Environment AECOM

Public Works and Government Services Canada
Northern Contaminated Sites Program

Remedial Action Plan
CAM-A Sturt Point, NU
Intermediate DEW Line Site

Prepared by:

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Project Number:

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Date:

March, 2011

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March 25, 2011

Matt McElwaine, P.Eng.
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Dear Mr. McElwaine:

Project No: 60156118

Regarding: Remedial Action Plan, CAM-A Sturt Point, NU, Intermediate DEW Line Site

AECOM is pleased to submit our report outlining a Remedial Action Plan for the CAM-A, Sturt Point, Intermediate DEW Line Site. We thank you for the opportunity to complete this work on behalf of Public Works and Government Services Canada. We trust that this report is consistent with your expectations and we look forward to receiving your comments.

Should you have any questions or require additional information, please do not hesitate to contact the undersigned at 780.486.7057.

Sincerely,
AECOM Canada Ltd.

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Revision Log

Revision #	Revised By	Date	Issue / Revision Description
1	KT/DS/NO	17-Dec-10	Draft – Remedial Action Plan – Issued for Review
2	KT/DS/NO	27-Jan-11	2nd Draft – Remedial Action Plan – Issued for Review
3	KT/NO	25-Mar-11	Final Report – Remedial Action Plan

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Executive Summary

CAM-A Sturt Point is located on Victoria Island, Nunavut (68º 47' N, 103º 20' W). The site is located along the coast and overlooks the Queen Maud Gulf. The site is located approximately 80 km east of Cambridge Bay. The terrain of the area is relatively flat with several ponds and lakes and an average elevation of 50 m above sea level.

AECOM completed a Phase III Environmental Site Assessment (ESA) at CAM-A in August 2010. The objective of the ESA was to collect all data necessary to develop a detailed clean-up design. The results of this assessment were used to develop the following Remedial Action Plan (RAP) according to the Abandoned Military Site Remediation Protocol (AMSRP) (INAC 2009), the Canadian Environmental Protection Act (CEPA), the Transportation of Dangerous Goods (TDG) Act and Regulations and the Nunavut/NWT Guideline for the General Management of Hazardous Waste (1998), under the territorial Environmental Protection Act (R.S.N.W.T 1998 c.E-7).

The CAM-A site areas are connected via gravel roads. The roads are generally in good condition, but will require some upgrading during construction for heavy equipment use and two-way traffic. The airstrip is in good condition and generally suitable for use by aircraft as large as a Hercules C-130 under dry conditions. During wet conditions, the granular structure may not be sufficient to accommodate the largest of the aircraft considered (Hercules C-130).

There is barge access to the site along the coast of the Queen Maud Gulf and a suitable beach landing area is present. Barge landing is not expected to be a concern. The site is also in relatively close proximity to Cambridge Bay and ice road and/or cat train access can be considered for contractor mobilization to CAM-A.

An archaeological investigation has been completed by Golder Associates for CAM-A and the "Archaeological Impact Assessment" Report is provided in this RAP in Appendix E.

The investigation and delineation of contaminated soil at CAM-A was completed for the contaminants of concern listed in the INAC AMSRP. This protocol specifies numerical clean-up criteria for inorganic elements, petroleum hydrocarbons (PHCs), and PCBs.

Seven buried debris lobes were identified during the 2010 ESA. The presence of buried debris was confirmed at Landfill A (Lobes A, B, C, & D) and Landfill B (Lobes F, G & H) as shown on Figures 3 and 4 in Appendix A. All other lobes identified on-site (Lobes E, I, J, K, M, N & O) and six small anomalies (Lobes L, P, Q, R, S & T) identified in the Associated Geosciences geophysics report were determined to be localized, partially buried debris and/or surface debris and were assessed as surface debris areas rather than buried debris. These partially buried debris and/or surface debris lobes are located within the debris extents shown on Figures 2, 3, 8, 9, and 10 and discussed as part of the surface debris extents in the surface debris section of this report.

The total area of buried debris between Landfill A and Landfill B at the CAM-A site is approximately 2,331 m^2. Once the perimeters of buried debris areas were identified, soil samples were taken in the proximity of the buried debris to identify if leaching of contaminants has historically occurred. Based on the location and physical condition of the buried debris areas and contaminant migration assessment results, each Lobe was designated as Class A, B or C in accordance with the INAC AMSRP. In addition, for development of remedial recommendations, site specific information for each buried debris area was considered, such as proximity to surface water bodies, presence and sensitivity of down-gradient receptors (terrestrial and aquatic), and long term geotechnical stability potential. Based on these evaluations, the buried debris areas, Landfill A (Lobes A, B, C, & D) and Landfill B (Lobes F, G, & H) were classified as Class C and have been recommended for regrading.

Based on the surface debris assessment, demolition inventory and sampling, barrel inventory, the volume of hazardous waste identified at CAM-A is 9 m^3. The estimated volume of non-hazardous waste is 525 m^3.

Based on the volume of non-hazardous waste, the quantities and types of granular materials identified during the 2010 investigation, and the identification of several suitable sites for new landfill development, it is recommended that a Non-Hazardous Waste (NHWLF) be constructed at CAM-A. The preferred location for construction of this facility is at Proposed Landfill LF-6, located in the station vicinity.

Approximate volumes of known contaminated soil identified at CAM-A include:

- Type B Hydrocarbon:
  - 425 m^3 of Type B hydrocarbon impacted soil was identified at the Beach POL within 30 m of the ocean.
  - 128.8 m^3 of Type B impacted soil was identified at the Beach POL Pad.
  - 571 m^3 of Type B impacted soil was identified at the module train foundation.
- Tier I:
  - 7.9 m^3 of Tier I contaminated soil was identified in the module train foundation.
  - 35.1 m^3 of Tier I contaminated soil was identified in the sewage outfall area.
- Tier II:
  - 9.25 m^3 of Tier II contaminated soil was identified in the garage.
  - 0.08 m^3 of Tier II contaminated soil was identified in the sumps on the garage foundation.
  - 21.48 m^3 of Tier II contaminated soil was identified in the module train foundation.
  - 44.19 m^3 of Tier II contaminated soil was identified in the worked area (Lobe J).

Tier I soil can be disposed of in a NHWLF. The small volume of Tier II Contaminated Soil identified does not warrant the consideration for the construction of an on-site Secure Soil Disposal Facility (SSDF). It is recommended that Tier II soil be containerized and disposed of off-site. The recommended remedial options for treatment of Type B soil are “alluing” or landfarming. Type B soils identified at the Beach POL are subject to the INAC near shore (more stringent) criteria while Type B soils at other locations, including the Beach POL Pad and the module train, are further away from water bodies and subject to the INAC remedial objectives (within 30 m of a water body). The Beach POL soils, however, have sufficiently high PHC level that they will require treatment to the remedial objectives (Protection of Terrestrial Wildlife). The recommended location for a landfarm/”allu” treatment area is Proposed Landfill LF-5, located northwest of the Beach Area.

Based on the above remedial recommendations, it is estimated that the clean-up at CAM-A will require one full construction season. When considering the timing for contractor mobilization by barge, the clean-up would occur over two calendar years. Contractor mobilization would be completed by barge during the late summer/fall of Season 1 and the contractor could initiate the work, weather permitting. Primary construction activities would be completed during Season 2, with contractor demobilization in the fall of Season 2. The number one priority for the contractor, in terms of main work elements, will be completion of the landfarm in Season 1, to allow for treatment of PHC-impacted soils to commence as soon as possible and to facilitate achieving the remedial endpoint criteria by the end of season 2. Following construction of the landfarm, the construction activity focus should switch to construction of the NHWLF. Hazardous waste segregation from demolition components is also recommended for completion as early as possible while facility construction is occurring to allow building demolition to proceed once the NHWLF is completed.

The CAM-A site is approximately 80 km from Cambridge Bay and there is potential for contractor mobilization by independent development of an ice road, utilization of a cat train or a combination of the two options. Mobilization by ice road and/or cat train offers more flexibility for a longer summer construction season as the contractor typically mobilizes his equipment and camp to site in March or April, clears snow from critical areas and re-mobilizes his staff to set up the camp and start work early in the summer. Barge access can be restricted in the early summer by ice conditions and barge availability can also be an issue. Mobilization by ice road and/or cat train could allow for the remediation work activities, excluding landfarm treatment, to be completed in one summer construction season. If the Contractor is able to stage his equipment, camp and materials at Cambridge Bay, the construction of an ice road alone or used in combination with a cat train would be considered a viable option for contractor mobilization to CAM-A.

A walk away solution was considered for the CAM-A site with the intent that following remediation of the site there will be no new landfill facilities or existing landfills on-site that would require long term monitoring. For the CAM-A site the major difference between a walk away remedial solution and a more conventional remedial solution is the disposal of the non-hazardous waste off-site as opposed to constructing an on-site facility which would require long term monitoring. Buried debris areas less than 1000 m^2 would be left in place, regraded and would not require future monitoring. Buried debris area in excess of 1000 m^2 would require excavation and off-site disposal. Due to the high costs and negligible risk/impact reduction, a walk away solution is not included in this RAP.

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1. Introduction

AECOM was retained by Public Works and Government Services Canada (PWGSC), on behalf of Indian and Northern Affairs Canada (INAC), Nunavut Regional Office Contaminated Sites Program, to complete a Phase III Environmental Site Assessment (ESA) and a Remedial Action Plan (RAP) with Class C Cost Estimate for the CAM-A, Sturt Point former Intermediate DEW Line site.

The scope of work for the Phase III ESA included the assessment of:

- Identification, characterization, and quantification of all hazardous and non-hazardous materials;
- Identification and delineation of contaminated areas;
- Evaluation of the potential impacts to the sediments and water in the Freshwater Lake and other significant water bodies;
- Completion of a detailed topographic and geophysical survey;
- Documentation of flora and fauna based on literature and professional experience;
- Identification of potential locations for an engineered landfill(s) and/or landfarm;
- Identification of borrow sources that may be used for the potential repair of site roads, airstrip, and barge landing areas as well as for the construction of a potential landfill(s) and/or landfarm;
- Evaluation of the condition of site access roads, barge/beach landing areas, and airstrip;
- Evaluation of the logistical challenges associated with mobilization, site remediation, and demobilization activities;
- Provision for local community and Inuit involvement in the program;
- Obtaining traditional knowledge regarding past and present land use of the site from the elders of the nearby communities; and,
- Conduct an Archaeological Impact Assessment (AIA).

The results of the Phase III ESA have been reported previously (AECOM 2010).

This report discusses remedial options for site issues identified during the Phase III ESA, and provides recommendations for the preferred option. This report has been structured as follows:

- Section 2.0 outlines the background information that forms the basis of the remedial option evaluations and recommendations;
- Section 3.0 discusses remedial options for site waste disposal areas;
- Section 4.0 identifies remedial requirements for hazardous waste elements at the site;
- Section 5.0 summarizes the sources of non-hazardous waste at the site and provides recommendations for disposal;
- Section 6.0 summarizes the findings of the contaminated soil investigation and assesses remedial options for the various types of contaminated soil; and,
- Section 7.0 discusses issues related to the implementation of the recommended remedial options - for waste disposal areas, demolition of buildings, surface debris pick-up, the construction of new containment facilities (landfills and/or landfarm), hazardous waste disposal, and availability of required granular borrow.

Figures are presented in Appendix A.

2. Background

2.1 Site Location and History

CAM-A Sturt Point is located on Victoria Island, Nunavut (68º 47' N, 103º 20' W). The site is located along the coast and overlooks the Queen Maud Gulf. The site is located approximately 80 km east of Cambridge Bay. The terrain of the area is relatively flat with several ponds and lakes and an average elevation of 50 m above sea level.

CAM-A was reserved by the Department of National Defence (DND) in 1956 for use as a DEW Line Site and was constructed in 1957. The radar facility was typical of all intermediate sites and consisted of a module train, warehouse, garage, a POL storage facility, a radar tower, an airstrip and a beach cargo landing area. In addition to the main site, a beach landing area was constructed along with gravel roads linking the various facilities. Access to the site is provided by airstrips and the beach cargo area. The main airstrip (~1,200 m long) is located north of the station facilities with an approximate northwest-southeast orientation. A Fresh Water Lake is located approximately 600 m northwest of the airstrip. Gravel roads were built linking the airstrip, beach areas and Fresh Water Lake to the station facilities. Overall site plans showing the site location and layout are shown on Figures 1 and 2 in Appendix A.

The site was abandoned as part of the DEW Line system in October 1963, and the responsibility for the site was assumed by INAC. Since that time, the POL tanks at both the Station and the Beach Areas have been removed. The warehouse, garage and module train structures have also been dismantled and removed from the Station Area leaving behind the concrete and wood foundations with miscellaneous debris. It should be noted that INAC did not remove the POL tanks or dismantle any buildings. A section of the module train building (powerhouse section) remains on-site. The fates of the POL tanks and removed structures are undetermined. The radar tower has been felled and is lying to the west of the module train.

CAM-A is located approximately 25 km southeast of CAM-A3A. During the modernization of the DEW Line in the late 1980's and early 1990's, the CAM-A3A Short Range Radar facility (SSR) was constructed under the umbrella of the North Warning System (NWS).

2.2 Remedial Protocols and Criteria

The remedial recommendations provided herein are based primarily on the latest version of the INAC Abandoned Military Site Remediation Protocol (AMSRP) (INAC 2009). This protocol provides assessment and remedial guidelines for Waste Disposal Areas (WDAs), disposal of barrel contents and provides clean-up criteria for contaminated soil. There are no criteria for the classification of hazardous waste at federal sites, except for materials regulated under the Canadian Environmental Protection Act (CEPA), including the Inter-provincial Movement of Hazardous Waste Regulations. The classification and remedial recommendations for materials not covered under CEPA has been based on the Transportation of Dangerous Goods (TDG) Regulations and the Nunavut/NWT Guideline for the General Management of Hazardous Waste (1998), under the territorial Environmental Protection Act (R.S.N.W.T 1998 c.E-7). More detailed information related to remedial guidelines or requirements under the sources noted above is provided in the issue-specific sections below.

2.3 Site Specific Remedial Considerations

The following sections provide site specific considerations that have been applied in the development of this remedial action plan.

2.3.1 Off-Site Access

The CAM-A site is located along the coast and barges have historically landed at the Beach Area. The ground at the beach is comprised of generally well-drained, coarse-grained beach deposits, which are not expected to pose a problem for beaching or using heavy equipment in the area for movement of materials upon landing. No significant change in the position of shoreline due to tidal influences was noted during the 2010 site investigation, suggesting that the near shore water conditions are not excessively shallow. Tidal prediction rates for August and September of 2011 are available for nearby Cambridge Bay, to the east, from the Department of Fisheries and Oceans (DFO) website. For this time of year, tidal fluctuations are in the order of approximately 0.6 m at Cambridge Bay. Based on the above information, barge landing at Sturt Point is not expected to pose a significant challenge.

AECOM has obtained a nautical chart for the Queen Maud Gulf Eastern Portion published by the Canadian Hydrographic Service. The nautical chart indicates the presence of an anchorage area approximately 1 km off shore from the Beach Area and ocean depth information for access corridors to Sturt Point.

The CAM-A site is 80 km east of Cambridge Bay and there is potential for independent development of an ice road or cat train that would be of use for contractor mobilization. Mobilization by ice road or cat train offers more flexibility for a longer summer construction season as the contractor typically mobilizes his equipment and camp to site in March or April, clears snow from critical areas and can mobilize his staff to set up the camp and start work early in the summer. Barge access can be hindered in the early summer by ice conditions. Barge availability can also be an issue. If the contractor is able to stage his equipment, camp and materials for CAM-A out of Cambridge Bay, overland mobilization (i.e. cat train) would be considered a viable option for contractor mobilization. It has therefore been assumed for the preparation of this RAP, and its associated cost estimate, that access to the site for mobilization and demobilization of contractor equipment and supplies will be either via barge, ice road or cat train.

An inspection of the airstrip at the site was completed during the 2010 Phase III ESA. The airstrip is about 1,200 m long and 28 m wide. The airstrip is constructed with granular material borrowed from adjacent areas north and south of the airstrip. The airstrip is generally in good condition; however, there are areas which may need regrading/repair, including an existing 600 mm barrel culvert near the west end, which is damaged and appears to be blocked. The restricted flow through the culvert may result in ponding of water near the airstrip which may weaken the subgrade of the section of airstrip near the culvert resulting in settlement. The culvert should be repaired if this section of the airstrip is to be used.

The charter pilots from Summit Air considered the airstrip to be in good condition for the landing of the planes used for the site investigation. Landing a Dornier 228 and Shorts Skyvan did not present any difficulties. Both in-situ CBR testing with a Dynamic Cone Penetrometer (DCP) and lab CBR testing was undertaken to confirm the suitability of the airstrip for larger and heavier aircraft. Results of the in-situ and lab CBR testing indicate a competent gravel surfacing and subgrade material, even in a saturated condition. The testing suggests that all of the following aircrafts (with full loads) would be able to use the airstrip during dry conditions at the site: Otter DHC-3, Twin Otter DHC-6, Shorts Skyvan, DC-3, Buffalo DHC-5, DC-4, DC-9 and Hercules C-130. Under saturated conditions, all of the noted aircrafts would still be able to land, with the exception of the Hercules C-130. However, because the testing did not consider the internal stability of the granular fill and potential for rutting, it is nonetheless considered essential that the airstrip be inspected by aircraft crews familiar with the necessary gravel surfacing requirements prior to its use, in particular for aircraft the size and weight of a Hercules C-130.

For the purposes of this RAP, it has therefore been assumed that aircraft access to the site will not be an issue, especially given the assumption that the primary mobilization of contractor equipment will be via barge or ice road or cat train. All landing at the site will be at the discretion of the pilot.

2.3.2 On-Site Access

There are a number of gravel roads throughout the site connecting the Station Area with the Airstrip, Fresh Water Lake, existing landfills, and Beach Areas. All of the major roadways were surveyed during the site investigation. The roadway sections include Road Section 1 from the Airstrip to the Fresh Water Lake; Road Section 2 from the Airstrip to the Station Area via Road Section 3; Road Section 3 connects the west end of the Airstrip to the Station Area; Road Section 4 connects the east end of the Airstrip to the Station Area; Road Section 5 from the Station Area to the Beach POL; Road Section 6 branches off of Road Section 5 to Barrel Pile B; Road Section 7 branches off Road Section 6 to Landfill A; and Road Section 8 connects the Airstrip with Borrow Area 3. The Road Sections are shown on Figure 2.

Road Sections 1, 2, 3, and 4 are approximately 5 to 6 m wide and Road Sections 5, 6, 7, and 8 are approximately 3 to 5 m wide. All Road Sections are generally in good condition for heavy equipment.

Road Section 1 has a 20 m zone of settlement located near the airstrip caused by ponding of water on both sides of the road. The section of settlement will need to be repaired prior to use by haul trucks and construction equipment.

Road Sections 2, 3, and 4 contain damaged culverts. At Road Section 2 a 600 mm barrel culvert is damaged at both ends with no soil cover. This culvert will require replacement and soil cover to protect it from damage by construction traffic. Road Section 3 contains a 600 mm Corrugated Steel Pipe (CSP) culvert currently extended with a barrel. This culvert will require minor repair (i.e. properly extending the CSP culvert) and fill placement for protection. An uncovered and damaged culvert is located on Road Section 4. This culvert will require replacement and protective fill placement.

Road Sections 1, 5, and 6 contain large turn-around sections to accommodate turn-around of vehicles. The turn-around at Road Section 5 may require fill placement to raise the road grade to facilitate vehicle turn-around.

The roads are constructed with local granular material and are well drained. The patches of vegetation are typical along the roadways, but are of no concern with respect to trafficability. The roads are in good condition for heavy equipment; although, regular grading will be required. The top width of the roads varies from 3 to 6 m with an average of about 5.0 m. The top widths of Sections 1 and 2 are satisfactory for single lane traffic. Widened or pull out sections will be required for two way heavy equipment traffic.

A potential suitable location for the camp/laydown area is located near the airstrip and Proposed Landfill LF-3. The area has been used for borrowing material in the past for construction of the airstrip and is relatively flat. Alternatively the contractor’s camp can be located on Proposed Landfill LF-1/Borrow Area BA-13 or Proposed Landfill 2/Borrow Area 14.

2.3.3 Environmental Considerations

While in Cambridge Bay, attempts were made to contact Elders familiar with the sites; however, many of the Elders were out on the land while the team was in Cambridge Bay. Current land use is limited to hunting and occasional trapping.

Characteristic wildlife of the region includes muskox, caribou, arctic hare, arctic fox, snowy owl, raptors, polar bear, seal, seabirds, and waterfowl. Specific wildlife identified during the 2010 site investigation included arctic hare, muskox, and geese. Muskox, hare and caribou droppings were also noted around the site.

Vegetation in the Amundsen Gulf Lowlands ecoregion is characterized by a nearly continuous cover of dwarf tundra vegetation, consisting of dwarf birch, willow, northern Labrador tea, dryas spp., and vaccinium spp. Tall dwarf birch, willow, and alder occur on warm sites; wet areas are dominated by willow and sedge.

As noted in the 1995 ESG report, there is very little soil to support vegetation at the station area plateau; however, in undisturbed areas on the site a fairly continuous vegetation cover was present. Species present include grasses (poa spp.), willows (salix spp.) and sedges (carex spp.). More specific information related to vegetative cover is described in area-specific discussion in the following sections.

2.3.4 Geology/Geomorphology/Hydrology

Coastal regions of southern Victoria Island are generally comprised of a discontinuous surface of marine deposits (1 to 3 m thick) of undifferentiated silt and sandy silt overlying bedrock, glacial till, or local gravel. Approaching the coast, the surficial sediments are generally comprised of glacial till drift, occasionally interbedded with sand and gravel. Flute formations are present where the glacial drift deposits are thin (1 to 2 m) and drumlins occur where the glacial drift is thick (10 to 15 m). Occasional bedrock outcrops occur throughout the region. The bedrock geology is comprised of sandstone, siltstone, shale, and carbonates of the Arctic Platform geological province.

Victoria Island is located in the Western Arctic Lowland physiographic region which comprises the low-lying islands in the south-western Arctic Archipelago. The coastlines of these islands range from extensive lowlands to tall cliffs. Most of the area has been affected by the passage of the continental ice sheets. Drumlins fields on southern Victoria Island are distinct from the flat horizon of adjacent lowlands.

The CAM-A site geomorphology is characterized by hummocks, low rolling hills, several ponds and lakes, and raised beaches composed of coarse-grained gravel over bedrock. Regional overland drainage from the site is generally towards the Queen Maud Gulf to the south.

Based on the results of the 2010 investigation, there are no areas of site activities exhibiting signs of erosion as a result of existing site drainage. None of the soil types identified are particularly prone to erosion. However, areas near the coast may be subject to future erosion by wave action in the event of sea level rise with global warming. Any borrow development in the vicinity of the Beach Area may require drainage control to prevent sediment loading to the coastal area. Areas identified for new development (borrow and potential new landfill construction) in the Station Area are not considered at risk for any significant erosion.

2.3.5 Archaeological Features

An archaeological investigation has been completed by Golder Associates to identify heritage features needing protection or avoidance during site remedial activities. The “Archaeological Impact Assessment” (AIA) Report identifies six historic sites at CAM-A and recommends that no impacts occur within 30 m of these historic sites during the site remediation. The AIA report also recommends that the Harrop Cairn be avoided and remain intact. The AIA report is provided in Appendix E of this report.

2.3.6 Site Assessment Information

The preparation of this RAP has been based on data from the following reports:

- AECOM, November 2010, Phase III Environmental Assessment Report, CAM-A, Sturt Point Intermediate DEW Line Site, prepared for Public Works and Government Services Canada; and,
- ESG, March 1995 - Environmental Study of Abandoned DEW Line Sites: One Auxiliary and Eight Intermediate Sites in the Canadian Arctic, prepared for Department of National Defence.

3. Waste Disposal Area Remediation

3.1 Waste Disposal Remedial Protocol

The evaluation of Waste Disposal Areas (WDA's) at CAM-A, including Dump Site, Landfill and Buried Debris Areas, was completed with the goal of classifying the WDA's according to the three categories specified under the INAC AMSRP, which are:

Class A: The WDA is located in an unstable, high erosion location. Remediation will involve relocation of buried debris to an engineered landfill. A WDA located at an elevation of less than two (2) metres above mean sea level will be removed.

Class B: The WDA is in a suitable, stable location, but there is evidence of contaminant migration. Remedial solutions include the installation of an engineered containment system, or relocation, whichever is deemed more cost effective.

Class C: The WDA is in a suitable, stable location, and there is no evidence of contaminant migration. In such cases, the debris may be left in place, with the placement of additional granular cover to ensure erosion protection and proper drainage.

WDA's greater than 1000 m^2 in size are typically referred to as Dump Sites or Existing Landfills and their assessment involves the collection of soil samples up and down-gradient of the WDAs, at surface and depth. Contaminant concentrations obtained from down-gradient samples were compared to those from up-gradient samples, and also to average levels of contaminants from all of the WDA assessment samples. Where down-gradient samples were consistently higher than up-gradient (by at least two times the concentration of average or up-gradient samples), and elevated concentrations were present over a significant proportion of the total sample locations (i.e. more than one isolated event), the WDA was evaluated to have evidence of contaminant migration. The potential for surface soil contamination was also assessed by noting any staining or the presence of types of debris that might act as contaminant sources (such as battery debris). In areas where contamination was suspected, surface and shallow depth soil samples were collected to assess and delineate the extent of contamination.

WDA's less than 1000 m^2 in size are typically referred to as Buried Debris Areas and typically not investigated to the same detail as Dump Sites or Existing Landfills, which are greater than 1000 m^2. It is unlikely that leachate containment will be cost effective when comparted to excavation for Buried Debris Areas. If contaminants are present, the AMSRP recommends that the Buried Debris Areas should be excavated to their full extent. If there is no contaminated soil present within Buried Debris Areas, then the AMSRP should be cut off and removed within the upper 0.5 m of the ground surface and the ground surface should be regraded to match surrounding topography.

The following sections describe specifics related to the three recommended requirements for each of the three classes of WDAs. For all WDAs, it is recommended that any surface debris or surface contaminated soil be removed prior to initiating the WDA remediation remedial requirements outlined above.

3.1.1 Excavation/Relocation (Class A)

All WDAs have the potential to contain buried hazardous waste materials and contaminated soil, in addition to the expected non-hazardous waste debris. For this reason, where the recommended remedial action is excavation and relocation of WDA contents, the contents of the WDA will require segregation during excavation to allow classification of the various waste streams. Debris should be separated from soil, with segregation of hazardous and non-hazardous waste. Soil should be sampled to identify any contaminant levels. Contaminated soil identified during sampling should be disposed of according to the requirements outlined in the INAC AMSRP.

Through work on the DND DEW Line sites, AECOM has developed and maintained a database recording the breakdown in WDA excavation components. This database is currently comprised of WDA excavation information from 15 sites. From this database, the average excavation volume breakdown is as follows:

- Tier I soil: 15%
- Tier II soil: 20%
- Non-hazardous debris: 15%
- Hazardous debris: 2%
- Clean fill: 48%

For excavation of WDAs on DEW Line sites under the jurisdiction of the Department of National Defence (DND), AECOM has typically applied these standard percentages during the design stage. However, where site-specific information suggests a higher or lower level of contaminated soil (based on the results of environmental sampling), a higher level of hazardous debris component (based on exposed debris observations), or different concentration of debris (i.e. higher or lower debris content based on extent of cover or a weak and/or spotty geophysical anomaly), the percentages have been modified accordingly.

Based on observations from other intermediate DEW Line sites under INAC's jurisdiction, and on observations from historical air photo review completed at DND DEW Line sites, it was common during the early stages of site operation that debris disposal at WDAs did not, generally, involve the placement of cover over debris upon disposal. WDAs in these circumstances were typically comprised almost entirely of debris and often times had contaminated soil associated with them as a result of the type of debris disposed, but there was little-to-no surface cover. At the DND sites; however, where the sites were in operation over a longer period of time, WDA operations gradually evolved such that debris began to be covered with granular fill. It became common implementation for excavation of existing ground, stockpiling of excavated granular material and placement of debris, with subsequent debris backfilling with the stockpiled granular material. The DND WDAs typically have reasonably good surface cover overlying debris, with the majority of debris exposure restricted to along the toe, where backfilling was not so thorough. Observations from CAM-A, suggest that a "trench and cover" debris disposal methodology was implemented from the start of operations at this site. For this reason, the same design principles applied at DND DEW Line sites, regarding WDA excavation component breakdown have been applied for the evaluation of WDA excavation quantities at CAM-A.

However, a review of the site and WDA-specific quantity breakdowns from the DND WDA excavation database was undertaken to further determine the appropriateness for applying these average concentrations to WDAs at CAM-A. It was noted during this review that the component breakdown from excavations, particularly related to contaminated soil quantities, could be fairly well correlated with the amount of contaminated soil identified at the landfill surface or down-gradient, and/or with the strength of evidence regarding contaminant migration. The results could also be well correlated with the other factors such as the strength of the geophysical anomaly (which is indicative of the density of debris within the WDA). This suggests that the average component concentrations noted above should be more strictly used as a starting point for evaluation, with ultimate component breakdown derived from much more consideration of WDA-specific information (where that information is available from the site investigations).

The results of the geophysical surveys at CAM-A WDAs (in terms of anomaly strength) suggest that a lower concentration of debris is present in these landfills, compared to typical DND site landfills, which is consistent with their operation over a much shorter timeframe. However, a definitive comparison could not be completed because the geophysical method used at CAM-A was slightly different than that which has been used at DND sites. However, contaminated soil was rarely identified at the CAM-A WDAs, and contaminant levels observed down-gradient were never at significantly high concentrations. These observations suggest that a lower level of contaminated soil should be expected from within landfill contents. The standard component breakdown for WDAs at the CAM-A site has therefore been assumed as the following:

- Tier I soil: 10%
- Tier II soil: 10 %
- Non-hazardous debris: 18 to 20%
- Hazardous debris: 1%
- Clean fill: 59 to 61%

The percentages of non-hazardous debris for the CAM-A site has been increased from the average breakdown from DND sites because of the inability to compare the geophysical survey results directly. This is felt to be a conservative measure. The percentages of Tier II and Tier I soils, and hazardous debris has been decreased, with a corresponding increase in the volume of clean fill. And as noted above, these standard percentages have been further modified where warranted by WDA-specific information.

Class A WDA’s should be excavated to the limits of debris. Where contaminated soil has been detected in the excavated contents, it is also recommended that confirmatory testing of the excavation base be completed to ensure no contaminated soil remains. The excavation area should be backfilled and graded to conform to surrounding terrain, and provide positive drainage.

Of the identified buried debris areas at CAM-A, none of them were classified as Class A according to the INAC AMSRP. As a result, there is no requirement for buried debris excavation at this site.

3.1.2 Leachate Containment (Class B)

The typical design that has been used for leachate containment at existing DEW Line WDAs involves the excavation of a trench just beyond the limits of the buried debris. The trench extends into either ice rich permafrost or saturated ground, typically at a depth of about 1.0 m at the CAM-A site. A geosynthetic liner system is placed extending from the base of the trench over the WDA area. The trench is then backfilled with low-permeability (Type 4) granular fill which may also extend upslope of the trench. Well graded sand and gravel (Type 2 fill) is placed and compacted over the surface to a thickness that will promote permafrost aggradation through the key trench and into the landfill contents. The primary long-term containment system is the saturated granular fill. Once the material freezes, it becomes a low-permeable containment barrier. The geosynthetic liner provides essential short-term containment until permafrost aggrades into the landfill and continues to provide longer-term containment following freeze back.

Geothermal modelling completed for the remedial design at the nearby PIN-4 Byron Bay site, where terrain and vegetative cover is similar, specified a design thickness of 3.8 m of Type 2 fill for freeze back of contents. Geothermal modelling considered soil type, soil thermal properties, presence or absence of insulating cover (vegetation or snow drift), measured ground temperatures at the site or at nearby sites, measured air temperature and climatic data (from 1959 to 1999 from Environment Canada), an estimated 1 in 100 warm year air temperatures, and an estimate of the effect of global warming. The effect of global warming was estimated using the most recently published data summarizing global warming rate estimates for Arctic environments (ACIA 2005). The design cover thickness specified for PIN-4 has been used for consideration of remedial options at CAM-A.

While the specific requirements for long-term WDA monitoring at INAC abandoned military sites have not yet been agreed upon, at DND DEW Line sites, this remedial option has initiated the need for significant post clean-up monitoring, with the installation of thermistors within the WDA to confirm that contents are frozen. To confirm that no further contamination migration is occurring, groundwater monitoring wells are installed up and down-gradient for the collection of groundwater samples and soil samples are collected adjacent to the monitoring wells. This monitoring has typically been done on a yearly basis for the first five years following site clean-up (which is the estimated time required to achieve thermal equilibrium), and then upon a reduced frequency after 5 years.

Of the identified buried debris areas at CAM-A, none of them were classified as Class B according to the INAC AMSRP. As a result, there is no requirement for leachate containment at this site.

3.1.3 Regrading (Class C)

For a WDAs located in a geotechnically stable location, with no evidence of contaminant migration, the recommended remedial action is to leave it in place. If required, the placement of additional granular cover should be placed to provide erosion protection and proper drainage. It is typically recommended that the extent of regrading be extended slightly beyond the extent of the identified limits of debris (a 2 m offset has been used historically). The granular fill cover placed over the WDA should be well-graded (Type 2), erosion resistant, and well-compacted to limit infiltration of water. Where there is the potential for erosion from surface drainage, it is typical to strategically place armouring (rip rap) material. The placement of fill should be configured in such a way so as not to promote ponding of water, and graded to conform to surrounding terrain. Typically, a fill thickness of 0.75 m has been used, but for smaller areas, with no appreciable topographic expression, a smaller fill thickness of 0.5 m has been applied.

3.2 Waste Disposal Areas

3.2.1 Landfill A - Lobes A, B, C, & D

Landfill A, the main landfill, is located at the west end of access road (Road Section 7), approximately 500 m southwest of the station area. During the site assessment four lobes (A, B, C, & D) were identified within one mound of material elevated from the surrounding topography. These four lobes were assessed collectively. A geophysical survey identified a WDA size of 1,500 m^2 and a depth was estimated between 1.5 m and 2.0 m. The locations of Landfill A and Lobes A, B, C, and D are shown on Figure 3.

Surface debris was observed on the surface and partially buried. The debris consisted of metal barrels, domestic glass, and tin cans. The cover soil was predominantly comprised of coarse sand with some gravel and organics, and large cobbles at surface. The vegetation cover was typical of the site consisting of willows, sedges, and mosses. The first 20 m down-gradient had approximately 50% vegetation coverage and greater than 20 m down-gradient from the toe of the lobe, the vegetation coverage was greater than 90%. It should be noted that the surface area down-gradient was scraped for material to cover the landfill.

The drainage in the area was dry overall. Shallow surficial water bodies were located approximately 90 m to the south and 175 m to the west, with areas of 400 m^2 and 5,000 m^2, respectively. There is no evidence of erosion in the area. The area is gently sloping south towards the ocean.

Based on the landfill evaluation matrix, Landfill A scored as a low potential risk or Class C landfill. The low score is due mainly to the lack of contamination, the stability of the lobes, lack of down-gradient receptors, and its small size. As a result, the remedial recommendation is to leave Landfill A in place and, if required, the placement of additional granular cover to a thickness of 0.75 m, following the removal of surface debris.

3.2.2 Landfill B - Lobes F, G & H

Landfill B, is located approximately 400 m west of the station area, north of Landfill A. During the site assessment three lobes (F, G, & H) were identified as separate, well defined mounds of material elevated from the surrounding topography. The location of Landfill B and Lobes F, G, and H are shown on Figure 4.

A geophysical survey identified Lobes F, G, and H having WDA sizes of 208 m^2, 495 m^2, and 128 m^2 and approximate depths of 1.0 m, 1.5 m, and 0.5 m, respectively.

For all three lobes, surface debris (noted metals) was observed. The cover soil was predominantly comprised of coarse sand with some gravel and organics, and large cobbles at surface. The vegetation cover was typical of the site consisting of willows, sedges, and mosses. The vegetation coverage was approximately 60% for Lobe F, 90% for Lobe G, and 90% for Lobe H. The distances to vegetation coverage was 20 m down-gradient for Lobe F, at the toe for Lobe G, and at the toe for Lobe H. It should be noted that the surface area down-gradient of Lobe F was scraped for material to cover the landfill.

The drainage in the area was dry, however a small drainage pattern was noted approximately 25 m down-gradient of Lobe G. A shallow surficial water body was located approximately 90 m to the west of Lobe G, with an area of approximately 900 m^2. There is no evidence of erosion in the area. The area is gently sloping south and west towards the ocean.

Based on the landfill evaluation matrix, Landfill B (Lobes F, G and H) scored as a low potential risk or Class C Buried Debris Area. The low score is due mainly to the lack of contamination, the stability of the lobes, lack of down-gradient receptors, and its small size. As a result, the remedial recommendation is to leave Landfill B in place and, if required, the placement of additional granular cover to a thickness of 0.75 m, following the removal of surface debris.

4. Hazardous Waste Remediation

4.1 Protocols and Regulatory Requirements

The Abandoned Military Site Remediation Protocol (AMSRP 2009) defines hazardous waste materials as any materials, which are designated as "hazardous" under Nunavut Territorial or Federal legislation; or as "dangerous goods" under the Transportation of Dangerous Goods Act (TDGA) and regulations.

As part of the assessment of CAM-A Sturt Point, an inventory of hazardous waste materials was compiled and supplemented with sampling during the 2010 site investigation. Various hazardous waste materials identified during the survey included: demolition and site debris consisting of asbestos and PCB/lead amended painted materials, batteries, and electrical components.

The storage, treatment, and destruction of PCB materials with concentrations of greater than 50 mg/kg are regulated under the Chlorobiphenyls Regulations, which are governed by the Canadian Environmental Protection Act (CEPA). The regulations have been amended recently and Part 1 Section 1(2) of SOR/2008-273, that came into effect on September 17, 2008, states, “For the purposes of these Regulations, if a solid or a liquid containing PCBs is composed of several matrices, the concentration of PCBs is based on the mass of the matrix in which the PCBs are located”. This means that for classification of waste painted with PCB amended paint, the mass of the substrate cannot be factored in with the mass of the paint to determine a total PCB concentration for the painted item as a whole, as has been done previously. For the purpose of the Phase III ESA, AECOM has assessed the classification of painted materials at CAM-A based on the new regulations, while providing an ‘Alternative’ classification that took the mass of the substrate into consideration.

Based on communications between Environment Canada and INAC, substrate calculations, as outlined in the protocol, can be completed based on an agreed upon Compliance Promotion Guideline that is to be published for the PCB Regulation. Therefore the hazardous material volumes estimated in the ‘Alternative’ assessment within the Phase III ESA have been used for the purpose of this RAP.

Previously, where materials were not regulated under CEPA, classification of hazardous waste defaulted to the federal TDG Act and Regulation under Guideline for the General Management of Hazardous Waste. At CAM-A materials classified under these regulations tend to be associated with painted materials where PCB concentrations were not in excess of CEPA concentrations, but where lead concentrations may be in excess of the leachate criterion stipulated under the TDG regulations, which have been amended (Amendment 6 - SOR/2008-34) so there is no longer a classification of materials with toxic leachate. Regulation regarding movement of these materials now falls to Environment Canada (EC) under the following two regulations: Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations (1999, 2005 amendment), and Interprovincial Movement of Hazardous Waste and Hazardous Recyclable Material Regulations (1999, 2002 amendment). Both EC documents specify a criterion for lead leachate at 5 mg/L, which was the same criterion previously specified under the TDG Act.

Projects that will result in the disturbance of asbestos-containing materials (ACMs) including vermiculite must satisfy the regulatory requirements under the Canada Labour Code - Part II and the Nunavut Environment Protection Act. In addition, the Canadian Occupational Safety and Health Regulations, Part X - Hazardous Substances would be applicable to asbestos-containing materials. The Environmental Guideline for Waste Asbestos (GN 2002) defines asbestos-containing materials as any type of material with greater than 1% asbestos by weight.

Treated creosote-impregnated waste materials (poles) are only considered "toxic", as defined under Section 11 of CEPA, if the waste creosote or its component compounds enter or are likely to enter the environment in a concentration or quantities or under conditions that could lead to exposure of humans or other biota at levels that could cause adverse effects. At DEW Line sites, these components have been determined to be non-hazardous as the components leach at a very slow rate and as such, do not present a threat to the environment if properly contained.

4.2 Surface Debris Component

A surface debris inventory was completed by collecting hand-held GPS waypoints where debris was visible or where debris fields appeared to terminate. At CAM-A, there are essentially two large scattered debris areas, one of which encompasses the station pad and surrounding area and one which encompasses the area from the East Beach shoreline to the location of the former Inuit huts. At the other isolated debris areas, the GPS waypoints were downloaded onto the site plan drawing to generate debris area perimeters. The areas of surface debris created with these perimeter limits were then assigned a numerical label. A total volume and description of debris types was recorded for each debris area. Where debris was identified sporadically within a large area, an individual description will be provided on the drawings as a reference to aid in locating these locations during site clean-up.

The survey identified approximately 1.2 m^3 of hazardous surface debris. A summary of hazardous waste components identified from the surface debris inventory is provided in Table C1 of Appendix C. Specifics related to barrels are discussed below.

4.3 Barrel Component

The classification of barrel contents and remedial requirements is based on the Barrel Protocol outlined in the INAC AMSRP. This protocol provides specifics related to when hydrocarbon-containing barrels may be safely incinerated on-site, may be safely discharged (in the case of aqueous contents), and where contents require off-site disposal. The specifics of the protocol are provided in Appendix D.

Approximately 680 barrels were identified at CAM-A during the 2010 assessment. Most of the barrels were concentrated within Barrel Storage Areas A and B, along the POL Line, (which were used as markers); and within the extents of the debris area. All of the barrels identified at CAM-A were empty, including those located at the Barrel Storage Areas. No barrel samples were collected.

4.4 Demolition Component

The demolition investigation conducted an inventory of all site buildings and other facilities that would require dismantling for disposal. The investigation noted their construction, and any anticipated special disposal requirements, with the collection of samples for applicable analysis to confirm disposal requirements. Samples were collected from painted substrate to identify whether the materials were PCB-containing in excess of CEPA regulations. All locations of asbestos were identified, and it was noted, in particular, where asbestos was covered with PCB-containing paint. Based on paint analytical data, and observations related to asbestos content, the hazardous and non-hazardous component of the demolition materials was determined.

Based on communications between Environment Canada and INAC, substrate calculations, as outlined in the protocol, can be completed based on an agreed upon Compliance Promotion Guideline that is to be published for the PCB Regulation. Therefore the hazardous material volumes estimated in the ‘Alternative’ assessment, which included a substrate calculation within the Phase III ESA have been used for the purpose of this RAP. Therefore, for the purposes of the RAP, if a solid containing PCBs is composed of several matrices, the concentration of PCBs is based on the mass of the painted item as a whole.

There was one facility remaining at the CAM-A site which was identified for demolition, the powerhouse module from the module train. In addition, the tower and remaining sections of the POL line and communication cables will need to be removed.

Twelve paint samples were collected at CAM-A to assess PCB and lead concentrations; 2 from the tower, 2 from the warehouse foundation and 8 from within the powerhouse module. The location, colour, substrate and percent coverage were also noted. The results from the paint analysis found 7 of the 12 samples to contain a PCB level above the Canadian Environmental Protection Act (CEPA) criteria. Six of the samples above the CEPA criteria were collected from the interior components of the module train, including the generator, a water tank, fan blades, above ground storage tank (AST), the floors, and the walls and one sample was collected from the exterior paint of the module train. However, when included in the substrate calculation, only 2 of the 8 samples exceed CEPA criteria (MAT22 – water tank, and MAT23 – module train exterior paint). Based on the results, these two materials are considered hazardous and should be disposed of as hazardous waste. The remainder can be disposed of within an on-site Non-Hazardous Waste Landfill.

Concrete surfaces at DEW Line Sites are often painted and in areas of PCB-oil storage or in the vicinity of transformers, it is common that the concrete floor may be contaminated with PCBs. Eight concrete samples were collected, two from the warehouse foundation, four from the garage foundation and two from the section of the module train floor. The results of the concrete analysis determined that four of the concrete samples with evidence of paint on the surface contained PCB levels above CEPA criteria. Of those four samples, two were collected from the garage foundation pad (MAT15 & MAT16) and two were collected from the module train floor (MAT25 & MAT26). PCB impacts in concrete are often limited by depth and hazardous concrete volumes can be minimized by grinding and collecting the upper surface (10 mm) of the slab for disposal as hazardous waste and providing confirmatory testing of the remaining slab. If the confirmatory testing shows PCB concentrations less than 50 ppm, then the remaining slab can be removed and disposed of in the NHW Landfill. Prior to grinding, any loose or chipping PCB paint or oil stained concrete surface should be removed, containerized and disposed of as hazardous waste. The analytical data for the concrete samples is provided in Table C3 of Appendix C.

Eight asbestos samples were collected, 4 from debris associated with the warehouse, 2 from the boiler on the garage pad, and 2 from insulation in the section of the module train. The results indicated 2 of the warehouse cement board samples contained 15 to 30% asbestos, the 2 garage boiler insulation samples had 30 to 50% and greater than 75% asbestos, and the 2 module train pipe and tank insulation samples had 15 to 30% and 30 to 50% asbestos. These specific instances were noted during the 2010 demolition inventory and must be segregated and proper handling techniques must be followed during packaging for off-site disposal to allow for proper handling at the on-site disposal.

While potential PCB-containing electrical equipment, including transformers, capacitors and fluorescent light ballasts are commonly present on DEW Line sites, it was clear during the 2010 investigation that a dedicated removal of these materials had been completed at an earlier date. No PCB-containing electrical equipment was identified during the 2010 investigation.

There is the potential for mercury-containing switches and thermostats at DEW Line sites, but none were identified at CAM-A in 2010. A summary of hazardous materials identified during demolition inventory is provided in Table C2 of Appendix C. The total volume identified is 8 m3 and includes asbestos, PCB-amended painted materials, and batteries.

4.5 Estimated Buried Debris Excavation Component

All buried debris areas identified at CAM-A were evaluated to be Class C and therefore do not require excavation.

4.6 Remedial Requirements

Generally, all hazardous materials identified at the site will be collected and transported off-site, in accordance with the Transportation of Dangerous Goods Act (TDGA) (TC 2002) and Regulations, and the CEPA Inter-provincial Movement of Hazardous Waste Regulations (SOR/2002-301), to a licensed hazardous waste disposal facility.

Particulars are described below:

- Asbestos: Asbestos waste will be collected, double bagged and disposed of in an on-site engineered landfill, in accordance with the appropriate legislation;
- Petroleum Products: Petroleum products, such as gasoline or diesel, which do not contain other hazardous products according to the Barrel Protocol (chlorine, PCB, heavy metals, etc.) will be incinerated on-site under appropriate emissions controls. Heavier petroleum products such as lubricating oil will be disposed of off-site or mixed with lighter petroleum products and incinerated on-site under appropriate emissions controls;
- Compressed Gas Cylinders: Compressed gas cylinders with known contents will be vented. Once empty, the metal cylinder will be disposed on-site in an engineered landfill;
- Creosote Treated Timbers: Timbers will be wrapped and sealed in polyethylene sheets, and disposed on-site in an engineered landfill;
- PCB Paint on Building Components: PCB paint and PCB painted components, which are regulated under the CEPA, will be collected and transported off-site, in accordance with the Transportation of Dangerous Goods Act and CEPA, to a licensed PCB disposal facility; and
- Lead-Based Paint on Building Components: Lead-based painted components which are classified as hazardous material will be collected and transported off-site, in accordance with the CEPA Inter-provincial Movement of Hazardous Waste Regulations, to a licensed hazardous waste disposal facility.

5. Non-Hazardous Waste Remediation

5.1 Surface Debris Component

The method for completion of the surface debris inventory is described above. Based on the 2010 ESA inventory, the majority of surface debris was identified as non-hazardous. The estimated crushed volume is 195 m^3. A summary of surface debris areas and volumes is provided in Table C1 of Appendix C.

5.2 Demolition Component

The method employed for demolition inventory and characterization of waste is described above. The results of this investigation indicate that the crushed volume of non-hazardous waste materials from demolition is approximately 330 m^3. A summary of demolition quantities is provided in Table C2 of Appendix C.

5.3 Estimated Buried Debris Excavation Component

All buried debris areas identified at CAM-A were evaluated to be Class C and therefore do not require excavation.

5.4 Remedial Recommendations

The total crushed volume of material identified as non-hazardous waste during the 2010 Phase III ESA is approximately 525 m^3. According to the INAC AMSRP, the assessment of the need for construction of an on-site NHWLF should consider primarily the availability of suitable locations to build such a facility at the site. Additional considerations include the availability of appropriate granular borrow materials and the volume of non-hazardous waste identified for disposal. Based on the volume of non-hazardous waste, the quantities and types of granular materials identified during the 2010 investigation, and the identification of several suitable sites for new landfill development, it is recommended that a Non-Hazardous Waste (NHWLF) be constructed at CAM-A. Four locations at CAM-A were identified during the Phase III ESA site investigation that would be suitable for construction of a new facility. Furthermore, no granular borrow material constraints were identified which would preclude any new development.

6. Contaminated Soil Remediation

6.1 Remedial Criteria and Clean-up Protocols

The investigation and delineation of contaminated soil at CAM-A was completed for the contaminants of concern identified under the INAC AMSRP: arsenic, cadmium, cobalt, copper, lead, nickel, zinc, and PCBs. The protocol identifies two levels of contamination, Tier I soil which is considered an environmental risk only when located at surface, and Tier II soil which is considered an environmental risk at any depth of impact.

Delineation of petroleum hydrocarbon (PHC) impacts was completed using the 2009 INAC AMSRP. Total Petroleum Hydrocarbon (TPH) soil analyses are typically completed using a methane extraction method, and measure concentrations of carbon chain sizes between C6 and C34. Type A hydrocarbons are defined as impacts comprised of 70% or more of the heavier fractions (F3 and F4), which corresponds to impacts derived from lubricating (lube) oil or grease spills. Type B hydrocarbons are defined as those impacts comprised primarily of lighter end components (F1-F3), derived from fuel spills. The INAC AMSRP process specifies different numerical cleanup criteria based on the type of hydrocarbon impacts (Type A versus Type B), proximity to significant water bodies, and depth of impacts.

Table 6-1 below provides a summary of contaminated soil remedial criteria and volumes identified during the Phase III ESA and evaluated based on the 2009 INAC criteria. Volumes estimated to arise from WDA excavations have also been noted, as these volumes have also been considered for evaluation of contaminated soil disposal options below. The options noted below combine the volumes from these two sources, with the volume derived from WDA excavation estimates noted in parentheses below.

Table 6-1 - Summary of Contaminated Soil: Remedial Criteria and Quantities

Designation	Description/Criteria	Soil Volume (m^3)	Remedial Options (INAC AMSRP)
Tier I Contaminated Soil	Soils containing concentrations of any or all contaminants listed: Lead 200 to 500 ppm PCBs 1 to <5 ppm	43 m^3	Cap in place with a minimum of 0.3 m of granular fill, or dispose in on-site Non-Hazardous Waste Landfill.
Tier II Contaminated Soil	Soils containing concentrations equal to or greater than any or all contaminants listed: Arsenic 30 ppm Cadmium 5 ppm Chromium 250 ppm Cobalt 50 ppm Copper 100 ppm Lead 500 ppm Mercury 2 ppm Nickel 100 ppm Zinc 500 ppm PCBs >5 to <50 ppm	75 m^3	Dispose in SSDF or transport off-site for disposal in engineered territorial or provincial Landfill.
TPH Type A Soil (F3 and F4 fractions)	Soils contaminated with PHCs consisting primarily of oil and grease at concentrations equal to or greater than: TPH, Sum of F3 and F4 fractions 20,000 ppm.	n/a	Scarify and leave in place if under criteria, or dispose in on-site Non-Hazardous Waste Landfill.
TPH Type B Soil (F1-F3 fractions) – Protection of (*) Freshwater Aquatic Life	Soils contaminated with PHCs consisting primarily of fuel oil, and/or diesel, and/or gasoline, with concentrations equal to or greater than the following: F1 fraction 1,290 ppm* F2 fraction 330 ppm* Station Area: Surface soils to 0.5 m depth 2500 ppm (TPH, sum of F1 through F3 fractions) for the Protection of Terrestrial Wildlife	1,124.8 m^3	Excavate and treat ex-situ through landfarming, treat in-situ with landfarming, or dispose of in SSDF. Note that disposal in the SSDF is only considered appropriate if concentrations are sufficiently low that there are no concerns for

	Subsurface soils below 0.5 m in depth 5000 ppm (TPH, sum of F1 through F3 fractions) for the Management Limit		inhibiting freezing of contents and/or with free-product development, which could compromise the liner integrity at the facility.

Notes: Source: Table 5.1 Summary of Remedial Options – Contaminated Soil (INAC AMSRP, 2009)

6.2 Tier I Soil

The 2010 site investigation identified:

- 7.9 m^3 of Tier I PCB contaminated soil near the module train foundation to an estimated depth of 0.3 mBGS to 0.5 mBGS (0.2 m depth, total).
- 35.1 m^3 of Tier I PCB contaminated soil in two locations of the sewage outfall area to an estimated depth of 0.3 mBGS.

The total volume of Tier I soil identified for remediation is 43 m^3 which has been delineated from contaminated soil areas. A detailed breakdown showing area-specific volumes of Tier I soil is provided in Appendix B.

The INAC AMSRP indicates that all soils with metal and/or PCB concentrations exceeding the DLCU Tier I Criteria (but not regulated by CEPA) will be disposed of according to the following options:

- On-site disposal in an on-site Non-Hazardous Waste Landfill (NHWLF); or,
- Cap in place with a minimum of 0.3 m of clean granular fill if in a stable location.

It is recommended that Tier I contaminated soils at CAM-A be disposed of in an on-site NHWLF. For an on-site NHWLF, the 2010 investigation identified three suitable locations for this facility, including preferred location LF-6 and alternate locations at LF-2 and LF-5. Assessment of existing and new potential granular borrow sources was completed during the 2010 investigation. The assessment identified various locations where suitable borrow types (Type 2) and quantities are available for construction of a NHWLF. Therefore, based on the results of the 2010 assessment, there are no site specific constraints for building an NHWLF at CAM-A.

6.3 Tier II Soil

The 2010 site investigation identified:

- 9.3 m^3 of Tier II PCB contaminated soil near the garage to an estimated depth of 0.5 mBGS;
- 0.1 m^3 of Tier II PCB contaminated soil was identified in the sumps on the garage foundation to an estimated depth of 0.3 mBGS;
- 21.5 m^3 of Tier II PCB contaminated soil near the module train foundation to an estimated depth of 0.3 mBGS; and,
- 44.2 m^3 of Tier II Lead contaminated soil was in the worked area (Lobe J) to an estimated depth of 0.3 mBGS.

The total volume of Tier II soil identified for remediation is 75 m^3 which has been delineated from contaminated soil areas. A detailed breakdown showing area-specific volumes of Tier II soil is provided in Appendix B.

The INAC AMSRP indicates that all soils with metal and/or PCB concentrations exceeding the DLCU Tier II Criteria (but not regulated by CEPA) will be disposed of according to the following options:

- On-site disposal within a secure soil disposal facility (SSDF) consisting of double containment within permafrost encapsulation and a geosynthetic liner system in the base and cover of the facility; or
- Off-site disposal at a licensed southern disposal facility.

The decision criteria to determine if a SSDF is required at a DEW Line Site are outlined in Table 5.3 of the INAC AMSRP. The site is not landlocked and the estimated Tier II soil volume is 75 m^3, which is less than the decision criteria volume of 300 to 500 m^3 and the risk of overrun is considered to be low to moderate. Therefore, the remedial recommendation is to containerize and Tier II contaminated soil and transport off-site for southern disposal.

6.4 Type A Soil

The 2010 site investigation did not identify any Type A contaminated soil.

6.5 Type B Soil

Three areas of Type B impacted soil requiring remedial action were identified as part of the 2010 investigation:

- 425 m^3 of Type B hydrocarbon impacted soil near the Beach POL within 30 m of the ocean to an estimated depth of 0.5 mBGS to 1.0 mBGS (0.5 m depth, total);
- 128.8 m^3 of Type B impacted soil on the Beach POL Pad to an estimated depth of 0.5 mBGS; and
- 571 m^3 of Type B impacted soil was identified near module train foundation to an estimated depth of 0.5 mBGS.

The total volume of PHC Type B soil identified for remediation is 1,125 m^3. A summary of contaminated soil volumes by area is presented in Appendix B.

Remedial options applicable to the hydrocarbon impacted soil include:

- In-situ biological treatment or chemical oxidation;
- Ex-situ, on-site aeration and biological treatment (landfarming);
- Ex-situ, on-site aeration (using an excavator equipped with a standard or “Allu” type bucket); and
- Ex-situ, off-site treatment and/or disposal in a Licensed Disposal Facility.

Advantages and disadvantages of each treatment option are described in Table 6-2. Based on the applicability of the various treatment options at the CAM-A site, the recommended remedial option is on-site ex-situ aeration (an excavator equipped with a standard or “Allu” type bucket) or on-site ex-situ aeration and biological treatment (landfarming).

Recent monitoring results from landfarm operations at another former DEW Line site (FOX-C Ekalugad Fjord) have indicated that treated soil criteria are achievable through on-site biological treatment methods; however, more highly contaminated soils may take extended periods of treatment to meet the treatment criteria. Based on the volume of impacted soil and moderate hydrocarbon concentrations observed during the 2010 investigation, it is anticipated that ex-situ biological treatment may be completed within a 1 year period provided site conditions are monitored and optimized where possible (i.e., moisture conditioning, nutrient amendment). It may be more appropriate to apply more intense aeration methods for the relatively small volume of soils requiring treatment at CAM-A in order to allow this work activity to be completed within the expected short overall construction period for this project.

Soils contaminated with Type B fractions should be excavated and treated ex-situ by aeration or aeration with biological treatment methods in an on-site treatment or landfarm facility. Soils concentrations should be reduced, as required, to meet the 2009 INAC Criteria.

Table 6-2 - Summary of Remedial Options - Hydrocarbon Contaminated Soil

Remedial Option	Description/Requirements	Applicability	Advantages	Disadvantages/Limitations	Implementation
In-situ Biological Treatment / Chemical Oxidation	• Application of ozone, peroxide or permanganate through instrumentation within the impacted area.	• Amendable to light and medium end hydrocarbons (F1, F2, F3 fractions).	• Under optimal conditions can reduce concentrations below criteria. • Minimize excavation and disturbance of existing vegetation.	• Monitoring required. • Difficult to confirm that target concentrations are met throughout the contaminated area. • Not applicable to metal contaminated soil.	• Not appropriate for hydrocarbon areas located in close proximity to water bodies (Beach POL).
On-Site, Ex-situ Landfarming / Bioremediation	• Hydrocarbon contaminated soils are excavated and placed within bermed treatment area. • Soils are periodically turned and nutrients added to optimize treatment conditions.	• Hydrocarbon contaminated soils, including F1, F2 and F3 fractions.	• Contaminant concentrations reduced. • No environmental risks associated with potential spills during off-site transport.	• More effective on lighter end hydrocarbons. • Generally requires 1-2 treatment seasons for contaminant reduction to criteria. • Restricts use of the site during treatment operations. • Impermeable membrane/low permeable soils required for containment.	• Adequate location and granular materials identified for construction. • Geosynthetic liner required for perimeter containment if permeable soils are used.
On-Site, Ex-Situ Aeration by Allu Bucket	• Hydrocarbon contaminated soils are excavated and placed within contained treatment area. • Soils are frequently turned for aeration.	• Hydrocarbon contaminated soils, including F1, F2 and F3 fractions.	• Contaminant concentrations reduced. • No environmental risks associated with potential spills during off-site transport. • Generally suitable for more intense treatment of small soil volumes.	• More effective on lighter end hydrocarbons. • May be difficult to aerate soils with excessive moisture, fine-grained soils and rock using the Allu system. • Impermeable membrane/low permeable soils required for containment.	• Adequate location and granular materials identified for construction of treatment area. • Geosynthetic liner required for perimeter containment.
Off-Site Treatment and Disposal	• Contaminated soils are transported off-site for treatment or disposal.	• All contaminated soil types.	• Contaminated soils removed from site eliminating risk of exposure.	• Considerable costs associated with off-site transport. • Project costs are very sensitive to contaminated soil volumes. • Potential environmental risks during transport.	• Shipment and disposal off-site is technically appropriate, but at considerable costs.

6.6 Summary

Remedial options evaluations for the remediation of contaminated soils were completed as part of the 2010 investigation. Based on the estimated volumes of contaminated soils and technical considerations, for locating and developing suitable disposal and/or treatment facilities, it is recommended that all Tier I and PHC soils at CAM-A be disposed of or treated on-site while Tier II soils be containerized and disposed of off-site. Based on the applicability of the various disposal and treatment options, the following recommendations are made:

- Soils contaminated with Tier I levels of PCBs and inorganic elements should be excavated and placed in the on-site Non-Hazardous Waste Landfill. The total volume of Tier I soil is estimated at 43 m^3. These soils may be utilized as intermediate fill during placement of non-hazardous waste within the landfill;
- There were no soils identified with Type A contamination;
- Soils contaminated with Tier II levels of PCB and/or inorganic elements should be excavated and disposed of off-site. The total volume of Tier II soil is estimated at 75 m^3; and,
- Soils contaminated with Type B fractions should be excavated and treated ex-situ by aeration or aeration with biological treatment methods in an on-site landfarm facility/"allu" treatment area. The total volume of hydrocarbon impacted soil requiring treatment is estimated at 1,125 m^3.

7. Implementation

7.1 Schedule

It is expected based on the assumption of barge access that the contractor would mobilize to the site in the late summer/early fall of Season 1. During this timeframe, it is reasonable to assume that the contractor would be able to set-up their camp, potentially investigate recommended borrow sources, and upgrade roadways as required. It is also recommended that during this season the contractor remove any birds' nest (used by rough-legged hawks or other species) on any of the DEW Line facilities to prevent nesting on the module train early during the main construction period, which would restrict timing of building demolition. It is understood, however, from past DEW Line experience, that when the existing structure still remains, that rough-legged hawks will rebuild the nest. It should be made clear to the contractor; however, that structures which hold nests with young shall not be demolished until the young birds have left the nest.

It is expected that, based on the assumption of ice road and/or cat train access, the contractor would mobilize to the site in the spring of Season 1, leave the site and return in early summer to set-up the camp, upgrade the roadways and initiate the work activities. Demobilization options are dependent on the time of year i.e. in fall the demobilization option is via barge, in late winter/early spring the demobilization option is via ice road and/or cat train.

Based on the recommended remedial actions outlined above, construction activities will require at least one full season of clean-up activity, following contractor mobilization to site. Specifics related to timing and prioritization of contractor activities is described in the sections below.

7.2 Waste Disposal Area Remediation

Table 7-1 below summarizes the recommended remedial requirements for WDAs at CAM-A. As all buried debris areas were classified as low environmental risk, the recommended remediation is regrading by placing additional granular cover over the areas. In terms of timing, the implementation of WDA regrading, should not proceed until the construction of the Non-Hazardous Waste (NHW) Landfill berms are complete and the facility is ready for the disposal of surface debris from the WDAs.

Table 7-1 - Summary of Recommended Waste Disposal Area Remedial Requirements

Waste Disposal Area	Area (m^2)	Depth (m)	Volume (m^3)	Environmental & Geotechnical Investigation	WDA Classification	Recommended Remediation Based on Engineering Considerations
Landfill A: Lobes A, B, C, & D	1,500	1.5–2.0	2,250 – 3,000	No evidence of contaminant migration. No potential for surface contaminated soil identified. Moderate vegetation. No erosion noted.	Class C	Regrade, based on the stability of this landfill.
Landfill B: Lobe F	208	1.0	208	No evidence of contaminant migration. No potential for surface contaminated soil identified. Moderate vegetation. No erosion noted.	Class C	Regrade, based on the stability of this landfill.
Lobe G	495	1.5	742.5			
Lobe H	128	0.5	64			

7.3 Demolition

The demolition inventory for CAM-A identified approximately 8.1 m^3 of hazardous and 329.9 m^3 of non-hazardous demolition debris (crushed). These volumes are based on segregation of hazardous and non-hazardous building components during demolition and do not include bulking factors that may be attributed to off-site packaging volumes or with on-site disposal volumes.

Hazardous building materials and related components, including Asbestos Containing Materials (ACM's) and PCB wastes will be removed prior to demolition of the structures. ACM's generally include mechanical insulation on pipes and chimneys, transite board, and asbestos core fire doors. ACM's that are painted are to be treated as PCB wastes and containerized separately for off-site disposal. Non-painted ACMs will be double bagged and disposed of in an on-site landfill. No painted ACM's were noted on-site. Vermiculite insulation contained within the inter-module wall cavities is not considered asbestos-containing (<1% asbestos); however, due to its friable nature should be removed in a manner consistent with a moderate risk (Type 2) abatement. Type 2 asbestos removal specifies parameters for removal of minor friable asbestos including loose asbestos on top of false ceilings and within piping or ducting.

Other hazardous materials, including batteries and potential glycol-containing liquids within the building heating systems will be containerized for off-site disposal or recycling in accordance with TDGA requirements. While no PCB-containing equipment or mercury switches were noted during the 2010 investigation, if these materials are identified during clean-up, they will also require containerizing for off-site disposal.

The majority of painted components in the powerhouse module and hazardous concrete in the garage slab are considered PCB wastes and are regulated under the Canadian Environmental Protection Act (CEPA). Loose and flaking paint is to be removed from all painted surfaces and collected for off-site disposal as PCB waste. Similarly, paint on concrete floors in the powerhouse module and garage contains PCBs in excess of 50 mg/kg and will be removed and treated as PCB waste. Consistent with CEPA and INAC's AMSRP, PCB amended painted material will be containerized in accordance with the TDGA and Regulations, and removed from site. These materials will be transported to a licensed facility for PCB destruction and disposal.

Non-hazardous wastes from demolition include unpainted wood and metal construction materials and concrete in foundations following surface paint removal. Painted structural materials with PCB paint concentrations less than 50 mg/kg can be disposed of in an on-site landfill following removal of any loose or flaking paint. If cutting torches will be used to dismantle structural steel components, paint must be removed from the surface in the locations to be cut.

Remaining building foundations at CAM-A include the module train timber crib foundation, the garage concrete slab on grade and the warehouse elevated concrete slab. The warehouse concrete slab is raised above grade on concrete footings and piles. The timber crib and elevated slab and piles should be demolished and disposed of in the Non-Hazardous Waste Landfill. The remaining concrete building foundations can remain in place once all paint and contaminated surface concrete has been removed from the surface of the slab. The preferred remediation option, from a technical perspective, is to place additional fill material and regrade around the foundations to match existing topography.

7.4 Surface Debris

A total of seven surface debris lobes were identified during the 2010 Phase III ESA. The presence of buried debris was confirmed at Landfill A (Lobes A, B, C, & D) and Landfill B (Lobes F, G & H) as shown on Figures 3 and 4. All other lobes identified on-site (Lobes E, I, J, K, M, N & O) and six small anomalies (Lobes L, P, Q, R, S & T) identified in the Associated Geosciences geophysics report were determined to be localized, partially buried debris and/or surface debris and were assessed as surface debris areas rather than buried debris. These partially buried debris and/or surface debris lobes are located within the debris extents shown on Figures 2, 3, 8, 9, and 10. The volume of hazardous materials identified is 1.2 m^3, while the crushed volume of non-hazardous waste is 195.1 m^3. A detailed breakdown of surface debris points and debris volumes is provided in Table C1 of Appendix C. Non-hazardous waste can be disposed of in the NHWLF. Hazardous waste must be packaged in accordance with TDGA regulations for shipping to an off-site licensed hazardous waste disposal facility.

In addition to the identified surface debris areas, it is also typically noted in clean-up specifications that all debris within 50 m of existing pads and roadways is picked up for on-site disposal in the NHW Landfill. The surface debris investigation generally covered off all of the areas near roadways and the existing perimeters were drawn to include debris identified in this vicinity. Nonetheless, it is recommended that a small contingency be carried for additional volume of debris from within 50 m from roadway criterion for design of the NHWLF.

7.5 Barrel Remediation

The 2010 inventory of barrels at CAM-A indicates there are an estimated 680 barrels on-site. Most of the barrels were concentrated within Barrel Storage Areas A and B, along the POL Line, which were used as markers, and within the extents of the debris areas. All of the barrels identified at CAM-A were empty, including those located at the Barrel Storage Areas. All empty barrels should be crushed and disposed on in an on-site NHWLF.

7.6 Proposed New Containment Facilities

7.6.1 Non-Hazardous Waste Landfill (NHWLF)

The total volume of non-hazardous waste, from all sources (including Tier I soil), is estimated at approximately 568.0 m^3. The estimated footprint for a NHWLF to accommodate this volume is approximately 12 x 12 m. Although Proposed Landfill sites LF-2 and LF-5 are each suitable for the placement of the NHWLF, the preferred location is Proposed Landfill LF-6. This site has suitable ground conditions and is close to the Station Area where the majority of demolition debris is located and close to borrow sources where Type 2 Granular Fill material is located. Of note, there are no contaminated soil areas for excavation in the near up-gradient area. Therefore, there is no requirement for provision of a sufficient buffer to avoid complication of long-term landfill monitoring data interpretation.

In terms of contractor priorities for construction of new facilities during clean-up, construction of the NHWLF is considered the second priority, behind the landfarm (see below).

7.6.2 Landfarm/"Allu" Treatment Area

The total volume of Type B soil identified for remediation is approximately 1,124.8 m^3. The Type B soil is distributed between the Beach Area and the module train at the Station site. It would be preferable to locate the landfarm facility or "allu" treatment area within easy access to both the Beach Area and Station sites. Proposed Landfill LF-5 has been identified as a suitable and the preferred site for a landfarm/treatment area. This LF-5 site is in close proximity to the Beach, meets siting requirements for a landfarm and is close to borrow sources where Type 2 Granular Fill material is located.

The construction of the landfarm/treatment area is a priority as the treatment of soil could potentially delay contractor's demobilization from site.

7.7 Borrow Sources

To confirm that sufficient sources of the various granular material types were identified during the Phase III ESA, an estimate of the required granular material volumes was completed for the recommended remedial options discussed above. The following summarizes the estimated volumes for each granular material type:

- Type 1: no requirements for Type 1 Granular Fill;
- Type 2: the estimated volume required is approximately 5,900 m^3, which includes construction of the NHWLF and the Landfarm. Volumes required for regrading of WDAs have also been included in this volume;
- Type 3: the estimated volume required is in the order of 1,300 m^3, which includes the material required for the backfilling of contaminated soil excavations;
- Type 4: the estimated volume of Type 4 Granular Fill required for construction of an on-site Landfarm is approximately 1,900 m^3;
- Type 5: no requirement for Type 5 Granular Fill since there will be no construction of a SSDF or leachate containment system; and
- Type 6: the intermediate fill requirements for the construction of the NHWLF are estimated at 200 m^3. Some of the requirements for intermediate fill may be met by using Tier I soil.

Based on these estimates, it is anticipated that sufficient granular material sources were identified during the Phase III ESA. The soil types encountered in the borrow areas generally include source material for Type 2 and Type 4 Granular Fill. A summary of granular material that can be obtained from the potential borrow areas at CAM-A is presented in Table 7-2 below. The Borrow Area locations are shown on Figure 2.

Table 7-2 - Summary of Borrow Areas

Borrow Area	Available Granular Fill Type	Area (m^2)	Depth (m)	Volume (m^3)	Comments
BA-1	Type 2, Type 3, Type 6	24,000	0.5	12,000	Undisturbed
BA-2	Type 2, Type 3, Type 6	22,000	0.7	15,400	Disturbed
BA-3	Type 2, Type 3, Type 6	51,000	0.7	35,700	Disturbed
BA-4A	Type 2, Type 3, Type 6	8,000	0.7	5,600	Disturbed
BA-4B	Type 2, Type 3, Type 6	26,000	0.7	18,200	Disturbed
BA-4C	Type 2, Type 3, Type 6	11,000	0.7	7,700	Disturbed
BA-4D	Type 2, Type 3, Type 6	7,000	0.7	4,900	Disturbed
BA-5	Type 2, Type 3, Type 6	9,000	0.7	6,300	Undisturbed
BA-5A	Type 4, Type 3, Type 6	27,000	0.7	18,900	Undisturbed
BA-6	Type 2, Type 3, Type 5,Type 6	19,000	0.7	13,300	Disturbed
BA-6A	Type 2, Type 3, Type 5, Type 6	48,000	0.7	33,600	Partially disturbed
BA-7	Type 2, Type 3, Type 5, Type 6	26,000	0.7	18,200	Disturbed
BA-8	Type 1	30,000	0.3	9,000	Disturbed
BA-9	Type 2, Type 3	24,000	0.5	12,000	Disturbed
BA-10	Type 4, Type 3	24,000	0.5	12,000	Undisturbed
BA-11	Type 2, Type 3	7,000	0.5	3,500	Undisturbed
BA-12	Type 4, Type 3	40,000	0.5	20,000	Undisturbed
BA-13 (LF-1)	Type 4, Type 2, Type 3	42,000	0.5	21,000	Undisturbed
BA-14 (LF-2)	Type 4, Type 2, Type 3	46,000	0.6	27,600	Undisturbed
BA-15 (LF-4)	Type 2, Type 3, Type 6	45,000	0.6	27,000	Partially Undisturbed

7.8 Summary

The following summarizes the site access and remediation implementation developed for CAM-A, Sturt Point:

- The remediation activities at CAM-A are anticipated to be completed in one full year with mobilization by barge in the late summer/fall of Season 1 and construction and demobilization in the summer/fall of Season 2;
- Seven buried debris lobes were identified during the 2010 ESA. The presence of buried debris was confirmed at Landfill A (Lobes A, B, C, & D) and Landfill B (Lobes F, G & H). Landfill A and Landfill B lobes represent a total area of about 2,331 m^2 and are designated for regrading. All other lobes identified on-site (Lobes E, I, J, K, M, N, & O) and six small anomalies (Lobes L, P, Q, R, S & T) identified in the Associated Geosciences geophysics report were determined to be localized, partially buried debris and/or surface debris and were assessed as surface debris areas rather than buried debris;
- The demolition of buildings and structures at CAM-A represents a crushed volume of 329.9 m^3 of non-hazardous debris requiring on-site disposal and 8.1 m^3 of hazardous debris requiring off-site disposal;
- A total of 31 surface debris areas were identified on-site with an estimated crushed volume of 195.1 m^3 of non-hazardous debris requiring on-site disposal and 1.2 m^3 of hazardous debris requiring off-site disposal;
- A total of 680 barrels were identified and assessed as surface debris. The barrels were empty and processing is not expected to require a significant effort;
- A NHWLF is proposed for the disposal of 568.0 m^3 of crushed demolition debris and contaminated soil;
- A landfarm/treatment area is proposed for the treatment of 1,125 m^3 of Type B hydrocarbon contaminated soil;
- The priority for contaminated soil excavation is dependent on the disposal or treatment requirements. The priority from high to low is as follows: 1. Type B (requires sufficient time for treatment), 2. Tier II and Hazardous Soil (requires suitable container volume) and 3. Tier I (requires disposal in NHW Landfill); and,
- A total of 17 borrow sources were identified at CAM-A. The estimated total volume of granular material required for CAM-A remediation construction is 9,300 m^3 while the total volume of borrow material identified is in excess of 320,000 m^3.

8. References

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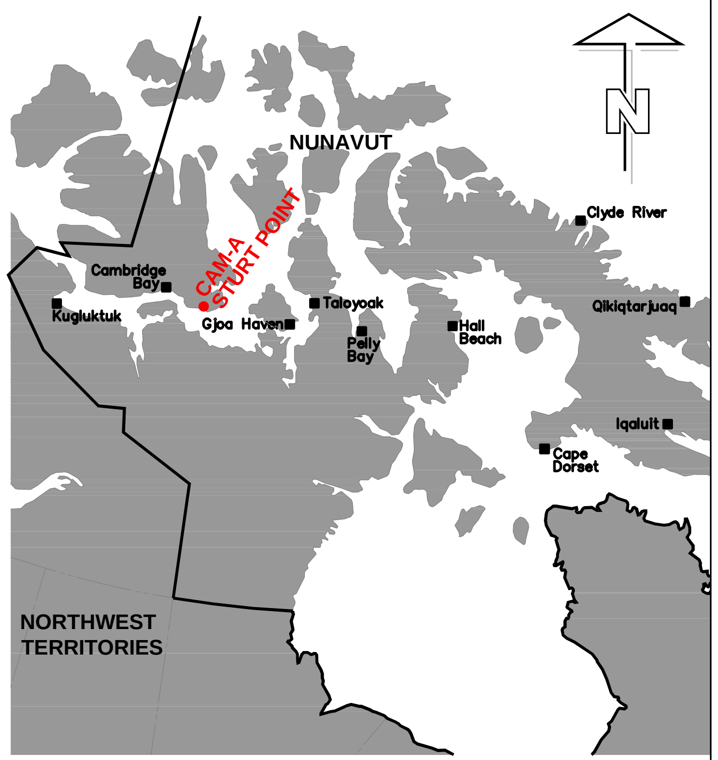
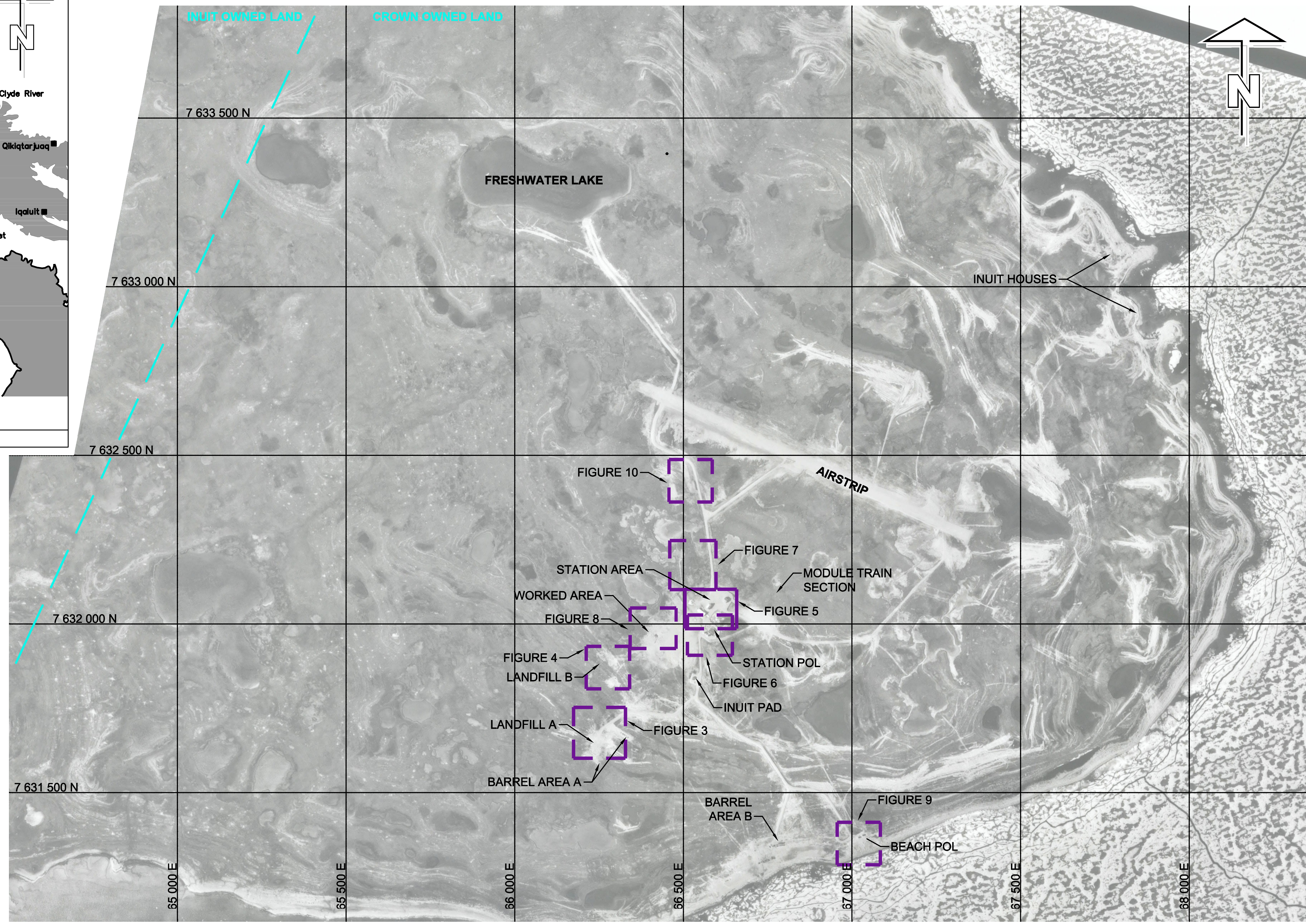
Appendix A

Figures



LOCATION OF STURT POINT
WITHIN NUNAVUT TERRITORY



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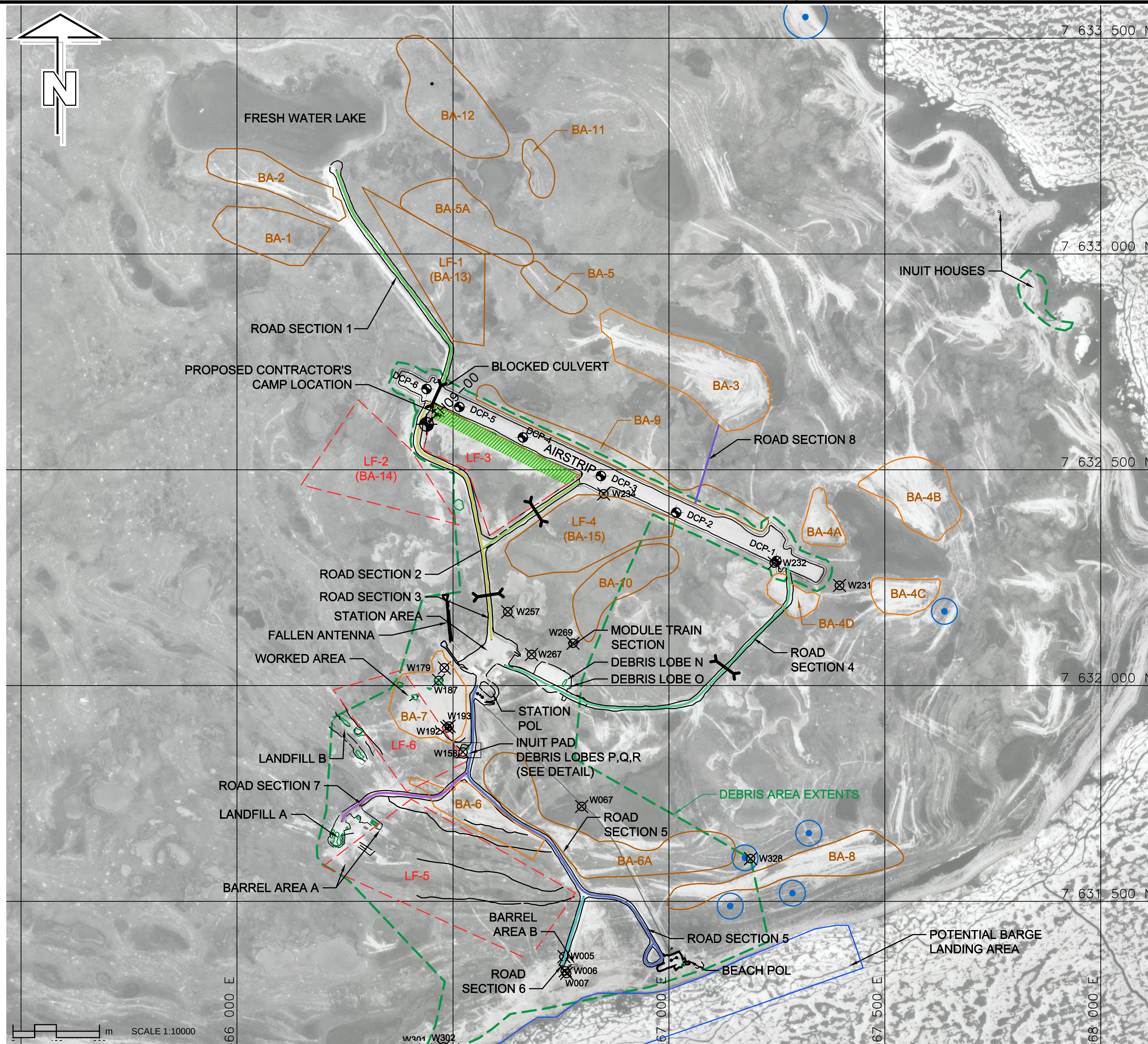
CAM-A Site Remedial Action Plan

Site Location

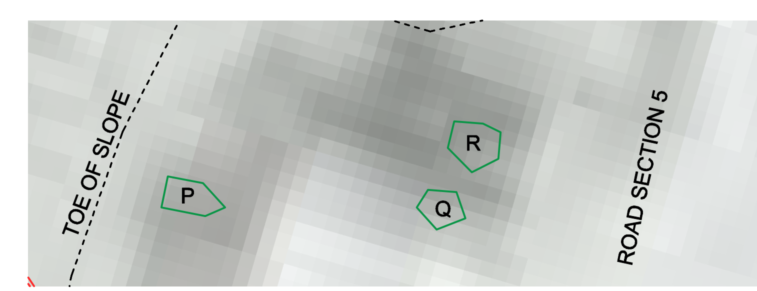
Figure 1



LEGEND

- PROPOSED LANDFILL LOCATIONS
- BORROW SOURCE LOCATIONS
- EXISTING CULVERTS
- HERITAGE BUFFER AREAS
- DCP-1 DCP POINT
- DEBRIS WAY POINT
- POTENTIAL CONTRACTOR LAY DOWN
- DEBRIS AREA EXTENTS

Landfill/Borrow area	AREA (m^2)
LF-1 (BA-13)	42,000
LF-2 (BA-14)	46,000
LF-3	45,000
LF-4 (BA-15)	45,000
LF-5	100,000
LF-6	43,000
BA-1	24,000
BA-2	22,000
BA-3	51,000
BA-4A	8,000
BA-4B	26,000
BA-4C	11,000
BA-4D	7,000
BA-5	9,000
BA-5A	27,000
BA-6	19,000
BA-6A	48,000
BA-7	26,000
BA-8	30,000
BA-9	24,000
BA-10	24,000
BA-11	7,000
BA-12	40,000



INUIT PAD - DEBRIS LOBES P,Q,R
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PWGSC
CAM-A Site Remedial Action Plan

Site Layout

Figure 2

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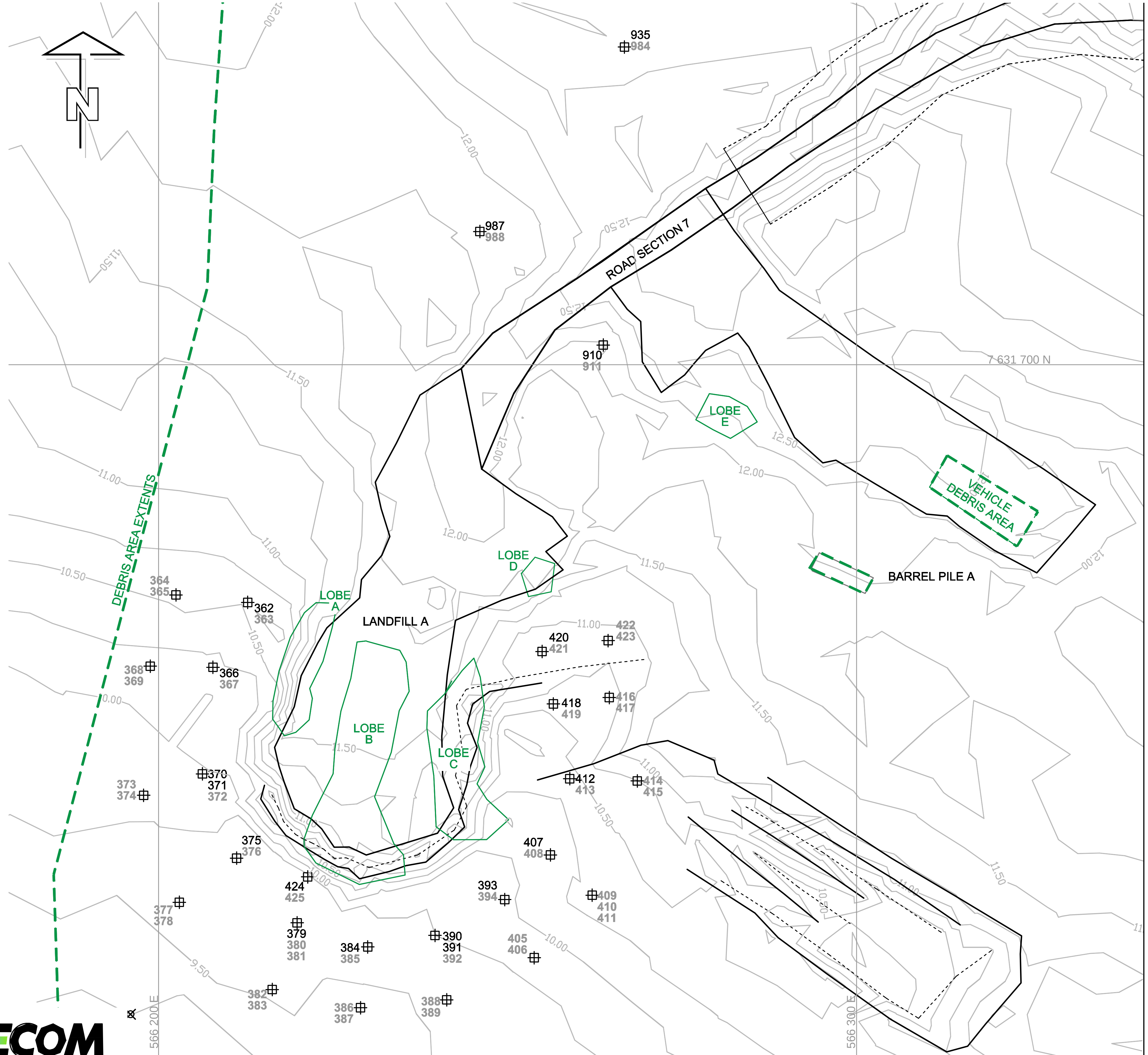

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####	SAMPLE NUMBER - HELD
####	SAMPLE NUMBER - EXCEEDS TIER II
####	SAMPLE NUMBER - EXCEEDS TIER I
####	SAMPLE NUMBER - TYPE B PHC CONTAMINATION
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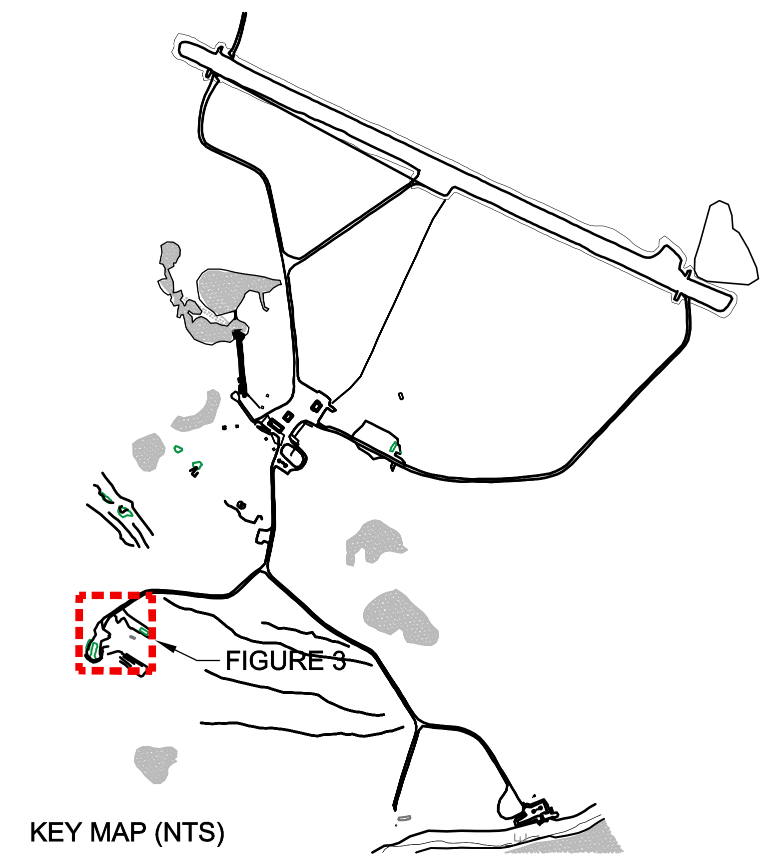

KEY MAP (NTS)

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AECOM

PWGSC

CAM-A Site Remedial Action Plan

Landfill A

Figure 3

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

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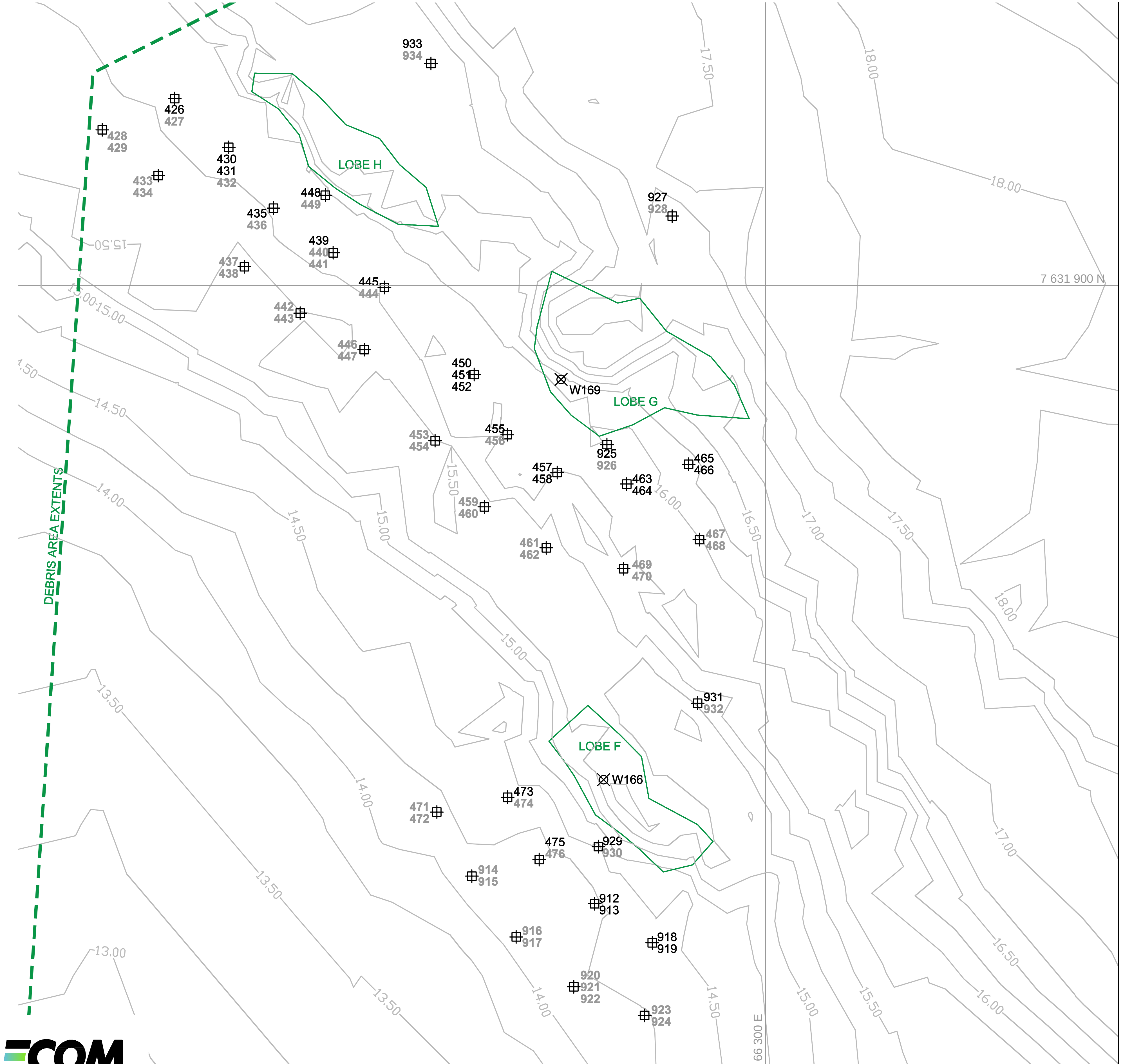

LEGEND

DEBRIS WAY POINT

SAMPLE POINT

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SAMPLE NUMBER - HELD

SAMPLE NUMBER - EXCEEDS TIER II

SAMPLE NUMBER - EXCEEDS TIER I

SAMPLE NUMBER - TYPE B PHC CONTAMINATION

TOE OF SLOPE

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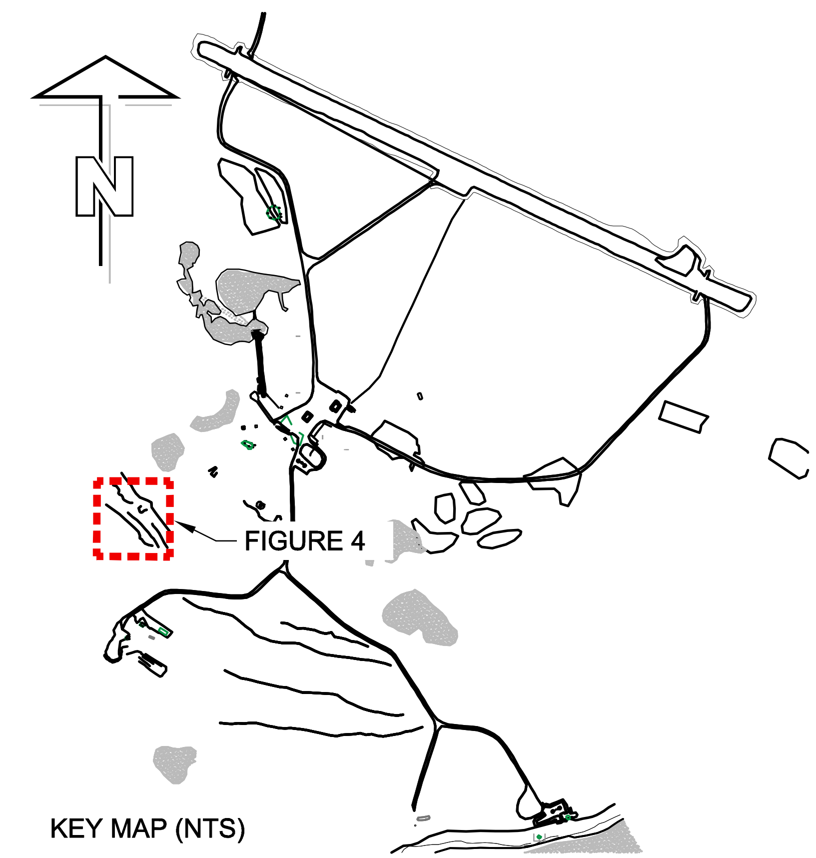

KEY MAP (NTS)

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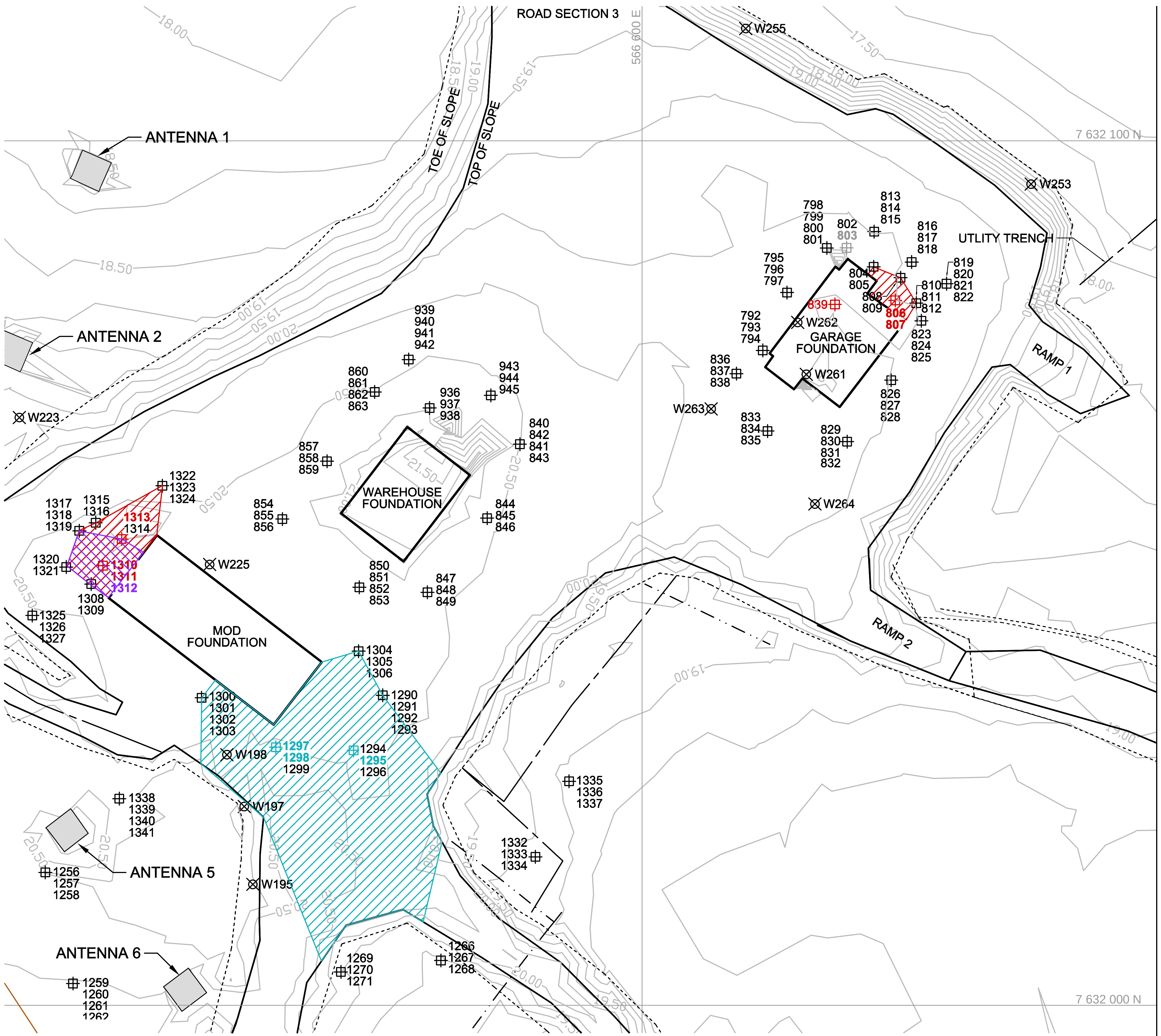
CAM-A Site Remedial Action Plan

Landfill B

Figure 4



LEGEND

⊠	DEBRIS WAY POINT
⊞	SAMPLE POINT
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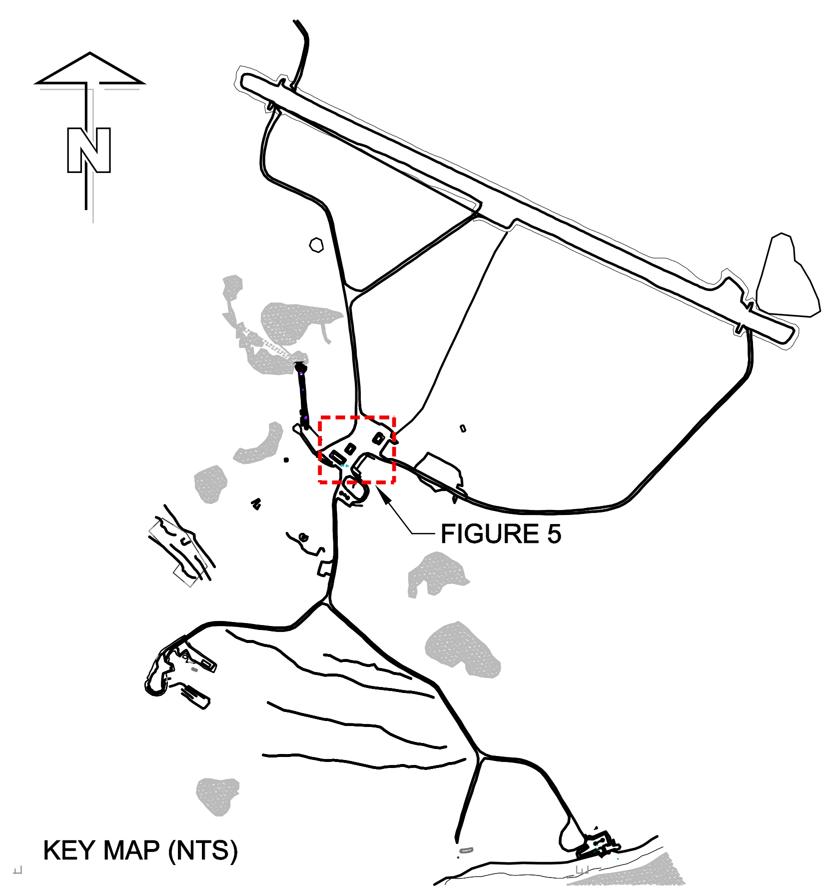
#### (grey)	SAMPLE NUMBER - HELD
#### (red)	SAMPLE NUMBER - EXCEEDS TIER II
red hatch	TIER II CONTAMINATED SOIL
#### (purple)	SAMPLE NUMBER - EXCEEDS TIER I
purple hatch	TIER I CONTAMINATED SOIL
#### (cyan)	SAMPLE NUMBER - TYPE B PHC CONTAMINATION
cyan hatch	TYPE B PHC CONTAMINATED SOIL
grey square	CONCRETE ANCHOR PAD
— —	UTILITY TRENCH
-·-·-	PIPE
------	TOE OF SLOPE

m 0 5 10 SCALE 1:500



KEY MAP (NTS)

PWGSC
CAM-A Site Remedial Action Plan

Station Area

Figure 5

AECOM

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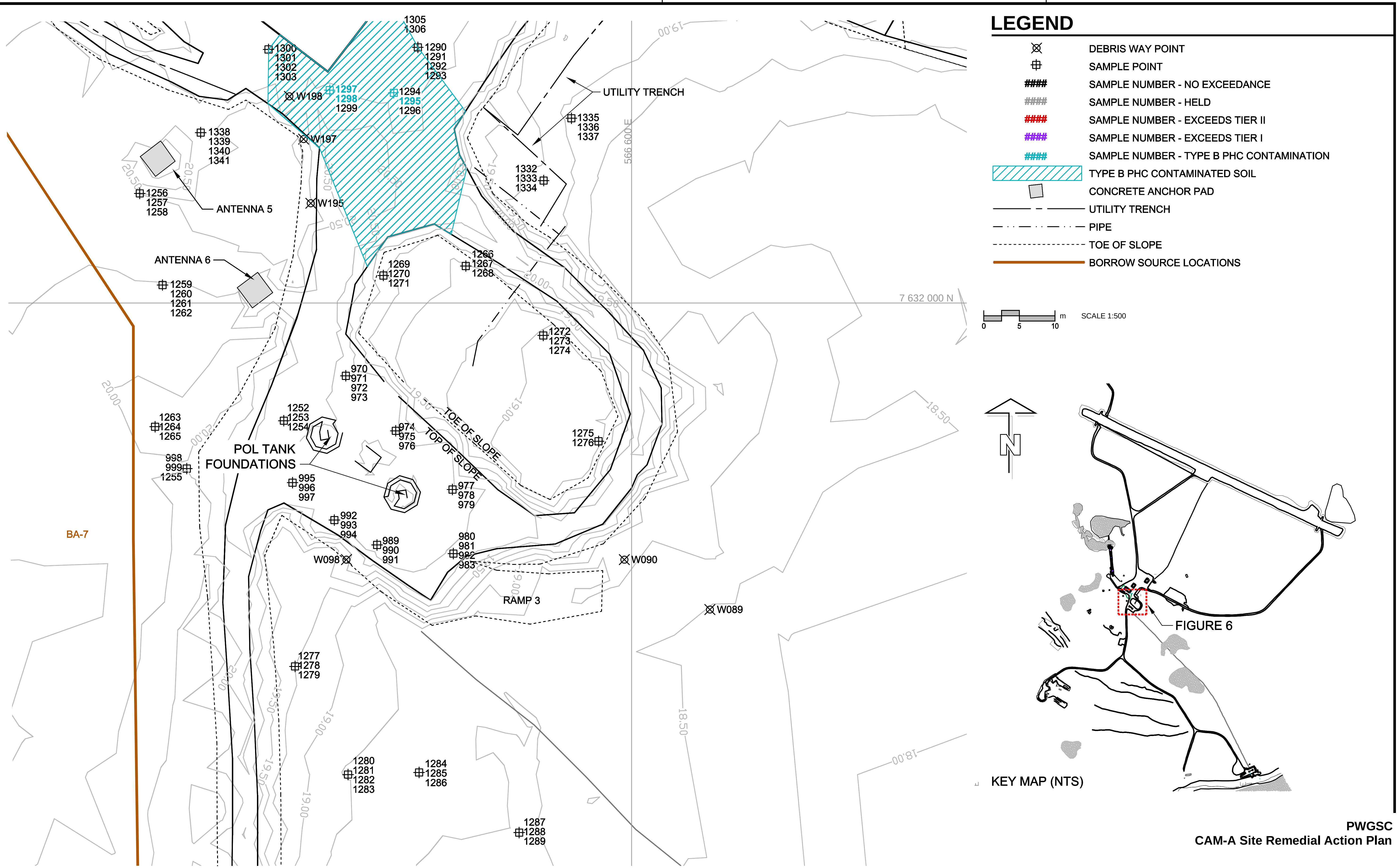
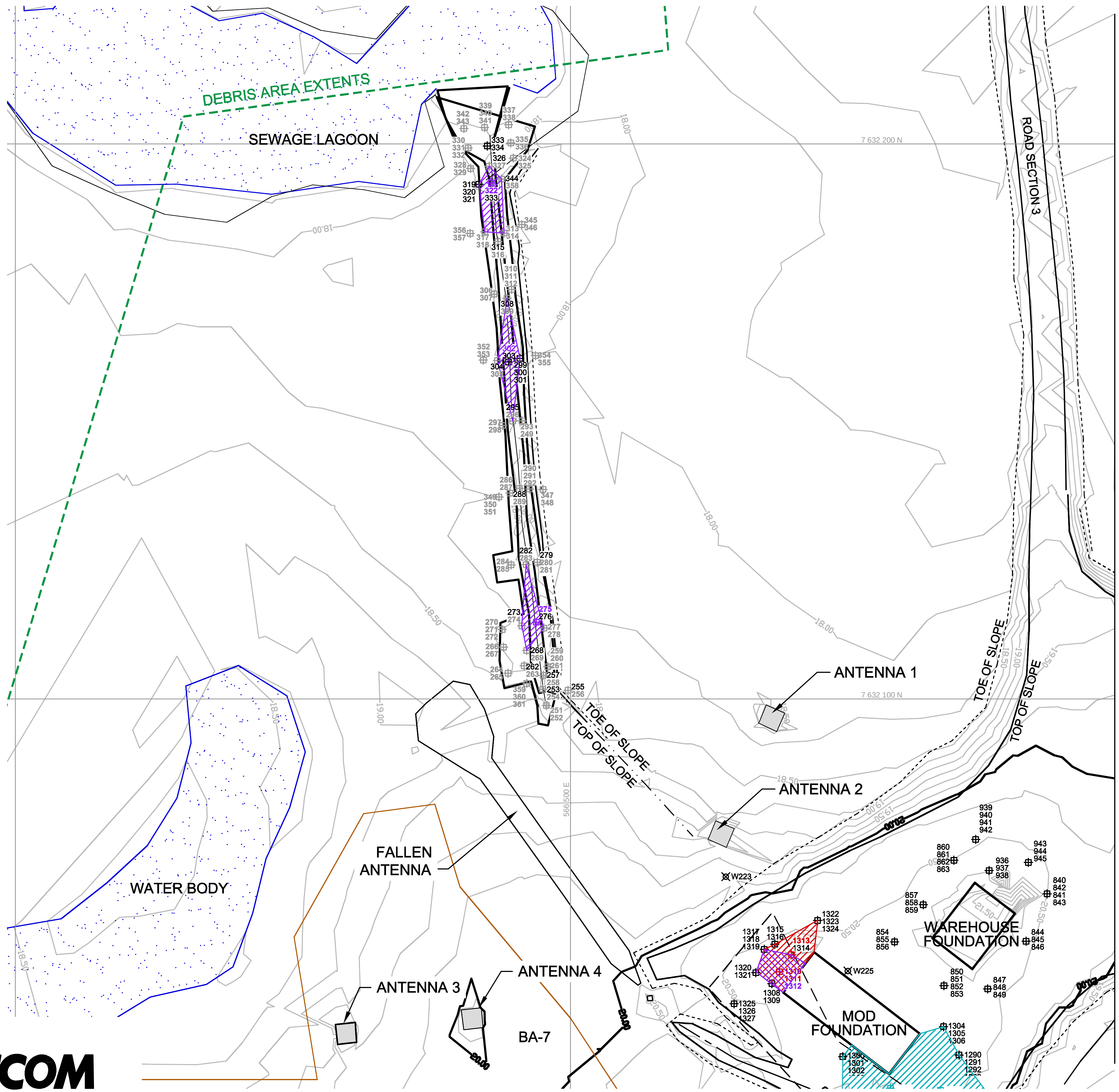


PWGSC
CAM-A Site Remedial Action Plan

Station POL

Figure 6

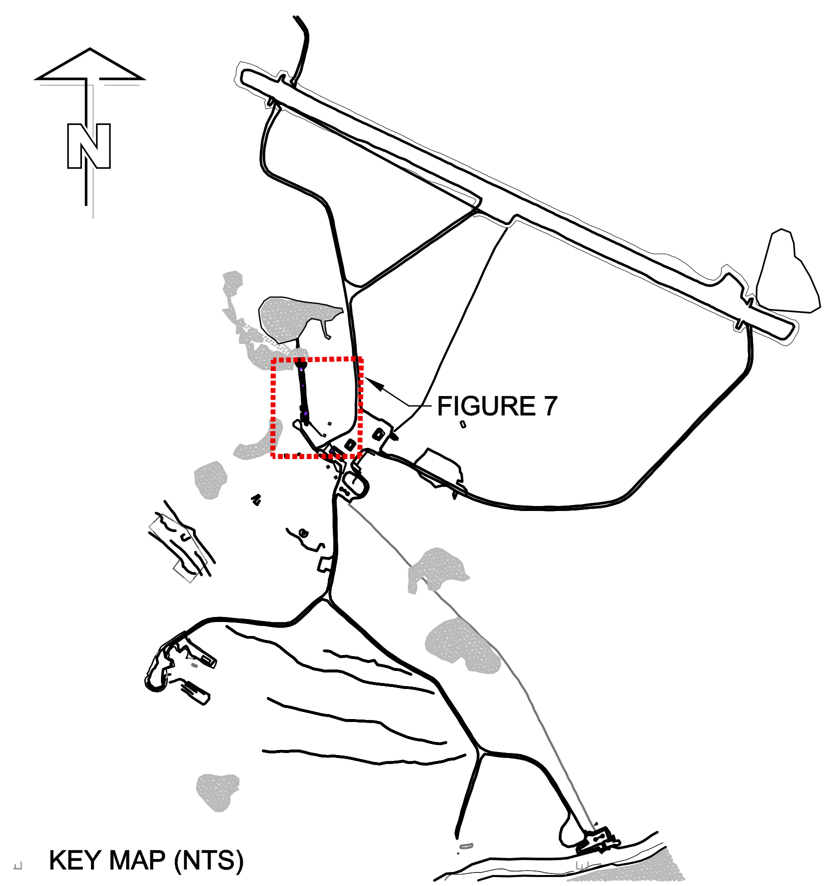


LEGEND

- DEBRIS WAY POINT
- SAMPLE POINT
- #### SAMPLE NUMBER - NO EXCEEDANCE
- #### SAMPLE NUMBER - HELD
- #### SAMPLE NUMBER - EXCEEDS TIER II
- TIER II CONTAMINATED SOIL
- #### SAMPLE NUMBER - EXCEEDS TIER I
- TIER I CONTAMINATED SOIL
- #### SAMPLE NUMBER - TYPE B PHC CONTAMINATION
- TYPE B PHC CONTAMINATED SOIL
- CONCRETE ANCHOR PAD
- BORROW SOURCE LOCATIONS
- PIPE

0 5 10 m SCALE 1:750

N



KEY MAP (NTS)

PWGSC
CAM-A Site Remedial Action Plan

Outfall

Figure 7

AECOM

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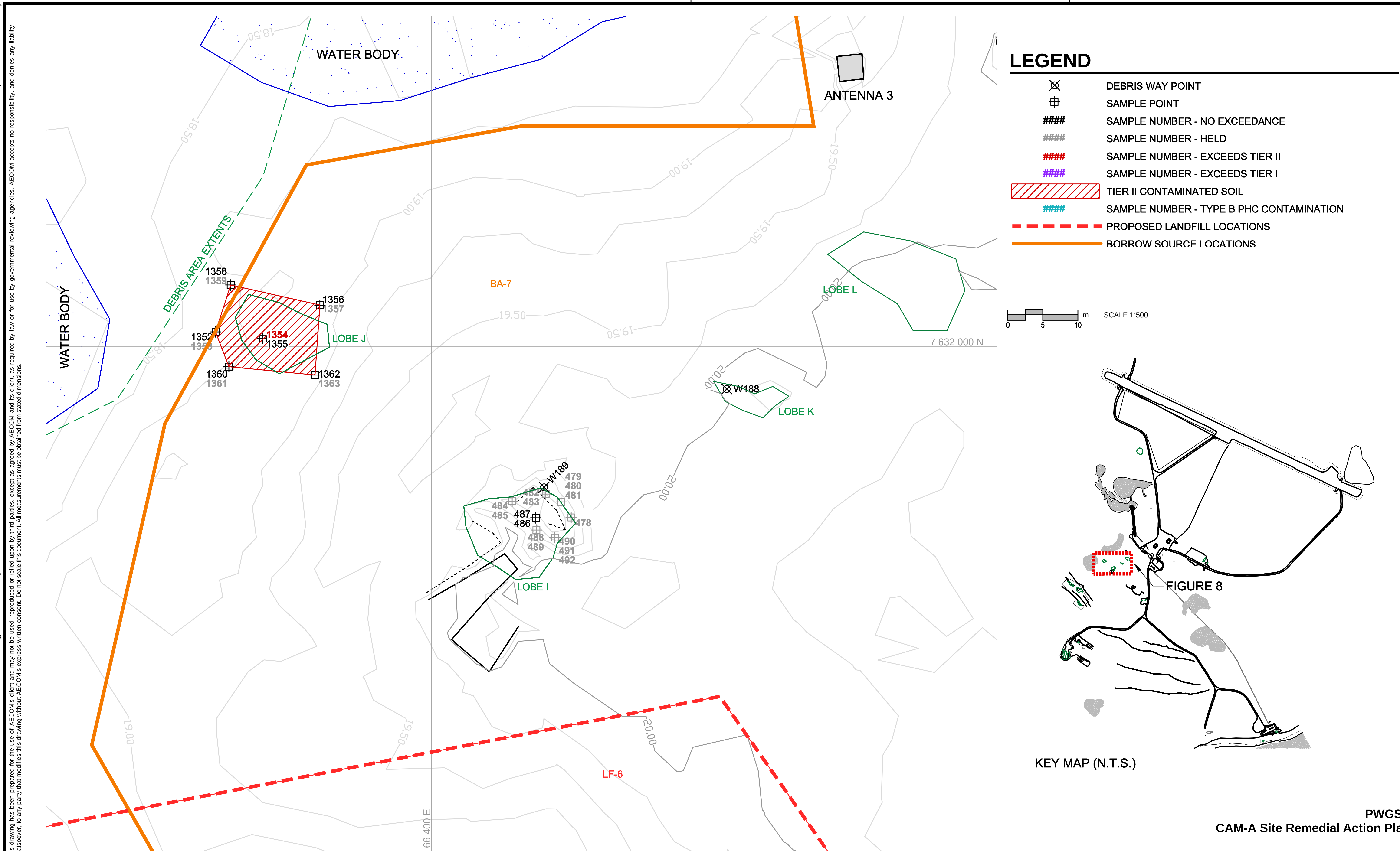

AECOM

PWGSC
CAM-A Site Remedial Action Plan

Worked Area

Figure 8

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Saved By: sandersonk

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ISS/REV: 0A

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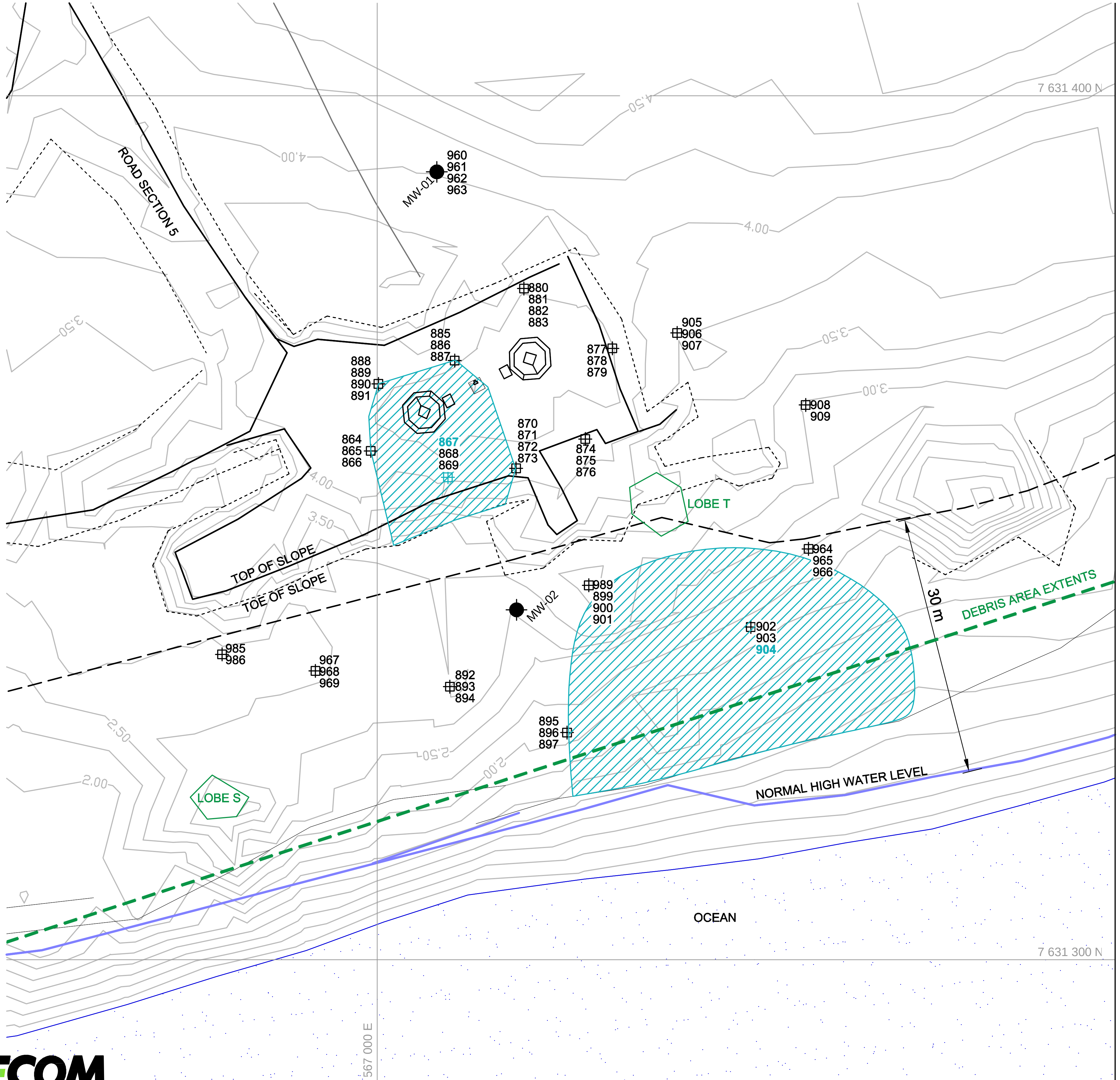
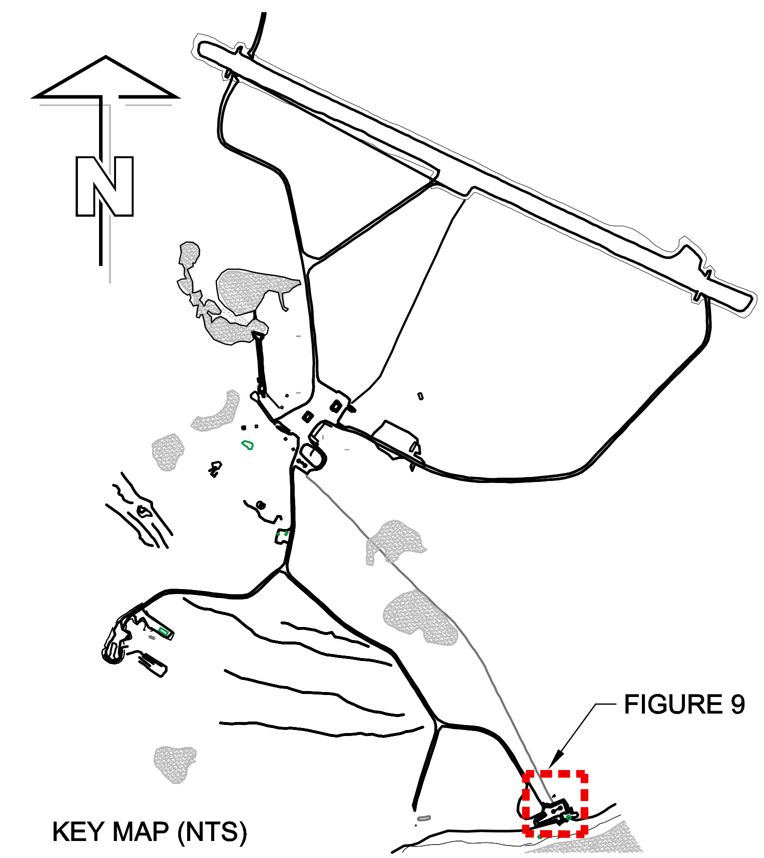


LEGEND

⊕	SAMPLE POINT
####	SAMPLE NUMBER - NO EXCEEDANCE
####	SAMPLE NUMBER - HELD
####	SAMPLE NUMBER - EXCEEDS TIER II
####	SAMPLE NUMBER - EXCEEDS TIER I
####	SAMPLE NUMBER - TYPE B PHC CONTAMINATION
	TYPE B PHC CONTAMINATED SOIL
- - - - -	TOE OF SLOPE
●	MONITORING WELL

0 5 10 m SCALE 1:500



KEY MAP (NTS)

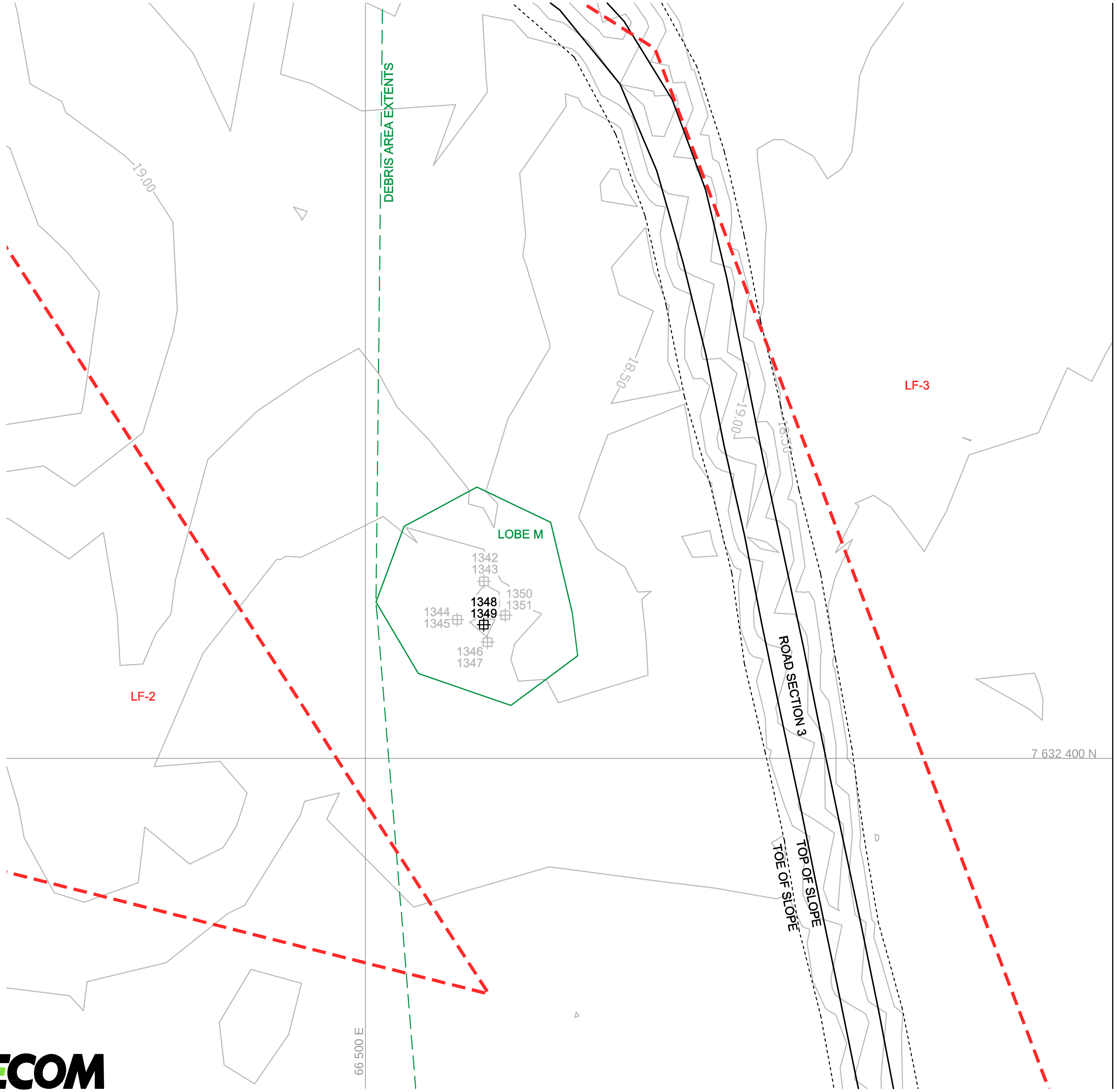
AECOM

PWGSC

CAM-A Site Remedial Action Plan

Beach POL

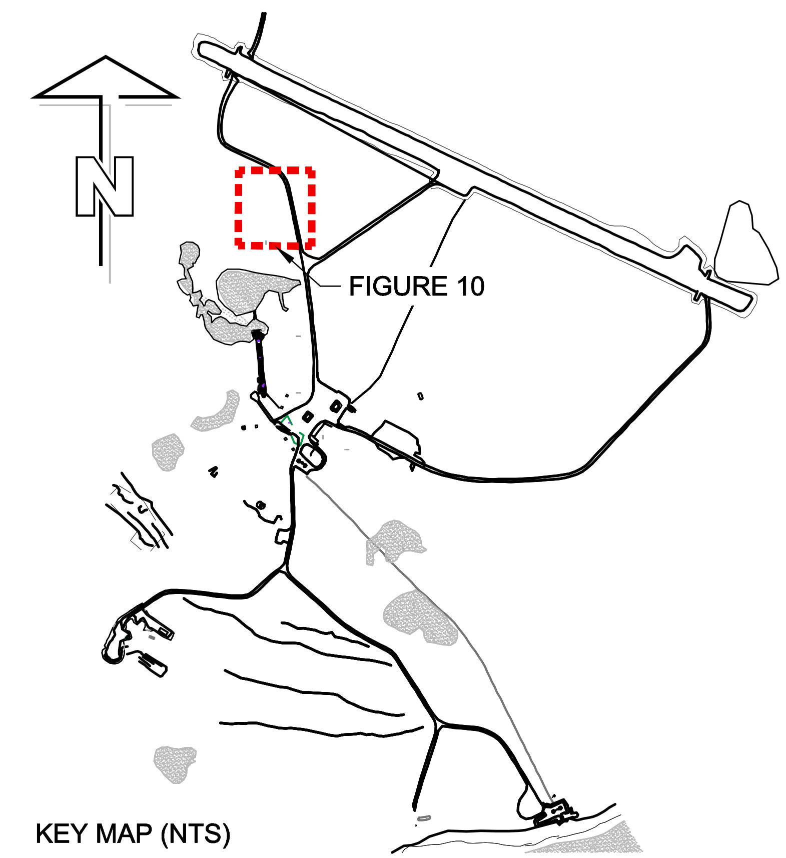
Figure 9



LEGEND

- DEBRIS WAY POINT
- SAMPLE POINT
- #### SAMPLE NUMBER - NO EXCEEDANCE
- #### SAMPLE NUMBER - HELD
- #### SAMPLE NUMBER - EXCEEDS TIER II
- #### SAMPLE NUMBER - EXCEEDS TIER I
- #### SAMPLE NUMBER - TYPE B PHC CONTAMINATION
- TOE OF SLOPE
- PROPOSED LANDFILL LOCATIONS

SCALE 1:500 (0, 5, 10 m)



KEY MAP (NTS)

PWGSC
CAM-A Site Remedial Action Plan

Lobe M

Figure 10

AECOM

Appendix B

Summary of Contaminated Soil Areas

Remedial Action Plan for CAM-A, Sturt Point
Table B1 - Summary of Contaminated Soil Areas

Location	Figure	Contaminants	Tier I			Tier II			PHC Type B			Comments
			Area (m^2)	Depth (m)	Volume (m^3)	Area (m^2)	Depth (m)	Volume (m^3)	Area (m^2)	Depth (m)	Volume (m^3)	
Beach POL	9	Type B PHCs	-	-	-	-	-	-	257.6	0.5	128.8	Delineated
		Type B PHCs	-	-	-	-	-	-	850	0.5-1.0	425	Not delineated
Garage	5	Tier II PCBs	-	-	-	18.5	0.5	9.25	-	-	-	Delineated laterally not vertically (assumed max depth of 0.5 m bgs)
			-	-	-	0.5	0.15	0.08	-	-	-	Delineated (contents of sump)
Mod Train	5	Tier I PCBs	39.5	0.2 (0.3-0.5)	7.9	-	-	-	-	-	-	Delineated laterally not vertically (assumed max depth of 0.5 m bgs)
		Tier II PCBs; Type B PHCs	-	-	-	71.6	0.3	21.48	571	1	571	Delineated
Sewage Outfall	7	Tier I PCBs	41	0.3	12.3	-	-	-	-	-	-	Delineated
			45	0.3	13.5	-	-	-	-	-	-	
			31	0.3	9.3	-	-	-	-	-	-	
Worked Area: Lobe J	8	Tier II Lead (Pb)	-	-	-	147.3	0.3	44.19	-	-	-	Delineated
Total Contaminated Soils Volumes (m^3)			43 m^3			75 m^3			1,124.8 m^3			1,242.8 m^3 (Site total)
WDA Excavation (m^3)			n/a			n/a			n/a			Class C WDA

Appendix C

Summary of Debris and Demolition

AECOM

Remedial Action Plan for CAM-A, Sturt Point
Table C1 - Summary of Surface Debris Areas

Figure	Location	Description	Photos	Waypoint	Estimated Areal Extent (m^2)	Estimated Uncrushed Volume (m^3)	Estimated Crushed Volume (m^3)	Estimated Crushed Hazardous Volume (m^3)
2	Marker Barrels	POL markers (39) or conduit markers (29)	E-66	-	-	68 m3	13.6 m3	-
8	Barrel Area A	Barrels (35)	E-102- E-106	-	-	35 m3	7 m3	-
2	Barrel Area B	Barrels (284)	E-82, E-83	W-005	-	284 m3	56.8 m3	-
	Barrel Area B	Large wooden cable spool	E-84	W-006	2 m2	6 m3	3.1 m3	-
Debris Area								
2	Airstrip Threshold Lights	One (1) light standard (threshold light) consisting of one (1) 15 m steel channel, two (2) 5 m long round pipes, galvanized cables, and a wood marker.	E-66	W-232, W-234	2 m2	1 m3	1 m3	-
2	Debris - Beach	Barrels (63)	-	-	-	63 m3	12.6 m3	-
	Debris - Beach	Wood debris	E-80	W-301	2 m2	0.5 m3	0.25 m3	-
	Debris - Beach	Scrap metal	-	W-302	0.5 m2	0.25 m3	< 0.25 m3	-
	Debris - Beach	Wood pallet	E-81	W-303	1 m2	0.5 m3	0.25 m3	-
	Debris - Beach	Angle iron (metal stand)	E-79	W-328	3 m2	1 m3	0.25 m3	-
8	Debris – Landfill A	Barrels (6)	-	-	-	6 m3	1.2 m3	-
	Debris – Landfill A	Metal garbage can	E-108	W-133	0.5 m2	0.5 m3	0.25 m3	-
	Debris – Barrel Area A	Vehicle debris & scrap metal	E-105	-	2 m2	0.6	0.6	-
9	Debris – Landfill B	Barrels (10.5)	-	-	-	10.5 m3	2.1 m3	-
	Debris – Landfill B	Partially buried cat track	E-95	W-166	3 m2	4 m3	2 m3	-
	Debris – Landfill B	Partially buried/crushed 5 gal metal pails (30)	E-97	W-169	5 m2	3 m3	0.6 m3	-
2	Debris – Station & Worked Area	Barrels (113)	E-87	W-067, W-073 to W-075	-	113 m3	22.6 m3	-
	Debris - Station	Wood pallets (3)	E-63	W-253	9 m2	0.6 m3	0.5 m3	-
	Debris - Station	Wood cable roll; scrap iron, tire (1); wood and steel debris	E-64	W-255	2 m2	0.5 m3	0.25 m3	-
	Debris - Station	Concrete debris	E-65	W-257	0.5 m2	0.25 m3	0.25 m3	-
	Debris - Station	Channel iron; steel pipe	E-19	W-263	1 m2	0.5 m3	0.25 m3	-
	Debris - Station	Tin cladding; scrap iron	E-20	W-264	2 m2	4.3 m3	3.5 m3	-
	Debris - Station	Steel pipe; angle iron	E-21	W-267	1 m2	0.5 m3	0.25 m3	-
	Debris - Station	Wood & metal debris	E-62	W-198	18 m2	3 m3	2 m3	-
	Debris - Station	Concrete antenna anchor pad x 6 pads; (3.6 m x 3.2 m x 0.6 m)	E-78	W-179	69 m2	42 m3	42 m3	-
	Debris - Station	Metal post 0.55 m stick-up	E-88	W-089	-	0.25 m3	< 0.25 m3	-
	Debris - Station	Steel pipe	E-90	W-098	4.2 m2	1 m3	0.5 m3	-
2	Debris – Worked Area	Steel pipe	E-76	W-187	1.6 m2	0.5 m3	0.25 m3	-
	Debris – Worked Area	Steel pipe	E-75	W-188	0.25 m2	0.25 m3	< 0.25 m3	-
7	Debris – Worked Area	Steel Debris/battery cells (4)	E-71, E-72 to E-74	W-189	4 m2	1.5 m3	-	1.2 m3
Inuit House Area								
13	Inuit House Area	Barrels (102)	E-112- E119	-	-	102 m3	20.4 m3	-
					TOTALS	754 m3	195.1 m3	1.2 m3

Remedial Action Plan for CAM-A, Sturt Point
Table C2 - Demolition Debris Inventory

Material/ Structure	Photo Reference	Description	Hazardous Material	Estimated Hazmat (m^3) (crushed)	Estimated Non-Haz (m^3) (crushed)	Comments
Radar Tower						
Painted surface	E-56, E-57	Painted steel pipe and triangular cross beam construction antenna. Cross section is approx. 66 m x 5 m x 5 m. Samples MAT-01 & MAT-02	No	n/a	Steel: 165 m^3 *(165 m^3 uncrushed)*	Paint samples were non-detect for PCBs and below 5 mg/L for leachable lead
Module Train						
Section of Module Train building	E-22 to E-43 MAT-23 (E-38)	Module train section is L: 12 m x W: 8 m (96m2) x H: 4.6 m Paint – exterior (MAT-23 & MAT-24) Building had a Timber crib foundation. Exterior is metal cladding. Plywood walls (both interior and exterior. Approx. 0.15 m thick walls are insulated Miscellaneous ducting, cables, structural steel for equipment, wiring, light fixtures (no bulbs) and wood doors	Yes, PCB paint, both adhered and flaked on the walls	PCB: Plywood: 7.1 m^3	Insulation: 28 m^3 *(57 m^3 uncrushed)* *Metal:* 0.7 m^3 *(2.9 m^3 uncrushed)* Misc. 3.3 m^3	Exterior paint after substrate calculation exceeds CEPA, 86.5 ppm (MAT-23)
	E-39 to E-43, E-37	The building contained electrical cabinets; three (3) CO2 tanks; two (2) generators; two (2) furnace fans two (2) diesel tanks. Paint – interior (MAT-17, MAT-18, MAT-19, MAT-20, MAT-21, MAT-22) Asbestos (ACM) pipe wrap & tank insulation	Yes, PCB paint, both adhered and flaked on the walls, ceiling, interior structures such as tanks and generators Yes, Asbestos (ACM)	PCBs: Tanks: 0.7 m^3 (3 m^3 uncrushed)	ACM: 1.8 m^3 Walls: 11.3 m^3 Tanks: 0.24 m^3 *(2.4 m^3 uncrushed)* Generator: 1 m^3 *(2 m^3 uncrushed)*	PCB paint after substrate calculation exceeds CEPA , 1,258 ppm (MAT-22) ACM: MAT-27, MAT-28, MAT-29, MAT-90
	E-43, E-35, E-36	Concrete 0.1 m thick (MAT-17, MAT-25 & MAT-26)	Yes, PCB paint No, PCB concrete	PCBs: 0.25 m^3	9.35 m^3	PCB concrete after substrate calculation does not exceed CEPA. Paint should be scraped off the concrete
Module Train Foundation	E-12	Eighteen (18) 9x9 timber beams, 11 m in length.	No, creosote levels were not of a concern.	n/a	10.35 m^3	
Associated Debris	E-58	Four (4) 9x9 timber beams, 2 m in length; fourteen (14) 2x4 timbers, 2 m in length	No	n/a	0.56 m^3	
	E-60	Plywood, entrance to module train 4 m x 1.5 m hollow wooden entrance with 2x4 wood frame (10 cm thick). Three (3) support beams (9x9 timbers) of 3 m length are associated with the entrance	No	n/a	3.7 m^3 *(4 m^3 uncrushed)*	
	E-62	Four (4) 9x9 timbers of 9 m length; metal basin 0.65 m x 70 cm x 30 cm (0.04 m thick)	No	n/a	1.9 m^3 *(2 m^3 uncrushed)*	

Material/ Structure	Photo Reference	Description	Hazardous Material	Estimated Hazmat (m^3) (crushed)	Estimated Non-Haz (m^3) (crushed)	Comments
Garage						
Foundation	E-13, E-14, E-15, E-47, E-46, E-45, E-44	12.5 m x 10.2 m pad, 0.1 m thick, (12.75 m^3) concrete floor with two grates on the pad Four (4) concrete samples were taken on the pad. ¼ of the concrete (MAT-14) exceeded Tier I PCBs, 1.02 ppm; ½ the pad (MAT-15, MAT-16) exceeded Tier II PCBs, 116, 126 ppm, respectively	PCB concrete (approx. ¾ of the pad, 9.56 m^3)	n/a	12.75 m^3	PCB concrete after substrate calculation does not exceed CEPA
Associated Debris	E-52	Boiler – paper insulation (MAT-06)	Asbestos wrap on boiler, >75% Asbestos	n/a	ACM: 1.1 m^3	
	E-52	Boiler – plaster (trowel) insulation (MAT-07)	Asbestos wrap on boiler, 30-50% Asbestos	n/a		
Warehouse						
Warehouse foundation	E-18,E-47, E-48, E-53, E-54, E-55 E-16, E-51	Concrete Floor elevated on concrete base. There are eight (8) 0.75 m x 0.75 m x 0.25 m footings and eight (8) 0.45 m x 0.45 m x 1.0 m footings. Concrete pad is 12.5 m x 9 m (112.5 m2) and 0.4 m thick. Paint on wooden stairs (MAT-08). PCB Paint exceeds Tier I criteria (1.89 ppm)	None	n/a	45 m^3 Tier I: 2 m^3	The concrete pad and footing remains intact. There is an area of extensive debris surrounding the foundation. Debris includes asbestos wallboard, painted diesel tanks (2), plywood, 5-step wood staircase
	E-16, E-49, E-50	Painted plywood, entrance to warehouse (MAT-09) 3.6 m x 2.5 m hollow wooden entrance with 2x4 wood frame. Three (3) support beams (9x9 timbers) of 3 m length are associated with the entrance	No	n/a	3.7 m^3 *(4 m^3 uncrushed)*	
Associated Debris	E-17, E-39 (MAT-21)	Painted AST tanks	Based on the results of the paint sample from the AST within the module train section, PCB impacts are assumed to be comparable	n/a	Tanks: *0.24* m^3 *(2.4 m^3 crushed)*	PCB concrete after substrate calculation does not exceed CEPA
	E-17, E-18	Concrete pad for ASTs 1.6 m x 2 m (3.2 m^2), 0.1 m thick	None	n/a	0.32 m^3	
	E-55	Vinyl tile (MAT-03)	No	n/a	0.5 m^3	
	E-54	Cement board (MAT-04)	15-30% Asbestos		0.5 m^3	
	E-53	Press board (MAT-05)	No	n/a	1.0 m^3	
POL Pad Piping and Associated Infrastructure						
POL Pad (Beach & Station POLs)	E-110	Concrete associated with former POL pads	No	n/a	7.6 m^3	
Inuit Houses						
House #1 (northern house)	E-112, E113, E-114	Degraded house (28 m2), 2x4 wood frame with plywood walls	No	n/a	7.5 m^3	
House #2 (southern house)	E-112, E-115 to E118	Degraded house (38 m2), 2x4 wood frame with plywood walls	No	n/a	10.5 m^3	
			TOTALS	8.05 m^3	329.91 m^3	(Total crushed volumes)

Table C3: Debris & Materials Analytical

Sample #	Area	Purpose	% Coverage	Aroclor 1242	Aroclor 1254	Aroclor 1260	PCB Total ppm	Asbestos (bulk) %	Asbestos (bulk) % Phase I	Asbestos (bulk) % Phase II	Lead (Total)	Lead Leachable	Naphthalene	Methyl Naphthalenes	Dimethyl Naphthalenes	Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo[a]anthracene, Chrysene, Benzo(b+j)fluoranthene, Benzo(k)fluoranthene, Benzo[a]pyrene, Indeno[1,2,3-cd]pyrene, Dibenzofuran, Dibenz[ah]anthracene, Benzo[ghi]perylene, Pentachlorophenol, Carbazole, Methyl Anthracenes, 3-Methylcholanthrene
CEPA							50									
Tier II							5									
Tier I							1									
MAT01	MAIN STATION	Paint - Antenna (orange)	70	<0.05	<0.05	<0.05	<0.05				150000	1.4				
MAT02	MAIN STATION	Paint - Antenna (white)	60	<0.05	<0.05	<0.05	<0.05				18000	<0.5				
MAT03	MAIN STATION	Vinyl tile - Warehouse	-					ND								
MAT04	MAIN STATION	Cement board - Warehouse	-					15-30								
MAT05	MAIN STATION	Press board - Warehouse	-					ND								
MAT06	MAIN STATION	Boiler paper insulation - Garage	-					>75								
MAT07	MAIN STATION	Boiler trowel insulation - Garage	-	<0.05	0.28	<0.05	0.28	30-50								
MAT08	MAIN STATION	Paint - Warehouse (off-white)	60	<0.05	<0.05	1.85	1.89				410	<0.5				
MAT09	MAIN STATION	Paint/plywood - Warehouse (white)	100	<0.05	0.58	<0.05	0.58				615	<0.5				
MAT10	MAIN STATION	Cement board - Warehouse	-					15-30								
MAT11	MAIN STATION	Concrete - Warehouse	-	<0.05	0.49	<0.05	0.49									
MAT12	MAIN STATION	Concrete - Warehouse	-	<0.05	<0.05	<0.05	<0.05									
MAT13	MAIN STATION	Concrete - Garage Pad	-	<0.05	0.79	<0.05	0.79									
MAT14	MAIN STATION	Concrete - Garage Pad	-	<0.05	1.02	<0.05	1.02									
MAT15	MAIN STATION	Concrete - Garage Pad (stain)	-	<0.05	116	<0.05	116									
MAT16	MAIN STATION	Concrete - Garage Pad	-	<0.05	126	<0.05	126									
MAT17	MAIN STATION	Paint Interior (floor) - Module Train (grey)	100	<0.05	261000	<0.05	261000				2530					
MAT18	MAIN STATION	Paint Interior (generator) - Module Train (grey)	75	<0.05	1310	<0.05	1310				486	<0.5				
MAT19	MAIN STATION	Paint Interior (walls) - Module Train (grey)	90	<0.05	8750	2400	11100				2540					
MAT20	MAIN STATION	Paint Interior (fan blades) - Module Train (red)	60	<0.05	162	<0.05	162				10,000					
MAT21	MAIN STATION	Paint Interior (ASTs) - Module Train (grey)	60	<0.05	1280	<0.05	1280				2380	<0.5				
MAT22	MAIN STATION	Paint Interior (water tank) - Module Train (grey & red)	85	<0.05	11100	<0.05	11100				2000	<0.5				
MAT23	MAIN STATION	Paint Exterior - Module Train (off-white)	60	<0.05	<0.05	763	763				1300	<0.5				
MAT24	MAIN STATION	Paint Interior (entrance) - Module Train (red & white)	40	<0.05	190	<0.05	190				3560					
MAT25	MAIN STATION	Concrete - Module Train	-	<0.05	250	<0.05	250									
MAT26	MAIN STATION	Concrete - Module Train	-	<0.05	473	<0.05	473									
MAT27	MAIN STATION	Pipe insulation - Module Train	-					30-50								
MAT28	MAIN STATION	Pipe insulation - Module Train	-						ND	>75						
MAT29	MAIN STATION	Tank insulation - Module Train	-					15-30								
MAT30	MAIN STATION	Tank insulation - Module Train	-						50-75	30-50						
MAT31	MAIN STATION	Wood - Module Train Foundation	-	<0.05	0.17	<0.05	0.17					<0.5	0.02	0.089	0.065	<0.01

Appendix D

INAC Abandoned Military Site Remediation Protocol

Affaires indiennes et du Nord Canada
Indian and Northern Affairs Canada

Abandoned Military Site Remediation Protocol

Volume I – Main Report

Indian and Northern Affairs Canada
Northern Affairs Organization
Contaminated Sites Program

Final
March 2009

Canada

Indian and Northern Affairs Canada / Affaires indiennes et du Nord Canada

Abandoned Military Site Remediation Protocol

Volume I – Main Report

March 2009

Indian and Northern Affairs Canada

ACKNOWLEDGMENTS

This Protocol is an update on the previous Indian and Northern Affairs Canada (INAC) Abandoned Military Site Remediation Protocol, which was produced in 2005. Considerable intellectual effort has gone into the revisions and updates contained in this new Protocol and INAC wishes to recognize and thank the organizations involved in its development.

This document, which is comprised of Volume I (Main Report) and Volume II (Supporting Technical Documentation) is a product of the collaborative efforts by the following organizations:

- Environmental Sciences Group, Royal Military College of Canada
- Golder Associates Ltd.
- EBA Engineering Consultants Ltd.
- UMA Engineering Ltd. (now AECOM)
- Qikiqtaaluk Environmental Inc.
- Jacques Whitford Ltd.
- Dept. of Geological Sciences and Geological Engineering, Queen's University

INAC also wishes to recognize and thank the members of the Technical Advisory Working Group who provided invaluable input to development of this Protocol.

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1 INTRODUCTION

In the 1950s, at the height of the Cold War, a number of facilities were constructed in the Canadian Arctic to provide surveillance of northern approaches to the continent. The largest installation was the Distant Early Warning (DEW) Line, a series of radar stations spanning the northern coastline from Alaska to Greenland. In total, 63 stations were constructed, 42 of which were located in Canada. In 1963, due to advances in technology, installations at 21 of the sites were considered redundant and these sites were abandoned. All buildings, vehicles, Petroleum Oil Lubricant (POL) storage tanks and miscellaneous debris were left in place. Administration of these sites was transferred to Indian and Northern Affairs Canada (INAC) (Fletcher 1989; INAC 2002). Other abandoned military sites include those associated with the Pole Vault line in the eastern Arctic. Locations of INAC military sites in the Canadian Arctic are indicated on Figure 1. The remainder of the installations on the DEW Line continued to operate until the early 1990s, at which point most of them were converted to the North Warning System (NWS). Decommissioning and cleanup of these 21 sites, excluding facilities that are required for the operation of the NWS, is the responsibility of the Department of National Defence (DND).

Several environmental issues were at these abandoned military sites based on previous preliminary and detailed assessments at the INAC and DND sites (ESG 1991, 1993). These issues include physical hazards related to unconsolidated debris and aged structures, and environmental impacts associated with soil contamination. In 1996, DND initiated remediation of the DEW Line sites under its jurisdiction and cleanup of these sites is on going. The cleanup follows the conditions of the DEW Line Cleanup Protocol (ESG, 1993 and ESG/UMA, 1995) and the co-operation agreements between DND and Nunavut Tunngavik Inc. (NTI) (DGE 1998) and DND and the Inuvialuit Regional Corporation (IRC) (DGE 1996).

INAC has completed the remediation of a number of sites across the Canadian Arctic namely Iqaluit Upper Base, Resolution Island (BAF-5), Horton River (BAR-E), Sarcpa Lake (CAM-F), and Pearce Point (PIN-A). The approach adopted for remediation of these sites has generally been consistent with the methodology applied at the DND DEW sites (PWGSC 2001 to 2003). Due to the commitment of the Federal Government to future funding of contaminated site clean up, INAC recognizes the need for a consistent protocol for abandoned military site cleanup (INAC 2002).

A number of factors must be considered when determining the most suitable approach to site remediation for remote sites in the Arctic environment. The Abandoned Military Site Remediation Protocol (AMSRP) is based on an approach that addresses legal requirements, INAC's Contaminated Sites Policy (including risk management requirements), and standard environmental management practices (INAC 2002).

This Protocol also takes into consideration financially prudent methodologies that address environmental issues while striking a balance with remedial cost. An over-arching principle has been to balance the environmental benefits of remediation activities with potential negative physical impacts to the Arctic environment.

The primary objectives of this document are to provide sufficient background information to understand the environmental issues present at these sites, and to describe the guiding principles for their assessment and remediation. AMSRP, Volume 2 (INAC 2009) provides additional supporting technical information.

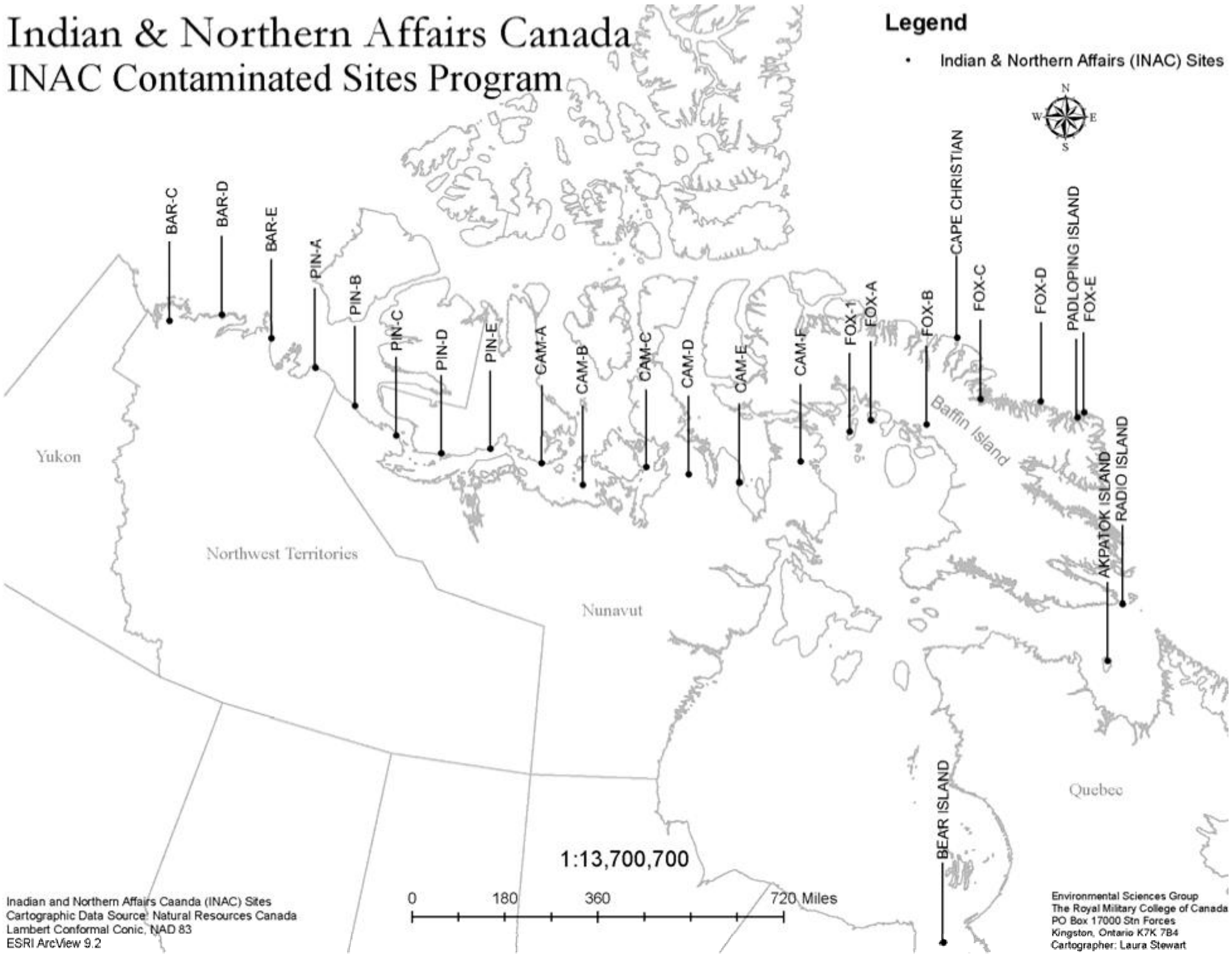

Figure 1 Location of INAC Military Sites

1.1 Scope of Document

This document is structured in a manner generally consistent with the steps outlined in the Federal Contaminated Sites Action Plan (CSM 2000) as shown in Figure 2. As previously indicated, issues of environmental concern have been identified at the INAC DEW Lines (Step 1). Extensive historical data (Steps 2 and 3) from initial environmental assessments, as well as detailed information collected through assessment of DEW sites under the jurisdiction of DND, has been used to develop the requirements for the detailed assessment of the INAC sites (Step 5), as described in Section 4. Guidelines for development of a remediation strategy (Step 7) are provided in Section 5. Implementation related issues, such as confirmatory sampling, waste manifesting, construction quality assurance/quality control measures (Step 9) are described in Section 6. Post-implementation monitoring requirements are described in Section 7 (Step 10).

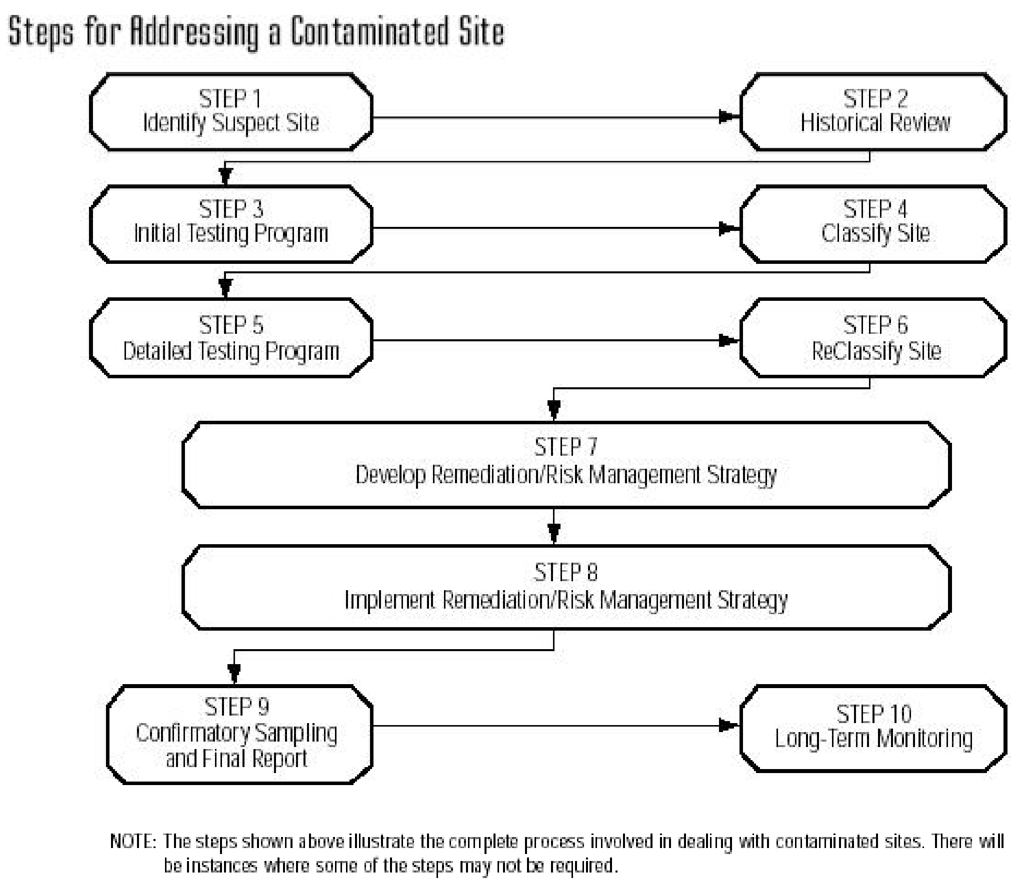

Figure 2 Steps for Addressing a Contaminated Site

2 BACKGROUND

2.1 CCME Environmental Quality Guidelines

Where remediation of federal real property is carried out, departments and agencies are to set remediation objectives in accordance with the most applicable of the three methods developed by the Canadian Council of Ministers of the Environment (CCME) (CCME 1997):

CCME Tier 1: Follow CCME Environmental Quality Guidelines (CCME 1997, 1999), as amended from time to time, and, where applicable, the *Canada-wide Standard for Petroleum Hydrocarbons in Soil* (CCME 2008), as amended from time to time. To the extent that guidelines do not exist for a particular type of contamination, or are technically or economically inappropriate for a particular situation, departments and agencies may follow equivalent guidelines or standards (e.g. provincial);

CCME Tier 2: Follow modified CCME Environmental Quality Guidelines where site conditions, land use, receptors, or exposure pathways differ only slightly from the protocols used in the development of the guidelines; and

CCME Tier 3: Develop site-specific remediation objectives based on a site-specific risk assessment, as outlined by the CCME, or equivalent, where site conditions are unique or particularly sensitive.

Although the CCME Environmental Quality Guidelines are broad in application and address a wide variety of land uses and potential contaminants from diverse sources, they do not specifically address the environmental conditions representative of the Arctic, as discussed in AMSRP Volume 2 (INAC 2009).

2.2 Department of National Defence (DND) DEW Line Cleanup (DLCU) Protocol

The initial environmental assessment of DEW Line sites under the jurisdiction of DND was one of the first major contaminant investigations in the Arctic related to point source contaminants. Following these assessments in the early 1990s, DND developed a remedial protocol in consultation with other government agencies and stakeholders (ESG 1991, 1993), and referred to it as the DEW Line Cleanup (DLCU) Protocol. This Protocol was developed at a time when no remediation standards and criteria specific to the Canadian Arctic existed. The remedial criteria were developed using a contaminant source and pathway targeted approach, consistent with CCME's Tier 3 method. A broad suite of chemicals was investigated and contaminants of concern at DEW Line sites were identified as those contaminants that were consistently elevated relative to the site background levels and the available Canadian federal or provincial guidelines (CCME 1991). The rationale for selection of contaminants of concern is provided in AMSRP Volume 2 (INAC 2009). Engineering input with respect to remediation strategies was used to refine the cleanup protocol (ESG/UMA 1995) prior to its implementation at the first DND sites in 1996.

Cleanup of Arctic sites presents a number of unique challenges, including but not limited to:

- Remote site location, with access limited to sea-lift and small aircraft during the summer months, and over-land during winter;
- Short construction season, typically from July to September, which may limit the technical feasibility of remedial options;
- Lack of centralized waste disposal facilities;
- High costs associated with mobilization of equipment and personnel to the sites, both during the site assessment and remedial phases; and
- Sensitivity of the Arctic ecosystem to changes in physical habitat.

Experience gained since 1996 at the DND sites has been reviewed annually to evaluate lessons learned and to incorporate new information and methodologies as they become available. The DLCU protocol therefore is the culmination of scientific and engineering expertise that has been applied across the Arctic at the DND sites.

Although there are many similarities between INAC and DND DEW sites, the INAC sites were in operation for a significantly shorter period of time, and environmental issues tend to differ in scale. In addition, there may have been other land use subsequent to the DEW Line activities. INAC sites and the associated known land uses are summarized in Table 2.1

Table 2.1 Summary of INAC Military Sites and Historic Land Use

Site Designation/Name	Location	Other Historic Land Use/ or Issues
BAR-C Tununuk Camp	NWT	Imperial Oil as Lessee
BAR-D, Atkinson Point	NWT	Canadian Marine Drilling (CANMAR) Canadian Reindeer Ltd. (note: cleanup on-going)
BAR-E Horton River	NWT	SRR, (note: cleanup completed, monitoring on-going)
PIN-A Pearce Point	NWT	Biological Research Station (note: cleanup completed, monitoring ongoing)
PIN-B Clifton Point	Nunavut/Kitikmeot	
PIN-C Bernard Harbour	Nunavut/Kitikmeot	
PIN-D Ross Point	Nunavut/Kitikmeot	
PIN-E Cape Peel	Nunavut/Kitikmeot	
CAM-A Sturt Point	Nunavut/Kitikmeot	
CAM-B Hat Island	Nunavut/Kitikmeot	Short Range Radar (SRR) as part of North Warning System
CAM-C Matheson Point	Nunavut/Kitikmeot	
CAM-D Simpson Lake	Nunavut/Kitikmeot	SRR (module train dismantled and buried on site)
CAM-E Keith Bay	Nunavut/Qikiqtaaluk	Module train gone/some evidence of burning
CAM-F Sarcpa Lake	Nunavut/ Qikiqtaaluk	Research Station (note: cleanup completed, monitoring ongoing)
FOX-1 Rowley Island	Nunavut/Qikiqtaaluk	SRR (large burn area, module train gone)
FOX-A Bray Island	Nunavut/Qikiqtaaluk	SRR (module train gone)
FOX-B Nudluardjuk Lake	Nunavut/Qikiqtaaluk	SRR (module train gone)
FOX-C Ekalugad Fiord	Nunavut/Qikiqtaaluk	
FOX-D Kivitoo	Nunavut/Qikiqtaaluk	Fire destroyed main building train in 1963
FOX-E Durban Island	Nunavut/Qikiqtaaluk	Partially burned building

Site Designation/Name	Location	Other Historic Land Use/ or Issues
Cape Christian	Nunavut/Qikiqtaaluk	LORAN Site
Padloping Island	Nunavut/Qikiqtaaluk	Navigational aid and weather station
Radio Island	Nunavut/Qikiqtaaluk	Navigational aid and weather station (note: cleanup completed, no monitoring required)
Bear Island	Nunavut/Qikiqtaaluk	Mid-Canada site
BAF-5 Resolution Island	Nunavut/Qikiqtaaluk	Pole-Vault site (note: cleanup completed, monitoring ongoing)
Iqaluit, Upper Base	Nunavut/Qikiqtaaluk	Pole-Vault site (note: cleanup completed, monitoring ongoing)

Cleanup objectives were set for the INAC sites, and the INAC AMSRP was developed as outlined in the following sections.

3 CLEANUP OBJECTIVES

Cleanup objectives, which are consistent with the Federal Contaminated Sites Management Working Group (CSMWG) objective to "integrate sustainable development and pollution prevention principles while meeting environmental regulations and protecting public health" (CSM 2000, TB 1998, 2000, 2002), are as follows:

- To restore sites to meet the environmental objectives established for northern sites;
- To prevent migration of contaminants into the Arctic ecosystem;
- To remove physical hazards for the protection of human health and safety; and
- To implement a cost effective remediation solution.

These objectives are consistent with those applied in the remediation of DEW Line sites under the jurisdiction of DND (DGE 1996, 1998). The following considerations need to be taken into account when developing and implementing a Remedial Action Plan (RAP) for INAC sites:

- Respect all historical agreements and obligations in a fair and reasonable manner;
- Ensure consistency with federal guidelines for management of contaminated sites;
- Apply the Canadian Council of Ministers of the Environment (CCME) environmental protection and management approaches (CCME 1996, 1997, 1999, 2001, 2008) as applicable;
- Apply simple, practical remedial solutions wherever possible, with flexibility as necessary to adjust to site-specific conditions when they are identified;
- Establish cost effective solutions through use of best practices to ensure appropriate levels of environmental protection for all sites;
- Recognize the concerns of climate change in an Arctic setting; and
- Ensure long-term effectiveness of the environmental remedial measures.

It is Canadian government policy that all federal departments and agencies ensure sound environmental stewardship with respect to property in their care by avoiding contamination and managing contaminated sites in a consistent and systematic manner that recognizes the principle of risk management and results in the best value for the Canadian taxpayer (TB 1998, 2000, 2002). The following section identifies the primary factors that have been considered in developing a remediation approach.

3.1 Biophysical Environment

The INAC abandoned military sites are located across the Arctic in the Southern Arctic Ecozone in the western Arctic, in the Northern Arctic Ecozone in the central and eastern Arctic, and the Arctic Cordillera along the east coast of Baffin Island. The majority of the sites are located along the coastline. (Agriculture and Agri-Food Canada, 1996).

Mean annual temperatures are in the range of $-11^{0}C$ in the western Arctic and tend to be colder in the central and eastern Arctic. Accordingly, all sites are located within the zone of continuous permafrost. Much of the Arctic region is classified as polar desert as annual precipitation, predominantly as snow, is generally within the range of 100 to 300 mm. One exception is the eastern coastline of Baffin Island near Cumberland Peninsula, where precipitation can be in the order of 400 to 600 mm annually.

As indicated, the Arctic ecosystem is characterized by extreme environmental conditions, including cold temperatures, large seasonal fluctuations in incoming solar radiation, extensive snow and ice cover, and short growing seasons. These conditions affect the productivity, species diversity, wildlife behaviour (e.g., migration), and food chain characteristics of Arctic ecozones. For example, productivity in terrestrial, freshwater, and marine environments is reduced due to limited nutrient availability, low light, low temperatures, ice cover, and short growing seasons. Compared to most other ecosystems, the Arctic is characterized by relatively low reproduction, organisms that are slower to reach sexual maturity and are generally longer lived, lower species diversity, and distinctive sub-ice biological communities. Relatively short food chains, which are characteristically known for their dominance of marine mammals and birds, are associated with simple predator-prey relationships (e.g. phytoplankton-zooplankton-fish-seal-polar bear or phytoplankton-zooplankton-whale). The combination of all these physical factors affect the sparse distribution and number of Arctic biological communities and makes them very sensitive to physical disturbances such as habitat destruction (AMAP 1998, CACAR 2003).

The assessment and remedial protocols developed are cognizant of striking a balance between the physical disturbances of existing impacted areas versus the physical disturbances of developing new areas required to support remediation activities.

4 ASSESSMENT PROTOCOL

The elements of the assessment protocol have been developed through the review of previous work at related sites (eg. PWGSC 2001a-c, 2002a-f, IEG 2001, EWG 1998, 1999, UMA 1994) and take into consideration information of particular relevance to the unique character of the INAC sites. Typical environmental issues at abandoned military sites include:

- Contaminated soils;
- Existing solid waste disposal areas;
- Debris on surface and in waters near the sites;
- Debris associated with the demolition of structures/facilities; and
- Hazardous waste.

The objective of the environmental assessment of these sites is to collect sufficient information to allow development of a Remedial Action Plan (RAP).

Issues related to implementation, including but not limited to: environmental screening, permitting, and construction, also require information to be collected at the assessment stage. These information requirements can include:

- Geotechnical site information relating to potential development areas for landfills and/or hydrocarbon contaminated soil treatment area, and available borrow sources;
- Site access, such as condition of roadways, the airstrip, barge landing areas, requirements for winter roads or CAT train routes;
- Potable water supply and seasonal fluctuations of potable water supply;
- Siting of camp facilities and temporary storage areas;
- Natural Environment Assessment;
- Traditional Knowledge Surveys/Assessment; and
- Archaeological Assessment.

This section of the protocol provides guidance related to conducting an environmental site assessment that meets the requirements of the INAC cleanup objectives.

4.1 Background Geo-Chemical Assessment

Application of remedial criteria must take into account background concentrations of inorganic elements, as naturally elevated concentrations of a select number of inorganic elements may impact assessment and subsequent remedial activities. High natural variability in concentrations of inorganic elements on a local scale has been observed at several DND DEW Line sites (PIN-1, DYE-M, FOX-2, FOX-3). Based on a desk-top study of the geochemistry and surficial and bedrock geology, a detailed investigation of background concentrations is required in conjunction with the environmental site assessment of the following sites:

- Ross Point (PIN-D)
- Nadluarjuk Lake (FOX-B),
- Kivitoo (FOX-D),
- Durban Island (FOX-E) and
- Padloping Island.

A statistically valid approach must be used to design a sampling program for the collection of representative samples from background areas. Guidance for the background geochemistry investigation is provided in AMSRP Volume 2 (INAC 2009).

4.2 Contaminated Soils

4.2.1 Inorganic Elements and PCBs – DCC Criteria

The contaminants of concern for INAC abandoned military sites, where historic land use is limited to former DEW Line operations, is based on a detailed review of data collected to date from DND and INAC site assessment and delineation programs. The DEW Line Cleanup (DLCU) Protocol, which includes criteria for a specific, limited set of contaminants, is considered appropriate for INAC sites. Supporting documentation for selection of these criteria is provided in AMSRP Volume 2 (INAC 2009).

This provides a consistent approach across all sites, and is generally considered protective of the Arctic ecosystem as described in AMSRP Volume 2 (INAC 2009). Table 4.1 identifies the parameters and criteria.

Table 4.1 DEW Line Cleanup Criteria (DCC) for Soil[a]

Parameter in Soil	**CRITERIA[b]** mg/kg	
Inorganic Elements	*DCC Tier I [c]*	*DCC Tier II[d]*
Arsenic (As)		30
Cadmium		5.0
Chromium		250
Cobalt		50
Copper		100
Lead	200	500
Mercury		2.0
Nickel		100
Zinc		500
Polychlorinated biphenyls		
PCBs	*1.0*	*5.0*

a. These criteria were adopted specifically for the cleanup of Arctic DEW Line Sites from the 1991 versions of the Quebec Soil Contamination Indicators and the Canadian Council of Ministers of the Environment Interim Canadian Environmental Criteria for Contaminated Sites. They were validated by an assessment of the soil concentration at which the substance was taken up by vascular plants and thereby constituted an input to the Arctic ecosystem.

b. Soil criteria are given in parts per million, ppm.

c. Soils containing lead and/or PCBs at concentrations in excess of DCC Tier I, but less than DCC Tier II, may be landfilled in a Non-Hazardous Waste Landfill,

d. Soils containing one or more substrates in excess of DCC Tier II are to be treated/disposed of in a manner that precludes contact with the Arctic ecosystem.

A review of data collected on INAC sites with land use other than DEW Line activities indicated that the likelihood of other parameters occurring systematically at concentrations exceeding applicable criteria in the absence of other contaminants of concern is low (AMSRP Volume 2 (INAC 2009)).

Based on historic patterns of waste disposal and contamination observed at other abandoned military sites, soils contaminated in excess of the DCC criteria are typically found in the following locations:

- In the vicinity of buildings;
- Former sewage discharge areas;
- Former open storage areas;
- Where surface debris is present;
- Solid waste disposal areas; and
- Petroleum, Oil, Lubricant (POL) bulk storage areas and along fuel lines and transfer locations.

Delineation of the lateral extent and depth of contamination is required to determine quantities of sufficient accuracy to develop a RAP and the subsequent Contractual Drawings and Specifications. A detailed sampling plan shall be developed for each potential area of concern identified as part of historic review, and shall include the following information:

- Description of the objective for each potential area of concern;
- Sampling locations;
- Sampling methodology;
- Proposed number of samples and media;
- Parameters for analyses; and
- Analytical requirements and Quality Assurance/Quality Control measures.

Delineation shall be achieved by sampling in a grid pattern over the affected area. The estimated size of the area determines the grid spacing: the larger the estimated area, the larger the grid spacing. Test pits shall be excavated to determine the depth of contamination. Test pits shall also be excavated outside the area of surface contamination to evaluate whether sub-surface migration of contaminants has occurred. Greater sample density may be warranted based on site specific conditions, particularly in areas where soils contaminated with PCB concentrations in excess of 50 ppm are suspected; such as near buildings where electrical transformers were housed, vehicle maintenance structures, and near exit doors of facilities. It is recommended that a reasonable degree of over-sampling and an iterative approach to analyses be employed to provide greater confidence that closure is achieved during the assessment phase, recognizing that the cost of analyses is only a fraction of disposal costs.

Additional samples shall be collected and analysed to determine transport and disposal requirements should off-site disposal of contaminated soils be required.

4.2.2 Hydrocarbon Contaminated Soils

Where free product is encountered, the free phase liquid will be addressed prior to the application of a qualitative risk assessment method for establishing remediation requirements.

A review of the assumptions used for the derivation of the CCME CWS for Petroleum Hydrocarbons (PHC) as well as the need to minimize physical disturbance suggests that direct application of criteria for the protection of all receptors may not be appropriate at the INAC sites AMSRP Volume 2 (INAC 2009). A revised set of criteria are provided in Table 4.2. These criteria incorporate the CWS PHC as appropriate, as well as previous quantitative risk assessment results. Two classes of hydrocarbons were identified, Type A – non-mobile, and Type B – mobile. Type A refers to heavy end products, such as lubricating oils, and are easily differentiated by dark staining. Relative to the CWS PHC, Type A consists of the sum of F3 and F4 constituents. Type B includes lighter end or more volatile hydrocarbon products such as MoGas, jet fuel and diesel, and is approximately equal to the sum of the F1 through F3 fractions. When all four fractions are present, the dominant hydrocarbon type is defined by the percentage of the sum of F3 and F4, relative to the sum of F1 to F4 (total TPH). For Type A contaminated soil, the sum of F3 plus F4 must be greater than 70% of the total TPH concentration **and** the F2 concentration must be less than the F4 concentration.

Table 4.2 Remedial Objectives – Hydrocarbon Contaminated Soil – INAC Abandoned Military Sites

Exposure Pathway	F1	F2	F3	F4	Type B Hydrocarbon Contamination	Type A Hydrocarbon Concentration
Protection of Freshwater Aquatic Life[(a)]	1290[(a)]	330[(a)]	NA	NA	330[(a)]	NA
Direct Soil Eco-Contact	Not utilized – See AMSRP Volume 2 (INAC 2009)					
Protection of Terrestrial Wildlife					2500[(b)]	
Human Health		11000	20000			20,000
Management Limit					5000[(c)]	

Notes:

(a) Within 30 m of a water body

(b) For surface soils to 0.5 metres depth.

(c) Below 0.5 m depth, a value of 5000 mg/kg may be applied based on professional judgement.

Based on historic patterns of contamination observed at other abandoned military sites, soils contaminated with hydrocarbons are typically found in the following locations:

- In the vicinity of buildings near fuel distribution lines, fuel dispensing tanks;
- Former open storage areas and/or debris areas where barrels may be present;
- Petroleum, Oil, Lubricant (POL) bulk storage areas; and
- Solid waste disposal areas.

Delineation of the lateral extent and depth of contamination is required to determine quantities of sufficient accuracy to develop a RAP and the subsequent Contractual Drawings and Specifications. A detailed sampling plan shall be developed for each potential area of concern identified as part of historic review, and must include the following information:

- Description of the objective for each potential area of concern;
- Sampling locations;
- Proposed sampling methods for shallow and depth samples, where the depth sampling should achieve a depth consistent with the estimated active layer thickness;
- Proposed number of samples and media;
- Parameters for analyses in accordance with Table 4.2;
- Sampling methodology, analytical requirements, Quality Assurance/Quality Control measures.

At minimum, the information requirements as outlined in Table 4.2 shall be incorporated into the Sampling Plan.

Table 4.3 Hydrocarbon Contaminated Soil Information Requirements

Item	Comments
Hydrocarbon Contaminated Soils – Stained Soils (F3/F4 fraction) – Type A	
Areal Extent -Visible surface staining	Topographic survey and location/coordinates of stained areas and sample locations Provide sketches with measurements
Topography	Examine for evidence of erosion (drainage channels)
Soil Description	Include description of grain size distribution, well graded or poorly graded. Fine grained, coarse grained, maximum particle size
Sampling	Collect soil samples for analyses of F1 to F4 fractions to characterize contamination, analyses for presence of co-contaminants such as PCBs.
Confirm Depth of Staining	Testpit to extent of stain, collect soil sample for PHC analyses at 0.5 m depth.
In areas of multiple staining	Identify and survey extent of stains Collect individual samples from most visibly stained areas to represent “worst” case. Focus on stained areas larger than 4 m^2
Evidence of residual or free product	
Hydrocarbon Contaminated Soils – Near Fuel Storage, Distribution or Dispensing Areas (F1-F3 fraction) Type B	
Within 30 m of water body supporting aquatic life	
Describe surrounding environment	Consulting locals and elders who use the area may prove to be useful.
Sampling – Hydrocarbons	Delineate **laterally and at depth** to 330 mg/kg as per on-site analytical capabilities Collect sufficient samples for laboratory analyses of hydrocarbon fractions to confirm correlation with on-site analytical results. Over-sampling (within reason) and iterative analyses may be required where there is poor correlation with test-kits (organic materials)
Sample groundwater in testpit excavation in source zone.	Collect groundwater samples and analyze for dissolved hydrocarbons (F1, F2) and wastewater discharge criteria (Section 6). Measure water levels, and presence of free product, if applicable

Item	Comments
Greater than 30 m distant of water body supporting aquatic life	
Sampling – Hydrocarbons	Delineate **laterally and at depth** to 2500 mg/kg as per on-site analytical capabilities. Collect sufficient samples for laboratory analyses of hydrocarbon fractions to confirm correlation with on-site analytical results For the purposes of comparison, use the summation of F1 to F3 concentrations.
Collect soil samples for grain size distribution	Representative samples should be taken of soils within and downgradient of the source zone for determination of grain size distribution, and water content.
All Hydrocarbon Contaminated Soil Areas	
Topography	Survey sample locations and topography of source zone and surrounding area. Include min. 25 m buffer zone around contaminated areas. Document seepage zones (toe of embankments), if applicable. Evidence of erosion
Evidence of impacted vegetation	Note presence and extent of vegetation; identify areas of stressed vegetation if applicable.
Wildlife	Note presence or evidence of wildlife (nests, burrows, etc.) within impacted and surrounding area. Review in context with overall Natural Environment Survey (Section 4.9)

Additional representative samples shall be collected and analysed to assist in the determination of treatment requirements. Samples should be collected from areas representing the largest contributions to the PHC contaminated soil volumes (such as bulk fuel storage areas). These analyses include, but are not limited to:

- Water content
- Total Available Nutrients; Total Organic Carbon
- Treatability tests to assess bioremediation potential (bacterial counts, hydrocarbon degraders).

4.3 Solid Waste Disposal Areas

Solid Waste Disposal Areas (WDA) on INAC abandoned military sites are generally smaller in extent than those located on DND DEW Line sites, and may be more appropriately referred to as buried debris areas or dump sites. As part of the historic review, areas of ground disturbance/landfill activity will be identified for further investigation. A detailed investigation/sampling plan shall be developed for each area, and must include the following information:

- Description of the objective for each potential area of concern
- Methodology for determining extent of buried debris using non-intrusive geophysical surveys, such as Electro-Magnetic Surveys (EM) or Ground Penetrating Radar (GPR), and associated ground-truthing. The consultant is to indicate the type of geophysical survey to be used based on anticipated ground conditions. In general, a grid-survey pattern shall be used that provides adequate coverage of the area. Identification of areas of surface debris within the geophysical survey area is required to allow correlation with geophysical survey results. All geophysical surveys must be referenced to a UTM coordinate system.
- Identification of sampling locations both up- and down-gradient of the landfill, debris area or dump site.
- Proposed sampling methods for shallow and depth samples, where depth sampling should achieve a depth consistent with the estimated active layer thickness.
- Proposed number of samples and media.
- Parameters for analyses.
- Sampling methodology, analytical requirements, and Quality Assurance/Quality Control measures.

In addition, general site information shall be collected as outlined in Section 4.9 and 4.10, as well as specific information for each WDA as described below to support the evaluation of the potential environmental risk associated with the WDA (Annex A).

Physical Characteristics:

Areal Extent of WDA Extent

Depth of Buried Debris, as applicable

Contaminant Characterization (concentrations/extent)

Volume and extent of exposed debris, where exposed debris is defined as surface and/or partially buried debris within 0.5 meters of the surface.

Pathway/Transport Mechanisms

Surface expressions of contaminated soil and/or leachate.

Grades/Topography

Surface cover materials type and depth

Evidence of erosion

Precipitation

Distance to downgradient perennial surface water bodies

Receptor Characteristics

Distance to freshwater/marine habitat and habitat usage.

Terrestrial Habitat

Traditional Land Use

Minor modifications to the evaluation matrix prepared by the DND/NTI Environmental Working Group (EWG 1998) will be used for the assessment of potential environmental risk (Annex A). These modifications included:

- Addressing remedial requirements for dump sites and debris areas (generally smaller in size than landfills)
- Modifying contaminant characterization to include leachate migration and the presence of contaminants as one category.
- Including consideration of snow pack as well as annual precipitation.

Additional detail regarding the evaluation of WDAs is provided in Annex A.

4.4 Surface Debris

Surface debris is present on many of the sites, and may consist of a variety of waste materials including:

- Scrap metal and wood wastes (painted/unpainted);
- Barrels, potentially containing product; and
- Asbestos, batteries, and electrical equipment.

All areas of debris shall be inventoried to the extent possible to provide volume estimates and characterization of waste materials. Site debris shall be classified as inert, non-hazardous wastes or hazardous wastes in accordance with the following Acts and Regulations.

- Federal Transportation of Dangerous Goods Act and Regulations
- The Canadian Environmental Protection Act
- The Nunavut or Northwest Territories Environmental Protection Act

The number of barrels containing product shall be inventoried where it is safe to do so. However, it is impractical to sample and analyse contents of all barrels on site during the assessment phase. To provide information required for the Remedial Action Plan, a statistically relevant number of barrels shall be sampled and analysed. The actual number of barrels sampled will depend on the total number of barrels at the site, and should be determined using professional judgement. Samples will be analysed for parameters in accordance with the barrel protocol, and as summarized below:

Organic Phase: Total Chlorine, PCBs, Cadmium, Chromium, Lead

Aqueous Phase: % Alcohols and Glycols, Total Chlorine, Cadmium, Chromium, Lead

If the aqueous phase is less than 2% alcohols or glycols, water shall be analysed in accordance with waste water discharge criteria. Annex B provides further information on the Barrel Protocol.

4.5 Submerged Debris

Debris may be present in the near shore marine environment and/or lakes that are present on the site. Observations of debris in water shall be recorded to the extent possible and supplemented with local and anecdotal knowledge. Previous studies have confirmed that such debris is primarily a risk to navigation in shallow waters (AMSRP Volume 2 (INAC 2009)).

4.6 Buildings/Structure Inventory

Existing buildings and infrastructure at a site will be demolished down to their foundations as part of the cleanup. To assist in the development of the RAP, an inventory of building contents, foundation construction materials and details, and building/structure construction materials and dimensions are required. Building contents, where present, shall be inventoried and classified as non-hazardous or hazardous wastes. Hazardous building materials may include, but not be limited to: PCB and lead-amended paint, asbestos containing materials (ACMs), fluorescent lights, and mercury containing switches.

Painted building materials shall be tested for total lead and PCBs, and leachable lead and PCBs in order to determine disposal requirements. The thickness and density of the paint and substrate material shall be recorded as it may be required to calculate total PCB concentrations. Samples of concrete, excluding paint, shall be collected and analysed for PCBs. The locations and number of samples are to be determined in the field. Samples should be collected from both stained and non-stained areas on concrete on surface and at depth. Over-sampling and iterative analyses is recommended. As part of the assessment, a detailed waste inventory shall be prepared that includes: dimensions, building materials, foundation materials (concrete slab, timber piles, timber crib), estimated volume and mass of wastes, and the basis of any assumptions used in the estimate. Painted materials must be specifically identified and the extent of paint coverage and adherence quantified.

4.7 Geotechnical Requirements

4.7.1 Potential Development Areas

New engineered landfills and hydrocarbon treatment areas may be required during cleanup. Potential locations shall be identified and surveyed during the site assessment phase. Guidelines for the siting of potential development areas include:

- Avoidance of permafrost sensitive areas, vegetated areas and archaeological features.
- Avoidance of contaminated areas.
- Maintain a distance of 300 m or more from downgradient permanent water features.
- Locate at elevations greater than 2 metres above sea level or storm surge level
- Ground surface topography with grades of 6% or less.
- Proximity to borrow sources, waste materials.

The INAC sites are all located within the zone of continuous permafrost. The sensitivity of permafrost to climate warming consists of two components, the thermal response to warming and the impact of thaw (physical response) (Smith, Burgess, 2004) as cited in AMSRP Volume 2 (INAC 2009). The physical response of the terrain to permafrost degradation is mainly dependent on the ice content of the frozen material (Dyke et al., 1997). Warming of ice-rich perennially frozen ground would eventually lead to its thawing and the resultant thaw settlement, slope instability, thaw slumping, thermokarst, and other permafrost degradation-related processes. Excess ground ice can be identified by landforms at surface, such as patterned ground. An evaluation of the potential for impacts due to climate change is provided in AMSRP Volume 2 (INAC 2009).

Potential development areas shall be surveyed to provide detailed topographic information to allow generation of ground contours. A buffer zone of a minimum of 50 m should be surveyed around all proposed development areas. In previously disturbed areas, soil sampling and analyses shall be carried out to confirm or disprove the presence of any historic contamination using a targeted approach. Additional sampling should be carried out over a grid with spacing of approximately 50 m x 50 m.

4.7.2 Borrow Sources

During cleanup, borrow material is required for construction of new landfills, development of treatment areas, backfilling of contaminated soil excavation, closure of existing landfills, general regrading and for road construction/maintenance.

Available existing sources of borrow material should be exhausted before exploiting new areas. Areas of excess ground ice or of biophysical significance (denning/nesting areas) are to be avoided. Use of abandoned gravel pads and road infrastructure as granular source material is preferable, wherever possible. Existing gravel pads shall be screened for the presence of contaminants during the assessment phase.

Borrow sources shall be identified and characterized and estimated quantities developed. Test-pits shall be excavated to confirm subsurface stratigraphy, seepage, depth to permafrost table or bedrock, and ground ice conditions. Select soil samples shall be retained for geotechnical laboratory testing to assist in the development of Specifications. Testing shall include, but not be limited to: water content, grain size distribution, and moisture density relationships. At sites where background inorganic element concentrations are elevated, additional samples shall be collected for geo-chemical characterization of the borrow material.

4.7.3 Site Access

Access to the sites is typically by barge/ship and aircraft and on site by existing access roads. A limited number of sites are land-locked. Use of the airstrip is essential to mobilize materials and equipment required for site activities. An inspection and sampling of the airstrip fill materials shall be completed during the assessment phase to determine the load capacity to support a variety of aircraft. Drainage and erosion features shall be documented in order to assess the useable length, and/or upgrading requirements.

Investigation of potential CAT Train and/or other equipment mobilization options shall be investigated for the mobilization of heavy equipment. Construction records for Short Range Radar (SRR) sites located in the vicinity may be available as reference. Suitability of the beach for barge landing/sea lift access shall also be assessed. Local knowledge and Traditional Knowledge (TK) may prove useful in evaluating potential CAT train routes as well as suitable barge landing sites.

Helicopter landing pads, associated with Short Range Radar sites, are within the DND reserve. Only a non-intrusive visual inspection should be carried out to document the physical status of these areas.

4.7.4 Siting of Camp Facilities and Temporary Storage areas.

Laydown areas are required for temporary camp structures, equipment and storage during the cleanup. Potential locations shall be identified during the site assessment phase. Where possible, these will be located in previously disturbed areas such as borrow or storage areas, to minimize any new disturbances.

4.8 Potable Water Supply

A suitable drinking water supply shall be identified during the site assessment phase. A qualitative assessment of the flow rates (as applicable) shall be made at the time of the site assessment, as flow will vary throughout the season, with higher flows typically in spring run-off. Identifying the high water mark, and estimating depth of the stream/lake, as applicable, will aid in this evaluation. The Contractor will be advised that water withdrawal rates may not exceed 10% of the flow volume or 10% of the water volume in a lake, and to modify consumption as appropriate. Water samples shall be collected and analysed for criteria in accordance with the latest edition of the CCME Guidelines for Drinking Water Quality.

4.9 Natural Environment Assessment

A thorough assessment of the natural environment of the site and surrounding area shall be conducted as part of the detailed environmental site assessment. This assessment shall be carried out mainly by a biologist with input from a local community representative, where appropriate. This study shall consist of describing the regional and local setting, local ecosystems, species assemblage as well as potential impacts to vegetation and wildlife from cleanup activities and proposed mitigation measures. Additional information requirements are outlined in the following subsections.

4.9.1 Regional and Local Setting

The report should address the following information requirements.

- Location (site coordinates, main natural and man-made features present);
- Ecosetting (ecozones and ecoregions);
- Climate (mean temperature and precipitation data);
- Vegetation;
- Landforms and soils (main land features, soil types, general topography); and
- Human usage and disturbance (TK input will be valuable to assess human usage of the area).

4.9.2 Local Ecosystems

This subsection should describe 1) the various inland ecosystems; 2) the ecosystems present in the former operational areas (*i.e.*, disturbed areas and areas with infrastructure); as well as, if applicable, 3) the shore/coastline ecosystem; and the 4) open ocean ecosystem.

Each identified ecosystem should be described in terms of the various terrestrial and freshwater habitats, the vegetation and wildlife species present in those habitats, as well as past and current impacts and disturbances to habitats. Local and traditional knowledge from people who use these areas for hunting and fishing may provide useful information on plant and wildlife species present as well as ecosystem health.

4.9.3 Species Assemblage

This subsection should describe the various species at risk (*i.e.*, extirpated, endangered, threatened, or special concern) according to the Species at Risk Act (SARA) that occur in the general vicinity of the site, as well as any migratory species that known to breed or nest in the area (Migratory Birds Convention Act).

All species (*i.e.*, birds, mammals, fish, and plants) observed or known to use the site and surrounding areas should be documented. Observations should be described in terms of numbers and behaviour during sighting (*e.g.*, migrating, nesting/breeding, feeding, etc.). Species not observed on site but known to use the area may be documented by consulting local community representatives as well as various studies and reports.

4.9.4 Impacts and Mitigation

Potential impacts to vegetation and wildlife from site investigation and remediation activities should be clearly identified. Proposed constraints and other recommendations should also be presented as part of the Natural Environment Assessment, in order to incorporate these requirements into the Environmental Protection Plan.

4.10 Traditional Knowledge Surveys/Assessment

Traditional Knowledge (TK) forms an integral part of the development of the RAP. Incorporating TK during the assessment phase can provide guidance on targeting specific areas of concern to local residents. Qualitative knowledge provided by local residents can be used to complement and enhance the largely quantitative information provided by the physical studies completed.

TK can be efficiently obtained through a local community representative (*i.e.*, local TK consultant) who can liaise between the Consultant and various TK holders in the community. The local TK consultant may either be an Elder or someone else who knows the site well (*e.g.*, hunter, ranger). The ideal local TK consultant possesses some TK, but more importantly knows who to consult in the community to obtain relevant site information and TK.

4.10.1 Typical TK and Local Knowledge

TK may be grouped into four main categories:

1. Historical and Archaeological Features
2. Wildlife Use
3. Land Use
4. Site Specific Information

Historical and archaeological features provide information on traditional land use of the area. These features, often hidden from the untrained eye, will be identified by local TK holders as to their use and relative age, and can complement the work of the archaeological assessment.

Wildlife use of the land in and around the site includes migration routes, mating and calving grounds, as well as summer and winter-feeding areas of large land mammals. Nesting, moulting, and summer feeding grounds of migratory birds such as geese and ducks, as well as migration routes and feeding areas of sea mammals must also be identified.

Land use relates to traditional usage of the land and sea for hunting, fishing, camping, and harvesting products on land (*e.g.*, berries, eggs, medicine, tea, drinking water), and harvesting of sea products (*e.g.*, clams, kelp).

Site-specific information about the military site while it was under construction or in operation, including events (spills, accidents), waste management practices (storage, dumping), as well as natural occurrences, should also be documented.

4.11 Archaeological Assessment

The overall purpose of the archaeological assessment is to obtain the necessary archaeological regulatory approval at the assessment stage as required to implement the remediation program. The scope of the archaeological assessment shall include:

- Preparation and submission of permit applications to the Department of Culture, Language, Elders and Youth (Nunavut) or the Prince of Wales Northern Heritage Centre (NWT).
- Completion of an Overview for each site, which would include file searches to determine the number, nature and terrain associations of previously recorded sites.
- Completion of a field inventory and assessment of each site;
- Completion of a heritage features or structures evaluation for consideration of heritage value;
- Provision of a heritage resource impact assessment for each site
- Implementation of more detailed investigations at key sites and appropriate mitigation at significant sites affected by proposed projects (if required); and
- Preparation of a final permit report for each site and, if required, provides a summary of these results suitable for inclusion in a screening document.

Areas of high and moderate archaeological potential for containing cultural material will require detailed examination during the assessment phase, to ensure the protection and if required, development of mitigation measures to be implemented prior to or during cleanup.

5 REMEDIATION PROTOCOL

The elements of the remediation protocol have been developed through the review of previous work at related sites by DND and INAC, and take into consideration information of particular relevance to the unique character of the INAC sites.

The primary components of cleanup on the INAC abandoned military sites include:

- Treatment/Disposal of Contaminated Soil
- Disposal of Debris/Demolition Waste
- Closure of Existing Solid Waste Disposal Areas
- Construction of New Landfills
- Development of Borrow Sources and Site Grading Activities

The goals of a RAP are to provide the foundation for development of a cleanup design that will reduce the environmental liabilities present at the site, maximize benefits to local communities and provide good value to the Crown. More specifically, the RAP is to identify and evaluate options applicable to the treatment and/or disposal of waste materials present at a site. These waste materials typically include:

- Soil contaminated with inorganic elements, PCBs and/or petroleum hydrocarbons;
- Non-hazardous and hazardous wastes associated with building/facility demolition;
- Visible/accessible debris including barrel contents; and
- Buried debris/landfills as identified by geophysical surveys

The estimated volume of waste materials in each stream shall be determined and options evaluated on the basis of effectiveness to reduce and/or mitigate environmental risks in the short and long term, long term liability or residual risks, relative costs, monitoring costs and community acceptance. The costs associated with implementing remedial solutions include, but are not limited to: resources, such as materials, equipment, and personnel, and site logistics. Mobilization and site access constitute a significant cost for remote site cleanups, and can have significant impact on selection of the preferred remedial option. The evaluations shall be summarized and preferred remedial options identified for each waste stream. Options shall be integrated to finalize the recommended approach for site remediation.

During remediation planning public community consultations are conducted in surrounding communities to obtain feedback on the draft RAP.

5.1 Contaminated Soils

Contaminated soils are considered in three primary categories: soils that are regulated; soils classified as hazardous; and, soils classified as contaminated but not hazardous waste. Contaminated soils that are regulated shall be remediated and/or disposed of in compliance with the applicable regulations. Hazardous contaminated soils are defined as those that exceed criteria as provided in the Transportation of Dangerous Goods Act and Regulations. Contaminated soils that are not regulated or hazardous shall be excavated to the depth and extent to meet the DCC (see section 4.2.1) or PHC remedial targets (Section 4.2.2).

Three primary contaminated soil types have been identified; inorganic element contaminated soil, PCB contaminated soil and hydrocarbon contaminated soil. Where multiple contaminants are present in the soils, the most conservative remedial option that addresses all contaminant types shall be applied. A summary of remedial options for contaminated soils is presented in Table 5.1.

Table 5.1 Summary of Remedial Options – Contaminated Soil

Contaminated Soil	Remedial Options
DCC Tier I	▪ Excavate and place in an on-site engineered landfill or ▪ Cap in place under 0.3 m of clean fill if in a stable location
DCC Tier II	• Excavate and dispose of in an on-site Tier II facility or • Containerize for off-site disposal[1]
Inorganic Elements Leaching	• Transport in accordance with the TDGA for disposal at an off-site facility
PCB Contaminated Soil in excess of CEPA	• Store in accordance with PCB Regulations pending a decision regarding disposal
Type A TPH (Non-Mobile Hydrocarbon Contaminated Soil)	• Excavate and place in an on-site engineered landfill or • Scarify surficial stains that meet PHC criteria.
DCC Tier I -Type A TPH	• Excavate and place in an on-site engineered landfill or • Cap in place under 0.3 m of clean fill if in a stable location
DCC Tier II -Type A TPH	• Excavate and place in an on-site Tier II disposal facility or • Containerize for off-site disposal[1]
Type B TPH (Mobile Hydrocarbon Contaminated Soil)	• *In-situ* or *ex-situ* treatment to reduce environmental risk to meet guidelines
DCC Tier I -Type B TPH	• Ex-situ treatment to meet guidelines and place in an on-site engineered landfill or cap under 0.3 m of clean fill in a stable location after treatment. • Small areas of contamination may be excavated and disposed of in a Tier II disposal facility
DCC Tier II -Type B TPH	• Excavate and place in an on-site Tier II Facility or • Containerize for off-site disposal[1]
Hazardous Soil	• Dispose in compliance with applicable regulations

[1] Decision of whether to dispose of on or off-site is based on cost –benefit analyses (see Section 5.4.2).

5.2 Debris – Site Debris and Demolition Wastes

Site debris shall be collected and segregated into hazardous and non-hazardous waste streams for disposal:

Non hazardous waste: The volume of the non-hazardous materials shall be minimized through crushing, shredding, or incineration, prior to placement in an on-site engineered landfill. If there is no existing landfill on-site, and no suitable location for a new engineered landfill, non-hazardous materials shall be disposed of off-site; and

Hazardous waste: These materials shall be disposed of off-site, in accordance with the current regulations governing the handling and disposal of hazardous materials.

Hazardous materials referred to in this section are defined as any materials, which are, designated "hazardous" or "dangerous goods" under Territorial or Federal legislation. Generally, all hazardous materials identified at the site shall be collected and transported off site, in accordance with the Transportation of Dangerous Goods Act (TC 2002), to a licensed hazardous waste disposal facility.

Hazardous materials that are typical of abandoned military sites and require special consideration include the following:

PCB Contaminated Concrete: Concrete (excluding paint) with PCB concentrations in excess of 50 ppm is regulated under the CEPA, and shall be collected and transported off-site, in accordance with the Transportation of Dangerous Goods Act and CEPA to a licensed hazardous waste disposal facility.

PCB Paint on Building Components: PCB paint and PCB painted components that are regulated under the CEPA, shall be collected and transported off site, in accordance with the Transportation of Dangerous Goods Act and CEPA, to a licensed hazardous waste disposal facility. The thickness and density of the paint and substrate material shall be recorded as it may be required to calculate total PCB concentrations. Loose paint materials/paint chips are regulated under CEPA when PCB concentrations in the paint are greater than 50 ppm.

Lead-Based Paint on Building Components: Lead-based painted components that are classified as hazardous material shall be collected and transported off site, in accordance with the Transportation of Dangerous Goods Act to a licensed hazardous waste disposal facility. Painted components that exceed the relevant federal or Territorial criteria but are not considered hazardous shall be collected and disposed in an on-site engineered landfill. Lead-based painted materials are considered hazardous when the lead leachate concentrations from a test of the component (paint and substrate) exceed 5 mg/L or the concentration as provided in the latest schedule of the TDGA. Additional discussion related to the classification of painted material is provided in AMSRP Volume 2, (INAC 2009).

There are also a few exceptions, which are described below:

Asbestos: Asbestos waste shall be collected, double bagged and disposed of in an on-site engineered landfill, in accordance with the appropriate legislation. Where no on-site facility is available, asbestos waste shall be shipped off-site for disposal. Where asbestos materials are painted, disposal requirements are based on paint analyses.

Petroleum Products: Petroleum products, such as gasoline or diesel, which do not contain other hazardous products (chlorine, PCB, metals, etc.) will be incinerated on-site under appropriate emissions controls. Heavier petroleum products such as lubricating oil will be disposed of off-site or mixed with lighter petroleum products and incinerated on-site under appropriate emissions controls in accordance with the Barrel Protocol provided in Annex B.

Compressed Gas Cylinders: Compressed gas cylinders with known contents shall be vented. Once empty, the metal cylinder shall be disposed on-site in an engineered landfill. Where no on-site facility is available, compressed gas cylinders shall be shipped off-site for disposal.

Creosote Treated Timbers: Timbers shall be wrapped in polyethylene sheets and disposed on-site in an engineered landfill. Where no on-site facility is available, creosote treated timbers shall be shipped off-site for disposal.

5.2.1 Submerged Debris

Submerged debris shall be removed from the near-shore environment to a depth of 2 metres or 30 metres off-shore, whichever is encountered first. Work in marine and freshwater environments shall be in accordance with all stipulations as provided by the Department of Fisheries and Oceans. Debris, once removed, shall be classified as hazardous or non-hazardous and disposed of as indicated in the previous sub-section.

5.2.2 Barrels

Barrels shall be handled according to the Barrel Protocol (Annex B) and as outlined below:

Empty Barrels: Empty barrels shall be crushed and disposed in an on-site engineered landfill;

Filled or Partially Filled Barrels: Barrel contents shall be inspected and tested if necessary and disposed of appropriately (off-site or incinerated). The empty barrel shall be rinsed, crushed and disposed on-site in an engineered landfill. The spent rinse liquid shall be tested and disposed of appropriately. Absorbent materials used as part of this process shall be incinerated if incineration criteria are met, or disposed of as hazardous material, as required; and

Buried Empty Barrels: Areas containing buried empty barrels will be inspected to determine if any of the barrels contain material and characterized through a geophysical survey. If the barrels are found to be empty, the area will be stabilized through compaction to crush any corroded barrels, if the area is deemed suitable from a geotechnical perspective. A cover of borrow material shall be placed over the area and compacted.

The criteria used to determine the acceptability of product for on-site incineration are summarized in Table 5.2 as follows:

Table 5.2 Barrel Protocol Criteria and Disposal Summary

Phase	% Alcohol or Glycols	PCBs	Chlorine ppm	Cadmium ppm	Chromium ppm	Lead ppm	Disposal
Organic		<2	<1000	<2	<10	<100	On-Site Incineration
Organic		>2	>1000	>2	>10	>100	Ship South
Aqueous	>2		>1000	>2	>10	>100	Ship South
Aqueous	>2		<1000	<2	<10	<100	On-Site Incineration
Aqueous	<2						Discard in accordance with wastewater discharge criteria

Wastewater generated during barrel cleaning shall be treated to meet discharge criteria in accordance with permits and licences issued for cleanup activities.

5.2.3 Buildings and Infrastructure

Existing buildings and infrastructure shall be demolished to concrete foundations. Above-grade timber foundations shall be removed. Where concrete foundations are above grade, the area will be re-graded with the placement of additional granular fill to match surrounding topography. Exposed timber piles shall be removed to a minimum of 0.3 m below ground surface. All hazardous materials shall be segregated prior to or during demolition. Non-hazardous demolition materials and asbestos shall be collected and disposed in an on-site engineered landfill. If there is no existing landfill on site and no suitable location for a new engineered landfill, the non-hazardous materials shall be disposed of off-site. Hazardous demolition materials shall be disposed off-site.

PCB amended painted material shall be containerized in accordance with the Transportation of Dangerous Goods Act, and transported off-site to a licensed treatment disposal facility.

Only in exceptional circumstances will existing buildings remain intact on site following the remediation program. These structures may remain as emergency shelters only once clear transfer of ownership has been established.

5.3 Solid Waste Disposal Area (WDA) Closure

The following section applies to landfills, dumps and debris areas, collectively referred to as WDA.Using the WDA evaluation matrix (Annex A), WDA can be classified into one of three broad categories. Actions associated with each category of WDA have been identified. Where a WDA exists on INAC abandoned military sites, the condition of the WDA shall be evaluated to determine the most appropriate action;

Class A: If the WDA is located in an unstable, high erosion location, it shall be relocated to a properly engineered landfill. A WDA located at an elevation of less than two metres above mean sea level will be removed. During the relocation process, any identified hazardous materials shall be segregated for off-site disposal.

Class B: If the WDA is located in a suitable, stable location, but there is evidence of contaminant migration, potential remedial solutions include excavation or provision of a suitably engineered containment system. Permafrost containment shall be designed in accordance with the geothermal requirements outlined in Section 5.4.2. The remedial solution selected shall be based on a cost-benefit analyses that includes consideration of construction costs and long-term monitoring costs.

Class C: If the WDA is located in a suitable, stable location, with no evidence of contaminant migration, it may be left in place. If required, additional granular fill shall be placed to ensure erosion protection and proper drainage. Consideration must be given to surrounding topography (to blend into existing terrain) and long term monitoring costs.

Additional information related to landfill design and closure is provided in AMSRP Volume 2, (INAC 2009).

5.4 Landfill Development

New engineered landfills may be required for the disposal of non-regulated contaminated soils and non-hazardous debris collected or generated during cleanup. Two classes of landfills are provided:

- Non-Hazardous Waste (NHW) Landfill
- Tier II Contaminated Soil Landfill

5.4.1 Non-Hazardous Waste Landfill

A NHW Landfill is a new landfill constructed for the disposal of non-hazardous debris and building demolition waste. Tier I contaminated soils and Type A PHC soil may also be disposed of in these landfills. Landfills constructed to date at DND DEW sites are predominately above ground facilities. These landfills do not rely on permafrost for containment nor do they include a geosynthetic liner.

The general design parameters include a perimeter berm and landfill cover constructed of a well graded sand and gravel. Clay is generally not available at the abandoned military sites. The sand and gravel should have a minimum of 8% fines (<0.08 mm) and be compacted to a minimum of 95% maximum dry density (ASTM D698). The landfill should have a maximum debris thickness of 3 m and minimum cover thickness of 1.0 m.

To reduce settlement and ground subsidence, debris should be placed in maximum 0.5 m thick lifts with granular fill placed over each lift of debris to fill the voids (intermediate fill). Intermediate fill should be a minimum of 0.15 m thick and worked into the underlying debris. The final landfill surface must be graded such that water ponding does not occur. Ponding and infiltration could increase the seasonal thaw depth or contribute to leachate generation. The landfill surface must not be so steep that it promotes erosion of the cover materials, which could expose debris.

Fill material for the landfill cap should be a well-graded material that is relatively erosion resistant and will have moderate water infiltration. Alternative designs or surface treatments, such as imported coarser gravels and cobbles, vegetation covers at sites where it is possible to vegetate the sites, roller compacted concrete or other synthetic surfaces, are required if erosion resistant materials are not present on site.

Final landfill design parameters including granular fill specifications, side slopes, cover thickness, and maximum height of landfill are dependent on site specific ground conditions and borrow availability. Designs must be reviewed by a geotechnical engineer with permafrost experience.

5.4.2 Tier II Contaminated Soil Landfill

The decision as to whether to construct a Tier II Contaminated Soil Landfill on site is based on a number of factors, including but not limited to those summarized in Table 5.3. These criteria were based on generic designs and relative cost estimates and may not accurately reflect site-specific conditions. These are provided as a guideline only.

Table 5.3 Decision Criteria Tier II Contaminated Soil Landfill

Is the site landlocked?	For landlocked sites, off-site transport costs increase significantly. Consideration should be given to on-site disposal facility.
Is landfill excavation required.	Landfill excavations pose contracting risks due to unknown quantities of waste material. To mitigate risks, an on-site Tier II disposal facility should be considered.
Are known contaminated soil volumes less than 300 to 500 m^3.	If yes, evaluate contingency factors and potential over-runs. If significant risk of quantity overrun is present, construct landfill on-site. If volume of contaminated soil estimated to be below these values, ship off-site for disposal.
Are known volumes of contaminated soil between 500 and 1000 m^3	Evaluate site specific conditions, and develop preliminary design and cost estimate for an on-site disposal facility using site specific information. Confirm availability and quality of borrow material.
Are known volumes of contaminated soil greater than 1000 m^3.	If yes, confirm availability and quality of granular borrow. If granular borrow sufficient, develop preliminary design and cost estimate for an on-site disposal facility, using site specific conditions. Re-evaluate on-site disposal costs versus off-site disposal and confirm cost-benefit.

The Tier II Contaminated Soil Landfill design is based on the containment of contaminated soil in a landfill provided with a geo-synthetic liner and a granular fill cover of sufficient thickness to maintain the contaminated soil in a frozen condition. The required fill thickness is a function of the climatic conditions selected as the design criteria.

Geothermal analyses are required to substantiate the use of permafrost as a means of containment for the landfills. Analyses are carried out to predict the short-term and long-term ground temperatures for the Tier II Contaminated Soil Landfill to determine:

- Length of time for landfill freezeback;
- Short-term and long-term thermal regime in the landfill; and
- Depth of annual thaw (active layer) in the cover material.

Geothermal analyses should be carried out for the landfills using two-dimensional finite element computer models. The models simulate transient, two-dimensional heat conduction with a change of phase for a variety of boundary conditions. Heat exchange at the ground surface should be modeled with an energy balance equation that considers air temperatures, wind velocity, snow depth, and solar radiation. The models should include the temperature phase change relationships for saline soils, such that freezing depression and unfrozen water content variations can be explicitly modeled.

Soil thermal properties required to carry out geothermal analyses include: porewater composition, latent heat, specific heat (frozen and unfrozen), and thermal conductivity (frozen and unfrozen). These properties are determined indirectly from well-established correlations with soil index properties, moisture content, grain size distribution, bulk density, salinity, etc. (Farouki, 1986; Johnston, 1981). Soil index properties are based on information collected during the site investigations.

Climatic data required for the thermal model include monthly mean air temperature, wind speed, solar radiation, and snow cover. The thermal analysis should be calibrated to measured temperatures and/or observed active layers thicknesses. The landfill designs include analyses for mean temperature conditions, warm conditions and long-term climate change. Statistical analyses are carried out to determine mean monthly temperatures representative of a 1 in 100 warm year. The freezing index and thawing index for each year are calculated from the recorded air temperature data. The index for each year is ranked in ascending order and plotted. A "best-fit" line is drawn through the set of points to estimate the 1 in 100 warm year index. Mean monthly air temperatures are increased by the ratio of the 1 in 100 warm year freezing or thawing index to the mean year freezing or thawing index to estimate the mean monthly temperatures of a 1 in 100 warm year. The influence of climate change should be evaluated by similar methods presented in ACIA (2005). This includes the average estimated seasonal temperature changes by various Global Circulation Models (GCMs).

Given the uncertainties in climate change and the cost of returning to a site at a future date, it is recommended that the Soil Disposal Facility be designed for 100 years of long-term climate warming (average of four GCMs) as a minimum. With this design condition, the active layer could penetrate the contaminated soil if a warm year occurred. Containment during this condition would be provided by the thick soil cover and the geomembrane liner. Additional factors of safety can also be applied to account for uncertainties in the geothermal model, soil input parameters, and climate input parameters, or the facilities can be designed for climate change plus one 1 in 100 warm year.

5.5 Borrow Source Development

Granular borrow material will be required for the development of new landfills and general site grading purposes.

5.5.1 Site Grading

Grading operations generally consist of the shaping and regrading of disturbed areas to blend in with the natural contours, in accordance with all applicable licenses. Disturbed areas may include:

- contaminated soil excavation areas,
- existing and new landfill areas,
- debris areas,
- areas disturbed during demolition activities,
- granular borrow areas, and
- any area disturbed during establishment and operation of the camp, equipment storage and maintenance activities.

5.6 Contractor Support Activities

For implementation of remedial activities, a Contractor will establish a camp and storage areas on-site, where required. Where possible, these will be located in previously disturbed areas such as borrow or storage areas, to minimize any new disturbances in accordance with all applicable licenses.

Domestic refuse generated by the camp shall be incinerated and disposed of on-site in an engineered landfill. Sewage shall be handled by an appropriately sized sewage treatment system, in accordance with applicable legislation and all applicable licenses.

Wastewater generated by the Contractor, shall be treated to meet discharge criteria as stipulated in permits and licenses issued for the project.

Potable water supplies at the site will be tested and used, only if they meet the Canadian Drinking Water Quality Standards (CCME 2002) or the latest edition thereof, in accordance with all applicable licenses.

Fuel required for the operation of the camp will be stored on-site in accordance with applicable legislation and licenses.

All hazardous materials shall be segregated prior to or during demolition. Non-hazardous demolition materials and asbestos shall be collected and disposed in an on-site engineered landfill. Hazardous demolition materials shall be disposed off-site.

Only in exceptional circumstances shall existing buildings remain intact on site following the remediation program. These structures may remain as emergency shelters once clear transfer of ownership has been established.

6 CONSTRUCTION RELATED IMPLEMENTATION REQUIREMENTS

Consistent with Step 9 of the Federal Contaminated Sites Action Plan, confirmation that the objectives of the RAP have been met is required. Based on the issues typically associated with the remediation of INAC sites, confirmatory testing encompasses a wider range of activities. These include, but are not necessarily limited to:

- Confirmatory testing of contaminated soils;
- Quality Assurance testing of earthworks associated with the remediation and construction of landfills;
- Testing as required for waste manifesting to allow for shipment and disposal of materials off-site; and
- Testing as required to meet the requirements of Land Use Permits, and/or other Licences/Permits issued for the cleanup program.

The requirements and/or guidelines for these testing programs are outlined in the following sub-sections.

6.1 Confirmatory Testing Contaminated Soils

Following excavation of contaminated material confirmatory samples shall be collected and analyzed to ensure that cleanup objectives have been met. Sampling will be conducted by a third party qualified to carry out such work. A detailed sampling plan shall be developed for each area of concern identified for excavation in the RAP, and must include the following information:

- Description of the objective for each potential area of concern
- Sampling locations
- Sampling methodology
- Proposed number of samples and media
- Parameters for analyses
- Analytical requirements, and Quality Assurance/Quality Control measures.

6.1.1 Tier I contaminated soils

Tier I criteria were developed to address aerial transport of contaminants; excavation and backfilling precludes this pathway. If, during the site assessment, sufficient evidence has been collected to demonstrate that soils at depths of greater than 0.3 m below surface do not exceed Tier II levels for inorganic elements or PCBs, confirmatory sampling will not be required.

6.1.2 Tier II contaminated soils

Confirmatory sampling shall be carried out using a systematic grid sampling design following the DND DLCU Confirmatory Sampling Protocol as summarized in Table 6.1. This design provides a practical and simple method for designating sample locations and ensures uniform coverage of a site. Discrete samples should be collected at every point on the grid. For small areas, all samples shall be analyzed, whereas for larger areas only a fraction of the interior grid samples shall be analyzed. When choosing sample locations for analysis, consideration shall be given to areas of previously high concentrations. No single sample result or the mean of a duplicate/replicate sample shall exceed the cleanup objectives. In cases where field analytical methodology is used, 10-20% of the samples analyzed in the field should also be analyzed in the laboratory for quality control purposes.

Table 6.1 Confirmatory Testing Grid Sizes

Size of area	Grid size	# Perimeter samples analyzed	# Interior grid samples analyzed
<100 m^2	3x3 m	all	all
>100 m^2, <2500 m^2	6x6 m	50%	40%
>2500 m^2	12x12 m	50%	40%

6.1.3 Hazardous Soils

Confirmatory sampling following excavation of soils considered hazardous according to CEPA (PCBs >50 ppm) or the TDGA may require a more closely spaced grid than outlined in Table 6.1 to minimize the overall volume of materials requiring off-site disposal.

6.1.4 Type B TPH (Fractions F1 to F3)

Confirmatory sampling following excavation of petroleum hydrocarbon impacted soils within 30 m of a water body supporting aquatic life will follow the confirmatory sampling protocol outlined in section 6.1.2. The remedial solution for petroleum hydrocarbon impacted soils further removed from surface water bodies involves excavation of source areas. In cases where field analytical methodology is used, 10-20% of the samples analyzed in the field should also be analyzed in the laboratory for quality control purposes. For comparison purposes, total petroleum hydrocarbons (TPH) data obtained by hexane extraction can be compared to data generated using the CCME analytical procedure for PHC in soils by summing fractions F1 to F3. The presence of residual petroleum hydrocarbon contamination is expected following excavation to design limits as outlined in the RAP. Representative samples from the base of the excavation will be collected and analyzed for record keeping purposes using the CCME analytical procedure for PHC in soils.

6.1.5 Ex-situ Confirmatory Sampling

Soils excavated from landfills and dumps will be classified ex-situ. Excavated soils will be placed in windrows or stockpiles with a maximum stockpile size of 20 m^3 (B.C. Environment, 1995). Debris is separated from the soil and sorted as potentially hazardous and non-hazardous under the supervision of the Hazardous Materials Specialist. Stained soil and soil associated with potentially contaminated debris such as battery waste or barrels must be stockpiled separately from other soil to prevent dilution and facilitate disposal.

As part of the sampling protocol, two types of soil samples shall be collected from stockpiles: discrete and composite. Sample locations are selected at various surface and depth locations in each stockpile to obtain samples that are representative of the entire pile. Five discrete samples are collected and analyzed for the first 20 stockpiles and every 20th stockpile thereafter. Composite samples shall be collected and analyzed at all stockpiles. Composite samples consist of approximately equal volumes of soil collected from five discrete sample locations.

The standard deviation for each stockpile shall be calculated based on discrete sample results. These standard deviations are then used to calculate the average standard error for all stockpiles (Equation 1). Twice the average standard error is added to the analytical result for the composite sample to provide a 95% upper confidence limit (Equation 2).

$$SE_{avg} = \frac{\sum_{1}^{m}\left(\frac{SD}{\sqrt{n}}\right)}{m} \qquad \textbf{(Equation 1)}$$

$$UCL = \left[Composite_x\right] + 2\left(SE_{avg}\right) \qquad \textbf{(Equation 2)}$$

n = number of sample values,

SE_{avg} = average standard error,

SD = standard deviation of the sample values,

m = number of stockpiles,

UCL = upper confidence limit and

x = the stockpile number.

Classification of stockpiles for disposal is based on a comparison of the 95% upper confidence limit values and the relevant clean up objectives. The first 20 stockpiles shall be analyzed for the eight inorganic elements for which the DCC criteria are applicable and PCBs. Selection of samples for analysis for petroleum hydrocarbon will be based on visual and/or olfactory evidence. This process shall be repeated for every 20th stockpile thereafter. All the remaining stockpiles will be tested for copper, lead and zinc and any other analyte that exceeded the DCC criterion previously until it is no longer present (Table 6.2). Field analysis can provide adequate detection limits for statistical classification of certain contaminants (PCBs and PHC), while others (inorganic elements) must be analyzed in CAEAL accredited laboratories for more precise results.

Table 6.2 Analytical Requirements for Stockpile Sampling

Stockpile No.	Samples Collected	Analytical Suite	Samples for Analyses
1 through 20	**5 discrete** 1 composite	**PCBs, Cu, Ni, Co, Cd, Pb, Zn, Cr, As** PHC and Hg where evident	All discrete and all composite samples are analyzed for first 20 stockpiles
Every 20th thereafter	**5 discrete** 1 composite	**PCBs, Cu, Ni, Co, Cd, Pb, Zn, Cr, As** PHC and Hg where evident	All discrete and all composite samples are analyzed
Remaining stockpiles	**1 composite**	**PCBs, Cu, Pb, Zn** PHC, Hg and other inorganic elements where evident	Every composite sample is analysed.

Once the excavation is complete, the base of the landfill excavation must be sampled in accordance with confirmatory sampling protocol for Tier II soils.

6.1.6 Confirmatory Sampling of Material Processing Areas

Residual contamination may be present at barrel processing areas, hazardous materials processing areas, and stockpile lay down areas after clean up activities are complete. Once an area is no longer in use, a detailed inspection for evidence of staining and other indicators of contamination such as visible debris or paint flakes shall be carried out. Samples must be collected in these areas in a grid pattern based on the size of the area (see Table 6.1). In cases where field analytical methodology is used, 10-20% of the samples analyzed in the field should also be analyzed in the laboratory for quality control purposes.

6.2 Quality Assurance Testing of Earthworks

At most sites, earthworks will be carried out as part of the construction of new landfills, remediation of existing landfills, and/or development of hydrocarbon contaminated soil treatment areas. Contract Specifications developed for the project will identify specific requirements for fill gradation and compaction standards. As part of the testing to be carried out during cleanup, quality assurance (QA) testing is required to confirm that the earthworks are in conformance with the Specifications. The number and type of testing will be dependent on the volume of fill to be placed and the number of different material types employed in the cleanup. A QA program shall be developed in conjunction with the design engineer to determine the optimal number of tests required.

6.3 Testing Related to Permits/Regulatory Requirements

The Owner representative and the Contractor will be required to carry out testing to confirm that the requirements of the Land Use Permits and Water Licenses issued for the project are met.

This testing typically includes:

- Effluent testing for waste water generated from camp operations.
- Testing to confirm potability of drinking water supplies
- Testing of waste water generated from cleanup operations.

7 POST-CONSTRUCTION MONITORING

7.1 Introduction

A post-construction landfill monitoring program was developed by DND in conjunction with the Inuvialuit in the Western Arctic and the Inuit in Nunavut for landfills remediated and/or constructed during the cleanup of DEW Line sites. DND initiated cleanup of their DEW Line sites in 1996 and have collected a significant volume of landfill monitoring data since that time. Indian and Northern Affairs Canada, INAC, have initiated cleanup of abandoned military sites under their jurisdiction, and will implement a site monitoring program following remedial construction activities.

This section describes the recommended monitoring plan. It has been based on the DND landfill monitoring program and on landfill monitoring data collected at DND and INAC DEW Line sites to date. Additional monitoring requirements related to the natural environment and traditional knowledge have been added to the program.

A detailed description of the post-construction monitoring program is provided in AMSRP Volume 2 (INAC 2009).

7.2 Monitoring Program

The recommended monitoring program for abandoned military sites consists of:

- Baseline Geo-chemical Monitoring.
- Natural Environment Monitoring.
- Landfill Monitoring.

These are briefly described in the following subsections.

7.2.1 Baseline Geo-Chemical Monitoring

Geochemical Characterization of Soil Conditions

In all proposed development areas, and existing landfill areas (with the exception of existing landfills to be excavated), it is recommended that geochemical characterization of soil conditions be carried out during the assessment or remediation phase. For proposed development areas, sampling should be carried out on a grid spacing of approximately 50 m by 50 m. For existing landfills, testpits should be excavated at a minimum spacing of 50 m of landfill perimeter with a minimum of five testpits per area. Soil stratigraphy is to be logged in accordance with the Unified Soil Classification System, and evidence of seepage and or soil staining recorded. Soil samples should be collected at surface and at 50 cm intervals to the maximum depth of the active layer, and analysed for the following parameters:

- PCBs (polychlorinated biphenyls);
- Hydrocarbon Fractions, F1, F2, F3 and F4; and
- Inorganic elements: arsenic, cadmium, chromium, cobalt, copper, lead, nickel, and zinc.

These data supplement information collected during the assessment phase of a site.

Geochemical Characterization of Groundwater Quality

In proposed landfill development areas or at landfills requiring leachate containment, it is recommended that a detailed characterization of groundwater quality be carried out. A minimum of three wells per area is recommended; however, this may be increased if the size of the landfill warrants increased coverage. The locations of monitoring wells should be selected based on the potential for groundwater (based on the testpit program for soil characterization), and to be representative of both up and downgradient areas. The depth of the monitoring well will be based on anticipated maximum depth of thaw. The monitoring wells should be located no further than 10 m beyond the final construction perimeter as defined by the design.

For baseline water quality, water samples should be collected at minimum monthly for one full season to allow assessment of changes in water quality as the active layer deepens. The wells for baseline sampling are typically installed in the final construction season. This minimizes the potential for damage during construction.

Recommended analytical requirements are outlined below:

- Petroleum Hydrocarbon Fractions, F1 and F2
- Total and dissolved metals.
- Major ions, hardness, total dissolved solids, total suspended solids.
- pH and conductivity.

Given the low solubility of PCBs, analyses of PCBs may be limited to once over the season, near the time of maximum thaw.

For each monitoring event, water level, pH, conductivity, and turbidity should be measured.

If significant variability is observed in groundwater monitoring data, a second season of baseline monitoring should be carried out following remedial activities.

Typically, only dissolved metals are measured in groundwater monitoring programs; however, previous concerns existed with respect to transport of contaminants with colloidal material. The requirement for total metal analyses should be reviewed at the completion of baseline monitoring, and eliminated if concentrations can be correlated with Total Suspended Solids (TSS) concentrations.

7.2.2 Natural Environment Monitoring

A natural environment assessment (NEA) conducted during the ESA phase of site remediation will serve as a reference for post-construction site monitoring. Local and traditional knowledge will be obtained from a local community representative familiar with the site (ideally the same person who assisted with the NEA). Natural environment data will be collected during the site visit as well as during community meetings with people who use or visit the site/area frequently (*i.e.*, year-round). The purpose of collecting this new data is not to find correlations with landfill monitoring data but rather to provide anecdotal data related to the presence of wildlife and changes over time.

Site specific data to be collected during the site visit should try to include as many of the following items:

- Wildlife sightings (species, number, gender, juveniles)
- Other evidence of recent presence of wildlife (droppings, tracks, feathers/fur, carcass remains, etc.)
- Wildlife activity (summering/nesting/denning, migratory/passing through)
- Qualitative assessment of relative numbers versus previous years (more, same, less)
- Revegetation of disturbed areas versus previous years (more, same, less)

Regional information to be collected during visits to the area throughout the year should include as many of the following items as possible:

- Use by people for traditional activities
- Season(s)
- Activities (hunting, fishing, trapping, camping, other harvesting)
- Relative frequency versus previous years (more, same, less)
- Wildlife species present (sightings or evidence)
- Wildlife presence versus previous years (more, same, less)
- Health of wildlife observed or harvested (good, average, poor)

- Relative health of wildlife versus previous years (better, same, worse)

7.2.3 Landfill Monitoring

In general, there are four types of landfills that require monitoring:

- New landfills for non-hazardous materials and Tier I soil;
- Landfills to be closed by the addition of granular fill and regraded;
- Landfills to be closed with leachate containment; and
- Tier II soil disposal facilities.

Based on site conditions at INAC's abandoned military sites, it is considered unlikely that leachate containment would be considered; however, it is included for consistency with previous monitoring plans at military sites. A summary of requirements is provided in Table 7.1.

Table 7.1 Summary of Landfill Monitoring Requirements

	Monitoring Requirements				
Landfill Type	**Baseline Monitoring** S- Soil GW - groundwater	**Visual Inspection**	**Soil Sampling**	**GW Sampling**	**Thermal Monitoring**
New Non-Hazardous Waste (NHW) Landfill (LF)	S, GW	✓	as required[a]	✓	
Regraded LF (low potential risk)	S	✓	as required[a]		
Leachate Contained LF (moderate potential risk)	S, GW	✓	as required[a]	✓	✓
New Tier II Soil Facility	S, GW	✓	as required[a]	✓	✓

[a] Refer to Section 7.3.4 for details.

Baseline monitoring requirements were described in Section 7.2.1. The details of the other four landfill monitoring elements are described in the following subsections.

7.3 Specific Monitoring Requirements

7.3.1 Visual Inspection

The physical integrity of the landfill should be inspected and reported using photographs (from the air, when possible, as well as ground level) and hand drawn sketches. Documented observations should at minimum include the items identified in Table 7.2. It is recommended that Table 7.2 be adapted for use as a field checklist to facilitate this data collection.

Table 7.2 Visual Inspection Requirements - Landfills

Item	Presence/ Absence	Extent	Description Photographic Reference
Settlement Erosion Frost Action Animal Burrows Vegetation Staining Vegetation Stress Seepage Points Exposed Debris Condition of Monitoring Instruments Other features of note	Yes or No	Provide dimensions, as applicable of: Length Width Depth	Features of note, photographic reference with scale, view point and direction

7.3.2 Groundwater Sampling

Results of analyses of groundwater samples from landfills should be compared to the baseline and background samples as this is indicative of changing environmental conditions at the site. In general, a minimum of three to four groundwater monitoring wells will be associated with Non-Hazardous Waste Landfills, Tier II landfills and Existing Landfills – Leachate Containment.

Consistent with the baseline analyses, groundwater samples should be tested for:

- Petroleum Hydrocarbon Fractions, F1 and F2
- Total and dissolved metals.
- Major ions, hardness, total dissolved solids, total suspended solids.
- pH and conductivity.
- PCBs

For each monitoring event, water level, pH, conductivity, and turbidity should be measured in-situ. The evaluation of whether both total and dissolved metals are required will be evaluated after baseline monitoring.

Given the low solubility of PCBs in water, analyses of PCBs may be discontinued if not detected in the first five years of monitoring.

7.3.3 Thermal Monitoring

One component of the leachate containment system incorporates aggradation of the permafrost through the landfill contents such that the active layer does not penetrate the waste materials. Geothermal analyses were carried out to predict the length of time for freezeback of the landfill; long-term and short-term thermal regime in the ground; and the depth of the active layer in the cover material. The analyses have shown that it takes several years for the landfill temperatures to equilibrate and stabilize.

A thermal monitoring system provides measurement of sub-surface ground temperatures, which allows comparison to and verification of the predicted ground temperatures. The thermal monitoring system consists of installation of thermistor strings, with “thermistor beads” at select intervals to provide ground temperature profiles at various locations within the landfill. The thermistor strings are attached to automated data-loggers which allow for remote data collection. In general, a minimum of three thermistors is placed; this is evaluated on a landfill-specific basis. Thermistor installation follows standard engineering practice.

7.3.4 Soil Sampling

As previously indicated, soil sampling and analyses provide limited information with respect to the performance of a landfill. Soil sampling will be limited to locations where seepage or staining has been identified as part of the visual inspection. Analytical requirements include:

- Petroleum Hydrocarbon Fractions, F1 to F4
- Arsenic, Cadmium, Cobalt, Copper, Chromium, Lead, Nickel, and Zinc
- PCBs
- Soil samples should be collected over the interval of 0 to 0.15 m, and 0.35 to 0.50 m depth.

7.4 Monitoring Frequency

Conceptually, three phases have been identified for landfill monitoring as described in the following sub-sections. Natural environment monitoring may be conducted according to the same schedule.

Phase I: Monitoring of conditions to confirm that thermal equilibrium and physical stability criterion are achieved.

During Phase I, monitoring would take place in years 1, 3, 5. The five-year term was selected on the basis that ground-temperature thermal regimes at these specific landfills would require three to five years to reach equilibrium.

Visual and thermal monitoring should be carried out on Tier II soil facilities and leachate contained landfills.

Visual inspections of the constructed and remediated landfills would also be carried out. It is anticipated that, if there is settlement or erosion within the initial years following remediation, it is likely attributable to construction quality. Changes after the first three years are more likely attributable to changes in the site conditions (i.e. warmer temperatures, changes in surface water drainage patterns).

It is recommended that groundwater monitoring take place in Years 3 and 5. The timing of the groundwater sampling event should consider the variability of water quality measured during the baseline monitoring.

An evaluation of the Phase I data would be carried out at the end of five years to confirm that thermal equilibrium has been achieved, and that no stability issues had been identified. The Phase I monitoring program may be extended, if required.

Phase II: Verification of equilibrium conditions established during Phase I.

At the completion of Phase I monitoring and review of the results, the Phase II monitoring frequency may be modified or downgraded. If no significant issues are identified for landfills of low potential environmental risk (as defined by the landfill evaluation matrix), monitoring may be discontinued at the conclusion of Phase I. If additional monitoring is warranted based on the thermal, groundwater or physical inspection, it is recommended that the monitoring frequency in Phase II be carried out according to the following schedule: Year 7, Year 10, Year 15, and Year 25. Year 25 would mark the end of Phase II monitoring.

Physical inspections of all landfills would be carried out at each monitoring event. The requirement for continued thermal monitoring would be based on Phase I results, or if significant climate changes had been recorded in the region.

Groundwater monitoring would be carried out at each monitoring event. The optimal time period for sampling would be based on the results obtained during baseline and Phase I monitoring.

Phase III: Monitoring for long term issues such as liner integrity, permafrost stability, and significant storm events.

At the end of Phase II, 25 years after implementation of the remedial actions for a given landfill, a re-evaluation of the monitoring program should be carried out prior to initiating Phase III. It is difficult to predict beyond 25 years how world events and improvements in technology may impact monitoring requirements.

7.5 Interpreting Monitoring Results

Landfill monitoring results (thermal, chemical and visual) have to be interpreted in concert with one another as described in AMSRP Volume 2 (INAC 2009).

7.6 Reporting Format

To provide a basis for comparison between monitoring events, it is recommended that a consistent format be used in reporting.

An outline is provided as follows:

1 Introduction. The introduction should provide an outline of the work elements, the timing of and weather conditions during field work, and describe the scope of the document.

For each individual landfill, the following information is to be provided.

2a. Landfill Summary: For each landfill, a summary should be prepared that describes the monitoring carried out, any notable groundwater analytical results, and any associated staining, seepage, exposed debris, and/or evidence of vandalism. In addition, visual inspection issues identified as significant or unacceptable should be identified. The overall performance rating of the landfill should be provided.

2b. Completed Visual Inspection Report.

2c. A preliminary stability assessment, as described in Section 4.

2d. Annotated drawings on a tabloid paper, indicating all visual inspection features.

2e. Completed thermistor inspection reports, where appropriate.

2f. Photographic records.

2g. Thermal monitoring data, where appropriate.

2h Groundwater analytical data.

2i. Monitoring well sampling logs.

In Annexes to the report, the following information is to be provided.

- Formal laboratory results.
- QA/QC evaluation of the analytical results.
- Handwritten field notes.

Example field note templates are provided in AMSRP Volume 2 (INAC 2009).

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Annex A – Dump site, landfill and debris area (waste disposal area – WDA) evaluation

SUMMARY

In 1997, the DEW Line Cleanup Environmental Working Group (EWG), comprised of members representing Nunavut Tungaavik Inc. (NTI) and the Department of National Defence (DND) / Defence Construction Canada (DCC), was formed to address environmental issues associated with the DEW Line sites under the jurisdiction of DND. One of their tasks was the development of a matrix to assess potential environmental risk associated with existing landfills at the DEW Line sites. The evaluation matrix considered three primary categories, contaminant source, exposure pathways and potential receptors. In the development of the matrix, landfills typical of the DND DEW Line sites were considered. The DND DEW Line sites were in operation for nearly 40 years, and landfill activity was generally extensive.

By comparison, most INAC Abandoned Military Sites were generally only operational for a much shorter period of time, approximately five to six years. Accordingly, waste disposal practices were different. At many sites, waste materials were not consolidated in a single area, and dump sites and/or isolated areas of partially buried debris are common. These areas are collectively referred to as Waste Disposal Areas (WDA).

This current document presents an Evaluation Matrix for WDAs that considers conditions more specific to INAC Abandoned Military sites.

1 INTRODUCTION

To address the varied nature of landfills at abandoned military sites, a consistent method for the assessment of their potential risk to the arctic environment, in the form of a risk evaluation matrix, was developed by the DND/NTI EWG in 1997 (EWG 1998). Since that time, the matrix has been utilized to develop recommendations for landfill remediation at DND DEW Line sites. This document provides a modified evaluation matrix to address the dump sites, landfills and buried debris areas more typical of the abandoned military sites under the jurisdiction of INAC. As a whole, these are referred to as Waste Disposal Areas (WDAs).

The DND/NTI evaluation matrix was based on the CCME National Classification System for Contaminated Sites, and adapted to address the particular concerns of the Arctic environment. This revised version also references the Federal Contaminated Site Action Plan (FCSAP) Contaminated Site Classification Guidance Document. The matrix is divided into three categories of equal weight: contaminated source, pathways, and receptors. The interaction of these three elements results in environmental risk. Each category is assigned 50 points, which are distributed among several factors. Each of these factors has been made as specific as possible in order to reduce the subjectivity of the matrix to a minimum. In addition, each of the three main categories is assigned a highly subjective "special considerations" factor according to the method described in the CCME Classification System. As it is unlikely that any classification system could address all possible factors, a special considerations factor allows the user to increase or decrease the score "to emphasize important concerns about a site and should be used as an exception rather than as a rule" (CCME 1992, p.6-7).

The intended purpose of the matrix is to evaluate the potential environmental risk posed by WDAs in their current condition.

Two conservative assumptions are made during the evaluation of all WDAs

- The contents of WDAs are generally unknown and all potential contaminants may be present.
- If contaminants come into contact with receptors, they could have adverse effects on the receptors.

2 MATRIX FACTORS

2.1 Contaminant Source – Category A

Four factors were considered under Contaminant Source to describe specific disposal areas as follows:

A.1 Areal extent of waste disposal.

A.2 Estimated depth of buried debris

A.3 Contaminant Characteristics – combined presence of leachate and surface contaminated soil.

A.4 Presence of Surface Debris

Contaminant characteristics were assigned the greatest weighting in this category as it is a strong indicator of potential environmental risk associated with the WDAs. The volume of a WDA is considered to be related to its potential to be contaminated – the greater the volume, the greater the risk that contaminants are present. The volume of the waste disposal area is divided into two parameters, area and depth. The area is relatively easy to measure; the estimated depth of the buried waste is given less weight in the matrix as it is difficult to measure using non-intrusive techniques.

A.1 Areal Extent of Waste Disposal

The larger the area impacted by waste disposal, the greater the potential for contaminants to be present exists. The areal extent of dump sites can be easily surveyed based on the presence of surface wastes. Landfill or buried debris areas are based on the results of geotechnical/geophysical site surveys and visual observations. A value of 10 000 m^2 is used as the basis for comparison. All WDAs greater than 10 000 m^2 are awarded the maximum points for this category. Scoring for all other WDAs is prorated relative to 10 000 m^2. WDAs less than 1000 m^2 are referred to as debris areas.

Scores are provided for all WDAs following the detailed field investigations that are carried out prior to cleanup/construction. The objectives of these investigations are to delineate the extent of known contamination, and confirm existing site and WDA conditions.

A.2 Estimated Depth

The depth of landfills and debris areas can be estimated by visual inspection of surrounding topographic features. The average depth of the active layer is used as a qualifier for the description of landfill depth, as this is generally the maximum depth of investigation. The depth of the active layer may range from one to two meters at these sites, depending on material type; therefore an average depth of 1.5 meters was used in the rating. Landfills and buried debris with estimated depths of greater than 1.5 meters were scored higher than those with estimated depths of less than 1.5 meters. For the majority sites, it is anticipated that the depth of buried waste is 1.5 metres or less. Exceptions to this may include dumping within ravine areas or other natural depressions. A minimum score of 2 is allotted to all WDAs in the absence of specific data.

A.3 Contaminant Characteristics

Contamination associated with WDAs may be elevated with respect to background concentrations, but less than applicable criteria. In this case, elevated concentrations may be indicative of chronic low levels of contaminants leaching from the WDA, as a result of infiltration and percolation of surface water, or flow of active layer groundwater through areas of buried debris. In some cases, contamination on the surface may exceed applicable criteria as a result of direct spills or leaking containers.

With consideration of the FSCAP Hazard Ranking of contaminants and the DCC Criteria, all contaminants included in the DCC are considered high concern, with the exception of Petroleum Hydrocarbon Fractions F3 and F4. The F3 and F4 fractions are considered essentially insoluble and are therefore immobile. In the scoring of this category, four categories are provided:

- Concentrations not elevated with respect to background; however, the potential for contamination is considered possible.
- Concentrations elevated with respect to background; but less than DCC criteria. Elevated with respect to background refers to a concentration in excess of the three times the mean background concentration. With respect to organic contaminants, such as hydrocarbons and PCBs, the method detection limit is assumed to represent background concentrations.
- Concentrations in excess of DCC Tier I guidelines.
- Concentrations in excess of DCC Tier II guidelines.

A.4 Presence of surface debris

At some WDAs, in particular dump sites, surface debris is very extensive, while at others there is almost no debris. Scoring needs to be quantitative; therefore the percentage of the surface area of the landfill that is covered with debris is used as the basis for scoring. A WDA that has surface debris covering more than 50% of its surface receives a full score. Debris areas, and dump sites as implied by the designation, generally receive full score for this category.

2.2 Pathways – Category B

The primary transport mechanisms for contaminants at these sites are considered to be:

B.1 Aerial transport of fine particles; and

B.2 Dissolved phase and/or colloidal transport in water, both as surface water run-off or subsurface water flow.

B.1 Aerial Transport of Contaminants

All contaminants can be transported as particles. Windblown debris is not considered in this category, as debris pickup is inherent in any cleanup. Surface contamination or surface expressions of leachate impacted soils imply the potential for aerial transport. This factor is given a low weight because the quantity of contaminated soil on the surface is generally low relative to the quantity of contaminated soil at the site as a whole. In addition, it is anticipated that relative to the effect of water movement, aerial transport contributes less to the transport of contaminants away from a landfill.

B.2 Water Movement

Dissolved phase and/or colloidal transport in water includes movement of surface water and subsurface water within the active layer. "Groundwater" is not addressed as an issue separate from surface water, as the movement of water within the active layer is generally subject to the same driving forces or gradients as surface water. The intent of this sub-category is to examine factors that affect migration away from the WDA – slope, runoff, extent and type of cover on below grade disposal areas, annual precipitation and distance to surface water. Among these factors, topography, runoff potential and proximity to surface water are given the greatest weight.

B.2.1 Topography

The degree of the slope on which the WDA is located is one of the major factors contributing to transport of contaminants. Scoring is carried out on a progressive scale. In cases where there are different slopes in the area, a weighted average is used.

B.2.2 Cover Material – Depth

The extent to which contaminants are available for transport is also dependent on the depth and type of cover material, where present. The potential for leachate generation and correspondingly, leachate migration, is related to infiltration of water. Cover over the WDA helps mitigate infiltration of water into the landfill contents. As the thickness of the cover increases, the likelihood that potential contaminants will be released decreases. If the active layer is contained in the cover material above the debris, then the potential for surface water infiltration into the WDA is small; this circumstance is assigned the lowest score.

B.2.3 Cover Material – Type

The erosion potential of a WDA is partly based on the type of cover material. Erosion can eventually lead to the exposure of the waste. Some cover materials are more susceptible to erosion than others; well graded gravels are the least susceptible, and silty materials are the most susceptible. In cases where there is no cover, this factor is assigned the highest score. Where the cover materials consist of a combination of soil types, the scoring should reflect the more conservative or higher score.

B.2.4 Surface Water/Run-Off Potential

This factor aims to describe the destructive potential of water action on the WDA, which could take the form of waves; streams, rivers or lakes; or seasonal drainage. Where there is significant seasonal drainage, the run-off potential is high. "Significant seasonal drainage" is defined as run-off that has the potential to transport large quantities and concentrations of contaminants to surface water courses over a short period of time (CCME 1992, p.23). Significant seasonal drainage also includes consideration of major snow drifting in the area.

B.2.5 Precipitation

The amount of precipitation received, either as rain or snow fall, affects the amount of surface water infiltration or run-off, and potentially erosion. The majority of the abandoned military sites receive less than 500 mm of precipitation annually, with the exception of sites on the lower east coast of Baffin Island. Typically, the amount of precipitation at any site is relatively low. Any given rainfall event is unlikely to generate major run-off; however, spring thaw and corresponding run-off may be significant at some sites. Detailed precipitation data is not available for the INAC sites; therefore data was interpolated from the Hydrological Atlas of Canada Maps [accessed on line: http://atlas.nrcan.gc.ca/site/english/maps/archives/5thedition] as summarized below for various areas. For sites not listed below, the aforementioned maps should be consulted.

Sites	Annual Precipitation (mm)	Annual Snowfall (cm)	Average Maximum Snow Pack depth (cm)
Clifton Point	100-200	100	30
Bernard Harbour east to Matheson Point	100-200	80	30
Simpson Lake to Sarcpa Lake	150-200	100	50
Bray Island, Rowley Island	150-200	100	60
Nadlaurdjuk Lake	200-300	100	60
Ekalugad Fiord	200-300	200	70
Kivitoo	350	240	100
Durban Island	+400	240	100

As spring run-off likely represents the maximum precipitation event, scoring is provided relative to the maximum snow pack depth, with a score of 4 allotted to snow pack depth of 100 cm. If site specific factors, such as drifting in the WDA are present, the score may be increased to 5, the maximum allotted to this category.

B.2.6 Distance to Down-gradient Perennial Surface Water/Seasonal Drainage Channel

The distance to surface water will affect the probability of contaminants reaching the watercourse. This factor can include streams, seasonal or perennial, running directly through the WDA, or streams and lakes downgradient from the WDA, but it is intended to exclude small ponds with no outflow. On very steep slopes, this distance should consider the horizontal distance to the water body rather than the elevation difference. The impact of drainage with respect to contaminant exposure is not considered in this category (it is considered under Receptors); this factor determines whether there is a drainage pathway away from the WDA.

2.3 Receptors – Category C

This section addresses the potential for impact on receptors, specifically, aquatic and terrestrial habitats, as well as human exposure. Impact on humans is the primary consideration; however, it should be recognized that impact on humans is implicit in the scoring of factors addressing ecosystem impact. The scoring within each category is to be based on recorded data, as well as local knowledge of the land use in the area, and therefore requires local input.

C.1 Potential Impact on Receiving Freshwater/Marine Habitat

Selection of the water body in this category is based on potential effects on the receiving habitat. Consideration must be given to the regional drainage patterns. For example, where the drainage from a WDA is overland (i.e. there is no direct connection between the WDA and the downgradient water body), water bodies beyond two kilometers should not be used in the evaluation. This is based on the premise that natural attenuation of any potential contamination will occur with overland flow. Where a direct connection between a WDA and a downgradient water body exists, via a stream or interconnected ponds, the two-kilometre limit should not be used.

C.1.1 Proximity to Receiving Freshwater/Marine Habitat

"Receiving habitat" is considered to be a significant body of water near the limit of the WDA where contaminants are likely to have an impact. The water body may support freshwater or marine life and/or may be used by avifauna and/or terrestrial mammals as a water source. It is not necessarily the seasonal drainage course or perennial water body closest to the limit of the WDA toe. The objective is to select a habitat that supports receptors rather than identify the closest body of water. It is assumed that only habitat downgradient from the WDA is to be considered (given that aerial transport of contaminants to habitat upgradient from the WDA will be addressed by the remediation of contaminated soil).

C.1.2 Estimated Habitat Usage – Freshwater/Marine

The score within this category is based on the frequency of usage within the selected receiving environment and considers the level of biodiversity and the occurrence of calving/spawning grounds. Freshwater and/or marine wildlife are potentially more at risk compared with terrestrial wildlife or avifauna, the latter of which are exposed through water ingestion. Thus, when terrestrial wildlife or avifauna are the primary receptor, the score for this factor should fall into the moderate or low category based on the potential frequency of usage. Otherwise, when the selected water body sustains freshwater and/or marine wildlife, the level of biodiversity should be used to evaluate the score. It should be noted that the most conservative approach - in the selection of the receiving water body - must be used when scores from section C.1.1 and C.1.2 are combined. Finally, "biologically sensitive" areas such as bird sanctuaries and/or endangered, threatened or vulnerable populations should be considered as "special considerations".

C.2 Potential Impact on Receiving Terrestrial Habitat

C.2.1 Extent of Vegetation

The extent of vegetation considers the area within 300 metres downgradient of the WDA. Within this distance, vegetation is expected to be most susceptible to uptake of contaminants if they are leaching from the WDA. However, topography and the potential for run-off must be considered and a greater or lesser distance could be considered.

C.2.2 Estimated Habitat Usage – Terrestrial/Avifauna

The same criteria as for usage of aquatic habitat are to be applied.

C.3 Potential Human Exposure Through Land Use

C.3.1 Presence/Occupation

This factor addresses strictly dermal exposure and inhalation; consumption of food and water from the area are dealt with in subsequent factors. The risk of dermal exposure or inhalation is much lower when soil is frozen; therefore winter occupation of the site is assigned a low risk. "Summer" in this factor is intended to include the spring, summer and fall periods when the ground surface is not frozen. Within this factor, the scoring takes into account the likelihood and the duration of contact. Using this method, proximity to a community is considered (high likelihood of contact), although proximity to a community does not necessarily trigger a high score if visits are infrequent (low duration of contact).

The likelihood of contact considers proximity to community or to a camp, as well as proximity to "travel routes". The duration of contact considers full time residences (i.e. permanent community for high, summer camp for moderate, winter camp or travel routes as low). Scores may be interpolated between the allocated points, according to Table 1 below. Unmanned Short Range Radar (SRR) sites, part of the North Warning System, are co-located at some of the former abandoned military sites, and periodic maintenance of these facilities is carried out. As a conservative approach, it may be considered that maintenance workers may have a low likelihood of contact and low duration of contact.

Table 1: Scoring Guide for Section C.3.1

	High Likelihood of Contact	Moderate Likelihood of Contact	Low Likelihood of Contact
High Duration of Contact	8	6	4
Moderate Duration of Contact	6	4	2
Low Duration of Contact	4	2	1

Different areas on a site may need to be considered individually.

C.3.2 Proximity to Drinking Water Source

Regardless of whether the source is seasonal or perennial, an established community or a summer camp water source located downgradient of the WDA is to be considered in this factor.

C.3.3 Food Consumption

This factor is divided into two sub-sections, and the score is the sum of the score for each of the two sub-sections.

Sedentary organisms are more susceptible to local inputs as their exposure is greater if they are downgradient from the WDA. These organisms can include bottom-dwellers such as sculpins, mussels, sea urchins etc., as well as terrestrial vegetation, which can be used for medicinal purposes. This kind of contamination "is quite localized when considered on a broad regional scale" (DIAND 1997, pg. 5).

Migratory marine animals may have body burdens of contaminants; these are not directly attributable to local contaminant sources, as the vast majority of organochlorines, for instance, arrive in the Arctic via long range transport. Caribou living in the general area of DEW sites do not have elevated levels of contaminants, as they feed over a very wide area. The Canadian Arctic Contaminant Assessment Report (DIAND, 1997) describes these results in more detail.

It is recognized, however, that sources such as abandoned military sites do contribute contaminants to the Arctic ecosystem. For the purpose of scoring the matrix, therefore, a high consumption of animals from the area surrounding the site has the potential to pose a higher risk than a low consumption, although in general the risk remains low.

2.4 Special Considerations

As indicated in the introduction to the matrix, each of the three main categories includes a "*special considerations*" factor. The proposed value of the special considerations factor is a maximum of ten percent of the overall score for each category. It is intended that no circumstance will allow a user to assign a special considerations score that will cause the score for that category to exceed the maximum allotted. To avoid undue bias, it is also suggested that the user should complete the entire evaluation form and score a site before addressing special considerations in the total score.

The Environmental Working Group (EWG) based their landfill risk evaluation matrix on the CCME model which defines three categories: contaminant source, pathways and receptors. Within those three categories, the EWG tried to address all of the possible factors contributing to risk. Recognizing that even a thorough matrix could never address all possible risk factors, special considerations were included to address specific risk factors that are not general to all of the abandoned military sites.

As noted in the CCME document, the special considerations factor is not intended to be applied on a regular basis, as it addresses very site-specific risk factors. In fact, if the special consideration factor was being consistently applied in the scoring of a WDA, it would indicate that the matrix itself was incomplete. Special considerations should be site-specific characteristics that can be documented.

Three examples of how special considerations could be applied are provided to clarify the use of such a classification:

Example 1. Wildlife on site

It may be that "special considerations" points would be assigned to the Receptors category when endangered, threatened and/or vulnerable species (COSEWIC, 1997) are known to visit the WDA.

Example 2. Proximity to a community

In the WDA risk evaluation matrix, human exposure to a WDA is measured in the following way: people can spend time at the WDA (potential dermal exposure), they can drink water from an area near the WDA (potential ingestion), they could live very close to the WDA (potential exposure through aerial transport) or they could eat animals that feed near the WDA (potential ingestion). These considerations form section C.3 of the risk evaluation matrix. If a WDA is located near a community, there is a greater likelihood that people will spend time at the site than there is for areas far from a community. It is not necessarily the case, however, that WDAs near communities receive frequent visits; therefore, instead of creating a special section addressing proximity to a community, the risk of human exposure (see Table 1-1) is more accurately evaluated by measuring time spent at a WDA. In these cases, however, "special considerations" points may be added to the receptors category to address a community's specific concerns, such as the physical hazards associated with an exposed dump site.

2.5 Traditional Knowledge

The matrix for the evaluation of potential environmental risk was developed recognizing that local input would be relied upon in the scoring of WDAs. Additional guidance on the collection of Traditional Knowledge is provided in Section 4.10 of the protocol.

3 INTERPRETATION OF SCORES

The score obtained through the application of the matrix is intended to represent the potential environmental risk posed by a given WDA in its current state. The objective of remediation is to mitigate the risk associated with a WDA by preventing the migration of contaminants that may be present in the landfill, and by removing physical hazards.

During the development of the matrix by the EWG, WDAs at four different sites were evaluated by environmental scientists and engineers to assess the applicability of the matrix and to determine cut-off values between categories. WDA scoring 105 points or more is classified as potentially high risk (Class A) and require excavation. The high score accorded to these WDAs is generally a result of the ecological sensitivity of the area and the geometry and surrounding topography of the landfill, which precludes the development of a cost-effective and long-term design solution such as pathway intervention and/or stabilization of the landfill. WDAs with a score of 100-104 points must be considered on a case by case basis – some may require complete excavation while others may be considered Class B landfills. WDAs that score less than 105 require excavation/removal if one or more of the following conditions are met:

- The WDA is located at an elevation of less than 2 m higher than an ocean.
- The WDA consists of unconsolidated wastes at surface. Debris should be removed, classified, and sorted, and non-hazardous contents placed in an engineered landfill.
- WDA, with areal extent of less than 1000 m^2 and scoring a total of 89 points or more are classified as potentially high risk and require excavation to the full extent/depth of the debris. In addition, if these WDAs score greater than 23 points in the contaminant source category, complete excavation of the area is recommended.

A WDA with a score in the range 75 to 99 points is classified as moderate potential environmental risk (Class B). An engineered leachate containment system will be provided for these WDAs to mitigate against potential environmental risks. In specific cases where an engineered leachate containment system cannot be constructed, an evaluation of excavation will be carried out with the objective of determining whether complete excavation or partial excavation with a leachate containment system is required.

For WDAs of less than 1000 m^2, it is considered unlikely that leachate containment will be cost-effective when compared to excavation and removal of debris. Consideration must therefore be given to the level of contamination present. If contaminants are present in excess of criteria, it is recommended that the debris area be excavated to its full extent. If contamination does not exceed criteria, debris should be cut-off and removed within the upper 0.5 metres of the ground surface. The area should then be regraded to match surrounding topography.

A WDA with a score of 75 or less is classified as low potential environmental risk (Class C). In general, the remediation approach for these areas includes placement of an engineered cover, following collection, sorting, and appropriate disposal of debris from the surface, and excavation and disposal of any surface contaminated soils from the area. Some of the factors to be considered in the design of the cover include: thickness and type of the existing cover materials; slopes on the landfill; surrounding topography and available granular fill. The cover is designed to promote surface water run-off (i.e. no areas of standing water), prevent erosion, and mitigate against settlement. Where required, the slope of the WDA may be modified and/or geotextiles may be incorporated into the granular cover to provide a long-term solution. Generally, the final thickness of cover material is approximately 0.75 metres, and may be greater, dependent on site specific conditions. The granular cover material is to be placed in layers and compacted before the placement of the next layer of granular fill, until the design thickness is reached.

Overall, it is to be stressed that the matrix is to be used in the assessment of potential environmental risks associated with a specific WDA. It is not intended to be used as the sole criterion in determining the remediation solution for a WDA. The results of the matrix, both total score and the score from each major category, are to be considered in conjunction with the engineering evaluation of site conditions, to determine appropriate design solutions. Review of the individual category scores relative to the total score will highlight particular areas of concern that are to be addressed during the design process.

The potential impacts of climate change are also to be considered in evaluating remedial solutions.

It should be emphasized that the total score has an error associated with it of approximately 5 points; there is inevitable subjectivity in the scoring process and scores that fall near decision points should be considered on a case by case basis.

4 REFERENCES

BC Environment. June 1996. Guideline #1 Contaminated Sites: Site Characterization and Confirmation Testing. Draft.

CCME. 1992 National Classification System for Contaminated Sites.

COSEWIC, 1997, Categories of the Committee on the Status of Endangered Wildlife in Canada, Canadian Wildlife Service, Environment Canada.

DIAND, 1997. Canadian Arctic Contaminants Assessment Report.

EWG 1998: *Environmental Working Group (EWG)*, DEW Line Cleanup, Nunavut, Environmental Working Group Report, Prepared for Nunavut Tunngavik Incorporated and the Department of National Defence, *1998*.

ATTACHMENT 1

WASTE DISPOSAL AREA

EVALUATION MATRIX

	ENVIRONMENTAL RISK EVALUATION MATRIX WASTE DISPOSAL AREAS - ABANDONED MILITARY SITES	Maximum Score
A. **A.1**	**CONTAMINANT SOURCE** **AREAL EXTENT OF WASTE DISPOSAL AREA**	
	>10,000 m2	10
	For areas less than 10,000 = Area of Waste Disposal Area X 10 / 10 000	2-9
	Minimum Score	1
A.2	**ESTIMATED DEPTH OF BURIED WASTES**	
	greater than 1.5 m	5
	less than 1.5 m	2-4
A.3	**CONTAMINANT CHARACTERIZATION**	
	Concentrations in excess of DCC Tier II Criteria	25
	Concentrations in excess of DCC Tier I Criteria	20
	Concentrations elevated relative to background	10
	Potential Contamination	5
A.5	**PRESENCE OF SURFACE DEBRIS**	
	>50% of surface area	10
	<50% of surface area, pro-rated	1-9
	No debris observed	0
	SPECIAL CONSIDERATIONS	+/- 5
	TOTAL SCORE - CONTAMINANT SOURCE	

	ENVIRONMENTAL RISK EVALUATION MATRIX WASTE DISPOSAL AREAS - ABANDONED MILITARY SITES	Maximum Score
B.	**PATHWAY/TRANSPORT MECHANISMS**	
B.1	**AERIAL TRANSPORT OF CONTAMINANTS**	
	All Waste Disposal Areas Scored as 2, if surface sol contamination (A.4) or leachate (A.3) has been identified.	
B.2	**WATER MOVEMENT**	
B.2.1	**TOPOGRAPHY**	
	Steeply Slope (>40 % Grade)	12
	Sloping (10% to 40% Grade)	4-11
	Subdued to 10% Slope	2-3
	Flat (< 3%)	1
B.2.2	**COVER MATERIALS –DEPTH**	
	No to little existing cover	4
	Greater than 50% exposed/surface debris	3
	Occasional exposed/surface debris	2
	Existing cover, minimal debris,	1
	Cover thickness > average active layer thickness	0
B.2.3	**COVER MATERIAL – TYPE**	
	No cover	5
	Silty/Sandy Material	4
	Sandy/Gravel Material	3
	Gravel Material	1-2

B.	**PATHWAY/TRANSPORT MECHANISMS continued**	
B.2.4	**SURFACE WATER/RUN-OFF POTENTIAL**	
	Very High - evidence of erosion, continuing run-off, or wave action	12
	High - evidence of erosion, seasonal, widespread, storm waves	10
	Moderate - % area affected by erosion	3-9
	Low - no evidence of erosion, slight slopes	1-2
B.2.5	**PRECIPITATION**	
	> 100 cm snow pack	4
	< 100 cm snowpack (pro-rated)	1-4
	Snow Drifting	1
B.2.6	**DISTANCE TO DOWNGRADIENT PERENNIAL SURFACE WATER/SEASONAL DRAINAGE CHANNEL**	
	0 to 100 m	10
	100 to 300 m	7-9
	300 to 1 km	2-6
	greater than 1 km	1
	SPECIAL CONSIDERATIONS	+/- 5
	TOTAL SCORE – PATHWAYS	

	ENVIRONMENTAL RISK EVALUATION MATRIX WASTE DISPOSAL AREAS - ABANDONED MILITARY SITES	Maximum Score
C.	**RECEPTORS**	
C.1	**POTENTIAL IMPACT ON RECEIVING FRESHWATER/MARINE HABITAT**	
C.1.1	**PROXIMITY TO RECEIVING FRESHWATER/MARINE HABITAT**	
	0 to 100 m	6
	100 to 300 m	4-5
	300 to 1 km	2-3
	greater than 1 km	1
C.1.2	**ESTIMATED HABITAT USAGE - FRESHWATER/MARINE**	
	High; High Biodiversity/ High Occurrence/Calving or Spawning Area	5-6
	Moderate: Moderate Biodiversity, Migratory	3-4
	Low: Low biodiversity; rare sightings	1-2
C.2	**POTENTIAL IMPACT ON RECEIVING TERRESTRIAL HABITAT**	
C.2.1	**Extent of Vegetation**	
	Extensive vegetation growth, (80 to 100 % ground cover)	6
	Moderate vegetation growth (40 to 80% ground cover)	4-5
	Low vegetation growth (20 to 40% ground cover)	2-3
	Sparse vegetation (<20% ground cover)	1
C.2.2	**ESTIMATED HABITAT USAGE - TERRESTRIAL/AVIFAUNA**	
	High; High Biodiversity/ High Occurrence/Calving, Denning or Nesting Area	5-6
	Moderate: Moderate Biodiversity, Migratory	3-4
	Low: Low biodiversity; rare sightings	1-2

C.	**RECEPTORS continued.**	
C.3	**POTENTIAL HUMAN EXPOSURE THROUGH LAND USE**	
C.3.1	**Presence/Occupation** Duration of Contact /Likelihood of Contact	7-8
	see chart and provide rationale for scoring	4-6
		1-3
C.3.2	**Proximity to Drinking Water Source**	
	0 to 100 m	8
	100 to 300 m	5-7
	300 to 1 km	2-4
	greater than 1 km	1
C.3.3	**Food Consumption**	
	High quantity of sedentary organisms - marine & plant life	8
	Moderate quantity of sedentary organisms - marine & plant life	6
	Low quantity of sedentary organisms - marine & plant life	4
	No consumption	0
	High quantity of migratory organisms	2
	Moderate quantity of migratory organisms	1
	Low quantity of migratory organisms	0.5
	No consumption	0
	SPECIAL CONSIDERATIONS ***TOTAL SCORE – RECEPTORS***	+/-5
	TOTAL SCORE	

Annex B – Barrel Protocol

1 INTRODUCTION

In order to determine the correct disposal method for barrels and their contents, the contents must first be identified. All barrel contents should be sampled and analyzed according to DND DEW Line Cleanup standard procedures, as described in this section.

Analytical data obtained for the samples collected from barrels located at the site should be compared to the criteria included in Table 1, below. Barrel contents are identified as organic or aqueous and the concentrations of glycols, alcohols, PCBs, chlorine, cadmium, chromium and lead are determined. The flash point of organic waste and aqueous waste (> 2% glycols/alcohols) must also be determined. Uncontaminated aqueous phases can be disposed of on the land according to the discharge criteria; uncontaminated organic phases can be incinerated; contaminated aqueous material should be scrubbed free of organic material; and contaminated organic material should be disposed of as hazardous material.

During the delineation phase of the site investigation, an inventory of the number and locations of barrels at the site is to be compiled. This inventory should include buried or partially buried barrels that will be taken out of the landfills during excavation. Where significant numbers of barrels are present on a site, and if safe to do so, representative samples shall be collected to provide a preliminary indication of whether on-site incineration is a viable alternative. Otherwise, barrels are only sampled during the cleanup phase and as such, the handling, transportation and opening of barrels is the responsibility of the site Contractor.

Other waste fuels and oils are also sampled according to this protocol. These may come from a variety of sources including, but not necessarily limited to, old generators, fuel tanks and pipelines, and transformers.

2 INSPECTION

All barrels are to be inspected to address the following items which shall be recorded and used as a guide prior to opening barrels.

- Symbols, words, or other marks on the barrel that identify its contents, and/or that its contents are hazardous: e.g. radioactive, explosive, corrosive, toxic, flammable.
- Symbols, words, or other marks on the barrel that indicate that it contains discarded laboratory chemicals, reagents, or other potentially dangerous materials in small-volume containers.
- Signs of deterioration or damage such as corrosion, rust, or leaks at seams, rims, and V grooves, or signs that the barrel is under pressure such as bulging and swelling.
- Spillage or discoloration on the top and sides of the barrel.

3 SAMPLING

Barrels shall not be transported until it has been determined that they are not under pressure, do not leak, and are sufficiently sound for transport.

Barrels to be sampled should be set in an upright position, provided that this does not cause them to leak and that it is physically possible.

Barrels should only be opened according to accepted procedures and under qualified supervision, preferably using remotely operated, non-sparking equipment.

Once open, barrels will be sampled by personnel wearing proper personal protective equipment as described below. Samples of the contents of all barrels shall be extracted using a drum thief and placed into a pre-labelled glass vial. The number and type of liquid phases, and their respective thickness, and the size of each barrel are to be recorded.

In instances where there are a large number of barrels with obviously similar contents, these can be grouped together and 30 to 40% of the barrels in the group sampled. Barrels containing less than 50 mm of liquid may be combined with compatible material prior to sampling; samples inferred to contain only water on a visual examination shall be tested prior to this consolidation. Barrel contents, which consist of black oil, shall not be consolidated.

All barrels shall be clearly numbered using spray paint or other suitable paint marker. The number on this label should be the only sample coding provided to the laboratory.

The barrel locations and barrel sample descriptions should be recorded.

Samples should be kept at ambient temperatures and shipped by guaranteed freight to laboratories where they should be kept cold pending analysis.

4 TESTING

Liquid samples shall be inspected and classified as either containing water or organic materials. Samples thought to contain water shall be analyzed to confirm that they are indeed water, and contain less than 2% glycols or alcohols.

The contents of barrels containing organic materials, including aqueous samples which contain more than 2% glycols or alcohols, shall be tested for flash point, PCBs, total chlorine, cadmium, chromium and lead following the targeted barrel testing approach presented in Figure 1. Analyses will be conducted on a rush basis where indicated. In addition, major organic components should be identified e.g. fuel oil, lubricating oil.

If on site incineration of waste is not planned, waste samples need only be tested for flash point, PCB, and pH (at regular turnaround time) in order to classify the waste for transport and disposal options.

Contents of barrels which contain two or more phases shall have all phases analyzed; the organic phases as described above and the aqueous phase to ascertain whether it contains less than 2% organic substances. In addition, the aqueous phase shall be tested for any components found in the organic phases above the criteria provided in the protocol.

5 DISPOSAL OF BARREL CONTENTS

Barrels containing only rust and sediment shall be treated as empty barrels.

Barrel contents comprising water only (less than 2% glycols or alcohols) shall be transferred to an open vessel such as a utility tub or half-barrel and any organic material removed by agitation with a pillow or segment of oil absorbent material. The water shall be tested prior to discharge in accordance with wastewater discharge criteria. Where water meets criteria, it may be discharged to the ground a minimum of 30 meters distance from natural drainage courses. Used oil absorbent material shall be treated as described in the following subsection.

Barrel contents which are composed of water with glycols and/or alcohols or organic phases, and which contain less than 2 ppm PCBs, 1000 ppm chlorine, 2 ppm cadmium, 10 ppm chromium, 100 ppm lead, and that have a flash point between 25°C and 225°C, may be disposed of by incineration. Alternatively these contents may be disposed of off-site at a licensed disposal facility. The solid residual material resulting from incineration shall be subjected to a leachate extraction test. Material found to not be leachable shall be disposed of as DCC Tier II contaminated soil. Leachable material shall be treated as hazardous waste and disposed of off-site at a licensed disposal facility.

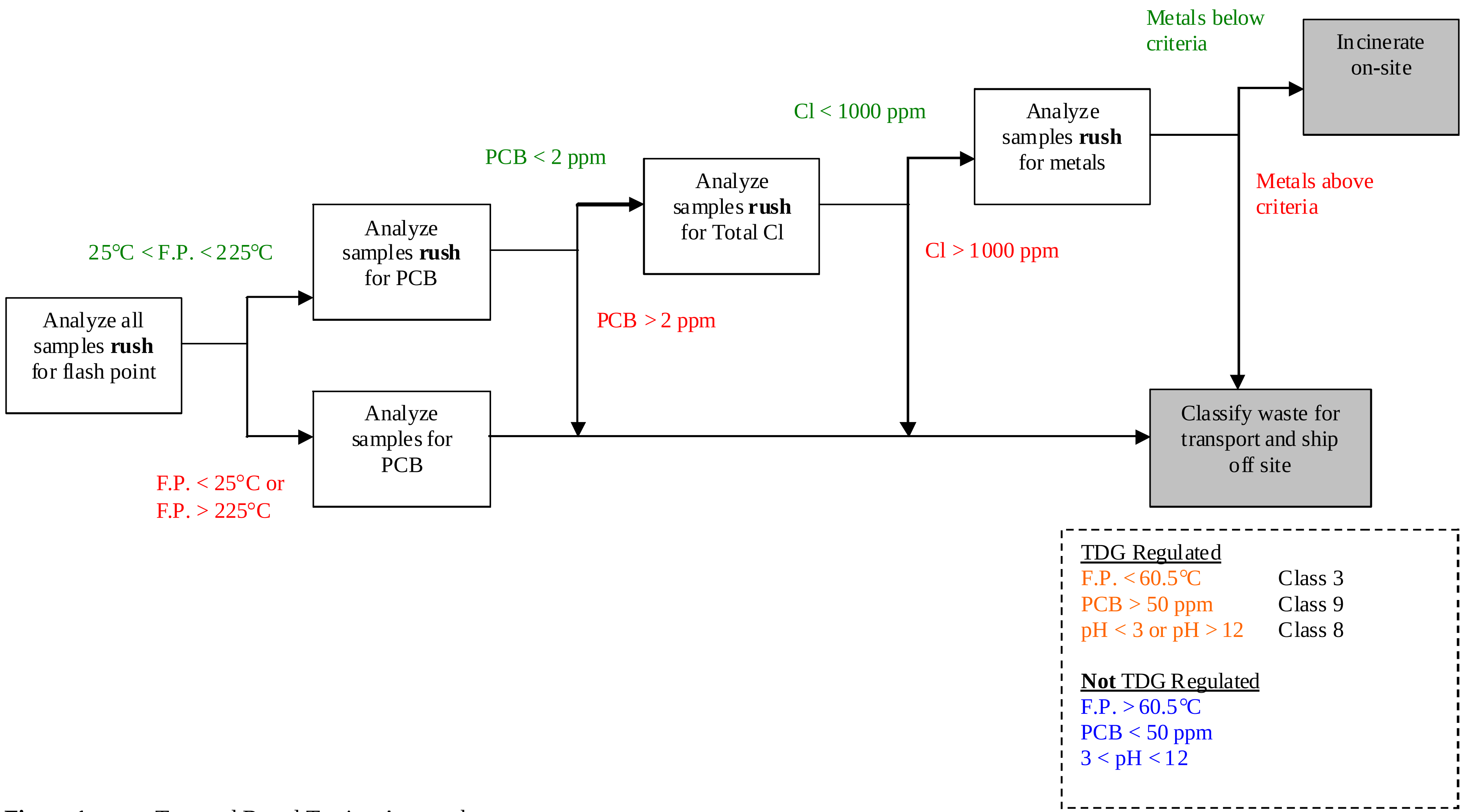

Figure 1 Targeted Barrel Testing Approach

Barrel contents, which contain greater than 2 ppm PCBs, 1000 ppm chlorine, 2 ppm cadmium, 10 ppm chromium or 100 ppm lead, or that have a flash point below 25°C or greater than 225°C shall be disposed of off-site at a licensed disposal facility. Contents may be combined with compatible materials for shipping purposes.

Used oil absorbent material should be treated as hazardous waste and disposed of off-site at a licensed disposal facility. If it is shown to be uncontaminated with PCBs (< 2 ppm), chlorine (< 1000 ppm), cadmium (< 2 ppm), chromium (< 10 ppm) and lead (< 100 ppm), it may be incinerated on-site.

6 DISPOSAL OF BARRELS

Empty barrels may be crushed or shredded and landfilled on-site as non-hazardous waste after they have been cleaned in an appropriate manner. The barrels shall be crushed in such a manner so as to reduce their volume by a minimum of 75%. Shredded barrels may be disposed of off-site as recycled metals.

7 PERSONNEL PROTECTIVE EQUIPMENT

Safety equipment required includes a respirator with organic vapour cartridges, safety glasses, a hard hat, rubber safety boots, double gloves (chemically resistant on the outside, and latex or vinyl on the inside) and disposable Syranex-coated coveralls.

A decontamination procedure should be established at the barrel sampling area(s) to prevent tracking potentially contaminated liquids outside of the sampling area(s).

It is advisable to have one person outside of the sampling area to observe the sampler(s) in case of unexpected hazards, and also to record the samplers' observations.

Appendix E

Golder Archaeological Impact Assessment Report

FINAL REPORT

ARCHAEOLOGICAL IMPACT ASSESSMENT (AIA) OF THE CAM-A INTERMEDIATE DEW LINE SITE, STURT POINT, NUNAVUT

NUNAVUT ARCHAEOLOGIST PERMIT 10-018A

Submitted to:

The Department of Culture, Language, Elders and Youth (CLEY), Nunavut

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December 2010 **10-1333-0022**

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EXECUTIVE SUMMARY

This report details the results of an Archaeological Impact Assessment completed under Nunavut Archaeologist Permit 10-018A issued by the Department of Culture, Language, Elders and Youth, Nunavut to Sean Webster of Golder Associates Ltd. This study was completed on behalf of AECOM and Public Works and Government Services Canada and included the assessment of the Sturt Point area on Victoria Island, located approximately 85 km east of Cambridge Bay, Nunavut. This Archaeological Impact Assessment was carried out in conjunction with the Phase III Environmental Site Assessment, Hazardous and Non-Hazardous Materials Audit, Geotechnical Evaluation and Remedial Action Plan being conducted in advance of planned reclamation activities at the CAM-A Intermediate Distant Early Warning Line site location.

Procedures employed for this project are considered standard for projects of this nature in the region and entailed pre-field studies, on-ground reconnaissance, site documentation and assessment, reporting and recommendation formulation. Project planning also included provisions for a representative of the local community to accompany the field crew during the field inspection. Gary Avalak of Cambridge Bay accompanied the team during the assessment.

Lack of vegetation and sedimentation enabled surface examination of the facility areas to adequately assess for the presence of cultural materials. In addition, areas adjacent to locations that will be impacted during remediation were also examined. During the study, six sites were identified and documented as per the *Nunavut Archaeological and Palaeontological Sites Regulations*, including NeLv 1, 2 and 3 and NeLw 1, 2 and 3. In addition, several sites representing more recent occupation of the area were also noted during the assessment. These sites are described in this report, however; they do not meet the technical requirements to be considered archaeological sites.

It is recommended that the remediation of the CAM-A site be allowed to proceed with the condition that no impacts occur within 30 m of sites NeLv 1, NeLv 2, NeLv 3, NeLw 1, NeLw 2 and NeLw 3.

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1. INTRODUCTION

In August of 2010, Golder Associates Ltd. (Golder) conducted an Archaeological Impact Assessment (AIA) of the CAM-A Intermediate Distant Early Warning (DEW) Line Site in conjunction with the Phase III Environmental Site Assessment (ESA), Hazardous and Non-Hazardous Materials Audit, Geotechnical Evaluation, Remedial Action Plan on behalf of AECOM and Public Works and Government Services Canada (PWGSC). The CAM-A Intermediate DEW Line site is located at Sturt Point, Victoria Island, approximately 85 km east of Cambridge Bay, Nunavut (Figure 1). All required fieldwork was completed under an Archaeological Permit (10-018A) issued by the Department of Culture, Language, Elders and Youth (CLEY), Nunavut to Sean Webster of Golder.

The purpose of the AIA was to conduct a pedestrian suvey and subsurface testing within the area of the CAM-A DEW Line site location to assess the potential for previously unrecorded archaeological resources. The intent of this program was not to conduct a full AIA of the entire Sturt point area; however, during traverses of the former DEW Line station some lands outside of proposed impacts were investigated. This report details the nature of the studies conducted, presents their results, and makes recommendations relating to heritage concerns in respect of the proposed remediation program.

1.1 Archaeological Resources Defined

The *Nunavut Archaeological and Palaeontological Sites Regulations* (2001) define an archaeological artifact as “any tangible evidence of human activity that is more than 50 years old and in respect of which an unbroken chain of possession or regular pattern of usage cannot be demonstrated.” An archaeological site is defined as “any site where an archaeological artifact is found”.

Archaeological sites are non-renewable resources that may be located at or near the ground surface or may be deeply buried. Archaeological sites are typically classified as prehistoric or historic. Prehistoric or precontact archaeological sites are those sites which

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PROJECT AREA

REFERENCE

TOPOGRAPHIC MAP 67B 4th EDITION OBTAINED FROM Canmatrix. COPYRIGHT 1995 HER MAJESTY THE QUEEN IN RIGHT OF CANADA. DEPARTMENT OF NATURAL RESOURCES : TRANSVERSE MERCATOR DATUM : NAD83 COORDINATE SYSTEM : UTM ZONE 13

PROJECT

CAM-A DEW LINE SITE STURT POINT

TITLE

CAM-A PROJECT LOCATION AND STUDY AREA BOUNDARY

Golder Associates
Calgary, Alberta

PROJECT	10.1333.0022.8470	FILE No. 10133300228470A001		
DESIGN	BM	31/03/10	SCALE AS SHOWN	REV. 0
CADD	SS	06/10/10		
CHECK	SW	10/12/10	FIGURE: 1	
REVIEW	GC	10/12/10		

contain features or artifacts that reflect the use of a given land base by people prior to European influences. Prehistoric sites typically include ancient campsites, resource harvesting and processing sites, features, artifact scatters and isolated artifact finds.

Features are non-portable articles that indicate a human modification of the local environment. In prehistoric sites in Nunavut these often include items such as hearths, tent rings, stone cairns, and caches. Artifacts are portable items that have been modified by people at some time in the past. These include such items as projectile points, stone flaking debris, cut and modified bone and ceramics. Historic sites generally represent the remains of 19^{th} and early-20^{th} century non-aboriginal habitation, as well as sites associated with industrial and military development. These sites are typically identified by the presence of buildings or structural remains, but may include any site that has evidence of historic use of the landscape. Although not consistently managed under the legislation another important category of historic sites are the remains of traditional use of the land by Aboriginal peoples.

1.2 Potential Impacts

Heritage resources are fragile, non-renewable resources that are generally situated on or near the ground surface. Alteration of the landscape can result in the damage or complete destruction of all or portions of archaeological sites. These alterations often involve the displacement of artifacts resulting in the loss of valuable contextual information or may involve the destruction of the artifacts and features themselves resulting in complete information loss. Losses are permanent and irreversible. Primary, secondary and tertiary impacts are possible with any development. The approach proposed herein is designed to mitigate any potential impacts to heritage resources that could result from the program.

Primary impacts include those disturbances resulting immediately from activity such as the proposed testing during the Phase III ESA and during planned remediation activities. The primary impact zones within the CAM-A DEW Line Site area will be within the remediation footprint including access roads, temporary work zones, borrow pits and dumps. During remediation, vegetation in the area will be cleared, soil will be removed during stripping and excavation, structures will be demolished, materials and equipment will be removed, and the weight of heavy equipment will be sufficient to compress soil strata within the work area resulting in impact to any buried artifacts and features. Individual sites are likely to be affected to varying degrees depending upon where they are located within the proposed areas of impact.

Secondary impacts are indirect impacts that occur after the remediation program is complete. Since the project is of limited duration and will not result in the creation of any permanent structures or facilities, there is no operation phase that will have an effect on heritage resources. Secondary impacts related to site revisits are anticipated to be minimal. Erosion of sloping terrain due to alterations in the vegetation and soils composition may affect sites; however, it is anticipated that excavated areas will be backfilled reducing dramatic changes in slope and therefore potential loss of context due to erosion is likely to be minimal.

Tertiary impacts are the results of changes in land use patterns induced by the program. This area has a long history of use by local people, and use of the area is expected to neither increase nor decrease as a result of the remediation program. Intentional and unintentional impacts to heritage resources can result from increased visitation to specific areas within the region. However, the potential for this type of tertiary impact is anticipated to be low.

2. OBJECTIVES

AIA's for projects of this nature are conducted as required by the Government of Nunavut according to requirements set out in the *Nunavut Archaeological and Palaeontological Sites Regulations* (2001) issued by the Department of Culture, Language, Elders and Youth (CLEY). AIA's are conducted in advance of development to ensure that any heritage resources present are identified and properly managed. The primary objectives of this study were to:

- identify and evaluate archaeological and heritage resources within the proposed area of impact;
- assess the significance of any additional sites identified;
- assess potential development impacts to heritage resources;
- recommend viable measures for managing potential adverse impacts; and
- prepare a Final Report for distribution as required, including submission to CLEY.

This report provides a detailed description of the program adopted to achieve these objectives, as well as its results.

3. PHYSICAL AND CULTURAL SETTING

3.1 Environmental Context

An understanding of past environmental conditions and the environmental factors that shape human approaches to subsistence and settlement patterns enable archaeologists to not only locate sites, but also to provide more accurate interpretations of individual sites. The physical aspects of the environs (topography, drainage, climate and soils) as well as resource availability (flora, fauna, lithic materials and water) are prime criteria for the identification of site location and function. Assessments of the universal cultural activities of site location, travel within and through the area, and resource exploitation are key components of any archaeological site analysis.

The regional environment influences where specific activities and occupation are located in a pattern of seasonal movements according to the availability of resources: a seasonal round. The variables of archaeological site distribution can be identified and combined into useful criteria for suggesting the potential of an environment to hold heritage resources that includes a wide variety of landforms frequently associated with coastlines and lake shores, river banks, eskers and kames, and bedrock knolls in Arctic environs. Distribution patterns partially reflect environmental opportunities presented to human groups as well as cultural preferences demonstrated by site location. Topography influences much human activity including travel, communication, resource catchments, dwelling locations and eventually constrains human activity areas to defined localities. Based on existing heritage resources, the environment is a key factor in human settlement patterns.

3.2 Regional Environment

Prior to contact with Europeans, the environment in which the people of North America lived strongly influenced their culture and economy. The people who inhabited the North took advantage of the seasons and all the resources that were available.

Victoria Island is mainly moraine covered low-lands and drumlin fields, with many raised beaches (Collignon 2005). The vegetation is typical of a tundra environment and consists of arctic willows, marshy lowlands and lichen on rocky outcrops. Inland small herds of musk-oxen and caribou as well as white foxes, wolves, ptarmigans and Arctic owls are found on the island; while seals and polar bears inhabit the coastal areas.

The CAM-A site area is characterized by hummocks, rolling hills and raised beaches compost of coarse grained gravel. The station facilities were constructed on the highest beach ridge at Sturt Point. During the study the only wildlife observed were several musk-oxen. Vegetation is limited to low lying, wet areas which are typically covered in moss. Exposed beach ridges are sparsely covered in moss and lichen.

3.3 Cultural Chronology

Many of the archaeological materials in the project area represent human activity after the ice sheet receded between 10,000 to 8,000 years ago. Most heritage resources sites have been located on eskers in this regional environment (Noble 1981: 97) and Wright (1995: 121) refers to this early period, 10,000 to 6,000 B.P., as the Early Shield culture and suggests a direct development out of eastern and northern predecessors based on technological characteristics and trends.

Between approximately 6,000 and 3,000 B.P. lanceolate projectile points are seen as horizon markers. The Shield Archaic is replaced by the Arctic Small Tool tradition (ASTt) components, attributable to *Palaeo-Eskimo* peoples.

3.3.1 Arctic Small Tool tradition (4200 B.P. to 2800 B.P.)

There is presently little evidence to link Palaeo-Arctic tradition occupations to the Arctic Small Tool tradition (ASTt) occupations that succeed them. The ASTt represents a widespread cultural manifestation that covers all of the Canadian Arctic as well as parts of Alaska and Greenland. The ASTt is typically thought to date between approximately

4,200 and 2,800 B.P. (McGhee 1990). It includes the Denbigh Flint complex in northern Alaska, the Independence I culture of the Canadian High Arctic, the Inuvik Phase and the Pre-Dorset culture in Arctic Canada, and the Sarqaq culture in Greenland. It is thought that the ASTt relates to a separate migration of peoples from Siberia and does not appear to be related to the preceding Palaeo-Arctic tradition. As the name implies, the toolkit of the ASTt is comprised of lithic artifacts that are finely made and smaller than tools of similar function and age from elsewhere in North America. These include microblades and microcores, burins, gravers, small side and end scrapers, side and end blades, and bipointed (arrow) and triangular (harpoon) projectile points (Wright 1995). In Alaska it appears to have developed into the cultures of the Norton tradition while in Canada it developed into the Dorset culture.

The Canadian Tundra Tradition (3,300 – 2,600 B.P.) has been described as a local variant of the ASTt which focused on caribou exploitation (Noble 1981). Sites of this cultural tradition are widespread, being represented in sites on Great Slave and Great Bear Lakes eastward to North Henik Lake near Hudson Bay. Characterized by large lenticular and oval bifaces, small triangular and side notched points, side blades, burin and microblade technology, these assemblages are most commonly associated with orange/pink and white quartzites. Native copper appears in some sites toward the end of this period.

Following the ASTt is the Taltheilei Shale Tradition (2,500 B.P. to 100 B.P.), seen as ancestral to development of the Athapaskan people (Noble 1981). Artifacts of siliceous shale originating on the eastern arm of Great Slave Lake are characteristic; although Taltheilei artifacts have also been identified in the Barrens south of Kugluktuk at Itchen Lake (Blower 2003). Lanceolate projectile points continue to be important in the tool assemblage but small corner and side notched points occur in the latter half of the tradition. The prominent biface and burin and microblade technologies of the preceding phase are notably absent.

3.3.2 Dorset Culture (2,500 B.P. to 1,000 B.P.)

The Dorset culture occupied the Canadian Arctic from 2,500 BP until at least 1,000 BP. (McGhee 1990). Best known for miniature carvings, Dorset appears to have been a more successful adaptation to the conditions of the north than the preceding ASTt cultures from which it developed. This is demonstrated by the huge area occupied by Dorset groups and by evidence that they had perfected winter hunting on the sea ice. Cooler conditions in the northern hemisphere around 3,000 years ago resulted in expansion of the sea ice and a shift away from terrestrial hunting of caribou and hunting of sea mammals from boats in open water to a procurement of sea mammals from coastal edges and sea ice. This is evidenced in the archaeological record with a shift away from bow hunting to harpoon and spear hunting (McGhee 1990). Artifacts recovered from sites representing this period are more diverse and “reflect a richer and more secure way of life than that of earlier Palaeo-Eskimos.” including the establishment of permanent winter villages (McGhee 1990).

However, when the people of the Thule culture arrived in the Canadian Arctic approximately 1,000 years ago, the Dorset culture had largely or entirely disappeared for reasons that are not well understood (McGhee 2001; Wright 1999).

3.3.3 Thule (800 B.P. to 400 B.P.)

The Thule tradition dates from approximately 800 to 400 B.P. and is derived from the Norton tradition in northern Alaska. More specifically, Thule grows out of the Old Bering Sea and Punuk traditions, which have numerous similarities to Thule cultural assemblages. These assemblages suggest subsistence based on maritime resources such as seals and whales that were hunted from kayaks or umiaks as identified by harpoon floats. Thule represented a new kind of adaptation to the Arctic environment, based on the hunting of large sea mammals in open water through the use of drag floats attached to the harpoon line. Large skin boats and the use of dogs to pull large sleds were other Thule innovations. Winters were spent in sometimes large communities of semi-subterranean houses, subsisting on a stored surplus obtained most typically by hunting bowhead whales. The introduction of Thule into the Canadian Arctic is noted by a distinct change in a number of cultural markers from the Dorset culture. The earliest Thule occupations currently recognized are on islands in the Bering Strait and exhibit an almost complete reliance on maritime resources; however, later sites demonstrate that both maritime and terrestrial resources were utilized (McGhee 1990). Climatic changes following the thirteenth century likely caused the Thule to modify their way of life into that of the various historic Inuit groups.

3.4 Historic Inhabitants

Historic use of the project area is identified with the ‘Copper Inuit’. The traditional territory of the Copper Inuit extends from the Coppermine River east to the Perry River and the south coast of Banks Island south to Great Bear Lake (Damas 1984). The subsistence, economy and settlement pattern of the Copper Inuit was greatly influenced by seasonal fluctuations. In the spring they would leave their more sedentary villages along the coast to hunt and fish inland. Subsistence from late May until November was reliant on caribou, fish, fowl and small game common on the interior tundra. In the fall during the caribou migration hunting caribou was often the most dominant form of subsistence. The Copper Inuit would return to the coast in the fall to build villages for the winter; breathing-hole sealing was the most prevalent activity during the winter months. This method involved specialty trained dogs to locate the seals’ breathing holes; each hunter would station themselves at a hole and quietly wait for a seal to come up to breathe (Damas 1984). Other resources that were occasionally used include polar bears in the winter and musk-oxen in the summer.

The largest grouping of Copper Inuit was during the winter months when they would gather in villages along the coast (more people was beneficial for breathing-hole sealing). Over the summer they split up into smaller groups and even individual nuclear families when subsistence was based on fishing, hunting small animals and foraging. In the late autumn many of these groups would reunite for the sewing period, when sewing their winter garments was the most important task (Damas 1984).

Although many of the characteristics described are similar with other Inuit groups there are some distinguishing characteristics that the Copper Inuit have. According to Damas (1984) aside form the territory that they inhabited, the Copper Inuit were also known for their wide use of copper; their distinctively tailored clothing; and their social and familial organization.

4. PROCEDURES

4.1 Pre-Field Studies

To identify areas of possible archaeological concern, several data sources were reviewed before fieldwork began. Archaeological site records maintained by the Archaeological Survey of Canada in Ottawa were examined as part of the background to the study. A review of general environmental information for the region was conducted to provide a context for the field work that followed and National Topographic Series (NTS) maps of the project area were also examined to determine the nature of landforms in the region. Previously conducted archaeological studies for the region were also consulted, such as both past and more recent documents and reports produced for the proposed Mackenzie Valley Pipeline.

Some of this information was incorporated into the permit application for review by the CLEY. A permit to conduct the AIA was issued by CLEY to Sean Webster of Golder on June 7th, 2010.

4.2 In-Field Studies

All of the potential areas of impact within the proposed Phase III ESA and remediation areas were examined using a combination of pedestrian traverses, visual examination and judgmental shovel tests. Pedestrian traverses and visual inspections were used to identify surface evidence of heritage resources such as historic buildings, depressions and other artifacts. All subsurface exposures present within the area, including natural exposures, were examined to determine the potential for buried cultural components. Existing disturbances such as eroding slopes were also examined if it appeared that they might aid in the identification of buried cultural components within the proposed areas of impact. In areas where there were no existing exposures and/or where dense vegetation was present, judgmental shovel tests were excavated to determine the potential for buried heritage resources.

4.3 Heritage Feature / Structure Evaluation

Evaluations of heritage features and standing structures were to be completed for features/structures that are observed during the investigations. These evaluations would consider perceived heritage resource value and community cultural value as well as the predicted impact from the proposed program. In general, disturbed sites with limited cultural remains would be assigned lower archaeological resource values than undisturbed sites, large sites with large amounts of cultural material, complex sites, and multicomponent sites. Undisturbed multicomponent sites would generally be assigned the highest heritage resource value.

4.4 Detailed Archaeological Site Investigations / Mitigation

If required, mitigation of significant heritage resources sites may include a number of different options. Prior to evaluation of these mitigative options, the perceived value of the identified archaeological sites will be discussed with the AECOM and PWGSC Project team to determine the feasibility of avoiding important sites. Only if site avoidance is not possible, will other mitigative measures such as collection and documentation, and controlled mapping/excavation be considered. In areas of no sediment deposition surface collection and mapping of artifacts and features may satisfy regulatory requirements for mitigation. Recommendations for excavation may include a controlled excavation mitigative plan and will specify the number of square metres and suggest locations for excavation units/blocks.

Overall mitigative options are summarized below:

- collection and documentation undertaken at the time of the field assessment at all sites with low archaeological resource value;
- avoidance if feasible at all sites assigned high archaeological resource value;

- mitigative excavations which will be recommended at those sites assigned high archaeological resource value that could not be avoided by borrow source relocation; and
- a management plan for required mitigation relative to the proposed construction schedule will be discussed with the site project team.

4.5 Reporting

The final permit report outlining the results of the archaeological studies, submitted in October of 2010 to CLEY, which summarizes the results of the AIA that was conducted under Nunavut Permit #10-018A, issued to Sean Webster of Golder. This report includes a project description, the environmental setting, the historical and archaeological context for the project area, field methodology, and the results of the field reconnaissance. The report includes both descriptive, as well as mapped data on the sites, artifacts, and features identified, as well as detailed information on the nature, content, and significance of the artifacts and features identified. Cultural material recovered has been inventoried, described, and discussed within the report text to aid in evaluation of scientific and interpretive value. All identified sites have been documented on appropriate site inventory forms.

5. RESULTS

5.1 Pre-Field Studies

A pre-field record review of the site files maintained at the Canadian Museum of Civilization was conducted to determine whether any previously recorded sites might be affected by the Phase III ESA and proposed remediation activities and to gain an appreciation of the distribution and nature of sites in the region prior to conducting the AIA. The search yielded no information on previously recorded heritage resources sites in the Sturt Point area prior to conducting the AIA. As such, no revisits or information updates to existing sites were required.

5.2 Field Investigations

The AIA assessment included examination of all of the areas of moderate to high archaeological potential that has been disturbed by the CAM-A DEW Line site as well as areas identified as having potential for future borrow sources or dumps. The disturbed areas that were surveyed included the station area, airstrip, beach, barrel dumps, landfills and all the existing roads and anywhere there was evidence of a bull dozer push or any other disturbance (Plate 1 and 2). Previously undisturbed areas that were examined included the periphery of all the impacted areas as well as several areas that were identified as potential borrow areas, landfills and landfarms for remediation activities.

During the survey six heritage resource sites were identified and recorded. In addition, several land use sites consisting of the remains of two Inuit houses, two areas with modern tent rings, a recent cairn and a burial were also observed. All of these sites are described in greater detail below.

Plate 1 View south of antenna and main facility location CAM-A DEW Line site.

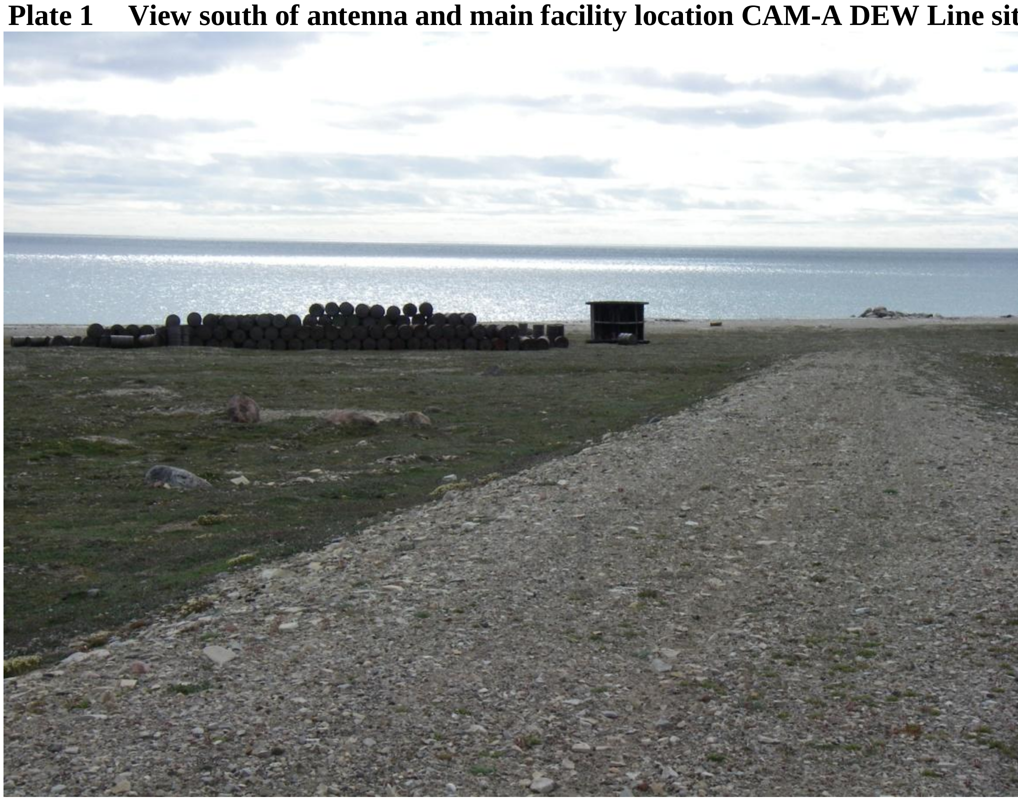

Plate 2 Barrels on the beach near the barge landing at CAM-A.

5.3 Newly Identified Heritage Resource Sites

5.3.1 NeLv 1

NeLv 1 is located approximately 280 southeast of the south end of the airstrip at CAM-A. The site is situated on an elevated beach ridge located 500 m northwest of the current coastline. The area immediately north and northwest of the site has been disturbed as a result of construction of the DEW Line Site, but the site itself remains undisturbed. The site consists of four caches and a rectangular feature identified by Gary Avalak as a hunting blind (Table 1). All of the features were found in an area roughly 45 m by 65 m E-W in size. The caches are aligned with the beach ridge, roughly running east-west with the hunting blind along the eastern edge of the site (Plate 3 and 4). No artifacts were noted in the vicinity of the features. The pattern of lichen growth suggests that the site predates the construction of the DEW Line Site. This site is considered to have moderate potential and it is recommended that the site be avoided.

Table 1 NeLv-1 Features

Feature No.	Feature Type	Measurements (m)	Notes
S1 F1	Cache	3.0 N-S x 4.0 E-W	Large partially collapsed cache. Interior compartment 1 x 0.5 m. Heavy lichen growth.
S1 F2	Cache	4.0 N-S x 3.0 E-W	Intact cache approximately 1 m high. Interior is box shaped and 1.5 x 0.5 m in size and 0.5 m deep.
S1 F3	Hunting Blind	2.0 N-S x 2.0 E-W	Three walls in a rectangular shape, with the open wall the the north. Walls have collapsed slightly, with the south wall being the highest at 0.7 m.
S1 F4	Cache	2.5 N-S x 3.0 E-W	Partially collapsed cache with an interior compartment roughly 0.7 x 0.7 m.
S1 F5	Cache	2.0 N-S x 2.0 E-W	Open cache, interior compartment 0.5 x 1.0 m.

Plate 3 View southeast of cache feature (S1 F5) at NeLv 1.

Plate 4 View southeast of hunting blind at NeLv 1.

5.3.2 NeLw 1

This is a newly recorded site consisting of four caches (Table 2; Plate 5 and 6). The caches are aligned with the beach ridge, roughly running east-west. The site is located on the fourth beach ridge, approximately 350 east of the barge landing at CAM-A and 100 m north of the current coastline. All of the caches have partially or completely collapsed. A caribou innominate and a fox cranium are located on the tundra immediately adjacent to one of the caches (S3 F4). No other artifacts were noted in the vicinity of the features. The pattern of lichen growth suggests that the site predates the construction of the DEW Line Site. This site is considered to have moderate potential and it is recommended that the site be avoided.

Table 2 NeLw 1 Features

Feature No.	Feature Type	Measurements (m)	Notes
S3 F1	Cache	1.0 N-S x 2.0 E-W	Large partially collapsed cache. Interior compartment 1 x 0.5 m. Heavy lichen growth.
S3 F2	Cache	2.0 N-S x 2.0 E-W	Collapsed cache located approximately 10 m northeast of Cache S3 F1.
S3 F3	Cache	2.5 N-S x 3.0 E-W	Large partially collapsed cache. Interior compartment 1.25 x 0.5 m and 0.75 m high.
S3 F4	Cache	2.0 N-S x 3.5 E-W	Large collapsed cache with an interior compartment roughly 1.0 x 0.75 m. Associated with faunal remains outside of cache.

5.3.3 NeLw 2

This is a newly recorded site consisting of two caches (Table 3). Both of the caches have been constructed using large boulders to form the northeast wall of the feature (Plate 7). Several unidentified faunal remains were noted in the sod around the surface of one of the caches (S4 F2). No other artifacts were noted. The pattern of lichen growth suggests that the site predates the construction of the DEW Line Site. This site is considered to have moderate potential and it is recommended that the site be avoided.

Plate 5 View west of NeLw 1 site area with cache feature (S4 F2) in foreground.

Plate 6 View southeast of large cache (S3 F3) at NeLw 1.

Table 3 NeLw-2 Features

Feature No.	Feature Type	Measurements (m)	Notes
S4 F1	Cache	4.0 N-S x 3.0 E-W	Large partially collapsed cache. Interior compartment 1 x 0.75 m. Heavy lichen growth.
S4 F2	Cache	3.5 N-S x 3.0 E-W	Large partially collapsed cache located 2 m south of Cache S4 F1. Interior compartment 1.5 x 0.75 m.

Plate 7 View east of large partially collapsed caches at NeLw 2.

5.3.4 NeLw 3

NeLw 3 is a newly recorded site consisting of three historic tent rings (Table 4). Two of the features are rectangular in shape while the third is roughly circular (Plate 8 and 9). A weathered vertebrae from an unidentified mammal is present within the second ring (S6 F2) and a humerus, radius and ulna from a seal were identified just outside of the third feature (S6 F3). An aluminum A-Frame tripod structure is located 9 metres south of the third ring (Plate 10). Rocks supporting the base of the A-Frame show a similar pattern of vegetation and lichen growth as the rocks in the rings and, as such, they are assumed to be historic rings possibly associated with the construction of the DEW Line Site. No other artifacts were noted in the immediate vicinity of the rings and therefore exact age is difficult to determine. This site is considered to have moderate potential and it is recommended that the site be avoided.

Table 4 NeLw-3 Features

Feature No.	Feature Type	Measurements (m)	Notes
S6 F1	Tent Ring	3.0 N-S x 2.0 E-W	Rectangular in shape, opening in north wall. Feature includes 19 exposed stones.
S6 F2	Tent Ring	3.0 N-S x 2.0 E-W	Rectangular in shape, consisting of 18 stones. South wall completely open. Vertebrae within feature.
S6 F3	Tent Ring	4.0 N-S x 3.5 E-W	Roughly circular in shape, consisting of 35 stones. There is a small (1 m) opening in the south wall. Limb elements from seal outside of feature.

Plate 8 View north of tent ring (S6 F1) at NeLw 3.

Plate 9 View west of NeLw 3 site area with tent ring (S6 F3) in foreground.

Plate 10 View southwest of aluminum tripod adjacent to NeLw 3.

5.3.5 NeLv 2

This is a newly recorded site consisting of a collapsed cache and a linear cairn (Plate 11). The cairn is approximately 4 m long and 0.75 m high, is oriented north-south and extends down a the slope to the next beach ridge. The function of the cairn is unknown. The cache is roughly 3.0 m north-south by 3.0 m east-west and is located immediately east of the cairn. The cairn has collapsed and there were no artifacts noted in the vicinity of the features. This site is considered to have moderate potential and it is recommended that the site be avoided.

Plate 11 View south of cache (left) and cairn (right) at NeLv 2.

5.3.6 NeLv 3

NeLv 3 is a newly recorded burial recorded after the completion of the AIA. The site was discovered by members of the Project management team from AECOM while conduicting a reconnaissance of the beach areas northwest of the CAM-A site. The burial is located approximately 600 m northwest of two Inuit houses associated with the DEW Line Site (described below). The site is situated above the active beach ridge, approximately 55 m west of the current coastline. Human remains, including a cranium, humerus, scapula, vertebrae and several ribs are scattered along the beach within a 4.0 x 5.0 m area along with the remains of a collapsed wooden box (possibly a makeshift coffin); pieces of the box may have been collected from the houses to the south. The site is outside of the archaeological study area associated with the DEW Line Site remediation project and will not be impacted by planned remediation activities.

5.4 Additional Cultural Resources

Several other cultural resources sites were identified during the AIA that were noted but not officially recorded as they do not meet the criteria to be designated as archaeological sites under the *Nunavut Archaeological and Palaeontological Sites Regulations* (2001). These sites include several Inuit houses, two sets of recent tent rings, and a dedicated cairn. These sites are described in further detail below.

5.4.1 Inuit Houses

The remains of two Inuit houses were recorded on the beach, approximately 850 m northeast of the CAM-A airstrip. Both of the houses have partially collapsed (Plate 12). A third structure, that may have been another house, has burned to the ground and only the framing from the floor remains. The area surrounding the houses includes numerous barrels, wire, broken boards, snowmobile parts, glass and a ladder. A circular tent ring is located to the south of one of the houses. Fragments of glass, several tin cans and some broken wood were recorded within the ring. In addition, the partial remains of a wooden boat are situated east of the tent ring, adjacent to the coastline (Plate 13).

Plate 12 View north of Inuit house on beach at Sturt Point.

Plate 13 Partial remains of a boat on beach next to Inuit houses at Sturt Point.

5.4.2 Tent rings (GAL S2 and GAL S5)

Two sets of recent tent rings were noted during the AIA. The first set (GAL S2) is located on the second beach ridge, approximately 75 m from the current coastline. The site includes three rings, all on the same ridge, across an area roughly 40 m long (Table 5; Plate 14). Many of the stones used to construct the rings have little to no lichen growth on the top surface suggesting recent use. In addition a shotgun shell, plastic, a zipper fragment and a tin can lid were associated with the rings.

Table 5 GAL S2 Features

Feature No.	Feature Type	Measurements (m)	Notes
S2 F1	Tent Ring	3.0 N-S x 2.0 E-W	Rectangular in shape, opening in south wall. Feature includes 14 stones, with a sandstone platform in the southwest corner. Associated with shotgun shell and plastic.
S2 F2	Tent Ring	2.0 N-S x 2.0 E-W	Square in shape, consisting of 50 stones. Slight opening in east wall. Numerous stones with no lichen growth.
S2 F3	Tent Ring	3.0 N-S x 2.0 E-W	Roughly circular in shape, consisting of 55 stones. There is a small (1 m) opening in the south wall. A zipper fragment and tin can lid are present inside the feature.

Site GAL S5 is located 65 m southwest of NeLw 3 on the same ridge line. The site includes two tent rings located approximately 20 m apart (Table 6; Plate 15). Areas to the west of the site have been impacted by previous development, likely as a granular source for the DEW line site. Materials associated with the rings include a tin can, a shotgun shell, wood fragments, and a heavily weathered fragment from a caribou antler.

Table 6 GAL S5 Features

Feature No.	Feature Type	Measurements (m)	Notes
S5 F1	Tent Ring	3.0 N-S x 3.0 E-W	Circular in shape, opening in north wall. Comprised of 20 stones. Associated with shotgun shell and a tin can.
S5 F2	Tent Ring	2.0 N-S x 2.0 E-W	Circular in shape with openings in the south and north wall. Wood and antler associated with feature.

Plate 14 View west of modern tent ring (GAL S2) on beach at Sturt Point.

Plate 15 View southeast of modern tent ring (GAL S5) on beach at Sturt Point.

5.4.3 Harrop Cairn

This site includes a cairn constructed on the top of an in-ground storage area at the west end of the main facilities location at CAM-A. The cairn was erected and dedicated on August 17, 1976 by Dr. A.H. Harrop and family. Dr. Harrop was the Chief Commissioner of the Order of St. John and the cairn includes a plaque indicating that the cairn was erected "in commemoration of the many Arctic explorers whose lives were lost in these vast Territories, in hope that it may some day be used to save lives." The cairn contains a survival kit, visible through the stones of the cairn. The cairn does not appear to have been opened since construction (Plate 16). Although not designated as a heritage resource, it is recommended that the site be avoided during remediation, in keeping with the intent of the dedication.

Plate 16 View southwest of Harrop Cairn at CAM-A facility location.

6. SUMMARY AND RECOMMENDATIONS

The AIA of the CAM-A Intermediate DEW Line site conducted under Nunavut Permit 10-018A led to the discovery of six new archaeological sites (NeLv 1, 2 and 3 and NeLw 1, 2 and 3) and a number of more contemporary sites including several tent rings, Inuit houses and a cairn. The disturbed nature of CAM-A area and the lack of vegetation and sedimentation enabled a high visibility surface examination of the facility areas to adequately assess for the presence of cultural materials.

Table 7 Site Summary and Recommendations

Site	Type	Significance	Recommendations
NeLv 1	Caches and blind	Moderate	Avoidance is recommended
NeLw 1	Caches	Moderate	Avoidance is recommended
NeLw 2	Caches	Moderate	Avoidance is recommended
NeLw 3	Historic tent rings	Low	Avoidance is recommended
NeLv 2	Cache and cairn	Moderate	Avoidance is recommended
NeLv 3	Burial	High	Avoidance is recommended; site will not be impacted.
Inuit Houses*	Cabins	Low	No further work recommended
GAL S2*	Tent rings	Low	No further work recommended
GAL S5*	Tent rings	Low	No further work recommended
Harrop Cairn*	Cairn	Moderate	Avoidance is recommended

* Sites not officially recorded as archaeological resources.

Based on the results of the AIA, AECOM and PWGSC have fulfilled the requirements to indentify the potential for impact to heritage resources during the proposed remediation/reclamation of the CAM-A DEW Line site at Sturt Point. **As a result, it is recommended that PWGSC be allowed to proceed with the remediation of the CAM-A DEW Line site area with the condition that no impacts occur within 30 m of sites NeLv 1, 2, 3, NeLw 1, 2, and 3. In addition, it is also recommended that the Harrop Cairn be avoided, if possible.**

7. CLOSURE

We trust the above meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

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