Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

Abandoned Military Site Remediation Protocol

March 2005

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CHAPTER 1

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.

CHAPTER 2

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);
- Apply simple, practical remedial solutions wherever possible, with flexibility as necessary to adjust to site-specific conditions when they are identified;
- Establish cost effective solutions through the use of best practices to ensure appropriate levels of environmental protection for all sites;
- Recognize the concerns of global warming in an Arctic setting; and
- Ensure the long-term effectiveness of the environmental remedial measures.

CHAPTER 3

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). Where contaminants (not including hydrocarbons) are not addressed by the adopted DEW Line Cleanup Criteria, the CCME risk assessment approach (Method 3) will be applied. Hydrocarbon related contaminants will be addressed according to the CCME Canada Wide Standards (CWS) (CCME 2001).

CLEANUP CRITERIA FOR ADDITIONAL CONTAMINANTS OF CONCERN

The DEW Line Cleanup (DLCU) Protocol that includes criteria for a specific limited set of contaminants will be adopted for the INAC sites. An alternative mechanism is required to establish the cleanup criteria for contaminants of concern, identified below, that are not included in the DLCU Criteria.

PETROLEUM HYDROCARBON CONTAMINANTS

Consistent with the *CCME Method 1,* hydrocarbon contamination will be addressed through the application of the CCME CWS for Petroleum Hydrocarbons (PHC) Tier 2 (CCME 2001). Where it can clearly be demonstrated that Tier 2 levels are inappropriate due to the absence of specific pathways or receptors, a Tier 3 risk assessment approach may be adopted (CCME 1996).

Where free product is encountered the free phase liquid will be addressed prior to the application of the CCME CWS PHC or risk assessment methods for establishing remediation requirements.

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 two sites, Sarcpa Lake (CAM-F) and Ekalugad Fiord (FOX-C) (JW 2005). 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 also negligible except in the case of PCBs where the risk is small; however below the Health Canada human health effects levels (HC 2002).

The Ecological and Human Health Risk Assessment will be used to establish appropriate remediation criteria for parameters that are not included in the DLCU Protocol.

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 DLCU 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 DLCU Criteria or the CCME PHC CWS, 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.

SENSITIVE RECEPTORS

Where contaminants are present in close proximity to sensitive receptors special attention, that may require a risk assessment, should be given to the remediation approach and residual contaminant levels post-cleanup to ensure effective protection of the sensitive receptors.

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.

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

CHAPTER 4

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

LANDFILL CLOSURE

Landfills on INAC abandoned military sites 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 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 is located in a suitable, stable location, but there is evidence of contaminated leachate, a suitably engineered containment system will be constructed. If this course of action is cost prohibitive, the landfill may be relocated to an engineered landfill or the waste may be disposed of off-site (Class B Landfill); and
- If the landfill is located in a suitable, stable location, with no evidence of contaminated leachate, it will be left in place. If required, additional granular fill will be placed to ensure erosion protection and proper drainage (Class C Landfill).

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 0.6m 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.

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 of the new landfills will be required to ensure that they are operating as intended. Monitoring activities may include visual inspection to ensure that water is not ponding on the landfill cover, that the cover is not eroding and that the permafrost is developing within the landfill consistent with the design.

PHYSICAL 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.

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 DLCU Criteria (see Appendix B). 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 CCME Canada Wide Standards - Petroleum Hydrocarbons in Soil (CCME 2001).

Three primary contaminated soil types have been identified; metal 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.

METALS CONTAMINATED SOILS

All soils with metal concentrations exceeding the DLCU Criteria or criteria derived through Risk Assessment processes will be either disposed of off-site or encapsulated on-site.

PETROLEUM HYDROCARBON CONTAMINATED SOILS

Hydrocarbon contaminated soil remediation levels will be established through the application of the CCME Canada Wide Standards - Petroleum Hydrocarbons in Soil. Tier 2 levels will be routinely applied with Tier 3 levels applied to sites where conditions are significantly different than the norm. 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 disposal. If they do not pose a significant environmental risk, they may be capped in place or left in place to remediate through natural attenuation.

Where free product is encountered the free phase liquid will be addressed prior to the application of the CCME CWS PHC or risk assessment methods for establishing remediation requirements.

PCB CONTAMINATED SOILS

All soils with PCB concentrations exceeding the DLCU Criteria will be either disposed of off-site or encapsulated 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, 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 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.

BARRELS

Barrels identified at the site will be handled according to the DLCU Barrel Protocol (see Appendix D) 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. Abandoned gravel pads and road infrastructure will be used as granular source material wherever possible. 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.

CHAPTER 5

5.0 POST CONSTRUCTION LANDFILL MONITORING

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 to ensure that water is not ponding on the landfill cover, that the cover is not eroding and that the permafrost is developing within the landfill consistent with the design.

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.

CHAPTER 6

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.

APPENDIX A:

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APPENDIX B:

DEW Line Cleanup Soil Criteria

GENERAL PROTOCOL FOR DEW LINE CLEANUP

A. STAINED SOIL

1. Remediation will be applied to all areas where inorganic elements and/or PCBs are at concentrations in excess of the Quebec B[1] or CCME R/P[2] criteria, whichever is lower.
2. This combination of the Quebec B and CCME R/P criteria form the DEW Line Cleanup Criteria (DCC). The DCC (Table 1) were determined, on the basis of site specific investigations, to be protective of the Arctic ecosystem.
3. Remediation responses differ depending on the tier of DCC, I or II that is applied. Thus:
   - All soils containing substances in excess of the DCC Tier II (numerically equal to CCME R/P) criteria will be containerized[3]; and
   - Excavated soils containing PCBs at concentrations between 1 and 5 ppm, and/or lead at concentrations between 200 and 500 ppm may be landfilled. The lower of the concentrations for these elements form the DCC Tier I criteria.
4. Some site specific exceptions may be applied; for example, the bird sanctuary at Cape Parry may be treated more rigorously.
5. Follow up (confirmation) testing will be to the DCC II (CCME R/P) criteria.

B. SEWAGE OUTFALLS

1. Use of active outfalls to be discontinued and secure sewage lagoons to be established where practical.
2. Abandoned outfalls to be considered as stained areas.

1. This refers to the Quebec Soil Contamination Guidelines (as of 1991).
2. Refers to the Interim Canadian Environmental Quality Criteria for Contaminated Sites (as of 1991) produced for the Canadian Council of Ministers of the Environment (CCME).
3. Containerized" refers to removal of the soil in a manner which precludes contact with the Arctic ecosystem.

C. SEWAGE LAGOONS

1. Existing lagoons which are not highly contaminated can continue in use provided measures are applied for leachate control.

2. Existing lagoons which are highly contaminated are to have their use discontinued, evaporation allowed to take place, and the dried residue removed and disposed in accordance with the protocol for stained soils.

D. LANDFILLS

Fall into one of three categories:

1. Located in an unstable, high erosion area; must be removed;
   Contents to be treated as per the procedures adopted for stained soils and physical debris.
2. Suitable location and no evidence of contaminated leachate;
   Can remain as is.
3. Suitable location, but source of contaminated leachate;
   Action must be taken to contain leachate. Options for the containment/stabilization of landfills can include the addition of clean fill; other suitable measures can be employed.

E. PHYSICAL DEBRIS

Visible physical debris is to be sorted into hazardous and non-hazardous components.

1. Hazardous material is to be containerized and stored in a secured location.
2. Non-hazardous material is to be buried in a suitable landfill location.

Debris from the demolition of facilities no longer required should be dealt with in the same manner as visible physical debris. Incineration of this material is not recommended; if burning is employed, the ash should be treated as hazardous waste.

It should be noted that this last requirement does not preclude the incineration of some non-hazardous materials, although it is advisable to ensure that the ash from all burning be buried in a suitable landfill. Structures that contain paints, metal etc

which could form a hazardous ash after combustion, should be broken down and buried; if this is not practical due to lack of a suitable landfill location and/or fill, then incineration may be considered as long as the ash is treated as hazardous waste.

TABLE 1: DEW LINE CLEANUP CRITERIA (DCC)[a]

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

a. These criteria were adopted specifically for the cleanup of Arctic DEW Line Sites from the 1991 versions of the Quebec Soil Contamination Indicators and the Canadian Council of Ministers of the Environment Interim Canadian Environmental Criteria for Contaminated Sites.

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

c. Soils containing lead and/or PCBs at concentrations in excess of DCC I, but less than DCC II, may be landfilled,

d. Soils containing one or more substrates in excess of DCC II must be containerized - i.e. removed in a manner which precludes contact with the Arctic ecosystem.

Table B-1: DEW Line Cleanup Summary

Cleanup requirement	DLCU Protocol
Building demolition and physical debris removal	– After demolitions sort debris into hazardous/nonhazardous waste. – Bury nonhazardous waste in unlined-engineered landfill and cover with clean fill. – Ship hazardous material South.
Barrels	– Crush or shred, analyze contents, then incinerate or ship to southern facility
Landfills - three types: 1. In unstable locations or leaching high levels of contaminants. 2. Contaminants leaching at low levels, and situated in a stable location which is not subject to erosion. 3. No contaminants leaching from the toe of dump.	After removal of any visible debris from the surface of the dump: 1. Excavate and sort into hazardous/nonhazardous debris. 2. Design engineering solution to stabilize in place by the use of liners and fill. 3. Cover with clean fill and recontour to direct surface waters away from the landfill.
Contaminated soil: 1. PCB level > 50 ppm (CEPA) 2. > DCC Tier II but < CEPA 3. > DCC Tier I but < DCC Tier II	1. Shipment to Southern licensed facility. 2. Isolate from the Arctic ecosystem (Northern Disposal Facility or ship South). 3. Burial in nonhazardous landfill.

APPENDIX C:

CCME CWS PHC Tier 1 and Tier 2 Criteria

HYDROCARBON CONTAMINATED SOIL
CANADA –WIDE STANDARDS FOR PETROLEUM HYDROCARBONS

A. INTRODUCTION

The Canadian Council of Ministers of the Environment (CCME) have developed the Canada Wide Standards (CWS) for petroleum hydrocarbons (PHC) in soil (CCME, 2001) in an attempt to provide a consistent evaluation and analytical approach to dealing with hydrocarbon contamination throughout Canada.

The PHC CWS is a three-tiered risk-based remedial standard for contaminated soil and subsoil occurring in four land use categories. Tier 1 sets generic numerical levels; Tier 2 allows for adjustments to Tier 1 levels based on site-specific information; whereas Tier 3 involves a site-specific risk assessment consistent with the CCME approach to the development of remedial objectives.

The PHC CWS four generic land uses are agriculture, residential/parkland, commercial and industrial. The exposure scenario associated with each of these land use categories forms the basis of the PHC CWS. Jurisdictions may also elect to define generic land uses involving the presence or absence of any relevant receptors and pathways, if appropriate in the context of geographic location, local land use and development trends.

B. CCME CWS PHC APPLICATION TO INAC SITES

LAND USE

Residential/Parkland has been applied to the INAC sites and is defined as the land use where the primary activity is residential or recreational activity. The parkland land use is defined as a buffer between the areas of residency and occupation, but this does not include wild lands such as national or provincial parks or undeveloped areas, other than campgrounds.

PATHWAYS AND RECEPTORS

The key receptors and exposure pathways considered for residential/parkland land use are as follows:

EXPOSURE PATHWAY	RECEPTOR
soil contact	invertebrates, plants, human (child)
soil ingestion	wildlife*, human (child)
groundwater / surface water	aquatic life, human (child)
vapour inhalation	child indoor

*wildlife dermal contact and ingestion is applicable when free product is present at surface, but there are insufficient data to develop guidelines that address this exposure pathway. Also, there are insufficient data to evaluate PHC exposure through the food chain. The few data available indicate that plant uptake of PHCs and subsequent exposure at higher trophic levels is not a concern.

HUMAN HEALTH EXPOSURE SCENARIOS

The critical receptor assumed at the residential/parkland land use category is a toddler. Exposed to PHC impacted soil and groundwater by ingestion, inhalation and dermal contact is assumed to be for 24 hours/day, 7 days/week, and 52 weeks/year. In addition, other receptor characteristics include soil ingestion rates (0.08 g/day), water ingestion rate (0.6 L/day), and inhalation rate (9.3 m^3/day). Route specific absorption rates are assumed to be 100% for ingestion and inhalation, and 20% for dermal contact. Additionally, to account for non-point source pollution, a soil allocation factor (SAF) of 0.5 is assumed for F1 and F2. SAFs of 0.6 and 0.8 are assumed for F3 and F4 respectively.

ECOLOGICAL EXPOSURE SCENARIOS

The ability for soil to support plant and soil invertebrate communities is deemed to be important for both short-term and long-term ecological sustainability. CWS does not consider mammalian and avian wild life as critical receptors as most PHCs are readily metabolized by vertebrates, modified into a more readily excretable form, and thus do not tend to accumulate in tissues. In addition, PHCs are not readily absorbed into and accumulated into plant tissues. The net result of consumption of either plants and/or other animals (as opposed to direct soil ingestion) does not tend to constitute a major component of exposure for PHCs in wild life and livestock populations. Therefore, direct

soil contact with soil invertebrates and plants is the only direct ecological exposure pathway considered applicable by CWS. The indirect contact of aquatic life with the PHCs is also considered by CWS.

TOXICOLOGICAL BASIS

The PHC CWS adopted the US Total Petroleum Hydrocarbons Working Group (TPHCWG) system and uses the oral reference doses (RfDs) and inhalation reference concentrations (RfCs) for each of the 14 aliphatic or aromatic sub-fractions identified in this system. Toxicological information for each TPHCWG sub-fraction is combined with the information on the expected mass of each sub-fraction to produce a toxicological benchmark for each of the four PHC CWS sub-fractions. The toxicological basis for ecological receptors is based on the toxicological data for vascular plants and soil invertebrates. Endpoints examined included chronic and sub-chronic responses (*e.g.,* root elongation, shoot growth, reproduction) as well as acute and lethal responses (*e.g.,* invertebrate survival and seed germination) in both field and artificial soils. The studies were based on the use of either whole products or vacuum distillates of fresh as opposed to weathered Whole Federated Crude Oil, using coarse textured soils.

ANALYTICAL METHOD

A significant development introduced through the CWS is the adoption of a benchmark method for the determination of PHC in soil. The adoption of a standard analytical method addresses major sources of variability and uncertainty related to the extraction, purification, quantification, and reporting of hydrocarbon contaminant levels in soils. Different analytical methods are prescribed for the four Fractions recognized by the PHC CWS. F1 PHC is isolated through purge and trap procedures followed by gas chromatography with a flame ionization detector (GC-FID). F2 - F4 PHC up to C50 are extracted by a Soxhlet procedure, “cleaned up” on silica gel and determined by GC-FID. C50+ PHC, if present, is determined either gravimetrically or through extended chromatography. Specific chromatograph calibration standards are required.

PHC CWS is implemented in three tiers: (1) the application of generic Tier 1 levels that are protective of the human health and the environment, (2) site-specific adjustments to Tier 1 levels to calculate Tier 2 levels that accommodate unique site characteristics, and (3) Tier 3 levels that are developed from site-specific ecological or human health risk assessment, when assumptions in the Tier 1 values are not appropriate for a site. The level of protection is the same for all three tiers.

Residential/parkland land use category was adopted as a conservative basis for the development of DEW Line Cleanup (DLCU) Criteria for inorganic elements and PCBs listed as the primary contaminants of concern. Residential/Parkland Tier 1 levels (mg/kg soil) for PHCs for coarse-grained surface soils are presented in Table 1 given below. Typical soil conditions at INAC military sites are located within 1.5 m from the ground surface and with grain size greater than 0.75 µm. These are defined as coarse-grained surface soils within the CWS system.

TABLE 1: CCME RESIDENTIAL/PARKLAND TIER 1 LEVELS (mg/kg SOIL) FOR PHCS FOR COARSE-GRAINED SURFACE SOILS

EXPOSURE PATHWAYS	F1 (C_6-C_{10})	F2 (>C_{10}-C_{16})	F3 (>C_{16}-C_{34})	F4 (>C_{34})
Soil ingestion	15,000	8,000	18,000	25,000
Vapour inhalation (slab-on-grade)	30	150	NA[3]	NA[3]
Protection of GW for aquatic life[1]	230	150	NA[3]	NA[3]
Eco soil contact[2]	130	450	400	2800

[1] Assumes surface water body at 10 m from HC source area.
[2] Tier 1 values based mainly on laboratory bioassay response to fractions derived from fresh Federated Crude Oil.
[3] NA – not applicable.

If Tier 1 levels, as outlined above, are implemented, the governing pathways are protection of aquatic life at the beach POLs, and ecological soil contact at other PHC impacted areas such as module train, garage, and hangars. Most of these source areas (*i.e.,* pads) contain sparse vegetation. Furthermore, invertebrates are not present at least at the sites in the central and eastern Arctic (Nunavut). The presence of PHCs in the soil may have some adverse impact on the microbial processes. Because of the sparse vegetation, the microbial processes in soil are relatively less important than aquatic ecosystem in the Arctic. Therefore, the ecological soil contact pathway can be qualitatively eliminated for soils well removed from the aquatic ecosystem. Exposure to indoor inhalation is not applicable as the garages and hangars are demolished during the cleanup. The remaining applicable pathways are soil ingestion and protection of aquatic life. Therefore, the most likely cleanup levels applicable are as follows (see Table 2).

The resulting soil remediation criteria for fuel oils in areas removed from life supporting water bodies is 8,000 ppm and the soil remediation criterion in areas in close proximity to life supporting water bodies within 10 m of the hydrocarbon contaminant source is 150 ppm.

TABLE 2: CCME RESIDENTIAL/PARKLAND TIER 1 LEVELS (MG/KG SOIL) APPLICABLE PATHWAYS

EXPOSURE PATHWAYS	F1 (C_6-C_{10})	F2 (>C_{10}-C_{16})	F3 (>C_{16}-C_{34})	F4 (>C_{34})
Soil ingestion (garages, hangars, etc.)	15,000	8,000	18,000	25,000
Protection of GW for aquatic life[1] (beach POLs)	230	150	NA[2]	NA[2]

[1] Assumes surface water body at 10 m from HC source area.
[2] NA – not applicable.

In cases where pertinent site conditions are similar relative to each other, it may be possible and cost effective to develop site-specific objectives based on one site. Provided the site similarities can be demonstrated to be sufficiently similar that the risk assessment assumptions and inputs for each site are equivalent the results may be generally applicable to all of the similar sites. Reviewing site assumptions and dependencies will require verification of the similarity of the sites. Where significant differences are identified the impacts of the differences on the risk assessment output will need to be assessed.

C. CONCLUSIONS AND RECOMMENDATIONS

The CCME guidelines for contaminated sites provide generic standards or the mechanism for modifying the standards and developing site-specific risk based standards.

The development of site-specific criteria through the application of a CCME Method 2 (modified generic guidelines) or Method 3 (risk assessment derived site-specific objectives) approach is provided for application. The approach used to modify the soil quality guidelines should adhere to the soil protocols and minimum data requirements established in the soil protocol (CCME 1996a). Risk assessment derived soil objectives applicable for a particular site may be transferable to the other similar sites.

The application of the CWS PHC at the Tier 2 level is considered to be more appropriate for the derivation of contaminant criteria. The standards achieved through the application of the CWS are of the order of 150 ppm for ecologically sensitive areas and 8000 ppm for areas removed from ecologically sensitive areas. However, the application of the CWS has some practical application limitations. The analytical requirements are rigorous and demanding especially for implementation in remote locations where on-site analytical capabilities are limited and significant time is required to transport samples to an analytical laboratory.

The soils at the sites are typically contaminated with petroleum hydrocarbons, PCBs, and inorganic elements specifically lead, copper and zinc. Soils impacted by petroleum hydrocarbons should be delineated to two different criteria as follows:

1. Petroleum hydrocarbon impacted soils close to fisheries sensitive environment should be delineated to 150 ppm; and
2. Petroleum impacted soils in other areas of the site should be delineated to 5,000 ppm.

Typical areas include POL facilities at the beach and the station areas. Stains of heavy end hydrocarbons (lube oil) are common around module trains and garages. The type of hydrocarbons present include diesel, gasoline, waste lube oils. The diesel and gasoline contamination typically extends to the permafrost boundary. Permafrost is typically encountered at 0.3 – 2.5 m below surface.

It is necessary to collect source, pathway and receptor information for all the petroleum hydrocarbon areas to ensure sufficient information is available to perform the appropriate level of risk assessment. Risk assessment derived soil objectives applicable for a particular site may be transferable to the other similar sites.

In many instances the volume of contaminated soil present at a site may be sufficiently small that removal of the contaminant through excavation and disposal or remediation is the most cost effective approach. It is therefore appropriate to address contaminated areas site-specifically and area specifically.

The completion of the Risk Assessment for a typical model site as well as the CCME Tier 2 comparison will provide a clear understanding of the primary influencing factors in the level of risk posed by contaminated soil at INAC contaminated sites. With this level of understanding flexibility in the implementation of the requirements and therefore the approach is available. The interaction of source, pathway and receptor in determining the risk posed by the contamination allows for various points of intervention to mitigate the risk. Where options are available field decisions may be required to ensure the most appropriate site-specific solution is applied.

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APPENDIX D:

DEW Line Cleanup Barrel Contents Criteria

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

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