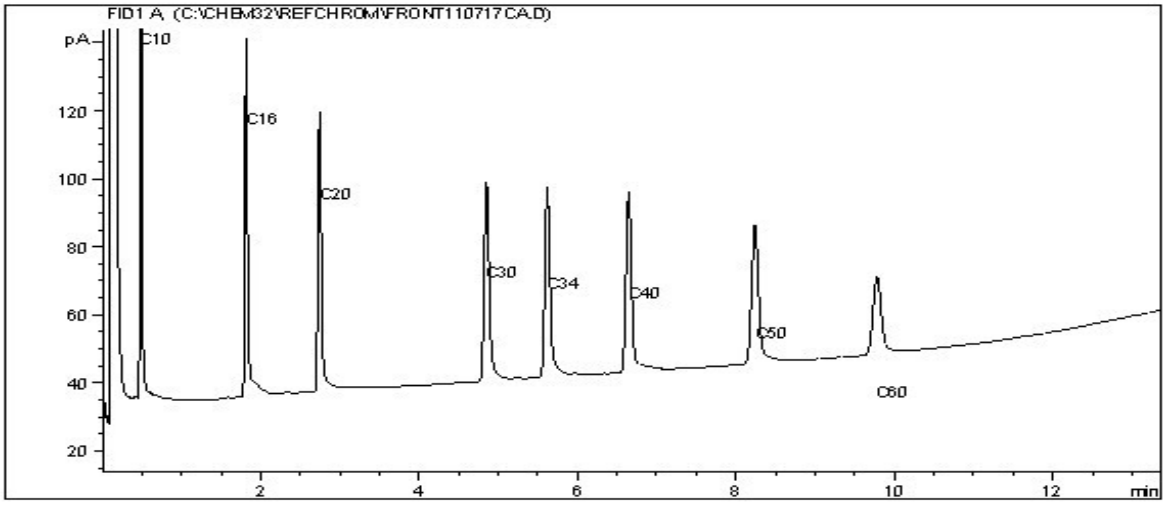
Report Date: 2012/01/06
Maxxam Job #: B1B7081
Maxxam Sample: CG7775

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Reference: DRUMHELLER INSTITUTE, ALBERTA
Client ID: TP9-11-07

CCME Hydrocarbons (F2-F4 in soil) Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40
Kerosene:	C7 - C16	Crude Oils:	C3 - C60+

Page 1 of 1

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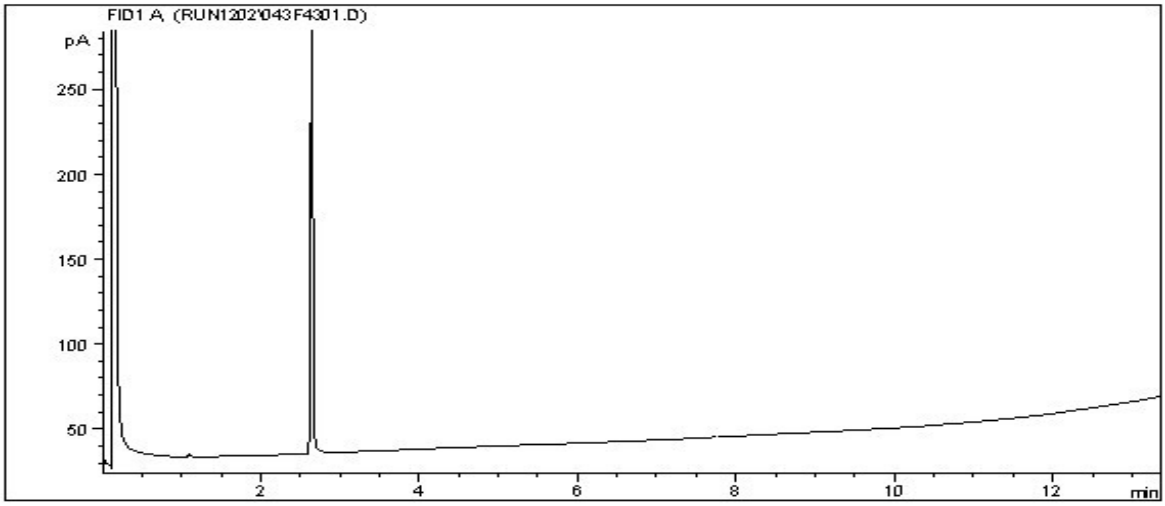
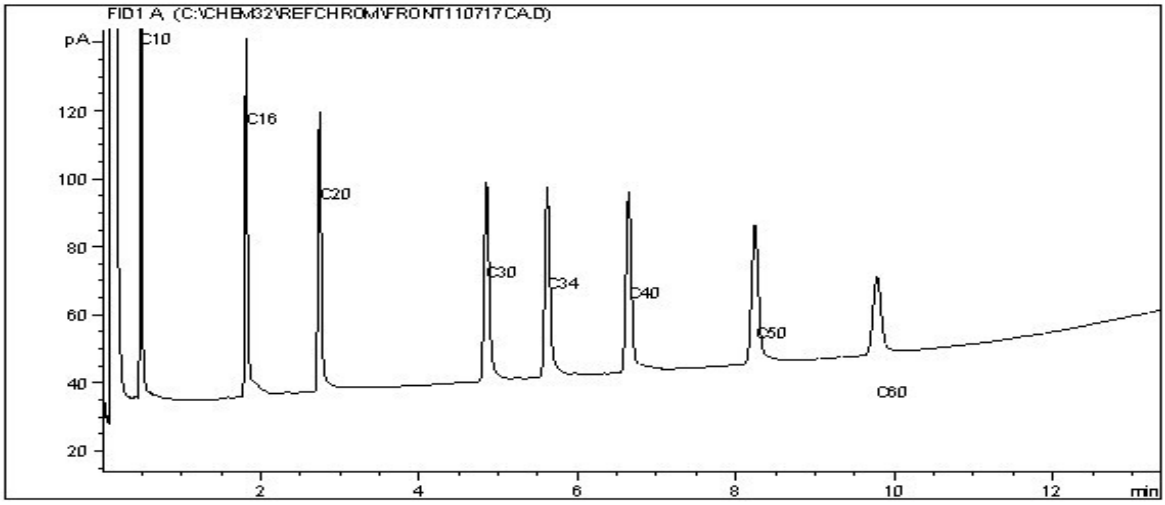
Report Date: 2012/01/06
Maxxam Job #: B1B7081
Maxxam Sample: CG7776

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Reference: DRUMHELLER INSTITUTE, ALBERTA
Client ID: TP10-11-02

CCME Hydrocarbons (F2-F4 in soil) Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40
Kerosene:	C7 - C16	Crude Oils:	C3 - C60+

Page 1 of 1

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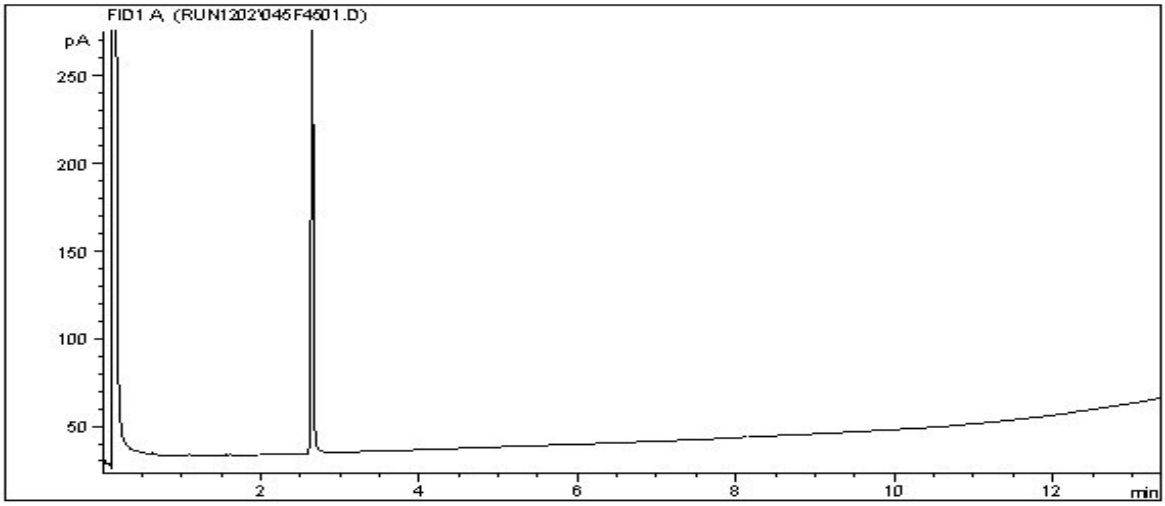
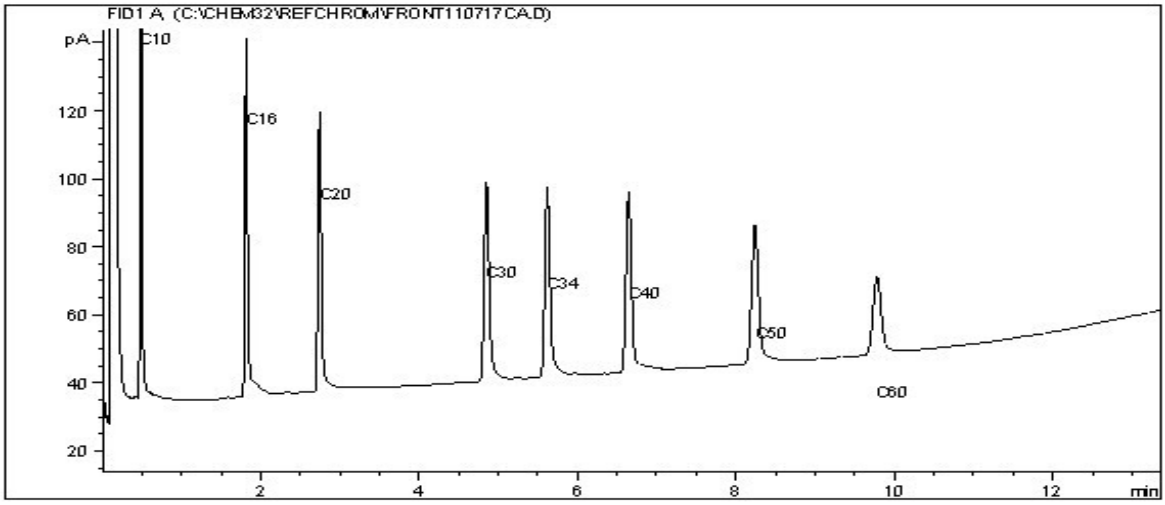
Report Date: 2012/01/06
Maxxam Job #: B1B7081
Maxxam Sample: CG7778

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Reference: DRUMHELLER INSTITUTE, ALBERTA
Client ID: TP11-11-03

CCME Hydrocarbons (F2-F4 in soil) Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40
Kerosene:	C7 - C16	Crude Oils:	C3 - C60+

Page 1 of 1

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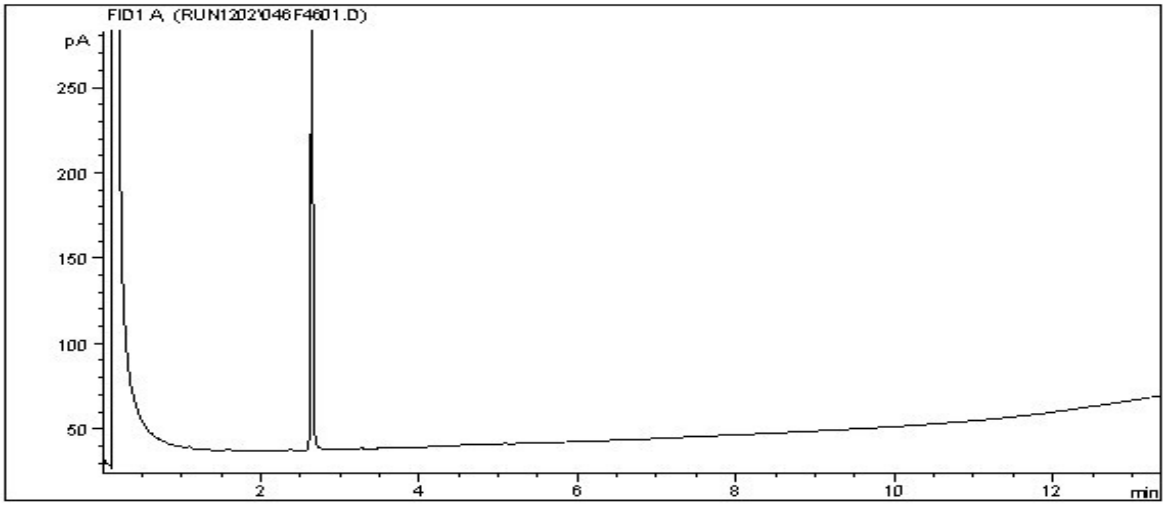
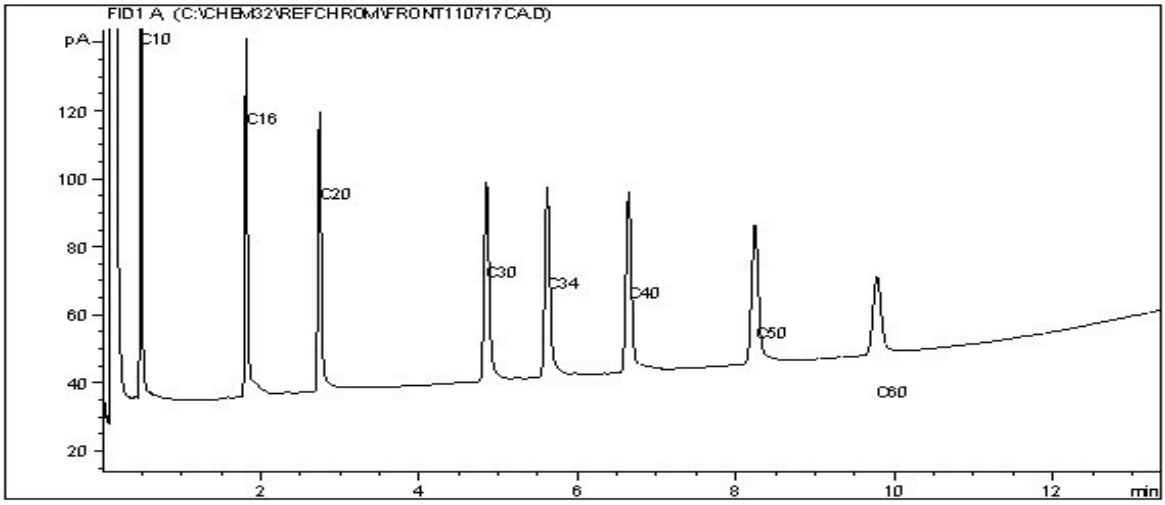
Report Date: 2012/01/06
Maxxam Job #: B1B7081
Maxxam Sample: CG7779

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Reference: DRUMHELLER INSTITUTE, ALBERTA
Client ID: TP12-11-04

CCME Hydrocarbons (F2-F4 in soil) Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40
Kerosene:	C7 - C16	Crude Oils:	C3 - C60+

Page 1 of 1

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

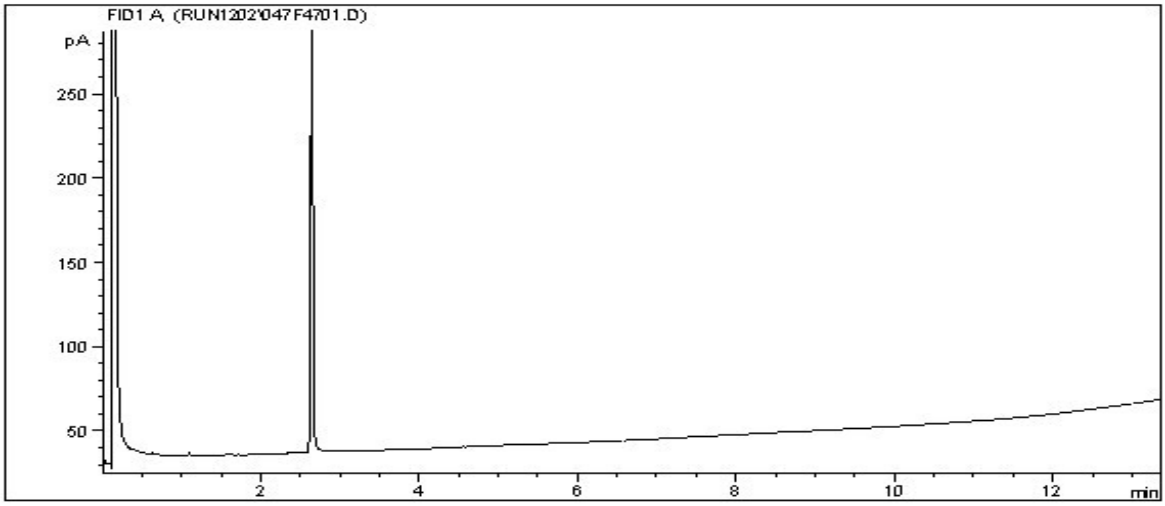
Maxxam

Success Through Science®

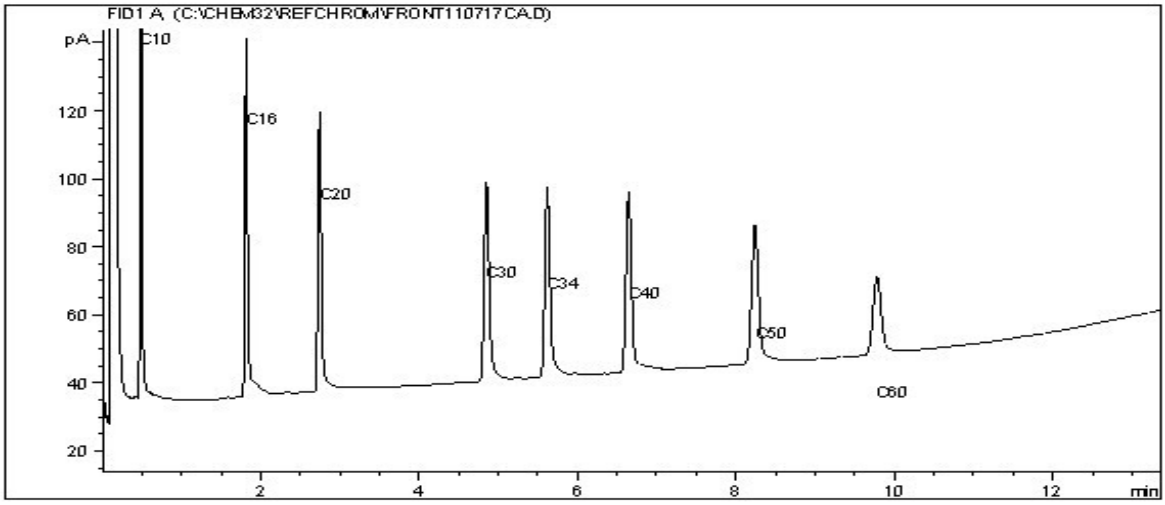
Report Date: 2012/01/06
Maxxam Job #: B1B7081
Maxxam Sample: CG7782

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Reference: DRUMHELLER INSTITUTE, ALBERTA
Client ID: TP15-11-03

CCME Hydrocarbons (F2-F4 in soil) Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40
Kerosene:	C7 - C16	Crude Oils:	C3 - C60+

Page 1 of 1

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

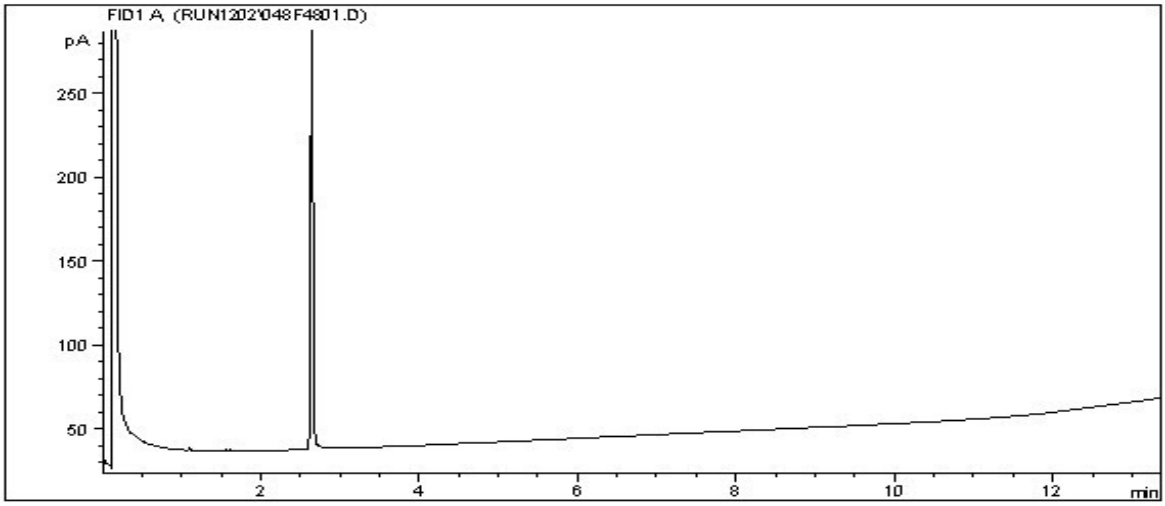
Maxxam

Success Through Science®

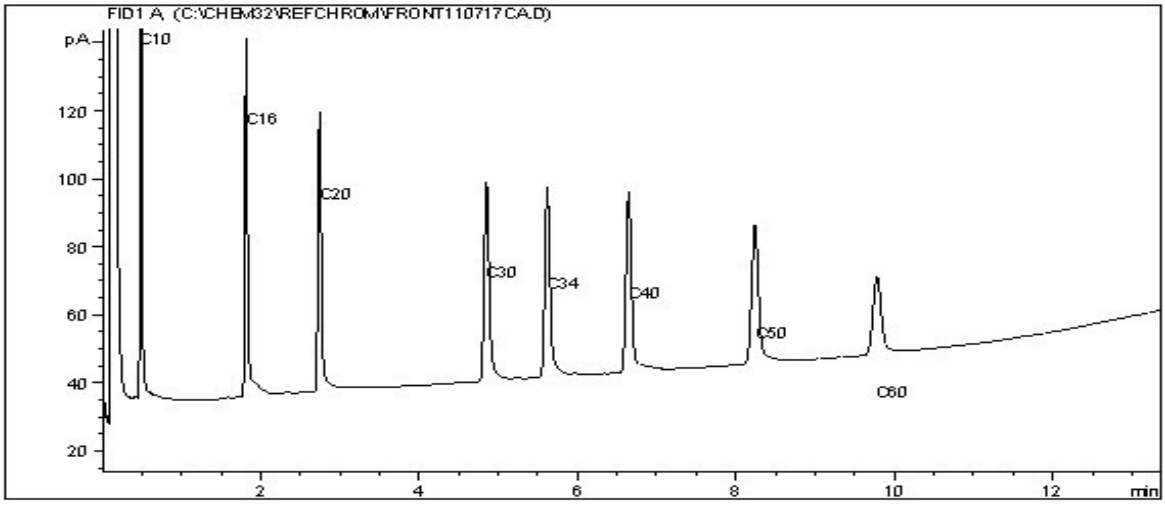
Report Date: 2012/01/06
Maxxam Job #: B1B7081
Maxxam Sample: CG7783

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Reference: DRUMHELLER INSTITUTE, ALBERTA
Client ID: TP15-11-04

CCME Hydrocarbons (F2-F4 in soil) Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40
Kerosene:	C7 - C16	Crude Oils:	C3 - C60+

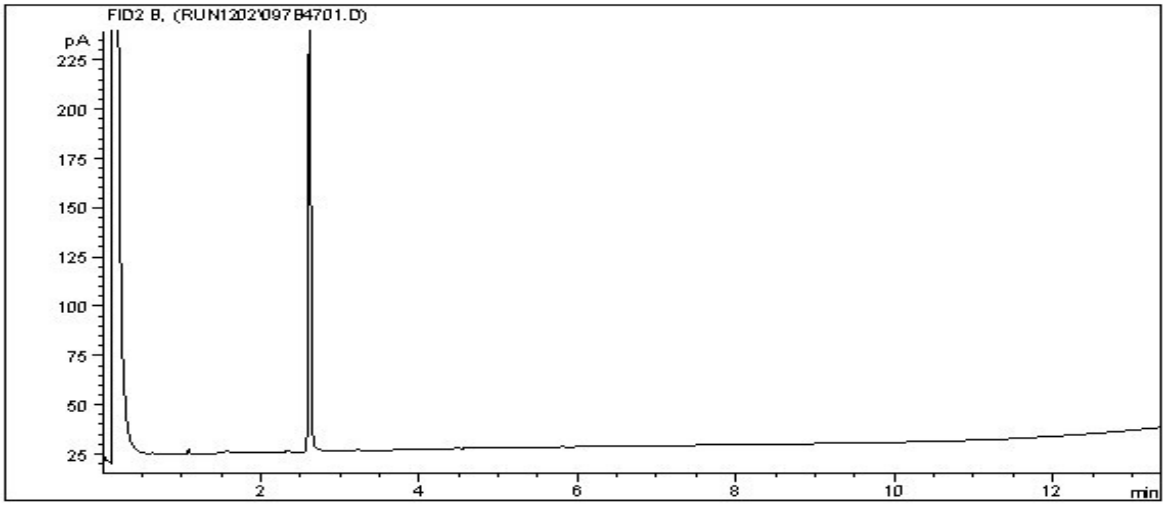
Page 1 of 1

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

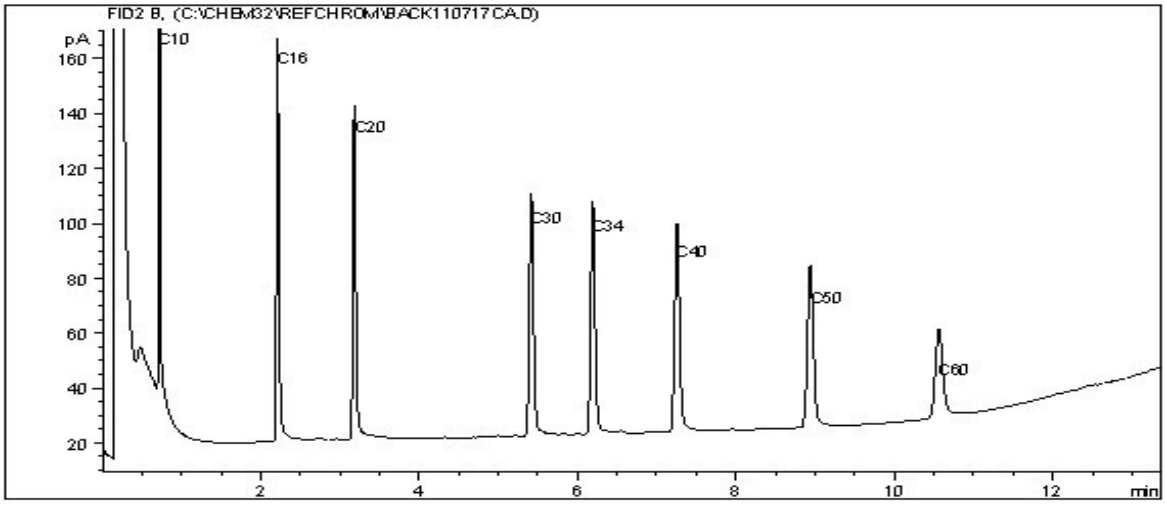
Report Date: 2012/01/06
Maxxam Job #: B1B7081
Maxxam Sample: CG7785

FRANZ ENVIRONMENTAL INC.
Client Project #: 2026-1103
Site Reference: DRUMHELLER INSTITUTE, ALBERTA
Client ID: TP16-11-02

CCME Hydrocarbons (F2-F4 in soil) Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40
Kerosene:	C7 - C16	Crude Oils:	C3 - C60+

Page 1 of 1

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

APPENDIX F

Biological Site Survey

Species of Interest: *Halimolobos virgata* (Nutt.) Schulz

Location: Drumheller Institution Landfill Stabilization Site

Author: Tan Bao (tan.bao@ualberta.ca)

Date of Field Work: November 28, 2011

Report Submitted: Dec. 5, 2011

Objective:

To determine the presence or absence of *Halimolobos virgata* (Nutt.) Schulz (Slender Mouse-ear-cress) at the Drumheller Institution Landfill Stabilization Site.

Summary:

Using a combination of line transect and quadrat sampling, the Drumheller Institution Landfill Stabilization Site was surveyed for the presence or absence of *H. virgata.* In total, a single individual that could be *H. virgata* was found atop the landfill site proper. Definitive identification will require flower and leaf traits which were not observable.

Introduction:

Halimolobos virgata is an annual (or biennial) mustard that tends to flower in the spring in dry prairie areas. It has been observed at only a handful of sites in Alberta, all in the SE part of the province, but has a range that includes Saskatchewan, Montana, Idaho, Wyoming, Utah, Colorado, Nevada and California. *H. virgata* is listed as "May be at Risk in Alberta" according to the Alberta Sustainable Resources Development (Macdonald 2005). The closest recorded observation of *H. virgata* to Drumheller is a single individual from 1914 at Rosedale, which is a few kilometers SE of Drumheller (Macdonald 2005).

Species Description (adapted from Moss and Packer (2000)):

> ***Halimolobos virgata:*** Stems, 1 or more. 10-40 cm tall stems, simple or branched, pubescent with a mixture of longer, straight, simple or forked hairs and shorter, branched hairs. Slender pedicels 7-11 mm long; fruit a glabrous, erect or nearly so, linear, terete, silique 1.5-4.0 cm long, 1 mm wide. Found in dry prairies.

Methods:

The landfill stabilization site at the Drumheller Institution (Figure 1) was surveyed on Nov. 28, 2011 in the presence of Tryfan Jones (Franz Environmental) and Terry Martin (CSC commissionaire). Tryfan Jones, who had previously worked on the site, led an initial walk through of the site pointing out boundary landmarks. The work area, as well as a 25m-50m margin around the work area, was then censused using a series of line transects (Figure 2 maps the approximate paths) and GPS located quadrats. The line transects were designed to survey as extensive a portion of the work area as possible.

The quadrats were then used to sample the vegetation in detail. 100 1x1 m quadrats were centered on the GPS positions reported (Figure 3 maps the approximate locations; Appendix A has the GPS co-ordinates).

Results:

1) No individuals of *H. virgata* were observed on the line transects.

2) A single individual plant was observed in quadrat 92 that was putatively identified as *H. virgata* (see Figure 4 for photo). 6 quadrats were placed immediately adjacent to quadrat 92 to try to find other individuals but none were found. Quadrat 92 rests on the landfill site proper, as opposed to the natural area surrounding the old landfill site. Quadrat 92 was located between 2 piles of construction material (rocks). No other quadrats had a plant that could be *H. virgata.*

3) The University of Alberta Vascular Plant Herbarium was consulted on Dec. 1, 2011 to see if any additional records of *H. virgata* existed in the vicinity of Drumheller. There were no specimens on record.

4) Common members of the vegetation community are identified in Appendix B.

Limitations:

On Nov. 28, 2011 there was a small amount of snow (~1 cm) on the ground and this may have hampered the survey. However, the snow was cleared as necessary in each quadrat sampled so this was not likely to be a major factor. *H. virgata* flowers in spring or early summer and it would be easier to find at these times. It is also potentially a biennial and therefore observed abundances may be a conservative estimate of actual abundances. Nevertheless, the stems of *H. virgata* are robust and are likely to persist in the field as long as the area is not heavily disturbed. Without flowers and leaves, however, it is not possible to definitively identify *H. virgata* and for this reason the individual observed is only putatively identified.

References:

Macdonald, I.D. 2005. Status of the Slender Mouse-ear-cress (*Halimolobos virgata*) in Alberta. Alberta Wildlife Status Report No. 55. Alberta Sustainable Resource Development.

Moss, E.H. and Packer, J.G. 2000. Flora of Alberta (2nd ed.). University of Toronto Press. Toronto. 687 pp.

Figure 1. Aerial photo of landfill stabilization site (circled in red) near the Drumheller Institution.

Figure 2. Map of approximate locations of line transects taken at work site.

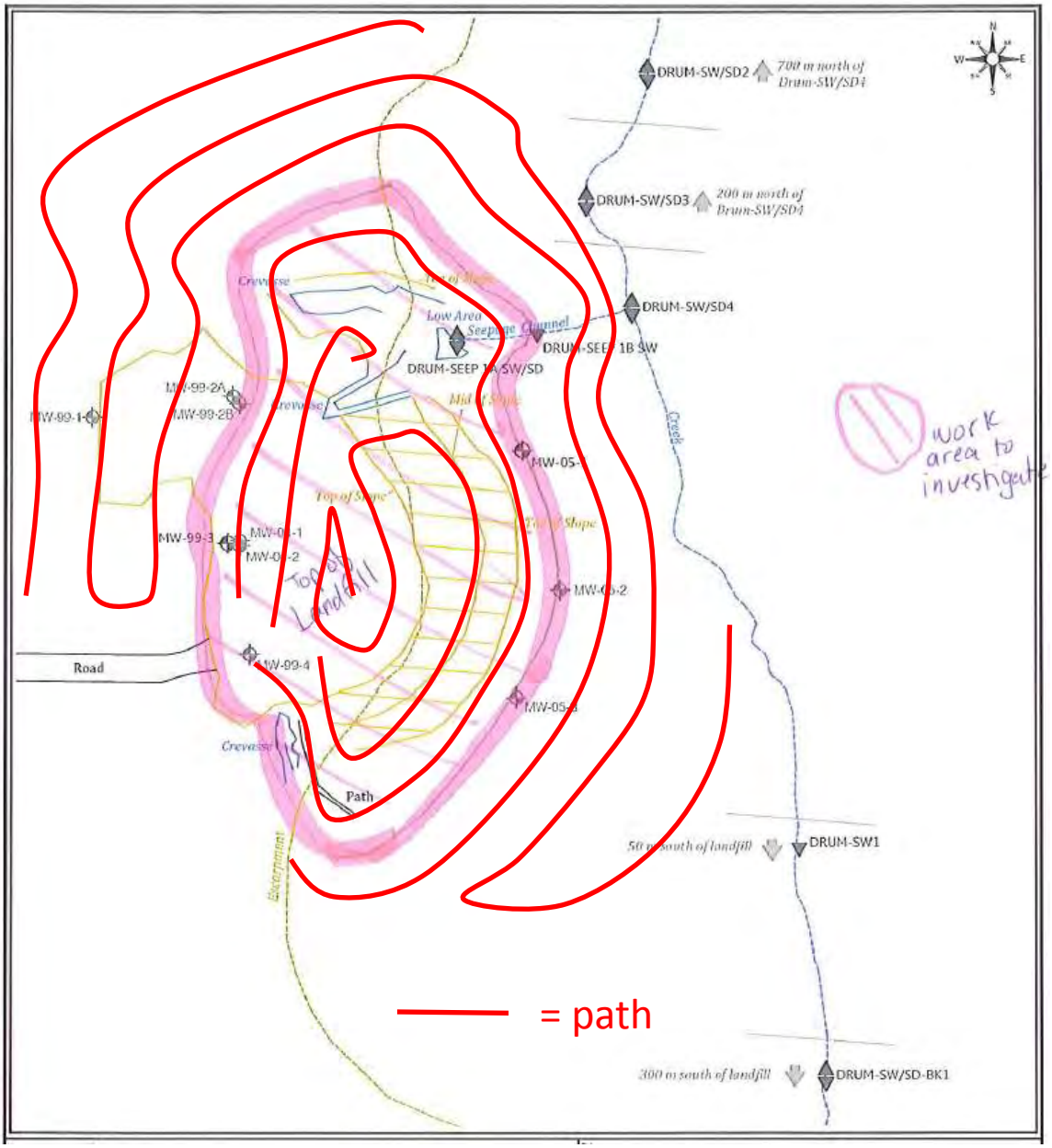


Figure 3. Map of 100 sample locations (1x1m quadrats) at work area. GPS locations listed in appendix A.

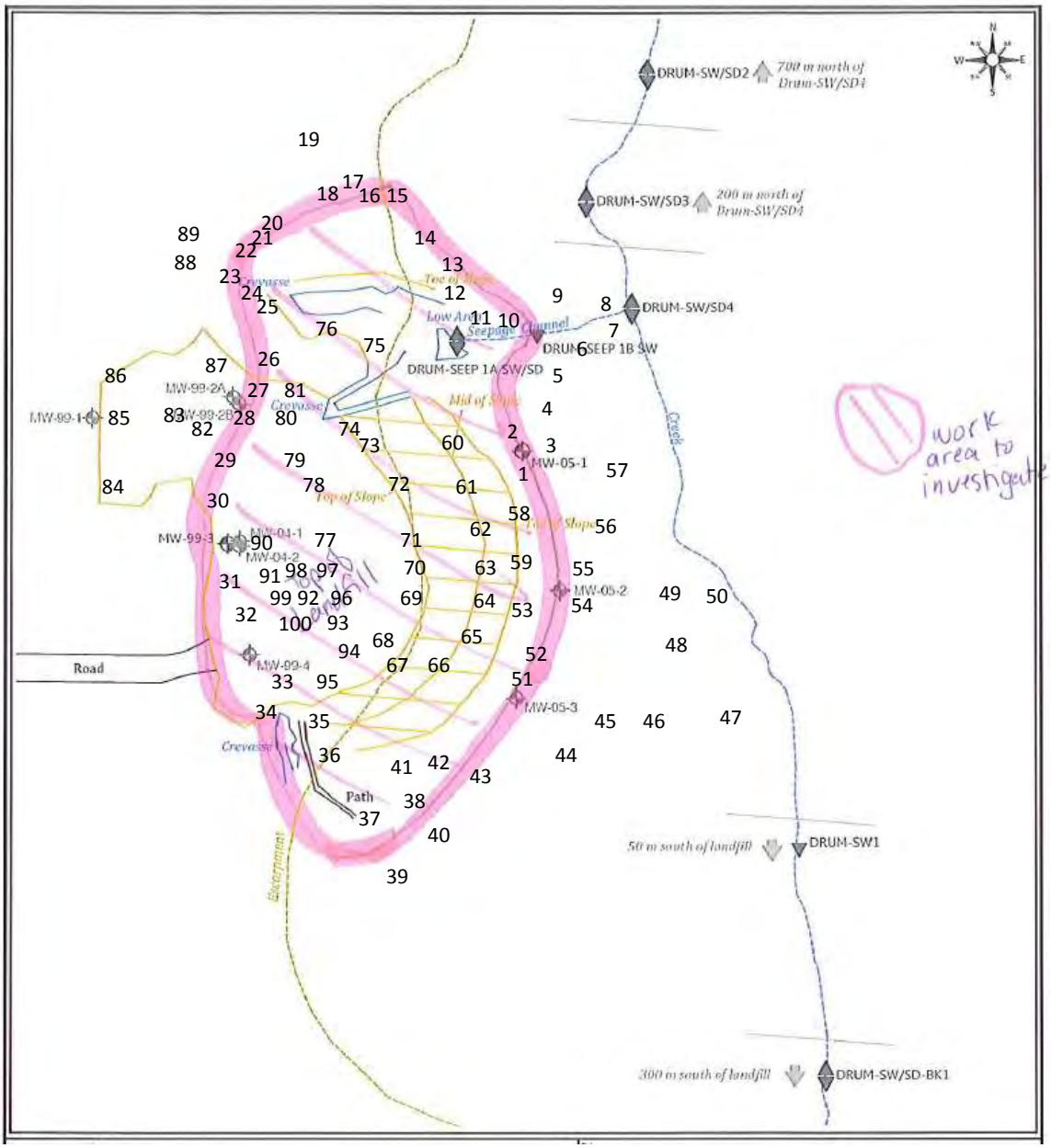


Figure 4. Photograph of stem of putatively identified *Halimolobos virgata* found in quadrat 92. This was the only individual found throughout the study area.

Appendix A: GPS locations of 100 1 x 1 m quadrats (~ +/- 4 m)

Plot	Location			
1	N 51^0 25.	310'	W 112^0 40.	939'
2	N 51^0 25.	312'	W 112^0 40.	941'
3	N 51^0 25.	314'	W 112^0 40.	927'
4	N 51^0 25.	319'	W 112^0 40.	923'
5	N 51^0 25.	323'	W 112^0 40.	914'
6	N 51^0 25.	332'	W 112^0 40.	921'
7	N 51^0 25.	343'	W 112^0 40.	906'
8	N 51^0 25.	347'	W 112^0 40.	910'
9	N 51^0 25.	352'	W 112^0 40.	913'
10	N 51^0 25.	352'	W 112^0 40.	921'
11	N 51^0 25.	351'	W 112^0 40.	926'
12	N 51^0 25.	350'	W 112^0 40.	929'
13	N 51^0 25.	352'	W 112^0 40.	936'
14	N 51^0 25.	357'	W 112^0 40.	944'
15	N 51^0 25.	367'	W 112^0 40.	952'
16	N 51^0 25.	372'	W 112^0 40.	955'
17	N 51^0 25.	378'	W 112^0 40.	957'
18	N 51^0 25.	383'	W 112^0 40.	971'
19	N 51^0 25.	381'	W 112^0 40.	978'
20	N 51^0 25.	373'	W 112^0 40.	985'
21	N 51^0 25.	364'	W 112^0 40.	995'
22	N 51^0 25.	354'	W 112^0 41.	001'
23	N 51^0 25.	350'	W 112^0 41.	010'
24	N 51^0 25.	343'	W 112^0 41.	029'
25	N 51^0 25.	339'	W 112^0 41.	037'
26	N 51^0 25.	334'	W 112^0 41.	050'
27	N 51^0 25.	331'	W 112^0 41.	052'
28	N 51^0 25.	317'	W 112^0 41.	054'
29	N 51^0 25.	313'	W 112^0 41.	044'
30	N 51^0 25.	319'	W 112^0 41.	015'
31	N 51^0 25.	314'	W 112^0 41.	007'
32	N 51^0 25.	363'	W 112^0 41.	003'

33	N 51^0 25.	283'	W 112^0 41.	013'
34	N 51^0 25.	266'	W 112^0 41.	008'
35	N 51^0 25.	264'	W 112^0 41.	000'
36	N 51^0 25.	277'	W 112^0 40.	999'
37	N 51^0 25.	250'	W 112^0 40.	987'
38	N 51^0 25.	256'	W 112^0 40.	977'
39	N 51^0 25.	241'	W 112^0 40.	954'
40	N 51^0 25.	247'	W 112^0 40.	953'
41	N 51^0 25.	259'	W 112^0 40.	974'
42	N 51^0 25.	262'	W 112^0 40.	962'
43	N 51^0 25.	262'	W 112^0 40.	942'
44	N 51^0 25.	264'	W 112^0 40.	936'
45	N 51^0 25.	259'	W 112^0 40.	917'
46	N 51^0 25.	255'	W 112^0 40.	898'
47	N 51^0 25.	255'	W 112^0 40.	892'
48	N 51^0 25.	268'	W 112^0 40.	897'
49	N 51^0 25.	276'	W 112^0 40.	911'
50	N 51^0 25.	284'	W 112^0 40.	903'
51	N 51^0 25.	272'	W 112^0 40.	939'
52	N 51^0 25.	282'	W 112^0 40.	941'
53	N 51^0 25.	287'	W 112^0 40.	937'
54	N 51^0 25.	289'	W 112^0 40.	929'
55	N 51^0 25.	294'	W 112^0 40.	930'
56	N 51^0 25.	300'	W 112^0 40.	930'
57	N 51^0 25.	308'	W 112^0 40.	915'
58	N 51^0 25.	306'	W 112^0 40.	941'
59	N 51^0 25.	299'	W 112^0 40.	938'
60	N 51^0 25.	317'	W 112^0 40.	964'
61	N 51^0 25.	307'	W 112^0 40.	954'
62	N 51^0 25.	302'	W 112^0 40.	952'
63	N 51^0 25.	295'	W 112^0 40.	953'
64	N 51^0 25.	291'	W 112^0 40.	954'
65	N 51^0 25.	286'	W 112^0 40.	953'
66	N 51^0 25.	283'	W 112^0 40.	962'
67	N 51^0 25.	283'	W 112^0 40.	968'

68	N 51^0 25.	279'	W 112^0 40.	982'
69	N 51^0 25.	287'	W 112^0 40.	972'
70	N 51^0 25.	294'	W 112^0 40.	966'
71	N 51^0 25.	299'	W 112^0 40.	970'
72	N 51^0 25.	305'	W 112^0 40.	979'
73	N 51^0 25.	310'	W 112^0 40.	986'
74	N 51^0 25.	315'	W 112^0 40.	990'
75	N 51^0 25.	321'	W 112^0 40.	994'
76	N 51^0 25.	332'	W 112^0 41.	010'
77	N 51^0 25.	297'	W 112^0 41.	007'
78	N 51^0 25.	301'	W 112^0 41.	002'
79	N 51^0 25.	308'	W 112^0 41.	005'
80	N 51^0 25.	312'	W 112^0 41.	009'
81	N 51^0 25.	317'	W 112^0 41.	011'
82	N 51^0 25.	319'	W 112^0 41.	021'
83	N 51^0 25.	318'	W 112^0 41.	036'
84	N 51^0 25.	310'	W 112^0 41.	050'
85	N 51^0 25.	320'	W 112^0 41.	053'
86	N 51^0 25.	334'	W 112^0 41.	052'
87	N 51^0 25.	335'	W 112^0 41.	035'
88	N 51^0 25.	349'	W 112^0 41.	019'
89	N 51^0 25.	354'	W 112^0 41.	012'
90	N 51^0 25.	313'	W 112^0 41.	005'
91	N 51^0 25.	309'	W 112^0 41.	001'
92	N 51^0 25.	302'	W 112^0 41.	000'
93	N 51^0 25.	301'	W 112^0 40.	999'
94	N 51^0 25.	299'	W 112^0 40.	998'
95	N 51^0 25.	298'	W 112^0 40.	993'
96	N 51^0 25.	302'	W 112^0 40.	999'
97	N 51^0 25.	304'	W 112^0 40.	998'
98	N 51^0 25.	304'	W 112^0 40.	000'
99	N 51^0 25.	303'	W 112^0 40.	003'
100	N 51^0 25.	302'	W 112^0 40.	000'

Appendix B: Common members of the plant community at the Drumheller Institution landfill site.

Grasses:

Agropyron smithii

Koeleria macrantha

Oryzopsis micrantha

Poa sp.

Stipa comata

Forbs:

Achillea millefolium

Amelanchier alnifolia

Arctostaphylos uva-ursi

Artemesia frigida

Aster sp.

Cirsium arvense

Galium boreale

Juniperus horizontalis

Monarda fistulosa

Populus tremuloides

Prunus virginiana

Rosa sp.

Solidago sp.

Symphoricarpos occidentalis

APPENDIX J

Federal and Provincial Government/Agency Review Comments

Environment Canada **Environnement Canada**

ENVIRONMENTAL PROTECTION
PRAIRIE & NORTHERN REGION
Room 200, 4999-98 Ave. NW
Edmonton, Alberta
T6B 2X3

Our file #: 4194-10-3/6101
Your file #: R.044325.002

November 16, 2011

Peggy Bainard Acheson
Senior Environmental Specialist
Public Works and Government Services Canada
Suite 100 – 167 Lombard Ave
Winnipeg, MB
R3C 2Z1

Dear Ms. Bainard Acheson:

RE: DRUMHELLER INSTITUTION NO. 530 LANDFILL REMEDIATION

Environment Canada (EC) has reviewed the Project Description for the above proposed project. EC is not a Responsible Authority (RA) under the *Canadian Environmental Assessment Act (CEAA)* because:

a) EC is not a proponent of the project and is not conducting any act or thing that commits the department to carrying out the project in whole or in part;
b) EC is not making or authorizing any form of payment or other financial assistance to the proponent for the purpose of enabling the project to be carried out in whole or in part;
c) EC does not administer any lands involved in enabling the project to be carried out in whole or in part; and
d) EC does not issue a permit, license, grant an approval or take any action for the purpose of enabling the project to be carried out in whole or in part.

EC possesses specialist advice or expert information or knowledge on the proposal as per subsection 12 (3) of the CEAA with a focus on federal statuettes, regulations, policy and associated program concerns as defined by EC's mandate. Participating and providing comments at this time is not a constraint or fetter on EC in fulfilling our statutory responsibilities under the *CEAA*, and under the Department's mandate as defined through specific statutes and regulations assigned to the Minister of the Environment. EC appreciates the opportunity to provide feedback on this matter and at this time has the following comments.

1. Species at Risk

EC reminds responsible authorities of their responsibilities under section 79(1) and 79(2) of the *Species at Risk Act.*

> "Every person who is required by or under an Act of Parliament to ensure that an assessment of the environmental effects of a project is conducted must, without delay, notify the competent minister or ministers in writing of the project if it is likely to affect a listed wildlife species or its critical habitat."
>
> "The person must identify the adverse effects of the project on the listed wildlife species and its critical habitat and, if the project is carried out, must ensure that measures are taken to avoid or lessen those effects and to monitor them. The measures must be taken in a way that is consistent with any applicable recovery strategy and actions plans."

To assist proponents in accounting and managing Species at Risk, EC has developed a guide titled, "*Environmental Assessment Best Practice Guide for Wildlife at Risk in Canada*" which can be found at the following website:
http://www.ec.gc.ca/Publications/default.asp?lang=En&xml=5407909E-10F6-4AFE-ACDF-75B9E820B4A1

The section titled Species at Risk with ranges in the Area, page 3 of the project description, states that the Northern Leopard Frog was observed at the site during a 2011 site investigation. **EC requests that the proponent provide measures to minimize the impact to any Leopard frogs in the area (i.e. preparing a mitigation plan which may include relocating the frogs to other suitable overwintering habitat). EC also recommends that the Proponent conduct a search for snake hibernacula and make all reasonable efforts to avoid impacts to any hibernacula found. Snakes are provincially mandated and therefore the Proponent is advised to contact a local Alberta Fish and Wildlife Biologist in the project area who can provide more guidance on the matter.**

2. *Migratory Birds*

EC's mandate includes the protection of migratory birds and their habitat. Regulations pursuant to the *Migratory Birds Convention Act* (MBCA) provide for the conservation of migratory birds and the protection of their nests and eggs. Section 5 of the regulations prohibits the hunting of a migratory bird except under authority of a permit, where "hunt" means chase, pursue, worry, follow after or on the trail of, lie in wait for, or attempt in any manner to capture, kill, injure or harass a migratory bird, whether or not the migratory bird is captured, killed or injured. Section 6 of the Regulations prohibits the disturbance, destruction, or taking of a nest, egg or nest shelter of a migratory bird. Possession of a migratory bird, nest or egg without lawful excuse is also prohibited. Section 5.1 of the *Migratory Birds Convention Act* prohibits the deposition of substances harmful to migratory birds in waters or areas frequented by migratory birds or in a place from which the substance may enter such waters or such an area.

EC provides timing restrictions as general guidelines for industry to protect the great majority of migratory birds while realizing the practicalities of development activities on the landscape. However the onus remains with the proponent to comply with the legislation.

3. Wetlands

The *Federal Policy on Wetland Conservation* (FPWC) was introduced "to promote the conservation of Canada's wetlands to sustain their ecological and socio-economic functions, now and in the future". The Policy promotes the wise use of wetlands and the promotion of wetland protection through adequate consideration of wetland concerns in environmental assessments of new development projects. The policy also promotes the maintenance of the functions and values derived from wetlands throughout Canada, enhancement and rehabilitation of wetlands in areas where continuing loss or degradation of wetlands have reached critical levels, and utilization of wetlands in a manner that enhances prospects for their sustained and productive use by future generations. In support of these goals, the FPWC and related implementation guidance identify the importance of planning, siting and designing a project in a manner that accommodates a consideration of mitigation options in a hierarchical sequence - avoidance, minimization, and as a last resort, compensation.

The section titled Site Description, page 3 of the project description, mentions that a small wetland, covering approximately 100 m² has formed at the toe of the landfill. Wetlands should be avoided irrespective of whether they are wet or dry and buffers or setbacks should originate from the high water mark. One hundred metre setbacks should be utilized where feasible. For

those wetlands where avoidance is not possible, the mitigation measures and monitoring plan, as well as a proposed compensation plan, should be consistent with the principles of the wetland policy.

EC looks forward to continued dialogue and co-operation with respect to this Project. If you have any questions, please contact me at (780) 951-8946.

(*original signed by)*

Krista Flood
Environmental Assessment Coordinator
Telephone (780) 951-8946
Facsimilie (780) 495-2444
Krista.Flood@ec.gc.ca

cc : Paul Gregoire, Wildlife Biologist, EC

Government of Alberta
Environment and Water

Environmental Operations, Regional Integration
111 Twin Atria Building
4999 - 98 Avenue
Edmonton, Alberta T6B 2X3
Canada
Telephone: 780-427-5828
Fax: 780-427-9102
www.environment.alberta.ca

November 07, 2011

Sean Carriere
Canadian Environmental Assessment Agency
61 Airport Road
Edmonton, AB T5G 0W6

Dear Mr. Carrière:

RE: Correctional Services Canada - Drumheller Institution NO. 530 Landfill Remediation Project

Thank you for informing us of this project. Alberta Environment and Water (AEW) has reviewed the project information and determined that the project will require some in stream work and therefore a *Water Act* approval will be required. AEW's involvement will be focused to the *Water Act* approval application, although we do have the following comments for Public Works and Government Services Canada:

- Any contamination issues need to be addressed as a component of the reclamation plan.
- Environmental monitoring should be considered if warranted.
- On Federal lands in Alberta, we would encourage the use of Alberta's criteria for soil and groundwater. Meeting these criteria would be required on any provincial lands that could be impacted.

For more information regarding these requirements, please contact Joseph Feehan at 403-297 5940 or Joseph.Feehan @gov.ab.ca.

The Historic Resources Management Branch (HRMB of Alberta Culture and Community Spirit (ACCS) has reviewed project information for this proposed development and would like to inform that it has a regulatory interest in this project but does not wish to participate in the Federal review. Pursuant to Section 31 of the *Historic Resources Act*, should any archaeological resources, palaeontological resources, Aboriginal traditional use sites and/or historic sites be encountered during development activities, the HRMB is to be contacted immediately for further direction. For more information, please contact George Chalut at George.Chalut@gov.ab.ca or 780-431 2329.

Alberta Sustainable Resource Development (SRD) has received the project information. A review of the land standing has confirmed there are no public lands associated with the indicated site. Therefore, SRD has no regulatory requirement under the *Public Lands Act*. SRD has no concerns and does not require further involvement in this project. For more information, please contact Linda Zimmerling at Linda.Zimmerling @gov.ab.ca or 780-638-3216.

Alberta Health and Wellness (AHW) has reviewed the project description and does not have regulatory requirements for the project or wish to participate in the Federal review For more information please contact Karina Thomas at Karina.Thomas @gov.ab.ca or 780-422-4593.

Alberta Transportation (AT) has received the project information. Based on the information provided, AT has determined that it does not have regulatory requirements for the proposed project and does not

wish to participate in the Federal review. For further information, please contact Peter Ngo at Peter.D.Ngo@gov.ab.ca or 780-427-8451.

No other department has indicated an interest in this project. Should any department inform us in the future that they have an interest in the project, we will advise you accordingly.

Please do not hesitate to contact me if you have any questions (Camille.Almeida@gov.ab.ca or 780-422-2207).

Sincerely,

"Original signed by"

Camille Almeida
Environmental Assessment Coordinator

cc:	J. Feehan (AEW)	M. Foy (AEW)	C. Kristensen (AEW)
	M. Daneluk (AEW)	K. Thomas (AHW)	D. Friesen (AHW)
	P. Ngo (AT)	L. Zimmerling (SRD)	G. Chalut (ACCS)
	C. Stamp-Cardinal (AEW)		