

Public Works and Government Services Canada
Remedial Action Plan
PIN-B, Clifton Point DEW Line Site

Prepared by:
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Project Number: 2977-343-00-14

May 2008

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May 29, 2008

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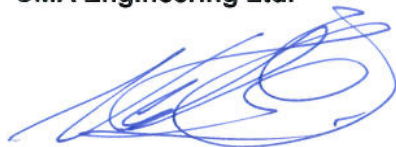
Re: Remedial Action Plan

UMA Engineering Ltd. is pleased to submit our report outlining the results of the Remedial Action Plan at the PIN-B, Clifton Point DEW Line Site.

We thank you for the opportunity to complete this work on behalf of Public Works and Government Services Canada. Should you have any questions or require additional information please contact undersigned at (780) 486-7000.

Sincerely,

UMA Engineering Ltd.



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Signature Page

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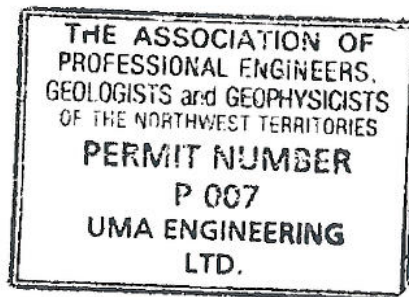
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Executive Summary

PIN-B, Clifton Point is located on the Amundsen Gulf coast in Nunavut (69° 12'N, 118° 37'W). The nearest communities are Paulatuk, located 220 km to the northwest, and Kugluktuk, approximately 220 km to the southeast. The nearest air charter bases are located in Cambridge Bay, 550 km to the east on Victoria Island, and in Yellowknife, located approximately 800 km to the south.

UMA completed a Phase III Environmental Site Assessment (ESA) at PIN-B in August 2007. The objective of the ESA was to collect all data necessary to develop a detailed clean-up design in accordance with the Abandoned Military Site Protocol (INAC 2005). The results of this assessment form the basis for this remedial action plan.

The PIN-B site areas are connected via gravel roads. The roads are generally in good condition, but will require some upgrading during construction for heavy equipment use and two-way traffic. Some areas are currently accessible only via poorly developed trails which will require upgrading. The airstrip is in good condition and generally suitable for use by aircraft as large as a Hercules C-130 under dry conditions. During wet conditions, the granular structure may not be sufficient to accommodate the largest of the aircraft considered (Hercules C-130). Aircraft with wide tires are best suited to the sandy gravel surface that by its nature may tend to rut. There is barge access to the site along the coast of the Amundsen Gulf, and a suitable beach landing area is present. Barge landing is not expected to be a concern.

Three archaeological areas were identified at the site: a suspected grave (PIN-B 1), a cluster of three tent rings and potential blind (NhPt-2, and an abandoned camp area NhPt-1). The former two features will require avoidance during construction activity, with the need for erection of barriers at NhPt-2 because the features are located in close proximity to a work area. The latter feature - the camp - has been identified for demolition because it was built from salvaged materials from the DEW Line site and contains hazardous waste items. Approval from the owner (an elder from Kugluktuk, interviewed during the traditional knowledge survey) was obtained for demolishing the camp. Prior to its demolition, a detailed archaeological documentation of the site will be required.

The investigation and delineation of contaminated soil at PIN-B was completed for the contaminants of concern listed in the INAC Abandoned Military Site Remediation Protocol. This protocol specifies numerical clean-up criteria for inorganic elements and PCBs. Delineation of petroleum hydrocarbon (PHC) impacts was completed using the CCME Canada Wide Standards (CWS) for PHC in Soil. For the CWS PHC methodology, the two remedial criteria exposure pathways applied for the site evaluation are eco-soil contact and protection of groundwater for aquatic life, under the Residential/Parkland Tier I levels. The eco-soil contact criteria were applied in hydrocarbon-impacted areas in the Station Area, while the criteria for protection of groundwater for aquatic life were applied in the assessment of the Beach POL area.

Seven existing dump sites and three small areas of buried debris were investigated during the 2007 ESA. The total area of buried debris within the dump sites is approximately 14,000 m². Based on the location and condition of the dumps and contaminant migration assessment results, each dump site was assigned as a Class A, B or C dump according to the INAC protocol. The remedial requirements for each dump were initially assessed according to the recommended remedial method specified in the INAC protocol for the various dump classifications. In addition, for development of remedial recommendations, site specific information for each dump was considered, such as proximity to surface water bodies, presence and sensitivity of down-gradient receptors (terrestrial and aquatic), and long term geotechnical stability potential. Where two remedial options were considered appropriate, a cost comparison was also completed to be factored into the decision. Based on these evaluations four dumps/areas of buried debris have been recommended for regrading: Station West Dump, Construction Camp Dump A, West Beach POL Buried Debris, and the Inuit Camp Meat Cache. The total area for regrading is 6,800 m². Five dumps have been recommended for excavation: Construction Camp Dump B, Construction Camp Dump C, Beach Dump, Beach Dump South A, and Beach Dump South B. The total volume for excavation is estimated as 6,600 m³. An estimate on waste stream breakdown (percent debris, contaminated soil, non-hazardous and hazardous debris, and clean fill) was completed for dump excavation; these quantities have been included in the derivation of remedial recommendations for contaminated soil treatment and non-hazardous waste disposal.

Based on the surface debris assessment, demolition inventory and sampling, barrel inventory and sampling, and the estimated component to be derived from dump excavations, the volume of hazardous waste identified at PIN-B is 194 m³. The estimated volume of non-hazardous waste is 2,180 m³.

Based on the volume of non-hazardous waste, the quantities and types of granular materials identified during the 2007 investigation, and the identification of several suitable sites for new landfill development, it is recommended that a Non-Hazardous Waste Landfill (NHWL) be constructed at PIN-B. The preferred location for construction of this facility is at Proposed Landfill 1, located in the station vicinity.

The following volumes of contaminated soil were identified at PIN-B:

- Tier I soil: 570 m³, of which 550 m³ is estimated to be derived from dump excavations.
- Tier II soil: 1,210 m³, of which 880 m³ is from dump excavations.
- PHC F3-F4 soil: 1,120 m³.
- PHC F1-F3 soil: 6,740 m³.

Tier I and PHC F3-F4 soil can be disposed of in the on-site NHWL. A cost estimate was completed to compare off-site disposal of Tier II soil versus on-site disposal in a Secure Soil Disposal Facility (SSDF). Based on the results of that cost estimate, and consideration of long-term liability issues, it is recommended that Tier II soil be disposed of off-site. The recommended remedial option for treatment of PHC F1-F3 soil is landfarming, with the preferred location for landfarm construction located at the Proposed Landfill 2 in the station vicinity. However, should the new INAC AMSRP PHC criteria be implemented for remedial design, the preferred location for landfarm construction is the Proposed Landfarm located at the abandoned airstrip; under this criteria, the volume of soil requiring remediation is smaller and can be accommodated at that location. Based on the volume of soil for treatment under the CWS methodology and the low remedial endpoints of treatment, complete treatment of PHC F1-F3 soil may require up to three years. Rather than extending the timing for site clean-up, it is recommended that a contingency be carried for the placement of 0.5 m granular cover over the landfarm, which would restrict the soil-eco contact potential of remaining impacts.

Based on the above remedial recommendations, it is estimated that the cleanup at PIN-B will require two full construction seasons. When considering the timing for contractor mobilization, the clean-up would require three years. Contractor mobilization would be completed by barge during the fall of season one. Primary construction activities would be completed during seasons two and three, with contractor demobilization in the fall of season three. The number one priority for the contractor, in terms of main work elements, will be completion of the landfarm as early as possible during season two, to allow treatment of PHC-impacted soils to commence as soon as possible and to facilitate achieving the remedial endpoint criteria by the end of season three. Following construction of the landfarm, the construction activity focus should switch to construction of the NHWL. Hazardous waste segregation from demolition components is also recommended for completion as early as possible while facility construction is occurring to allow building demolition to proceed once the NHWL is completed. Because of some unknowns related to barrel contents, barrel consolidation is recommended to be completed as much as possible during season two to allow for collection of samples and analysis. Given the unknowns associated with Tier II soil volumes that may be derived during dump excavation, it is recommended that the larger dump areas at the beach be the initial focus, with completion of as much excavation as possible during season two to allow for transport of additional containers to site for season three, if required. For this same reason, it is desirable to complete excavation of known Tier II soil areas during season two.

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1.0 Introduction

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

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

- Contaminated soil areas;
- Surface water and sediment quality;
- Building materials and demolition requirements, including identification of hazardous materials;
- Existing dumps (aided by the completion of a geophysical survey of the area);
- Barrel contents;
- Areas of surface debris;
- Any other potentially hazardous materials on-site other than barrels or demolition items;
- The sources and volume of non-hazardous waste materials;
- Site access roads, barge landing areas, and airstrip;
- Borrow sources for use during clean-up activities;
- Traditional knowledge regarding past and present land use of the site from the elders of the nearby communities.

The results of the Phase III ESA have been reported previously (UMA 2007).

This report discusses remedial options for site issues identified during the Phase III ESA, and provides recommendations for the preferred option. Where different remedial options have been evaluated, a cost estimate comparing the options has been prepared. These estimates have been appended to the Class C cost estimate for overall site remediation, which is provided under separate cover from this report. This report has been structured as follows:

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

Figures are presented in Appendix A.

2.0 Background

2.1 Site Location and History

PIN-B, Clifton Point was constructed as an Intermediate DEW Line site in 1957 by the Department of National Defence (DND). The station was abandoned as part of the DEW Line system in 1963, at which time site responsibility was assumed by INAC. The site is located in Nunavut, at 69°13' N, 118° 38' W, along the coast of the Amundsen Gulf, near the discharge of the Dolphin and Union Strait. The nearest communities are Kugluktuk, located approximately 200 km to the southeast and Paulatuk, located approximately 220 km to the west in the Northwest Territories (NWT). The nearest air charter bases are located in Cambridge Bay, 550 km to the east on Victoria Island and Yellowknife, located approximately 800 km to the south. Only smaller planes, such as DCH-6 Twin Otter, Embraer Bandeirante ("Bandit"), and possibly Beechcraft King Air are available out of Cambridge Bay, while in Yellowknife there are multiple size aircrafts available, including large aircrafts such as DC-3, DC-4, DCH-5, and Hercules.

The PIN-B station area is comprised of a five-module building train (the "module train"), a warehouse, a garage, a small house for Inuit staff (the "Inuit House"), a petroleum, oil and lubricants (POL) storage facility with associated distribution system, and a downed radar tower. In addition to the Station facilities, a cargo beaching area was constructed at the beach area. A second POL storage facility was located at the beach, in the vicinity of the beach (cargo) landing area. Two airstrips were constructed at the site. The primary (operational) airstrip is approximately 1 km long and is located south of the beach area. The second (abandoned) airstrip is about 300 m long and located a short distance northwest of the primary airstrip. Gravel roads were built linking the airstrip, water supply lake and beach landing area to the station area. A small construction camp was erected during building of site facilities, but was demolished once site construction was completed. The former camp of an Inuit family is located approximately 1.5 km southeast of the PIN-B site; the demolition and clean-up of this camp is to be included as part of the PIN-B site remediation.

2.2 Remedial Protocols and Criteria

The remedial recommendations provided herein are based primarily on the INAC Abandoned Military Site Remediation Protocol (AMSRP) (INAC 2007). This protocol provides assessment and remedial guidelines for dumps, disposal of barrel contents, and provides clean-up criteria for contaminated soil. There are no criteria for the classification of hazardous waste at federal sites, except for materials regulated under the Canadian Environmental Protection Act (CEPA). For this site, the only hazardous waste elements regulated under CEPA are those containing polychlorinated biphenyls (PCBs). The classification and remedial recommendations for other hazardous waste items at the site has been based on the Transportation of Dangerous Goods (TDG) Regulations and the Nunavut/NWT Guideline for the General Management of Hazardous Waste (1998), under the territorial Environmental Protection Act (R.S.N.W.T 1998 c.E-7). More detailed information related to remedial guidelines or requirements under the sources noted above is provided in the issue-specific sections below.

2.3 Site Specific Remedial Considerations

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

2.3.1 Off-Site Access

The site is located along the coast. It is clear from historical air photo review and site layout along the coastal (beach) area that there was barge access to the site, and the landing area appears to have been northwest of the Beach POL pad. Information obtained from a local elder whose family lived at the nearby Inuit Camp during site operation indicates that barge access to the site was never a problem during operation. The ground at the beach is comprised of generally well-drained, coarse-grained beach deposits, which are competent and are not expected to pose a problem for beaching or using heavy equipment in the area for movement of materials upon landing. The area to the southeast of the Beach POL pad however, has softer conditions due to discharge of groundwater and is therefore not a preferred landing area. The depth of water in the near shore environment could unfortunately not be assessed from air photo review because of ice presence at the time the photos were taken. However, no significant change in the position of shoreline due to tidal influences was noted during the 2007 investigation, suggesting that the near shore water conditions are not excessively shallow. Tidal prediction rates for August and September were available for two nearby sites - Bernard Harbour to the east and Tysoe Point to the west - from the Department of Fisheries and Oceans (DFO) website. For this time of year, tidal fluctuations are in the order of approximately 0.5 m.

Barge refueling of beach POL tanks was observed during our site investigation in 2003 at the DND PIN-2 Cape Young site, located 50 miles to the east. No difficulties were observed, but there was no actual beaching completed at that time, since the refueling was completed via a fuel line from the barge and no other materials were being off-loaded. A review of air photos from the PIN-2 site taken in 1985; however, does not show any dredging of the nearshore sediments in the area of continued barge landing for the operation of the operational North Warning System PIN-2 site. Based on the above information, barge landing at Clifton Point is not expected to pose a significant challenge.

There are no nearby mining operations, and therefore, no potential for independent development of an ice road that would be of use for contractor mobilization. Because of the long distance from any communities, combined with the availability of barge access, it is considered unlikely that overland mobilization (i.e. cat train) would be considered a viable option for contractor mobilization. It has therefore been assumed for the preparation of this RAP, and its associated cost estimate, that primary access to the site for mobilization and demobilization of contractor equipment and supplies during remediation will be via barge.

An inspection of the primary airstrip at the site was completed during the 2007 Phase III ESA. The airstrip is about 1,000 m long. The granular materials at the airstrip are well compacted. There are no significant erosion channels and rutting is minimal. Small mounds of vegetation have become established on the entire surface of the airstrip. These mounds are typically 300 mm across and mounded up to about 75 mm in some cases.

The Arctic SunWest Chief Pilot present during the 2007 site assessment considered the airstrip to be in good condition with the exception of the vegetation mounds. Landing a Twin Otter did not present any difficulties and he concluded that it was possible to land a Buffalo (DCH-5) should it be necessary for demobilization from the site. A sample was collected for CBR testing to confirm the suitability of the airstrip for larger and heavier aircraft. Results of the CBR testing indicate a very competent gravel surfacing and subgrade material, even in a saturated condition. The testing suggests that all of the following aircrafts (with full loads) would be able to use the airstrip during dry conditions at the site: DC-3, DC-4, Hercules C-130, Otter DHC-3, Twin Otter DHC-6, Shorts Skyvan, and Buffalo DHC-5. Under saturated conditions, all of the noted aircrafts would still be able to land, with the exception of the Hercules C-130. However, because the testing did not consider the internal stability of the rounded (pit run) granular fill and potential for rutting, it is nonetheless considered essential that the airstrip be inspected by aircraft crews familiar with the necessary gravel surfacing requirements prior to its use, in particular for aircraft the size and weight of a Hercules C-130.

For the purposes of this RAP, it has therefore been assumed that aircraft access to the site will not be an issue, especially given the assumption that the primary mobilization of contractor equipment will be via barge.

2.3.2 On-Site Access

There are a number of gravel roads throughout the site connecting the Station Area with the Airstrip and Beach Areas. There are also several trails where vehicular and tracked equipment have traveled in the past. All of the major roadways and significant trails were surveyed during the site investigation. The gravel roads are well elevated and in good condition with the exception of localized areas on the main access road where bears burrowing for ground squirrels have created a low spots in the road surface. There are only two culverts crossing the access roads; one on the main access road and the second on the road into the Beach Dump Area.

The roads are in good condition for heavy equipment; although, regular grading will be required. The low areas where bear burrows are present will require infilling prior to gaining access from the airstrip to the Station Area. The top width of the roads varies from 3.7 to 6 m with an average of about 5.0 m. These widths are satisfactory for single lane traffic. The construction of widened or pull out sections will be required for two way heavy equipment traffic. The existing trails would require upgrading if considered for hauling routes. Small extensions of the existing road system will be required to access some of the other site areas; these are noted in detailed discussions below.

Access for trucks and heavy equipment e.g. excavator to the Inuit Camp east of the site will be required. It is unlikely that an overland route to the Station Area will be possible without construction of a haul road, the development of which will require numerous low areas to be bridged. Access along the beach between the Beach POL and Inuit Camp with tracked equipment is also possible although there are a number of shallow flowing creeks that would have to be crossed. Truck access along the beach may be difficult and best attempted later in the season when low creek flows would be expected. The preferred approach may be to use only track mounted equipment along the beach and skid demolition material to the non-hazardous waste landfill or to a staging area for containerization (PAP). If an overland route is contemplated, it should follow the existing trail between the Station and the Inuit Camp to minimize damage to undisturbed tundra.

2.3.3 Environmental Considerations

Information regarding traditional knowledge and land use of the site was obtained during the site investigation from residents of Kugluktuk. People interviewed included Logon Pigalak (site assessment bear monitor from Kugluktuk), George Taptuna (site assessment equipment operator) and elders John and Ida Kapakatoak. Mr. Kapakatoak and his family had lived in the Inuit Camp at the site between 1955 and 1964, while Mrs. Kapakatoak's family had lived nearby in the Cape Young area in the same time frame. The following information was recorded regarding on-site receptors and traditional land use of the area. Most of the information was provided by Mr. Kapakatoak.

- Fishing is very poor at the site. No fishing was done along the coast. No lakes at the PIN-B site have fish in them. Fish were only found in a lake much further south of the site. The big lake between the station and airstrip is relatively shallow, with an estimated depth of five feet and was thought to freeze to the bottom in winter.
- It was stated by all four locals interviewed that no one from Kugluktuk came by the site to hunt or fish anymore because it is too far.
- Sometimes the Rangers from Paulatuk pass by the site in winter to check on the Short Range Radar Site at PIN-2, and overnight at the Inuit house at PIN-B.
- Caribou are typically gone from the area by October, and the area is generally poor for hunting in winter; the only land fauna remaining during winter were foxes, and the only viable hunting was for seals off-shore.

During the 2007 Phase III ESA investigation, the following fauna (or evidence of their presence) were observed:

- | | |
|--------------------|--|
| • Grizzly bears | • Rough-legged hawks |
| • Caribou | • Tundra swans |
| • Arctic foxes | • Loons (Arctic) |
| • Ground squirrels | • Plovers (semi-palpated) |
| • Lemmings | • Bowhead whales (remains along shoreline) |

During the 2007 assessment in mid to late-August, large flocks of snow geese passed over the site, but they did not appear to land in the vicinity. In addition to the bird species noted above, the 1994 ESG assessment also noted the presence of common eider, lesser golden plover, savannah sparrow, lapland longspur, and snow bunting.

Vegetation at the site is moderate to abundant in undisturbed areas and consists primarily of grasses and sedges, with willows and some flowering plants also present. A detailed list of vegetation species identified at the PIN-B site was completed as part of the 1994 Phase II ESG (ESG 1995). More specific information related to vegetative cover is described in area-specific discussion below.

2.3.4 Geology/Geomorphology/Hydrology

Bedrock at the Clifton Point Area is comprised of limestone and dolostone. Outcrops are present along the beach area, north of the Beach Dump, and south of the Beach POL pad. Limestone observed in this area was vuggy and weathered.

The primary soil type at the Clifton Point site is comprised of stratified sand and gravel - beach deposits derived from marine re-working of till. Soil at lower elevations off the beach ridges has not been subjected to the same sort of washing and is generally finer-grained, comprised of sand and silt grading to silt and clay at depth. The effects of frost action are prevalent across the site, with well-developed frost wedges within the beach ridge areas near the Station, and frost boils in the finer-grained soil areas off the beach ridges.

There are several shallow lakes on inland beach terraces at the site. Regional overland drainage from the site is generally towards the Amundsen Gulf to the northeast. Approaching the existing shoreline, surface drainage becomes concentrated into creeks flowing within well-developed gullies cutting through the lower-elevation beach deposits at several locations southeast of the site.

The overall grade for the site is described as gentle. However, since the site terrain consists of a series of beach terraces and strands grading towards the existing shoreline, there are localized areas of drops in elevation where the grade would be considered as moderate.

Based on the results of the 2007 investigation, there are no areas of site activities exhibiting signs of erosion as a result of existing site drainage. None of the soil types identified are particularly prone to erosion. However, areas near the coast may be subject to future erosion by wave action in the event of sea level rise with global warming. Any borrow development in the vicinity of the beach or airstrip areas may require drainage control to prevent sediment loading to the coastal area. Areas identified for new development (borrow and potential new landfill construction) in the Station Area are not considered at risk of any significant erosion.

2.3.5 Archaeological Features

An on-site archaeological investigation of the site was completed by Golder Associates in conjunction with the UMA Phase III ESA during the early stages of the site work. The purpose of the study was to identify heritage features needing protection or avoidance during site remedial activities. As such, the field inspection focused on locations identified for remediation or potential new development areas (borrow areas and proposed landfill/landfarm construction locations). These locations were provided by UMA at the start of the field program and were based on a review of previous site assessment data and terrain evaluation regarding potential borrow sources or new landfill development sites. Any changes to these initial locations or the identification of new areas were communicated to the archaeologist while he was still on-site.

A review of the existing database of archaeological sites, maintained by the Nunavut Department of Culture, Language, Elders and Youth (CLEY), was completed by Golder prior to site work. This review indicated that two archaeological sites (NhPt-1 and -2) had previously been recorded in the site vicinity. During the course of the field program, a new site - PIN-B 1 - was also identified. The features are described below, with information regarding the need for mitigative measures during site clean-up. All information below is based on the draft report submitted by Golder (2008).

- **NhPt-1:** This site is located on the edge of a stream where it discharges into the Dolphin and Union Strait. The site was recorded as a campsite with both prehistoric and historic components. Features include cabins, tent rings, and a beached schooner (the "Gertrude E"). The location of these features is shown on Figure 2 in Appendix A. Only one tent ring was identified during the 2007 inspection, and assessed to date prior to the occupation of the cabins. Information obtained from elder John Kapakatoak indicated that his mother had built the cabins and their family lived there from approximately 1955 to 1964. The cabins were built using information salvaged from the DEW Line site. An assessment of hazardous materials at the cabins was completed by UMA, and indicated that there was asbestos present and that cabins had been painted using PCB-amended paint. Because of the hazardous materials present, it has been recommended that the cabins be demolished as part of the PIN-B site clean-up. Approval for their demolition was obtained from Mr. Kapakatoak, given the poor condition of the buildings and that his family no longer uses the camp. In advance of the demolition of the camp buildings and removal of associated surface debris, it is recommended that mapping and detailed documentation of features be completed. Systematic shovel testing should be completed to determine whether there are precontact features in the affected areas.
- **NhPt-2:** This site is situated on a bedrock ridge above the beach, approximately 820 m northeast of the north end of the airstrip. It is prehistoric in age and consists of three tent rings and a possible blind. The tent rings are complete, with some rocks buried in moss and wind-blown sediments. The features are in close to an area with surface debris requiring pick-up and a Tier II contaminated soil area requiring excavation. One tent ring is particularly close - within 15 m of the identified Tier II area. It is recommended that barricades be erected around the feature to delineate them for avoidance prior to commencing remedial activity in the area.

- PIN-B 1: This previously unrecorded feature is located approximately 125 m east-northeast of the airstrip. It is comprised of a large elongated stone cairn (3.4 m x 2.3 m), several tiers of rocks thick, and has a few associated lithic flakes and machine cut planks. The rocks are covered in a significant amount of lichen, with the lowest level of rocks well buried. The cairn is visible in a 1964 air photo, but not clearly apparent in a 1950 one. Community members from Kugluktuk were asked about the cairn, but did not recall it from the time of site operation. It is suspected that the cairn is a grave site. There is no remedial activity planned for this general area, so it is not expected that the feature will be disturbed. However, it is in a potentially high traffic area during remediation, so will likely require flagging-off prior to commencement of site remedial activities to ensure avoidance.

2.3.6 Site Assessment Information

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

- UMA, October 2007, Draft Phase III Environmental Assessment Report, PIN-B Clifton Point DEW Line Site, prepared for Public Works and Government Services Canada;

ESG, March 1995 - Environmental Study of Abandoned DEW Line Sites: One Auxiliary and Eight Intermediate Sites in the Canadian Arctic, prepared for Department of National Defence.

3.0 Dump Remediation

3.1 Dump Remedial Protocol

The assessment of dumps at PIN-B Clifton Point was completed with the goal of classifying the dumps according to the three categories specified under the INAC Abandoned Military Site Remediation Protocol:

- **Class A:** buried debris is located in an unstable, high erosion location. Remediation will involve relocation of dump contents to an engineered landfill.
- **Class B:** the dump is in a suitable, stable location, but there is evidence of contaminant migration. Remedial solutions include the installation of an engineered containment system, or relocation, whichever is deemed more cost effective.
- **Class C:** the dump is in a suitable, stable location, and there is no evidence of contaminant migration. In such cases, the debris may be left in place, with the placement of additional granular cover as required.

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

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

3.1.1 Excavation/Relocation (Class A Dump)

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

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

- Tier II soil: 20%
- Tier I soil: 15%
- Non-hazardous debris: 20%
- Hazardous debris: 2%
- Clean fill: 43%

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

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

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

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

- Tier II soil: 15%
- Tier I soil: 10%
- Non-hazardous debris: 20%
- Hazardous debris: 1%
- Clean fill: 54%

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

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

3.1.2 Leachate Containment (Class B Dump)

The typical design that has been used for leachate containment at existing DEW Line dumps involves the excavation of a trench just beyond the limits of the buried debris. The trench extends into either ice rich permafrost or saturated ground, typically at a depth of about 1.5 m at the PIN-B site. A geosynthetic liner system is placed extending from the base of the trench over the dump area. The trench is then backfilled with low-permeability (Type 4) granular fill which may also extend upslope of the trench. Well graded sand and gravel (Type 2 fill) is placed and compacted over the surface to a thickness that will promote permafrost aggradation through the key trench and into the landfill contents. A schematic diagram showing a typical leachate containment system is provided in Figure 16 in Appendix A. The primary long-term containment system is the saturated granular fill. Once the material freezes, it becomes a low-permeable containment barrier. The geosynthetic liner provides essential short-term containment until permafrost aggrades into the landfill and continues to provide longer-term containment following freezeback.

Geothermal modelling completed for the remedial design at the nearby PIN-2 Cape Young site, where terrain and vegetative cover is similar, specified a design thickness of 4.0 m of Type 2 fill for freezeback of contents. Geothermal modelling considered soil type, soil thermal properties, presence or absence of insulating cover (vegetation or snow drift), measured ground temperatures at the site or at nearby sites, measured air temperature and climatic data (from 1959-1999 from Environment Canada), an estimated 1 in 100 warm year air temperatures, and an estimate of the effect of global warming. The effect of global warming was estimated using the most recently published data summarizing global warming rate estimates for Arctic environments (ACIA 2005). The design cover thickness specified for PIN-2 has been used for consideration of remedial options at PIN-B.

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

Because of the complicated construction requirements for the contractor, and the need for long-term monitoring, this remedial option is oftentimes not cost-effective, when compared to excavation, for smaller dumps. For this reason, the option of excavation has also been evaluated in discussions below for dumps classified as Class B.

3.1.3 Regrading (Class C Dump)

For dumps located in a geotechnically stable location, with no evidence of contaminant migration, the recommended remedial action is regrading with the placement of additional granular cover. It is typically recommended that the extent of regrading be extended slightly beyond the extent of the identified limits of debris (a 2 m offset has been used historically). The granular fill cover placed over the dump should be well-graded (Type 2), erosion resistant, and well-compacted to limit infiltration of water. Where there is the potential for erosion from surface drainage, it is typical to strategically place armouring material (Type 1 granular fill). The placement of fill should be configured in such a way so as not to promote ponding of water, and graded to conform to surrounding terrain. Typically, a fill thickness of 0.75 m has been used, but for smaller areas, with no appreciable topographic expression, a smaller fill thickness of 0.5 m has been applied.

3.2 Station West Dump (Figure 5)

The Station West Dump is located approximately 500 m northwest of the Station, along the west side of the main access road to the airstrip. Two lobes of buried debris were identified - Lobe A and Lobe B. Lobe A is the primary lobe, comprising the majority of buried debris, with an area of 3,150 m². Lobe B is a small lobe immediately up-gradient of Lobe A, with an area of 400 m².

The debris has been buried along the edge of a former beach ridge. The northern portion of Lobe A has a well-defined toe located at the base of the beach ridge, while the southern part of the lobe has spotty buried debris extending onto the low-lying tundra off the ridge and is not as well-defined topographically. Lobe B has no topographic expression. Buried debris exposure is primarily along the toe of Lobe A; cover over the majority of the lobe is good. No debris exposure was noted at Lobe B. An area of scattered battery and copper surface debris is present at the southern margin of Lobe A.

Substrate for most of the lobe is comprised of well-drained sand and gravel beach deposits. Down-gradient of the beach deposit, the soil consists of low-lying, wet, silt and sand grading to silt and clay at depth, with well-developed frost boils present. Ponded water is common. The average grade across the dump is approximately 6% towards the west-southwest. No erosion was noted.

Vegetative cover along the beach ridge is sparse to moderate. Off the beach ridge, vegetation is much more lush, at 100% coverage, with an organic mat at surface. A fairly large lake is located approximately 150 m down-gradient of the dump. Loons and tundra swans were noted at the lake during the 2007 investigation; although, information from the local elder who lived at the site indicated that the lake does not contain fish. Nesting plovers were identified up-gradient of the dump, across the road. Ground squirrel burrows were present within the dump, along with signs of grizzly bear activity evidenced by burrowing around ground squirrel holes.

The environmental investigation of the dump did not indicate that it was leaching contaminants. Soil samples collected at the location of the surficial battery and copper debris at the southern edge of the dump identified localized Tier II lead contamination in the vicinity of this debris, with an estimated extent of 42 m², to an estimated depth of 0.5 m. This contaminated soil area is just outside of the limits of buried debris, therefore excavation of contaminated soil is not expected to encounter dump debris.

Based on the results of the 2007 investigation, the Station West Dump is considered a Class C landfill, with a recommendation for regrading. It is felt that this dump is sufficiently removed from the nearby lake (approximately 100 m down-gradient at its closest point) so as not to be considered an environmental risk, particularly since no evidence of contaminant migration was noted. The Tier II soil must be excavated prior to regrading. There are no special considerations with respect to regrading at this dump, beyond the typical requirements noted in Section 3.1.3.

3.3 Construction Camp Dump A (Figure 6)

The Construction Camp Dump A area is located 350 m northwest of the station, off the northern edge of the main barrel storage pad for the station. The geophysical survey identified a dump size of 320 m².

Debris was buried off the edge of the barrel storage pad where the substrate is primarily sand. A fairly well-developed drainage channel towards the east is present approximately 5 m down-gradient of the toe. Water was present at or slightly below grade in shallow (up to 0.6 m) test pits excavated down-gradient of the dump, while no groundwater was encountered up-gradient. Grade across the dump is approximately 6%. No evidence of erosion was noted. The environmental investigation did not indicate contaminant migration from the dump. The Construction Camp Dump A was therefore assessed as a Class C dump, with a recommended remedial action of regrading.

Observations from 2007 indicate that the down-gradient drainage channel does not convey a significant volume of water. However, if the dump is regraded to a fill thickness of 0.75 m (which is recommended), with an offset of two metres, then the toe of the granular fill may intersect the drainage channel. It is therefore recommended that armouring be put in place along the toe. It should be noted that there are some pieces of debris (cable and pipe) exposed at this dump that may be more feasible to cut at surface rather than attempting complete removal prior to regrading.

Construction Camp Dump B (Figure 7)

The Construction Camp Dump B is located along the northeastern edge of the former Construction Camp Area, approximately 500 m north of the Station. Access is via the road to the Construction Camp from the Station, although a road extension will be required to reach the dump. A geophysical survey identified a dump size of 230 m².

Debris is buried within a low-lying, wet area, with sandy, silty soil. Ponded water is present up-gradient and down-gradient of the dump. The overall area is within a broad drainage area migrating towards the shallow lake between the Station and airstrip. Drainage channels are present along the north and south edges of the dump, and one drainage channel cuts through the centre of the dump. Grade is gentle to flat, at approximately 3%. No erosion was noted at the dump, although this is likely due to the surface protection offered by the relatively lush vegetative cover. The drainage channel cutting through the dump appears to be in an area with no debris burial.

The results of the 2007 environmental investigation suggest that no contaminant migration is occurring from the dump. Geotechnically, the dump also appears stable, despite the drainage conditions in the area. For these reasons, it would be classified as a Class C dump. However, because of the dump position within a drainage basin receiving significant water, with well-developed drainage channels passing adjacent or through the area, the potential for erosion is considered high in the event of regrading, where the existing vegetated surface (which is likely providing existing stability) would be covered with new granular fill. For this reason, the classification of this dump has been upgraded to a Class A, and it is recommended that it be excavated. The estimated depth of debris is 0.5 m, with an excavation volume of approximately 120 m³.

Up-gradient drainage control will be required for the excavation of this dump. Because no contamination or hazardous waste materials were observed at the dump, the estimated excavation component breakdown has been assumed as the average values: 15% Tier II, 10% Tier I, 20% non-hazardous debris, 54% clean fill, with a hazardous waste allowance of 1%.

3.5 Construction Camp Dump C (Figure 7)

The Construction Camp Dump C is located east of the former Construction Camp, approximately 350 m north of the Station. There is no direct road access to the area and remediation will require construction of a road. The dump is approximately 230 m east of the Construction Camp access road. The dump size is estimated as 180 m².

Substrate at the dump area is primarily composed of sand with cobbles and boulders. An organic mat of approximately 0.1 m was present. In shallow test pits surrounding the dump, groundwater seepage was encountered at 0.4-0.5 m. The overall area is flat, with an estimated grade of 2%. There is no evidence of erosion at the dump.

The shallow lake between the Station and airstrip (described in Section 2.3.3) is the aquatic receptor for this dump. The high water mark for the lake is 20 m down-gradient from the toe of the dump. No animal burrows were identified at the dump, likely because of soil saturation levels.

The geotechnical and environmental data collected during the 2007 investigation indicate that the dump is stable and not leaching contaminants, which would classify it as a Class C dump. However because of its proximity to the lake, it is nonetheless recommended that the dump be excavated. The estimated depth of debris is 0.5 m, for an excavation volume of 90 m³. The estimated excavation component breakdown has been assumed as the average values: 15% Tier II, 10% Tier I, 20% non-hazardous debris, 54% clean fill, with a hazardous waste allowance of 1%.

3.6 Beach Dump (Figure 10)

The Beach Dump is located approximately 230 m east-northeast of the north end of the airstrip. The results of the 2007 ESA identified an area of 2,550 m².

The debris has been buried along the slope of a former beach ridge. The existing ground has apparently been excavated for debris placement, with stockpiling of soil along the northeastern limit. The edge of ground excavation is well-defined along the down-gradient toe by the position of this stockpiled soil. Some debris was noted within the stockpiled soil near the south end of the dump, however the geophysical survey indicated that debris is not present within this mounded soil area along the northern half of the dump area. Some ponded water, estimated as approximately 0.5 m deep, is present between the main beach ridge to the east, and the stockpiled soil to the west.

Substrate consists of gravel with sand and cobbles. No groundwater was encountered in shallow test pits excavated close to the dump perimeter, but groundwater seepage was noted in the second row of down-gradient samples at a depth varying between 0.4 to 0.5 m. The average grade across the area is approximately 8%. The dump is located on a former beach deposit located some 3 m higher than the existing water level, and approximately 50 m away from the marine storm surge line. No evidence of erosion was noted in 2007.

The results of the 2007 ESA showed elevated zinc levels down-gradient of the dump at three locations along the southeast edge. The elevated zinc levels were present in the first row of samples collected near the dump toe, and in the second row of samples collected closer to the ocean shoreline. Contaminant levels decreased in the second row of samples which provided some confirmation that the dump was the source. This was therefore evaluated as evidence of contaminant migration.

The ocean is located approximately 70 m away from the existing dump toe. It is understood from the traditional knowledge survey that seals frequent the area, but fishing conditions are not good. Bowhead whale remains were identified along the shoreline indicating that they also pass through the area. Some ground squirrel burrows were noted in the area, with grizzly bear burrowing around the holes. Bear tracks were also noted along the beach. Because of the evidence of contaminant migration, the Beach Dump has been classified as a Class B landfill, requiring either leachate containment or excavation. While not a criterion according to the INAC protocol, the close proximity of the ocean has also been considered as a compelling argument to add to this classification.

Because of its relatively small size, a cost comparison has been completed comparing the options of leachate containment versus excavation for this dump. Assumptions used for this cost estimate are as follows:

- A fill thickness of 4 m is required to achieve and maintain frozen conditions over the long term, consistent with geothermal modelling conducted at the nearby PIN-2 Cape Young site;
- A slope configuration of 4H:1V will be used for final, overall slope;
- Landfill monitoring requirements will be the similar to DND DEW Line sites;
- The dump excavation volume (2,570 m³) has been estimated assuming a conical frustum-type configuration for debris buried along the slope, while the debris volume buried within the linear mounded area along the east side has been estimated by integration from the detailed topographic survey, using the area of horizontal slices of equal elevation from the detailed topographic survey; and

- The component breakdown for excavation waste stream has been estimated using the average values identified above.

The cost estimate indicates that excavation will be significantly less costly than leachate containment. In addition to cost, however, the geotechnical issues related to long term stability with the leachate containment design have also been considered.

While the dump is currently considered geotechnically stable because of distance and elevation difference from the existing high water mark, this will not necessarily be the case for the final dump configuration with a leachate containment system put in place. In particular, based on an approximate down-gradient key trench position, the required fill thickness to achieve freezeback, and a final slope configuration of 4H:1V, the final toe position for this dump will be located approximately 30 m from and about 0.75 to 1.0 m higher than the high water mark. With the high potential for sea level rise associated with global warming, an elevation difference of 1 m or less is considered at risk for future erosion. Effective monitoring may also be problematic, as monitoring wells will be located in close proximity to the high water mark, where groundwater chemistry will be influenced by sea water. Soil in this area is primarily gravel and cobbles, which cannot be properly characterized for contaminant levels; contaminants are unlikely to sorb to this material, and laboratories typically cannot perform proper contaminant analyses on material this coarse.

Based on all of the considerations noted above, it is recommended that the Beach Dump be excavated.

3.7 Beach South Dump A (Figure 9)

The Beach Dump South A is located approximately 120 m southeast of the Beach Dump. The 2007 investigation identified a dump size of 3,930 m².

As with the Beach Dump, debris has been buried along the edge of a beach ridge. Buried debris exposure is little to moderate. There are some small lush, wet areas within the limits of the dump and areas of groundwater discharge along the north edge. Receptors are the same as for the Beach Dump.

Substrate consists of sand and gravel with cobbles. Groundwater was encountered in the up-gradient test pit at 0.5 m. No groundwater was encountered in the first row of test pits away from the dump toe, but was present in the second row of test pits near surface. The average grade across the dump is approximately 8%. No evidence of erosion was noted. The toe is located approximately 40 m from the high water mark and is at an elevation 2.5 m higher. The shoreline is approximately 60 m from the toe.

Some battery and copper debris is present within the dump near the north edge. Tier II lead and copper contamination was detected in this area. The size of the contaminated area is 82 m², to a depth of 0.3 m.

A review of contaminant levels for down-gradient samples yielded several samples that had elevated levels of metal impacts. This information suggests that there has been contaminant migration from the dump. The dump proximity to the shoreline further elevates the environmental risk associated with the suggested contaminant migration. Based on these factors, the dump has been classified as a Class B dump, requiring either leachate containment or excavation.

Because of its relatively small size, a cost comparison has been completed comparing the options of leachate containment versus excavation for this dump. The same assumptions used for the Beach Dump cost estimate leachate containment costing have been applied to the Beach Dump South A. The dump excavation volume is estimated as 1,620 m³ (also derived from assuming a conical frustum-type configuration for debris buried along the slope), and the component breakdown has assumed the average percentages identified above.

The cost estimate indicates that excavation will be significantly less costly than leachate containment. In addition to cost, however, the geotechnical issues related to long term stability with the leachate containment design have also been considered.

Similar to the Beach Dump, when the final toe position for the implementation of a leachate containment system, there are concerns related to long-term geotechnical stability. At the worst location, the estimated final toe position with leachate containment is located approximately 20 m from the high water mark, at an elevation of only 0.75 m higher than the storm surge limit. This position is considered at risk for long term geotechnical stability. The same issues related to effective long term monitoring that were discussed for the Beach Dump also apply here.

Based on the considerations noted above, it is recommended that the Beach Dump South A be excavated.

3.8 Beach South Dump B (Figure 9)

The Beach Dump South B is located immediately south of the Beach Dump South A. The estimated size of the dump is 3,170 m².

The position of debris burial is the same as for the other Beach Dumps, off the edge of the beach ridge. Debris burial at this dump appears spotty, particularly along the eastern edge, and there is no well-defined toe. Substrate is comprised of sand and gravel with cobbles. Seepage was observed into several test pits at 0.6 m depth. Average grade is 8%. No evidence of erosion was identified. The toe of the dump is located within 15 m of the high water mark - at an elevation approximately 0.8 m higher - and 30 m from the shoreline. Receptors are the same as those described for the Beach Dump.

The results of the environmental investigation did not suggest that this dump is leaching. Samples were collected in the vicinity of copper debris, but no concentrations above criteria were detected.

While the dump does not appear be leaching, because of its proximity to the high water mark, it is considered at potential risk for erosion, particularly in the long term in the event of sea level rise. It is therefore considered a Class A landfill, and it is recommended that the dump be excavated.

The dump excavation volume has been estimated assuming a conical frustum-type configuration for debris buried along the slope. The estimated volume for excavation is 2,150 m³, with an excavation depth of 1.0 m. Because debris appeared to be spotty at this dump and because no contaminated soil or evidence of contaminant migration was identified, the estimated component breakdown has been modified from the average values. The following waste stream breakdown has been assumed: 10% Tier II, 5% Tier I, 15% debris, 69% clean fill, with a 1% hazardous waste allowance.

3.9 Beach POL Buried Debris (Figure 8)

There is an area where a large number of surficial or partially buried barrels are located along the toe of the north edge of the POL pad. The barrels appear to have been placed along the edge of the POL pad, with subsequent burial by wind action. It is expected that some completely buried barrels are also present at that location, but a geophysical survey to delineate the area would not have been useful because of the prevalence of overlying surficial barrels. The estimated size of the area is 100 m². The visible barrels are within the limits of an area identified for contaminated soil excavation. There is the possibility, however, that the lateral extent of the barrels at depth may extend beyond the limits of the contaminated soil excavation. The contaminated soil excavation is recommended to a depth of 1.2 m. Therefore, it is expected that the majority of buried barrels will be excavated during the course of contaminated soil excavation. Because the barrels were mostly partially buried and could not be moved, an assessment of potential contents was not feasible. The 1994 ESG report did note hydrocarbon product in soil in the vicinity of the barrels, suggesting that the barrels may have contents.

The barrels are located within approximately 40 m of the coastal shoreline. It is therefore recommended that all buried barrels at this location be excavated. Any barrels excavated with contents will require assessment according to the DLCU Barrel Protocol (INAC 2007). Because this excavation is taking place within a documented hydrocarbon-impacted area, no segregation and testing of soil is considered required, aside from that already required under the INAC AMSRP confirmatory testing for contaminated soils.

3.10 Beach Inuit Camp Meat Cache (Figure 2)

While this location does not constitute a dump, the remedial recommendations for this area are consistent with dump remedial requirements. The area comprises a mounded area, approximately 1.5 above surrounding grade, that was a meat cache "freezer," constructed by the Inuit living at the camp, with assistance from a DEW Line station staff member using a dozer. A compartment exists within the earthen mound, created and stabilized with the use of empty barrels and wood. A cavity is present, with an opening at surface. The opening forms a physical hazard and the cavity should be in-filled and the opening closed-off. Some additional fill placement is recommended along the surface of this area following in-filling to account for settlement. An estimated 1 m³ of fill will be required to fill in the cavity. A fill thickness of 0.5 m is recommended for placement over an overall area of 125 m².

3.11 West Beach POL Buried Debris (Figure 8)

The West Beach POL Buried Debris consists of a small, rectangular mound of buried debris located approximately 100 m west of the Beach POL pad. Geophysics was not completed at the location; debris limits were identified visually. The size is 22 m², and the debris mound is raised 0.5 m or less above surrounding grade, which is flat. Debris noted includes rusted paint cans, small drums, and wood. No environmental investigation was completed because of its small size and limited potential environmental impact. The debris is considered primarily an aesthetic concern.

Because of its small size and limited topographic expression, it is recommended that the area be regraded with the placement of 0.5 m of granular fill, with an offset of only 1 m from the edge of the debris.

4.0 Hazardous Waste Remediation

4.1 Protocols and Regulatory Requirements

The Abandoned Military Site Remediation Protocol (AMSRP 2007) defines hazardous waste materials as any materials, which are designated as "hazardous" under Nunavut Territorial or Federal legislation; or as "dangerous goods" under the Transportation of Dangerous Goods Act (TDGA) and regulations.

As part of the assessment of PIN-B Clifton Point, an inventory of hazardous waste materials was compiled and supplemented with sampling during the 2007 site investigation. Various hazardous waste materials identified during the survey included: demolition and site debris consisting of asbestos and PCB/lead amended painted materials, batteries, barrel contents and electrical components and miscellaneous chemicals.

The storage, treatment, and destruction of PCB materials in concentrations of greater than 50 mg/kg are regulated under the Chlorobiphenyls Regulations (PCBs) which are governed by the Canadian Environmental Protection Act (CEPA).

In addition to these regulations, stakeholders including INAC, DND, Environment Canada and Health Canada recognized that it is technically feasible to landfill demolition debris coated with PCB-amended paint in an environmentally sound safe manner (EC 1999). PCBs in paints, affixed to a solid substrate, leach at a very slow rate and, as such, do not present a threat to the environment if properly contained. Accordingly, calculations factoring in the mass of the painted substrate were completed to determine the total PCB concentration for the painted substrate as a whole. Painted substrate with total concentrations greater than 50 mg/kg are deemed hazardous and regulated by CEPA.

Where materials are not regulated under CEPA, classification of hazardous waste defaults to federal TDG Act and Regulation under Guideline for the General Management of Hazardous Waste. At PIN-B, materials classified under these regulations tend to be associated with painted materials where PCB concentrations are not a concern under CEPA, but where lead concentrations may be in excess of the leachate criterion stipulated under the TDG regulations.

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

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

4.2 Surface Debris Component

Surface debris inventory was completed by dividing the site into sections, with coverage of the areas completed on foot or by ATV. The limits of debris were identified by hand-held GPS by collecting waypoints at each transect where no further debris was visible, or in areas where debris was more sporadic, by collecting waypoints at debris locations. The GPS waypoints were downloaded onto the site plan drawing and the debris area perimeters were drawn by connecting the debris limit waypoints, or by grouping individual debris locations accordingly. The areas of surface debris created by these debris limits or groupings were assigned a numerical label. Along transects, debris types were noted, and volumes were tracked, with a total volume and description of all types of debris recorded for each debris area.

The survey identified approximately 4.5 m³ of hazardous site debris, including barrel contents, and demolition wastes consisting primarily of asbestos containing materials and batteries. A summary of hazardous waste components identified from the surface debris inventory is provided in Table 1 of Appendix C. Specifics related to barrel contents are discussed below.

4.3 Barrel Component

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

The assessment of barrels was completed at the same time as the inventory of surface debris; contents were identified as either aqueous or hydrocarbon-containing, and their classification was noted on the barrel with a paint marker. A representative number of samples were collected from the main barrel stockpiles, as well as other barrels at the site that were identified as having non-aqueous contents.

The 2007 inventory of barrels at PIN-B indicates there are 820 barrels on-site, including marker barrels. Of these, 124 were identified with aqueous contents, seven with mixed phase contents (oil or fuel and water), and 38 with hydrocarbon contents.

There are four primary barrel stockpiles at the site:

- Barrel Stockpile A is located on what appears to have been the main barrel storage area for the site, on a pad north of the Station. Thirty barrels are stockpiled; 19 have oil contents (mostly partial), 5 are a mix of oil and water, 2 are empty, 1 has only sludge remaining, and 3 have aqueous contents. Two samples - 910 and 911 - were collected from barrels with primarily oil contents. Both samples met incineration criteria.
- Barrel Stockpile B is located at the former Construction Camp. Seventy-eight barrels were present; 54 of these were empty and 24 had minimal aqueous contents, estimated to be the equivalent of one barrel volume. No samples were collected from this stockpile because the contents were all aqueous and the total volume was minimal.
- Barrel Stockpile C is located off the south end of the airstrip. The barrels were all painted orange, suggesting that they were marker barrels. There are 32 barrels present. All are quite rusted and most are rusted through in some locations. Eleven of the barrels had partial aqueous contents. Because it appeared that the barrels had been markers and because they were rusted through, it is likely that the aqueous contents are all from precipitation. No samples were therefore collected here.
- Barrel Stockpile D is located east of the airstrip, adjacent to the POL line. There are 157 drums in total at this location, all lying on their sides. Where the label was visible, it stated "fuel oil-diesel". Forty-six barrels had partial contents, all of which were aqueous. Most were deteriorated and rusted through. Because there was a fairly large volume of aqueous contents present at this location, five barrels were sampled, one of which was sampled in duplicate. No samples exceeded criteria, indicating that aqueous contents can be discharged.
- The Beach POL area had a large number of barrels present. Just off the north edge of the POL tank pad, 95 barrels were present, partially buried. All are quite rusted and in poor condition. Because they were partially buried, an assessment of their contents could not be made. The 1995 report had noted that there appeared to be free-phase product in their vicinity, but a test pit excavated at the edge of the barrels had no samples exceeding PHC criteria. It is likely that additional barrels are present at this location and are fully buried. The total number of barrels present at this location has been assumed as 100. Barrels were also stockpiled on the top of the pad; these barrels apparently had lubricating oil contents, as a small area of staining was present in their vicinity. One sample - 906 - was collected from one barrel that had sufficient contents for a sample to be collected. This sample exceeded the total organic halides criterion and cannot be incinerated. Based on the inventory completed at this location, it is anticipated that there are two additional barrels in this vicinity that also will exceed criteria. A second sample - sample 907 - was collected from a barrel with oil contents at the toe of the POL bladder pad. This sample met incineration criteria.

Based on the 2007 survey, it is estimated that 9,500 litres of liquids are present in the barrels at the PIN-B site. The majority of barrels identified are empty and will require no sampling or processing during clean-up. In particular, the main Barrel Stockpile Areas (A-D) have no exceedences. Based on the results of sampling, those with aqueous contents can be discharged, while those with hydrocarbon contents can be incinerated.

The samples identified with hydrocarbon concentrations exceeding the barrel criteria tend to be isolated occurrences: a few barrels on the Beach POL pad; one barrel near the Beach Dump; and one barrel by the water supply lake. These barrels will require consolidation for off-site disposal. The estimated total volume for off-site disposal is 530 L.

It should be noted that much of the scattered barrels, particularly along the beach in Site Debris 13, and along the water supply lake at Site Debris 12, did not have contents assessed as thoroughly as those from the main areas outlined above (bungs were not opened). For these areas, the contents should be consolidated and sampled to confirm disposal requirements.

The most significant portion of this volume that has not been classified is associated with 95 partially buried barrels located immediately north of the Beach POL tank pad. Because they were partially buried, an assessment of their contents could not be made to confirm the 5,000 litres assumed for this area.

A summary of the analytical results for the samples collected from barrels is provided in Appendix D.

4.4 Demolition Component

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

The results of paint analytical sampling indicate that the majority of paint on structural materials associated with the module train, warehouse and garage contain PCBs in excess of 50 mg/kg. Calculations factoring in the mass of the painted substrate for these materials identified total PCB concentrations greater than 50 mg/kg in the majority of structural materials sampled in the module train and only select materials in the warehouse. A summary of the results of paint sampling, showing PCB concentrations for the paint samples themselves, and also showing PCB concentrations when the substrate has been factored in, are provided in Table 3 of Appendix C.

While lead-containing paint is a common occurrence on DEW Line sites, the disposal requirements for most painted material are generally superseded by PCB concentration under CEPA. However, based on findings on other DEW Line sites, there are some materials where PCB concentrations in paint are low, and disposal requirements are ultimately dictated by lead content. These are generally associated with POL facilities where the paint is typically silver colour, or on other exterior metal substrates. At PIN-B, two samples were collected where this typical silver paint colour was present: on the Station POL pumphouse, and on the warehouse loading bay door. Because the lead paint criterion is based on a leachable lead content, painted substrate samples were collected to properly assess the potential for leachate generation from the overall material. Neither of the samples exceeded leachate criteria for any metals.

In areas of PCB-oil storage or in the vicinity of transformers, it is common that the concrete floor may be contaminated with PCBs. Concrete floor samples were collected from the powerhouse end of the module train, the generator room of the garage, and from the warehouse. Only one sample - collected from the module train powerhouse - contained PCBs in excess of the 50 mg/kg criteria. The analytical data for these samples is provided in Table 3 of Appendix C.

The 1994 ESG investigation had collected two samples for asbestos analysis. The samples consisted of floor tile and pipe insulation from the module train. Both samples exceeded chrysotile asbestos content (ESG 1995). During the 2007 investigation, no samples were collected for asbestos analysis, because no materials were identified that were not already known to be asbestos containing, based on experience from other DEW Line sites. In many cases, however, asbestos-containing material - particularly pipe wrap insulation - was painted with PCB-amended paint. These specific instances were noted during the 2007 demolition inventory, as this material will require disposal as PCB waste, but must be segregated during packaging for off-site disposal to allow for proper handling at the PCB-waste disposal facility.

While potential PCB-containing electrical equipment, including transformers, capacitors and fluorescent light ballasts are commonly present on DEW Line sites, it was clear during the 2007 investigation that a dedicated removal of these materials had been completed at an earlier date. At the module train in particular, it was noted that a sweep of each room had been completed, with removal of PCB-containing equipment, and subsequent notation on doorways or walls that PCBs had been removed. No PCB-containing electrical equipment was identified during the 2007 investigation.

There is the potential for mercury-containing switches and thermostats at DEW Line sites, but none were identified at PIN-B in 2007.

A summary of hazardous materials identified during demolition inventory is provided in Table 2 of Appendix C. The total volume identified is 79 m³. From this, the estimated breakdown of hazardous material types is as follows:

- Asbestos: 8 m³
- PCB-amended painted materials: 63 m³
- PCB-amended paint over asbestos: 8 m³
- Batteries: 0.2 m³

4.5 Estimated Dump Excavation Component

Nominal volumes of hazardous material are typically encountered during dump excavation, including but not limited to battery waste, electrical components, asbestos, and petroleum products. As noted above, based on experience from other DEW Line sites, it is anticipated that a small quantity of hazardous soil will be encountered during excavation of dump sites, generally in the range of 1% of the overall excavation volume.

Based on the volume of dumps where the recommended remedial action is excavation, the estimated volume of hazardous waste to be derived is 66 m³.

4.6 Remedial Requirements

Generally, all hazardous materials identified at the site will be collected and transported off site, in accordance with the Transportation of Dangerous Goods Act (TDGA) (TC 2002) and Regulations, to a licensed hazardous waste disposal facility.

Particulars are described below:

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

5.0 Non-Hazardous Waste Remediation

5.1 Surface Debris Component

The method for completion of the surface debris inventory is described above. Based on the 2007 ESA inventory, the majority of surface debris was identified as non-hazardous, including barrel contents. The estimated volume (crushed) is 380 m³. A summary of surface debris areas and volumes is provided in Table 1 of Appendix C.

5.2 Demolition Component

The method employed for demolition inventory and characterization of waste is described above. The results of this investigation and calculations related to ultimate classification of PCB waste indicate that the volume of non-hazardous waste materials from demolition is approximately 590 m³. A summary of demolition quantities is provided in Table 2 of Appendix C.

5.3 Estimated Dump Excavation Component

As note above, the estimated volume of non-hazardous waste from dump excavations has been based on-site-specific modification of average values obtained from dump excavations at other DEW Line sites. In certain cases, based on the results of the geophysical survey and ground truthing, this number has been modified. The total volume estimated to arise from dump excavations has been estimated as 1,210 m³.

5.4 Remedial Recommendations

The total volume of material identified as non-hazardous waste during the 2007 Phase III ESA is approximately 2,180 m³. According to the INAC AMSRP, the assessment of the need for construction of an on-site Non-Hazardous Waste Landfill should consider primarily the availability of suitable locations to build such a facility at the site. Additional considerations include the availability of appropriate granular borrow materials, and the volume of non-hazardous waste identified for disposal. At PIN-B Clifton Point, several locations were identified during the Phase III ESA site investigation that would be suitable for construction of a new facility. Furthermore, no granular borrow material constraints were identified which would preclude any new development. Finally, based on information from DEW Line intermediate sites, the volume of demolition and surface debris at this site does suggest that construction of an on-site facility for disposal is warranted. It is therefore recommended that a Non-Hazardous Waste Landfill be constructed at the PIN-B site during clean-up.

6.0 Contaminated Soil Remediation

6.1 Remedial Criteria and Clean-up Protocols

The investigation and delineation of contaminated soil at Clifton Point was completed for the contaminants of concern identified under the INAC AMSRP: arsenic, cadmium, cobalt, copper, lead, nickel, zinc, and PCBs. The protocol identifies two levels of contamination - Tier I soil which is considered an environmental risk only when located at surface, and Tier II soil which is considered an environmental risk at any depth of impact. Delineation of petroleum hydrocarbon (PHC) impacts was completed using the CCME Canada Wide Standards (CWS) for PHC in Soil. For the CWS PHC methodology, the two pathway remedial criteria applied for the site evaluation are eco-soil contact and protection of groundwater for aquatic life, under the Residential/Parkland Tier I levels. The eco-soil contact criteria were applied in hydrocarbon-impacted areas in the Station Area, while the criteria for protection of groundwater for aquatic life were applied in the assessment of the Beach POL area. Table A below provides a summary of contaminated soil remedial criteria and volumes identified during the Phase III ESA. Volumes estimated to arise from dump excavations have also been noted, as these volumes have also been considered for evaluation of contaminated soil disposal options below. The total volumes noted below combine the volumes from these two sources, with the volume derived from dump excavation estimates noted in parentheses below.

Table A: Summary of Contaminated Soil Remedial Criteria and Quantities

Contaminant Designation	Description	Soil Volume (m ³)
Tier I Contaminated Soil	Soils containing concentrations of any or all contaminants listed as follows: - Lead.....200 to 499 ppm - PCBs.....1 to <5 ppm	570 (550 from dump excavations)
Tier II Contaminated Soil	Soils containing concentrations equal to or greater than any or all contaminants listed as follows: - Arsenic 30 ppm - Cadmium.....5 ppm - Chromium.....250 ppm - Cobalt.....50 ppm - Copper 100 ppm - Lead.....500 ppm - Mercury 2 ppm - Nickel 100 ppm - Zinc.....500 ppm - PCBs.....>5 ppm;<50 ppm	1,210 (880 from dump excavations)
Petroleum Hydrocarbons F3 and F4 fractions	Soils contaminated with hydrocarbons consisting primarily of oil and grease at concentrations equal to or greater than: - F3 fraction 400 ppm - F4 fraction 2800 ppm	1,120
Petroleum Hydrocarbons F1-F3 fractions	Soils contaminated with hydrocarbons consisting primarily of fuel oil, and/or diesel, and/or gasoline, with concentrations equal to or greater than the following concentrations (applies to all depths): - Beach POL Area: - F1 fraction 230 ppm - F2 Fraction 150 ppm - Station Area: - F1 fraction 130 ppm - F2 fraction 450 ppm - F3 fraction 400 ppm	6,740

The specified remedial requirements under the INAC AMSRP are as follows:

- **Tier I soil:** cap in place with a minimum of 0.3 m of granular fill, or dispose in on-site Non-Hazardous Waste Landfill.
- **Tier II soil:** dispose in SSDF or transport off-site for disposal in engineered territorial or provincial Non-Hazardous Waste Landfill;
- **PHC soil, F3 and F4 fractions:** regrade in place with the placement of a minimum 0.5 m of granular fill, or dispose of in on-site Non-Hazardous Waste Landfill; and
- **PHC soil, F1-F3 fractions:** excavate and treat ex-situ through landfarming, treat in-situ with landfarming, or dispose of in SSDF. Note that disposal in the SSDF is only considered appropriate if concentrations are sufficiently low that there are no concerns for inhibiting freezing of contents and/or with free-product development, which could compromise the liner integrity at the facility.

6.2 Tier I and PHC F3-F4 Soil

The discussion for these two types of soil contamination has been combined since their disposal requirements are the same.

The total estimated volume of this soil type is 1,690 m³. This includes Tier I soil area located at the garage and module train, and PHC F3-F4 soil by the garage and Barrel Stockpile A. This volume also includes the estimated Tier I component of soil that will be encountered during dump excavations, as noted above. A detailed breakdown showing area-specific volumes of Tier I and PHC F3-F4 soil is provided in Appendix B. It is recommended that this soil be disposed of in the on-site Non-Hazardous Waste Landfill, constructed during site clean-up.

6.3 PHC F1-F3 Soil

Five areas of PHC F1-F3 impacted soil requiring remedial action were identified as part of the 2007 investigation: at the module train, garage, station POL and beach POL. The total volume of PHC F1-F3 soil identified for remediation 6740 m³. A summary of contaminated soil volumes by area is presented in Appendix B.

Remedial options applicable to the hydrocarbon impacted soil include:

- On-site disposal in a secure soil disposal facility (SSDF);
- In-situ biological treatment or chemical oxidation;
- Ex-situ, on-site biological treatment; and
- Ex-situ, off-site treatment and/or disposal in a Licensed Disposal Facility.

In-situ treatment of the hydrocarbon impacted soil at the beach POL is not considered an option due to its close proximity to the shoreline.

Advantages and disadvantages of each treatment option are described in Table B. Based on the applicability of the various treatment options at the Clifton Point site, the recommended remedial option is on-site ex-situ treatment, i.e. landfarming.

Recent monitoring results from landfarm operations at another former DEW Line site (FOX-C Ekalugad Fjord) have indicated that CWS PHC Tier I eco-soil contact levels are achievable through on-site biological treatment methods; however, more highly contaminated soils may take extended periods of treatment to meet the CWS PHC F2 and F3 remedial targets of 450 mg/kg and 400 mg/kg, respectively. Based on the significant volume of impacted soil and moderate hydrocarbon concentrations observed during the 2007 investigation, it is anticipated that ex-situ biological treatment may be completed within a 2-3 year period provided site conditions are monitored and optimized where possible (i.e., moisture conditioning, nutrient amendment).

To preclude the requirement for a third year of treatment, it is recommended that a contingency be incorporated into the clean-up specifications to consolidate and cover any remaining hydrocarbon impacted soil that does not meet the remedial levels at the end of the clean-up schedule. The thickness of clean soil cover should be consistent with the depth to exclude contact with soil invertebrates (i.e.: 0.5 m).

Table B: Summary of Remedial Options - Hydrocarbon Contaminated Soil

Remedial Option	Description/Requirements	Applicability	Advantages	Disadvantages/Limitations	Implementation
Secure Soil Disposal Facility	- Contaminated soils are excavated and placed in SSDF with Tier II inorganic and PCB impacted soil. - SSDF utilizes geosynthetic liner and frozen core berms for containment. Contents remain frozen.	- Inorganic and PCB contaminated soils. - Type A and low concentration of Type B hydrocarbon soil	- Removes soils from contact with ecosystem. - Environmental risks associated with potential spills during off-site transport.	- Long term monitoring required. - Not applicable to highly contaminated light end hydrocarbons.	Acceptable borrow types and quantities available for construction with limited material processing.
In-situ Biological Treatment / Chemical Oxidation	Application of ozone, peroxide or permanganate through instrumentation within the impacted area.	Amendable to light and medium end hydrocarbons (F1, F2, F3 fractions).	- Under optimal conditions can reduce concentrations below criteria. - Minimize excavation and disturbance of existing vegetation.	- Monitoring required. - Difficult to confirm that target concentrations are met throughout the contaminated area. - Not applicable to metal contaminated soil.	Not appropriate for hydrocarbon areas located in close proximity to water bodies (Beach POL).
On-Site, Ex-situ Landfarming / Bioremediation	- Hydrocarbon contaminated soils are excavated and placed within bermed treatment area. - Soils are periodically turned and nutrients added to optimize treatment conditions.	Hydrocarbon contaminated soils, including F1, F2 and F3 fractions.	- Contaminant concentrations reduced. - No environmental risks associated with potential spills during off-site transport.	- More effective on lighter end hydrocarbons. - Generally requires 2-3 treatment seasons for contaminant reduction to criteria. - Restricts use of the site during treatment operations. - Impermeable membrane/low permeable soils required for containment.	- Adequate location and granular materials identified for construction. - Geosynthetic liner required for perimeter containment.
Off-Site Treatment and Disposal	Contaminated soils are transported off-site for treatment or disposal.	All contaminated soil types.	Contaminated soils removed from site eliminating risk of exposure.	- Considerable costs associated with off-site transport. - Project costs are very sensitive to contaminated soil volumes. - Potential environmental risks during transport.	Shipment and disposal off-site is technically appropriate, but at considerable costs.

6.4 Tier II Soil

The 2007 site investigation identified Tier II levels of PCBs and/or inorganic elements in nine areas of the site, including the module train (2), sewage outfall, incinerator, garage, POL battery debris area, north of the airstrip, Station West Dump, and Beach Dump South A. Individual Tier II contaminated soil areas ranged between 5 m³ to 84 m³ in size typically extended to 0.3 m in depth. The total volume of Tier II soil identified for remediation is 1,210 m³, of which 880 m³ is the estimated Tier II soil component from dump excavations, and 330 m³ is from delineated contamination areas. A summary of contaminated soil by area is presented in Appendix B.

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

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

Assessments carried out during the 2007 investigation identified two suitable locations for the development of a SSDF, including Proposed Landfill 2 situated immediately east of the station and Proposed Landfill 3 situated at the end of the road in the Construction Camp area. Assessment of existing and new potential granular borrow sources was completed during the 2007 investigation. The assessment identified various locations where suitable borrow types (Type 2, 4, and 5) and quantities are available for construction of a SSDF. Therefore, based on the results of the 2007 assessment, there are no site specific constraints for building an SSDF at PIN-B.

An evaluation was completed comparing the relative construction costs associated with developing an on-site SSDF capable of accommodating the identified volume of Tier II soil versus costs associated with off-site disposal of the same volume of soil. A rounded volume of 1,200 m³ was used for the calculations. The cost estimate was based on recently tendered pricing from nearby DEW Line sites and was consistent with pricing used by Golder and UMA (2007) in the study regarding feasibility of on-site disposal of Tier II soil at abandoned military sites under the jurisdiction of INAC, modified to reflect site specific conditions at PIN-B. Assumptions made in the evaluation include:

Option 1: On-site Disposal within a SSDF

- Square footprint;
- 1.5 m deep key trench backfilled with Type 4 granular fill;
- Perimeter berms constructed with Type 2 granular fill incorporating a core of Type 4 granular fill;
- 2.5:1 interior side slopes and 2:1 exterior side slopes;
- HDPE geosynthetic liner system on the base and cover;
- Final cover of 4.0 m over the contaminated soil to ensure freezeback;

- Instrumentation including four thermistors and four monitoring wells; and
- Long term facility monitoring over a 25 year period (DLCU schedule).

Option 2: Off-site Transport and Disposal

- Excavation and containerization of Tier II soil;
- Off-site transport by barge (sea accessible) to Hay River and truck transport to the disposal facility; and
- Disposal of soil in a licensed southern disposal facility (i.e.: High Level, Alberta).

The results of the cost evaluation indicate that on-site disposal is only slightly less expensive than off-site disposal. Given that approximately 70% of the Tier II soil quantity used in the evaluation is an estimated volume from dump excavations, that the cost comparison did not indicate a significant savings with on-site disposal, and that INAC has concerns related to long-term liability with constructing such a facility on-site, off-site disposal is considered the preferred remedial option for disposal of Tier II soil. It should be stressed, however, that there is the potential for the volume of Tier II derived from dump excavations to be higher than that estimated. It is therefore recommended that a significant contingency be carried in terms of volume for off-site disposal to ensure that there are sufficient containers on-site for soil containerization during remediation, so as not to delay project completion.

6.5 Summary

Remedial options evaluations for the remediation of contaminated soils was completed as part of the 2007 investigation. Based on the estimated volumes of contaminated soils and technical considerations, for locating and developing suitable disposal and/or treatment facilities, it is recommended that all Tier I and PHC soils at Clifton Point be disposed of or treated on-site, while Tier II soils be containerized and disposed of off-site. Based on the applicability of the various disposal and treatment options, the following recommendations are made:

- Soils contaminated with Tier I levels of PCBs and inorganic elements and/or PHC F3-F4 fractions should be excavated and placed in the on-site Non-Hazardous Waste Landfill. The total volume of Tier I/PHC F3-F4 soil, including approximately 45% from dump excavations, is estimated at 1,690 m³. These soils may be utilized as intermediate fill during placement of non-hazardous waste within the landfill.
- Soils contaminated with Tier II levels of PCB and/or inorganic elements should be excavated, containerized, and shipped off-site for disposal. The total volume of Tier II soil, including approximately 70% from dump excavations is estimated at 1,210 m³.
- Soils contaminated with PHC F1-F3 fractions should be excavated and treated ex-situ by biological treatment methods in an on-site landfarm facility. Soils concentrations should be reduced to meet the CWS PHC Residential/Parkland Tier I levels for eco-soil contact levels. The total volume of hydrocarbon impacted soil requiring remediation is estimated at 6740 m³.

7.0 Implementation

7.1 Schedule

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

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

7.2 Dump Remediation

Table C below summarizes the recommended remedial requirements for dumps at PIN-B. Where the recommended remediation is excavation, waste segregation during excavation is recommended to separate hazardous and non-hazardous waste. Non-hazardous waste can be disposed of in the Non-Hazardous Waste Landfill on-site. Hazardous waste will require off-site disposal and must be segregated based on PCB-containing waste (for disposal at a licensed PCB disposal facility), or other hazardous waste, which can be disposed of in a licensed Hazardous Waste Landfill. It is recommended that soil be separated from debris during excavation, and stockpiled in such a manner to allow sampling and classification according to the contaminant criteria outlined under the INAC AMSRP. Soil that does not exceed any contaminant criteria may be used as for backfilling excavations, but based on the difficulty with removing small pieces of debris during waste segregation, it is recommended that this soil be used for intermediate fill and not be used for surface backfilling.

In terms of timing for excavation, because of the anticipated contaminated soil and debris components from excavation, the implementation of dump excavations should not proceed until the construction of the Non-Hazardous Waste Landfill (NHWL) is completed. This should be able to commence late during season 2.

Because no on-site containment facility will be completed, excavation of Tier II soil could commence early during season 2. Furthermore, because of the uncertainty regarding Tier II contaminated soil volumes from dump excavations, it would be preferred that the contractor commence excavation at the larger dumps (i.e. the Beach area) in season two (following completion of the NHWL), to ensure that there are ultimately sufficient containers on-site. This would allow for mobilization of additional containers during the second year. If required, the stockpiling of Tier II soils (preferably on a liner or on the surface of an existing Tier II soil contaminated area) beyond the containerization volume could be completed until additional containers are brought to site.

For dumps where the recommended remedial action is regrading, this work can likely commence upon completion of the NHWL construction, when surface debris pickup at the dumps can be completed efficiently.

Table C: Summary of Recommended Dump Remedial Requirements

Dump	Size (m ²) & Depth (m)	Environmental and Geotechnical Investigation	Dump Classification	Recommended Remediation Based on Engineering Considerations
Station West	3,550 0.8	- No evidence of contaminant migration. - Small area of Tier II soil associated with surface debris near edge of dump. - Lush vegetation down-gradient. - Lake located 150 m down-gradient. - No evidence of erosion.	Class C	Excavate Tier II contaminated soil. Regrade dump.
Construction Camp Dump A	320 0.5	- No evidence of contaminant migration and no potential for surface contaminated soil identified. - Drainage channel located near toe.	Class C	Regrade dump. Provide armouring along toe in vicinity of drainage channel.
Construction Camp Dump B	240 0.5	- No evidence of contaminant migration and no potential for surface contaminated soil identified. - Well-vegetated. - Within drainage basin with drainage channels cutting through and adjacent to dump. - No existing erosion, but likely due to existing vegetation.	Class C, upgraded to A	Excavate because within significant drainage basin and potential for erosion when additional cover placed overlying existing stabilizing vegetation.
Construction Camp Dump C	180 0.5	- No evidence of contaminant migration and no potential for surface contaminated soil identified. - Moderate vegetation. - Existing dump toe located within 20 m of a large lake. - No erosion noted.	Class C, upgraded to A	Excavate because of proximity to lake
Beach Dump	2,550 2.0	- Some evidence of contaminant migration. - No potential for surface contaminated soil identified. - No erosion noted. - Existing toe is located 50 m from high water mark at an elevation of 3 m higher. - Leachate contain toe will be within 1 m elevation difference from existing high water mark so is considered at potential risk for long-term erosion.	Class B	Excavate, based on results of cost estimate and concerns with long-term geotechnical stability with leachate containment.

Dump	Size (m ²) & Depth (m)	Environmental and Geotechnical Investigation	Dump Classification	Recommended Remediation Based on Engineering Considerations
Beach Dump South A	3,930 0.75-1.0	- Some evidence of contaminant migration. - Localized Tier II surface contamination detected associated with surface debris. - No erosion noted. - Existing toe is located 40 m from high water mark and 2.5 m higher. - Leachate contain toe will be within less than 1 m elevation difference from existing high water mark so is considered at potential risk for long-term erosion. .	Class B	Excavate, based on results of cost estimate and concerns with long-term geotechnical stability with leachate containment.
Beach Dump South B	3,170 0.75-1.0	- No evidence of contaminant migration. - Potential for surface contamination investigated near suspect surface debris, but no contamination detected. - No evidence of erosion. - Existing toe is located within 15 m of high water mark; with 0.75 m elevation difference so is considered at risk for long-term erosion.	Class A	Excavate because of concerns with long-term geotechnical stability.
Beach POL Buried Debris	100 1.2	- Within an area of PHC contaminated soil identified for excavation. - It could not be discerned whether barrels had contents. - The quantity of fully buried barrels could not be identified because of the large quantity of overlying partially buried barrels.	Class C	Will be mostly excavated with contaminated soil excavation at Beach POL. Excavate any remaining debris along contaminated soil excavation margins.
Beach Inuit Camp	125 2.0	- Is comprised of a meat cache freezer, with portal from surface and internal void. - Should be infilled for long-term geotechnical stability and to remove physical hazard.	Class C	Backfill subsurface void. Regrade surface.
West Beach POL Buried Debris	25 0.5	- No investigation of contaminants because of its small size. - Primarily an aesthetic concern. .	Class C	Regrade

7.3 Demolition

The demolition inventory for Clifton Point identified approximately 79 m³ of hazardous and 589 m³ of non-hazardous demolition debris. These volumes are based on segregation of hazardous and non-hazardous building components during demolition and do not include bulking factors that may be attributed to off-site packaging volumes or with on-site disposal volumes.

Hazardous building materials and related components, including asbestos containing materials (ACMs) and PCB wastes will be removed prior to demolition of the structures. ACMs generally include mechanical insulation on pipes and chimneys, transite board, and fire asbestos core doors. ACMs that are painted are to be treated as PCB wastes and containerized separately for off-site disposal. Non-painted ACMs will be double bagged and disposed of in an on-site landfill. Vermiculite insulation contained within the inter-module wall cavities is not considered asbestos-containing (<1% asbestos); however, due to its friable nature should be removed in a manner consistent with a moderate risk (Type 2) abatement.

Other hazardous materials, including batteries and potential glycol containing liquids within the building heating systems will be containerized for off-site disposal or recycling in accordance to TDGA requirements. While no PCB-containing equipment or mercury switches were noted during the 2007 investigation, if these materials are identified during clean-up, they will also require containerizing for off-site disposal.

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

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

Building foundations at PIN-B consist of wood post and beam (module train), concrete slab on grade (garage, warehouse, and POL pumphouse). Wood posts and beams can be disposed of in the on-site landfill whereas the concrete slabs can remain in place once all paint has been removed from the surface of the slab. The preferred remediation option from the technical perspective is to place additional fill material and regrade around the foundations to match existing topography.

It is recommended that the segregation and containerization of hazardous waste components be commenced early during season two. This will facilitate the completion of full demolition, which can be commenced once construction of the Non-Hazardous Waste Landfill is completed.

7.4 Surface Debris

Fourteen surface debris areas were identified during the 2007 Phase III ESA. The identified limits of these areas cover approximately 1,730,900 m². The volume of hazardous materials identified is 5 m³, while the volume of non-hazardous waste is 374 m³. Both of these volumes represent crushed volume estimates. These volumes also include barrels and their contents, based on results of barrel inventory and sampling. A detailed breakdown of surface debris areas and debris volumes is provided in Table 1 of Appendix C. The limits of surface debris areas are shown on Figure 1. Non-hazardous waste can be disposed of in the Non-Hazardous Waste Landfill. Hazardous waste must be packaged in accordance with TDGA regulations for shipping to an off-site licensed hazardous waste disposal facility.

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

Collection of surface debris can proceed upon completion of the NHWL construction. This can likely begin mid-season during season two.

7.5 Barrel Remediation

The 2007 inventory of barrels at PIN-B indicates there are 820 barrels on-site, including marker barrels. Of these, 124 were identified with aqueous contents, seven with mixed phase contents (oil or fuel and water), and 38 with hydrocarbon contents.

There are four primary barrel stockpiles at the site;

The results of the Phase III ESA indicate that the majority of barrels are empty and will require no sampling or processing during clean-up. In particular, the main Barrel Stockpile Areas (A-D) have no exceedences. Based on the results of sampling, those with aqueous contents can be discharged, while those with hydrocarbon contents can be incinerated.

The samples identified with hydrocarbon concentrations exceeding the barrel criteria tend to be isolated occurrences: a few barrels on the Beach POL pad; one barrel near the Beach Dump; and one barrel by the water supply lake. These barrels will require consolidation and packaging according to TDGA regulations for off-site disposal. The estimated total volume for off-site disposal is 530 L.

As noted above, many of the scattered barrels, particularly along the beach in Site Debris 13, and along the water supply lake at Site Debris 12, did not have contents assessed as thoroughly as those from the main areas outlined above (bungs were not opened). For these areas, the contents should be consolidated and sampled to confirm disposal requirements. In addition, the estimated 100 partially or fully buried barrels at the Beach POL will require assessment of their contents following removal.

Because of the need to classify some barrels that could not be properly assessed during the ESA, it is recommended that collection of barrels, with consolidation of like products, be completed during the season two to allow for sampling of contents in a timely manner, with incineration or additional consolidation for off-site transport completed during the third season of clean-up.

7.6 Proposed New Containment Facilities

7.6.1 Non-Hazardous Waste Landfill (NHWL)

The total volume of non-hazardous waste, from all sources (including Tier I and PHC Type A soil), is estimated as 2,900 m³. The estimated footprint for a non-hazardous waste landfill (NHWLF) to accommodate this volume is approximately 75 x 75 m. Based on this size, Proposed Landfill 4 is not sufficiently large to accommodate the facility. The preferred location is, therefore, Proposed Landfill 1. When considering the perimeter of the area identified from the Phase III ESA and existing ground conditions, it is considered preferable to place the landfill as close as possible to the northwestern limit during design; ground in this area is already disturbed. Furthermore, it is preferable to locate the landfill as close as possible to the existing pad to minimize transport costs and need for road development. Of note, there are no contaminated soil areas for excavation in the near up-gradient area. Therefore, there is no requirement for provision of sufficient buffer to avoid complication of long-term landfill monitoring data interpretation.

In terms of contractor priorities for construction of new facilities during clean-up, construction of the NHWL is considered the second priority, behind the landfarm (see below). It is expected that construction of the facility can be completed during season two, with disposal of waste also commencing this same season.

7.6.2 Landfarm

The total volume of PHC F1-F3 soil identified for remediation is approximately 6,740 m³. The majority of this soil is at the Station Area. Based on this, it is preferable to locate the landfarm facility as close as possible to the Station. Proposed Landfill 2 is therefore considered the preferred location. The Proposed Landfarm area at the airstrip is not sufficiently large to accommodate the treatment requirements for this volume of soil. Based on a soil depth placement of 0.4 m, the estimated footprint is approximately 60 m x 380 m, for a total area of 22,800 m².

The perimeter initially identified for a landfarm at Proposed Landfill 2 will need to be extended further to the southeast to accommodate the required size. The identified limits along the northeast and southwest sides should be maintained for the following reasons:

- There is a drainage channel just beyond the southwest side, lying between the beach ridge to the southwest and the beach ridge/terrace upon which Proposed Landfill 2 sits. This channel will need to be avoided during construction. The currently identified southwestern limit for the Proposed Landfill/Landfarm avoids this area.
- The existing slope within the currently identified limits is an ideal grade for landfarm construction; no building up of the base will be required, and the berm along the down-gradient perimeter will not need to be significantly higher than the up-gradient one for drainage control.
- While the 2007 topographic survey did not extend sufficiently to the southeast to cover the full area required for landfarm construction, the topography in this area is relatively consistent, such that the existing topography can safely be extrapolated for design purposes.

As noted above, with endpoint remedial criteria of 230 ppm F1 fraction or 150 F2 fraction, it will be difficult to achieve soil remediation within a two-year period. A third year for landfarming may be required. The construction of the landfarm is considered the contractor's priority for the second season. It is expected that construction can be completed within the early stages of that year, with excavation and placement of soil by August 1 to allow for the addition of nutrients and several tilling events before the close of the season.

It is understood that the ultimate remedial design for the PIN-B site may be based on a different set of PHC criteria than those noted above - criteria developed specific to northern sites under the INAC Abandoned Military Site Remedial Criteria. The 2007 UMA ESA report and the draft RAP for the PIN-B site provided an evaluation of remedial requirements under this draft criteria (Golder and ESG 2007) as well as the CWS methodology described above. Evaluation under the draft INAC AMSRC indicated a much lower volume of PHC-impacted soil for remediation. It should therefore, be noted, that if this criteria is implemented for the remedial design of the PIN-B site, the preferred location for construction of a landfarm is at the proposed landfarm area investigated during the site investigation at the abandoned airstrip area. This area should be sufficient in size to accommodate the lower soil volumes under the INAC protocol, and is preferable in that it is in a previously disturbed area, already has some containment built-in, and will not restrict usage of the potential borrow source located in the vicinity of Proposed Landfill 2. It is also much closer to the primary PHC-impacted area requiring remediation under the INAC criteria, which is the Beach POL; limited remediation will be required at the Station Area under this criteria.

7.7 Contaminated Soil Excavation

- Tier I and PHC F3-4 soil: Excavation of this soil may commence as soon as the NHWL is constructed.
- Tier II soil: Because of the uncertainty regarding ultimate Tier II soil volumes that will be derived from dump excavations, it is recommended that excavation and containerization of Tier II soils commence early during the first full season (season two). This will allow a better assessment of the ultimate number of containers that will be required for shipping off-site, and will allow the contractor opportunity to bring in additional containers for the following season.
- PHC F1-F3 soil: Excavation of this soil should be completed immediately upon landfarm construction, which should be the number one priority for the contractor, as noted above.

7.8 Borrow Sources

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

- **Type 1:** the estimated volume required is approximately 35 m³, based on use during regrading at Construction Camp Dump A.
- **Type 2:** the estimated volume required is approximately 20,400 m³, which includes construction of the Non-Hazardous Waste Landfill, and the Landfarm (under the CWS methodology). Volumes required for regrading of dumps have also been included in this consideration.
- **Type 3:** the estimated volume required is in the order of 5,100 m³, which includes backfilling of dump and contaminated soil excavations. It should be noted here, that, based on our estimate of clean fill that will be derived from dump excavations, the majority of the dump backfilling requirements will likely be met by using this soil. However, as noted above, the clean soil derived from dump excavations will likely contain small pieces of debris, so this material is only recommended for intermediate backfill.
- **Type 4:** no requirement since no SSDF or leachate containment of existing dumps will be constructed.
- **Type 5:** again, no requirement, similar to Type 4.
- **Type 6:** the intermediate fill requirements for the construction of the NHWL is estimated as 1,170 m³. Some of the requirements for intermediate fill may be met by using Tier I/Type A soil.

Based on these estimates, it is anticipated that sufficient granular material sources were identified during the Phase III ESA. As noted in that report, there will likely be a requirement for screening to produce Type 1 materials.

8.0 References

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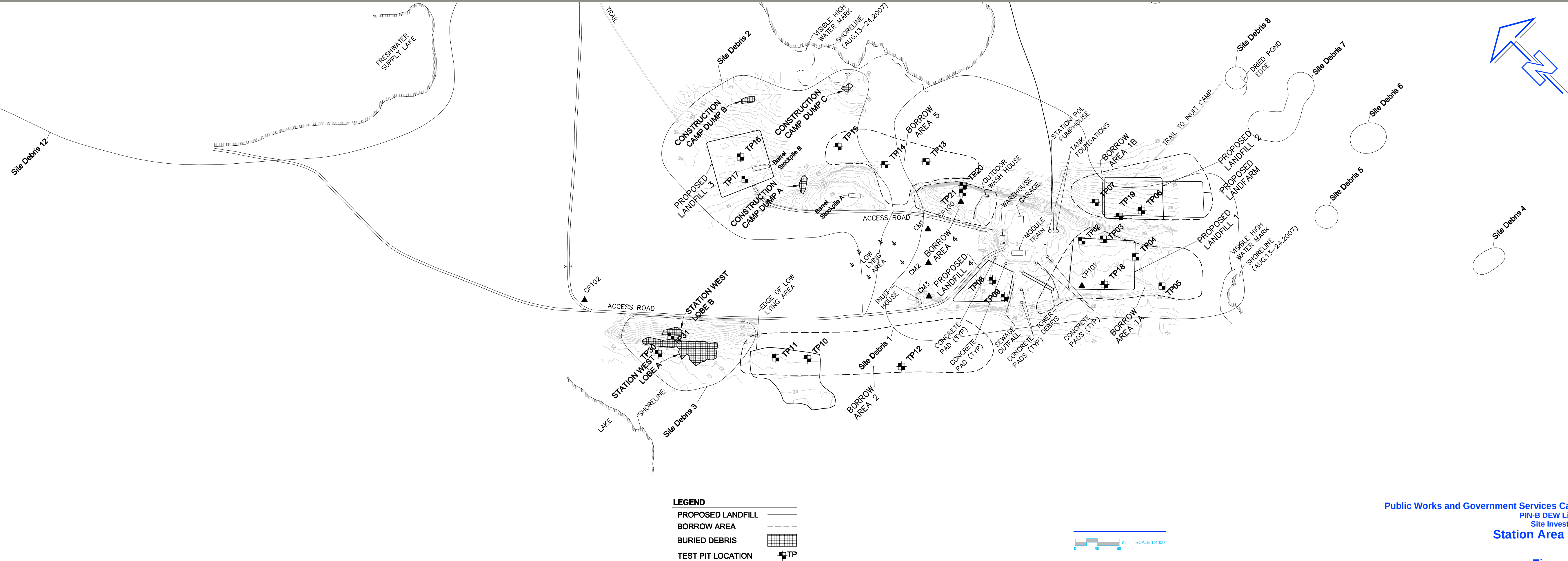
Appendix A Figures

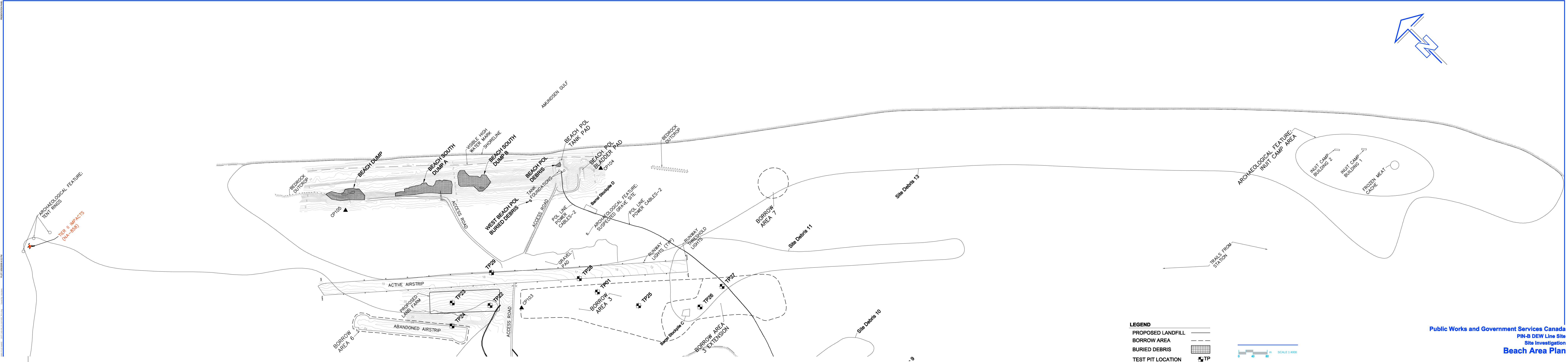


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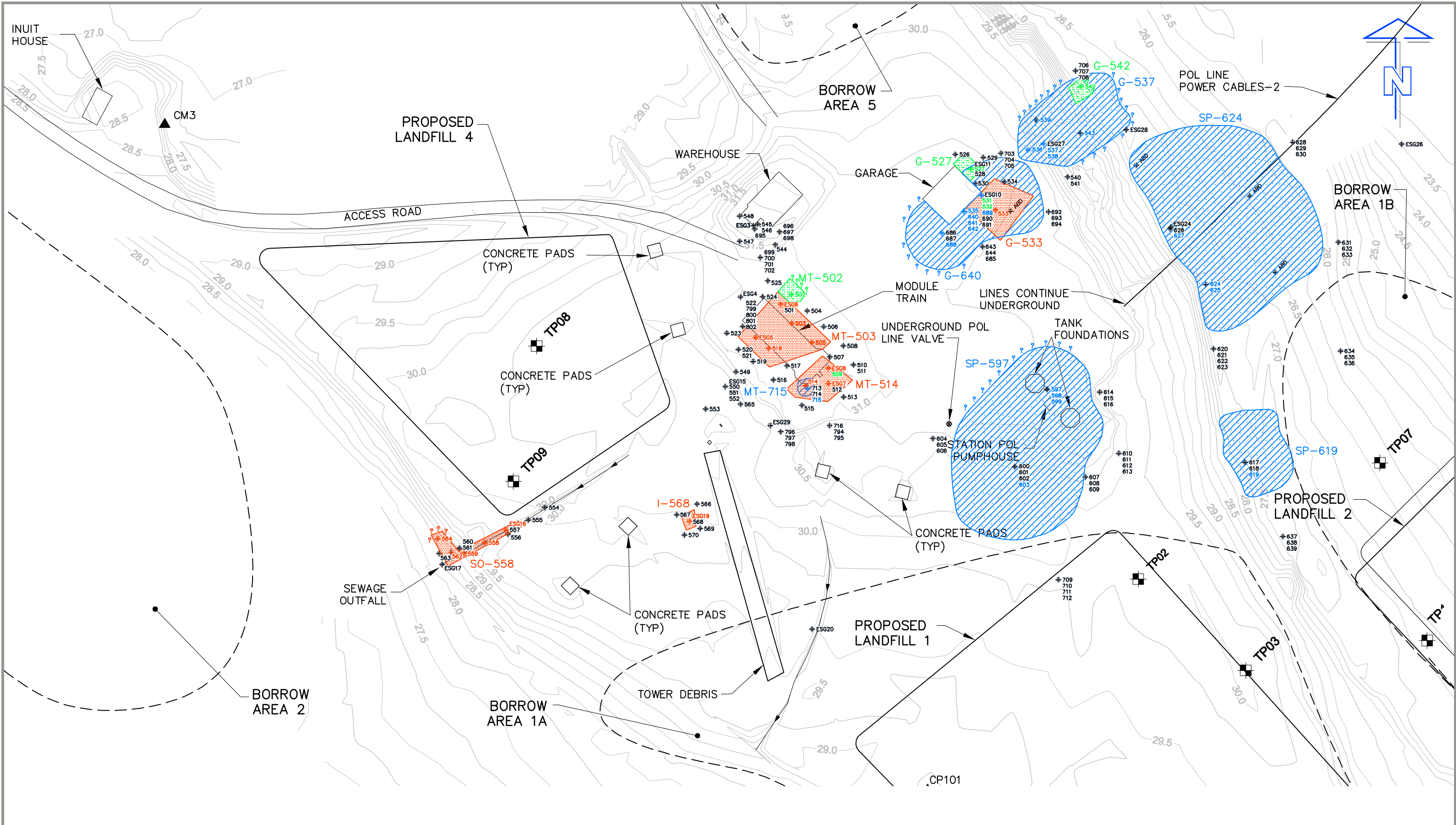
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PIN-B DEW Line Site
Site Investigation
OVERALL SITE PLAN

Figure - 01





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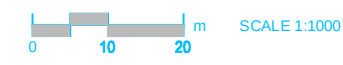
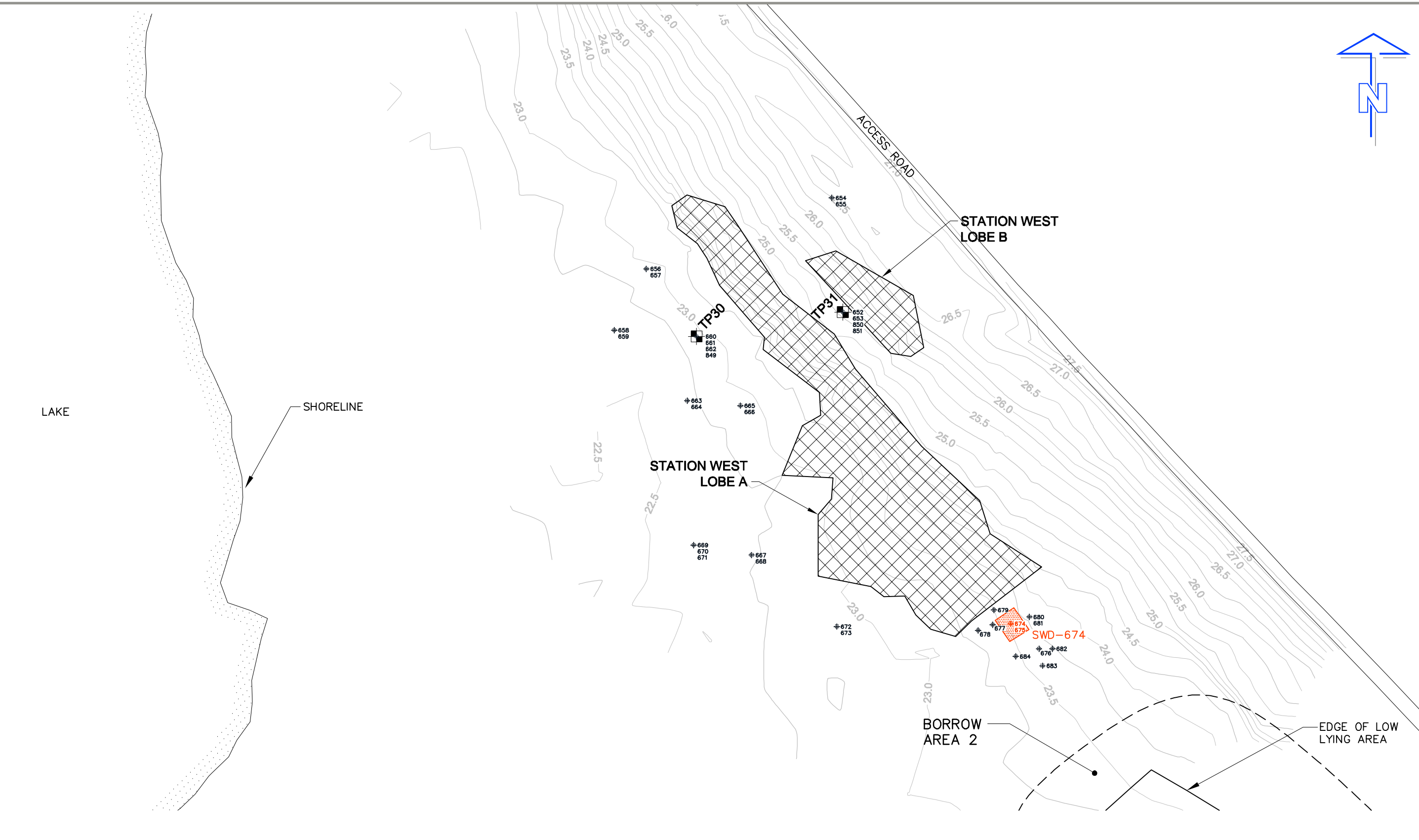


LEGEND

PROPOSED LANDFILL	—	BURIED DEBRIS	▨
BORROW AREA	—	SAMPLE POINT	⊕ 513
TEST PIT LOCATION	■ TP		

TIER I IMPACTS	▨
TIER II IMPACTS	▨
PHC IMPACTS	▨

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PIN-B DEW Line Site
Site Investigation
Station Area

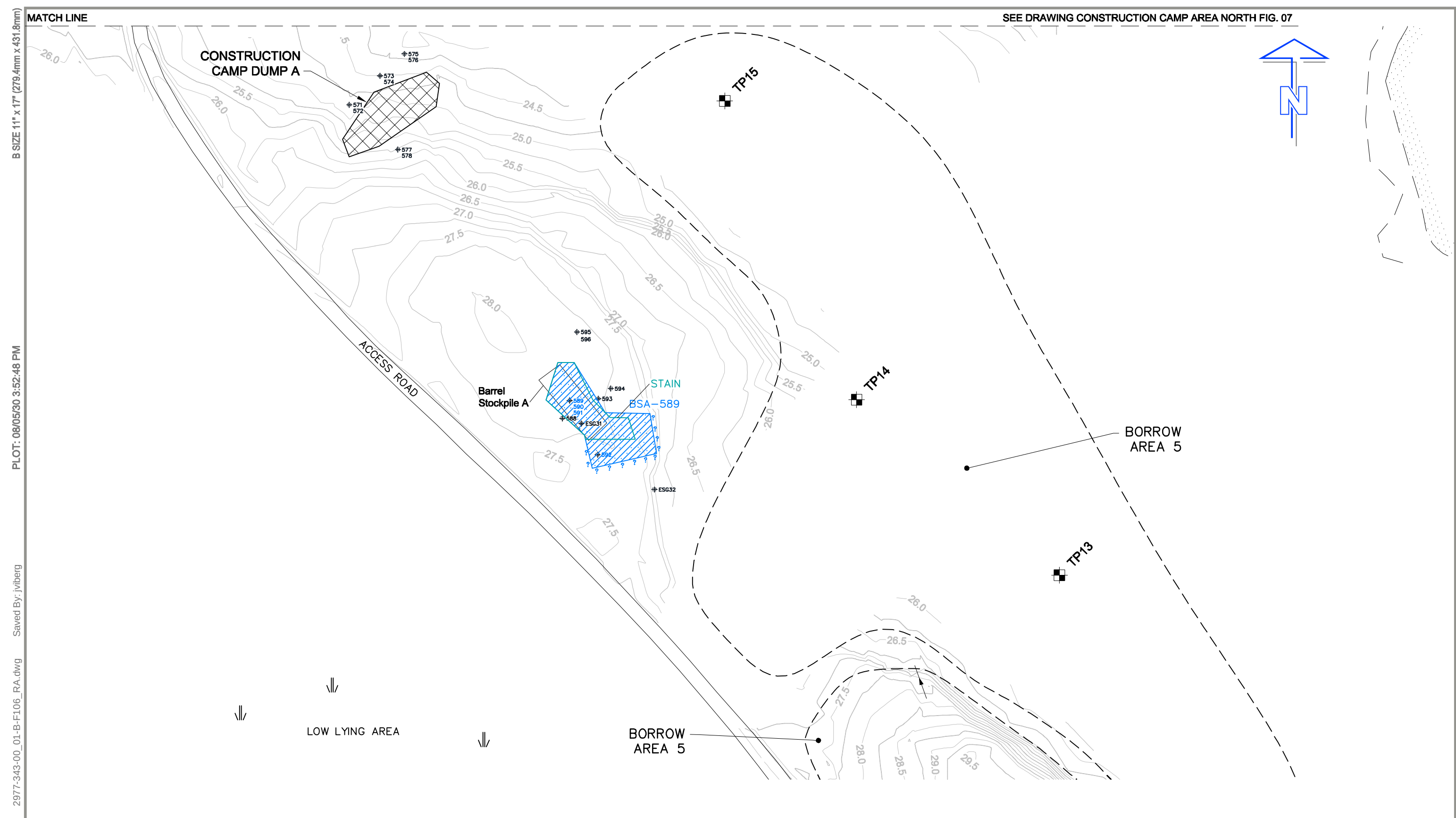


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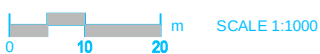
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BORROW AREA		SAMPLE POINT	
TEST PIT LOCATION			

TIER I IMPACTS	
TIER II IMPACTS	
PHC IMPACTS	

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PIN-B DEW Line Site
Site Investigation
Station West Dump Area



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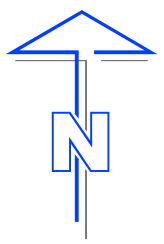
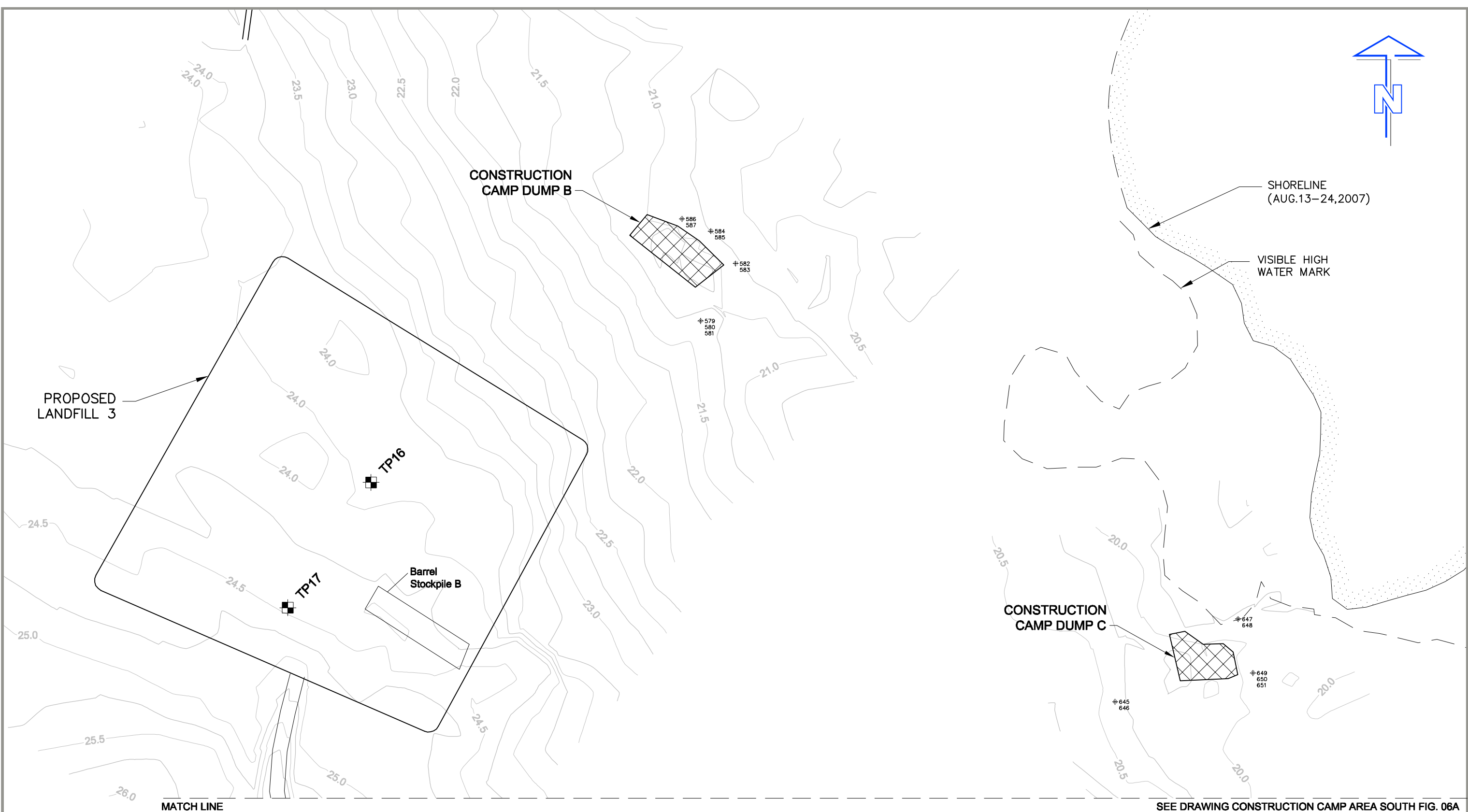
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PROPOSED LANDFILL		BURIED DEBRIS	
BORROW AREA		SAMPLE POINT	
TEST PIT LOCATION			

TIER I IMPACTS	
TIER II IMPACTS	
PHC IMPACTS	

Public Works and Government Services Canada
PIN-B DEW Line Site
Site Investigation
Construction Camp Area South

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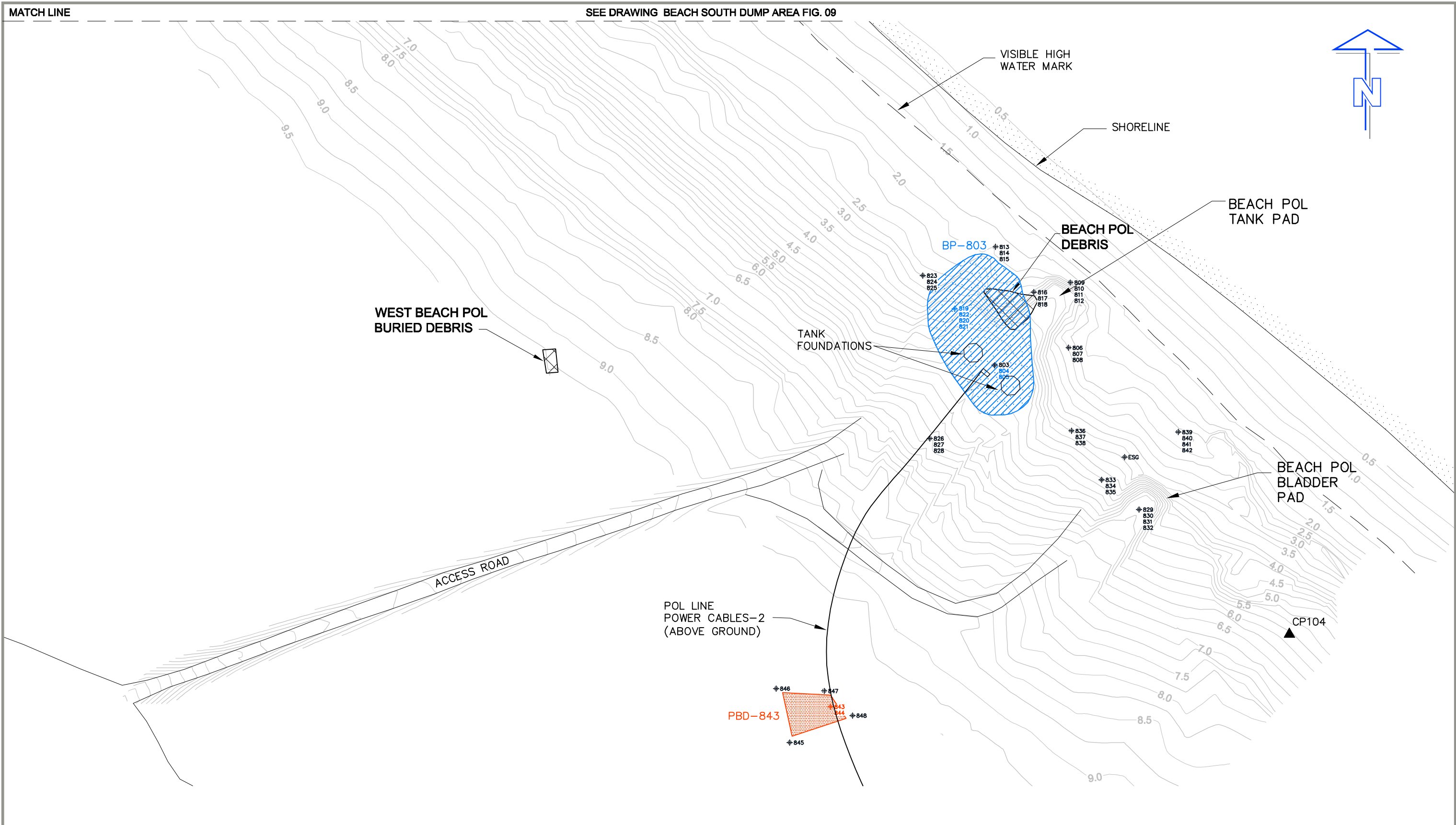
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TEST PIT LOCATION			

TIER I IMPACTS	
TIER II IMPACTS	
PHC IMPACTS	

SEE DRAWING CONSTRUCTION CAMP AREA SOUTH FIG. 06A

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PIN-B DEW Line Site
Site Investigation
Construction Camp Area North

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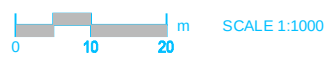
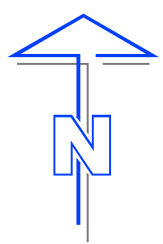


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PROPOSED LANDFILL		BURIED DEBRIS	
BORROW AREA		SAMPLE POINT	
TEST PIT LOCATION			

TIER I IMPACTS	
TIER II IMPACTS	
PHC IMPACTS	

Public Works and Government Services Canada
PIN-B DEW Line Site
Site Investigation
Beach POL Area



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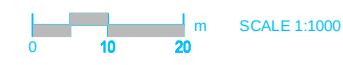
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TEST PIT LOCATION	TP		

TIER I IMPACTS	
TIER II IMPACTS	
PHC IMPACTS	

Public Works and Government Services Canada
PIN-B DEW Line Site
Site Investigation
Beach South Dump Area

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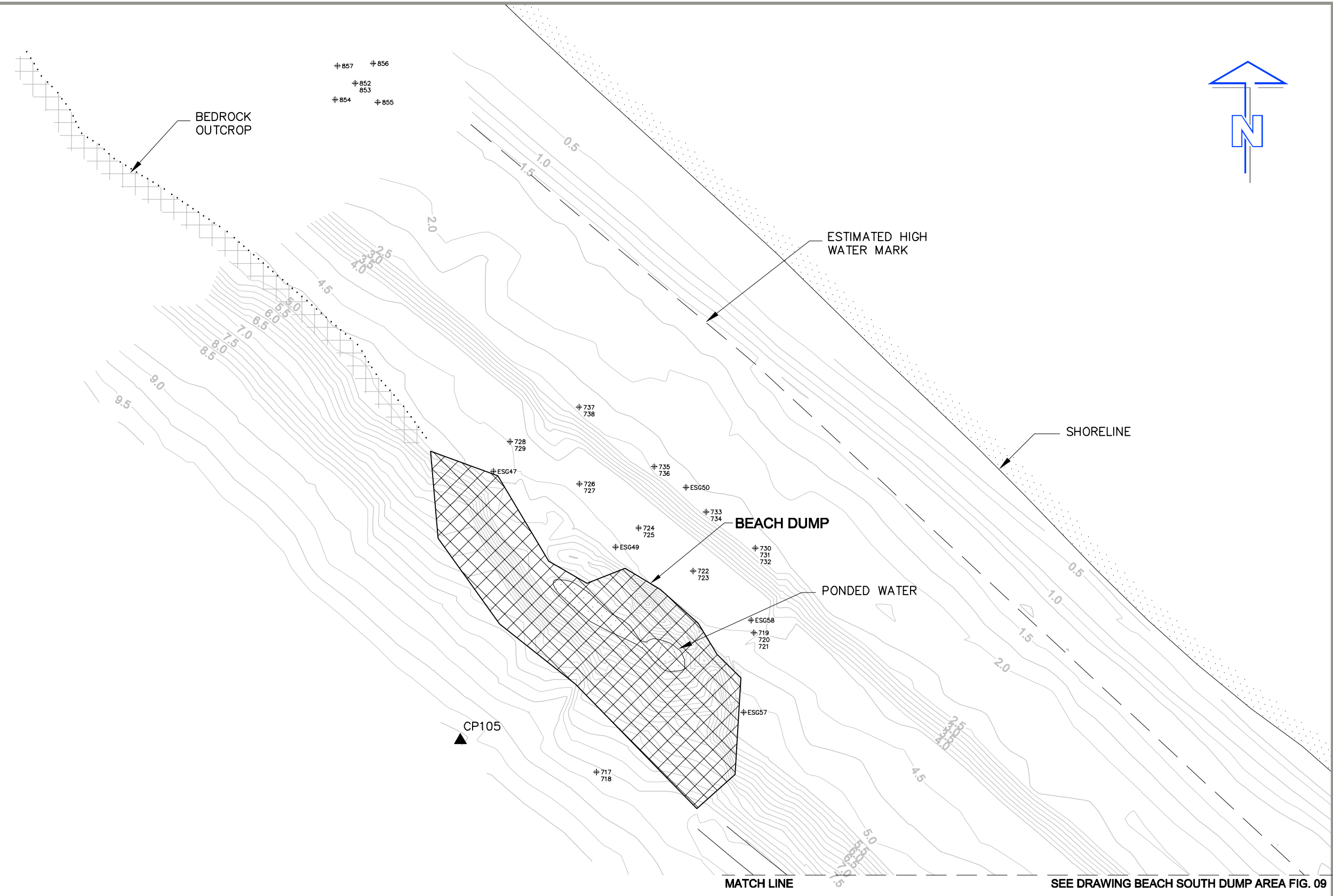
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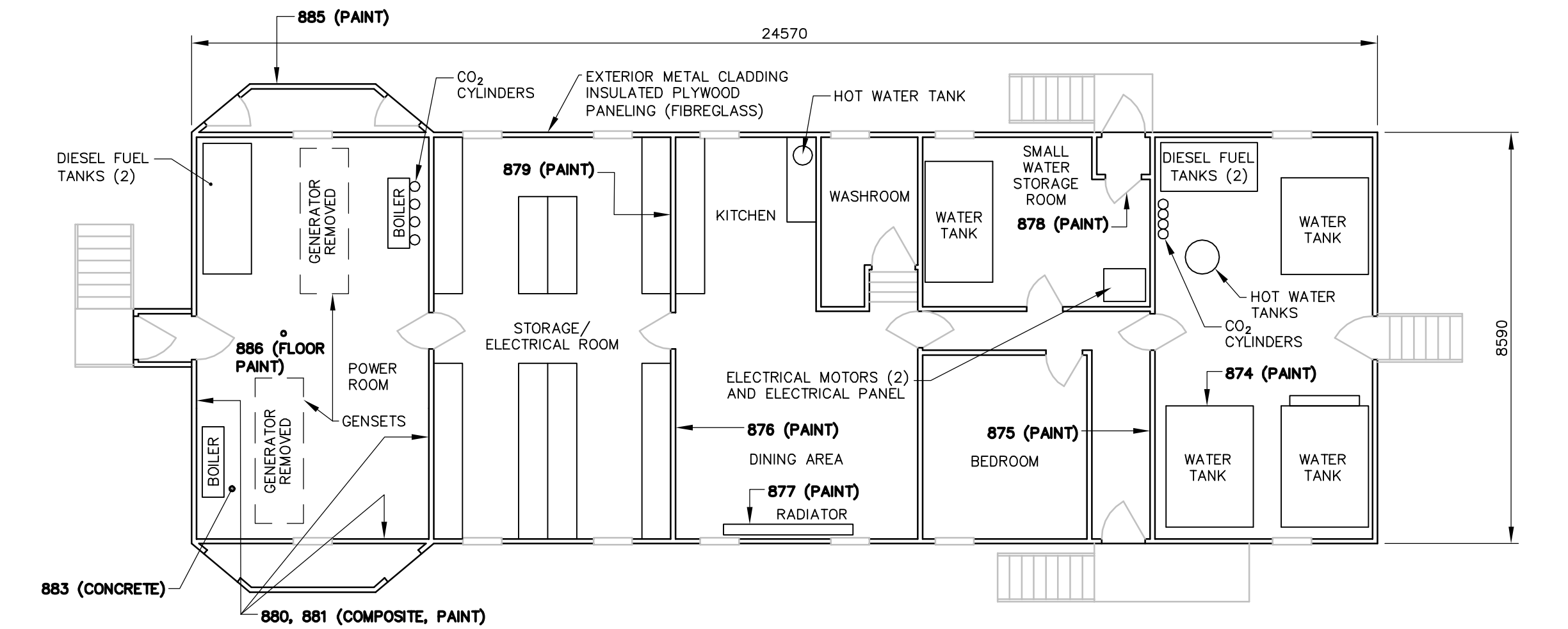
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| PHC IMPACTS | |

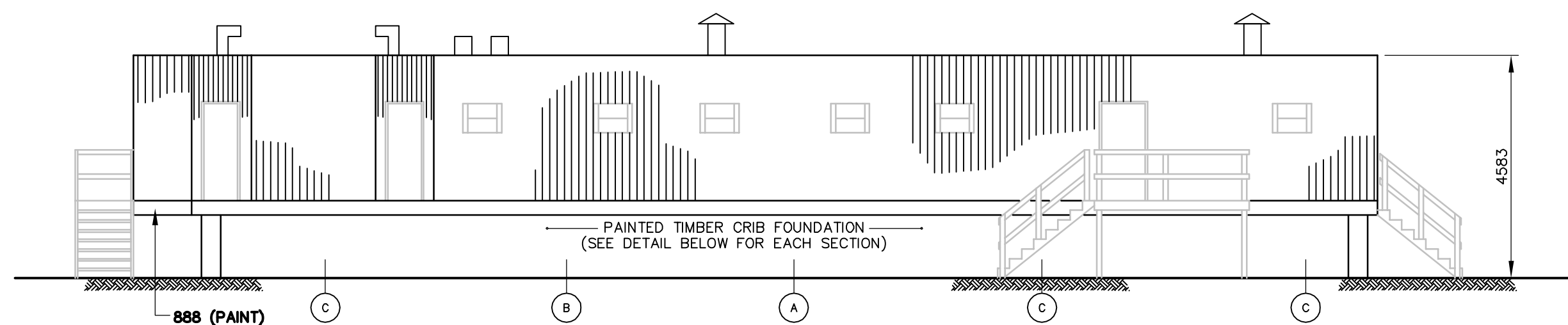


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Site Investigation
Beach Dump Area

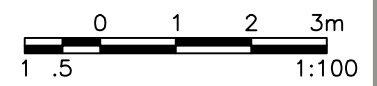
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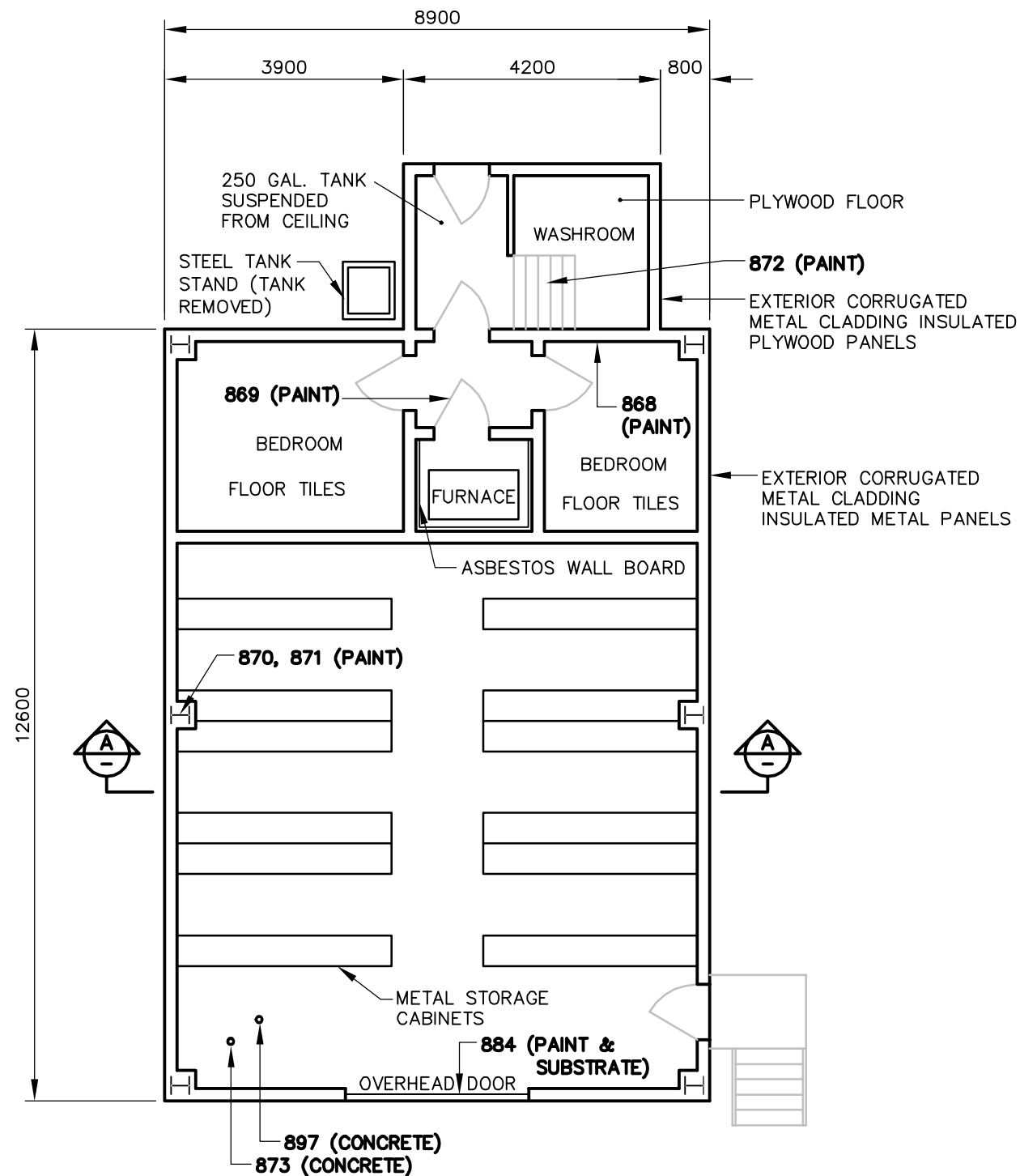


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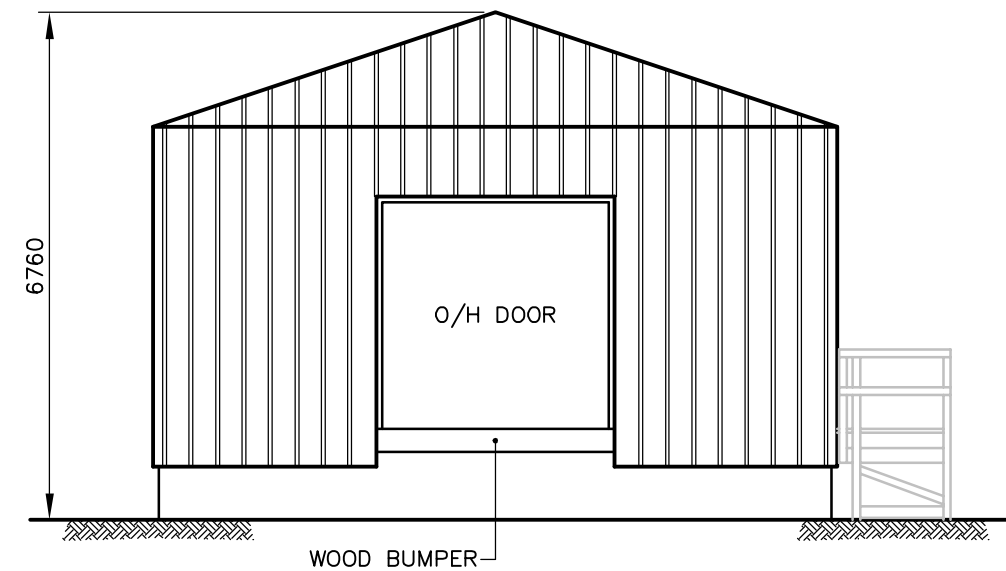


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PIN-B DEW Line Site
Site Investigation
Module Train
Floor Plan and Elevation
Figure - 11

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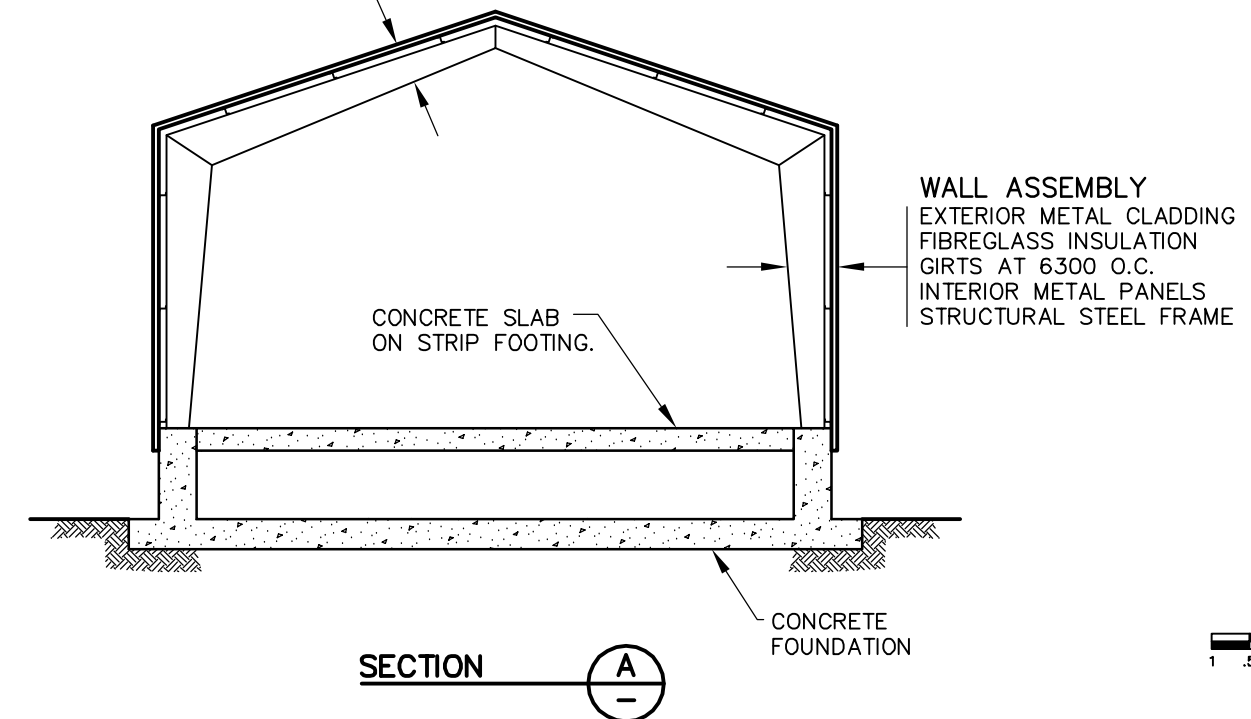


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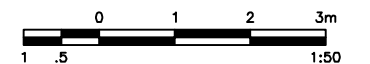


ELEVATION

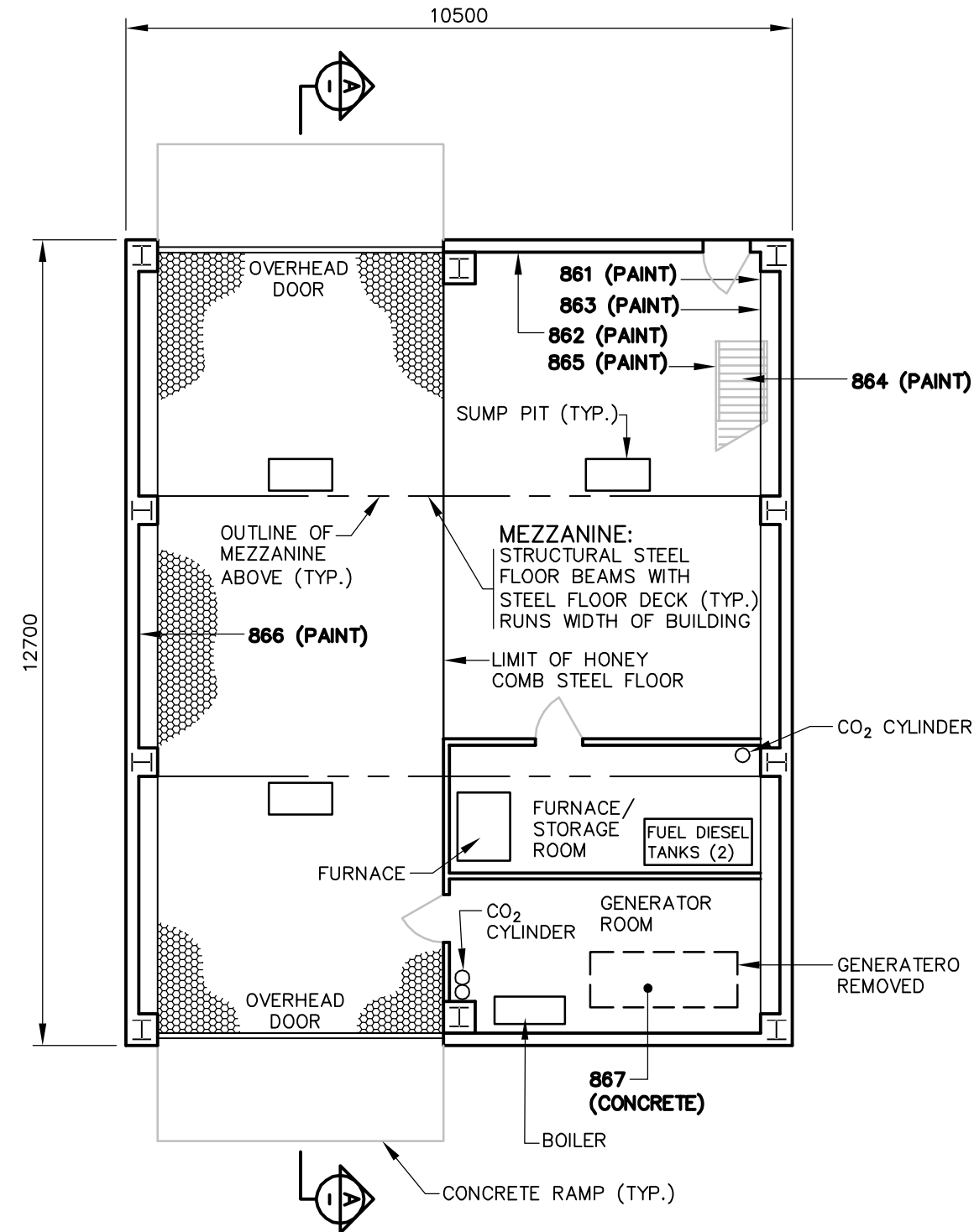
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EXTERIOR METAL CLADDING
FIBREGLASS INSULATION
15 PURLINS
INTERIOR METAL PANELS
STRUCTURAL STEEL FRAME



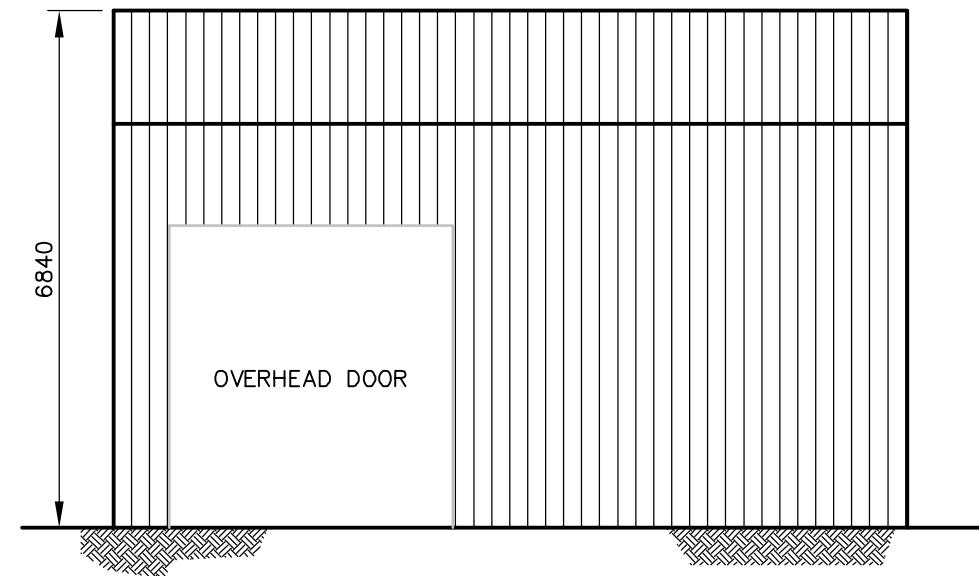
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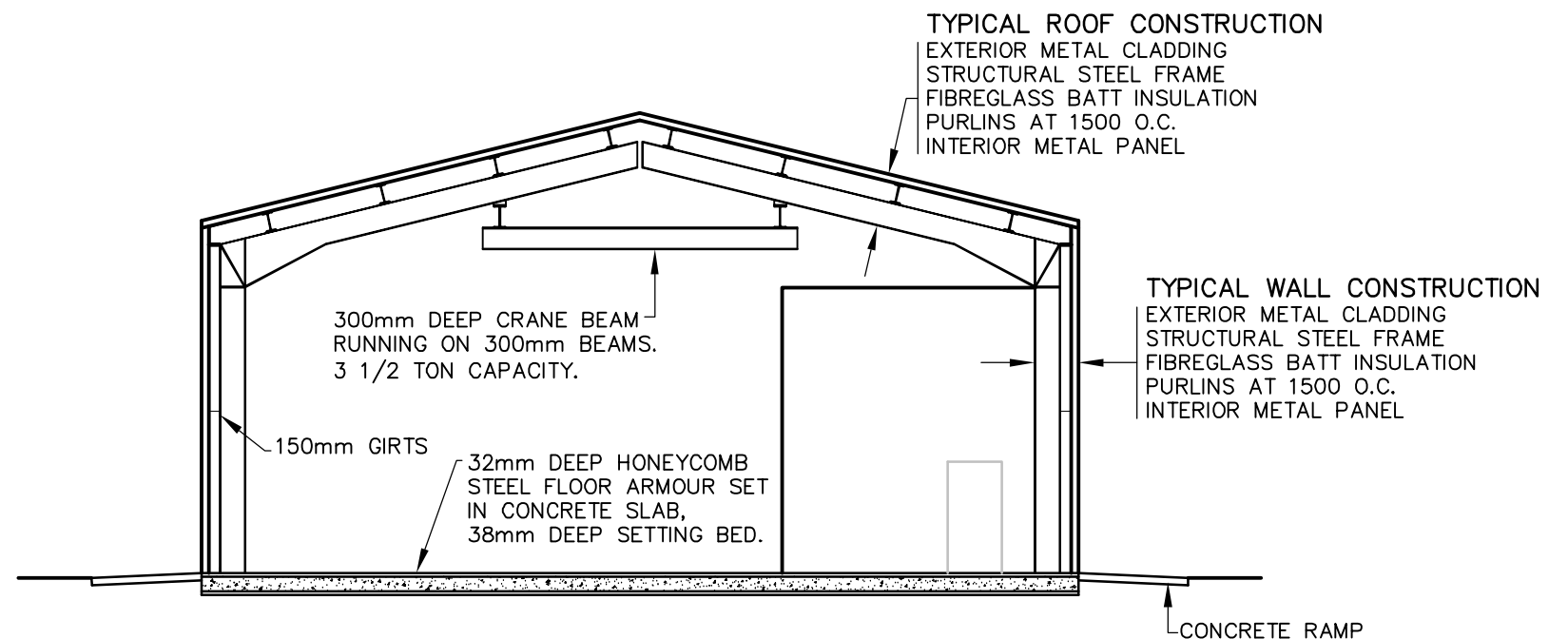
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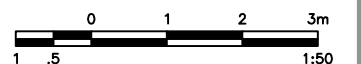
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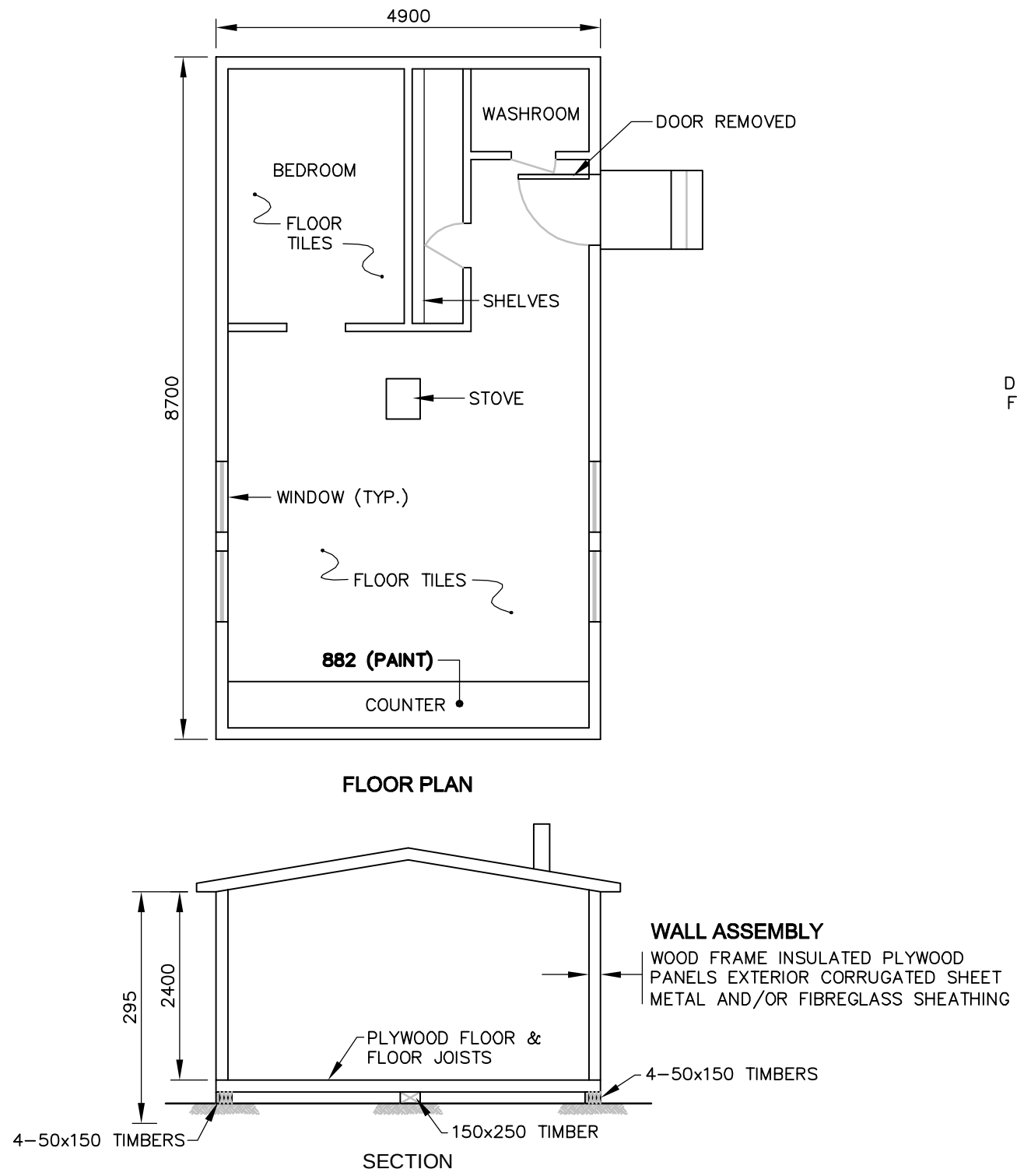
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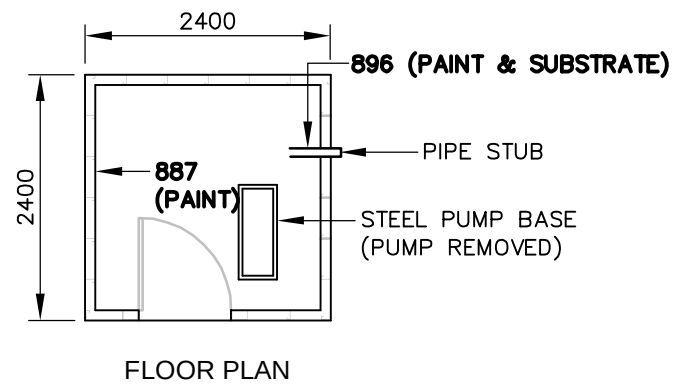
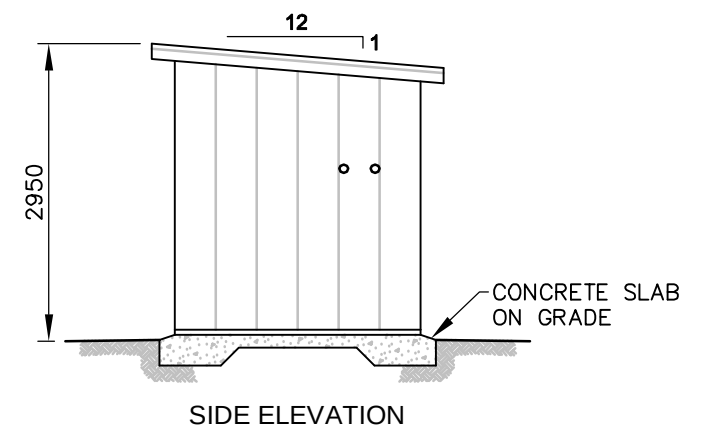
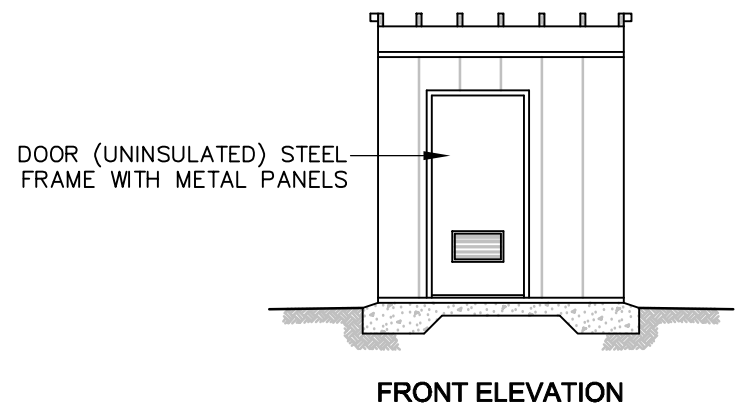


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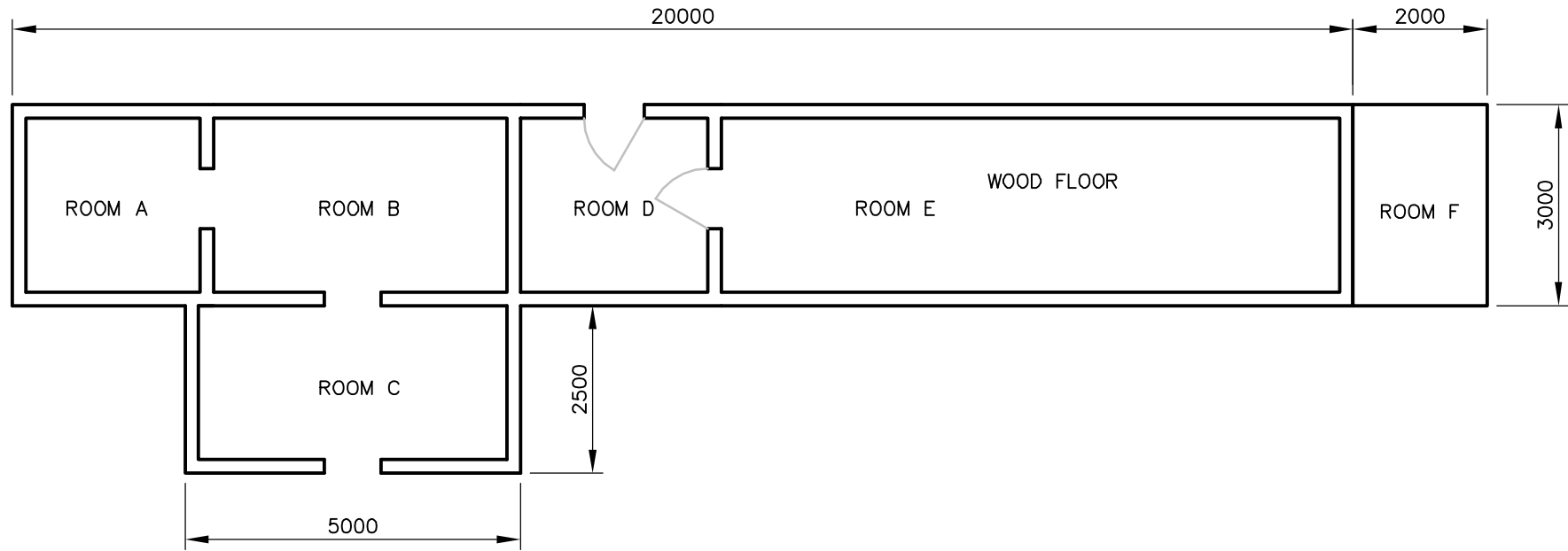
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SEE SPECIFICATIONS FOR IDENTIFICATION OF PCB CONTENT IN PAINT / BUILDING COMPONENTS



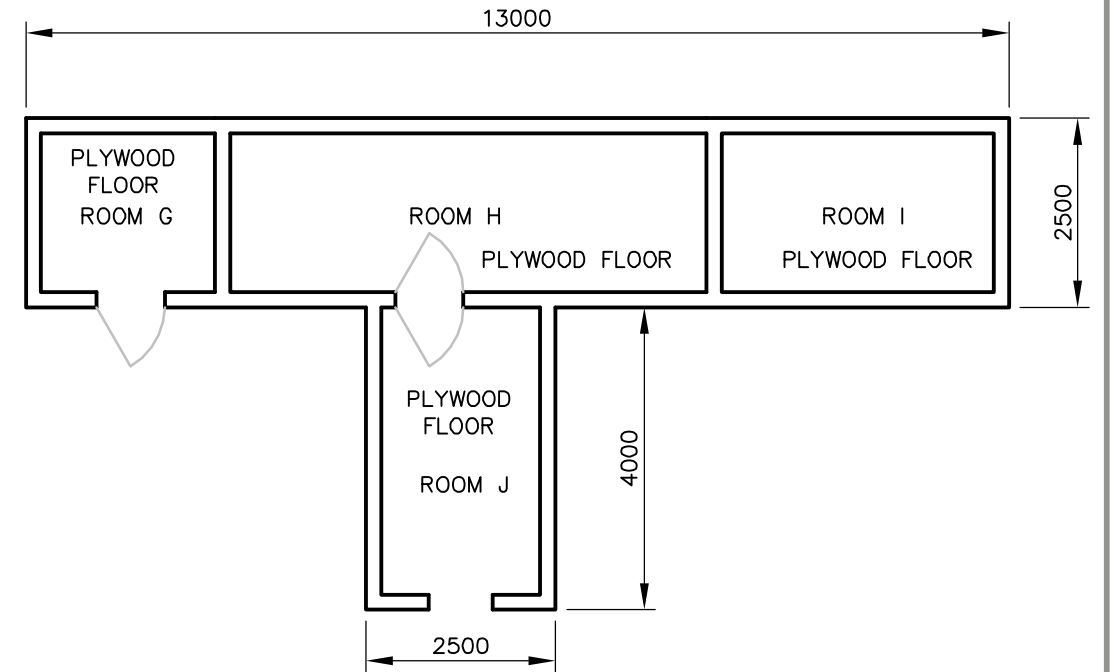
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- GENERAL NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES
UNLESS NOTED OTHERWISE.

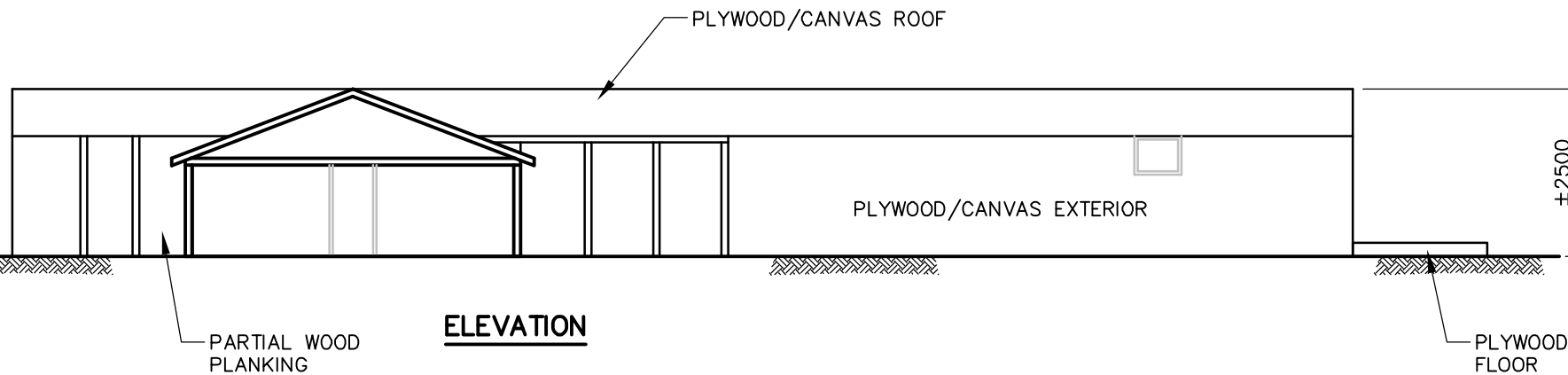
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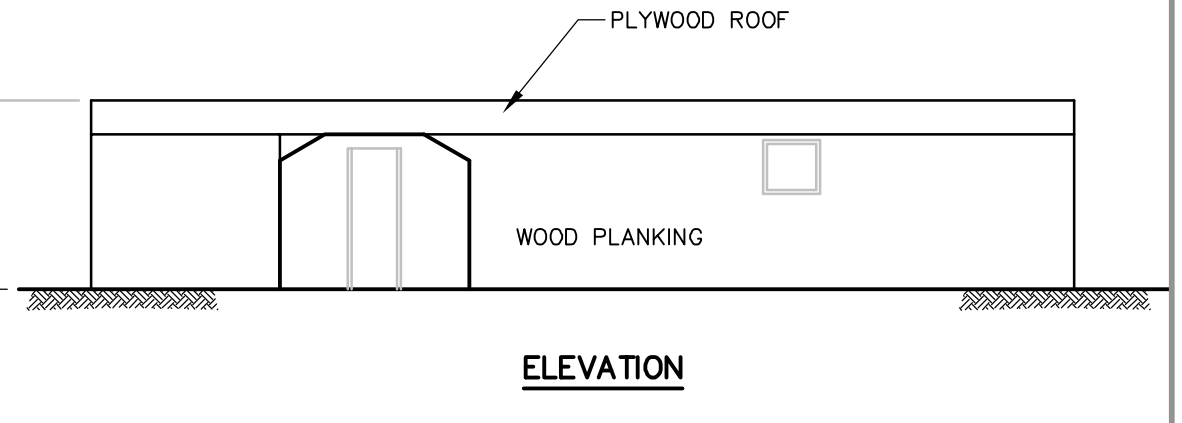
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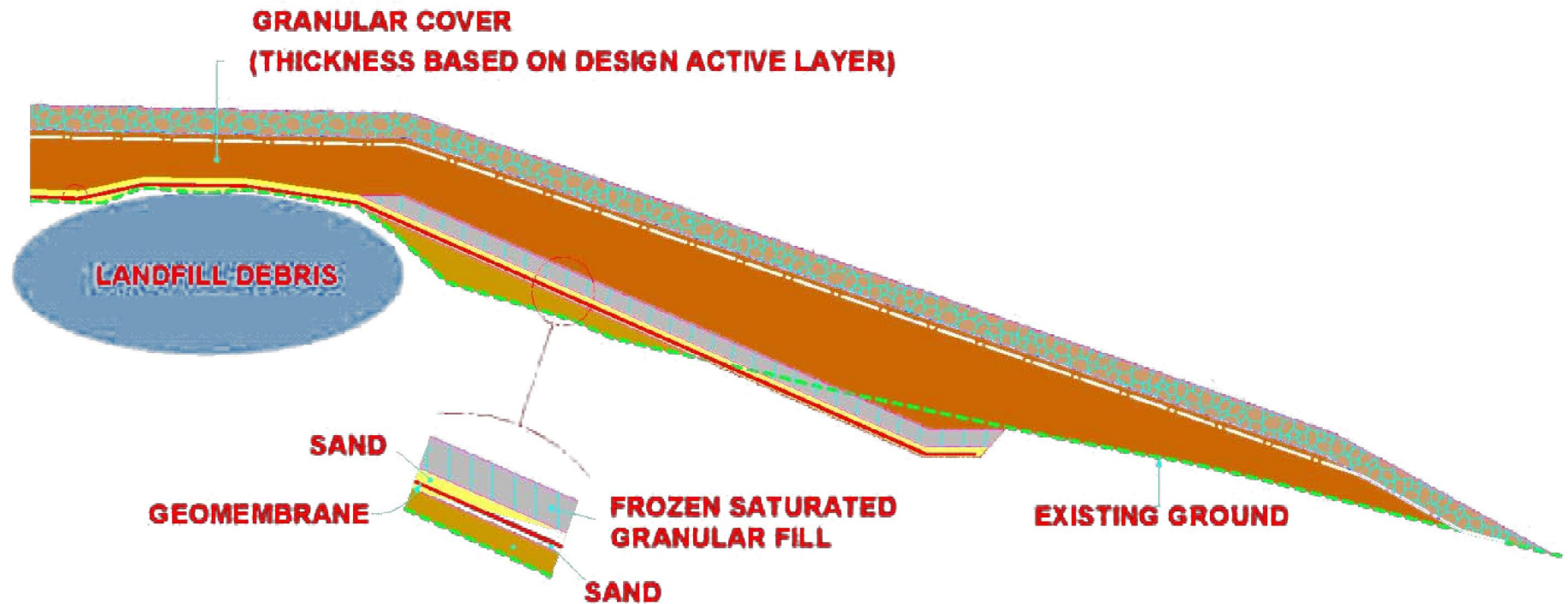
FLOOR PLAN



ELEVATION
BUILDING 1



ELEVATION
BUILDING 2



Public Works and Government Services Canada
PIN-B DEW Line Site
Site Investigation
Leachate Containment Cross-Section

Appendix B
Summary of Contaminated Soil Areas

Summary of Contaminated Soil Areas - CWS PHC Evaluation

Location	Area (Ref. by Tag Number)	Contaminants	Tier I		Tier II		PHC F3 & F4		PHC F1, F2 & F3		Comments	Tier I Volume m ³	Tier II Volume m ³	PHC F3&F4 Volume m ³	PHC F1,F2&F3 Volume m ³
			Area m ²	Depth m	Area m ²	Depth m	Area m ²	Depth m	Area m ²	Depth m					
Module Train	MT-503	Zn, PCBs			280	0.3						0	84	0	0
Module Train	MT-514	Zn, PCBs			130	0.3					Tier I at depth to be backfilled	0	39	0	0
Module Train	MT-502	PCBs	30	0.3							Eastern limits not delineated	9	0	0	0
Module Train	MT-715	PHC F2							22	0.2	Impacts limited to the depth interval of 0.8-1.0	0	0	0	4
Sewage Outfall	SO-558	Cu			75	0.3					Northern limit not delineated	0	23	0	0
Incinerator	I-568	Cu			15	0.3						0	5	0	0
Garage	G-527	PCBs	30	0.3								9	0	0	0
Garage	G-533	PCBs			162	0.3						0	49	0	0
Garage	G-537	PHC F3					542	1.5			Small area of Tier I PCBs included	0	0	813	0
Garage	G-640	PHC F1, F2, F3							646	1.5	Western limit not delineated	0	0	0	969
Station POL	SP-597	PHC F2, F3							1646	1.5		0	0	0	2469
Station POL	SP-619	PHC F2, F4							375	0.5	Impacts limited to the depth interval of 0.5-1.0	0	0	0	188
Station POL	SP-624	PHC F2, F5							1942	1		0	0	0	1942
Barrel Stockpile A	BSA-589	PHC F3, F4					425	0.7				0	0	298	0
Beach POL	BP-803	PHC B							968	1.2		0	0	0	1162
POL Line Battery Debris	PBD-843	Pb			138	0.5					Depth delineation not achieved	0	69	0	0
North of Airstrip	NA-858	Cu			40	0.3						0	12	0	0
Station West Dump	SWD-674	Pb			42	0.5						0	21	0	0
Beach Dump South A	BDSA-770	Pb, Cu			82	0.3						0	25	0	0

CONTAMINATED SOIL AREAS
20
330
1120
6740

Appendix C Tables

Table 1: Summary of Surface Debris Areas

Debris Area	Description	Location	Estimated Areal Extent (m ²)	Estimated Uncrushed Volume (m ³)	Estimated Crushed Volume (m ³)	Hazardous Volume Component (m ³)	Comments
Site Debris 1	Tin cans, canvas, metal siding, stove pipe, tent frame, metal strapping, wood, electrical cable, pipe, braided metal cable, incinerator barrel on stand, barrel culvert and pipe at outfall, barrel barbecue, day tank stand, bathroom sink and fixtures, 1 x1 m asbestos board, pallet, qamotiq (1/2), water tank, toilet seat, plastic kid's toboggan, cat tracks, filters, metal posts, spool and cable, window frames, asbestos tile, glass, pail, rebar, rubber, chair, 2x6" wood barrel stand, heavy equipment cab, power pole (creosote). Wash house remains: 1.5x1x5x1.5 m square tank, propane tank (2 m by 0.5 m dia.), metal shower stall, copper piping, plywood and 2x4" construction, electrical panel and cables. Barrels: 37 empty, 6 marker barrels, 9 with aqueous contents, 2 mixed phase, 1 oil.	Station Area	213,100	44.0	27.0	0.2 (asbestos) 2 (creosote pole)	Scattered debris away from station area, more concentrated piles at station. Volume and description does not include debris within buildings
Site Debris 2	Includes Barrel Stockpiles A and B. Barrel Stockpile A: 22 marker barrels with signposts, 30 stacked barrels, bulging, leaking, 19 oil contents, 5 oil/water mix, 2 empty, 1 sludge, 3 aqueous. Barrel Stockpile B: 78 barrels, 54 empty, 24 with minimal aqueous contents (all could likely be consolidated into 1 barrel). Debris: pipe sections, snow fencing, 1x1 m asbestos board and smaller scattered pieces, plywood, rebar, metal strapping, metal pail, 2x2"s, metal grating, tins, cable, rubber, mesh, roller and toe bar, pallets, canvas, metal siding, wire, angle iron, wood fragments.	Construction Camp Area	97,000	40.0	25.0	0.3 (asbestos)	Debris is mostly scattered, locally more concentrated in vicinity of dumps
Site Debris 3	Tin cans, glass, tire, wood, cable, 1 barrel (empty), metal strapping, oil filter, battery fragments	Station West Dump Area	1,600	3.0	2.0	0.1 (battery)	Debris is concentrated mainly near the dump toe (some partially buried) and scattered away from dump
Site Debris 4	metal pail, piece of stovepipe, empty barrel	0.8 km Southeast of Station	1,900	0.4	0.2		
Site Debris 5	1 piece aluminum siding	0.5 km East-southeast of Station	1,400	0.2	0.1		
Site Debris 6	2 empty barrels	0.6 km East of Station	2,900	0.5	0.2		
Site Debris 7	4 barrels, piece of metal sheeting. 2 barrels are approx. 1/4 full but are rusted through so contents are likely aqueous. 1 barrel in pond	0.4 km East of Station	7,200	1.0	0.5		
Site Debris 8	1 empty barrel at edge of dried up pond	0.4 km East of Station, along old trail	1,300	0.3	0.1		
Site Debris 9	1 sheet of plywood	0.4 km East-northeast of Station	1,000	0.1	0.1		
Site Debris 10	scattered wood debris, wood box, tins, barrel with aqueous contents, metal sheet, cylinder, metal pails, rubber	0.080 km east of POL Line, mid-way between station and airstrip	15,000	1.0	0.8		
Site Debris 11	Includes Barrel Stockpile C, 5 airstrip approach marker barrels, end of airstrip signs, lights, recent fuel cache. Barrel Stockpile C: 32 barrels, barrels painted orange (so may have been marker barrels), all quite rusted, many rusted through in locations, 11 with apparent aqueous contents. Recent fuel cache: 4 barrels at end of airstrip with contents, labels read Jet-B fuel, 5th barrel (empty) in creek bed nearby.	At southeast end of airstrip, extending to southeast	60,300	12.0	6.0		
Site Debris 12	5 airstrip approach marker barrels, end of airstrip signs, lights, Three recent fuel caches (Jet-B): 2 small stockpiles by abandoned airstrip: 8 in total, 3 full, remainder empty. Third cache on east side of water lake: 7 barrels, Jet-B, "INA" spray painted on sides, 5 with contents, equivalent of 2 full drums. Remainder of barrels: 16 empty, 4 with aqueous contents, 1 mostly full of fuel (sample 914). Other debris: pallets, pipe, tins, copper pipe, sheets, melted metal fragments, bolts, pail, pot, water pump, wood, barrel raft constructed with 6 drums, a tire, metal rods, and asbestos core door as platform, signpost, plastic, metal cable, misc. small scattered debris.	Around abandoned airstrip, shoreline of water lake and extending north of lake and airstrip	644,500	19.0	13.0	0.3 (barrel sample 914), 0.5 (asbestos core door)	Debris is located along shoreline and is not submerged within lake itself
Site Debris 13	Includes Barrel Stockpile D. Debris: misc. engine pieces, plastic jugs, wood timbers, mechanical equipment, cable reels, wire, metal pails, misc. rusted out metallic debris, glass, garbage pails, rubber, angle iron, cement pails, wooden washboard, vacuum hose, runway lights, plywood, intact battery at Beach Dump, 2 intact batteries at Inuit camp, partially filled jerry can, tires, metal shelving, skid, mesh fabric, 2 4'x8' asbestos board, inner tube, pallets, radiator, bolts, canvas . Barrel Stockpile D: 157 drums in total; visible labels stated "fuel oil-diesel!"; 46 had partial contents - all aqueous, most were deteriorated and rusted through, 5 samples collected. Other scattered barrels: 276 empty, 62 marker barrels (52 at north end of Beach Dump), 43 with contents (mostly aqueous), 10 with suspected hydrocarbon contents, 2 with confirmed fuel contents (samples 908 and 909). Beach POL Area: 95 barrels partially buried and visible, some more expected to be buried (assume 100), some with oil contents on top of tank pad and beside bladder pad (samples 906 and 907).	Along beach from north of Beach Dumps to Inuit camp, extending west to airstrip	682,300	197.0	109.0	0.3 (battery) 0.6 (barrel samples 906 and 909) 0.2 (asbestos)	Debris is more concentrated along the beach in the vicinity of the POL pad, dumps, and Inuit Camp, then scattered towards airstrip and along beach to north and south of site
POL Line	POL line, 51 marker barrels, 2 power cables	POL line between Station POL and Beach POL	1,400	200.0	190.0		
TOTALS			1,730,900	519.0	374.0	4.5	

Table 2: Demolition Debris Inventory

Structure	Quantity	Description of Components	Hazardous Material	Building Contents (during 2007 survey)	Non-Haz. (m³)	Hazard. (m³)	Comments
POL Pumphouse	1	Painted steel clad, steel frame	None	None	4.8		Concrete foundations may require removal for contaminated soil excavation, depending on the PHC remedial criteria selected.
		Concrete foundation			2.0		
Inuit House	1	Prefabricated wood and metal clad panels with rigid insulation. Structure 10m L x 5m W x 2.5m H on shallow wood foundation.	Likely asbestos in chimney components and stove and potentially in floor tiles	Shelving, bed frames, stove	21	3	
Radar Tower	1	Steel pipe and beam construction with associated communication cables. Triangular cross-section: 65 m L x 5 m B x 5 m H	None - see comments	N/A	160		Paint and substrate samples collected from CAM-F and FOX-C were below criteria for PCBs and leachable Pb
Module Train Five joined 4.9m L modules. Total dimensions 25.2m L x 8.6m W x 3.7 m H. Constructed timber crib foundation. Wood frame construction	1	Module 1 - Powerhouse					
		Foundation			7.9		
		Floor/Ceiling	PAP interior and exterior plywood	Heat exchanger, mechanical and electrical conduits, 2 x 275 gal fuel tanks, nitrogen cylinders, exhaust piping	18.4	0.5	
		Concrete Floor	PCB contaminated concrete		1.5	0.5	
		Walls	PAP interior and exterior plywood		12.2	2.0	
		Fuel Tanks	PAP			3.0	
		Misc. Mechanical and Piping	PAP over asbestos wrap		2.0	3.0	
		Misc. Electrical			0.0	1.0	
		Module 2 - Storage/Electrical Room					
		Foundation		Communication panels and cabinets, electrical and mechanical, shelving	4.0		
		Floor/Ceiling	PAP interior and exterior plywood		17.4	1.5	
		Walls	PAP interior and exterior plywood		10.7	1.5	
		Shelving	PAP			2.0	
		Electrical Panels			7.0		
		Misc. Mechanical and Piping	PAP over asbestos wrap		0.5	1.5	
		Misc. Electrical			0.5	1.5	
		Module 3 - Kitchen/Dining/Washroom					
		Foundation		Shelving, hot water tank, sink, radiators, mechanical and electrical components	5.2		
		Floor/Ceiling	PAP interior and exterior plywood		17.4	1.5	
		Walls	PAP interior and exterior plywood		11.4	2.3	
		Fixtures/Shelving	PAP		1.0	2.0	
		Misc. Mechanical and Piping	PAP over asbestos wrap		0.5	1.0	
		Misc. Electrical	PAP		0.5	0.5	
		Module 4 - Tank Room/Bedroom					
		Foundation		Water tank, bed frames, radiators	6.6		
		Floor/Ceiling	PAP interior and exterior plywood		17.4	1.5	
		Concrete Floor	PCB Paint to be removed		1.1	0.1	
		Walls	PAP interior and exterior plywood		12.6	2.6	
		Tanks	PAP		0.6	3.0	
		Misc. Mechanical and Piping	PAP over asbestos wrap		0.5	1.0	
		Misc. Electrical	PAP			1.0	
		Module 5 - Tank Room					
		Foundation		3 water tanks, mechanical and electrical components	6.6		
		Floor/Ceiling	PAP interior and exterior plywood		17.4	1.5	
		Walls	PAP interior and exterior plywood		10.2	2.0	
		Tanks	PAP			9.8	
		Misc. Mechanical and Piping	PAP over asbestos wrap		0.5	1.5	
		Misc. Electrical	PAP			1.0	
		Doors	Asbestos core		11 total	2.5	
		Vermiculite		4 compartments	4.1		
		Exterior Stairs	PAP	4 total		9.0	
Warehouse 12.6 m L x 8.9 m W x 6.8 m H on concrete footings. Structural steel braced frame with corrugated aluminium cladding.	1	Exterior Walls with Metal Cladding/Rigid Insulation		Furnace, metal shelving, toilets, hot water tank, electrical panels, ducting	20	1.0	Concrete foundation to be left in place and regraded
		Interior walls, partitions, ceiling, doors	PAP on partial interior metal cladding walls, all plywood walls, and ceiling		2.0	0.5	
		Structural Steel			5.0		
		Access steps	PAP			3.0	
		Vestibule	PAP on interior walls		8.5	1.5	
		Furnace and Chimney	Asbestos containing materials in chimney, fire doors and furnace room wall panels		1.0	1.5	
		Shelving			2.0		
		Floor	PAP on plywood floors in dormitory and vestibule area			0.6	
		Misc. Mechanical, ducting	Asbestos wrap had been removed		2.0		
		Misc. Electrical			1.5		
Garage 12.6 m L x 8.9 m W x 6.6 m H on concrete footings. Structural steel braced frame with exterior metal cladding.	1	Building envelope (includes cladding and insulation)			81		Concrete foundation to be left in place and regraded
		Overhead doors			4.5		
		Interior walls, partitions, ceiling, doors			3.7		
		Piping, hoist beams, interior shelving, ladders, etc.					
		Structural Steel			7.0		
		Floor (paint only)	PCB Paint to be removed			0.1	
		Mezzanine - stairs, deck, beams			4.5		
		Furnace and Chimney	Asbestos wrap		0.5	1.0	
		Fuel Tanks			3.0		
		Misc. Mechanical			1.0		
Camp Building 1	1	Wood frame structure (16.5m x 3m x 2.5m) with partial wood/canvas roof on shallow wood foundation	4 batteries	Desks, bed frames, cans, misc. domestic waste, pump, cable spool	22	0.2	
			PAP plywood walls and ceiling			3.0	
Camp Building 2	1	Wood frame structure (16.5m x 3m x 2.5m) with partial canvas/wood roof on shallow wood foundation	Asbestos containing sheeting (1 piece)	Shelving, bed frames, misc domestic waste	14	0.1	
			2 Paint cans			2.0	
			PAP plywood walls and ceiling				
Boat	1	Wood frame structure with plywood wood siding, metal keel. Main body: 12m L x 2m H x 2.5m W. Cabin: 2m L x 2m H x 2m W	None - see comments	Rope, canvas, plastic, metal clamp, wood, engine	21		Main body painted orange, but this paint typically not PAP
TOTAL (Crushed) Volume					589	79	

Table 3: Summary of Paint and Concrete Demolition Samples

Tag Number	Date Sampled	Sampled By	Building / Location	Structure	Substrate	Paint Colour	Paint Condition	% Paint Coverage on Structure	Paint Thickness - Field Measurement (mm)	PCB Paint Concentration (mg/kg)	PCB Paint / Substrate Concentration (mg/kg)
Paint											
861	19-Aug	Leigh	Garage	Wall	Metal	Bluish Grey	Flaking	60	0.22	376	7.6
862	19-Aug	Mark	Garage	Wall	Metal	Khaki grey	Flaking	99	0.15	153	3.5
863	19-Aug	Mark	Garage	Wall	Metal	White	Flaking	40	0.18	194	2.1
864	19-Aug	Leigh	Garage	Stairs	Metal	Black	Good	95	0.2	325	4.0
865	19-Aug	Mark	Garage	Hand Rail	Metal	Red	Slight Flaking	90	0.25	288	4.2
866	19-Aug	Mark	Garage	Wall	Metal	Brown	Flaking	15	0.13	155	0.5
868	19-Aug	Dan	Warehouse	Bedroom Wall	Metal	Yellowy Beige	Flaking	95	0.22	71100	2287
869	19-Aug	Leigh	Warehouse	Furnace Room Door	Metal	Red	Good	100	0.15	1900	43.9
870	19-Aug	Mark	Warehouse/Duplicate of 871	I-Beam	Metal	Brown	Flaking	85	N/A*	5.1	
871	19-Aug	Mark	Warehouse/Duplicate of 870	I-Beam	Metal	Brown	Flaking	85	N/A	3.28	
872	19-Aug	Mark	Warehouse	Washroom Stairs	Wood	Grey	Good	99	N/A	28800	3880
874	19-Aug	Mark	Module Train	Water Tank	Metal	Dark Grey	Flaking	95	0.27	17700	146
875	19-Aug	Dan	Module Train	Hallway Partition Wall	Wood	Grey	Flaking	50	N/A	15000	124
876	19-Aug	Leigh	Module Train	Wall	Wood	Mint Green	Flaking	95	N/A	37100	2066
877	19-Aug	Mark	Module Train	Radiant Heater	Dark Metal	Grey	Flaking	25	N/A	23100	92.9
878	19-Aug	Leigh	Module Train	Interior Door	Wood	Grey	Flaking	60	N/A	3660	129
879	19-Aug	Dan	Module Train	Wall	Wood	Grey	Flaking	60	N/A	8830	311
880	19-Aug	Dan	Module Train/ Duplicate of 881	Composite from 3 walls	Wood	Pale Beigy Grey	Flaking	95	N/A	15800	880
881	19-Aug	Dan	Module Train/ Duplicate of 880	Composite from 3 walls	Wood	Pale Beigy Grey	Flaking	95	N/A	36500	2033
882	19-Aug	Mark	Inuit House	Counter Top	Wood	Grey	Flaking	80	N/A	399	13.8
885	19-Aug	Dan	Module Train	Exterior Powerhouse Wall	Metal	Cream	Flaking	50	N/A	4240	65.3
886	19-Aug	Ken	Module Train	Concrete Floor	Concrete	Grey	Good	90	N/A	14100	14100
887	19-Aug	Leigh	POL pumphouse	Wall	Metal	Silver	Good	90	N/A	3.89	
888	19-Aug	Leigh	Module Train	Foundation Cribbing	Wood	Cream	Flaking	75	N/A	144	1.2
Concrete											
867	19-Aug	Ken	garage	Floor	concrete		Minor staining			6.54	6.54
873	19-Aug	Ken	warehouse	Floor	concrete		No staining			6.77	6.77
883	20-Aug	Ken	MT-powerhouse	Floor	concrete		Minor staining			1300	1300
897	24-Aug	Ken	warehouse	Floor	concrete		Floor not painted			3.58	3.58

* N/A = not available

Appendix D Analytical Results

Barrel Sample Summary

Sample Number	Location	% Full	Contents Description	Label	Comments	Analytical Results
900	Barrel Stockpile D	20	Aqueous, single phase	none		Meets criteria
901	Barrel Stockpile D	20	Aqueous, single phase	none	Duplicate of 900	Meets criteria
902	Barrel Stockpile D	15	Aqueous, single phase	none	Sheen on surface	Meets criteria
903	Barrel Stockpile D	10	Aqueous, single phase	none		Meets criteria
904	Barrel Stockpile D	20	Aqueous, single phase	none		Meets criteria
905	Barrel Stockpile D	10	Aqueous, single phase	none	Sheen on surface	Meets criteria
906	Beach POL, top of pad	35	Two phases - oil and aqueous	none	Oil component analyzed	Exceeds Total Organic Halides (Cl) criterion
907	Beach Bladder pad toe	40	Two phases - oil and aqueous	none	Oil component analyzed	Meets criteria
908	Between Beach Dump South B and Beach POL	65	Aqueous, single phase	none		Meets criteria
909	Along beach near Beach Dump	85	Oil, single phase	none	Suspected hydraulic or transmission fluid	Exceeds Total Organic Halides (Cl) criterion
910	Barrel Stockpile A	35	Two phases, primarily oil with some water	none	Lube oil	Meets criteria
911	Barrel Stockpile A	20	Two phases, primarily oil with some water	none	Lube oil	Meets criteria
912	West of garage	20	Oil, single phase	none	Lube oil	Meets criteria
913	East of Station POL	50	Two phases, fuel and aqueous	none	Fuel oil, fuel component analyzed	Meets criteria
914	Water Lake	70	Fuel, single phase	none	Fuel oil	Exceeds lead criterion

Appendix E
INAC Protocols



Indian and Northern
Affairs Canada

Affaires indiennes
et du Nord Canada

Abandoned Military Site Remediation Protocol

March 2005

Indian And Northern Affairs Canada

Abandoned Military Site Remediation Protocol

Modified June 2007



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1.0 INTRODUCTION

The Department of Indian and Northern Affairs Canada (INAC) is responsible for contaminated military sites, including intermediate and auxiliary Distant Early Warning (DEW) Line sites, in the Canadian Arctic (Fletcher 1989; INAC 2002). Environmental issues of concern at these sites have been identified that need to be addressed. This site remediation Protocol provides the guiding principles for the remediation of the contaminated sites under the control of INAC. The main DEW Line sites are the responsibility of the Department of National Defence (DND). Most of the INAC sites differ from the related DND sites in that they were in operation for a very limited period of time and were significantly smaller than the DND sites. Six of the INAC sites, Hat Island (CAM-B), Simpson Lake (CAM-D), Rowley Island (FOX-1), Bray Island (FOX-A), Nadluarjuk Lake (FOX-B) and Resolution Island (BAF-5), have currently operational North Warning System (NWS) sites co-located with the original DEW Line Site reserve.

INAC has undertaken the remediation of a number of sites across the Canadian Arctic namely Iqaluit Upper Base, Resolution Island, Horton River (BAR-E), and Pearce Point (PIN-A). The approach adopted for the remediation of these sites has generally been consistent with the DLCU Protocol (ESG 1991, 1993) with some site-specific modifications. Although no formal protocol was established or followed, remediation levels achieved at these sites were established for the protection of the environment. Due to the federal governments commitment to future funding of contaminated site clean up, INAC recognizes the need for a consistent protocol for abandoned military site cleanup (INAC 2002).

There are a number of factors that must be considered when determining the most suitable approach to site remediation. This protocol is based on an approach which addresses all legal requirements, INAC's Draft 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 all the site environmental issues while striking a balance with remedial cost.



2.0 CLEANUP OBJECTIVES

The following cleanup objectives, which are consistent with the CSMWG objectives to “integrate sustainable development and pollution prevention principles while meeting environmental regulations and protecting public health” (CSM, 2000, TB 1998, 2000, 2002), have been identified:

- To restore sites to an environmentally safe condition;
- 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 by DND in the remediation of DEW Line sites under DND control (ESG 1991, 1993). The following considerations need to be taken into account when developing and implementing a remediation plan for the INAC sites:

- Respect all historical agreements and obligations in a fair and reasonable manner;
- Ensure consistency with federal guidelines for the management of contaminated sites;
- Apply the Canadian Council of Ministers of the Environment (CCME) environmental protection and management approaches (CCME 1996, 1997, 1999, 2001) 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 the 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 the long-term effectiveness of the environmental remedial measures.



3.0 BACKGROUND

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 (TBRP 1998, 2000, 2002). The following sections discuss the various factors that have been taken into consideration in developing a remediation approach.

CANADIAN COUNCIL OF MINISTERS OF THE ENVIRONMENT APPROACH

Where remediation of federal real property is undertaken, 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):

- *Method 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 2001). To the extent that such 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);
- *Method 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
- *Method 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.

DEPARTMENT OF NATIONAL DEFENCE (DND) DEW LINE CLEAN UP PROTOCOL

The DLCU Protocol was developed by DND, with other government agency and stakeholder involvement, as a functional strategy for the effective remediation of the DND DEW Line sites (ESG 1991, 1993, 2003). The Protocol was developed at a time when no remediation standards and criteria specific to the Canadian Arctic existed. The DEW Line Cleanup Criteria (DLCU Criteria) was validated through the collection of soil and vegetation samples from all of the DEW Line sites to monitor contaminant uptake



using a contaminant source and pathway targeted approach. A broad suite of chemicals was investigated and the 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 importance of the sites acting as point sources for contaminants in the Canadian Arctic was demonstrated through radial studies conducted at a number of DEW Line sites (ESG 1995). Contaminant concentrations were demonstrated to decrease with the increase in distance from the site but with constant contaminant patterns.

In 1996 DND initiated remediation of the first DEW Line sites using the DLCU Protocol and since then has applied this Protocol to all DND sites. A number of developments and modifications have been made to the approach to address issues that have arisen during the DND site remediations, such as the addition of petroleum hydrocarbons (PHC), elevated metal background concentrations in excess of the DLCU Criteria etc. These have been necessary due to the changing regulatory framework and to address site-specific conditions (e.g. CCME 2001, ESG 2005).

The development of the DLCU Protocol, the DND application of the Protocol and the Protocol itself has been reviewed by INAC to determine the applicability of the DLCU Protocol to the INAC abandoned military sites (WESA 2004). The Protocol has been determined to be generally applicable and indicates that this approach can be adopted to address specific remediation technical issues, is applicable at the smaller sites, and is appropriate for the INAC military sites. The DLCU Protocol has therefore been retained with minor modifications for application to the INAC sites. The supporting technical protocols have been developed to ensure the INAC Protocol remains relevant to the unique characteristics of INAC's sites.

The DEW Line Protocol has been retained with modifications appropriate to the scale of the site remediation requirements. These criteria remain relevant in accordance with the federal real property approach. The Criteria are adopted under the *CCME Method 1* where equivalent guidelines or standards are permissible for technical or economical reasons (CCME 1997).

CLEANUP CRITERIA FOR ADDITIONAL CONTAMINANTS OF CONCERN

Based on a detailed review of data collected to date from DND and INAC site assessments and delineations it was determined that the DEW Line Cleanup (DLCU) Protocol that includes criteria for a specific limited set of contaminants is appropriate for



the INAC sites.. This provides a consistent approach across all sites, and is generally considered protective of the most sensitive receptors. Supporting documentation is found in annex A. These criteria are referred to hereinafter as Arctic Remediation Criteria (ARC)

SUBSTANCE	CRITERIA	
	Tier-I	Tier-II
<i>Inorganic Elements</i>		
Arsenic		30
Cadmium		5.0
Chromium		250
Cobalt		50
Copper	-	100
Lead	200	500
Nickel		100
Zinc		500
<i>Polychlorinated biphenyls</i>		
PCBs	1.0	5.0

ASSESSMENT OF BACKGROUND CONCENTRATIONS

Application of remedial criteria must take into account background concentrations of inorganic elements. Based on a review of existing site assessment data, a minimum of three sites are expected to have naturally occurring elevated concentrations of a select number of parameters. It is recommended that INAC conduct a detailed desk-top study of geochemistry of surficial and bedrock geology and provide the results of this study to consultants, prior to initiating site investigations. If required, a detailed investigation of background concentrations will be carried out in conjunction with the environmental site assessment. The requirements for the background geochemistry investigation are provided in Annex B.

PETROLEUM HYDROCARBON CONTAMINANTS

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 inherent in the derivation of the CCME CWS for Petroleum Hydrocarbons suggests that direct application of criteria for the protection of receptors is



not appropriate at the INAC sites. Therefore, based on a review of the CCME Method, the process currently utilized on DND DEW Lines sites, and the quantitative risk assessment carried out to date, a qualitative assessment of potential environmental risk will be used. This approach has been modified to mitigate against subjective input. The details of the hydrocarbon contamination evaluation process are provided in Annex C.

INSERT MATRICES

ADDITIONAL NON-HYDROCARBON CONTAMINANTS

The level of environmental protection afforded the Arctic through the remediation of these contaminated sites needs to be consistent with the increased sensitivity of the receptors that are present, or frequent the sites. Environmental cleanup criteria developed for application at other more southerly latitudes are not necessarily sufficient to protect the sensitive Arctic ecosystem (INAC 2000). In order to demonstrate that the cleanup criteria adopted for the INAC military sites are sufficiently protective, an Ecological and Human Health Risk Assessment was conducted at a number of sites in the central and eastern Arctic. The impacts of the contaminants with a wide range of parameters on selected representative receptors were assessed and the related risk to the ecological or human health determined. The results of the risk assessment applying the DLCU Protocol showed that the level of risk posed by residual contaminants following remediation to these standards is well below the acceptable risk levels for both ecological and human receptors. The ecological risks at the DLCU levels are negligible. The human health risks are all below the Health Canada human health effects levels (HC 2002).

In a limited number of cases the INAC military sites served as centres for other non-military activities. In these cases it is possible that contaminants have been introduced and are present that have not been identified as common to all sites and therefore are not included in the INAC Protocol. At sites where this is known or suspected to be the case, the ecological and human health data will be collected and the corresponding risk assessment completed to determine the appropriate remedial standard for any additional elements detected during the investigation phase. The contaminants, not addressed by the ARC, will be addressed through *CCME Method 3 site-specific risk assessment* (CCME 1996). A site-specific risk assessment is required due to the unique and sensitive nature of the Arctic environment.



ECONOMIC CONSIDERATIONS - COST BENEFIT ANALYSIS

Prior to implementing any remedial plan the costs of implementing all potentially suitable remedial solutions for each component of the site need to be evaluated and the total costs of the alternative solutions established to determine the most cost effective solution. The total costs should include consideration of the logistical and resource requirements. In addition to these costs, the long-term monitoring and maintenance of the sites should be considered and the future liability of residual site contamination and facilities be addressed.

The costs associated with implementing approved remedial solutions during site remediation arise from a number of assorted expenses. These include, but are not limited to, resources (i.e. materials, suitable equipment, human resources with the necessary technical skill sets, on-site maintenance and support services) and logistics (transportation and communication).

Typically the complexities of the post-cleanup monitoring and maintenance efforts conducted under remote Arctic conditions are associated with the logistical aspects of the operation and the remoteness of the sites from technical resources and support services. The cost of implementing an acceptable technical remedial solution is often overshadowed by the costs of mobilizing the necessary resources including material, equipment and human resources with the required skill sets for demanding work under difficult conditions.

Following implementation of a technically feasible remedial solution, increased costs may be incurred to ensure effective monitoring of the sites. Problems identified during the monitoring program may result in a requirement to perform additional remedial action with additional costs.

RISK MANAGEMENT CONSIDERATIONS - RISK ASSESSMENT

The risks to the Department during the monitoring and maintenance of the site need to be identified (eg. National Classification System (NCS) and Northern Environmental Risk Assessment Strategy (NERAS)). The costs incurred during the implementation of the cleanup need to be commensurate with the environmental benefit and the residual risk to the Department (TB 2000). The risks associated with the site may be more readily reduced during the remediation phase than during the post-cleanup monitoring phase.



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The risks to the project should be evaluated through standard risk assessment tools applied to Departmental projects.



4.0 INAC MILITARY SITE PROTOCOL - TECHNICAL ASPECTS

The elements of this remediation protocol have been developed through the review of previous work at related sites (eg. PWGSC 2001, 2001b, 2001c, 2002, 2002b, 2002c, 2002d, 2002e, 2002f, 2003, IEG 2001, EWG 1998 & 1999, UMA 1994) and taking into consideration information of particular relevance to the unique character of the INAC sites. Typical environmental issues and their associated remedial action procedures addressed by the Protocol are outlined below.

LANDFILLS/Buried Debris Areas

LANDFILL CLOSURE

Landfills on INAC abandoned military sites are generally smaller in extent than those located on DND DEW Line sites, and in some cases, may be more appropriately referred to buried debris areas. These landfills/debris areas can be classified into one of three broad categories. Actions associated with each category of landfill have been identified. Where a landfill exists on INAC abandoned military sites, the condition of the landfill will be evaluated to determine the most appropriate action;

- If the landfill/debris area is located in an unstable, high erosion location, it will be relocated to a properly engineered landfill. During the relocation process, any identified hazardous materials will be segregated for off-site disposal (Class A landfill);
- If the landfill/debris area 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. The remedial solution selected will be based on a cost-benefit analyses that includes consideration of construction costs and long-term monitoring costs. (Class B landfill)
- If the landfill/Debris Areas are located in a suitable, stable location, with no evidence of contaminant migration they may be left in place. If required, additional granular fill will be placed to ensure erosion protection and proper drainage (Class C Landfill). Consideration must be given to surrounding topography (to blend into existing terrain) and potential long term monitoring requirements.



The evaluation matrix prepared by the DND/NTI Environmental Working Group (EWG), was adopted with minor modifications for the assessment of potential environmental risk. These modifications included:

- Addressing remedial requirements for 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.

The revised supporting documentation is provided in Annex D.

LANDFILL DEVELOPMENT

New engineered landfills may be required to address specific contaminants. These landfills will be used for the disposal of non-hazardous materials and non-regulated contaminated soils only. The landfills will be capped with a minimum of [to be determined] m of granular fill material or other thickness as determined by site conditions, which will be graded to promote surface run-off and minimize erosion. The cover thickness will promote redevelopment of the permafrost layer to stabilize the non-regulated contaminated soil landfill contents [to be discussed]. [add EBAs Material]

Consideration for the location of any new landfill will include the proximity to drainage courses, material to be placed within the landfill, borrow source locations and the overall topography of the site.

Monitoring requirements for a specific landfill are dependent on the landfill design. A detailed review of monitoring requirements has not been carried out at this time. This section of the protocol will be modified and updated as required.

SURFACE DEBRIS

Visible site debris will be collected and segregated into hazardous and non-hazardous waste streams for disposal;

Non hazardous waste: The volume of the non-hazardous materials will be minimized through crushing, shredding, or incineration, prior to their placement 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 will be disposed of off-site; and



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

SUBMERGED DEBRIS

The underwater disposal of waste was common in North America and also took place at Arctic Military Installations. Two detailed studies at five different sites in the central and eastern arctic were conducted. A review of these studies and of data collected during the DND DLCU Project confirm that chemical contamination from such inputs are insignificant when compared to shoreline run-off. As a result, consistent with the stakeholder approved DND approach, cleanup actions should be restricted to foreshore areas and not deep waters. (Appendix F).

CONTAMINATED SOILS

Contaminated soils will be considered in three primary categories; soils that are regulated, soils that are classified as hazardous and soils that are classified as contaminated but not hazardous waste. Contaminated soils that are regulated will be remediated and/or disposed of in compliance with the applicable regulations. Contaminated soils that are not regulated or hazardous will be remediated to meet the ARC (see Appendix A). Where the historical land use has been for another industry in addition to the military operations, additional parameters will be assessed and remediated to levels established through Site Specific Risk Assessments. Hydrocarbon contaminated soil remediation levels will be established through the application of the INAC Arctic PHC Evaluation Process.

Three primary contaminated soil types have been identified; inorganic element contaminated soil, hydrocarbon contaminated soil and PCB contaminated soil. Where multiple contaminants are present in the soils, the most conservative remedial option that addresses both contaminant types will be applied.

Contaminated Soil Type	Remediation Action Options
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
Tier II	• Excavate and dispose in an on-site engineered landfill
Inorganic elements leaching	• Transport in accordance with the TDGA for disposal at an off-site facility
CEPA	• Package in accordance with the TDGA for disposal at an off-



	site facility
Type A TPH	• Treat as per INAC Arctic PHC Evaluation Process
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
Tier II-Type A TPH	• Excavate and place in an on-site engineered landfill
Type B TPH and co-contaminated	• Treat as per INAC Arctic PHC Evaluation Process

INORGANIC ELEMENT CONTAMINATED SOILS

All soils with inorganic element concentrations exceeding the ARC Criteria or criteria derived through Risk Assessment processes for sites with non-military activities will be either disposed of off-site or disposed of on-site [subject to discussion]

PETROLEUM HYDROCARBON CONTAMINATED SOILS

Where free product is encountered the free phase liquid will be addressed prior to the application of the INAC Arctic PHC Application Process prior to establishing remediation requirements.

Hydrocarbon contaminated soil remediation levels will be established through the application of the INAC Arctic PHC Evaluation Process. Where hydrocarbon contamination is determined to exceed these protective levels, in-situ or ex-situ remediation options will be considered. Where on-site remediation is not cost effective, hydrocarbon contaminated soils may be transported off site for treatment/disposal.

PCB CONTAMINATED SOILS

All soils with PCB concentrations exceeding the ARC will be either disposed of off-site or disposed of on-site. If the PCB contaminated soils are considered to be a PCB Waste under the Canadian Environmental Protection Act (CEPA 1999), soil handling and disposal will be governed by the PCB regulations.

HAZARDOUS MATERIALS

Hazardous materials referred to in this section are defined as any materials, which are, designated "hazardous" or "dangerous goods" under Nunavut Territorial or federal



legislation. Generally, all hazardous materials identified at the site will be collected and transported off site, in accordance with the Transportation of Dangerous Goods Act (TC 2002), to a licensed hazardous waste disposal facility. There are a few exceptions, which are described below:

- **Asbestos:** Asbestos waste will be collected, double bagged and disposed of in an on-site engineered landfill, in accordance with the appropriate legislation;
- **Petroleum Products:** Petroleum products, such as gasoline or diesel, which do not contain other hazardous products (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;
- **Compressed Gas Cylinders:** Compressed gas cylinders with known contents will be vented. Once empty, the metal cylinder will be disposed on-site in an engineered landfill;
- **Creosote Treated Timbers:** Timbers will be wrapped in polyethylene sheets and disposed on-site in an engineered landfill;
- **PCB Paint on Building Components:** PCB paint and PCB painted components which are regulated under the CEPA, will be collected and transported off site, in accordance with the Transportation of Dangerous Goods Act and CEPA, to a licensed hazardous waste disposal facility; and
- **Lead-Based Paint on Building Components:** Lead-based painted components which are classified as hazardous material will be collected and transported off site, in accordance with the Transportation of Dangerous Goods Act and CEPA, to a licensed hazardous waste disposal facility. Painted components that exceed the relevant federal or Territorial criteria but are not considered hazardous will be collected and disposed in an on-site engineered landfill. [clarification required]

BARRELS

Barrels identified at the site will be handled according to the DLCU Barrel Protocol (see Appendix E) as outlined below:

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



- Filled or Partially Filled Barrels: Barrel contents will be inspected and tested if necessary and disposed of appropriately (off-site or incinerated). The empty barrel will be rinsed, crushed and disposed on-site in an engineered landfill. The spent rinse liquid will be treated with absorbent material and disposed 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. A cover of borrow material will be placed over the area and compacted.

BUILDINGS AND INFRASTRUCTURE

The existing buildings and infrastructure at a site will be demolished to their foundations. All hazardous materials will be segregated prior to or during demolition. Non-hazardous demolition materials and asbestos will be collected and disposed in an on-site engineered landfill. Hazardous demolition materials will be disposed off-site.

Only in exceptional circumstances will 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.

BORROW SOURCES

Granular borrow material will be required for the development of new landfills and general site grading purposes. Available existing sources of borrow material will be exhausted before exploiting new areas. Use abandoned gravel pads and road infrastructure as granular source material wherever possible. Specially gravel pads should be screened for the presence of ARC and PHC contaminants. At the completion of the remedial activities, all borrow areas will be recontoured to restore natural drainage and to match the surrounding topography, in accordance with all applicable licenses.

SITE GRADING

Grading operations will consist of the shaping and regrading of disturbed areas to blend in with the natural contours, in accordance with all applicable licenses. The 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 the establishment and operation of the remediation camp, equipment storage and maintenance activities.

CONTRACTOR SUPPORT ACTIVITIES

For the implementation of the 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 will be incinerated and disposed of on-site in an engineered landfill. Sewage will be handled by an appropriately sized sewage treatment system, in accordance with applicable legislation, in accordance with all applicable licenses.

Potable water supplies at the site will be tested and used, only if they meet the Canadian Drinking Water Quality Standards (CCME 2002), 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.



5.0 POST CONSTRUCTION LANDFILL MONITORING (to be reviewed)

Monitoring of the historical landfills and new landfills will be required to ensure that they are operating as intended. Monitoring activities may include visual inspection, assessment of potential contaminant migration and thermal monitoring, depending on the specific design criteria for the landfill.

The landfill monitoring will follow a pre-established monitoring program and will occur at regular intervals following closure of the site. Once it has been demonstrated that the landfill is stable physically and chemically then the frequency of monitoring will be reduced. Physical stability of the landfill will be established as a minimum through visual inspection and may include instrumentation for thermal monitoring. Chemical stability of the landfill will be established through the collection of suitable samples from around the landfill site consistent with the monitoring program and site specific monitoring plan.



6.0 CLOSURE

The approach presented here and to be adopted during the INAC abandoned military site remediation program is consistent with federal and departmental policies. It takes advantage of the historical research and development previously completed and respects the approach adopted and experience gained in the past to remediate similar contaminated sites. It accounts for site-specific conditions and allows flexibility to address unforeseen issues at individual sites through risk assessment and risk management methods consistent with federal guidelines.

The supporting technical guidance documents will provide sufficient information and detail to ensure the consistent application of this approach which will provide a consistent level of environmental protection and quality assurance for all of the sites remediated during the program.

The financial analyses and control coupled with the risk evaluation and management approach will ensure that the funds expended on the remediation effort are most beneficial to the local and greater Canadian community stakeholders over the lifetime of the project and the ensuing years.



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APPENDIX A:

ARCTIC REMEDIATION CRITERIA – SUPPORTING DOCUMENTATION

APPENDIX B:

BACKGROUND SOIL GEOCHEMISTRY ASSESSMENT

APPENDIX C:

INAC ARCTIC PHC EVALUATION PROCESS

APPENDIX D:

LANDFILL/DEBRIS AREA EVALUATION MATRIX

APPENDIX E:

LANDFILL DESIGN AND SITING GUIDELINES

APPENDIX F

SUBMERGED DEBRIS

APPENDIX G

CONFIRMATORY TESTING

APPENDIX H

LANDFILL MONITORING PROTOCOLS

APPENDIX I



DEW LINE CLEANUP BARREL PROTOCOL

APPENDIX I

DEW LINE CLEANUP BARREL PROTOCOL

A. 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 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. Uncontaminated aqueous phases can be disposed of on the land; 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. 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.

TABLE 1: DLCU BARREL PROTOCOL CRITERIA AND DISPOSAL SUMMARY

		% glycols PCB Cl Cd Cr Pb					
PHASE	Disposal						
or alcohols ppm							
Organic	<2 <1000 <2 <10 <100	Incineration					
Organic	>2 >1000 >2 >10 >100	Ship south Aqueous					
>2 %	<2 <1000 <2 <10 <100	Incineration Aqueous					
>2 %	<2	Scrub and discard					



B. INSPECTION

- 1 All barrels are to be inspected to address the following items which shall be recorded and used as a guide prior to opening barrels.
- 2 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.
- 3 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.
- 4 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.
- 5 Spillage or discoloration on the top and sides of the barrel.

C. SAMPLING

- 1 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.
- 2 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.
- 3 Barrels should only be opened according to accepted procedures and under qualified supervision, preferably using remotely operated, non-sparking equipment.
- 4 Once open, barrels will be sampled by personnel wearing proper personal protective equipment as described below (G.1). Samples of the contents of all barrels shall be extracted using a drum thief and placed into a pre-labelled glass vial. The depth of liquid and the size of each barrel are to be recorded.
- 5 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.
- 6 All barrels shall be clearly numbered using spray paint or other suitable marker. The number on this label should be the only sample coding provided to the laboratory.
- 7 The barrel locations and barrel sample descriptions should be recorded.



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

D. TESTING

1 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.

2 The contents of barrels containing organic materials, including aqueous samples which contain more than 2% glycols or alcohols, shall be tested for PCBs, total chlorine, cadmium, chromium and lead, in addition to identification of the major components e.g. fuel oil, lubricating oil.

3 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 described below.

E. DISPOSAL OF BARREL CONTENTS

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

2 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 may then be discarded on to the ground that is a minimum of 30 meters distance from natural drainage courses. Used oil absorbent material shall be treated as described in below (E.5.).

3 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, and 100 ppm lead, 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.

4 Barrel contents, which contain greater than 2 ppm PCBs, 1000 ppm chlorine, 2 ppm cadmium, 10 ppm chromium or 100 ppm lead shall be disposed of off-site at a licensed disposal facility. Contents may be combined with compatible materials for



shipping purposes. Flash points may be required to be determined if they cannot be inferred from the product identification.

5 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.

F. DISPOSAL OF BARRELS

1. 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.

G. PERSONNEL PROTECTIVE EQUIPMENT

- 1 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 on the inside) and disposable Syranex-coated coveralls.
- 2 A decontamination procedure should be established at the barrel sampling area(s) to prevent tracking potentially contaminated liquids outside of the sampling area(s).
- 3 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 A:

Contaminants of Concern

DRAFT

EXECUTIVE SUMMARY

This report evaluates the suitability of applying the Distant Early Warning (DEW) Line Clean Up (DLCU) Protocol, as developed by the Environmental Sciences Group (ESG) for the Department of National Defence (DND), to abandoned military sites in the Arctic that fall under the jurisdiction of Indian and Northern Affairs Canada (INAC). The DLCU strategy may need to be modified to take into account the smaller size and shorter duration of use of the INAC sites, as well as advances in scientific knowledge since the protocol originated. Any cleanup strategy for INAC abandoned military sites, while being practical and cost-effective, must also be flexible to accommodate scientific advances and community involvement.

This review examines the sources, occurrence and history of contaminants found at northern military installations. Only those contaminants relevant to the construction and operation of DEW Line sites are considered in this report. Prior research has shown that eight inorganic elements (the Arctic suite – copper, lead, zinc, cadmium, cobalt, chromium, nickel and arsenic), polychlorinated biphenyls (PCBs) and petroleum hydrocarbons (PHCs) are the main contaminants of concern at abandoned military sites.

A statistical analysis of more than 4,000 data points from 14 DND and 11 INAC DEW Line sites was carried out in 2006 by ESG. The distribution of organic and inorganic contaminants of concern from DND DEW Line sites was compared with INAC DEW Line sites to determine if there were significant differences between them. Generally the data show that inorganic element concentrations do not vary between INAC and DND DEW Line sites, and that background concentrations of some elements are elevated at eastern sites. The box plots suggest that PCB contamination may be more acute at INAC sites than at DND sites. Frequency analyses confirmed that most contaminants co-occur with copper, lead and zinc, after excluding sites with elevated background concentrations for all three of these datasets. Copper, lead and zinc can be detected using portable field-model X-ray fluorescence (XRF) analysis, which can save time and money.

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ABBREVIATIONS

ABN	acid-base-neutral
As	arsenic
CCME	Canadian Council of Ministers of the Environment
Cd	cadmium
CEPA	Canadian Environmental Protection Act
Co	cobalt
COC	contaminant of concern
Cr	chromium
Cu	copper
DEW Line	Distant Early Warning Line
DIAND	Department of Indian and Northern Affairs (now INAC)
DLCC	DEW Line Cleanup Criteria
DLCU	DEW Line Clean Up
DND	Department of National Defence
ESG	Environmental Sciences Group
Hg	mercury
INAC	Indian and Northern Affairs Canada (formerly DIAND)
n/a	not applicable
Ni	nickel
NWS	North Warning System

ABBREVIATIONS, cont'd

PAH	polycyclic aromatic hydrocarbon
Pb	lead
PCBs	polychlorinated biphenyls
PHCs	petroleum hydrocarbons
POL	petroleum, oil and lubricants
ppb	parts per billion
ppm	parts per million
SSTLs	site-specific target levels
TPH	total petroleum hydrocarbons
USAF	United States Air Force
U.S. EPA	U.S. Environmental Protection Agency
VOC	volatile organic compound
Zn	zinc

1. INTRODUCTION

This report reviews the Indian and Northern Affairs Canada (INAC) Abandoned Military Sites Protocol (INAC Abandoned Military Site Remediation Protocol, 2005) and will determine whether modifications should be made to the existing protocol to address remediation requirements and enhance its scientific validity. As part of this objective, the Department of National Defence (DND) Distant Early Warning (DEW) Line Clean Up (DLCU) Protocol was reviewed for its applicability to the INAC program, while accounting for differences between the INAC and DND DEW Line sites, such as size, operational period and subsequent land use. The INAC abandoned Military Sites Protocol should provide consistency, to ensure that decisions are based on sound science and prior experience.

The Environmental Sciences Group (ESG), under the direction of Dr. Ken Reimer, was tasked to provide INAC with scientific advice on several aspects of its DEW Line site cleanup program. ESG holds all environmental data pertinent to the project and is aware of the public concerns expressed throughout the DLCU project. This background was used to facilitate the INAC review.

1.1 Background

The DLCU Protocol was designed to restore the DEW Line sites to an environmentally safe condition and prevent migration of contaminants into the Arctic food chain (ESG, 1993). This protocol has formed the basis for cleanup recommendations for DND DEW Line sites and other Arctic military installations. It includes recommendations for dealing with contaminants of concern and provides a set of numerical criteria – the DEW Line Cleanup Criteria (DLCC) – for contaminant tolerances in soil. The DLCU Protocol has been reviewed by federal, territorial and provincial government agencies and has been modified in co-operation with Inuit stakeholders.

1.2 Objective

INAC is responsible for managing 21 abandoned intermediate and auxiliary DEW Line sites in the Arctic. These sites operated for a brief period between the late 1950s and early 1960s, but were abandoned in the mid-1960s as technological advances made the 21 sites obsolete.

INAC is planning to undertake remedial action at the former military sites under its jurisdiction. Plans are being developed for the progressive remediation of 14 sites in Nunavut and others in NWT and Yukon by the year 2020. In 2005, INAC established a Protocol for the Remediation of Abandoned Military Sites (INAC Abandoned Military Site Remediation Protocol, 2005) that adopted many aspects of the DLCU protocol.

A Technical Advisory (TA) Subcommittee for abandoned military sites was formed in 2006 to provide ongoing advice on overarching issues to the INAC Contaminates Sites Program (CSP). The subcommittee met in May 2006 with the objective to develop a list of short and long-term risks to the program related to abandoned military site management, to prioritize these risks, to identify data gaps and to develop a draft work plan to address these issues.

One of the data gaps identified relates to the issue of contaminants of concern (COC). The DEW Line Cleanup Criteria (DLCC) have been adopted by INAC for the suite of eight inorganic elements and PCBs. A consistent and scientifically defensible approach is required to determine whether additional COCs need to be addressed as part of the INAC Protocol. Appropriate remediation targets are required for these additional COCs. This report provides the following information:

- A review of the suite of contaminants for which remediation targets should be established
- A review of appropriate remediation target levels
- Summary and recommendation for Arctic Remediation Criteria (ARC)

1.3 General Approach

The results presented in the following report (Section 2.1-2.4) are based on key findings of an extensive literature review and on a comprehensive statistical analysis of inorganic and organic contaminant data in soil from 14 DND and 11 INAC DEW Line sites.

1.3.1 Literature review

A literature review of the following reports and studies was conducted:

1. Documents that provided the basis for the initial DLCU Protocol and follow-up studies that investigated the impact of the DEW Line sites on the Arctic environment;
2. Reports that describe the derivation of the DLCC, establishment of the criteria and exclusion of certain contaminants;
3. Peer-reviewed literature (most from ESG) published in scientific journals that describe the aerial redistribution of contaminants within the Arctic, and associated references to the international Northern Contaminants Program (NCP) explaining why it is critical to remove “within-Arctic” sources of contaminants; and
4. Documents that provide additional information and address apparent gaps in the DLCU Protocol.
5. Risk assessments conducted for INAC abandoned military sites.

1.3.2 Statistical Analyses

Statistical analysis was performed on three sets of data:

- A DND assessment dataset, including 14 sites and consisting of 4,663 data points from 1998-2006;

- A DND delineation dataset, including 14 sites and consisting of 14,354 data points from 1998-2006;
- An INAC assessment dataset, including 11 sites and consisting of 545 data points from 1992-1994.

Descriptive statistical methods were used to summarize the data and show the distribution of contaminants in soil at DND and INAC DEW Line sites, using the statistical package SPSS v. 12.0. Multivariate analyses were performed using Canoco v. 4.5 to identify major environmental gradients and to visualize the structure of the data.

2. RESULTS

2.1 Review of DEW Line Contaminant Data

2.1.1 Common Sources of Contaminants

Environmental contaminants can be classified into two categories: organic and inorganic compounds. Organic contaminants are compounds consisting primarily of carbon and hydrogen, while inorganic contaminants are generally metals and metalloids that may be in the pure (elemental) form, or bound to other molecules. Examples of the former are polychlorinated biphenyls (PCBs), fuels, oils and some pesticides, and examples of the latter include arsenic, cadmium and lead. Inorganic compounds can occur in elevated concentrations in the environment because of anthropogenic activity or because of naturally high concentrations in the bedrock. In contrast, organic compounds become elevated only through anthropogenic activity. See Section 2.1.6 for a detailed discussion of natural background elevations of inorganic elements.

The most common contaminants at DEW Line sites are copper, lead, zinc, chromium, cobalt, nickel, cadmium and arsenic, also known as the Arctic suite of minerals. Most of these (copper, lead, zinc, chromium, cobalt and nickel) can leach from metallic materials such as steel into the surrounding environment, a process that can be accelerated by exposure to water and/or oxygen. Paint is a common source of contamination at DEW Line sites, as it often contains inorganic elements (e.g. copper, lead, zinc, chromium, cadmium, cobalt) and PCBs, which make the paint last longer in the harsh northern environment. Over time, as paint breaks down, these elements are released to the surrounding environment. Similarly, arsenic, a common component of fuels but also of wood preservatives, often contaminates areas near wooden structures. Finally, lead-based fuels and batteries are major sources of lead contamination, with the latter also being common sources of cadmium and nickel.

2.1.2 PCBs and their Aerial Redistribution

PCBs were once widely used in electrical applications (transformers, capacitors, etc.) because of their excellent insulating properties and general inertness, but were banned from manufacture in 1973 because of concerns regarding their environmental persistence and their toxicity. Primary sources of PCBs in the Arctic are operational and abandoned mining and industrial sites and waste disposal sites. Abandoned military sites, however, are thought to be the greatest source of PCBs (Stow, 2005).

Concern about PCBs in the Arctic arises from the fact that most of the 209 PCB congeners, especially those with five or more chlorine atoms, are biomagnified in food chains because of their great biological stability and lipophilicity (Barrie *et al.*, 1992). The most common sources of PCBs contamination at DEW Line sites are old electrical equipment and PCB-amended paint. PCBs were also used to coat building structures and protect them from biological breakdown. Outfall areas are generally the most contaminated, with on average 1.7 ppm PCBs, followed by areas impacted by landfill leachate (0.5 ppm) and isolated spills (Bright *et al.*, 1995).

A comparison of PCB concentrations in background samples taken from areas near the radar stations and samples taken in remote locations (>20 km away) provides evidence of short-range PCB redistribution (Bright *et al.*, 1995).

According to Grundy *et al.* (1996), soil samples taken from the 21 INAC sites contain either high or very low concentrations of PCBs, whereas the sites that were recently abandoned or are still operational exhibit a broad range of concentrations. Since PCB-containing oil and equipment was left unattended for several decades during which containers and equipment could have failed and spilled their contents, it might be possible to find relatively high levels of localized contamination at the 21 I sites (Stow, 2005). Results of PCB experiments show that

live and detrital vegetation may play a key role in the release and retention of PCBs (Grundy *et al.*, 1996).

Abandoned DEW Line sites contribute to local redistribution of PCBs in the surrounding terrestrial environment, with a halo of influence with a radius in the range of 5 to 27 km. Removing the more highly PCB-contaminated soils as directed under the DLCU project appears to be the most efficient way to eliminate the dominant sources of local PCB redistribution (Stow *et al.*, 2005).

2.1.3 History of the DEW Line

The DEW Line was a surveillance system built by the United States across the Arctic in the 1950s. It consisted of 63 radar stations installed along 5,000 km on the 66th parallel, from northwest Alaska, across Baffin Island to the east coast of Greenland. Operated by the United States Air Force (USAF), these radar sites were built to detect Soviet military activity in Arctic airspace during the Cold War era. The DEW Line was comprised of six main stations, 26 auxiliary stations and 31 intermediate stations (I-sites). Forty-two of these installations, including 21 I-sites, were located in Canada.

As a result of technological advances, 20 I-sites and one auxiliary site (FOX-1) became obsolete five years after the DEW Line opened and were abandoned in 1963. The remaining main and auxiliary sites (21 of the original 42 Canadian sites) continued to operate until the late 1980s/early 1990s. From 1989 to 1993, these active DEW Line sites were gradually replaced by the modernized North Warning System (NWS). Most of the sites that were once the DEW Line main and auxiliary stations, are now NWS installations. Today, the abandoned intermediate sites fall under the jurisdiction of INAC, while the decommissioned auxiliary and main sites are the responsibility of DND.

All of the DEW Line sites, regardless of jurisdiction or date of closure, required environmental assessments to ensure that the properties would be physically and environmentally sound. In 1989-1990, ESG completed an environmental study of 10 DND DEW Line sites on behalf of the North Warning System Office (Reimer *et al.*, 1991). The purpose of the study was to:

1. identify and confirm the nature of contamination at the sites;
2. determine the impact that introduced substances were having on the Canadian Arctic; and
3. propose realistic environmental objectives and corresponding cleanup strategies for the sites.

In 1990, UMA Engineering Ltd. completed a similar study of all 21 DND DEW Line sites, at the request of the USAF (UMA, 1991).

The results of both ESG and the UMA investigations, and the recommendations of the ESG report, were reviewed at a workshop held in 1991 by Canada's Director-General, Environment. This was attended by several government agencies, including DND, INAC, Environment Canada, Fisheries and Oceans and the Government of the Northwest Territories. Workshop attendees reached a consensus on the proposed DLCU Protocol included in ESG's 1991 report; the finalized General Protocol for the DEW Line Cleanup was released shortly thereafter (ESG, 1993) (see Annex H).

This protocol has since formed the basis for cleanup recommendations at DEW Line sites and other Arctic and northern military installations. It includes recommendations for dealing with contaminants of concern (those that would result in long-term environmental damage, at the time of publication of the DLCU Protocol identified as PCBs, petroleum hydrocarbons and eight inorganic elements) and outlines the DLCC for contaminant tolerances in soil. Two tiers of soil contamination levels were established: Tier I soil concentrations are high enough to potentially migrate via aerial transport, while Tier II concentrations have the potential to be transferred into

the food chain via plant uptake. The DLCU approach has been reviewed by federal, territorial and provincial government agencies, and was modified in co-operation with Inuit stakeholders. The Protocol and its associated soil criteria formed the basis of the DLCU project. The DLCU began in 1996, and is anticipated by to be completed by 2012.

The DLCU protocol was subsequently revised to include some additional protocols and amendments that have been developed during implementation of the DLCU in response to remediation requirements and concerns raised by the Inuit. These additional protocols deal with specific work elements, such as submerged debris or decision matrices for the risk evaluation and remedial action plans of areas impacted by petroleum hydrocarbons (PHC) and landfills, as well as long-term monitoring plans.

2.1.4 Determination of Contaminants of Concern (COCs) at DEW Line Sites

Prior to the 1989-1990 assessments of DND DEW Line sites, reliable information on the range of materials used at the sites during their operation was not available (Reimer *et al.*, 1991). Thus, tests were run for a wide variety of Environment Canada (EC) and U.S. Environmental Protection Agency (EPA) priority pollutants in the various soil, sediment, water and biological samples collected by both ESG and UMA. ESG sample analyses targeted four categories of primary contaminants: PCBs, inorganic elements, acid-base-neutral (ABN) extractable contaminants and volatile organic compounds (VOCs) (Reimer *et al.*, 1991). The UMA assessment focused on similar compounds (UMA, 1991). A list of the specific analytes evaluated during these assessments has been included in Annex A and B of this report. Results from ABN and VOC analysis in 1990-91 indicate that ABNs and VOCs are either non-detect or in locations where cleanup was recommended, based on either the PCB or inorganic element results.

From the list of potential contaminants shown in Annex A and B, the 1989-1990 environmental assessments concluded that the inorganic elements Cu, Pb, Zn, Cr, Co, Ni and Cd, as well as PCBs were the major contaminants of concern (COCs) for the DND DEW Line sites.

Mercury was analyzed in the 1990/1991 investigation, but was detected in only seven of 635 samples, and only three of those samples had concentrations higher than the guideline. Therefore it was concluded that the occurrence of Hg in contamination at the radar sites is relatively isolated and confined to sewage disposal areas.

The key findings of the 1989-1990 environmental assessments of DND DEW Line sites (Reimer *et al.*, 1991), with respect to inorganic element and PCB contamination, are summarized here:

1. inorganic elements:
 - a. Of the samples tested, 18 percent were contaminated with inorganic elements, frequently by more than one element;
 - b. The most widespread contamination among sites involved Cu, Pb, and Zn; and
 - c. Inorganic element contamination was most often found in sewage outfalls, landfills, and POL areas (lead).
2. PCBs:
 - a. Every soil sample collected near the sites contained PCBs in excess of background concentrations;
 - b. Of the soil/sediment samples analyzed, 36 percent contained PCBs >0.1 ppm; and
 - c. Ten percent of soils analyzed contained PCBs >1.0 ppm, most of which were located in sewage outfalls and, to a lesser degree, landfills, pallet lines, and adjacent to buildings.

The conclusion that ABNs, PAHs and pesticides had minimal impact at DEW Line sites was further substantiated by results from the 1993/1994 study conducted at 11 of the INAC I-

sites (Reimer *et al.*, 1993b; 1994). A total of 96 samples were analyzed for PAHs, ABNs and pesticides. The levels of these compounds in soil samples were either below detection limits or very low. The marginally detected parameters were mostly PAHs and phenols. Samples containing PAHs were most often collected from heavily stained areas, whereas phenols were generally found in outfall samples. In all instances, these samples were collected from locations that had high levels of PCBs and/or inorganic elements (Reimer *et al.*, 1993b, 1994).

At present, samples from INAC sites are analyzed for an extended list of inorganic elements. To demonstrate that it is sufficient to analyze only for the Arctic suite (Cu, Pb, Zn, Cd, Co, Cr, Ni, As) at INAC sites, ESG analyzed data from three site investigations carried out at INAC DEW Line sites BAR-D, CAM-D and CAM-F (IEG, 2006; Earth Tech, 2005, 2006). The extended list of inorganic elements included antimony (Sb), silver (Ag), boron (B), barium (Ba), beryllium (Be), mercury (Hg), selenium (Se) and Tin (Sn). From a total of 224 soil samples, only two samples exceeded guidelines for barium and four samples for selenium, suggesting that more than 98 percent of the samples did not exceed guidelines for any of the extended inorganics. The two soil samples exceeding the barium criterion of 500 ppm were collected at CAM-D at the Burn Pit Area (1720 ppm) and at CAM-F at the Dump Area (768 ppm). The four soil samples exceeding the selenium criterion of 1 ppm were all collected at BAR-D from the South Landfill (range 1.1 – 2.0 ppm).

These results are supported by an investigation carried out by ESG at intermediate DEW Line site BAR-B, located within Ivvavik National Park, where analysis was performed for 23 inorganics. Of the 15 inorganic elements additional to the Arctic suite, only one sample exceeded guidelines for antimony (ESG 2007). The analysis of these datasets led to the conclusion that the eight inorganic elements Cu, Pb, Zn, Cd, Co, Cr, Ni, As can be considered to be the major contaminants of concerns at INAC sites.

Table 1. Summary of Samples Exceeding Ecological Criteria for Inorganics in Soil Samples From Three INAC Abandoned Military Sites (BAR-D, CAM-D and CAM-F).

Inorganic element	Ecological Criteria (CCME)	Number of soil samples analyzed	Number of samples exceeding criteria
Sb	20	224	
Ba	12	224	2
Be	500	224	
B	4	157	
Mo	6.6	191	
Se	1	224	4
Th	1	224	
Sn	50	224	
V	130	224	
Hg	7	224	
Ag	10	224	

Hydrocarbon contamination, also a significant concern at DEW Line sites, is discussed in detail in Appendix C.

2.1.5 Determination of COC Criteria at DND DEW Line Sites

In the absence of environmental criteria specific to the Canadian Arctic, determining the appropriate contaminant criteria for the cleanup of the DND DEW Line sites was challenging. All available guidelines for environmental contaminants in Canada were based on ecotoxicological concentrations derived from southern plant and animal species (Reimer *et al.*, 1991). Given that southern plant species are not commonly found in Arctic regions, the extrapolation from data on non-Arctic species to Arctic species living under very different environmental conditions introduced significant uncertainty. The Arctic ecosystem is further set apart because it is more sensitive to environmental stressors such as transport of contaminants (Richter-Menge *et al.*, 2006) and climate change.

A primary goal of the 1989-1990 ESG work was to derive environmental criteria that would be protective of the Arctic ecosystem (Reimer *et al.*, 1991). Two strategies were used to develop Arctic-specific criteria:

1. Evaluate existing guidelines: Quebec B soil criteria
2. Perform bioaccumulation studies on contaminant uptake within Arctic-specific species. For initial comparisons, ESG used the Quebec B soil criteria as outlined in the – Politique de protection des sols et de réhabilitation des terrains contaminés, Annexe 2 (Ministère de l'Environnement et de la Faune, 1991) - in its 1989-1990 research for evaluating inorganic and organic contamination in soil collected at the DND DEW Line sites (Reimer *et al.* 1991).

In areas where the potential for ecosystem impact was high (i.e. high biological productivity), results were also compared with the more stringent Quebec A criteria so that contaminant sources and migration paths could be identified. The Quebec soil criteria were chosen as a starting point in the 1989-1990 ESG research because:

1. They were among the most stringent in Canada;
2. They were comprehensive and employed limits similar to those adopted by other provinces;
3. The Quebec B criteria were similar to those proposed by the Canadian Council of Ministers of the Environment for (CCME) residential/parkland use; residential/parkland most accurately described the end use of the decommissioned sites;
4. The Quebec A criteria were comparable to those proposed by the CCME for maintenance and protection of agricultural land, thereby offering a more rigorous assessment of results obtained from biologically productive areas of the sites; and

5. The application of these criteria provided a common basis of comparison to the conclusions reached by UMA in the preparation of its USAF report.

ESG assessed the degree of contamination present in the soil samples using the Quebec B contaminated soil guidelines and the results were interpreted in terms of the potential impact on the ecosystem.

ESG carried out bioaccumulation studies on several Arctic plant species: Arctic willow (*Salix arctica*), bluegrass (*Poa arctica*), sedge (*Carex aquatilis*), groundsel (*Senecio congestus*) wood rush (*Luzula confusa*). These species were selected because they are part of the diet of a large number of Arctic terrestrial animals. Plants were used as indicators of ecosystem impact because:

1. They are at the base of the food chain, and thus could serve as a gauge for contaminant levels entering the terrestrial system;
2. They provide a crude indication of the availability of chemical substances to other organisms, particularly those in nearby aquatic systems;
3. They can be used to estimate the potential for soil (or aerial) migration of a given substance from a potential source; and
4. They are easy to locate and sample, and are also valuable indicators of prevailing environmental conditions (air, soil, water, light, temperature) in a given area or habitat.

The concentration of contaminants (inorganics and PCBs) was measured in plants and the underlying soil, and relationships were established to determine the extent to which contaminants were entering the food chain. These relationships were used in determining the maximum concentration of contaminants that can be present in soils without posing a threat to the food chain, and helped to formulate the Arctic soil criteria for contaminants: analytical results from

exposure plants (plants that had been growing on contaminated soil) were compared with plants from background areas.

The baseline concentration value for PCBs and inorganics causing a significant impact on the environment was chosen as the soil concentration above which PCBs or inorganics in affected plants were at least twice the average background value. These Arctic-specific benchmark concentrations derived from the bioaccumulation studies were then compared to the Quebec B criteria to provide a measure of the success of the Quebec guidelines for detection of environmental effects, indicating the impact of soil contamination on plants in the Arctic. It was concluded that site areas containing concentrations of PCBs and/or inorganic elements above Quebec B criteria were contaminated and in need of remediation (Reimer *et al.*, 1991). Remediation, also defined by the ESG investigators, was designed to be site-specific and take into account the potential of the contaminant impact on the ecosystem (Reimer *et al.*, 1991). These thresholds were adopted as the DEW Line Cleanup Criteria (DLCC) after they were harmonized in 1991 with the CCME Interim Canadian Environmental Quality Criteria for Contaminated Sites.

In 1993, ESG completed a follow-up study to evaluate the environmental impact of the DEW Line on the Canadian Arctic, and to provide confirmation that the DLCU Protocol would achieve its objective of safeguarding human and environmental health (Reimer *et al.*, 1993). Based on environmental data collected from 1989-1992, ESG analysts concluded that the DLCU Protocol and the DLCC were appropriate guidance documents for remediation of the DND DEW Line sites (Reimer *et al.* 1993).

2.1.6 Determination of COCs at INAC sites: Comparisons Between Datasets

The work that culminated in the formation of the DLCU Protocol and the DLCC is shown in Sections 2.1.2 to 2.1.4. As outlined in 2.1.3, the initial site assessments on the DEW Line sites completed in 1991 screened for a wide range of Environment Canada and U.S.

Environmental Protection Agency (USEPA) priority contaminants in soil, water and sediment. From the broad list of potential contaminants, ESG concluded that eight inorganic elements (the Arctic suite – Cu, Pb, Zn, Cd, Co, Cr, Ni, As), polychlorinated biphenyls (PCBs) and hydrocarbons were the contaminants of concern at DND DEW Line sites. Because the INAC DEW Line sites belonged to the same radar system, it is reasonable to conclude that if no other activities took place at the site, the list of contaminants should be the same. At INAC sites, stained areas are generally of smaller extent, but contaminants may be present at higher concentrations.

PCBs have been used extensively at DEW Line sites for a variety of purposes and their presence is of particular concern because of their tendency to magnify up the food chain (Douglas *et al.*, 1995). In 1985, a cleanup crew consisting of representatives of EC, DIAND and DND visited the abandoned I-sites and removed equipment considered hazardous or containing hazardous materials. During this cleanup operation ~7,300 kg of PCB-contaminated liquid contained in electrical equipment were removed (Holtz *et al.*, 1986). Nonetheless, PCBs remained on site for several decades following the closure of the DEW Line I-site facilities, which suggests that container failure may have resulted in localized spills. High levels of localized PCB contamination may be present at the INAC DEW Line sites today (Stow, 2005).

Data from DND and INAC sites were compared to evaluate the presence of inorganic and organic compounds of concern at the INAC sites. Datasets from both groups were compared using box plots (see Annex C) to determine if there were any significant differences between the two. The results of these comparisons are summarized in Table 2.1.

Generally the data show that inorganic element concentrations are consistent between INAC and DND DEW Line sites, and that background elevations of some elements are evident in eastern INAC and DND sites (see Section 2.1.6). The box plots suggest that PCB contamination may be more acute at the INAC sites than at the DND DEW Line sites, as mentioned above.

Table 2. Summary of dataset trends at DND and INAC DEW Line sites. See Annex C.

Site Group	CONTAMINANTS OF CONCERN								
	Copper	Lead	Zinc	Nickel	Cadmium	Cobalt	Chromium	Arsenic	PCBs
DND vs. INAC	Similar data distribution	Similar data distribution	Similar data distribution	Similar data distribution, consider elevated background at eastern sites	Similar data distribution	Similar data distribution, consider elevated background at eastern sites	Similar data distribution, consider elevated background at eastern sites	Similar data distribution, consider elevated background at eastern sites	More acute at INAC sites

2.1.7 Determination of COC Criteria at INAC Sites

In previous sections we demonstrated that the DLCC Arctic Suite of contaminants is common at INAC sites (2.1.5) and that these were selected based on Arctic-specific vegetation data on ecosystem uptake of contaminants (see 2.1.4).

The INAC Protocol is largely based on the DLCU Protocol. However, some issues, such as guideline comparison for soil contaminants, are not applied consistently across the INAC sites and do not reflect the current DLCU approach. To establish a consistent and scientifically defensible approach to chemical remediation at INAC sites, environmental guidelines were compared to site-specific target levels developed by Jacques Whitford Ltd. for INAC abandoned military sites. The environmental guidelines and the DLCC were also reviewed in terms of the derivation of the guidelines to determine if the DLCC are still protective of human and ecological health.

Numerical values for Cu, Pb and Zn contamination used in the DLCC were compared with the CCME interim criteria of 1991 and 2006, and SSTLs were developed for INAC abandoned military sites (Jacques Whitford 2005 a, b, 2006). In all cases SSTLs are higher than the DLCC, while the DLCC are similar to the 1991 CCME guidelines, but higher than 1999 CCME guidelines. Since the 1999 CCME guidelines for Cu, Pb and Zn were derived from ecotoxicological studies on southern vascular plants (barley, birch trees) and soil invertebrates (earthworms), while the DLCC were established based on Arctic specific data, it can be concluded that the DLCC were found to be protective of the environment and human health. In fact, SSTLs developed using the risk assessments were often much higher than the DLCC, and significantly higher than generic CCME soil quality guidelines. Based on these findings, the review suggests that the DLCC remediation guidelines be adopted for use at INAC's northern abandoned military sites.

Table 3. Comparison of Three Guidelines (CCME 1999, CCME 1991 and DCC) for Inorganics With SSTLs Developed for INAC Abandoned Military Sites. Ecological receptors used to derive the criteria for CCME 1999, DCC and SSTLs are also listed.

Element	CCME 1999 (mg/kg)		CCME (mg/kg) 1991	DCC (mg/kg)		SSTL (mg/kg)	
	Criteria	Receptor	Criteria	Tier 1 Criteria	Tier 2 Criteria	Criteria	Receptor
Copper	63	ecological: based on birch tree & earthworm	100		100	3600	Lemming
Lead	140	human health	500	200	500	3380	Ptarmigan
Zinc	200	ecological: based on plant turnip & earthworm exposure	500		500	590	Human
Cadmium	10	ecological: based on reduced crop yeild in various plants & earthworm exposure	5		5	29000	Ptarmigan
Cobalt	50	CCME 1991 guideline	50		50	320	Ptarmigan
Mercury	6.6	human health	6.6		2		
Chromium	64	ecological: based on reduced crop yeild in various plants & earthworm exposure	250		250	2075	Ptarmigan
Arsenic	12	human health	30		30	206	Lemming
Nickel	100	ecological: based on various phytotoxic effects & earthworm exposure	50		100	6075	Ptarmigan

The level of cleanup effort for remediation was compared to DLCC vs. generic 1999 CCME guidelines. Fig. 2.1 shows the number of samples exceeding the DLCC (blue bars) vs. the number of samples exceeding 1999 CCME guidelines (green bars) for 14 DND and 11 INAC DEW Line sites.

The number of soil samples with concentrations exceeding the DLCC is significantly (two or three times) lower than the number of samples exceeding 1999 CCME guidelines (Fig. 2.1). This analysis suggests that the application of the DLCC results in significantly lower remediated soil volume and thus cost savings over remediation to CCME guidelines, while still protecting the Arctic environment and human health.

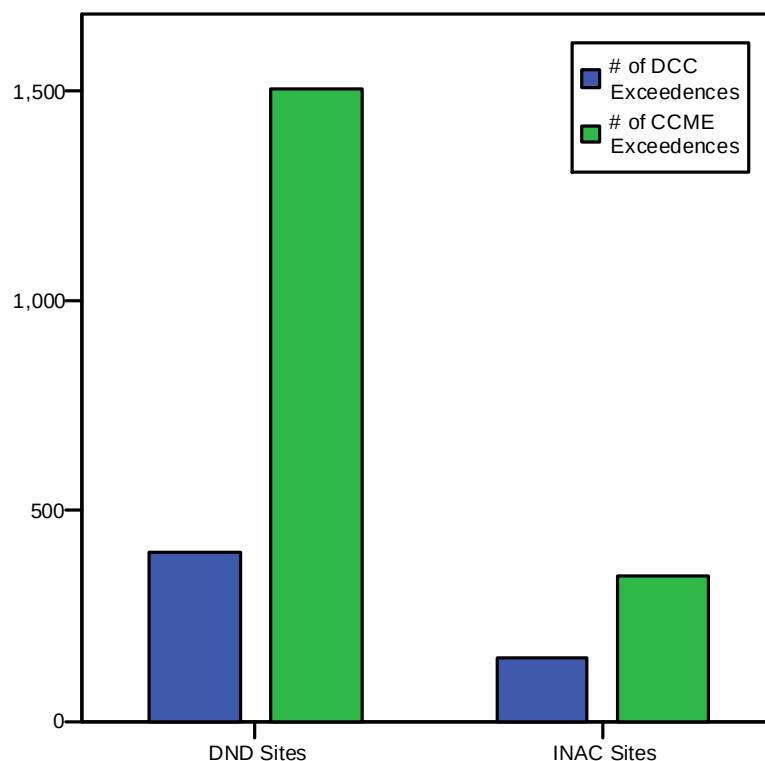


Figure 1. Number of samples exceeding the DLCC (blue bars) vs. the number of samples exceeding 1999 CCME guidelines (green bars) for 14 DND and 11 INAC DEW Line sites.

2.1.8 Special Consideration: Co-Contamination and Cost Efficiency

This section explores the major contaminants of concern of the Arctic suite of eight inorganics at DND and INAC sites as well as co-location of contaminants.

Principal component analysis (PCA) was applied to visualize the structure and the relationship of the Arctic suite inorganic elements. Results from the PCA, based on assessment data from 14 DND DEW Line sites, indicate that copper, lead, zinc, nickel and cobalt are the primary inorganic contaminants (Fig. 2 a).

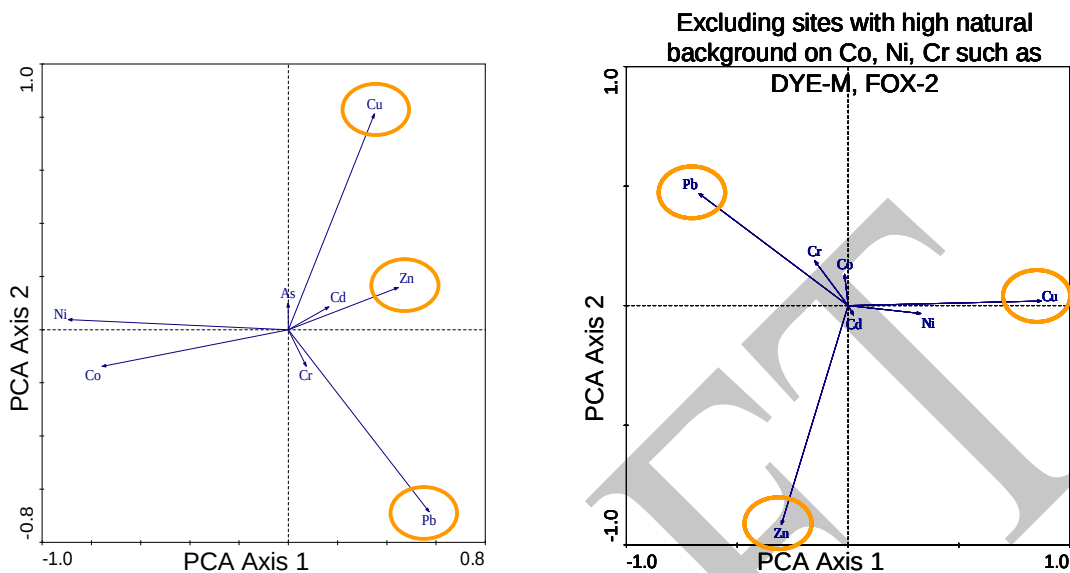


Figure 2 a, b. PCA ordination plot for inorganic contaminants at DND sites. a) based on 14 sites; b) based on 11 sites after excluding sites with elevated background

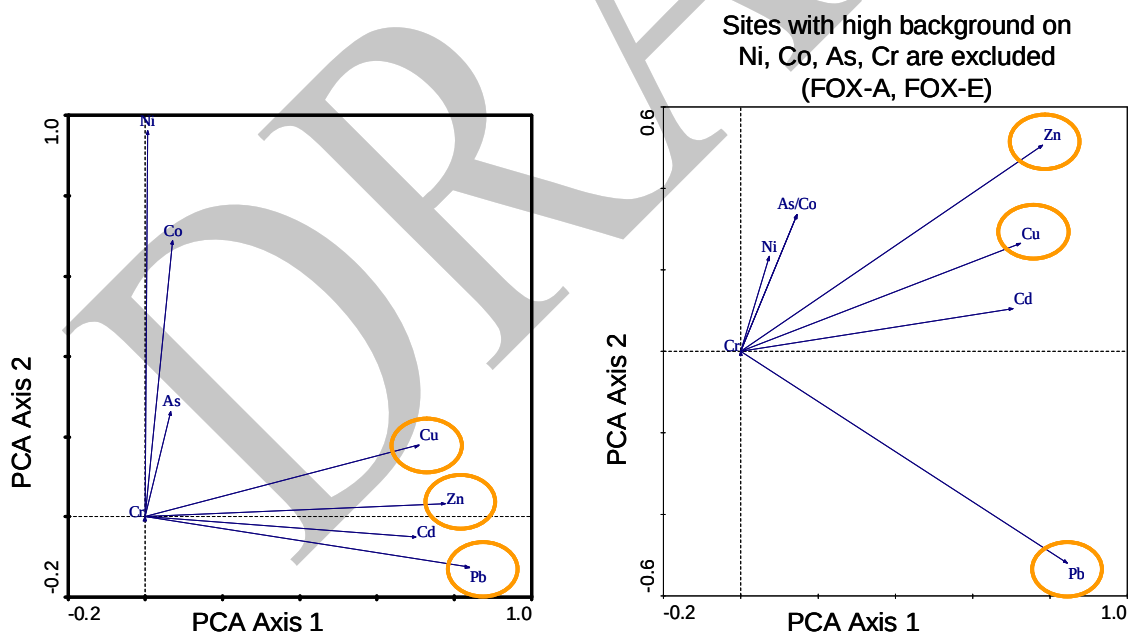


Figure 3 a, b. PCA ordination plot for inorganic contaminants at INAC sites. a) based on 11 sites; b) based on nine sites after excluding sites with elevated background

In a second PCA (Fig.2.b), sites with high natural background concentrations were removed as they influence the outcome of the ordination. The major contaminants at the remaining 11 DND sites are Cu, Pb and Zn.

A PCA was also performed on data from 11 INAC sites (assessment dataset) (Figs. 3.a and b). Fig. 3.a shows an ordination plot including all sites. The primary contaminants are Cu, Pb, Zn, Ni and Co. After removing sites with naturally elevated background concentrations, the primary inorganic contaminants of concern are Cu, Pb and Zn (Fig. 3.a).

To determine the co-location of contaminants with the major inorganic contaminants (Cu, Pb and Zn), a frequency analysis was performed of more than 4,000 data points collected at DND and INAC DEW Line sites. The number of samples exceeding the DLCC and correlated to Cu, Pb or Zn contamination was determined for DND and INAC DEW Line sites.

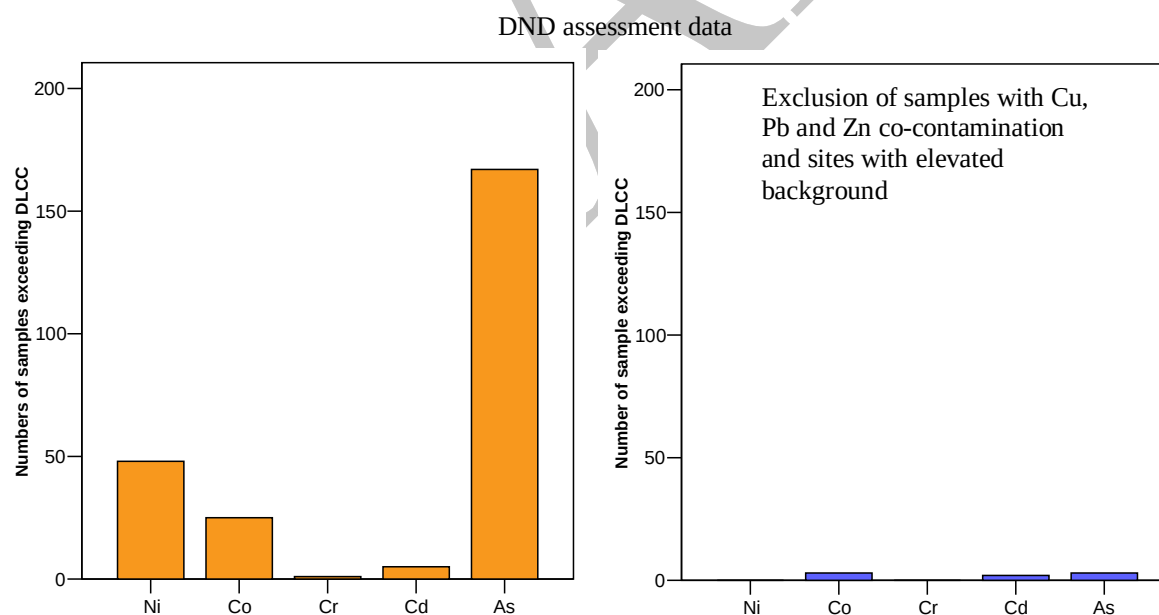


Figure 4 a,b. Number of samples exceeding DCC for DND assessment data. Total number of soil samples screened for Fig. 4 a: $n_{Ni}=4206$, $n_{Co}=4198$, $n_{Cr}=4196$, $n_{Cd}=4197$, $n_{As}=4203$ and in Fig. 4 b: $n_{Ni}=3786$, $n_{Co}=3778$, $n_{Cr}=3776$, $n_{Cd}=3777$, $n_{As}=3783$.

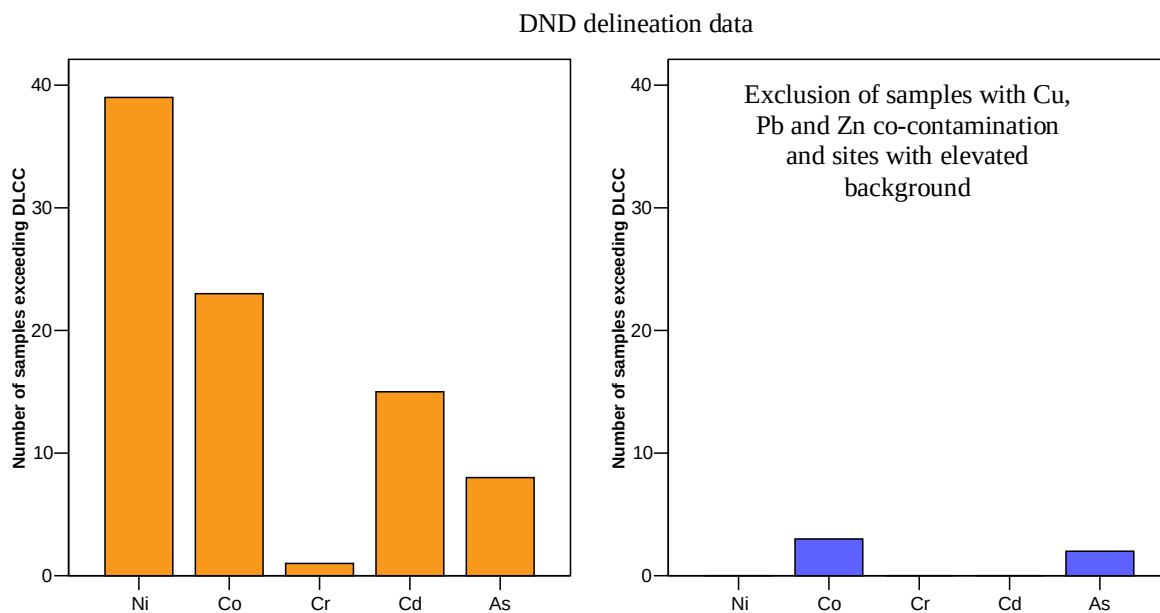


Figure 5 a, b. Number of samples exceeding DCC for DND delineation data. Total number of soil samples screened for Fig. 5 a: $n_{Ni}=1005$, $n_{Co}=996$, $n_{Cr}=996$, $n_{Cd}=1134$, $n_{As}=1005$ and in Fig 5 b: $n_{Ni}=887$, $n_{Co}=878$, $n_{Cr}=878$, $n_{Cd}=1016$, $n_{As}=887$.

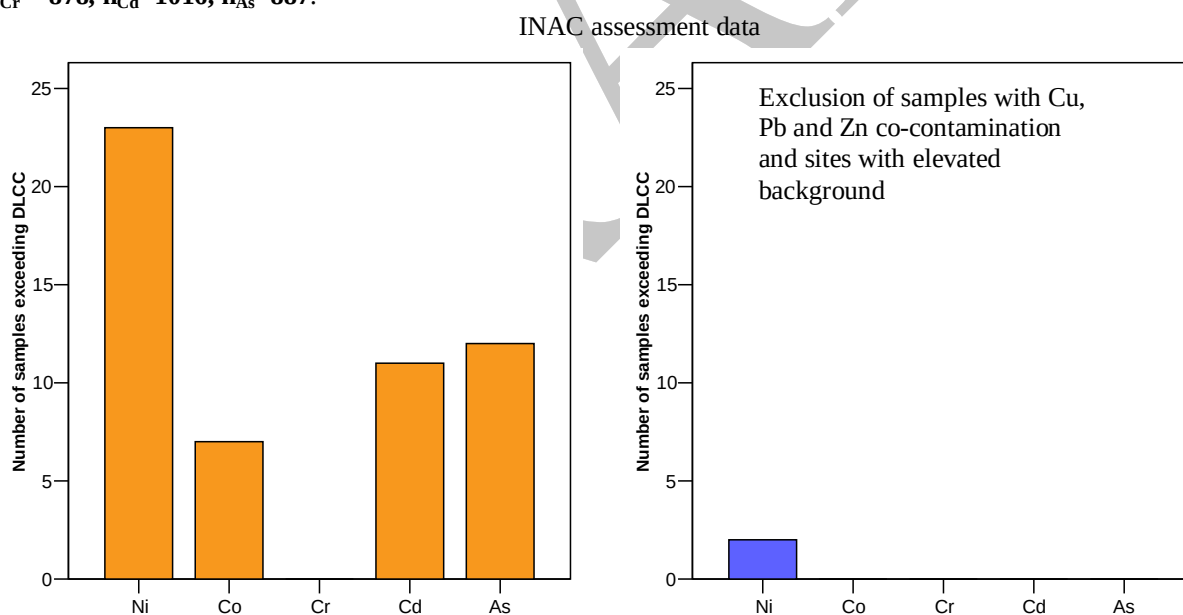


Figure 6 a, b. Number of samples exceeding DCC for INAC assessment data. Total number of soil samples screened for Fig. 6 a: $n_{Ni}=446$, $n_{Co}=446$, $n_{Cr}=446$, $n_{Cd}=446$, $n_{As}=446$ and in Fig. 6 b: $n_{Ni}=387$, $n_{Co}=387$, $n_{Cr}=387$, $n_{Cd}=387$, $n_{As}=387$.

Figs. 4 a,b – 6 a,b summarize the total number of samples exceeding the DLCC and not co-located with Cu, Pb or Zn in the DND and the INAC data set. The total number of samples exceeding the DLCC and not co-located with Cu, Pb or Zn contamination decreases to less than or equal to three samples, after excluding sites with elevated background concentrations for all three datasets.

Multivariate analysis confirmed that the primary inorganic contaminants at DND and INAC sites are Cu, Pb and Zn. Most other contaminants co-occur with Cu, Pb or Zn. These elements can be detected using field-portable X-ray fluorescence (XRF) analytical methodology, resulting in cost and time savings over standard laboratory analysis.

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ANNEX

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ANNEX A: LIST OF CONTAMINANTS EVALUATED AT DND DEW LINE SITES BY THE ESG, 1989-1990

- PCBs: Aroclors and congeners
- TPH
- Organochlorines: hexachlorobenzene; alpha-HCH; beta-HCH; gamma-HCH; oxychlordane; trans-chlordane; cis-chlordane; trans-nonachlor; cis-nonachlor; heptachlor; heptachlor epoxide; alpha-endosulphan; aldrin; dieldrin; endrin; mirex; o'p'-DDE; p'p'-DDE; o'p'-DDD; p'p'-DDD; p'p'-DDT; methoxychlor
- Inorganics: As, Be, Cd, Co, Cr, Cu, Pb, Hg, Mo, Se, Zn, Mn, Ni
- ABNs: bis-2-chloroethyl ether; 1,3-dichlorobenzene; 1,4-dichlorobenzene; 1,2-dichlorobenzene; bis (2-chloroisopropyl) ether; hexachloroethane; N-nitrosodi-n-propylamine; nitrobenzene; isophorone; bis (2-chlorethoxy) methane; 1,2,4-trichlorobenzene; naphthalene; hexachlorobutadiene; hexachloropentadiene; 2-chloro-naphthalene; acenaphthylene; 2,6-dinitrotoluene; 2,4-dinitrotoluene; acenaphthene; fluorene; 4-chlorophenyl phenyl ether; N-nitrosodiphenylamine; 4-bromophenyl phenyl ether; hexachlorobenzene; phenanthrene; anthracene; fluoranthene; pyrene; chrysene; benzo (a) anthracene; 3,3-dichlorobenzidine; benzo (b) fluoranthene; benzo (k) fluoranthene; benzo (a) pyrene; indenopyrene; dibenzo (a,h) anthracene; benzo (g,h,i) perylene; phenol; 2-chlorophenol; 2-nitrophenol; 2,4-dimethylphenol; 2,4-dichlorophenol; 4-chloro-3-methylphenol; 2,4,6-trichlorophenol; 2,6-dibromophenol; 2,4-dinitrophenol; 4-nitrophenol; 2-methyl-4,6-dinitrophenol; pentachlorophenol
- Soil purgeables: 1,1-dichloroethene; trans-1,2-dichloroethene; 1,1-dichloroethane; trichloromethane; 1,1,1-trichloroethane; 1,2-dichloroethane; tetrachloromethane; benzene; 1,2-dichloropropane; trichloroethene; bromodichloromethane; cis-1,3-

dichloropropene; toluene; trans-1,3-dichloropropene; 1,1,2-trichloroethane;
dibromochloromethane; tetrachloroethene; chlorobenzene; ethylbenzene; tribromomethane;
1,1,2,2-tetrachloroethane; total xylenes

ANNEX B: LIST OF CONTAMINANTS EVALUATED AT DND DEW LINE SITES BY UMA ENGINEERING LTD., 1990

- Total PCBs
- TPH
- Inorganics: As, Se, Hg, Ba, Be, Cd, Cr, Pb, Ni, Ag
- Pesticides: aldrin; a-BHC; b-BHC; g-BHC (lindane); d-BHC; p,p'-DDD; p,p'-DDE; p,p'-DDT; dieldrin; a-endosulfan; b-endosulfan; endosulfan sulfate; heptachlor; heptachlor epoxide
- ABNs: phenol; bis-2-chloroethyl ether; 2-chlorophenol; 1,3-dichlorobenzene; 1,4-dichlorobenzene; 1,2-dichlorobenzene; bis (2-chloroisopropyl) ether; hexachloroethane; N-nitrosodi-n-propylamine; nitrobenzene; isophorone; 2-nitrophenol; 2,4-dimethylphenol; bis (2-chlorethoxy) methane; 2,4-dichlorophenol; 1,2,4-trichlorobenzene; naphthalene; hexachlorobutadiene; 4-chloro-3-methylphenol; hexachlorocyclopentadiene; 2,4,6-trichlorophenol; 2-chloro-naphthalene; acenaphthylene; dimethyl phthalate; 2,6-dinitrotoluene; acenaphthene; 2,4-dinitrophenol; 2,4-dinitrotoluene; 4-nitrophenol; fluorene; 4-chlorophenyl phenyl ether; diethyl phthalate; 4,6-dinitro-2-methylphenol; N-nitrosodiphenylamine; 4-bromophenyl phenyl ether; hexachlorobenzene; pentachlorophenol; phenanthrene; anthracene; di-n-butyl phthalate; fluoranthene; pyrene; benzyl butyl phthalate; benzo (a) anthracene; chrysene; bis-2-ethylhexyl-phthalate; di-n-octyl phthalate; benzo (b) fluoranthene; benzo (k) fluoranthene; benzo (a) pyrene; ideno(1,2,3-cd)pyrene; dibenzo (a,h) anthracene; benzo (g,h,i) perylene; d5 phenol; d5-nitrobenzene; 2-fluorobiphenyl; 2,4,6-tribromophenol; d-14-p-terphenyl

- VOCs: Cl-methane; vinyl chloride; Br-methane; Cl-ethane; Cl₃F₃-methane; 1,1-Cl₂-ethylene; methylene chloride; trans 1,2-Cl₂-ethylene; 1,1-Cl₂-ethane; chloroform; 1,1,1-Cl₃-ethane; 1,2-Cl₂-ethane; carbon tetrachloride; benzene; 1,2-Cl₂-propane; Cl₃-ethylene; BrCl₂-methane; 2-Cl-ethylvinyl ether; cis-1,2-Cl₂-propylene; toluene; trans-1,2-Cl₂-propylene; 1,1,2-Cl₃-ethane; ClBr₂-methane; Cl₄-ethylene; Cl-benzene; ethyl benzene; bromoform; 1,1,2,2-Cl₄-ethane; d₄-1,2-dichloroethane; d₈-toluene; bromofluorobenzene

Figure 7. Box plots showing total PCB concentrations (ppm) at DND (left) and INAC (right) DEW Line sites.

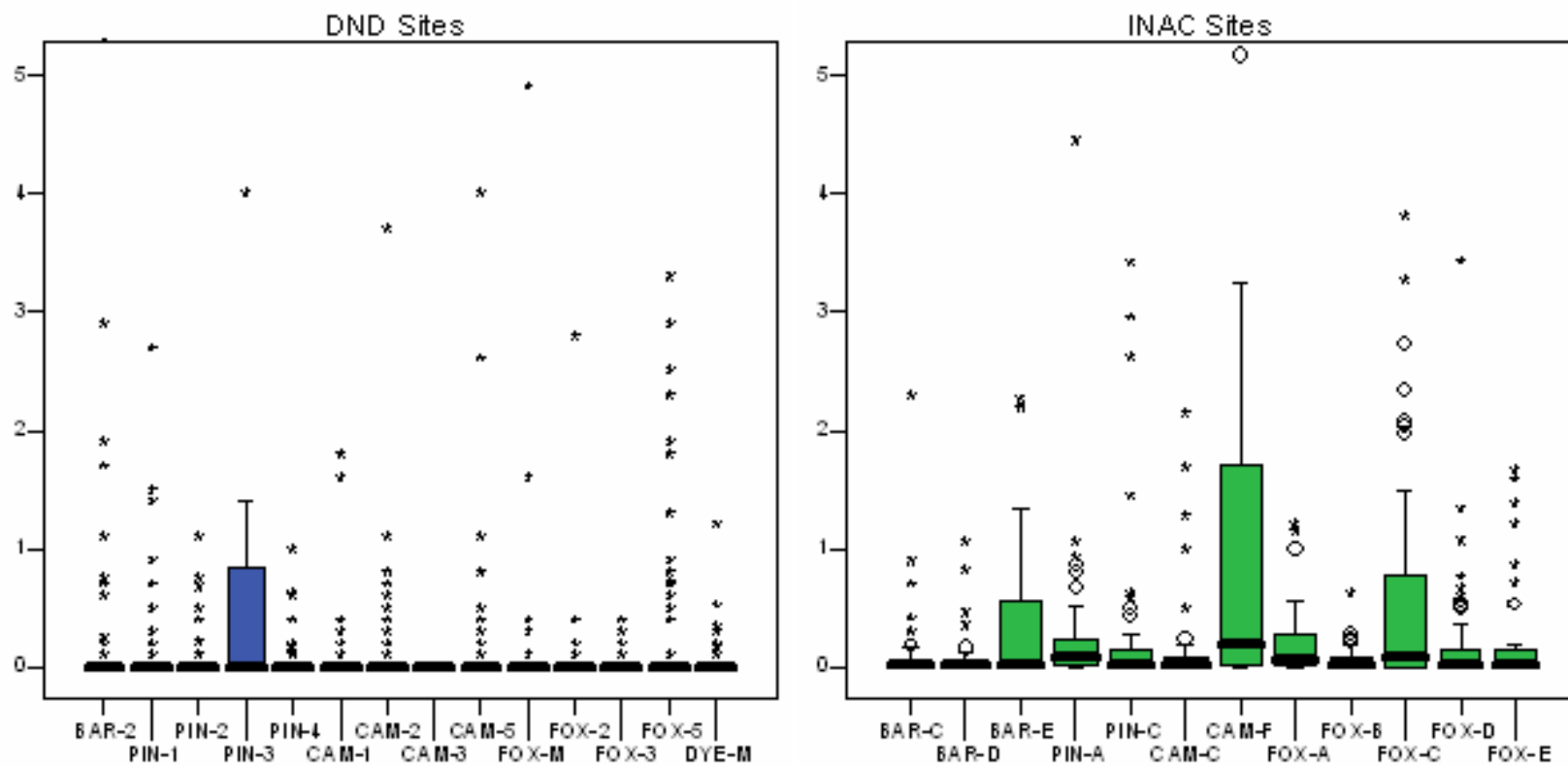


Figure 8. Box plots showing Cu (ppm) at DND (left) and INAC (right) DEW Line sites.

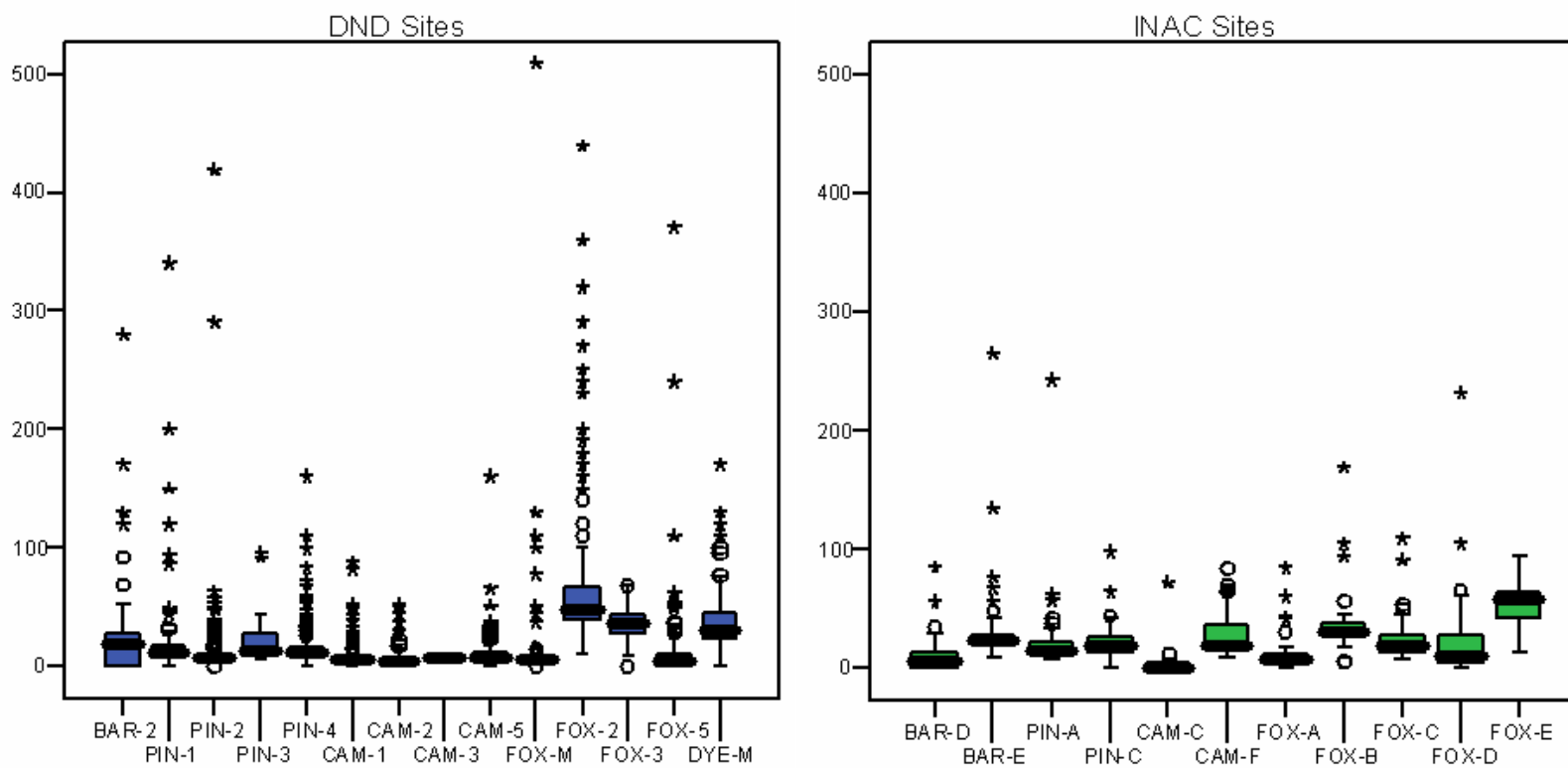


Figure 9. Box plots showing Pb concentrations (ppm) at DND (left) and INAC (right) DEW Line sites.

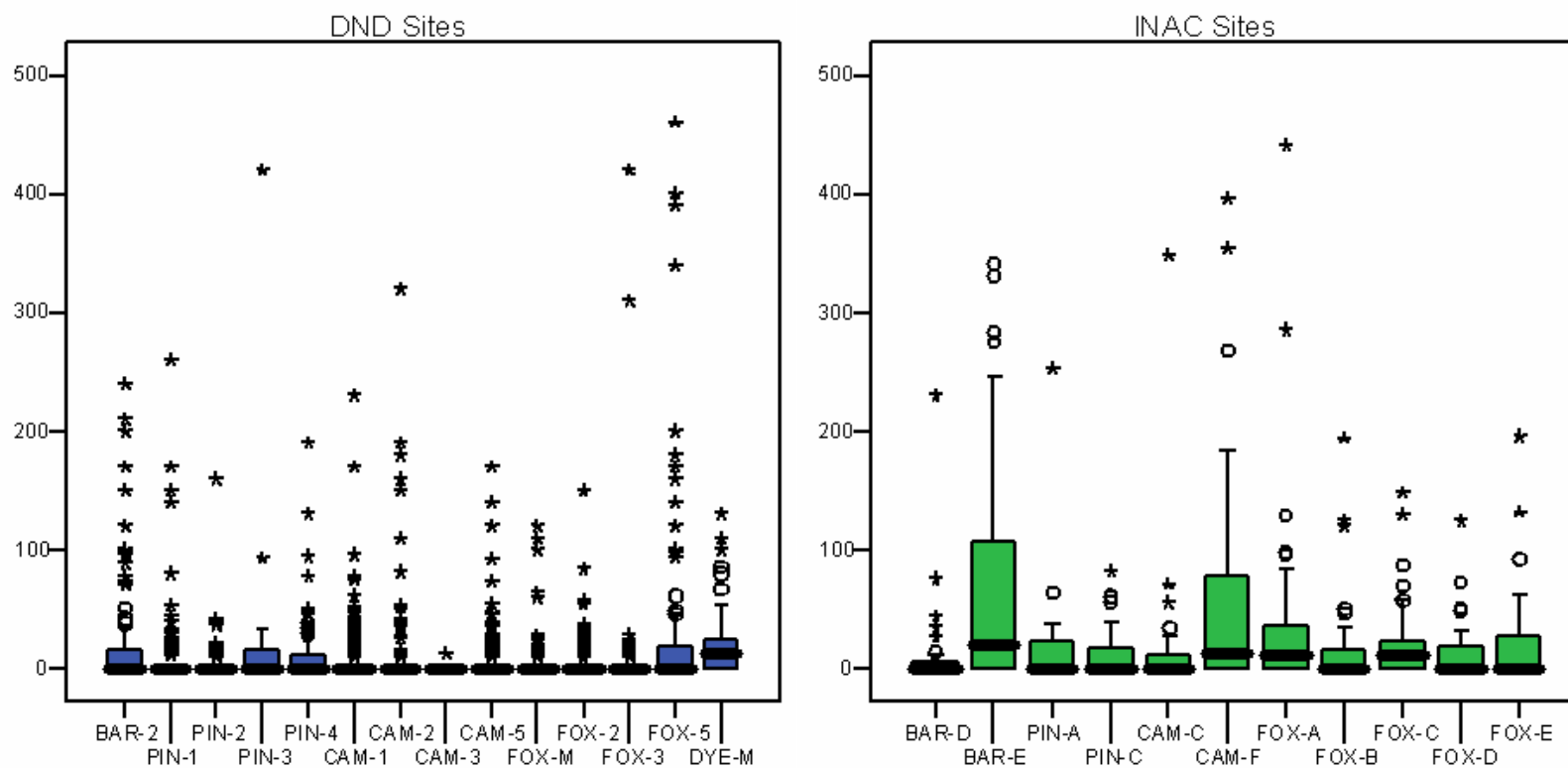


Figure 10. Box plots showing Zn concentrations (ppm) at DND (left) and INAC (right) DEW Line sites.

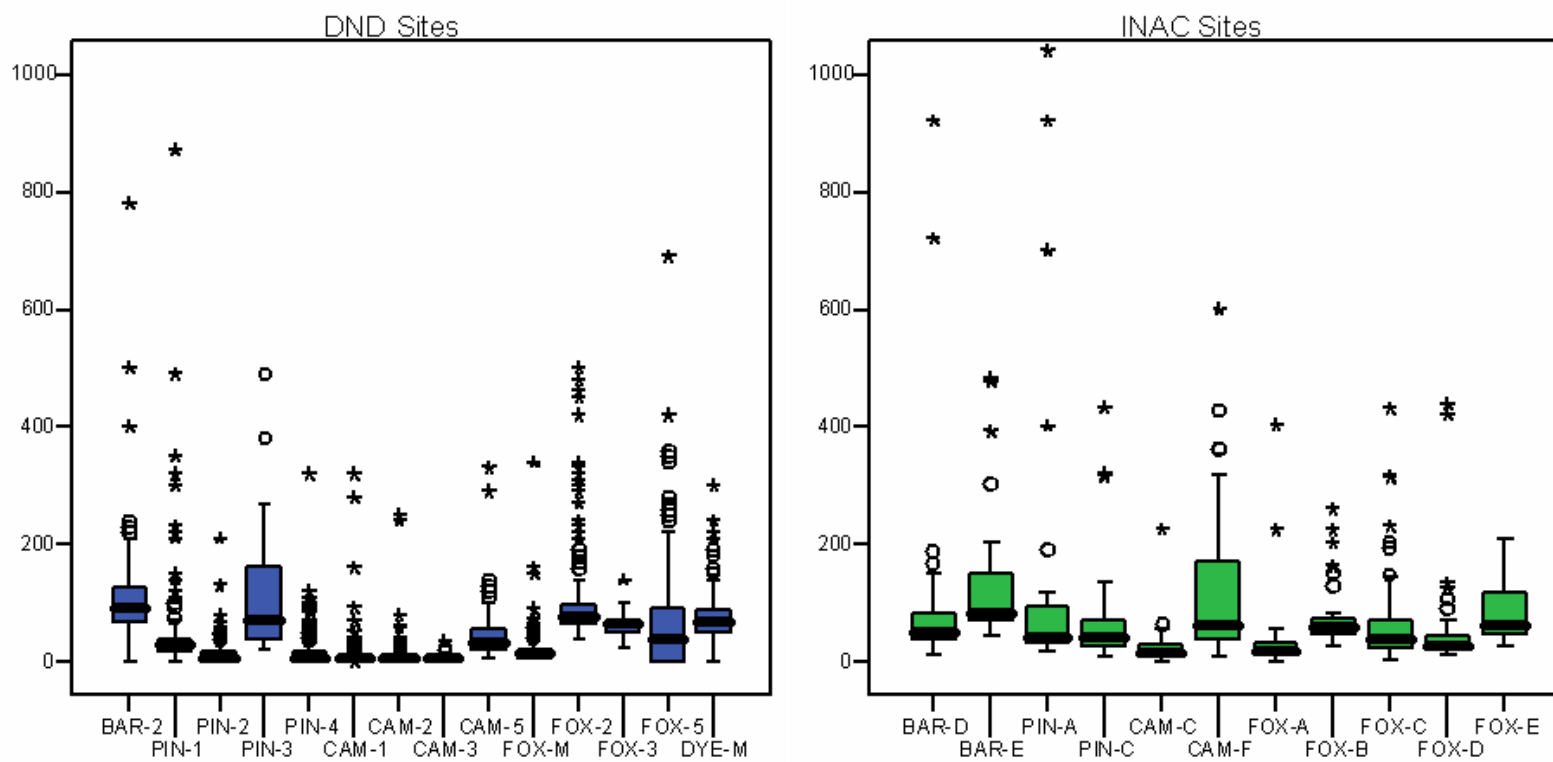


Figure 11. Box plots showing Cd concentrations (ppm) at DND (left) and INAC (right) DEW Line sites.

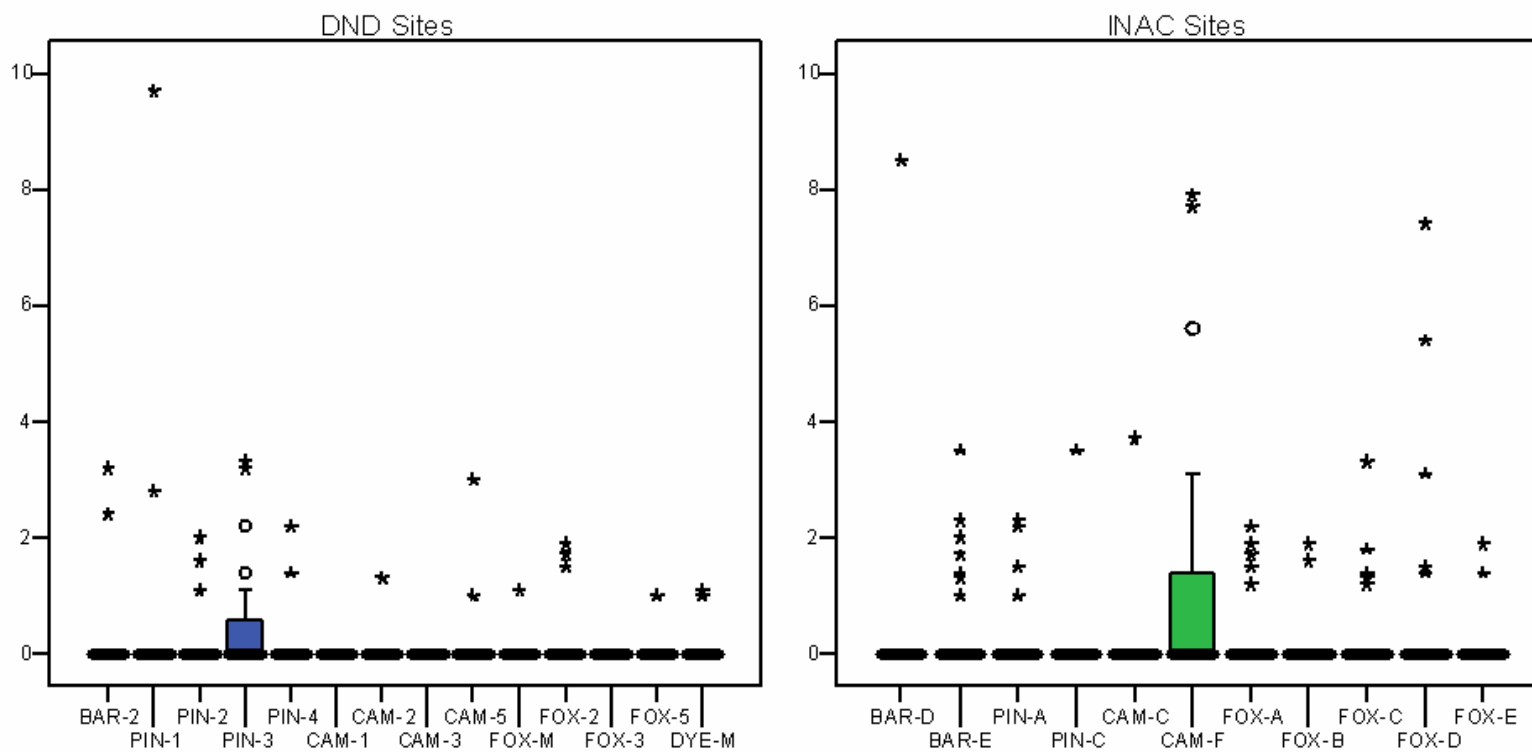


Figure 12. Box plots showing As concentrations (ppm) at DND (left) and INAC (right) DEW Line sites.

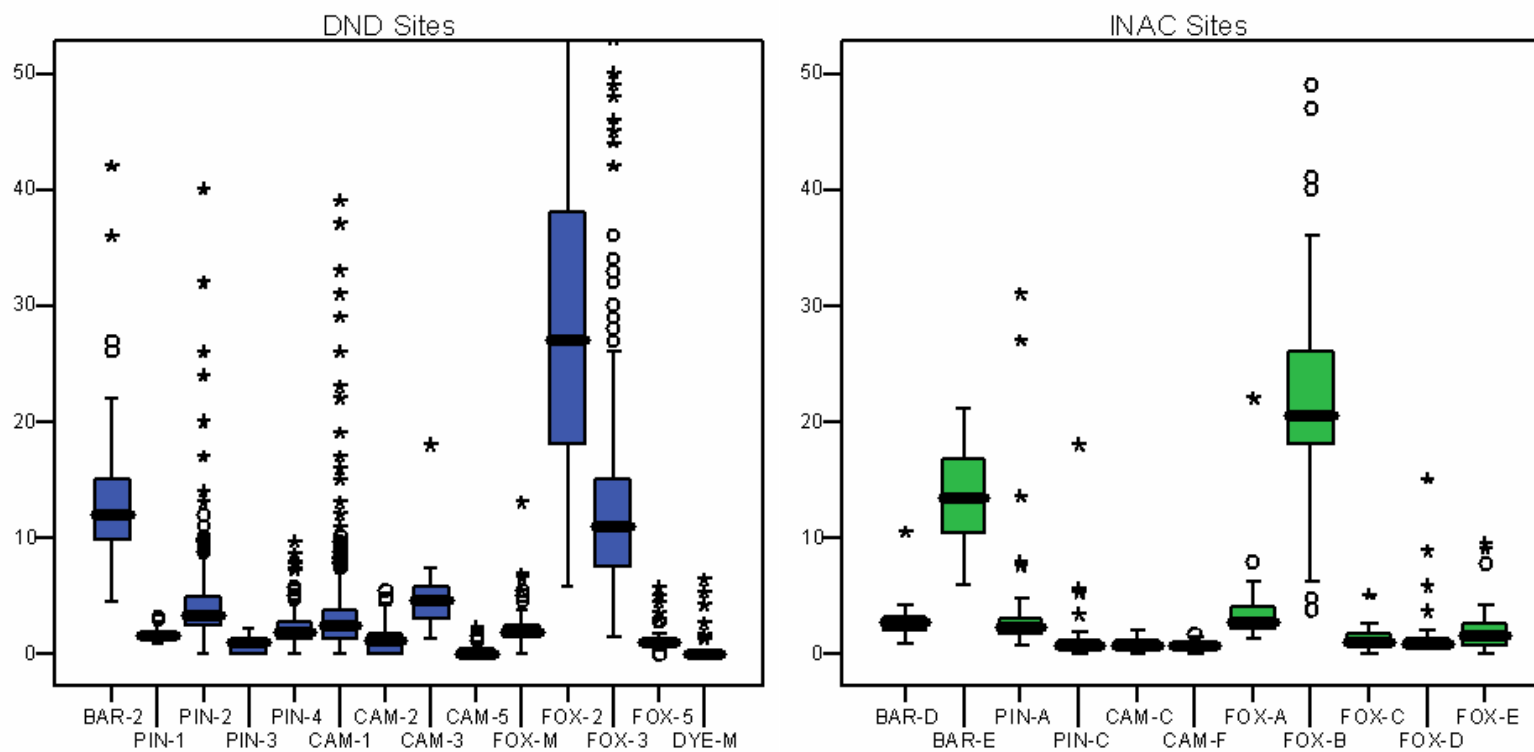


Figure 13. Box plots showing Ni concentrations (ppm) at DND (left) and INAC (right) DEW Line sites.

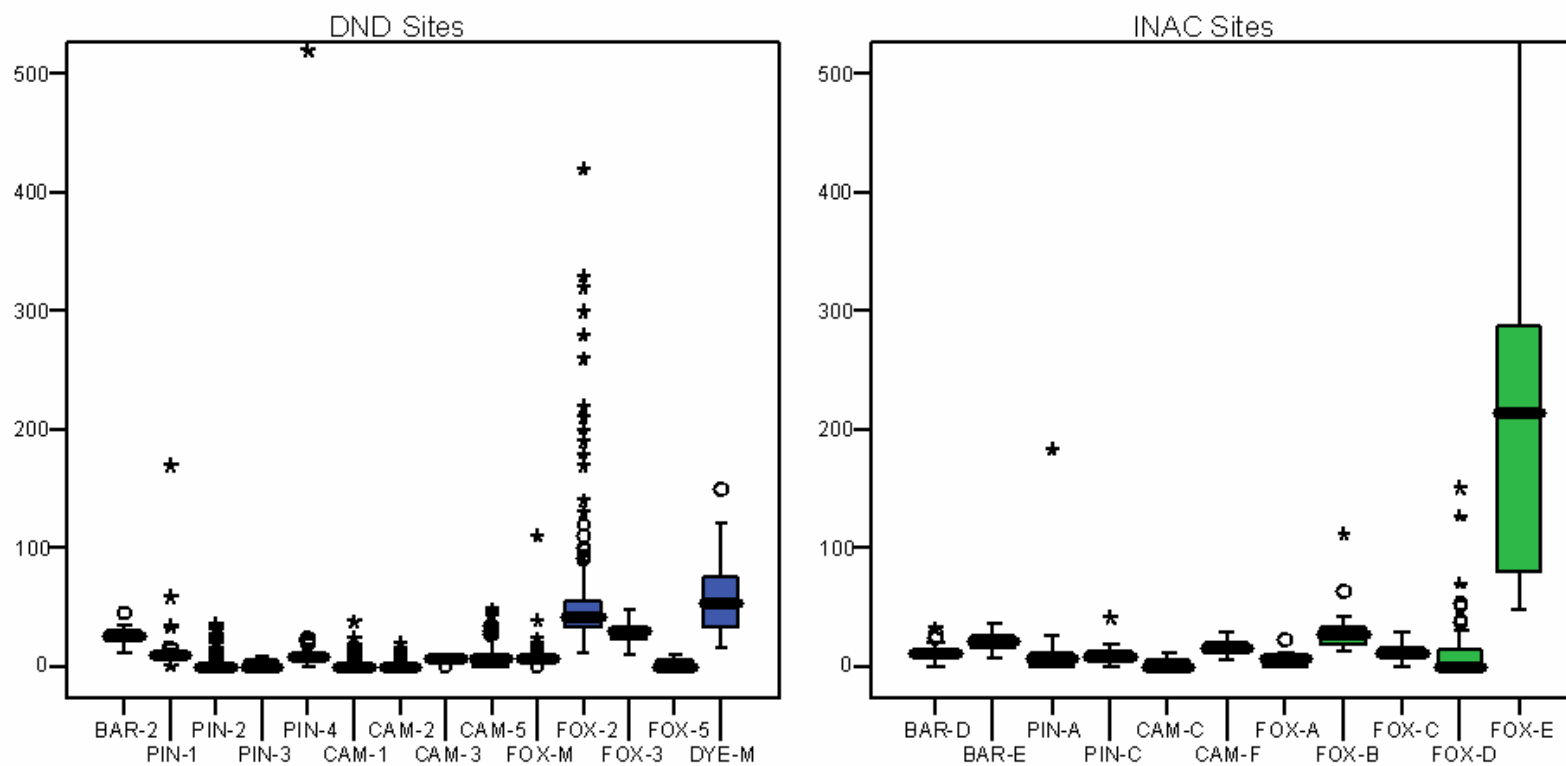


Figure 14. Box plots showing Co concentrations (ppm) at DND (left) and INAC (right) DEW Line sites.

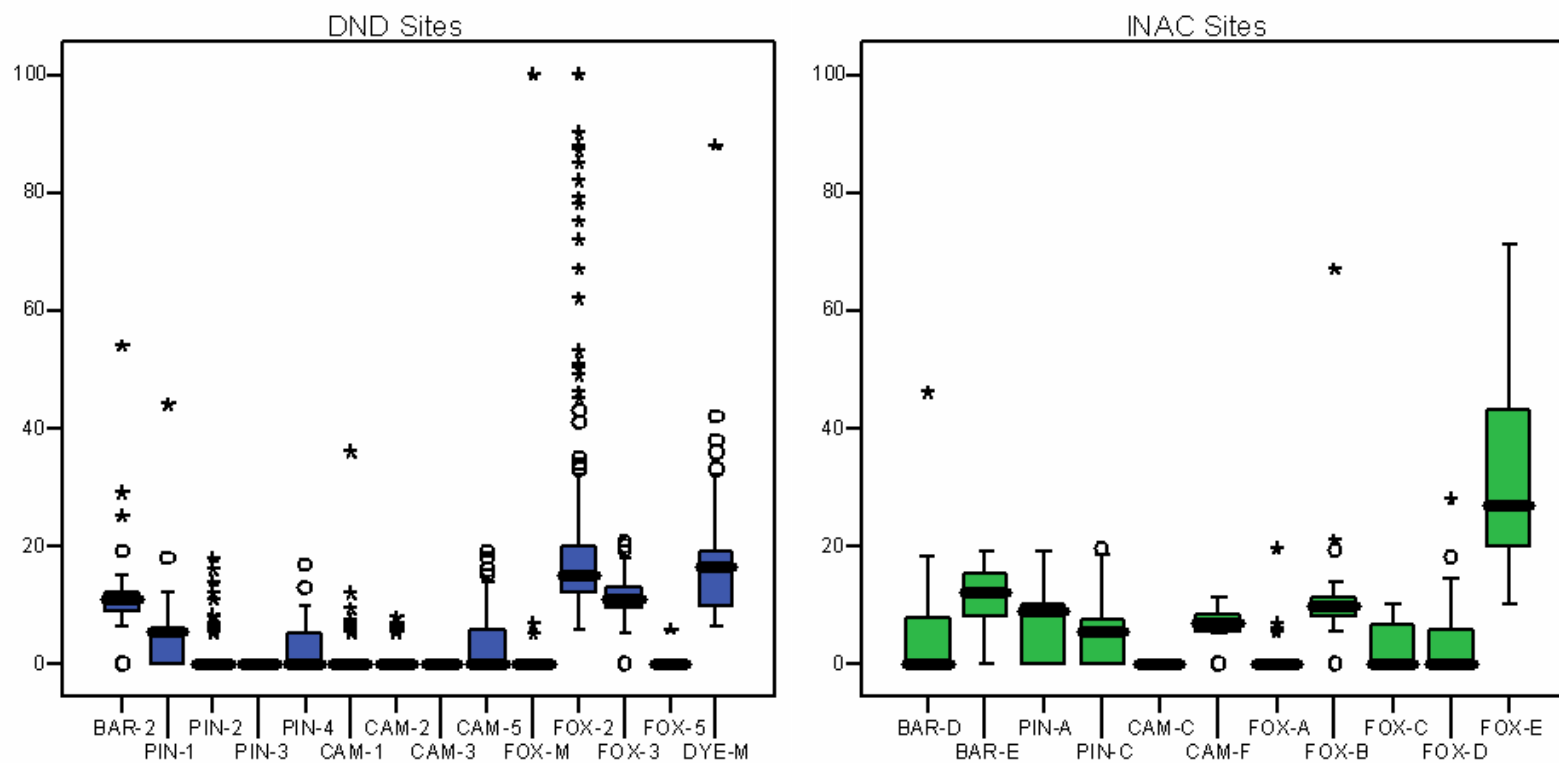
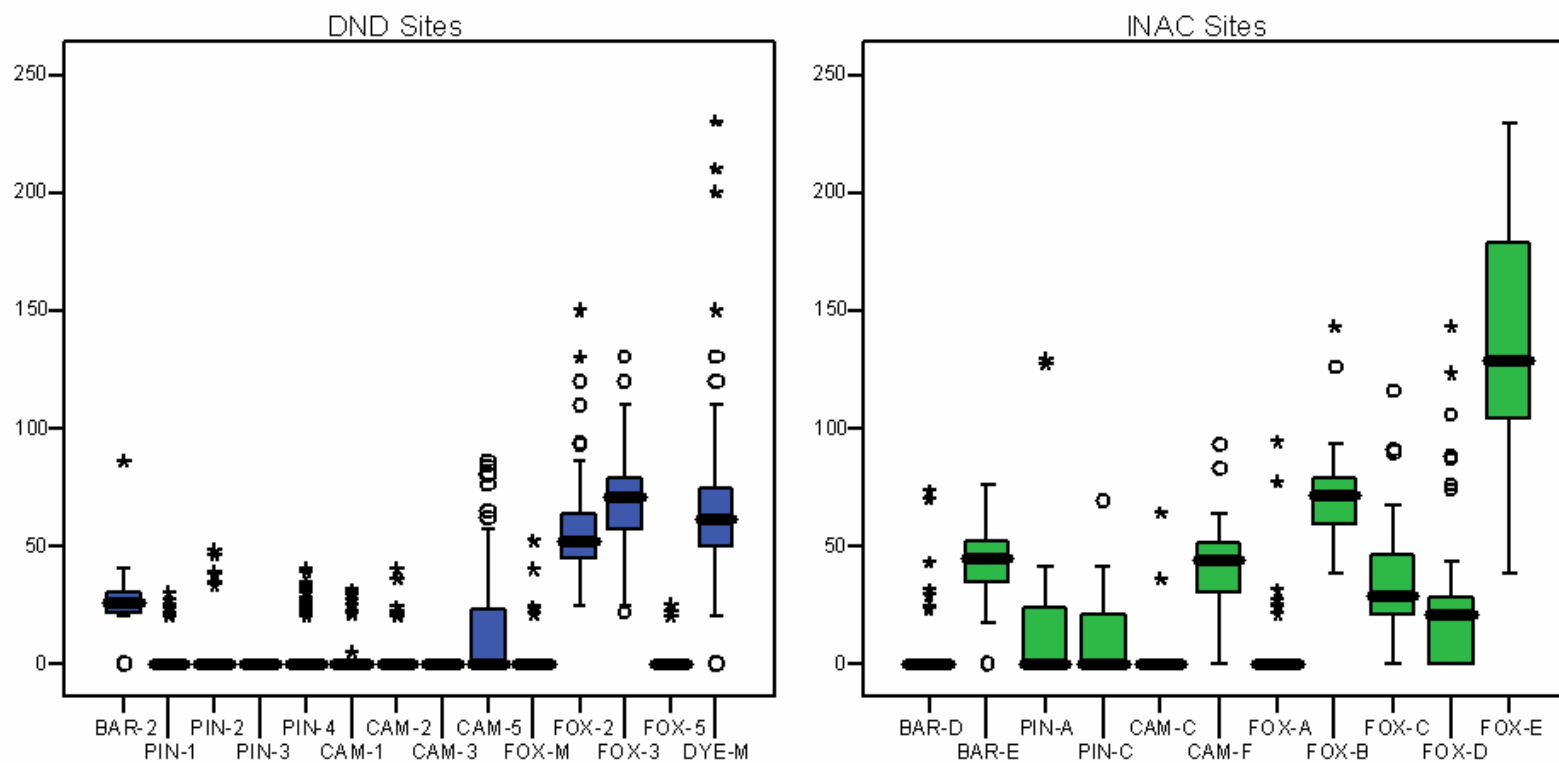


Figure 15. Box plots showing Cr concentrations (ppm) at DND (left) and INAC (right) DEW Line sites.



APPENDIX B:
BACKGROUND SOIL GEOCHEMISTRY
ASSESSMENT

DRAFT

INTRODUCTION

Site investigations conducted as part of the DEW Line Clean Up (DLCU) project revealed naturally occurring high concentrations of inorganic elements at the following sites: DYE-M (Co, Cr, Cu, and Ni); FOX-2 (Cu, Ni, Co and As); and FOX-3 (As). Site-specific target levels were derived from background data to minimize costly and unnecessary disturbance of these areas. Site-specific evaluation matrices were created to help standardize the process of determining whether the concentrations that exceeded the site-specific criteria were anthropogenic or naturally elevated “hot spots”. For those areas that were judged through this process to be natural, it was recommended that they be excluded from remediation and remain in place. The DLCC apply to all other contaminants and areas with contaminant concentrations in excess of criteria are included in the cleanup.

A review of the data collected during the INAC site assessments from 1993-1994 suggests that naturally elevated concentrations of inorganic elements may be present at a minimum of three INAC DEW Line Sites. It is recommended that INAC conduct a detailed desk-top study of geochemistry of surficial and bedrock geology and provide the results of this study to consultants prior to initiating site investigations. If required, a detailed investigation of background concentrations will be carried out in conjunction with the environmental site assessment.

DEVELOPMENT OF SITE-SPECIFIC ENVIRONMENTAL CRITERIA FROM BACKGROUND DATA AT DND DEW LINE SITES

The presence of inorganic elements at DEW Line sites is investigated and results interpreted using the DEW Line Cleanup Criteria (DLCC) in the protocol as it appears in the DND/NTI Co-operation Agreement (DGE, 1998). Although the protocol makes no reference to naturally occurring concentrations of inorganic elements, the importance of considering these on a site-specific basis was recognized during protocol development and is reflected in site investigation approaches. Naturally occurring concentrations of inorganic elements are evaluated at each site during the investigation phase to obtain local background levels. A more detailed background characterization is not generally required for site investigation and remediation when there are applicable generic soil quality guidelines, i.e. the DLCC, and when contaminant sources are clearly identifiable and anthropogenic. Consequently, up to 10 samples are usually collected to determine background levels at each site.

However, where concentrations of trace metals are naturally high, further characterization of the background data is warranted to minimize unnecessary disturbance. Baffin Island in particular is known to have geologic units with naturally high concentrations of various inorganic elements; sometimes approaching or exceeding the DLCC. Therefore, as part of the DND DEW Line Cleanup Program, site-specific remediation criteria were developed from background data to protect the sensitive Arctic ecosystem and human health while staying within the constraints of fiscal responsibility to the DEW Line Cleanup Project. [1,2]

Characterization of background concentrations of inorganic elements for contaminated-site investigation and remediation typically includes a soil sampling program conducted in areas of background units comparable to on-site areas but free of anthropogenic inputs. The objectives of the sampling program are as follows:

- a) To establish local inorganic element levels in the soil
- b) Differentiate between natural and anthropogenic concentrations;
- c) Assist in definition of boundaries for excavations; and

d) Calculate acceptable levels for confirmatory testing.

A thorough understanding of the geology in the area, which includes the geochemistry of the soil, is important to correctly assess inorganic element migration patterns for the assessment of landfills and in support of the long-term monitoring program. A geology-based uniform random sampling approach is implemented because this minimizes bias, and useful statistical inferences can be confidently determined from such a data set. [3] The data set is examined to determine whether calculation of site-specific target levels is warranted.

Once the presence of naturally high levels of inorganic elements has been confirmed, there are three general approaches to delineating contamination: a) development of criteria specific to terrain units, b) development of site criteria, and/or c) using a combination of the two.

While the first approach – the development of different criteria for each terrain unit – would arguably result in the most accurate cleanup target, this approach is difficult to implement as soils originating from specific units may have been transported and utilized as borrow material in other terrain units. In addition, wind and water transport mechanisms they have been transported materials elsewhere on site. Conversely the second approach, developing a set of global criteria, is simple to develop and implement. The primary disadvantage is that it ignores the presence of the different terrain units. The recommended third approach, a combination of global criteria and unit-specific criteria, can be used to address possible exceptions. Site-specific evaluation matrices were created to help standardize the process of determining whether or not the concentrations that exceeded the site-specific criteria were anthropogenic or isolated occurrences of naturally elevated hot spots. Those judged through this process to be natural are recommended to be excluded from remediation and remain in place based. The DLCC apply to all other contaminants and areas with contaminant concentrations in excess of criteria are included in the cleanup.

Detailed analyses of the most commonly used statistical techniques for developing site-specific criteria can be found in ESG (2004) and Looock *et al.* (2005). [1,2] These statistical techniques vary widely in their application, technical merit, complexity, risk of error, degree of protection, and ease of implementation. These techniques include: i) use of the maximum

measured background concentration; or calculation of ii) a mean + n standard deviations; iii) an upper tolerance limit; and iv) an upper prediction limit. Selection of the appropriate statistical technique depends on the sample set size, its distribution characteristics (normal, log-normal, other) and the frequency number and fraction of non-detects.

Site investigations conducted as part of the DEW Line Cleanup revealed naturally high concentrations at the following sites: DYE-M (Co, Cr, Cu and Ni); FOX-2 (Cu, Ni, Co and As); and FOX-3 (As). [4,5] Site-specific target levels were derived. It is recommended that a detailed review of local geology be conducted as part of the INAC site investigation activities to determine whether a vigorous background characterization program is warranted. A review of the data collected during the INAC site assessments from 1993-1994 suggests that naturally elevated concentrations of inorganic elements may be present at FOX-B, FOX-E and BAR-E.

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