Remedial Action Plan for FOX-D (Kivitoo, NU)

Final Report

March 2014

Remedial Action Plan for FOX-D (Kivitoo, NU)

Project No. 13-7942-3000

Douglas Bell, M.Sc., P.Geo. - Project Manager

Submitted by

Dillon Consulting Limited

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(In reply, please refer to)
Our File: 13-7942

March 31, 2014

Northern Contaminated Sites
Public Works and Government Services Canada
Suite 420, Greenstone Building, 5101 – 50th Avenue
Yellowknife, Northwest Territories X1A 3Z4

Attention: Ms. Janice Lee
Project Manager

RE: Remedial Action Plan for FOX-D (Kivitoo, Nunavut)

Dear: Ms. Lee

Please find enclosed one (1) digital copy of the above mentioned report.

This report contains the recommended remediation methods for the various environmental issues identified at the site and also provides information regarding remedial design, implementation and anticipated remedial costs.

If you have any questions or comments, please feel free to contact Douglas Bell, M.Sc., P.Geo., or Indra Kalinovich, Ph.D., C.Chem. E.I.T., at 204-453-2301.

Yours truly,

DILLON CONSULTING LIMITED

Doug Bell, M.Sc., P.Geo
Partner

IKK/knh

Attached:

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EXECUTIVE SUMMARY

Public Works and Government Services Canada (PWGSC) retained Dillon Consulting Limited (Dillon) to complete a Remedial Action Plan (RAP) for the former military base FOX-D, located at 67°57'58"N and 64°54'28"W near the former whaling station and Inuit spring/summer camp at Kivitoo, Nunavut. Dillon, along with KGS Group (KGS) have prepared this report which identifies remediation options, critiques potential remediation methods, and provides recommendations for site restoration, as well as a preliminary cost estimate to undertake the remedial work.

This RAP for the former FOX-D Intermediate DEW Line Site was designed in accordance with the INAC AMRSP (March 2009). This Protocol is designed to address legal requirements, health, and safety issues, Aboriginal and Northern Development Canada (AANDC)'s Contaminated Sites Management Policy requirements and standard environmental issues. The Protocol identifies financially prudent methodologies that address all the requirements listed above, while maintaining a cost-effective remediation project.

The table below provides a summary of the environmental issues identified at FOX-D and the proposed remedial action plan for each:

Environmental Concern	Site Assessment Findings	Recommendation Remediation Method
Metals Contaminated Soils	193 $m^3$of soils with concentrations of Cu, Cd, and Zn, which exceed the DCC Tier II criteria were identified on-site. This volume includes material that is co-contaminated with PAHs and PHCs.	Excavate, containerize, and label soils that exceed DCC Tier II criteria and dispose off-site at an appropriately licensed facility.
Petroleum Hydrocarbon Contaminated Soils	Approximately 3,205 m^3 of hydrocarbon contaminated soil in exceedance of the INAC Abandoned Military Site Remediation Protocol for PHC Soils.	Screen PHC Type A soils and treat in on-site constructed biological and/or aeration treatment unit (3,005 m^3). Excavate PHC Type B soils (200 m^3) and place into containers, and ship off-site to a licensed disposal facility.
Non-Hazardous Materials	Approximately 14,834 m^3 of non-hazardous debris consisting of heavy equipment, barrels, scrap metal, scrap wood, concrete, electrical equipment and plumbing parts to be handled and shipped off-site.	All buried and partially buried debris in Class B dumps (APEC 11) should be excavated, sorted and separated into different waste types where it is safe and practical to do so, and disposed off-site in an appropriate licensed facility. Buried debris that is inaccessible for excavation in Class C dumps (APECs 9 and 10) should be buried and re-stabilized in-situ. Rocks and concrete foundations from APECs 1-4 to be used as rip-rap and fill in void space at APEC 9. Area will be covered with rip rap and erosion resistant material for stability.

Environmental Concern	Site Assessment Findings	Recommendation Remediation Method
		All other debris is to be consolidated, packaged and shipped off-site to an appropriate licenced disposal facility.
Water in Barrels	Analysis of collected water in the abandoned barrels indicates that the dissolved metals meet DLCU barrel protocol.	Disposal on ground is permitted once water has been polished with an absorbent materials, additional sampling of more barrels during remediation program is required.
PCB/Lead Amended Paint Products	Approximately 0.031 m^3 of PCB/lead amended paint materials were discovered on-site (not including metal)	Dismantle contaminated paint items and ship off-site to an appropriate disposal facility.
Hazardous Materials	Approximately 1.82 $m^3$of hazardous materials were identified at the site. These materials consisted of lead acid batteries (0.22 m^3) and asbestos containing materials (1.32 m^3).	All hazardous materials (such as batteries) will be containerized and labeled and shipped to be disposed at a licensed facility.
Structures	Upper Site POL Tanks (2) Upper Site Transfer Tank (1) Concrete Foundations	All non-hazardous materials and debris from Upper Site structures buildings shall be demolished to their foundations and removed off-site for disposal at an appropriate licensed facility.

Successful implementation of the recommended remedial actions will require logistical coordination of various on-site elements; these are summarized below with additional details provided in the body of the report:

- ***Site access*** - there is currently an airstrip at the Site, and numerous locations suitable for helicopter and/or fixed wing aircraft landing. Mob/demob is possible by sealift or barge, although it is anticipated that mob/demob will take place via sealift, with support and re-supply service provided by helicopter and/or charter plane.
- ***Facilitation and operation of an on-site camp*** - a camp will be required during the remedial activities. Although the hamlet of Qikiqtarjuaq is nearby, the ability to house and efficiently mobilize workers to the Site is not deemed to be feasible. The camp must be large enough to support approximately 20 site workers and approximately three to five camp staff.
- ***Infrastructure/Roads*** - due to lack of upkeep and erosion, some portions of the existing roads to be utilized during remedial activities will require repair and upgrading. The main road to be utilized on-site will be the road leading from the airstrip to the main station area. There are sections of the road requiring extensive rebuilding, regrading, and significant drainage control. This level of repair and rebuilding constitutes approximately 375 m (5%) of the total road length. The remainder of the road will require some patching and topping up of existing road topping (medium grading) and/or localized grading (light grading).
- ***Borrow Source Development*** - required borrow material can be drawn preferentially from the main station area gravel. The sand and gravel borrow sources are estimated to contain approximately 68,000 m^3. It is anticipated that this amount is adequate for the remedial activities.

Once the borrow source requirements for the FOX-D remediation have been satisfied all borrow sources will be re-contoured to restore natural drainage and to match surrounding topography and minimize changes to the existing permafrost regime.

- ***Potential Biological and/or Aeration Treatment CellConstruction*** **-** the potential treatment cell location (saddle at Upper Site) was selected based on the required treatment cell size, distance to material to be treated and distance to borrow sources. The treatment cell shall be constructed in a controlled manner with minimal lifts to control compaction and settlement. Surface water run-on and run-off will be controlled through proper grading to positively shed water and to prevent ponding and seepage into the treatment cell. Consideration to the treatment cell cap angles must be designed as to not to encourage erosion of the impacted soil surface.
- ***Waste handling facility Construction*** - a Waste Handling Facility (WHF) will be required at the FOX-D site to receive and sort various waste items. The fluids handling area within the WHF shall be lined with an engineered synthetic liner to prevent the migration of contaminants resulting from any accidental spills. The fluids handling area is to be bermed and the engineered liner should have some fill cover to protect the liner integrity. The WHF area shall be located west of the barge landing area.

Assuming the project is tendered in the winter of 2014, the anticipated project duration will be from 2014 – 2017, including mobilization and demobilization via sealift and barge.

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1 INTRODUCTION

1.1 Site Description

FOX-D was constructed as an Intermediate Distant Early Warning (DEW) Line Site in 1957 and operated until October 1963. The Site is located on the Davis Strait at 67°57'58"N and 64°54'28"W, on the northeast side of the Cumberland Peninsula and the northeast coast of Baffin Island (**Figure 1**).

The Site can be separated into four distinct areas connected along a gravel road:

- An Upper Site on the crest of a hill 447 metres above sea level (masl) north of Beach Site;
- A Lower Site between the beach and the airstrip (the latter two described below);
- A Beach Site at the mouth of Kivitoo Harbour; and,
- An airstrip approximately 2 km east of the beach.

Shortly before the site closed in 1963, a fire completely destroyed the main building train. A clean-up of physical debris was sponsored by Parks Canada (now Heritage Canada) in the mid-1970s, due to Kivitoo's proximity to Auyuittaq National Park. The fate of debris removed during the Parks Canada clean-up is unclear. Much of the debris can be found in what is now known as the construction camp, on the Lower Site. There are persistent word-of-mouth accounts that ocean disposal methods were practiced.

The Site is located near Kivitoo, a former Inuit spring/summer camp region and whaling station, which was abandoned when the settlement was moved to nearby Qikiqtarjuaq in the 1950s. A graveyard associated with the prior settlement is present on-site. Most of the previously inhabited Site areas are within the current Crown parcel of land (**Figure 1**).

Two abandoned airstrips have been reported to be in the area. However, only the Upper and Lower Sites as described above lie within the Crown parcel of land. One of these airstrips is visible from the main summit, looking north east. Reportedly, the airstrip was abandoned due to soil strength issues associated with the marine sediments (Pers. Communication, 2013).

The Upper Site consists of the following identified areas:

- Transfer Tank;
- POL Tanks;
- Antenna;
- Burnt Building Remains;
- Warehouse Foundation;
- Two Distinct Soil Stains (identified as Stain #1 and Stain #2 by Franz Environmental Inc., 2011);
- Former Garage;
- Burnt Debris; and,
- Dump Site.

The Lower Site is located on a coast plain to the south of the Upper Site. It once consisted of two POL tanks, a beach landing area, drum storage, and an airstrip. The foundation of the two POL tanks, remnants of the airstrip and one small shed are all that remain. Within the area lie a freshwater lake, borrow source areas and a former construction camp area. The Lower Site is connected to the Upper Site by a 5 km access road.

The majority of the original facilities at FOX-D have been demolished and partially buried. The transfer tank, two Upper Site POL tanks, concrete foundations, airstrip, and shed are the only remaining structures on-site.

Potential borrow source areas are located approximately 900 m northwest of the airstrip and contain various potential borrow sources. Debris in this area was limited to caches of empty barrels. **Figures 2-3** provide detailed site drawing of FOX-D, including the location of all sub sites listed above.

1.2 Background

Data from previous assessments conducted by Environmental Services Group (ESG, Royal Military College) and others from 1994-2013 indicate that hydrocarbon, polychlorinated biphenyl (PCBs) and metals contamination exists on the former DEW Line site and may require remediation under Territorial and/or Federal Acts and Regulations. In 2013, Dillon Consulting Limited (Dillon) scored the site as 87.9 under the National Classification System for Contaminated Sites (NCSCS), making the Site a Class "1" site – High Priority Action.

Environmental Site Investigations were first initiated on the site by Environmental Services Group (ESG) in 1994, and subsequently in 1995 and 2010.

As part of a larger investigation into environmental conditions at former military stations in Canada's North, an environmental study was performed at the FOX-D, (Kivitoo, Nunavut) site in August 1994 by ESG at Royal Roads Military College in Victoria, BC. A total of 70 soil samples and 36 plant samples were collected for evaluation of contaminants, potential migration pathways, and potential impacts on the terrestrial food chain. The Site was divided into six areas (three Upper Site, three Lower Site) based on historical site use and drainage patterns. Soils were sampled and analysed for PCBs, metals, pesticides, polyaromatic hydrocarbons (PAHs), and acid base neutral (ABN) extractable analysis. Plant samples were analysed for PCBs and metals.

Four marine areas in the Baffin Region were also surveyed during August – September 1994 to evaluate the extent and effect of historic ocean disposal practices. Kivitoo was chosen to represent a smaller, DEW Line Site that was abandoned in the early 1960s. Side-scan sonar was used to determine objects on the seabed floor. Scuba divers and remote operated vehicles equipped with cameras identified and documented the sea floor condition. Sediment and biological samples were analysed to evaluate the presence and associated impacts with chemical contamination. Eleven marine sediment samples were analysed for inorganic elements and PCBs. Nine of the samples were analysed for chlorinated pesticides, and two were analyzed for PAHs. There was no evidence for local inputs of inorganic elements, PAHs or chlorinated pesticides. No objects of human origin were found near Kivitoo. The fjord depths and large survey area prohibited ease of investigation required outside the survey area.

In August and September of 2009, ESG performed a background geochemical assessment and limited contaminated soil sampling program on behalf of Indian and Northern Affairs Canada (INAC, now Aboriginal Affairs and Northern Development Canada (AANDC)). The goal of the background geochemical assessment was to establish the natural levels of inorganic contaminants in the surrounding environment.

In July 2011, Franz Environmental Inc. (Franz) was retained by AANDC to conduct a visual inspection and a sampling program at FOX-D. A total of 12 test pits were advanced by Franz, and 11 soil samples were collected. Evidence of buried drums or olfactory evidence of Petroleum Hydrocarbons (PHC) on the Lower Site was not observed. Localized staining was observed around the Lower Site. In 2011, Franz scored the site as 72.6 under the National Classification System for Contaminated Sites (NCSCS), making the Site a Class "1" site – High Priority Action.

A Phase III Environmental Site Assessment (ESA) was conducted by Dillon in 2013, which provided the necessary information to complete this Remedial Action Plan (RAP).

This RAP was prepared to provide a conceptual remediation design and preliminary specifications for clean-up of the FOX-D site.

2 OBJECTIVES

The main purpose of this RAP was to identify remediation options, critique potential remediation methods, and provide recommendations for site restoration. Based on assessment activities completed by Dillon and KGS Group in August 2013, a comprehensive site remediation work plan was developed. Remediation options were developed for each waste stream identified at the site, and were critically evaluated to discuss potential risks, advantages, and disadvantages of each remediation option. Based on a number of factors, outlined below, recommendations were made for the preferred remediation approach. Community meetings with Public Works and Government Services Canada (PWGSC) and AANDC will be conducted to incorporate community contribution in selecting the remedial option for each waste stream.

This RAP was designed to meet the following clean-up objectives in accordance with the AANDC Abandoned Military Site Remediation Protocol (AMSRP):

1. Restore the site to an environmentally safe condition;
2. Prevent the migration of contaminants into the Arctic ecosystem;
3. Remove physical hazards for the protection of human health and safety; and,
4. Implement a cost-effective remediation solution.

The end product will be a cost effective RAP for FOX-D, complete with a cost estimate to undertake remedial work (to be attached as a separate document).

3 BIOPHYSICAL ENVIRONMENT

3.1 Physiographic Description

The FOX-D site is located just north of the Pangnirtung Upland ecoregion which rises rapidly from sea level and consists of a belt of deeply dissected, crystalline Archean aged rocks. Its general aspect is one of a broad, gently warped, old erosion surface etched by erosion along joint systems, and zones of weakness. Long arms of the sea penetrate the ecoregion as glacier-filled sounds or fjords. Bare bedrock is common, and Static Cryosols with some Turbic and some Organic Cryosols, developed on discontinuous morainal, organic, and marine deposits, are the dominant soils in the ecoregion (Smith et al. 1998). Permafrost and/or bedrock were estimated to be at a depth of 1.4 to 1.5 m. The FOX-D site is located in the zone of continuous permafrost, which is defined as those areas where 90% to 100% of the soil and rock remain at a temperature continuously below 0^{o}C for a period of at least two years. Overburden material at the site consists of till and granular deposits that are typically free from ground ice.

3.2 Climate

The FOX-D site is located in the Northern Arctic Ecozone region of Canada. Canadian Climate Normals Data from 1971 to 2000 for the Iqaluit weather station (Environment Canada, 2013) showed that the annual daily mean temperature is -9.8°C with daily mean temperatures ranging from -26.6°C (January) to 7.7°C (July). The daily maximum temperatures range from -22.5°C (January) to 11.6°C (July), and daily minimum temperatures range from -32.2°C (February) to 3.7°C (July). The extreme temperature range is from -45.6°C (February) to 25.8°C (July). In general, precipitation falls primarily as snow during the winter months, with the greatest snowfalls occurring in October, November, and April. Rainfall dominates during the summer season, with overall levels of precipitation peaking in July and August. Annually, the average precipitation level is about 412 mm.

3.3 Flora and Fauna

Vegetation in the Pangnirtung Upland 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.

Fauna in the area includes arctic hare, arctic char, arctic lemming, polar bears, various species of birds, and geese. Marine species include walrus, ring seal, narwhal, walrus, and bowhead whale.

4 AANDC SITE REMEDIATION PROTOCOL

4.1 General

Numerous factors can impact the suitability of site remediation plans and should be considered when evaluating a site-specific remediation plan. For this reason, Indian and Northern Affairs Canada (INAC, now AANDC) created the AMSRP (2005, 2009) to provide a consistent approach for designing RAPs for abandoned military sites. This protocol was designed to address all legal requirements, health and safety issues, Territorial and Federal requirements, and standard environmental issues. The protocol identifies financially prudent methodologies that address all of the requirements listed above, while maintaining a cost-effective remediation project. This RAP for the former FOX-D Intermediate DEW Line Site was designed in accordance to the INAC Protocol.

The following sections provide an outline of typical environmental issues and their remedial action procedures addressed by the Protocol. These technical aspects are described in greater detail in the INAC AMSRP (**Appendix B**). The following considerations should be considered in the development and implementation of the RAP for the FOX-D site:

- Respect all historical agreements and obligations in a fair and reasonable manner;
- Ensure consistency with Federal and Territorial regulations and guidelines for the management of contaminated sites;
- Apply the Canadian Council of Ministers of the Environment (CCME) environmental protection and management approaches (CCME 2007, 2008);
- 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 the use of best practices to ensure appropriate levels of environmental protection for all sites;
- Recognize the concerns of global warming in an Arctic setting; and,
- Ensure the long-term effectiveness of the environmental remedial measures.

The applicable AMSRP, Federal, and/or Territorial guidelines were reviewed and are summarized below:

Table 4-1: Summary of Applicable Remedial Guidelines

Guideline Author	Title	Description	Year
INAC	Abandoned Military Site Remediation Protocol	Barrel content guideline	2009
Government of Nunavut	Environmental Guideline for Waste Lead and Waste Paint	Lead paint waste guideline	2011
Government of Nunavut	Environmental Guideline for Waste Paint	Waste paint guideline	2010
Government of Nunavut	Environmental Guideline for Mercury-Containing Products and Waste Mercury	Mercury disposal guideline	2010
Government of Nunavut	Environmental Guideline for the General Management of Hazardous Waste	Reference and waste guidelines	2010
Government of Nunavut	Environmental Guideline for the Burning and Incineration of Solid Waste	Guidelines for incineration considerations	2012
Government of Nunavut	Environmental Guideline for Waste Asbestos	Guideline required for handling and abatement	2011
Government of Nunavut	Environmental Guideline for Waste Batteries	Guideline and disposal options	2011
Government of Nunavut	Environmental Guideline for Waste Solvent	Waste solvent disposal options	2011
Canadian Council of Ministers of the Environment	Environmental Quality Guidelines	Soil and water quality guidelines for metals, hydrocarbons, and inorganics.	2008
Canadian Environmental Protection Act	PCB Regulations	Waste remediation and landfill guideline	2011
Environment Canada	Industrial Treated Wood Users Guidance Document	Management of treated wood	2004

4.2 Landfills

4.2.1 Landfill Closure

Landfills on AANDC abandoned military sites are classified as Class A, Class B, or Class C. A Class A landfill is a landfill located in an unstable, high erosion location and requires relocation. If, during the relocation process, hazardous materials are noted, the hazardous materials are segregated for off-site disposal. A Class B landfill is a landfill situated in a suitable, stable location but has contaminated leachate release. The leachate from these landfills must be contained within an engineered containment system. Otherwise, the landfill must be relocated to an engineered landfill or waste removed for off-site disposal. A Class C landfill is suited in a stable and suitable location, with no release of contaminated leachate. These landfills can be left in place. Additional granular material can be placed to prevent erosion and promote proper drainage if required.

4.2.2 Landfill Development

Landfill design at abandoned military sites must consider waste types to be retained within the landfill, proximity to drainage courses and distance to borrow sources required for landfill construction. Non-hazardous and/or non-regulated contaminated soils are to be stored in newly constructed, on-site landfills. All hazardous waste is to be disposed of off-site.

4.3 Physical Debris

Debris across the site must be collected and segregated into hazardous and non-hazardous waste streams. Non-hazardous material shall be crushed, shredded, and/or incinerated prior to off-site disposal to reduce volumes. Hazardous materials shall be disposed of off-site in accordance with applicable guidelines and regulations.

4.4 Soils

Soil conditions at FOX-D were assessed using the INAC AMSRP as the governing criteria. Heavy metals, PHC, which includes F1-F4 fraction hydrocarbons and BTEX parameters, and PCB concentrations in soils were compared to the DEW Line Clean-Up (DLCU) Criteria, which was developed for the Department of National Defence.

The AMSRP incorporates the CCME guidelines as appropriate, with the consideration of previously conducted quantitative risk assessments within the guidance documents. There are four exposure pathways and they include:

- Human and ecological contact;
- Soil and food ingestion;
- Ground/surface water; and,
- Indoor vapour intrusion.

All pathways are deemed applicable to the Site, as there is the potential for new shacks or cabins to be built at the Site in the future. As part of the data interpretation, the most stringent criteria among the four exposure pathways are used.

Soil depth and soil type are important factors affecting the availability and transport of contaminants. The AMSRP provides specific guidelines for contaminants based upon their depth below ground surface. All soil samples were collected within 0.6 metres below ground surface (mbgs) which represented refusal, or maximum encountered depth, during the Phase III ESA field program.

For Type B hydrocarbons (which are defined as the sum of PHC F1, F2, and F3, as stated in the AMSRP), soils below 0.5 mbgs are considered sub-surface and will have a higher guideline threshold applied. Special consideration for the proximity to water bodies is included in the AMSRP.

The remedial requirements for hydrocarbons are shown below:

Table 4-2: AMSRP Guidelines for Petroleum Hydrocarbons in Soil

Depth below Ground Surface (mbgs)	Hydrocarbon Type	Within 30 m to Water (Yes/No)	Criteria[1] (mg/kg)
< 0.5	B	NO	2,500[1]
> 0.5	B	NO	5,000[1]
Any depth	B	YES	330[1]
Any depth	PHC Fraction F2	NO	11,000
Any depth	PHC Fraction F3	NO	20,000
Any depth	A (F3 + F4)	NO	20,000

[1] AMSRP Guidelines, AMSRP Tier 1/2: Abandoned Military Site Remediation Criteria (INAC, 2009)

For Type A contaminated soil, the sum of F3 and F4 must be greater than 70% of the total PHC concentration, and the F2 concentration must be less than the F4 concentration.

Contaminated soils identified will be categorized as:

- Regulated;
- Hazardous, or,
- Contaminated, but not hazardous.

Soils that are identified as being regulated will be remediated and/or disposed of following applicable regulations. Hazardous soils will be disposed of off-site. Contaminated but not hazardous soils must be remediated to meet DCC DLCU Criteria. Soils classified as contaminated, but not hazardous, are to be remediated based on one of three primary contaminated soil types:

1. Metal contaminated soils must be disposed off-site or encapsulated on-site;
2. Remediation options for hydrocarbon contaminated soil include remediated in-situ, ex-situ, or off-site; capped in place; natural attenuation; or chemical amendment; and,
3. PCB contaminated soil must be either disposed off-site or encapsulated on-site.

In cases where co-contamination of soils is present, the most conservative remedial option that addresses both contaminants must be applied.

4.5 Water

Surface water with heavy metal contamination (in exceedance of the CCME Freshwater Aquatic Life Criteria) was observed in one location at FOX-D; however, it should be noted that the concentrations are diluted relatively quickly and all elevated levels were observed in seasonal drainage water, only. The areas where exceedances were noted are a significant distance away from any possible fish habitats and drainage direction is away from the nearest known fish habitat. It should be noted that the volumes of surface water where the exceedances were noted are minimal. It is not anticipated that contamination noted on-site is adversely affecting water sources downgradient and off-site. It is expected that removal of the source contamination (buried barrels) would address the problem and therefore no remedial options for contaminated water are discussed in this RAP.

The Freshwater Lake, located near the Construction Camp, was assumed to be used as a potable water source for hunters and trappers in the area. Further surface water assessment and monitoring should be conducted; this is further discussed in Section 7.8. In the event that surface water bodies show water impacts related to site activities, remedial activities should be conducted to applicable CCME *Canadian Water Quality Guidelines for the Protection of Freshwater/Marine Aquatic Life* (PFAL) (CCME 2007) and/or the *Canadian Drinking Water Guidelines* (DW), (Health Canada 2012). With the absence of federal guidelines for PHC fractions F1 and F2 in water, the *Alberta Tier 1 Guidelines* (AENV 2010) should be used. In the event of a discrepancy between the PFAL and DW guidelines, the most stringent guideline value should be applied for remedial activities.

The majority of the water guidelines are obtained from the summary table of the CCME PFAL (CCME 2007); however, various inorganic compounds are pH, temperature or water hardness dependent. These compounds include aluminum, ammonia, cadmium, copper, lead, and nickel.

Based on the equations provided in the summary table, specific guideline values were calculated using the average laboratory pH and hardness.

4.6 Hazardous Materials

In general, all hazardous materials will be shipped off-site to a licensed hazardous waste disposal facility. Petroleum products (free of chlorine, PCBs, heavy metals, etc.), are to be incinerated. Heavier petroleum products are to be mixed and burned on-site, or shipped off -site.

PCB paint and PCB painted components regulated under the CEPA (>50 ppm) are to be disposed of off-site at an appropriate facility. Lead-based paint (leachable lead >5 mg/L) considered to be hazardous will be collected and transported off-site, whereas painted components not considered hazardous may be disposed of in on-site landfills.

4.7 Barrels

Barrels located at the site will be addressed in accordance with the DLCU Barrel Protocol (**Appendix C**). In general, empty barrels will be crushed and disposed in on-site landfills. The contents of filled barrels will be inspected and tested, and either incinerated on-site or shipped off-site for disposal.

The now empty barrels will be rinsed, crushed and disposed in on site landfills. Buried barrels will be addressed by geophysical testing. If the buried barrels are empty, the area will be stabilized by compaction and covered in place. If fluids are noted in the barrels, the barrels will be excavated and the contents will be inspected and tested. Depending on the results, the contents will either be incinerated on site or shipped off-site for disposal. Barrel contents were collected by Dillon from several barrels on-site and submitted for laboratory analysis (Dillon, 2013). Results indicated that neither glycol nor non-aqueous phase liquids were observed in the barrels, and dissolved metals concentrations were below the DLCU Barrel Protocol. Consequently, specific barrels were identified to be within the allowable range for disposal to ground following polishing with absorbent material.

4.8 Buildings and Infrastructure

All existing buildings and infrastructure shall be demolished to their foundations. All hazardous material is to be removed prior to or during demolition activities. All removed hazardous material is to be disposed of in accordance with protocol outlined in Section 5.4. Under special circumstances, some buildings may be left place once clear ownership of the building has been determined.

4.9 Borrow Sources

Borrow sources for granular material will be required for the construction of new landfills and for general site grading purposes. Existing borrow sources located on AANDC's property, including abandoned gravel pads and road infrastructure, will be fully exhausted prior to exploiting new sources. Upon completing remedial activities, all borrow areas will be re-contoured to restore natural drainage and to match surrounding topography.

4.10 Site Grading

Disturbed areas on the site will be graded and shaped to blend in with the natural contours and to eliminate potential hazards for wildlife and humans accessing the site in the future. The disturbed areas include contaminated soils excavations, existing and new landfills, debris areas, disturbed areas resulting from demolition activities; borrow areas, and any areas disturbed as a result of remediation activities.

4.11 Contractor Support Activities

For the completion of remedial activities, a camp will be established on-site and will be situated in a previously disturbed location to minimize the extent of new disturbances. Waste generated by the camp will be incinerated and disposed of off-site. Sewage will be treated using an appropriately sized treatment system, and effluent quality will adhere to applicable licenses. Potable water located on site will be tested and used in accordance with the applicable water license.

Contingencies for water supply will include filters, and a supply of bottled water. Fuel required to operate the camp and to complete remedial activities will be stored on-site in accordance with applicable legislation and licenses.

5 COMMUNITY CONSULTATION

A draft copy of the RAP was distributed by AANDC to the community of Qikiqtarjuaq for their review and comment. In addition, a community consultation open to the public, hosted by AANDC, was held in January 2014. Minutes from the community consultation are located in Appendix D.

6 EVALUATION OF REMEDIAL OPTIONS

6.1 Cleanup Objectives

The following remedial objectives are based on guidance provided from Northern Contaminated Sites, PWGSC and the INAC AMSRP, March 2009.

- Restore the site to an environmentally safe condition;
- Prevent the migration of contaminants into the Arctic ecosystem;
- Remove physical hazards for the protection of human health and safety; and,
- Implement a cost effective remediation solution.

6.2 Remedial Options Analysis

Evaluation of the various remedial options was done using a systematic process that identifies parameters in which to rank the options, and the relative importance of those parameters. A decision-making matrix based on the Kepner-Tregoe process was used. For each remedial option identified, the following weighted attributes are considered important for determining which option may be the most preferred.

Cost - This will include all costs including initial costs of implementing the option and any long-term costs such as monitoring. This attribute is weighted the highest at 25%.

Effectiveness in Meeting Remedial Goals - This attribute includes an evaluation on whether the option will meet a regulatory target, such as a guideline criteria or site-specific risk-based criteria. Where criteria or site-specific criteria are not met an evaluation is made on whether the exposure pathway can be effectively managed or a receptor can be prevented from being impacted by the contaminant or hazard. This attribute has been weighted moderately at 15%.

Ease of Implementation - This includes how easily an option can be implemented, with proven solutions and the solutions that can be done easy on remote sites ranking higher than solutions that are problematic, less proven or are more complex. This attribute has been weighted moderately at 15%.

Regulatory Acceptance - Is the likelihood that an option could be readily accepted by the various regulators including Environment Canada and Territorial regulators. This attribute has been weighted relatively moderately at 15%.

Community Acceptance - This is how likely stakeholders from the community and First Nations nearby Hope Lake, Willow Creek, and Husky Creek will accept the remedial option. This attribute is weighted relatively moderate at 15%.

Loss of Natural Capital - Natural capital can be defined as the value that natural ecosystems contribute in terms of ecosystem goods (i.e., fish, wildlife, trees) or services (water catchment, erosion control, carbon cycling). The loss of the natural ecosystem through disturbance does have an impact to natural capital. The higher ranking corresponds to a lesser chance that there will be a loss of natural capitol. This attribute has been weighted lower at 10%.

Timeframe for Remediation - Is the length of time that an option will take to remediate to applicable criteria. Options involving risk management will rank lower typically due to the timeframe required (i.e. natural attenuation). This attribute has been weighted at 5%.

6.3 Site Issues

The following sections present a summary of the contaminant and waste disposal issues, as well as the potential remedial methods, for site issues identified from past site assessments. In the cases where more than one remedial method is identified, the options will be evaluated based on the remedial objectives and a recommendation for the favourable remedial method will be provided. Specific issues that need to be addressed at the FOX-D site include:

- Disposal of contaminated soils (PHC, metals, PCBs);
- Treatment/disposal of impacted soils (PHCs, and PAHs);
- Collection and disposal of hazardous materials (asbestos containing materials, batteries);
- Collection and disposal of lead and PCB amended paint;
- Proper disposal for the buried and partially buried debris located in two locations at the Upper Site, and in two locations at the Lower Site;
- POL tanks and transfer tank on the Upper Site; and,
- Collection and disposal of non-hazardous surface debris piles and dumps (located at Upper Site, Construction Camp, Airstrip Fuel Cache Dump, barrels, electrical cabinet, airstrip, borrow areas and scattered in other areas of the site).

6.4 Contaminated Soils

A summary of the contaminated soils and the preferred remedial options are presented in **Table 6-1.**

In accordance with the INAC AMSRP, March 2009, the following remedial options are presented for consideration. FOX-D is an abandoned and remote site; therefore the remedial plan must be designed accordingly. Solutions that achieve remedial objectives and minimize site remediation costs will be deemed favourable.

Despite the fact that in-situ technologies reduce contaminant exposure to humans and the environment, in-situ remediation technologies were not researched in detail. In-situ remedial technologies are care and maintenance intensive and have not generally proven to be pragmatic technologies for remote, northern site remediation. For this reason in situ technologies were not explored in great detail.

Table 6-1: Summary of Impacted Soils at FOX-D

Location	Exceedance of Applicable Guidelines	Within 30 m of a Water Body	DCC I (m^3)	DCC II (m^3)	Volume of PHC Impacted Soil (m^3)	Comments
APEC 1 – POL Tanks	PHC Type B	No	-	-	200	On-Site Biological Treatment and/or Aeration
APEC 3- Burnt Building Remains	PHCs/metals	No	-	190	50	Exceeds DCC Level II Criteria. Remove for off-site Disposal in an appropriately licensed facility.
APEC 5 – Stain #1	PHC Type B	No	-	-	80	On-Site Biological Treatment and/or Aeration
APEC 6 – Former Garage	PHC Type B	No	-	-	50	On-Site Biological Treatment and/or Aeration
APEC 7 – Stain #2	PHC Type B	No	-	-	230	On-Site Biological Treatment and/or Aeration
APEC 8 – Burnt Debris	PHCs/metals	No	-	3	-	Exceeds DCC Level II Criteria. Impacted area is co-contaminated. Remove for off-site disposal in an appropriately licensed facility.
APEC 9 – Northeast Slope Dump	PCBs, PHCs	No	-	< 1	615	Isolated hot spots of PCBs – remove for off-site Disposal in an appropriately licensed facility; On-Site Biological Treatment and/or Aeration
APEC 11A – Construction Camp	PHC Type B	No	-	-	1,140	On-Site Biological Treatment and/or Aeration
APEC 11B – Airstrip Fuel Cache Dump	PHC Type B	No	-	-	220	On-Site Biological Treatment and/or Aeration
APEC 12 – Landing Area	PHC Type A/B	Yes	-	-	620	On-Site Biological Treatment and/or Aeration

6.4.1 PCB Contaminated Soils

6.4.1.1 Contaminant Issue

The approximate 1 m^3 of PCB contaminated soil that exists on-site is located at the northeastern slope dumps site, as shown on **Figure 12** of **Appendix A**. The soil exceeds the INAC AMSRP (Greater than DCC Tier II) for PCBs. There are no DCC Tier I exceedances for PCBs in soil.

6.4.1.2 Recommended Remedial Method

Due to the limited quantities delineated, the soil shall be excavated, containerized, labelled in accordance with the Transportation of Dangerous Goods Act and shipped off-site to a disposal facility that is licensed to accept metal contaminated soils co-contaminated with PCBs. These soils should be addressed as per the Tier II soils identified in **Section 6.4.2** below.

6.4.2 Metal Contaminated Soils

6.4.2.1 Contaminant Issue

The 193 m^3 of metal contaminated soil that exists on site is located at the two burned debris areas: APECs 3 and 8, as shown on **Figures 6** and **11**, respectively, of **Appendix A**. The soil exceeds the INAC AMSRP (Greater than DCC Tier II). The soil exceeds the site-specific criteria as outlined by ESG in 2011. The soils are classified as exceeding Tier II.

6.4.2.2 Recommended Remedial Method

Due to the small amounts of metal contaminated soils on-site and the large operational and maintenance costs of metal contaminated soil remedial technologies as well as the high costs to construct and maintain a landfill, on-site remediation or disposal of the soils on-site was not explored. All metal contaminated soils that exceed the DCC Level II criteria (193 m^3) be excavated, containerized, labelled in accordance with the Transportation of Dangerous Goods Act and shipped off-site to a disposal facility that is licensed to accept metals contaminated soils.

6.4.3 Hydrocarbon Contaminated Soils

6.4.3.1 Contaminant Issue

The Phase III site investigation identified approximately 3,205 $m^3$of PHC contaminated soils that exceed the INAC AMSRP. This includes an estimate of 1,225 m^3 of PHC contaminated soil at the Upper Site, and 1,980 m^3 of PHC contaminated soils at the Lower Site. Assumed depths of impacts to 0.5 m were used for estimates, shown in **Table 6-2**. These values will be incorporated into estimated soil volumes that are likely to increase as a result of bulking during excavation (25% contingency). The estimates take into account both screening and bulking, which are likely to off-set each other. The hydrocarbon contaminated soils are located at the following areas (as shown on **Figures 4-16**):

- APEC 1 (POL Tank);
- APEC 3 (Burnt Building Remains);

- APEC 5 (Stain #1);
- APEC 6 (Former Garage);
- APEC 7 (Stain #2);
- APEC 9 (Northeast Slope Dump);
- APEC 11 (Construction Camp and Airstrip Fuel Cache Dump); and,
- APEC 12 (Landing Area).

Hydrocarbon fractions in the contaminated soils at the POL tank are mostly F2's and F3's, typical of weathered arctic diesel fuel contamination. The heavier end hydrocarbons are associated with waste oils and contamination remaining from the burning of oils and heavier fuels.

Table 6-2: PHC Impacted Soil Volume Estimates

Area	Estimated Volume of PHC-impacts exceeding (AMSRP SQG) m^3	Estimated Volume of PHC-impacts exceeding Type A AMSRP SQG m^3	Estimated Volume of PHC-impacts exceeding Type B AMSRP SQG m^3	Dominant Hydrocarbon Type
APEC 1B	200	200	-	B
APEC 3	50	-	50	A
APEC 5	80	-	80	A
APEC 6	50	-	70	A
APEC 7	230	-	230	A
APEC 9	615	100	615	A
APEC 11	1,240	320	1,360	A/B
APEC 12	620	260	575	A
TOTAL	**3,205**	**880**	**2,960**	

6.4.3.2 Remedial Options

Option #1: Excavation and Off-Site Disposal

The first potential remedial option for the hydrocarbon soils at FOX-D is to excavate all PHC contaminated soils ship them south to a facility licensed to accept hydrocarbon contaminated soils. The steps are as follows:

- Excavate PHC impacted soils from specified areas and package for transport according to TC TDG regulations. The excavation work would be completed during the summer;
- Haul impacted materials to staging area;
- PHC impacted soil would be loaded onto a barge/sealift and moved off site to Churchill, Manitoba, or Valleyfield, Quebec. The PHC impacted soil would then be transported to a licensed disposal facility with appropriate waste manifests and landfill approvals; and,
- Backfilling of excavations, then re-contouring and re-vegetation would be completed as required in areas of excavation, once backfilling is complete. It is then recommended to conduct a geotechnical evaluation to confirm soil compaction/settlement has occurred sufficiently at the Site.

This remedial option requires several barges and/or ships to mobilize and land various remedial equipment and supplies to the Site, so that the remedial work can be completed. Heavy equipment would be required to move PHC impacted soils from the site.

Since the contamination will be completely removed from the Site, it meets all of the remedial objectives; however, the major disadvantage of this method is the cost for shipping the material off-site.

This option is favourable because it removes the material from the site, thus prohibiting future site visits for biological and/or aeration treatment or monitoring purposes. It is anticipated that the cost of removing the material via barge is more cost effective than building, operating and monitoring a biological and/or aeration treatment cell or landfill. This remedial option would meet all clean-up objectives.

Option #2: On-Site biological and/or aeration treatment(Type B Hydrocarbon exceedances) Off-Site Disposal (Type A exceedances)

Option 2 for handling the petroleum contaminated soils is the use of a land farm for Type B exceedances with removal and off-site disposal of Type A exceedances (which are recalcitrant to biological and/or aeration treatment activities in the Canadian North). The off-site landfill disposal option is described above in Option #1. Biological and/or aeration treatments are a remediation technique used to reduce the hydrocarbon levels in soil via volatilization, biodegradation and photo degradation. The hydrocarbon soils are spread out on a self-contained, lined treatment cell Chemical amendments (fertilizer) and water may be added to the soil to promote biodegradation of the hydrocarbons. The soil is scarified or "turned" using heavy equipment to break up the soil, add oxygen and promote volatilization. Microbes in the soil (bacteria and fungi) breakdown the hydrocarbon chains converting them into biomass.

On-site borrow sources may be used for the construction of the Biological/Aeration Treatment Unit. In order to carry out this remedial process, a Biological/Aeration treatment unit footprint area of approximately 6,410 m^2 would be required for the Site (at a lift thickness of 0.3 m). A suitable location with this area was identified as the saddle location along the road connecting the Upper Site and the Lower Site.

In a northern climate, a minimum of two to five years is required for remediation depending on temperatures, moisture, soil contaminants, and fertilizer application/soil turning. More rapid attenuation has been observed in using an Allu bucket technique at other DEW Line locations. Biological and/or aeration treatment requires a work crew to visit the FOX-D site to scarify the contaminated soil, add the chemical fertilizer, and monitor the soil contamination levels. Once the soil has been remediated below the applicable criteria, the biological/aeration cell may be decommissioned in place and contoured into natural topography. Biological/aeration treatment processes will be carried out while the site is in operation. It is anticipated that concentrations in soil may be reduced to values below the applicable AMSRP criteria in this timeframe.

The general steps for on-site treatment are as follows:

- Perform bench scale testing to optimize the treatment process prior to treatment cell construction and mobilization of equipment to Site;

- Grading and construction of a biological and/or aeration treatment cell with an impermeable liner and perimeter berms. Seepage collection points or groundwater monitoring wells should be included to ensure the integrity of the impermeable liner. Some leachate is anticipated based upon the Phase III ESA findings for F2 and F3 PHCs. The design requires a sump and leachate collection within the design;
- Excavation and hauling of PHC impacted soils to the treatment cell site;
- Treatment and tillage of PHC impacted soils. Demarcation of the impermeable liner is needed to ensure that it is not damaged during treatment. Treatment including nutrients and aeration should be considered to meet the remedial targets;
- Collection and submission of soil analytical samples from the treatment cell to quantify the level of contamination, nutrient and microbial levels, and determine need for additional treatment; and,
- Once the soils are successfully remediated, clean soils will be backfilled into original locations or used as fill for areas across the site. Reclamation activities may include grading to promote natural drainage of water, seeding, and if required, fertilization. The artificial liner will be removed and disposed off-site prior to site closure activities.

An advantage of biological and/or aeration treatment is that the contamination is eventually eliminated. This eliminates the need for long-term inspections and monitoring, and removes any long-term liability of the site. Notable disadvantages include the time and effort required for the construction of the treatment cell and the remediation process, as well as monitoring the activity and ensuring the material is remediated to the applicable criteria.

Biological and/or aeration treatment of the PHC contaminated soils would meet the INAC Clean-up Objectives one, two and three.

Option #3: Landfill On-Site

A secure landfill was evaluated as a third option. A landfill can be constructed at the FOX-D site using the available borrow sources. A landfill containing contaminated soils shall have an engineered clay or synthetic liner to ensure the contaminants within the soil are not allowed to become mobile. Proper design of the landfill will ensure that permafrost is developed within the landfill to further decrease the mobility potential of the contaminants.

Advantages of the landfill are that the remedial work can be completed in one season. Disadvantages for this option are similar to the capping option (described below). The main disadvantages of landfilling the contaminated soils are that the contamination will remain on-site. This requires long term inspections and monitoring of the landfill at significant extra capital and labour costs to ensure the contamination remains contained within the landfill.

The landfill option meets INAC Clean-up Objectives one, two, and three; however, long term monitoring and inspections of the landfill are required as the contamination will remain on-site. Consequently, the cost for building and monitoring a landfill is likely off-set by the cost to excavate the material and dispose of it off-site. Due to the lack of suitable space for landfilling soils on-site, this will not be pursued further as a viable remedial option.

Option #4: Engineered Cap in Place

Option 4 for dealing with the hydrocarbon contamination at the FOX-D site is to grade and cover the contaminated areas with an engineered cap. The cap would consist of a 1.0 m thick layer of compacted engineered fill, graded to promote drainage.

A cap would reduce the amount of rain and surface water coming into contact with the contamination and prevent further dispersion of the hydrocarbon contamination. The cap would eliminate the possibility of humans and/or fauna from coming into contact with the contamination. This remedial option has a relatively low cost and a minimal level of effort. The capping of the hydrocarbon contaminated soils could easily take place during other site remedial activities.

In addition to the engineered cap a chemical amendment can be added to the contaminated soil. The chemical amendment (fertilizers, nutrients, nitrogen etc.) promote biodegradation of the hydrocarbons by providing the necessary chemicals and nutrients required by the microbes for the degradation to occur.

The hydrocarbon impacted soils are excavated and the chemical amendment would be mixed into the soils and the soils would be replaced and capped as noted above. The additional costs for the chemical amendment include the costs for the excavation of the impacted areas; the addition of the amendment, the amendment itself and the cost to replace and compact the soils after the amendment is added. The availability of suitable borrow materials required for an engineered cap may impact cost and/or feasibility.

Disadvantages associated with this remedial option are that it would require further monitoring events to ensure the capping system remains in good condition (no erosion, frost heaving) and that the hydrocarbons do not become mobile. The capping would greatly reduce the natural occurring bioremediation of the soils by limiting the amount of oxygen reaching the contaminated soil. Less oxygen reduces the rate of aerobic degradation of the hydrocarbons. There would be little to no control over the bioremediation process and on-going monitoring of the contaminated area would be required. As the impacts are not being attenuated and remain on-site, long-term monitoring may be required.

Option #5: In Situ Soil Vapour Extraction

Vapour extraction is a remedial method used to remediate hydrocarbon contaminated soils. Air is pushed or drawn through the contaminated soils and the lighter end hydrocarbons volatilize into the air. The air is then released into the atmosphere or run through carbon filters to remove the hydrocarbons. Contamination favouring this option is light end hydrocarbons (F1 Fractions). Heavier fractions of hydrocarbons are less likely to volatilize and require different remediation methods. The soils must be porous, freely allowing the air to move through the soil and volatilize the hydrocarbons. Poorly graded dry sands and gravels are ideal for vapour extraction. Saturated well graded soils are not favourable for Soil Vapour Extraction.

Vapour Extraction systems rely on powered blowers and require frequent adjustments and maintenance during the extraction process. FOX-D is a remote, unmanned site, rendering this remedial measure to be costly. The types of hydrocarbon contamination at FOX-D are not compatible with vapour extraction remediation methods. The contamination at the FOX-D site comprises the larger fractions of hydrocarbons (F2, F3 and F4 at some locations). Vapour extraction will not be explored further as a remedial option.

Option #6: Biopile

A biopile is a remediation technology used to remediate hydrocarbon contaminated soils. The PHC contaminated soils are collected into piles and wrapped in synthetic liners to promote anaerobic degradation of the hydrocarbons and retain heat to promote the bioactivity. Temperatures measured within an active biopile are often much higher than ambient temperatures.

Biopiling has had limited success as an effective remediation technique at remote and unmanned northern sites due to low ambient temperatures and the care and maintenance involved with operating the biopile system. Biopiles will not be explored further as a remedial option.

6.4.3.3 Remedial Options Analysis

Cost of Remediation

Each remedial option has been ranked as following:

***Lowest Cost*:** Option 4, In-situ engineered cap, is anticipated to be the most cost effective option.

***Middle Cost*:** The costs for remedial Option 2 (biological and/or aeration treatment with some off-site disposal) are greater than for Option 4 due to cost for borrow material as well as design and the construction of the treatment cell and off-site disposal.

Highest Cost: Off-Site Disposal to an approved Facility (Option 1) is estimated to have the greatest cost.

Effectiveness in Meeting Remedial Goals

Each remedial option has been ranked as following:

Most Effective: Excavate the impacted soil and remove it off-site for disposal in an approved off-site licensed disposal facility. This option results in the complete removal of the source and its associated environmental liabilities.

***Middle*:** Single stage biological and/or aeration treatment is considered to be the next most effective option as PHCs will biodegrade and be chemically broken down over time within a reduced timeframe. All biological and/or treatment options will achieve the remedial targets required for the Site.

Least Effective: In-situ engineered capping is considered to be the least effective as the source will remain on-site and minimal degradation will occur.

Timeframe for Remediation

Each remedial option has been ranked as following:

Shortest Timeframe: Excavate the impacted soil and remove off site for disposal is considered the most time effective, as it is anticipated that this option will require one to two years to complete including off-site transport via barge/ship.

Middle: In-situ engineered capping is anticipated to be completed within one to two years.

Longest Timeframe: Biological and/or aeration treatment is anticipated to take two years until remedial works are completed that meet applicable remedial targets.

Ease of Implementation

Easiest to Implement: Covering impacted soils in situ using developed aggregated on-site is anticipated to have the greatest ease of implementation.

Middle: Biological and/or aeration treatment using onsite developed aggregate is anticipated to have more complexity than option #4, due to the design and construction of a suitable treatment facility.

Hardest to Implement: Off-site removal to an approved off-site facility is anticipated to have some difficulty due to the logistical challenges of transporting a large volume of impacted soil from Davis Strait by barge, and to transport the impacted soil to an approved off-site facility.

Regulatory Acceptance

Each remedial option has been ranked as following:

Greatest Regulatory Acceptance: Excavate the impacted soil and remove off site for disposal is considered to have greatest regulatory acceptance due to removing fully removing site impacts in a short timeframe from the Site.

Middle: Biological and/or aeration treatment (Option 2) using on-site developed aggregate is anticipated to have regulatory support as native bedrock will be used ensure no invasive species are introduced from off-site aggregate.

Lowest Regulatory Acceptance: Engineered Cap, Leave In-Situ is expected to have the lowest level of regulatory support as remediation efforts are non-destructive and will require further visitation at the Site.

Community Acceptance

Biological and/or aeration treatment was presented as the selected remedial option at the Community Consultation. No objections were raised.

Preferred Remedial Option:

The options are evaluated below:

Table 6-3: Hydrocarbon Remedial Options Analysis

Option/Attribute	Attribute Weighting	Excavate, Off-Site Disposal	Biological and/or Aeration Treatment On-Site	Engineered Cap, Leave In-Situ
Cost	25%	1	2	3
Effectiveness in Meeting Remedial Goals	15%	3	2	1
Ease of Implementation	15%	2	1	3
Regulatory Acceptance	15%	3	2	1
Anticipated Community Acceptance	*15%*	2.5	2.5	1
No Loss of Natural Capitol	10%	1	3	2
Timeframe for Remediation	5%	3	1	2
Total Score		16	14	13
Weighted Score		1.8	1.8	1.5
Number of High Scores		3	1	2
Ranking		1	3	2

Based upon the remedial option assessment, biological and/or aeration treatment on-site combined with off-site disposal at an approved disposal facility is the preferred remedial option. This option will address all remedial objectives in a more cost-effective approach than shipping all PHC-impacted soils off-site.

The following are potential issues with disposing of the PHCs at an approved off-site facility:

Special approval from AANDC and PWGSC, after further community discussion, should be considered regrading backfilling excavations; this may further reduce the need for aggregate and reduce the overall cost for this remedial option.

- All excavations should be sloped to the natural terrain to ensure safety if this alternate option is adopted;
- All of the PHC impacted soil should be acceptable for disposal in a licensed disposal facility subject to landfill characterization. Waste manifests, and off-site landfill approval is required before removing the PHC impacted soil from the property, as per the Government of Nunavut waste transfer guidelines defined in the Contaminated Site Remediation Guidelines (Government of Nunavut, 2009);
- Proper containment for sea transport is needed;
- Impacted soil should be handled properly, following Government of Nunavut and other Federal guidelines (regardless of remedial option); and,
- There will be additional logistical planning associated with transporting the required material (i.e. geosynthetic liner) to Site. The equipment requirements will likely remain similar to construction equipment required for other tasks associated with Site clean-up.

6.5 Site Materials

6.5.1 Non-Hazardous Materials

Approximately 21,827 m^3 of non-hazardous materials are estimated to be deposited at the FOX-D Intermediate DEW Line site. This volume estimate includes an estimate for 6,645 m^3 of buried, half-buried debris and scattered debris in Class C dumps, and 800 m^3 of debris that will be generated when the remaining structures and foundations buildings are demolished. Once all the structures have been demolished to their foundations, the demolished material can be collected and transported off-site. The total non-hazardous materials to be moved off-site is approximately 6,040 m^3, with a potential additional 8,793 m^3 from APEC 11A (Landfill, unknown waste). The following table presents a summary of the non-hazardous locations of the non-hazardous materials.

Table 6-4: Summary of Non-Hazardous Materials

Location	Volume (m^3)	Comments
Upper and Lower Sites	1.50	76 steel drums were observed scattered throughout the upper and lower sites. Does not include suspected buried or partially buried drums.
APEC 1A - Transfer Tank APEC 1B - POL Tanks	17.3	Tanks include the POL tanks at the upper site and the transfer tank at the upper site.
APEC 1B - POL Tanks APEC 3 - Burnt Building Remains APEC 12 - Landing Area	0.2	Pipes/drains include the valve at the former POL tanks at the Lower site and the underground pipes at the burnt remains and the POL tanks area at the upper site.
APEC 2 - Antenna	1.8	Radio Antenna
APEC 9A - Dump Site	1.75	Includes the metal cabinets within the dump site and the metal cabinets located 20 - 25 m northeast of the dump site.
APEC 6 - Former Garage (Upper Site)	256.2	Staining observed on the concrete foundation.
APEC 4 - Warehouse Foundation (Upper Site)	215.4	Concrete Foundation
APEC 1B - POL Tanks (Upper Site)	32.5	POL Tank Foundation (2 foundations)
APEC 2 - Antenna (Upper Site)	100	Concrete Anchors (3 anchors)
APEC 11A - Construction Camp (Lower Site)	43.9	Concrete Foundation at Construction Camp
APEC 12 - Barge Landing (Lower Site)	32.5	Former POL Tank Foundation (2 foundations)
APEC 12 - Barge Landing (Lower Site)	1.7	Thrust Blocks (3 blocks)
APEC 12 - Barge Landing (Lower Site)	1.8	Valve Thrust Blocks (2 blocks)
APEC 9 - Dump Site (Upper Site)	6,095	Exposed and partially buried metal waste, drums, metal cabinets, PCB transformer and asbestos observed within the dump site.
APEC 10 - Dump Site (Upper Site)	550.7	Landfill area not identified in previous reports. Exposed and partially buried metal waste and drums observed within the dump site.
APEC 11A - Construction Camp Landfill (Lower Site)	4,885	Landfill area not identified in previous reports. Exposed and partially buried metal waste and drums observed in landfill.
APEC 11A - Construction Camp Landfill (Lower Site)	8,793	Landfill area not identified in previous reports.
APEC 11A - Construction Camp (Lower Site)	577.9	Surface staining.
APEC 11B - Construction Camp (Lower Site)	219	Partially buried drums visible.
TOTAL ESTIMATED VOLUME OF NON-HAZARDOUS DEBRIS		**21,827m^3**

The total estimated volume of on-site non-hazardous debris is 21,827 m^3, taking into account the volume of crushed barrels. Based on the soil sample results and inspections of the buried debris, the buried debris areas on the Upper Site are classified as Class C landfills in accordance with the INAC AMSRP, March 2009. Non-hazardous waste remaining behind in Class Dumps is estimated to be 6,645 m^3, with a total estimated volume of 14,834 m^3 non-hazardous waste to be handled.

Remedial options for the buried debris include the following: Firstly, the buried or partially buried debris areas can be crushed and stabilized/capped in place. The second option involves unearthing the debris, followed by assessing and sorting the debris, and disposing of the debris according to the remedial option selected.

The 2013 Phase III ESA included the collection and analysis of concrete samples collected from three areas of the site. As reported, the analysis indicated PCBs concentrations less than 50 ppm in all the samples.

All buildings/infrastructure shall be demolished to their foundations in accordance with the INAC AMSRP, March 2005/2009. All barrels shall be addressed using the Department of National Defence (DND) DLCU Barrel Protocol (**Appendix C)**.

A detailed summary of the non-hazardous materials located at the FOX-D site is provided in **Appendix E**. Remedial options for non-hazardous materials are described below, and options for hazardous materials are discussed in **Section 6.5.2**.

6.5.1.1 Remedial Options

Option #1: Buried in Place

Once all the structures have been demolished to their foundations, the site materials can be buried in place. The debris would be flattened and covered with compacted engineered fill or placed in a nearby excavation or low spot in the surrounding terrain and then covered with compacted fill. The cover of compacted fill must be engineered to promote positive drainage and the cap must be graded to match surrounding terrain. Advantage of this method is that it is less expensive as the contractor does not have to remove, transport and place material in a landfill some distance away. The disadvantages of this method is that the material is not placed in a secure engineered landfill and that a large contractor effort would be required to move fill to cover the debris piles that are scattered around the site. In the event that additional debris is discovered on site, the debris shall be addressed using the INAC AMSRP, March 2009. In the event that the materials are buried on-site, future monitoring would be required.

Option #2: Consolidate Wastes and Place in On Site Non-hazardous Waste Landfill

Once all the structures have been demolished to their foundations, the demolished materials as well as the non-hazardous materials from the surface debris piles that are scattered around the site, as well as from the buried debris area would be transported to an engineered, on-site landfill. This option is more cost intensive, but it gathers all the site material into one secure area reducing future monitoring inspection efforts.

Placing the non- hazardous demolition waste in an on-site engineered landfill is in accordance with the INAC AMSRP, March 2009.

The largest volume of non-hazardous materials that a new, on-site, engineered landfill is estimated to accommodate is 12,000 m^3, assuming 1 m of excavation (to bedrock) and 2 m of above grade material, with a footprint of 50 x 70 m. The estimated volume of debris at the upper site is 800 m^3 (not including debris located at APEC 9 (northeastern dump site). The total estimated volume of on-site non-hazardous debris to be handled is 14,834 m^3. The amount of debris is greater than what an on-site engineered landfill can accommodate. Regardless, some debris materials will need to be removed off-site for disposal.

Option #3: Off-site Disposal

Once all the structures have been demolished to their foundations, the demolished material can be collected and transported off-site (approximately 14,834 m^3). As FOX-D has sea access, materials would be hauled down to the Lower Site barge landing area (APEC 12) for barge pick up and disposal at another location. Due to the large costs associated with hauling demolition material and barging, off-site disposal is often deemed to be a lesser cost-effective remedial option.

6.5.1.2 Remedial Options Analysis

Cost of Remediation

Each remedial option has been ranked as following:

***Lowest Cost*:** Option 1, In-situ engineered cap, is anticipated to be the most cost effective option.

***Middle Cost*:** Off-Site Disposal to an approved Facility (Option 3) is estimated to have the next lowest cost.

Highest Cost: The most costly remedial option is landfilling (Option 2). Regardless, some non-hazardous material will need to be shipped off-site. The costs for this remedial option are very high due to cost for borrow material as well as design and the construction of the landfill.

Effectiveness in Meeting Remedial Goals

Each remedial option has been ranked as following:

Most Effective: Debris removal from the site for disposal in an approved off-site licensed disposal facility. This option results in the complete removal of the source and its associated environmental liabilities. No further site monitoring required.

***Middle*:** Landfilling is anticipated to be less effective than full removal, and more effective than in-situ burial. Material will be contained on-site in a controlled, engineered facility.

Least Effective: In-situ engineered capping is considered to be the least effective as all materials will remain on-site.

Timeframe for Remediation

Each remedial option has been ranked as following:

Shortest Timeframe: Debris burial is anticipated to have the shortest timeframe and may take two to three years.

Middle: Debris removal for off-site disposal is anticipated to take longer than capping, as material will need to be crushed and packaged for transport.

Longest Timeframe: Landfill construction is anticipated to take the longest, as both a landfill facility will need to be constructed and extraneous debris materials will need to be crushed and packaged for transport.

Ease of Implementation

Easiest to Implement: Covering impacted soils in situ using developed aggregated on-site is anticipated to have the greatest ease of implementation.

Middle: Off-site removal to an approved off-site facility is anticipated to have some difficulty due to the logistical challenges of transporting a large volume of impacted soil from Davis Strait by barge, and to transport the impacted soil to an approved off-site facility.

Hardest to Implement: Landfill construction, combined with off-site removal to an approved off-site facility is anticipated to have the greatest difficulty due to the logistical challenges as mentioned above, as well as the construction of an engineered landfill on-site at a remote, northern location.

Regulatory Acceptance

Each remedial option has been ranked as following:

Greatest Regulatory Acceptance: Debris removal for off-site disposal is considered to have greatest regulatory acceptance due to fully removing site impacts in a short timeframe from the Site.

Middle: Landfilling is anticipated to have regulatory support, as both debris removal for off-site disposal and landfilling non-hazardous debris in an engineered landfill is acceptable under the Remediation Protocol (INAC, 2009).

Lowest Regulatory Acceptance: Engineered Cap, Leave In-Situ is expected to have the lowest level of regulatory support as remediation efforts are non-destructive and will require further visitation at the Site.

Community Acceptance

Off-site disposal was presented as the selected remedial option at the Community Consultation. No objections were raised.

Preferred Remedial Option:
The options are evaluated below:

Table 6-5: Non-Hazardous Materials Remedial Options Analysis

Option/Attribute	Attribute Weighting	Off-Site Disposal	Landfill On-Site	Engineered Cap, Leave In-Situ
Cost	25%	1	2	3
Effectiveness in Meeting Remedial Goals	15%	3	2	1
Ease of Implementation	15%	2	1	3
Regulatory Acceptance	15%	3	2	1
Anticipated Community Acceptance	*15%*	*3*	*2*	*1*
No Loss of Natural Capitol	10%	3	2	3
Timeframe for Remediation	5%	3	2	1
Total Score		18	9.5	14.5
Weighted Score		2.4	1.9	2.0
Number of High Scores		5	0	3
Ranking		1	3	2

6.5.1.3 Recommendation

It is recommended that non-hazardous waste materials (14,834 m^3, excluding materials to remain in APECs 9 and 10) to be collected, consolidated and packaged for off-site disposal. APECs 9 and 10 will be regraded and remain in place.

Remedial options for APEC 9 are assessed separately and discussed in **Section 6.5.3**.

6.5.2 Hazardous Materials

Hazardous materials are known to be present at the FOX-D Site based on assessment work completed in 2013. A detailed inventory of hazardous waste is provided in **Appendix E**. All hazardous materials (with the exception of Asbestos Containing Materials) will be containerized and labelled in accordance with the Transportation of Dangerous Goods Act in Accordance with the INAC Abandoned Military Sites Remediation protocol and disposed of off-site.

Approximately 0.031 m^3 of PCB/Lead painted materials and 1.54 m^3 of hazardous materials (asbestos materials and lead-acid batteries) were identified during the 2013 environmental site assessment. Lead impacts associated with paint samples from APEC 2 (Antenna) were deemed to be non-hazardous; however, PCBs measured in paint samples from APEC 2 were above the Federal Health Canada guideline (2.0 µg/g), but below the CCME waste management criteria (<50 mg/kg).

A detailed description of the painted materials that are considered hazardous/ non-hazardous is provided in **Appendix E**. The presented volumes of hazardous materials, includes potential materials that may have been deposited in the northeast slope dump, based on previous assessments (1994) and field observations.

6.5.2.1 Collected Water

Disposal on Ground

The investigation work completed by Dillon and KGS Group in 2013 confirmed that the dissolved metal concentrations in the water that has collected in the barrels meets DLCU barrel protocol and is suitable for ground disposal following polishing with adsorbent material.

6.5.2.2 Asbestos

Asbestos is an inhalation hazard and is more of a safety hazard than a hazardous waste, but due to special handling, precautions and disposal, it is similar in nature to hazardous waste and needs to be dealt with adequately. Approximately 1.3 m^3 of asbestos will need to be removed and appropriately disposed of, according to the applicable guideline (Government of Nunavut, 2011).

Asbestos Containing Materials (ACM) at the FOX-D site is limited to the main station area. Asbestos is located throughout the remaining structures and within the buried debris piles. Asbestos Containing Materials (ACM) includes floor tiles, pipe insulation, fire door insulation, transit board, and vermiculite insulation. All asbestos is to be properly abated, in accordance with applicable Federal and Territorial Asbestos regulations, prior to any demolition activities.

Option #1: Asbestos Abatement, Place in On-Site Landfill

All asbestos is to be abated in accordance with applicable Federal and Territorial Asbestos regulations and guidelines. All ACM debris shall be abated and placed in a sealed, airtight container, clearly labelled "ASBESTOS". The material will be double-bagged or containerized in a sound, sealable and not-damaged or leaking container, in accordance with the applicable guideline. The asbestos is then placed in the engineered landfill constructed on-site. The location of the asbestos material located within the landfill should be noted for future reference. This method is in accordance with the INAC AMSRP.

Option #2: Asbestos Abatement, Remove Off-Site

The asbestos would be hauled to a staging area, and then hauled by barge or ship to another suitable location for landfilling. The steps are as follows:

- Conduct removal of asbestos materials. Asbestos should be handled and removed by trained personnel and double-bagged or containerized in a sound, sealable, undamaged and/or non-leaking container, in accordance with the applicable guideline;
- Haul to staging area; and,
- Load and haul for further shipment to a licensed disposal landfill for this type of hazardous waste.

The options are evaluated below:

Table 6-6: Asbestos Remedial Options Analysis

Option/Attribute	Attribute Weighting	Excavate, Off-Site Disposal	Landfill On-Site
Cost	25%	1	2
Effectiveness in Meeting Remedial Goals	15%	2	1
Ease of Implementation	15%	2	1
Regulatory Acceptance	15%	2	1
Anticipated Community Acceptance	*15%*	*2*	*1*
No Loss of Natural Capitol	10%	2	1
Timeframe for Remediation	5%	2	1
Total Score		13	6
Weighted Score		2	1
Number of High Scores		6	1
Ranking		1	2

The highest ranked and preferred option meets the INAC Abandoned Military Site Clean-up Protocol Clean-up Objectives one, two, and three. It is recommended that the asbestos-containing materials be containerized and disposed off-site. There will be additional logistical planning associated with transporting the asbestos waste off-site and determining landfill acceptance of the asbestos waste at a licensed disposal facility.

6.5.2.3 PCB & Lead Contaminated Paint

Landfill On-Site

Paint abatement consists of physically removing the PCB and/or lead contaminated paint from the substrate. This is accomplished by physical scrapping, chemical stripping, sand blasting and various other abrasive physical removal techniques. As the paint being removed contains lead and or PCBs, abatement methods must be conducted in a manner that protects the worker and the environment from PCB and lead contamination. Abatement methods generating dust must be conducted in a sealed, negative pressure environment with the area exhaust filtered with a certified High Efficiency Particulate Air (HEPA) Filter. Misted water is used to control the paint dust, requiring the waste water to be filtered to remove the contaminated paint or collected and treated as hazardous waste. These required mitigation measures increase costs dramatically.

The lead paint would be removed from the POL tanks; they would be then be dismantled and placed in the landfill. The steps are as follows:

- Clean the inside of the tanks and drain any remaining fuel/fluids from the excavator (note liquid from cleaning would need to be treated/tested for disposal);
- Construct an enclosure over and around the tanks and excavator that will sufficiently collect the paint chips and prevent them from contaminating adjacent areas. Remove paint by sandblasting or scrapping and collect the sand/paint for disposal off-site in a licensed disposal facility for hazardous waste;

- Dismantle and cut apart;
- Sample the surrounding soil to determine that the paint did not contaminate the soil; and,
- Landfill and cover.

Paint Removal, Off-site Disposal

This option would meet the INAC clean-up objectives for restoring the site to an environmentally safe condition and preventing the migration of the contaminants as all of the PCB containing paint would be removed from site. The abatement process as described above is involved and costly. The abatement costs combined with the disposal costs make this option less cost effective.

Leave Paint, Off-site Disposal

As an alternative to paint abatement, building materials painted with contaminated paint can be dismantled and disposed of as hazardous materials, bypassing the requirement for the paint to be abated. The transport and disposal costs are higher due to the fact that the painted building materials are disposed of along with the paint; however, these additional costs are smaller than the additional costs of paint abatement. As there is minimal scrapping and abrasion during the dismantling activities, negative air enclosures and filtration systems are not required. Dismantled material volumes can be minimized by cutting and compacting.

Table 6-7: Summary of Remedial Options for PCB & Lead Contaminated Paint

Option/Attribute	Attribute Weighting	Leave Paint, Off-Site Disposal	Remove Paint, Off-Site Disposal	Remove Paint, Landfill On-Site
Cost	25%	3	2	1
Effectiveness in Meeting Remedial Goals	15%	1.5	1.5	3
Ease of Implementation	15%	2	1	3
Regulatory Acceptance	15%	3	2	1
Anticipated Community Acceptance	*15%*	*3*	*2*	*1*
No Loss of Natural Capitol	10%	3	2	1
Timeframe for Remediation	5%	3	2	1
Total Score		18.5	12.5	11
Weighted Score		2.6	1.8	1.6
Number of High Scores		5	0	2
Ranking		1	2	3

The highest ranked and preferred option meets the INAC Abandoned Military Site Clean-up Protocol Clean-up Objectives one, two, and three.

It is recommended that the lead and PCB amended paint materials that are tested to be hazardous, be dismantled and disposed off-site.

This remedial method is in accordance with the INAC AMSRP, March 2009. Care is to be taken during the dismantling to prevent dust and paint chips from being released into the environment and to protect the workers that are conducting the dismantling from PCB and lead contamination. All dismantled PCB and/or lead contaminated paint material shall be packaged, transported and disposed of in accordance with the current regulations governing the handling and disposal of hazardous materials.

6.5.3 Buried Debris in Existing Class C Landfills

Ordinarily, due to the high potential that hazardous building materials have been deposited in the buried debris areas, and that these materials may contain products with PCB levels greater than 50 ppm (regulated by CEPA), it would be recommended that the buried waste sites be unearthed, sorted, and disposed of accordingly. Field investigations conducted in 2013 (Dillon, 2013) observed minimal, isolated PCB impacts in the dump areas. However, the health and safety risks associated with access and de-stabilizing the northeast slope dump (APEC 9) by debris removal may outweigh the environmental hazards posed by burying and stabilizing the debris in-situ. Steep slopes govern the area and limits access. There are health and safety concerns associated with de-stabilizing the northeast slope by debris removal.

Two options are available for the material located at APECs 9 and 10 and are discussed below.

6.5.3.1 Remedial Options

Option #1: Re-stabilize and Bury In-Situ

Remedial Option 1 would involve re-stabilizing non-hazardous materials in the Northeastern slope dump and eliminating void space to the fullest extent possible. An access road, starting from the POL Tank Area and extending along the north side of the slope will need to be constructed, to allow heavy equipment access to the area. Un-buried debris will be removed for off-site disposal. The material will be stabilized, covered with borrow material and re-graded to protect the area from erosion and cover degradation.

Under this remedial option, it is recommended that non-hazardous debris at the Upper Site (such as concrete foundation fragments and paint-splattered rocks) be used to fill void space in the dump site and brace the material from erosion down-slope. Both concrete and the rocks are non-hazardous, but are heavy materials and will increase shipping and disposal costs for off-site disposal.

Soil impacts associated with this area were observed to be non-migratory. Stabilization and covering of this material would effectively cut off all potential ecological, environmental and human health risks.

On-going monitoring of the site would not be required under the AMSRP (INAC, 2009), as the area will remain a Class C landfill. Based on results from the Phase III Environmental Site Assessment and field observations in 2013 (Dillon-KGS Group, 2013), there is no evidence for contaminant migration from the dump.

Option #2: Excavate all Materials for Off-Site Disposal

Under Option 2, all materials in APECs 9 and 10 would be removed, packaged for off-site disposal. Provided the unknowns associated with the buried materials, the amount of visible void space and topography, the length of time for Option 2 will extend the remediation program by an estimated three years. A secondary access road may need to be constructed on the southern side of the summit. The removal of materials from APEC 9 will need to proceed slowly, with great care taken to maintaining slope stability.

6.5.3.2 Remedial Options Analysis

Additional costs associated with Option 2 include the addition of heavy materials for disposal and additional time during the remediation phase. Option 2 would allow for a complete, walk-away site approach and fulfill all remedial objectives.

Table 6-8: Class C Dump Remedial Options Analysis

Option/Attribute	Attribute Weighting	Excavate, Off-Site Disposal	Leave In-Situ
Cost	25%	1	2
Effectiveness in Meeting Remedial Goals	15%	2	1
Ease of Implementation	15%	1	2
Regulatory Acceptance	15%	2	1
Anticipated Community Acceptance	*15%*	*2*	*1*
No Loss of Natural Capitol	10%	1	2
Timeframe for Remediation	5%	1	2
Total Score		10	11
Weighted Score		1.5	1.5
Number of High Scores		3	4
Ranking		2	1

Based upon the remedial option assessment, in-situ burial is the preferred remedial option. Off-site disposal is more effective removing all impacted soils from the Site, however, due to the longer timeframe is significantly more expensive than stabilizing and burial.

6.5.3.3 Recommendations

It is recommended that the northeastern dump slope be stabilized and covered with granular material. It is recommended that the remedial/excavation work in the buried debris areas be completed following a specific work procedure and on-site workers will need to wear the appropriate level of PPE and be properly trained. During the sorting operation, specific items that should be removed from the non-hazardous debris include asbestos containing material tiles and insulation. Stabilization, compaction and erosion protection were presented as the recommended remedial options for the Upper Site Dumps (APECs 9 and 10).

6.5.4 Physical Hazards

Physical Hazards are considered to be man-made structures; openings and other features that could constitute a risk to humans. All areas with half-buried debris pose physical hazards to humans. A specific safety plan will have to be completed for removal of debris that is located on steep slopes and for sorting of material in the debris areas. This will include, but not be limited to type and placement of equipment and proper safety gear for people working in these areas.

6.6 Recommended Remediation Options

Table 6-9: Summary of Recommended Remediation Methods

Environmental Concern	Site Assessment Findings	Recommendation Remediation Method
Metals Contaminated Soils	193 $m^3$of soils with concentrations of Cu, Cd, and Zn, which exceed the DCC Tier II criteria were identified on-site. This volume includes material that is co-contaminated with PAHs and PHCs.	Excavate, containerize, and label soils that exceed DCC Tier II criteria and dispose off-site at an appropriately licensed facility.
Petroleum Hydrocarbon Contaminated Soils	Approximately 3,205 m^3 of hydrocarbon contaminated soil in exceedance of the INAC Abandoned Military Site Remediation Protocol for PHC Soils.	Screen PHC Type A soils and treat in on-site constructed biological and/or aeration treatment unit (3,005 m^3). Excavate PHC Type B soils (200 m^3) and place into containers, and ship off-site to a licensed disposal facility.
Non-Hazardous Materials	Approximately 14,834 m^3 of non-hazardous debris consisting of heavy equipment, barrels, scrap metal, scrap wood, concrete, electrical equipment and plumbing parts to be handled and shipped off-site.	All buried and partially buried debris in Class B dumps (APEC 11) should be excavated, sorted and separated into different waste types where it is safe and practical to do so, and disposed off-site in an appropriate licensed facility. Buried debris that is inaccessible for excavation in Class C dumps (APECs 9 and 10) should be buried and re-stabilized in-situ. Rocks and concrete foundations from APECs 1-4 to be used as rip-rap and fill in void space at APEC 9. Area will be covered with rip rap and erosion resistant material for stability. All other debris is to be consolidated, packaged and shipped off-site to an appropriate licenced disposal facility.
Water in Barrels	Analysis of collected water in the abandoned barrels indicates that the dissolved metals meet DLCU barrel protocol.	Disposal on ground is permitted once water has been polished with an absorbent materials, additional sampling of more barrels during remediation program is required.
PCB/Lead Amended Paint Products	Approximately 0.031 m^3 of PCB/lead amended paint materials were discovered on site (not including metal)	Dismantle contaminated paint items and ship off-site to an appropriate disposal facility.
Hazardous Materials	Approximately 1.82 $m^3$of hazardous materials were identified at the site. These materials consisted of lead acid batteries (0.22 m^3) and asbestos containing materials (1.32 m^3).	All hazardous materials (such as batteries) will be containerized and labeled and shipped to be disposed at a licensed facility.
Structures	Upper Site POL Tanks (2) Upper Site Transfer Tank (1) Concrete Foundations	All non-hazardous materials and debris from Upper Site structures buildings shall be demolished to their foundations and removed off-site for disposal at an appropriate licensed facility.

7 REMEDIAL DESIGN AND IMPLEMENTATION

7.1 Remedial Objectives

The remedial design for the FOX-D Intermediate DEW Line site has been developed in accordance with the Indian Affairs and Northern Development, AMSRP, March 2009. The following section outlines the general design and implementation of the preliminary draft FOX-D RAP.

Remedial Design and Implementation Objectives:

1. Ensure safety of workers on-site;
2. Prevent further contamination at the FOX-D DEW Line site;
3. Minimize impact to environment, fauna, flora; and,
4. Achieve remedial objectives.

The contractor shall have a site specific, Health and Safety Plan in place and understood by all involved workers prior to work starting on the site. Contractor shall have a spill contingency plan in place to deal with any unforeseen and accidental releases of contaminants.

7.2 Remediation Logistics

There is currently an airstrip at the Site and numerous locations suitable for helicopter and/or fixed wing aircraft landing. Mob/demob is possible by sealift or barge, although it is anticipated that mob/demob will take place via sealift, with support and re-supply service provided by helicopter and/or charter plane.

7.3 Camp

A camp will be required during the remedial activities. Although the hamlet of Qikiqtarjuaq is nearby, the ability to house and efficiently mobilize workers to the Site is not deemed to be feasible. The camp must be large enough to support approximately 20 site workers and approximately three to five camp staff. The camp shall include a potable water source, sewage collection, and treatment in accordance with all applicable guidelines and regulations, bear safety measures, emergency rations and an emergency rescue contingency plan.

Two areas were identified as potential locations for construction and workers camps (**Figure G-1**). The camp will need to house workers and will need to meet the specifications laid out by PWGSC and Workers Safety and Compensation Committee. Facilities that will be required include the following:

- Sleeping quarters;
- Office (contains communications area);
- Kitchen and dining area;
- Bathroom and showers;
- Laundry facilities;

- First aid facilities (may depend on the number of workers);
- Sewage lagoon or water treatment system;
- Incinerator;
- Mechanics and equipment area that would have a petroleum and lube containment area, tanks and drums;
- Water supply and pumps;
- Diesel powered generator and back-up; and,
- Emergency shelter.

A water sample was collected by Dillon from the freshwater lake (**Figures 1** and **3**) and submitted for routine potable and total metals analysis (Dillon, 2013). Results for major ion and total metals in the water sample were found to be below the CCME Guidelines for Canadian Drinking Water Quality. It should be noted; however, that additional testing would be required on an on-going basis for potable use during remediation.

7.4 Anticipated Contracting Equipment

Anticipated equipment needs for this project are:

- Excavator(s) to remove impacted soils for treatment and for use in trail and/or road improvements;
- Front end loader(s) to consolidate materials and for road improvements;
- Haul truck(s) to move materials to staging and treatment areas;
- Crusher(s) to develop on-site aggregate material;
- Waste incinerator(s) (both for the camp waste and for incineration of certain materials currently located on-site);
- Dozer (s) to be used for landfill construction and road improvements;
- Water truck to haul water to camp if required or for dust suppression;
- Waste compactor;
- Drum crusher;
- All-terrain vehicle (s) with trailers;
- Packer to ensure compaction is appropriate with the natural terrain;
- Generators (for remedial equipment); and,
- Other miscellaneous equipment determined by contractor.

7.5 Infrastructure/Roads

7.5.1 Airstrip

A more detailed discussion on the Airstrip condition is presented in the Phase III ESA. If contractors are preparing to use the airstrip at FOX-D, it is recommended that the contractor evaluate the runway condition prior to use. The contractor shall utilize the airstrip at its own risk. The airstrip must be continually evaluated by the operational pilots and staff at the FOX-D site. If and when excessive erosion and/or rutting are noted, the airstrip shall be repaired immediately as required and to the satisfaction of the operational pilots. Further assessments and the use of a Boeing Penetrometer shall be employed before larger aircraft are taken under consideration for landing on the airstrip at FOX-D.

Dillon-KGS recommend that no aircraft larger than the DHC-8 Twin Otter with tundra tires land at the airstrip at FOX-D. Other permissible choices of similar weighted aircraft include DHC-6 Twin Otter Series 300, Beech King Air 100, 200 Series, and Beech King Air 300, 300C 350, 350C all equipped with larger tires suitable for gravel runway landings.

7.5.2 Existing Roads

Due to lack of upkeep and erosion, some portions of the existing roads to be utilized during remedial activities will require repair and upgrading. The main road to be utilized on site will be the road leading from the airstrip to the main station area. Areas requiring rebuilding, regrading and significant drainage control are shown on **Figure 16** as "heavy regrading". This level of repair and rebuilding constitutes approximately 375 m (5%) of the total road length. The remainder of the road will require some patching and topping up of existing road topping (medium grading) and/or localized grading (light grading). This work can be completed using existing fill from the main station area and borrow material from the borrow source areas shown on **Figures 2** and **19**. Suitable borrow materials are generally poorly graded sands and gravels with fine contents ranging from 2% to 32%.

7.6 Borrow Source Development

Borrow sources shall be developed in accordance with the Indian and Northern Affairs Canada AMSRP. Required borrow material shall be drawn preferentially from the main station area gravel. Borrow source requirements required beyond those available amounts shall be taken from the borrow source areas as shown on **Figure 19**.

Once the borrow source requirements for the FOX-D remediation have been satisfied all borrow sources will be re-contoured to restore natural drainage and to match surrounding topography and minimize changes to the existing permafrost regime.

The sand and gravel borrow sources are estimated to contain approximately 68,000 m^3. It is anticipated that this amount is adequate for the remedial activities.

7.7 Potential Biological and/or Aeration Treatment Cell Construction

The potential biological and/or aeration treatment cell location was selected based on the required treatment cell size, distance to material to be landfilled and distance to borrow sources. The treatment cell location (shown on **Figure 18**) at the saddle requires the least amount of transportation for the majority of the soil and it is situated in an area where the probability of erosion and infiltration are minimized, has a southern exposure, and is contained within AANDC's property boundary.

The treatment cell shall be constructed in a controlled manner with minimal lifts to control compaction and settlement. Surface water run-on and run-off will be controlled through proper grading to positively shed water and to prevent ponding and seepage into the treatment unit. Consideration to the treatment cell cap angles must be designed as to not to encourage erosion of the capping material. The treatment and surrounding berm areas will be lined with a geomembrane liner to prevent the migration of nutrients and PHC-impacted surface waters.

7.8 Waste Handling Facility Construction

A Waste Handling Facility (WHF) will be required at the FOX-D site to receive and sort various waste items. The fluids handling area within the WHF shall be lined with an engineered clay/synthetic liner to prevent the migration of contaminants resulting from any accidental spills. The fluids handling area is to be bermed and the engineered liner should have some fill cover to protect the liner integrity. The waste handling facility shall have applicable safety items and PPE which include but are not limited to: extinguisher, first aid kit, eye wash station, emergency spill kit etc. Materials to be received and sorted at the WHF include but are not limited to:

- Barrels (Barrel Protocol);
  - Empty;
  - Unknown fluids;
  - POLs;
  - Cleaning, rinsate, crushing;
- Batteries;
- Compressed Gas Cylinders;
- Items painted with PCB and Lead Paint; and,
- Soils for off-site removal.

The WHF area shall be located west of the barge landing area as shown on **Figure 18**. The WHF will be surrounded by temporary road to provide access to vehicles and equipment required in the delivery sorting and transport of the site waste. Upon decommissioning of the WHF the area beneath the facility shall be sampled for confirmatory purposes.

7.9 Schedule

Assuming the project is tendered in the winter 2014, the following is a proposed schedule for the remediation of this site:

- Community meetings (Winter 2014);
- Permitting (Winter 2014 or Spring 2015);
- Bidders site meeting (Summer 2014);
- Contract tender (Summer 2014);
- Contract award (Fall 2014);
- Mobilization (Summer 2015);
- Year 1 Remedial Activities (Summer 2016);
- Year 2 Remedial Activities (Summer 2017);
- Demobilization (Summer 2017); and,
- Sea-lift Demobilization of Equipment (Summer/Fall 2017).

8 PROJECT AND LONG-TERM MONITORING

The purpose of project and long term monitoring is to confirm compliance of the remedial activities with the specified clean-up objectives and clean-up criteria. During the remedial program, quantities of all site materials should be estimated, tracked and measured. Contaminated areas that have been excavated shall be confirmed clean by field screening methods and then samples shall be taken for laboratory confirmation.

8.1 Verification and Monitoring During Remediation Activities

Verification and monitoring of construction works, environmental clean-up, verification of quantities, and quality of work will need to be carried out during the remediation works of this project (INAC 2009). Skill sets needed include residential engineering experience, hazardous materials testing and abatement, environmental health and safety monitoring, soil sampling, and geotechnical and materials testing. The following work tasks will need to be performed:

Disposal of Non-Hazardous Waste

- Ensuring removal of all hazardous materials prior to removal or demolition of buildings;
- Removal of all non-wood materials identified as non-hazardous from buildings and verification of hauling to the staging area;
- Verification of clean-up of all debris areas and hauling to the on-site staging area;
- Verification of building demolition, wood collection from buildings/debris areas and removal to burn area. Supervision and air monitoring, followed by sampling and testing of ashes, if necessary; and,
- Photo documentation and surveying of above activities where applicable.

Hazardous Materials Testing and Abatement

- Supervision and air monitoring of asbestos abatement and verification of contractor activities against applicable regulations for such work;
- Testing of liquid in drums, ASTs and equipment for TDG and disposal options as required;
- Supervision and verification of depressurization and evacuation of cylinders and fire extinguishers;
- Testing of solid suspected hazardous materials to determine appropriate disposition;
- Verification of appropriate storage of hazardous waste in staging area until shipment; and,
- Verification of shipments including waste manifests and quantities of materials off-site.

Remediation of Impacted Soil Areas

- Soil confirmatory sampling beneath and adjacent to PHC, metal, and Co-contaminated impacted soil areas to ensure complete removal of on-site sources;
- Baseline soil sampling to be completed prior to construction of temporary storage area, camp workers area, sewage lagoon, incinerator areas, fuel and lube oil storage facilities, camp area, and mechanics area;
- Verification of waste manifests for impacted soil that it transported off-site to an off-site landfill disposal facility;
- Photo documentation and surveying of all soil remediation areas, including pre-construction, and post construction/site closure activities;
- Verification of quantities taken from borrow area; and,
- Compaction monitoring following completion of remedial activities at the Site.

8.2 Post Remediation Long-term Monitoring

Long Term Monitoring will be evaluated with the Remedial Activities at FOX-D are completed.

9 LIMITATIONS

This report was prepared exclusively for the purposes, project and site location(s) outlined in the report. The report is based on information provided to, or obtained by Dillon as indicated in the report, and applies solely to site conditions existing at the time of the site investigation(s). Dillon's report represents a reasonable review of available information within an agreed work scope, schedule and budget. It is therefore possible that currently unrecognized contamination or potentially hazardous materials may exist at the site(s), and that the levels of contamination or hazardous materials may vary across the site(s). Further review and updating of the report may be required as local and site conditions, and the regulatory and planning frameworks, change over time.

This report was prepared by Dillon for the sole benefit of our Client (Public Works and Government Services Canada). The material in the report reflects Dillon's judgment in light of the information available to Dillon at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibilities of such third parties. Dillon accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

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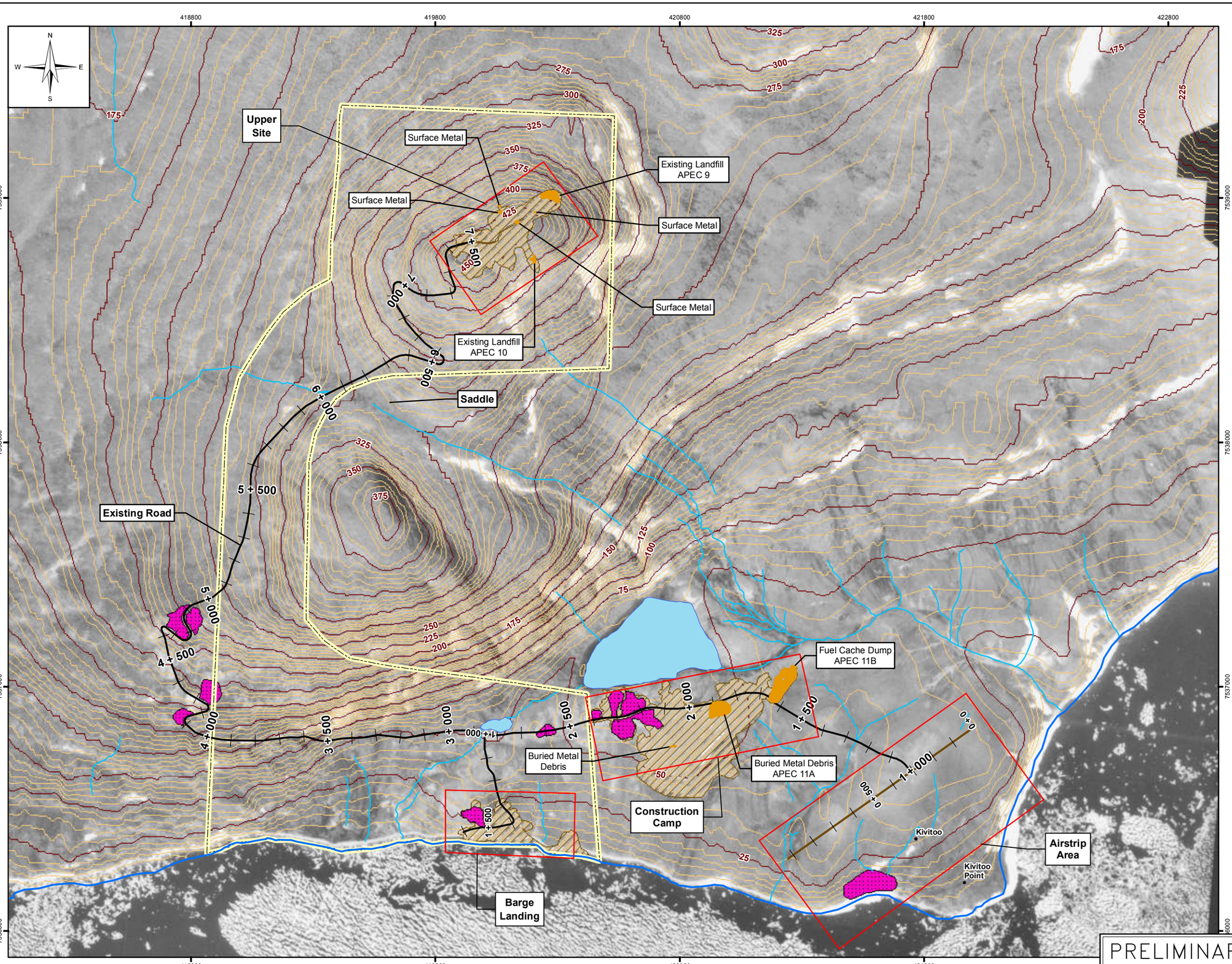
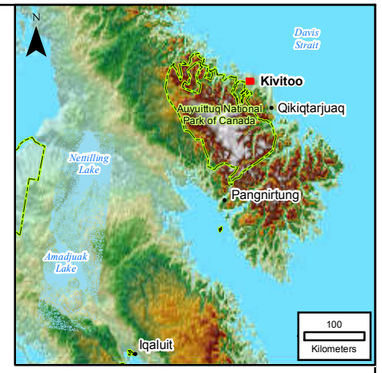
APPENDIX A

FIGURES





LEGEND:

- Drainage Pathway
- Shoreline
- 5 m Contour
- 25 m Index Contour
- Existing Road
- Airstrip
- Property Boundary
- Existing Landfills
- Freshwater Lake
- Borrow Areas
- Area of Disturbance/Worked Area

NOTES:

1. Imagery: 1:20,000 scale imagery, 1948. National Air Photo Library (NAPL).
2. Contours are supplied from NRCAN, derived from 1:60,000 stereo pair imagery.

200 0 200 400 600
Metres

SCALE: 1:15,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 20
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
0	14/03/21	ISSUED WITH FINAL RAP REPORT	AMH

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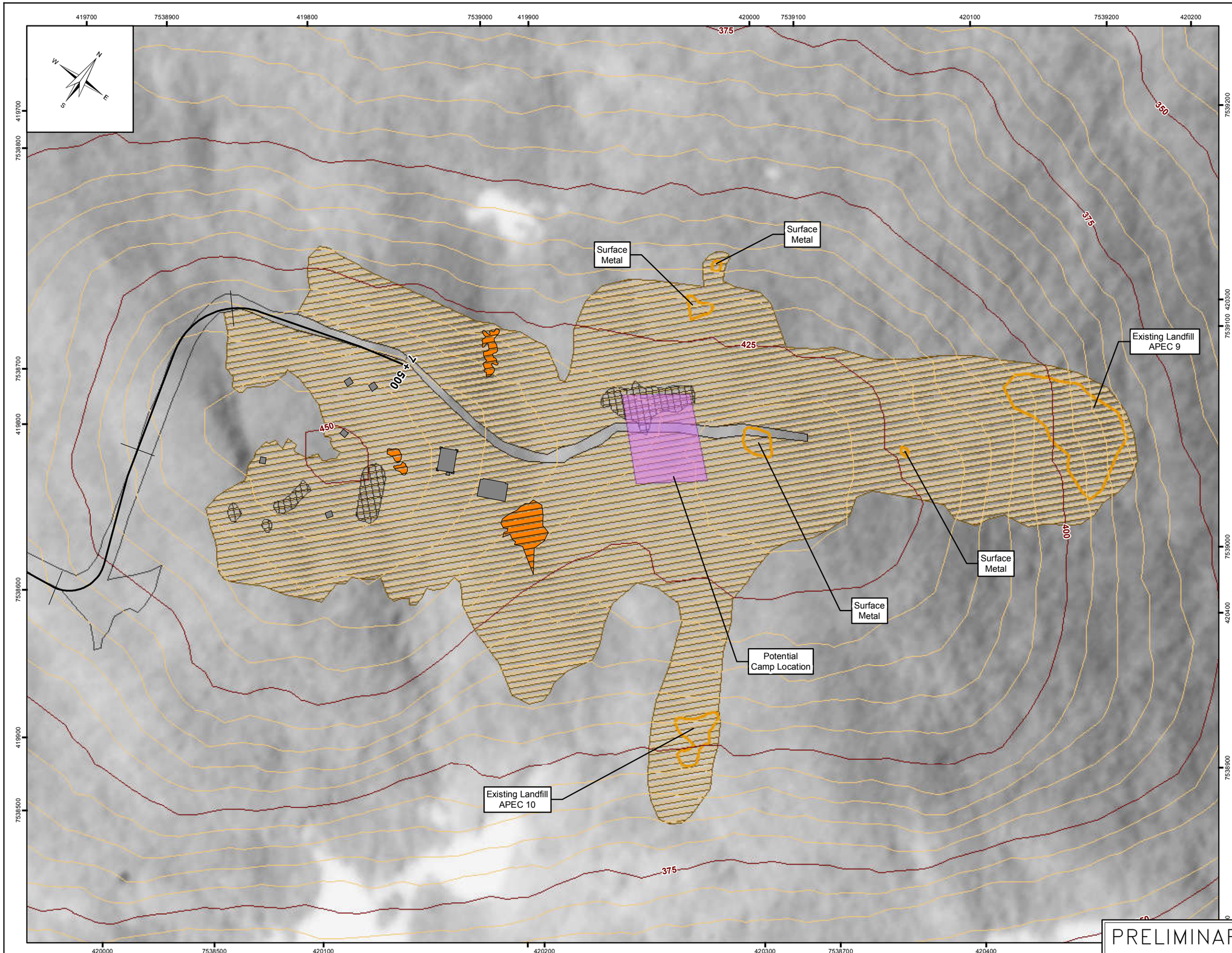
HAZARDOUS MATERIALS ASSESSMENT
SITE SURVEY & GEOTECHNICAL SERVICES
FOX D DEW LINE SITE BAFFIN ISLAND

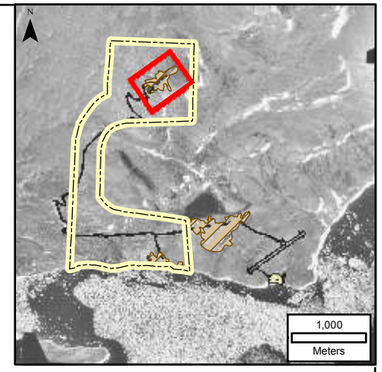
REMEDIAL ACTION PLAN REPORT
SITE PLAN

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

MARCH 2014 | FIGURE 1 | REV: 0

FileName: P:\Projects\2013\13-0163-002\Dwg\GIS\MXDs\Dillon_RAP_Report\Rev0\13-0163-002_Fig01_Rev0.mxd
11"x17" PLOT SCALE 1:1





LEGEND:

- Existing Road
- 5 m Contour
- 25 m Index Contour
- Existing Landfills
- Concrete Foundation
- Area of Staining
- Road/Airstrip
- Debris
- Area of Disturbance/Worked Area
- Potential Camp Location

NOTES:

1. Imagery: 1:20,000 scale imagery, 1948. National Air Photo Library (NAPL).
2. Contours are supplied from NRCAN, derived from 1:60,000 stereo pair imagery.

20 0 20 40 60 80
Metres

SCALE: 1:2,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 20
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
0	14/03/21	ISSUED WITH FINAL RAP REPORT	AMH

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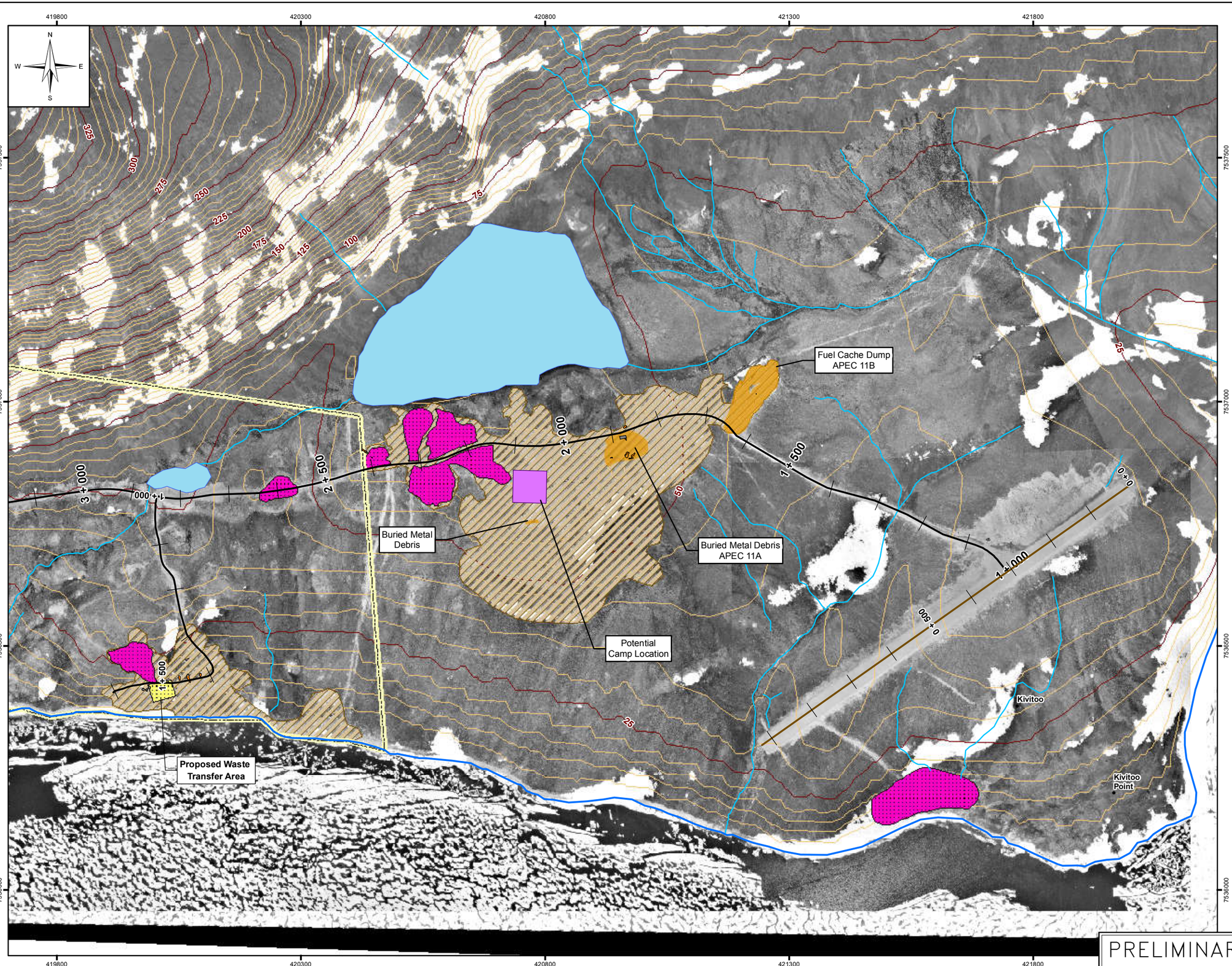
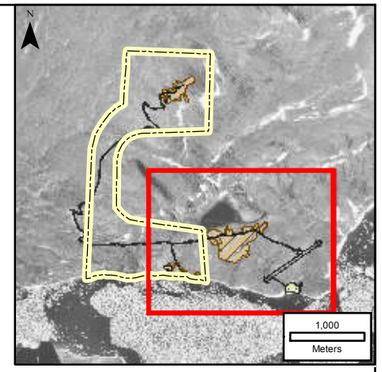
HAZARDOUS MATERIALS ASSESSMENT
SITE SURVEY & GEOTECHNICAL SERVICES
FOX D DEW LINE SITE BAFFIN ISLAND

REMEDIAL ACTION PLAN REPORT
UPPER SITE

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

MARCH 2014 | FIGURE 2 | REV: 0





LEGEND:

- Shoreline
- Drainage Pathway
- Existing Airstrip
- Existing Road
- 5 m Contour
- 25 m Index Contour
- Property Boundary
- Existing Landfill
- Freshwater Lake
- Concrete Foundation
- Borrow Areas
- Proposed Waste Transfer Area
- Area of Staining
- Area of Disturbance/Worked Area
- Potential Camp Location

NOTES:

1. Imagery: 1:20,000 scale imagery, 1948. National Air Photo Library (NAPL).
2. Contours are supplied from NRCAN, derived from 1:60,000 stereo pair imagery.

100 0 100 200 300
Metres

SCALE: 1:7,500 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 20
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
0	14/03/21	ISSUED WITH FINAL RAP REPORT	AMH

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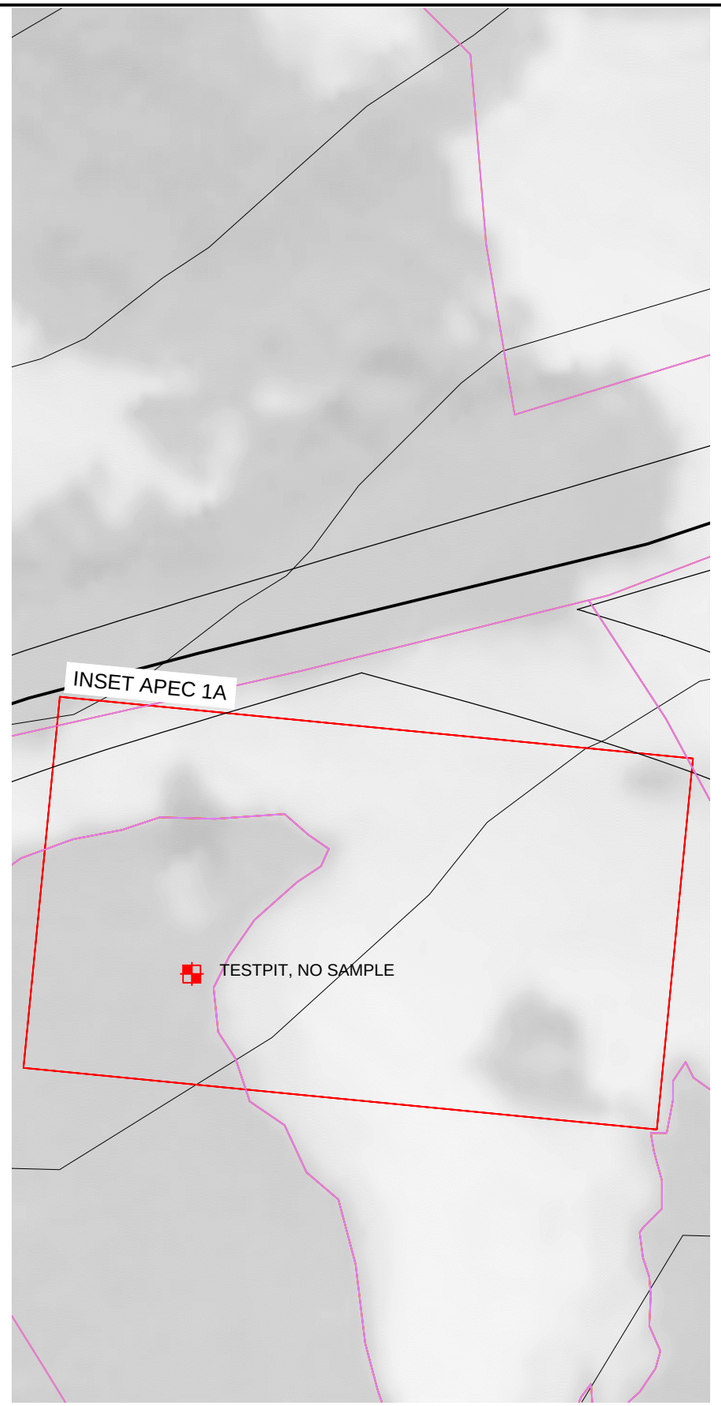
HAZARDOUS MATERIALS ASSESSMENT
SITE SURVEY & GEOTECHNICAL SERVICES
FOX D DEW LINE SITE BAFFIN ISLAND

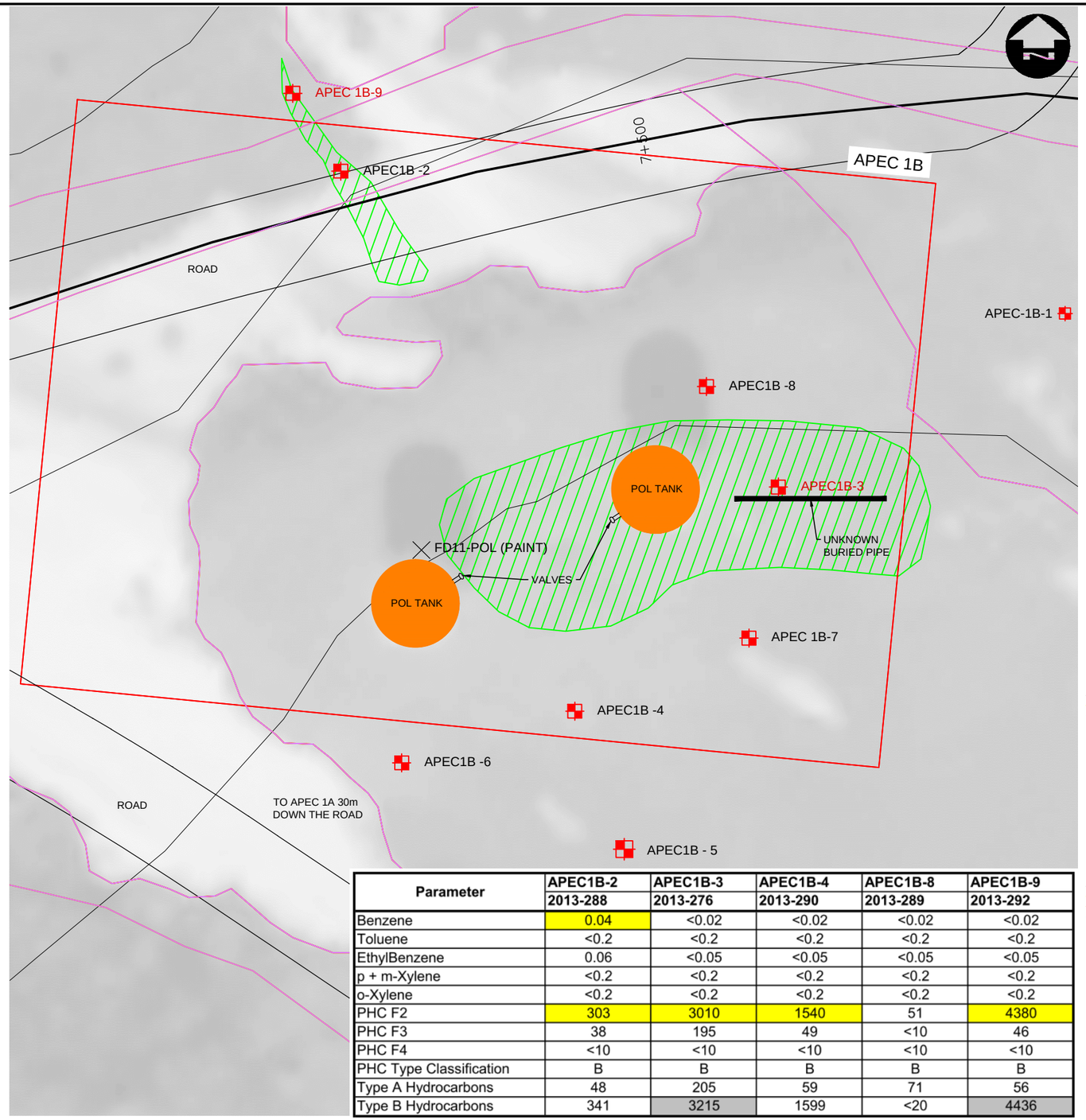
REMEDIAL ACTION PLAN REPORT
LOWER SITE

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

MARCH 2014 | FIGURE 3 | REV: 0

FileName: P:\Projects\2013\13-0163-002\Dwg\GIS\MXDs\Dillon_RAP_Report\Rev0\13-0163-002_Fig03_Rev0.mxd
11"x17" PLOT SCALE 1:1





LEGEND

- Testpit Location
- Water Sample
- Exceeds AMSRP Criteria Type A Hydrocarbons
- Exceeds AMSRP Criteria Type B Hydrocarbons
- Staining
- Debris
- APEC
- Concrete
- Crown Land
- Water
- Road
- Drainage Pathways
- Airstrip
- Geophysical Survey Area
- Disturbed Limits
- EM 31 survey Area

Parameter		AMSRP Clean-up Criteria Type B	AMSRP Clean-up Criteria Type A	CSW for PHC in Soil
PHC (ppm)	PHC F1	---	---	210
	PHC F2	---	---	150
	PHC F3	---	---	300
	PHC F4	---	---	2800
	PHC Type	---	---	---
	PHC Concentration	2500[a]	20000[b]	---

20= Denotes exceedances for AMSRP Clean-up Criteria
20= Denotes exceedances for Federal Guidelines
20= Denotes exceedances for Federal and AMSRP Criteria

a = AMSRP Clean-up Criteria, Protection of Terrestial Wildlife, Type B Hydrocarbon (sum of F1 + F3 + F4), 0 - 0.5 metres below ground surface

b = AMSRP Clean-up Criteria, Protection of Human Health, Type A Hydrocarbon (sum of F3 + F4 >70% of the total PHC concentration (F1 to F4) and (F2<F4)

Parameter	AMSRP Clean-up Criteria[1] Tier I	AMSRP Clean-up Criteria[1] Tier II	ESG Recommended Remediation Criteria (2010)	Federal CCME[2] Residential/ Parkland
Polychlorinated Biphenyls (ppm)				
Copper	---	100	109	63
Zinc	---	500	Same as AMSRP	200
Total PCB	1.0	5.0	---	1.3

20= Denotes exceedances for DCC DEW Line Clean-up Criteria
20= Denotes exceedances for CCME 2007 Residential/Parland Guidelines
20= Denotes exceedances of Site Specific criteria
20= Denotes exceedances for Federal and AMSRP Criteria
--- No Criteria

1 = Indian and Northern Affairs Canada, Abandoned Military Site Remediation Protocol, Table 4.1, DCC DEW Line Criteria for soil, March 2009.
2 = Canadian Council of Ministers of the Environment, Canada Soil Quality Guidelines, Summary Tables (Update 7.0), Sept 2007, Residential/Parland, Coarse Grained Soils.

Parameter	APEC1B-2 2013-288	APEC1B-3 2013-276	APEC1B-4 2013-290	APEC1B-8 2013-289	APEC1B-9 2013-292
Benzene	0.04	<0.02	<0.02	<0.02	<0.02
Toluene	<0.2	<0.2	<0.2	<0.2	<0.2
EthylBenzene	0.06	<0.05	<0.05	<0.05	<0.05
p + m-Xylene	<0.2	<0.2	<0.2	<0.2	<0.2
o-Xylene	<0.2	<0.2	<0.2	<0.2	<0.2
PHC F2	303	3010	1540	51	4380
PHC F3	38	195	49	<10	46
PHC F4	<10	<10	<10	<10	<10
PHC Type Classification	B	B	B	B	B
Type A Hydrocarbons	48	205	59	71	56
Type B Hydrocarbons	341	3215	1599	<20	4436

NOTES:
1. Imagery: 1:20,000 Scale Imagery, 1948. National Air Photo Library (NAPL).
2. Contours are supplies from NRCAN, derived from 1:60,000 stereo pair imagery.
3. Survey Completed by KGS Group, August 2013

FINAL

Metres
HORIZONTAL SCALE: 1:250 11" X 17"

0 5 10 15 20 25

NO.	YY/MM/DD	DESCRIPTION	BY
0	14/03/27	Completed Final	P.M.W.

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REMEDIAL ACTION PLAN,
FOX-D

MARCH 2014 | FIGURE 4 | REV. 0

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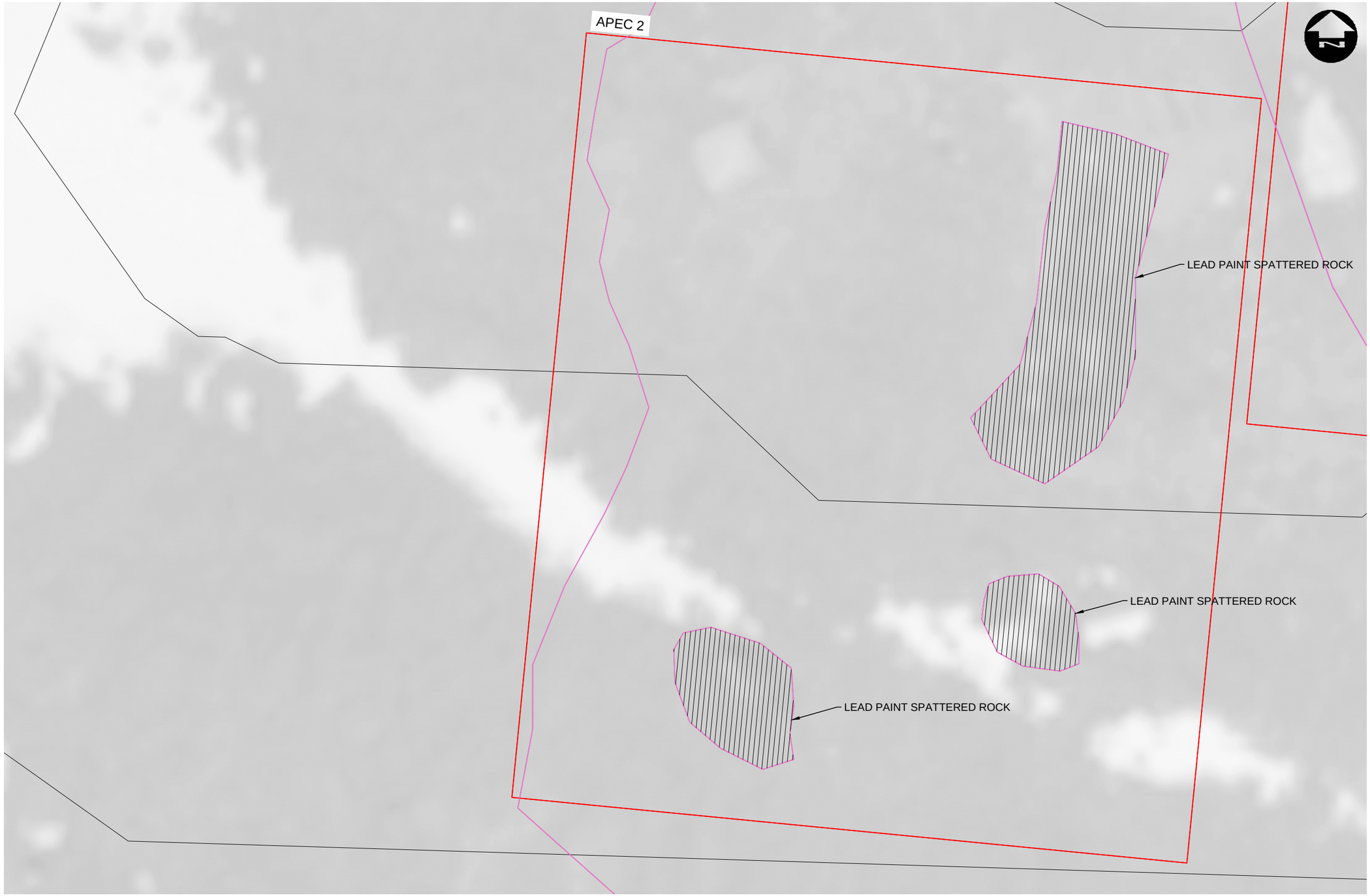

LEGEND

- Testpit Location
- Water Sample
- Exceeds AMSRP Criteria Type A Hydrocarbons
- Exceeds AMSRP Criteria Type B Hydrocarbons
- Staining
- Debris
- APEC
- Concrete
- Crown Land
- Water
- Road
- Drainage Pathways
- Airstrip
- Geophysical Survey Area
- Disturbed Limits
- EM 31 survey Area

Parameter		AMSRP Clean-up Criteria Type B	AMSRP Clean-up Criteria Type A	CSW for PHC in Soil
PHC (ppm)	PHC F1	---	---	210
	PHC F2	---	---	150
	PHC F3	---	---	300
	PHC F4	---	---	2800
	PHC Type	---	---	---
	PHC Concentration	2500 [a]	20000 [b]	---

20= Denotes exceedances for AMSRP Clean-up Criteria
20= Denotes exceedances for Federal Guidelines
20= Denotes exceedances for Federal and AMSRP Criteria

a = AMSRP Clean-up Criteria, Protection of Terrestial Wildlife, Type B Hydrocarbon (sum of F1 + F3 + F4), 0 - 0.5 metres below ground surface

b = AMSRP Clean-up Criteria, Protection of Human Health, Type A Hydrocarbon (sum of F3 + F4 >70% of the total PHC concentration (F1 to F4) and (F2<F4)

Parameter	AMSRP Clean-up Criteria[1] Tier I	AMSRP Clean-up Criteria[1] Tier II	ESG Recommended Remediation Criteria (2010)	Federal CCME[2] Residential/ Parkland
Polychlorinated Biphenyls (ppm)				
Copper	---	100	109	63
Zinc	---	500	Same as AMSRP	200
Total PCB	1.0	5.0	---	1.3

20= Denotes exceedances for DCC DEW Line Clean-up Criteria
20= Denotes exceedances for CCME 2007 Residential/Parland Guidelines
20= Denotes exceedances of Site Specific criteria
20= Denotes exceedances for Federal and AMSRP Criteria
--- No Criteria

1 = Indian and Northern Affairs Canada, Abandoned Military Site Remediation Protocol, Table 4.1, DCC DEW Line Criteria for soil, March 2009.

2 = Canadian Council of Ministers of the Environment, Canada Soil Quality Guidelines, Summary Tables (Update 7.0), Sept 2007, Residential/Parland, Coarse Grained Soils.

NO.	YY/MM/DD	DESCRIPTION	BY
0	14/03/27	Completed Final	P.M.W.

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DILLON CONSULTING

REMEDIAL ACTION PLAN,
FOX-D

APEC 2 - ANTENNA

MARCH 2014 | FIGURE 5 | REV: 0

FINAL

Metres

HORIZONTAL SCALE: 1:250 11" X 17"

0 5 10 15 20 25

NOTES:
1. Imagery: 1:20,000 Scale Imagery, 1948. National Air Photo Library (NAPL).
2. Contours are supplies from NRCAN, derived from 1:60,000 stereo pair imagery.
3. Survey Completed by KGS Group, August 2013

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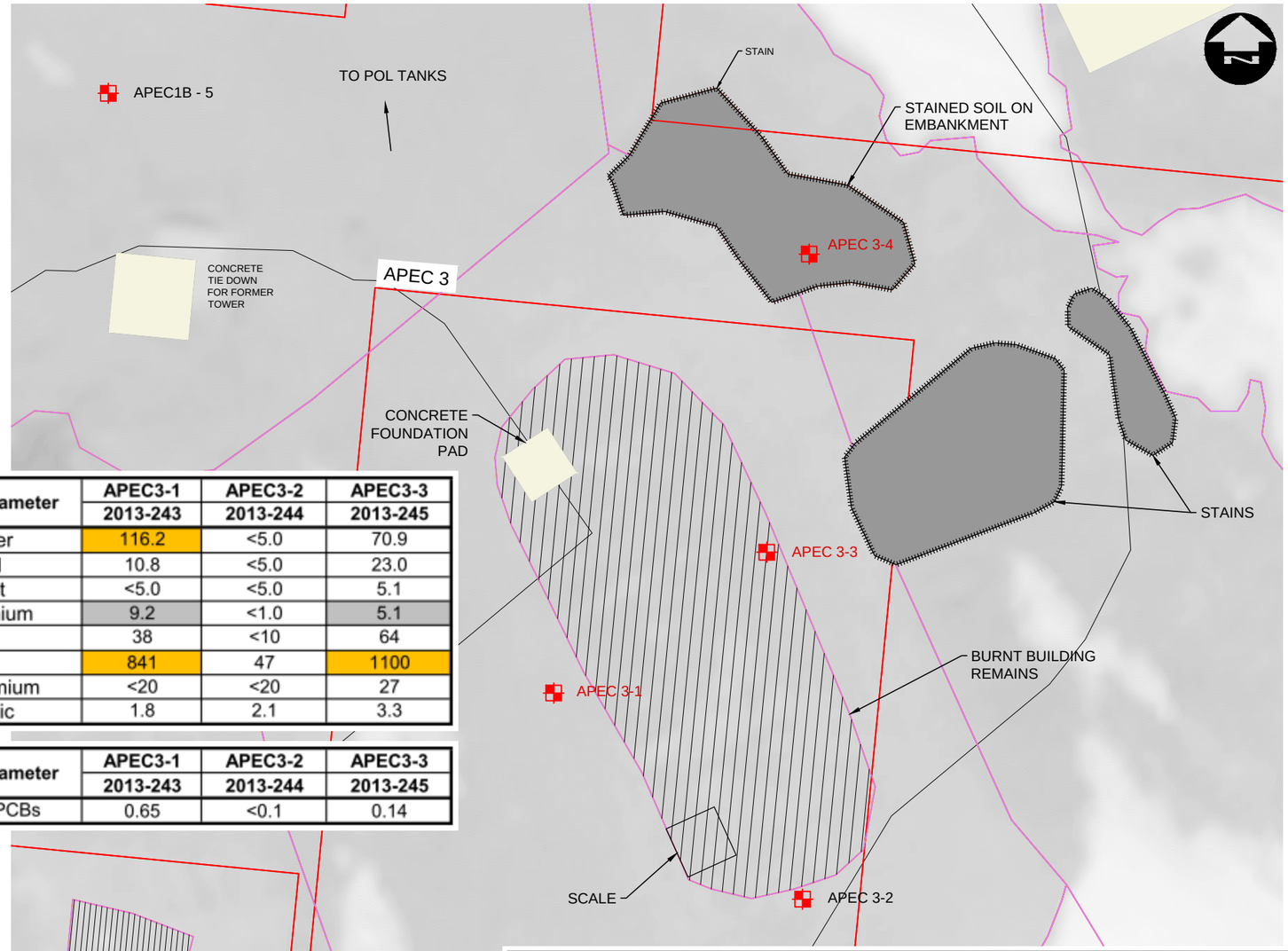

Parameter	APEC3-1	APEC3-2	APEC3-3
	2013-243	2013-244	2013-245
Copper	116.2	<5.0	70.9
Nickel	10.8	<5.0	23.0
Cobalt	<5.0	<5.0	5.1
Cadmium	9.2	<1.0	5.1
Lead	38	<10	64
Zinc	841	47	1100
Chromium	<20	<20	27
Arsenic	1.8	2.1	3.3

Parameter	APEC3-1	APEC3-2	APEC3-3
	2013-243	2013-244	2013-245
Total PCBs	0.65	<0.1	0.14

Parameter	APEC3-1	APEC3-2	APEC3-2	APEC3-3	APEC3-3D	APEC3-4
	2013-321	2013-280	2013-281	2013-279	2013-322	2013-328
Benzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Toluene	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
EthylBenzene	<0.05	0.10	<0.05	0.09	<0.05	<0.05
p + m-Xylene	<0.2	<0.2	<0.2	0.06	<0.2	<0.2
o-Xylene	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
PHC F2	<10	<10	262	<10	<10	851
PHC F3	<10	<10	248	<10	<10	14600
PHC F4	<10	<10	<10	<10	<10	3620
PHC TYPE	N/A	N/A	B	N/A	N/A	A
Type A Hydrocarbons	<20	<20	258	<20	<20	18220
Type B Hydrocarbons	<30	<30	520	<30	<30	15461

FINAL

Metres

HORIZONTAL SCALE: 1:300 11" X 17"

0 6 12 18 24 30

NOTES:
1. Imagery: 1:20,000 Scale Imagery, 1948. National Air Photo Library (NAPL).
2. Contours are supplies from NRCAN, derived from 1:60,000 stereo pair imagery.
3. Survey Completed by KGS Group, August 2013

LEGEND

- Testpit Location
- Water Sample
- Exceeds AMSRP Criteria Type A Hydrocarbons
- Exceeds AMSRP Criteria Type B Hydrocarbons
- Staining
- Debris
- APEC
- Concrete
- Crown Land
- Water
- Road
- Drainage Pathways
- Airstrip
- Geophysical Survey Area
- Disturbed Limits
- EM 31 survey Area

	Parameter	AMSRP Clean-up Criteria Type B	AMSRP Clean-up Criteria Type A	CSW for PHC in Soil
PHC (ppm)	PHC F1	---	---	210
	PHC F2	---	---	150
	PHC F3	---	---	300
	PHC F4	---	---	2800
	PHC Type	---	---	---
	PHC Concentration	2500[b]	20000[b]	---

20= Denotes exceedances for AMSRP Clean-up Criteria
20= Denotes exceedances for Federal Guidelines
20= Denotes exceedances for Federal and AMSRP Criteria

a = AMSRP Clean-up Criteria, Protection of Terrestial Wildlife, Type B Hydrocarbon (sum of F1 + F3 + F4), 0 - 0.5 metres below ground surface

b = AMSRP Clean-up Criteria, Protection of Human Health, Type A Hydrocarbon (sum of F3 + F4 >70% of the total PHC concentration (F1 to F4) and (F2<F4)

Parameter	AMSRP Clean-up Criteria[1] Tier I	AMSRP Clean-up Criteria[1] Tier II	ESG Recommended Remediation Criteria (2010)	Federal CCME[2] Residential/ Parkland
Polychlorinated Biphenyls (ppm)				
Copper	---	100	109	63
Zinc	---	500	Same as AMSRP	200
Total PCB	1.0	5.0	---	1.3

20= Denotes exceedances for DCC DEW Line Clean-up Criteria
20= Denotes exceedances for CCME 2007 Residential/Parland Guidelines
20= Denotes exceedances of Site Specific criteria
20= Denotes exceedances for Federal and AMSRP Criteria
--- No Criteria

1 = Indian and Northern Affairs Canada, Abandoned Military Site Remediation Protocol, Table 4.1, DCC DEW Line Criteria for soil, March 2009.
2 = Canadian Council of Ministers of the Environment, Canada Soil Quality Guidelines, Summary Tables (Update 7.0), Sept 2007, Residential/Parland, Coarse Grained Soils.

NO.	YY/MM/DD	DESCRIPTION	BY
0	14/03/27	Completed Final	P.M.W.

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KGS GROUP CONSULTING ENGINEERS

DILLON CONSULTING

REMEDIAL ACTION PLAN, FOX-D

APEC 3 - BURNT BUILDING REMAINS

MARCH 2014 | FIGURE 6 | REV. 0

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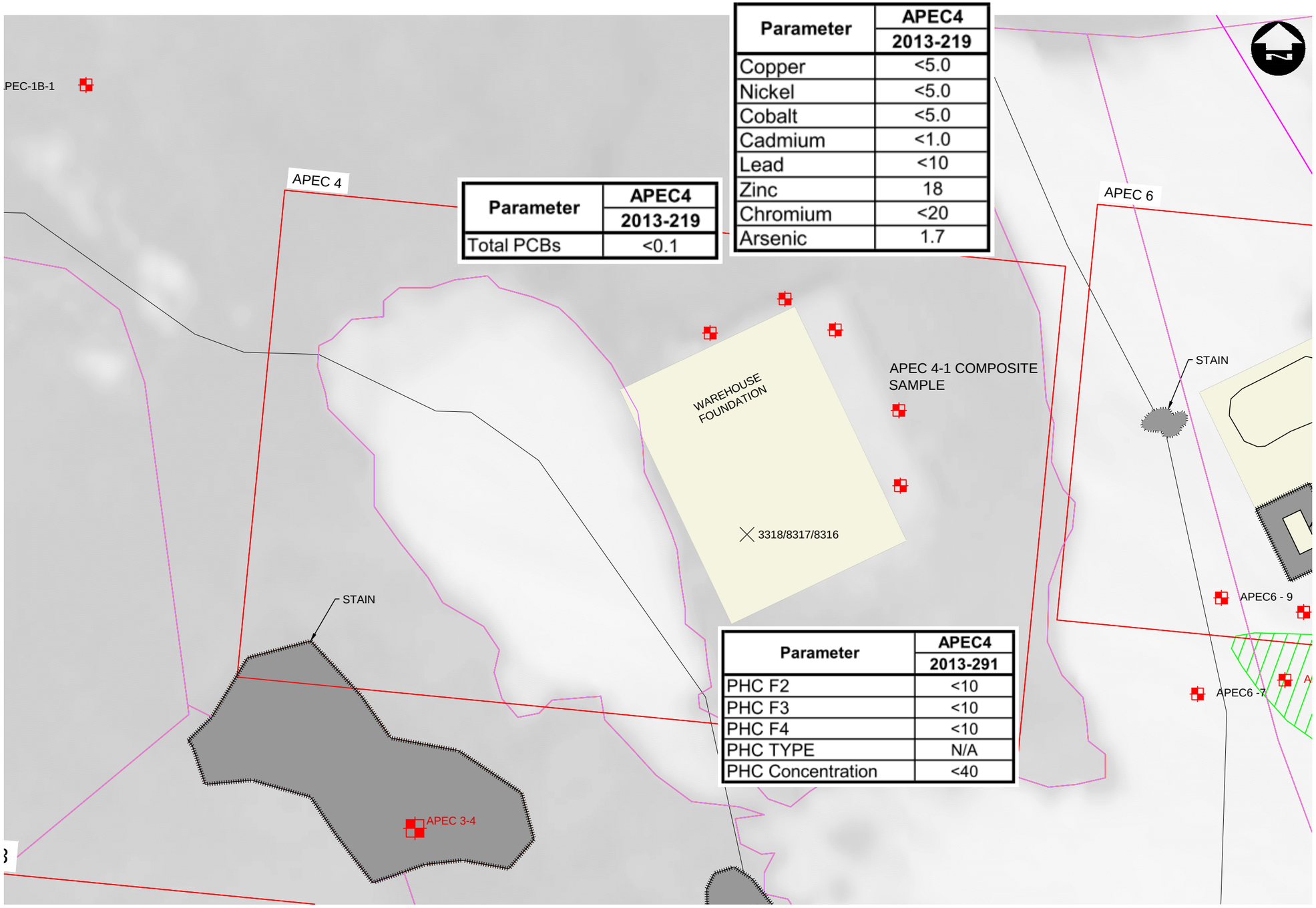

Parameter	APEC4 2013-219
Total PCBs	<0.1

Parameter	APEC4 2013-219
Copper	<5.0
Nickel	<5.0
Cobalt	<5.0
Cadmium	<1.0
Lead	<10
Zinc	18
Chromium	<20
Arsenic	1.7

Parameter	APEC4 2013-291
PHC F2	<10
PHC F3	<10
PHC F4	<10
PHC TYPE	N/A
PHC Concentration	<40

LEGEND

- Testpit Location
- Water Sample
- Exceeds AMSRP Criteria Type A Hydrocarbons
- Exceeds AMSRP Criteria Type B Hydrocarbons
- Staining
- Debris
- APEC
- Concrete
- Crown Land
- Water
- Road
- Drainage Pathways
- Airstrip
- Geophysical Survey Area
- Disturbed Limits
- EM 31 survey Area

	Parameter	AMSRP Clean-up Criteria Type B	AMSRP Clean-up Criteria Type A	CSW for PHC in Soil
PHC (ppm)	PHC F1	---	---	210
	PHC F2	---	---	150
	PHC F3	---	---	300
	PHC F4	---	---	2800
	PHC Type	---	---	---
	PHC Concentration	2500[a]	20000[b]	---

20= Denotes exceedances for AMSRP Clean-up Criteria
20= Denotes exceedances for Federal Guidelines
20= Denotes exceedances for Federal and AMSRP Criteria

a = AMSRP Clean-up Criteria, Protection of Terrestial Wildlife, Type B Hydrocarbon (sum of F1 + F3 + F4), 0 - 0.5 metres below ground surface

b = AMSRP Clean-up Criteria, Protection of Human Health, Type A Hydrocarbon (sum of F3 + F4 >70% of the total PHC concentration (F1 to F4) and (F2<F4)

Parameter	AMSRP Clean-up Criteria[1] Tier I	AMSRP Clean-up Criteria[1] Tier II	ESG Recommended Remediation Criteria (2010)	Federal CCME[2] Residential/ Parkland
Polychlorinated Biphenyls (ppm)				
Copper	---	100	109	63
Zinc	---	500	Same as AMSRP	200
Total PCB	1.0	5.0	---	1.3

20= Denotes exceedances for DCC DEW Line Clean-up Criteria
20= Denotes exceedances for CCME 2007 Residential/Parland Guidelines
20= Denotes exceedances of Site Specific criteria
20= Denotes exceedances for Federal and AMSRP Criteria
--- No Criteria

1 = Indian and Northern Affairs Canada, Abandoned Military Site Remediation Protocol, Table 4.1, DCC DEW Line Criteria for soil, March 2009.
2 = Canadian Council of Ministers of the Environment, Canada Soil Quality Guidelines, Summary Tables (Update 7.0), Sept 2007, Residential/Parland, Coarse Grained Soils.

NO.	YY/MM/DD	DESCRIPTION	BY
0	14/03/27	Completed Final	P.M.W.

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REMEDIAL ACTION PLAN,
FOX-D

APEC 4 - WAREHOUSE FOUNDATION

MARCH 2014 | FIGURE 7 | REV. 0

FINAL

Metres

HORIZONTAL SCALE: 1:200 11" X 17"

0 4 8 12 16 20

NOTES:
1. Imagery: 1:20,000 Scale Imagery, 1948. National Air Photo Library (NAPL).
2. Contours are supplies from NRCAN, derived from 1:60,000 stereo pair imagery.
3. Survey Completed by KGS Group, August 2013

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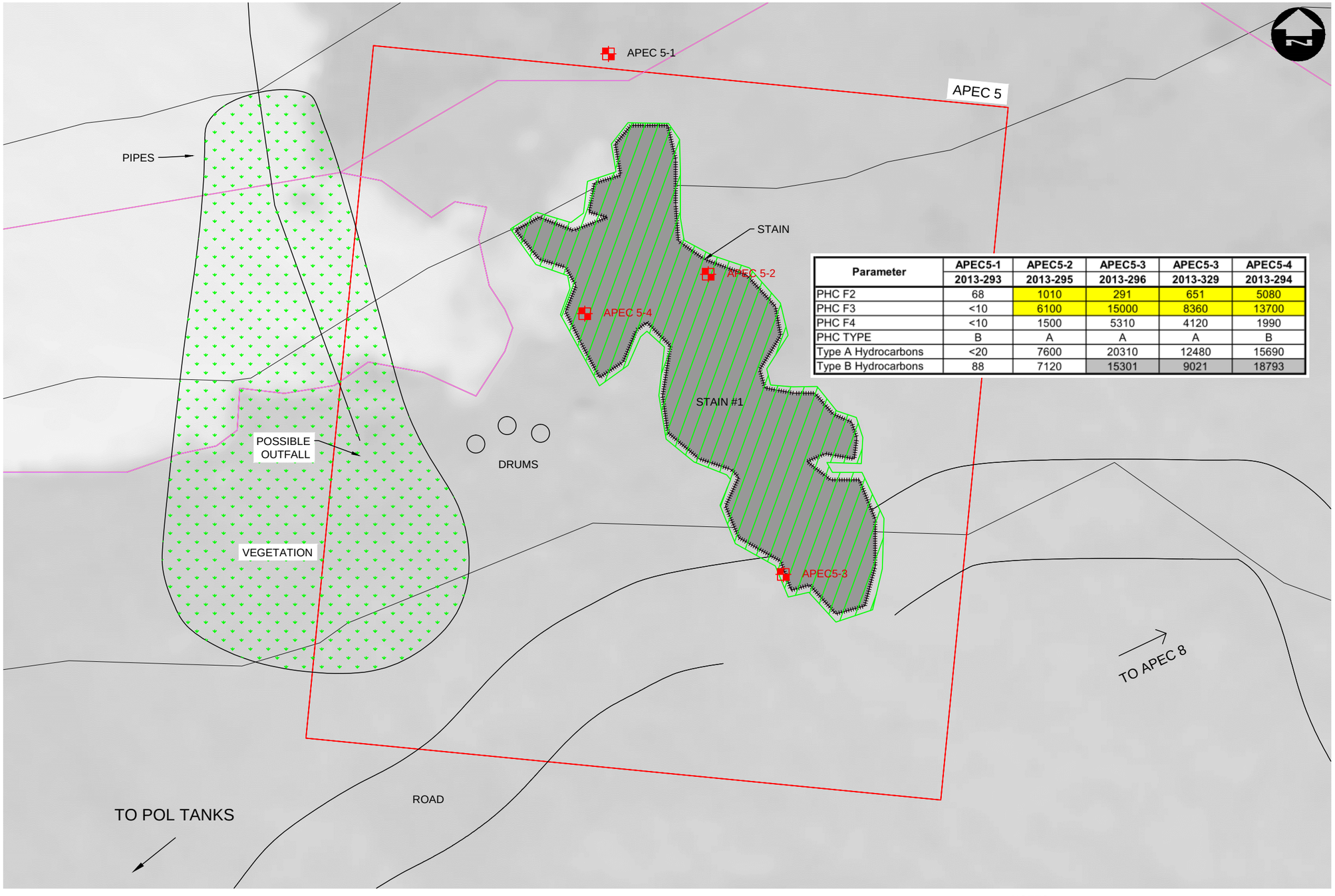

Parameter	APEC5-1 2013-293	APEC5-2 2013-295	APEC5-3 2013-296	APEC5-3 2013-329	APEC5-4 2013-294
PHC F2	68	1010	291	651	5080
PHC F3	<10	6100	15000	8360	13700
PHC F4	<10	1500	5310	4120	1990
PHC TYPE	B	A	A	A	B
Type A Hydrocarbons	<20	7600	20310	12480	15690
Type B Hydrocarbons	88	7120	15301	9021	18793

LEGEND

- Testpit Location
- Water Sample
- Exceeds AMSRP Criteria Type A Hydrocarbons
- Exceeds AMSRP Criteria Type B Hydrocarbons
- Staining
- Debris
- APEC
- Concrete
- Crown Land
- Water
- Road
- Drainage Pathways
- Airstrip
- Geophysical Survey Area
- Disturbed Limits
- EM 31 survey Area

	Parameter	AMSRP Clean-up Criteria Type B	AMSRP Clean-up Criteria Type A	CSW for PHC in Soil
PHC (ppm)	PHC F1	---	---	210
	PHC F2	---	---	150
	PHC F3	---	---	300
	PHC F4	---	---	2800
	PHC Type	---	---	---
	PHC Concentration	2500[a]	20000[b]	---

20= Denotes exceedances for AMSRP Clean-up Criteria
20= Denotes exceedances for Federal Guidelines
20= Denotes exceedances for Federal and AMSRP Criteria

a = AMSRP Clean-up Criteria, Protection of Terrestial Wildlife, Type B Hydrocarbon (sum of F1 + F3 + F4), 0 - 0.5 metres below ground surface

b = AMSRP Clean-up Criteria, Protection of Human Health, Type A Hydrocarbon (sum of F3 + F4 >70% of the total PHC concentration (F1 to F4) and (F2<F4)

Parameter	AMSRP Clean-up Criteria[1] Tier I	AMSRP Clean-up Criteria[1] Tier II	ESG Recommended Remediation Criteria (2010)	Federal CCME[2] Residential/ Parkland
Polychlorinated Biphenenyls (ppm)				
Copper	---	100	109	63
Zinc	---	500	Same as AMSRP	200
Total PCB	1.0	5.0	---	1.3

20= Denotes exceedances for DCC DEW Line Clean-up Criteria
20= Denotes exceedances for CCME 2007 Residential/Parland Guidelines
20= Denotes exceedances of Site Specific criteria
20= Denotes exceedances for Federal and AMSRP Criteria
--- No Criteria

1 = Indian and Northern Affairs Canada, Abandoned Military Site Remediation Protocol, Table 4.1, DCC DEW Line Criteria for soil, March 2009.

2 = Canadian Council of Ministers of the Environment, Canada Soil Quality Guidelines, Summary Tables (Update 7.0), Sept 2007, Residential/Parland, Coarse Grained Soils.

NO	YY/MM/DD	DESCRIPTION	BY
0	14/03/27	Completed Final	P.M.W.

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REMEDIAL ACTION PLAN,
FOX-D

APEC 5 - STAIN #1

MARCH 2014 | FIGURE 8 | REV. 0

FINAL

Metres

HORIZONTAL SCALE: 1:200 11" X 17"

0 4 8 12 16 20

NOTES:
1. Imagery: 1:20,000 Scale Imagery, 1948. National Air Photo Library (NAPL).
2. Contours are supplies from NRCAN, derived from 1:60,000 stereo pair imagery.
3. Survey Completed by KGS Group, August 2013

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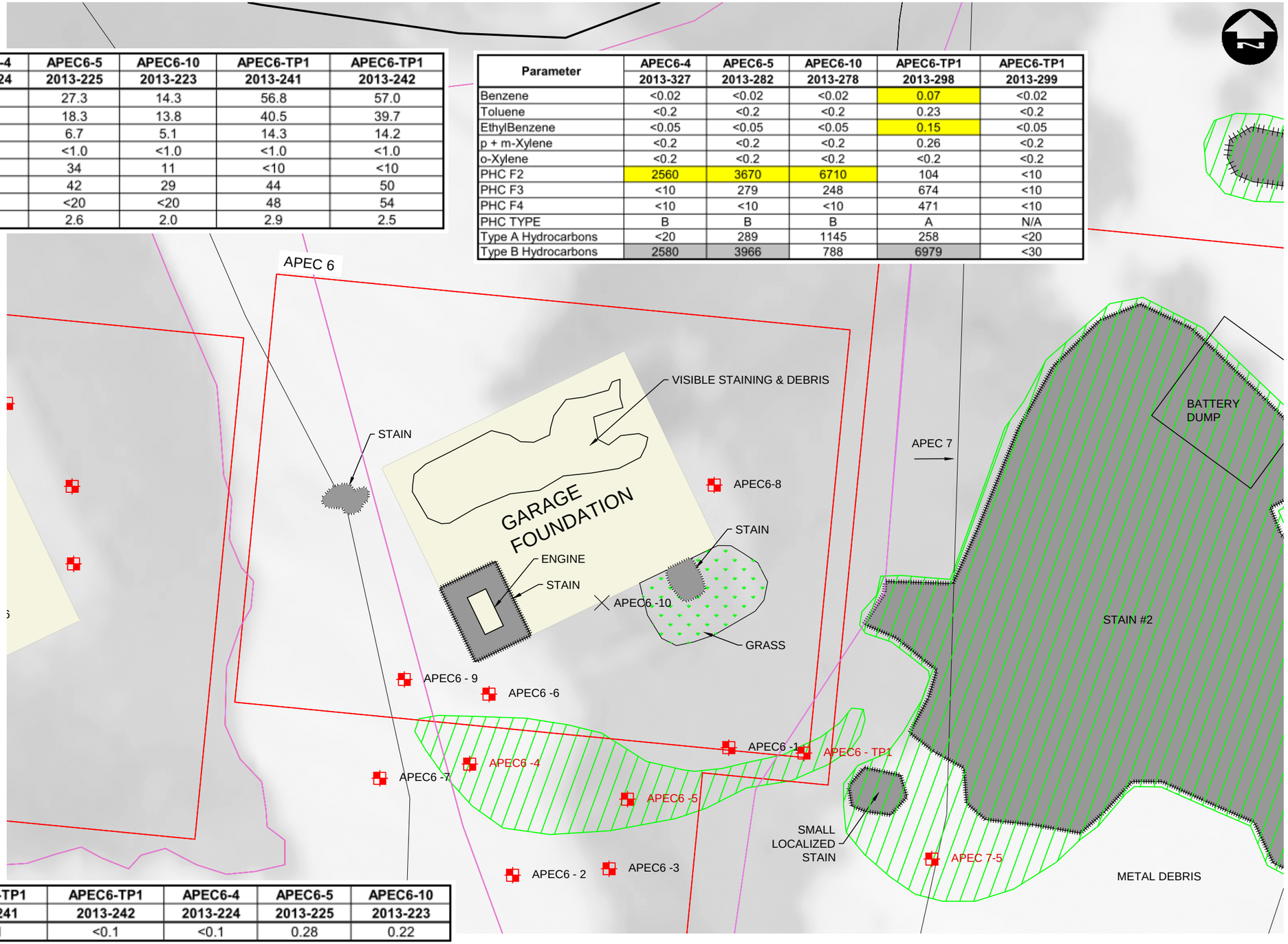
Parameter	APEC6-4 2013-224	APEC6-5 2013-225	APEC6-10 2013-223	APEC6-TP1 2013-241	APEC6-TP1 2013-242
Copper	5.7	27.3	14.3	56.8	57.0
Nickel	<5.0	18.3	13.8	40.5	39.7
Cobalt	<5.0	6.7	5.1	14.3	14.2
Cadmium	<1.0	<1.0	<1.0	<1.0	<1.0
Lead	<10	34	11	<10	<10
Zinc	19	42	29	44	50
Chromium	<20	<20	<20	48	54
Arsenic	1.8	2.6	2.0	2.9	2.5

Parameter	APEC6-4 2013-327	APEC6-5 2013-282	APEC6-10 2013-278	APEC6-TP1 2013-298	APEC6-TP1 2013-299
Benzene	<0.02	<0.02	<0.02	0.07	<0.02
Toluene	<0.2	<0.2	<0.2	0.23	<0.2
EthylBenzene	<0.05	<0.05	<0.05	0.15	<0.05
p + m-Xylene	<0.2	<0.2	<0.2	0.26	<0.2
o-Xylene	<0.2	<0.2	<0.2	<0.2	<0.2
PHC F2	2560	3670	6710	104	<10
PHC F3	<10	279	248	674	<10
PHC F4	<10	<10	<10	471	<10
PHC TYPE	B	B	B	A	N/A
Type A Hydrocarbons	<20	289	1145	258	<20
Type B Hydrocarbons	2580	3966	788	6979	<30



Parameter	APEC6-TP1 2013-241	APEC6-TP1 2013-242	APEC6-4 2013-224	APEC6-5 2013-225	APEC6-10 2013-223
Total PCBs	<0.1	<0.1	<0.1	0.28	0.22

LEGEND

- Testpit Location
- Water Sample
- Exceeds AMSRP Criteria Type A Hydrocarbons
- Exceeds AMSRP Criteria Type B Hydrocarbons
- Staining
- Debris
- APEC
- Concrete
- Crown Land
- Water
- Road
- Drainage Pathways
- Airstrip
- Geophysical Survey Area
- Disturbed Limits
- EM 31 survey Area

Parameter		AMSRP Clean-up Criteria Type B	AMSRP Clean-up Criteria Type A	CSW for PHC in Soil
PHC (ppm)	PHC F1	---	---	210
	PHC F2	---	---	150
	PHC F3	---	---	300
	PHC F4	---	---	2800
	PHC Type	---	---	---
	PHC Concentration	2500[a]	20000[b]	---

20= Denotes exceedances for AMSRP Clean-up Criteria
20= Denotes exceedances for Federal Guidelines
20= Denotes exceedances for Federal and AMSRP Criteria

a = AMSRP Clean-up Criteria, Protection of Terrestial Wildlife, Type B Hydrocarbon (sum of F1 + F3 + F4), 0 - 0.5 metres below ground surface

b = AMSRP Clean-up Criteria, Protection of Human Health, Type A Hydrocarbon (sum of F3 + F4 >70% of the total PHC concentration (F1 to F4) and (F2<F4)

Parameter	AMSRP Clean-up Criteria[1] Tier I	AMSRP Clean-up Criteria[1] Tier II	ESG Recommended Remediation Criteria (2010)	Federal CCME[2] Residential/ Parkland
Polychlorinated Biphenenyls (ppm)				
Copper	---	100	109	63
Zinc	---	500	Same as AMSRP	200
Total PCB	1.0	5.0	---	1.3

20= Denotes exceedances for DCC DEW Line Clean-up Criteria
20= Denotes exceedances for CCME 2007 Residential/Parland Guidelines
20= Denotes exceedances of Site Specific criteria
20= Denotes exceedances for Federal and AMSRP Criteria
--- No Criteria

1 = Indian and Northern Affairs Canada, Abandoned Military Site Remediation Protocol, Table 4.1, DCC DEW Line Criteria for soil, March 2009.
2 = Canadian Council of Ministers of the Environment, Canada Soil Quality Guidelines, Summary Tables (Update 7.0), Sept 2007, Residential/Parland, Coarse Grained Soils.

NO	YY/MM/DD	DESCRIPTION	BY
0	14/03/27	Completed Final	P.M.W.

REVISIONS / ISSUE

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REMEDIAL ACTION PLAN,
FOX-D

APEC 6 - FORMER GARAGE

MARCH 2014 | FIGURE 9 | REV. 0

FINAL

Metres

HORIZONTAL SCALE: 1:200 11" X 17"

0 4 8 12 16 20

NOTES:
1. Imagery: 1:20,000 Scale Imagery, 1948. National Air Photo Library (NAPL).
2. Contours are supplies from NRCAN, derived from 1:60,000 stereo pair imagery.
3. Survey Completed by KGS Group, August 2013

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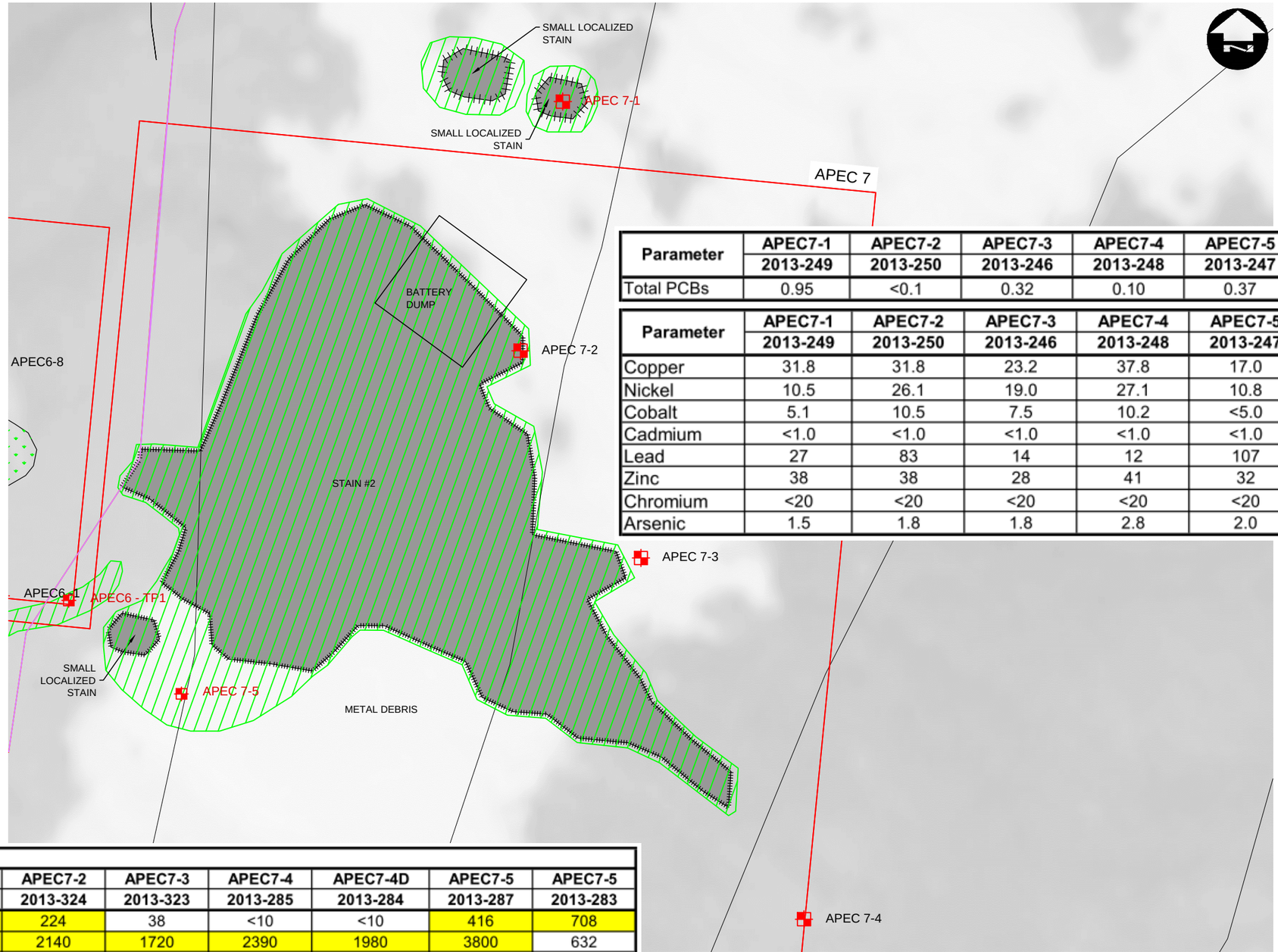

Parameter	APEC7-1	APEC7-2	APEC7-3	APEC7-4	APEC7-5
	2013-249	2013-250	2013-246	2013-248	2013-247
Total PCBs	0.95	<0.1	0.32	0.10	0.37

Parameter	APEC7-1	APEC7-2	APEC7-3	APEC7-4	APEC7-5
	2013-249	2013-250	2013-246	2013-248	2013-247
Copper	31.8	31.8	23.2	37.8	17.0
Nickel	10.5	26.1	19.0	27.1	10.8
Cobalt	5.1	10.5	7.5	10.2	<5.0
Cadmium	<1.0	<1.0	<1.0	<1.0	<1.0
Lead	27	83	14	12	107
Zinc	38	38	28	41	32
Chromium	<20	<20	<20	<20	<20
Arsenic	1.5	1.8	1.8	2.8	2.0

Parameter	APEC7-1	APEC7-2	APEC7-3	APEC7-4	APEC7-4D	APEC7-5	APEC7-5
	2013-286	2013-324	2013-323	2013-285	2013-284	2013-287	2013-283
PHC F2	836	224	38	<10	<10	416	708
PHC F3	7200	2140	1720	2390	1980	3800	632
PHC F4	1440	116	<10	887	680	1530	<10
PHC TYPE	A	B	B	A	A	A	B
Type A Hydrocarbons	8640	2256	1730	3277	2660	5330	642
Type B Hydrocarbons	8046	2374	1768	2410	2000	4226	1350

FINAL

Metres

HORIZONTAL SCALE: 1:250 11" X 17"

0 5 10 15 20 25

NOTES:
1. Imagery: 1:20,000 Scale Imagery, 1948. National Air Photo Library (NAPL).
2. Contours are supplies from NRCAN, derived from 1:60,000 stereo pair imagery.
3. Survey Completed by KGS Group, August 2013

LEGEND

- Testpit Location
- Water Sample
- Exceeds AMSRP Criteria Type A Hydrocarbons
- Exceeds AMSRP Criteria Type B Hydrocarbons
- Staining
- Debris
- APEC
- Concrete
- Crown Land
- Water
- Road
- Drainage Pathways
- Airstrip
- Geophysical Survey Area
- Disturbed Limits
- EM 31 survey Area

	Parameter	AMSRP Clean-up Criteria Type B	AMSRP Clean-up Criteria Type A	CSW for PHC in Soil
PHC (ppm)	PHC F1	---	---	210
	PHC F2	---	---	150
	PHC F3	---	---	300
	PHC F4	---	---	2800
	PHC Type	---	---	---
	PHC Concentration	2500[a]	20000[b]	---

20= Denotes exceedances for AMSRP Clean-up Criteria
20= Denotes exceedances for Federal Guidelines
20= Denotes exceedances for Federal and AMSRP Criteria

a = AMSRP Clean-up Criteria, Protection of Terrestial Wildlife, Type B Hydrocarbon (sum of F1 + F3 + F4), 0 - 0.5 metres below ground surface

b = AMSRP Clean-up Criteria, Protection of Human Health, Type A Hydrocarbon (sum of F3 + F4 >70% of the total PHC concentration (F1 to F4) and (F2<F4)

Parameter	AMSRP Clean-up Criteria[1] Tier I	AMSRP Clean-up Criteria[1] Tier II	ESG Recommended Remediation Criteria (2010)	Federal CCME[2] Residential/ Parkland
Polychlorinated Bipherenyls (ppm)				
Copper	---	100	109	63
Zinc	---	500	Same as AMSRP	200
Total PCB	1.0	5.0	---	1.3

20= Denotes exceedances for DCC DEW Line Clean-up Criteria
20= Denotes exceedances for CCME 2007 Residential/Parland Guidelines
20= Denotes exceedances of Site Specific criteria
20= Denotes exceedances for Federal and AMSRP Criteria
--- No Criteria

1 = Indian and Northern Affairs Canada, Abandoned Military Site Remediation Protocol, Table 4.1, DCC DEW Line Criteria for soil, March 2009.
2 = Canadian Council of Ministers of the Environment, Canada Soil Quality Guidelines, Summary Tables (Update 7.0), Sept 2007, Residential/Parland, Coarse Grained Soils.

NO	YY/MM/DD	DESCRIPTION	BY
0	14/03/27	Completed Final	P.M.W.

REVISIONS / ISSUE

KGS GROUP CONSULTING ENGINEERS

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REMEDIAL ACTION PLAN,
FOX-D

APEC 7 - STAIN #2

MARCH 2014 | FIGURE 10 | REV. 0

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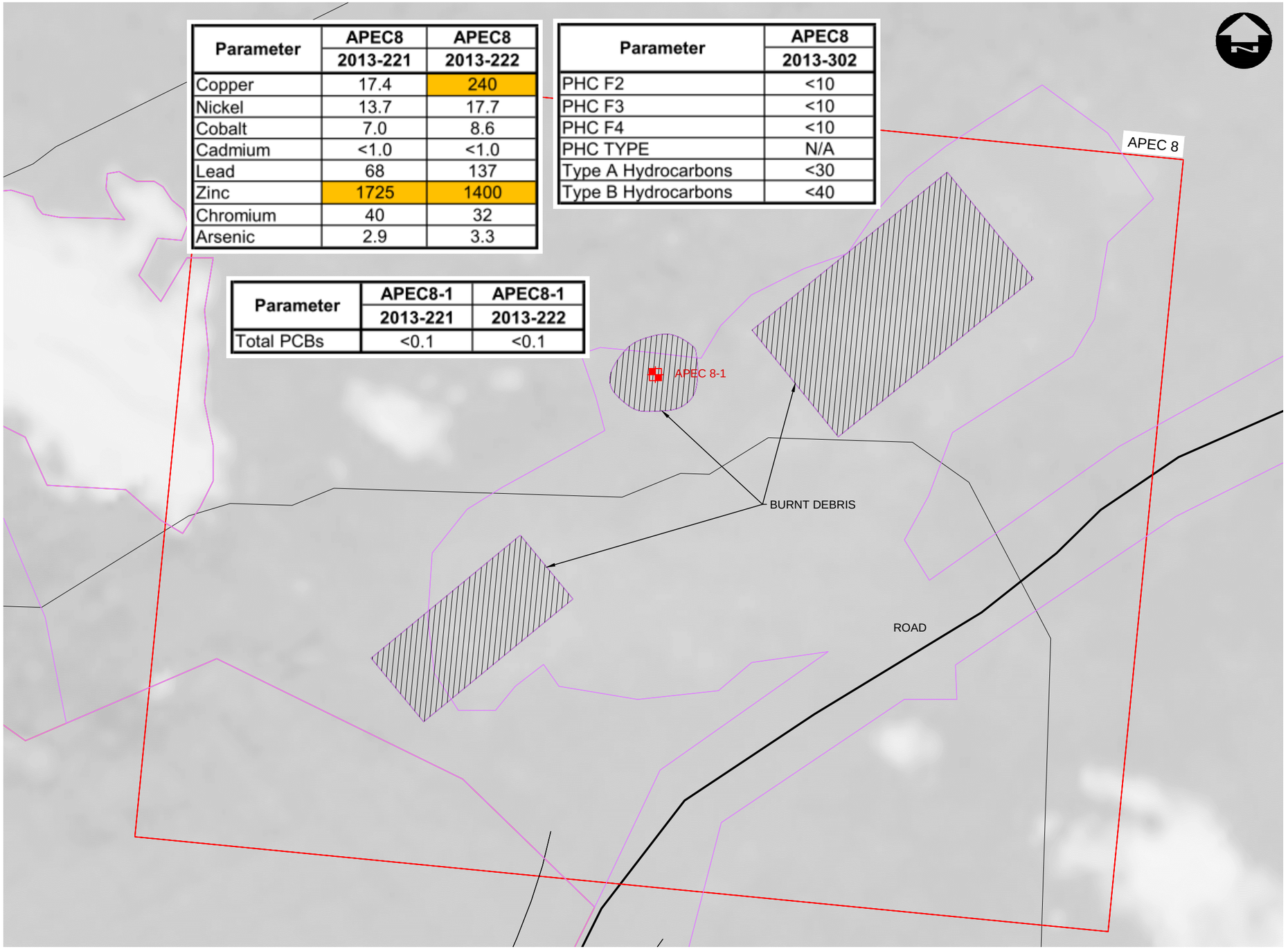
Parameter	APEC8 2013-221	APEC8 2013-222
Copper	17.4	240
Nickel	13.7	17.7
Cobalt	7.0	8.6
Cadmium	<1.0	<1.0
Lead	68	137
Zinc	1725	1400
Chromium	40	32
Arsenic	2.9	3.3

Parameter	APEC8 2013-302
PHC F2	<10
PHC F3	<10
PHC F4	<10
PHC TYPE	N/A
Type A Hydrocarbons	<30
Type B Hydrocarbons	<40

Parameter	APEC8-1 2013-221	APEC8-1 2013-222
Total PCBs	<0.1	<0.1



LEGEND

- Testpit Location
- Water Sample
- Exceeds AMSRP Criteria Type A Hydrocarbons
- Exceeds AMSRP Criteria Type B Hydrocarbons
- Staining
- Debris
- APEC
- Concrete
- Crown Land
- Water
- Road
- Drainage Pathways
- Airstrip
- Geophysical Survey Area
- Disturbed Limits
- EM 31 survey Area

	Parameter	AMSRP Clean-up Criteria Type B	AMSRP Clean-up Criteria Type A	CSW for PHC in Soil
PHC (ppm)	PHC F1	---	---	210
	PHC F2	---	---	150
	PHC F3	---	---	300
	PHC F4	---	---	2800
	PHC Type	---	---	---
	PHC Concentration	2500[a]	20000[b]	---

20= Denotes exceedances for AMSRP Clean-up Criteria
20= Denotes exceedances for Federal Guidelines
20= Denotes exceedances for Federal and AMSRP Criteria

a = AMSRP Clean-up Criteria, Protection of Terrestial Wildlife, Type B Hydrocarbon (sum of F1 + F3 + F4), 0 - 0.5 metres below ground surface

b = AMSRP Clean-up Criteria, Protection of Human Health, Type A Hydrocarbon (sum of F3 + F4 >70% of the total PHC concentration (F1 to F4) and (F2<F4)

Parameter	AMSRP Clean-up Criteria[1] Tier I	AMSRP Clean-up Criteria[1] Tier II	ESG Recommended Remediation Criteria (2010)	Federal CCME[2] Residential/ Parkland
Polychlorinated Biphenenyls (ppm)				
Copper	---	100	109	63
Zinc	---	500	Same as AMSRP	200
Total PCB	1.0	5.0	---	1.3

20= Denotes exceedances for DCC DEW Line Clean-up Criteria
20= Denotes exceedances for CCME 2007 Residential/Parland Guidelines
20= Denotes exceedances of Site Specific criteria
20= Denotes exceedances for Federal and AMSRP Criteria
--- No Criteria

1 = Indian and Northern Affairs Canada, Abandoned Military Site Remediation Protocol, Table 4.1, DCC DEW Line Criteria for soil, March 2009.
2 = Canadian Council of Ministers of the Environment, Canada Soil Quality Guidelines, Summary Tables (Update 7.0), Sept 2007, Residential/Parland, Coarse Grained Soils.

NO.	YYMMDD	DESCRIPTION	BY
0	14/03/27	Completed Final	P.M.W.

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KGS GROUP CONSULTING ENGINEERS

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REMEDIAL ACTION PLAN,
FOX-D

APEC 8 - BURNT DEBRIS

MARCH 2014 | FIGURE 11 | REV. 0

FINAL

Metres
HORIZONTAL SCALE: 1:250 11" X 17"

0 5 10 15 20 25

NOTES:
1. Imagery: 1:20,000 Scale Imagery, 1948. National Air Photo Library (NAPL).
2. Contours are supplies from NRCAN, derived from 1:60,000 stereo pair imagery.
3. Survey Completed by KGS Group, August 2013

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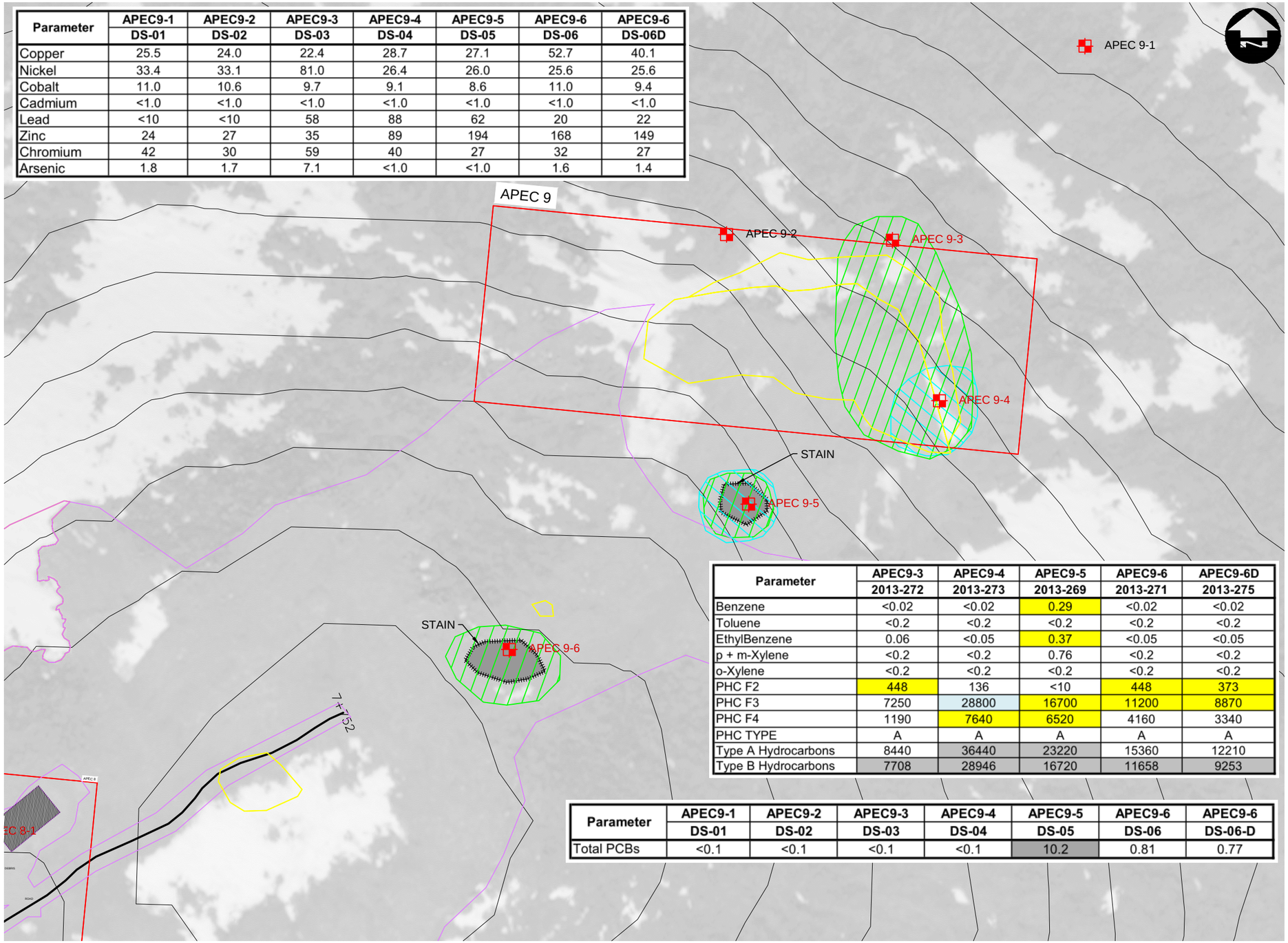
Parameter	APEC9-1 DS-01	APEC9-2 DS-02	APEC9-3 DS-03	APEC9-4 DS-04	APEC9-5 DS-05	APEC9-6 DS-06	APEC9-6 DS-06D
Copper	25.5	24.0	22.4	28.7	27.1	52.7	40.1
Nickel	33.4	33.1	81.0	26.4	26.0	25.6	25.6
Cobalt	11.0	10.6	9.7	9.1	8.6	11.0	9.4
Cadmium	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Lead	<10	<10	58	88	62	20	22
Zinc	24	27	35	89	194	168	149
Chromium	42	30	59	40	27	32	27
Arsenic	1.8	1.7	7.1	<1.0	<1.0	1.6	1.4



Parameter	APEC9-3 2013-272	APEC9-4 2013-273	APEC9-5 2013-269	APEC9-6 2013-271	APEC9-6D 2013-275
Benzene	<0.02	<0.02	0.29	<0.02	<0.02
Toluene	<0.2	<0.2	<0.2	<0.2	<0.2
EthylBenzene	0.06	<0.05	0.37	<0.05	<0.05
p + m-Xylene	<0.2	<0.2	0.76	<0.2	<0.2
o-Xylene	<0.2	<0.2	<0.2	<0.2	<0.2
PHC F2	448	136	<10	448	373
PHC F3	7250	28800	16700	11200	8870
PHC F4	1190	7640	6520	4160	3340
PHC TYPE	A	A	A	A	A
Type A Hydrocarbons	8440	36440	23220	15360	12210
Type B Hydrocarbons	7708	28946	16720	11658	9253

Parameter	APEC9-1 DS-01	APEC9-2 DS-02	APEC9-3 DS-03	APEC9-4 DS-04	APEC9-5 DS-05	APEC9-6 DS-06	APEC9-6 DS-06-D
Total PCBs	<0.1	<0.1	<0.1	<0.1	10.2	0.81	0.77

LEGEND

- Testpit Location
- Water Sample
- Exceeds AMSRP Criteria Type A Hydrocarbons
- Exceeds AMSRP Criteria Type B Hydrocarbons
- Staining
- Debris
- APEC
- Concrete
- Crown Land
- Water
- Road
- Drainage Pathways
- Airstrip
- Geophysical Survey Area
- Disturbed Limits
- EM 31 survey Area

	Parameter	AMSRP Clean-up Criteria Type B	AMSRP Clean-up Criteria Type A	CSW for PHC in Soil
PHC (ppm)	PHC F1	---	---	210
	PHC F2	---	---	150
	PHC F3	---	---	300
	PHC F4	---	---	2800
	PHC Type	---	---	---
	PHC Concentration	2500[b]	20000[b]	---

20= Denotes exceedances for AMSRP Clean-up Criteria
20= Denotes exceedances for Federal Guidelines
20= Denotes exceedances for Federal and AMSRP Criteria

a = AMSRP Clean-up Criteria, Protection of Terrestial Wildlife, Type B Hydrocarbon (sum of F1 + F3 + F4), 0 - 0.5 metres below ground surface

b = AMSRP Clean-up Criteria, Protection of Human Health, Type A Hydrocarbon (sum of F3 + F4 >70% of the total PHC concentration (F1 to F4) and (F2<F4)

Parameter	AMSRP Clean-up Criteria[1] Tier I	AMSRP Clean-up Criteria[1] Tier II	ESG Recommended Remediation Criteria (2010)	Federal CCME[2] Residential/ Parkland
Polychlorinated Biphenyls (ppm)				
Copper	---	100	109	63
Zinc	---	500	Same as AMSRP	200
Total PCB	1.0	5.0	---	1.3

20= Denotes exceedances for DCC DEW Line Clean-up Criteria
20= Denotes exceedances for CCME 2007 Residential/Parland Guidelines
20= Denotes exceedances of Site Specific criteria
20= Denotes exceedances for Federal and AMSRP Criteria
--- No Criteria

1 = Indian and Northern Affairs Canada, Abandoned Military Site Remediation Protocol, Table 4.1, DCC DEW Line Criteria for soil, March 2009.
2 = Canadian Council of Ministers of the Environment, Canada Soil Quality Guidelines, Summary Tables (Update 7.0), Sept 2007, Residential/Parland, Coarse Grained Soils.

NO.	YY/MM/DD	DESCRIPTION	BY
0	14/03/27	Completed Final	P.M.W.

REVISIONS / ISSUE

KGS GROUP CONSULTING ENGINEERS

DILLON CONSULTING

REMEDIAL ACTION PLAN,
FOX-D

APEC 9 - NORTHERN SLOPE DUMP SITE

MARCH 2014 | FIGURE 12 | REV 0

FINAL

Metres
HORIZONTAL SCALE: 1:1000 11" X 17"

0 20 40 60 80 100

NOTES:
1. Imagery: 1:20,000 Scale Imagery, 1948. National Air Photo Library (NAPL).
2. Contours are supplies from NRCAN, derived from 1:60,000 stereo pair imagery.
3. Survey Completed by KGS Group, August 2013

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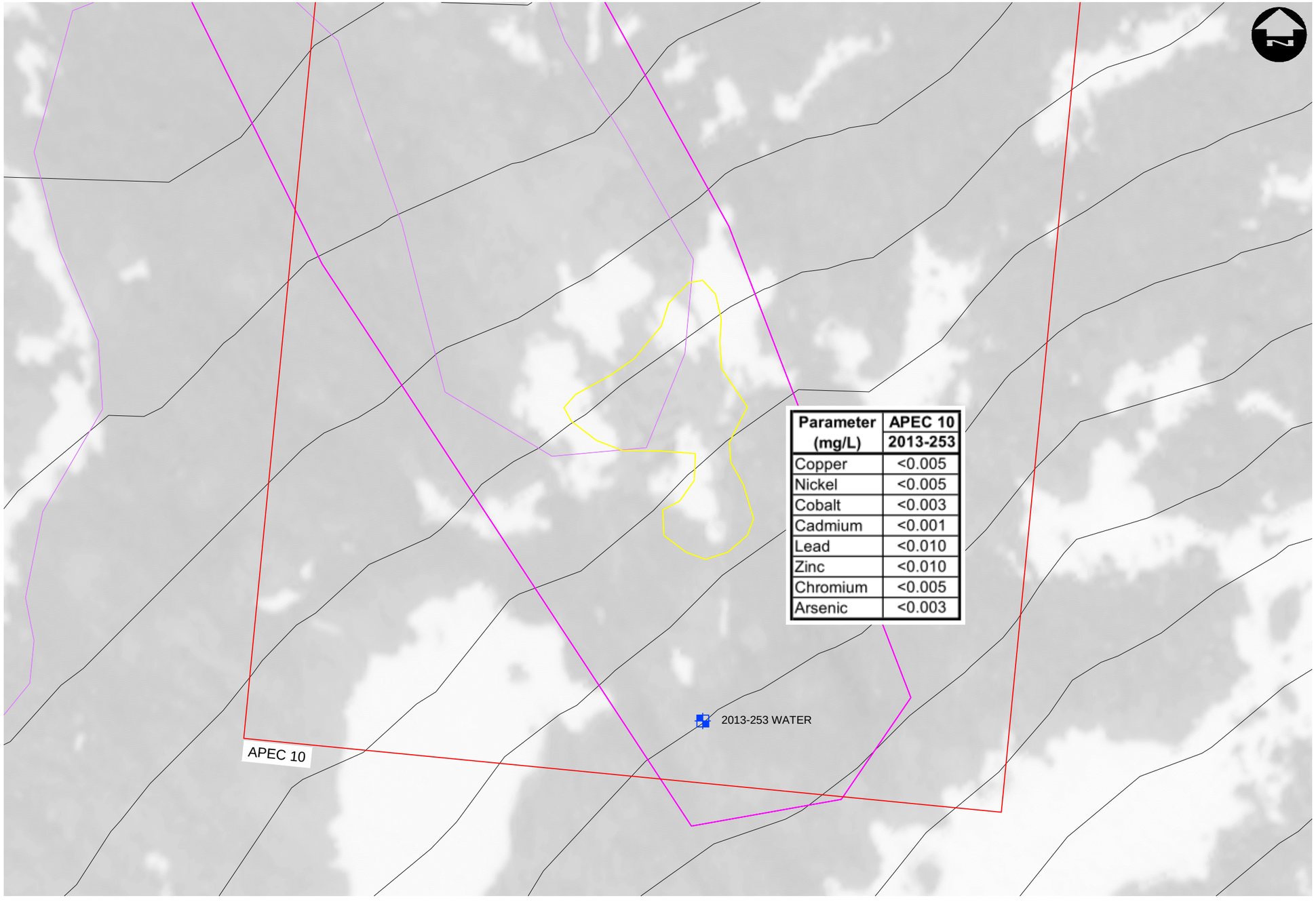

Parameter (mg/L)	APEC 10 2013-253
Copper	<0.005
Nickel	<0.005
Cobalt	<0.003
Cadmium	<0.001
Lead	<0.010
Zinc	<0.010
Chromium	<0.005
Arsenic	<0.003

LEGEND

- Testpit Location
- Water Sample
- Exceeds AMSRP Criteria Type A Hydrocarbons
- Exceeds AMSRP Criteria Type B Hydrocarbons
- Staining
- Debris
- APEC
- Concrete
- Crown Land
- Water
- Road
- Drainage Pathways
- Airstrip
- Geophysical Survey Area
- Disturbed Limits
- EM 31 survey Area

	Parameter	AMSRP Clean-up Criteria Type B	AMSRP Clean-up Criteria Type A	CSW for PHC in Soil
PHC (ppm)	PHC F1	---	---	210
	PHC F2	---	---	150
	PHC F3	---	---	300
	PHC F4	---	---	2800
	PHC Type	---	---	---
	PHC Concentration	2500[a]	20000[b]	---

20= Denotes exceedances for AMSRP Clean-up Criteria
20= Denotes exceedances for Federal Guidelines
20= Denotes exceedances for Federal and AMSRP Criteria

a = AMSRP Clean-up Criteria, Protection of Terrestial Wildlife, Type B Hydrocarbon (sum of F1 + F3 + F4), 0 - 0.5 metres below ground surface

b = AMSRP Clean-up Criteria, Protection of Human Health, Type A Hydrocarbon (sum of F3 + F4 >70% of the total PHC concentration (F1 to F4) and (F2<F4)

Parameter	AMSRP Clean-up Criteria[1] Tier I	AMSRP Clean-up Criteria[1] Tier II	ESG Recommended Remediation Criteria (2010)	Federal CCME[2] Residential/ Parkland
Polychlorinated Biphenenyls (ppm)				
Copper	---	100	109	63
Zinc	---	500	Same as AMSRP	200
Total PCB	1.0	5.0	---	1.3

20= Denotes exceedances for DCC DEW Line Clean-up Criteria
20= Denotes exceedances for CCME 2007 Residential/Parland Guidelines
20= Denotes exceedances of Site Specific criteria
20= Denotes exceedances for Federal and AMSRP Criteria
--- No Criteria

1 = Indian and Northern Affairs Canada, Abandoned Military Site Remediation Protocol, Table 4.1, DCC DEW Line Criteria for soil, March 2009.
2 = Canadian Council of Ministers of the Environment, Canada Soil Quality Guidelines, Summary Tables (Update 7.0), Sept 2007, Residential/Parland, Coarse Grained Soils.

NO.	YY/MM/DD	DESCRIPTION	BY
0	14/03/27	Completed Final	P.M.W.

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REMEDIAL ACTION PLAN,
FOX-D

APEC 10 - SOUTHERN SLOPE DUMP SITE

MARCH 2014 | FIGURE 13 | REV. 0

FINAL

Metres

HORIZONTAL SCALE: 1:500 11" X 17"

0 100 200 300 400 500

NOTES:
1. Imagery: 1:20,000 Scale Imagery, 1948. National Air Photo Library (NAPL).
2. Contours are supplies from NRCAN, derived from 1:60,000 stereo pair imagery.
3. Survey Completed by KGS Group, August 2013

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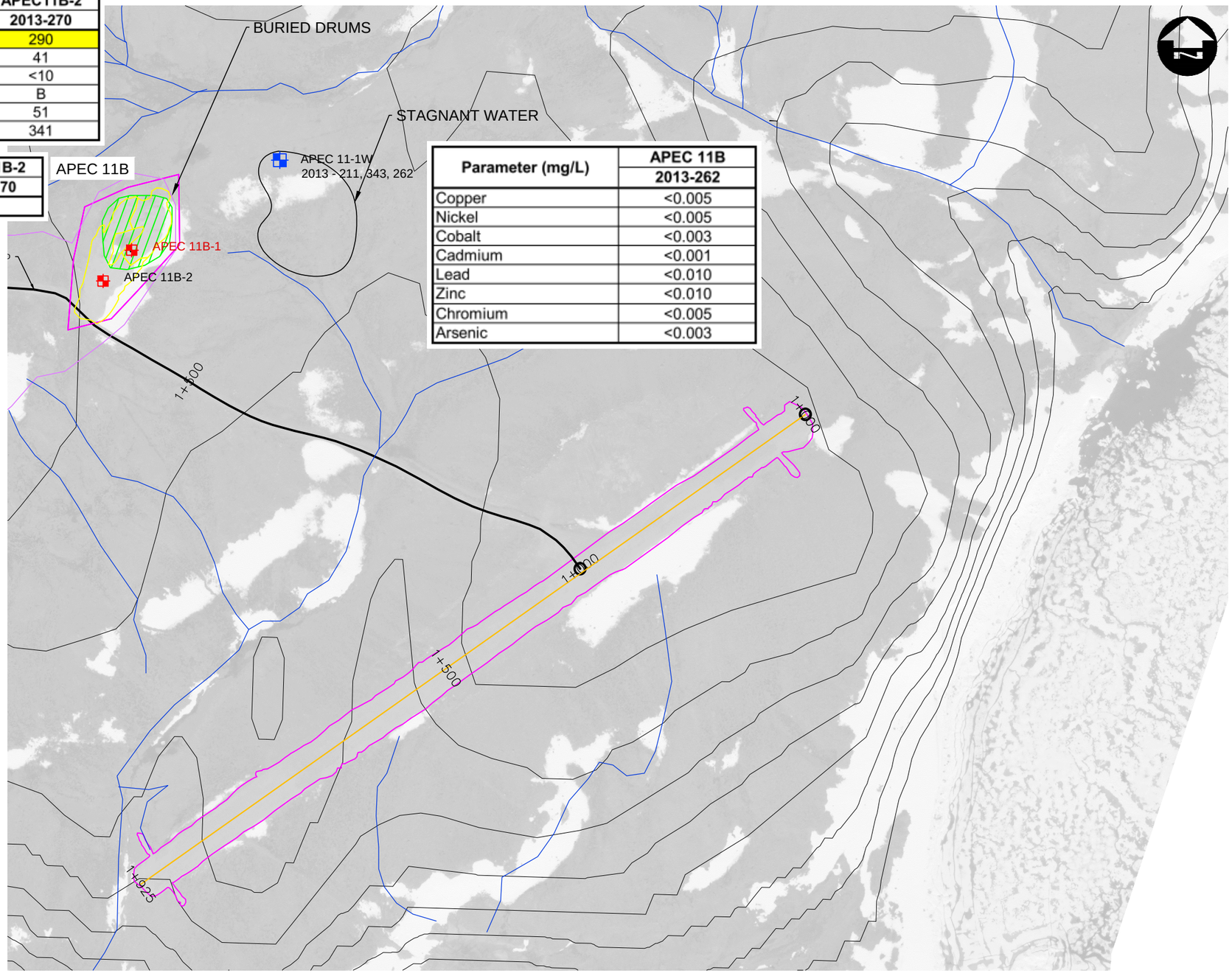
Parameter	APEC11B-1	APEC11B-2
	2013-317	2013-270
PHC F2	<10	290
PHC F3	11800	41
PHC F4	<10	<10
PHC TYPE	A	B
Type A Hydrocarbons	11810	51
Type B Hydrocarbons	11820	341

Parameter	APEC 11B-1	APEC11B-2
	FC-1	2013-270
Total PCBs	<0.1	<0.1



Parameter (mg/L)	APEC 11B
	2013-262
Copper	<0.005
Nickel	<0.005
Cobalt	<0.003
Cadmium	<0.001
Lead	<0.010
Zinc	<0.010
Chromium	<0.005
Arsenic	<0.003

LEGEND

- Testpit Location
- Water Sample
- Exceeds AMSRP Criteria Type A Hydrocarbons
- Exceeds AMSRP Criteria Type B Hydrocarbons
- Staining
- Debris
- APEC
- Concrete
- Crown Land
- Water
- Road
- Drainage Pathways
- Airstrip
- Geophysical Survey Area
- Disturbed Limits
- EM 31 survey Area

Parameter		AMSRP Clean-up Criteria Type B	AMSRP Clean-up Criteria Type A	CSW for PHC in Soil
PHC (ppm)	PHC F1	---	---	210
	PHC F2	---	---	150
	PHC F3	---	---	300
	PHC F4	---	---	2800
	PHC Type	---	---	---
	PHC Concentration	2500[a]	20000[b]	---

20= Denotes exceedances for AMSRP Clean-up Criteria
20= Denotes exceedances for Federal Guidelines
20= Denotes exceedances for Federal and AMSRP Criteria

a = AMSRP Clean-up Criteria, Protection of Terrestial Wildlife, Type B Hydrocarbon (sum of F1 + F3 + F4), 0 - 0.5 metres below ground surface

b = AMSRP Clean-up Criteria, Protection of Human Health, Type A Hydrocarbon (sum of F3 + F4 >70% of the total PHC concentration (F1 to F4) and (F2<F4)

Parameter	AMSRP Clean-up Criteria[1] Tier I	AMSRP Clean-up Criteria[1] Tier II	ESG Recommended Remediation Criteria (2010)	Federal CCME[2] Residential/ Parkland
Polychlorinated Biphenyls (ppm)				
Copper	---	100	109	63
Zinc	---	500	Same as AMSRP	200
Total PCB	1.0	5.0	---	1.3

20= Denotes exceedances for DCC DEW Line Clean-up Criteria
20= Denotes exceedances for CCME 2007 Residential/Parland Guidelines
20= Denotes exceedances of Site Specific criteria
20= Denotes exceedances for Federal and AMSRP Criteria
--- No Criteria

1 = Indian and Northern Affairs Canada, Abandoned Military Site Remediation Protocol, Table 4.1, DCC DEW Line Criteria for soil, March 2009.
2 = Canadian Council of Ministers of the Environment, Canada Soil Quality Guidelines, Summary Tables (Update 7.0), Sept 2007, Residential/Parland, Coarse Grained Soils.

NO.	YY/MM/DD	DESCRIPTION	BY
0	14/03/27	Completed Final	P.M.W.

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FINAL

Metres
HORIZONTAL SCALE: 1:5000 11" X 17"

0 100 200 300 400 500

NOTES:
1. Imagery: 1:20,000 Scale Imagery, 1948. National Air Photo Library (NAPL).
2. Contours are supplies from NRCAN, derived from 1:60,000 stereo pair imagery.
3. Survey Completed by KGS Group, August 2013

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REMEDIAL ACTION PLAN,
FOX-D

APEC 11B - FUEL CACHE DUMP

MARCH 2014 | FIGURE 14 | REV. 0

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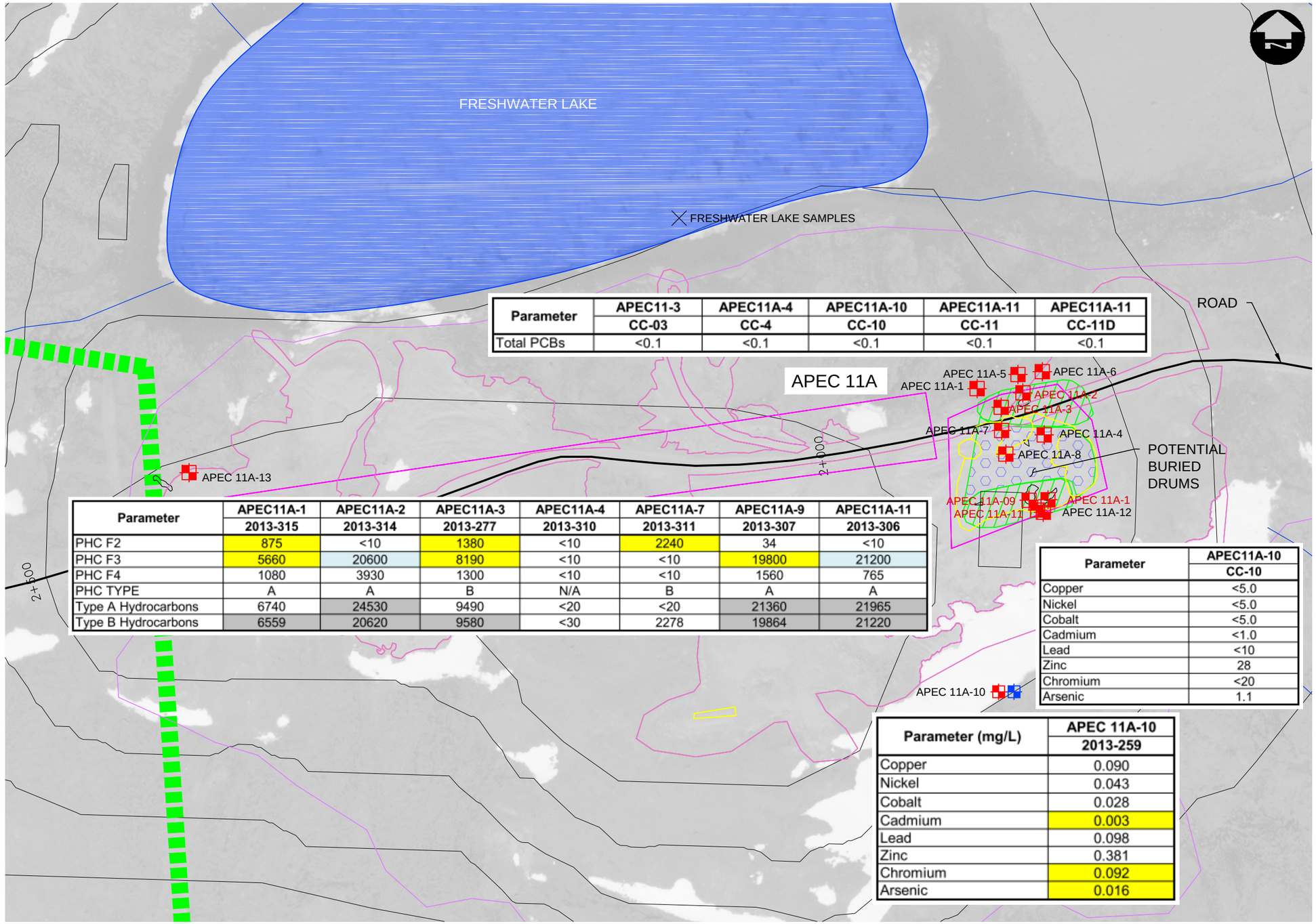

Parameter	APEC11-3	APEC11A-4	APEC11A-10	APEC11A-11	APEC11A-11
	CC-03	CC-4	CC-10	CC-11	CC-11D
Total PCBs	<0.1	<0.1	<0.1	<0.1	<0.1

Parameter	APEC11A-1	APEC11A-2	APEC11A-3	APEC11A-4	APEC11A-7	APEC11A-9	APEC11A-11
	2013-315	2013-314	2013-277	2013-310	2013-311	2013-307	2013-306
PHC F2	875	<10	1380	<10	2240	34	<10
PHC F3	5660	20600	8190	<10	<10	19800	21200
PHC F4	1080	3930	1300	<10	<10	1560	765
PHC TYPE	A	A	B	N/A	B	A	A
Type A Hydrocarbons	6740	24530	9490	<20	<20	21360	21965
Type B Hydrocarbons	6559	20620	9580	<30	2278	19864	21220

Parameter	APEC11A-10
	CC-10
Copper	<5.0
Nickel	<5.0
Cobalt	<5.0
Cadmium	<1.0
Lead	<10
Zinc	28
Chromium	<20
Arsenic	1.1

Parameter (mg/L)	APEC 11A-10
	2013-259
Copper	0.090
Nickel	0.043
Cobalt	0.028
Cadmium	0.003
Lead	0.098
Zinc	0.381
Chromium	0.092
Arsenic	0.016

FINAL

Metres

HORIZONTAL SCALE: 1:2500 11" X 17"

0 50 100 150 200 250

NOTES:
1. Imagery: 1:20,000 Scale Imagery, 1948. National Air Photo Library (NAPL).
2. Contours are supplies from NRCAN, derived from 1:60,000 stereo pair imagery.
3. Survey Completed by KGS Group, August 2013

LEGEND

- Testpit Location
- Water Sample
- Exceeds AMSRP Criteria Type A Hydrocarbons
- Exceeds AMSRP Criteria Type B Hydrocarbons
- Staining
- Debris
- APEC
- Concrete
- Crown Land
- Water
- Road
- Drainage Pathways
- Airstrip
- Geophysical Survey Area
- Disturbed Limits
- EM 31 survey Area

	Parameter	AMSRP Clean-up Criteria Type B	AMSRP Clean-up Criteria Type A	CSW for PHC in Soil
PHC (ppm)	PHC F1	---	---	210
	PHC F2	---	---	150
	PHC F3	---	---	300
	PHC F4	---	---	2800
	PHC Type	---	---	---
	PHC Concentration	2500[a]	20000[b]	---

20= Denotes exceedances for AMSRP Clean-up Criteria
20= Denotes exceedances for Federal Guidelines
20= Denotes exceedances for Federal and AMSRP Criteria

a = AMSRP Clean-up Criteria, Protection of Terrestial Wildlife, Type B Hydrocarbon (sum of F1 + F3 + F4), 0 - 0.5 metres below ground surface

b = AMSRP Clean-up Criteria, Protection of Human Health, Type A Hydrocarbon (sum of F3 + F4 >70% of the total PHC concentration (F1 to F4) and (F2<F4)

Parameter	AMSRP Clean-up Criteria[1] Tier I	AMSRP Clean-up Criteria[1] Tier II	ESG Recommended Remediation Criteria (2010)	Federal CCME[2] Residential/ Parkland
Polychlorinated Biphenyls (ppm)				
Copper	---	100	109	63
Zinc	---	500	Same as AMSRP	200
Total PCB	1.0	5.0	---	1.3

20= Denotes exceedances for DCC DEW Line Clean-up Criteria
20= Denotes exceedances for CCME 2007 Residential/Parland Guidelines
20= Denotes exceedances of Site Specific criteria
20= Denotes exceedances for Federal and AMSRP Criteria
--- No Criteria

1 = Indian and Northern Affairs Canada, Abandoned Military Site Remediation Protocol, Table 4.1, DCC DEW Line Criteria for soil, March 2009.
2 = Canadian Council of Ministers of the Environment, Canada Soil Quality Guidelines, Summary Tables (Update 7.0), Sept 2007, Residential/Parland, Coarse Grained Soils.

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REMEDIAL ACTION PLAN, FOX-D

APEC 11A - CONSTRUCTION CAMP

MARCH 2014 | FIGURE 15 | REV. 0

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Parameter	APEC12-4 2013-308	APEC12-4 2013-309	APEC12-5 2013-320	APEC12-5D 2013-319	APEC12-6 2013-318	APEC12-7 2013-274	APEC12-8 2013-313	APEC12-9 2013-312	APEC12-10 2013-326
PHC F2	1330	<10	<10	<10	<10	<10	<10	<10	<10
PHC F3	72	<10	17000	12600	19900	9560	2610	<10	<10
PHC F4	<10	<10	2120	2150	10500	9020	2280	<10	<10
PHC TYPE	B	N/A	A	A	A	A	A	N/A	N/A
Type A Hydrocarbons	82	<20	19120	14750	30400	18580	4890	<20	<20
Type B Hydrocarbons	1416	<30	17020	12620	19920	9580	2630	<30	<30

Parameter (mg/L)	APEC 12 2013-342	APEC 12 2013-344	APEC 12 2013-345
F1 (C6-C10 Hydrocarbons)	-	<0.1	-
F2 (C10-C16 Hydrocarbons)	-	<0.1	-
F3 (C16-C34 Hydrocarbons)	-	<0.5	-
F4 (C34-C50 Hydrocarbons)	-	<0.5	-
Fuel Oil	<1.0	-	<1.0
Lubricating Oil and Grease	<1.0	-	<1.0

ROAD
CULVERT
STAIN
APEC 12-8
APEC 12-5
APEC 12-6
STAIN
DRAINAGE PATHWAY
APEC 12-9
DISTURBED LIMITS
POL TANK
CULVERT
1+500
DRAINAGE PATHWAY
APEC 12-7
2013- 215 WATER
APEC 12-2
APEC 12-1
1+604
2013- 344 WATER
APEC 12-10
APEC 12-4
APEC 12-3
SHORELINE
DAVIS STRAIT

FINAL

Metres
HORIZONTAL SCALE: 1:1000 11" X 17"

0 20 40 60 80 100

NOTES:
1. Imagery: 1:20,000 Scale Imagery, 1948. National Air Photo Library (NAPL).
2. Contours are supplies from NRCAN, derived from 1:60,000 stereo pair imagery.
3. Survey Completed by KGS Group, August 2013

LEGEND

- Testpit Location
- Water Sample
- Exceeds AMSRP Criteria Type A Hydrocarbons
- Exceeds AMSRP Criteria Type B Hydrocarbons
- Staining
- Debris
- APEC
- Concrete
- Crown Land
- Water
- Road
- Drainage Pathways
- Airstrip
- Geophysical Survey Area
- Disturbed Limits
- EM 31 survey Area

Parameter		AMSRP Clean-up Criteria Type B	AMSRP Clean-up Criteria Type A	CSW for PHC in Soil
PHC (ppm)	PHC F1	---	---	210
	PHC F2	---	---	150
	PHC F3	---	---	300
	PHC F4	---	---	2800
	PHC Type	---	---	---
	PHC Concentration	2500[a]	20000[b]	---

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20= Denotes exceedances for Federal and AMSRP Criteria

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b = AMSRP Clean-up Criteria, Protection of Human Health, Type A Hydrocarbon (sum of F3 + F4 >70% of the total PHC concentration (F1 to F4) and (F2<F4)

Parameter	AMSRP Clean-up Criteria[1] Tier I	AMSRP Clean-up Criteria[1] Tier II	ESG Recommended Remediation Criteria (2010)	Federal CCME[2] Residential/ Parkland
Polychlorinated Biphenyls (ppm)				
Copper	---	100	109	63
Zinc	---	500	Same as AMSRP	200
Total PCB	1.0	5.0	---	1.3

20= Denotes exceedances for DCC DEW Line Clean-up Criteria
20= Denotes exceedances for CCME 2007 Residential/Parland Guidelines
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REMEDIAL ACTION PLAN,
FOX-D

APEC 12 - BEACH POL AND LANDING AREA

MARCH 2014 | FIGURE 16 | REV. 0

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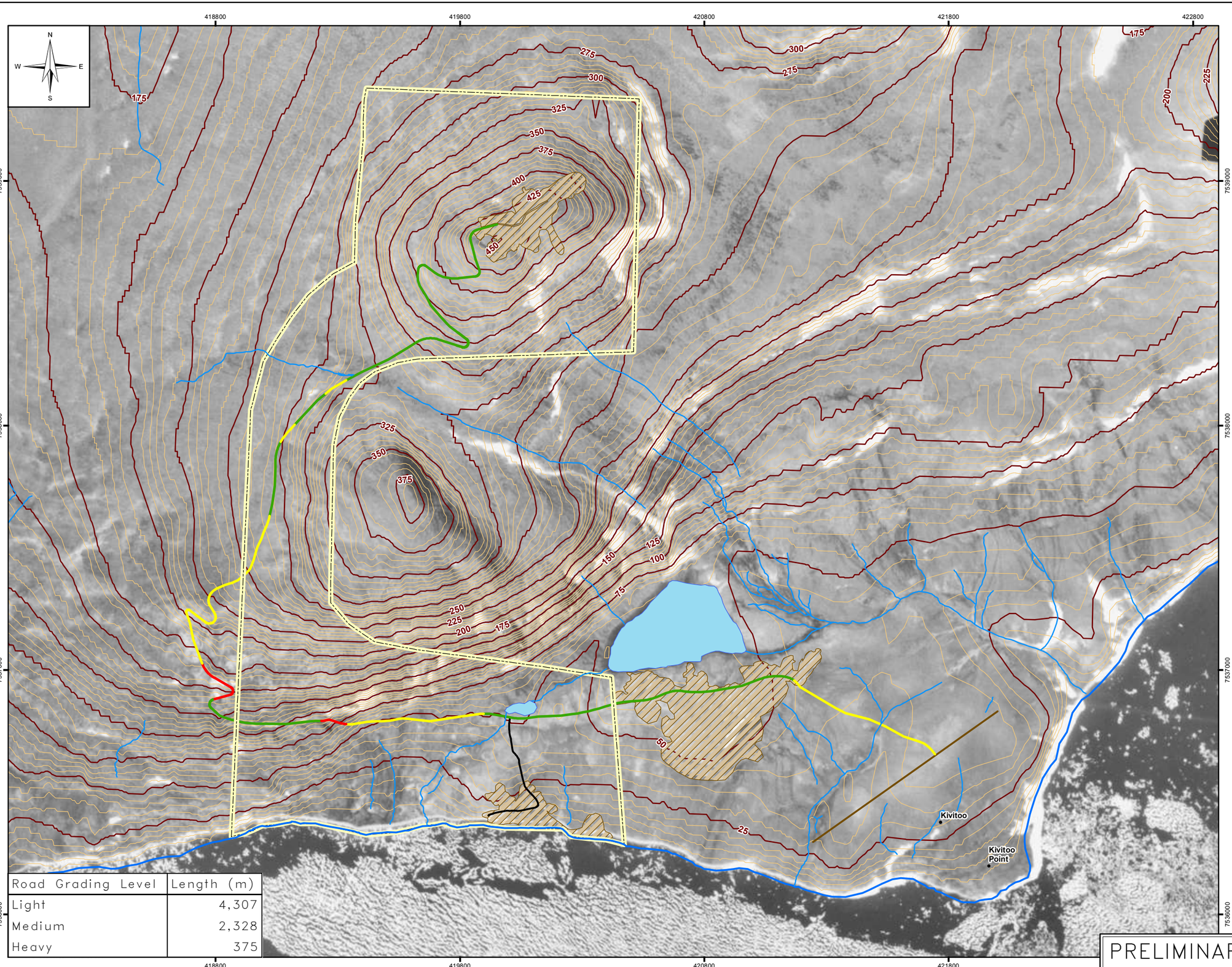

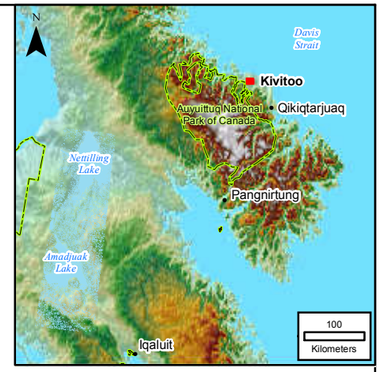

LEGEND:

- Drainage Pathway
- Shoreline
- 5 m Contour
- 25 m Index Contour
- Existing Road
- Airstrip
- Light Grading
- Medium Grading
- Heavy Grading
- Property Boundary
- Lake
- Area of Disturbance/Worked Area

Road Grading Level	Length (m)
Light	4,307
Medium	2,328
Heavy	375

NOTES:

1. Imagery: 1:20,000 scale imagery, 1948. National Air Photo Library (NAPL).
2. Contours are supplied from NRCAN, derived from 1:60,000 stereo pair imagery.

200 0 200 400 600
Metres

SCALE: 1:15,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 20
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
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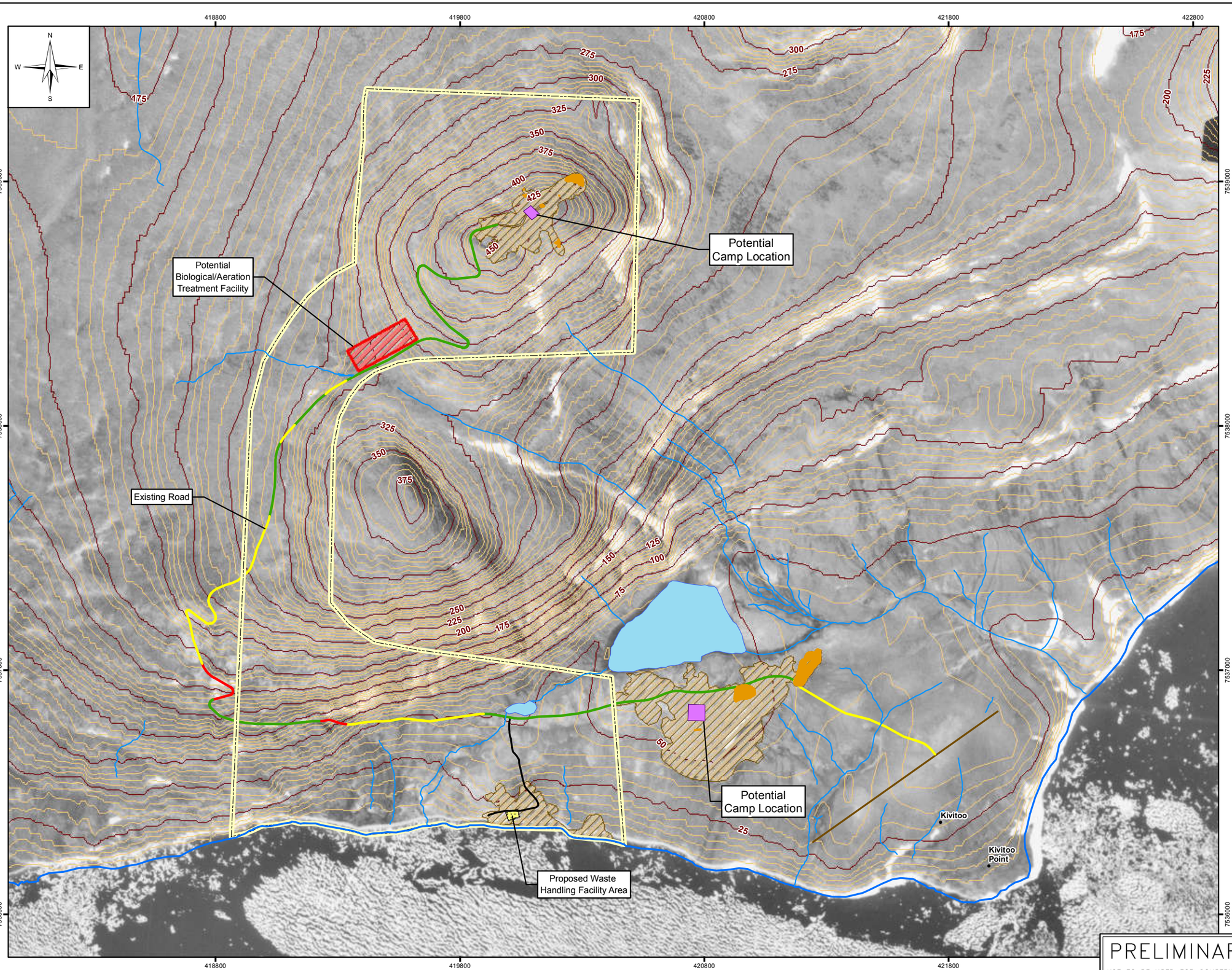
HAZARDOUS MATERIALS ASSESSMENT
SITE SURVEY & GEOTECHNICAL SERVICES
FOX D DEW LINE SITE BAFFIN ISLAND

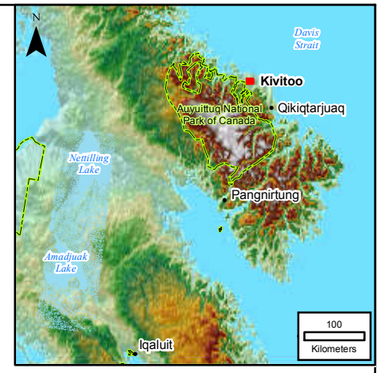
REMEDIAL ACTION PLAN REPORT
AREA ROAD UPGRADES

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

MARCH 2014 | FIGURE 17 | REV: 0

FileName: P:\Projects\2013\13-0163-002\Dwg\GIS\MXDs\Dillon_RAP_Report\Rev0\13-0163-002_Fig17_Rev0.mxd
11"x17" PLOT SCALE 1:1





LEGEND:

- Drainage Pathway
- Shoreline
- 5 m Contour
- 25 m Index Contour
- Existing Road
- Airstrip
- Light Grading
- Medium Grading
- Heavy Grading
- Property Boundary
- Existing Landfill
- Lake
- Area of Disturbance/Worked Area
- Proposed Waste Transfer Area
- Potential Biological/Aeration Facility
- Potential Camp Location

NOTES:

1. Imagery: 1:20,000 scale imagery, 1948. National Air Photo Library (NAPL).
2. Contours are supplied from NRCAN, derived from 1:60,000 stereo pair imagery.

200 0 200 400 600
Metres

SCALE: 1:15,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 20
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
0	14/03/21	ISSUED WITH FINAL RAP REPORT	AMH

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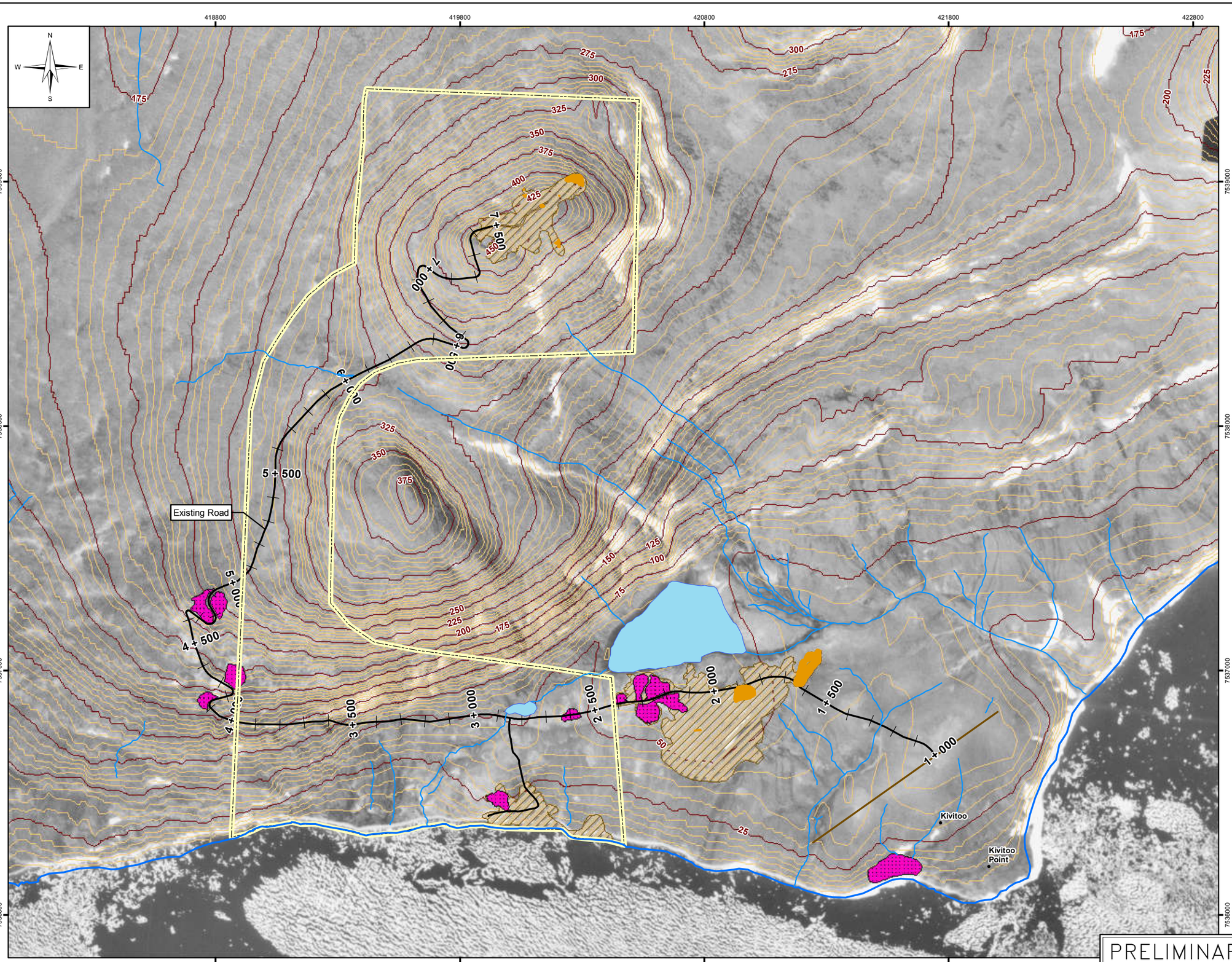
HAZARDOUS MATERIALS ASSESSMENT SITE SURVEY & GEOTECHNICAL SERVICES FOX D DEW LINE SITE BAFFIN ISLAND

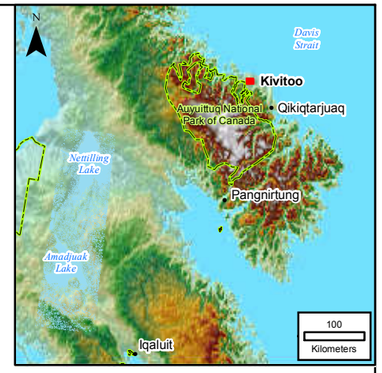
REMEDIAL ACTION PLAN REPORT PROPOSED WORKS

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

MARCH 2014 | FIGURE 18 | REV: 0

FileName: P:\Projects\2013\13-0163-002\Dwg\GIS\MXDs\Dillon_RAP_Report\Rev0\13-0163-002_Fig18_Rev0.mxd
11"x17" PLOT SCALE 1:1





LEGEND:

- Drainage Pathway
- Shoreline
- 5 m Contour
- 25 m Index Contour
- Existing Road
- Airstrip
- Property Boundary
- Existing Landfill
- Freshwater Lake
- Borrow Areas
- Area of Disturbance/Worked Area

NOTES:

1. Imagery: 1:20,000 scale imagery, 1948. National Air Photo Library (NAPL).
2. Contours are supplied from NRCAN, derived from 1:60,000 stereo pair imagery.

200 0 200 400 600
Metres

SCALE: 1:15,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 20
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
0	14/03/21	ISSUED WITH FINAL RAP REPORT	AMH

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HAZARDOUS MATERIALS ASSESSMENT
SITE SURVEY & GEOTECHNICAL SERVICES
FOX D DEW LINE SITE BAFFIN ISLAND

REMEDIAL ACTION PLAN REPORT
BORROW SOURCES

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

MARCH 2014 | FIGURE 19 | REV: 0

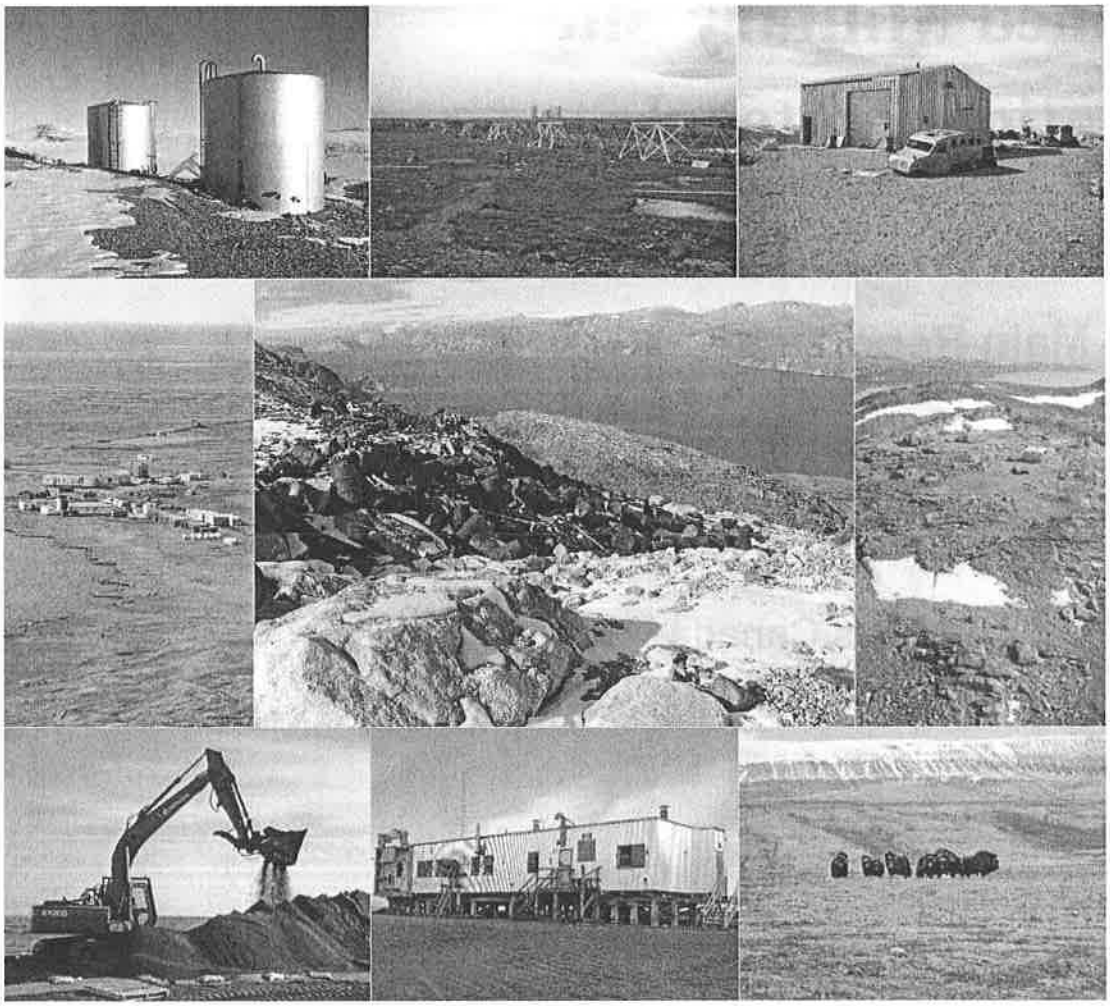
FileName: P:\Projects\2013\13-0163-002\Dwg\GIS\MXDs\Dillon_RAP_Report\Rev0\13-0163-002_Fig19_Rev0.mxd
11"x17" PLOT SCALE 1:1

APPENDIX B

AANDC 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

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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List of Figures

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.

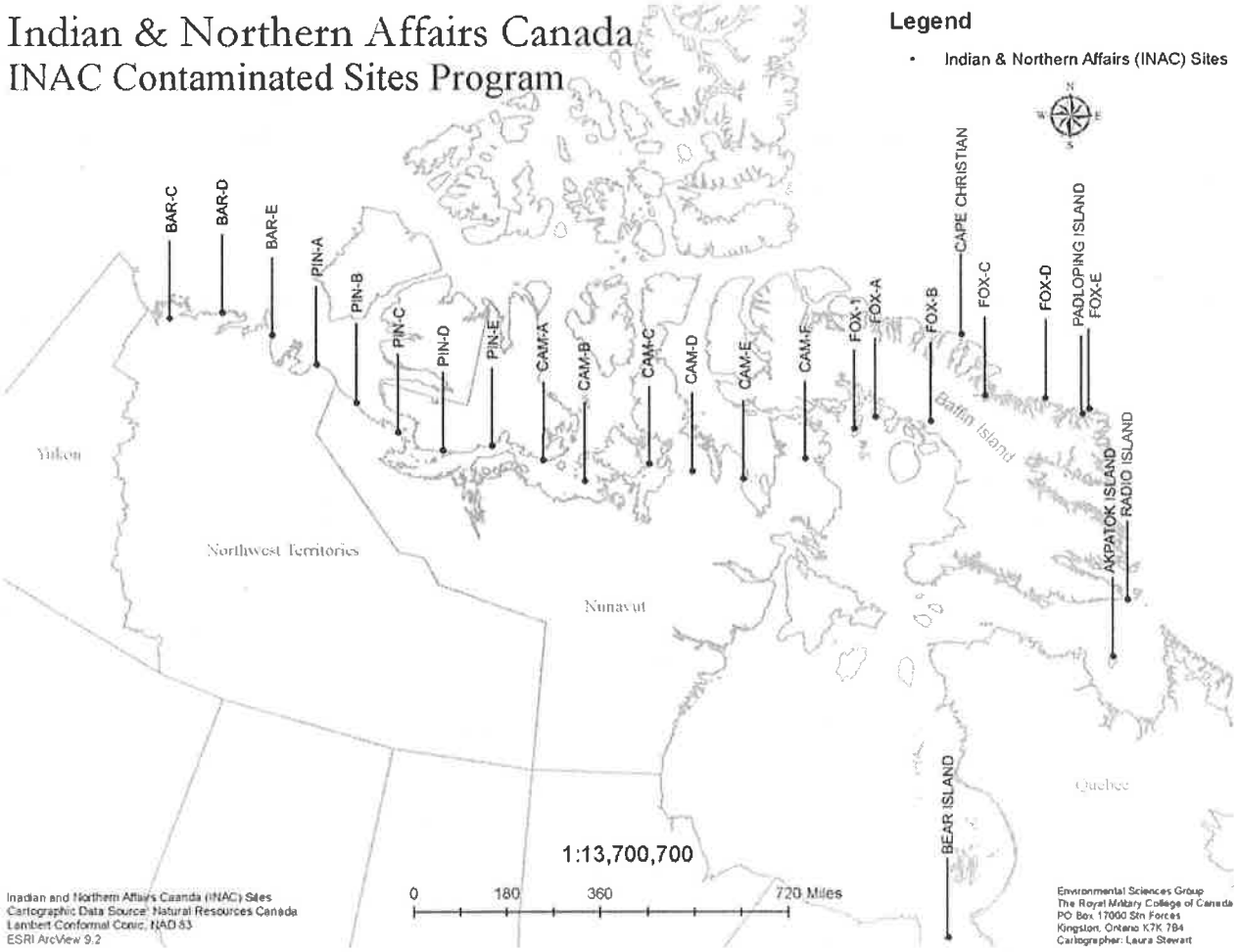

Figure 1 Location of INAC Military Sites

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).

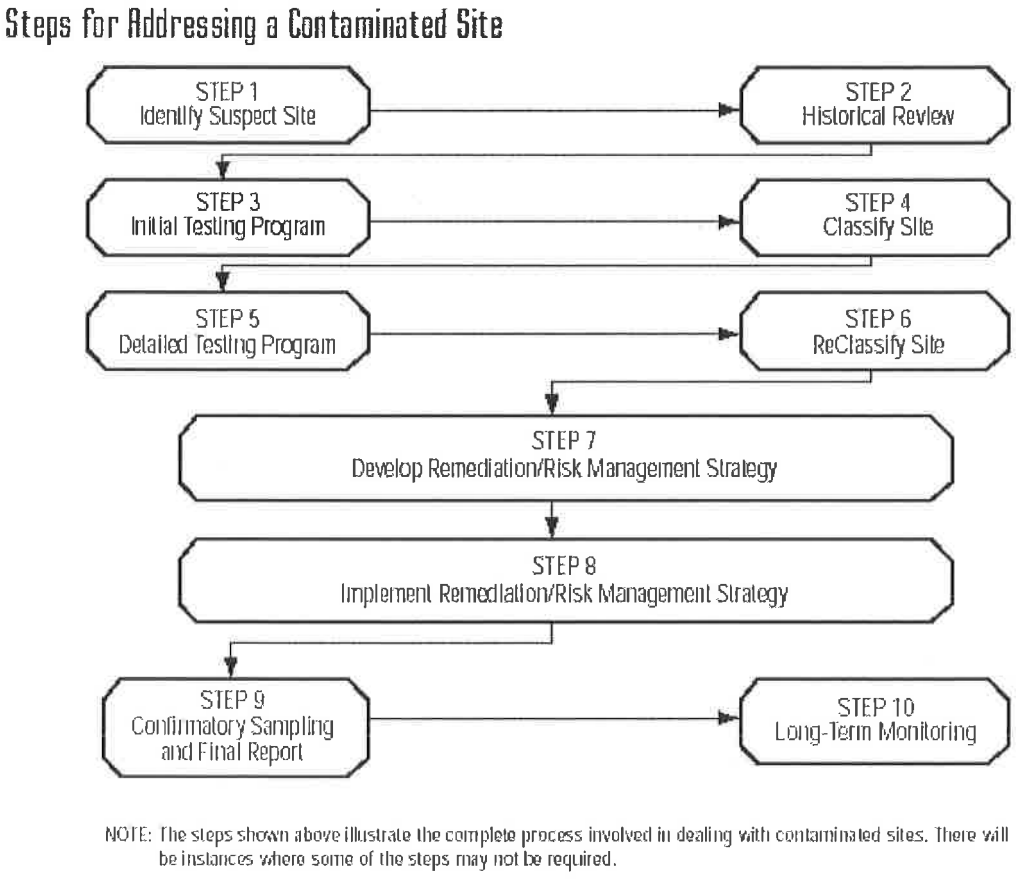

Figure 2 Steps for Addressing a Contaminated Site

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 20^{th} 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).

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

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

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.

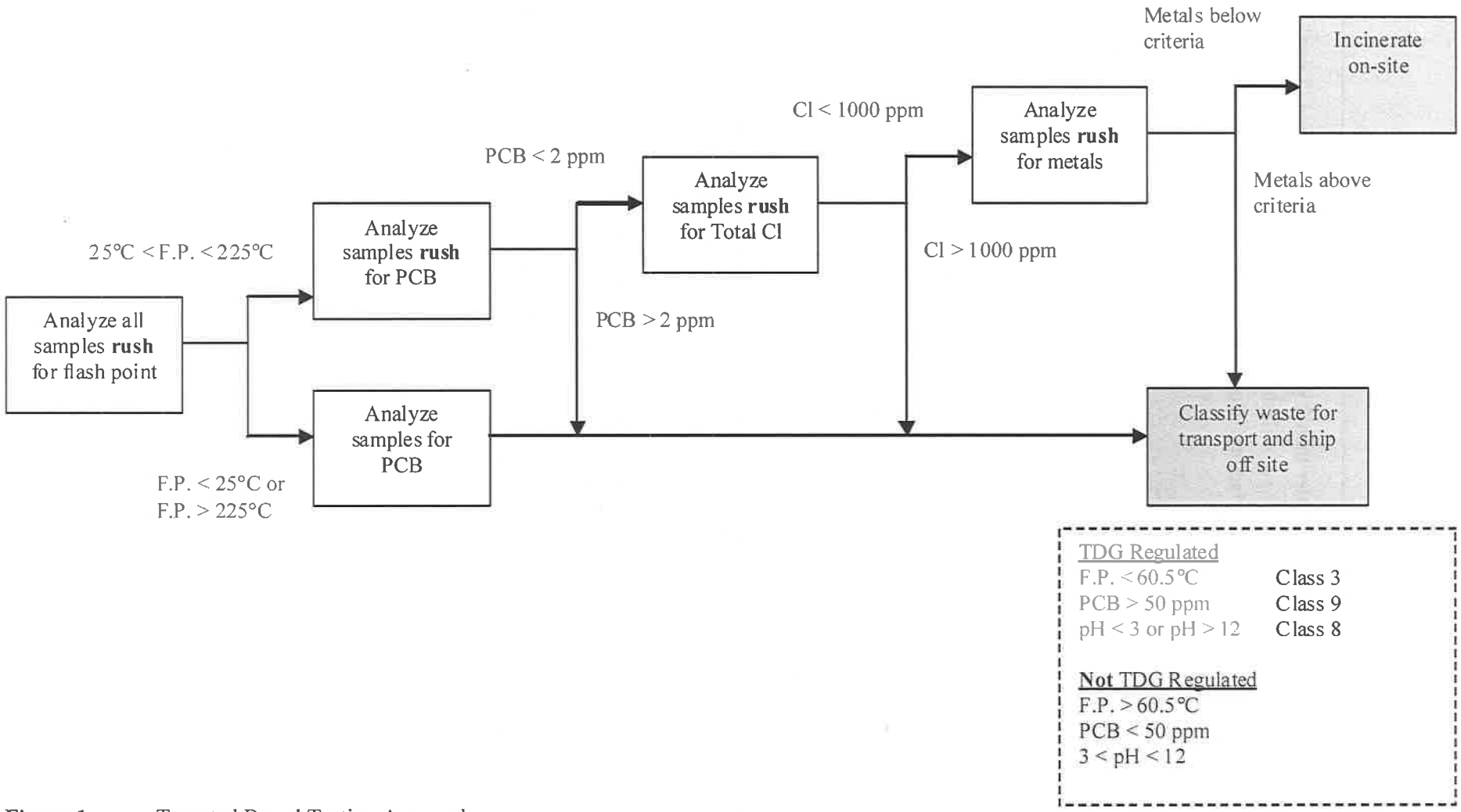


Figure 1 Targeted Barrel Testing Approach

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.

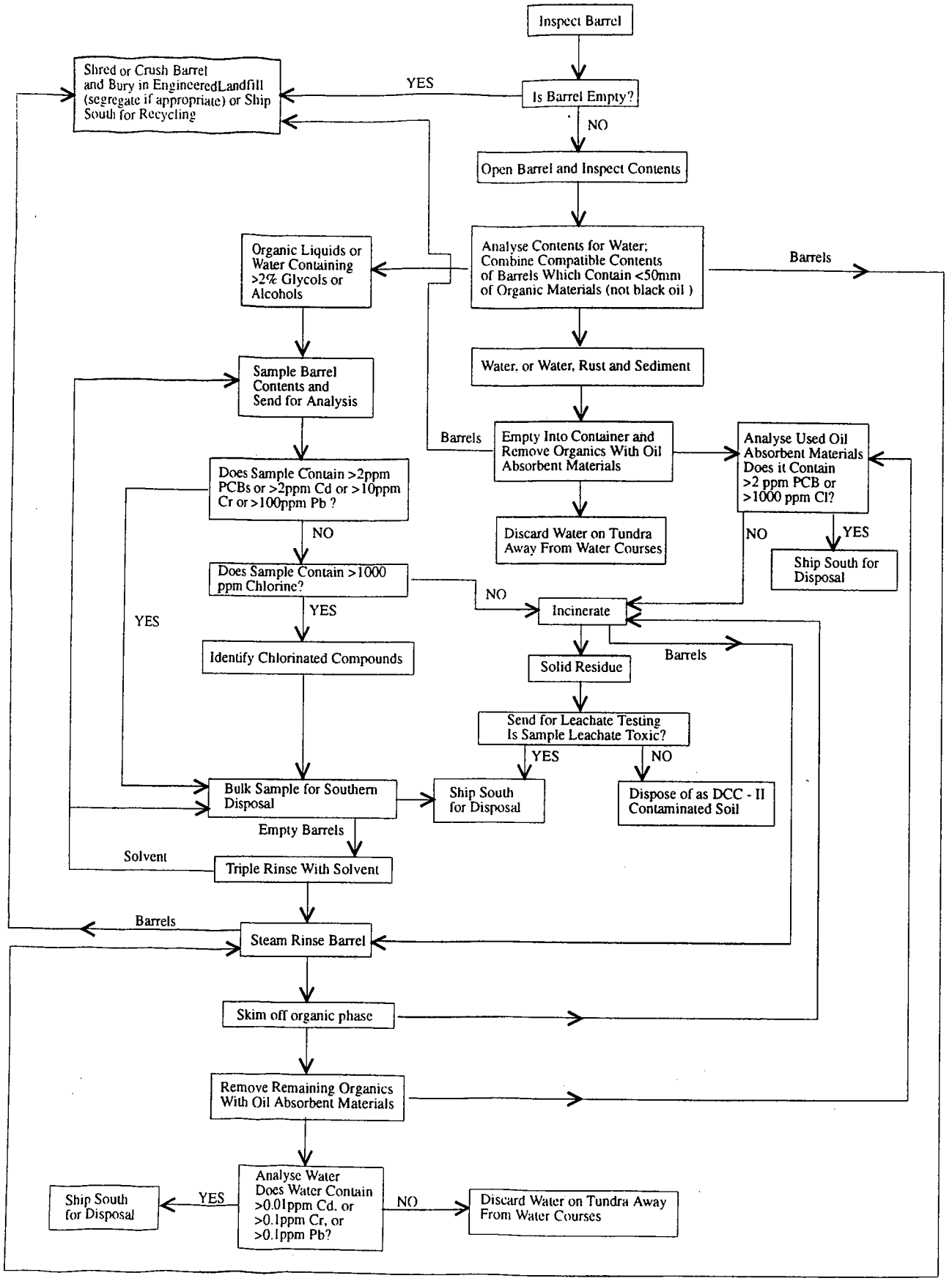
A decontamination procedure should be established at the barrel sampling area(s) to prevent tracking potentially contaminated liquids outside of the sampling area(s).

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 C

DND DEW LINE CLEANUP BARREL PROTOCOL

FLOW CHART FOR THE DEW LINE CLEAN UP BARREL PROTOCOL



APPENDIX D

MEETING MINUTES – COMMUNITY CONSULTATION

Qikiqtarjuaq Community Consultation on FOX-D Remedial Action Plan

Date: January 29th, 2014 (7:00- 9:00 PM EST)

Location: Qikiqtarjuaq Community School Gymnasium, Qikiqtarjuaq, Nunavut

Present: Janice Lee (PWGSC), Erika Solski (AANDC), Indra Kalinovich (Dillon Consulting), Rosemary Metuq (translator from Qikiqtarjuaq, Nunavut).

The consultation was advertised over the radio and by posters. The original community consultation was scheduled for January 28th, 2014 and was postponed to January 29th, 2014 due to weather. Presentation handouts were printed in English and Inuktitut. Information on AANDC's contaminated sites program were made available in English, French and Inuktitut. All information was presented on a table near the entrance, where attendees could sign in with Janice Lee (PWGSC). Most attendees picked up all available information.

The consultation was attended by 58 individuals from the community, with some additional children. Janice Lee (PWGSC) recorded the names of attendees for record keeping.

The presentation outlined AANDC's contaminated sites program, the bidding and tender process, the applicable guidelines and site criteria to FOX-D, environmental concerns at FOX-D, archaeological areas of interest near the site, the proposed remedial action plan and the project timeline. The presentation was delivered by Erika Solski (AANDC) and Indra Kalinovich (Dillon Consulting).

After the presentation, a question and answer period was held, inviting the community to share stories and any knowledge about activities (be it traditional or related to the former DEW Line) with AANDC. The community was invited to share any concerns and ask any questions with respect to the proposed remedial activities for FOX-D.

Community Questions and Comments
(Gamailee Nookiguak to Erika Solski):
<<in the powerpoint presentation to the community, there was a slide during the archaeological impact assessments that contained a photograph of an old snowmobile toy made of wood >>

I used to camp up there in the late 1960s and made that toy snowmobile out of power corp shop (*wood*). I remember camping there in the spring, often. At the time, it was the furthest camp from the community of Qikiqtarjuaq. I would like the co-ordinates of the toy location and would like my toy back.

(Johnny Kooneeliusie to Indra Kalinovich): I worked for Parks Canada during the clean-up in the 1980s. I was involved with the clean-up. The large Doppler building and all the site was pushed out onto the ice for ocean disposal. I know the ice disposal location.

General Comments
There were a number of general comments and questions from community members about where to submit applications for work and when the work going to start. AANDC and Dillon Consulting re-iterated the bidding and tender process and that site mobilization activities were tentatively scheduled for 2015. Once the contract was won, a separate contractor other than AANDC would be arranging for employment. There would likely be a second community consultation after the contract was won – in winter of 2015.

APPENDIX E

SUMMARY TABLES

TABLE 1
LEAD PAINT SAMPLING
FOX-D KIVITOO DEW LINE SITE, NU

Sample ID [1]	Location	Paint Source	Colour	Total Lead Concentration (mg/kg)	Leachable Lead (mg/L)	Condition
RDL					*0.10*	
LP-01	Lower Site Former POL Tank Area	Plywood	White	796 [2]	<0.10	poor condition
LP-02	Upper site, APEC 1A and 1B	Diesel Tank	Silver	100000 [3]	**46.10**	good condition
LP-03	Upper Site, APEC 2	Radio Antenna	White/ Orange	49000 [4]	0.24	poor condition
Northwest Territiories Environmental Protection Act [5]						
Minimum concentration of lead in paint considered lead-based		-	-	600 mg/kg	-	
Transportation of Dangerous Goods Regulation (SOR/2001-245, Amended 2012-12-05)[5]						
Minimum leachable lead concentration considered hazardous		-	-	-	5	

Notes:
RDL = Reportable Detection Limits

1. Samples obtained on August 10, 2013 by Katey Miller.
2. Laboratory detection limit for Lead is 3.0 mg/kg.
3. Laboratory detection limit for Lead is 300 mg/kg.
4. Laboratory detection limit for Lead is 60 mg/kg.
5. As specified in the Abandoned Military Site Protocol (Volume 1, Main Report, December 2008).

- Lead-based Paint.
BOLD - Exceeds TDGA Leachate Quality Criteria

TABLE 2
BULK ASBESTOS CONTENT
FOX-D KIVITOO DEW LINE SITE, NU

Sample ID [1]	Sample Description	Source/ Location	Bulk Asbestos Content [2, 3]												
			Asbestos Type						Asbestos Content	Other Content					
			Actinolite	Amosite	Anthophylilite	Chrysotile	Crocidolite	Tremolite		Cellulose	Glass Fibres	Cellulose and Glass	Hair	Filler	Filler and Tar
									0.50%	0.50%	0.50%	0.50%		0.50%	0.50%
AS-01	White, Friable, poor condition	Pipe Insulation, in northern slope landfill area - APEC 9	ND	ND	ND	60-80	ND	ND	-	ND	ND	-	ND	20-40	-
AS-02	White/grey, non friable, good condition	Wall board, at former warehouse area - APEC 4	ND	ND	ND	10-30	ND	ND	-	ND	ND	-	ND	70-90	-

Sample ID [1]	Sample Description	Source	Asbestos Identification	Asbestos Identification (%) [4]	Total Asbestos (%)
AS-03	White/ brown, non friable, good condition	Floor tile, at former warehouse area - APEC 4	Non-detected	0	<0.1
AS-03	Black fibrous backing, non friable, good condition	Floor tile, at former warehouse area - APEC 4	Chrysotile	30	1.7

Notes:
ND = Not detected
1. Samples obtained on August 10, 2013 by Katey Miller.
2. Bulk asbestos content expressed as a percentage (%) volume fibre found/submitted (%vol/vol).
3. Analyzed via Polarized Light Microscopy (PLM)
4. Analyzed via Transmission Electron Microscopy (TEM).

- Asbestos Containing Material (ACM)

TABLE 3
DRUM INVENTORY
FOX-D KIVITOO DEW LINE SITE, NU

Number	Location	Description	Contents	Sample ID
001	Outfall	yellow, intact.	empty	
002	Outfall	yellow	empty	
003	Northeast summit slope	intact, brown and rusty.	rocks	
004	Northeast summit slope	intact, brown and rusty.	rocks	
005	Northeast summit slope	intact, brown and rusty.	rocks	
006	Northeast summit slope	intact, brown and rusty.	rocks	
007	Northeast summit slope	intact, green and rusty	1/8 liquid	
008	Northeast summit slope	intact, brown and rusty.	rocks	
009	Northeast summit slope	intact, brown and rusty.	empty	
010	Northeast summit slope	old paint can (5 gallon)	filled with dried grey chips (concrete)	
011	Northeast summit slope	rusty	empty	
012	Northeast summit slope	5 gallon paint can rusty	empty	
013	Northeast summit slope	green with rust	empty	
014	Northeast summit slope	green with rust	empty	
015	Northeast summit slope	green with rust	empty	
016	Northeast summit slope	green with rust	empty	
017	Northeast summit slope	green & rusty	empty	
018	Northeast summit slope	green & rusty	thin layer liquid across bottom, not enough to sample	
019	Northeast summit slope	rusty brown	1/4 full, spout at drainage pathway, no smell to liquid, no colour. Just water.	
020	Northeast summit slope near bottom	brown rusty	empty	
021	North slope of summit	green & rusty, cap on.	empty	
022	East of North slope dump	rusty brown	empty	
023	North slope dump	green with rust, caps off	1/5 full	
024	North slope dump	green, rusty, caps off	1/5 full	
025	North slope dump	rusty brown, lid off	empty	
026	North slope dump	lid cut open, rusty brown	empty	
027	North slope dump	lid cut open, rusty brown	empty	
028	North slope dump	lid cut open, rusty brown	empty	
029	North slope dump	lid cut open, rusty brown	empty	
030	North slope dump	green with rust, lid cut off	empty	
031	North slope dump	yellow with rust	empty	
032	North slope dump	green with rust (rusted fuel)	empty	
033	North slope dump	green with rust (rusted fuel)	empty	
034	North slope dump	green with rust (rusted fuel)	empty	
035	North slope dump	green with rust (rusted fuel)	empty	
036	North slope dump	green with rust (gasoline)	empty	
037	North slope dump	rusted	empty	
038	North slope dump	intact, green paint with rust. Top main cap open. Writing: CCC 5B US 165552	rusty orange water, sediment at bottom. 1 phase. 1/10 full.	2013-142
039	North slope dump	green, lid cut off	empty	
040	North slope dump	yellow, lid cut off,	empty	
041	North slope dump	green, rust, (gasoline)	empty	
042	North slope dump	rusty, cut off lid	empty	
043	North slope dump	good condition, rusty (green or yellow?), 1 puncture on side, top open.	1 phase, rusty orange water with black sediment. 1/10 full.	2013-147
044	North slope dump	brown ,rusty green with splashes of red paint	empty	
045	North slope dump	brown, rusty, open at the top	empty	
046	North slope dump	once green, rusted, lid cut off	empty	
047	North slope dump	green, rusted plug open	empty	
048	North slope dump	green, rusted	empty	
049	North slope dump	rusty brown, shadow at bottom	empty	
050	North slope dump	green, rusted	rocks	
051	North slope dump	yellow, rusted	rocks	
052	North slope dump	top cut open	has water	
053	North slope dump	green paint, rusty, top cut open	clear liquid, transparent, one pahse, slight yellow tinge. No sheen	2013-151
054	North slope dump	green with rust, lid cut open	empty	
055	North slope dump	green with rust, lid cut open	empty	
056	North slope dump	green with rust, sealed	empty	
057	North slope dump	black/blue, rusted (gasoline), sealed	empty	
058	North slope dump	yellow with rust, intact open	one phase, murky, brown-orange sediment. Putrid smelling.	2013-144
059	North slope dump	green with rust, yellow writing. Buried, labelled 'automotive'. Class C 9130-264-6216	sheen on water, sediment on bottom. 1 phase, rusty orange water.	2013-152
060	South Slope (down from warehouse foundations)	blue, rusted, cap off	empty	
061	South Slope (down from warehouse foundations)	rusty, lid off	empty	
062	South Slope (down from warehouse foundations)	rusty, cap off	empty	
063	South Slope (down from warehouse foundations)	green, rusted, lid cut off	empty	
064	South Slope (down from warehouse foundations)	cap open and pointed upstream	(has some liquid, water)	
065	South Slope (down from warehouse foundations)	green, cap off	empty	
066	South Slope (down from warehouse foundations)	green	empty	
067	South Slope (down from warehouse foundations)	brown, rusty, cap off	empty	
068	South Slope (down from warehouse foundations)	green, rusted	empty	
069	South Slope (down from warehouse foundations)	green, rusted	empty	
070	South Slope (down from warehouse foundations)	open at top	empty	
071	South Slope (down from warehouse foundations)	green, open,		
072	South Slope (down from warehouse foundations)	green, sealed	has some liquid.	
073	South Slope (down from warehouse foundations)	green, rusted, cap on	empty	
074	South Slope (down from warehouse foundations)	green, rusted	empty	
075	South Slope (down from warehouse foundations)	green, rusted	empty	
076	On top of summit	green barrel, open at top, rusted	empty	

Notes:

1. Drum inventory and sampling conducted on August 6, 2013 by Indra Kalinovich.
2. A minimum of 50 drums/barrels were marked as debris.
3. A total of 5 samples of were collected from liquid drums. Laboratory results identified the liquid as water for each sample.

TABLE 4
SUMMARY HAZARDOUS MATERIALS
FOX-D KIVITOO DEW LINE SITE, NU

Type	Description	Location	Photo	Estimated Area (m^2)	Estimated Volume (m^3)	Estimated Weight	Methodology	Comments
Asbestos [1]	Insulation on pipes	APEC 9 - Northern Slope Dump Site	1, 2	7.87	0.54	0.54 kg	Calculations based on field measurements and visual observations	Exposed pipe insulation observed scattered within the dump site. Poor condition, friable. Sample AS-01 (Table 2).
	Wallboard	APEC 4 - Warehouse Foundation	4, 5, 6	0.93	0.43	0.43 kg	Calculations based on field measurements and visual observations	Wallboard observed at the foundation of the former warehouse. Generally in good condition, non-friable. Sample AS-02 (Table 2).
	Floor tile	APEC 4 - Warehouse Foundation	4, 5, 6	4.65	0.35	0.35 kg	Calculations based on field measurements and visual observations	Floor tile observed at the foundation of the former warehouse. Good condition, non-friable. Sample AS-03 (Table 2).
Lead Paint [2]	White paint on plywood	near APEC 12 - Beach POL and Landing Area	7, 8, 9	13.83	0.0018	0.022 kg	Calculations based on field measurements and visual observations	Unclear if building where sample was taken is apart of the subject property. Sample LP-01 (Table 1). Non-hazardous (<5 mg/kg).
	Silver paint on POL tanks and Transfer tank	APEC 1A Transfer Tank APEC 1B - POL Tanks	10, 11, 12, 13, 14	227.33	0.029	0.35 kg	Calculations based on field measurements and visual observations	Same paint on the POL tanks and the transfer tank. Sample LP-02 (Table 1). Hazardous (>5 mg/kg).
	White/ Orange paint on radio antenna	APEC 2 - Antenna	15, 16, 17, 18	11.94	0.0015	0.018 kg	Calculations based on field measurements and visual observations	Includes area of paint splattered on rocks adjacent to antenna. Sample LP-03 (Table 1). Non-hazardous (< 5mg/kg).
PCBs [3]	Transformer in landfill	APEC 9 - Northern Slope Dump Site	36	0.5	0.25	1.96 metric tonnes	Calculations based on field measurements and visual observations	PCBs confirmed during previous investigations. Volume and weight includes entire metal cabinet with transformer and PCB oil.
Battery Remains	Batteries	APEC 7 - Stain #2	19, 20	0.72	0.22	0.29 metric tonnes	Calculations based on field measurements and visual observations	Weight calculated using an estimated weight of 80 lbs per battery. Batteries found scattered within APEC 7 - Stain #2.

Notes:
1. Estimated density of 1 $kg/m^{3.}$
2. Density of 12 kg/m^3 (as complete paint matrix).
3. Density of 7850 kg/m^3 (cast iron).

TABLE 5
SUMMARY NON-HAZARDOUS MATERIALS
FOX-D KIVITOO DEW LINE SITE, NU

Type	Description	Location	Photo #	Estimated Area (m^2)	Estimated Volume (m^3)	Estimated Weight (Metric Tonne)	Methodology	Comments
Metal [1]	Drums	Upper and Lower Sites	3, 23, 24, 30	153.1	1.5	11.80	- Volume based on dimensions of a typical 205 L steel drum: diameter 0.57 m, height 0.84 m, and thickness 0.01 m.	- 76 steel drums were observed scattered throughout the upper and lower sites. Refer to Drum Inventory table for exact locations (Table 3). - Does not include suspected buried or partially buried drums.
	Tanks	APEC 1A - Transfer Tank APEC 1B - POL Tanks	10, 14	227.3	17.3	136.00	- Calculations based on field measurements and visual observations.	- Tanks include the POL tanks at the upper site and the transfer tank at the upper site.
	Pipes/Drains	APEC 1B - POL Tanks APEC 3 - Burnt Building Remains APEC 12 - Landing Area	28	28.7	0.2	1.6	- Calculations based on visual observations and survey data.	- Pipes/drains include the valve at the former POL tanks at the Lower site and the underground pipes at the burnt remains and the POL tanks area at the upper site.
	Radio Antenna	APEC 2 - Antenna	15, 16, 17, 18	11.94	1.8	14.1	- Calculations based on field measurements and visual observations.	
	Cabinets	APEC 9A - Dump Site	22, 23, 37	3.5	1.8	13.72	- Calculations based on field measurements and visual observations.	- Includes the metal cabinets within the dump site and the metal cabinets located 20 - 25 m northeast of the dump site.
Concrete [2]	Concrete Foundation	APEC 6 - Former Garage (Upper Site)	25, 26	160.1	256.2	594.4	- Calculations based on visual observations and survey data.	- Staining observed on the concrete foundation.
	Concrete Foundation	APEC 4 - Warehouse Foundation (Upper Site)	4, 5, 6	122.5	215.4	499.7	- Calculations based on visual observations and survey data.	
	POL Tank Foundation (2 foundations)	APEC 1B - POL Tanks (Upper Site)	13	29	32.5	75.4	- Calculations based on visual observations and survey data.	
	Concrete Anchors (3 anchors)	APEC 2 - Antenna (Upper Site)	34	33.3	100.0	232	- Calculations based on visual observations and survey data.	
	Concrete Foundation at Construction Camp	APEC 11A - Construction Camp (Lower Site)	15, 17	70.9	43.9	101.8	- Calculations based on visual observations and survey data.	
	Former POL Tank Foundation (2 foundations)	APEC 12 - Barge Landing (Lower Site)	27, 29	29	32.5	75.4	- Calculations based on visual observations and survey data.	
	Thrust Blocks (3 blocks)	APEC 12 - Barge Landing (Lower Site)	27, 28	1.12	1.7	3.9	- Calculations based on visual observations and survey data.	
	Valve Thrust Blocks (2 blocks)	APEC 12 - Barge Landing (Lower Site)	27, 28, 29	3	1.8	4.2	- Calculations based on visual observations and survey data.	
Landfill/Buried debris [3]	Landfill	APEC 9 - Dump Site (Upper Site)	3, 21, 22, 23, 24	2287.9	6095.1	-	- Calculations based on visual observations and survey data.	- Exposed and partially buried metal waste, drums, metal cabinets, PCB transformer and asbestos observed within the dump site.
	Landfill	APEC 10 - Dump Site (Upper Site)	35	367.1	550.7	-	- Calculations based on visual observations and survey data.	- Landfill area not identified in previous reports. - Exposed and partially buried metal waste and drums observed within the dump site.
	Landfill (Metal Waste)	APEC 11A - Construction Camp Landfill (Lower Site)	30, 31, 32, 33	2713.7	4885.0	-	- Calculations based on visual observations and survey data.	- Landfill area not identified in previous reports. - Exposed and partially buried metal waste and drums observed in landfill.
	Landfill (Unknown Waste)	APEC 11A - Construction Camp Landfill (Lower Site)	30, 31, 32, 33	5081	8793.0	-	- Calculations based on visual observations and survey data.	- Landfill area not identified in previous reports.
	Construction Camp Area	APEC 11A - Construction Camp (Lower Site)	35	1155.8	577.9	-	- Calculations based on visual observations and survey data.	- Surface staining.
	Fuel Drum Cache	APEC 11B - Construction Camp (Lower Site)	30, 35	109.5	219.0	-	- Calculations based on visual observations and survey data.	- Partially buried drums visible.
TOTALS				**12588.46**	**21827.25**	**1764.02**		

Notes:
1. Density of cast iron 7850 kg/m^3.
2. Average concrete density 2320 kg/m^3.
3. Unknown density for landfill areas. Unable to calculate weight.