ARCADIS Design & Consultancy for natural and built assets

Indigenous and Northern Affairs Canada – Nunavut Regional Office

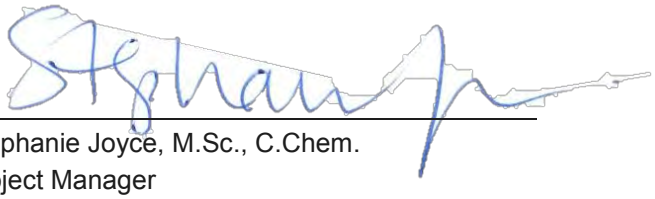
LONG TERM MONITORING, 2016

FOX-C Ekalugad Fjord, Nunavut

February 3, 2017

LONG TERM MONITORING, 2016

FOX-C Ekalugad Fjord



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100347-001

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February 3, 2017

CONTENTS

TABLES

FIGURES

APPENDICES

ACRONYMS AND ABBREVIATIONS

AMSRP	Abandoned Military Site Remediation Protocol
BTEX	Benzene, Toluene, Ethylbenzene and Xylenes
CCME	Canadian Council of Ministers of the Environment
CEQG	Canadian Environmental Quality Guidelines
CSQG	Canadian Soil Quality Guidelines
DEW	Distant Early Warning
FCSAP	Federal Contaminated Sites Action Plan
FIGQG	Federal Interim Groundwater Quality Guidelines
GIS	Geographic Information System
GPS	Global Positioning System
HASP	Health and Safety Plan
INAC	Indigenous and Northern Affairs Canada
LTM	Long Term Monitoring
NHWL	Non-Hazardous Waste Landfill
PCBs	Polychlorinated Biphenyls
PHCs	Petroleum Hydrocarbons
POL	Petroleum, Oil and Lubricants
UMA	UMA Engineering Ltd./AECOM

EXECUTIVE SUMMARY

Arcadis Canada Inc. was retained by Indigenous and Northern Affairs Canada (INAC) – Nunavut Regional Office to conduct long term monitoring (LTM) activities at the former Distant Early Warning (DEW) Line site FOX-C. This project was completed under INAC Standing Offer Number 4600000861, Order Number 4500352890.

The FOX-C Ekalugad Fjord site is located on the northeast coast of Baffin Island, Nunavut, on the southern shore of Ekalugad Fjord. A remediation project was conducted at the former intermediate DEW Line site between 2005 and 2008. After demolition, remediation consisted of disposal of non-hazardous waste and contaminated soils in on-site facilities.

Monitoring efforts were conducted on August 15, 2016, while based out of Clyde River, approximately 260 km to the north. Time on site was limited, due to fog approaching the community of Clyde River. The landfill monitoring program consisted of a visual inspection of the non-hazardous waste landfill (NHWL). The five monitoring wells on site could not be sampled as groundwater was frozen. Physical and anecdotal evidence and other information collected during natural environment monitoring suggest that wildlife and local hunters continue to frequent the site.

Overall, physical observations suggest that the NHWL is in acceptable condition and performing as designed to contain the enclosed waste. One area of potential settlement was noted on the top of the landfill, running north to south; this area was also noted during previous monitoring events (2009, 2011 and 2013). This settlement appears to be the result of the techniques used to build the NHWL and is not considered to be an issue related to integrity. It appeared less noticeable in 2016 than previous monitoring events.

A noticeable depression was observed adjacent to the northwest berm between monitoring well MW-North and the beach access road (Feature H in Figure 2). This depression was dry during the 2016 site visit; however, it likely contains ponded water at times of high rainfall and spring melt as evident by the dry cracking soil conditions and moss growth.

Minor erosion channels were observed on the northeast, southwest and south sides of the landfill; these erosion channels were also noted in previous monitoring events (2009, 2011 and 2013). Very minor changes to the length and depth of these channels were observed. Increased growth was noted in these erosion channels, leading away from the NHWL.

Several potholes were noted along the berms of the NHWL. These features may be a result of water run-off and erosion, based on the presence of a mound of cobbles which collect run-off water on the up-gradient side and cause a loss of finer grained material as water overflows. No evidence of burrowing animals, vegetation re-establishment, staining, seepage points or exposed debris was observed.

A brief visual aerial survey of surrounding areas via helicopter was conducted during the 2016 monitoring event. Areas surrounding the landfill site were visually scarred from the remediation activities. The areas directly surrounding the landfill site were mostly devoid of vegetation due to remediation activities. No changes were observed to the Lake Area, Beach Area and Mid- and Upper Station Areas.

Due to the length of the site visit, a detailed natural environment survey was not conducted in 2016. No evidence of wildlife (e.g. scat, tracks or visual observation) was observed.

All physical observations suggest that the NHWL is performing as designed and is containing the enclosed waste. Groundwater samples were not taken due to the frozen state of groundwater in all the monitoring wells. It is recommended that the locks on monitoring well MW NW and MW East be replaced during the next visit. Soil samples were not collected given the lack of evidence (e.g. seepage and staining) of anomalies. The facility appears in acceptable condition. It is recommended that monitoring continue as per the schedule set out in the LTM Plan. The next monitoring event (Year 10) should be scheduled for 2018.

This executive summary should be read in conjunction with the main report and is subject to the same limitations described in Section 8.0.

1 INTRODUCTION

Arcadis Canada Inc. was retained by Indigenous and Northern Affairs Canada (INAC) – Nunavut Regional Office to conduct long term monitoring (LTM) activities at the former Distant Early Warning (DEW) Line site FOX-C. This project was completed under INAC Standing Offer Number 4600000861, Order Number 4500352890.

This report describes the monitoring activities completed for INAC at FOX-C and was prepared in accordance with the Arcadis proposal Number 566661-000, dated June 23, 2016.

Throughout this report the INAC DEW Line site FOX-C will be referred to as "the site."

1.1 Project Objectives

The objective of the 2016 LTM program was to complete Year 8 monitoring activities as described in the *FOX-C Ekalugad Fjord Long-Term Monitoring Plan* (INAC, 2008; referred to as the LTM Plan). The program included visual observations, chemical analyses (where useful and possible) and interviews with members of the nearby community knowledgeable about local activities at the site. The purpose of the program was to assess the condition of the natural environment and whether the site infrastructure is performing as designed.

1.2 Scope of Work

Consistent with previous years monitoring activity, the scope of work undertaken at the site in 2016 was described in the 2008 LTM Plan. Activities included:

1. Visual Monitoring of the Non-Hazardous Waste Landfill (NHWL), including
    - Visually checking the physical integrity of the NHWL and looking for evidence of settlement, erosion, frost action, animal burrows, vegetation, staining, vegetation stress, seepage points, exposed debris, and the condition of wells; and
    - Taking photographs to document the condition of the NHWL and substantiate the recorded observations.
2. Active Layer Water Monitoring, including
    - Collection of samples from the 4 monitoring wells installed around the NHWL; and
    - Analysis of the samples with the results compared to those from background samples.

3. Soil Monitoring (as required)
    - Limited to locations where seepage or staining was identified as part of the visual inspection.
4. Natural Environment Monitoring, including
    - Collection of direct and indirect evidence of wildlife presence and activity; and
    - Observations regarding the re-vegetation of disturbed areas.
5. Preparation of a 2016 monitoring program report.

The following tasks were assessed as necessary to fulfill the scope:

a. Review of the FOX-C LTM Plan, previous LTM reports for FOX-C, and the Abandoned Military Site Remediation Protocol (AMSRP);
b. Preparation of a health and safety plan;
c. Preparation of a sampling plan for soil and groundwater;
d. Collection of water level data and observation of monitoring well condition at the site;
e. Visual inspection, measurement and photo documentation of the site;
f. Interviewing local residents and officials to understand land use and wildlife trends; and
g. Reporting.

2 BACKGROUND INFORMATION

2.1 Site Description

According to INAC's FOX-C Ekalugad Fjord LTM plan, the Intermediate DEW Line Site was constructed in 1957 and abandoned in 1963. The site is located on the northeast coast of Baffin Island, a mountainous area characterized by deep fjords and glaciers (see Figure 1). The site comprises three areas: the Upper Station, Mid Station, and Lower Station. The Lower Station is further divided into three sections: the Lake Area, the Beach Area, and the Landfill Area, now occupied by the non-hazardous waste landfill.

The Upper Station is so called because of its location, at 770 m above mean sea level. Before remediation was completed in 2008, the main site facilities were located in this area and included a module train, warehouse, garage, a former Quonset building, Inuit house, bulk fuel storage tanks, a radar tower as well as other site debris.

The Mid Station is located at the base of the summit approximately 500 m east of the Upper Station. A glacier located across from the Mid Station feeds a river that flows alongside the access road to an unnamed lake. Before remediation, the Mid Station area contained a dump area, barrel storage pad, four former Quonset buildings and numerous barrel and debris areas. A site access road travels east from the Upper Station, through the Mid Station to a junction in the Lake Area. The road, which was decommissioned after remediation, is approximately 5.9 km long.

At the Lower Station near the Lake Area, the site access road from the Upper Station splits into two parts. One section heads southwest to the Lake Area and is approximately 1.1 km long. A river flows out of this lake and empties into the ocean at the Beach Area. The other section of the road heads north to the Beach Area and is approximately 2.2 km long. Before remediation, there were two petroleum, oil and lubricants (POL) storage tanks at the beach area, barrel caches and abandoned construction equipment. The landing area at the beach was used to transfer equipment and supplies to the site, including bulk fuel transfers to the POL storage tanks. The remediation construction camp was located near this Beach Area.

A NHWL was constructed at the site in 2006-2007 and closed in 2008. It was designed to contain non-hazardous materials only. It was constructed on natural ground surface with the organic matter stripped. The NHWL consists of four perimeter berms constructed of granular material. The non-hazardous waste was placed in the landfill in layers consisting of 0.5 m lifts of waste covered by 0.15 m of granular fill. The

waste layers were compacted and a final cover consisting of a minimum of 1.0 m of granular fill was used to cap the landfill. The NHWL contains the following:

- Tier I contaminated soil (i.e., soil with lead content between 200 and 500 parts per million (ppm) and polychlorinated biphenyl (PCB) content between 1 and 5 ppm);
- Soil contaminated with petroleum hydrocarbon compound (PHC) fractions F3 and F4;
- Non-hazardous demolition debris, such as timbers, plywood, and sheet metal;
- Non-hazardous site debris, such as scrap metal and wood;
- Non-hazardous debris/soil excavated from landfills;
- Creosote timbers; and
- Double-bagged asbestos.

The site is not regularly inhabited and groundwater in the wells at the site tend to freeze due to the presence of permafrost. As a result, groundwater is not considered to be used for water supply purposes. The area is known to be used by hunters and fishermen. Interviews in previous years of the LTM program with residents of the nearby community of Qikiqtarjuaq indicate that hunting does still take place in the area. Several local Qikiqtarjuaq residents are known to have cabins in the area.

2.2 Baseline Soil and Groundwater Data

During site remediation activities in 2008 at FOX-C, UMA Engineering Ltd./AECOM (UMA) collected baseline soil and groundwater data to use for comparison during future monitoring events.

2.2.1 Groundwater

In 2006, UMA installed four monitoring wells (MW-A through MW-D) around the NHWL, each to a depth of approximately 3.7 m below ground surface (UMA, 2008a). Groundwater samples were collected from MW-A, MW-B and MW-C. A sample was not collected from MW-D as it was considered dry. No samples were collected from any wells in 2007 as they were either dry or groundwater was frozen.

Three new monitoring wells were installed around the NHWL in 2008. During the 2008 construction season, the NHWL was redesigned and expanded to accommodate an additional 18,400 m^3 of waste (UMA, 2009). Field adjustments were made to the east berm at this time and as a result, two of the wells installed in 2006 were removed (MW-A and MW-D) and replaced with two of the newly installed wells.

UMA's (2008a) Figure 3.0 (attached in Appendix A) depicts the original NHWL size and the location of the wells in 2006. UMA's (2009) Figure 5.0 (attached in Appendix A) depicts the final layout of NHWL with the expansion to the east and the monitoring well locations as they remain today. No groundwater samples were collected in 2008 as the wells were dry. Table 2-1 depicts the baseline groundwater analytical data for FOX-C, based on the groundwater samples collected in 2006.

Table 2-1: Baseline Groundwater Analytical Data (Samples collected in 2006)

Parameter (ug/L)	MW-A	MW-B (now MW-Northwest)	MW-C (now MW-Southwest)	Average Concentration	Standard Deviation
Year Installed	2006	2006	2006	---	---
pH	7.8	7.4	7	7.4	0.4
Total Oil & Grease	1.4	1	1.4	1.3	0.2
Benzene	ND	ND	ND	---	---
Toluene	ND	ND	ND	---	---
Ethylbenzene	ND	ND	ND	---	---
Total Xylenes	ND	ND	ND	---	---
F1 (C60-C10)	ND	ND	ND	---	---
F2 (C10-C16)	ND	ND	ND	---	---
F3 (C16-C34)	830	1100	480	803	310.9
F4 (C34-C50)	ND	140	ND	140	---
Total As	7	6	10	7.6	2.1
Dissolved Cd	ND	ND	0.3	0.3	---
Total Cr	63	78	98	80	17.5
Dissolved Co	1.1	8	11	6.7	5.1
Dissolved Cu	ND	ND	5	5	---
Dissolved Pb	ND	ND	ND	---	---
Dissolved Ni	5	25	1	10.3	12.8
Total Zn	370	180	1	243.6	184.5
Total PCB	ND	ND	ND	---	---

Data collected from Appendix C, Table C-7a (UMA, 2008a)
ND: Not detected
-- : Not available

2.2.2 Soil

In 2007, UMA collected eight soil samples around the NHWL and submitted them for copper and lead analysis (UMA, 2008b). The average concentration of copper in the soil samples was reported to be 16.4 mg/kg. Concentrations of lead in soil were reported as non-detectable. During the installation of the three new wells in 2008, UMA collected soil samples from the base of all five wells around the NHWL (UMA, 2009). A total of 10 soil samples were collected. Table 2-2 depicts the copper and lead baseline soil analytical data for FOX-C collected in both 2007 and 2008. Table 2-3 depicts the baseline soil analytical data for FOX-C for the remaining analytical parameters collected in 2008.

Table 2-2: Baseline Copper and Lead Soil Analytical Data

Sample ID	Year Collected	Copper (mg/kg)	Lead (mg/kg)
FC-459	2007	18	ND
FC-460		13	ND
FC-461		14	ND
FC-462		17	ND
FC-463		22	ND
FC-464		17	ND
FC-465		15	ND
FC-466		15	ND
1178	2008	10.2	ND
1179		10.4	ND
1180		13.7	ND
1181		13.7	ND
1182		7.3	ND
1183		7.9	ND
1184		10.7	ND
1185		8.6	ND
1186		12.1	ND
1187		12.0	ND
1188		16.1	ND
Avg. Conc.	n/a	13.3	---
Standard Deviation	n/a	3.8	---

Data collected from Appendix C, Table C-2 (UMA, 2008b) and Appendix B, Table 7.0 (UMA, 2009).
ND: Not detected
-- : Not available

Table 2-3: Baseline Soil Analytical Data – Remaining Parameters

Parameter (mg/kg)	Sample ID											Avg. Conc.	Std. Dev.
	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188		
Depth (cm)	0	30	0	0	30	0	30	0	30	0	33	---	---
Cd	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---	---
Cr	21	ND	28	26	ND	ND	21	ND	24	30	29	25.6	3.7
Co	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---	---
Ni	7.6	5.8	9.0	9.1	ND	ND	7.5	6.1	7.0	8.9	8.9	7.8	1.3
Zn	20	18	24	23	ND	ND	19	17	21	25	26	21.4	3.2
As	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---	---
Total PCBs	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---	---
F1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---	---
F2	20	235	28	18	11	ND	18	ND	20	ND	ND	50	81.7
F3	ND	ND	61	ND	ND	112	90	303	36	149	ND	125	95.8
F4	ND	ND	ND	ND	ND	ND	73	ND	ND	ND	ND	73	---

Data collected from Appendix B, Table 7.0 (UMA, 2009).
Std. Dev. = Standard Deviation
ND: Not detected
-- : Not available

2.3 Previous Monitoring Programs

The post construction landfill monitoring frequency has followed the schedule recommended in the AMSRP (INAC, 2009). The three phases recommended by the protocol are:

- Phase I: Years 1, 3 and 5.
- Phase II (if required): Years 7, 10, 15 and 25
- Phase III (if required): beyond 25 years

Monitoring was attempted in 2015, to complete the Year 7 program. However, due to weather conditions, the site visit could not be completed. The 2016 monitoring program was the fourth (Year 8) of a proposed seven that are scheduled over a 25 year period.

To become familiar with the site, Arcadis reviewed the following reports pertaining to DEW Lines sites:

- Long Term Monitoring, 2013, FOX-C, Ekalugad Fjord, Nunavut, January 20, 2014 by Franz Environmental Inc.;
- Long Term Monitoring, 2011, FOX-C, Ekalugad Fjord, Nunavut, January 17, 2012 by Franz Environmental Inc.;
- Long Term Monitoring, 2009, FOX-C, Ekalugad Fjord, Nunavut, dated March 27, 2010 by Franz Environmental Inc.;
- FOX-C Ekalugad Fjord Long-Term Monitoring Plan, dated March 23, 2008 by Indian and Northern Affairs Canada; and
- Abandoned Military Site Remediation Protocol, dated March 2009 by Indian and Northern Affairs Canada, Contaminated Sites Program.

3 REGULATORY REVIEW

3.1 Guideline Review

Arcadis reviewed the FOX-C Ekalugad Fjord LTM Plan and AMSRP for mention of specific guidelines to use for comparison purposes. Federal guidelines were used where site-specific criteria were absent and/or were less strict than federal standards.

3.2 Groundwater

3.2.1 Comparison to Background Concentrations

There are no groundwater guidelines provided in the FOX-C LTM Plan. In the absence of site-specific guidelines, the AMSRP guidance on post-construction monitoring indicates that "comparison to background and baseline values is recommended." The AMSRP provides the following table for the assessment of analytical data in groundwater.

Table 3-1: Groundwater Assessment

Geochemical Assessment	Acceptable	Marginal	Significant	Unacceptable
Groundwater concentrations within average ± three standard deviations or within analytical variability	Performing as expected	-	-	-
Increasing trend in contaminant data over 2 or more successive monitoring events (variation in excess of average ± three standard deviations or analytical variability)	-	Low risk of failure	-	-
Groundwater concentrations in excess of three times average baseline concentrations in more than one monitoring event	-	-	Moderate risk of failure	-
Where applicable, surface water concentrations in excess of surface water quality guidelines for the protection of aquatic life	-	-	-	Failure

Geochemical Assessment	Acceptable	Marginal	Significant	Unacceptable
Required Actions	Monitor as per schedule	Increase monitoring frequency. Monitor surface water quality, if applicable, in downgradient water bodies within 300 m.	Assess causes of increasing contaminant concentrations. Evaluate whether remediation is required.	Assess cause of contaminant concentrations. Develop remedial plan. Implement remedial plan.

Note: This table is reproduced from AMSRP Chapter 11, Table 4.2

This is the fourth monitoring event for the LTM plan to be implemented within the first eight years at FOX-C. No groundwater samples have ever been collected, as groundwater in the wells has always been frozen (FRANZ, 2009, 2012 and 2014) during the documented site visits.

3.2.2 Federal Interim Groundwater Quality Guidelines

In May 2010, Environment Canada under 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. The FIGQGs were last updated in November 2015.

The FIGQGs were not developed with the scientific rigour associated with the Canadian Environmental Quality Guidelines (CEQG). Instead, Environment Canada requested the development of guidelines based on a review and evaluation of existing approaches in other jurisdictions.

The FIGQGs follow a tiered framework, consistent with the Canadian Soil Quality Guidelines (CSQGs) development through the Canadian Council of Ministers of the Environment (CCME). The tiers are:

- Tier 1: direct application of the generic numerical guidelines; specifically, application of the lowest guideline for any pathway;
- Tier 2: 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 FIGQGs are based on the consideration of a number of potential receptors and exposure pathways, including:

- Groundwater transport to surface water at least 10 m from the contamination and subsequent exposure of freshwater and marine life;
- Direct contact of soil organisms with contaminated groundwater;
- Use of groundwater for irrigation water;
- Use of groundwater for livestock watering;
- Groundwater transport to surface water at least 10 m from the contamination and subsequent ingestion by wildlife;
- Migration of contaminant vapours to indoor air and subsequent inhalation by humans; and
- Use of groundwater for human consumption (i.e., drinking water).

The generic guidelines are point estimates of a chemical concentration in groundwater associated with an approximate no- to low-effects level based on toxicological information about the chemical, along with a screening-level evaluation and environmental fate and transport and estimated intake rates, or exposure, by potential receptors.

At FOX-C, the "Table 2 *Federal Interim Groundwater Quality Guidelines*, *Generic Guidelines for Residential/Parkland Land Uses"* Tier 1, Freshwater Life pathway for coarse-grained soil (FIGQG Table 2 Tier 1) should be referenced for comparison purposes. Due to the impossibility to collect groundwater samples at the site, this has not yet been required.

3.3 Soil

3.3.1 Comparison to Background Concentrations

Similar to groundwater, historical baseline soil data collected by UMA and described in Section 2.2.2 can be used to calculate the mean and standard deviation of analytical results for comparison with results

from the most recent field program. However, no soil samples have been collected at FOX-C in the four LTM events (2009, 2011, 2013 and 2016), as no indications of seepage have been observed.

3.3.2 CCME Federal Guidelines

No soil samples were collected in 2016. Soil samples have only been collected during the remediation activities (2007 through 2009), which can serve as background samples for future soil sampling, laboratory analysis and analytical comparison (if needed). Soil guidelines used for comparison in previous monitoring programs included the following:

- AMSRP, Volume I – Main Report (INAC, 2009).
- *CSQGs for the Protection of Environmental and Human Health* (CCME, 1999, with updates) for residential/parkland use, including fact sheets for benzene, toluene, ethylbenzene and xylenes (BTEX). Non-potable groundwater is stipulated and coarse-grain material is assumed based on a 2009 grain-size analysis, field observation (generally sandy material) as well as for conservative reasons – being that coarse-grain criteria are more stringent than those applied to fine grain.
- *Canada-Wide Standard for Petroleum Hydrocarbons in Soil* (CCME, 2008a) - Tier 1 Residential/Parkland, coarse-grained soil, non-potable groundwater.

These can be referenced in future monitoring events, should soil samples be collected.

4 INVESTIGATIVE METHODOLOGY

The monitoring program was carried out at the FOX-C DEW Line site on August 15, 2016 by Jason Mauchan of Arcadis, accompanied by INAC representative Courtney White. A copy of the field notes are located in Appendix B. During the field investigations, weather conditions were clear, sunny and cool. However, the site visit had to be cut short due to fog approaching the community of Clyde River (and making the return difficult). This decision was made by the helicopter pilot. The program consisted of the following:

- Completing a health and safety kick-off meeting;
- Visually observing and photographically documenting the physical integrity of the landfill;
- Collection of ground water samples from existing wells (if possible);
- Collection of soil samples (if necessary, as per the LTM plan); and
- Gathering information through first hand observation as well as through knowledgeable persons regarding local wildlife and human activity.

The field investigation procedures are described below.

4.1 Health and Safety Plan

Before commencing site activities, a site-specific health and safety plan (HASP) was developed. The HASP identified and provided mitigative actions for potential physical and chemical hazards associated with the monitoring work. 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 is located in Appendix D.

A copy of the HASP was presented to INAC for review and approval before site activities began. This plan was reviewed, discussed and signed off by all personnel involved in the investigative program prior to conducting any work on-site. A copy of the HASP has been retained on file at Arcadis and at the INAC Nunavut Regional Office.

4.2 Visual Inspection

The physical integrity of the NHWL and surrounding areas were assessed using systematic visual observations and empirical measurements to record evidence of erosion, ponding, frost action, settlement and lateral movement of the landfills. Definitions for completing the checklist are found in Table 4-1 (below). A visual monitoring checklist, presented in the FOX-C LTM Plan, was completed for the landfill

and is found in Tables 5-1 and 5-2 in Section 5.3. A photographic record was completed to document the condition of the NHWL and substantiate the visual observations (Appendix C).

Table 4-1: Preliminary Visual Inspection Report NHWL - Definitions

Performance / Severity Rating	Description
Acceptable	Noted features are of little consequence. The landfill is performing as designed. Minor deviations in environmental or physical performance may be observed, such as isolated areas of erosion, settlement.
Marginal	Physical/environmental performance appears to be deteriorating with time. Observations may include an increase in size or number of features of note, such as differential settlement, erosion or cracking. No significant impact on landfill stability to date, but potential for failure is assessed as low or moderate.
Significant	Significant or potentially significant changes affecting landfill stability, such as significant changes in slope geometry, significant erosion or differential settlement; scarp development. The potential for failure is assessed as imminent.
Unacceptable	Stability of landfill is compromised to the extent that ability to contain waste materials is compromised. Examples may include: • Debris exposed in erosion channels or areas of differential settlement. • Liner exposed. • Slope failure.
Extent	**Description**
Isolated	Singular feature
Occasional	Features of note occurring at irregular intervals/locations
Numerous	Many features of note, impacted less than 50% of the surface area of the landfill
Extensive	Impacting greater than 50% of the surface area of the landfill

Unlike previous years, the Trimble Pro XRT Global Positioning System (GPS) was not used to locate features of note and photo locations and to collect Geographical Information System (GIS) information. Due to shipping problems, it was not received in time for the field visit. Photo and feature locations were assessed based on the previous site plan (FRANZ, 2014). Thus the 2013 SSF file remains the most up-to-date version of the SSF file (detailed data dictionary holding site information from the LTM Plan).

4.3 Wildlife Survey

Arcadis made observations of the natural environment at the time of the site visit and recorded these observations in field notes. Observations could have included direct sightings of wildlife, other evidence

of wildlife (e.g., droppings, tracks, feathers/fur), wildlife activities (migrating, nesting, etc.), numerical estimates of wildlife, and vegetation observations. No evidence of wildlife was observed during the 2016 field visit.

As part of the investigation, the Arcadis field representative interviewed community members knowledgeable about surrounding areas. They noted that summers have become longer, increasing in length from one week to four. In previous LTM programs, several members of the Hunters and Trappers Association and community members in Qikiqtarjuaq were interviewed. Land uses by humans and wildlife, as well as changes in use over previous years by each, were discussed and pertinent information is documented in this report.

4.4 Groundwater Sample Collection

Upon arrival at the FOX-C site, the Arcadis field assessor made an attempt to measure water levels at each of the wells. Using a water level tape, the field assessor found that none of the monitoring wells contained groundwater; all of the water in the wells was frozen. The depth to ice and/or well bottom were recorded, but no water samples could be obtained. General well conditions were also recorded, and the wells were re-locked using keyed-alike padlocks, wherever possible. The lock on monitoring well MW NW could not be closed and the hinge was broken on monitoring well MW East. It is recommended that these be replaced during the next visit.

4.5 Soil Sample Collection

Because there were no indications of seepage or staining as part of the visual inspection, no soil samples were collected during the 2016 monitoring activities, as per the 2008 LTM Plan for the site. Note that time on-site was limited due to weather and the Arcadis field assessor did not have sufficient time for a detailed inspection.

4.6 Analytical Program

No groundwater or soil samples were collected as part of the 2016 FOX-C LTM program. Consequently, no laboratory analytical work was completed.

5 NON-HAZARDOUS WASTE LANDFILL

5.1 Area Summary

The NHWL is located in the Lower Site Landfill Area, between the Beach and Lake Areas of the site. The monitoring of the landfill included visual observations to assess its physical integrity, including evidence for erosion, ponding, frost action, settlement and lateral movement. Groundwater and soil samples were to be collected at locations up- and downgradient of the NHWL. Due to frozen groundwater in the wells during the site visit, groundwater samples could not be collected. As there were no apparent signs of NHWL malfunction (areas of seepage or staining), collection of soil samples was deemed unnecessary by both the Arcadis and INAC personnel on site. The visual inspection report, including supporting photos and figure, is presented in Section 5.3.

5.2 Photographic Record

The photographic record of the NHWL was completed by the Arcadis field assessor. Given the limited time on-site and hasty departure dictated by the helicopter pilot (due to approaching fog in Clyde River), there was not time to review photo documentation while on-site. As a result, several viewpoints were missed (Viewpoints 1, 2, 9, 10, 18, 25, 52, 53, 62, 63, 64, 77 and 79). The remaining photos (Viewpoints 1 through 82, with the listed exceptions) are provided on the attached DVD. Those portions of the record referenced in the body of this document are included in Appendix C. The complete photographic record, of full-resolution photographs, is provided in the attached DVD. Note that in this report, Photo numbers refer to the selected photos in Appendix C and Viewpoint numbers refer to the photos on the DVD.

5.3 Visual Inspection Report

Monitoring consisted in part of visual observations of the NHWL to assess its physical integrity, by looking for evidence of erosion, ponding, frost action, settlement and lateral movement. A plan view of the NHWL indicating photographic viewpoints, salient observations and locations of ground water monitoring wells can be seen in Figure 2, located following Section 9. Table 5-1 presents the preliminary visual inspection results for the NHWL at FOX-C. The visual monitoring checklist provided in the FOX-C LTM Plan has been completed and pertinent information is summarized in Table 5-2 of this report.

Table 5-1: Preliminary Visual Inspection Report NHWL

Feature	Presence (Y/N)	Severity Rating	Extent
Settlement	Y	Acceptable	Isolated
Erosion	Y	Acceptable	Occasional
Frost Action	N	Not Observed	None
Animal Borrows	N	Not Observed	None
Vegetation	N	Not Observed	None
Staining	N	Not Observed	None
Vegetation Stress	N	Not Observed	None
Seepage / Ponded Water	N	Not Observed	None
Debris Exposure	N	Not Observed	None
Monitoring Well Condition	Y	MW-NORTHWEST was slightly bent and lock could not be closed; the hinge on MW-EAST was broken.	
Overall Landfill Performance		**Acceptable**	

Settlement

A linear area of settlement was observed running from north to south on the entire top of the landfill (Figure 2; located after Section 9), in the central area along the apex of the NHWL. It was suggested in the 2009 LTM report (FRANZ, 2010) that this is result of the techniques used to build the NHWL and may not be a settlement issue. Based on the photographic evidence from 2009, 2011 and 2013, the extent of the depression has not changed significantly since previously noted and, if anything, has decreased in importance. As noted in Figure 2, the landfill surface appears to be traversed by a ridge in a north-south direction. The landfill gently slopes westward and eastward from this ridge. Photo 12 (Appendix C) is taken looking along this ridge.

An area of noticeable depression was observed directly north of the NHWL in 2011 (Feature H, Figure 2; and Photo 11). This approximately 390 m^2 depression was dry during the 2013 and 2016 site visits; however, it likely contains ponded water at times of high rainfall and spring melt as evident by the dry

cracking soil conditions and moss growth. It appears to have increased in volume (length, width and depth) since 2013.

On the south side of the NHWL, minor settlement was observed at the top of the berm (Features Q and S, Photo 8). The depression and minor settlement area do not currently appear to impact the structure of the landfill.

Several potholes were noted in 2011 ranging in volume from approximately 0.006 m^3 to approximately 0.016 m^3 (Features B, I, R, and T, Figure 2 and Viewpoints 51, 66 and 77 on the attached DVD). These features remain unchanged in 2016. These features may be a result of erosion and not settlement as most of the potholes contained one or more large cobbles at the downgradient extent. The presence of large cobbles embedded in the landfill berms might cause eddy currents to form in the run-off water and therefore mechanically erode away some of the fine soil particles. This action is likely contributing to the pothole development.

Erosion

Minor erosion channels were observed running down the berms of the landfill on the east and west sides (Features A, E, F, G, K, M, N, O, and P, Figure 2 and see Table 5-2 for photograph references); and to a lesser extent the south side (Feature Q). Additional erosion channels were observed at the toe of the landfill on the east side (Feature C and D, Figure 2 and Viewpoints 54, 56, 58 and 59 on the DVD) running down towards MW-East, as well as on the north and northeast side (Features H and J, Figure 2 and Viewpoints 19, 65, 67, 68 and 80). Features C, D, H and J have all increased in size since 2013. These erosion channels lead away from the NHWL and are likely the result of meltwater and rainwater flowing away from the NHWL. They do not appear to currently affect the integrity of the NHWL. Measurements were not obtained in 2016, due to limited time on-site, so this should be made a priority in future field visits.

A new erosion channel was observed in 2016. It is located approximately 15 m from the southeast corner of the NHWL, along the toe of the eastern berm (Figure 2). Designated Feature V, it was observed to be approximately 4 m long, 3 cm wide and 1 cm deep (see Photo 9).

Some larger particles (cobbles) are exposed at the top of the berms on the southwest and south sides of the NHWL. These features appear to be a result of water washing the finer grained soils away down the slope of the berm. An area of exposed cobbles was observed at the toe of the berm on the northwest side (Feature U, Figure 2 and Viewpoint 81; DVD).

Several potholes (see settlement above) were noted along the berms of the NHWL. These features may be a result of water run-off and erosion based on the presence of cobbles which appear to be collecting run-off water and causing loss of finer grained material.

Frost Action

No evidence of frost action on the landfill or the landfill berms was observed.

Evidence of Burrowing Animals

No evidence of burrowing animals was observed in the area of the NHWL.

Re-establishment of Vegetation

Based on the regional setting of this landfill, reestablishment of vegetation is likely to take a significant amount of time. No growth was observed on the top or sides of the landfill. Increased growth was noted in erosion channels leading away from the NHWL (Features C, J and H).

Staining

No staining was observed in the area of the NHWL.

Seepage Points

Feature D has been identified as a potential seepage point in past reports (FRANZ, 2014). Adjacent to Feature D, Feature C could also be considered a potential seepage point. These were first reported in 2011 and appear to have grown in width and depth since 2011. No staining was observed in 2016 but close attention should be paid to this in future monitoring programs.

Another potential seepage point observed in 2016 was on the north side of the NHWL, at Feature H. This feature has increased in size since previous monitoring events but appears to be the result of ponded water (meltwater or rainwater). No staining was observed during the 2016 site visit, but it should continue to be monitored during future LTM events.

Exposed Debris

No exposed debris was observed in the area of the NHWL.

Discussion

All physical observations suggest that the NHWL is performing as designed and is containing the enclosed waste. Groundwater samples were not taken due to frozen groundwater in all of the monitoring wells. Soil samples were not collected given the lack of evidence (e.g. seepage and staining) of any substantial anomalies. The facility appears in acceptable condition. It is recommended that monitoring

continue as per the schedule set out in the LTM Plan. The next monitoring event (Year 10) should be scheduled for 2018.

Table 5-2 below summarizes the results of the visual inspection.

Table 5-2: Visual Monitoring Checklist – FOX-C

Checklist Item	Feature Letter	Relative Location	Length* (m)	Width* (m)	Depth* (m)	Extent	Description (Change)	Additional Comments	Viewpoint Reference
Erosion	A	20m northwest of the southeast corner	10	0.2	0.02	<1%	Minor erosion channel	Measurements of worst case	50
Settlement	B	40 m northwest of the NHWLs southeast corner	0.25	0.3	0.1	<1%	Small pothole, may be result of erosion and not settlement	Measurements of worst case	51
Erosion	C	Northeast of NHWL running down and to the southeast of MW-East	50	3	0.1	<1%	Minor erosion channel developing starting at the southeast corner of the NHWL, running north towards MW-East. The length has decreased since 2011.	Measurements of width are worst case and measurements of depth are average; size has increased since 2013	8, 54, 55, 56
Erosion	D	6 m northeast of the toe of NHWL at edge of access road	16	1.5	0.5	<1%	Channel carved into the edge of the road. May be caused by either erosion or potential seepage point. The width and depth has increased since 2011.	Measurements of worst case. No staining or evidence of landfill seepage was observed; size has increased since 2013	58
Erosion	E	Center of northeast berm	13	0.3	0.02	<1%	Minor erosion channel	Measurements of worst case	59
Erosion	F	20 m southeast of northeast corner of NHWL	12	0.35	0.02	<1%	Minor erosion channel	Measurements of worst case	49 and 60

Checklist Item	Feature Letter	Relative Location	Length* (m)	Width* (m)	Depth* (m)	Extent	Description (Change)	Additional Comments	Viewpoint Reference
Erosion	G	8 m southeast of northeast corner of NHWL	13	0.2	0.01	<1%	Minor erosion channel	Measurements of worst case	61
Settlement/Erosion	H	North corner of the NHWL, just beyond the berm		390 m^2		<1%	Area of settlement and erosion. Appears to contain ponded water during rain and melt events from evidence of moss growth.	Does not affect the landfill integrity; size has increased since 2013	65 and 80
Settlement/Erosion	I	46 m southwest of the northeast corner of the NHWL	0.3	0.2	0.1	<1%	Small pothole, may be result of erosion and not settlement	-	66
Erosion	J	At toe of northwest corner of the NHWL	45	2	0.1	<1%	Erosion channel at the base of the NHWL	Does not affect the landfill integrity; size has increased since 2013	67 and 68
Erosion	K	2 m north of MW-northwest	12	0.3	0.1	<1%	Erosion channel	Measurements of worst case	69 and 70
Erosion	L	14 m southeast of northwest corner of NHWL		16 m^2		<1%	Exposed cobbles at top of berm	-	46
Erosion	M	14 m southeast of northwest corner of NHWL	18	0.05	0.05	<1%	Two minor erosion channels stemming from feature L	Measurements of worst case	72
			10	0.05	0.05	<1%			

Checklist Item	Feature Letter	Relative Location	Length* (m)	Width* (m)	Depth* (m)	Extent	Description (Change)	Additional Comments	Viewpoint Reference
Erosion	N	18 m southeast of northwest corner of NHWL	10	0.05	0.05	<1%	Three grouped minor erosion channel	Measurements of worst case	73
		20 m southeast of northwest corner of NHWL	11	0.1	0.05	<1%			
		21 m southeast of northwest corner of NHWL	22	0.25	0.1	<1%			
Erosion	O	11 m northwest of southwest corner of NHWL	10	0.05	0.03	<1%	Four grouped minor erosion channels	Measurements of worst case. Measurement of location to center of erosion channel grouping	74
			11	0.25	0.05	<1%			
			18	0.5	0.05	<1%			
			12	0.15	0.05	<1%			
Erosion	P	5 m northwest of southwest corner of NHWL	14	0.35	0.05	<1%	Minor erosion channel	Measurements of worst case	75
Settlement/Erosion	Q	19 m east of southwest corner of NHWL		22 m^2		<1%	Exposed cobbles at top of berm, minor settlement at top of berm	Measurements of worst case	76
			8	0.05	0.01	<1%	Eastern minor erosion channel stemming from exposed cobbles		

Checklist Item	Feature Letter	Relative Location	Length* (m)	Width* (m)	Depth* (m)	Extent	Description (Change)	Additional Comments	Viewpoint Reference
Settlement/Erosion	R	30 m east of southwest corner of NHWL	0.3	0.35	0.15	<1%	Small pothole, may be result of erosion and not settlement	-	77
Erosion	S	35 m east of southwest corner of NHWL		30 m^2		<1%	Exposed cobbles at top of berm, minor settlement at top of berm	-	78
Settlement/Erosion	T	50 m east of southwest corner of NHWL	0.2	0.2	0.1	<1%	Small depression area, pothole	-	79 – photo not available
Erosion	U	8 m southeast of northwest corner of NHWL		12 m^2		<1%	Exposed cobbles at toe of berm	First identified in 2013	70 (23 and 81)
Erosion	V	15 m from southeast corner of the NWHL	4.0	0.03	0.01	< 1%	Narrow drainage channel located at base of berm	New feature identified during the 2016 site visit	Photo 6

*All measurement are from 2013, as there was no time for measurements in 2016. Measurements of Feature V are from 2016. Significant changes have been noted in the “Additional Comments” column.

6 SURROUNDING AREAS

A brief visual aerial survey of surrounding areas via helicopter was conducted during the 2016 monitoring event. Areas surrounding the landfill site were visually scarred from the remediation activities. The areas directly surrounding the landfill site were mostly devoid of vegetation due to remediation activities.

Lake Area

To the southwest of the NHWL (Lower Site Landfill Area) lies the Lake Area, including Borrow Areas 5 and 6 and the *in-situ* treatment area. Based on aerial observations, no change was observed as compared to 2013.

Beach Area

To the north of the NHWL lies the Beach Area, containing Borrow Area 4, the former camp and the decommissioned sewage lagoon. All areas appeared to be generally devoid of vegetation and graded level. No changes were observed when compared to 2013 observations.

Mid- and Upper Station Areas

The Upper Station Area is located on the nearest peak to the east of the NHWL, at over 700 m above mean sea level. The Mid Station Area is slightly east of this, roughly 100 vertical m lower than the Upper Station. Both areas were observed from the helicopter during the 2016 monitoring activities. Two cement pads were observed - one on the edge of an embankment. The cement pad noted on the edge of the embankment was a tower anchor block, as reported in previous monitoring reports. The decommissioned road, used to access the Upper Station area from the Beach area, was observed to be in fair condition; however, if access along the road is required, further inspection is recommended.

7 NATURAL ENVIRONMENT

Information regarding the natural environment was gathered directly, through observation, and indirectly, through consultation with knowledgeable local persons in order to better understand the presence and temporal change of wildlife. The FOX-C LTM Plan recommends monitoring the following parameters:

- Wildlife sightings;
- Other evidence of recent presence of wildlife (e.g. droppings, tracks);
- Wildlife activity (e.g. nesting, migration);
- Qualitative assessment of relative numbers versus previous years; and
- Revegetation of disturbed areas versus previous years.

Wildlife and Human Activity

According to information collected during 2011, Harry Alookie from the Qikiqtarjuaq Hunters and Trappers Association stated the area around FOX-C is used during the winter and summer for harvesting narwhal, char, caribou, and goose. Hunting for polar bear occurs from October to March and does occur in the area around FOX-C. Wolves are reported to be rare and it has been around ten years since the last sighting. Beluga whales are also rare in the FOX-C area. According to Mr. Alookie, there has been an increase in Killer Whale sightings in the past couple of years with observed pods numbering 100 to 150 whales observed.

During the 2016 site visit, the Arcadis field assessor observed no evidence (e.g. scat, tracks or visual observation) of wildlife activity. However, as time was limited at the site due to incoming weather at the discretion of the helicopter pilot, a wider visual survey of the area was not conducted. Future monitoring events should include a wider inspection of the lands surrounding the regraded area to examine potential wildlife evidence.

Re-establishment of Vegetation

Based on the regional setting of this site, reestablishment of vegetation is likely to take a significant amount of time (e.g. decades). Very limited growth was observed on the regraded areas. This likely factored into the absence of wildlife evidence observed.

8 CONCLUSIONS AND RECOMMENDATIONS

Overall, physical observations suggest that the NHWL is performing as designed to contain the enclosed waste. Several erosion features have been observed over the years: minor erosion channels were observed running down the berms of the landfill on the east and west sides, and to a lesser extent, the south side. Several of these channels have increased in size since 2013. These erosion channels lead away from the NHWL and are likely the result of meltwater and rainwater flowing away from the NHWL. They do not appear to currently affect the integrity of the NHWL. Measurements were not obtained in 2016, due to limited time on-site, so this should be made a priority in future field visits.

Three potential seepage points have been identified on the NHWL; one at the north corner and two at the bottom of the east berm. No staining was observed in 2016 but close attention should be paid to this in future monitoring programs.

Groundwater samples were not taken due to frozen groundwater in all of the monitoring wells. It was noted that the lock on monitoring well MW NW could not be closed and the hinge was broken on monitoring well MW East. It is recommended that the locks be replaced during the next visit. Soil samples were not collected given the lack of evidence (e.g. seepage and staining) of any substantial anomalies.

A brief visual aerial survey of surrounding areas via helicopter was conducted during the 2016 monitoring event. Areas surrounding the landfill site were visually scarred from the remediation activities. The areas directly surrounding the landfill site were mostly devoid of vegetation due to remediation activities. No changes were observed to the Lake, Beach and Station Areas, although it is recommended that if access along the road used to access Upper Station from the Beach Area is required, further inspection is recommended.

Based on the results of Year 8 LTM, the facility appears in acceptable condition. It is recommended that monitoring continue as per the schedule set out in the LTM Plan. The next monitoring event (Year 10) should be scheduled for 2018.

9 LIMITATIONS

This report has been prepared exclusively for Indigenous and Northern Affairs Canada. Any other person or entity may not rely upon the report without the express written consent from Indigenous and Northern Affairs Canada.

Any use, which a third party makes of this report, or any reliance on decisions made based on it, is the responsibility of such third parties. Arcadis Canada 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, Arcadis Canada 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 15, 2016. 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, Arcadis Canada 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), Arcadis Canada Inc. should be requested to re-evaluate the conclusions of this report, and to provide amendments as required.

10REFERENCES

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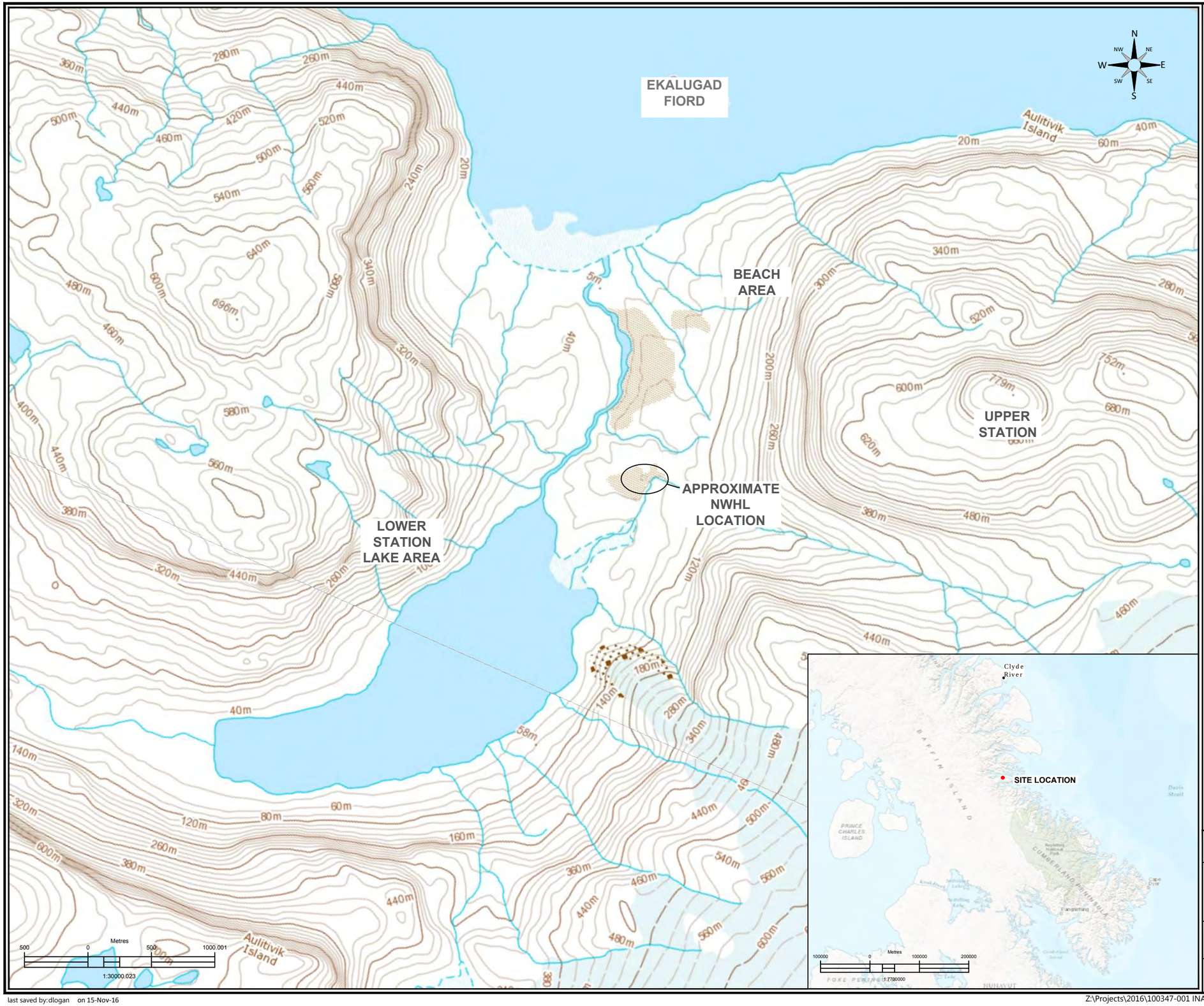
AECOM Canada Ltd. (formerly UMA Engineering Ltd.). April, 2009. FOX-C Ekalugad Fjord, 2008 Construction Clean-up Summary (CIDM# 360761).

FIGURES



Legend

Title: Site Location

ARCADIS

Project: FOX-C Ekalugad Fiord 100347-001

Date: October 2016

Client: Indigenous and Northern Affairs Canada

Scale as shown

Figure 1

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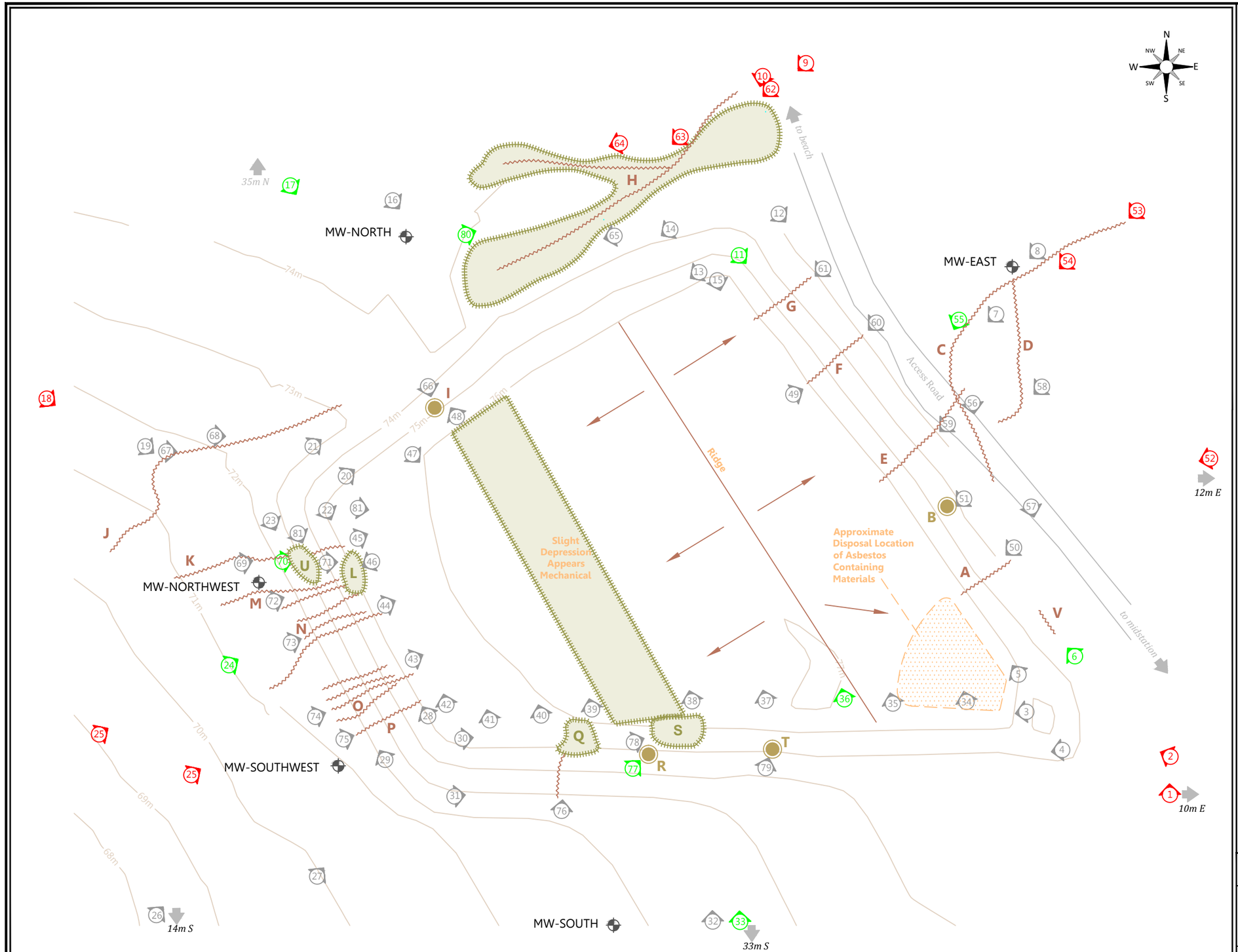
Z:\Projects\2016\100347-001 INAC DEW Line LTM\Individual Sites\FOX-C\2016 Figures\1-CAD\100347-001 FOX-C 2016.dwg(layout)



Legend

- MW — Monitoring Well Locations
- 25 — Picture Viewpoint Number
- 25 — Viewpoint Photograph included in Appendix D
- 8 — Viewpoint Photograph not taken in 2016
- A — Settlement or Depression
- Pothole
- Erosion
- A — Feature Reference Letter
- Slope Direction

Note:
Picture numbers refer to photograph names as they appear on the attached DVD.

Title: Non-Hazardous Waste Landfill

ARCADIS

Project: FOX-C Ekalugad Fiord 100347-001

Date: October 2016

Client: Indigenous and Northern Affairs Canada

Metres 7 0 7 14
1:575

Figure 2

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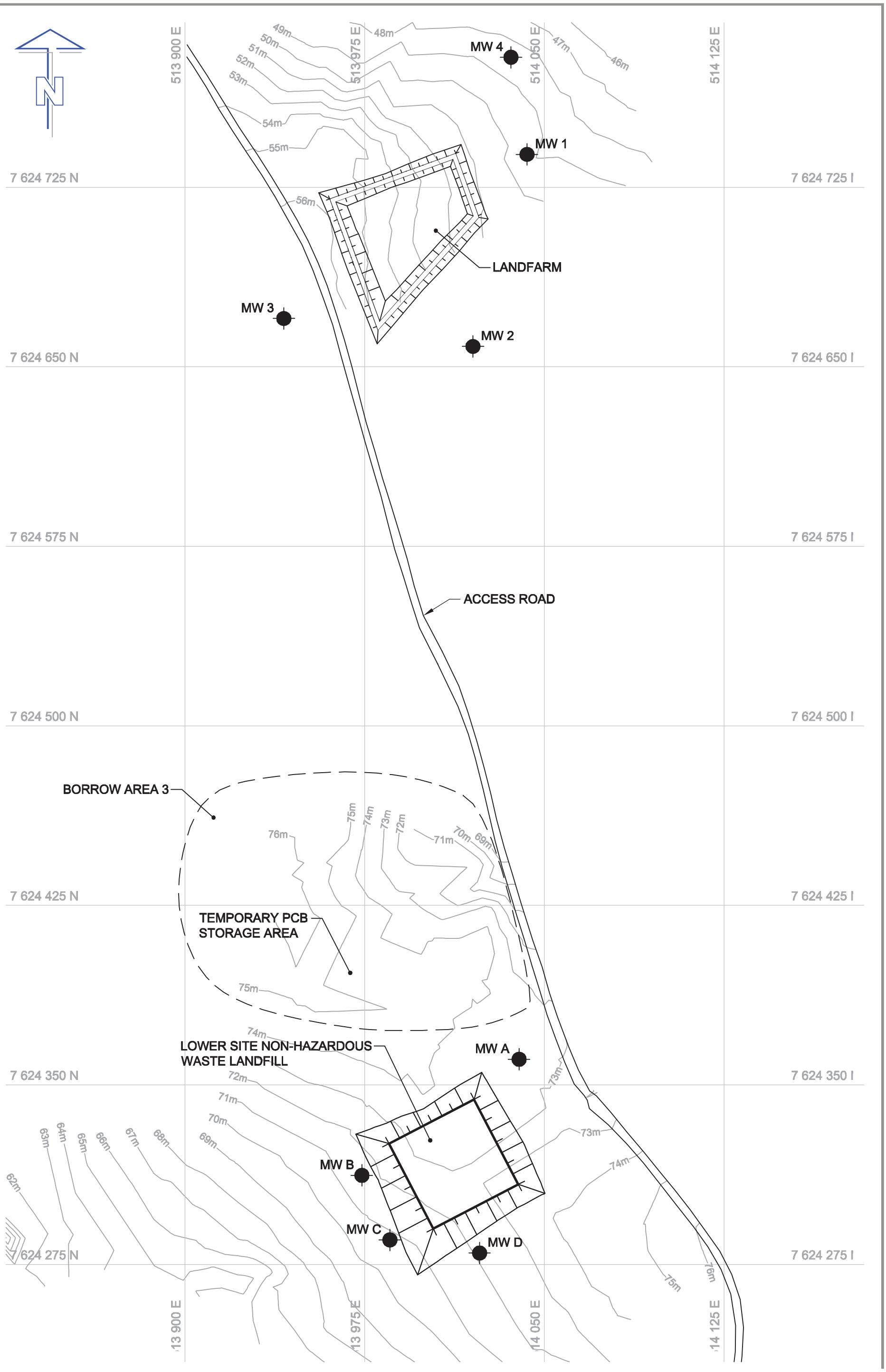
APPENDIX A

Figures from 2008 and 2009 UMA Reports

B SIZE 11" x 17" (279.4mm x 431.8mm)



m SCALE 1:150

LEGEND:

MW 2 MONITORING WELL

Public Works and Government Services Canada
FOX - C Ekalugad Fiord - Monitoring Services

Landfarm and Landfill
2006 Field Season
Figure - 3.0

UMA | AECOM

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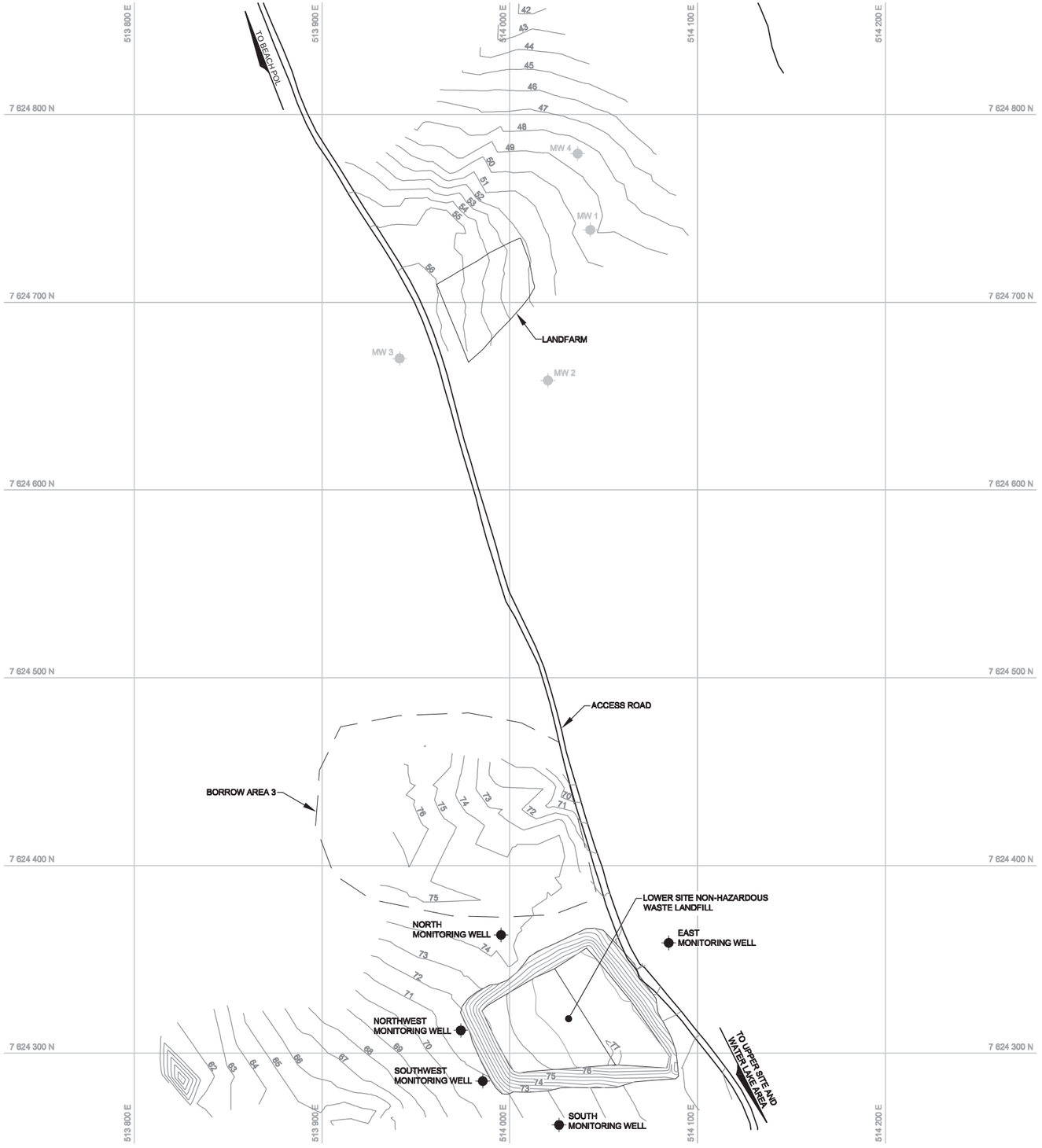

GENERAL NOTES:

1. GROUND CONTOURS ARE SHOWN AT AN INTERVAL OF 1m.
2. LANDFILL CONTOURS ARE SHOWN AT AN INTERVAL OF 0.5m.

LEGEND:

- 71 — GROUND CONTOURS
- 71 — LANDFILL CONTOURS
- MONITORING WELL LOCATION
- MW 2 — FORMER MONITORING WELL LOCATION

0 25 50 m SCALE 1:2500

AECOM

Public Works and Government Services Canada
FOX - C Ekalugad Fiord - Monitoring
FOX-C 2008 Services

Lower Site Landfill Area
Site Plan
Figure 5.0