Report to:

GOVERNMENT OF NUNAVUT
DEPARTMENT OF COMMUNITY AND
GOVERNMENT SERVICES

Kugaaruk Landfarm Facility – 2011 Annual Report

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TETRA TECH

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GOVERNMENT OF NUNAVUT
DEPARTMENT OF COMMUNITY AND GOVERNMENT SERVICES

KUGAARUK LANDFARM FACILITY – 2011 ANNUAL REPORT

DECEMBER 2012

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REVISION HISTORY

REV. NO	ISSUE DATE	PREPARED BY AND DATE	REVIEWED BY AND DATE	APPROVED BY AND DATE	DESCRIPTION OF REVISION
1	December 2012	C. Longobardi 13-DEC-2012	S. Sebastian 19-DEC-2012	M. Gregoire 19-DEC-2012	Correction to Table 2; EQG for F2 from 260 mg/kg to 1000 mg/kg as per Gov. of NU DoE. Letter from DoE added in Appendix E.

ᐅᓂᒃᑳᓕᐊᖑᓯᒪᔪᓂᒃ ᐃᓗᓕᖕᒋᑦ

ᑎᐅᕋ ᑎᐊᒃ ᐊᐃ (Tetra Tech WEI Inc.) ᐃᖅᑲᓇᐃᔭᖅᑎᑕᐅᑲᐃᓐᓇᓚᐅᖅᐳᑦ ᓄᓇᓕᖕᓂᒃ ᐊᒻᒪ ᒐᕙᒪᖕᒋᓐᓂᒃ ᐱᔨᑦᓯᕋᖅᑎᒃᑯᓐᓂᒃ ᓄᓇᕗᑦ ᒐᕙᒪᒃᑯᖕᒋᓐᓂ, ᕿᒥᕐᕈᓇᕐᑯᔭᐅᓪᓗᑎᒃ ᐃᔾᔪᒥᒃ ᐊᒻᒪ ᑐᐊᐸᒥᒃ ᐊᕙᑎᖕᒐᓂᒃ ᑰᒑᕈᖕᒥ ᑐᐊᐸᓕᕆᕕᖕᒐᓂ ᒪᓕᒡᓗᒋᑦ ᓄᓇᕗᒻᒥ ᐃᒪᓕᕆᔨᓐᓇᐅᑏᑦ 1BR-KRK1112.

2011-ᒥ ᐱᓕᕆᐊᕐᑐᓚᐅᖅᐳᑦ ᕿᒥᕐᕈᓇᖕᓂᒃ ᐊᕙᓗᖕᒐᓐᓂᒃ ᑭᓈᓗᕐᑲᕐᕕᐅᑉ, ᐃᒪᖕᒐᓂᒡᓗ ᖃᐅᔨᓴᕐᕖᑦ ᐊᒻᒪ ᑭᓈᓗᕐᑲᕐᕕᐅᑉ ᐃᒪᖕᒐᓂᒃ, ᐊᒻᒪ ᐃᔾᔪᖕᒐᓂᒃ ᑖᑉᓱᒪ ᐃᓗᐊᓂ. ᑖᒃᑯᐊ ᓄᐊᑕᐅᓚᐅᖅᑐᑦ ᖃᐅᔨᓴᕐᑫᒃᓴᑦ ᓇᒃᓯᐅᔾᔭᐅᓚᐅᖅᐳᑦ ᖃᐅᔨᓴᕐᕕᖕᒧᑦ ᑕᒪᒃᑯᓂᖕᒐ ᖃᐅᔨᓴᕈᓐᓇᕐᓂᕐᒥᒃ ᐃᓕᓴᓇᔭᐅᔾᔪᑎᓕᖕᓄᑦ.

ᑖᒃᑯᐊ ᐃᒪᖕᒐᓂᒃ ᖃᐅᔨᓴᖅᑕᐅᔪᑦ ᓇᓄᓇᐃᖅᓯᓚᐅᖅᐳᑦ ᓱᕉᓗᐊᕐᓂᖕᒋᓐᓂᒃ ᓄᓇᐅᑉ ᕐᑯᓛᓂ ᐊᒻᒪ ᐃᑭᖕᒐᓂ ᐃᒪᓇᔭᐅᔪᓐᓇᖅᑐᓂᒃ. ᑕᒪᓐᓇ ᓱᕉᓂᖕᒐ ᑭᓯᐊᓂ ᑎᒃᑯᐊᕈᑕᐅᔪᓐᓇᓚᐅᓐᖏᓚᖅ ᐃᔾᔪᒥᒃ ᑐᐊᐸᒥᓪᓗ ᖃᐅᔨᓴᕐᕕᐅᔪᒧᑦ. ᑖᒃᑯᐊ ᐃᒪᕐᒥᒃ ᖃᐅᔨᓴᕐᕖᑦ ᐱᕕᐅᓚᐅᓐᖏᓚᑦ ᔪᓚᐃᒥ ᖃᐅᔨᓴᓇᐊᖅᓯᒪᑎᓪᓗᑕ ᑖᒃᑯᐊ ᖃᐅᔨᓴᐅᑎᕗᑦ ᔭᒐᓚᐅᕐᓂᖕᒋᓐᓂᒃ ᑎᑭᑎᑕᐅᓇᓱᒃᑎᓪᓗᒋᑦ ᖃᖓᑕᓲᒃᑯᑦ.

ᑐᐊᐸᒥᒃ ᐃᔾᔪᒥᒡᓗ ᖃᐅᔨᓴᖅᑕᑦᑎᓐᓂᒃ ᓱᕉᓗᐊᓚᐅᖅᑐᑐᐊᖅ F2 ᐅᖅᓱᐊᓗᖕᒥᒃ ᑭᓂᖅᑎᓯᒪᔪᒥᒃ. 2011-ᒥ ᖃᐅᔨᓴᓚᐅᖅᑕᕗᑦ ᐊᖕᒋᓪᓕᒋᐊᖅᓯᒪᓚᐅᖅᐳᑦ 75%-ᒥᒃ ᑕᐃᒪᓐᖓᓂᑦ 2010-ᒥ ᖃᐅᔨᓴᓚᐅᖅᑕᑦᑎᓐᓂᒃ. 2011 ᓱᕗᓂᐊᓂ, F2 ᐅᖅᓱᐊᓗᖕᒥᒃ ᑭᓂᖅᑎᓯᒪᔪᒥᒃ ᖃᐅᔨᓴᖅᑕᕗᑦ ᒥᑭᓪᓕᒋᐊᖅᓯᒪᓂᕐᑲᓚᐅᖅᐳᑦ 62%-ᒥᒃ ᑕᐃᒪᓐᖓᓂᑦ ᓴᓗᒻᒪᖅᓴᐃᓂᖅ ᐱᒋᐊᓚᐅᖅᑎᓪᓗᒍ 2007-ᒥ. ᑕᒪᓐᓇ ᐊᖕᒋᓪᓕᒋᐊᕐᓂᖅ F2 ᐅᖅᓱᐊᓗᖕᒥᒃ ᑭᓂᖅᑎᓯᒪᔪᒥᒃ ᓴᖅᑭᑎᑕᐅᓚᐅᖅᑎᒋᔭᐅᕗᖅ ᓄᓇᐅᑉ ᐃᑭᖕᒐᓄᑦ ᕐᑲᒨᖕᒐᑐᕐᑲᐅᓂᖅᓴᖅ ᓄᐊᑦᑎᓚᐅᕐᓂᑦᑎᓐᓂᒃ ᓴᓗᒻᒪᖅᓴᐃᓂᕐᒧᑦ ᐃᓴᒃᓯᒪᓐᖓᖕᒋᓐᓂᕐᒧᑦ ᓱᓕ ᓄᓇᐅᑉ ᕐᑯᓛᓅᓐᓂᖅᓴᒥᒃ. ᑎᐅᕋ ᑎᐊᒃᑯᑦ ᐱᒋᐊᕐᓂᖕᒐᓂᒃ ᓂᕆᐅᖕᓂᕐᑲᓚᐅᖅᐳᑦ ᑐᐊᐸᒥᒃ ᓴᓗᒻᒪᖅᓴᐃᓂᖅ ᐅᑎᕐᓂᐊᖅᑐᕆᓚᐅᕐᓗᒍ ᑎᑭᑎᑕᐅᓇᓱᒃᑐᒧᑦ ᓴᓗᒻᒪᖅᓴᐃᓂᕐᒥᒃ 2012 ᓄᖑᓐᓂᐊᓂ. ᑕᒪᓐᓇ ᐊᖕᒋᓪᓕᒋᐊᕈᑕᐅᓚᐅᖅᑐᖅ ᖃᐅᔨᓴᕐᓂᑦᑎᓐᓂ F2 ᐅᖅᓱᐊᓗᖕᒥᒃ ᑭᓂᖅᑎᓯᒪᔪᒥᒃ 2011-ᒥ, ᓖᓐᓇ ᓂᕆᐅᖕᓂᕆᔭᕗᑦ ᐋᖅᑭᐊᖅᓯᒪᓕᖅᐳᑦ ᒪᕐᕿᖕᓂᒃ ᐊᕐᕌᒎᖕᓂᒃ ᓱᓕ ᐱᓕᕆᔭᕆᐊᖃᕐᓂᐊᕐᓂᑦᑎᓐᓂᒃ ᒥᑭᓪᓕᒋᐊᖅᑎᑕᐅᓱᒡᓗᓂ F2 ᐅᖅᓱᐊᓗᖕᒥᒃ ᑭᓂᖅᑎᓯᒪᔪᖅ ᐃᔾᔪᒦᑦᑐᖅ ᐊᒻᒪ ᑐᐊᐸᖕᒦᑦᑐᖅ ᒪᓕᒡᓗᒋᑦ ᓇᓗᓇᐃᖅᑕᐅᓯᒪᔪᑦ ᓄᓇᕗᑦ ᒐᕙᒪᒃᑯᖕᒋᑕ ᐊᕙᑎᓕᕆᔾᔪᖕᒋᓐᓄᑦ.

EXECUTIVE SUMMARY

Tetra Tech WEI Inc. was retained by the Department of Community and Government Services of the Government of Nunavut, to carry out the annual soil sampling and environmental monitoring program at the Kugaaruk Soil Treatment Landfarm in accordance with Nunavut Water Licence number 1BR-KRK1112.

The 2011 scope of work included a general inspection of the berm conditions, sampling of the monitoring wells, sampling of the water within the retention cell, and collection of soil samples from the treatment cell. Water and soil samples were submitted to an accredited laboratory for analysis.

The water sample analyses indicated values exceeding several applicable surface or groundwater quality limits. None of the exceeding values are attributable to the operation of the landfarm. Samples were not taken from monitoring wells during the July site visit as the required sampling equipment was lost in transit by the air carrier.

The only soil sample that exceeded regulatory limits was the F2 Petroleum Hydrocarbon concentration. The 2011 samples showed a 75% increase in the F2 concentration in comparison to the 2010 sampling program. Prior to 2011, an overall reduction of 62% in F2 concentrations had been achieved since the commencement of treatment in 2007. The increase in the F2 concentration appears to be the result of deeper sampling of the soil that may have not have experienced the same biotreatment as the upper soil profile. Tetra Tech had originally estimated that the soil would be treated to target levels by the end of the 2012 season. With the increases noted in the 2011 results, it is now estimated that at least two additional years will be required to reduce the F2 hydrocarbon concentrations in the soil to the levels specified by the Nunavut Department of Environment.

TETRA TECH

TABLE OF CONTENTS

1.0 BACKGROUND

In 2006, Tetra Tech WEI Inc. (Tetra Tech) formerly Wardrop Engineering Inc., carried out a Phase III Environmental Site Assessment (ESA) on the site of the former fuel storage compound operated by the Government of Nunavut in the Hamlet of Kugaaruk. The ESA revealed several areas where soil had been contaminated by petroleum hydrocarbons to values that exceeded the CCME Environmental Quality Guidelines for the surrounding land use. The Tetra Tech findings were consistent with prior work in 2000 by another consultant.

In anticipation of the requirement to remove the impacted soil, the Nunavut Department of Community and Government Services undertook the design and construction of a soil treatment landfarm outside of the hamlet in 2005. Tetra Tech participated in a site remediation project in July, 2007 whereby the impacted soil was excavated and hauled to the landfarm for placement in the lined treatment cell (Figure 1). A series of composite samples were collected from the soil pile after placement in the cell.

During 2008 the soil pile was turned over once to improve aeration and approximately 800 cubic metres of water was discharged from the retention cell. No monitoring activity occurred during 2008.

In 2009, five monitoring wells were installed downgradient of the facility. The soil pile was turned over once to improve aeration. Approximately 900 cubic meters of water was discharged from the retention cell. Soil and water samples were collected by Tetra Tech for laboratory analysis. Repairs were performed on an eroded section of the containment berm.

In 2010, an additional monitoring well (MW6) was installed upgradient of the landfarm. Approximately 885 cubic metres of water was discharged from the water retention cell. Repair work was performed on eroded sections of the containment berm.

2.0 SUMMARY OF REPORT REQUIREMENTS LICENCE 1BR-KRK1112

Part B of Licence 1BR-KRK1112 contains specific information requirements to be included in the annual reports to be submitted to the Nunavut Water Board during the operation of the landfarm. The requirements and related comments are summarized in this section and, where applicable, references are included to the information provided in the other sections of this report.

2.1 SECTION B1.I – WATER USE ACTIVITIES

2.1.1 QUANTITY OF WATER COLLECTED AS SURFACE RUN-OFF OR COLLECTED IN THE BERMS

No external surface run-off is collected. Precipitation and melt water within the landfarm berms are the only water collected. An estimated 1200 cubic metres of water has accumulated in the retention cell since the previous September 2010 discharge. The basis of this volume estimate is described in Section 3.2 of this report.

2.1.2 QUANTITY OF WATER DISCHARGED DAILY TO THE TREATMENT CELL

The soil pile in the treatment cell was irrigated on four occasions using water from the landfarm retention cell. On each, occasion soil irrigation took place over two days and used an average of 127 cubic metres of water per day.

2.1.3 QUANTITY OF WATER DISCHARGED TO THE RECEIVING ENVIRONMENT

Approximately 1180 cubic meters of water was released in September 2011. Details are included in Section 3.2 of this report.

2.1.4 QUANTIFICATION OF DATA AND RATIONALE

The methods used to collect data on discharge volumes are described in Section 3.2 of this report.

2.1.5 DATA

The available data is provided in Section 3.2 of this report.

2.2 SECTION B1.II

2.2.1 CHARACTERISTICS OF SOIL IN LANDFARM

No soil was added to the landfarm in 2011. The characteristics of the soil placed in the landfarm in 2007 were described in the Wardrop Engineering Inc. report entitled, *Former Tank Farm Site Remediation, Kugaaruk, Nunavut, August 2008*. This report was included as Appendix B of the 2006-2008 annual report submitted to the Nunavut Water Board in February 2010.

2.2.2 SOIL SITE DELINEATION

The soil placed in the treatment cell as described in the previous section is the only contaminated soil present in the landfarm.

2.2.3 HISTORICAL SOIL TONNAGE

A total of 2172 cubic metres of contaminated soil was placed in the landfarm. A breakdown of this volume is included in the August, 2008 remediation report referenced above.

2.2.4 RATE OF DEGRADATION

The degradation rate is based on the reduction in the average concentration of F2 Petroleum Hydrocarbons (PHC) in the soil volume. The F2 PHC is being monitored as this is the parameter that exceeded applicable guideline limits. The 2011 monitoring data shows an overall reduction of 33% in the average F2 concentration, in comparison to the 2007 samples. The average F1, F2 and F3 concentrations showed an increase in 2011 compared to the 2010 sampling data. These results are discussed in Section 4.1 of this report.

2.2.5 TREATMENT EFFICIENCY

Due to the apparent increase in PHC concentrations noted in the 2011 samples, no comments on treatment efficiency are provided.

2.2.6 WASTE ROCK

During 2011, a number of large rocks were removed from the treatment area. The rocks were examined by TetraTech staff and there was no evidence of visible staining. The rocks were not cleaned prior to removal. The rocks removed were piled in an area adjacent to the landfarm (Photo 2).

2.2.7 Location and Quality of Discharge Effluent

The discharge location is described in Section 3.2 of this report. The quality of the effluent is discussed in Section 4.3 of this report.

2.2.8 Soil Pile Data

Soil moisture levels were analyzed in the laboratory on the six composite samples that were submitted for hydrocarbon analysis. Soil temperatures and pH were not recorded. No nutrient application was implemented in 2011.

2.2.9 Data and Procedures

The data accumulated during the 2011 operation and monitoring of the Kugaaruk landfarm is discussed in Sections 3, and 4 of this report.

2.3 Section B1.III

2.3.1 Unauthorized Discharge

Other than the discharge of water from the retention cell described in Section 3.2, there were no other known discharges occurred from the landfarm.

2.3.2 Plan Revisions

In accordance with direction from the Nunavut Water Board as part of the renewal of license 1BR-KRK0609 (precedes 1BR-KRK1112), revisions were made to the Spill Contingency Plan, the Quality Assurance/Quality Control (sampling) Plan and the Operations Maintenance Plan for the Kugaaruk landfarm. The plans were consolidated under the title of Operations and Maintenance Manual, Kugaaruk Landfarm Facility and were submitted the Nunavut Water Board on April 15, 2011.

2.3.3 Progressive Reclamation

No progressive reclamation work was undertaken during the report period.

2.3.4 Dust Control

Part D, Section 6 contains provisions for dust control and water ponding in temporary storage areas. No temporary storage areas were in use during the report period.

2.3.5 Spill contingency Plan Information

The Spill Contingency Plan was revised to include additional data. The revised plan was incorporated into the Operations and Maintenance Manual which was submitted to the Nunavut Water Board on April 15, 2011. There have been no reportable incidents at the landfarm site during the current report period.

2.3.6 MONITORING PROGRAM SUMMARY

The analytical results of the 2011 Monitoring Program are presented in Tables 2, 4, and 5. (See Appendix B).

2.3.7 DATA ANALYSIS

The results of the Monitoring Program are discussed in Section 4 of this report. Future studies will generally consist of a regular monitoring program similar to that described in this report unless directed otherwise by the regulator.

2.3.8 SITE PHOTOGRAPHS

Photographs are included in Appendix A of this report.

3.0 2011 SITE ACTIVITIES

3.1 SOIL CELL AERATION

The soil pile was turned three times during the 2011 treatment season. The purpose of turning the pile was to provide aeration for the soil bacteria that degrade petroleum hydrocarbons. Turning of the pile was conducted by the general contractor using an excavator.

3.2 RETENTION CELL DISCHARGE

The volume of water discharged from the retention cell was determined by measuring the water depth before the discharge and calculating the volume using the cell dimensions. An adjustment was made for the estimated residual volume left in the bottom of the cell after discharge. There was approximately 1150 cubic meters of water in the cell prior to discharge, and an estimated 100 cubic meters remained after pumping, for a net discharge volume of 1050 cubic meters. Pumping occurred over a 24 hour period, resulting in an estimated flow rate of 700 liters per minute. All water discharge was directed to a splash pad to prevent erosion.

3.3 REMOVAL OF BOULDERS

The general contractor recommended removal of a number of small boulders from the soil treatment area to improve the soil turning operation. The boulders were first piled on top of the soil treatment layer where they were visually examined by TetraTech during the September, 2011 monitoring program. No visible evidence of hydrocarbon staining was found and the contractor was directed to remove the boulders from the landfarm. The boulders were piled across the public road on the north of the landfarm (Photo 2).

3.4 SOIL SAMPLE COLLECTION

A total of six composite samples (LF1, LF2, LF3, LF4, LF5 and LF6), were collected from the treatment area of the landfarm facility on September 08, 2011, for laboratory analysis of hydrocarbon concentrations. To ensure that samples were representative of the material, the Landfarm was divided into six longitudinal segments. The northwest berm was divided into six equal lengths, and then perpendicular lines were extended to the opposite side of the cell. For segment lengths of 50 meters or less, four discrete

samples were collected from equidistant points along the centreline of the segment. For segments over 50 meters in length, an additional discrete sample was taken for every 10 meters or less. Samples were collected from approximately 0.6 meters below grade. Sample row LF4 was comprised of three discrete samples as a result of the boulder pile limiting access for sampling. The sample locations are shown on Figure 2 (see Appendix C).

To screen for the potential presence of hydrocarbon constituents during the program, soil samples were collected for headspace combustible vapour concentration measurements. These measurements were recorded using a portable Gastech® 1238ME combustible gas detector calibrated to hexane (a standard used for gasoline) and set on methane elimination mode. It should be noted that the headspace test is a semi-quantitative screening method and can only be considered to represent relative volatile contaminant concentrations. The soil headspace combustible vapour concentration results are presented in Table 1 (see Appendix B).

The landfarm facility soil treatment area was sampled only once in 2011. The soil being treated is frost free and undergoing active remediation from June until September each year; therefore, one soil sample collection event was scheduled – to coincide with the end of the active treatment season for 2011.

3.5 GROUNDWATER MONITORING

Groundwater well monitoring consisted of measurement of the depth to static groundwater level using a dual phase electronic water level indicator. Additional monitoring included measurement of headspace vapour concentrations in the well using a Gastech® 1238ME calibrated to hexane, checking for the presence of Light Nonaqueous Phase Liquids (LNAPL), as well as any observation of the physical characteristics of the groundwater during purging. The wells were purged three times or until dry, prior to groundwater sampling. All groundwater well monitoring activities were conducted in accordance with the procedures set out in the Operations and Maintenance Manual, Kugaaruk Landfarm Facility (April, 2011).

A Tetra Tech technician was on site on July 9, 2011 to conduct the first round of surface and groundwater sampling. After staff arrived in Kugaaruk, it was discovered that the well sampling equipment had been lost in transit by the airline. As a result, no groundwater samples could be gathered during this sampling trip.

Wells MW1 to MW5 were monitored on September 8, 2011. Due to an error in the field, MW6 was not monitored. MW3 and MW4 were found to be dry. A small volume of water was detected in MW2 and MW5, however when these wells were purged minimal recovery was detected. MW1 recovered quickly after purging and was sampled on September 10, 2011.

Well monitoring data is included in Table 3 of Appendix B.

3.6 RETENTION CELL SAMPLING

On July 9, 2011 Tetra Tech staff collected a water sample from the retention cell. The sample was analyzed for the parameters specified in Section J.7 of Licence 1BR-KRK1112 and the analytical results are shown in Table 5, Appendix B.

In accordance with directions received from the Nunavut regional office of Aboriginal Affairs and Northern Development Canada (AANDC), Tetra Tech staff collected a water sample from the splash pad during discharge of the retention cell on September 9, 2011. The sample was analyzed for the parameters included in the discharge limits specified by AANDC. The analytical results are provided in Table 5, Appendix B.

4.0 DISCUSSION OF SAMPLE RESULTS

4.1 SOIL SAMPLES

The analytical results of the six composite soil samples taken in September, 2011 are shown in Table 2 (see Appendix B). The results from previous years are also included in the table for comparison. The 2011 results indicate values exceeding of applicable soil quality criteria for F2 petroleum hydrocarbons in all six samples. With the exception of one toluene result in the 2007 samples, the F2 hydrocarbon range is the only parameter that exceeds applicable soil quality guidelines. This observation is consistent with the findings of the site assessment that was carried out prior to the remediation of the area where the contaminated soil originated.

In 2010 the average F2 Petroleum Hydrocarbon (PHC) results showed a 62% reduction since the initial sampling in 2007. The 2011 results show an increase of 75% in the average F2 PHC concentration in comparison to the 2010 data. The F2 PHC levels in four of the six composite samples were found to be higher than the previous year's results. Increases in F3 PHC were also noted for the same four samples. All six F1 PHC results were higher than in 2010.

Tetra Tech has investigated several possible explanations for the increase in PHC concentrations in the soil samples. During the July site inspection of the facility, it was noted that approximately twenty drums containing diesel fuel-water mixture had been left within the treatment cell at the landfarm. It is not certain whether any of the contents of the drums had been dumped on the soil treatment pile. Some small stains (Photos 3 & 4) were noted on the inside of the treatment cell berm and on the edge of the treatment pile, but that was not considered to be significant enough in itself to account for the increases observed in the 2011 results.

In the two previous years, soil samples were collected from 30 centimeters below the top of the soil pile in accordance with the procedure which had been established by Tetra Tech. The 2011 program took samples at 60 centimeters below grade. During the soil turning operation, the contractor has been careful not to disturb the layer of granular material directly above the geotextile liner. The increased sampling depth has likely resulted in the composite samples including soil which is below the average turning depth and has not been subject to the same level of bio treatment as the upper soil profile which has been turned and aerated more frequently.

4.2 GROUNDWATER SAMPLES

Laboratory analysis indicate that the concentrations of BTEX, PHC Fractions F1 to F4, and Polycyclic Aromatic Hydrocarbons (PAHs) in submitted samples from well MW1 were below the laboratory detection limits and/or below the applicable guidelines. Laboratory analytical results are presented in Tables 4 (see Appendix B).

Laboratory analysis showed a phenol concentration over the guideline limit. The concentrations of several metals exceeded the guideline limit in MW1. Most of the metals detected in 2011 groundwater sampling were also found in the 2010 program, including the upgradient well. This would suggest that these metals are naturally occurring in the groundwater.. Mercury was not detected in the laboratory analysis; however, laboratory detection limit is greater than the guideline limit.

Several routine water analysis parameters were found to exceed the guideline limit in MW1. These materials are believed to be naturally occurring in the groundwater. Since none of the same parameters were found in the water retention cell samples no nutrients are being added to the soil treatment area.

It should be noted that the license specifies total metal analyses rather than dissolved metal analysis. Industry standard is generally to field-filter turbid groundwater samples from shallow wells in soils and analyze for dissolved metals, to prevent dissolving the sediments through the acid digestion process required by total metal analysis.

4.3 WATER RETENTION CELL SAMPLE

The analytical results of water sample taken by Tetra Tech on July 9 and September 9, 2011 are shown in Table 5 (see Appendix B). No detectable BTEX, PHC Fractions F1 to F4 or PAHs were found in either sample.

The July 9, 2011 result showed a phenol concentration marginally over the guideline limit. Since phenols are not expected to be a constituent of the soil in the treatment area and the result is less than five times greater than the detection limit, it is likely that the result is a false positive. The concentrations of Total Cadmium was found to exceed the guideline limit. Similar to the groundwater sample laboratory results, these are believed to be naturally occurring minerals from the soils used to construct the retention cell. All other parameters were below guideline limits. Ammonia Nitrogen and Mercury were not detected; however, laboratory analysis detection limits are greater than the guideline limits for these parameters.

The water sample collected at the splash pad during discharge was required to confirm that the water quality conformed with the limits established by AANDC. The results are shown in in Table 5 and below:

Retention Cell Water Discharge (Splash Pad) Sample Laboratory Results September 8, 2011 Kugaaruk Landfarm Facility – Kugaaruk, NU		
Parameter	**AANDC Limit**	**Result**
pH	6.0 to 9.5	8.1
Total Suspended Solids	50 mg/L	17 mg/L
Oil & Grease	15 mg/L, no sheen	<1.0
Benzene	0.37 mg/L	<0.0005 mg/L
Toluene	0.002 mg/L	<0.0005 mg/L
Ethylbenzene	0.090 mg/L	<0.0005 mg/L
Lead	0.001 mg/L	0.00084 mg/L

5.0 CLOSURE

A review of the 2011 monitoring results does not indicate that contaminants are being released from the Kugaaruk landfarm facility to the surrounding environment. This conclusion is based primarily on the observations that no hydrocarbon levels above guideline limits were found in the monitoring well samples or in the samples taken from the retention cell and splash pad, and that the structural integrity of the landfarm has been maintained. The guideline exceedance of metals, phenols and routine parameters found in the water samples are considered by TetraTech to be either naturally occurring or from other external sources. Tetra Tech recommends that future phenols samples be analyzed by 4AAP and GCMS to confirm the absence of phenols in the water samples. Tetra Tech recommended that future metals samples should be analyzed for dissolved metals constituents; however, this would require an amendment to NWB License No. 1BR-KRK1112, which requires metals samples to be analyzed for total metal constituents.

The increase in the F2 Petroleum Hydrocarbon concentrations can be attributed primarily to the increase in sampling depth. This finding will be used to refine both the soil management and monitoring program for 2012 to ensure that the analytical results are indicative of the overall soil volume within the treatment cell. For the reasons discussed in the report, the 2011 soil sample results will not be used to estimate the timeframe required to achieve the target concentrations. It is evident that at least two more years of treatment will be required. Therefore, NWB License No. 1BR-KRK1112 will need to be renewed before it expires on December 31, 2012.

TETRA TECH

APPENDIX A

LANDFARM FACILITY PHOTOGRAPHS

SITE PHOTOGRAPHS

Photo 1: View of the landfarm from the southwest corner – September 2011.

Photo 2: View of the removed boulders piled across public road to the north of the landfarm – September 2011.

SITE PHOTOGRAPHS

Photo 3: View of the stains on the edge of the treatment pile – September 2011.

Photo 4: View of the stains on the inside of the treatment cell berm – September 2011.

SITE PHOTOGRAPHS

Photo 5: View of the water retention cell prior to discharge – September 2011.

Photo 6: View of the water retention cell after discharge – September 2011.

SITE PHOTOGRAPHS

Photo 7: View of the treatment pile sampling locations LF6 to LF4 (left to right) – September 2011.

Photo 8: View of the treatment pile sampling locations LF1 to LF3 (right to left) – September 2011.

TETRA TECH

APPENDIX B

TABLES

TABLE 1

Soil Petroleum Hydrocarbon Vapour Concentrations
September 8, 2011
Kugaaruk Landfarm Facility - Kugaaruk, NU

Sample Identification	Depth (mm)	Hydrocarbon Vapour (ppm)
LF1	600	120
LF2	600	150
LF3	600	220
LF4	600	160
LF5	600	85
LF6	600	90

Notes: ppm = parts per million

TABLE 2

Soil Petroleum Hydrocarbon Laboratory Analytical Results
Kugaaruk Landfarm Facility - Kugaaruk, NU

Sample Identification	Date	Laboratory Analytical Results (mg/kg)								
		Benzene	Toluene	Ethyl-benzene	Xylenes	F1 ($>nC_6$-nC_{10})	F2 ($>nC_{10}$ - nC_{16})	F3 ($>nC_{16}$ - nC_{34})	F4 ($>nC_{34}$)	Moisture Content
LF1	Sep. 8, 2011	<0.0050	<0.050	<0.015	<0.100	22	**1140**	312	<20	8.94
	Sep. 1, 2010	<0.0050	<0.050	<0.015	<0.100	<10.0	393	147	<20	6.65
	Sep. 11, 2009	<0.0050	<0.010	<0.010	<0.030	<5.0	896	349	29.2	8.70
	July 21, 2007	<0.0050	0.040	**0.200**	1.900	70.0	**3500**	420	46.0	9.90
LF2	Sep. 8, 2011	<0.0050	<0.050	<0.015	<0.100	122.0	**1540**	397	<20	9.37
	Sep. 1, 2010	<0.0050	<0.050	<0.015	<0.100	83.0	**3430**	695	<20	9.35
	Sep. 11, 2009	<0.0050	<0.010	<0.010	<0.030	13.8	**1130**	406	18.1	7.00
	July 21, 2007	<0.0050	0.010	**0.150**	0.920	53.0	**1300**	120	22	12.0
LF3	Sep. 8, 2011	<0.0050	<0.050	<0.015	0.52	124.0	**1910**	411	<20	8.49
	Sep. 1, 2010	<0.0050	<0.050	<0.015	<0.100	30.0	**1210**	232	<20	9.69
	Sep. 11, 2009	<0.0050	<0.010	<0.010	<0.030	23.1	970	372	31.5	9.10
	July 21, 2007	<0.0050	**0.140**	**1.500**	**18.000**	350	**4200**	570	17.0	17.0
LF4	Sep. 8, 2011	<0.0050	<0.050	<0.015	0.35	213	**4630**	794	<20	10.50
	Sep. 1, 2010	<0.0050	<0.050	<0.015	<0.100	<10.0	576	214	<20	9.81
	Sep. 11, 2009	<0.0050	<0.010	<0.010	<0.030	31.0	**2590**	534	18.6	11.0
	July 21, 2007	<0.0050	<0.010	<0.010	0.340	24.0	**2300**	490	30.0	6.30
LF5	Sep. 8, 2011	<0.0050	<0.050	<0.015	<0.100	51.0	**1420**	302	<20	9.3
	Sep. 1, 2010	<0.0050	<0.050	<0.015	<0.100	26.0	**2380**	908	<20	10.5
	Sep. 11, 2009	<0.0050	<0.010	<0.010	<0.030	30.6	**1890**	545	21.4	12.0
	July 21, 2007	<0.0050	0.020	**0.280**	2.300	72.0	**3500**	620	26.0	17.0
LF6	Sep. 8, 2011	<0.0050	<0.050	<0.015	<0.100	189	**3590**	662	<20	9.32
	Sep. 1, 2010	<0.0050	<0.050	<0.015	<0.100	<10.0	157	117	<20	8.16
	Sep. 11, 2009	<0.0050	<0.010	<0.010	<0.030	30.9	**1940**	342	13.2	11.0
	July 21, 2007	<0.0050	0.020	**0.330**	3.700	96.0	**6500**	1100	31.0	7.50
Average	Sep. 8, 2011	<0.0050	<0.050	<0.015	0.212	120.2	**2372**	480	<20	9.32
	Sep. 1, 2010	<0.0050	<0.050	<0.015	<0.100	25.7	**1358**	386	<20	9.03
	Sep. 11, 2009	<0.0050	<0.010	<0.010	<0.030	22.0	**1569**	425	22.0	9.80
	July 21, 2007	<0.0050	0.039	**0.411**	4.527	110.8	**3550**	553	28.7	11.6
CCME Guidelines[1,2,3,4]		**0.03**	**0.37**	**0.082**	**11**	**320**	**1000[5]**	**1700**	**3,300**	**N.G.**

Notes:

[1]Soils were classified in the field, by visual inspection. All soils were determined to be coarse-grained.

[2]Summation of m, p, and o-Xylene concentrations.

[3]Canadian Council of Ministers of the Environment (CCME), *Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil* , May 2001, revised January 2008 (for Fraction 1 to 4 values for coarse-grained soils for management limits within an industrial land-use setting).

[4]CCME, Canadian Environmental Quality Guidelines, 2004 (for BTEX values for coarse-grained surface soil for the protection of human health in an industrial land-use setting).

[5]Revison of F2 fraction from 260 mg/kg to 1000 mg/kg approved by Nunavut Department of Environment, Jan. 28, 2010, based on soil being used as landfill cover material.

TABLE 3

Groundwater Well Monitoring Results
September 8, 2011
Soil Landfarm Facility - Kugaaruk, Nunavut

Monitoring Well	Depth to Groundwater (m below casing)	Headspace Vapour Concentration (ppm)	Light Nonaqueous Phase Liquid (mm)
MW1	0.516	0.00	N.D.
MW2	1.168	0.00	N.D.
MW3	Dry at 1.231	0.00	N.D.
MW4	Ice at 1.451	0.00	N.D.
MW5	1.149	10.00	N.D.
MW6	N.M.	N.M.	N.M.

Notes: ppm = parts per million
N.M = Not Measured
N.D. = Not Detected

TABLE 4

Groundwater Sample Laboratory Analytical Results
September 8, 2011
Kugaaruk Landfarm Facility - Kugaaruk, NU

Laboratory Analyses	Guidelines (mg/L)	Laboratory Analytical Results (mg/L)		
		MW1	FIELD BLANK	TRIP BLANK
Metals				
Aluminium (Al) - Total	N.G.	19.3	N.A.	N.A.
Arsenic (inorganic) (As) - Total	0.005[1]	**0.00788**	N.A.	N.A.
Cadmium (Cd) - Total	0.000017[1]	**0.000225**	N.A.	N.A.
Calcium (Ca) - Total	N.G.	219	N.A.	N.A.
Chromium (Cr) - Total	0.0089[1]	**0.0422**	N.A.	N.A.
Cobalt (Co) - Total	0.1[3]	0.0131	N.A.	N.A.
Copper (Cu) - Total	0.023[3]	**0.0251**	N.A.	N.A.
Iron (Fe) - Total	0.3[4]	**27.5**	N.A.	N.A.
Lead (Pb) - Total	0.032[3]	0.0163	N.A.	N.A.
Magnesium (Mg) - Total	N.G.	140	N.A.	N.A.
Manganese (Mn) - Total	N.G.	0.998	N.A.	N.A.
Mercury (Hg) - Total	0.000026[1]	<0.00010	N.A.	N.A.
Nickel (Ni) - Total	1.6[3]	0.0278	N.A.	N.A.
Potassium (K) - Total	N.G.	54.8	N.A.	N.A.
Zinc (Zn) - Total	0.03[4]	**0.0765**	N.A.	N.A.
Routine				
Alkalinity - Total	N.G.	265	N.A.	N.A.
Ammonia Nitrogen	0.019[1]	**1.10**	N.A.	N.A.
Chlroide (Cl^-)	640[1]	**2400**	N.A.	N.A.
Hardness	N.G.	1200	N.A.	N.A.
Nitrate+Nitrite (NO_3^- + NO_2^-)	N.G.	0.55	N.A.	N.A.
pH	6.0 to 9.5[5]	7.95	N.A.	N.A.
Phosphorus (P) - Total	N.G.	1.12	N.A.	N.A.
Sodium (Na) - Total	2300[3]	1090	N.A.	N.A.
Sulfate (SO_4^{2-})	N.G.	536	N.A.	N.A.
Total Suspended Solids	50[5]	**1390**	N.A.	N.A.
Conductivity (in mS/cm)	N.G.	8510	N.A.	N.A.
BTEX				
Benzene	0.37[1]	<0.00050	<0.00050	<0.00050
Toluene	0.002[1]	<0.00050	<0.00050	<0.00050
Ethylbenzene	0.09[1]	<0.00050	<0.00050	<0.00050
Xylenes	18[2,4]	<0.00071	<0.00071	<0.00071
CCME Fractions				
F1 - BTEX (>nC_6 - nC_{10})	9.8[4]	<0.10	<0.10	<0.10
F2 (>nC_{10} - nC_{16})	1.3[4]	<0.5	N.A.	N.A.
F3 (>nC_{16} - nC_{34})	0.5[3]	<0.25	N.A.	N.A.
F4 (>nC_{34})	0.5[3]	<0.25	N.A.	N.A.
Total Petroleum Hydrocarbons	1.0[4]	N.A.	N.A.	N.A.
Polycyclic Aromatic Hydrocarbons (PAHs)				

TABLE 4

Groundwater Sample Laboratory Analytical Results
September 8, 2011
Kugaaruk Landfarm Facility - Kugaaruk, NU

Laboratory Analyses	Guidelines (mg/L)	Laboratory Analytical Results (mg/L)		
		MW1	FIELD BLANK	TRIP BLANK
1-Methyl Naphthalene	13[3]	N.A.	N.A.	N.A.
2-Methyl Naphthalene	13[3]	N.A.	N.A.	N.A.
Acridine	0.0044[1]	<0.000020	N.A.	N.A.
Acenaphthene	0.0058[1]	0.000021	N.A.	N.A.
Acenaphthylene	0.0460[4]	N.A.	N.A.	N.A.
Anthracene	0.000012[1]	<0.000010	N.A.	N.A.
Benzo(a)anthracene	0.000018[3]	<0.000010	N.A.	N.A.
Benzo(a)pyrene	0.000015[1]	<0.0000050	N.A.	N.A.
Benzo(b)fluoranthene	0.00700[3]	N.A.	N.A.	N.A.
Benzo(b&j)fluoranthene	0.00048[4]	<0.000010	N.A.	N.A.
Benzo(ghi)perylene	0.00017[4]	0.000026	N.A.	N.A.
Benzo(k)fluoranthene	0.00048[4]	<0.000010	N.A.	N.A.
Chrysene	0.00140[4]	<0.000020	N.A.	N.A.
Dibenzo(a,h)anthracene	0.00026[4]	<0.0000050	N.A.	N.A.
Fluoranthene	0.00004[1]	<0.000020	N.A.	N.A.
Fluorene	0.00300[1]	0.000031	N.A.	N.A.
Indeno(1,2,3-cd)pyrene	0.00021[4]	<0.000010	N.A.	N.A.
Naphthalene	0.00110[1]	<0.000050	N.A.	N.A.
Phenanthrene	0.00040[1]	0.000062	N.A.	N.A.
Pyrene	0.000025[1]	<0.000020	N.A.	N.A.
Quinoline	0.00340[1]	<0.000020	N.A.	N.A.
Miscellaneous Organic Parameters				
Oil and Grease	15 & no sheen[5]	<1.0	N.A.	N.A.
Phenols	0.004[1]	**0.0166**	N.A.	N.A.

Notes:

[1]Canadian Council of Minsters of the Environment (CCME), *Canadian Environmental Quality Guidelines* (CEQG), September 2007, in a commerical/industrial land use setting, for the protection of aquatic life pathway.

[2]Summation of m, p, and o-Xylene concentrations.

[3]Ontario Ministry of the Environment (MOE), Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act (March 9, 2004), for non-potable water conditions (Table 3).

[4]Alberta Environment, *Alberta Tier 2 Soil and Groundwater Remediation Guidelines* , August 2008, in a Commerical/Industrial land use setting, for the protection of aquatic life pathway (course-grained soil).

[5]Limits provided by Keim, Aboriginal Affairs and Northern Development Canada (AANDC), Aug 30, 2010.

N.G. = No Guideline

N.A. = Not Analyzed

Bold Text = Laboratory analytical results in excess of the referenced guidelines

TABLE 5

Retention Cell Water Sample Laboratory Analytical Results
Kugaaruk Landfarm Facility - Kugaaruk, NU

Laboratory Analyses	Guidelines (mg/L)	Laboratory Analytical Results (mg/L)	
		SUMP (Cell Water) July 9, 2011	SUMP (Splash Pad) Sep. 9, 2011
Metals			
Aluminium (Al) - Total	N.G.	0.315	N.A.
Arsenic (inorganic) (As) - Total	0.005[1]	0.0004	N.A.
Cadmium (Cd) - Total	0.000017[1]	**0.000236**	N.A.
Calcium (Ca) - Total	N.G.	14.7	N.A.
Chromium (Cr) - Total	0.0089[1]	<0.0050	N.A.
Cobalt (Co) - Total	0.1[3]	<0.0020	N.A.
Copper (Cu) - Total	0.023[3]	0.0027	N.A.
Iron (Fe) - Total	0.3[4]	0.28	N.A.
Lead (Pb) - Total	0.01[5]	0.0004	0.00084
Magnesium (Mg) - Total	N.G.	3.24	N.A.
Manganese (Mn) - Total	N.G.	0.0119	N.A.
Mercury (Hg) - Total	0.000026[1]	<0.00010	N.A.
Nickel (Ni) - Total	1.6[3]	<0.0020	N.A.
Potassium (K) - Total	N.G.	1.94	N.A.
Zinc (Zn) - Total	0.03[4]	<0.0040	N.A.
Routine			
Alkalinity - Total	N.G.	63.2	N.A.
Ammonia Nitrogen	0.019[1]	<0.050	N.A.
Chlroide (Cl^-)	640[1]	5.09	N.A.
Hardness	N.G.	57	N.A.
Nitrate+Nitrite (NO_3^- + NO_2^-)	N.G.	<0.071	N.A.
pH	6.0 to 9.5[5]	8.1	8.42
Phosphorus (P) - Total	N.G.	0.0141	N.A.
Sodium (Na) - Total	2300[3]	7.7	N.A.
Sulfate (SO_4^{2-})	N.G.	5.61	N.A.
Total Suspended Solids	50[5]	<3.0	17
Conductivity (in mS/cm)	N.G.	152	N.A.
BTEX			
Benzene	0.37[5]	<0.00050	<0.00050
Toluene	0.002[5]	<0.00050	<0.00050
Ethylbenzene	0.09[5]	<0.00050	<0.00050
Xylenes	18[2,4]	<0.00071	<0.00071
CCME Fractions			
F1 - BTEX (>nC_6 - nC_{10})	9.8[4]	<0.10	<0.10
F2 (>nC_{10} - nC_{16})	1.3[4]	<0.25	<0.25
F3 (>nC_{16} - nC_{34})	0.5[3]	<0.25	<0.25
F4 (>nC_{34})	0.5[3]	<0.25	<0.25
Total Petroleum Hydrocarbons	1.0[4]	N.A.	N.A.

TABLE 5

Retention Cell Water Sample Laboratory Analytical Results
Kugaaruk Landfarm Facility - Kugaaruk, NU

Laboratory Analyses	Guidelines (mg/L)	Laboratory Analytical Results (mg/L)	
		SUMP (Cell Water) July 9, 2011	SUMP (Splash Pad) Sep. 9, 2011
Polycyclic Aromatic Hydrocarbons (PAHs)			
1-Methyl Naphthalene	13[3]	N.A.	N.A.
2-Methyl Naphthalene	13[3]	N.A.	N.A.
Acridine	0.0044[1]	<0.000020	N.A.
Acenaphthene	0.0058[1]	<0.000020	N.A.
Acenaphthylene	0.0460[4]	N.A.	N.A.
Anthracene	0.000012[1]	<0.000010	N.A.
Benzo(a)anthracene	0.000018[3]	<0.000010	N.A.
Benzo(a)pyrene	0.000015[1]	<0.0000050	N.A.
Benzo(b)fluoranthene	0.00700[3]	N.A.	N.A.
Benzo(b&j)fluoranthene	0.00048[4]	<0.000010	N.A.
Benzo(ghi)perylene	0.00017[4]	<0.000040	N.A.
Benzo(k)fluoranthene	0.00048[4]	<0.000010	N.A.
Chrysene	0.00140[4]	<0.000020	N.A.
Dibenzo(a,h)anthracene	0.00026[4]	<0.0000050	N.A.
Fluoranthene	0.00004[1]	<0.000020	N.A.
Fluorene	0.00300[1]	<0.000020	N.A.
Indeno(1,2,3-cd)pyrene	0.00021[4]	<0.000010	N.A.
Naphthalene	0.00110[1]	<0.00050	N.A.
Phenanthrene	0.00040[1]	<0.000020	N.A.
Pyrene	0.000025[1]	<0.000010	N.A.
Quinoline	0.00340[1]	<0.00020	N.A.
Miscellaneous Organic Parameters			
Oil and Grease	15 & no sheen[5]	<1.0	<1.0
Phenols	0.004	**0.0042**	N.A.

Notes:

[1]Canadian Council of Minsters of the Environment (CCME), *Canadian Environmental Quality Guidelines* (CEQG), September 2007, in a commerical/industrial land use setting, for the protection of aquatic life pathway.

[2]Summation of m, p, and o-Xylene concentrations.

[3]Ontario Ministry of the Environment (MOE), Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act (March 9, 2004), for non-potable water conditions (Table 3).

[4]Alberta Environment, *Alberta Tier 2 Soil and Groundwater Remediation Guidelines* , August 2008, in a Commerical/Industrial land use setting, for the protection of aquatic life pathway (course-grained soil).

[5]Limits provided by Keim, Aboriginal Affairs and Northern Development Canada (AANDC), Aug 30, 2010.

N.G. = No Guideline

N.A. = Not Analyzed

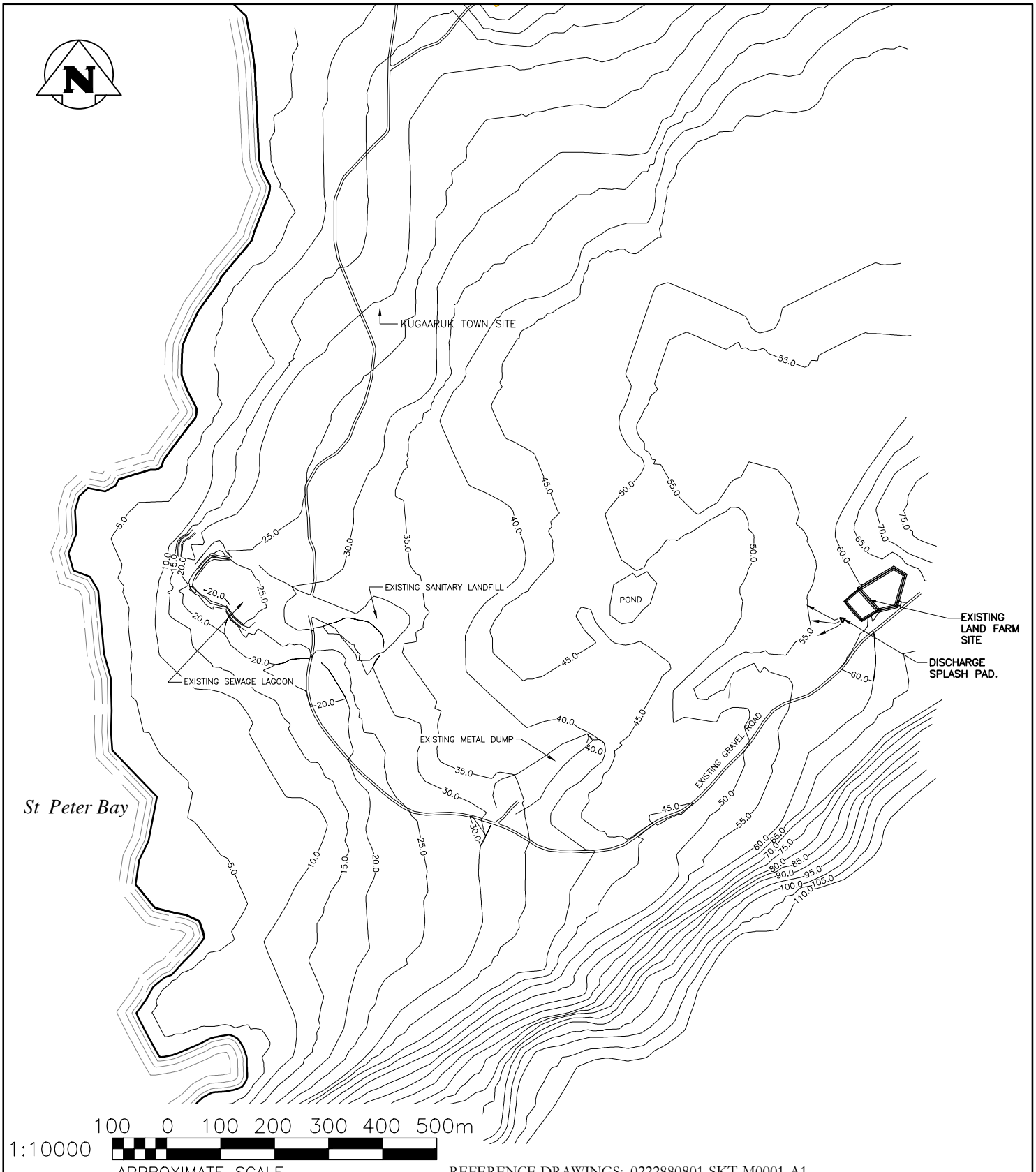
Bold Text = Laboratory analytical results in excess of the referenced guidelines

TETRA TECH

APPENDIX C

FIGURES

X:\A-G\GOVERNMENT OF NUNAVUT\0222808.05 - LAND FARM WATER LICENSE COMPLIANCE ASSISTANCE\CAD\ENV\0222880805-SKT-V0004-00.DWG 12.04.03 9:36 AM PRECOURT, SYLVIO



REFERENCE DRAWINGS: 0222880801-SKT-M0001-A1

TETRA TECH

NO.	DATE	DESCRIPTION	ISSUED BY

REVISIONS/ISSUE

AUTHORIZED BY: CL
DATE: 12/04/03
CLIENT DRAWING NO.

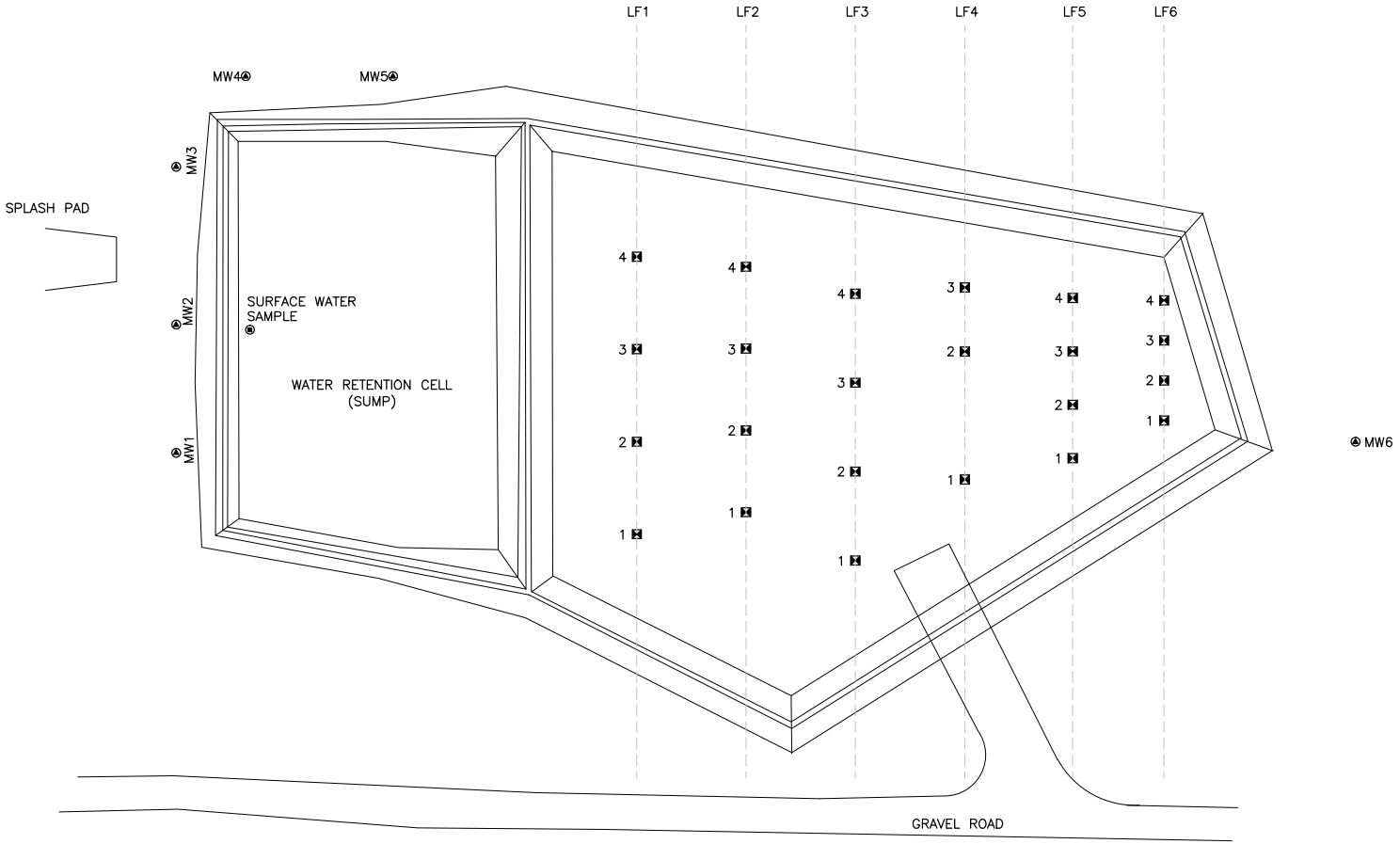
CLIENT
GOVERNMENT OF NUNAVUT

DRAWING DESCRIPTION
FIGURE 1: LANDFARM FACILITIES TOPOGRAPHICAL AREA MAP KUGAARUK, NUNAVUT

DESIGNED BY:	SP	DRAWN BY:	SP	DRAWING NO.	REV.
REVIEWED BY:	DE	SCALE:	1:10 000	0222880805-SKT-V0004	00

A (8.5" x 11")

X:\A-G\GOVERNMENT OF NUNAVUT\02228808.05 - LAND FARM WATER LICENSE COMPLIANCE ASSISTANCE\CAD\ENV\0222880805-SKT-V0003-00.DWG 12.04.03 9:31 AM PRECOURT, SYLVIO



LEGEND
- SOIL SAMPLE LOCATION
- SOIL SAMPLING LINE
- MONITORING WELL
- SURFACE WATER SAMPLE

REFERENCE DRAWINGS: 0222880801-SKT-V0004-A4

0 10 20 30 40 50 m
SCALE 1:800 (APPROXIMATE)

NO.	DATE	DESCRIPTION	ISSUED BY
		ISSUED FOR CONSTRUCTION	

REVISIONS/ISSUE

TETRA TECH

AUTHORIZED BY: CL
DATE: 12/04/03
CLIENT DRAWING NO.

CLIENT
GOVERNMENT OF NUNAVUT

DRAWING DESCRIPTION
FIGURE 2: SITE PLAN SHOWING 2011 LANDFARM SAMPLING LOCATIONS KUGAARUK, NUNAVUT

DESIGNED BY:	SP	DRAWN BY:	SP	DRAWING NO.	REV.
REVIEWED BY:	CL	SCALE:	1:800	0222880805-SKT-V0003	00

AL (11" x 8.5")

TETRA TECH

APPENDIX D

WELL LOGS

TETRA TECH

RECORD OF BOREHOLE

MW1

Sheet 1 of 1

0222880805

CLIENT: Government of Nunavut | DATE DRILLED: September 11, 2009 | DATUM:

PROJECT TITLE: Landfarm Water License Compliance | PROJECT SITE: Kugaaruk Landfarm | NORTHING:

BOREHOLE LOCATION: Approximately 3 m outside landfarm berm to west of the southwest corner and to north of stream | EASTING:

BORING METHOD	DEPTH SCALE m ft	SUBSURFACE PROFILE: ELEV DEPTH (m)	DESCRIPTION	SYMBOLS	SAMPLES: SAMPLE NAME	SAMPLE TYPE	LAB TESTING (Primary)	LAB TESTING (Secondary)	GUIDELINE COMPARISON	MONITORING WELL: MW1
Tetra Tech WEI Inc. Backhoe	0.00	0.00	Ground Surface							
			Sand Some Gravel, Tan, Damp.							-0.10
			- Water							Native Sand
	1	-1.00 1.00	***Clay*** Grey, Moist.							
		-1.40 1.40	- Refusal on Permafrost ***End of Borehole at 1.40m***							
	5									
	2									

-0.10
50 mm Solid PVC
-0.20

50 mm Screen PVC

SCALE 1: 11.0 | LOGGED BY: SZ | CHECKED BY: DE

WARDROP LOG - ANALYTICAL 0222880805-BOR-V0001-00.GPJ 4/3/12

TETRA TECH

RECORD OF BOREHOLE

MW2

Sheet 1 of 1

0222880805

CLIENT: Government of Nunavut | DATE DRILLED: September 11, 2009 | DATUM:

PROJECT TITLE: Landfarm Water License Compliance | PROJECT SITE: Kugaaruk Landfarm | NORTHING:

BOREHOLE LOCATION: Approximately 3 m outside landfarm berm at approximately center of the westsouthwest wall and to northwest of MW1 | EASTING:

BORING METHOD	DEPTH SCALE m ft	SUBSURFACE PROFILE: ELEV DEPTH (m)	DESCRIPTION	SYMBOLS	SAMPLES: SAMPLE NAME	SAMPLE TYPE	LAB TESTING (Primary)	LAB TESTING (Secondary)	GUIDELINE COMPARISON	MONITORING WELL: MW2
Tetra Tech WEI Inc. Backhoe	0.00	0.00	Ground Surface							
			Sand Some Gravel, Tan and Brown, Damp, Roots and Organics.							-0.10
			- No Roots							-0.10 50 mm Solid PVC -0.20
	1		- No Organics							50 mm Screen PVC
		-1.15 1.15	- Refusal on Permafrost ***End of Borehole at 1.15m***							Native Sand
	5									
	2									

SCALE 1: 11.0 | LOGGED BY: SZ | CHECKED BY: DE

WARDROP LOG - ANALYTICAL 0222880805-BOR-V0001-00.GPJ 4/3/12

TETRA TECH

RECORD OF BOREHOLE

MW3

Sheet 1 of 1

0222880805

CLIENT: Government of Nunavut | DATE DRILLED: September 11, 2009 | DATUM:

PROJECT TITLE: Landfarm Water License Compliance | PROJECT SITE: Kugaaruk Landfarm | NORTHING:

BOREHOLE LOCATION: Approximately 3 m outside landfarm berm to south of the west corner and to northwest of MW2 | EASTING:

BORING METHOD	DEPTH SCALE m ft	SUBSURFACE PROFILE: ELEV DEPTH (m)	DESCRIPTION	SYMBOLS	SAMPLES: SAMPLE NAME	SAMPLE TYPE	LAB TESTING (Primary)	LAB TESTING (Secondary)	GUIDELINE COMPARISON	MONITORING WELL: MW3
Tetra Tech WEI Inc. Backhoe	0.00	0.00	Ground Surface							
			Sand Some Gravel, Organics.							-0.10
			- No Organics							-0.10 50 mm Solid PVC -0.20
	1									Native Sand
		-1.25 1.25	- Refusal on Permafrost ***End of Borehole at 1.25m***							50 mm Screen PVC
	5									
	2									

SCALE 1: 11.0 | LOGGED BY: SZ | CHECKED BY: DE

WARDROP LOG - ANALYTICAL 0222880805-BOR-V0001-00.GPJ 4/3/12

TETRA TECH

RECORD OF BOREHOLE

MW4

Sheet 1 of 1

0222880805

CLIENT: Government of Nunavut | DATE DRILLED: September 11, 2009 | DATUM:

PROJECT TITLE: Landfarm Water License Compliance | PROJECT SITE: Kugaaruk Landfarm | NORTHING:

BOREHOLE LOCATION: Approximately 3 m outside landfarm berm to north of the west corner and to north of MW3 | EASTING:

Tetra Tech WEI Inc.

Backhoe

BORING METHOD	DEPTH SCALE m / ft	SUBSURFACE PROFILE: ELEV DEPTH (m)	SUBSURFACE PROFILE: DESCRIPTION	SUBSURFACE PROFILE: SYMBOLS	SAMPLES: SAMPLE NAME	SAMPLES: SAMPLE TYPE	SAMPLES: LAB TESTING (Primary)	SAMPLES: LAB TESTING (Secondary)	SAMPLES: GUIDELINE COMPARISON	MONITORING WELL: MW4
	0.00	0.00	Ground Surface							
			Sand Some Gravel.							-0.10
	1									Native Sand
	5		- Water							50 mm Screen PVC
		-1.70								
		1.70	- Refusal on Permafrost ***End of Borehole at 1.70m***							

MW4 well construction: -0.10 to 50 mm Solid PVC; -0.20 to 50 mm Screen PVC

SCALE 1: 11.0 | LOGGED BY: SZ | CHECKED BY: DE

WARDROP LOG - ANALYTICAL 0222880805-BOR-V0001-00.GPJ 4/3/12

TETRA TECH

RECORD OF BOREHOLE

MW5

Sheet 1 of 1

0222880805

CLIENT: Government of Nunavut | DATE DRILLED: September 11, 2009 | DATUM:

PROJECT TITLE: Landfarm Water License Compliance | PROJECT SITE: Kugaaruk Landfarm | NORTHING:

BOREHOLE LOCATION: Approximately 3 m outside landfarm berm to northeast of the west corner and to northeast of MW4 | EASTING:

BORING METHOD	DEPTH SCALE m ft	SUBSURFACE PROFILE: ELEV DEPTH (m)	DESCRIPTION	SYMBOLS	SAMPLES: SAMPLE NAME	SAMPLE TYPE	LAB TESTING (Primary)	LAB TESTING (Secondary)	GUIDELINE COMPARISON	MONITORING WELL: MW5
Tetra Tech WEI Inc. Backhoe	0.00	0.00	Ground Surface							
			Sand Gravel							-0.10 -0.10 50 mm Solid PVC -0.20
		-0.90	- Water							
		0.90	***Silt***							Native Sand
	1	-1.00								50 mm Screen PVC
		1.00	***Silt and Clay***							
		-1.30								
		1.30	- Refusal on Permafrost ***End of Borehole at 1.30m***							
	5									
	2									

SCALE 1: 11.0 | LOGGED BY: SZ | CHECKED BY: DE

WARDROP LOG - ANALYTICAL 0222880805-BOR-V0001-00.GPJ 4/3/12

TETRA TECH

RECORD OF BOREHOLE

MW6

Sheet 1 of 1

0222880805

CLIENT: Government of Nunavut | DATE DRILLED: September 1, 2010 | DATUM:

PROJECT TITLE: Landfarm Water License Compliance | PROJECT SITE: Kugaaruk Landfarm | NORTHING:

BOREHOLE LOCATION: Approximately 10 m outside landfarm berm to east of the east corner | EASTING:

BORING METHOD	DEPTH SCALE m / ft	ELEV DEPTH (m)	DESCRIPTION	SYMBOLS	SAMPLE NAME	SAMPLE TYPE	LAB TESTING (Primary)	LAB TESTING (Secondary)	GUIDELINE COMPARISON	VAPOURS ppm (100 200 300 400) / VAPOURS LEL % (20 40 60 80)	MONITORING WELL MW6
Tetra Tech WEI Inc. Backhoe	0.00 / 0	0.00	Ground Surface								
			Sand Fine to Medium-Grained, Some Silt, Little Clay (Blackish Grey), Brown, Non-plastic, Wet, Trace Organics.		MW6 @ 0.5 m	G				20	-0.10 / 50 mm Solid PVC / -0.30 / Native Sand
		-0.80									
	1	0.80	***Clay*** Some Silt, Trace Gravel (Large) Blackish Grey, Very Hard, Non-plastic, Moist.		MW6 @ 1 m	G				20	50 mm Screen PVC
			- Water								
	5				MW6 @ 1.5 m	G				5	
		-1.70									
		1.70	- Refusal on Permafrost ***End of Borehole at 1.70m***								
	2										

SCALE 1: 11.0 | LOGGED BY: CL | CHECKED BY: DE

WARDROP LOG - ANALYTICAL 0222880805-BOR-V0001-00.GPJ 4/3/12

TETRA TECH

APPENDIX E

REGULATORY CORRESPONDENCE

Department of Environment

Avatiligiyiit

Ministère de l'Environnement

28 January 2010

Mr. David Ediger
Senior Environmental Engineer
Wardrop Engineering Inc.
400-386 Broadway,
Winnipeg, Manitoba. R3C 4M8

Dear Mr. Ediger

Re: Request for Revision to Soil Quality Limits - Your letter dated January 21, 2010

In your letter of 21 January 2010 provided me with the following information:

- Wardrop has been engaged by the Department of Community and Government Services (CGS) to manage 2200m^3 of hydrocarbon-contaminated soil excavated from a former tank farm.
- Soil samples collected in Sept 2009 indicate concentrations of hydrocarbons in the F2 range from 900 - 2600 ppm (figures rounded).
- This exceeds the GN criteria of 260 ppm in the F2 range (ref.Table A3-1, *Environmental Guideline for Contaminated Site Remediation*) for coarse-grained soil on industrial sites.
- Your client, CGS, wishes to use this soil as landfill cover and is seeking a revision of the threshold limit from 260 ppm to 1000 ppm.

Wardrop/CGS has requested this revision based on the following arguments:

- The GN standard (which is derived from CWS) is based on eco-soil contact which does not take into account the relative sterility of some Arctic soils where there is little to no biological activity (this is a greatly simplified summary of Wardrop's argument).
- The proposal to use the land-farmed soil as landfill cover renders the remaining contaminants in the soil largely unavailable to the environment.
- In general, the eco-contact pathway criteria is not applicable to this situation.

The GN's *Environmental Guideline for Contaminated Site Remediation* provides for some flexibility in prescribing what measures are required to remediate a contaminated site.

In considering your request, I consulted both the GN's Guide and specifically table A3-3; Indian and Northern Affairs *"Abandoned Military Site Remediation Protocol"*, Vol 1 & Vol 2; as well as discussed the issue with several colleagues in the environmental engineering field.

After reviewing your request and proposal, DoE has arrived at the following conclusions:

- DoE agrees with Wardrop with respect to the applicability of the CWS eco-contact criteria for the F2 range as it relates to this to this particular situation only.

- The parameters proposed by Wardrop/CGS – that is, 1000 ppm in the F2 range – conform to the Management Limit parameter listed in Table A-3-3 of GN's *Environmental Guideline for Contaminated Site Remediation* and further, are well within those parameters listed in INAC's *Abandoned Military Site Remediation Protocol*.

- INAC's guide sets the threshold value at 2500 ppm for "Type B" hydrocarbons for the protection of wildlife, including birds; the latter being the receptors most likely to be exposed to the soil within a secure landfill. Wardrop's proposed limit of 1000 ppm falls well within that parameter.

- By convention, the parameters listed in Table A3-1 of the GN's *Environmental Guideline for Contaminated Site Remediation* indicate to what level the concentration of hydrocarbon contamination must be reduced in a location where the remaining soil – which is still essentially contaminated; albeit at concentrations deemed to be acceptable – is readily available to all receptors and further, is in direct contact with surrounding uncontaminated soils. Under the scenario proposed by Wardrop/C&GS, the contaminated soil will be isolated from all receptors – save for birds and small mammals – but at concentrations well within acceptable limits for those receptors.

- A few of the expert advisors that I consulted suggested that the very action of moving the soil from the land farm and spreading it over the landfill will result in a further decline in F2 concentration.

- DoE's only outstanding concern pertains to the possibility of offsite migration (from the landfill) of the remaining contaminants within the soil to be used as landfill cover. Based on our most recent telephone discussion, this concern may have already been addressed given the recent sampling of runoff from the landfarm which yielded non-detect for hydrocarbons. Nevertheless, DoE would have a greater level of confidence if Wardrop/CGS could provide a brief discussion on the ultimate fate of the remaining hydrocarbons within the soil matrix. On that note can Wardrop provide a volumetric estimate on how much fuel is locked into the soil at 1000 ppm?

Based on the above conclusions, DoE believes that using the material for landfill cover poses an extremely low risk, if any, to the environment therefore DoE is prepared to allow Wardrop/C&GS to proceed as proposed: that is, to reduce the concentration of the hydrocarbons in the contaminated soil to 1000 ppm; after which it will be used solely as landfill cover material.

It should be understood this revision of the F2 limit from 260 ppm to 1000 ppm applies only to this situation and does not constitute a blanket approval to repeat this practice for other applications. DoE will continue to evaluate such requests on a case by case basis.

If you have any questions please do not hesitate to contact me.

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