HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT
CAMBRIDGE BAY AIRPORT, CAMBRIDGE BAY, NUNAVUT

Prepared for:

Transport Canada
On behalf of
Public Works and Government Services Canada

Prepared by:

Franz Environmental Inc.
308-1080 Mainland Street
Vancouver, BC V6B 2T4

FRANZ ENVIRONMENTAL INC.

♦ CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

Project No. 1748-0902
March 2010

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March 2010

EXECUTIVE SUMMARY

Franz Environmental Inc. (FRANZ) was retained by Public Works and Government Services Canada (PWGSC) Pacific Region on behalf of Transport Canada (TC), Prairie and Northern Region and Environmental Affairs Division to complete a risk assessment for the Cambridge Bay Airport on Victoria Island, Nunavut. The risk assessment report consists of a preliminary human health and a qualitative ecological risk assessment. The work was conducted to assess if environmental conditions at areas of potential environmental concern (APECs) present a potential risk to human and ecological receptors.

The Airport is a civil airport located near the West Arm of Cambridge Bay, 3km west of the Hamlet of Cambridge Bay. The property covers an area of approximately 140 ha. Historical reports identified six APECs including two disposal areas, namely the TC Shoreline Disposal Area, and the Screening Plant "Boneyard" as well as four areas potentially impacted by historical fuel use and storage. Subsurface investigations were conducted to confirm the presence/absence of Chemicals of Potential Concern (COPC) in APEC soils and groundwater; delineation was conducted at APECs with identified contamination.

Human Health Risk Assessment

Methodology

The human health risk assessment was conducted in accordance with Health Canada PQRA guidance documents (Health Canada, 2004, 2007, 2009 updates).

Screening chemicals of potential concern (COPC) for the human health assessment was completed by comparing maximum concentrations of contaminants in media primarily with federal CCME guidelines and standards. The following were identified as COPC in environmental media onsite and used as inputs in the human health PQRA spreadsheets:

- Soil - PHC Fraction F2, benzene, ethylbenzene, toluene, xylenes, arsenic, copper, and lead; and
- Groundwater - PHC Fraction 1 and Fraction 2, benzene, ethylbenzene, benzo(a)pyrene, and lead.

FRANZ reviewed factors such as property/area use, current/proposed property/site activities, and access and identified the following potential human receptors identified at the sites include:

- Adult airport employees involved in operational and maintenance activities onsite. This would be considered a chronic exposure scenario.
- Remedial workers involved in Site remediation. These workers would be onsite for intense short term exposures during the summer season. Workers returning to the sites would also be considered in a chronic exposure scenario.

Franz reviewed routes of contaminant exposures at the sites and identified the following exposure pathways:

- Incidental ingestion of soil particles, and inhalation of soil particles (fugitive dust, vapours);
- Dermal contact with soil; and
- Dermal contact with groundwater.

Risk Characterization

The target hazard quotient of 0.2 has been exceeded in the remediation worker receptor scenario, and unacceptable risks (HQ>0.2) were identified for the site remediation worker with chronic oral/dermal exposure to petroleum hydrocarbons (PHCs) F1 in groundwater and F2 in soil and groundwater. Unacceptable risks (HQ>1.0) to the site remediation worker also exist from sub-chronic oral/dermal exposure to the COPC mixture PHC F2. The Health Canada recommended threshold for ILCR (1.0E-05) has been exceeded by exposure to carcinogens (benzene) for remedial workers.

Ecological Risk Assessment

Methodology

A qualitative evaluation of COPC, receptors, and relevant exposure pathways was conducted to develop an Ecological Conceptual Site Model for both the “foreshore” and “terrestrial” sub-sites, and to support an ecological risk assessment (ERA) of the property as a whole.

Initial screening of COPC for ecological assessment was completed by comparing maximum concentrations of contaminants in media primarily with federal CCME guidelines and standards. COPC identified in environmental media were subject to a further “qualitative screening assessment” which characterized the Site as two smaller sub-sites (a “foreshore sub-site” (APEC 1, AEC 2,AEC 3) and a “terrestrial sub-site”(AEC 4,APEC 5,APEC 6)); COPC from the initial screening process, considered to potentially harm ecological receptors were:

- Soil – PHC Fraction 1, PHC Fraction 2, PHC Fraction 3, PHC Fraction 4, benzene, ethylbenzene, toluene, xylene, arsenic , copper, and lead; and
- Groundwater – PHC Fraction 1, PHC Fraction 2, benzene, toluene, xylenes, aluminum, cadmium, iron, nickel, strontium, zinc, manganese, and naphthalene.

The "qualitative screening assessment" involved a comparison of the COPC concentrations in media to toxicological benchmark values protective of ecological receptor guilds. The outcome was a qualitative ranking of the COPC according to their potential to cause harmful effects to ecological receptors.

Direct contact with groundwater was deemed an incomplete exposure pathway for ecological receptors in the ERA. However, groundwater will eventually drain into receiving surface waters (marine and freshwater) which are utilized by terrestrial wildlife receptors as well as aquatic life at both the "terrestrial sub-site" and "foreshore sub-site". A tenfold dilution factor, to account for groundwater mixing and dilution within the transition zone between groundwater and receiving water (BC MOE, Technical Guidance Document 15-Draft, August 2009) was applied to max concentrations of COPC in groundwater. Diluted concentrations of COPC in groundwater at both the "terrestrial sub-site" and "foreshore sub-site" were screened against wildlife and aquatic life toxicological benchmarks. This provided a means with which to preliminarily identify potential COPC in receiving surface water at both sub-sites.

The ERA considered species known or likely to be on or in the immediate vicinity of the sites. Feeding guilds considered include terrestrial/aquatic primary producers, primary consumers (e.g., soil and aquatic invertebrates, herbivorous mammals), secondary consumers (e.g., omnivorous birds, mammals, and fish) and tertiary consumers (e.g., carnivorous mammals).

Routes of environmental exposure pathways for ecological receptors identified at the sites include:

- Leaching of subsurface contamination into groundwater and transport into surface waters in the Site vicinity, followed by trans-dermal uptake by aquatic species (higher and lower trophic levels) through contact with surface water, and sediments;
- Ingestion of contaminated surface waters (terrestrial and aquatic);
- Ingestion of contaminated food items (aquatic and terrestrial) as well as ingestion of contaminated soil (terrestrial) or sediment (aquatic);
- Inhalation of volatile soil contaminants (terrestrial) and
- Direct dermal contact with contaminated soil (terrestrial).

Risk Characterization

Risks from exposure to COPC in marine/freshwater sediment in receiving waters near the "foreshore" and "terrestrial" sub-sites have not been evaluated in this ERA; further investigation will be required for the evaluation of this media in a detailed ERA.

Preliminary ERA conclusions are as follows:

- PHC F2, and lead in soil represent medium risk to terrestrial plants at the "foreshore" sub-site through dermal contact, and to soil invertebrates via contaminated soil ingestion;
- Volatile COPC in soil represent low risk to burrowing terrestrial receptors (e.g. small burrowing mammals) exposed via inhalation of soil vapours at the "terrestrial" or "foreshore" sub-sites;
- Estimated COPC concentrations in receiving marine water at the "foreshore" sub-site indicate PHCs F1, F2, aluminum, nickel, iron, cadmium and toluene from discharging groundwater may represent medium risks to aquatic invertebrates exposed via dermal contact and ingestion of contaminated water. Estimated PHC F1 and F2 concentrations in surface water may represent a medium risk to piscivorous fish exposed via ingestion of contaminated food;
- Estimated concentrations in receiving marine water at the "foreshore" sub-site indicate xylene, aluminum, and naphthalene from discharging groundwater may represent medium risks to piscivorous shorebirds exposed via ingestion of contaminated marine water and food items,;
- PHC F2 in soil represents a **high** risk to terrestrial plants at the "terrestrial" sub-site through soil dermal contact, and to soil invertebrates via soil ingestion. PHC F1 and F3, and lead concentrations in soil at the "terrestrial" sub-site represent medium risk to terrestrial plants and soil invertebrates via dermal contact and ingestion exposure pathways; and
- Potential concentrations of COPC in receiving freshwater near the "terrestrial" sub-site indicate PHCs F1, F2, and cadmium may represent medium risks to aquatic invertebrates exposed via dermal contact with, and ingestion of contaminated water. Ingestion of food items from receiving waters of discharging groundwater was not considered to represent significant risks to potential aquatic receptors (piscivorous fish);
- Ingestion of food items from receiving waters of discharging groundwater at the "terrestrial" sub-site was not considered to represent significant risks to terrestrial receptors (terrestrial birds and large carnivores) exposed via ingestion of contaminated water and contaminated food items from the receiving freshwater environment.

HHRA and ERA Recommendations

Action should be taken to manage high contaminant concentrations at the sites that drive the human health risk assessment results (unacceptable risks to the site remediation worker from oral/dermal exposure to PHCs in soils onsite). Management of potential oral/dermal exposure to PHCs and benzene in soils and groundwater should include the remediation worker's adherence to a site specific health and safety plan.

If no action is taken to manage the contamination at the sites, further refinement of the human health and ecological risk assessment is warranted. The most appropriate areas to further refine the risk assessments include:

1) Refine the human health and ecological exposure scenarios to better reflect actual patterns of exposure for onsite receptors.
2) Refine the statistical database/input parameters to determine the most appropriate statistic values (e.g. 95% upper confidence limits) for contaminant concentrations.
3) Conduct an ERA in which site specific modelling of ecological receptors exposure to contaminants is applied to quantitatively assess risks to ecological receptors. A site specific ERA will require further investigation and data collection.

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1.0 INTRODUCTION

Franz Environmental Inc. (FRANZ) was retained by Public Works and Government Services Canada (PWGSC) Pacific Region on behalf of Transport Canada (TC), Prairie and Northern Region and Environmental Affairs Division to complete a Human Health and Ecological Risk Assessment for 6 areas of potential environmental concern (APECs) the Cambridge Bay Airport on Victoria Island, Nunavut. The risk assessment report consists of a human health and a qualitative ecological risk assessment.

1.1 Risk Assessment Objectives

This report presents the methodology and findings of a risk assessment that was conducted to determine if the environmental conditions that exist at the Cambridge Bay Airport APECs present a potential risk to humans and ecological receptors. The specific objectives of this assessment were to:

- Complete a review of all previous environmental site assessments and other information pertaining to the environmental conditions and potential risks posed by contamination detected on the site;
- Document the environmental conditions that exist at the site based on historical data, including the Phase IIIA ESA, for use in the risk assessment;
- Undertake a risk assessment to determine the significance of the current environmental conditions on the Cambridge Bay site with respect to human and ecological receptors, consistent with federal Canadian Council of Ministers of the Environment (CCME) and Health Canada risk assessment methodologies.

1.2 Project Team

A multi-disciplinary team was used for this project. The key individuals and their respective roles are summarized below:

- Steve Livingstone, M.Sc., P.Geol. – Project Director
- Michael Shum, Ph.D., P.Ag., R.P.Bio. – Senior Risk Assessor
- James Smith, B.Sc. – Project Manager
- Meagan Gourley, M.E.T. – Environmental Scientist

2.0 SITE DESCRIPTION

2.1 Site Owner

The Cambridge Bay Airport is near the West Arm of Cambridge Bay, 3km west of the Hamlet of Cambridge Bay on the southeast side of Victoria Island in Nunavut, Canada (see Appendix D). The Airport has been in operation since the 1950s and serves as a major transportation centre in the Central Arctic. The Site has also served as a Distant Early Warning (DEW) line site operated by the Canadian Military. The Airport's administration and control was transferred from Transport Canada to the Government of the Northwest Territories in 1995. Since 1999, the airport has been owned by the Government of Nunavut (GN).

2.2 Site Features and Background

The Airport is a civil airport located near the West Arm of Cambridge Bay, 3km west of the Hamlet of Cambridge Bay. The following buildings are present in the northeastern part of the site: the Air Terminal Building (ATB), the airport maintenance garage as well as five other buildings used for storage. The Airport runway is located southwest of the buildings, parallel to the shore. A gravel road looping around the runway from the terminal building is also present onsite. The site covers an area of approximately 140 ha.

Historical reports and the RFP identified six areas of potential environmental concern (APECs) that warranted further investigation. They included two disposal areas, namely the TC Shoreline Disposal Area, and the Screening Plant "Boneyard" as well as four areas potentially impacted by historical fuel use and storage. FRANZ conducted a Phase II/III ESA (2010) to assess the presence/absence and extent of contamination in the following 6 APECs.

2.2.1 APEC 1 – Historical Screening Plant / Boneyard

The Screening Plant / Boneyard is about 100m southwest of the Airport runway and was historically used for screening and stockpiling gravel and storing old discarded equipment. Aerial photographs did not identify screening plant/boneyard activities in APEC 1; however, a gap may exist in aerial photographs.

Historical investigations (Dillon 1994, and Agra 1999) and Franz's ESA did not identify any contaminants of concern (COCs) in soil and groundwater at APEC 1. Molybdenum in vegetation is present in concentrations greater than the referenced guidelines; however, it is possible that elevated concentrations are a natural occurrence.

2.2.2 AEC 2 - TC Shoreline Disposal Area

Dillon's (1995) Environmental Baseline Study (EBS) identified an extensive disposal area approximately 50m southwest of the Fire Fighting Training Area (FFTA) along the Cambridge Bay shoreline. It extends for approximately 2km, from 300 m southwest of the Fire Fighting Training Area to downgradient of the Department of National Defence (DND) Frontec facility. Materials previously identified included metal debris, glass, wood, and semi-submerged fuel drums. Dillon (1995) noted most of the drums appeared to be empty with no evidence of surface staining. A cleanup of the area was reportedly completed by Transport Canada in 1994 and by the Department of National Defence (DND); only minor debris was identified during FRANZ's 2009 Site visit.

FRANZ (2010) identified shallow (0-0.6m below ground surface: bgs) copper (Cu) and arsenic (As) exceeding CCME guidelines at two test pit locations (2-09-TP5 and 2-09-TP6) along the shoreline. Copper and arsenic concentrations greater than the guidelines could be a natural occurrence, and not from anthropogenic activities, as regional geology indicates that there is a potential for base metals deposit on Victoria Island which could cause elevated regional background metal levels.

2.2.3 AEC 3 - Firefighting Training Area

The former firefighting training area (FFTA) was southwest of the airstrip along the west part of the airport. It included an aircraft mock-up area within an earthen secondary containment berm where fuel was burned for training purposes. An AST with buried piping distributed fuels that were used as propellants.

Dillon (1995) noted an environmental status investigation of the FFTA was conducted by EBA Engineering Consultants Ltd. (1993) and identified the migration of suspected contamination beyond the southeast corner of the berm. Soil sampling indicated that approximately 750m^3 of petroleum hydrocarbon contaminated soil was present. No groundwater investigation was conducted. Groundwater sampling by Dillon (1995) identified groundwater TPH contamination; however, it was largely attributed to the presence of Butyl Carbitol (CAS# 112-34-5:DGME) which is often present in aircraft firefighting foams.

Dillon concluded that DGME was not considered a risk due to its low toxicity and the absence of receptors. No anomalies were reported in FRANZ's VOC FFTA groundwater sampling (2010) to suggest the presence of DGME. This coupled with the absence of quantitative laboratory data in Dillon's report prohibited inclusion of this compound as a PCOC in this risk assessment.

The FFTA was decommissioned and soils aerated via tilling on two or three occasions over a two year period in the mid 1990s. Agra (1995) conducted groundwater sampling which identified increased concentrations of BTEX exceeding the referenced criteria/guidelines.

Sampling conducted by FRANZ (2010) identified benzene, ethylbenzene and petroleum hydrocarbon (PHC) fraction F2 as COCs in soil from 0 to 2 m bgs. The estimated volume of petroleum hydrocarbon contaminated soil is 15,000 m^3. Lead, benzene and naphthalene were identified as COCs in groundwater. The estimated area of lead and benzene, and naphthalene impacted groundwater is about 1,600 m^2 and 2,500m^2 respectively.

2.2.4 AEC 4 - Former F.H. Ross Tank Site

Dillon (1995) noted a bulk fuel storage facility was formerly present just west of the existing tank farm that was constructed in 1992. Aerial photographs indicate the facility was likely present when the airport was originally constructed in the 1950's and remained in operation for about 40 years. The facility consisted of 5 bulk tanks but their contents and sizes could not be confirmed. The replacement system consists of three 100,000L ASTs containing Avgas, and Jet B fuel and presumably the old facility stored similar products/volumes.

Dillon (1995) installed one test pit/monitoring well near the former ASTs to assess the presence/absence of contamination. Soil samples had slightly elevated vapour concentrations; however, analytical results were less than the detection limits. Also, groundwater samples met the referenced criteria/guidelines. Subsequent groundwater sampling (Agra, 1999) in the same well identified benzene, toluene, and xylenes contamination.

Additional investigation by FRANZ (2010) identified lead, benzene, ethylbenzene, toluene, xylenes, and PHC fractions F1-F4 contamination in soils from about 0 to 2m bgs. The estimated extent of lead, and petroleum hydrocarbon contamination is 500 m^3 to 3,500 m^3 respectively. Also, naphthalene contaminated groundwater (about 300m^2) within the PHC contaminated zone was also identified.

2.2.5 APEC 5 – Former AST Location North of Building T-5

A former diesel AST (2,200L) associated with a fuel dispensing facility was present north of building T-5 (Powerhouse / Field Electrical Centre). The fuel dispensing facility was utilized by airport maintenance personnel for vehicle fuelling. Agra (1999) indicated the AST was installed on a concrete pad.

Historical investigations (Dillon 1994, Agra 1999) noted fuel odours and staining was present near the AST and chemical analytical results identified petroleum hydrocarbon contaminated soil and groundwater. FRANZ's ESA did not identify presence of COCs in soil and groundwater at APEC 5.

2.2.6 APEC 6 – Former AST Location West of Building T-4

APEC 6 consists of a former AST installed west of the existing maintenance garage and fire-hall compound (Building T-4). Both Dillon (1995) and Agra (1999) noted that floor drains in Building T-4 drain onto the ground surface below the building. No COCs were identified in soil and groundwater at APEC 6.

2.3 Current and Future Land Use

FRANZ understands historical uses of environmental concern at APECs 2 to 5 have been discontinued and the APECs are considered inactive. Also, the working area has decreased at APEC 1: no changes to APEC 6 were noted in the last 15 years. There are no known proposed changes at the 6 APECs.

2.4 Climate Conditions

Cambridge Bay is within a climatic zone characteristic of the Arctic Circle. The average daily temperature range is –33.0 ºC to 8.4 ºC. The average monthly temperature is below freezing for ten months of the year. The average annual precipitation is 138.8 mm. There is 69.6 mm annual rainfall and 82.1 mm annual snowfall (www.climate.weatheroffice.ec.gc.ca). The site is in the zone of continuous permafrost. Polar desert conditions limit vegetation to prostrate dwarf trees and lichens and mosses.

2.5 Natural Environment - Overview

Cambridge Bay lies within the Arctic Lowlands physiographic region with local relief generally measuring less than 20m. Several water bodies surround the Airport. The west arm of Cambridge Bay (marine environment) abuts the property boundary and is approximately 300 m south of the airport runway. An offsite freshwater lake abuts the north property boundary with several smaller freshwater bodies east and west of the runway.

Regionally, predominant vegetation consists primarily of tundra. Shrubs are less common, giving way to communities of grasses, sedge, lichens, mountain avens, and other flowers.

Area mammalian species include caribou, red fox, musk-oxen, brown and collared lemmings, and arctic hare. Various bird species frequent the area on a regular/seasonal basis. Swans, geese, red fox, musk-oxen, and arctic hare were observed in the area during the site visit.

Aquatic species, including ringed seals, inhabit the west arm and occasionally the shoreline to the south and west of the Airport. Char and lake trout return to inland freshwater to spawn in the late summer or early fall. These species are the most sensitive fisheries in the area.

There are no agriculture or forestry in the area.

3.0 PHYSICAL SITE CHARACTERISTICS

This section describes the physical setting of the property/sites, including topography, drainage as well as subsurface and surficial geology.

3.1 Regional and Local Topography

The regional topography in the Cambridge Bay area is relatively flat, with elevations ranging between 0 and 80 m above mean sea level (amsl). A few peaks of higher elevation are in the area. Mount Pelly, 17 km northeast of the Airport, reaches 600 m amsl.

The approximate elevation at the Airport is 15m amsl. The property topography is flat, except along the shores of Cambridge Bay, where it drops steeply to sea level.

3.2 Regional and Local Drainage

The Airport regional drainage is part of the Arctic Ocean Drainage Basin. Property surface water is inferred to follow topography and drain to the South and Southwest, towards the Cambridge Bay.

3.3 Geological Characterization

This section summarizes information collected with regards to regional and site specific bedrock and soil characteristics.

3.3.1 Regional Bedrock Geology

Regional bedrock geology consists of sedimentary rocks of the Arctic Platform. According to Geological Survey of Canada (Harrison et al., 2008), this formation is up to 3 km thick and is overlying the Canadian Shield. In and around the Airport, bedrock geology consists of Cambrian to Devonian flat-lying to gently dipping carbonates.

A study of the mineral potential of the Canadian Arctic islands, conducted by Dewing et al. (2007) indicated that although little exploration has been conducted on Victoria Island, it has mineral exploration potential for copper deposits, base metals volcanic massive sulphide (VMS) deposits and Zn-Pb Mississipi Valley Types (MVT) deposits. According to the Geological Survey of Canada (http://gsc.nrcan.gc.ca/mindep/), VMS deposits are major sources of zinc, copper, lead, silver and gold, and significant sources for cobalt, tin, selenium, manganese, cadmium, indium, bismuth, tellurium, gallium, and germanium. They also indicate that lead and zinc are the primary commodities of MVT deposits, with arsenic, copper, cobalt, nickel, cadmium, silver,

indium, germanium, gallium, antimony, bismuth, molybdenum, selenium, and gold commonly associated.

3.3.2 Regional Surficial Soils

The Geological Survey of Canada (Sharpe, 1993) indicates that glacial till deposits are predominant in the Airport area. The deposits are 1 to 5 m thick and are locally interbedded or underlaid by sand and gravel. The Canada Permafrost Map (NRCAN, 1995) indicates that the Airport is in a zone of continuous permafrost. Permafrost conditions have been documented throughout the airport property indicating an active layer of 1.5 to 2.4 m below ground surface (bgs) (M.M. Dillon, 1994).

3.3.3 Local Scale Geology

The geology of Cambridge Bay airport consists of a varying thickness of glacial and glaciofluvial deposits overlying a bedrock sequence of Silurian and Ordovician sediments. The surficial geology is characterized by the presence of extensive glacial and glaciofluvial deposits consisting primarily of sandy clay and silt tills containing abundant fragments of weathered bedrock.

Soils encountered during sampling conducted at the Airport in August 2009 are described in Section 9 and in the Test Pit and Borehole Logs (Appendix C). In some areas, peat or organic topsoil was observed as a surficial layer (no thicker than 0.15 m). Soils observed in the test pits conducted consist mostly of medium sand to sandy silt, with some gravel and cobbles, light grey to medium brown. Water seepage was encountered at depths ranging from 0.5 to 1.3m below ground surface (bgs) in some of the test pits. When possible, test pits were conducted to permafrost, which was encountered between 1.3 and 2.2 m bgs.

At shoreline sample locations, weathered clay overlying sand and silt was observed.

3.4 Hydrogeological Characterization

This section summarizes information collected with regards to regional and site specific hydrogeology.

3.4.1 Regional Hydrogeology

Victoria Island lies within the continuous permafrost zone. Permafrost occurs on the earth's surface where the ground has remained below 0°C continuously for a minimum of two years. In the continuous permafrost zone the ground remains frozen during the entire year, except for the

uppermost soil layer which thaws out during the short summer. This upper layer of soil that is subjected to the annual freeze-thaw cycle is known as the active layer.

Groundwater in the continuous permafrost zone is confined to this shallow active layer. Based on the regional geology and the presence of permafrost, the groundwater flow is likely complex and controlled by topography, surface water bodies and bedrock structure. Vertical groundwater flow is limited by the shallow permafrost. The period of groundwater flow is highly influenced by climatic conditions and flow is likely also limited to the short summer season when the active layer thaws, thus allowing water to flow in this horizon. It is expected that the surface water bodies are expressions of the water table.

3.4.2 Property Hydrogeology

Land around the Cambridge Bay Airport is surrounded by lakes to the north and west, and the west arm of Cambridge Bay to the south. During subsurface investigation, permafrost was observed at depths between 1.3 and 2.1 m bgs. Groundwater flow is expected to follow surface topography, and appears to be directed towards the south and southeast, into Cambridge Bay, which is consistent with the local topography.

4.0 REVIEW OF PREVIOUS INVESTIGATIONS

Three environmental investigations have been conducted at the Airport over about the last 15 years to identify and delineate potential contamination. One report (Bonley, 1992) was not available for review; however, the following reports were reviewed and relevant information summarized:

- M. M. Dillon Limited, 1994. Environmental Baseline Study;
- AGRA Earth & Environmental Limited, 1999. Remedial Action Plan Follow-Up, Cambridge Bay Airport, Nunavut Territory. Draft Report. November 1999.

The following summarizes our historical report review:

M.M. Dillon Limited, 1994

M.M. Dillon (Dillon) conducted an Environmental Baseline Study (EBS) at the Airport in 1994. Most of the facilities operated by TC were visited as part of a site audit. The EBS also included a hydrogeological investigation designed to characterize the subsurface conditions and identify potential environmental concerns in APECs. Hazardous materials and fuels under TC operations were quantified and a storage tank inventory was prepared. Regulatory compliance was assessed and a mitigation action plan including cost estimates and priority rating was prepared.

Dillon identified potential environmental issues at 6 APECs. Preliminary soil and groundwater assessment were conducted at the property. For analysed parameters, soil concentrations were compared against Government of the Northwest Territories (GNWT) Environmental Guidelines for Site Remediation (Draft, 1994) and CCME Interim Canadian Environmental Guidelines for Contaminated Sites (1991). Groundwater concentrations where compared against Quebec Ministry of Environment (MOE) Summary of Contaminant Rehabilitation Policy (1988). Table 1 summarizes the findings and recommendations from subsurface investigation conducted at the APECs during the EBS.

Table 1: Findings & recommendations from subsurface investigation (Dillon, 1994)

APEC	Description	Investigation conducted	Investigation results	
			Soil	Groundwater
1	Screening Plant/ Boneyard	2 testpits, 1 installed as a monitoring well	No issues	Groundwater well dry.
2	TC Shoreline Disposal Area	1 testpit	No issues	Not sampled
3	Firefighting Training Area	1 grab sample and 3 testpits, 2 installed as monitoring wells	TPHC concentrations greater than GNWT guideline	TPHC, benzene and xylenes concentrations greater than Quebec MOE criteria
4	Former F.H. Ross Tank Site	1 testpit, installed as a monitoring well	No issues	No issues
5	Former AST Location North of building T-5	1 testpit, installed as a monitoring well	TPHC concentrations greater than GNWT guideline.	TPHC benzene, toluene and xylenes concentrations greater than Quebec MOE criteria
6	Former AST Location West of Building T-4	1 testpit	No issues	Not sampled

*TPHC is for Total Petroleum Hydrocarbon in soil and Total Purgeable Hydrocarbon in groundwater

AGRA Earth & Environmental Limited, 1999

In 1999, AGRA Earth & Environmental Limited (AGRA) conducted a follow-up site investigation of the Airport to document the status of environmental mitigation activities, identify other areas of environmental non-compliance that were not assessed in the 1994 EBS, and to update the Airport remedial action plan .

A soil and groundwater assessment was conducted at the sites. Soil concentrations were compared against Government of the Northwest Territories (GNWT) Environmental Guidelines for Site Remediation (Draft, 1994) and CCME Interim Canadian Environmental Guidelines for Contaminated Sites (1991). Groundwater concentrations where compared against Guidelines for Canadian Drinking Water Quality (Health Canada, 1996) and CCME Interim Canadian

Environmental Quality Criteria for Contaminated Sites (1991). Table 2 summarizes the findings and recommendations from subsurface investigation conducted at the APECs by AGRA.

Table 2: Findings and recommendations from subsurface investigation (AGRA, 1999)

APEC	Description	Investigation conducted	Investigation results	
			Soil	Ground water
1	Screening Plant/ Boneyard	No sampling conducted	-	-
2	TC Shoreline Disposal Area	No sampling conducted	-	-
3	Firefighting Training Area	Two grab soil samples collected; sampling of monitoring wells onsite and review of sampling conducted in 1998 by GNWT	HC[1] odours noted, soil not analysed	BTEX greater than GCDWQ and/or CCME guidelines
4	Former F.H. Ross Tank Site	1 grab soil sample collected; and Sampling of monitoring well onsite	HC[1] staining and odours noted, soil not analysed	BTEX exceeding GCDWQ and/or CCME guidelines
5	Former AST Location North of building T-5	1 grab soil sample collected; and Sampling of monitoring well onsite and review of sampling conducted in 1998 by GNWT	HC[1] staining and odours noted, soil not analysed	BTEX exceeding GCDWQ and/or CCME guidelines
6	Former AST Location West of Building T-4	No sampling conducted	-	-

[1] Hydrocarbons

Franz Environmental Incorporated, 2010

FRANZ conducted a Phase II/III ESA which included sampling/analysis from 37 test pits, 15 groundwater monitoring wells, 1 surface water body, and 7 vegetation locations within the 6 previously identified APECs. The ESA findings and recommendations are summarized in the following table:

AEC	Description	Contaminated Media	COC	Estimated Volume (m^3)	Recommendation
2	Cu and As exceedences in soil along the Shoreline	Soil	Cu and As	20	Additional investigation. Remediate (excavation and offsite disposal or risk assessment)
3	Fire-fighter Training Area	Soil	Benzene, Ethylbenzene and F2 fraction	15,000	Delineate PHC contaminated soils. Excavate and treat in an onsite LTF.
		Groundwater	Benzene, Naphthalene and Pb	-	Excavate with PHC contaminated soils
4	Former F.H. Ross Tank Site	Soil	BTEX, F1-F4 fractions and Pb	3,500 (includes 10m^3 for Pb)	Delineate extent of PHC contamination. Excavate and treat PHC contaminated soils in LTF. Segregate Pb contaminated soils and disposed offsite or manage (risk assessment) onsite.
		Groundwater	Naphthalene, Toluene, and Zn	-	Naphthalene and Toluene excavated and treated in LTF Resample and delineate PHC and Zn contamination.

FRANZ's ESA recommended PHC contaminated soils and groundwater (including metals) be treated in an onsite land treatment facility (LTF). Also, additional soil and groundwater sampling was recommended to fully delineate the extents of PHC and metals contamination. Post remediation groundwater monitoring was recommended following soil remediation activities as part of a natural attenuation assessment.

4.1 Identification of Areas of Potential Environmental Concern (APECs) and Areas of Environmental Concern (AECs)

Based on previous environmental work and the historical review, the property was divided into 6 distinct APECs. APEC sampling locations and analytical results for sampling locations are shown in Figures from the Phase II/III ESA (FRANZ, 2010) and included in Appendix D of this report.

Based on the previous environmental assessment activities completed to date and the historical records review, the following APECs and PCOCs formed the basis for the Phase II/III ESA sampling plan.

Table 3: Summary of APECs/AECs and PCOCs

APEC/AEC	DESCRIPTION	PCOCs
APEC 1	Historical Screening Plant / Boneyard	BTEX, F1-F4, PAH, VOC, Glycols, Metals, PCBs and Pesticides
AEC 2	TC Shoreline Disposal Area	BTEX, F1-F4, PAH, VOC, Metals, PCBs and Pesticides
AEC 3	Firefighter Training Area	BTEX, F1-F4, PAH, VOC, Lead, PCBs and PFOS.
AEC 4	Former F.H. Ross Tank Site	BTEX, F1-F4, PAH and Metals.
APEC 5	Former AST Location North of Building T-5	BTEX, F1-F4, PAH, VOC and Metals.
APEC 6	Former AST Location West of Building T-4	BTEX, F1-F4, PAH, VOC and Metals.

These findings formed the basis for FRANZ's Phase II/III ESA sampling plan.

5.0 SCREENING OF CONTAMINANTS OF POTENTIAL CONCERN

Overview

This section presents the methodology used to screen the environmental quality data for the Cambridge Bay Airport sites and from which to identify contaminants of potential concern (COPC) for the human health and qualitative ecological risk assessment (HHRA and ERA). Data retained for this risk assessment report was sourced from FRANZ (2010, Phase II/III Environmental Site Assessment of the Cambridge Bay Airport (APECs 1 to 6)), and an Environmental Baseline Study (EBS) completed by Dillon (1995), and Agra (1999) at the same APECs.

The areas of investigation completed by FRANZ were based on the historical sampling, observations and chemicals results. Further details regarding the FRANZ Phase II/III Environmental Site Assessment are included in the FRANZ (2010) report under separate cover.

COPC were identified by comparing the maximum concentrations of chemicals detected in soil and groundwater samples obtained through previous investigations/assessments, with guidelines/standards/criteria protective of human health and the environment. Commercial land use has been applied to the sites.

Federal guidelines are relevant since the property is currently federally managed and the Government of Nunavut has adopted the CCME approach. Property groundwater and surface water in the vicinity is non-potable and not used as a community water supply; however, as a measure of conservatism in the HHRA, groundwater COPC concentrations were primarily screened against Health Canada drinking water standards when available. Substances for which there are no CCME environmental quality guidelines, were screened against those established by provincial authorities. In cases where applicable provincial guidelines were unavailable, chemical concentrations in soil, and groundwater were compared to USEPA Region IX Soil (Residential Land Use) and Tapwater Regional Screening Level Guidelines (2009) for the protection of human health, and Environment Canada Compendium of Environmental Quality Benchmarks (1999) for the protection of human health and environmental health.

Federal Guidelines

- CCME 1999 “Canadian Environmental Quality Guidelines” and recent updates (2007) for commercial (CL) use for coarse grained soil;
- CCME 2008 “Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil” Human Health and Environmental Health Guidelines, commercial (CL) use;
- CCME guidelines for the protection of freshwater aquatic life (FWAL; 2007 Update –

used for groundwater); and

- Health Canada 2008 "Guidelines for Canadian Drinking Water Quality" Summary Table.

Substances screened into the HHRA and ERA, and their respective maximum measured concentrations in environmental media are identified in Tables 4 and 5. Use of the maximum values is a conservative approach and provides a protective estimate of potential risks to human health and the environment.

All parameters recorded as 100% non-detect (ND) in all samples, and for which detection limits were below the applicable screening criteria are not considered COPC and have been omitted from further evaluation.

For the HHRA, if a contaminant exceeded the relevant guidelines/standards in one environmental medium, its corresponding maximum concentration in other media (soil, or groundwater) was also screened in, as appropriate, for detailed exposure calculations. Since the ERA did not involve a quantitative approach, COPC exceedences in each media were identified, but their respective concentrations in other media were not screened into quantitative exposure models.

Soil and groundwater summary tables included in Appendix A of this report provide the summary statistics (number of samples, average, standard deviation, minimum, maximum), screening criteria, and sample associated with the maximum concentration for sampled media.

Table 4: COPC screened into the Human Health Risk Assessment

COPC in Soil (ug/g)	COPC in Groundwater (ug/L)
F1(4800)	**F1 (3,500)**
F2 (12,000)	**F2 (3,800)**
Benzene (4.6)	**Benzene (1,700)**
Ethylbenzene (6.8)	**Ethylbenzene (180)**
Toluene (37)	*Toluene (2,800)*
Xylenes (140)	*Xylenes* **(2,300)**
Benzo(a)pyrene (1)	**Benzo(a)pyrene (0.013)**
Arsenic (40.6)	*Arsenic (NA)*
Copper (102)	*Copper (23)*
Lead (294)	**Lead (100)**

Bold lettering indicates the substance concentration exceeded guidelines in that specific media.

Table 5: COPC screened into the Ecological Qualitative Risk Assessment

COPC in Soil (ug/g)	**COPC in Groundwater (ug/L)**
F1 (C6-C10) (4800)	F1 (C6-C10) (10000)
F2 (C10-C16) (12000)	F2 (C10-C16) (3800)
F3 (C16-C34) (6400)	Benzene (1700)
F4 (C34-C50) (3900)	Toluene (2800)
Benzene (4.6)	Xylenes (2300)
Ethylbenzene (6.8)	Aluminum (1000)
Toluene (37)	Cadmium (2)
Xylenes (140)	Iron (1700)
Copper (102)	Nickel (176)
Lead(294)	Strontium (1200)
Arsenic (40.6)	Zinc (280)
	Naphthalene (330)
	Manganese (460)

Substances that were screened out of the HHRA or ERA, and the rationale for screening them out as COPC for human and ecological receptors are included in Table 6.

Table 6: COPC screened out of the HHRA and/or ERA

COPC	Rationale for exclusion from the HHRA and/or ERA
Sodium (*Excluded from HHRA and ERA*)	Sodium in a natural alkali element present in the earth's crust and can be produced by the weathering of salt deposits and contact of water with igneous rock. Sodium content in groundwater (mean: 319 mg/L , range:24-1,000 mg/L) samples collected by Franz (2010) onsite and in the Site vicinity are above the normal background ranges for groundwater (6-130 mg/L) in Canada, however much higher levels can be associated with saline salts, sea spray, and seawater intrusion in coastal areas (Health Canada Sodium - Technical Document Updated December 1992). With regards to human health, sodium is not considered to be a toxic element. Up to 5 g/day of sodium is consumed by normal adults without apparent adverse effects. Sodium concentrations in groundwater onsite exceed the aesthetic objective indicated by Health Canada (≤200 mg/L) for drinking water. Considering that groundwater on site is non potable,and ingestion in not an operable pathway for human receptors at this site, sodium has not been retained as a COPC in the HHRA. Given the unique nature of the property/sites, exposure to groundwater is not an operable pathway for terrestrial receptors at this Site. With regards to receptors in receiving waters of groundwater drainage, predicted receiving water concentrations (max: 100 mg/L, based on a ten-fold dilution of groundwater concentrations in the transition zone, BC MOE, Technical Guidance Document 15-Draft, August 2009) are below the lowest chronic toxicological benchmark for aquatic organisms (680 mg/L, Suter and Tsao,1996). As such the likelihood of negative health effects from groundwater drainage into aquatic environments is considered very unlikely, and sodium has not been retained as a COPC in the ERA.
Aroclor 1262 and 1268 (*Excluded from ERA and HHRA*)	There are no available groundwater criteria for the protection of human health or the environment for Aroclor 1262 and Aroclor 1268. However the concentrations of these contaminants in soil and sediment are non-detect (ND) in all samples analyzed.

TPH and Total Extractable Hydrocarbons *(Excluded from HHRA and ERA)*	There are no available recent soil or groundwater criteria for the protection of human health and environmental health for Total Extractable Hydrocarbons and Total Petroleum Hydrocarbons. However CCME soil guidelines for the protection of environmental and human health are available for Petroleum hydrocarbons Fractions 1-4, that encompass the carbon ranges of TPH and were used for screening PHC concentrations in soil instead. Alberta Environment groundwater guidelines for the protection of environmental and human health are also available for petroleum hydrocarbons Fractions 1-4, and were used for screening PHC concentrations in groundwater instead.
Magnesium (*Excluded from HHRA*)	Magnesium is the eighth most abundant natural element and it is present in all natural waters and is a major contributor to water hardness. Water in areas of magnesium containing rock may have magnesium concentrations in the range of 10-50 mg/L. However, if the rock contains sulphates and chlorides of magnesium, which are very soluble, the water may contain several hundred milligrams of magnesium per litre. As summarized in Health Canada (1978), a survey of surface water in Canada found that magnesium levels in water varied greatly from location and season where concentrations were usually below 25 mg/L, but concentrations as high as 168 mg/L were found. Concentrations of magnesium in groundwater samples taken onsite are variable (mean: 145 mg/L, range:38-330mg/L) and fall within the range of Canadian surface water concentrations. Magnesium is an essential element in human metabolism and is the fourth most common mineral constituent in the body. Magnesium is absorbed in the small intestine with an efficiency of between 45 and 55 percent. The most observable effect of excess magnesium in the drinking water is laxative, particularly with magnesium sulphate at concentration above 700 mg/L. Toxicity is very rare except in certain instances where renal failure prevents urinary excretion (i.e., in the situation where magnesium-containing drugs are given to a patient with renal inabilities). Groundwater is non-potable and ingestion in not an operable pathway for human receptors at this site. As such the likelihood of negative health effects associated with dermal exposure to magnesium is considered negligible and was not assessed further.
Manganese (*Excluded from HHRA*)	As summarized in Health Canada (1987) manganese is generally present in natural surface waters as dissolved or suspended matter at concentrations below 50 µg/L. A survey of Canadian surface waters undertaken in 1980–1981 showed that the usual range of manganese in freely flowing river water was 10–400 µg/L. The highest concentrations recorded were in the Carrot River in Saskatchewan; dissolved manganese reached 1,700 µg/L, whereas extractable manganese peaked at 4,000 µg/L. Manganese is more prevalent in groundwater supplies than in surface water supplies owing to the reducing conditions that exist underground. Therefore, the manganese concentrations of groundwater samples taken at the Cambridge Bay Airport sites (mean 125 µg/L, range 20-460 µg/L) are within reported values for lakes and rivers across Canada, and not unexpected for groundwater conditions. With respect to human health, manganese is an essential element functioning both as an enzyme co-factor and as a constituent of metalloenzymes. The Recommended Daily Intake (RDI) of

	manganese for Canadians has yet to be established. The main routes of absorption for manganese are the respiratory and gastrointestinal tracts whereas cutaneous absorption of inorganic manganese is negligible.The aesthetic objective for manganese in drinking water is therefore ≤0.05 mg/L. Manganese at this recommended limit is not considered to represent a threat to health, and drinking water with much higher concentrations has been safely consumed. A maximum acceptable concentration has, therefore, not been set. As groundwater onsite is non-potable, the critical exposures pathway for humans is dermal contact with groundwater. Given the above discussion, the risk of dermal exposure to manganese in groundwater is negligable, as such manganese is not considered a COPC.
Potassium (*Excluded from HHRA and ERA*)	Potassium is a naturally occurring element in the earth's crust, most commonly found in the form of potassium chloride (Health Canada, Guidance on Potassium from Water Softeners, May 2008). Potassium is an essential element in plants and animals. There are no available water criteria for the protection of human health or the environment for potassium. Generally potassium levels in Canadian lakes and rivers are <10,000 µg/L, and the average potassium concentration for potable surface water and groundwater ranges from <1,000 to 8,000 µg/L. (Health Canada 2008). Groundwater samples collected onsite indicate the presence of this element at a mean concentration of 41 mg/L (range: 14-110 mg/L). In terms of human health potassium is an essential element and normally does not cause adverse effects. However, a disruption in the body's potassium homeostasis may result in adverse affects when potassium concentrations exceed (hyperkalemia) or fall below (hypokalemia) the normal range in the blood. Potassium levels generally found in drinking water are not a health concern to the general population, and a drinking water guideline is not proposed for potassium. Groundwater is non-potable onsite and ingestion in not an operable pathway for human receptors at this site. As such the likelihood of negative health effects associated with dermal exposure to potassium is considered negligible and was not assessed further as a COPC. With regards to ecological health, predicted concentrations of potassium in surface water (11000 µg/L, based on a ten-fold dilution of groundwater concentrations in the transition zone, BC MOE, Technical Guidance Document 15-Draft, August 2009) are well below toxicological benchmarks for aquatic receptors in receiving waters (53,000 µg/L). Given the above-mentioned information, potassium was not retained as a COPC for ecological receptors in the ERA.
Acenaphth-ylene (*Excluded from HHRA and ERA*)	Acenaphthylene concentrations in soil are non-detect in all 16 samples collected onsite with only the method detection limits of <0.1 (2 samples) and <0.4 (1 sample) exceeding the OMOE guideline (0.15 µg/g) for the protection of human and ecological health. Acenaphthylene is considered to have a toxic/potency equivalence factor (TEF) of 0.001 to Benzo [a]pyrene (Law et al. 2002). Given that a B[a]P concentration of 0.37 µg/g soil is considered protective of human health (CCME 2008) a concentration of 370 µg/g acenaphthylene in soil would also be protective of human health. Acenaphthylene concentrations in soil onsite are well below both 370 and 0.37 µg/g guidelines for B[a]P for the protection of human health.

	All three soil samples with MDLs exceeding OMOE guidelines for acenapthylene concentrations are well below Alberta Environment (ANEV) Tier I Soil Remediation Guidelines for coarse soils, commercial land use (6.0 µg/g). These guidelines are applicable to the specific characteristics of the sites, and like the OMOE guidelines have been developed to be protective of human health as well as environmental health.
Iron (*Excluded from HHRA*)	Iron is the fourth most abundant element in the earth's crust and its presence in waters can be attributed to the weathering of rocks and minerals, acidic mine drainage, landfill leachate, sewage effluents, and iron-related industries. Iron is generally found in surface waters as salts containing Fe(III) when the pH >7. Most of the salts are insoluble in water and settle out or are adsorbed into surfaces (Health Canada Supporting Documentation 1978). Concentrations of iron in Canadian surface waters are generally below 10 000 µg/L, but based on data collected from National Water Quality Database stations range between 1.0 – 90,000 µg/L in lakes and rivers across Canada (Health Canada Supporting Documentation 1978). The maximum concentration in groundwater (mean 589 µg/L, range 70-1,700 µg/L) are well within this range. Iron is an essential element for human health, integral to the functioning of cytochromes, porphyrins, and metalloenzymes. Its absorption occurs mainly through the intestines upon dietary intake. Iron toxicity is mainly due to underlying disease etiologies, and dietary over-ingestion. Total daily intake of iron from food, air, and water for an average adult is approximately 18 000 µg /day (Health Canada Supporting Documentation 1978). The Health Canada 2008 Drinking Water Quality Guideline for iron (300 µg/L) is currently not health based but an aesthetic objective based on the evidence that concentrations over 300 ug/L tend to cause rust coloured silt in water supplies, which is unpalatable, stains clothing, and above this concentration can promote the growth of iron bacteria in water systems (Health Canada Supporting Documentation 1978). Groundwater and surface waters in the site vicinity are not potable and the application of drinking water standards to waters onsite is a measure of conservatism in this human health assessment.
Uranium (*Excluded from HHRA*)	Uranium is a naturally occurring element and is present in water bodies throughout Canada. Site groundwater concentrations range from 6-33 µg/L with an average of 15.3 µg/L while a Health Canada survey (1975-1986 study) identified ground/drinking water concentrations in the Northwest Territories (1975-1986 study) ranging from 19-2,500 µg/L (Health Canada, 2001). The maximum Site concentration is well within this range. Groundwater and surface water in the Site vicinity are not potable and the drinking water pathway is considered inoperative; applying drinking water standards onsite is a measure of conservatism, and uranium is not carried further as a COPC in the HHRA.
Aluminum (*Excluded from HHRA*)	Aluminum is a naturally occurring element and is present in all the water bodies in Canada. Varying amounts of aluminum are present naturally in groundwater and surface water, including those used as sources of drinking water. The amount of aluminum in surface water varies, ranging from 12 to 2250 µg/L in North American rivers.

	Groundwater aluminum concentrations at the Site (mean 200 µg/L, range 10-1,000 µg/L) are well within reported values for North American surface waters. Aluminum has no known beneficial effect in humans. However there is no consistent, convincing evidence that aluminum in drinking water causes adverse health effects in humans, and aluminum does not affect the acceptance of drinking water by consumers or interfere with practices for supplying good water. Therefore, a health-based guideline or aesthetic objective for treated drinking water has not been established for aluminum in drinking water. Groundwater and surface waters in the site vicinity are not potable and the application of drinking water standards to waters onsite is a further measure of conservatism in this human health assessment, as such aluminum is not carried further as a COPC in the HHRA.

6.0 HUMAN HEALTH RISK ASSESSMENT - PROBLEM FORMULATION

The HHRA was conducted in accordance with the Health Canada guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA) guidance documents *Federal (Contaminated Site Risk Assessment in Canada - Parts I, II, III and IV,* September 2004, June 2007, and 2009 drafts). These documents were specifically developed for HHRA, and are useful in developing this HHRA as this is the first evaluation of overall risk to human health that has been completed on the sites.

6.1 Problem Formulation

The problem formulation is the first and most critical step of the risk assessment process to identify substances that potentially have adverse effects to human and ecological receptors. The result of the problem formulation is a Conceptual Site Model (CSM) which represents the current understanding of the sources of contamination, release and transport within and among environmental media, and exposure and pathways by which contaminants may contact receptors. This phase involves:

1. Screening and identification of contaminants of potential concern (COPC);
2. Identification and description of potential receptors based on the current and future use of the sites; and
3. Identification of operable exposure pathways.

Consistent with the recommendations of Health Canada (Health Canada, 2007), this Human Health Risk Assessment assumes the current land use will remain unchanged.

6.2 Screening and Identification of Contaminants of Potential Concern

The COPC are chemicals in soil, and groundwater that may be a potential hazard to receptors from site activities. COPCs and their respective concentrations screened into the HHRA for further evaluation of exposure and risk to onsite receptors have been identified in Section 5.0 (Table 4 and Table 5).

6.3 Potential Receptors

Characterization of potential human receptors should consider present and future land uses. Characterization, therefore, requires an understanding of where the contaminants are under the present conditions and where they will likely be in the future.

Potential human receptors at the sites include:

- adult airport employees involved in operational and maintenance activities onsite; and
- remedial workers or adult construction workers involved in demolition, remediation and maintenance activities at the sites. These workers would be onsite for intense short term exposures (acute) during the summer season. Workers returning to the sites would be considered in a chronic exposure scenario as well.

Exposure to airport passengers and local residents was considered; however, exposure is expected to be insignificant as:

- APECs are not near residences or recreational facilities where the general public would frequent;
- access is restricted/limited at the airport and APECs are not near normal passenger areas; trespassers are not expected.

6.4 Operable Exposure Pathways

An exposure pathway is a mechanism by which a human receptor is exposed to chemicals from a source. Several possible ways of exposure to contaminants may exist at a site. The following four elements constitute a complete exposure pathway.

- A source and mechanism of chemical release;
- A retention or transport medium;
- A point of potential receptor contact with the affected medium, and
- A means of entry into the body (e.g. ingestion) at the contact point.

Complete pathways therefore, represent situations where there is a potential for receptors to be exposed to the contaminants. Incomplete pathways represent situations where exposure or contact with the contaminant is unlikely to occur resulting in no risk to the receptor.

Groundwater Ingestion

The sites are in a non-potable land use environment. Ingestion of drinking groundwater is therefore not considered an operable exposure pathway.

Surface water – Dermal Contact with Water

There are no surface water features on the APECs for recreational exposure. The potential for dermal contact by human receptors (airport employees) with surface waters is considered unlikely and an incomplete exposure pathway. Contact to groundwater by remediation workers is considered a more conservative expression of exposure since COPC concentrations are typically higher in groundwater than surface water.

Sediment – Dermal Contact

The property is in the zone of continuous permafrost. As stated previously, the average monthly temperature is below 0°C for ten months of the year. The active warm months are July and August, which daily average temperatures are 8.4 ºC and 6.4 ºC, respectively. The potential for dermal contact of receptors with surface water sediment onsite is considered negligible.

Food Sources - Ingestion

There are no known gardens or significant food sources in this area, particularly associated with the contaminated medium as compared to the “open range” in which terrestrial or aquatic foods could occupy. As such, the ingestion of contaminated food or traditional country foods has not been considered.

Soil – Dermal Contact, Ingestion and Vapours

Exposure to COPC in contaminated soil is possible through incidental ingestion, dermal contact and particulate inhalation. Dermal contact is assumed for hands, arms, and feet.

Exposure to volatile COPC present in soil through outdoor inhalation of soil vapours is not considered an operable exposure pathway. The presence of a continuous permafrost layer prevents the use of subsurface utility conduits and subsurface building foundations where construction and utility workers may typically be exposed to high concentrations of volatile COPC in the confined spaces of utility trenches and excavations.

Vapour intrusion into property/site buildings is not considered an operable exposure pathway. Some of the buildings have slab-on-grade (e.g., terminal building) construction and some (e.g., maintenance building) are erected on piles due to the shifting of land during the annual freeze-

thaw cycle in the permafrost layer. The airspace beneath these latter buildings would decouple the vapour migration pathway from the soil into the building. Also, the nearest distance from an identified vapour contaminant source (AEC 4) to a slab-on-grade building (terminal building) is 70m, well beyond the 30m lateral screening guideline recommended by several agencies (i.e., Health Canada (2008), Atlantic RBCA (2006), Region 9 EPA (2004).

6.5 Conceptual Site Model

The Conceptual Site Model (CSM) represents the current understanding of the sources of contaminants, release and transport within and among environmental media, and exposure and pathways by which they may contact receptors. The COPC for the operable exposure pathways are: PHC fractions F1 and F2, benzene, ethylbenzene, toluene, xylenes, arsenic, copper, lead, and benzo(a)pyrene. The CSM is represented in Figure 6-1. As shown, the operable pathways are:

- Incidental Ingestion of Soil;
- Inhalation of Soil particulates;
- Dermal Contact with Soil; and
- Dermal Contact with Groundwater.

6.6 Problem Formulation Checklist

The land use, receptors and identified complete exposure pathways in establishing the problem formulation step is summarized as follows.

Problem Formulation Checklist

	Land Uses (check as appropriate)		**Receptor Group(s) (check as appropriate)**		**Critical Receptors (check as appropriate)**		**Exposure Pathways (check as appropriate)**
	Agricultural		General Public		Infant	√	Soil Accidental Ingestion
	Residential/urban parkland	√	Employees		Toddler	√	Soil Dermal Absorption
	Commercial with daycare	√	Remediation Workers		Child	√	Particulate Inhalation
√	Commercial without daycare		Native Communities		Teen	√	Vapour Inhalation
	Industrial			√	Adult	√	Dermal Contact with water
	Consumption of Traditional Country foods						Country Food Ingestion
	Recreational						

7.0 EXPOSURE ASSESSMENT

An exposure assessment estimates the dose of each COPC for each potential receptor (employee user and remedial worker). Most of the assumptions are taken from Health Canada's Federal Contaminated Site Risk Assessment in Canada. Part 1-Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2 (June 2007).

A toxicity assessment for an acute exposure scenario was also considered in the HHRA for the remediation worker receptor. To assess potential risks from short-term contaminant exposure (5 days/week for 14 weeks) under this scenario, doses (mg/kg/day) of threshold response chemicals (non-carcinogens) were compared to chronic toxicity reference values (TRVs) without additionally amortizing the exposure over a yearly period. Derived sub-chronic hazard quotients were then used to quantitatively assess the acute risks from contaminant exposure.

7.1 Characterization of Potential Receptors

The characteristics for the receptors considered in this risk assessment were mainly obtained from Health Canada (June 2007) and are summarized as follows:

Parameters	Airport Employee	Remedial Worker
Age	≥ 20 y	≥ 20 y
Body Weight (kg)	70.7	70.7
Soil Ingestion Rate (g/d)	0.02	0.1 [b]
Inhalation rate (m^3/d)	15.8	15.8
Total exposed skin surface area (cm^2)	3,390 [a]	3,390
Soil loading to exposed skin (g/cm^2/event)	$1X10^{-4}$	$1x10^{-4}$

[a] Surface area per Richardson, G.M. (1997)
[b] (Health Canada, PQRA guidance Part I, 2004)

The exposed skin surface area applied to the airport employee scenario was the sum of the adult skin surface area for hands and arms as determined from Richardson, G.M. (1997). These are conservative estimates of exposed skin surface area for receptors given that the property is located within an arctic climate and potential receptors onsite would be expected to have legs and feet covered year-round.

The skin surface area applied for the site remediation worker scenario was obtained from the "Human Health Risk Assessment Supplemental Guidance, Exposure Assessment for the Construction and Utility Worker" prepared for Health Canada by Dillon Consulting Ltd. (March 2005). This exposed skin surface (3,390 cm^2) area is the adult skin surface area for the hands and upper and lower arms as derived by Richardson, G.M. (1997). Given the arctic climate of the site and workplace safety regulations this exposed skin surface estimate is considered reasonable.

7.1.1 Exposure Frequency and Duration

Assumptions concerning exposure frequency and duration are mainly derived from Health Canada (2004 and 2007 updates) for commercial land use and construction/remediation workers, as well as site-specific exposure assumptions for remedial workers. The assumptions for all receptors are considered to be conservative because there are no known or reasonably foreseeable routine activities at these APECs/AECs, and remedial work is not routinely conducted at the sites.

Exposure Frequency and Duration – All Operative Pathways

Scenario	Airport Employee (chronic)	Remedial Worker (acute)	Remedial Worker (chronic)
Hours per day (indoors)	4	0	0
Hours per day (outdoors)	4	10	10
Days per week	5	6	6
Weeks per year	14	14	14
Dermal exposure events per day	1	1	1
Water contact events per day	0	1	1
Duration of water contact event (h)	0	1	1
Days/year of contaminated food ingestion	0	0	0
Exposure Duration (years)	35	0.27 (98 days)	10
Years for carcinogen amortization	60	0.27	60

[a] Time outdoors (adult) - Richardson, G.M. (1997)

These assumptions are considered to be conservative because:

- Remedial Workers – It was assumed that long term remediation work would be conducted annually during summer months (6 days/week, 14 weeks/year). Albeit, remedial work is not routinely conducted at the sites there is the potential for some remedial work in the next 8 to 10 years.

- Remedial Workers – The potential for dermal contact with groundwater is realistic as the groundwater table is shallow onsite; however given the climate, it is deemed unlikely that remedial workers would be in dermal contact with groundwater for up to 9 hours/day ("Human Health Risk Assessment Supplemental Guidance, Exposure Assessment for the Construction and Utility Worker" prepared for Health Canada by Dillon Consulting Ltd. (March 2005)). Daily one hour dermal exposures to groundwater are considered a conservative estimate of exposure duration for remedial workers under these site specific conditions;
- Ground cover – It is likely that exposure pathways related to incidental contact with soil, or inhalation of fugitive dust particles would be **inoperable** during months when snow is present. Though Cambridge Bay is characterized by a dry arctic climate, precipitation usually in the form of snowfall tends to occur from August to September. The average annual precipitation is 138.8 mm, with 69.6 mm of annual rainfall and 82.1 mm of annual snowfall, therefore the ground surface at the Property/sites are covered or frozen for much of the year.

7.2 Exposure Equations and Models

For this HHRA, the estimates of exposure were based on standard risk assessment equations used by Health Canada (2004 and 2007 update), and the Health Canada PQRA spreadsheet model (*Federal Contaminated Site Risk Assessment in Canada Part IV, 2009).* Equations used in the model are provided in Appendix C.

7.3 Relative Absorption Factors

Bioavailability is the degree to which a chemical or other substance is absorbed or becomes physiologically available to cause an adverse effect. Bioavailability is generally less than 100% of the amount of contaminant to which there is exposure. The amount of absorption will depend on the contaminant's chemical form, the exposure pathway, biological and individual susceptibility, and absorption characteristics. The default Relative Absorption Factors (RAF) from the Health Canada PQRA spreadsheet model: *Federal Contaminated Site Risk Assessment in Canada Part IV* (2009) were applied in this preliminary risk assessment. Bioavailability is assumed to be 100% for the ingestion and inhalation pathways as per Health Canada guidance (2004 and 2007).

8.0 TOXICITY ASSESSMENT

The toxicity assessment identifies toxicity reference values (TRV) with which to compare estimated exposure at a site in order to estimate risk. For this HHRA default TRVs from the spreadsheet tool *Federal Contaminated Site Risk Assessment in Canada: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA) Part IV, 2009*) were applied.

8.1 Carcinogens and Non-Carcinogens

Of the COPC, arsenic, benzene and benzo(a)pyrene were considered carcinogenic. Exposures to these carcinogenic substances were estimated for all potential receptors using exposure durations recommended in Health Canada PQRA guidance (Health Canada 2007).

The non-carcinogens for this HHRA were copper, lead, toluene, ethylbenzene, xylenes, and PHC fractions F1 and F2.

8.2 Toxicological Effects

A description of the toxicological effects or health concerns of the contaminants of potential concern are summarized as follows:

Health Concerns and Carcinogen Classification

	Health Concern or Target Organ [1,2]											
COPC	**Non Carcinogen**	**Carcinogen**	**Brain & Nervous System (neurotoxicity)**	**Liver (hepatic changed)**	**Blood circulation/pressure (haematological changes)**	**Decrease in body weight**	**Kidney (nephrotoxicity)**	**Lung/Respiratory system**	**Bladder**	**Skin (exterior and orifice)**	**Digestive system (estomac & Instestin)**	**Reproductive system**
arsenic		X	X	X			X	X	X	X		
copper	X			X			X					
lead	X		X		X		X					X
benzene		X	X	X	X			X			X	X
toluene			X	X			X	X		X	X	X
ethylbenzene				X		X				X		
xylenes				X		X	X	X				
Benzo(a)pyrene		X				X		X		X	X	
Fraction 1	X		X	X	X	X						
Fraction 2	X			X	X	X						

1: Denotes main health concern or target organ, others may exist.

2: Concerns are related to oral, dermal, and/or inhalation pathways.

8.2.1 Dose-Response Assessment

Toxicity reference values (TRVs) should be specific for a particular exposure route, therefore it is necessary to identify multiple TRVs for a single chemical when exposure occurs via multiple routes (i.e., inhalation, ingestion and dermal); however, few, if any, TRVs exist specifically for the dermal exposure pathway. In these instances, dermal exposures were added to the oral dose, following adjustment for relative bioavailability or absorption, for subsequent comparison to the oral TRV. This approach is considered acceptable when multiple exposures are occurring for a single contaminant (Health Canada 2007, Part 1).

The most scientifically defensible and health protective TRVs established by Health Canada were used for each COPC. If a Health Canada TRV was not available, the applicable TRV developed by the US EPA was used.

TRVs are commonly reported in several different formats, and it is possible to express the same degree of toxicity in different ways. While the different formats may represent equivalent toxicity, they are applied differently during the risk characterization. TRVs used in this assessment include the following.

- **Tolerable Daily Intake or Reference Dose:**

  The tolerable daily intake (TDI) or the Reference Dose (RfD) represents the maximum dose of a threshold substance to which an individual could be exposed daily over a lifetime without any expected deleterious effects (Health Canada, 2007). It is expressed as the amount of substance per unit body weight per unit time (e.g., mg/kg body weight/day).

- **Tolerable Concentration or Reference Concentration:**
  The tolerable concentration (TC) or reference concentration (RfC) represents the maximum concentration (usually airborne) of a threshold substance to which a person may be continually exposed over a lifetime without any expected deleterious effects (Health Canada, 2007). It is expressed as a concentration (e.g., $\mu g/m^3$).

Slope Factor:

A slope factor relates the exposure dose of a non-threshold substance to the expected probability of developing cancer. It is expressed as the inverse of a dose (e.g., $(mg/kg\ body\ weight/day)^{-1}$) and quantifies the number of predicted cancers per unit dose. The exposure dose multiplied by the slope factor is the expected cancer risk. The slope factor is referred to by some agencies as a cancer potency factor, and denoted as q*.

8.2.2 Summary of Toxicological Reference Values (TRVs)

To select the most appropriate TRVs, we considered the environmental conditions at the sites and identified values that were representative of the substances at the sites. The TRVs used were taken from Health Canada (2004, 2009) and/or US EPA's Integrated Risk Information System (2009). Toxicity reference values used in this study are presented in Table 7, below.

Table 7: Toxicity Reference Values

COPC	RfD (mg/kg/day)/Tolerable Concentration (TC)	q* $(mg/kg/day)^{-1}$	Source
Arsenic		1.8 (ingestion)	Health Canada (2009)

		28 (inhalation)	
Copper	0.141	na	Health Canada (2009)
Lead	0.0036	na	Health Canada (2009)
Benzene		0.226 (ingestion) 0.0146 (inhalation)	Health Canada (2009)
Toluene	0.22	na	Health Canada (2009)
Ethylbenzene	0.1	na	Health Canada (2009)
Xylenes	1.5	na	Health Canada (2009)
Benzo(a)pyrene		2.3 (ingestion) 0.137 (inhalation)	Health Canada (2009)
F1	**Ingestion (mg/kg/day)** 5 (Aliphatic C>6-C8) 0.1 (Aliphatic C8-C10) 0.04(Aromatic C>8-C10) **Inhalation-TC (mg/m^3)** 18.4 (Aliphatic C>6-C8) 1 (Aliphatic C8-C10) 0.2(Aromatic C>8-C10)	na	Health Canada (2009)
F2	**Ingestion (mg/kg/day)** 0.1 (Aliphatic C>10-C12) 0.1 (Aliphatic C12-16) 0.04 (Aromatic C>10-C12) 0.04 (Aromatic C>12-C16) **Inhalation-TC (mg/m^3)** 1 (Aliphatic C>10-C12) 1 (Aliphatic C12-16) 0.2 (Aromatic C>10-12) 0.2 (Aromatic C>12-C16)	na	Health Canada (2009)

8.2.3 Evaluation of Potential Toxic Interactions

Typically, criteria, guidelines, and standards developed by provincial and federal regulatory agencies do not account for potential interactions of chemicals. The approach of summing the HQ values is very conservative and may be overly protective, as it assumes that substances interact on the same cellular target and via the same mechanism of action. In reality, interactions (via synergism and/or antagonism) are typically considered to be rare at

"environmental concentrations". Currently, two groups of chemicals considered to have the potential to act similarly are: 1) carcinogenic polycyclic aromatic hydrocarbons, and 2) polychlorinated dibenzo-p-dioxins/furans and dioxin-like PCBs. No contaminants from the latter of these two groups of chemicals have been detected at levels exceeding EQGs on the sites.

9.0 HHRA RISK CHARACTERIZATION

The risk characterization stage brings together all the previous components of the risk assessment into an overall quantitative assessment of the potential health effects to each human receptor.

For substances presenting risks other than cancer, a Hazard Quotient (HQ) is derived as the ratio of the estimated exposure to an appropriate toxicity reference value (TRV) according to the following equation:

$$\text{Hazard Quotient} = \frac{\text{Estimated Exposure}}{\text{Toxicity Reference Value}}$$

Toxicity risks are evaluated separately for each contaminant and pathway. For purposes of preliminary quantitative risk assessment, exposures associated with HQ ≤ 0.2 will be deemed negligible.

For simultaneous exposure to multiple COPC, the HQ is assumed to be additive and the sum of the hazard quotients for each COPC and pathway with the same target organ should not equal/exceed 0.2 to be considered acceptable (Health Canada, 2007).

For substances deemed to be carcinogenic, the estimated exposure should be multiplied by the appropriate slope factor or unit risk to derive a conservative estimate of the potential incremental lifetime cancer risk (ILCR). Cancer risks are considered negligible if the estimated ILCR is less than or equal to 1-in-100,000 or 1.00E-05 (Health Canada, 2007).

9.1 Summary of Hazard Quotients

Hazard Quotient (HQ) calculations using the Health Canada spreadsheet model are shown in Appendix B. Maximum calculated HQs are shown in Table 8.

Table 8: Maximum Hazard Quotients All Operative Pathways

COPC	Pathways	Adult- Airport Employee	Adult- Remediation Worker (chronic)
METALS			
copper	oral/dermal	5.28E-05	2.52E-04
	inhalation	3.94E-09	1.18E-08
	Total	5.28E-05	2.52E-04
lead	oral/dermal	4.59E-03	2.69E-02
	inhalation	4.45E-07	1.33E-06
	Total	4.60E-03	2.69E-02
PHC			
ethylbenzene	oral/dermal	4.33E-06	1.83E-03
	inhalation	5.85E-04	1.75E-05
	Total	5.89E-04	3.58E-03
toluene	oral/dermal	1.07E-05	3.19E-02
	inhalation	1.45E-03	4.35E-03
	Total	1.46E-03	3.63E-02
xylenes	oral/dermal	5.95E-06	1.27E-02
	inhalation	3.77E-02	1.13E-01
	Total	3.77E-02	1.26E-01
Fraction 1	oral/dermal	3.33E-03	**4.46E-01**
	inhalation	1.65E-02	4.95E-02
	Total	1.98E-02	**4.96E-01**
Fraction 2	oral/dermal	1.82E-02	**1.80E+00**

	inhalation	3.19E-02	9.58E-02
	Total	5.01E-02	**1.89E+00**

NA-Health Canada did not provide a TDI for this pathway

The target HQ of 0.2 has been exceeded for:

- multiple COPC for the remedial worker:
  - PHC Fraction 1 (oral/dermal)
  - PHC Fraction 2 (oral/dermal)
- The sum of the HQ's for the remedial worker; and
- The sum of the HQs for each COPC with the same target organ.

The results indicate there the unacceptable risk is primarily a function of oral/dermal exposures. The modeling suggests that the highest potential risk is from the oral/dermal exposure for the following listed in order of descending HQ: PHC F2 and F1. Note that the HHRA calculations are estimates only and do not represent actual risks.

9.1.1 Evaluation of Sub-Chronic Risk

The Health Canada PQRA spreadsheet model is primarily developed to evaluate chronic health risks from contaminant exposures. As such, the equations built into the PQRA model averages short term exposures over a yearly period.

In the case of receptors (e.g. site remediation worker) which are likely subject to an intense short term exposure to contaminated media, amortizing a short term exposure duration over a yearly period does not account for acutely toxic effects that may result from short term exposure episodes.

Short term exposures (mg/kg-d) through oral, dermal and inhalation of soil particulate pathways were calculated for the exposure episode (6 days/week for 14 weeks, without amortizing the exposure over a yearly period). A sub-chronic hazard quotient was derived for each COPC by comparing total short term exposures (mg/kg-d) to chronic toxicity reference values (mg/kg-d) (Health Canada, 2009) for each COPC. Derivation of these sub-chronic hazard quotients for the site remediation worker is included in Appendix C. Non-carcinogenic COPC with sub-chronic HQ ≤ 1.0 were deemed to be of negligible risk (Wilson Scientific Consulting Inc., 2007).

Derived Sub-chronic Hazard Quotients for Non-Carcinogens

COPC	HQ	COPC	HQ	COPC	HQ
Copper	2.52E-04	Ethylbenzene	3.58E-03	PHC F2	**1.89E+00**
Lead	2.69E-02	PHC F1	4.96E-01	Xylenes	1.26E-01
Toluene	3.63E-02				

Bold and Underlined values exceed the acceptable HQ of 1.0.

The results of this modeling suggest that the target HQ of 1.0 has been exceeded by COPC mixture PHC F2, for the site remediation worker over a short term exposure duration, and that unacceptable risk is mainly a function of oral/dermal exposure (see Appendix C). Note that the sub-chronic HQ calculations are estimates only and do not represent actual risks.

9.2 Summary of Carcinogenic Risks

Estimates of ILCR were made using the Health Canada spreadsheet tool and are shown in Appendices B. The maximum calculated ILCRs are shown in Table 9.

Table 9: Estimate of Potential Carcinogenic Risks - All Operative Pathways

Receptor/Exposure	ILCR Risk Estimates		
	arsenic	**benzene**	**benzo(a)pyrene**
Airport Employee - Adult			
Cancer Risk from Oral/Dermal Exposure	2.72E-06	3.86E-08	1.27E-07
Cancer Risk from Inhalation Exposure	3.69E-09	2.08E-06	1.97E-11
Cancer Risk - Total	2.72E-06	2.12E-06	1.27E-07
Remedial Worker - Adult			
Cancer Risk from Oral/Dermal Exposure	4.11E-06	**9.92E-05**	1.04E-06
Cancer Risk from Inhalation Exposure	3.16E-09	1.79E-06	1.69E-11
Cancer Risk - Total	4.11E-06	1.01E-04	1.04E-06

Bold and Underlined values exceed the maximum acceptable ILCR of 1.0E-05.

The Health Canada recommended threshold for ILCR (1.0E-05) has been exceeded for benzene for the remedial worker. The modeling suggests that the highest potential risk is from the oral/dermal exposure pathway. Note that the HHRA calculations are estimates only and do not represent actual risks.

9.2.1 Summary of Risk Characterization

The risk characterization has shown there are unacceptable risks for onsite remediation workers from exposure to three COPC; PHC F1 and F2, and benzene.

For threshold response chemicals (non-carcinogens), the unacceptable chronic risks (HQ > 0.2) to site remediation workers are due to oral/dermal exposure to petroleum hydrocarbons (Fraction 1 and Fraction 2) via incidental ingestion of soil, inhalation of fugitive dust and vapours, and dermal contact with soil and groundwater.

Derivation of sub-chronic hazard quotients to assess acute risks to site remediation workers from short-term exposure to non-carcinogens suggest that the target HQ of 1.0 has been exceeded by the COPC mixture PHC F2, and that unacceptable sub-chronic risk is mainly a function of oral/dermal exposure.

For non-threshold chemicals (carcinogens) benzene exceeded the ILCR (1.0E-05) for the remedial worker. Note that the HHRA calculations are estimates only and do not represent actual risks.

9.2.2 Risk Management

The HHRA indicate that remediation or risk management measures are required to reduce the risks to human health (for site remediation workers) at the sites. The main risks to human receptors are associated with PHCs, and benzene in soils and groundwater.

To manage the potential risks from onsite exposure, all workers involved in remediation work should follow a site specific health and safety plan; and adhere to general PPE guidance (e.g. wear appropriate personal protective equipment (e.g., gloves, long-sleeved clothes, pants) and practice prudent hygiene (e.g. wash hands prior to eating and when exiting the sites).

9.3 HHRA Uncertainty Evaluation

Sources of uncertainty associated with modeling in risk assessment can include variability in input parameters due to spatial and temporal variation in the parameters, lack of data for key parameters, and the structure of the model due to simplification and assumptions within the model.

The table below describes some of the uncertainties associated with this HHRA.

Uncertainty Analysis

Factor	Uncertainty	Effect on Risk Assessment
Model Assumptions Regarding Patterns of Exposure	<u>User Defined Exposure Scenario</u> The user-defined exposure scenarios were based on assumed patterns of access to the sites for specific receptors. These assumptions are believed to reasonably over-estimate exposures at the sites. The actual pattern of exposure at the sites for these specific receptors is not known, however, there are no known routine activities or planned activities at the APECs/AECs.	Overestimation. Estimated pattern of exposure believed to be overestimation. This overestimation of exposure will result in an overestimation of risk.
Model Assumptions Regarding Receptor Characteristics	The risk assessment was based on assumed generic receptor characteristics provided in the Health Canada guidance, while actual receptor characteristics may differ from these standard assumptions. Any variance in actual receptor characteristics (e.g. weight, soil and water ingestion, inhalation rates, etc.) to the standard values of the model will be a source of uncertainty.	Possible over-estimation of risks to user defined receptors.
Model Assumptions Regarding Contaminant Concentrations and Distributions	<u>Concentration of Contaminants</u> There is always uncertainty associated with the collection and analysis of environmental sampling data. Sources of uncertainty typically include: • Which samples are collected and assumed to represent actual site conditions; and • Inherent variance in procedures for sample collection, shipment/storage and laboratory analysis.	Unknown; however many of the known and highly toxic chemicals (such as arsenic, lead and benzene) have been accounted for in the HHRA. Additionally, the sampling program was targeted at potential "hotspots" (AECs), and it is reasonable to assume that the data collected may be representative of the highest concentrations at the sites (especially considering that for a number of COPCs, concentrations were non-detect (ND) in many samples). The contaminant concentrations across much of the sites are likely much lower than those used in the calculations, thus the risk estimates are conservatively high.

Factor	Uncertainty	Effect on Risk Assessment
Model Assumptions Regarding Toxicological Mechanisms and Effects	Toxicity reference values used in this assessment are published by regulatory agencies based on animal studies. Toxicity reference values are derived by the extrapolation of the animal study data. Since humans and animals differ in their response to the absorption and distribution of chemicals, the extrapolated toxicity reference values are typically numerically adjusted to add margins of conservatism (safety factors) that are built into the final toxicity reference values.	Unknown. Generally an overestimation of risk will result. Additionally, bioavailability of most COPC in media (e.g. soil, sediment) was assumed to be 1 (e.g. the contaminant is assumed to be 100% bioavailable). This assumption would result in a highly conservative calculated dose as not all COPC in soil and sediment are 100% bioavailable.

9.4 HHRA Summary and Conclusions

Purpose and Methodology

A human health risk assessment was conducted using the Human Health Preliminary Quantitative Risk Assessment (PQRA) guidance documents (Health Canada, 2004, 2007, 2009 updates). The HHRA consists of a Site Characterization, Problem Formulation, Exposure Assessment, Toxicity/Hazard Assessment and Risk Characterization. To quantify risks due to the presence of onsite contaminants, the updated version of the Health Canada PQRA spreadsheet model (March 2009) was used.

Chemical Screening

An initial chemical screening process identified the following as Chemicals of Potential Concern (COPC) based on their concentrations in environmental media. This information was further used as inputs in the PQRA spreadsheets:

arsenic	**benzene**	**benzo(a)pyrene**
copper	**toluene**	
lead	**ethylbenzene**	
	xylenes	
	Fraction 1	
	Fraction 2	

Potential Receptors and Operable Pathways

Potential human receptors at the sites include:

- Adult airport employees involved in operational and maintenance activities onsite. This would be considered a chronic exposure scenario; and
- Remedial workers or adult construction workers involved in demolition, remediation and maintenance activities at the sites. This would be considered as both acute and chronic exposure scenarios

The operable pathways considered for the HHRA were:

- Incidental ingestion of soil particles, and inhalation of soil particles (fugitive dust); and
- Dermal contact with soil and groundwater.

Risk Characterization

The target HQ of 0.2 has been exceeded in the site remediation worker receptor chronic scenario, for multiple COPC. The results indicate there are unacceptable risks primarily with oral/dermal exposures. The modeling suggests that the highest potential risk is from the oral/dermal exposure for the following listed in order of descending HQ: PHC F2, and PHC F1.

Derivation of sub-chronic hazard quotients to assess acute risks to site remediation workers from short-term exposure to non-carcinogens suggest that the target HQ of 1.0 has been exceeded by the COPC mixture PHC F2, and that unacceptable sub-chronic risk is mainly a function of oral/dermal exposure.

The Health Canada recommended threshold for ILCR (1.0E-05) has been exceeded by exposure to carcinogens (i.e., benzene) for onsite site remediation workers. The results indicate there are unacceptable risks primarily with oral/dermal exposures. The HHRA calculations are estimates only and do not represent actual risks.

Conclusions and Risk Management

Based on the high risk estimate (HQ) for the site remediation worker, this HHRA has likely overestimated the risk. This overestimation is consistent with the intent of a HHRA: to provide a protective estimate of potential risks.

To manage the potential oral/dermal exposure to PHCs in soils onsite, workers involved in remediation work should follow a site specific health and safety plan.

10.0 ECOLOGICAL RISK ASSESSMENT (ERA)

This section presents the assumptions, methodologies and results of a qualitative Ecological Qualitative Risk Assessment (ERA) that was conducted to provide an understanding of potential risks to potential ecological receptors based on the environmental conditions at the Cambridge Bay Airport.

The qualitative screening method used in this ERA is intended to provide a record of the assumptions made in performing this qualitative estimation of risk and to identify the limitations of the data used in this risk estimation process. The results of the qualitative ERA can then be used towards the next stages of quantitative risk assessment.

10.1 ERA Objectives

The primary objective of the ERA was to qualitatively assess ecological risks to determine if COPCS in soil and groundwater represent a potential risk to ecological receptors. Unlike the human health risk assessment, the goal of the ERA was not to protect each individual ecological receptor from toxic effects, but rather to protect the viability of populations and the overall community of organisms within the ecosystem.

10.2 Problem Formation

The objective of this problem formulation is to identify which chemicals can potentially pose risks to ecological receptors. In the following section an evaluation of COPCS identified from present and historical activities onsite, ecological receptors, and relevant pathways of exposure was conducted in order to identify which substances had the potential to cause adverse effects to ecological receptors. This information was used to develop an Ecological Conceptual Site Model (ECSM) that represents the current understanding of contaminant sources, release and transport mechanisms within and among environmental media, and exposure pathways by which ecological receptors may be exposed to contaminants.

10.3 Contaminants of Potential Concern

Please refer to Section 5.0 of this report for the initial screening of contaminants of potential concern (and respective maximum concentrations) identified in soil and groundwater and included in the ERA for further evaluation of exposure and risk to onsite receptors.

To better evaluate the risks posed to specific ecological receptors by COPC present in soil and groundwater at the Cambridge Bay Airport sites, the sites were characterized as two smaller sub-sites (a “foreshore sub-site” and a “terrestrial sub-site”) for the purpose of the ERA. The “foreshore sub-site” is comprised of APEC 1, and AEC 2 and 3, as determined from previous

environmental investigations. Approximately 1.5 km east of the foreshore sub-site is the "terrestrial sub-site", comprised of AEC 4, APEC 5, and APEC 6 as determined from previous environmental investigations. The COPCs identified in the initial screening of contaminants in Section 5.0, were carried forward into a subsequent detailed characterization of contamination at the two sub-sites. For each sub-site area the maximum COPC concentrations in environmental media in that area were included in this secondary screening process.

Information Level for COPC

Information Level	Definition
High	Greater than 20 samples have been analyzed for the COPC in this environmental media.
Low	Greater than 20 samples have been analyzed for the COPC in this environmental media.

- Based on the information level expected for this sample number (Health Canada PQRA Guidance Part I (2007))

Table 10: Hazard Data for Chemicals of Potential Concern in Environmental Media at the "Foreshore Sub-site" (APEC 1, AEC 2, and AEC 3)

Hazard	Max. Conc.	# Exceedences (# samples)	Threshold Limit	Inferred Extent of Contamination	Info. Level
COPC in soil (µg/g)	F1 (C6-C10) (47)	0 (15)	320 µg/g [1]	NA	Low
	F2 (C10-C16)(1,700)	3 (24)	260 µg/g [1]	Localized (AEC 3)	High
	F3 (C16-C34) (430)	0 (27)	1,700 µg/g [1]	NA	High
	F4 (C34-C50+) (190)	0 (27)	3,300 µg/g [1]	NA	High
	Copper (102)	2 (23)	91 µg/g [2]	Localized (AEC 2)	High
	Arsenic (40.6)	1 (22)	12 µg/g [2]	Localized (AEC 2)	High
	Lead (26.6)	0 (23)	260 µg/g [2]	NA	High
	Benzene (1.2)	5 (30)	0.03 µg/g [2]	Localized (AEC 3)	High
	Ethylbenzene (3.654)	3 (30)	0.082 µg/g [2]	Localized (AEC 3)	High
	Toluene (0.28)	0 (30)	0.37 µg/g [2]	NA	High
	Xylenes (2.9)	0 (30)	11 µg/g[2]	NA	High
COPC in GW (µg/L)	F1 (C6-C10) (10,000)	2(11)	750 µg/L [3]	Localized (AEC 3)	Low
	F2 (C10-C16) (3,800)	3(11)	150 µg/L [3]	Localized (AEC 3)	Low
	Aluminum (1,000)	7 (11)	100 µg/L [4]	Non-localized (APEC 1 and AEC 3)	Low
	Cadmium(<2)	1 (12)	0.6 µg/L [5]	Localized (AEC 3)	Low
	Nickel (176)	1 (12)	83 µg/L [5]	Localized (AEC 3)	Low
	Iron (1,700)	10 (11)	300 µg/L [6]	Non-localized (APEC 1, AEC 2, and AEC 3)	Low
	Manganese (460)	5 (11)	50 µg/L [6]	Non-localized (APEC 1, AEC 2,and AEC 3)	Low
	Strontium (1200)	11 (11)	7 µg/L [7]	Non-localized (APEC 1, AEC 2, and AEC 3)	Low
	Zinc (<30)	0 (12)	100 µg/L [5]	NA	Low
	Naphthalene (330)	2 (7)	10 µg/L [5]	Localized (AEC 3)	Low
	Benzene (1,700)	1(13)	1,000 µg/L [5]	Localized (AEC 3)	Low
	Toluene (2,800)	1(13)	390 µg/L[5]	Localized (AEC 3)	Low
	Xylenes (2,300)	1(13)	300 µg/L[6]	Localized (AEC 3)	Low

NA- not applicable; concentrations in media at this sub-site do not exceed applied guidelines, and are likely not a hazard.

1) CL CWS, CCME 2008 (coarse grained, surface)
2) CL EQG, CCME 2007
3) Table 3, OMOE 2009
4) FWAL, CCME 2007
5) BC CSR, Schedule 6, Aquatic Life
6) AENV, Tier 1, Table 2, Coarse soil (CL)
7) Compendium of Environmental Quality Benchmarks App 2-4

Table 11: Hazard Data for Chemicals of Potential Concern in Environmental Media at the "Terrestrial Sub-site" (AEC 4, APEC 5, and APEC 6)

Hazard	Max. Conc.	# Exceedences (# samples)	Threshold Limit	Inferred Extent of Contamination	Info. Level
COPC in soil (µg/g)	F1 (C6-C10) (4,800)	3 (8)	320 µg/g [1]	Localized (AEC 4)	Low
	F2 (C10-C16)(12,000)	3 (15)	260 µg/g [1]	Localized (AEC 4)	Low
	F3 (C16-C34) (6,400)	1 (15)	1,700 µg/g [1]	Localized (AEC 4)	Low
	F4 (C34-C50+) (3,900)	1 (15)	3,300 µg/g [1]	Localized (AEC 4)	Low
	Copper (13.7)	0 (11)	91 µg/g [2]	NA	Low
	Arsenic (2.7)	0 (11)	12 µg/g [2]	NA	Low
	Lead (294)	1 (11)	260 µg/g [2]	Localized (AEC 4)	Low
	Benzene (4.6)	6 (17)	0.03 µg/g [2]	Non- Localized (AEC 4 and APEC 5)	Low
	Ethylbenzene (9.337)	4 (17)	0.082 µg/g [2]	Non- Localized (AEC 4 and APEC 5)	Low
	Toluene (37)	4 (17)	0.37 µg/g [2]	Non- Localized (AEC 4 and APEC 5)	Low
	Xylenes (140)	4 (17)	11 µg/g[2]	Non- Localized (AEC 4 and APEC 5)	Low
COPC in GW (µg/L)	F1 (C6-C10) (4,200)	2(6)	750 µg/L [3]	Localized (AEC 4)	Low
	F2 (C10-C16)(1,400)	2(6)	150 µg/L [3]	Localized (AEC 4)	Low
	Aluminum (60)	0 (6)	100 µg/L [4]	NA	Low
	Cadmium(<2)	1 (7)	0.6 µg/L [5]	Localized (AEC 4)	Low
	Nickel (10)	0 (7)	83 µg/L [5]	Localized (AEC 4)	Low
	Iron (970)	2 (6)	300 µg/L [6]	Localized (AEC 4)	Low
	Manganese (260)	6 (6)	50 µg/L [6]	Non-localized (AEC 4, APEC 5 and APEC 6)	Low
	Strontium (500)	6 (6)	7 µg/L [7]	Non-localized (AEC 4, APEC 5 and APEC 6)	Low
	Zinc (280)	1 (7)	100 µg/L [5]	Localized (AEC 4)	Low
	Naphthalene (14)	1 (5)	10 µg/L [5]	Localized (AEC 4)	Low
	Benzene (790)	1 (8)	1,000 µg/L [5]	Localized (AEC 4)	Low
	Toluene (1,000)	1 (8)	390 µg/L[5]	Localized (AEC 4)	Low
	Xylenes (640)	1 (8)	300 µg/L[6]	Localized (AEC 4)	Low

NA- not applicable; concentrations in media at this sub-site do not exceed applied guidelines, and are likely not a hazard.

1) CL CWS, CCME 2008 (coarse grained, surface)
2) CL EQG, CCME 2007
3) Table 3, OMOE 2009
4) FWAL, CCME 2007
5) BC CSR, Schedule 6, Aquatic Life
6) AENV, Tier 1, Table 2, Coarse soil (CL)
7) Compendium of Environmental Quality Benchmarks App 2-4

10.4 Effects Assessment

A secondary chemical screening approach, referred to as a "qualitative screening assessment", was conducted. This assessment employed toxicological benchmark values protective of ecological receptors for each environmental medium.

The effects assessment qualitatively ranked chemicals according to their potential to cause harmful effects to ecological receptors. The ranking is based on the chemicals inherent toxicity to receptor populations, as well as potential for exposure. Evaluation criteria for potential effects on receptors populations and the results of the qualitative screening assessment against toxicological benchmark values are discussed below.

Potential Effects on Receptors

Severity of Effect	Definition
Severe	Expected to affect a population of species in sufficient magnitude to cause a decline in abundance beyond which natural recruitment would not return for that population, or any population or species depending upon it, to its former level within several generations. Expect a major change in ecosystem structure and function. Maximum and/or mean concentration exceeds the toxicity threshold value by greater than 10-fold.
Moderate	Expected to affect a portion of a population that results in a measurable change in abundance and/ or distribution over one or more generations of that population or any population dependant on it., but does not change the integrity of the population as a whole. It may be localized and recovery would be expected over many generations if exposure to COPC was stopped. Maximum and/or mean concentration exceeds the toxicity threshold value by 5 to 10-fold.
Minor	Expected to affect a portion of a population at a localized area and over a short period of time (one generation or less), but not affecting other trophic levels, and having little impact on the size or dynamics of the population itself. Rapid recovery of the population would be expected if exposure to COPC was stopped. Maximum and/or mean concentration exceeds the toxicity threshold value by less than 5-fold.
Minimal	Expected to affect a population or specific group at a localized area and over a short period of time in such a way as to be similar in effect to natural variation the population due to environmental irregularities, but having an undetectable effect on the population as a whole. Expected that maximum and/or mean concentration does not exceed toxicity threshold value.

Note ecological definitions are modeled after Fletcher (2005).

Table 12: Hazard Data for Chemicals of Potential Concern in Soil at the "Foreshore Sub-site" (APEC 1, AEC 2, and AEC 3)

COPC in soil (µg/g)	Hazard Measure (Toxicological Benchmark)	Severity of Effect	Basis for Assessment
F1 (C6-C10) (47)	320 µg/g (50th percentile of EC20 for soil invertebrates and plants growth, mortality,and reproduction endpoints) (1)	minimal	-Max concentration is below toxicity benchmark, (mean=12.47, 93% non-detect) -Contaminant mixture and volatile
F2 (C10-C16) (1700)	260 µg/g (50th percentile of EC20 for soil invertebrates and plants mortality and reproduction endpoints) (1)	minor	-Max concentration is above toxicity benchmark, (mean=137, 70% non-detect) -Contaminant mixture and sorption to organics -high bio-concentration potential from soil exposure (Kow >6.0 for aliphatics and aromatics), and high potential for bioaccumulation in food webs
F3 (C16-C34) (430)	390-1100 µg/g (50th percentile of EC20 for soil invertebrates and plants mortality and reproduction endpoints) (2)	minimal	-Max concentration is below toxicity benchmark (mean=61.8, 41% non-detect) -Contaminant mixture
F4 (C34-C50+) (190)	8,321 µg/g (guideline derivation- 50th percentile of EC20 for soil invertebrates and plants growth, mortality and reproduction endpoints) (2)	minimal	-Max concentration is below toxicity benchmark (mean=23.6, 88% non-detect) -Contaminant mixture
Copper (102)	28 µg/g (Avian Eco-SSL, Lowest Eco-SSL for plants, invertebrates, avian and mammals) (3)	minimal	-Max concentration is above toxicity benchmark (mean=21.8, 0% non-detect); however mean concentration is below the toxicity benchmark applied -Essential element in plants and animals -Potential for bioconcentration and multiple target organs
Arsenic (40.6)	18 µg/g (Plant Eco-SSL, Lowest Eco-SSL for plants, invertebrates, avian and mammals) (4)	minimal	-Max concentration is above toxicity benchmark (mean=4.9, 10% non-detect); however mean concentration is below the toxicity benchmark applied
Lead (26.6)	(11 µg/g (Avian Eco-SSL, Lowest Eco-SSL for plants, invertebrates, avian and mammals) (8)	minor	-Max concentration is above toxicity benchmark (mean=10.8, 4% non-detect) -multiple target organs

Benzene (1.2)	25 µg/g (CCME Soil Quality Check Guideline for the ingestion of soil and food (based on ingestion toxicity data for mammalian and avian species)[5]	minimal	Max concentration is below toxicity benchmark (mean=0.08, 80% non-detect) -low bioconcentration potential (Kow<4.0)
Ethylbenzene (3.7)	16 µg/g (NOEC for adverse effects in earthworms in coarse soil) [6]	minimal	-Max concentration is below toxicity benchmark (mean=0.15, 80% non-detect). -Multiple target organs, low bioconcentration potential (Kow<4.0), volatile
Toluene (0.28)	200 µg/g (phytotoxicity) [7]	minimal	-Max concentration is below toxicity benchmark (mean=0.05, 86% non-detect).. -low bioconcentration potential (Kow<4.0), volatile -Multiple target organs
Xylenes (2.9)	78 µg/g (LOEC for adverse effects in earthworms in coarse soil) [9]	minimal	-Max concentration is below toxicity benchmark (mean=0.39, 80% non-detect). -low bioconcentration potential (Kow<4.0), volatile

(1) CCME CWS for PHC in Soil Scientific Rationale, Supporting Technical Document, January 2008
(2) CCME CWS for PHC in Soil Scientific Rationale, Supporting Technical Document, January 2008, Appendix F, Table 17. Summary of Revised F3 Guidelines.
(3) USEPA Ecological Soil Screening Levels for Copper (Revised Feb 2007)
(4) USEPA Ecological Soil Screening Levels for Arsenic (March 2005)
(5) CCME Soil Quality Guidelines for the Protection of Environmental and Human Health, Benzene 2004 Fact Sheet
(6) CCME Soil Quality Guidelines for the Protection of Environmental and Human Health, Ethylbenzene 2004 Fact Sheet
(7) Oak Ridge National Laboratory - Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision (ORNL, 1997). Table1 1. Screening benchmark concentrations for the phytotoxicity of chemicals in soil and soil solution.
(8) USEPA Ecological Soil Screening Levels for Lead (March 2005)
(9) CCME Soil Quality Guidelines for the Protection of Environmental and Human Health, Xylenes 2004 Fact Sheet

Table 13: Hazard Data for Chemicals of Potential Concern in Soil at the "Terrestrial Sub-site" (AEC 4, APEC 5, and APEC 6)

COPC in soil (µg/g)	Hazard Measure (Toxicological Benchmark)	Severity of Effect	Basis for Assessment
F1 (C6-C10) (4800)	320 µg/g (50th percentile of EC20 for soil invertebrates and plants growth, mortality,and reproduction endpoints) [1]	moderate	-Max concentration is above toxicity benchmark, (mean=1731.25, 62.5% non-detect) -Contaminant mixture and volatile
F2 (C10-C16) (12000)	260 µg/g (50th percentile of EC20 for soil invertebrates and plants mortality and reproduction endpoints) [1]	severe	-Max concentration is above toxicity benchmark, (mean=1113.33, 73% non-detect) -Contaminant mixture and sorption to organics -high bioconcentration potential from soil exposure (Kow >6.0 for aliphatics and aromatics), and high potential for bioaccumulation in food webs

F3 (C16-C34) (6400)	390-1100 µg/g (50th percentile of EC20 for soil invertebrates and plants mortality and reproduction endpoints) [(2)]	minor	-Max concentration is above toxicity benchmark (mean=521.4, 33% non-detect) -Contaminant mixture
F4 (C34-C50+) (3900)	8321 µg/g (guideline derivation- 50th percentile of EC20 for soil invertebrates and plants growth, mortality and reproduction endpoints) [(2)]	minimal	-Max concentration is below toxicity benchmark (mean=276.2, 67% non-detect) -Contaminant mixture
Copper (13.7)	28 µg/g (Avian Eco-SSL, Lowest Eco-SSL for plants, invertebrates, avian and mammals) [(3)]	minimal	-Max concentration is below toxicity benchmark (mean=10.26, 0% non-detect) -Essential element in plants and animals -Potential for bioconcentration and multiple target organs
Arsenic (2.7)	18 µg/g (Plant Eco-SSL, Lowest Eco-SSL for plants, invertebrates, avian and mammals) [(4)]	minimal	-Max concentration is below toxicity benchmark (mean=1.8, 0% non-detect)
Lead (294)	11 µg/g (Avian Eco-SSL, Lowest Eco-SSL for plants, invertebrates, avian and mammals) [(8)]	moderate	-Max concentration is above toxicity benchmark (mean=34.9, 18% non-detect) -multiple target organs
Benzene (4.6)	25 µg/g (CCME Soil Quality Check Guideline for the ingestion of soil and food (based on ingestion toxicity data for mammalian and avian species)[(5)]	minimal	Max concentration is below toxicity benchmark (mean=0.54, 64.7% non-detect) -low bioconcentration potential (Kow<4.0)
Ethylbenzene (9.337)	16 µg/g (NOEC for adverse effects in earthworms in coarse soil) [(6)]	minimal	-Max concentration is below toxicity benchmark (mean=1.77, 59% non-detect). -Multiple target organs, low bioconcentration potential (Kow<4.0), volatile
Toluene (37)	200 µg/g (phytotoxicity) [(7)]	minimal	-Max concentration is below toxicity benchmark (mean=3.64, 71% non-detect). -low bioconcentration potential (Kow<4.0), volatile -Multiple target organs
Xylenes (140)	78 µg/g (LOEC for adverse effects in earthworms in coarse soil) [(9)]	minimal	-Max concentration is above toxicity benchmark (mean=15.58, 71% non-detect) however mean concentration is below the toxicity benchmark applied -low bioconcentration potential (Kow<4.0), volatile

1) CCME CWS for PHC in Soil Scientific Rationale, Supporting Technical Document, January 2008
2) CCME CWS for PHC in Soil Scientific Rationale, Supporting Technical Document, January 2008, Appendix F, Table 17. Summary of Revised F3 Guidelines.
3) USEPA Ecological Soil Screening Levels for Copper (Revised Feb 2007)
4) USEPA Ecological Soil Screening Levels for Arsenic (March 2005)
5) CCME Soil Quality Guidelines for the Protection of Environmental and Human Health, Benzene 2004 Fact Sheet
6) CCME Soil Quality Guidelines for the Protection of Environmental and Human Health, Ethylbenzene 2004 Fact Sheet
7) Oak Ridge National Laboratory - Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision (ORNL, 1997). Table1 1. Screening benchmark concentrations for the phytotoxicity of chemicals in soil and soil solution.
8) USEPA Ecological Soil Screening Levels for Lead (March 2005)
9) CCME Soil Quality Guidelines for the Protection of Environmental and Human Health, Xylenes 2004 Fact Sheet

Exposure of terrestrial wildlife receptors to contaminated groundwater is considered negligible for both the "foreshore" and "terrestrial" sub-sites. Exposure of deep-rooted plants and trees in low-lying areas to groundwater is considered unlikely due to the stunted growth in the continuous permafrost layer, and that the majority of plant root colonization typically occurs in the upper meter of soil, above the inferred water table onsite. Contact with groundwater was therefore deemed an incomplete exposure pathway for ecological receptors and was not considered further in the ERA.

Groundwater will eventually drain into receiving surface waters (marine and freshwater) which are utilized by terrestrial wildlife receptors as well as aquatic life at both the "terrestrial sub-site" and "foreshore sub-site". Without available analytical information regarding surface water quality at the Cambridge Bay Airport sites, screening diluted (ten-fold, BC MOE, Technical Guidance Document 15-Draft, August 2009) contaminant concentrations in groundwater against wildlife toxicological benchmarks as well as aquatic life toxicological benchmarks provides preliminary and conservative indicators of receiving surface water quality and potential effects of COPC in groundwater on aquatic and terrestrial receptors utilizing the receiving water.

A ten-fold dilution factor was applied to the maximum concentration of COPC in groundwater. This tenfold dilution factor is to account for groundwater mixing and dilution within the transition zone between groundwater and receiving water, and is applicable to groundwater greater than 10m from the closest surface water containing life (BC MOE, Technical Guidance Document 15-Draft, August 2009) Given that the closest monitoring wells on both sub-sites are greater than 25m from receiving waters, this dilution factor was applied to groundwater concentrations, the inferred concentration at the point of discharge to the receiving aquatic environment was compared to toxicological benchmarks to refine effect severity for these COPC and to determine potential COPC in receiving surface water at both the terrestrial and foreshore sub-sites.

Table 14: Hazard Data for Potential COPC in surface water at the "Foreshore Sub-site" (APEC 1, AEC 2, and AEC 3)

COPC in ground water (µg/L)	Inferred conc. at point of discharge (µg/L)	Hazard Measure (Toxicological Benchmark)	Severity of Effect	Basis for Assessment (Groundwater is expected to eventually drain into receiving surface waters utilized by terrestrial foreshore wildlife as well as aquatic life).
F1 (C6-C10) (10,000)	F1 (C6-C10) (1,000)	167 µg/L (Derived Aquatic Life TRV) [3] 53,000 µg/L (RfC Livestock Drinking Water) [3]	moderate (aquatic) minimal (terrestrial)	-Derived max concentration is above both aquatic and terrestrial toxicity benchmarks (mean=1275.5, 73% non-detect)
F2 (C10-C16) (3,800)	F2 (C10-C16) (380)	42 µg/L (Derived Aquatic Life TRV) [3] 53,000 µg/L (RfC Livestock Drinking Water) [3]	moderate (aquatic) minimal (terrestrial)	-Derived max concentration is above the aquatic benchmark but below the terrestrial toxicity benchmarks (mean=964, 63% non-detect)
Aluminum (1,000)	Aluminum (100)	540 µg/L (Lowest Test EC_{20} for Daphnids) [2] 183 µg/L (Lowest LOEL Based Benchmark for Piscivore) [4]	minimal (aquatic) minimal (terrestrial)	-Derived max concentration is below both aquatic and terrestrial toxicity benchmarks (mean=294.6, 18% non-detect) -Can accumulate in aquatic plants and algae, does not appear to biomagnify in food webs
Cadmium(<2)	Cadmium(<0.2)	0.15 µg/L (Lowest Chronic Value for Daphnids) [1] 3.16 µg/L (Lowest LOEL Based Benchmark) [4]	minor (aquatic) minimal (terrestrial)	-Derived max concentration is above aquatic toxicity benchmark, but below terrestrial toxicity benchmark (mean=0.24, 67% non-detect) -Potential for biomagnification in food web (piscivorous species) -Known to partition to organics and bioconcentrate in tissues
Nickel (176)	Nickel (17.6)	5 µg/L (Lowest Chronic Value for All Aquatic Organisms) [1] 1,988 µg/L (Lowest LOEL Based Benchmark for Piscivore) [4]	minor (aquatic) minimal (terrestrial)	-Derived max concentration is above aquatic toxicity benchmark but below terrestrial toxicity benchmark (mean=29.25, 33% non-detect)
Iron (1,700)	Iron (170)	158 µg/L (Lowest Chronic Value for Daphnids) [1] 300 µg/L (Maximum,Warrington 1987) [5]	minor (aquatic) minor (terrestrial)	-Derived max concentration is above aquatic toxicity benchmark and below terrestrial toxicity benchmarks (mean=726.36, 0% non-detect) -Essential element in plants and animals, not known to bioaccumulate or biomagnify in aquatic food webs
Manganese (460)	Manganese (46)	1,100 µg/L (Lowest Test EC_{20} for Daphnids) [2] 1,217,000 µg/L (Lowest LOEL Based Benchmark) [4]	minimal (aquatic) minimal (terrestrial)	-Derived max concentration is below both aquatic and terrestrial toxicity benchmarks (mean=120.82, 0% non-detect)

Strontium (1200)	Strontium (120)	42,000 µg/L (Lowest Chronic Value for All Organisms) [1] 1127000 µg/L (Lowest LOEL Based Benchmark) [4]	minimal (aquatic) minimal (terrestrial)	Derived max concentration is below both aquatic and terrestrial toxicity benchmarks (mean=421.82, 0% non-detect)
Zinc (<30)	Zinc (<3)	30 µg/L (Lowest Chronic Value for Aquatic Plants) [1] 268 µg/L (Lowest LOEL Based Benchmark) [4]	minimal (aquatic) minimal (terrestrial)	-Derived max concentration is below both the aquatic and terrestrial toxicity benchmark (mean=28.58, 100% non-detect) -Essential element in plants and animals, toxicity affected by water hardness (> hardness, >bioavailable Zn) -Known to partition to organics and bioconcentrate in tissues, affects multiple target organs and toxicological endpoints; Potential for biomagnification in food web (piscivorous species)
Naphthalene (330)	Naphthalene (33)	450 µg/L (Lowest Test EC_{20} for Fish) [2] 13 µg/L (Ecological Screening Level (ESL), USEPA Region 5) [6]	minimal (aquatic) minor(terrestrial)	Derived max concentration is below the aquatic toxicity benchmark but above the terrestrial toxicity benchmark (mean=59.5, 57% non-detect)
Benzene (1700)	Benzene (170)	229 µg/L (Population EC_{20}) [2] 22930 µg/L (Lowest LOEL Based Benchmark) [4]	minimal (aquatic) minimal (terrestrial)	Derived max concentration is below aquatic and terrestrial receptor benchmarks (mean=182.8, 69% non-detect)
Toluene (2800)	Toluene (280)	200 µg/L (Population EC_{20}) [2] 7638 µg/L (Lowest LOEL Based Benchmark) [4]	minor (aquatic) minimal (terrestrial)	Derived max concentration is above aquatic toxicity benchmark but below terrestrial receptor benchmark (mean=224.9,15% non-detect)
Xylenes (2300)	Xylenes (230)	2680 µg/L (Lowest Test EC_{20} for Fish) [2] 35 µg/L (Lowest LOEL Based Benchmark for Piscivore) [4]	minimal (aquatic) moderate (terrestrial)	Derived max concentration is below aquatic toxicity benchmark but above terrestrial receptor benchmark (mean=200.4, 69% non-detect)

(1) Suter II GW and Tsao CL. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. Oak Ridge National Laboratory. Table 1. Summary of conventional benchmarks for priority contaminants in fresh water

(2) Suter II GW and Tsao CL. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. Oak Ridge National Laboratory. Table 2. Summary of alternative benchmarks for priority contaminants in fresh water based on levels of chronic effects

(3) CCME CWS for PHC in Soil Scientific Rationale, Supporting Technical Document, Appendix H, Estimation of Toxicity of PHC to Aquatic Receptors, January 2008

(4) Suter II GW and Tsao CL. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects in WIldlife: 1996 Revision. Oak Ridge National Laboratory. Appendix D: Table 12

(5) A Compendium of Environmental Quality Benchmarks (Environment Canada, 1999) Appendix 2-8 A Summary of Available Water Quality Criteria and Guidelines for the Protection of Wildlife (Water Consumption)

(6) Ecological Screening Level (ESL) for water, USEPA, Region 5, RCRA, (August 23, 2003). http://www.epa.gov/reg5rcra/ca/edql.htm

Table 15: Hazard Data for Potential COPC in surface water at the "Terrestrial Sub-site" (AEC 4, APEC 5, and APEC 6)

COPC in ground water (µg/L)	Inferred conc. at point of discharge (µg/L)	Hazard Measure (Toxicological Benchmark)	Severity of Effect	Basis for Assessment (Groundwater is expected to eventually drain into receiving surface waters utilized by terrestrial wildlife as well as aquatic life).
F1 (C6-C10) (4200)	F1 (C6-C10) (420)	167 µg/L (Derived Aquatic Life TRV) (3) 53000 µg/L (RfC Livestock Drinking Water) (3)	minor (aquatic) minimal (terrestrial)	-Derived max concentration is above aquatic toxicity benchmark and below terrestrial toxicity benchmark (mean=950, 33% non-detect)
F2 (C10-C16) (1400)	F2 (C10-C16) (140)	42 µg/L (Derived Aquatic Life TRV) (3) 53000 µg/L (RfC Livestock Drinking Water) (3)	minor (aquatic) minimal (terrestrial)	- Derived max concentration is above aquatic toxicity benchmark and below terrestrial toxicity benchmark (mean=383.3, 33% non-detect)
Aluminum (60)	Aluminum (6)	540 µg/L (Lowest Test EC_{20} for Daphnids) (2) 183 µg/L (Lowest LOEL Based Benchmark for Piscivore) (4)	minimal (aquatic) minimal (terrestrial)	Derived max concentration is below both the aquatic and terrestrial toxicity benchmarks (mean=25, 67% non-detect) Can accumulate in aquatic plants and algae, does not appear to biomagnify in food webs
Cadmium(<2)	Cadmium(<0.2)	0.15 µg/L (Lowest Chronic Value for Daphnids) (1) 3.16 µg/L (Lowest LOEL Based Benchmark) (4)	minor (aquatic) minimal (terrestrial)	Derived max concentration is above aquatic toxicity benchmark and below terrestrial toxicity benchmark (mean=0.45, 86% non-detect) -Potential for biomagnification in food web (piscivorous species) -Known to partition to organics and bioconcentrate in tissues
Nickel (10)	Nickel (1)	5 µg/L (Lowest Chronic Value for All Aquatic Organisms) (1) 1988 µg/L (Lowest LOEL Based Benchmark for Piscivore) (4)	minimal (aquatic) minimal (terrestrial)	Derived max concentration is below aquatic and terrestrial toxicity benchmark (mean=8.71, 0% non-detect)
Iron (970)	Iron (97)	158 µg/L (Lowest Chronic Value for Daphnids) (1) 300 µg/L (Maximum,Warrington 1987) (5)	minimal (aquatic) minimal (terrestrial)	Derived max concentration is below both the aquatic and terrestrial toxicity benchmarks (mean=336.67, 0% non-detect) -Essential element in plants and animals, not known to bioaccumulate or biomagnify in aquatic food webs
Manganese (260)	Manganese (26)	1100 µg/L (Lowest Test EC_{20} for Daphnids) (2) 1217000 µg/L (Lowest LOEL Based Benchmark) (4)	minimal (aquatic) minimal (terrestrial)	Derived max concentration is below both the aquatic and terrestrial toxicity benchmarks (mean=133.17, 0% non-detect)
Strontium (500)	Strontium (50)	42,000 µg/L (Lowest Chronic Value for All Organisms) (1) 1127000 µg/L (Lowest LOEL Based Benchmark) (4)	minimal (aquatic) minimal (terrestrial)	Derived max concentration is below both the aquatic and terrestiral toxicity benchmarks (mean=275, 0% non-detect)

Zinc (280)	Zinc (28)	30 µg/L (Lowest Chronic Value for Aquatic Plants) (1) 268 µg/L (Lowest LOEL Based Benchmark) (4)	minimal (aquatic) minimal (terrestrial)	Derived max concentration is below both the aquatic and terrestrial toxicity benchmarks (mean=62.43, 71% non-detect) -Essential element in plants and animals, toxicity affected by water hardness (> hardness, >bioavailable Zn) -Known to partition to organics and bioconcentrate in tissues, affects multiple target organs and toxicological endpoints; Potential for biomagnification in food web (piscivorous species)
Naphthalene (14)	Naphthalene (1.4)	450 µg/L (Lowest Test EC_{20} for Fish) (2) 13 µg/L (Ecological Screening Level (ESL), USEPA Region 5) (6)	minimal (aquatic) minimal (terrestrial)	Derived max concentration is below the aquatic toxicity benchmark, and the terrestrial toxicity benchmark (mean=3.03, 20% non-detect)
Benzene (790)	Benzene (79)	229 µg/L (Population EC_{20}) (2) 22930 µg/L (Lowest LOEL Based Benchmark) (4)	minimal (aquatic) minimal (terrestrial)	Derived max concentration is below aquatic and terrestrial toxicity benchmark (mean=125.2, 63% non-detect)
Toluene (1000)	Toluene (100)	200 µg/L (Population EC_{20}) (2) 7638 µg/L (Lowest LOEL Based Benchmark) (4)	minimal (aquatic) minimal (terrestrial)	Derived max concentration is below aquatic and terrestrial toxicity benchmark (mean=126.1,25% non-detect)
Xylene (640)	Xylene (64)	2680 µg/L (Lowest Test EC_{20} for Fish) (2) 35 µg/L (Lowest LOEL Based Benchmark for Piscivore) (4)	minimal (aquatic) minor (terrestrial)	Derived max concentration is below aquatic toxicity benchmark and above the terrestrial toxicity benchmark (mean=85.1, 50% non-detect)

(1) Suter II GW and Tsao CL. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. Oak Ridge National Laboratory. Table 1. Summary of conventional benchmarks for priority contaminants in fresh water

(2) Suter II GW and Tsao CL. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. Oak Ridge National Laboratory. Table 2. Summary of alternative benchmarks for priority contaminants in fresh water based on levels of chronic effects

(3) CCME CWS for PHC in Soil Scientific Rationale, Supporting Technical Document, Appendix H, January 2008

(4) Suter II GW and Tsao CL. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects in WIldlife: 1996 Revision. Oak Ridge National Laboratory. Appendix D: Table 12

(5) A Compendium of Environmental Quality Benchmarks (Environment Canada, 1999) Appendix 2-8 A Summary of Available Water Quality Criteria and Guidelines for the Protection of Wildlife (Water Consumption)

(6)Ecological Screening Level (ESL) for water, USEPA, Region 5, RCRA, (August 23, 2003). http://www.epa.gov/reg5rcra/ca/edql.htm

10.5 . Receptor Characterization and Exposure Assessment

Data from available resources on regional species form the basis for developing a list of species that use or could potentially use or inhabit the sub-sites. This list focused on species designated as protected under the federal Species at Risk Act (SARA).

Under SARA, the federal government species-at-risk public registry includes a database of species at risk across Canada and the extent of their habitats. The database was searched for information on species at risk that may occupy the Cambridge Bay Airport sites and the risk status for each species (endangered, threatened and special concern). Identified Species at Risk were included as representative onsite receptors. The following at-risk species was identified in the database as having habitat located in the vicinity of the Cambridge Bay Airport sites:

- Bowhead Whale *(Balaena mysticetus)* Bering-Chukchi - Beaufort population – Special Concern, Schedule 1

Feeding guilds were selected to represent species with a potential for exposure to onsite contamination, including primary producers, primary consumers (e.g., herbivorous invertebrates and mammals), secondary consumers (e.g. omnivorous birds and mammals) and tertiary consumers (e.g., carnivorous mammals). Multiple ecological receptors were selected to capture exposure from dermal exposures, drinking water, and consumption of vegetation, fish, invertebrates, soil and sediments, and small mammals.

10.5.1 Terrestrial Receptors

The following terrestrial receptors were selected for evaluation in the qualitative assessment.

Primary Producers – Terrestrial Plants and Lichens

Plants are a primary feature of terrestrial habitats and provide an important food source for herbivores. Exposure to COPC can be through dermal absorption from contaminated soils, and may result in a loss of net ecosystem productivity by directly impacting the ability of plant species to photosynthesize and produce biomass and/or reproduce. Disruption of ecosystem function may also occur indirectly through negative health impacts for organisms that consume plant tissues contaminated by COPC. Terrestrial plants can be grazed upon by large herbivorous mammals (eg. musk ox) and are foraged by herbivorous birds (eg. migrating snow geese) (Aiken et al. 1999).

Soil Invertebrates

Soil-dwelling invertebrates play an important role in the degradation of organic materials and constitute a significant food source for animals at higher trophic levels. Negative impacts to soil invertebrates could occur via exposure to contaminants through ingestion of contaminated soil or via direct dermal contact of COPC in soil, and could impair nutrient cycling and adversely impact the health and population dynamics of animals that feed on them.

Terrestrial Birds

Terrestrial (herbivorous and omnivorous) birds have populations that are found seasonally and year-round on Victoria Island and islands within the Canadian High Arctic. Terrestrial birds such as the ptarmigan and snowy owl are potentially present at the "terrestrial (AEC 4, APEC 5, APEC 6)"sub-site. These birds nest in dry, upland areas and feed upon berries, mosses, and low vegetation as well as soil invertebrates, and small mammals. Their predators include the arctic fox, polar bears, and wolves. These birds may be exposed to bioaccumulated COPC via ingestion of prey animals, contaminated drinking waters (surface water), as well as ingestion of and dermal contact with contaminated soil.

Small Burrowing Mammals

Small burrowing mammals such as lemmings and snowshoe hares are considered ecological receptors at both the "foreshore (APEC 1, AEC 2, AEC 3)" and "terrestrial (AEC 4, APEC 5, APEC 6)" sub-sites. These organisms play important roles in insect and vegetation control, seed dispersal and as prey for higher trophic level predators. Small mammals may be exposed to COPC by consuming contaminated vegetation or soil invertebrates, inhaling soil vapours or ingesting soil particulates, or by coming into direct dermal contact with contaminated soil when digging or burrowing. Burrowing mammals mainly forage for willows, berries, sedges, mosses (Canadian Wildlife Service, 2003).

Carnivorous Mammals

Carnivorous mammals in the high Arctic, and potentially present at both the "foreshore (APEC 1, AEC 2, AEC 3)" and "terrestrial (AEC 4, APEC 5, APEC 6)"sub-sites include the Arctic fox, polar bears, and the Arctic wolf. Though of special concern, the polar bear is not considered as an ecological receptor in this risk assessment due to the areas of the sub-sites comprising less than 2% of the organism's estimated home range as per guidance in Suter (2006) (Ferguson et al. 1999). Large carnivores may be exposed to bioaccumulated COPC through ingestion of other animals (caribou, muskox), contaminated drinking waters, and direct dermal contact with contaminated soil. Carnivores tend to have large home ranges and are present throughout the Canadian high arctic. Permanent populations of carnivorous mammals on Victoria Island are

unlikely, but their irregular presence can occur when ice bridges connect several islands together.

Herbivorous Mammals

Herbivorous mammals are potentially present at both the "foreshore (APEC 1, AEC 2, AEC 3)" and "terrestrial (AEC 4, APEC 5, APEC 6)" sub-sites. Herbivores in the high arctic include large animals such as musk-oxen and caribou, as well as smaller organisms such as the snowshoe hare. Herbivores can be exposed to COPC through drinking contaminated surface waters, ingestion of bio-accumulated COPC in vegetation, and ingestion and dermal contact with contaminated soils as they graze on vegetation. Large and small herbivores can be an important food source for top predators (e.g. wolves, foxes).

10.5.2 Aquatic Receptors

The following aquatic receptors were identified and selected for evaluation in the qualitative assessment.

Aquatic Primary Producers

Primary producers are potential ecological receptors in the vicinity of both the "foreshore" and "terrestrial" sub-sites, which can be exposed to COPC via groundwater drainage into receiving waters. Primary producers use solar radiation and inorganic molecules to produce biomass that serves as a food source for higher trophic levels and as habitat to fish and invertebrates. Benthic and planktonic algae species in freshwater lakes and the marine environment of the Canadian high arctic can take up COPC from both the water column and sediment.

Benthic Invertebrates

Benthic invertebrates are potential ecological receptors in the vicinity of both the "foreshore" and "terrestrial" sub-sites, which can be exposed to COPC via groundwater drainage into receiving waters. Benthic invertebrates such as freshwater chironomids and marine amphipods, polychaetes and mollusks live and feed within the sediment consuming decaying organic matter and playing a role in nutrient cycling, or feeding within the water column. They are an important food source to fish species in the high arctic. Sediments and overlying water are principal routes through which invertebrates may be exposed to contaminants.

Fish

Piscivorous fish like the Arctic Char can be present in marine or freshwater environments, feed on benthic invertebrates, surface insects, and smaller fish, and are an important food source for larger predators (wolves, foxes, piscivorous birds). Fish species may be at risk from exposure to COPC that migrate from surface runoff or through groundwater transport to surface waters. Fish are exposed via respiration (diffusion of COPC across the gill membrane) and trans-dermal contact with the water column, and by ingestion of contaminated food items including sediment, benthic invertebrates and other fish.

Shorebirds

Shorebirds (herbivorous, omnivorous, and piscivorous) such as sandpipers, Canada geese, terns and eiders have populations that migrate seasonally to Victoria Island and islands within the Canadian High Arctic for breeding. Shorebirds are potentially present at the "foreshore (APEC 1, AEC 2, AEC 3)" sub-site. These birds can nest in coastal and nearshore areas and feed upon benthic and water column invertebrates, fish, coastal vegetation, as well as soil invertebrates. Their predators include the predatory birds, arctic foxes, polar bears, and wolves. These birds may be exposed to bioaccumulated COPC via ingestion of prey animals and ingestion of and dermal contact with contaminated water, soil, and sediment.

Marine Mammals

Marine mammals, including whales (e.g. Bowhead Whale identified as a species of special concern by SARA), seals, and walrus are not considered as ecological receptors in the risk assessment of the "foreshore sub-site". This decision is based on the limited likelihood of exposure to COPC in surface water/sediment along the shoreline of AEC 2, which is estimated to comprise far less than 2% of the species large home range and can be excluded as a potential receptor as per guidance in Suter (2006), (Ferguson et al. 1999).

Summary of Exposure Pathways

The three components in an operable exposure pathway are a source chemical, transport pathway and exposure mechanism. The following exposure pathways are identified as most significant for the "foreshore sub-site" and the "terrestrial sub-site":

1) Leaching of subsurface contamination into groundwater and transport into surface waters in the Site vicinity, followed by trans-dermal uptake by aquatic species (higher and lower trophic levels) through contact with surface water, and sediments
2) Ingestion of contaminated surface waters (terrestrial and aquatic).

3) Ingestion of contaminated food items (aquatic and terrestrial) as well as ingestion of contaminated soil (terrestrial) or sediment (aquatic).
4) Inhalation of volatile soil contaminants (terrestrial).
5) Direct dermal contact with contaminated soil (terrestrial)

10.5.3 Ecological Conceptual Site Models

Ecological Conceptual Site Models (ECSMs) for the "foreshore sub-site" and the "terrestrial sub-site" are a description of how ecological receptors may be exposed to contaminants present on the sites, and identifies ecological receptors and exposure routes.

The ERA was conducted for species known or likely to be on each sub-site, or in the immediate vicinity of the Cambridge Bay Airport sites. The ECSM developed and relied upon for this assessment is shown in Figures 12-1 and 12-2. This model was prepared based on current use of the Cambridge Bay Airport sites and incorporates information onsite characteristics and environmental conditions.

10.6 Risk Characterization

In order to characterize risk based on exposure to contaminants in environmental media a qualitative estimate of the likelihood of exposure for each pathway was made based on the definitions presented in the table below.

Likelihood	Definition
Very Unlikely	Exposure levels not expected to have adverse effects
Unlikely	Exposure Level that could result in adverse effects would probably not occur
Possible	Level of exposure that could result in adverse effects might be expected
Likely	Level of exposure that could have adverse effects is expected. Exceedance of this exposure level might be expected

The potential risks associated with each potential hazard- exposure-receptor scenario are estimated by comparing the severity of the hazard with the likelihood of exposure (e.g. consideration of home range, receptor characteristics) according to the matrix seen below.

Risk Characterization		Exposure Assessment			
		Very Unlikely	**Unlikely**	**Possible**	**Likely**
Hazard Assessment	**Minimal**	Low	Low	Low	Low
	Minor	Low	Low	Medium	Medium
	Moderate	Low	Medium	Medium	High
	Severe	Low	Medium	High	High

Table 16: Risk Estimate for Qualitative Risk Assessment of the "Foreshore Site"

Hazard Description	Hazard Severity	Exposure Pathway Description	Likelihood of exposure	Critical Receptor	Potential Risk	COC Info. Level
COPC in surface soil	Minor (F2, Pb) Minimal (F1,F3, F4, Cu, As, Benzene, Ethylbenzene, Toluene, Xylene)	Dermal contact with soil	Likely	Terrestrial primary producers	Medium (F2,Pb) Low (F1,F3, F4, Cu, As, Benzene, Ethylbenzene, Toluene, Xylene**)**	High
	Minor (F2, Pb) Minimal (F1,F3, F4, Cu, As, Benzene, Ethylbenzene, Toluene, Xylene)	Ingestion of contaminated food items (e.g. tissue and/or vegetation)	Unlikely	Large Carnivores	Low (F1,F2, F3, F4, Cu, As, Pb, Benzene, Ethylbenzene, Toluene, Xylene**)**	High
	Minor (F2) Minimal (F1,F3, F4 Benzene, Ethylbenzene, Toluene, Xylene)	Inhalation of soil vapours	Very Unlikely	Small burrowing mammals	Low (F1,F2, F3, F4, Benzene, Ethylbenzene, Toluene, Xylene**)**	High
	Minor (F2, Pb) Minimal (F1,F3, F4, Cu, As, Benzene, Ethylbenzene, Toluene, Xylene)	Ingestion of soil particles	Possible	Soil invertebrates	Medium (F2,Pb) Low (F1,F3, F4, Cu, As, Benzene, Ethylbenzene, Toluene, Xylene)	High
COPC in sediment	Not Evaluated	Ingestion of Sediment	Unknown	Fish	Unknown	None
	Not Evaluated	Dermal Contact with Sediment	Unknown	Aquatic primary producers	Unknown	None
COPC in	Moderate (Xylene,	Dermal contact	Not	Terrestrial	Not evaluated	Low

GW	Naphthalene) Minor (Al, Fe) Minimal (F1, F2, Cd, Ni, Mn, St, Zn, Benzene, Toluene)	with GW	considered as an operable pathway	primary producers		
Possible COPC in surface water *	Moderate (F1,F2) Minor (Al, Ni, Fe, Cd, Toluene) Minimal (Mn, St, Zn, Naphthalene, Benzene, Xylenes)	Dermal Contact with Water (Aquatic)	Possible	Aquatic Invertebrates	Medium (F1,F2,Al, Ni, Fe, Cd, Toluene) Low (Mn, St, Zn, Naphthalene, Benzene, Xylenes)	None
	Moderate (F1,F2) Minor (Al, Ni, Fe, Cd, Toluene) Minimal (Mn, St, Zn, Naphthalene, Benzene, Xylenes)	Ingestion of contaminated water by aquatic receptors	Possible	Aquatic Invertebrates	Medium (F1,F2,Al, Ni, Fe, Cd, Toluene) Low (Mn, St, Zn, Naphthalene, Benzene, Xylenes)	None
	Moderate (Xylene), Minor (Al, Naphthalene), Minimal (F1, F2, Cd, Fe, Ni, Mn, St, Zn, Benzene, Toluene)	Ingestion of contaminated water by terrestrial receptors	Possible	Shore Birds	Medium (Xylene, Al, Naphthalene), Low (F1, F2, Cd, Fe, Ni, Mn, St, Zn, Benzene, Toluene)	None
	Moderate (F1,F2) Minor (Al, Ni, Fe, Cd, Toluene) Minimal (Mn, St, Zn, Naphthalene, Benzene, Xylenes)	Ingestion of contaminated food items (e.g. tissue and/or vegetation) by aquatic receptors	Unlikely	Fish	Medium (F1,F2) Low (Al, Ni, Fe, Cd, Toluene, Mn, St, Zn, Naphthalene, Benzene, Xylenes)	None
	Moderate (Xylene), Minor (Al, Naphthalene), Minimal (F1, F2, Cd, Fe, Ni, Mn, St, Zn, Benzene, Toluene)	Ingestion of contaminated food items (e.g. tissue and/or vegetation) by terrestrial receptors	Unlikely	Shore Birds	Medium (Xylene), Low (Al, Naphthalene, F1, F2, Cd, Fe, Ni, Mn, St, Zn, Benzene, Toluene)	None

*** -**based on an assumed dilution of COPCs in groundwater, at the point of discharge to the receiving aquatic environment

Risks from exposure to COPC in marine sediment in the sub-site vicinity have not been evaluated in this ERA, and further investigation is required for the evaluation of this media in a detailed ERA.

Table 17: Risk Estimate for Qualitative Risk Assessment of the "Terrestrial Site"

Hazard Description	Hazard Severity	Exposure Pathway Description	Likelihood of exposure	Critical Receptor	Potential Risk	COC Info. Level
COCs in surface soil	Severe (F2) Moderate (F1, Pb) Minor (F3) Minimal (F4, Cu, As, Benzene, Ethylbenzene, Toluene, Xylene)	Dermal contact with soil	Possible	Terrestrial primary producers	High (F2) Medium (F1,Pb,F3) Low (F4, Cu, As, Benzene, Ethylbenzene, Toluene, Xylene)	Low
	Severe (F2) Moderate (F1, Pb) Minor (F3) Minimal (F4, Cu, As, Benzene, Ethylbenzene, Toluene, Xylene)	Ingestion of contaminated food items (e.g. tissue and/or vegetation)	Very Unlikely	Large Carnivores	Low (F2, F1, Pb, F3, F4, Cu, As, Benzene, Ethylbenzene, Toluene, Xylene)	Low
	Severe(F2) Moderate(F1) Minor (F3) Minimal (F4, Benzene, Ethylbenzene, Toluene, Xylene)	Inhalation of soil vapours	Very Unlikely	Small burrowing mammals	Low (F2, F1, F3, F4, Benzene, Ethylbenzene, Toluene, Xylene)	Low
	Severe(F2) Moderate(F1, Pb) Minor (F3) Minimal (F4, Cu, As, Benzene, Ethylbenzene, Toluene, Xylene)	Ingestion of soil particles	Possible	Soil invert-ebrates	High (F2) Medium (F1,Pb,F3) Low (F4, Cu, As, Benzene, Ethylbenzene, Toluene, Xylene)	Low
COCs in sediment	Not Evaluated	Ingestion of sediment	Unlikely	Fish	Not Evaluated	None
	Not Evaluated	Dermal contact with sediment	Possible	Aquatic primary producers	Not Evaluated	None
COCs in GW	Minor (Fe, Napthalene, Xylene) Minimal (F1, F2, Al, Cd, Ni, Mn, St, Zn, Benzene, Toluene)	Dermal contact with GW	Not considered as an operable pathway	Terrestrial primary producers	Not evaluated	Low
Possible COPC in surface water*	Minor (F1, F2, Cd) Minimal (Benzene, Zn, Ni, Fe, Al, Mn, St, Naphthalene, Toluene,	Dermal Contact with Water (Aquatic)	Possible	Aquatic invert-ebrates	Medium (F1, F2, Cd) Low (Benzene, Zn, Ni, Fe, Al,	None

	Xylene)				Mn, St, Naphthalene, Toluene, Xylene)	
	Minor (F1, F2, Cd) Minimal (Benzene, Zn, Ni, Fe, Al, Mn, St, Naphthalene, Toluene, Xylene)	Ingestion of contaminated water by aquatic receptors	Possible	Aquatic invert-ebrates	Medium (F1, F2, Cd) Low (Benzene, Zn, Ni, Fe, Al, Mn, St, Naphthalene, Toluene, Xylene)	None
	Minor (Xylene) Minimal (F1, F2, Napthalene, Al, Fe, Cd, Ni, Mn, St, Zn, Benzene, Toluene)	Ingestion of contaminated water by terrestrial receptors	Very Unlikely	Terrestrial birds	Low (Xylene, F1, F2, Napthalene, Al, Fe, Cd, Ni, Mn, St, Zn, Benzene, Toluene)	None
	Minor (F1, F2, Cd) Minimal (Benzene, Zn, Ni, Fe, Al, Mn, St, Naphthalene, Toluene, Xylene)	Ingestion of contaminated food items (e.g. tissue and/or vegetation) by aquatic receptors	Very Unlikely	Fish	Low (F1, F2, Cd, Benzene, Zn, Ni, Fe, Al, Mn, St, Naphthalene, Toluene, Xylene)	None
	Minor (Xylene) Minimal (F1, F2, Napthalene, Al, Fe, Cd, Ni, Mn, St, Zn, Benzene, Toluene)	Ingestion of contaminated food items (e.g. tissue and/or vegetation) by terrestrial receptors	Very Unlikely	Large Carnivores	Low (Xylene, F1, F2, Napthalene, Al, Fe, Cd, Ni, Mn, St, Zn, Benzene, Toluene)	None

*** -**based on an assumed dilution of COPCs in groundwater, at the point of discharge to the receiving aquatic environment

Details from the field investigation conducted during the Phase II/III ESA, indicate that at the time of the investigation little to no vegetation was observed on the "terrestrial sub-site" (FRANZ, 2010). Surface waters in the sub-site vicinity are generally ephemeral, activated by melt waters from thawed permafrost, and unlikely to contain aquatic life. As a measure of conservatism the presence of aquatic life has been assumed in large surface water bodies in the sub-site vicinity, until the absence of aquatic life can be confirmed by further investigation.

COPC in the sediment of freshwater surface water in the sub-site vicinity have not been evaluated in this ERA, and further information and investigation is required for the evaluation of this media in a detailed ERA.

10.6.1 Discussion of Uncertainty

The major sources of uncertainty associated with this qualitative ecological risk assessment includes factors such as representative chemical concentrations, the behaviour of chemicals in mixtures and under variable environmental conditions, assumed receptor characteristics for species within feeding guilds, and species sensitivities to COPC in environmental media.

Representative Chemical Concentrations

One source of uncertainty is the use of maximum COPC concentrations recorded for various media to assess potential impacts to ecological receptors. This approach overestimates the potential for negative effects for several reasons. First, many ecological receptors are mobile to varying degrees within and outside of the study area, and therefore will not be continuously exposed to the highest COPC concentrations recorded. This is true even for plants, which have some limited capacity for movement as roots extend progressively in colonized soil. Secondly, environmental conditions that influence exposure to COPC can be extremely variable, both temporally and spatially, and this variability can have a direct influence on the toxic response of receptors.

Initial risk estimates for aquatic and terrestrial receptors exposed to receiving waters are based on an assumed tenfold dilution of groundwater at the point of discharge to the receiving environment; as insufficient surface water and sediment data was available to delineate the intensity and magnitude of contaminant flow into water bodies in the vicinity of the sites. The effect of applying a ten-fold dilution factor to concentrations of contaminants in groundwater in the risk assessment for surface water exposures is unknown, but likely overestimates risk. A refinement of risk estimates for aquatic receptors will require further investigation and data collection from the aquatic environment (sediment and surface water).

Representative Receptors for Feeding Guilds

Feeding guilds considered in the ERA were chosen based on the likelihood of species within the guild being present onsite, and their classification as an endangered or at risk species (e.g. Bowhead whale). That not all receptor species were considered in this ERA represents a source of uncertainty in the assessment and potential overestimation of risk for all species belonging to each feeding guild.

Toxicological Benchmarks

Another major source of uncertainty is the applicability of the toxicological benchmarks chosen in the effects assessment to the various exposure pathways and ecological receptors identified in this report. The benchmarks chosen were considered to be protective of the most sensitive receptor guild given the exposure pathways for each environmental media. However these toxicological benchmarks are for general receptor guilds, not specific to site-specific species and are considered to be protective of all receptor guild populations that may be present in a given location. As such, they are likely to overestimate potential risk as they are designed to ensure comprehensive protection to even the most sensitive species of each receptor guild. The lack of toxicological benchmarks for specific COPC in each environmental media, and for combinations of COPC in media represents an important source of uncertainty. Toxicological benchmarks for potentially less sensitive, higher level receptors onsite were not considered in the effects assessment and as such represents a source of uncertainty in the assessment. Finally, the use of established benchmark values for comparison with contaminant concentrations in environmental media may lead to an overestimation of the actual risks. In general, these values have been developed using highly conservative assumptions regarding chemical fate and transport characteristics, physicochemical properties, ecotoxicological endpoints and exposure calculations.

Chemical Interactions

Finally, there is uncertainty regarding the potential chemical interaction of the various COPC identified at the sites. It is accepted that chemical interactions can cause antagonistic, additive or synergistic toxic effects. Although interactions have been described in the literature for specific endpoints of specific receptors for simple combinations of some of the COPC identified in this report, the nature and effect of the vast majority of possible interactions is unknown.

10.7 ERA Conclusions

An ERA was conducted to **qualitatively** identify potential risks to ecological receptors at the "foreshore" and "terrestrial" sub-sites at the Cambridge Bay Airport. Potential impacts were evaluated using the maximum chemical concentrations in environmental media.

Based on the results of the chemical screening, effects assessment, exposure assessment and **qualitative** risk characterization preliminary conclusions are as follows:

- Petroleum hydrocarbon fraction 2 (F2), and lead concentrations in soil represent medium risk to terrestrial plants at the "foreshore" sub-site through dermal contact with contaminated soil, and to soil invertebrates with the potential to ingest contaminated soil particles;
- Concentrations of volatile COPC in soil represent low risk to burrowing terrestrial receptors (e.g. small burrowing mammals) exposed via inhalation of soil vapours at the "terrestrial" or "foreshore" sub-sites;
- Exposure to groundwater was considered an incomplete exposure pathway at both sub-sites and, was not evaluated as a potential risk to ecological receptors;
- Potential concentrations of COPC in receiving marine water at the "foreshore" sub-site (derived from an assumed ten-fold dilution of COPC in groundwater) indicate that concentrations of PHCs F1, F2, aluminum, nickel, iron, cadmium and toluene from discharging groundwater represent medium risks to aquatic invertebrates exposed via dermal contact with, and ingestion of contaminated water. Potential concentrations of Potential PHC F1 and F2 concentrations in surface water also represent medium risk to piscivorous fish exposed via ingestion of contaminated food items;
- Potential concentrations of COPC in receiving marine water at the "foreshore" sub-site indicate that concentrations of xylene, aluminum, and naphthalene from discharging groundwater represent medium risks to piscivorous shorebirds exposed via ingestion of contaminated water and contaminated food items from the marine environment;
- PHC F2 concentrations in soil represents a high risk to terrestrial plants at the "terrestrial" sub-site through dermal contact with contaminated soil and to soil invertebrates via ingestion of soil particles. Petroleum hydrocarbons F1 and F3, and lead concentrations in soil at the "terrestrial" sub-site represent medium risk to terrestrial plants through dermal contact with contaminated soil, and to soil invertebrates with the potential to ingest contaminated soil particles;
- Potential concentrations of COPC in receiving freshwater near the "terrestrial" sub-site (derived from an assumed ten-fold dilution of COCs in groundwater) indicate that concentrations of PHCs F1, F2, and cadmium from discharging groundwater represent medium risks to aquatic invertebrates exposed via dermal contact with, and ingestion of

contaminated water. Ingestion of food items from receiving waters of discharging groundwater was not considered to represent significant risks to aquatic receptors (piscivorous fish);

- Ingestion of food items from receiving waters of discharging groundwater was not considered to represent significant risks to terrestrial receptors (terrestrial birds and large carnivores) exposed via ingestion of contaminated water and contaminated food items from the receiving freshwater environment.

11.0 OVERALL CONCLUSIONS

The primary objective of this Human Health and Ecological Risk Assessment Report was to preliminarily assess risks to human health and the ecology from previously identified COPC in soil, and groundwater the risk assessment consisted of both a preliminary human health risk assessment (HHRA) and an ecological qualitative risk assessment (ERA).

11.1 Human Health

A human health risk assessment was conducted in accordance Health Canada PQRA guidance documents (Health Canada, 2004, 2007, 2009 updates).

A screening to identify Chemicals of Potential Concern (COPC) was completed by comparing maximum concentrations of contaminants with select guidelines/standards. The following COPC were identified and used as inputs in the PQRA spreadsheets:

- Metals – arsenic, copper, and lead
- PHCs – benzene, ethylbenzene, toluene, xylenes, PHC fraction F 1 and F2
- PAHs – benzo(a)pyrene

Potential Receptors and Operable Pathways

Potential human receptors at the sites include:

- Adult airport employees involved in operational and maintenance activities onsite; and
- Remedial workers or adult construction workers involved in demolition, remediation and maintenance activities.

The operable pathways considered for the HHRA were:

- Accidental ingestion of soil particles, and inhalation of soil particles (fugitive dust); and
- Dermal contact to soil and groundwater.

Risk Characterization

The target HQ of 0.2 has been exceeded in the site remediation worker receptor chronic scenario, for multiple COPC. The results indicate there are unacceptable risks primarily with oral/dermal exposures. The modeling suggests that the highest potential risk is from the oral/dermal exposure for the following listed in order of descending HQ: PHC F2, and PHC F1.

Derivation of sub-chronic hazard quotients to assess acute risks to site remediation workers from short-term exposure to non-carcinogens suggest that the target HQ of 1.0 has been exceeded by the COPC mixture PHC F2, and that unacceptable sub-chronic risk is mainly a function of oral/dermal exposure.

The Health Canada recommended threshold for ILCR (1.0E-05) has been exceeded by exposure to carcinogens (i.e., benzene) for onsite site remediation workers. The results indicate there are unacceptable risks primarily with oral/dermal exposures. The HHRA calculations are estimates only and do not represent actual risks.

Risk Management

To help reduce the risk of oral/dermal exposure to PHCs in soils onsite, all remediation workers should wear appropriate personal protective equipment and practice prudent hygiene.

11.2 Ecological

An evaluation of COPC, ecological receptors, and relevant exposure pathways was conducted to develop Ecological Conceptual Site Models for the "foreshore" and "terrestrial" sub-sites to support an ERA. The ERA considered species known or likely to be on or in the immediate vicinity of the sites. Feeding guilds considered include primary producers, primary consumers (e.g., herbivorous invertebrates and mammals), secondary consumers (e.g. omnivorous birds and mammals) and tertiary consumers (e.g., carnivorous mammals).

COPC identified in environmental media were subject to a further "qualitative screening assessment". This involved a comparison of the COPC concentrations in media to toxicological benchmark values protective of ecological receptor guilds. The outcome was a qualitative ranking of the COPC according to their potential to cause harmful effects to ecological receptors. The COPC identified include:

- Soil – F1,F2, F3, F4, Cu, As, Pb, Benzene, Ethylbenzene, Toluene, Xylene; and
- Groundwater- F1,F2, Al, Cd, Ni, Fe, Mn, St, Zn, Naphthalene, Benzene, Toluene, Xylene

Direct contact with groundwater was deemed an incomplete exposure pathway for ecological receptors in the ERA. However, groundwater will eventually drain into receiving surface waters (marine and freshwater) which are utilized by terrestrial wildlife receptors as well as aquatic life at both the "terrestrial sub-site" and "foreshore sub-site". A tenfold dilution factor, to account for groundwater mixing and dilution within the transition zone between groundwater and receiving water (BC MOE, Technical Guidance Document 15-Draft, August 2009) was applied to max

concentrations of COPC in groundwater. Diluted concentrations of COPC in groundwater at both the "terrestrial sub-site" and "foreshore sub-site" were further screened against wildlife and aquatic life toxicological benchmarks to provide preliminary and conservative indicators of receiving surface water quality and potential effects of COPC on aquatic and terrestrial receptors.

Operable Pathways

The following exposure pathways are identified as most significant to ecological receptors on/near the sites:

- Leaching of subsurface contamination into groundwater and transport into surface waters, followed by trans-dermal uptake by aquatic species (higher and lower trophic levels) through contact with surface water, and sediments.
- Ingestion of contaminated surface waters (terrestrial and aquatic).
- Ingestion of contaminated food items (aquatic and terrestrial) as well as ingestion of contaminated soil (terrestrial) or sediment (aquatic).
- Inhalation of volatile soil contaminants (terrestrial).
- Direct dermal contact with contaminated soil (terrestrial).

Risks from exposure to COPC in marine/freshwater sediment in receiving waters near the "foreshore" and "terrestrial" sub-sites have not been evaluated in this ERA; further investigation is required for the evaluation of this media in a detailed ERA.

Risk Characterization

Based on the chemical screening, effects assessment, exposure assessment and qualitative risk characterization preliminary conclusions are as follows:

- PHC F2, and lead concentrations in soil represent medium risk to terrestrial plants at the "foreshore" sub-site through dermal contact with contaminated soil, and to soil invertebrates with the potential to ingest contaminated soil particles;
- Volatile COPC in soil represent low risk to burrowing terrestrial receptors (e.g. small burrowing mammals) exposed via inhalation of soil vapours at the "terrestrial" or "foreshore" sub-sites;
- Exposure to groundwater was considered an incomplete exposure pathway at both sub-sites and, was not evaluated as a potential risk to ecological receptors;
- Potential concentrations of COPC in receiving marine water at the "foreshore" sub-site (derived from an assumed ten-fold dilution of contaminants in groundwater) indicate that

concentrations of PHCs F1, F2, aluminum, nickel, iron, cadmium and toluene from discharging groundwater represent medium risks to aquatic invertebrates exposed via dermal contact with, and ingestion of contaminated water. Potential PHC F1 and F2 concentrations in surface water also represent medium risk to piscivorous fish exposed via ingestion of contaminated food items;

- Potential concentrations of COPC in receiving marine water at the "foreshore" sub-site indicate that concentrations of xylene, aluminum, and naphthalene from discharging groundwater represent medium risks to piscivorous shorebirds exposed via ingestion of contaminated water and contaminated food items from the marine environment;
- PHC F2 concentrations in soil represent **high** risk to terrestrial plants at the "terrestrial" sub-site through dermal contact with contaminated soil and to soil invertebrates via ingestion of soil particles. Petroleum hydrocarbons F1 and F3, and lead concentrations in soil at the "terrestrial" sub-site represent medium risk to terrestrial plants and soil invertebrates through these exposure pathways;
- Potential COPC in receiving freshwater near the "terrestrial" sub-site indicate PHCs F1, F2, and cadmium from discharging groundwater represent medium risks to aquatic invertebrates exposed via dermal contact with, and ingestion of contaminated water. Ingestion of food items from receiving waters of discharging groundwater was not considered to represent significant risks to aquatic receptors (piscivorous fish);
- Ingestion of food items from receiving waters of discharging groundwater was not considered to represent significant risks to terrestrial receptors (terrestrial birds and large carnivores) exposed via ingestion of contaminated water and contaminated food items from the receiving freshwater environment.

Sources of uncertainty associated with this qualitative ERA includes factors such as representative chemical concentrations, the behaviour of chemicals in mixtures and under variable environmental conditions, assumed receptor characteristics for species within feeding guilds, and species sensitivities to contaminants in environmental media.

11.3 Recommendations

Action should be taken to manage the high concentrations of contamination at the sites that drives the human health risk assessment results.

If no action is taken to manage the high concentration of contamination at the sites, then further refinement of the human health and ecological risk assessment is warranted. The most appropriate areas to further refine the risk assessment include:

1) Refine the human health and ecological exposure scenarios to better reflect actual

patterns of exposure for onsite receptors.

2) Refine the statistical database/input parameters to determine the most appropriate statistic values (e.g. 95% upper confidence limits) for contamination concentrations.

3) Carry out a site specific ERA in which site specific modelling of ecological receptors exposure to contaminants is applied, and risks to ecological receptors are quantitatively characterized. A site specific ERA will require further investigation and data collection from receiving surface water and sediment in the site vicinity to quantify risk to receptors via exposure to these media .

12.0 LIMITATIONS

Franz Environmental Inc. prepared this report for Public Works and Government Services Canada – Pacific Region on behalf of Transport Canada. The material in this report reflects Franz Environmental Inc.'s judgment in light of the information available to us at the time of preparation.

There is no warranty expressed or implied that this risk assessment has resolved all potential environmental liabilities associated with the subject property. It is believed however, that the level of detail carried out for this work is appropriate to meet the study objectives. The findings and conclusions are site-specific and were developed in a manner consistent with the level of care and skill normally exercised by environmental professionals currently practicing under similar conditions in the area. The undersigned believe this report to be accurate, however they cannot guarantee the completeness or accuracy of information supplied to them.

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Figures

Figure 6-1 Cambridge Bay Airport APEC Sites
Human Health (PQRA) Conceptual Model

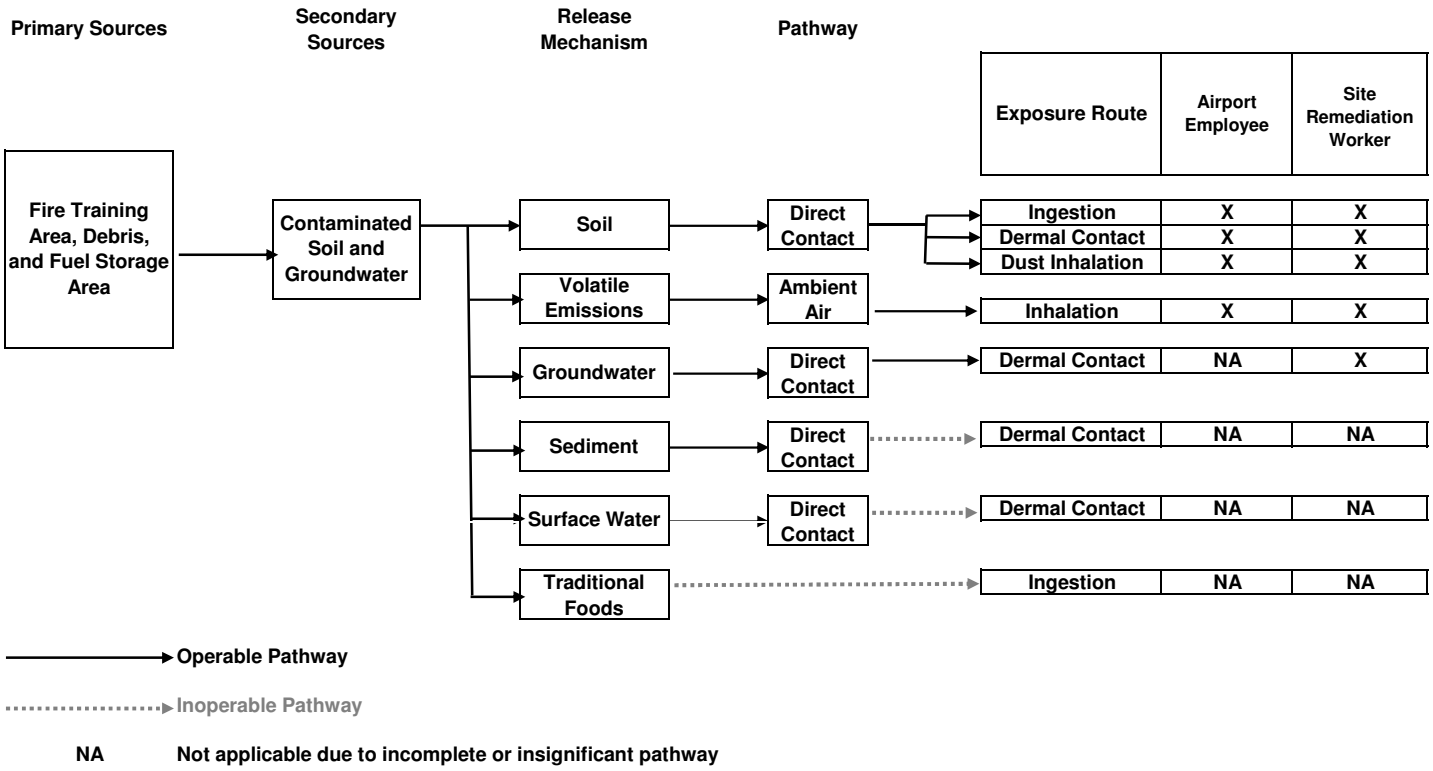
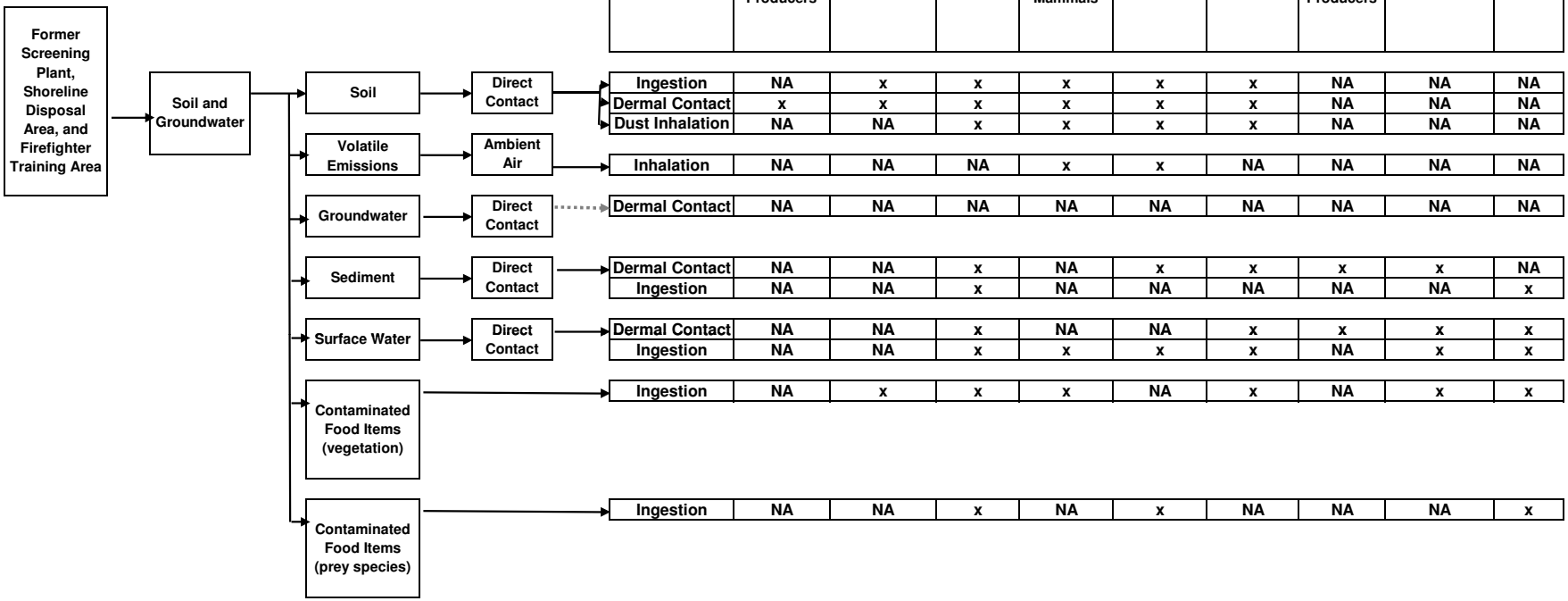


Fig. 12-1
Cambridge Bay
"Foreshore" sub-site (APEC 1, AEC 2,AEC 3)
Ecological (ERA) CSM



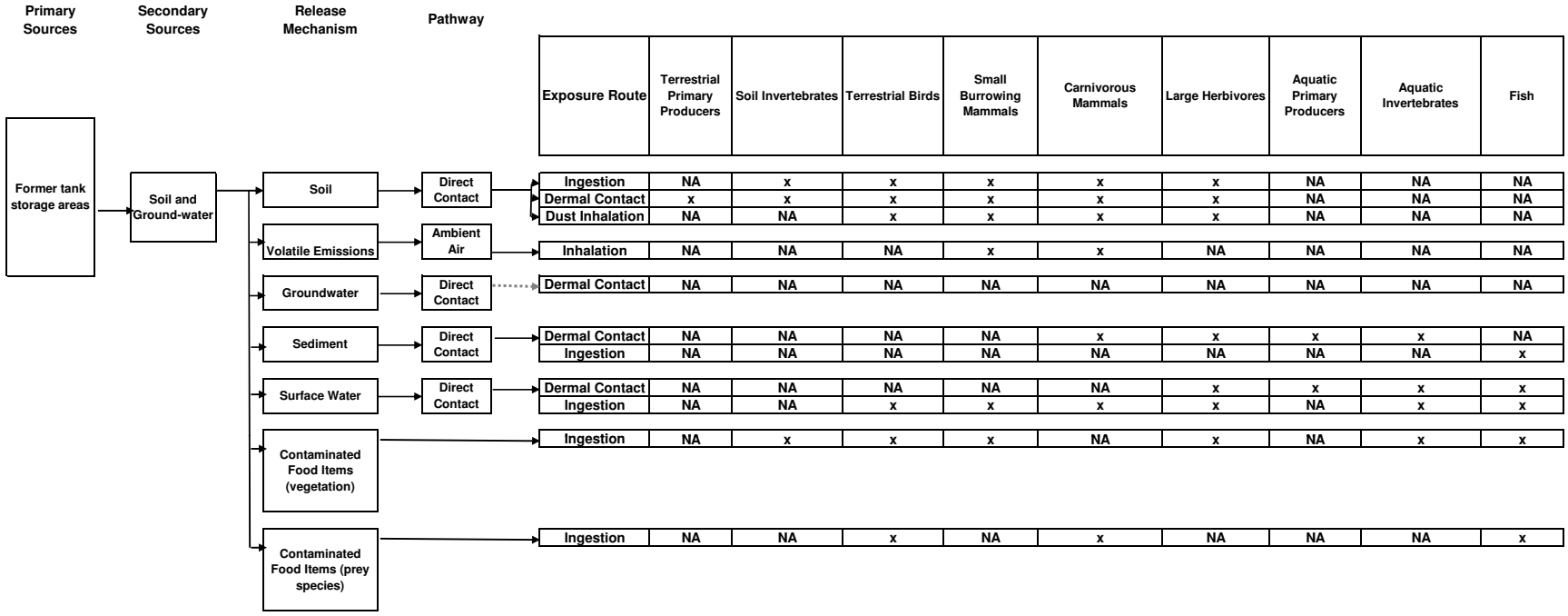
Exposure Route	Terrestrial Primary Producers	Soil Invertebrates	Shore Birds	Small Burrowing Mammals	Carnivorous Mammals	Large Herbivores	Aquatic Primary Producers	Aquatic Invertebrates	Fish
Ingestion	NA	x	x	x	x	x	NA	NA	NA
Dermal Contact	x	x	x	x	x	x	NA	NA	NA
Dust Inhalation	NA	NA	x	x	x	x	NA	NA	NA
Inhalation	NA	NA	NA	x	x	NA	NA	NA	NA
Dermal Contact	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dermal Contact	NA	NA	x	NA	x	x	x	x	NA
Ingestion	NA	NA	x	NA	NA	NA	NA	NA	x
Dermal Contact	NA	NA	x	NA	NA	x	x	x	x
Ingestion	NA	NA	x	x	x	x	NA	x	x
Ingestion	NA	x	x	x	NA	x	NA	x	x
Ingestion	NA	NA	x	NA	x	NA	NA	NA	x

→ Operable Pathway

⇢ Inoperable Pathway

NA Not applicable due to incomplete or insignificant pathway

Fig 12-2
Cambridge Bay Airport
"Terrestrial" subsite (AEC 4, APEC 5, APEC 6)
Ecological (ERA) CSM



Exposure Route	Terrestrial Primary Producers	Soil Invertebrates	Terrestrial Birds	Small Burrowing Mammals	Carnivorous Mammals	Large Herbivores	Aquatic Primary Producers	Aquatic Invertebrates	Fish
Ingestion	NA	x	x	x	x	x	NA	NA	NA
Dermal Contact	x	x	x	x	x	x	NA	NA	NA
Dust Inhalation	NA	NA	x	x	x	x	NA	NA	NA
Inhalation	NA	NA	NA	x	x	NA	NA	NA	NA
Dermal Contact	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dermal Contact	NA	NA	NA	NA	x	x	x	x	NA
Ingestion	NA	NA	NA	NA	NA	NA	NA	NA	x
Dermal Contact	NA	NA	NA	NA	NA	x	x	x	x
Ingestion	NA	NA	x	x	x	x	NA	x	x
Ingestion	NA	x	x	x	NA	x	NA	x	x
Ingestion	NA	NA	x	NA	x	NA	NA	NA	x

Operable Pathway

Inoperable Pathway

NA Not applicable due to incomplete or insignificant pathway

Appendix A

Risk Assessment Data Summary Tables

Soil Chemistry - Summary
Cambridge Bay Airport Risk Assessment
Franz Project # 1748-0902

Parameter	Media	EcoRA Screening Criteria	EcoRA Screening Criteria Source	PQRA Screening Criteria	PQRAScreening Criteria Source	Units	Number of Samples	Average	Standard Deviation	Minimum	Maximum	Location of Max	% ND	Screened into Eco RA?	Screened into PQRA?
Benzene	soil	0.03	CL EQG, CCME 2007	0.03	CL EQG, CCME 2007	ug/g	42	0.26	0.86	0.005	**4.6**	4A-09-5	74%	**yes**	**yes**
Ethylbenzene	soil	0.082	CL EQG, CCME 2007	0.082	CL EQG, CCME 2007	ug/g	42	0.47	1.64	0.01	**6.8**	4A-09-4	76%	**yes**	**yes**
Toluene	soil	0.37	CL EQG, CCME 2007	0.37	CL EQG, CCME 2007	ug/g	42	1.32	6.10	0.03	**37**	4A-09-4	83%	**yes**	**yes**
Xylenes (total)	soil	11	CL EQG, CCME 2007	11	CL EQG, CCME 2007	ug/g	42	6.13	24.53	0.1	**140**	4A-09-4	81%	**yes**	**yes**
Total Purgeable Hydrocarbons	soil	NC	NC	NC	NC	ug/g	5	57.63	107.31	0.25	247.54	YCB-09 (APEC5)	40%	no	no
Total Extractable Petroleum Hydrocarbons	soil	NC	NC	NC	NC	ug/g	6	3435.17	5926.62	20	15248	YCB-FFTA (APEC3)	33%	no	no
Total Petroleum Hydrocarbons	soil	2500	GNWT Remediation Guidelines for Soil	2500	GNWT Remediation Guidelines for Soil	ug/g	6	3483.11	5921.79	20	**15248**	YCB-FFTA (APEC3)	33%	no	no
F1 (C6-C10)	soil	320	CL CWS, CCME 2008 (cg, surface)	19000	CL CWS, CCME 2008 (cg, surface, dir Cont.)-tech guidance	ug/g	23	610.30	1581.10	10	**4800**	4A-09-3M	83%	**yes**	no
F2 (C10-C16)	soil	260	CL CWS, CCME 2008 (cg, surface)	10000	CL CWS, CCME 2008 (cg, surface, dir. Cont.)-tech guidance	ug/g	42	485.71	1929.92	10	**12000**	**4A-09-5**	71%	**yes**	**yes**
F3 (C16-C34)	soil	1700	CL CWS, CCME 2008 (cg, surface)	23000	CL CWS, CCME 2008 (cg, surface, dir. Cont.)-tech guidance	ug/g	42	225.93	982.66	10	**6400**	**4A-09-5**	38%	**yes**	no
F4 (C34-C50)	soil	3300	CL CWS, CCME 2008 (cg, surface)	30000	CL CWS, CCME 2008 (cg, surface, dir. Cont.)-tech guidance	ug/g	42	113.83	599.83	10	**3900**	4A-09-5	81%	**yes**	no
Antimony	soil	40	CL, Table 3, OMOE 2009	40	CL EQG, CCME 2007	ug/g	24	0.16	0.11	0.1	0.6	2-09-TP6-1	42%	no	no
Arsenic	soil	12	CL EQG, CCME 2007	12	CL EQG, CCME 2007	ug/g	34	3.90	6.80	0.7	**40.6**	2-09-TP6-1	0%	**yes**	**yes**
Barium	soil	2000	CL EQG, CCME 2007	2000	CL EQG, CCME 2007	ug/g	34	46.60	88.50	17.1	545	YCB-FFTA (APEC 3)	0%	no	no
Beryllium	soil	8	CL EQG, CCME 2007	8	CL EQG, CCME 2007	ug/g	24	0.42	0.16	0.2	0.7	2-09-TP10-1	0%	no	no
Cadmium	soil	22	CL EQG, CCME 2007	22	CL EQG, CCME 2007	ug/g	34	0.20	0.40	0.1	1.7	2-09-TP5 (GR2)	71%	no	no
Chromium	soil	87	CL EQG, CCME 2007	87	CL EQG, CCME 2007	ug/g	34	14.90	4.90	7.0	27	2-09-TP2-2	0%	no	no
Cobalt	soil	300	CL EQG, CCME 2007	300	CL EQG, CCME 2007	ug/g	34	5.60	3.10	1.2	16.0	2-09-TP10-1	0%	no	no
Copper	soil	91	CL EQG, CCME 2007	91	CL EQG, CCME 2007	ug/g	34	18.10	21.10	4.3	**102**	**2-09-TP5 (GR2)**	0%	**yes**	**yes**
Lead	soil	260	CL EQG, CCME 2007	260	CL EQG, CCME 2007	ug/g	34	18.60	49.30	3.0	**294**	**4A-09-5-1**	9%	**yes**	**yes**
Mercury	soil	24	CL EQG, CCME 2007	24	CL EQG, CCME 2007	ug/g	34	0.00	0.00	0.0	0.1	nc	71%	no	no
Molybdenum	soil	40	CL EQG, CCME 2007	40	CL EQG, CCME 2007	ug/g	34	1.20	1.70	0.2	7.4	2-09-TP6-1	29%	no	no
Nickel	soil	50	CL EQG, CCME 2007	50	CL EQG, CCME 2007	ug/g	34	13.50	6.60	4.1	32.1	2-09-TP5-1	0%	no	no
Selenium	soil	2.9	CL EQG, CCME 2007	2.9	CL EQG, CCME 2007	ug/g	24	0.52	0.08	0.5	0.9	2-09-TP1-2	96%	no	no
Silver	soil	40	CL EQG, CCME 2007	40	CL EQG, CCME 2007	ug/g	24	0.06	0.02	0.1	0.1	2-09-TP8-1	38%	no	no
Thallium	soil	1	CL EQG, CCME 2007	1	CL EQG, CCME 2007	ug/g	24	0.11	0.03	0.1	**0**	2-09-TP8-1	0%	no	no
Vanadium	soil	130	CL EQG, CCME 2007	130	CL EQG, CCME 2007	ug/g	34	22.60	10.60	9.8	69.0	2-09-TP6-1	0%	no	no
Zinc	soil	360	CL EQG, CCME 2007	360	CL EQG, CCME 2007	ug/g	34	25.50	35.80	5.1	185.0	YCB-FFTA (APEC 3)	0%	no	no
Acenaphthene	soil	96	CL, Table 3, OMOE 2009	96	CL, Table 3, OMOE 2009	ug/g	16	0.07	0.20	0.01	0.8	4A-09-5-1	81%	no	no
Acenaphthylene	soil	0.15	CL, Table 3, OMOE 2009	0.15	CL, Table 3, OMOE 2009	ug/g	16	0.05	0.10	0.01	**0.4**	**4A-09-5-1**	100%	**yes**	**yes**
Anthracene	soil	32[E]	CL SoQG for PAH, CCME 2008	0.67	CL, Table 3, OMOE 2009	ug/g	16	0.04	0.08	0.01	0.3	4A-09-5-1	94%	no	no
Benzo(a)anthracene	soil	10	CL EQG, CCME 2007	10	CL EQG, CCME 2007	ug/g	20	0.07	0.08	0.01	0.2	APEC 1 and 3	75%	no	no
Benzo(a)pyrene	soil	72[E]	CL SoQG for PAH, CCME 2008	3 (BaP TPE)	CL SoQG for PAH, CCME 2008	ug/g	20	0.23	0.40	0.01	1	APEC 1 and 3	75%	no	no
Benzo(b+j)fluoranthene	soil	10	CL EQG, CCME 2007	10	CL EQG, CCME 2007	ug/g	20	0.23	0.40	0.01	1	APEC 1 and 3	75%	no	no
Benzo(g,h,i)perylene	soil	6.8[PW]	CL SoQG for PAH, CCME 2008	6.8[PW]	CL SoQG for PAH, CCME 2008	ug/g	16	0.05	0.06	0.02	0.2	4A-09-4-1	94%	no	no
Benzo(k)fluoranthene	soil	10	CL EQG, CCME 2007	10	CL EQG, CCME 2007	ug/g	20	0.22	0.40	0.01	1	APEC 1 and 3	75%	no	no
Chrysene	soil	6.2[R/PL]	CL SoQG for PAH, CCME 2008	2.1[PW]	CL SoQG for PAH, CCME 2008	ug/g	16	0.03	0.05	0.01	0.19	5-09-TP3-1	94%	no	no
Dibenz(a,h)anthracene	soil	10	CL EQG, CCME 2007	10	CL EQG, CCME 2007	ug/g	20	0.43	0.81	0.02	0.2	APEC 1 and 3	80%	no	no
Fluoranthene	soil	180[E]	CL SoQG for PAH, CCME 2008	9.6	CL, Table 3, OMOE 2009	ug/g	16	0.06	0.15	0.01	0.6	5-09-TP3-1	88%	no	no
Fluorene	soil	15.4[I]	CL SoQG for PAH, CCME 2008	62	CL, Table 3, OMOE 2009	ug/g	16	0.21	0.65	0.01	2.6	4A-09-5-1	75%	no	no
Indeno(1,2,3-cd)pyrene	soil	10	CL EQG, CCME 2007	10	CL EQG, CCME 2007	ug/g	19	0.36	0.73	0.02	2	APEC 1 and 3	79%	no	no
2-Methylnaphthalene	soil	76	CL, Table 3, OMOE 2009	76	CL, Table 3, OMOE 2009	ug/g	16	3.40	9.91	0.01	39	4A-09-5-1	69%	no	no
Naphthalene	soil	22	CL EQG, CCME 2007	22	CL EQG, CCME 2007	ug/g	20	0.99	2.99	0.01	13	4A-09-5-1	50%	no	no
Phenanthrene	soil	50	CL EQG, CCME 2007	50	CL EQG, CCME 2007	ug/g	20	0.22	0.57	0.01	2.6	4A-09-5-1	60%	no	no
Pyrene	soil	100	CL EQG, CCME 2007	100	CL EQG, CCME 2007	ug/g	20	0.05	0.10	0.01	0.4	APEC 1,3, and 5	65%	no	no
Polychlorinated biphenyls	soil	33	CL EQG, CCME 2007	33	CL EQG, CCME 2007	ug/g	3	1.00	0.00	1	1	APEC 1	0%	no	no
Benzene	soil	0.03	CL EQG, CCME 2007	0.03	CL EQG, CCME 2007	ug/g	42	0.26	0.86	0.005	**4.6**	**4A-09-5-1**	76%	**yes**	**yes**
Bromodichloromethane	soil	18	CL, Table 3, OMOE 2009	18	CL, Table 3, OMOE 2009	ug/g	23	0.05	nc	nc	nc	nc	100%	no (ND)	no (ND)
Bromoform	soil	0.61	CL, Table 3, OMOE 2009	0.61	CL, Table 3, OMOE 2009	ug/g	23	0.05	nc	nc	nc	nc	100%	no (ND)	no (ND)
Bromomethane	soil	0.05	CL, Table 3, OMOE 2009	0.05	CL, Table 3, OMOE 2009	ug/g	23	0.30	nc	nc	nc	nc	100%	no (ND)	no (ND)
Carbon tetrachloride	soil	50	CL EQG, CCME 2007	50	CL EQG, CCME 2007	ug/g	23	0.03	nc	nc	nc	nc	100%	no (ND)	no (ND)
Chlorobenzene	soil	10	CL EQG, CCME 2007	10	CL EQG, CCME 2007	ug/g	23	0.03	nc	nc	nc	nc	100%	no (ND)	no (ND)
Chlorodibromomethane	soil	13	CL, Table 3, OMOE 2009	13	CL, Table 3, OMOE 2009	ug/g	23	0.05	nc	nc	nc	nc	100%	no (ND)	no (ND)
Chloroform	soil	50	CL EQG, CCME 2007	50	CL EQG, CCME 2007	ug/g	23	0.05	nc	nc	nc	nc	100%	no (ND)	no (ND)
1,2-Dichlorobenzene	soil	10	CL EQG, CCME 2007	10	CL EQG, CCME 2007	ug/g	23	0.03	nc	nc	nc	nc	100%	no (ND)	no (ND)
1,3-Dichlorobenzene	soil	10	CL EQG, CCME 2007	10	CL EQG, CCME 2007	ug/g	23	0.03	nc	nc	nc	nc	100%	no (ND)	no (ND)
1,4-Dichlorobenzene	soil	10	CL EQG, CCME 2007	10	CL EQG, CCME 2007	ug/g	23	0.03	nc	nc	nc	nc	100%	no (ND)	no (ND)
1,1-Dichloroethane	soil	50	CL EQG, CCME 2007	50	CL EQG, CCME 2007	ug/g	23	0.03	nc	nc	nc	nc	100%	no (ND)	no (ND)
1,2-Dichloroethane	soil	50	CL EQG, CCME 2007	50	CL EQG, CCME 2007	ug/g	23	0.03	nc	nc	nc	nc	100%	no (ND)	no (ND)
1,1-Dichloroethene	soil	50	CL EQG, CCME 2007	50	CL EQG, CCME 2007	ug/g	23	0.03	nc	nc	nc	nc	100%	no (ND)	no (ND)
cis-1,2-Dichloroethene	soil	50	CL EQG, CCME 2007	50	CL EQG, CCME 2007	ug/g	23	0.03	nc	nc	nc	nc	100%	no (ND)	no (ND)
trans-1,2-Dichloroethene	soil	50	CL EQG, CCME 2007	50	CL EQG, CCME 2007	ug/g	23	0.03	nc	nc	nc	nc	100%	no (ND)	no (ND)
Dichloromethane	soil	50	CL EQG, CCME 2007	50	CL EQG, CCME 2007	ug/g	23	0.10	nc	nc	nc	nc	100%	no (ND)	no (ND)
1,2-Dichloropropane	soil	50	CL EQG, CCME 2007	50	CL EQG, CCME 2007	ug/g	23	0.03	nc	nc	nc	nc	100%	no (ND)	no (ND)
cis-1,3-Dichloropropene	soil	50	CL EQG, CCME 2007	50	CL EQG, CCME 2007	ug/g	23	0.05	nc	nc	nc	nc	100%	no (ND)	no (ND)
trans-1,3-Dichloropropene	soil	50	CL EQG, CCME 2007	50	CL EQG, CCME 2007	ug/g	23	0.05	nc	nc	nc	nc	100%	no (ND)	no (ND)

Soil Chemistry - Summary
Cambridge Bay Airport Risk Assessment
Franz Project # 1748-0902

Parameter	Media	**EcoRA Screening Criteria**	EcoRA Screening Criteria Source	**PQRA Screening Criteria**	PQRAScreening Criteria Source	Units	Number of Samples	Average	Standard Deviation	Minimum	Maximum	Location of Max	% ND	Screened into Eco RA?	Screened into PQRA?
Ethylbenzene	soil	0.082	CL EQG, CCME 2007	0.082	CL EQG, CCME 2007	ug/g	42	0.47	1.64	0.087	**6.8**	**4A-09-4-1**	76%	**yes**	**yes**
Methyl-tert-butylether	soil	11	CL, Table 3, OMOE 2009	11	CL, Table 3, OMOE 2009	ug/g	42	0.10	nc	nc	nc	nc	100%	no (ND)	no (ND)
Styrene	soil	50	CL EQG, CCME 2007	50	CL EQG, CCME 2007	ug/g	42	0.10	nc	nc	nc	nc	100%	no (ND)	no (ND)
1,1,1,2-Tetrachloroethane	soil	0.087	CL, Table 3, OMOE 2009	0.087	CL, Table 3, OMOE 2009	ug/g	23	0.03	nc	nc	nc	nc	100%	no (ND)	no (ND)
1,1,2,2-Tetrachloroethane	soil	50	CL EQG, CCME 2007	50	CL EQG, CCME 2007	ug/g	23	0.03	nc	nc	nc	nc	100%	no (ND)	no (ND)
Tetrachloroethene	soil	50	CL EQG, CCME 2007	50	CL EQG, CCME 2007	ug/g	23	0.03	nc	nc	nc	nc	100%	no (ND)	no (ND)
Toluene	soil	0.37	CL EQG, CCME 2007	0.37	CL EQG, CCME 2007	ug/g	42	1.32	6.10	0.03	**37**	**4A-09-4-1**	83%	**yes**	**yes**
1,1,1-Trichloroethane	soil	50	CL EQG, CCME 2007	50	CL EQG, CCME 2007	ug/g	23	0.03	nc	nc	nc	nc	100%	no (ND)	no (ND)
1,1,2-Trichloroethane	soil	50	CL EQG, CCME 2007	50	CL EQG, CCME 2007	ug/g	23	0.77	nc	nc	nc	nc	100%	no (ND)	no (ND)
Trichloroethene	soil	50	CL EQG, CCME 2007	50	CL EQG, CCME 2007	ug/g	23	0.01	nc	nc	nc	nc	100%	no (ND)	no (ND)
Vinyl chloride	soil	0.032	CL, Table 3, OMOE 2009	0.032	CL, Table 3, OMOE 2009	ug/g	23	0.08	nc	nc	0.08	nc	100%	no (ND)	no (ND)
m+p-Xylene	soil	26	CL, Table 3, OMOE 2009	26	CL, Table 3, OMOE 2009	ug/g	42	4.65	18.35	0.1	100	4A-09-4-1	81%	no (ND)	no (ND)
o-Xylene	soil	26	CL, Table 3, OMOE 2009	26	CL, Table 3, OMOE 2009	ug/g	42	1.41	5.52	0.1	34	4A-09-4-1	81%	no (ND)	no (ND)
Xylenes (total)	soil	11	CL EQG, CCME 2007	11	CL EQG, CCME 2007	ug/g	42	6.13	24.53	0.1	140	4A-09-4-1	81%	no (ND)	no (ND)

[R/PL]-Soil quality guideline for the protection of soil and food ingestion for Residental/ Parkland land use (Environmental Health Guideline, CCME SoQC PAH 2008).

[PW] Soil quality guideline for the protection of potable water (Human Health Guidelines, CCME SoQG PAH2008)

[I] Soil Quality guideline for the protection of soil and food ingestion (Environmental Health Guideline, CCME SoQC PAH 2008).

[E] Soil quality guideline for environmental health (CCME SoQG PAH2008)

CL, Table 3, OMOE 2009- Ontario MOE, Table 3, 2009 Update, Soil standards for non-potable groundwater conditions, commercial land use and coarse grained soils

CL CWS, CCME 2008 (cg, surface, dir. Cont.) Table 3, Tier 1 levels for PHCs for Coarse Grained Surface Soils, Direct Contact (Ingestion+Dermal Contact)Technical Guidance Document

* As no commercial guideline exists for this chemical parameter the Residential/ Parkland guideline was applied.

USEPA Region 9, Dec 2009- USEPA Regional Screening Level (RSL) Master Summary Table, Residential Soil Standards, December 2009 Update

CL, Table 1, AENV Tier 1- Alberta Environment, Table 1. Soil Remediation Guidelines for Coarse Soils, CL use, February 2009 update

NC-No Criteria Available for this parameter

Ground Water Chemistry - Summary
Cambridge Bay Airport Risk Assessment
Franz Project # 1748-0902

Parameter	Media	EcoRA Screening Criteria	EcoRA Screening Criteria Source	HHRA Screening Criteria	HHRA Screening Criteria Source	MDL	Units	Number of Samples	Average	Standard Deviation	Minimum	Maximum	Location of Max	% ND	Screened into EcoRA?	Screened into HHRA (PQRA)?
Benzene	groundwater	1000 [M]	BC CSR Schedule 6, Aquatic Life	5	DWQ, Health Canada 2008	0.04	ug/L	21	160.84	416.2	0.005	**1700**	**3-09-4M**	0.78	yes	yes
Ethylbenzene	groundwater	2000 [FW]	BC CSR Schedule 6, Aquatic Life	2.4	DWQ, Health Canada 2008	0.1	ug/L	21	16.95	47.3	0.001	180	3-09-4M	0.67	no	yes
Toluene	groundwater	390 [FW]	BC CSR Schedule 6, Aquatic Life	18000	Table 3,OMOE 2009	0.1	ug/L	21	187.25	637	0.005	**2800**	3-09-4M	0.56	yes	no
Xylenes (total)	groundwater	300	AENV,Tier 1, Table 2, Coarse soil (CL)	4200	Table 3,OMOE 2009	0.3	ug/L	21	156.49	513.1	0.005	**2300**	3-09-4M	0.67	yes	no
Total Purgeable Hydrocarbons	groundwater	750	Table 3,OMOE 2009	750	Table 3,OMOE 2009		ug/L	4	0.69	0.8	0.11	1.9	YCB-07	0.25	no	no
Total Extractable Petroleum Hydrocarbons	groundwater	NC	NC	NC	NC		ug/L	4	5.93	10.7	0.3	22	YCB-07	0.00	no	no
Total Petroleum Hydrocarbons	groundwater	NC	NC	NC	NC		ug/L	4	6.55	11.6	0.3	23.9	YCB-07	0.00	no	no
F1 (C6-C10)	groundwater	750	Table 3,OMOE 2009	750	Table 3,OMOE 2009	100	ug/L	17	1160.58824	2550.69224	100	**10000**	3-09-4M	0.71	yes	yes
F1 (C6-C10) minus BTEX	groundwater	750	Table 3,OMOE 2009	750	Table 3,OMOE 2009	100	ug/L	17	545.882353	924.635461	100	**3500**	3-09-4M	0.71	yes	yes
F2 (C10-C16)	groundwater	150	Table 3,OMOE 2009	150	Table 3,OMOE 2009	100	ug/L	17	758.823529	1261.97208	100	**3800**	3-09-4M	0.71	yes	yes
F3 (C16-C34)	groundwater	500	Table 3,OMOE 2009	500	Table 3,OMOE 2009	100	ug/L	17	129.411765	98.5184366	100	500	3-09-6M	0.88	no	no
F4 (C34-C50)	groundwater	500	Table 3,OMOE 2009	500	Table 3,OMOE 2009	100	ug/L	17	100	0	100	100	nc	1.00	no	no
Aluminum	groundwater	100[eJ]	FWAL, CCME 2007	100	DWQ, Health Canada 2008	5	ug/L	17	199.411765	302.189315	10	**1000**	3-09-4M	0.47	yes	yes
Antimony	groundwater	200	BC CSR Schedule 6, Aquatic Life	6	DWQ, Health Canada 2008	0.5 - 1	ug/L	17	2.41176471	1.17573506	2	6	6-09-MW1	0.71	no	no
Arsenic	groundwater	50 [FW]	BC CSR Schedule 6, Aquatic Life	10	DWQ, Health Canada 2008	1 - 5	ug/L	19	2.7	1.4	2	6	3.09-6M	0.89	no	no
Barium	groundwater	5000[M]	BC CSR Schedule 6, Aquatic Life	29000	Table 3,OMOE 2009			19	59.8	37.3	20	151	YCB-01	0.05	no	no
Beryllium	groundwater	53[FW]	BC CSR Schedule 6, Aquatic Life	67	Table 3, OMOE 2009	0.5 - 1	ug/L	17	10	0	10	10	All	1.00	no	no
Boron	groundwater	50000	BC CSR Schedule 6, Aquatic Life	5000	DWQ, Health Canada 2008	50	ug/L	17	451.176471	313.466154	70	1200	2-09-MW4	0.45	no	no
Cadmium	groundwater	0.6***	BC CSR Schedule 6, Aquatic Life	5	DWQ, Health Canada 2008	0.1	ug/L	19	0.3	0.6	0.05	**2**	APEC 3 and 4	0.42	yes	no
Calcium	groundwater	1000000[L]	BC CSR Schedule 6, Aquatic Life	1000000[L]	BC CSR Schedule 6, Aquatic Life		ug/L	17	164352.941	93269.7306	70000	410000	1-09-5M	0.06	no	no
Chromium	groundwater	810	Table 3, OMOE 2009	50	DWQ, Health Canada 2008	5 -7	ug/L	19	9.4	1.9	4	10	1-09-1M	0.79	no	no
Cobalt	groundwater	40	BC CSR Schedule 6, Aquatic Life	66	Table 3, OMOE 2009	0.5 - 5	ug/L	19	5.9	6.2	3	28	YCB-01	0.79	no	no
Copper	groundwater	90	BC CSR Schedule 6, Aquatic Life	1000	DWQ, Health Canada 2008	1 - 2	ug/L	19	8.8	6	2	23	YCB-01	0.11	no	no
Iron	groundwater	300	AENV,Tier 1, Table 2, Coarse soil (CL)	300	DWQ, Health Canada 2008	6 - 100	ug/L	17	588.823529	510.831214	70	**1700**	3-09-4M	0.00	yes	yes
Lead	groundwater	110**	BC CSR Schedule 6, Aquatic Life	10	DWQ, Health Canada 2008	0.5 - 1	ug/L	19	10.1578947	23.6226425	2	**100**	3-09-4M	0.74	no	yes
Magnesium	groundwater	600 000	Compendium of Environmental Quality Benchmarks App 2-7	100 000	BC CSR Schedule 6, DW Standard		ug/L	17	144941.176	97060.2072	38000	**330 000**	1-09-5M	0.06	no	yes
Manganese	groundwater	50	AENV,Tier 1, Table 2, Coarse soil (CL)	50	DWQ, Health Canada 2008		ug/L	17	125.176471	122.533789	20	**460**	3-09-6M	0.00	yes	yes
Mercury	groundwater	1	BC CSR Schedule 6, Aquatic Life	1	DWQ, Health Canada 2008	0.05 - 0.1	ug/L	17	0.00476471	0.00207754	0.002	0.009	3-09-6M	0.00	no	no
Molybdenum	groundwater	10 000	BC CSR Schedule 6, Aquatic Life	9200	Table 3, OMOE 2009	1 - 6	ug/L	19	11.8947368	11.2639777	2	40	4A-09-1M	0.11	no	no
Nickel	groundwater	83[M]	BC CSR Schedule 6, Aquatic Life	490	Table 3, OMOE 2009	1 - 8	ug/L	19	21.6842105	39.7856097	5	**176**	YCB-01	0.21	yes	no
Potassium	groundwater	NC	NC	NC	NC		ug/L	17	41058.8235	30751.9727	14000	110000	3-09-4M	0.00	no	no
Selenium	groundwater	10	BC CSR Schedule 6, Aquatic Life	10	DWQ, Health Canada 2008	1 - 2	ug/L	17	2	0	2	2	All	0.82	no	no
Silver	groundwater	15	BC CSR Schedule 6, Aquatic Life	1.5	Table 3, OMOE 2009	0.1	ug/L	17	1	0	1	1	All	1.00	no	no
Sodium	groundwater	200 000	AENV,Tier 1, Table 2, Coarse soil (CL)	200 000	DWQ, Health Canada 2008		ug/L	17	318764.706	279307.521	24000	**1 000 000**	2-09-MW4	0.18	yes	yes
Strontium	groundwater	7[FW]	Compendium of Environmental Quality Benchmarks App 2-4	22 000	USEPA,Region 9, Dec 2009		ug/L	17	370	320.409894	140	1200	2-09-MW4	0.00	yes	no
Thallium	groundwater	3	BC CSR Schedule 6, Aquatic Life	510	Table 3, OMOE 2009	0.05 - 0.8	ug/L	17	2	0	2	2	nc	0.82	no	no
Tin	groundwater	2.2	Netherlands 1999 Groundwater Target Value	22 000	USEPA,Region 9, Dec 2009		ug/L	17	10	0	10	**10**	nc	1.00	yes	no

Parameter	Media	EcoRA Screening Criteria	EcoRA Screening Criteria Source	HHRA Screening Criteria	HHRA Screening Criteria Source	MDL	Units	Number of Samples	Average	Standard Deviation	Minimum	Maximum	Location of Max	% ND	Screened into EcoRA?	Screened into HHRA (PQRA)?
Titanium	groundwater	1000	BC CSR Schedule 6, Aquatic Life	100	Compendium of Environmental Quality Benchmarks App 2-1		ug/L	17	15.8823529	12.2774303	10	50	1-09-1M	0.82	no	no
Uranium	groundwater	1000[M]	BC CSR Schedule 6, Aquatic Life	20	DWQ, Health Canada 2008	0.3 - 1	ug/L	17	15.2941176	8.99836586	6	**33**	1-09-3M	0.12	no	**yes**
Vanadium	groundwater	250	Table 3, OMOE 2009	250	Table 3, OMOE 2009	1 - 50	ug/L	17	10.5882353	2.42535625	10	20	3-09-4M	0.71	no	no
Zinc	groundwater	100	BC CSR Schedule 6, Aquatic Life	5000	DWQ, Health Canada 2008	5	ug/L	19	41.0526316	58.2127074	7	**280**	4A-09-2M	0.89	**yes**	no
Acenaphthene	groundwater	60	BC CSR Schedule 6, Aquatic Life	600	Table 3, OMOE 2009		ug/L	12	0.115	0.03343923	0.1	0.2	3-09-5M	0.75	no	no
Acenaphthylene	groundwater	46	AENV,Tier 1, Table 2, Coarse soil (CL)	1.8	Table 3, OMOE 2009		ug/L	12	0.1	1.4495E-17	0.1	0.1	nc	1.00	no	no
Acridine	groundwater	0.5	BC CSR Schedule 6, Aquatic Life	0.5	BC CSR Schedule 6, Aquatic Life		ug/L	12	0.2	2.899E-17	0.2	0.2	nc	1.00	no	no
Anthracene	groundwater	1	BC CSR Schedule 6, Aquatic Life	2.4	Table 3, OMOE 2009		ug/L	12	0.01158333	0.00548483	0.01	0.029	1-09-5M	0.92	no	no
Benzo(a)anthracene	groundwater	1	BC CSR Schedule 6, Aquatic Life	4.7	Table 3, OMOE 2009		ug/L	12	0.009125	0.00216506	0.0085	0.016	6-09-MW1	0.92	no	no
Benzo(a)pyrene	groundwater	0.1	BC CSR Schedule 6, Aquatic Life	0.01	DWQ, Health Canada 2008		ug/L	12	0.00795833	0.00158771	0.0075	**0.013**	6-09-MW1	0.92	no	**yes**
Benzo(b+j)fluoranthene	groundwater	0.48	AENV,Tier 1, Table 2, Coarse soil (CL)	0.75	Table 3, OMOE 2009		ug/L	12	0.009375	0.00303109	0.0085	0.019	6-09-MW1	0.92	no	no
Benzo(e)pyrene	groundwater	NC	NC	NC	NC		ug/L	12	0.05	7.2474E-18	0.05	0.05	nc	1.00	no	no
Benzo(g,h,i)perylene	groundwater	0.21	AENV,Tier 1, Table 2, Coarse soil (CL)	0.2	Table 3, OMOE 2009		ug/L	12	0.009125	0.00216506	0.0085	0.016	6-09-MW1	0.92	no	no
Benzo(k)fluoranthene	groundwater	0.48	AENV,Tier 1, Table 2, Coarse soil (CL)	0.4	Table 3, OMOE 2009		ug/L	12	0.0085	1.8119E-18	0.0085	0.0085	nc	1.00	no	no
Chrysene	groundwater	1	BC CSR Schedule 6, Aquatic Life	1	Table 3, OMOE 2009		ug/L	12	0.00920833	0.00245374	0.0085	0.017	6-09-MW1	0.92	no	no
Dibenz(a,h)anthracene	groundwater	0.26	AENV,Tier 1, Table 2, Coarse soil (CL)	0.52	Table 3, OMOE 2009		ug/L	12	0.0075	2.7178E-18	0.0075	0.0075	nc	1.00	no	no
Fluoranthene	groundwater	2	BC CSR Schedule 6, Aquatic Life	130	Table 3, OMOE 2009		ug/L	13	0.0485	0.02589665	0.04	0.13	6-09-MW1	0.77	no	no
Fluorene	groundwater	120	BC CSR Schedule 6, Aquatic Life	400	Table 3, OMOE 2009		ug/L	12	0.15966667	0.19971222	0.05	0.55	3-09-5M	0.67	no	no
Indeno(1,2,3-cd)pyrene	groundwater	0.23	AENV,Tier 1, Table 2, Coarse soil (CL)	0.2	Table 3, OMOE 2009		ug/L	12	0.0085	1.8119E-18	0.0085	0.0085	nc	1.00	no	no
2-Methylnaphthalene	groundwater	1800	Table 3, OMOE 2009	1800	Table 3, OMOE 2009		ug/L	12	15.1075	30.623193	0.1	82	3-09-5M	0.58	no	no
Naphthalene	groundwater	10	BC CSR Schedule 6, Aquatic Life	1400	Table 3, OMOE 2009		ug/L	12	35.9716667	95.645929	0.1	**330**	3-09-4M	0.50	**yes**	no
Perylene	groundwater	NC	NC	NC	NC		ug/L	12	0.05	7.2474E-18	0.05	0.05	nc	1.00	no	no
Phenanthrene	groundwater	3	BC CSR Schedule 6, Aquatic Life	580	Table 3, OMOE 2009		ug/L	12	0.11358333	0.13305328	0.05	0.47	4A-09-3M	0.75	no	no
Pyrene	groundwater	0.2	BC CSR Schedule 6, Aquatic Life	68	Table 3, OMOE 2009		ug/L	12	0.03158333	0.0260505	0.02	0.11	6-09-MW1	0.67	no	no
Quioline	groundwater	34	BC CSR Schedule 6, Aquatic Life	0.022	USEPA,Region 9, Dec 2009		ug/L	12	0.2	2.899E-17	0.2	0.2	nc	1.00	no	no(ND)
Aroclor 1016	groundwater	0.96	USEPA,Region 9, Dec 2009	0.96	USEPA,Region 9, Dec 2009		ug/L	3	0.05	8.4984E-18	0.05	0.05	nc	1.00	no	no
Aroclor 1221	groundwater	0.0068	USEPA,Region 9, Dec 2009	0.0068	USEPA,Region 9, Dec 2009		ug/L	3	0.05	8.4984E-18	0.05	0.05	nc	1.00	no(ND)	no(ND)
Aroclor 1232	groundwater	0.0068	USEPA,Region 9, Dec 2009	0.0068	USEPA,Region 9, Dec 2009		ug/L	3	0.05	8.4984E-18	0.05	0.05	nc	1.00	no(ND)	no(ND)
Aroclor 1242	groundwater	0.034	USEPA,Region 9, Dec 2009	0.034	USEPA,Region 9, Dec 2009		ug/L	3	0.05	8.4984E-18	0.05	0.05	nc	1.00	no(ND)	no(ND)
Aroclor 1248	groundwater	0.034	USEPA,Region 9, Dec 2009	0.034	USEPA,Region 9, Dec 2009		ug/L	3	0.05	8.4984E-18	0.05	0.05	nc	1.00	no(ND)	no(ND)
Aroclor 1254	groundwater	0.034	USEPA,Region 9, Dec 2009	0.034	USEPA,Region 9, Dec 2009		ug/L	3	0.05	8.4984E-18	0.05	0.05	nc	1.00	no(ND)	no(ND)
Aroclor 1260	groundwater	0.034	USEPA,Region 9, Dec 2009	0.034	USEPA,Region 9, Dec 2009		ug/L	3	0.05	8.4984E-18	0.05	0.05	nc	1.00	no(ND)	no(ND)
Aroclor 1262	groundwater	NC	NC	NC	NC		ug/L	3	0.05	8.4984E-18	0.05	0.05	nc	1.00	no(ND)	no(ND)
Aroclor 1268	groundwater	NC	NC	NC	NC		ug/L	3	0.05	8.4984E-18	0.05	0.05	nc	1.00	no(ND)	no(ND)
Diethylene glycol	groundwater	11000	PWQO, OMOE 1994	370	BC CSR Schedule 10, 2009		ug/L	1	10000	0	10000	10 000	2-09-MW4	1.00	no(ND)	no(ND)
Ethylene glycol	groundwater	192000	BC CSR Schedule 6, Aquatic Life	31000	AENV,Tier 1, Table 2, Coarse soil (CL)		ug/L	1	10000	0	10000	10 000	2-09-MW4	1.00	no(ND)	no(ND)

Parameter	Media	EcoRA Screening Criteria	EcoRA Screening Criteria Source	HHRA Screening Criteria	HHRA Screening Criteria Source	MDL	Units	Number of Samples	Average	Standard Deviation	Minimum	Maximum	Location of Max	% ND	Screened into EcoRA?	Screened into HHRA (PQRA)?
Propylene glycol	groundwater	500000	BC CSR Schedule 6, Aquatic Life	18000	BC CSR Schedule 10, 2010		ug/L	1	10000	0	10000	10 000	2-09-MW4	1.00	no(ND)	no(ND)
Tetraethylene glycol	groundwater	NC	NC	NC	NC		ug/L	1	10000	0	10000	10 000	2-09-MW4	1.00	no(ND)	no(ND)
Triethylene glycol	groundwater	NC	NC	NC	NC		ug/L	1	10000	0	10000	10 000	2-09-MW4	1.00	no(ND)	no(ND)
** Cu guideline for a hardness of 100 to < 300 mg/L																
*** Cd guideline for a hardness of 150 to <210 mg/L																
[b] CCME Lead guideline =	7 ug/L at a water hardness of >180 mg/L (very hard) as $CaCO_3$															
[c] CCME Nickel guideline =	150 ug/L at a water hardness of >180 mg/L (very hard) as $CaCO_3$															
[d] Average calculated hardness: APEC 1 = 274 mg/L and APEC 2 = 216 mg/L																
[e] An average pH of 8.2 was calculated from all the groundwater data. The lowest pH was 7.8.																
L- livestock watering guideline																
[f] CCME aluminum guideline = 100 ug/L at pH $\geq$ 6.5.																
g The methyl napthalene standards are applicable to both 1-methyl napthalene and 2-methyl napthalene with the provision that if both are detected the sum of the two must not exceed the standard (Table 3, OMOE 2009)																
DWQ, Health Canada 2008= Health Canada Guidelines for Canadian Drinking Water Quality, March 2008 Update																
Environment Canada, Compendium of Environmental Quality Benchmarks, 1999 -Appendix 2-9, A Summary of the Available Water Quality Criteria and Guidelines for the Protection of Wildlife (Bioaccumulation in Aquatic Organisms)																
Environmenta Canada, Compendium of Environmental Quality Benchmarks, 1999-Appendix 2-1 Available Water Quality Criteria and Guidelines for the Protection of Human Health (Water Supplies)																
Environmenta Canada, Compendium of Environmental Quality Benchmarks, 1999-Appendix 2-4 Available Water Quality Criteria and Guidelines for the Protection of Freshwater Aquatic Life																
CL, Table 2, AENV Tier 1- Alberta Environment, Table 2. Groundwater Remediation Guidelines for Coarse Soils, CL use, February 2009 update																
USEPA Region 9, Dec 2009- USEPA Regional Screening Level (RSL) Master Summary Table, Tapwater Standards, December 2009 Update																
BC CSR Schedule 10, DW- BC CSR Contaminated Sites Regulation, Schedule 10, Drinking Water Standard																
FWAL, CCME, Update 2010- CCME, Table 1. CWQG for Endosulfan for the Protection of Aquatic Life (Long Term Exposure), 2010 Update																
FWAL, CCME, Boron 2009 Update- CCME Table 1. CWQG for Boron for the Protection of Aquatic Life, Long Term Exposure , 2009 Update																
Environmenta Canada, Compendium of Environmental Quality Benchmarks, 1999-Appendix 2-7 Available Water Quality Criteria and Guidelines for the Protection of Livestock																
AENV,Tier 1, Table 2, Coarse soil (CL)= Alberta Environment, Soil and Groundwater Guidelines, 2009, Table 2. Alberta Tier 1 Groundwater Remediation Guidelines, Coarse soil , (CL) land use																
Netherlands 1999 Groundwater Target Value-Maximal Permissible Risk for Intake , Target Value for Soil and Groundwater, Ecotoxicological Intervention Value, Intervention Value for Soil and Groundwater (Risk Analysis Vol. 19 No. 6, 1999; Risk Based																
Assessment of Soil and Groundwater Quality in the Netherlands: Standards and Remediation Urgency)																
BC CSR Schedule 6-Generic Numerical Water Standards for the Protection of Aquatic Life (AW)- most stringent of marine and or freshwater standards was applied																
PWQO, OMOE 1994-OMOE, Water Management- Policies, Guidelines, Provincial Water Quality Objectives, Table of PWQOs and Interm PWQOs (July 1994)																

Appendix B

Human Health (PQRA) Input

And Output Tables

Airport Employee

HEALTH CANADA PQRA SPREADSHEET
USER INPUT SHEET

User Name:	Franz Environmental Inc.	Site:	Cambridge Bay Airport AECs
Proponent:	Transport Canada	File #:	1748-0901
Date:		Comment:	Metals +

PROBLEM FORMULATION

Potential Land Uses (Yes/No)		Default
Agricultural	No	Yes
Residential/urban parkland	No	Yes
Commercial	Yes	Yes
Industrial	No	Yes
Occupational - outdoors	Yes	Yes
Recreational	No	Yes
Other	No	No
specify:		

Operative Pathways (Yes/No)		Default
Inadvertent ingestion of soil	Yes	Yes
Inhalation of soil particles	Yes	Yes
Inhalation of indoor contaminant vapours	No	Yes
Inhalation of outdoor contaminant vapours	Yes	Yes
Ingestion of drinking water	No	Yes
Dermal contact with soil	Yes	Yes
Dermal contact with water	No	Yes
Ingestion of contaminated food	No	No

Exposure Scenario		
	User-Defined	Commercial

Vapour Transport Modelling		
Vapour source for exposure calculations	Most Conservative	Most Conservative

Receptor Groups (Yes/No)		Default
General public or residents	No	Yes
Employees	Yes	Yes
Canadian native communities	No	No
Other	No	No
specify:		

Active Critical Receptors (Yes/No)		Default
Infant	No	No
Toddler	No	No
Child	No	No
Teen	No	No
Adult	No	Yes
Other	Yes	Yes
specify:	Adult Airport Employee	

Contaminant Concentrations

Chemical Name	required	Arsenic	Copper	Lead	Benzo(a)pyrene		
Soil (mg/kg)	required	40.6	102	294	1		
Groundwater - source (mg/L)	optional			0.1	0.000013		
Drinking water (mg/L)	optional						
Bathing/swimming water (mg/L)	optional						
Indoor air - vapours (mg/m^3)	optional						
Outdoor air - vapours (mg/m^3)	optional						
Outdoor air - particulate (mg/m^3)	optional						
Root vegetables (mg/kg wet weight)	optional						
Other vegetables (mg/kg wet weight)	optional						
Fish (mg/kg wet weight)	optional						
Wild game (mg/kg wet weight)	optional						
					PAH-Carcinogenic		

Risk Assessment Endpoints		Default
Acceptable hazard index:	0.2	0.2
Acceptable cancer risk:	1.00E-05	1.00E-05

Precluding Conditions for Fate and Transport Models

Are non-aqueous phase liquids (NAPL) present?	No
Is groundwater contamination present in fractured bedrock?	No
Is groundwater contamination migrating through a confined aquifer?	No
Is there active pumping or drawdown of groundwater at the site?	No
Is contamination present within 1 m of building foundation?	No
Do any buildings within 5 m of contamination have earthen foundations?	No
Are any buildings constructed on very high permeability media?	No
Are there preferential vapour flow pathways connecting contamination to a building?	No

Fate and Transport Model Input

	Value	Default	Models Affected
Soil Type	coarse-grained	coarse-grained	PS, V-I, V-O, GW
Significant vehicle traffic on unpaved roads?	No	No	P-O
Site Characteristics			
Depth to Groundwater (m)	1	3	GW, V-O
Depth from Surface to Contamination (m)	0.1	0	GW, V-O
Distance - Contaminated Soil to Building (m)	70	1	V-I
Distance - Contaminated GW to Building (m)	70	1	V-I
Distance to potable water user (m)	0	0	GW
Distance to Bathing/Swimming Water (m)	0	0	GW
Particulate Concentration in Air (ug/m^3)	0.76	0.76	P-O
Building Type	Commercial/Industrial	Residential	V-I

Optional Sections

User-defined Chemicals

Note: user-defined chemicals should be named in this section before being selected in the 'Contaminant Concentrations' table above

		Chemical 1	Chemical 2	Chemical 3
Name				
CAS Number				
Chemical class (organic/inorganic)				
Tolerable daily intake (mg/kg/d) - infant	*Enter all applicable and appropriate toxicity benchmarks; values must be referenced and justified in the PQRA report.*			
Tolerable daily intake (mg/kg/d) - toddler				
Tolerable daily intake (mg/kg/d) - child				
Tolerable daily intake (mg/kg/d) - teen				
Tolerable daily intake (mg/kg/d) - adult				
Tolerable concentration (mg/m^3)				
Oral slope factor $(mg/kg/d)^{-1}$				
Inhalation slope factor $(mg/kg/d)^{-1}$				
Inhalation unit risk $(mg/m^3)^{-1}$				
Relative dermal absorption factor				
Organic carbon partitioning coefficient (mL/g) - Koc				
Log Kow (unitless)				
Henry's Law constant at 25°C (unitless) - H'				
Henry's Law constant at 25°C (atm-m3/mol) - H				
Water Solubility at 25°C (mg/L)				
Molecular Weight (g/mol)				
Vapour Pressure at 25°C (atm)				

Note: values in grayed cells will not be used; Health Canada default values are applied.

User-defined Receptor

Name	Adult Airport Emp	Defaults
Age group	Adult	Toddler
Body weight (kg)	70.7	70.7
Soil ingestion rate (g/d)	0.02	0.02
Inhalation rate (m^3/d)	15.8	15.8
Water ingestion rate (L/d)	1.5	1.5
Skin surface area (cm^2)		
- hands	890	890
- arms	2500	2500
- legs	0	5720
- total	3390	17640
Soil loading to exposed skin (g/cm^2/event)		
- hands	1.00E-04	0.0001
- surfaces other than hands	1.00E-05	0.00001
Food ingestion (g/d)		
- root vegetables	188	188
- other vegetables	137	137
- fish	111	111
- wild game	0	0
Evaluate Cancer Risks (Yes/No)?	Yes	Yes

User-defined Land-Use / Exposure Scenario

Scenario name	User-Defined	Defaults
Hours per day (indoors)	0	22.5
Hours per day (outdoors)	4	1.5
Days per week	5	7
Weeks per year	14	52
Dermal exposure events/day	1	1
Water contact events per day	0	1
Duration of water contact event (h)	0	1
Days/year contaminated food ingestion	0	365
Exposure duration (years)	35	60
Years for carcinogen amortization	60	60

HEALTH CANADA PQRA SPREADSHEET Version: March 16, 2009
OUTPUT SHEET - Adult Airport Employee **Adult**

User Name: Franz Environmental Inc. **Site:** Cambridge Bay Airport AECs
Proponent: Transport Canada **File #:** 1748-0901
Date: **Comment:** Metals +

Exposure Scenario: **User-Defined**
Native population not considered
Cancer Risks Calculated? **Yes**

User-Defined Receptor Characteristics
Body weight (kg): 70.7
Soil ingestion rate (g/d): 0.02
Inhalation rate (m3/d): 15.8
Water ingestion rate (L/d): 1.5
Skin surface area (cm2) - hands: 890
- arms: 2500
- legs: 0
- total: 3390
Soil loading (g/cm2-event) - hands: 0.0001
- other: 0.00001
Food ingestion rates (g/d)
Root vegetables: 188
Other vegetables: 137
Fish: 111
Wild game: 0

Chemical Properties	Units	Arsenic	Copper	Lead	Benzo(a)pyrene		
Tolerable daily intake	mg/kg/d	NA	0.141	0.0036	NA	NA	NA
Tolerable concentration	mg/m^3	NA	NA	NA	NA	NA	NA
Oral slope factor	$(mg/kg/d)^{-1}$	1.8	NA	NA	2.3	NA	NA
Inhalation slope factor	$(mg/kg/d)^{-1}$	28	NA	NA	0.137	NA	NA
Inhalation unit risk	$(mg/m^3)^{-1}$	6.4	NA	NA	0.03	NA	NA
Dermal slope factor	$(mg/kg/d)^{-1}$	NA	NA	NA	NA	NA	NA
Critical oral exposure benchmark		slope factor	TDI	TDI	slope factor	NA	NA
Critical inhalation exposure benchmark		NA	NA	NA	NA	NA	NA
Relative dermal absorption factor	unitless	0.03	0.06	0.006	0.13	1	1

Chemical Concentrations	Units	Arsenic	Copper	Lead	Benzo(a)pyrene		
Soil	mg/kg	4.06E+01	1.02E+02	2.94E+02	1.00E+00	0.00E+00	0.00E+00
Drinking water	mg/L	NA	NA	NA	NA	NA	NA
Bathing/swimming water	mg/L	NA	NA	NA	NA	NA	NA
Indoor air vapours	mg/m^3	NA	NA	NA	NA	NA	NA
Outdoor air vapours	mg/m^3	0.00E+00	0.00E+00	0.00E+00	3.37E-08	0.00E+00	0.00E+00
Outdoor air particulate	mg/m^3	3.09E-08	7.75E-08	2.23E-07	7.60E-10	0.00E+00	0.00E+00
Amortized total air concentration	mg/m^3	9.88974E-10	2.48462E-09	7.16154E-09	1.10432E-09	0	0
Root vegetables	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated
Other vegetables	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated
Fish	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated
Wild game	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated

RESULTS

	Exposure (mg/kg/d)					
	Arsenic	Copper	Lead	Benzo(a)pyrene		
Inadvertent ingestion of contaminated soil	1.29E-06	5.55E-06	1.60E-05	3.17E-08	0.00E+00	0.00E+00
Inhalation of contaminated soil particles	2.21E-10	5.55E-10	1.60E-09	5.44E-12	0.00E+00	0.00E+00
Inhalation of contaminant vapours - indoor	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Inhalation of contaminant vapours - outdoor	0.00E+00	0.00E+00	0.00E+00	2.41E-10	0.00E+00	0.00E+00
Ingestion of contaminated drinking water	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Dermal contact with contaminated soil	2.20E-07	1.90E-06	5.47E-07	2.35E-08	0.00E+00	0.00E+00
Dermal contact with water	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ingestion of contaminated food	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total ingestion exposure	1.29E-06	5.55E-06	1.60E-05	3.17E-08	0.00E+00	0.00E+00
Total dermal exposure	2.20E-07	1.90E-06	5.47E-07	2.35E-08	0.00E+00	0.00E+00
Ingestion + dermal exposure	1.51E-06	7.45E-06	1.65E-05	5.52E-08	0.00E+00	0.00E+00
Total inhalation exposure	2.21E-10	5.55E-10	1.60E-09	2.47E-10	0.00E+00	0.00E+00
Total Exposure (all pathways)	1.51E-06	7.45E-06	1.65E-05	5.55E-08	0.00E+00	0.00E+00

		Hazard/Risk Estimates					
		Arsenic	Copper	Lead	Benzo(a)pyrene		
Hazard Quotient - Oral/Dermal		NA	5.28E-05	4.59E-03	NA	NA	NA
Hazard Quotient - Inhalation		NA	3.94E-09	4.45E-07	NA	NA	NA
Hazard Index - Total		NA	5.28E-05	4.60E-03	NA	NA	NA
Target Hazard Index:	0.2						
Cancer Risk - Oral		2.32E-06	NA	NA	7.30E-08	NA	NA
Cancer Risk - Dermal		3.97E-07	NA	NA	5.41E-08	NA	NA
Cancer Risk - Oral + Dermal		2.72E-06	NA	NA	1.27E-07	NA	NA
Cancer Risk - Inhalation		3.69E-09	NA	NA	1.97E-11	NA	NA
Cancer Risk - Total		2.72E-06	NA	NA	1.27E-07	NA	NA
Target Cancer Risk:	1.00E-05						

SUMMARY OF PQRA RESULTS Version: March 16, 2009

User Name:	Franz Environmental Inc.	**Site:**	Cambridge Bay Airport AECs
Proponent:	Transport Canada	**File #:**	1748-0901
Date:		**Comment:**	Metals +

		Maximum Hazard/Risk Estimates					
		Arsenic	**Copper**	**Lead**	**Benzo(a)pyrene**		
Hazard Quotient - Oral/Dermal		NA	5.28E-05	4.59E-03	NA	NA	NA
Hazard Quotient - Inhalation		NA	3.94E-09	4.45E-07	NA	NA	NA
Hazard Index - Total		NA	5.28E-05	4.60E-03	NA	NA	NA
Target Hazard Index:	0.2						
Cancer Risk - Oral		2.32E-06	NA	NA	7.30E-08	NA	NA
Cancer Risk - Dermal		3.97E-07	NA	NA	5.41E-08	NA	NA
Cancer Risk - Oral + Dermal		2.72E-06	NA	NA	1.27E-07	NA	NA
Cancer Risk - Inhalation		3.69E-09	NA	NA	1.97E-11	NA	NA
Cancer Risk - Total		2.72E-06	NA	NA	1.27E-07	NA	NA
Target Cancer Risk:	1.00E-05						

	Critical Receptors					
	Arsenic	**Copper**	**Lead**	**Benzo(a)pyrene**		
Oral/Dermal - non-cancer effects	NA	User-Defined Receptor	User-Defined Receptor	NA	NA	NA
Inhalation - non-cancer effects	NA	Adult	Adult	NA	NA	NA
Total - non-cancer effects	NA	User-Defined Receptor	User-Defined Receptor	NA	NA	NA
Oral - cancer effects	Adult	NA	NA	Adult	NA	NA
Dermal - cancer effects	User-Defined Receptor	NA	NA	User-Defined Receptor	NA	NA
Oral + Dermal - cancer effects	User-Defined Receptor	NA	NA	User-Defined Receptor	NA	NA
Inhalation - cancer effects	Adult	NA	NA	Adult	NA	NA
Total - cancer effects	User-Defined Receptor	NA	NA	User-Defined Receptor	NA	NA
Source of indoor air vapours	NA	NA	NA	Soil	NA	NA
Model used for vapour transport	NA	NA	NA	Health Canada	NA	NA

Key Calculated Model Parameters						
Vapour Intrusion Model Parameters	Note: parameters show as "NA" if relevant exposure pathways are inoperative or if user-input concentration is used instead of modelled value					
Qsoil/Qbuilding	NA	NA	NA	NA	NA	NA
Soil alpha	NA	NA	NA	NA	NA	NA
Groundwater alpha	NA	NA	NA	NA	NA	NA
Groundwater model dilution factors						
DF1 (soil to leachate)	NA	NA	NA	NA	NA	NA
DF2 (leachate at source to water table):	NA	NA	NA	NA	NA	NA
DF3 (leachate at water table to groundwater):	NA	NA	NA	NA	NA	NA
DF4 (source to receptor) - drinking water:	NA	NA	NA	NA	NA	NA
DF4 (source to receptor) - bathing/swimming water:	NA	NA	NA	NA	NA	NA

Notes/Comments

Vapour Intrusion Model

Chemical Interactions

All chemicals of concern present at the site should be evaluated for potential additive effects based on target organs and mechanisms of effect.
All carcinogenic PAH present at the site must be treated additively

Concentration Checks

Precluding Conditions

Other Notes

Site-specific PHC composition data applied; please print 'PHC' page for report
Provide justification for all non-default model parameters in PQRA report
Error functions in groundwater model could not be calculated; installation of Analysis ToolPak is required

HEALTH CANADA PQRA SPREADSHEET
USER INPUT SHEET

User Name:	Franz Environmental Inc.	Site:	Cambridge Bay Airport AECs
Proponent:	Transport Canada	File #:	1748-0901
Date:		Comment:	Petroleum Hydrocarbons

PROBLEM FORMULATION

Potential Land Uses (Yes/No)		Default
Agricultural	No	Yes
Residential/urban parkland	No	Yes
Commercial	Yes	Yes
Industrial	No	Yes
Occupational - outdoors	Yes	Yes
Recreational	No	Yes
Other	No	No
specify:		

Operative Pathways (Yes/No)		Default
Inadvertent ingestion of soil	Yes	Yes
Inhalation of soil particles	Yes	Yes
Inhalation of indoor contaminant vapours	No	Yes
Inhalation of outdoor contaminant vapours	Yes	Yes
Ingestion of drinking water	No	Yes
Dermal contact with soil	Yes	Yes
Dermal contact with water	No	Yes
Ingestion of contaminated food	No	No

Exposure Scenario		
	User-Defined	Commercial

Vapour Transport Modelling		
Vapour source for exposure calculations	Most Conservative	Most Conservative

Receptor Groups (Yes/No)		Default
General public or residents	No	Yes
Employees	Yes	Yes
Canadian native communities	No	No
Other	No	No
specify:		

Active Critical Receptors (Yes/No)		Default
Infant	No	No
Toddler	No	No
Child	No	No
Teen	No	No
Adult	No	Yes
Other	Yes	Yes
specify:	Adult Airport Employee	

Contaminant Concentrations

Blue numbers exceed theoretical saturation/solubility limits; site should be evaluated for potential NAPL

Chemical Name		F1	Benzene	Toluene	Ethylbenzene	F2	Xylenes (total)
Soil (mg/kg)	required	***4800***	4.6	37	6.8	***12000***	140
Groundwater - source (mg/L)	optional	3.5	1.7		0.18	3.8	
Drinking water (mg/L)	optional						
Bathing/swimming water (mg/L)	optional						
Indoor air - vapours (mg/m^3)	optional						
Outdoor air - vapours (mg/m^3)	optional						
Outdoor air - particulate (mg/m^3)	optional						
Root vegetables (mg/kg wet weight)	optional						
Other vegetables (mg/kg wet weight)	optional						
Fish (mg/kg wet weight)	optional						
Wild game (mg/kg wet weight)	optional						
		See also PHC Sheet				See also PHC Sheet	

Risk Assessment Endpoints		Default
Acceptable hazard index:	0.2	0.2
Acceptable cancer risk:	1.00E-05	1.00E-05

Precluding Conditions for Fate and Transport Models

Are non-aqueous phase liquids (NAPL) present?	No
Is groundwater contamination present in fractured bedrock?	No
Is groundwater contamination migrating through a confined aquifer?	No
Is there active pumping or drawdown of groundwater at the site?	No
Is contamination present within 1 m of building foundation?	No
Do any buildings within 5 m of contamination have earthen foundations?	No
Are any buildings constructed on very high permeability media?	No
Are there preferential vapour flow pathways connecting contamination to a building?	No

Fate and Transport Model Input

	Value	Default	Models Affected
Soil Type	coarse-grained	coarse-grained	PS, V-I, V-O, GW
Significant vehicle traffic on unpaved roads?	No	No	P-O
Site Characteristics			
Depth to Groundwater (m)	1	3	GW, V-O
Depth from Surface to Contamination (m)	0.1	0	GW, V-O
Distance - Contaminated Soil to Building (m)	70	1	V-I
Distance - Contaminated GW to Building (m)	70	1	V-I
Distance to potable water user (m)	0	0	GW
Distance to Bathing/Swimming Water (m)	0	0	GW
Particulate Concentration in Air (ug/m^3)	0.76	0.76	P-O
Building Type	Commercial/Industrial	Residential	V-I

Optional Sections

User-defined Chemicals

Note: user-defined chemicals should be named in this section before being selected in the 'Contaminant Concentrations' table above

		Chemical 1	Chemical 2	Chemical 3
Name				
CAS Number				
Chemical class (organic/inorganic)				
Tolerable daily intake (mg/kg/d) - infant	*Enter all applicable and appropriate toxicity benchmarks; values must be referenced and justified in the PQRA report.*			
Tolerable daily intake (mg/kg/d) - toddler				
Tolerable daily intake (mg/kg/d) - child				
Tolerable daily intake (mg/kg/d) - teen				
Tolerable daily intake (mg/kg/d) - adult				
Tolerable concentration (mg/m^3)				
Oral slope factor $(mg/kg/d)^{-1}$				
Inhalation slope factor $(mg/kg/d)^{-1}$				
Inhalation unit risk $(mg/m^3)^{-1}$				
Relative dermal absorption factor				
Organic carbon partitioning coefficient (mL/g) - Koc				
Log Kow (unitless)				
Henry's Law constant at 25°C (unitless) - H'				
Henry's Law constant at 25°C (atm-m3/mol) - H				
Water Solubility at 25°C (mg/L)				
Molecular Weight (g/mol)				
Vapour Pressure at 25°C (atm)				

Note: values in grayed cells will not be used; Health Canada default values are applied.

User-defined Receptor

Name	Adult Airport Emp	Defaults
Age group	Adult	Toddler
Body weight (kg)	70.7	70.7
Soil ingestion rate (g/d)	0.02	0.02
Inhalation rate (m^3/d)	15.8	15.8
Water ingestion rate (L/d)	1.5	1.5
Skin surface area (cm^2)		
- hands	890	890
- arms	2500	2500
- legs	0	5720
- total	3390	17640
Soil loading to exposed skin (g/cm^2/event)		
- hands	1.00E-04	0.0001
- surfaces other than hands	1.00E-05	0.00001
Food ingestion (g/d)		
- root vegetables	188	188
- other vegetables	137	137
- fish	111	111
- wild game	0	0
Evaluate Cancer Risks (Yes/No)?	Yes	Yes

User-defined Land-Use / Exposure Scenario

Scenario name	User-Defined	Defaults
Hours per day (indoors)	0	22.5
Hours per day (outdoors)	4	1.5
Days per week	5	7
Weeks per year	14	52
Dermal exposure events/day	1	1
Water contact events per day	0	1
Duration of water contact event (h)	0	1
Days/year contaminated food ingestion	0	365
Exposure duration (years)	35	60
Years for carcinogen amortization	60	60

PHC Fraction Composition (%)	Soil		Note: water and air defaults are calculated based on soil properties Water		Air (Vapour)	
Fraction 1		Default		Default		Default
Aliphatics C_6-C_8		55		60.5		85.3
Aliphatics $C_{>8}$-C_{10}		36		6.3		14.2
Aromatics $C_{>8}$-C_{10}		9		33.2		0.4
Total		100		100		100
Fraction 2						
Aliphatics $C_{>10}$-C_{12}		36		2.4		76.7
Aliphatics $C_{>12}$-C_{16}		44		0.1		20.6
Aromatics $C_{>10}$-C_{12}		9		60.3		2.3
Aromatics $C_{>12}$-C_{16}		11		37.1		0.5
Total		100		100		100
Fraction 3						
Aliphatics $C_{>16}$-C_{21}		56		9.54E-03		89.79
Aliphatics $C_{>21}$-C_{34}		24		2.58E-07		7.83
Aromatics $C_{>16}$-C_{21}		14		95		2.37
Aromatics $C_{>21}$-C_{34}		6		5		0.01
Total		100		100		100
Fraction 4						
Aliphatics $C_{>34}$		80		0		0
Aromatics $C_{>34}$		20		100		0
Total		100		100		0

HEALTH CANADA PQRA SPREADSHEET Version: March 16, 2009
OUTPUT SHEET - Adult Airport Employee **Adult**

User Name: Franz Environmental Inc. **Site:** Cambridge Bay Airport AECs
Proponent: Transport Canada **File #:** 1748-0901
Date: **Comment:** Petroleum Hydrocarbons

Exposure Scenario: **User-Defined**
Native population not considered
Cancer Risks Calculated? **Yes**

User-Defined Receptor Characteristics
Body weight (kg): 70.7
Soil ingestion rate (g/d): 0.02
Inhalation rate (m3/d): 15.8
Water ingestion rate (L/d): 1.5
Skin surface area (cm2) - hands: 890
- arms: 2500
- legs: 0
- total: 3390
Soil loading (g/cm2-event) - hands: 0.0001
- other: 0.00001
Food ingestion rates (g/d)
Root vegetables: 188
Other vegetables: 137
Fish: 111
Wild game: 0

Chemical Properties	Units	F1	Benzene	Toluene	Ethylbenzene	F2	Xylenes (total)
Tolerable daily intake	mg/kg/d	NA	NA	0.22	0.1	NA	1.5
Tolerable concentration	mg/m^3	NA	NA	3.8	1	NA	0.18
Oral slope factor	$(mg/kg/d)^{-1}$	NA	0.226	NA	NA	NA	NA
Inhalation slope factor	$(mg/kg/d)^{-1}$	NA	0.0146	NA	NA	NA	NA
Inhalation unit risk	$(mg/m^3)^{-1}$	NA	0.0033	NA	NA	NA	NA
Dermal slope factor	$(mg/kg/d)^{-1}$	NA	NA	NA	NA	NA	NA
Critical oral exposure benchmark		NA	slope factor	TDI	TDI	NA	TDI
Critical inhalation exposure benchmark		NA	NA	TC	TC	NA	TC
Relative dermal absorption factor	unitless	0.2	0.03	0.03	0.03	0.2	0.03

Chemical Concentrations	Units	F1	Benzene	Toluene	Ethylbenzene	F2	Xylenes (total)
Soil	mg/kg	4.80E+03	4.60E+00	3.70E+01	6.80E+00	1.20E+04	1.40E+02
Drinking water	mg/L	NA	NA	NA	NA	NA	NA
Bathing/swimming water	mg/L	NA	NA	NA	NA	NA	NA
Indoor air vapours	mg/m^3	NA	NA	NA	NA	NA	NA
Outdoor air vapours	mg/m^3	8.21E-01	3.38E-02	1.72E-01	1.82E-02	7.62E-01	2.12E-01
Outdoor air particulate	mg/m^3	3.03E-06	2.78E-09	2.46E-08	4.78E-09	9.06E-06	1.01E-07
Amortized total air concentration	mg/m^3	0.026299465	0.001082664	0.005516043	0.000584645	0.02440941	0.006780047
Root vegetables	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated
Other vegetables	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated
Fish	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated
Wild game	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated

RESULTS

	Exposure (mg/kg/d)					
	F1	Benzene	Toluene	Ethylbenzene	F2	Xylenes (total)
Inadvertent ingestion of contaminated soil	2.61E-04	1.46E-07	2.01E-06	3.70E-07	6.53E-04	7.62E-06
Inhalation of contaminated soil particles	2.17E-08	1.99E-11	1.76E-10	3.42E-11	6.49E-08	7.23E-10
Inhalation of contaminant vapours - indoor	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Inhalation of contaminant vapours - outdoor	5.88E-03	2.42E-04	1.23E-03	1.31E-04	5.45E-03	1.52E-03
Ingestion of contaminated drinking water	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Dermal contact with contaminated soil	2.98E-04	2.50E-08	3.44E-07	6.33E-08	7.44E-04	1.30E-06
Dermal contact with water	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ingestion of contaminated food	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total ingestion exposure	2.61E-04	1.46E-07	2.01E-06	3.70E-07	6.53E-04	7.62E-06
Total dermal exposure	2.98E-04	2.50E-08	3.44E-07	6.33E-08	7.44E-04	1.30E-06
Ingestion + dermal exposure	5.59E-04	1.71E-07	2.36E-06	4.33E-07	1.40E-03	8.92E-06
Total inhalation exposure	5.88E-03	2.42E-04	1.23E-03	1.31E-04	5.46E-03	1.52E-03
Total Exposure (all pathways)	6.44E-03	2.42E-04	1.24E-03	1.31E-04	6.85E-03	1.52E-03

		Hazard/Risk Estimates					
		F1	Benzene	Toluene	Ethylbenzene	F2	Xylenes (total)
Hazard Quotient - Oral/Dermal		3.33E-03	NA	1.07E-05	4.33E-06	1.82E-02	5.95E-06
Hazard Quotient - Inhalation		1.65E-02	NA	1.45E-03	5.85E-04	3.19E-02	3.77E-02
Hazard Index - Total		1.98E-02	NA	1.46E-03	5.89E-04	5.01E-02	3.77E-02
Target Hazard Index:	0.2						
Cancer Risk - Oral		NA	3.30E-08	NA	NA	NA	NA
Cancer Risk - Dermal		NA	5.64E-09	NA	NA	NA	NA
Cancer Risk - Oral + Dermal		NA	3.86E-08	NA	NA	NA	NA
Cancer Risk - Inhalation		NA	2.08E-06	NA	NA	NA	NA
Cancer Risk - Total		NA	2.12E-06	NA	NA	NA	NA
Target Cancer Risk:	1.00E-05						

SUMMARY OF PQRA RESULTS Version: March 16, 2009

User Name:	Franz Environmental Inc.	**Site:**	Cambridge Bay Airport AECs
Proponent:	Transport Canada	**File #:**	1748-0901
Date:		**Comment:**	Petroleum Hydrocarbons

		Maximum Hazard/Risk Estimates					
		F1	**Benzene**	**Toluene**	**Ethylbenzene**	**F2**	**Xylenes (total)**
Hazard Quotient - Oral/Dermal		3.33E-03	NA	1.07E-05	4.33E-06	1.82E-02	5.95E-06
Hazard Quotient - Inhalation		1.65E-02	NA	1.45E-03	5.85E-04	3.19E-02	3.77E-02
Hazard Index - Total		1.98E-02	NA	1.46E-03	5.89E-04	5.01E-02	3.77E-02
Target Hazard Index:	0.2						
Cancer Risk - Oral		NA	3.30E-08	NA	NA	NA	NA
Cancer Risk - Dermal		NA	5.64E-09	NA	NA	NA	NA
Cancer Risk - Oral + Dermal		NA	3.86E-08	NA	NA	NA	NA
Cancer Risk - Inhalation		NA	2.08E-06	NA	NA	NA	NA
Cancer Risk - Total		NA	2.12E-06	NA	NA	NA	NA
Target Cancer Risk:	1.00E-05						

	Critical Receptors					
	F1	**Benzene**	**Toluene**	**Ethylbenzene**	**F2**	**Xylenes (total)**
Oral/Dermal - non-cancer effects	User-Defined Receptor	NA	User-Defined Receptor	User-Defined Receptor	User-Defined Receptor	User-Defined Receptor
Inhalation - non-cancer effects	All Age Groups	NA	All Age Groups	All Age Groups	All Age Groups	All Age Groups
Total - non-cancer effects	User-Defined Receptor	NA	User-Defined Receptor	User-Defined Receptor	User-Defined Receptor	User-Defined Receptor
Oral - cancer effects	NA	Adult	NA	NA	NA	NA
Dermal - cancer effects	NA	User-Defined Receptor	NA	NA	NA	NA
Oral + Dermal - cancer effects	NA	User-Defined Receptor	NA	NA	NA	NA
Inhalation - cancer effects	NA	Adult	NA	NA	NA	NA
Total - cancer effects	NA	User-Defined Receptor	NA	NA	NA	NA
Source of indoor air vapours	Soil	Soil	Soil	Soil	Soil	Soil
Model used for vapour transport	Health Canada	Health Canada	Health Canada	Health Canada	Health Canada	Health Canada

Key Calculated Model Parameters						
Vapour Intrusion Model Parameters	Note: parameters show as "NA" if relevant exposure pathways are inoperative or if user-input concentration is used instead of modelled value					
Qsoil/Qbuilding	NA	NA	NA	NA	NA	NA
Soil alpha	NA	NA	NA	NA	NA	NA
Groundwater alpha	NA	NA	NA	NA	NA	NA
Groundwater model dilution factors						
DF1 (soil to leachate)	NA	NA	8.65E-01	NA	NA	2.16E+00
DF2 (leachate at source to water table):	NA	NA	1.00E+00	NA	NA	1.00E+00
DF3 (leachate at water table to groundwater):	NA	NA	3.36E+00	NA	NA	3.36E+00
DF4 (source to receptor) - drinking water:	NA	NA	NA	NA	NA	NA
DF4 (source to receptor) - bathing/swimming water:	NA	NA	NA	NA	NA	NA

Notes/Comments

Vapour Intrusion Model

Chemical Interactions

All chemicals of concern present at the site should be evaluated for potential additive effects based on target organs and mechanisms of effect.

Concentration Checks

Precluding Conditions

Other Notes

Provide justification for all non-default model parameters in PQRA report

Error functions in groundwater model could not be calculated; installation of Analysis ToolPak is required

Site Worker-

Chronic Exposure

HEALTH CANADA PQRA SPREADSHEET
USER INPUT SHEET

User Name:	Franz Environmental Inc.	Site:	Cambridge Bay Airport AECs
Proponent:	Transport Canada	File #:	1748-0901
Date:		Comment:	Metals +

PROBLEM FORMULATION

Potential Land Uses (Yes/No)		Default
Agricultural	No	Yes
Residential/urban parkland	No	Yes
Commercial	Yes	Yes
Industrial	No	Yes
Occupational - outdoors	Yes	Yes
Recreational	No	Yes
Other	No	No
specify:		

Operative Pathways (Yes/No)		Default
Inadvertent ingestion of soil	Yes	Yes
Inhalation of soil particles	Yes	Yes
Inhalation of indoor contaminant vapours	No	Yes
Inhalation of outdoor contaminant vapours	Yes	Yes
Ingestion of drinking water	No	Yes
Dermal contact with soil	Yes	Yes
Dermal contact with water	Yes	Yes
Ingestion of contaminated food	No	No

Exposure Scenario		
	User-Defined	Commercial

Vapour Transport Modelling		
Vapour source for exposure calculations	Most Conservative	Most Conservative

Receptor Groups (Yes/No)		Default
General public or residents	No	Yes
Employees	Yes	Yes
Canadian native communities	No	No
Other	No	No
specify:		

Active Critical Receptors (Yes/No)		Default
Infant	No	No
Toddler	No	No
Child	No	No
Teen	No	No
Adult	No	Yes
Other	Yes	Yes
specify:	Remediation Worker_Chronic Exposure	

Contaminant Concentrations

Chemical Name	required	Arsenic	Copper	Lead		Benzo(a)pyrene	
Soil (mg/kg)	required	40.6	102	294		1	
Groundwater - source (mg/L)	optional			0.1		0.000013	
Drinking water (mg/L)	optional						
Bathing/swimming water (mg/L)	optional						
Indoor air - vapours (mg/m^3)	optional						
Outdoor air - vapours (mg/m^3)	optional						
Outdoor air - particulate (mg/m^3)	optional						
Root vegetables (mg/kg wet weight)	optional						
Other vegetables (mg/kg wet weight)	optional						
Fish (mg/kg wet weight)	optional						
Wild game (mg/kg wet weight)	optional						
						PAH-Carcinogenic	

Risk Assessment Endpoints		Default
Acceptable hazard index:	0.2	0.2
Acceptable cancer risk:	1.00E-05	1.00E-05

Precluding Conditions for Fate and Transport Models

Are non-aqueous phase liquids (NAPL) present?	No
Is groundwater contamination present in fractured bedrock?	No
Is groundwater contamination migrating through a confined aquifer?	No
Is there active pumping or drawdown of groundwater at the site?	No
Is contamination present within 1 m of building foundation?	No
Do any buildings within 5 m of contamination have earthen foundations?	No
Are any buildings constructed on very high permeability media?	No
Are there preferential vapour flow pathways connecting contamination to a building?	No

Fate and Transport Model Input

	Value	Default	Models Affected
Soil Type	coarse-grained	coarse-grained	PS, V-I, V-O, GW
Significant vehicle traffic on unpaved roads?	No	No	P-O
Site Characteristics			
Depth to Groundwater (m)	1	3	GW, V-O
Depth from Surface to Contamination (m)	0.1	0	GW, V-O
Distance - Contaminated Soil to Building (m)	70	1	V-I
Distance - Contaminated GW to Building (m)	70	1	V-I
Distance to potable water user (m)	0	0	GW
Distance to Bathing/Swimming Water (m)	0	0	GW
Particulate Concentration in Air (ug/m^3)	0.76	0.76	P-O
Building Type	Commercial/Industrial	Residential	V-I

Optional Sections

User-defined Chemicals

Note: user-defined chemicals should be named in this section before being selected in the 'Contaminant Concentrations' table above

		Chemical 1	Chemical 2	Chemical 3
Name				
CAS Number				
Chemical class (organic/inorganic)				
Tolerable daily intake (mg/kg/d) - infant	*Enter all applicable and appropriate toxicity benchmarks; values must be referenced and justified in the PQRA report.*			
Tolerable daily intake (mg/kg/d) - toddler				
Tolerable daily intake (mg/kg/d) - child				
Tolerable daily intake (mg/kg/d) - teen				
Tolerable daily intake (mg/kg/d) - adult				
Tolerable concentration (mg/m^3)				
Oral slope factor $(mg/kg/d)^{-1}$				
Inhalation slope factor $(mg/kg/d)^{-1}$				
Inhalation unit risk $(mg/m^3)^{-1}$				
Relative dermal absorption factor				
Organic carbon partitioning coefficient (mL/g) - Koc				
Log Kow (unitless)				
Henry's Law constant at 25°C (unitless) - H'				
Henry's Law constant at 25°C (atm-m3/mol) - H				
Water Solubility at 25°C (mg/L)				
Molecular Weight (g/mol)				
Vapour Pressure at 25°C (atm)				

Note: values in grayed cells will not be used; Health Canada default values are applied.

User-defined Receptor

Name	Remediation Wo	Defaults
Age group	Adult	Toddler
Body weight (kg)	70.7	70.7
Soil ingestion rate (g/d)	0.1	0.02
Inhalation rate (m^3/d)	15.8	15.8
Water ingestion rate (L/d)	1.5	1.5
Skin surface area (cm^2)		
- hands	890	890
- arms	2500	2500
- legs	0	5720
- total	3390	17640
Soil loading to exposed skin (g/cm^2/event)		
- hands	1.00E-04	0.0001
- surfaces other than hands	1.00E-05	0.00001
Food ingestion (g/d)		
- root vegetables	188	188
- other vegetables	137	137
- fish	111	111
- wild game	0	0
Evaluate Cancer Risks (Yes/No)?	Yes	Yes

User-defined Land-Use / Exposure Scenario

Scenario name	User-Defined	Defaults
Hours per day (indoors)	0	22.5
Hours per day (outdoors)	10	1.5
Days per week	6	7
Weeks per year	14	52
Dermal exposure events/day	1	1
Water contact events per day	1	1
Duration of water contact event (h)	1	1
Days/year contaminated food ingestion	0	365
Exposure duration (years)	10	60
Years for carcinogen amortization	60	60

HEALTH CANADA PQRA SPREADSHEET Version: March 16, 2009
OUTPUT SHEET - Remediation Worker_Chronic Expos Adult

User Name:	Franz Environmental Inc.	**Site:**	Cambridge Bay Airport AECs
Proponent:	Transport Canada	**File #:**	1748-0901
Date:		**Comment:**	Metals +

Exposure Scenario:	**User-Defined**	**User-Defined Receptor Characteristics**	Skin surface area (cm2) - hands: 890	
Native population not considered		Body weight (kg): 70.7	- arms: 2500	Food ingestion rates (g/d)
Cancer Risks Calculated?	**Yes**	Soil ingestion rate (g/d): 0.1	- legs: 0	Root vegetables: 188
		Inhalation rate (m3/d): 15.8	- total: 3390	Other vegetables: 137
		Water ingestion rate (L/d): 1.5	Soil loading (g/cm2-event) - hands: 0.0001	Fish: 111
			- other: 0.00001	Wild game: 0

Chemical Properties	**Units**	**Arsenic**	**Copper**	**Lead**		**Benzo(a)pyrene**	
Tolerable daily intake	mg/kg/d	NA	0.141	0.0036	NA	NA	NA
Tolerable concentration	mg/m^3	NA	NA	NA	NA	NA	NA
Oral slope factor	$(mg/kg/d)^{-1}$	1.8	NA	NA	NA	2.3	NA
Inhalation slope factor	$(mg/kg/d)^{-1}$	28	NA	NA	NA	0.137	NA
Inhalation unit risk	$(mg/m^3)^{-1}$	6.4	NA	NA	NA	0.03	NA
Dermal slope factor	$(mg/kg/d)^{-1}$	NA	NA	NA	NA	NA	NA
Critical oral exposure benchmark		slope factor	TDI	TDI	NA	slope factor	NA
Critical inhalation exposure benchmark		NA	NA	NA	NA	NA	NA
Relative dermal absorption factor	unitless	0.03	0.06	0.006	1	0.13	1

Chemical Concentrations	**Units**	**Arsenic**	**Copper**	**Lead**		**Benzo(a)pyrene**	
Soil	mg/kg	4.06E+01	1.02E+02	2.94E+02	0.00E+00	1.00E+00	0.00E+00
Drinking water	mg/L	NA	NA	NA	NA	NA	NA
Bathing/swimming water	mg/L	0.00E+00	0.00E+00	1.00E-01	0.00E+00	1.30E-05	0.00E+00
Indoor air vapours	mg/m^3	NA	NA	NA	NA	NA	NA
Outdoor air vapours	mg/m^3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.37E-08	0.00E+00
Outdoor air particulate	mg/m^3	3.09E-08	7.75E-08	2.23E-07	0.00E+00	7.60E-10	0.00E+00
Amortized total air concentration	mg/m^3	2.96692E-09	7.45385E-09	2.14846E-08	0	3.31297E-09	0
Root vegetables	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated
Other vegetables	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated
Fish	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated
Wild game	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated

RESULTS

	Exposure (mg/kg/d)					
	Arsenic	**Copper**	**Lead**		**Benzo(a)pyrene**	
Inadvertent ingestion of contaminated soil	2.21E-06	3.33E-05	9.60E-05	0.00E+00	5.44E-08	0.00E+00
Inhalation of contaminated soil particles	6.63E-10	1.67E-09	4.80E-09	0.00E+00	1.63E-11	0.00E+00
Inhalation of contaminant vapours - indoor	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Inhalation of contaminant vapours - outdoor	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.24E-10	0.00E+00
Ingestion of contaminated drinking water	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Dermal contact with contaminated soil	7.55E-08	2.28E-06	6.56E-07	0.00E+00	8.06E-09	0.00E+00
Dermal contact with water	0.00E+00	0.00E+00	1.11E-07	0.00E+00	3.89E-07	0.00E+00
Ingestion of contaminated food	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total ingestion exposure	2.21E-06	3.33E-05	9.60E-05	0.00E+00	5.44E-08	0.00E+00
Total dermal exposure	7.55E-08	2.28E-06	7.67E-07	0.00E+00	3.97E-07	0.00E+00
Ingestion + dermal exposure	2.28E-06	3.56E-05	9.67E-05	0.00E+00	4.52E-07	0.00E+00
Total inhalation exposure	6.63E-10	1.67E-09	4.80E-09	0.00E+00	7.40E-10	0.00E+00
Total Exposure (all pathways)	2.28E-06	3.56E-05	9.67E-05	0.00E+00	4.53E-07	0.00E+00

		Hazard/Risk Estimates					
		Arsenic	**Copper**	**Lead**		**Benzo(a)pyrene**	
Hazard Quotient - Oral/Dermal		NA	2.52E-04	2.69E-02	NA	NA	NA
Hazard Quotient - Inhalation		NA	1.18E-08	1.33E-06	NA	NA	NA
Hazard Index - Total		NA	2.52E-04	2.69E-02	NA	NA	NA
Target Hazard Index:	0.2						
Cancer Risk - Oral		3.98E-06	NA	NA	NA	1.25E-07	NA
Cancer Risk - Dermal		1.36E-07	NA	NA	NA	9.14E-07	NA
Cancer Risk - Oral + Dermal		4.11E-06	NA	NA	NA	1.04E-06	NA
Cancer Risk - Inhalation		3.16E-09	NA	NA	NA	1.69E-11	NA
Cancer Risk - Total		4.11E-06	NA	NA	NA	1.04E-06	NA
Target Cancer Risk:	1.00E-05						

SUMMARY OF PQRA RESULTS Version: March 16, 2009

User Name:	Franz Environmental Inc.	**Site:**	Cambridge Bay Airport AECs
Proponent:	Transport Canada	**File #:**	1748-0901
Date:		**Comment:**	Metals +

		Maximum Hazard/Risk Estimates					
		Arsenic	**Copper**	**Lead**		**Benzo(a)pyrene**	
Hazard Quotient - Oral/Dermal		NA	2.52E-04	2.69E-02	NA	NA	NA
Hazard Quotient - Inhalation		NA	1.18E-08	1.33E-06	NA	NA	NA
Hazard Index - Total		NA	2.52E-04	2.69E-02	NA	NA	NA
Target Hazard Index:	0.2						
Cancer Risk - Oral		3.98E-06	NA	NA	NA	1.25E-07	NA
Cancer Risk - Dermal		1.36E-07	NA	NA	NA	9.14E-07	NA
Cancer Risk - Oral + Dermal		4.11E-06	NA	NA	NA	1.04E-06	NA
Cancer Risk - Inhalation		3.16E-09	NA	NA	NA	1.69E-11	NA
Cancer Risk - Total		4.11E-06	NA	NA	NA	1.04E-06	NA
Target Cancer Risk:	1.00E-05						

	Critical Receptors					
	Arsenic	**Copper**	**Lead**		**Benzo(a)pyrene**	
Oral/Dermal - non-cancer effects	NA	User-Defined Receptor	User-Defined Receptor	NA	NA	NA
Inhalation - non-cancer effects	NA	Adult	Adult	NA	NA	NA
Total - non-cancer effects	NA	User-Defined Receptor	User-Defined Receptor	NA	NA	NA
Oral - cancer effects	User-Defined Receptor	NA	NA	NA	User-Defined Receptor	NA
Dermal - cancer effects	User-Defined Receptor	NA	NA	NA	User-Defined Receptor	NA
Oral + Dermal - cancer effects	User-Defined Receptor	NA	NA	NA	User-Defined Receptor	NA
Inhalation - cancer effects	Adult	NA	NA	NA	Adult	NA
Total - cancer effects	User-Defined Receptor	NA	NA	NA	User-Defined Receptor	NA
Source of indoor air vapours	NA	NA	NA	NA	Soil	NA
Model used for vapour transport	NA	NA	NA	NA	Health Canada	NA

Key Calculated Model Parameters						
Vapour Intrusion Model Parameters	Note: parameters show as "NA" if relevant exposure pathways are inoperative or if user-input concentration is used instead of modelled value					
Qsoil/Qbuilding	NA	NA	NA	NA	NA	NA
Soil alpha	NA	NA	NA	NA	NA	NA
Groundwater alpha	NA	NA	NA	NA	NA	NA
Groundwater model dilution factors						
DF1 (soil to leachate)	NA	NA	NA	NA	NA	NA
DF2 (leachate at source to water table):	NA	NA	NA	NA	NA	NA
DF3 (leachate at water table to groundwater):	NA	NA	NA	NA	NA	NA
DF4 (source to receptor) - drinking water:	NA	NA	NA	NA	NA	NA
DF4 (source to receptor) - bathing/swimming water:	NA	NA	1.00E+00	NA	1.00E+00	NA

Notes/Comments

Vapour Intrusion Model

Chemical Interactions

All chemicals of concern present at the site should be evaluated for potential additive effects based on target organs and mechanisms of effect.
All carcinogenic PAH present at the site must be treated additively

Concentration Checks

Precluding Conditions

Other Notes

Site-specific PHC composition data applied; please print 'PHC' page for report
Provide justification for all non-default model parameters in PQRA report
Error functions in groundwater model could not be calculated; installation of Analysis ToolPak is required

HEALTH CANADA PQRA SPREADSHEET
USER INPUT SHEET

User Name:	Franz Environmental Inc.	Site:	Cambridge Bay Airport AECs
Proponent:	Transport Canada	File #:	1748-0901
Date:		Comment:	Petroleum Hydrocarbons

PROBLEM FORMULATION

Potential Land Uses (Yes/No)		Default
Agricultural	No	Yes
Residential/urban parkland	No	Yes
Commercial	Yes	Yes
Industrial	No	Yes
Occupational - outdoors	Yes	Yes
Recreational	No	Yes
Other	No	No
specify:		

Operative Pathways (Yes/No)		Default
Inadvertent ingestion of soil	Yes	Yes
Inhalation of soil particles	Yes	Yes
Inhalation of indoor contaminant vapours	No	Yes
Inhalation of outdoor contaminant vapours	Yes	Yes
Ingestion of drinking water	No	Yes
Dermal contact with soil	Yes	Yes
Dermal contact with water	Yes	Yes
Ingestion of contaminated food	No	No

Exposure Scenario	User-Defined	Commercial

Vapour Transport Modelling		
Vapour source for exposure calculations	Most Conservative	Most Conservative

Receptor Groups (Yes/No)		Default
General public or residents	No	Yes
Employees	Yes	Yes
Canadian native communities	No	No
Other	No	No
specify:		

Active Critical Receptors (Yes/No)		Default
Infant	No	No
Toddler	No	No
Child	No	No
Teen	No	No
Adult	No	Yes
Other	Yes	Yes
specify:	Remediation Worker Chronic Exposure	

Contaminant Concentrations

Blue numbers exceed theoretical saturation/solubility limits; site should be evaluated for potential NAPL

Chemical Name		F1	Benzene	Toluene	Ethylbenzene	F2	Xylenes (total)
Soil (mg/kg)	required	***4800***	4.6	37	6.8	***12000***	140
Groundwater - source (mg/L)	optional	3.5	1.7		0.18	3.8	
Drinking water (mg/L)	optional						
Bathing/swimming water (mg/L)	optional						
Indoor air - vapours (mg/m^3)	optional						
Outdoor air - vapours (mg/m^3)	optional						
Outdoor air - particulate (mg/m^3)	optional						
Root vegetables (mg/kg wet weight)	optional						
Other vegetables (mg/kg wet weight)	optional						
Fish (mg/kg wet weight)	optional						
Wild game (mg/kg wet weight)	optional						
		See also PHC Sheet				See also PHC Sheet	

Risk Assessment Endpoints		Default
Acceptable hazard index:	0.2	0.2
Acceptable cancer risk:	1.00E-05	1.00E-05

Precluding Conditions for Fate and Transport Models

Are non-aqueous phase liquids (NAPL) present?	No
Is groundwater contamination present in fractured bedrock?	No
Is groundwater contamination migrating through a confined aquifer?	No
Is there active pumping or drawdown of groundwater at the site?	No
Is contamination present within 1 m of building foundation?	No
Do any buildings within 5 m of contamination have earthen foundations?	No
Are any buildings constructed on very high permeability media?	No
Are there preferential vapour flow pathways connecting contamination to a building?	No

Fate and Transport Model Input

	Value	Default	Models Affected
Soil Type	coarse-grained	coarse-grained	PS, V-I, V-O, GW
Significant vehicle traffic on unpaved roads?	No	No	P-O
Site Characteristics			
Depth to Groundwater (m)	1	3	GW, V-O
Depth from Surface to Contamination (m)	0.1	0	GW, V-O
Distance - Contaminated Soil to Building (m)	70	1	V-I
Distance - Contaminated GW to Building (m)	70	1	V-I
Distance to potable water user (m)	0	0	GW
Distance to Bathing/Swimming Water (m)	0	0	GW
Particulate Concentration in Air (ug/m^3)	0.76	0.76	P-O
Building Type	Commercial/Industrial	Residential	V-I

Optional Sections

User-defined Chemicals

Note: user-defined chemicals should be named in this section before being selected in the 'Contaminant Concentrations' table above

		Chemical 1	Chemical 2	Chemical 3
Name				
CAS Number				
Chemical class (organic/inorganic)				
Tolerable daily intake (mg/kg/d) - infant	*Enter all applicable and appropriate toxicity benchmarks; values must be referenced and justified in the PQRA report.*			
Tolerable daily intake (mg/kg/d) - toddler				
Tolerable daily intake (mg/kg/d) - child				
Tolerable daily intake (mg/kg/d) - teen				
Tolerable daily intake (mg/kg/d) - adult				
Tolerable concentration (mg/m^3)				
Oral slope factor $(mg/kg/d)^{-1}$				
Inhalation slope factor $(mg/kg/d)^{-1}$				
Inhalation unit risk $(mg/m^3)^{-1}$				
Relative dermal absorption factor				
Organic carbon partitioning coefficient (mL/g) - Koc				
Log Kow (unitless)				
Henry's Law constant at 25°C (unitless) - H'				
Henry's Law constant at 25°C (atm-m3/mol) - H				
Water Solubility at 25°C (mg/L)				
Molecular Weight (g/mol)				
Vapour Pressure at 25°C (atm)				

Note: values in grayed cells will not be used; Health Canada default values are applied.

User-defined Receptor

Name	Remediation Wo	Defaults
Age group	Adult	Toddler
Body weight (kg)	70.7	70.7
Soil ingestion rate (g/d)	0.1	0.02
Inhalation rate (m^3/d)	15.8	15.8
Water ingestion rate (L/d)	1.5	1.5
Skin surface area (cm^2)		
- hands	890	890
- arms	2500	2500
- legs	0	5720
- total	3390	17640
Soil loading to exposed skin (g/cm^2/event)		
- hands	1.00E-04	0.0001
- surfaces other than hands	1.00E-05	0.00001
Food ingestion (g/d)		
- root vegetables	188	188
- other vegetables	137	137
- fish	111	111
- wild game	0	0
Evaluate Cancer Risks (Yes/No)?	Yes	Yes

User-defined Land-Use / Exposure Scenario

Scenario name	User-Defined	Defaults
Hours per day (indoors)	0	22.5
Hours per day (outdoors)	10	1.5
Days per week	6	7
Weeks per year	14	52
Dermal exposure events/day	1	1
Water contact events per day	1	1
Duration of water contact event (h)	1	1
Days/year contaminated food ingestion	0	365
Exposure duration (years)	10	60
Years for carcinogen amortization	60	60

PHC Fraction Composition (%)	Soil		Note: water and air defaults are calculated based on soil properties Water		Air (Vapour)	
Fraction 1		Default		Default		Default
Aliphatics C_6-C_8		55		60.5		85.3
Aliphatics $C_{>8}$-C_{10}		36		6.3		14.2
Aromatics $C_{>8}$-C_{10}		9		33.2		0.4
Total		100		100		100
Fraction 2						
Aliphatics $C_{>10}$-C_{12}		36		2.4		76.7
Aliphatics $C_{>12}$-C_{16}		44		0.1		20.6
Aromatics $C_{>10}$-C_{12}		9		60.3		2.3
Aromatics $C_{>12}$-C_{16}		11		37.1		0.5
Total		100		100		100
Fraction 3						
Aliphatics $C_{>16}$-C_{21}		56		9.54E-03		89.79
Aliphatics $C_{>21}$-C_{34}		24		2.58E-07		7.83
Aromatics $C_{>16}$-C_{21}		14		95		2.37
Aromatics $C_{>21}$-C_{34}		6		5		0.01
Total		100		100		100
Fraction 4						
Aliphatics $C_{>34}$		80		0		0
Aromatics $C_{>34}$		20		100		0
Total		100		100		0

HEALTH CANADA PQRA SPREADSHEET Version: March 16, 2009
OUTPUT SHEET - Remediation Worker Chronic Exposı Adult

User Name:	Franz Environmental Inc.	**Site:**	Cambridge Bay Airport AECs
Proponent:	Transport Canada	**File #:**	1748-0901
Date:		**Comment:**	Petroleum Hydrocarbons

Exposure Scenario:	**User-Defined**	**User-Defined Receptor Characteristics**	Skin surface area (cm2) - hands: 890	
Native population not considered		Body weight (kg): 70.7	- arms: 2500	Food ingestion rates (g/d)
Cancer Risks Calculated?	**Yes**	Soil ingestion rate (g/d): 0.1	- legs: 0	Root vegetables: 188
		Inhalation rate (m3/d): 15.8	- total: 3390	Other vegetables: 137
		Water ingestion rate (L/d): 1.5	Soil loading (g/cm2-event) - hands: 0.0001	Fish: 111
			- other: 0.00001	Wild game: 0

Chemical Properties	**Units**	**F1**	**Benzene**	**Toluene**	**Ethylbenzene**	**F2**	**Xylenes (total)**
Tolerable daily intake	mg/kg/d	NA	NA	0.22	0.1	NA	1.5
Tolerable concentration	mg/m^3	NA	NA	3.8	1	NA	0.18
Oral slope factor	$(mg/kg/d)^{-1}$	NA	0.226	NA	NA	NA	NA
Inhalation slope factor	$(mg/kg/d)^{-1}$	NA	0.0146	NA	NA	NA	NA
Inhalation unit risk	$(mg/m^3)^{-1}$	NA	0.0033	NA	NA	NA	NA
Dermal slope factor	$(mg/kg/d)^{-1}$	NA	NA	NA	NA	NA	NA
Critical oral exposure benchmark		NA	slope factor	TDI	TDI	NA	TDI
Critical inhalation exposure benchmark		NA	NA	TC	TC	NA	TC
Relative dermal absorption factor	unitless	0.2	0.03	0.03	0.03	0.2	0.03

Chemical Concentrations	**Units**	**F1**	**Benzene**	**Toluene**	**Ethylbenzene**	**F2**	**Xylenes (total)**
Soil	mg/kg	4.80E+03	4.60E+00	3.70E+01	6.80E+00	1.20E+04	1.40E+02
Drinking water	mg/L	NA	NA	NA	NA	NA	NA
Bathing/swimming water	mg/L	3.50E+00	1.70E+00	1.27E+01	1.80E-01	3.80E+00	1.93E+01
Indoor air vapours	mg/m^3	NA	NA	NA	NA	NA	NA
Outdoor air vapours	mg/m^3	8.21E-01	3.38E-02	1.72E-01	1.82E-02	7.62E-01	2.12E-01
Outdoor air particulate	mg/m^3	3.03E-06	2.78E-09	2.46E-08	4.78E-09	9.06E-06	1.01E-07
Amortized total air concentration	mg/m^3	0.078898394	0.003247993	0.016548128	0.001753936	0.073228231	0.02034014
Root vegetables	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated
Other vegetables	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated
Fish	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated
Wild game	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated

RESULTS

	Exposure (mg/kg/d)					
	F1	**Benzene**	**Toluene**	**Ethylbenzene**	**F2**	**Xylenes (total)**
Inadvertent ingestion of contaminated soil	1.57E-03	2.50E-07	1.21E-05	2.22E-06	3.92E-03	4.57E-05
Inhalation of contaminated soil particles	6.50E-08	5.98E-11	5.28E-10	1.03E-10	1.95E-07	2.17E-09
Inhalation of contaminant vapours - indoor	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Inhalation of contaminant vapours - outdoor	1.76E-02	7.26E-04	3.70E-03	3.92E-04	1.64E-02	4.55E-03
Ingestion of contaminated drinking water	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Dermal contact with contaminated soil	3.57E-04	8.56E-09	4.13E-07	7.59E-08	8.93E-04	1.56E-06
Dermal contact with water	6.44E-02	4.39E-04	7.01E-03	1.80E-04	9.90E-02	1.90E-02
Ingestion of contaminated food	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total ingestion exposure	1.57E-03	2.50E-07	1.21E-05	2.22E-06	3.92E-03	4.57E-05
Total dermal exposure	6.48E-02	4.39E-04	7.01E-03	1.80E-04	9.99E-02	1.90E-02
Ingestion + dermal exposure	6.64E-02	4.39E-04	7.02E-03	1.83E-04	1.04E-01	1.91E-02
Total inhalation exposure	1.76E-02	7.26E-04	3.70E-03	3.92E-04	1.64E-02	4.55E-03
Total Exposure (all pathways)	8.40E-02	1.16E-03	1.07E-02	5.75E-04	1.20E-01	2.36E-02

		Hazard/Risk Estimates					
		F1	**Benzene**	**Toluene**	**Ethylbenzene**	**F2**	**Xylenes (total)**
Hazard Quotient - Oral/Dermal		4.46E-01	NA	3.19E-02	1.83E-03	1.80E+00	1.27E-02
Hazard Quotient - Inhalation		4.95E-02	NA	4.35E-03	1.75E-03	9.58E-02	1.13E-01
Hazard Index - Total		4.96E-01	NA	3.63E-02	3.58E-03	1.89E+00	1.26E-01
Target Hazard Index:	0.2	**Target Hazard Index Exceeded**				**Target Hazard Index Exceeded**	
Cancer Risk - Oral		NA	5.66E-08	NA	NA	NA	NA
Cancer Risk - Dermal		NA	9.92E-05	NA	NA	NA	NA
Cancer Risk - Oral + Dermal		NA	9.92E-05	NA	NA	NA	NA
Cancer Risk - Inhalation		NA	1.79E-06	NA	NA	NA	NA
Cancer Risk - Total		NA	1.01E-04	NA	NA	NA	NA
Target Cancer Risk:	1.00E-05		**Target Cancer Risk Exceeded**				

SUMMARY OF PQRA RESULTS Version: March 16, 2009

User Name:	Franz Environmental Inc.	**Site:**	Cambridge Bay Airport AECs
Proponent:	Transport Canada	**File #:**	1748-0901
Date:		**Comment:**	Petroleum Hydrocarbons

		Maximum Hazard/Risk Estimates					
		F1	**Benzene**	**Toluene**	**Ethylbenzene**	**F2**	**Xylenes (total)**
Hazard Quotient - Oral/Dermal		4.46E-01	NA	3.19E-02	1.83E-03	1.80E+00	1.27E-02
Hazard Quotient - Inhalation		4.95E-02	NA	4.35E-03	1.75E-03	9.58E-02	1.13E-01
Hazard Index - Total		4.96E-01	NA	3.63E-02	3.58E-03	1.89E+00	1.26E-01
Target Hazard Index:	0.2	**Target Hazard Index Exceeded**				**Target Hazard Index Exceeded**	
Cancer Risk - Oral		NA	5.66E-08	NA	NA	NA	NA
Cancer Risk - Dermal		NA	9.92E-05	NA	NA	NA	NA
Cancer Risk - Oral + Dermal		NA	9.92E-05	NA	NA	NA	NA
Cancer Risk - Inhalation		NA	1.79E-06	NA	NA	NA	NA
Cancer Risk - Total		NA	1.01E-04	NA	NA	NA	NA
Target Cancer Risk:	1.00E-05		**Target Cancer Risk Exceeded**				

	Critical Receptors					
	F1	**Benzene**	**Toluene**	**Ethylbenzene**	**F2**	**Xylenes (total)**
Oral/Dermal - non-cancer effects	User-Defined Receptor	NA	User-Defined Receptor	User-Defined Receptor	User-Defined Receptor	User-Defined Receptor
Inhalation - non-cancer effects	All Age Groups	NA	All Age Groups	All Age Groups	All Age Groups	All Age Groups
Total - non-cancer effects	User-Defined Receptor	NA	User-Defined Receptor	User-Defined Receptor	User-Defined Receptor	User-Defined Receptor
Oral - cancer effects	NA	User-Defined Receptor	NA	NA	NA	NA
Dermal - cancer effects	NA	User-Defined Receptor	NA	NA	NA	NA
Oral + Dermal - cancer effects	NA	User-Defined Receptor	NA	NA	NA	NA
Inhalation - cancer effects	NA	Adult	NA	NA	NA	NA
Total - cancer effects	NA	User-Defined Receptor	NA	NA	NA	NA
Source of indoor air vapours	Soil	Soil	Soil	Soil	Soil	Soil
Model used for vapour transport	Health Canada	Health Canada	Health Canada	Health Canada	Health Canada	Health Canada

Key Calculated Model Parameters						
Vapour Intrusion Model Parameters	Note: parameters show as "NA" if relevant exposure pathways are inoperative or if user-input concentration is used instead of modelled value					
Qsoil/Qbuilding	NA	NA	NA	NA	NA	NA
Soil alpha	NA	NA	NA	NA	NA	NA
Groundwater alpha	NA	NA	NA	NA	NA	NA
Groundwater model dilution factors						
DF1 (soil to leachate)	NA	NA	8.65E-01	NA	NA	2.16E+00
DF2 (leachate at source to water table):	NA	NA	1.00E+00	NA	NA	1.00E+00
DF3 (leachate at water table to groundwater):	NA	NA	3.36E+00	NA	NA	3.36E+00
DF4 (source to receptor) - drinking water:	NA	NA	NA	NA	NA	NA
DF4 (source to receptor) - bathing/swimming water:	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

Notes/Comments

Vapour Intrusion Model

Chemical Interactions

All chemicals of concern present at the site should be evaluated for potential additive effects based on target organs and mechanisms of effect.

Concentration Checks

Precluding Conditions

Other Notes

Provide justification for all non-default model parameters in PQRA report

Error functions in groundwater model could not be calculated; installation of Analysis ToolPak is required

Site Worker-

Sub-Chronic Exposure

HEALTH CANADA PQRA SPREADSHEET
USER INPUT SHEET

User Name:	Franz Environmental Inc.	Site:	Cambridge Bay Airport AECs
Proponent:	Transport Canada	File #:	1748-0901
Date:		Comment:	Metals +

PROBLEM FORMULATION

Potential Land Uses (Yes/No)		Default
Agricultural	No	Yes
Residential/urban parkland	No	Yes
Commercial	Yes	Yes
Industrial	No	Yes
Occupational - outdoors	Yes	Yes
Recreational	No	Yes
Other	No	No
specify:		

Operative Pathways (Yes/No)		Default
Inadvertent ingestion of soil	Yes	Yes
Inhalation of soil particles	Yes	Yes
Inhalation of indoor contaminant vapours	No	Yes
Inhalation of outdoor contaminant vapours	Yes	Yes
Ingestion of drinking water	No	Yes
Dermal contact with soil	Yes	Yes
Dermal contact with water	Yes	Yes
Ingestion of contaminated food	No	No

Exposure Scenario	User-Defined	Commercial

Vapour Transport Modelling		
Vapour source for exposure calculations	Most Conservative	Most Conservative

Receptor Groups (Yes/No)		Default
General public or residents	No	Yes
Employees	Yes	Yes
Canadian native communities	No	No
Other	No	No
specify:		

Active Critical Receptors (Yes/No)		Default
Infant	No	No
Toddler	No	No
Child	No	No
Teen	No	No
Adult	No	Yes
Other	Yes	Yes
specify:	Remediation Contractor_Acute	

Contaminant Concentrations

Chemical Name	required	Arsenic	Copper	Lead		Benzo(a)pyrene	
Soil (mg/kg)	required	40.6	102	294		1	
Groundwater - source (mg/L)	optional			0.1		0.000013	
Drinking water (mg/L)	optional						
Bathing/swimming water (mg/L)	optional						
Indoor air - vapours (mg/m^3)	optional						
Outdoor air - vapours (mg/m^3)	optional						
Outdoor air - particulate (mg/m^3)	optional						
Root vegetables (mg/kg wet weight)	optional						
Other vegetables (mg/kg wet weight)	optional						
Fish (mg/kg wet weight)	optional						
Wild game (mg/kg wet weight)	optional						
						PAH-Carcinogenic	

Risk Assessment Endpoints		Default
Acceptable hazard index:	0.2	0.2
Acceptable cancer risk:	1.00E-05	1.00E-05

Precluding Conditions for Fate and Transport Models

Are non-aqueous phase liquids (NAPL) present?	No
Is groundwater contamination present in fractured bedrock?	No
Is groundwater contamination migrating through a confined aquifer?	No
Is there active pumping or drawdown of groundwater at the site?	No
Is contamination present within 1 m of building foundation?	No
Do any buildings within 5 m of contamination have earthen foundations?	No
Are any buildings constructed on very high permeability media?	No
Are there preferential vapour flow pathways connecting contamination to a building?	No

Fate and Transport Model Input

	Value	Default	Models Affected
Soil Type	coarse-grained	coarse-grained	PS, V-I, V-O, GW
Significant vehicle traffic on unpaved roads?	No	No	P-O
Site Characteristics			
Depth to Groundwater (m)	1	3	GW, V-O
Depth from Surface to Contamination (m)	0.1	0	GW, V-O
Distance - Contaminated Soil to Building (m)	70	1	V-I
Distance - Contaminated GW to Building (m)	70	1	V-I
Distance to potable water user (m)	0	0	GW
Distance to Bathing/Swimming Water (m)	0	0	GW
Particulate Concentration in Air (ug/m^3)	0.76	0.76	P-O
Building Type	Commercial/Industrial	Residential	V-I

Optional Sections

User-defined Chemicals

Note: user-defined chemicals should be named in this section before being selected in the 'Contaminant Concentrations' table above

		Chemical 1	Chemical 2	Chemical 3
Name				
CAS Number				
Chemical class (organic/inorganic)				
Tolerable daily intake (mg/kg/d) - infant	*Enter all applicable and appropriate toxicity benchmarks; values must be referenced and justified in the PQRA report.*			
Tolerable daily intake (mg/kg/d) - toddler				
Tolerable daily intake (mg/kg/d) - child				
Tolerable daily intake (mg/kg/d) - teen				
Tolerable daily intake (mg/kg/d) - adult				
Tolerable concentration (mg/m^3)				
Oral slope factor $(mg/kg/d)^{-1}$				
Inhalation slope factor $(mg/kg/d)^{-1}$				
Inhalation unit risk $(mg/m^3)^{-1}$				
Relative dermal absorption factor				
Organic carbon partitioning coefficient (mL/g) - Koc				
Log Kow (unitless)				
Henry's Law constant at 25°C (unitless) - H'				
Henry's Law constant at 25°C (atm-m3/mol) - H				
Water Solubility at 25°C (mg/L)				
Molecular Weight (g/mol)				
Vapour Pressure at 25°C (atm)				

Note: values in grayed cells will not be used; Health Canada default values are applied.

User-defined Receptor

Name	Remediation Cor	Defaults
Age group	Adult	Toddler
Body weight (kg)	70.7	70.7
Soil ingestion rate (g/d)	0.1	0.02
Inhalation rate (m^3/d)	15.8	15.8
Water ingestion rate (L/d)	1.5	1.5
Skin surface area (cm^2)		
- hands	890	890
- arms	2500	2500
- legs	0	5720
- total	3390	17640
Soil loading to exposed skin (g/cm^2/event)		
- hands	1.00E-04	0.0001
- surfaces other than hands	1.00E-05	0.00001
Food ingestion (g/d)		
- root vegetables	188	188
- other vegetables	137	137
- fish	111	111
- wild game	0	0
Evaluate Cancer Risks (Yes/No)?	Yes	Yes

User-defined Land-Use / Exposure Scenario

Scenario name	User-Defined	Defaults
Hours per day (indoors)	0	22.5
Hours per day (outdoors)	10	1.5
Days per week	6	7
Weeks per year	14	52
Dermal exposure events/day	1	1
Water contact events per day	1	1
Duration of water contact event (h)	1	1
Days/year contaminated food ingestion	0	365
Exposure duration (years)	0.27	60
Years for carcinogen amortization	0.27	60

HEALTH CANADA PQRA SPREADSHEET Version: March 16, 2009
OUTPUT SHEET - Remediation Contractor_Acute **Adult**

User Name:	Franz Environmental Inc.	**Site:**	Cambridge Bay Airport AECs
Proponent:	Transport Canada	**File #:**	1748-0901
Date:		**Comment:**	Metals +

Exposure Scenario:	**User-Defined**	**User-Defined Receptor Characteristics**	Skin surface area (cm2) - hands: 890	
Native population not considered		Body weight (kg): 70.7	- arms: 2500	Food ingestion rates (g/d)
Cancer Risks Calculated?	**Yes**	Soil ingestion rate (g/d): 0.1	- legs: 0	Root vegetables: 188
		Inhalation rate (m3/d): 15.8	- total: 3390	Other vegetables: 137
		Water ingestion rate (L/d): 1.5	Soil loading (g/cm2-event) - hands: 0.0001	Fish: 111
			- other: 0.00001	Wild game: 0

Chemical Properties	**Units**	**Arsenic**	**Copper**	**Lead**		**Benzo(a)pyrene**	
Tolerable daily intake	mg/kg/d	NA	0.141	0.0036	NA	NA	NA
Tolerable concentration	mg/m^3	NA	NA	NA	NA	NA	NA
Oral slope factor	$(mg/kg/d)^{-1}$	1.8	NA	NA	NA	2.3	NA
Inhalation slope factor	$(mg/kg/d)^{-1}$	28	NA	NA	NA	0.137	NA
Inhalation unit risk	$(mg/m^3)^{-1}$	6.4	NA	NA	NA	0.03	NA
Dermal slope factor	$(mg/kg/d)^{-1}$	NA	NA	NA	NA	NA	NA
Critical oral exposure benchmark		slope factor	TDI	TDI	NA	slope factor	NA
Critical inhalation exposure benchmark		unit risk	NA	NA	NA	slope factor	NA
Relative dermal absorption factor	unitless	0.03	0.06	0.006	1	0.13	1

Chemical Concentrations	**Units**	**Arsenic**	**Copper**	**Lead**		**Benzo(a)pyrene**	
Soil	mg/kg	4.06E+01	1.02E+02	2.94E+02	0.00E+00	1.00E+00	0.00E+00
Drinking water	mg/L	NA	NA	NA	NA	NA	NA
Bathing/swimming water	mg/L	0.00E+00	0.00E+00	1.00E-01	0.00E+00	1.30E-05	0.00E+00
Indoor air vapours	mg/m^3	NA	NA	NA	NA	NA	NA
Outdoor air vapours	mg/m^3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.37E-08	0.00E+00
Outdoor air particulate	mg/m^3	3.09E-08	7.75E-08	2.23E-07	0.00E+00	7.60E-10	0.00E+00
Amortized total air concentration	mg/m^3	2.96692E-09	7.45385E-09	2.14846E-08	0	3.31297E-09	0
Root vegetables	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated
Other vegetables	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated
Fish	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated
Wild game	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated

RESULTS

	Exposure (mg/kg/d)					
	Arsenic	**Copper**	**Lead**		**Benzo(a)pyrene**	
Inadvertent ingestion of contaminated soil	1.33E-05	3.33E-05	9.60E-05	0.00E+00	3.26E-07	0.00E+00
Inhalation of contaminated soil particles	6.63E-10	1.67E-09	4.80E-09	0.00E+00	1.63E-11	0.00E+00
Inhalation of contaminant vapours - indoor	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Inhalation of contaminant vapours - outdoor	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.24E-10	0.00E+00
Ingestion of contaminated drinking water	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Dermal contact with contaminated soil	4.53E-07	2.28E-06	6.56E-07	0.00E+00	4.84E-08	0.00E+00
Dermal contact with water	0.00E+00	0.00E+00	1.11E-07	0.00E+00	3.89E-07	0.00E+00
Ingestion of contaminated food	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total ingestion exposure	1.33E-05	3.33E-05	9.60E-05	0.00E+00	3.26E-07	0.00E+00
Total dermal exposure	4.53E-07	2.28E-06	7.67E-07	0.00E+00	4.38E-07	0.00E+00
Ingestion + dermal exposure	1.37E-05	3.56E-05	9.67E-05	0.00E+00	7.64E-07	0.00E+00
Total inhalation exposure	6.63E-10	1.67E-09	4.80E-09	0.00E+00	7.40E-10	0.00E+00
Total Exposure (all pathways)	1.37E-05	3.56E-05	9.67E-05	0.00E+00	7.65E-07	0.00E+00

		Hazard/Risk Estimates					
		Arsenic	**Copper**	**Lead**		**Benzo(a)pyrene**	
Hazard Quotient - Oral/Dermal		NA	2.52E-04	2.69E-02	NA	NA	NA
Hazard Quotient - Inhalation		NA	1.18E-08	1.33E-06	NA	NA	NA
Hazard Index - Total		NA	2.52E-04	2.69E-02	NA	NA	NA
Target Hazard Index:	0.2						
Cancer Risk - Oral		2.39E-05	NA	NA	NA	7.51E-07	NA
Cancer Risk - Dermal		8.16E-07	NA	NA	NA	1.01E-06	NA
Cancer Risk - Oral + Dermal		2.47E-05	NA	NA	NA	1.76E-06	NA
Cancer Risk - Inhalation		1.90E-08	NA	NA	NA	1.01E-10	NA
Cancer Risk - Total		2.47E-05	NA	NA	NA	1.76E-06	NA
Target Cancer Risk:	1.00E-05	**Target Cancer Risk Exceeded**					

SUMMARY OF PQRA RESULTS Version: March 16, 2009

User Name:	Franz Environmental Inc.	**Site:**	Cambridge Bay Airport AECs
Proponent:	Transport Canada	**File #:**	1748-0901
Date:		**Comment:**	Metals +

		Maximum Hazard/Risk Estimates					
		Arsenic	**Copper**	**Lead**		**Benzo(a)pyrene**	
Hazard Quotient - Oral/Dermal		NA	2.52E-04	2.69E-02	NA	NA	NA
Hazard Quotient - Inhalation		NA	1.18E-08	1.33E-06	NA	NA	NA
Hazard Index - Total		NA	2.52E-04	2.69E-02	NA	NA	NA
Target Hazard Index:	0.2						
Cancer Risk - Oral		2.39E-05	NA	NA	NA	7.51E-07	NA
Cancer Risk - Dermal		8.16E-07	NA	NA	NA	1.01E-06	NA
Cancer Risk - Oral + Dermal		2.47E-05	NA	NA	NA	1.76E-06	NA
Cancer Risk - Inhalation		1.90E-08	NA	NA	NA	1.01E-10	NA
Cancer Risk - Total		2.47E-05	NA	NA	NA	1.76E-06	NA
Target Cancer Risk:	1.00E-05	**Target Cancer Risk Exceeded**					

	Critical Receptors					
	Arsenic	**Copper**	**Lead**		**Benzo(a)pyrene**	
Oral/Dermal - non-cancer effects	NA	User-Defined Receptor	User-Defined Receptor	NA	NA	NA
Inhalation - non-cancer effects	NA	Adult	Adult	NA	NA	NA
Total - non-cancer effects	NA	User-Defined Receptor	User-Defined Receptor	NA	NA	NA
Oral - cancer effects	User-Defined Receptor	NA	NA	NA	User-Defined Receptor	NA
Dermal - cancer effects	User-Defined Receptor	NA	NA	NA	User-Defined Receptor	NA
Oral + Dermal - cancer effects	User-Defined Receptor	NA	NA	NA	User-Defined Receptor	NA
Inhalation - cancer effects	Adult	NA	NA	NA	Adult	NA
Total - cancer effects	User-Defined Receptor	NA	NA	NA	User-Defined Receptor	NA
Source of indoor air vapours	NA	NA	NA	NA	Soil	NA
Model used for vapour transport	NA	NA	NA	NA	Health Canada	NA

Key Calculated Model Parameters						
Vapour Intrusion Model Parameters	Note: parameters show as "NA" if relevant exposure pathways are inoperative or if user-input concentration is used instead of modelled value					
Qsoil/Qbuilding	NA	NA	NA	NA	NA	NA
Soil alpha	NA	NA	NA	NA	NA	NA
Groundwater alpha	NA	NA	NA	NA	NA	NA
Groundwater model dilution factors						
DF1 (soil to leachate)	NA	NA	NA	NA	NA	NA
DF2 (leachate at source to water table):	NA	NA	NA	NA	NA	NA
DF3 (leachate at water table to groundwater):	NA	NA	NA	NA	NA	NA
DF4 (source to receptor) - drinking water:	NA	NA	NA	NA	NA	NA
DF4 (source to receptor) - bathing/swimming water:	NA	NA	1.00E+00	NA	1.00E+00	NA

Notes/Comments

Vapour Intrusion Model

Chemical Interactions

All chemicals of concern present at the site should be evaluated for potential additive effects based on target organs and mechanisms of effect.
All carcinogenic PAH present at the site must be treated additively

Concentration Checks

Precluding Conditions

Other Notes

Site-specific PHC composition data applied; please print 'PHC' page for report
Provide justification for all non-default model parameters in PQRA report
Error functions in groundwater model could not be calculated; installation of Analysis ToolPak is required

HEALTH CANADA PQRA SPREADSHEET
USER INPUT SHEET

User Name:	Franz Environmental Inc.	Site:	Cambridge Bay Airport AECs
Proponent:	Transport Canada	File #:	1748-0901
Date:		Comment:	Petroleum Hydrocarbons

PROBLEM FORMULATION

Potential Land Uses (Yes/No)		Default
Agricultural	No	Yes
Residential/urban parkland	No	Yes
Commercial	Yes	Yes
Industrial	No	Yes
Occupational - outdoors	Yes	Yes
Recreational	No	Yes
Other	No	No
specify:		

Operative Pathways (Yes/No)		Default
Inadvertent ingestion of soil	Yes	Yes
Inhalation of soil particles	Yes	Yes
Inhalation of indoor contaminant vapours	No	Yes
Inhalation of outdoor contaminant vapours	Yes	Yes
Ingestion of drinking water	No	Yes
Dermal contact with soil	Yes	Yes
Dermal contact with water	Yes	Yes
Ingestion of contaminated food	No	No

Exposure Scenario	User-Defined	Commercial

Vapour Transport Modelling		
Vapour source for exposure calculations	Most Conservative	Most Conservative

Receptor Groups (Yes/No)		Default
General public or residents	No	Yes
Employees	Yes	Yes
Canadian native communities	No	No
Other	No	No
specify:		

Active Critical Receptors (Yes/No)		Default
Infant	No	No
Toddler	No	No
Child	No	No
Teen	No	No
Adult	No	Yes
Other	Yes	Yes
specify:	Remediation Contractor_Acute	

Contaminant Concentrations

Blue numbers exceed theoretical saturation/solubility limits; site should be evaluated for potential NAPL

Chemical Name		F1	Benzene	Toluene	Ethylbenzene	F2	Xylenes (total)
Soil (mg/kg)	required	***4800***	4.6	37	6.8	***12000***	140
Groundwater - source (mg/L)	optional	3.5	1.7		0.18	3.8	
Drinking water (mg/L)	optional						
Bathing/swimming water (mg/L)	optional						
Indoor air - vapours (mg/m^3)	optional						
Outdoor air - vapours (mg/m^3)	optional						
Outdoor air - particulate (mg/m^3)	optional						
Root vegetables (mg/kg wet weight)	optional						
Other vegetables (mg/kg wet weight)	optional						
Fish (mg/kg wet weight)	optional						
Wild game (mg/kg wet weight)	optional						
		See also PHC Sheet				See also PHC Sheet	

Risk Assessment Endpoints		Default
Acceptable hazard index:	0.2	0.2
Acceptable cancer risk:	1.00E-05	1.00E-05

Precluding Conditions for Fate and Transport Models

Are non-aqueous phase liquids (NAPL) present?	No
Is groundwater contamination present in fractured bedrock?	No
Is groundwater contamination migrating through a confined aquifer?	No
Is there active pumping or drawdown of groundwater at the site?	No
Is contamination present within 1 m of building foundation?	No
Do any buildings within 5 m of contamination have earthen foundations?	No
Are any buildings constructed on very high permeability media?	No
Are there preferential vapour flow pathways connecting contamination to a building?	No

Fate and Transport Model Input

	Value	Default	Models Affected
Soil Type	coarse-grained	coarse-grained	PS, V-I, V-O, GW
Significant vehicle traffic on unpaved roads?	No	No	P-O
Site Characteristics			
Depth to Groundwater (m)	1	3	GW, V-O
Depth from Surface to Contamination (m)	0.1	0	GW, V-O
Distance - Contaminated Soil to Building (m)	70	1	V-I
Distance - Contaminated GW to Building (m)	70	1	V-I
Distance to potable water user (m)	0	0	GW
Distance to Bathing/Swimming Water (m)	0	0	GW
Particulate Concentration in Air (ug/m^3)	0.76	0.76	P-O
Building Type	Commercial/Industrial	Residential	V-I

Optional Sections

User-defined Chemicals

Note: user-defined chemicals should be named in this section before being selected in the 'Contaminant Concentrations' table above

		Chemical 1	Chemical 2	Chemical 3
Name				
CAS Number				
Chemical class (organic/inorganic)				
Tolerable daily intake (mg/kg/d) - infant	*Enter all applicable and appropriate toxicity benchmarks; values must be referenced and justified in the PQRA report.*			
Tolerable daily intake (mg/kg/d) - toddler				
Tolerable daily intake (mg/kg/d) - child				
Tolerable daily intake (mg/kg/d) - teen				
Tolerable daily intake (mg/kg/d) - adult				
Tolerable concentration (mg/m^3)				
Oral slope factor $(mg/kg/d)^{-1}$				
Inhalation slope factor $(mg/kg/d)^{-1}$				
Inhalation unit risk $(mg/m^3)^{-1}$				
Relative dermal absorption factor				
Organic carbon partitioning coefficient (mL/g) - Koc				
Log Kow (unitless)				
Henry's Law constant at 25°C (unitless) - H'				
Henry's Law constant at 25°C (atm-m3/mol) - H				
Water Solubility at 25°C (mg/L)				
Molecular Weight (g/mol)				
Vapour Pressure at 25°C (atm)				

Note: values in grayed cells will not be used; Health Canada default values are applied.

User-defined Receptor

Name	Remediation Cor	Defaults
Age group	Adult	Toddler
Body weight (kg)	70.7	70.7
Soil ingestion rate (g/d)	0.1	0.02
Inhalation rate (m^3/d)	15.8	15.8
Water ingestion rate (L/d)	1.5	1.5
Skin surface area (cm^2)		
- hands	890	890
- arms	2500	2500
- legs	0	5720
- total	3390	17640
Soil loading to exposed skin (g/cm^2/event)		
- hands	1.00E-04	0.0001
- surfaces other than hands	1.00E-05	0.00001
Food ingestion (g/d)		
- root vegetables	188	188
- other vegetables	137	137
- fish	111	111
- wild game	0	0
Evaluate Cancer Risks (Yes/No)?	Yes	Yes

User-defined Land-Use / Exposure Scenario

Scenario name	User-Defined	Defaults
Hours per day (indoors)	0	22.5
Hours per day (outdoors)	10	1.5
Days per week	6	7
Weeks per year	14	52
Dermal exposure events/day	1	1
Water contact events per day	1	1
Duration of water contact event (h)	1	1
Days/year contaminated food ingestion	0	365
Exposure duration (years)	0.27	60
Years for carcinogen amortization	0.27	60

PHC Fraction Composition (%)	Soil		Note: water and air defaults are calculated based on soil properties Water		Air (Vapour)	
Fraction 1		Default		Default		Default
Aliphatics C_6-C_8		55		60.5		85.3
Aliphatics $C_{>8}$-C_{10}		36		6.3		14.2
Aromatics $C_{>8}$-C_{10}		9		33.2		0.4
Total		100		100		100
Fraction 2						
Aliphatics $C_{>10}$-C_{12}		36		2.4		76.7
Aliphatics $C_{>12}$-C_{16}		44		0.1		20.6
Aromatics $C_{>10}$-C_{12}		9		60.3		2.3
Aromatics $C_{>12}$-C_{16}		11		37.1		0.5
Total		100		100		100
Fraction 3						
Aliphatics $C_{>16}$-C_{21}		56		9.54E-03		89.79
Aliphatics $C_{>21}$-C_{34}		24		2.58E-07		7.83
Aromatics $C_{>16}$-C_{21}		14		95		2.37
Aromatics $C_{>21}$-C_{34}		6		5		0.01
Total		100		100		100
Fraction 4						
Aliphatics $C_{>34}$		80		0		0
Aromatics $C_{>34}$		20		100		0
Total		100		100		0

HEALTH CANADA PQRA SPREADSHEET Version: March 16, 2009
OUTPUT SHEET - Remediation Contractor_Acute **Adult**

User Name: Franz Environmental Inc. **Site:** Cambridge Bay Airport AECs
Proponent: Transport Canada **File #:** 1748-0901
Date: **Comment:** Petroleum Hydrocarbons

Exposure Scenario: **User-Defined**
Native population not considered
Cancer Risks Calculated? **Yes**

User-Defined Receptor Characteristics
Body weight (kg): 70.7
Soil ingestion rate (g/d): 0.1
Inhalation rate (m3/d): 15.8
Water ingestion rate (L/d): 1.5
Skin surface area (cm2) - hands: 890
- arms: 2500
- legs: 0
- total: 3390
Soil loading (g/cm2-event) - hands: 0.0001
- other: 0.00001
Food ingestion rates (g/d)
Root vegetables: 188
Other vegetables: 137
Fish: 111
Wild game: 0

Chemical Properties	Units	F1	Benzene	Toluene	Ethylbenzene	F2	Xylenes (total)
Tolerable daily intake	mg/kg/d	NA	NA	0.22	0.1	NA	1.5
Tolerable concentration	mg/m^3	NA	NA	3.8	1	NA	0.18
Oral slope factor	$(mg/kg/d)^{-1}$	NA	0.226	NA	NA	NA	NA
Inhalation slope factor	$(mg/kg/d)^{-1}$	NA	0.0146	NA	NA	NA	NA
Inhalation unit risk	$(mg/m^3)^{-1}$	NA	0.0033	NA	NA	NA	NA
Dermal slope factor	$(mg/kg/d)^{-1}$	NA	NA	NA	NA	NA	NA
Critical oral exposure benchmark		NA	slope factor	TDI	TDI	NA	TDI
Critical inhalation exposure benchmark		NA	unit risk	TC	TC	NA	TC
Relative dermal absorption factor	unitless	0.2	0.03	0.03	0.03	0.2	0.03

Chemical Concentrations	Units	F1	Benzene	Toluene	Ethylbenzene	F2	Xylenes (total)
Soil	mg/kg	4.80E+03	4.60E+00	3.70E+01	6.80E+00	1.20E+04	1.40E+02
Drinking water	mg/L	NA	NA	NA	NA	NA	NA
Bathing/swimming water	mg/L	3.50E+00	1.70E+00	1.27E+01	1.80E-01	3.80E+00	1.93E+01
Indoor air vapours	mg/m^3	NA	NA	NA	NA	NA	NA
Outdoor air vapours	mg/m^3	8.21E-01	3.38E-02	1.72E-01	1.82E-02	7.62E-01	2.12E-01
Outdoor air particulate	mg/m^3	3.03E-06	2.78E-09	2.46E-08	4.78E-09	9.06E-06	1.01E-07
Amortized total air concentration	mg/m^3	0.078898394	0.003247993	0.016548128	0.001753936	0.073228231	0.02034014
Root vegetables	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated
Other vegetables	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated
Fish	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated
Wild game	mg/kg wet wt	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated	not evaluated

RESULTS

	Exposure (mg/kg/d)					
	F1	Benzene	Toluene	Ethylbenzene	F2	Xylenes (total)
Inadvertent ingestion of contaminated soil	1.57E-03	1.50E-06	1.21E-05	2.22E-06	3.92E-03	4.57E-05
Inhalation of contaminated soil particles	6.50E-08	5.98E-11	5.28E-10	1.03E-10	1.95E-07	2.17E-09
Inhalation of contaminant vapours - indoor	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Inhalation of contaminant vapours - outdoor	1.76E-02	7.26E-04	3.70E-03	3.92E-04	1.64E-02	4.55E-03
Ingestion of contaminated drinking water	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Dermal contact with contaminated soil	3.57E-04	5.14E-08	4.13E-07	7.59E-08	8.93E-04	1.56E-06
Dermal contact with water	6.44E-02	4.39E-04	7.01E-03	1.80E-04	9.90E-02	1.90E-02
Ingestion of contaminated food	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total ingestion exposure	1.57E-03	1.50E-06	1.21E-05	2.22E-06	3.92E-03	4.57E-05
Total dermal exposure	6.48E-02	4.39E-04	7.01E-03	1.80E-04	9.99E-02	1.90E-02
Ingestion + dermal exposure	6.64E-02	4.40E-04	7.02E-03	1.83E-04	1.04E-01	1.91E-02
Total inhalation exposure	1.76E-02	7.26E-04	3.70E-03	3.92E-04	1.64E-02	4.55E-03
Total Exposure (all pathways)	8.40E-02	1.17E-03	1.07E-02	5.75E-04	1.20E-01	2.36E-02

		Hazard/Risk Estimates					
		F1	Benzene	Toluene	Ethylbenzene	F2	Xylenes (total)
Hazard Quotient - Oral/Dermal		4.46E-01	NA	3.19E-02	1.83E-03	1.80E+00	1.27E-02
Hazard Quotient - Inhalation		4.95E-02	NA	4.35E-03	1.75E-03	9.58E-02	1.13E-01
Hazard Index - Total		4.96E-01	NA	3.63E-02	3.58E-03	1.89E+00	1.26E-01
Target Hazard Index:	0.2	**Target Hazard Index Exceeded**				**Target Hazard Index Exceeded**	
Cancer Risk - Oral		NA	3.39E-07	NA	NA	NA	NA
Cancer Risk - Dermal		NA	9.92E-05	NA	NA	NA	NA
Cancer Risk - Oral + Dermal		NA	9.95E-05	NA	NA	NA	NA
Cancer Risk - Inhalation		NA	1.07E-05	NA	NA	NA	NA
Cancer Risk - Total		NA	1.10E-04	NA	NA	NA	NA
Target Cancer Risk:	1.00E-05	**Target Cancer Risk Exceeded**					

SUMMARY OF PQRA RESULTS Version: March 16, 2009

User Name:	Franz Environmental Inc.	**Site:**	Cambridge Bay Airport AECs
Proponent:	Transport Canada	**File #:**	1748-0901
Date:		**Comment:**	Petroleum Hydrocarbons

		Maximum Hazard/Risk Estimates					
		F1	**Benzene**	**Toluene**	**Ethylbenzene**	**F2**	**Xylenes (total)**
Hazard Quotient - Oral/Dermal		4.46E-01	NA	3.19E-02	1.83E-03	1.80E+00	1.27E-02
Hazard Quotient - Inhalation		4.95E-02	NA	4.35E-03	1.75E-03	9.58E-02	1.13E-01
Hazard Index - Total		4.96E-01	NA	3.63E-02	3.58E-03	1.89E+00	1.26E-01
Target Hazard Index:	0.2	**Target Hazard Index Exceeded**				**Target Hazard Index Exceeded**	
Cancer Risk - Oral		NA	3.39E-07	NA	NA	NA	NA
Cancer Risk - Dermal		NA	9.92E-05	NA	NA	NA	NA
Cancer Risk - Oral + Dermal		NA	9.95E-05	NA	NA	NA	NA
Cancer Risk - Inhalation		NA	1.07E-05	NA	NA	NA	NA
Cancer Risk - Total		NA	1.10E-04	NA	NA	NA	NA
Target Cancer Risk:	1.00E-05		**Target Cancer Risk Exceeded**				

	Critical Receptors					
	F1	**Benzene**	**Toluene**	**Ethylbenzene**	**F2**	**Xylenes (total)**
Oral/Dermal - non-cancer effects	User-Defined Receptor	NA	User-Defined Receptor	User-Defined Receptor	User-Defined Receptor	User-Defined Receptor
Inhalation - non-cancer effects	All Age Groups	NA	All Age Groups	All Age Groups	All Age Groups	All Age Groups
Total - non-cancer effects	User-Defined Receptor	NA	User-Defined Receptor	User-Defined Receptor	User-Defined Receptor	User-Defined Receptor
Oral - cancer effects	NA	User-Defined Receptor	NA	NA	NA	NA
Dermal - cancer effects	NA	User-Defined Receptor	NA	NA	NA	NA
Oral + Dermal - cancer effects	NA	User-Defined Receptor	NA	NA	NA	NA
Inhalation - cancer effects	NA	Adult	NA	NA	NA	NA
Total - cancer effects	NA	User-Defined Receptor	NA	NA	NA	NA
Source of indoor air vapours	Soil	Soil	Soil	Soil	Soil	Soil
Model used for vapour transport	Health Canada	Health Canada	Health Canada	Health Canada	Health Canada	Health Canada

Key Calculated Model Parameters						
Vapour Intrusion Model Parameters	Note: parameters show as "NA" if relevant exposure pathways are inoperative or if user-input concentration is used instead of modelled value					
Qsoil/Qbuilding	NA	NA	NA	NA	NA	NA
Soil alpha	NA	NA	NA	NA	NA	NA
Groundwater alpha	NA	NA	NA	NA	NA	NA
Groundwater model dilution factors						
DF1 (soil to leachate)	NA	NA	8.65E-01	NA	NA	2.16E+00
DF2 (leachate at source to water table):	NA	NA	1.00E+00	NA	NA	1.00E+00
DF3 (leachate at water table to groundwater):	NA	NA	3.36E+00	NA	NA	3.36E+00
DF4 (source to receptor) - drinking water:	NA	NA	NA	NA	NA	NA
DF4 (source to receptor) - bathing/swimming water:	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

Notes/Comments

Vapour Intrusion Model

Chemical Interactions

All chemicals of concern present at the site should be evaluated for potential additive effects based on target organs and mechanisms of effect.

Concentration Checks

Precluding Conditions

Other Notes

Provide justification for all non-default model parameters in PQRA report

Error functions in groundwater model could not be calculated; installation of Analysis ToolPak is required

Appendix C

Human Health Risk Assessment Exposure Equations from Health Canada

Human Health Preliminary Quantitative Risk Assessment (PQRA) guidance documents (*Federal Contaminated Risk Assessment in Canada- Part 1 (2007 Update*))

TABLE 7. Recommended General Equations for Dose Estimation

Note: Presented below are generalized equations; actual equations presented by individual contractors may vary according to the manner in which different variables are presented, the units used, and the precise presentation of exposure frequency, exposure duration and averaging times. Abbreviations denoting variables have been harmonized through all equations; variables are not necessarily represented in every equation.

Inadvertent Ingestion of Contaminated Soil

The predicted intake of each contaminant via ingestion of contaminated soil is calculated as:

$$Dose\ (mg/kg/day) = \frac{C_S \times IR_S \times RAF_{Oral} \times D_2 \times D_3 \times D_4}{BW \times LE}$$

Where:

C_S = concentration of contaminant in soil (mg/kg)
IR_S = receptor soil ingestion rate (kg/d)
RAF_{Oral} = relative absorption factor from the GI tract (unitless)
D_2 = days per week exposed/7 days
D_3 = weeks per year exposed/52 weeks
D_4 = total years exposed to site (to be employed for assessment of carcinogens only)
BW = body weight (kg)
LE = life expectancy (yr) (to be employed for assessment of carcinogens only)

NOTE: the terms D_3 and D_4 should be omitted when considering exposures posed by chemicals with developmental (foetal) effects.

Inhalation of Contaminated Soil Particles

The predicted intake of each contaminant via inhalation of dust entrained into the air is calculated as:

$$Dose\ (mg/kg/day) = \frac{C_S \times P_{Air} \times IR_A \times RAF_{Inh} \times D_1 \times D_2 \times D_3 \times D_4}{BW \times LE}$$

Where:

C_S = concentration of contaminant in soil (mg/kg)
P_{Air} = particulate concentration in air (kg/m^3)
IR_A = receptor air intake (inhalation) rate (m^3/day)
RAF_{Inh} = relative absorption factor by inhalation (unitless)
D_1 = hours per day exposed/24 hours
D_2 = days per week exposed/7 days
D_3 = weeks per year exposed/52 weeks
D_4 = total years exposed to site (to be employed for assessment of carcinogens only)
BW = body weight (kg)
LE = life expectancy (yr) (to be employed for assessment of carcinogens only)

Notes: P_{Air} may be directly measured or may be estimated using methods discussed in the text. Alternately, C_A (air-borne concentration; mg/m^3) may be

directly measured, negating the prediction of air-borne concentration using C_S and P_{Air}. The terms D_3 and D_4 should be omitted when considering exposures posed by chemicals with developmental (foetal) effects.

TABLE 7 (continued)
Recommended General Equations for Dose Estimation

Inhalation of Contaminant Vapours

The predicted intake of each contaminant via inhalation of vapours is calculated as:

$$Dose\ (mg/kg/day) = \frac{C_A \times IR_A \times RAF_{Inh} \times D_1 \times D_2 \times D_3 \times D_4}{BW \times LE}$$

Where:
C_A = concentration of contaminant in air (mg/m^3)
IR_A = receptor air intake (inhalation) rate (m^3/day)
RAF_{Inh} = relative absorption factor for inhalation (unitless)
D_1 = hours per day exposed/24 hours
D_2 = days per week exposed/7 days
D_3 = weeks per year exposed/52 weeks
D_4 = total years exposed to site (to be employed for assessment of carcinogens only)
BW = body weight (kg)
LE = life expectancy (yr) (to be employed for assessment of carcinogens only)

Notes: C_A may be directly measured or may be estimated from soil-borne or groundwater-borne concentrations of volatile COPCs using methods discussed in the text. The terms D_3 and D_4 should be omitted when considering exposures posed by chemicals with developmental (foetal) effects.

Ingestion of Contaminated Drinking Water

The predicted intake of each contaminant via ingestion of contaminated drinking water is calculated as:

$$Dose\ (mg/kg/day) = \frac{C_w \times IR_w \times RAF_{Oral} \times D_2 \times D_3 \times D_4}{BW \times LE}$$

Where:
C_w = concentration of contaminant in drinking water (mg/L)
IR_w = receptor water intake rate (L/d)
RAF_{Oral} = relative absorption factor from the GI tract (unitless)
D_3 = weeks per year exposed/52 weeks
D_4 = total years exposed to site (to be employed for assessment of carcinogens only)
BW = body weight (kg)

D_2 = days per week exposed/7 days

LE = life expectancy (yr) (to be employed for assessment of carcinogens only)

Notes: C_w may be directly measured or may be estimated from soil-borne or groundwater-borne concentrations of COPCs using methods discussed in the text. The terms D_3 and D_4 should be omitted when considering exposures posed by chemicals with developmental (foetal) effects.

TABLE 7 (continued)
Recommended General Equations for Dose Estimation

Dermal Absorption from Contaminated Soil

The predicted intake of each contaminant via dermal contact with contaminated soil is calculated as:

$$Dose\ (mg/kg/day) = \frac{[(C_S \times SA_H \times SL_H) + (C_S \times SA_O \times SL_O)] \times RAF_{Derm} \times D_2 \times D_3 \times D_4}{BW \times LE}$$

Where:

C_S = concentration of contaminant in soil (mg/kg)
SA_H = surface area of hands exposed for soil loading (cm^2)
SA_O = surface area exposed other than hands (cm^2)
SL_H = soil loading rate to exposed skin of hands (kg/cm^2-event)
SL_O = soil loading rate to exposed skin other than hands (kg/cm^2-event)
D_2 = days per week exposed/7 days
D_3 = weeks per year exposed/52 weeks
D_4 = total years exposed to site (for assessment of carcinogens only)
RAF_{Derm} = relative dermal absorption factor (unitless)
BW = body weight (kg)
LE = life expectancy (yr) (for assessment of carcinogens only)

NOTE: the terms D_3 and D_4 should be omitted when considering exposures posed by chemicals with developmental (foetal) effects.

Ingestion of Contaminated Foods (Produce, Fish, Game, etc.)

The predicted intake of each contaminant via ingestion of contaminated food is calculated as:

$$Dose\ (mg/kg\ day) = \frac{[\sum [C_{Food\ i} \times IR_{Foodi} \times RAF_{Orali} \times D_i]] \times D_4}{BW \times 365 \times LE}$$

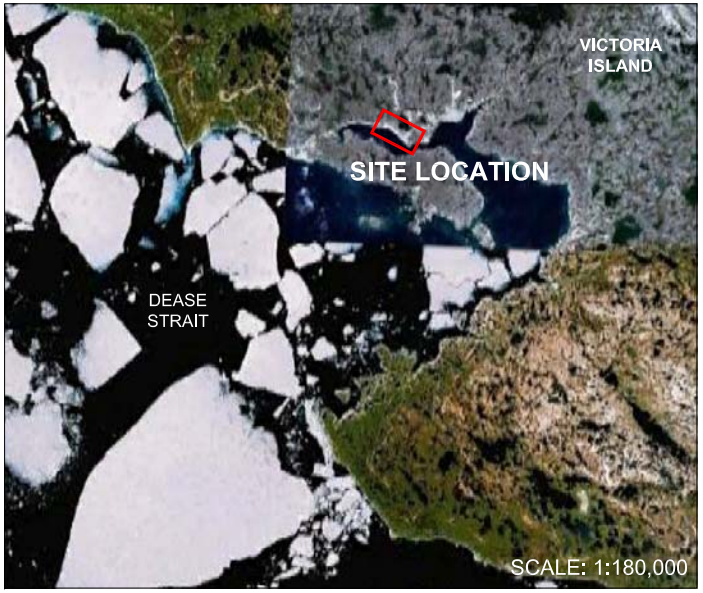
Where:

C_{Foodi} = concentration of contaminant in food *i* (mg/kg)
IR_{Foodi} = receptor ingestion rate for food *i* (kg/d)
RAF_{Orali} = relative absorption factor from the GI tract for contaminant *i* (unitless)
D_i = days per year during which consumption of food *i* will occur (d/yr)
D_4 = total years exposed to site (for assessment of carcinogens only)
BW = body weight (kg)
LE = life expectancy (for assessment of carcinogens only)
365 = total days per year (constant) (d/yr)

Notes: Concentrations of contaminants in foods can be measured directly, or can be predicted using methods discussed in the text. The terms D_3 and D_4 should be omitted when considering exposures posed by chemicals with developmental (foetal) effects.

Appendix D

Excerpt Figures from the Phase II/III ESA (FRANZ, 2010)



LEGEND

Extent of Study Area

References:

Google Earth satellite image, 2009
Site location based on dGPS coordinates (NAD 83)

Title: STUDY AREA

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Scale: See figures for scale

FIGURE 1

1748-0901/CAD/Cambridge Bay.dwg FINAL Mar 1/10

LEGEND

- Area of Potential Environmental Concern (APEC)
- Background Soil Sampling Location (Franz 2009)
- Background Vegetation Sampling Location (Franz 2009)
- YCB-01 Soil/Groundwater Sample Location - Dillon 1995
- 99-1 Soil/Groundwater Sample Location - AGRA 1999

APEC #	Description
1	Screening Plant / Boneyard
2	Shoreline Disposal Area
3	Former Fire Training Area
4	Former F.H. Ross Tank Farm
5	Former AST North of Building T-5
6	Former AST West of Building T-4

APPROXIMATE SCALE 1:6,800

200 150 100 50 0 200
metres

References:
Google Earth satellite image, 2009
APEC locations based on dGPS coordinates (UTM - NAD 83)
Sampling locations derived from historical reports

Title: APEC LOCATIONS

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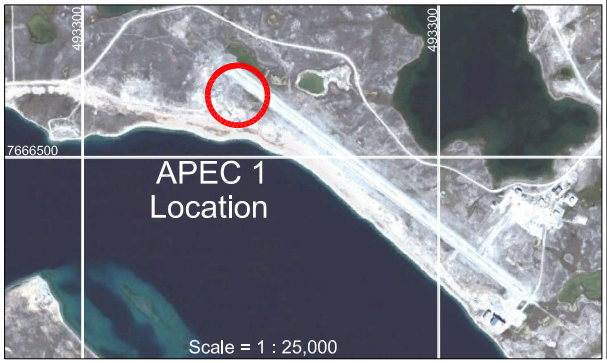
Scale: 1 : 6,600

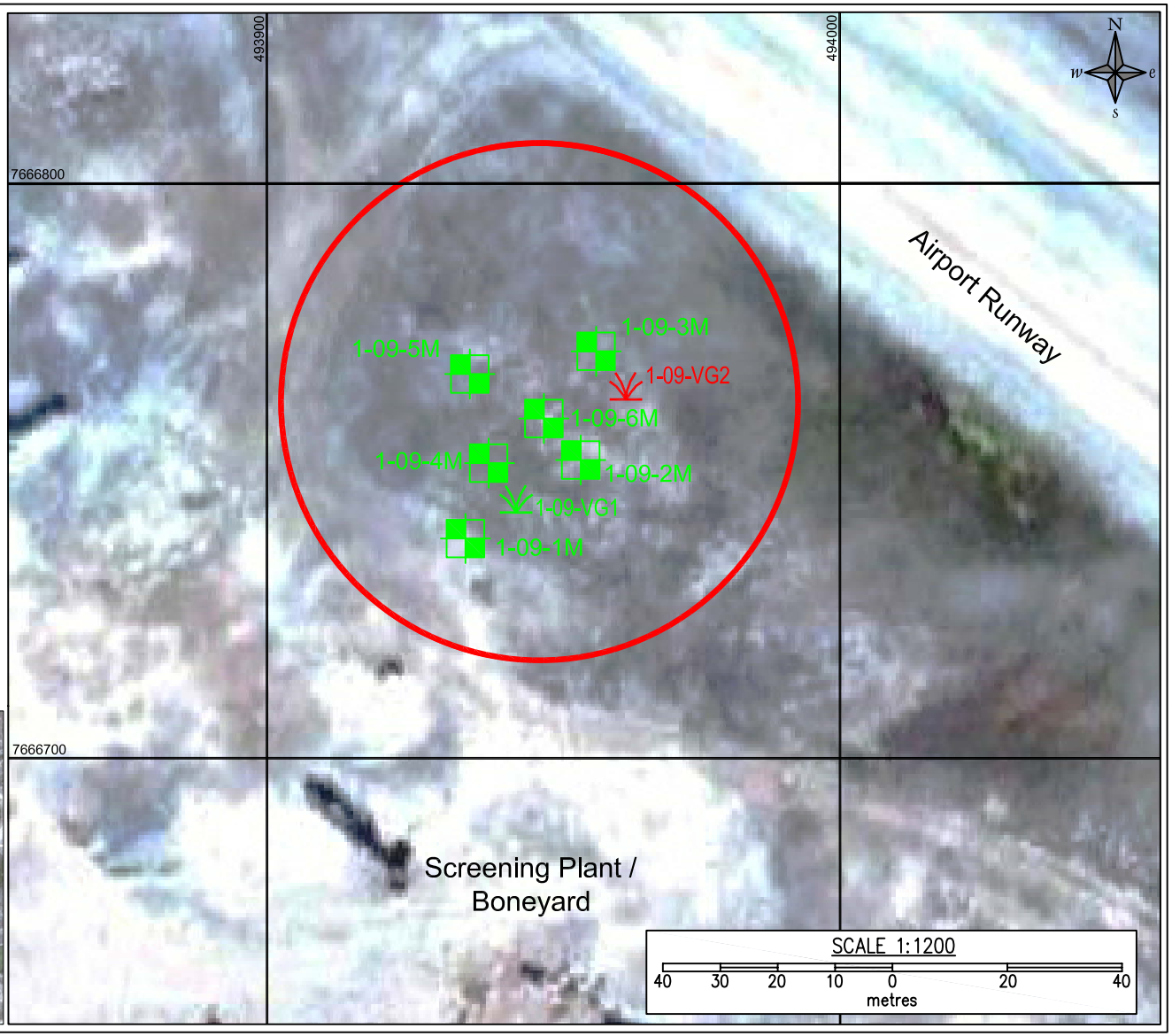
FIGURE 2

1748-0901/CAD/Cambridge Bay.dwg FINAL Mar 1/10

VEGETATION

Station ID	MOE Vegetation Guidelines (ppm)	1-09-VG2
Duplicate ID		
Date		2/Sep/09
Lab report ID		A948579
Molybdenum	1.5	2.6





LEGEND

- Extent of APEC
- Soil Sample (TP); compliant with CCME guidelines
- Vegetation Sample (VG); compliant with Ontario MOE guidelines
- Vegetation Sample (VG); exceeds Ontario MOE guidelines

References:
Google Earth satellite image, 2009
No exceedances were found for soil in APEC 1
Analytical results for soil and vegetation are in ug/g and can be found in Appendix G
Site locations based on dGPS coordinates (UTM - NAD 83)
CCME Soil Guidelines for Commercial land use (2008)
Vegetation analytical results compared to Ontario MOE Vegetation Guidelines

Title: APEC 1 - Screening Plant / Boneyard Sampling Locations and Analytical Results (Soil & Vegetation)

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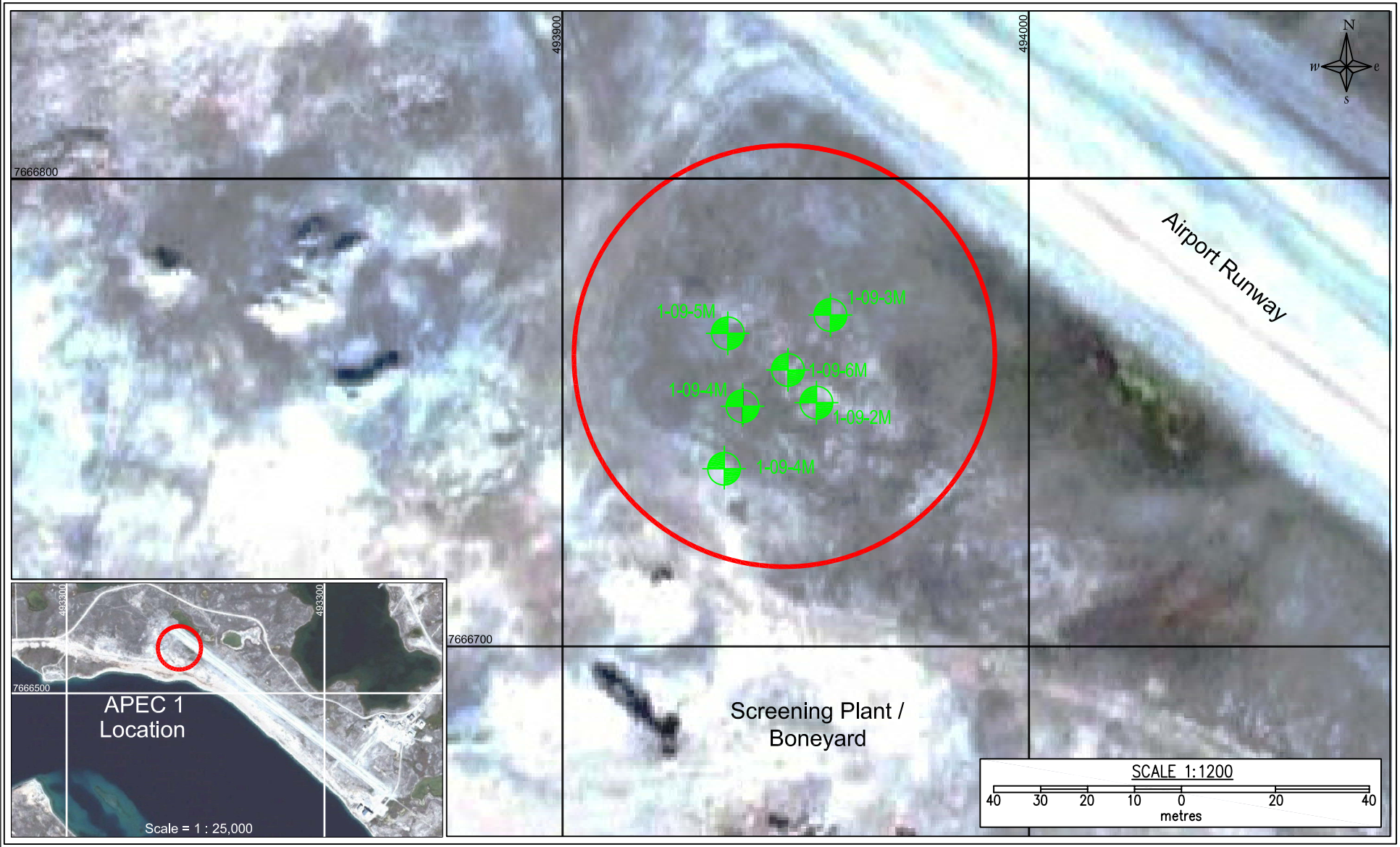
Scale: 1 : 1,200

FIGURE 3

1748-0901/CAD/Cambridge Bay.dwg FINAL Mar 31/10



LEGEND

Extent of APEC

Groundwater Sample (GW); compliant with BC-CSR guidelines

References:
Google Earth satellite image, 2009
No exceedances were found for groundwater in APEC 1
Analytical results for groundwater are in ug/L and can be found in Appendix G
Site locations based on dGPS coordinates (UTM - NAD 83)
British Columbia Contaminated Site Regulation (CSR) for Marine Receptors (2009)

Title: APEC 1 - Screening Plant / Boneyard Sampling Locations and Analytical Results - Groundwater

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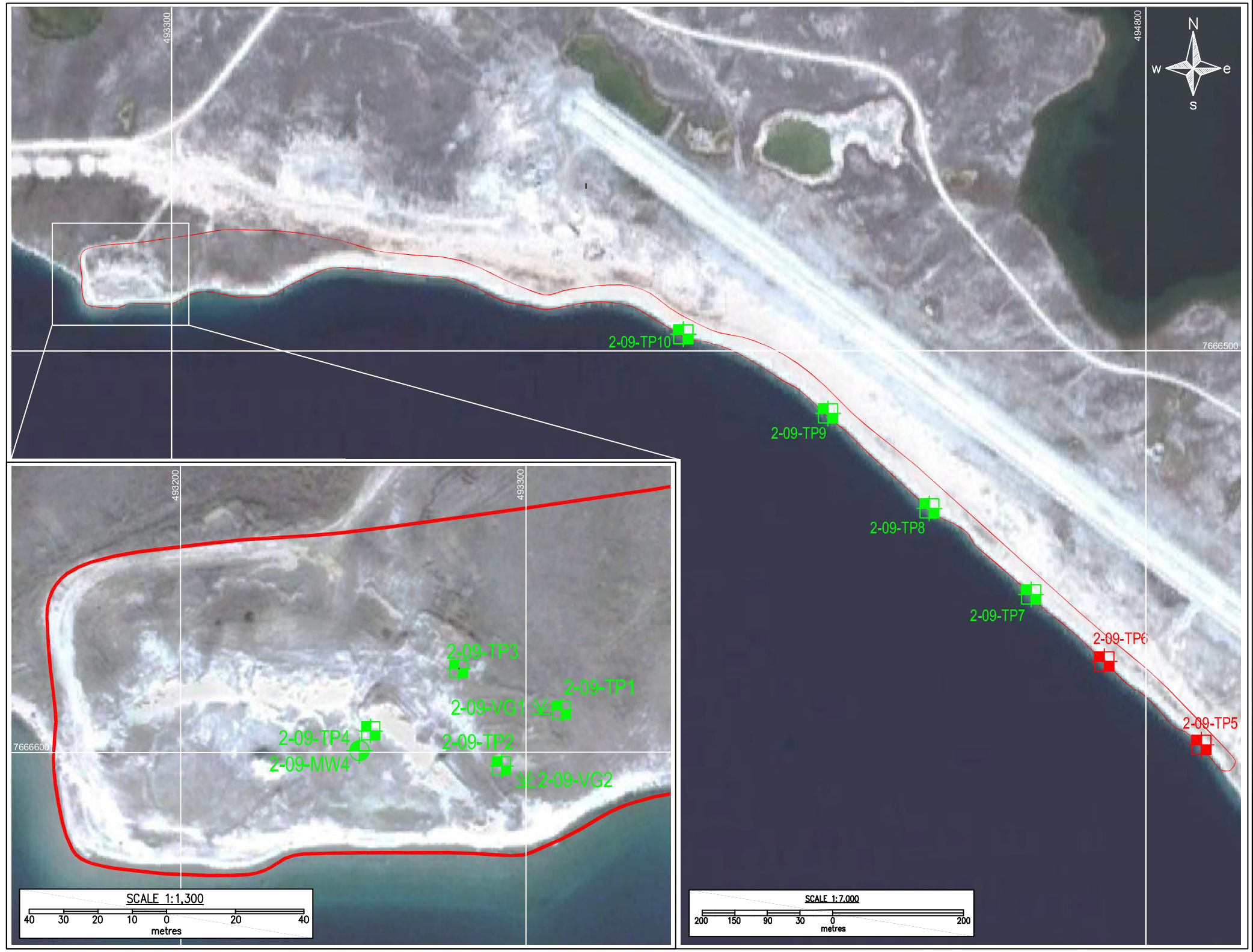
Scale: 1 : 1,200

FIGURE 4

1748-0901/CAD/Cambridge Bay.dwg FINAL Mar 31/10

SOIL

Station ID	CCME Soil (Commercial)	2-09-TP5	2-09-TP5	2-09-TP6
Field label		2-09-TP5-1	GR2	2-09-TP6-1
Duplicate ID		GR2	2-09-TP5-1	
Date		29/Aug/09	29/Aug/09	29/Aug/09
Lab report ID		A947822	A947822	A947822
Depth (m)		0.4 – 0.6	0.4 – 0.6	0.2 – 0.6
Metals				
Arsenic	12	3.3	2.0	40.6
Copper	91	94.5	102.0	24.5



LEGEND

- Extent of APEC
- Soil Sample (TP); compliant with CCME guidelines
- Soil Sample (TP); exceeds CCME guidelines
- Groundwater Sample (GW); compliant with BC-CSR guidelines
- Vegetation Sample (VG); compliant with Ontario MOE guidelines

References:
Google Earth satellite image, 2009
No exceedances were found in vegetation or groundwater at APEC 2
Analytical results/guidelines for soil and vegetation are in ug/g and can be found in Appendix G
Analytical results/guidelines for groundwater are in ug/L and can be found in Appendix G
Site locations based on dGPS coordinates (UTM - NAD 83)
CCME Soil Guidelines for Commercial land use (2008)
British Columbia Contaminated Sites Regulations (CSR) for Marine Receptors (2009)
Vegetation analytical results compared to Ontario MOE Vegetation Guidelines

Title: APEC 2 - Shoreline Disposal Area Sampling Locations and Analytical Results - Soil, Vegetation & Groundwater

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Scale: See figures for scale

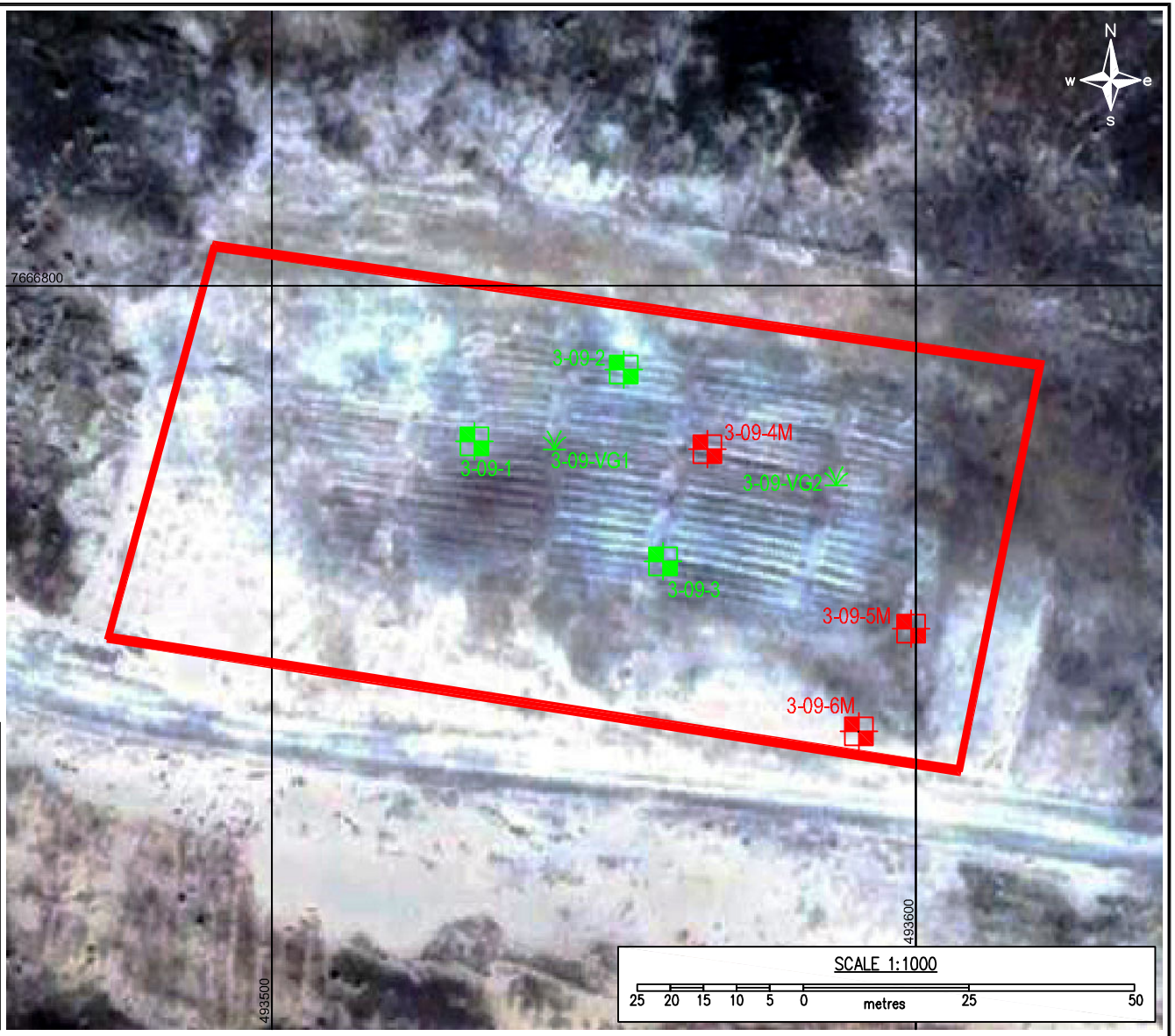
FIGURE 5

1748-0901/CAD/Cambridge Bay.dwg FINAL Mar 1/10

SOIL

Station ID	CCME Soil (Commercial)	3-09-4M	3-09-4M	3-09-5M
Field label		3-09-4M-2	3-09-4M-3	3-09-5M-2
Duplicate ID				
Date		29/Aug/09	29/Aug/09	29/Aug/09
Lab report ID		A947822	A947822	A947822
Depth (m)		0.5 – 2	2 – 2.1	0.5 – 1
PHCs				
Benzene	0.03	0.86	1.2	<0.005
F2 (C10-C16)	260*	16	27	1700

Station ID	CCME Soil (Commercial)	3-09-6M	3-09-6M
Field label		3-09-6M-3	3-09-DUP-2
Duplicate ID		3-09-DUP-2	3-09-6M-3
Date		29/Aug/09	29/Aug/09
Lab report ID		A947822	A947822
Depth (m)		1 – 2	1 – 2
PHCs			
Ethylbenzene	0.082	0.08	0.10
F2 (C10-C16)	260*	850	860



LEGEND

- Extent of APEC
- Soil Sample (TP); compliant with CCME guidelines
- Soil Sample (TP); exceeds CCME guidelines
- Vegetation Sample (VG); compliant with Ontario MOE guidelines

References:
Google Earth satellite image, 2009
No exceedances were found in vegetation in APEC 3
Analytical results/guidelines for soil and vegetation are in ug/g and can be found in Appendix G
Site locations based on dGPS coordinates (UTM - NAD 83)
CCME Soil Guidelines for Commercial land use (2008)
Vegetation analytical results compared to Ontario MOE Vegetation Guidelines

Title: APEC 3 - Former Fire Training Area Sampling Locations and Analyticals Results - Soil & Vegetation

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Scale: 1 : 1,000

FIGURE 6

1748-0901/CAD/Cambridge Bay.dwg FINAL Mar 1/10

GROUNDWATER

Station ID	BC CSR (Marine)	3-09-4M	3-09-5M
Field label		3-09-4M	3-09-5M
Duplicate ID			
Date		2/Sep/09	2/Sep/09
Lab report ID		A948731	A948731
Metals			
Lead	20	100	<2
BTEX / PHCs			
Benzene	1000	1700	670.0
PAHs			
Naphthalene	10	330	84

LEGEND

- Extent of APEC
- Groundwater Sample (GW); compliant with BC-CSR guidelines
- Groundwater Sample (GW); exceeds BC-CSR guidelines

SCALE 1:1000

25 20 15 10 5 0 metres 25 50

References:
Google Earth satellite image, 2009
Analytical results/guidelines for groundwater are in ug/L and can be found in Appendix G
Site locations based on dGPS coordinates (UTM - NAD 83)
British Columbia Contaminated Site Regulations (CSR) for Marine Receptors (2009)

Title: APEC 3 - Former Fire Training Area Sampling Locations and Analytical Results - Groundwater

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FIGURE 7

1748-0901/CAD/Cambridge Bay.dwg FINAL Mar 1/10

SOIL

Station ID	CCME Soil (Commercial)	4A-09-3M	4A-09-4	4A-09-5	4A-09-8
Field label		4A-09-3M-1	4A-09-4-1	4A-09-5-1	4A-09-8-1
Duplicate ID					
Date		30/Aug/09	30/Aug/09	30/Aug/09	30/Aug/09
Lab report ID		A947622	A947622	A947622	A947622
Depth (m)		0.5 – 1	1.5 – 2	1.5 – 1.5	1 – 1.7
Metals					
Lead	260	15.5	14.4	294.0	-
BTEX / PHCs					
Benzene	0.05	1.0	2.9	4.6	0.046
Ethylbenzene	0.082	5.6	6.6	6.5	0.07
Toluene	0.37	15.00	37.0	1.5	0.06
Xylenes (total)	11	22.0	140.0	76.0	2.5
F1 (C6-C10)	320*	4600	4600	4400	-
F1 (C6-C10) minus BTEX	320*	4700	4400	4000	150
F2 (C10-C16)	260*	740	3700	12000	150
F3 (C16-C34)	1700*	140	520	5400	120
F4 (C34-C50)	3300*	<100	11	3900	<100

* CCME Canada-Wide Standards for Petroleum Hydrocarbons in Soil

LEGEND

- Extent of APEC
- Soil Sample; compliant with CCME guidelines
- Soil Sample; exceeds CCME guidelines

SCALE 1:1000

25 20 15 10 5 0 metres 25 50

References:
Google Earth satellite image, 2009
Analytical results/guidelines for soil are in ug/g and can be found in Appendix G
Site locations based on dGPS coordinates (UTM - NAD 83)
CCME Soil Guidelines for commercial land use (2008)
CCME Canada-Wide Standards for Petroleum Hydrocarbons in soil (2008)

Title: APEC 4 - Former F.H. Ross Tank Site Sampling Locations and Analytical Results - Soil

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Scale: 1 : 1,000

FIGURE 8

1748-0901/CAD/Cambridge Bay.dwg FINAL Mar 1/10

GROUNDWATER

Area ID	BC CSR (Freshwater)	BC CSR (Marine)	APEC 4	APEC 4
Station ID			4A-09-2M	4A-09-3M
Field label			4-09-2M	4-09-3M
Duplicate ID				
Date			2-Sep-09	2-Sep-09
Lab report ID			A948579	A948579
Metals				
Zinc	2400	100	280	<30
PAHs				
Naphthalene	10	10	<0.10	14.0
PHCs				
Toluene	390	3300	<0.4	1000.0

SURFACE WATER

Area ID	BC CSR (Freshwater)	CCME AW (Freshwater)	APEC 4
Station ID			4-09-SW1
Field label			4-09-SW1
Duplicate ID			
Date			2-Sep-09
Lab report ID			A948579
Screen depth (m)			A948579
Aluminum	-	5	20

LEGEND

- Extent of APEC
- Groundwater Sample (GW); compliant with BC-CSR guidelines
- Groundwater Sample (GW); exceeds BC-CSR guidelines
- Surface Water sample (SW); exceeds CCME guidelines

References:
Google Earth satellite image, 2009
Analytical results/guidelines for groundwater are in ug/L and can be found in Appendix G
Site locations based on dGPS coordinates (UTM - NAD 83)
British Columbia Contaminated Site Regulations (BC-CSR) for Freshwater and Marine Receptors (2009)

Title: APEC 4 - Former F.H. Ross Tank Site Sampling Locations and Analytical Results - Groundwater

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Scale: 1 : 1,000

FIGURE 9

1748-0901/CAD/Cambridge Bay.dwg FINAL Mar 1/10

LEGEND

- Extent of APEC
- Soil Sample; compliant with CCME guidelines
- Soil sample (TP); compliant with CCME guidelines
- Groundwater sample (GW); compliant with BC-CSR guidelines

References:
Google Earth satellite image, 2009
No exceedances were found for soil or groundwater in APECs 5 & 6
Analytical results for soil are in ug/g and can be found in Appendix G
Analytical results for groundwater are in ug/L and can be found in Appendix G
Site locations based on dGPS coordinates (UTM - NAD 83)
British Columbia Contaminated Site Regulations (CSR) for Marine Receptors (2009)

Title:
APECs 5 & 6 Sampling Locations and Analytical Results - Groundwater

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1 : 1,000

FIGURE 10

1748-0901/CAD/Cambridge Bay.dwg FINAL Mar 1/10