PHASE I/II ENVIRONMENTAL SITE ASSESSMENT

VEHICLE DUMP AND COMMUNITY LANDFILL, IQALUIT, NUNAVUT

Prepared for:
Public Works & Government Services Canada
800 Burrard Street
Vancouver, BC
V6Z 2V8

On behalf of Transport Canada

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

Project No. 1584-0801
February 2009

FRANZ ENVIRONMENTAL INC.
♦ CONSULTING ♦ ENGINEERING ♦ TECHNOLOGIES ♦

REPORT

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Steve Livingstone, M.Sc., P.Geo(I).
Richard Wells, P.Eng.
Ryan Fletcher, C.Tech, CEPIT
Tamra Reynolds, P.Geo.
Marta Rosa, B.Sc.

EXECUTIVE SUMMARY

The Iqaluit Vehicle Dump and Community Landfill is situated approximately 1.7 km southwest of the city of Iqaluit, Nunavut. Universal Transverse Mercator (UTM) co-ordinates taken from the center of the site are E521904.94, N7067812.69. Only the top section of the site is accessible by road. The site is located adjacent to Sylvia Grinnell Territorial Park.

The total area of the Landfill and Vehicle dump occupies an area of approximately 7.25 ha (72,500 m^2), which includes the up-gradient debris area. The area has been used as a military and municipal landfill since the late 1950's to early 1960's.

The United States Air Force (USAF) used this site from between 1955 to 1963 as a metal dump for vehicles, truck bodies, barrels and scrap metal. The majority of materials were deposited in 1963 when the US Military left Frobisher Bay. Shops, buildings, and other materials were simply bulldozed over the cliff. The cliff is a bedrock outcrop rising approximately 50 m above the tidal area where the Sylvia Grinnell River meets Frobisher Bay. The area to the north side of the slope was used by the USAF and the community of Iqaluit as a landfill site for household garbage until sometime in the 1970's.

The study area was found to contain known and discrete PHC, PCB, metals, and pesticide soil, sediment, and surface water impacts associated with the historical waste disposal activities. Elevated metals (particularly cadmium, copper, lead, and zinc) are widespread; however, spatial distribution appears to be concentrated mostly at the toe of the main landfill and the central portion of the vehicle dump.

Waste disposal practices have attributed to a slow release of metals into the environment. It was concluded that the leaching of metals from the waste debris represents a measureable loading risk to the aquatic environment on site and possibly other surface water bodies (Sylvia Grinnell River). However, further studies are recommended to measure seasonal variances in order to better understand the contaminant migration pathway and receptor relationship.

It is our opinion that remediation/risk management priorities should be based on the removal of physical hazards and source area impacts, as well as the containment and control of metals in the surface water pathways (i.e., Main Drainage through Vehicle Dump) discharging to Sylvia Grinnell River.

The long-term strategy for the Vehicle Dump and Community Landfill should be based on the following goals, in order of priority:

- Removal of Physical Hazards and contaminant source areas;
    a. Vehicles in Vehicle Dump
    b. Waste Debris- Main Landfill
- Containment and control, including risk management, passive treatment systems and monitoring of surface water drainage systems (AEC 3);
- Risk management/remediation of PHC, PCB, and pesticide impacted soils/sediments; and
- Site monitoring and inspections.

For all the options, Class D (+/- 50%) cost estimates were calculated. Based on our evaluation, the cost estimates range from approximately $3.98 M to $7.63 M.

The CCME National Classification System for Contaminated Sites (NCSCS) was used to score the site in terms of priority ranking. The site score was 84.1 which classifies the Vehicle Dump and Community Landfill as a Class 1 site (Action Required).

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1.0 INTRODUCTION

Franz Environmental Inc. (FRANZ) was retained by Public Works and Government Services Canada (PWGSC) Pacific Region and Transport Canada (TC), Prairie and Northern Region and Environmental Affairs Division to complete a Phase I/II Environmental Site Assessment (ESA) of the Vehicle Dump/Community Landfill, Iqaluit, Nunavut (**Figure 1**).

This project was completed based on the FRANZ proposal, P-2704, dated August, 2008 which followed the tasks outlined in PWGSC/Transport Canada's Terms of Reference (ToR), dated May 20, 2008.

1.1 Purpose and Project Objectives

The purpose of this project was to undertake a Phase I and Phase II Environmental Site Assessment (ESA) at the vehicle dump/landfill site adjacent to the Iqaluit Airport. Transport Canada will use this report to demonstrate due diligence and reduce liabilities in order to remediate/risk manage the site to an acceptable level. Previous assessments have been completed at the vehicle dump/landfill site. The purpose of this Phase I/II ESA was to determine the current environmental and physical conditions at the site. This included the identification and quantification of environmental impacts to soil, sediment, surface water, and vegetation, as well as the identification of hazardous and non-hazardous materials at the site.

To accomplish this goal, the objectives included the following:

Phase I ESA

- Complete a historical property land use search;
- Review previous studies and reports regarding the site;
- Complete a site visit in order to characterize the site including identifying the type and volume of material in the metal dump and household landfill;
- Prepare site plans to present general information and relevant environmental concerns;
- Identify actual and/or potential liabilities and site contamination;

- The investigation and reporting will follow the requirements and format for a Phase I Environmental Site Assessment as prescribed under the Canadian Standards Association CSA Z768-01.

Phase II ESA

- Obtain representative samples of soil, water, sediment, and vegetation in suspect areas;
- Determine the source, type, and nature of contamination in soil, surface water, sediment, and vegetation;
- Complete the National Classification Score (NCS) for this site based on: CCME, 2008 National Classification System for Contaminated Sites: Guidance Document. Canadian Council of Ministers of the Environment, Winnipeg;
- Develop a detailed remedial action plan that includes 3 different methods to remediate/manage the site, and provide related indicative cost estimate, associated with each of the 3 methods described above; and
- The investigation will follow the requirements for a Phase II Environmental Site Assessment as prescribed under the Canadian Standards Association CSA Z769-00.

1.2 Site Features and Background

Iqaluit (formerly named Frobisher Bay) is located on the southern tip of Baffin Island (**Figure 1**). Prior to July 1, 1995 Iqaluit Airport was owned by the Government of Canada and operated by the Quebec Region of the Department of Transport. From July 1, 1995 until April 1, 1999 the airport was owned by the Government of Northwest Territories and operated by the Arctic Airports Division of the Department of Transportation. Since April 1, 1999 the airport has been owned by the Government of Nunavut (GN) and operated by the Nunavut Airports Division of the Nunavut Department of Community Government, Housing and Transportation.

The Hudson's Bay Company set up a trading post along the shores of Frobisher Bay in 1914. Much of the development of the community occurred as a result of both World War II and the Cold War. Between 1941 and 1945 the USAF occupied this region as it served as an air base in the North Atlantic Ferry Route to supply Europe during WWII. In the summer of 1942, 550 personnel and 15,000 tons of equipment were shipped to Iqaluit. In 1943 the airport runway was completed and over 300 airport arrivals were recorded. The site was never used as a ferry route and the US military left Iqaluit in 1945. In 1952, construction of the Distant Early Warning (DEW) Line sites began. The US Military returned and used Iqaluit as a Strategic Air Command Base and one of the stations of the Pole Vault communication systems. The site was also used as a major trans-shipment, communications, and construction center for the establishment of the eastern sites of the DEW line (Härtling, 1988).

The study area is located at the West 40 area on the border of Sylvia Grinnell Park, 1.7 km southwest of the City of Iqaluit. The United States Air Force (USAF) used this site from between 1955 to 1963 as a metal dump for vehicles, truck bodies, barrels and scrap metal. The majority of materials were deposited in 1963 when the US Military left Frobisher Bay. Shops, buildings, and other materials were simply bulldozed over the cliff. The cliff is a bedrock outcrop rising approximately 50 m above the tidal area where the Sylvia Grinnell River meets Frobisher Bay. The area to the north side of the slope was used by the USAF and the community of Iqaluit as a landfill site for household garbage until sometime in the 1970’s.

1.3 Previous Environmental Investigations

Environmental investigations have previously been carried out including chemical analysis of selected media and a volume estimate of metal waste.

Any reference to specific documents is clearly documented in this report. Significant reports for this study include:

- Avati Ltd., 1993. Remediation Options For an Abandoned US Airforce Base and Two Waste Sites at Iqaluit, NWT. October 1993.
- Earth Tech Canada Inc., 2001. Desk Top Review of Scrap Metal Dump Site West of Iqaluit Airport, Iqaluit, Nunavut, Canada. Prepared for Transport Canada, Prairie and Northern Region-Programs.
- Härtling, J., 1988. PCB and Trace Metal Pollution from a Former Military Waste Disposal Site at Iqaluit, Northwest Territories. Master’s Thesis.
- Peramaki, L.A and J.D. Decker, Lead in Soil and Sediment in Iqaluit, Nunavut, Canada and Links with Human Health, Environmental Monitoring and Assessment, 63: 329 – 339, 2000.
- Public Works Canada Literature Review, 1992.

- Royal Military College – Environmental Sciences Group, Victoria, BC, 1995. Environmental Study of a Military Installation and Six Waste Disposal Sites at Iqaluit, NWT. Prepared for Department of Indian and Northern Affairs Canada & Environment Canada.

1.4 Project Team

This project was undertaken by a multi-disciplinary team. Key individuals and their respective roles are summarized below:

- Steve Livingstone, M.Sc., P.Geo(l). Senior Hydrogeologist, Reviewer
- Richard Wells, P.Eng., Project Manager
- Ryan Fletcher, C.Tech., CEPIT, Environmental Technician
- Tina Ranger, Dip. Tech., Environmental Technologist
- Marta Rosa, B.Sc., Environmental Geoscientist
- Tamra Reynolds, M.Sc., P.Geo., Hydrogeologist

2.0 STUDY AREA CHARACTERISTICS

2.1 Site Overview

Iqaluit (formerly named Frobisher Bay) is located on the southern tip of Baffin Island in the Nunavut region of the Northwest Territories. With a population of approximately 6100, Iqaluit is the largest community in the eastern Arctic and serves as a regional service and administrative centre. Solid waste disposal both from military activities and the community itself have resulted in the creation of several landfill sites. Historically, the subject site has been referred to as Sylvia Grinnell Park Dump and West 40 – Dump Site # 1. For the purpose of this report, the subject property will be referred to as the Vehicle Dump and Community Landfill or simply “site”.

As shown in **Figure 2**, the study area is divided into two distinct areas:

- The main debris/community landfill area which includes exposed metal debris. A portion of the waste including 45 gallon drum dumps are located at the toe of the bedrock escarpment; and
- the vehicle dump approximately to the south and parallel with the main landfill;

The landfill site is situated on the slope of an escarpment leading to the Sylvia Grinnell River and has several shallow ravines and coulees partially filled with metal debris. The debris is scattered over a large area and consists of vehicles, equipment, barrels, and scrap metal. Areas of concern include the low areas within the ravines, containing the scrap metal; the base of the escarpment; and the soft bog area where the barrels are stockpiled at the base of the escarpment.

2.2 Current Use of the Landfill Site and Adjacent Lands

Due to the remote location of the landfill, current use of the site is minimal. Deposition of landfill waste has been discontinued. Local residents occasionally use the site for dumping personal waste and as an access point to Silvia Grinnell Park. The Sylvia Grinnell River is located on the southern side of the landfill site (see **Figure 2**).

Sylvia Grinnell Territorial Park, the oldest of Nunavut's territorial parks borders the site to the north-western extent. Sylvia Grinnell Park is divided in two by the Sylvia Grinnell River. The park plays a vital role in the community of Iqaluit by providing an important fishing ground for Arctic Char.

2.3 Current Permit Information and Future Land Use

FRANZ understands that there are no current plans for the use of the property. The property remains undeveloped and part of Transport Canada's inventory of sites. A request put in to INAC mining records department, on November 17, 2008, to search for past and present mineral claims on the property turned up negative. No land claims have been made on the subject property.

2.4 Climate Conditions

Iqaluit is located within an arctic climatic zone despite being well outside of the Arctic Circle. The average daily temperature range is -28°C to 7.7 °C. The area is characterized by very cold winters and short summers that permit the growth of very small, stunted trees. The average monthly temperature is below freezing for eight months of the year. The average annual precipitation is 412.1 mm, which is much wetter than many other localities in the Canadian Arctic islands. There is 198.3 mm annual rainfall and 235.8 mm annual snowfall (www.climate.weatheroffice.ec.gc.ca).

2.5 Natural Environment – Overview

The landfill site covers an area of approximately 72,500 m^2. Iqaluit lies within the low arctic tundra zone, which is ecologically sensitive. The area is underlain by continuous permafrost. Soils are nutrient-poor, silty, shallow and have little, if any profile development (Peramaki and Decker, 2000). The topography, structural geology and drainage of the study area follow a northwest-southeast trend. Ground cover is a combination of black, silty sand with organic soil, bedrock outcrops, grass and lichens.

Sylvia Grinnell Park is also home to Arctic Hare, Arctic Fox, Caribou, lemmings and other small mammals. Polar Bear have even been sighted on occasion, although they do not frequent the area.

The park also plays a significant role in bird migration and over 40 species have been recorded in the park at different times of the year. The park is also the most southern breeding ground for the Ringed Plover. The local vegetation above and below the cliff consists of wet grassland tundra species including mosses, grasses and sedges. On the cliff and bedrock outcrops vegetation is sparse and consists of lichens with patches of grasses and mosses.

3.0 HISTORICAL REVIEW AND EVALUATION

3.1 Sources of Information

The main historical sources of information for this report were obtained from interviews, historical reports and archives, historical maps, plans, online databases, and previous environmental reports. The historical information reviewed included:

3.2 Interviews

The list of people interviewed for this investigation included:

Interviewee	Title/Role	Date	Location
Rob Eno	Manager, Pollution Control Environmental Protection Service Department of Sustainable Development Government of Nunavut	Sept 4, 2008	Iqaluit, Nu
John Graham	Manager, Iqaluit Airport – Government of Nunavut	Sept 4, 2008	Iqaluit, Nu
Paul Burrino	Heavy Machine Operator – City of Iqaluit	Sept 4, 2008	Iqaluit, Nu
Michelle Burtol	Acting Head of Engineering (Temporary) – City of Iqaluit	Sept 4, 2008	Iqaluit, Nu
Jose Trembley	Assistant Manager – Iqaluit Airport – Government of Nunavut	Sept 5, 2008	Iqaluit, Nu
Mike Bowser	City of Iqaluit – long standing citizen of Iqaluit	Sept 5, 2008	Iqaluit, Nu
Amanda Wells	Lands Department – City of Iqaluit	Sept 5, 2008	Iqaluit, Nu
Reception	DIAND – Contaminated Sites Division	Sept 5, 2008	Iqaluit, Nu
Reception	NRCan (Surveys and Cadastral Lands Division)	Sept 5, 2008	Iqaluit, Nu
John Craig	Assistant Land Administrator Operations – DIAND (Lands Division)	Sept 5, 2008	Iqaluit, Nu
Claude Martel	Manager/shareholder – Nunavut Construction Corp.	Sept 7, 2008	Iqaluit, Nu
Allain Carriere	Owner – Nunatta Environmental Services Inc.	Sept 10, 2008	Iqaluit, Nu

Salient issues from the telephone interviews and e-mail exchanges are outlined in the relevant portions of the text. It is noted that the statements made by the interviewees were not made categorically and are limited by their personal knowledge of, and experience with, the subject property to the best of their memory. Therefore, no issues of environmental concern were discounted solely on the basis of these statements.

All relevant historical materials (documents, drawings, maps and photographs) are provided in the text or in **Appendix A** through **C**, and are to be used as supporting documentation for the text included in the report.

3.3 Reports and Historical Archives

- Avati Ltd., 1993. Remediation Options For an Abandoned US Airforce Base and Two Waste Sites at Iqaluit, NWT. October 1993.
- Earth Tech Canada Inc., 2001. Desk Top Review of Scrap Metal Dump Site West of Iqaluit Airport, Iqaluit, Nunavut, Canada. Prepared for Transport Canada, Prairie and Northern Region-Programs.
- Härtling, J., 1988. PCB and Trace Metal Pollution from a Former Military Waste Disposal Site at Iqaluit, Northwest Territories. Master's Thesis.
- Peramaki, L.A and J.D. Decker, Lead in Soil and Sediment in Iqaluit, Nunavut, Canada and Links with Human Health, Environmental Monitoring and Assessment, 63: 329 – 339, 2000.
- Public Works Canada Literature Review, 1992.
- Royal Military College – Environmental Sciences Group, Victoria, BC, 1995. Environmental Study of a Military Installation and Six Waste Disposal Sites at Iqaluit, NWT. Prepared for Department of Indian and Northern Affairs Canada & Environment Canada.

3.4 Maps and Plans

A visit to the Iqaluit Airport and interview with the current airport manager, John Graham took place on September 4, 2008. Historical maps and plans of the airport property were investigated at this time. No relevant information pertaining to the official boundaries of the airport property were obtained during this interview and investigation.

On September 5, 2008 a visit was made to Natural Resource Canada – Department of Surveys and Cadastral Lands Division. An official site survey was obtained during this visit and is presented in **Appendix A**.

Google Earth (Google, 2008) provided a detailed and relatively high resolution aerial view of the site. The Google Earth images were used in conjunction with the above mentioned articles in the creation of the site base map figures for this report.

3.5 Databases

The database searches included:

- NWT Archives, Prince of Wales Heritage Centre;
- Environmental Protection Service of the GNWT www.e-ngine.ca/eps_spillreport/;
- National Archives, Ottawa; and
- Canadian Museum of Civilization, Gatineau, QC.

3.5.1 Historical Overview

Based on the available historical information, the Vehicle Dump and Community Landfill has had a varied history since the mid 1940s and the construction of the Iqaluit Airport. The known uses, from the past to present, are outlined as follows:

Site Use	Approximate Timelines
1. Vacant Land	1930s to 1940s
2. Airport Runway – End of the old airstrip terminated at this point. Actual site use remained vacant.	1942/43 to late 1940s
3. Landfill and Metal Dump	Late 1950s-Present

3.5.2 Historical Site Features and Overview

Based on a review of the available information, and the interpretation completed by Royal Military College – Environmental Sciences Group in 1995, the historical development is described as follows:

The Iqaluit Airport was constructed in the year of 1942-1943 in an effort by the joint effort of a United States and Canadian military initiative known as the “Crimson Route”. This route was mandated as a flight path designed to ferry aircraft and equipment to Europe during World War II. The city of Iqaluit was formed as part of an airbase for military support purposes. Activities in Iqaluit eventually diminished with the end of the Second World War.

However, the spark of the Cold War inspired a resurgence of activity at the Iqaluit Airport and the City of Iqaluit as a whole. The main function of this new activity was the construction of the Distant Early Warning (DEW) Line, a series of radar stations stretching from Greenland on the Yukon-Alaska border. The Iqaluit Airport served as a base station for much of the construction activities in the eastern arctic region.

The study area was vacant from the conception of the airbase until a time between 1958 and 1964 as noted during aerial photographs review. According to Härtling, 1988; it is believed that the site was first used as a disposal facility in 1963. These dates concur with the United States Air Force (USAF) withdrawal from the area. The nature of the debris in the main landfill and scrap metal dump suggest that the USAF was likely responsible for depositing a large portion of the wastes currently found on the site.

The site was believed to be used for the disposal of small quantities of municipal waste from the town of Iqaluit in the 1960's, but was abandoned in the early 1970's in favour of the newly constructed Apex dump site. Upon closure of the site, it is believed that a cap consisting of granular material was placed on top and on the face of the landfill site to cover much of the debris (ESG, 1994). A few examples of municipal wastes disposed of at the site include food cans and bottles, kitchen appliances, bicycles, tires, wooden pallets, animal remains, water heaters, toys, etc.

The site has seen little activity since its abandonment in the 1970's. The site is now used as a location for burning of wood debris and a rogue dumping area for residents of the community (these types of activities were observed during the field investigation). Some residents occasionally scavenge the vehicle dump for parts and useful items.

3.5.3 Aerial Photographs and Databases

Aerial photographs (recent and historical) of the study area were obtained from the National Air Photo Library in Ottawa, Ontario. Historical land use changes as well as potential sources of environmental impacts observed from the photographs were noted. Aerial photographs of the area taken in 1948, 1953, 1955, 1964, 1976, and 1985 were available and are presented in **Appendix B.** The following table describes observations about current and historical land use for the subject property and surrounding properties that were noted during review of aerial photographs.

Date	Roll # (Scale)	Review
1948 1948/07/23	A11535-43 (1:20,000)	The immediate area does not appear to be impacted by human activity at this point. No evidence of debris or disturbed land is present on the subject property. The runway does not appear to be in use for aircraft at the time of the air photo. This is supported by the presence of debris and drums stacked in rows on the tarmac. One single roadway runs off the center of the runway heading east to the location of the current tank farm and municipal landfill. Visible drainage patterns and water pounding appears to be unchanged with respect to the 2008 site visit observations and the Google (2008) satellite images.
1952 1952/07/21	A13519-343 (1:15,000)	The immediate area does not appear to be impacted by human activity at this point. No evidence of debris or disturbed land is present on the subject property. The runway is not in use for aircraft at the time of the air photo. There is a large quantity of debris stacked in the center of the airstrip and a roadway is clearly visible down the center of the airstrip. No roadways or paths are visible extending from the southeast extent of the runway. One single roadway runs from the center of the runway heading east to what appears to be three large above ground storage tanks (likely the construction of the current tank farm area). Drainage patterns on site appear in the same as those observed during the 2008 site visit.
1955 1955/07/23	A14869-3 (1:15,000)	The immediate area does not appear to be impacted by human activities. No evidence of debris or disturbed land is evident in the current position of the landfill. The runway is no longer in use for aircraft. Large quantities of debris are present stacked in rows on the far southeast portion of the airstrip. Items visible include vehicles and drums. Vehicle tracks are visible north of the subject property in the marshy area. A small road is beginning off the southeast extent of the runway. Drainage patterns on site appear in the same as those observed during the 2008 site visit.
1964 1964/08/14	VRR2618-195 (1:6000)	The main landfill area (APEC 3) is clearly impacted by dumping activities. The extents of the main landfill appear to coincide with the current landfill extents. The landfill does not appear to be capped and scattered debris is also visible throughout all landfill areas. The vehicle dump (APEC 2) area appears to be more centrally located in the drainage gully than was observed in this past field investigation (2008). The land surrounding the up

Date	Roll # (Scale)	Review
		gradient suspected dumping area (APEC 1) seems to be disturbed by heavy machinery. This is evidenced by many tracks crossing the tundra all throughout the area and clearly disturbed soil in parts of the area. The runway appears to be completely decommissioned and a heavy roadway runs down the center of it. One rough roadway leads from the southeast extent to the vehicle dump and one defined roadway leads from the southeast extent to the main landfill area. Drainage is difficult to see on this aerial photograph, but appears to be the same as that observed during the 2008 site visit.
1976 1976/08/19	A24492-70 (1:20,000)	The main landfill area (APEC 3) is clearly impacted by dumping activities. The extents of the main landfill appear to coincide with those observed during the 2008 site investigation. The vehicle dump (APEC 2) area appears to be more centrally located and not spread up the hillside as was observed during the field program. No evidence of dumping is noticeable in the up gradient (APEC 1) area. The runway is no longer in use for aircraft and a defined roadway (in its current position) is seen down the center of the airstrip. One roadway runs off the far southeast end of the runway leading to the landfill area. One other, less defined, roadway also leads off the southeast extent of the airstrip and heads east across the marshy area and to the top of the adjacent hillside. A roadway also leads off to the west (also in its current position). Drainage appears concurrent with 2008 observations.
1985 1985/07/10	A26763-22 (1:10,000)	Observations of the immediate area remain unchanged from the previous (1976) aerial photo. The less defined roadway is now intermittent and does not appear to be in use. It appears that the tank farm has been expanded from the previous aerial photo reviewed. Drainage appears concurrent with 2008 observations.
2008	Google Earth	Observations of the immediate area remain unchanged from the previous (1976 & 1985) aerial photos. The less defined roadway is now gone and no evidence of its use exists. The tank farm appears in its current state. Drainage is as observed during the 2008 site visit.

After a review of the aerial photographs, it appears that the debris was stored for a period of time and then simply bulldozed off the cliff to lie in its current position. The aerial photographs confirmed that the landfill site was created between 1955 and 1964.

3.5.4 Environmental Database Search

The following table provides a summary of findings related to potential environmental issues.

Item of Concern	Findings
Accidents/Spills	There are no spill records on file with the Environmental Protection Service of the Government of Nunavut and Northwest Territories (GN and GNT). www.e-engine.ca/eps_spillreport/ However, with the site usage and history of fuel handling and storage, there were very likely spills and discharges over the time.
Previous Use of Site	• No previous uses are known • Possibly used as a camp area for historical fishing prior to US Military Presence (pre 1942)
Geology, Mineral claims, wildlife areas, mineral deposits	INAC-SID reviewer was queried for updated physical and site characteristics data. www.ainc-inac.gc.ca
Maintenance/ Operational Areas	There are no maintenance areas at the site.
Water and land permits	Mackenzie Valley Land and Water Board was contacted through www.mvlwb.com. No work is proposed at the site.
Hazardous Materials Storage	Storage of hazardous materials on the site is not likely, however disposal of such chemicals is suspected.
Fuel Storage Tanks	Approximately 300-400 empty drums are located throughout the site. There has been extensive history of fuel storage and handling at the airport and historical air photos show storage of drums in the vicinity of the site.
Odours	Faint greasy odours are present near the vehicle dump and main landfill areas based on the preliminary site investigations.
Potable Water	The site is presently not serviced with water. However, the site is adjacent to the Sylvia Grinnell River and Territorial Park.
Pesticides and Herbicides	Given the time frame that the site was in use, the use and disposal of pesticides and/or herbicides is possible, during the operational period of the site.
Mould	No mould related issues were identified.
Major Mechanical Equipment	Older equipment including vehicles, tractors, trailers, generators, and boilers have been observed at the site. Mostly in the vehicle dump area (APEC 2).
Waste oils, Solvents, Batteries	Evidence of the disposal of waste oils, solvents and batteries were apparent on site.
PCBs	Based on the historical testing completed on-site disposal of PCB-containing equipment is likely, however; most PCB containing transformers were removed during previous site remediation attempts.

Item of Concern	Findings
Soil and Water Conditions	Surficial soil and waters have been impacted by the fuels, metals and other COCs originating from the vehicle dump (APEC 2) and the main Landfill (APEC 3). Transport Canada provided us with all known environmental studies completed to date.
Waste Disposal	The entire site area was used for waste disposal as outlined in section 3.5.2.
Asbestos	No evidence of asbestos containing material (ACM) was directly observed during the initial site visit, however; it is expected that ACMs do exist in the brake lining of the vehicles (APEC 2) and possibly within the debris of the main landfill area (APEC 3).
Physical Hazards	Metal debris, vehicles piled on top of one another, and steep slopes of the landfill are considered physical hazards on site.

3.6 Previous Environmental Investigations and Outcomes

Numerous environmental investigations have been carried out including chemical analysis of selected media. To date, much of the work has focused on historical reviews and the potential for impacted soil and surface water with metals, polychlorinated biphenyls (PCBs), and to a lesser degree with petroleum hydrocarbons (PHCs), pesticides, and polycyclic aromatic hydrocarbons (PAHs).

The following is a brief description of the previous environmental investigations reviewed by FRANZ as well as information obtained from the historical environmental investigations.

Härtling, 1988

Sylvia Grinnell Park was the focus of a thesis paper written by Härtling, and Joachim Walter titled “PCB and Trace Metal Pollution from a Former Military Waste Disposal Site at Iqaluit, Northwest Territories”. The purpose of Härtling’s Thesis was to study the concentrations of PCBs and inorganics in soil, surface water, and sediments within the vicinity of the Sylvia Grinnell Landfill Site.

This thesis states that historical PCB sampling was completed in the fall of 1984 by the Environmental Protection Service. Two of the samples showed “significant” levels of Aroclor 1260 (actual concentration unavailable for review). PCB and inorganic elements in soil and sediments were sampled in the summer of 1987 for the purpose of producing the thesis paper.

It was found that soil concentrations of inorganic elements at the toe of the main landfill (APEC 3), namely arsenic and zinc, exceeded DCC Tier II levels (ESG, 1995). The Härtling thesis did not make comparisons against any specific environmental criteria. Elevated levels of PCBs were detected at the toe of the main landfill and below the vehicle dump site (APEC 2), these PCB levels ranged from 0.02 to 0.5 ppm (µg/g). One elevated (in comparison to the remainder of results) surface water sample was collected from an oily puddle and produced PCB concentrations of 11.1 ppb (µg/L); however, this sample is not expected to be representative of the average surface water conditions at the site.

PCB concentrations were found at minor concentrations in soil and sediments below the main landfill in the area directly impacted by landfill debris. PCB concentrations were also present in the surface sediments of the ponds directly down gradient of the main landfill area and the vehicle dump.

It was concluded that several series of parallel bedrock outcrops are limiting the migration of both PCB and inorganics in soils and surface waters within the site. Minor amounts of the contaminants of concern could be migrating to the River; however, these elements are in trace amounts.

PWGSC, 1992

Public Works and Government Services Canada, Pacific-Western Region, Manitoba Division conducted a literature review in 1992 titled “Literature Review on Abandoned and Waste Disposal Sites in the Iqaluit Area, Northwest Territories.” The review focused on all landfill sites around Iqaluit, but summarizes data obtained mainly by Härtling, 1988 on pages 6 and 7 of the review.

During the years of 1986-1989 DIAND initiated a cleanup of the area which included the removal of 97 pieces of electrical equipment and steel drums thought to contain PCBs. These items were removed from the site, stored in barrels in a concrete building near the landfill and then transported to the Ministry of Transport PCB storage facility at the airport. Drums from the landfill were also collected and piled in their current positions at the toe of the main landfill (APEC 3).

Finley, C., 1992

C. Finley from the University of Toronto reviewed the Avati report and the 1992 PWGSC literature review in a publication summary of the state of solid waste disposal in Iqaluit. No new information pertaining to the site was brought to light with this report.

Avati, 1993

Avati Ltd. completed an environmental assessment on Sylvia Grinnell Dump site in 1993 (volume 1993a). During this investigation, four surface water samples and 14 soil samples were collected. Inorganic elements were tested in 11 of the soil samples, none of which exceeded the CCME Residential/Parkland (R/P) criteria at that time. Three of the water samples contained concentrations of inorganic elements that exceeded the CCME FAL criteria at that time. Avati Ltd. also completed a remedial options analysis (volume 1993b). This volume of their report did not address the above mentioned exceedances.

PCBs were detected and exceeded the CCME R/P Remediation Criteria at that time in three soil samples collected during the 1993 investigation.

Remedial options presented included:

- Excavating all debris, sorting, and shipping south all materials or
- Excavating all debris, sorting, and shipping only hazardous materials south and burying remaining debris in local landfill facility.

ESG, 1995

Royal Military College, Environmental Services Group (ESG) conducted an environmental site assessment of the site in 1995. Eight soil samples, one surface water sample, three vegetation samples, and three sediment samples were collected as part of this investigation.

Inorganics

Four of the seven soil samples analyzed contained elevated concentrations of inorganic elements (specifically lead and zinc) which exceeded the DEW Line Cleanup Criteria

(DCC). One vegetation sample analyzed for inorganics contained concentrations of zinc elevated when compared to the soil samples taken in the same location. One of the three sediment samples analyzed contained concentrations of chromium exceeding the Environment Canada Interim Freshwater Sediment Quality Guidelines (ISQG); however, elevated levels of chromium were also detected in background sediment samples.

PCBs

Eight soil samples were analyzed for PCBs and all contained concentrations below the DCC criteria at that time. It should be noted that soil samples were elevated considerably in comparison to background sample locations. One vegetation sample was analyzed for PCBs and contained concentrations 41 times background. The three sediment samples contained detectable levels of PCBs, but remained below the Environment Canada ISQG.

Pesticides were tested in one soil sample and contained concentrations below the applicable criteria at that time. Two soil samples were also analyzed for PAHs, most PAH analytes were present, but below the CCME R/P criteria.

Recommendations & Conclusions

Inorganics

It was found that lead (409, 414, and 1140 ug/g) and zinc (720 and 12820 ug/g) were elevated in soils; however, plants remained unaffected by the elevated inorganic elements. Sediments from Sylvia Grinnell River contained trace inorganic elements only slightly elevated when compared to background. It was suggested that sediment loading was not occurring in Sylvia Grinnell River as a result of land filling activities at the site.

PCBs

Soils at the toe of the main landfill (APEC 3) were elevated (mean level of 0.13 ug/g, high of 0.71 ug/g) and approached the DCC criteria, while concentrations elsewhere remained low. PCBs remained un-detected in surface water collected below the vehicle dump (APEC 2). Vegetation appeared to be impacted due to the presence of elevated

PCB concentrations in soil at the toe of the main landfill. No evidence was established to suggest migration of PCBs to the Sylvia Grinnell River.

Cleanup Recommendations

It was recommended that soil remediation take place at the toe of the landfill site to address the elevated levels of inorganic elements identified through this and previous environmental investigations. Soils should be removed from contact with the arctic ecosystem between the toe of the landfill and the first set of parallel bedrock outcrops.

It was recommended that all metallic debris be removed from the site and be recycled and/or shipped south. The stability of the main landfill (APEC 3) should also be addressed, as it presents an immediate physical hazard and risk to those using the area for recreational purposes. It was proposed that sufficient amounts of granular material be added to the landfill face to achieve a safe and suitable slope angle and ensure that all debris remains buried at an adequate depth. The newly obtained slope should be seeded to prevent erosion and help maintain slope stability.

Peramaki, A., Decker, J.F., 1998

A study was conducted with regard to lead contamination at the Landfill Site. The study was conducted to determine the spatial distribution of soil and sediment-associated lead.

Sylvia Grinnell Park exhibited the highest concentrations of lead found in any of the sites considered during this investigation. These lead concentrations were found to be in the same order of magnitude as previously reported by ESG, 1995.

3.7 Identification of APEC's

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 ESA sampling plan. Based on the timelines of the project initiation some of the archive materials and other historical information were only available following the field investigation.

The Vehicle Dump and Community Landfill site has three main areas that contain a zone(s) of contamination and has been divided into four APECs as follows (See **Figure 2**):

APEC 1 – Upgradient Buried Debris

The area of the landfill directly upgradient from the vehicle dump contained evidence of potential buried metal debris during the site visit. The area also appears to be disturbed on the 1964 aerial photographs.

APEC 2 – Vehicle Dump

The second area of concern is the vehicle dump located in the drainage feature to the east of the main Landfill area. This area is composed of vehicles, such as trucks, cars, trailers, boilers, tankers, and others. A drainage channel runs directly through the center of this debris pile discharging to the ponds, then the river.

APEC 3 – Main Landfill

The third area is the main landfill area consisting of a mixture of debris spread across a steep graded bedrock slope. The top of the landfill area has been capped with granular material and the toe is left exposed with debris scattered throughout the area.

APEC 4 – Downgradient, Off-site

The fourth APEC is comprised of any area of the site that is off-site and in Sylvia Grinnell Park. All downgradient and off-site sampling locations were given a separate sampling nomenclature in order to clearly differentiate their results from those of the on-site sampling locations.

The APECs and PCOCs are further broken down for each area in the following table:

APEC	PCOCs
APEC 1- Up Gradient Buried Debris	PHCs, Metals, PCBs, and Pesticides
APEC 2 – Vehicle Dump	PHCs, PAHs, Volatile Organic Compounds (VOCs), Metals, PCBs, and Pesticides
APEC 3 – Main Landfill	PHCs, PAHs, VOCs, Metals, PCBs, and Pesticides
APEC 4 – Down Gradient, Off Site	PHCs, PAHs, VOCs, Metals, PCBs, and Pesticides

3.8 Present Conditions

The Vehicle Dump and Community Landfill is not in active use. **Figure 2** presents an aerial view of the site and representative photos are shown in **Appendix C**.

The site was abandoned as a landfill in the mid 1970's. Since then it has remained relatively unchanged. The extent of the vehicle dump area has increased and approximately 100 pieces of electrical equipment were removed between 1987 and 1989. No buildings or infrastructure are present on the site. Site use is understood to be strictly recreational with no known development strategies for the future.

The site consists of a main landfill area, a vehicle dump, and a series of streams and ponds meandering ther way to the Sylvia Grinnell River via linear surficial features.

4.0 SUPPLEMENTAL FIELD INVESTIGATION

4.1 Field Reconnaissance

A preliminary site visit was conducted by FRANZ personnel on August 13, 2008 and accompanied by Mr. Leo Twerdin, Assistant Airport Manager – Transport Canada. The following observations were compiled during this initial site visit:

Vehicle Dump – APEC 2

- To the south and parallel with the main landfill is a significant vehicle dump;
- The landfill consists of approximately 86 large vehicles/trucks, boilers, tankers, flat beds, vehicle parts, drums/tanks, construction debris, some domestic debris. The debris is not covered and is randomly placed within a bedrock low lying area; and
- A surface water pathway draining via a series of ponds into the Sylvia Grinnell River is located at the toe of the vehicle dump.

Main Debris/Community Landfill – APEC 3

- A significant amount of exposed waste was classified as metal debris consisting of old auto parts, boilers, cans, tires, metal gas containers, 45 gallon drums, rods and metal braces;
- A portion of the waste including 45 gallon drum dumps are located at the toe of the bedrock escarpment;
- A portion of the waste appears to be unstable and would represent a potential for slope failure;
- The upper portion of the waste pile at the top of the bedrock outcrop appears to be capped with a thin veneer of sand/silt material. This cap appears to be weathering, exposing the waste materials. There was evidence of burning of wastes;
- Potential hazardous waste materials including batteries, potential asbestos (liner of boilers); gas drums and storage tanks; electrical equipment were noted; and
- Down gradient from the landfill is the Sylvia Grinnell River, which supports arctic char fishing. From the toe of the landfill, minor surface water pathways were noted that may be seasonally active. Some of the waste materials at the toe of the landfill were wet and saturated.

A detailed site visit was completed by FRANZ personnel on September 1, 2008. This site visit expanded on the above mentioned items and included:

- A detailed inventory of waste debris located in each section of the landfill area;
- A breakdown of the site into four distinct Areas of Potential Concern (APECs);
- Identification of historical sample locations;
- Identification of potential and observed contaminant source areas;
- Mapping of drainage pathways, waste debris areas, seepage and leachate, and pooling surface water bodies;
- Mapping of bedrock outcrops and geologically dependant surface water pathways;
- Mapping of stained areas and any areas used for open burning; and
- Evidence of vegetation stress.

The information collected above, in combination with the complete historical records review was used in the design of the detailed sampling plan.

4.2 Detailed Sampling Plan

Based on the results of the Phase I ESA site visit and interview program conducted on September 1 and 2, 2008, as well as the review of available historical reports and documents pertaining to the site, a detailed sampling plan was designed to conduct a Phase II ESA of the site. The purpose of the Phase II ESA with respect to soils, sediments, surface water, and waste materials was to characterize known environmental impacts, investigate newly discovered potential sources of environmental impact, confirm and/or refute the presence of suspected contaminants of concern (COCs), summarize and classify on-site wastes, and to generate a qualitative geotechnical stability assessment of the landfill. The sampling plan was established within the agreed-upon scope, timeline, and budget of the program. The detailed sampling plan submitted to PWGSC via e-mail September 2, 2008 described the following aspects of the program:

- proposed sampling locations and numbers;
- proposed sampling or measurement methods;
- parameters being sampled;

- details on methodologies including sample collection, measurement, transportation, and analysis;
- description of objectives with rational;
- proposed QA/QC methods;
- proposed background sampling protocols;
- updated health and safety plan (See **Appendix D**); and
- updated budget.

During the field activities, areas of environmental concern were prioritized and assessed in accordance with the proposed scope of work. In addition, based on visual observations at the time of the field program, testing locations were refined from the initial sampling plan to target most likely impacted areas and/or to attempt coarse grid delineation of impacts.

4.3 Health and Safety Procedures

FRANZ field programs are always subject to a site-specific Health and Safety Plan (HSP). We use a Corporate Health and Safety as a general guide in developing the site-specific plan to which all team members and subcontractors must adhere. Protection of the public and personnel from exposure to any contaminated materials at the site was priority during the field program.

Prior to conducting any of the onsite work, a site-specific health and safety plan was developed, distributed, and discussed with all field personnel (see **Appendix D**). As a minimum, full personal protective equipment (e.g., hard hats, safety glasses, safety boots, reflective vests, and Nitrile gloves) was worn at all times during field activities. Tyvek overalls and respirators were made available to all field personnel, should the site health and safety officer (SHSO) find their use necessary.

4.4 Subsurface Sampling Methodology

4.4.1 Test Pit Excavations

Test-pitting was considered the appropriate method for conducting observations of soil condition and collecting near surface soil samples in areas of potential environmental concern (APECs).

Between September 5, 2008 and September 9, 2008, 25 hand excavated test pits were advanced by FRANZ personnel to a maximum depth of 1.6 m below ground surface. One soil sample from each test pit was collected and analyzed for various contaminants of concern (please refer to **Tables 1** and **2**). All test pits were completed with a spade shovel to the maximum achievable depth, the majority of test pits encountered refusal at bedrock.

At each test pit location, composite soil samples were collected using a decontaminated trowel. Depending on the depth of the test pit, the nature of the stratigraphy, and any evidence of contamination, composite samples generally were collected over a range of 50-60 cm.

Prior to sampling, soil descriptions including approximate grain size, colour, moisture content, stratigraphy, and any evidence of contamination were recorded (**Table 1**).

Following the completion of the test pit field log and prior to backfilling the pit to grade, soil samples were collected and stored in sealable polyethylene bags (for soil vapour headspace analysis) and dedicated glass sample containers (for laboratory analysis). Following sample collection, jarred soils were refrigerated and/or stored on ice in laboratory supplied coolers from the day of collection until delivery to the project laboratory in Vancouver, British Columbia.

The 2008 test pitting program was limited by the fact that no mechanical equipment was available for advancing the test pits on or below the escarpment. Therefore, most test pitting was completed by hand using a spade tipped shovel (with the exception of the test pits excavated in APEC 1). A test pit depth of 1.5 m was the maximum accessible depth from the ground surface. This method also limited the ability of field personnel to perform visual vertical profiling below 1 m, which would have been possible using traditional test pitting equipment (i.e., backhoe or excavator).

Test pit locations are indicated on the site instrumentation map (**Figure 2)**. Test pit logs were prepared for all of the locations tested and are located in **Table 1**. The number of logs prepared was sufficient to provide adequate coverage of the stratigraphy which appears to be fairly constant across the site and over the depth tested.

4.4.2 Soil Sampling Field Vapour Screening

Vapour screening is a frequently used method for detecting and measuring the quantity of volatile organic compounds present in soil. When taken continuously from the ground surface to the end of a test pit, vapour readings can provide an indication of the relative level of contamination and whether it derived from a localized source or migrated from a more distant one. As a result, field screening is a useful tool to facilitate selection of samples to be submitted for laboratory analysis.

During the investigation, field vapour screening was completed in-situ by partially filling and sealing standard volumes of soil into dedicated polyethylene bags. When stored at room temperature, headspace vapours were allowed to develop and equilibrate in the sealed bag. Gas samples retrieved by piercing the bag with a needle were then analyzed with an RKI Eagle organic vapour meter (OVM), and the concentration of combustible gases present (other than methane) by volume (ppm) of the calibrating gas (hexane) was measured. Only those soil samples suspected of hydrocarbon contamination were tested for head space vapours. The results of the soil vapour headspace analyses are included in the test pit logs (**Table 1**).

4.4.3 Selection Criteria for Soil Chemical Analyses

Soils were analyzed based upon three distinct rationales:

1) to delineate confirm/refute potential soil impacts related to land filling procedures;
2) to provide a better understanding of metal concentrations in the soil and other native materials across the site; and
3) generate a thorough understanding of environmental receptors, as well as fate and transport of contaminants of concern (COCs).

Soil sample selection for metals analyses was based on a detailed review of previous soil analyses completed on the various soil types found on the site and near impacted source areas, as well as visual site inspection of potential source areas and natural environmental pathways and receptors.

Samples for potential hydrocarbon analysis were screened for soil vapour concentrations and reviewed for staining and visual impacts. In general, soil samples submitted for VOC or hydrocarbon analysis were based on elevated soil vapour concentrations, odours and/or staining.

Samples for potential PCBs were selected based on historical site usage and visual impacts.

Background samples for metals were based on areas that appeared to be free of influence by human activities or land filling. Selected laboratory analyses for each sample are presented in **Table 2**.

4.4.4 Site Survey

A complete site survey was carried out during the 2008 field program. The site survey consisted of georeferencing site features and sample locations with the use of a Differential Global Positioning System (DGPS) unit horizontally accurate to < 30 cm.

The survey data was placed on a 2008 Google Earth image (2008, Google) and orthorectified to correspond with data points collected during the field survey.

In addition to the DGPS mapping, measurements of key site features (i.e., streams, pounding areas, some debris piles, etc.) were also conducted using a 30 m tape and compass. These site features were also incorporated into the final site base mapping.

4.4.5 Surface Water Characterization

A total of 19 surface water samples were collected from four areas across the site in 2008. One sample was collected in the upgradient debris area (APEC 1), four along the drainage channels passing through the vehicle dump (APEC 2), four at the toe of the main landfill area (APEC 3), eight downgradient of the main landfill and vehicle dump areas (APEC 4), and two background samples.

The surface samples were collected from the shores of the pond areas and Sylvia Grinnell River or by wading into the ponds with hip waders. The surface water locations collected during the field program corresponded with sediment sampling locations (with the exception of A1-SW08-1, A3-SW08-1, and A4-SW08-7). Specific sample locations for each site are indicated on **Figure 2**.

The samples were collected from a depth of 5-15 cm below the water surface, into laboratory supplied sample containers. Field parameters including pH, temperature and conductivity were measured at each surface water station at the time of sample collection. Each sample was labelled and refrigerated and/or kept on ice until they were relinquished to the project laboratory. Results of the field parameters are presented in **Table 3**.

4.5 Stream Flow Measurements

Measurements of stream flow were taken at three separate locations during the 2008 field investigation. One at the discharge from Pond 1 to the Sylvia Grinnell River, one at the discharge of Pond 4 to the Sylvia Grinnell River, and one directly below the vehicle dump (APEC 2) before entering Pond 6.

Simple stream flow estimates were conducted using the Q=VkA method, where Q = total rate of discharge, V = velocity, A = area, and k = correction factor. The site of the field measurements was selected based on the following available criteria:

- Slope of the stream not to great;
- Roughness of channel bottom; and
- Not in proximity to backwater effects, eddy currents, or other influencing factors.

The selected site was prepared by first removing any debris or large cobbles from the stream bed and clearing any obstructions from the stream walls.

Velocity measurements were conducted using float methodology, where a float was timed on a given (measured) portion of the stream seven times and averaged to gain distance/time. A correction factor of 0.85 (k) was applied to the velocity calculations to account for faster moving water at the surface of the stream in comparison that that moving in the middle or bottom.

The area of the stream cross-section was obtained by collecting depth measurements at nine locations across the stream transect and averaging out the depth and multiplying that by the stream width.

4.6 Sediment Characterization

A total of 16 pond and river sediment samples were collected across the site. Four samples were collected in the drainage through the vehicle dump (APEC 2), three at the toe of the main landfill (APEC 3), eight downgradient of the main landfill and vehicle dump areas, and two background samples. Sediment sample stations were located based on the most likely contaminant entrance point to the individual water body being tested.

The sediment sampling was completed using an Eckman sediment dredge. Sediment samples at each location were collected from the top 0 - 10 cm of pond and river sediments in the dredge and placed in a stainless steel bowl for observation, photographing, and logging. For each sample collected, a depth measurement, GPS coordinates, and description of the sediment (including colour, odour, sheens, staining, water depth, grain size, sample recovery, and % natural organic material), the presence of debris, and any unusual characteristics were recorded. The sediments were then placed in laboratory supplied sample containers with the aid of a stainless steel spoon or nitrile gloves and refrigerated and/or kept on ice until they could be relinquished to the project laboratory. The sampling equipment was washed with Alconox and rinsed with lake water between sampling locations. Specific 2008 sample locations are indicated on **Figure 2** and sediment field observations are summarized in **Table 4**.

4.7 Vegetation Sampling

The 2008 field investigation included the collection of 11 vegetation samples throughout the site. One was collected in the upgradient debris area (APEC 1), one was collected down gradient of the vehicle dump next to the main drainage channel (APEC 2), four were collected at the toe of the main landfill (APEC 3), three downgradient of the main landfill and vehicle dumps (APEC 4), and two background samples.

Vegetation samples were collected from the same species (wherever possible) and only foliage from each sample location was submitted for analysis. Samples were collected using nitrile gloves and placed in Ziploc bags. Each sample location was photographed and mapped. The samples were refrigerated and/or kept on ice until they could be relinquished to the project laboratory. Specific sample locations are indicated on **Figure 2**.

4.8 Waste Debris Inventory

For the purpose of future landfill decommissioning and potential removal of debris, an inventory of site waste in the form of debris, abandoned machinery, old transformers, miscellaneous chemicals and other debris scattered across the site (e.g., trucks, domestic waste, etc.) was completed. The waste materials were identified as hazardous or non-hazardous to assist in characterizing materials for potential disposal considerations.

Waste materials associated with the main landfill area and the vehicle dump were quantified by measuring their in-situ dimensions (length and width) using the DGPS system.

The other site waste was itemized as individual scattered pieces (e.g., drums, scrap metal, scrap wood and abandoned vehicles etc.).

A complete summary of waste material characterization and associated inventories categorized by APEC and location is provided in **Section 10.1.2, Table 26**.

4.9 Background Sampling Program

A background quality program was implemented to determine the natural physical and chemical characteristics of soil, sediment, surface water and vegetation in the vicinity of the Vehicle Dump and Community Landfill, but outside of any APECs. The purpose of the program was to obtain data regarding natural conditions that could be used for analytical comparison to conditions within the APECs. Soil, sediment, surface water and vegetation samples were collected and analyzed for metals.

Two background soil sample stations were selected up the river from the site. At each station, surface water, sediment, and vegetation samples were submitted for metals analysis.

Each soil sample was a composite of three sub-samples collected from the overburden unit, excluding the top organic layer.

Background sediment and surface water samples were collected as per the methodologies described in preceding sections under the appropriate media above.

4.10 Chemical and Physical Analysis

4.10.1 Chemical and Physical Analysis Program

ALS Laboratories (ALS) was selected to complete the analytical testing for this project. ALS is certified by the Canadian Association of Environmental Analytical Laboratories (CAEAL), and follows strict internal quality assurance/quality control (QA/QC) protocols. The ALS quality control program includes replicate analysis, blank spikes, matrix spikes, instrument calibration, internal standards, method blanks, and internal QC checks. The standard ALS analytical quality control protocols meet or exceed the requirements of all United States and Canadian regulators. A copy of the chain-of-custody forms used for sample submission is provided with the laboratory reports (**Appendix E**).

4.10.2 Selection Process for Chemical Analyses

Samples were analysed for three reasons: to document pesticide, PCB, metal, VOC, PAH and petroleum hydrocarbon concentrations across the site; to delineate the spatial distribution of impacts for the identified contaminants of concern; and to determine the current environmental and physical conditions which represent the most important potential risks to human and environmental health. Sample locations and analytical parameters were selected on the basis of a review of previous results and site history.

4.10.3 Chemical Analytical Program

The quantity of soil, sediment, surface water and vegetation samples by parameter, and the associated testing protocols are listed in the following table:

Analysis	Medium				Totals
	Soil	Surface water	Sediment	Vegetation	
PHCs	20 (2)	9 (1)	8 (1)		**37**
Metals	27 (2)	19 (1)	20 (1)	11 (1)	**77**
PCBs	13 (1)	15 (1)	11 (1)	9 (1)	**48**
VOCs	5 (1)	2	2		**9**
PAHs	7 (1)	2	2		**11**
Pesticides	5 (1)	3	3		**11**
Grain Size	5		2		**7**
Total number of analyses:	**82**	**50**	**48**	**20**	**200**

(XX) Denotes number of QA/QC samples.

4.10.4 Physical Testing Program

Grain size analyses (± 0.075 mm) were completed on five composite soil samples representative of the area surrounding the landfill and two sediment samples. Grain size analysis (fine/coarse) was conducted to aid in the selection of a site specific environmental criteria and for use in consideration of future landfill capping solutions. Grain size analyses results in both soil and sediment are presented in **Table 5**.

4.11 Quality Assurance/Quality Control

The purpose of the quality assurance/quality control (QA/QC) program was to confirm that field sampling methods and laboratory analyses were reliable. In implementing the QA/QC program, FRANZ verified that the quality of the reported results was suitable to support the environmental impact and human health risk conclusions drawn from the data.

The 2008 field program included the following QA/QC protocol elements:

- Decontamination (Alconox wash and distilled water rinse) of sampling equipment / instrumentation between all sample locations;
- Fresh, chemical-resistant nitrile gloves at each sampling location;
- Proper documentation of all aspects of the sampling program, with particular detail to the introduction of potential bias;
- Elimination of headspace for all volatile parameters (soils and water);
- Collection of one blind analytical duplicate for approximately every 10 samples of environmental media;
- Calculation of the relative percent difference between a sample and its duplicate; and
- Calibration of field instruments.

4.12 Data Reduction and Validation

Data reduction of the investigation results primarily involved, summary tabulation of analytical results and transcription of field observations. Following data reduction, data validation was performed to ensure that the raw data were not altered and that an audit trail was developed for managing the data. Data validation was also performed to verify the quantitative and qualitative reliability of the information. A comparative review of sample collection records, chain-of-custody, holding times, dilution factors, estimated quantitation limits (EQLs), and laboratory and field QC sample records were evaluated against original laboratory reports.

4.13 Quality Assurance/Quality Control Samples

Laboratory reports detailing the handling and secure storage of samples, and the significant dates with respect to sample delivery, extraction, and analysis were reviewed by FRANZ and found to be within control limits.

External QA/QC samples in the form of blind field duplicates were submitted by FRANZ for laboratory analysis. Approximately one duplicate was collected per 10 samples for a given medium. The nomenclature Dup-XX ensured that the sample number corresponding to the blind duplicate was not evident to the lab, allowing the external verification of laboratory accuracy and precision.

4.14 Data Validation of QA/QC Samples

Sampling procedures and laboratory analytical precision were evaluated by calculating the relative percent difference (RPD) for a sample and duplicate pair according to the following equation:

$$RPD = | X_1 - X_2 | / X_{avg} \times 100$$

where x_1 and x_2 are the duplicate concentrations and x_{avg} is the mean of these two values.

The duplicate results were evaluated using criteria developed by Zeiner (1994), which draw from several data validation guidelines developed by the United States Environmental Protection Agency (USEPA). According to these criteria, the RPD for duplicate samples should be less than 20% for aqueous samples and less than 40% for solid samples. RPDs can only be calculated when the compound is detected in both the original and the duplicate sample at a concentration five times above the reportable detection limit (or method detection limit - MDL).

The results of the data validation are presented in the Tables section of this report along with the analytical results. The precision is considered acceptable when evaluation criteria are met, or when both results are below the MDL. When the evaluation criteria are not satisfied, the following apply:

- ND vs positive – unacceptable imprecision: the positive result is considered an estimate and the ND result is considered inconclusive.
- Positive vs positive – unacceptable imprecision: the results are considered an estimate.

4.15 Data Evaluation – Results

<u>Duplicate Analysis</u>

Blind field duplicates (labelled as Dup-xx) were collected and submitted for PHC (2), PAHs (1), VOCs (1), metals (3), PCBs (1) and pesticides (1) analyses in soils. Blind field duplicates were collected and submitted for PHC (1), metals (1), and PCB (1) analyses in sediment. For surface waters, blind field duplicates were collected for PHCs (1), PCBs (1) and metals (1).

In general, the results show satisfactory precision. The following discussion presents the results of the RPD calculations.

In the comparison of soil test samples and their duplicates, PHC Fraction 3 and PCB concentrations were above 40% in one duplicate pair (A3-TP08-13/A3-TP08-DUP2). Variations are likely due to the low concentrations being measured, the relatively small amounts of sample required for the analysis method used and possibly due to heterogeneity in the samples, despite efforts to homogenize them.

In the sediment samples, one sample duplicate pair (A3-SD08-2 / SD-DUP1) displayed unsatisfactory results for one parameter (Copper) at 55%. The two Copper concentrations did not exceed the criteria. The other parameters remained within the acceptable precision and therefore the concentrations do not change the outcome of the assessment and have been kept as part of the assessment. All other parameters had acceptable RPD precision.

Surface water duplicate analysis was completed for PHCs, metals, and PCBs. The concentrations were all within the acceptable precision. Therefore, the sample results are considered valid and were kept as part of the assessment.

Duplicate analysis was completed on the vegetation samples for metals and PCBs. All concentrations for PCBs remained below detection limits; therefore RPD calculations were not required. The concentrations for duplicate metals analysis remained below acceptable precision, with the highest percent difference at 27% for Phosphorus (P).

5.0 PHYSICAL SITE CHARACTERISTICS

5.1 Regional and Local Topography

The study area is characterized by rolling terrain that slopes towards the Sylvia Grinnell River. The bedrock over which the metal debris was dumped is approximately 30 m above the River valley. Local terrain consists mainly of bare rocky outcrops with a thin layer of glacial and marine sediments in low lying areas between outcrops.

The elevation of the landfill site is approximately 20 to 30 metres above sea level (m asl) and the Sylvia Grinnell River is at approximately 0 to 5 m asl (http://atlas.nrcan.gc.ca).

5.2 Regional and Local Drainage

The Sylvia Grinnell River is the principal drainage system in the region which discharges into Frobisher Bay. The river is influenced by the tidal action of the ocean which has some of the largest tides in Canada. The river is a major migratory route for Arctic Char.

The natural drainage around the study area is influenced by the bedrock structure and numerous small, elongated ponds that have formed along fault lines and joints. The ponds are shallow (approximately less than 0.5 m deep), and are poorly drained. The high ratio of sediment surface to pond volume allows maximal exchange between the sediment and the water. In the summer, mixing throughout the water column is provided by the strong prevailing winds. In the winter, the ponds are frozen to the bottom. There are four large ponds and two smaller ponds. There are small intermittent drainages that join these water bodies (See **Figure 2**).

Pond 1 is located adjacent to the river and is fed from the southeast and north. From the southeast side feed, a metallic sheen in the water and orange staining along the shoreline and water bed was observed. The flow rate is low but sourced directly below the west end of the landfill. The north side feed is of medium flow rate, also with a metallic sheen and orange staining. This north side feed discharges from Pond 2. Surface sediments in Pond 1 consisted of mainly orangey, decomposed organic matter mixed with fine black sand. This pond has a discharge into the river with a measured flow rate of 1.35 L/s.

Pond 2 appears to be fed from the southeast and northeast by slow groundwater discharge seeps possibly through fractured bedrock. Minor orange staining was observed around the shoreline and debris was present in the pond (tires). The pond is approximately 1 to 1.5 m deep. The pond discharges to the south towards Pond 1. Sediments in Pond 2 consist of fine brown sand mixed with a thin top layer of decomposed organic matter.

Pond 3 is directly down-gradient from the main landfill site. Two gullies are present on the northeast side that would direct rain water and overland flow into the pond. A feed on the northeast side was observed in a flat, low lying area. The discharge is from the southwest corner and is only visibly active during high water events. Surface sediments in Pond 3 consisted of brown to black decomposed organic matter mixed with brown fine sand.

Pond 4 is at a slightly lower elevation than Pond 3 and not connected hydraulically. It is located downstream of the landfill with a quite high recharge from the vehicle dump area. Discharge is from the southwest corner of the pond at a measured flow rate of 9.13 L/s to several small intermittent ponds before discharging to the river. Surface sediments in Pond 4 consisted of black to dark grey fine sand with trace decomposed organic matter.

Pond 5 was also observed to have orange staining along the shoreline. It is located upgradient of Pond 4, approximately 85 m southwest of the vehicle dump.

Pond 6 is located below the escarpment, directly below the vehicle dump. Seeps are present primarily from the north (from vehicle dump), with small seeps from the east and west. The seep from the north is through a grassy area between bedrock outcrops at a measured flow rate of 5.41 L/s. Sediments in both Ponds 5 and 6 consisted of 50% decomposed black organic matter and 50% black fine sand.

5.3 Geological Characterization

5.3.1 Regional Bedrock Geology

The southern portion of Baffin Island consists of primarily Precambrian Canadian Shield crystalline rocks. The regional bedrock geology in the study area is part of the Churchill

Structural province. The bedrock in the study area is from the Aphebian Era and consists of a variety of metamorphic rocks. Quartz-feldspar-gneissic rocks are the predominant facies in the area around Iqaluit (Härtling, 1988).

The structural geology follows the general northwest – southeast trend of the area. The northwest – southeast aligned fault system in southern Baffin Island were the result of the Upper Cretaceous and early Tertiary rifting associated with the spreading in the Baffin Bay and Davis Strait. The study area lies at the boundary between the Frobisher Bay graben and the Hall Peninsula horst, and the cliff line and the bedrock outcrops follow the overall trend. This structural feature greatly impacts the migration of contaminants from the waste disposal site (Härtling, 1988).

5.3.2 Regional Surficial Soils

The major landforms developed along lines of weakness related to the Upper Cretaceous to Tertiary faulting and along pre-existing draining systems. During the Cenozoic, the area was affected by several glacial advances and retreats. Glacial ice streams flowed southeastward along the Sylvia Grinnell valley and surrounding areas. The landscape was developed during deglaciation when glacial, glaciofluvial and glaciomarine processes dominated (Mode and Jacobs, 1987). Following glacial retreat of the Frobisher Bay outlet glacier past the study area, the Sylvia Grinnell valley was covered by marine waters until approximately 2 – 3,000 years ago. This would limit the time for modern soil development in the area downslope of the lower cliff line. The area above the cliff line became free of marine influence approximately 5,000 years ago and thus had a longer time for soil development. This time would be too short for substantial bedrock weathering, thus reducing the influence of the bedrock geochemistry on the overlying soils. Both areas would be subject to fluvial and colluvial processes. The predominant weathering process would be mechanical disintegration by differential thermal expansion, frost action and salt weathering in the Sylvia Grinnell estuary (Härtling, 1988).

The shallow soils observed on the site were primarily black sands with some gravel and silts. The soil would have been deposited during glaciation (till) and by marine deposition (silts).

5.3.3 Local Scale Geology

The surficial geology in the region has been described as a thin layer of silty sand with trace to some gravel. The soil is dark brown to black with a high organic content and the presence of rootlets. Bedrock was encountered between 0.8 to 1.6 m bgs (Area 1); 0.1 m bgs (Area 2); between 0.1 and 0.4 m bgs (Area 3); and between 0.3 to 0.8 m bgs (Area 4). Logs for the test pits completed by FRANZ are provided in **Table 1**.

5.4 Hydrogeological Characterization

5.4.1 Regional Hydrogeology

Overland flow is the primary mode of water transport in the area. Groundwater associated with fractures in the bedrock and through the thin overburden would be likely be minor. Groundwater is not used as a drinking water source in the area. The site lies within the continuous permafrost zone. Permafrost occurs when the ground remains at or below a temperature of 0^oC for a minimum of two years. Almost all the moisture in permafrost occurs in the form of ground ice. Within the continuous permafrost zone, permafrost underlies most types of terrain except rivers, lakes and newly consolidated soils, and is at depth under well–drained, coarse-grained landforms such as eskers and kames.

Based on the regional geology, and the presence of permafrost, the groundwater flow directions and velocities are likely complex and controlled by topography, surface water bodies and large faults and fracture zones. It is expected that the surface water bodies are expressions of the water table and are discharge zones for fractured bedrock.

5.4.2 Site Hydrogeology

The shallow soil and presence of bedrock did not allow for the installation of any monitoring wells.

6.0 REGULATORY REVIEW AND ENVIRONMENTAL QUALITY CRITERIA

6.1 Soil, Sediment, Groundwater and Surface Water Guidelines

6.1.1 Regulatory Framework

The *Contaminated Sites Management Working Group* for federal government departments has defined a **contaminated site** as a site at which substances occur in concentrations that either: 1) are above background levels and pose, or are likely to pose, an immediate or long-term hazard to human health or the environment; or 2) exceed levels specified in policies and/or regulations. For the latter, the Canadian Council of Ministers of the Environment (CCME) *Canadian Environmental Quality Guidelines* (CCME, 1999 and annual updates), including the *Canada-Wide Standards for Petroleum Hydrocarbons in Soil* (CCME, 2001 and updates) were applied in the numerical comparison of laboratory data to determine whether the site should be deemed a contaminated site.

In Nunavut, environmental site assessments and site remediation projects are typically based on the use of federally developed generic guidelines. Risk assessment principles have been used extensively in developing federal generic clean-up criteria for contaminated sites. However, as the term “generic” implies, they are intended for broad applications and are usually over-protective to avoid underestimating potential risks associated with a wide range of site conditions and potential land uses.

The chemical data obtained during this Phase I/II ESA were preferentially compared to established guidelines from the federal CCME. The federal guidelines are relevant since the site is currently federally managed and Nunavut has adopted the CCME approach.

The federal CCME guidelines were derived based on potential impacts to humans and ecological receptors. However, the CCME guidelines also take into account potential risks to humans associated with the consumption of groundwater on the site. The CCME have not established an equivalent set of non-potable thresholds for federal lands. For these reasons, a chemical-specific selection process was used to identify the appropriate guideline for use in the chemical evaluation (as discussed below).

6.1.2 Federal Guidance

The CCME "Canadian Environmental Quality Guidelines" (1999) publication compiled all previously released soil and groundwater criteria and guidelines into one publication. Updates have been issued for selected chemicals over the past several years. These guidelines for soil, sediment and water are numerical limits intended to maintain, improve or protect environmental quality and human health at contaminated sites. The guidelines are derived using toxicological data. There are four separate sets of guidelines for soil quality and five sets of guidelines for water quality. The guidelines are separated into groups for different types of land and water use.

Soil

The soil analytical results were compared to the Canadian Council of Ministers of the Environment (CCME) Canadian Environmental Quality Guidelines, specifically the Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (CSQG), and with the Canada-Wide Standards (CWS) for Petroleum Hydrocarbons (PHC) in soil. These are applied to most federal contaminated sites. The criteria are numerical limits intended to maintain, improve or protect environmental quality and human health at contaminated sites. The guidelines are derived using toxicological data and aesthetic considerations.

The standards or guidelines adopted for this evaluation are as follows:

- *Canadian Environmental Quality Guidelines* (CEQGs; CCME, 2007) for commercial land use (parkland/residential land use standards were also shown for comparison purposes); and
- *Canada-Wide Standards for Petroleum Hydrocarbons* (CWS - PHC) in Soil (CCME, 2008a) - Tier 1 Levels also for commercial land use (parkland/residential land use were also shown for comparison purposes).

The Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil (CCME, 2008a) presents criteria for petroleum hydrocarbons in soil. These numerical standards are based on the assessment and consistent management of risks posed to humans, plants, animals and environmental processes under four common land uses (agricultural, residential/parkland, commercial and industrial). Under Tier 1 of the CWS, specific numerical levels are presented for the four land uses, two soil textures (coarse and fine) and the four defined petroleum hydrocarbon fractions (F1 (nC6-nC10); F2 (nC10-nC16); F3 (nC16-nC34); F4 (nC34+)). There are several additional levels for fractions F1 and F2 to protect surface water where groundwater discharges to surface water, where groundwater is used for potable purposes and where residential buildings have slab-on-grade construction. These levels are deemed to be protective of all receptors based on the defined conditions in all settings.

The CWS also includes the option to generate Tier 2 levels where site-specific information indicates that site conditions exist that modify human or ecological exposure to PHC contamination. Such conditions may alter risks significantly relative to the generic conditions used to derive Tier 1 levels. Furthermore, Tier 3 under the CWS involves developing site-specific cleanup levels and management options using general and site-specific information in conducting a risk assessment.

Given the nature of the work, only the Tier 1 levels are used as comparison criteria. The appropriate levels are presented with the laboratory analytical data in tables.

Sediment

Established sediment assessment guidelines depend on the probability of an effect to occur in organisms inhabiting the sediment. Sediment quality guidelines are scientific tools that synthesize information regarding the relationships between sediment concentrations of chemicals and any adverse biological effects resulting from exposure to these chemicals. Federally, the CCME has established Interim Sediment Quality Guidelines (ISQG) and the Probable Effect Level (PEL). Sediment chemical concentrations below ISQG values are not expected to be associated with any adverse biological effects, while concentrations above PEL values are expected to be frequently associated with biological effects. Chemical concentrations between the ISQG and PELs represent the range in which effects are occasionally observed.

Water

Canadian water quality guidelines are intended to provide protection of freshwater and marine life from anthropogenic stressors such as chemical inputs or changes to physical conditions. In 1999, CCME also updated the surface water quality guidelines for the protection of aquatic life. The Freshwater Aquatic Life (FWAL) water quality guidelines were applied to the surface waters at the Site.

Summary

The guidelines adopted for this evaluation are summarized as follows:

- CCME 1999 "Canadian Environmental Quality Guidelines" and recent updates (2004 and 2007) for commercial (CL) land use and for comparison purposes to the residential/parkland (RD/PL) land use for coarse grained soil were employed.
- CCME 2000 "Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil". For this assessment, the Tier 1 Commercial guidelines for coarse-grained soils were used in addition to the residential/parkland guidelines for comparison purposes.
- Surface water quality was compared to the CCME guidelines for the protection of freshwater aquatic life (FWAL; 2007 Update).
- Sediment quality was compared to the CCME guidelines for the protection of ecosystems (ISQG and PEL, 2002 Update).

6.1.3 Chemical Evaluation - Process for Selection of Environmental Criteria

The chemical evaluation was conducted by comparing the detected concentrations for each substance to the CCME guideline for CL (and RD/PL) land use standards. The following selection process was used to identify which EQG to use for the chemical evaluation.

- If only one guideline was available from the federal CCME for a chemical, then it was adopted for use.
- If normal average background concentrations for a chemical in the study area were higher than CCME criteria, then the background concentration was selected as the most appropriate point of comparison. It should be noted that the average background concentrations were below the CCME guidelines.

6.2 Designated Substances

6.2.1 Selection of Environmental Quality Guidelines

Criteria, rationale, and regulatory jurisdictions for each component of the designated substances property survey are presented below.

Material Type	Classifications	Evaluation Criteria
PCBs in Soils	PCBs in soils are regulated under the Canadian Environmental Protection Act (CEPA) and transported according to TDGA and CEPA.	PCB content >50 ug/g is considered a hazardous waste. Material with PCBs above the CCME soil criteria (e.g., 1.3 ug/g) but below 50 ug/g is not hazardous waste.
Liquids/Chemicals	Waste solvents and liquids are a contaminant under the EPA of Nunavut and must be managed as a hazardous waste.	Absence/presence of liquids/chemicals in containers.
Batteries	Waste batteries are a contaminant under the EPA of Nunavut and must be managed as a hazardous waste.	Absence/presence of waste batteries.

6.3 Vegetation Evaluation Guidelines

The Ontario Ministry of the Environment (MOE) “Upper Limit of Normal” contaminant guidelines (ULN) represent the expected maximum concentrations of contaminants in surface soil (non-agricultural), foliage (deciduous and current year coniferous trees and shrubs) grass, moss bags and/or snow from areas of Ontario not subject to the influence of point sources of emissions. Rural guidelines are based upon samples collected from undeveloped areas.

These guidelines do not represent maximum desirable or allowable levels of contaminants. Rather, they serve as levels which, if exceeded, would prompt further investigation on a case-by-case basis to determine the significance, if any, of above-normal concentrations. Concentrations which exceed the guidelines are not necessary toxic to plants, animals or humans. Concentrations below the guidelines would not normally be considered toxic (MOEE HCB Phytotoxicology Field Investigation Manual (014-3511-93).

7.0 INVESTIGATION RESULTS

Samples from soil, sediment, surface water, and vegetation were collected at the four identified APECs and analysed for selected parameters including metals, benzene, toluene, ethylbenzene, and xylenes (BTEX), PHC fractions F1 to F4, PAHs, VOC, PCBs, and pesticides (**Table 2**). The analytical data is summarized in **Tables 6** to **25** and on **Figures 3** to **13**.

7.1 APEC 1 - Upgradient Buried Debris

The sampling program at APEC 1 included three soil samples (A1-TP08-1, -2 and -3), one surface water sample (A1-SW08-1) and one vegetation sample (VEG-6). Based on site activities, the potential contaminants of concern were identified as being PHCs, metals, PCBs and pesticides. At the three test pits locations, the soil profile from 0.0 to 1.6 m bgs was described as a brown fine to coarse sand and gravel mixed with buried debris. The buried debris included tires, drums, wood, iron bracing, vehicle parts, rubber hose, cable wire, and rods.

Surface Water

Metals and PCBs were analysed from the surface water sample A1-SW08-1 collected at APEC 1. Metal analytical results indicated that the aluminum concentration (0.0144 mg/L) was greater than the CCME freshwater guideline of 0.005 mg/L. PCB concentrations were below the laboratory detection limit. Sample locations and analytical results for surface water at APEC 1 are presented on **Figure 3**.

Vegetation

One representative sample (VEG-6) of vegetation from APEC 1 was submitted for metals and PCBs analysis. Metal results are below the Ontario Vegetation Criteria and PCB results are lower than the laboratory detection limit. Sample locations and analysed parameters are presented on **Figure 3**.

Soil

Soil analytical results from A1-TP08-1 indicated that the copper concentration of 103 mg/kg exceeds both the CCME residential/parkland and commercial land use guidelines. The same sample contains a lead concentration (190 mg/kg) greater than the CCME guideline for residential/parkland land use (140 mg/kg) but lower than the guideline for commercial land use (260 mg/kg). Concentrations of PHC, pesticides and PCB at A1-TP08-1 were all below the applicable guidelines. The exceedances in soil at APEC 1 are provided on **Figure 4**.

Metal analytical results from test pits A1-TP08-2 and 3 were lower than the CCME residential/parkland and commercial land use guidelines.

7.2 APEC 2 – Vehicle Dump

APEC 2 is located to the east of the main Landfill and has been used as a disposal area for trucks, cars, trailers, boilers, and tankers. The potential contaminants of concerns are PHC, PAH, metals, PCB, pesticides and VOC.

Four sediment samples (A2-SD08-1 to 4) and four surface water samples (A2-SW08-1 to 4) were collected along the main drainage channel that runs directly through the center of the debris pile and discharges into Sylvia Grinnell River. Sediment in the channel varies from a dark, grey, fine to coarse sand to brown sand and gravel. Orange staining was observed at the four sediment sample locations.

A total of two shallow test pits (A2-TP08-1 and 2) were excavated to bedrock at APEC 2. Soil from 0.0 to 0.10 mbg was described as a dark brown fine to medium sand, with trace gravel and some organic matter. One representative vegetation sample (VEG-4) was collected at APEC 2 and submitted for metals and PCB analyses.

Surface Water

With respect to the CCME freshwater guidelines, there are four surface water samples that exceeded metal concentrations of aluminum, cadmium, copper and lead. The highest metal concentrations were measured at A2-SW08-3 and at A2-SW08-4. At these two locations concentrations of PHC, PCB and pesticides were below the laboratory detection limit.

Vegetation

Analytical results from VEG-4 indicate that a sodium concentration of 55 mg/kg (wwt) slightly exceeds the Ontario vegetation criteria of 50 mg/kg (**Figure 5**). PCB concentrations are lower than the laboratory detection limit.

Soil

At A2-TP08-1 a cadmium concentration of 22.4 mg/kg is greater than the CCME guidelines for residential/parkland and commercial land use. At this location, a total PCB concentration of 4.76 mg/kg also exceeds the CCME guideline of 1.3 mg/kg for residential/parkland and a barium concentration of 134 mg/kg is four times higher than the background concentrations. A summary of soil exceedances at APEC 2 is presented on **Figure 6**. PHC, pesticides, VOC and PAH concentrations were below the applicable guidelines.

With respect to the samples collected from test pit A2-TP08-2 the results for metals, PHC, pesticides, VOC, and PAH were below the applicable guidelines.

Sediment

Concentrations of arsenic, cadmium, chromium, copper and 4,4-DDD concentrations exceed the applicable guidelines for sediments in sample A2-SD08-4 with respect to CCME Interim Freshwater Sediment Quality guidelines (ISQG) but the results are less than the CCME Probable Effect Levels (PELs). Lead, zinc, total PCB, 4,4-DDE and 4,4-DDT concentrations exceed both ISQG and PEL CCME guidelines.

In sample A2-SD08-3, concentrations of cadmium, chromium, copper and zinc are greater than the ISQG but lower than the PEL values. Lead and total PCB concentrations exceed both ISQG and PEL CCME guidelines.

The highest zinc and copper concentrations were measured, respectively, in samples A2-SD08-1 (499 mg/kg) and A2-SD08-2 (292 mg/kg) at levels greater than both the ISQG and PEL CCME guidelines.

A summary of the exceedances encountered in sediment from APEC 2 is presented on **Figure 7.**

7.3 APEC 3 – Main Landfill

The main landfill area consists of a mixture of debris spread across a steep graded bedrock slope. The top of the landfill has been capped with granular material and the toe is left exposed with debris scattered throughout the area. PHC, metals, PCB, pesticides, VOC, and PAH were identified as the contaminants of concern based on site use.

The majority of the landfill material is within the boundaries of APEC 3. This area was investigated via 18 test pits (A3-TP08-1 to A3-TP08-18). Soil at APEC 3 consists of a black/brown fine to medium sand, occasionally with some silt or gravel and organic matter. Buried metal debris was encountered at test pits A3-TP08-1 and 18 and staining was observed at test pits A3-TP08-1, 5 and 13. In addition, representative vegetation samples were collected at four discrete locations (VEG-1, 2, 3, and 5).

There are four main ponds at APEC 3 in which surface water (A3-SW08-1 to 4) and sediment (A3-SD08-2 to 4) samples were collected. Sediment at these ponds was described as dark grey/black fine sand. Samples A3-SW08-3 and 4 were collected in the secondary ponds that receive upgradient waters from the main drainage channel that runs across APEC 2.

Surface Water

Metal analytical results from sample A3-SW08-1 indicate a variety of exceedances including aluminum, cadmium, copper, lead and zinc. Cadmium concentrations also exceed the CCME freshwater guideline in samples A3-SW08-3 and 4. A summary of the exceedances in surface water at APEC 3 is presented on **Figure 8**. PHC and PCB results were below laboratory detection limits or below the applicable guidelines.

Vegetation

Of the four vegetation samples collected at the site only VEG-1 (62 mg/kg wwt) and 2 (53 mg/kg wwt) had sodium concentrations greater than the Ontario vegetation criteria of

50 mg/kg wwt (**Figure 8**). PCB concentrations were below the laboratory detection limit for all four samples.

Soil

Hydrocarbon exceedances were observed at test pits A3-TP08-2 and 3 located just downgradient of the exposed debris area. The highest F2 to F4 hydrocarbon concentrations were measured in sample A3-TP08-2, these concentrations are considerably higher than the CCME guidelines for both commercial and residential/parkland land use. In the same sample, total PCB (17.1 mg/kg) also exceeds the CCME residential/parkland guideline of 1.3 mg/kg and sample A3-TP08-2 contained a concentration of barium of 425 mg/kg which is more than 10 times the background levels.

Analytical results from sample A3-TP08-12 indicate that copper (82 mg/kg) and lead (256 mg/kg) concentrations are greater than the CCME residential/parkland guideline but lower than the CCME commercial land use guidelines. The corresponding zinc concentration (488 mg/kg) exceeds both CCME commercial and residential/parkland guidelines.

PAH and zinc concentrations in the duplicate sample (A3-TP08-DUP2) from A3-TP0813 exceeded the applicable guidelines.

In a number of locations, sample results for pH were below 6. Despite the exceedance of the CCME interim remediation criteria, these results are likely reflect a natural condition of the soil. **Figure 9** presents the sample locations and exceedances in soil at APEC 3. The remaining analytical results were below laboratory detection limit and/or below with the applicable guidelines.

Sediment

Cadmium, lead and zinc concentrations in samples A3-SD08-3 and 4 are higher than the CCME Interim Freshwater Sediment Quality guidelines (ISQG) but lower than the CCME Probable Effect levels (PELs). The total PCB concentration from A3-SD08-4 exceeds both CCME guidelines for freshwater sediments (ISQG and PEL).

Sediment collected at the largest pond at APEC 3 contains a lead concentration greater than the CCME Interim Freshwater Sediment Quality guidelines (ISQG). Sediment sample locations and exceedances are presented on **Figure 10**.

7.4 APEC 4 – Downgradient, Off-Site

APEC 4 encompasses the area of the Sylvia Grinnell Park, directly downgradient of the site. A total of two test pits (A4-TP08-1 and 2) were excavated at the downgradient northwest border of the main landfill. A dark grey/brown fine to medium sand with some organic matter was encountered at both test pits to a maximum depth of 0.8 m bgs. Representative vegetation samples (A4-VEG-1 to 3) from APEC 4 were collected and submitted for metals and PCB analyses.

There are three main ponds at APEC 4 in which surface water and sediment samples were collected. Two of them (Ponds 1 and 2) receive upgradient water from the main landfill area (APEC 3) and one (Pond 4) is a receptor of upgradient waters from the drainage channel that runs across APEC 2 and 3. These ponds are connected directly or indirectly to the Sylvia Grinnell River. Surface water and sediment samples were collected along the margins of Sylvia Grinnell River. According to field observations, sediment texture varies from fine to coarse sand, with occasional gravel. Debris was encountered at Ponds 1 and 2.

Surface Water

Cadmium concentrations exceed the CCME freshwater guideline at Pond 4 (A4-SW08-3) and at two locations along the Sylvia Grinnell River (A4-SW08-4 and A4-SW08-7). The corresponding copper concentration also exceeds the applicable guideline at Pond 4. At Pond 1, the analytical results indicate that a trichloroethylene concentration of 0.0226 mg/L is slightly greater than the CCME freshwater guideline of 0.021 mg/L. Exceedances in surface water from APEC 4 are presented on **Figure 11**.

Vegetation

Three locations were sampled at APEC 4, sodium and iron concentrations respectively exceed, the Ontario vegetation criteria of 50 mg/kg wwt and 500 mg/kg wwt. A summary of the analytical results from APEC 4 is presented on **Figure 11**.

Soil

Analytical results for PHC, PCB and metals from test pits A4-TP08-1 and 2 were below the CCME guidelines for both residential/parkland and commercial land use (**Figure 12**).

Sediment

Metals and PCB analytical results from all sediment samples collected at APEC 4 are below both CCME guidelines (ISQG and PEL) or are below the laboratory detection limit. Sample locations and analysed parameters for APEC 4 are presented on **Figure 13.**

8.0 CHEMICAL SPATIAL ANALYSES

A variety of spatial analyses were conducted in order to infer the connectivity and distribution of previously identified contaminants of concern in soil and surface water. Based on the concentration and mobility, representative parameters were selected to demonstrate the transport and fate of contaminants from various soil sources present in APECs 1, 2 and 3. The following steps were taken to develop a site conceptual model.

8.1 Parameters and Identified Potential Source Areas

The major concern associate with landfills is the production and subsequent loss of contaminants in landfill leachate which can result in environmental impairment. Leachate is produced when moisture enters the landfill waste and dissolves contaminants found in the refuse into the liquid phase (i.e., groundwater). The types, amounts and production rates of contaminants in landfill leachates are influences by several factors including: physical and chemical composition of the wastes, refuse, density, placement sequence and depth, moisture loading, temperature, and time.

It is generally accepted that there is a finite mass of contaminants in landfills which can be leached from the solid wastes. Leachate contaminants generally reach a peak concentration then decline over time due to dilution, biodegradation and leachate from the landfill. The more soluble the contaminants, including the inorganic components, appear first in the leachate, reach a peak concentration, then slowly reduce over time. In turn, readily biodegradable organics appear, reach peak concentration then diminish with time. The poorly biodegradable/soluble contaminants are the last to reach peak concentrations resulting in persistence in the leachate over a number of years. In northern climates, low temperatures and precipitation events, prolong the production of leachate which slows the release of contaminants to the environment.

Based on the age of the landfills and dump areas within the study area, it is expected that contaminant concentrations in the surface waters are likely close to peak concentrations and perhaps declining. The impacts to sediments are likely a result of mass loading events over the contaminating lifespan of the landfills/dumps. The poorly biodegradable/soluble contaminants such as PHCs (F3-F4), PCBs, PAHs, and

Pesticides would be trapped in the high organic sediments and would contribute only minor concentrations to surface water. These chemicals would thus be considered immobile. The more soluble contaminants such as some metals would be present in both sediments and surface water. As such, these chemicals would be more mobile and would contribute to impacts along the flow path. It would also be expected that the metals would attenuate along the flow path as a result of absorption or chemical precipitation.

PCB, PHC and metals are the three classes of contaminants of concern (COCs) identified in soil at APECs 1, 2 and 3. PCB sources were encountered in APEC 2 (A2-TP08-1) and APEC 3 (A3-TP08-2). Hydrocarbon sources were identified only at APEC 3 at two locations downgradient of the exposed debris (A3-TP08-2 and 3) and at depths ranging from 0.0 to 0.2 mbg. Hydrocarbon exceedances included CWS F2 to F4. Pesticides were also detected above the PEL in APEC 2 (SD-TP08-4).

Metals were the COC parameter group encountered most frequently across the site and represented the highest number of source areas. A variety of metals were identified within APECs 1, 2 and 3 and included copper, lead, cadmium, and zinc. The main metal sources were present in samples collected from test pits A1-TP08-1 (copper), A2-TP08-1 (cadmium) and A3-TP08-12 (lead and zinc).

8.2 Stationary Sources

As discussed previously, shallow depth hydrocarbon sources are present at A3-TP08-2 and 3, located within APEC 3. Samples collected from nearby delineation test pits and at the main surface water receptors, contained hydrocarbon concentrations below laboratory detection limits. Therefore, the two shallow hydrocarbon sources identified at APEC 3 are considered stationary and transport pathways were not included in the site conceptual model and spatial analyses.

The PCB sources were encountered at APEC 2 (A2-TP08-1) and APEC 3 (A3-TP08-2) and remain restricted to these source locations and presently are not reaching the main surface water receptors. This parameter group was also not included in the analyses.

8.3 Mobile Sources

Based on soil analytical results, the main metal sources within APECs 1, 2 and 3 were detected at test pits A1-TP08-1 for copper, A2-TP08-1 for cadmium and at A3-TP08-13 for lead and zinc. Samples collected from the main surface water receptors contained concentrations of copper, lead, cadmium, and zinc that are high and non-compliant when compared to CCME freshwater guidelines. In comparing the metal results from soil sources and from surface water receptors, it is possible to infer a connection between the exceedances in both media. This indicates that metal sources are likely contributing to the metal concentrations present in some of the surface water drainage channels and ponds. Therefore, the soil and surface water metal concentrations were combined on the same figure with metal surface water results in order to develop a visual site conceptual model.

8.4 Site Conceptual Model

A site conceptual model was developed linking the soil and surface water concentrations for copper, lead, cadmium, and zinc. These metal concentration gradients were plotted and presented on **Figures 14** to **17.** In general, the metals impacts appear to be attenuating along the flow path, prior to discharge in Sylvia Grinnell River.

Cadmium Spatial Analysis

The cadmium soil source is likely impacting surface water quality of the main drainage channel present in APECs 2 and 3 (**Figure 14**). The soil source of cadmium can likely be attributed to debris piled up-gradient. An example of high cadmium soil results were seen at A2-TP08-1 (22.4 mg/kg). Several surface water samples collected along this drainage channel and at the discharge point to Sylvia Grinnell River contained concentrations of cadmium above the CCME freshwater guideline of 0.000017 mg/L.

A second cadmium source was identified at APEC 3 at test pit A3-TP08-12 (1.34 mg/kg). Even though this soil concentration is compliant with the applicable guidelines it might be high enough to contribute to the non-compliant surface water cadmium concentration measured in the nearby downgradient pond (A3-SW08-1).

Copper Spatial Analysis

Most of the copper exceedances in surface water were detected within the main drainage channel that runs from APEC 1 to the Sylvia Grinnell River. These exceedances might be attributed to the upgradient source at A1-TP08-1, where the copper concentration of 103 mg/kg in soil was the highest in comparison to the other sampling locations (**Figure 15**).

A secondary copper source at APEC 3 (A3-TP08-12 – 82 mg/kg) might be affecting the surface water quality in location of sample A3-SW08-1. This sample contains a copper concentration greater than the CCME freshwater guideline. Although both the impacted pond and drainage channel are connected directly or indirectly to the Sylvia Grinnell River, samples collected from the river were compliant with the applicable copper guideline.

Lead Spatial Analysis

The primary lead soil source was encountered at sample location A3-TP08-12 in APEC 3. The lead concentration of 256 mg/kg is greater than the CCME guideline for park land. Immediately downgradient of this source, there is a pond in which the lead concentration detected at A3-SW08-1 impacted surface water quality, **Figure 16**. A section of the main drainage channel that runs across APEC 2, contained a lead concentration (A2-SW08-3) that similarly exceeds the applicable guideline. This Lead impact may be a result of leaching from the A2-TP08-2 source area.

The samples collected along the Sylvia Grinnell River contained compliant lead concentrations. Therefore, upgradient lead impacts were not reaching the main surface water receptor.

Zinc Spatial Analysis

The primary zinc source was identified within APEC 3 at sample location A3-TP08-12. The sample zinc concentration of 488 mg/kg exceeded both the CCME guidelines for park and commercial lands. Leachate originating from this source may be affecting the quality of the surface water in the downgradient pond located near sample A3-SW08-1,

Figure 17. The upgradient zinc impact in the pond has not migrated to Sylvia Grinnell River, even though the surface water flows are connected to the River.

There are two locations in which zinc concentrations are compliant but three times higher than the background concentrations: A1-TP08-1 (122 mg/kg) and A3-TP08-2 (126 mg/kg). Some samples from the downgradient drainage channel and nearby these sample locations contained also measurable but compliant zinc concentrations.

9.0 GEOTECHNICAL AND STABILITY EVALUATION

Scope of Stability Assessment

The scope of the stability assessment was limited to a qualitative evaluation of the site and setting to identify potential physical hazards and stability issues to human health and safety. The regional and site conditions were reviewed and general assumptions were developed regarding the type and distribution of debris, the presence and depth of the soil active layer and presence and depth to bedrock. Further general assumptions were made regarding the operation of the landfill such as dumping and capping practises.

The intent of the qualitative assessment is to identify issues related to human health and safety so that these issues can be incorporated into the proposed landfill decommissioning plans. Additional work may be required to quantify the likelihood of occurrence and the risk associated with the identified stability or hazard issues.

Landfill Areas

The landfill was divided into four areas based on the type of physical hazard or stability concerns, **Figure 18**. These four areas are as follows:

- **Upper Bench and Vehicle Dump** - this area of the landfill encompasses the upper level bench and the upper level portions of APEC 1, Main Landfill areas as well as APEC 2, Vehicle Dump Area.
- **Main Slope** - the second area consists of the debris covered slope connecting the lower bench area with the upper bench area.
- **Gully** - the third area consists of the gully connecting the upper bench area to the lower bench area. This area located within the southwest portion of APEC 2.
- **Lower Bench** – the fourth area is located within the lower portions of APECs 1, 2 and 4.

Upper Bench and Vehicle Dump

The following conditions were assumed based on non-intrusive field observations and reviews of the previous environmental reports. The upper bench area consists of debris placed over the top of existing soil and bedrock conditions. The debris may consist of domestic and industrial refuse, with the industrial refuse consisting primarily of relic equipment, drums, steel cables, and other metallic debris. The area has been partially or completely capped using available soil.

Based on the previously noted assumptions the physical hazard and stability concerns primarily were assumed to be secondary settlement of the landfill debris due to decomposition and consolidation of the debris. This may create voids within the landfill and these voids may collapse when subjected to foot traffic. Hazard mitigation can be accomplished by posting warning signs and/or using fences to limit public access.

Main Slope

Based on observations of the surficial debris deposited on the slope this material is assumed to consist of a mixture of soil and refuse with significant variability in the ratios of soil to refuse. The slope may potentially represent a significant hazard and would normally warrant a quantitative analysis however the material is not homogenous and conventional quantitative stability analysis may not be possible. Instead the field and report data was reviewed to determine the probable method of material placement on the slope. It appears that the material was either dumped over the slope or pushed over the slope with heavy equipment. There were likely many episodes of material deposition on the slope.

The method of depositing the material from the top of the slope and allowing the material to accumulate causes the material to be deposited at or near its natural angle of repose. If this is indeed the case the factor of safety can be inferred to be 1.0. This is significantly less than the preferred conservative factor of safety for slope stability of 1.5.

Since the factor of safety is likely low any changes to the material properties as a result of stability (factor of safety) may be reduced if the moisture content in the debris approaches saturation, or the loads on the slope increase or when debris decomposition occurs. If the factor of safety is reduced the slope may fail. Slope stability can be improved by:

- Removal of all debris on the slope,
- Counter weighting or reinforcing the toe of the slope. The counter weighting should be appropriately designed to achieve the required factor of safety; and,
- Re-constructing the slope from the base and continuing up the slope using an appropriate material such as blast rock and placing the material at less than its natural angle of repose to achieve the required factor safety.

If these options are not possible another option may be to limit personnel access to both the area of the slope and a suitable run-out distance at the base of the slope. The run-out distance should be calculated by a suitably qualified professional. It was assumed that in all cases, overland drainage would be properly managed to direct all surface water away from the debris located on the face of the slope.

Gully

Large metallic debris consisting of relic cars and drums were placed in the gully. The debris represents a physical hazard for anyone trying to traverse the gully. The gully may have a debris flow or torrent potential. A debris flow potential could exist if there is sufficient peak water flow directed through the gully. A more detailed study would be required to determine if the range of peak water flow would be sufficient to create a debris torrent.

Lower Bench

The lower bench area consists of debris that has been randomly distributed via the dumping activities occurring at the top of the slope. The debris may consist of domestic and industrial refuse, with the industrial refuse consisting primarily of relic equipment, drums, steel cables, and other metallic debris. This area has not been capped.

Based on our conceptual understanding of the lower bench area, the physical hazard and stability concerns primarily relate to the random and uneven distribution of debris. There is also a potential that either a slope failure or debris flow event could suddenly deposit debris in this area. Hazard mitigation for these issues was discussed previously.

10.0 CONCEPTUAL REMEDIAL OR RISK MANAGEMENT ACTION PLANS

10.1 Areas of Environmental Concern (AEC)

The results of the chemical distribution and impacts evaluation (Section 7), the spatial analysis and contaminant transport model (Section 8), and the geotechnical evaluation (Section 9) indicate that at selected areas, risk management or remediation may be required to reduce the physical safety hazards and mitigate exposure to chemicals of concern present at concentrations greater than the Environmental Quality Guidelines (EQG).

For this discussion, APECs have transitioned to Areas of Environmental Concern (AECs) (i.e., no longer "potential") based on the confirmation of chemical or physical impacts. The numbering system remains the same between the APECs and associated AECs; however, some changes to the area boundaries have occurred based on the locations of environmental pathways and receptors. **Figure 19** shows the AEC divisions. Recommendations for supplemental work have been outlined in Section 10.6.

Based on chemical analyses and evaluation of physical risk factors, a number of AECs were identified. The AECs with their identified contaminants and estimated volumes are summarized in **Section 10.2.1 – Table 26**. Detailed remedial option cost breakdowns are provided in **Appendix F (Tables F1 to F3)**.

This Conceptual Remedial Action Plan outlines the strategies that can be used to mitigate potential physical risks and exposure of human and ecological receptors to contaminants. A Preliminary Quantitative Risk Assessment (PQRA) and Ecological Risk Evaluation (ERE) is being completed as part of this contract (provided as a separate report). The PQRA and ERE will identifiy the potential risks to human health and environmental receptors based on the appropriate pathways, concentrations and chemicals of concern. The extent of impacts, volumes of impacted media and final risk management approaches may be guided by the outcomes of the PQRA/ERE or a higher level Site Specific Risk Assessment (if required). As such, the PQRA/ERE coupled with this conceptual Remediation/Risk Management Plan (Rem/RM Plan) could be used as the basis for a more detailed Remedial/Risk Management Plan.

10.1.1 Contaminant Impacts

Within the study area, there are known and discrete metal impacted soils associated with up-gradient waste burial, vehicle dump, and main land filling activities. Elevated metals (particularly cadmium, zinc, copper, and lead) exist on site and are somewhat heterogeneous in terms of spatial distribution and concentrations. Upon completion of the spatial analysis model, it was determined that the source area for each of the COC's remains consistent with each parameter tested. As such, it is our opinion that the soil, surface water and sediment chemistry reflects environmental impacts related to the historical land filling activities on site. Our evaluation indicates that the buried and exposed metallic debris imparts a slow release of metals into the environment.

Isolated PHC, PAH, PCB, Pesticide and to a much lesser degree VOC (e.g. TCE) impacts were detected in several locations on site. These impacts are likely associated with chemical waste materials historically discharged at the site. PCBs were likely released by the historical disposal of transformers and electrical equipment on site. In 1987, site remediation activities removed electronic equipment suspected as a point source for PCBs on site.

A summary of the contaminant impacts is provided in the table below:

<table>
<tr><th>Area Identification</th><th>AEC</th><th>Identified Contaminant</th><th>Impacted Media</th></tr>
<tr><td>Up-Gradient Debris Area</td><td>AEC 1</td><td>lower priority – metal impacts</td><td>Soil and surface water</td></tr>
<tr><td rowspan="2">Vehicle Dump</td><td rowspan="2">AEC 2</td><td>Higher priority – metal impacts</td><td>Soil, surface water, and stream sediments</td></tr>
<tr><td>Lower priority – PCB, PAH, PHC, Pesticide impacts</td><td>Discrete near source impacts - soil and stream sediments</td></tr>
<tr><td rowspan="3">Main Landfill</td><td rowspan="2">AEC 3</td><td>Higher priority metal impacts</td><td>Soil, surface water, and pond sediments</td></tr>
<tr><td>Lower priority – PHCs, PAHs, and PCB impacts</td><td>Soil, and pond sediments</td></tr>
<tr><td>AEC 3a</td><td colspan="2">Higher priority- Geotechnical slope stability hazard</td></tr>
<tr><td rowspan="2">Down-Gradient and Off Site</td><td rowspan="2">AEC 4</td><td>Higher priority – metal impacts</td><td>Surface water</td></tr>
<tr><td>Lower priority – VOC impacts</td><td>Surface water</td></tr>
</table>

10.1.2 Non-Hazardous and Hazardous Waste Debris

A variety of non-hazardous waste debris types are found within the different areas/AECs. The major waste streams are rusted metallic debris, abandoned vehicles and parts, fuel drums, and domestic waste debris.

The site was historically used as for land filling activities, therefore miscellaneous debris was found scattered throughout the site. However, the majority of the debris was found in AEC 2 (Vehicle Dump) and AEC 3 (Main Landfill Area).

It is anticipated that the majority of the waste will be considered non-hazardous. However, hazardous debris (e.g., asbestos, unknown liquids, batteries) may be present but currently buried or inaccessible. Provisions should be made within any remedial work to anticipate the presence of hazardous waste.

Table 26 describes the debris located at the site.

10.1.3 Main Landfill Slope Stability (AEC 3a)

Based on the geotechnical assessment of the Main Landfill southern slope (AEC 3a), it appears that the slope is at its maximum angle of repose and that the landfill poses a significant current and potential physical hazard. Remedial work is proposed for this area.

10.2 Approach and Evaluation Criteria

It is our opinion that the remediation/risk management priorities should be based on the removal of physical hazards (i.e., slope stabilization and debris removal and/or capping) and the containment and control of metals in the surface water pathways (i.e., Vehicle Dump main drainage) discharging to Sylvia Grinnell River.

The buried and exposed debris is the main source of the metal impacts to the environment. Considering the spatial distribution and volume of this material, a two tierred remedial approach could be adopted for this site. Remedial plans could include partial or complete removal of source debris in conjunction with proper capping, as well as a strategy focusing on controlling/removing the contaminants in the surface water pathways (i.e., Vehicle Dump main drainage) prior to discharge into the receiving water body (e.g., Sylvia Grinnell River). The specific approach to the area wide metals in soil, sediment, and surface water will depend on the outcomes of the PQRA/ERE. Essentially immobile contaminants found at discrete locations and close to the source areas (i.e., PCBs, PAHs, Pesticides, PHCs) would need to be addressed but are considered a lower priority.

The long-term strategy for the study area should be based on the following goals, in order of priority:

- Removal of Physical Hazards/contaminant source debris
    a. Vehicle Dump Scrap Metal (Full Removal)
    b. Main Landfill Debris (Full or Partial Removal)
    c. Re-capping of Main Landfill
- Containment and control, including risk management, passive treatment systems and monitoring of surface water drainage systems (Discharge to Silvia Grinnell River);
- Risk management/remediation of impacted soils/sediments; and
- Site monitoring and inspections.

For all the options, Class D (+/- 50%) cost estimates have been included in **Appendix F**. It is our understanding that more detailed cost estimates would be completed as part of a future Remediation/Risk Management Plan, as the relevant strategies and options are carried forward.

Evaluation Criteria

For the analysis of remedial and risk management strategies, a set of criteria for the evaluation of the options includes:

- Overall protection of human health and the environment;
- Removal of hazards;
- Long term effectiveness;
- Ease of implementation;
- Maximal level of confidence in remediation results;
- Minimal remediation time;
- Minimal site disruption;

- Regulatory acceptance; and
- Cost effectiveness.

It should be noted that our responses to the criteria have been established based on our professional opinion and available information. A more detailed analysis would be required in a specific Remedial/Risk Management Plan.

Assumptions

For all the options, the following assumptions have been made:

- Individual options have been provided with cost estimates. Some options require heavy equipment. As such, there will be common costs (e.g., permitting, and mobilization, health and safety) associated with a remedial approach. It is assumed that these common costs would be added to the individual work options.

- Depending on the final option or strategy selected, several excavators, cranes, dump trucks and bulldozers, would be required. At this point, it is difficult to determine the exact equipment list as it would vary depending on the final plan. However, order-of-magnitude costs have been provided in this analysis.

- General costs for the preparation of tenders, laboratory analysis and reporting have been incorporated into the individual cost estimate spreadsheets.

- A recycling contractor is currently active in the City of Iqaluit. The estimated costs for recycling have been based on unit prices from the current operation and may change if the operations cease in the future.

- Based on the site topography and access, options to recover the waste, via heavy equipment and trucks at the toe of the bedrock escarpment are limited. For this analysis, we have not costed the construction of a temporary road or the ability to construct a winter road (which would likely require access through the Territorial Park).

The estimated common costs for the remedial approach are summarized in the following table:

Summary of Common Costs Remedial Approach

Activity/Item	Unit	Quantity	Unit Price	Total
Environmental Impact Assessment	Estimate	1	$80,000	$80,000
Permit Applications	Estimate	1	$50,000	$50,000
Health and Safety	Estimate	1	$20,000	$20,000
Total Common Costs for Remedial Approach				**$150,000**
+/- Approximate				**$150,000**

10.3 Mitigation of Physical Hazards

The Main Landfill area and Vehicle dump were identified as physical hazards to humans using the site for recreational purposes and to wildlife. The exposed debris and the geotechnical slope stability of the main landfill area (AEC 3) was identified as a physical hazard. Two options to mitigate these physical hazards have been proposed and are summarized as follows:

Option 1: Removal of Physical Hazards

- Option 1A- Consolidate, Recycle, Waste Materials disposal into Engineered On-Site Landfill
- Option 1B – Consolidate, Recycle, and Waste Materials disposal Off-Site

Option 2: Capping of Physical Hazards

10.3.1 Removal of Physical Hazards (Option 1)

Metal debris, scrap machinery, vehicles, drums, tanks and other building materials are found throughout the landfill area. The approximate total volume of metallic debris is estimated to be on the order of ~16,000 m^3 and other miscellaneous (non-metallic) debris is on the order of 6800 m^3. Two options could be used to physically remove and dispose of the physical hazards:

Option 1A – Consolidate, Recycle, Waste Materials disposal into Engineered On-Site Landfill; and
Option 1B – Consolidate, Recycle, and Waste Materials disposal Off-Site

An options analysis based on the evaluation criteria is presented as follows. Detailed Class "D" cost estimates supporting the options are provided in **Table F1**, Waste Dumps and Metal Debris- Removal of Physical Hazards.

Both debris removal options would include removal and re-location of debris to a temporary staging ground located in AEC 1 where sorting of the materials could take place. Metallic objects would be sent for recycling and other debris would be disposed of via one of the options provided below.

Due to the difficult site access, materials could be recovered by using a truck mounted or stationary anchored crane with a magnetic attachment for metallic debris and a clam attachment for non-metallic debris. The crane would be mounted on the upper bench of the Main Landfill (AEC 3) and debris would be transported from the slope and toe of the landfill to the upper bench, where loaders would then move the debris to a temporary staging ground located in AEC 1 for sorting. Based on our research, a suitable crane is available in Iqaluit. The magnetic and clam attachments are specialized pieces of equipment which would be shipped from the south.

Both option 1A and option 1B require complete removal of waste debris. Both options would also include separation of recyclable materials and disposal of non-metallic items.

Option 1A – Consolidate into Engineered Landfill

In this option, all the waste debris and materials would be consolidated and placed in an engineered landfill constructed in AEC 1 close to the current location of buried metallic debris. Some of the metal pieces would require cutting into smaller, more manageable pieces and transporting to recycling area. This option would remove this material as a physical hazard. The material would be placed in an engineered landfill and covered with a geotextile (or equivalent), covered with soil and re-vegetated. This burial option will require some monitoring over time to ensure the cover materials remain stable and any potential leachate remains contained within landfill area.

Option 1B – Consolidate and move off-site

This option would involve consolidating the waste materials and transporting to the City of Iqaluit municipal landfill. It is our understanding that the City is currently limiting the acceptance of wastes due to over capacity issues. A significant quantity of waste material exists at the site, as shown in **Table 26**, including relic metallic debris, appliances, municipal waste, construction debris etc. Debris would be first transported to the staging ground in AEC 1 and sorted for recyclable metallic materials and materials suitable for land filling.

These options provide long-term solutions to remediating non-hazardous wastes and would be consistent with other aesthetic clean-ups in the region. A summary of the options is provided as follows:

OPTIONS	**Option 1A Consolidate Waste and On-site Engineered Landfill**	**Option 1B Consolidate Waste and move off-site**
Project Goals	Remove physical hazard by providing a permanent solution	
Operating Principle	All material would be consolidated and placed within an engineered waste landfill. The wastes would be placed in excavated; lined; covered with borrow pit soils and re-vegetated.	All material would be consolidated and removed from the site. Waste materials would be consolidated and transported to municipal landfill.
Protection of Human Health and the Environment	Yes	Yes
Degree of Site Disruption	High	Moderate to High
Confidence Level	Moderate to High	High
Estimated Time for Implementation	Four weeks to prepare disposal area; 1.5 months to consolidate and move into disposal area.	1.5 months to consolidate and transport to municipal landfill
Long-term Effectiveness	Yes- additional monitoring required	Yes
Ease of Implementation	Low- Moderate	Moderate
Regulatory and Community Acceptance	Low	Moderate
Estimated Capital Cost	**$2,351,154**	**$1,628,225**
Estimated Operating Cost (5 years)	**$150,000**	**$0**
Total Estimated Remediation Cost +/-	**$2.5M**	**$1.6M**

10.3.2 Capping of Physical Hazards (Option 2)

The placement of an engineered cap or backfill would be another option to eliminate the physical hazards created by the Main Landfill Area. The general approach would be to completely cap the Main Landfill Area with quarried sand and gravel fill material.

Quarried blast rock and/or sand and gravel material would need to be trucked on site and placed on the Main Landfill. The calculations were based on a 1.5 metre cap on the upper bench and side portions of the site and an average depth of 10 m for the lower section of the site. The rationale for the thicker cover in the bottom portion of the site is to achieve the appropriate grade to provide slope stability and allow for adequate re-vegetation.

It should be noted that metallic debris from the vehicle dump should be removed and recycled prior to applying the capping material. Costs for removal of only recyclable materials prior to capping are expected to be on the order of $830,000..

The approximate total volume of fill materials required to provide adequate capping and obtain slope stability is estimated to be on the order of 70,000 m^3 (See **Table F2 -** Waste Dumps and Metal Debris- Capping).

This option would also provide a long-term solution to remediating non-hazardous wastes. A summary of the capping option is provided as follows:

OPTIONS	**Option 2 Capping Waste Debris**
Project Goals	Remove physical hazard by providing a permanent solution
Operating Principle	Metallic debris from the Vehicle Dump (AEC 2) is to be removed and recycled. The remainder of the debris and impacted area are to be capped with fill material. Slope stability is to be achieved by applying the appropriate amount of capping materials to the toe of the landfill.
Protection of Human Health and the Environment	Yes
Degree of Site Disruption	High
Confidence Level	Low-Moderate
Estimated Time for Implementation	4 months transport the appropriate quantities of fill material.
Long-term Effectiveness	Yes
Ease of Implementation	Low-Moderate

OPTIONS	Option 2 Capping Waste Debris
Regulatory and Community Acceptance	Low
Estimated Capital Cost	**$5,896,078**
Estimated Operating Cost (5 years)	**$150,000**
Total Estimated Remediation Cost +/-	**$6M**

10.3.3 Removal of Hazardous Waste Materials.

A small quantity of hazardous waste debris types may be located in the different areas/AECs. The approximate total volume of potentially hazardous debris is currently unknown. All hazardous debris should be consolidated, packaged appropriately and shipped south for adequate disposal practices.

Potential hazardous material on site could include asbestos, batteries, and unknown liquids. Due to the nature of the landfill, buried debris could also expose other hazardous materials not visible during the site inspection.

A conservative estimated cost for the packaging and removal of the hazardous materials is approximately $50,000.

10.4 Surface Water Drainage Systems

The historical metal loading and current slow release of metals associated with the metallic and non-metallic debris deposited on site have resulted in impacted surface waters and sediments down-gradient of the Main Landfill (AEC 3) and more significantly down-gradient of the Vehicle Dump (AEC 2). A preliminary quantitative risk assessment (PQRA) and ecological risk evaluation (ERE) are currently being completed to determine the potential for risks to human health and ecological receptors from the metal impacted areas. The outcomes of the PQRA or a higher level SSRA, can be used to guide the long-term strategies for the site. Two general approaches are possible:

Option 1 – Long-term monitoring;
Option 2 – Passive in-situ treatment.

As the surface water metal contributions will continue with time (due to the presence of the waste debris), dredging of sediments and on-site treatment was not considered a viable option. In fact, pond and creek bathymetry would be affected by dredging, leading to a loss of natural habitat for fish, wildlife and benthic organisms which are a food source for fish and wildlife and possibly releasing metals (including Arsenic) to the water column.

An options analysis based on the evaluation criteria is presented as follows. Detailed Class "D" cost estimates supporting the options are provided in **Table F3**, Surface Water Drainage Systems.

10.4.1 Option 1 – Long-term Monitoring

Surface Water Drainage

The goal of the long-term monitoring program would be to ensure that present and future risks are negligible and that monitoring could be terminated with confidence, based on findings of no risk and no depreciation of site environmental status. The program would be developed specifically to:

- Inspect and monitor surface water integrity, flow rates, channelling and physical conditions;
- Monitor, evaluate and analyze for metals in surface waters over time; and
- Ensure the protection of human health and environment from exposure to chemicals of concern.

Both passive and active monitoring would be undertaken at the property. A site inspection program (passive monitoring) would be conducted to observe the physical condition of the surface water bodies. An active surface water monitoring program would be developed upon which future risk management decisions could be based. This plan would effectively provide an early warning system that could be implemented in association with a Contingency Plan and could provide the decision criteria for termination. As an outcome of Option 1, a passive in-Situ treatment evaluation may be warranted.

Sediments

Based on our preliminary evaluation, it would appear that the chemicals of concern are not currently having an impact on aquatic life. Site monitoring may be required as an outcome of the PQRA.

10.4.2 Option 2 – Passive In-Situ Treatment

In recent years, a variety of passive treatment systems have been developed that do not require continuous chemical inputs and that take advantage of naturally occurring chemical and biological processes to treat metal impacted waters. The primary passive technologies include constructed wetlands, anoxic limestone drains (ALD), successive alkalinity producing systems (SAPS), limestone ponds, and open limestone channels (OLC).

For the Vehicle Dump site, the existing drainage systems could be modified to reduce the surface water/sediment metal loading to the environment and Sylvia Grinnell River by:

- providing a predictable and steady flow path to the discharge points by enhancing the physical drainage systems with weirs, banks or channels to avoid overflow, flooding or hydraulically cross-connecting with other low-lying areas during heavy run-off periods ; and
- enhancing the natural treatment system to trap or remove metals along the flow path.

Enhanced wetlands are characterized by water-saturated soils or sediments with supporting vegetation adapted to reducing conditions in their rhizosphere. Often they consist of shallow excavations filled with flooded gravel, soil, and organic matter to support wetland plants such as *Typha*, *Juncus*, and *Scirpus* sp. Treatment depends on dynamic biogeochemical interactions as contaminated water travels through the constructed wetland.

At their present stage of development, passive systems can be reliably implemented as a single permanent solution for many types of metal impacted waters, which is similar in nature to that of the Vehicle Dump (AEC 2) and at a much lower cost than active treatment.

Selection of an appropriate passive system is based on water chemistry, flow rate, local topography and site characteristics. Mechanisms of metal retention within wetlands, listed in their order of importance, include: 1) formation and precipitation of metal hydroxides, 2) formation of metal sulfides, 3) organic complexation reactions, 4) exchange with other cations on negatively-charged sites, and 5) direct uptake by living plants. Other mechanisms include neutralization by carbonates, attachment to substrate materials, adsorption and exchange of metals onto algal mats, and microbial dissimilatory reduction of Fe hydroxides and sulfate.

The way in which a wetland is constructed ultimately affects how water treatment occurs. Two construction styles currently predominate: 1) "aerobic" wetlands consisting of *Typha* and other wetland vegetation planted in shallow (<30 cm), relatively impermeable sediments comprised of soil, clay or mine spoil, and 2) "anaerobic" wetlands consisting of *Typha* and other wetland vegetation planted into deep (>30 cm), permeable sediments comprised of soil, peat moss, spent mushroom compost, sawdust, straw/manure, hay bales, or a variety of other organic mixtures, which are often underlain or admixed with limestone. In aerobic wetlands, treatment is dominated by processes in the shallow surface layer. In anaerobic wetlands, treatment involves major interactions within the substrate.

Implementation: Prior to implementation, this approach requires that the site be well characterized and that the processes which affect surface water and sediment chemistry be well understood. For this option to be successful, an in-depth evaluation of the chemical, biological and physical characteristics of the site should be conducted through seasonal monitoring, detailed hydrology studies and bench-scale treatment tests.

A summary of the options is provided as follows:

OPTIONS	Option 1 Long-term Monitoring	Option 2 Passive Treatment
Project Goals	Ensure the protection of human health and environment from exposure to chemicals of concern.	
Operating Principle	Complete detailed monitoring of surface water and sediments, as required. Evaluated data based on trigger criteria and contingency plans	Enhance the natural removal of metals along the surface water flow systems prior to discharge to receiving bodies. Enhancements could include surface water drainage routing and construction of wetlands and filters to reduce chemical concentrations.
Protection of Human Health and the Environment	Yes	Yes
Degree of Site Disruption	Low	Moderate
Confidence Level	Low	Moderate
Estimated Time for Implementation	Long-term (>10 years)	2-3 years
Long-term Effectiveness	Low	High
Ease of Implementation	High	Moderate, studies required
Regulatory and Community Acceptance	Low	High
Estimated Capital Cost	**$100,000**	**$630,000**
Estimated Operating Cost (10 years)	**$300,000**	**$300,000**
Total Estimated Remediation Cost	**$400,000**	**$930,000**

10.5 Site Specific Risk Assessment- Area Wide Impacts

Following the completion of the PQRA/ERE, a site specific risk assessment (SSRA) could be completed to determine the absence/presence of risks to human health and the environment and develop site specific remedial guidelines for clean-up.

As such, the SSRA could be useful as the primary option with the outcomes of the assessment used to guide other remedial requirements. The SSRA would specifically target the mobile and immobile CoCs in soil and sediments which are considered low priority issues, but not addressed in the active remedial options.

The main elements of the risk assessment would include:

- Chemical hazard assessment;
- Receptor identification;
- Exposure pathways and assessment; and
- Qualitative risk characterization and estimates.

The cost for a risk assessment is expected to be approximately $100,000

10.6 Summary of Remedial Cost

Based on the discussion provided above, a summary of the options and costs is provided on the following table:

AEC	Option	Costs	
		Total	**+ Common**
Removal of Physical Hazard	Option 1A: On-Site Engineered Landfill	$2,500,000 (high)	Yes
	Option 1B: Off-Site Disposal	$1,600,000 (low)	Yes
	Option 2: Capping	$6,000,000 (high)	Yes
Surface Water Drainage	Monitoring	$400,000 (low)	No
	Passive Treatment	$930,000 (high)	Yes
Hazardous Waste Materials	Asbestos Containing Materials and Other Hazardous Materials (estimate)	$50,000 (l/h)	No
Area Wide impacted soils and sediments	Site Specific Risk Assessment	$100,000 (l/h)	No
Lowest estimate + common costs	**$3,980,000 + 150,000 (common costs)**	**$3,980,000 ($3.98M)**	
Highest estimate + common costs	**$7,480,000 + $150,000 (common costs)**	**$7,630,000 ($7.63M)**	

Lowest estimate= selecting the lowest cost option per AEC

Highest estimate = selecting the highest cost option per AEC

The common costs are included only once = $150,000

10.7 Supplemental Investigations

The impacts to the site are well defined and additional assessment work would enhance the quantity estimates, confidence and the overall distributions of the impacts. Preliminary activities may include the following:

- Detailed delineation of impacts to soils surrounding the Vehicle Dump (AEC 2) in terms of horizontal distribution;
- Further delineation of up-gradient debris area (AEC 1) to classify debris and obtain horizontal delineation of impacts;
- Seasonal (i.e., spring, summer, and fall) surface water flow rate monitoring to help better understand surface hydrology and contaminant pathway characteristics;
- Seasonal (i.e., spring, summer, and fall) surface water and sediment sampling to fully characterize contaminant distribution in peak and low flow situations; and
- Hazardous waste materials sampling and characterization.

10.8 2008 NCSCS Site Score

The CCME National Classification System for Contaminated Sites (NCSCS) was revised in 2008 to supersede the 1992 NCS system and also the Federal Contaminated Sites Action Plan (FCSAP) scoring system (2005 version, developed by Franz Environmental Inc.). The NCSCS is a tool to aid in the evaluation of contaminated sites. The revised system retains the general classification structure of Class 1, 2, 3, “I” or “N” based on the site’s current or potential adverse impact on human health and/or the environment.

The site score was 84.1 which classifies the Vehicle Dump and Community Landfill as a Class 1 site (Action Required) (See Appendix G).

11.0 SUMMARY AND CONCLUSIONS

11.1 Introduction and Purpose

Franz Environmental Inc. (FRANZ) was retained by Public Works and Government Services Canada (PWGSC) Pacific Region and Transport Canada (TC), Prairie and Northern Region and Environmental Affairs Division to complete a Phase I/II Environmental Site Assessment (ESA) of the Vehicle Dump/Community Landfill, Iqaluit, Nunavut. This project was completed based on the FRANZ proposal, P-2704, dated August, 2008 which followed the tasks outlined in PWGSC/Transport Canada's Terms of Reference (ToR), dated May 20, 2008.

11.2 Study Area

The landfill site is situated 1.7 km southwest of the town of Iqaluit, on the slope of an escarpment leading to the Sylvia Grinnell River and contains several shallow ravines and coulees partially filled with metal debris. The site covers an area of approximately 7.25 ha (72,500 m^2) and has central UTM coordinates of E521904.94, N7067812.69. The waste streams consist of vehicles, equipment, barrels, domestic waste, and scrap metal. The study area is divided into two distinct areas:

- The main debris/community landfill area which includes exposed metal debris. A portion of the waste including 45 gallon drum dumps are located at the toe of the bedrock escarpment; and
- The vehicle dump to the south and parallel with the main landfill.

11.3 Site Investigation

FRANZ conducted a Phase I/II ESA targeting Areas of Potential Environmental Concern (APECs) and potential Contaminants of Concern (COCs) based on the historical review. The field investigation included test pit excavation and soil sampling, surface water sampling, sediment sampling, vegetation sampling and chemical analysis of soil, sediment, surface water, and vegetation. The field program was completed from September 5 to 9, 2008.

11.4 Site Characterization

The study area is characterized by rolling terrain that slopes towards the Sylvia Grinnell River. The bedrock over which the metal debris was dumped is approximately 30 m above the River valley. Local terrain consists mainly of bare rocky outcrops with a thin layer of glacial and marine sediments in low lying areas between outcrops.

The elevation of the landfill site is approximately 20 to 30 masl and the Sylvia Grinnell River is at approximately 0 to 5 masl (http://atlas.nrcan.gc.ca).

The Sylvia Grinnell River is the principal drainage system in the region which discharges to Frobisher Bay. The river is influenced by the tidal action of the ocean which has some of the largest tides in Canada. The river is a major migratory route for Arctic Char.

The natural surficial drainage around the study area is influenced by the bedrock structure and numerous small, elongated ponds that have formed along fault lines and joints. The ponds are shallow (~ less than 0.5 m deep), and are poorly drained.

11.5 Environmental Quality Guideline (EQG)

The chemical data obtained through the Phase II ESA were compared to established commercial and residential/parkland guidelines from the federal CCME. The federal guidelines are relevant since the site is currently federally managed and Nunavut has adopted the CCME approach.

11.6 Summary of Impacts

The area covered by the Vehicle Dump and Community Landfill site is extensive and its history is long, but environmental impacts present in 2008 were associated with disposal of metallic debris, disposal of items containing hydrocarbons (i.e, drums), disposal of PCB containing electronic equipment, disposal of pesticide containing containers. Whereas hydrocarbon, PCB, and pesticide impacts were localized to small areas near their original sources, apparent contamination from metals was more widespread and largely associated with metalloid dissolution and distribution along surface water flow pathways.

11.6.1 PHC, PCB, and pesticides

PHC, PCBs, and pesticides were identified in soil and sediments in AECs 2 and 3. These impacts appeared to be localized to discrete areas of impacts. The PHC fractions were primarily associated with the F2/F3 fractions. Delineation of the PHC soil impacts was not completed in all instances during this study.

PCBs and pesticides in sediment were identified in AEC 2 down-gradient of the Vehicle Dump. Testing was completed further down-stream and no evidence of contaminant migration was present. Impacts appear to be localized and temporarily contained within the sediments.

11.6.2 Metal Impacts and Evaluation

Leaching of metals from buried and exposed metallic debris has impacted soil, sediment, and surface water on site, as well as to a lesser extent vegetation.

Since the creation of the site (i.e., early 1960's), concentrations of metals and metalloids in environmental media (e.g., soil, sediments) have likely been accumulating slowly over time. Based on analysis conducted on background samples collected in the vicinity and up-gradient of the site, it is unlikely that these elevated metals concentrations can be attributed to naturally occurring geological elements.

Site conceptual models were created and showed that metal concentrations consistently decrease across the site as the preferential pathways (i.e., drainages and ponds) advance further down-gradient from the source areas. A degree of natural attenuation and/or entrapment is currently being demonstrated on site.

11.6.3 Physical Hazards

The major physical hazards observed during the FRANZ (2008) field program were related to the slope stability of the Main Landfill (AEC 3) and debris piles in the Vehicle Dump (AEC 2). It was found that the Main Landfill slope, in its current state, remains at its maximum angle of repose and presents a physical hazard to humans frequenting the site for recreational purposes and wildlife.

The potential for the slope to fail is considered high. The Vehicle Dump (AEC 2) was also found to contain physical hazards of unstable debris piles with potential to slide with added weight or heavy water run-off.

11.6.4 Conceptual Remedial or Risk Management Action Plans

A Conceptual Remedial and Risk Management Action Plan is presented which outlines the strategies that can be used to mitigate exposure of contaminants to potential human and ecological receptors. A Preliminary Quantitative Risk Assessment (PQRA) and Ecological Risk Evaluation (ERE) are being completed as part of this contract (provided under a separate cover). The PQRA/ERE will determine the potential risks to human health and environmental receptors based on the appropriate pathways, concentrations and chemicals of concern. The extent of impacts, volumes of impacted media and final approaches will rely on the outcomes of the PQRA/ERE. As such, the PQRA coupled with this conceptual Remedial Action Plan (RAP) could be used as the basis for a more detailed Remediation/Risk Management Plan (Rem/Rm Plan).

It is our opinion that the remediation/risk management priorities should be based on the removal of physical hazards and the containment and control of metals in the surface water pathways (i.e., Main drainage from Vehicle Dump) discharging to Sylvia Grinnell River.

The buried waste debris is likely the main source of the metal impacts to the environment. The strategy to deal with these metals impacts should focus on, first removing the source of the impacts (i.e., buried debris) and/or controlling/removing the contaminants in the surface water pathways (i.e. Main Drainage in AEC 2) prior to discharge to the receiving body (Sylvia Grinnell River). The specific approach to the area wide metals in soil and sediments will depend on the outcomes of the PQRA. Due to the apparent immobility, Petroleum hydrocarbon, PCB, and pesticide impacts to soil/sediments would be considered a lower priority.

The long-term strategy for the Vehicle Dump and Community Landfill should be based on the following goals, in order of priority:

- Removal of Physical Hazards and contaminant source areas;

a. Vehicles in Vehicle Dump
b. Waste Debris- Main Landfill

- Containment and control, including risk management, passive treatment systems and monitoring of surface water drainage systems (AEC 2 and 3);
- Risk management/remediation of PHC, PCB, and pesticide impacted soils/sediments; and
- Site monitoring and inspections.

11.6.5 Summary of Options and Costs

For all the options, Class D (+/- 50%) cost estimates were calculated. Based on our evaluation, the cost estimates range from approximately $3.98 M to $7.63 M.

AEC	Option	Costs	
		Total	**+ Common**
Removal of Physical Hazard	Option 1A: On-Site Engineered Landfill	$2,500,000 (high)	Yes
	Option 1B: Off-Site Disposal	$1,600,000 (low)	Yes
	Option 2: Capping	$6,000,000 (high)	Yes
Surface Water Drainage	Monitoring	$400,000 (low)	No
	Passive Treatment	$930,000 (high)	Yes
Hazardous Waste Materials	Asbestos Containing Materials and Other Hazardous Materials (estimate)	$50,000 (l/h)	No
Area Wide impacted soils and sediments	Site Specific Risk Assessment	$100,000 (l/h)	No
Lowest estimate + common costs	**$3,980,000 + 150,000 (common costs)**	**$3,980,000 ($3.98M)**	
Highest estimate + common costs	**$7,480,000 + $150,000 (common costs)**	**$7,630,000 ($7.63M)**	

Lowest estimate= selecting the lowest cost option per AEC

Highest estimate = selecting the highest cost option per AEC

The common costs are included only once = $150,000

11.6.6 CCME NCS Score

The CCME National Classification System for Contaminated Sites (NCSCS) was revised in 2008 to supersede the 1992 NCS system and also the Federal Contaminated Sites Action Plan (FCSAP) scoring system version (2005) developed by Franz Environmental.

The site score was 84.1 which classifies the Vehicle Dump and Community Landfill as a Class 1 site (Action Required).

11.7 Supplemental Investigations

The impacts to the site are well defined and additional assessment work would enhance the quantity estimates, confidence and the overall distributions of the impacts. Preliminary activities may include the following:

- Detailed delineation of impacts to soils surrounding the Vehicle Dump (AEC 2) in terms of horizontal distribution;
- Further delineation of up-gradient debris area (AEC 1) to classify debris and obtain horizontal delineation of impacts;
- Seasonal (i.e., spring, summer, and fall) surface water flow rate monitoring to help better understand surface hydrology and contaminant pathway characteristics;
- Seasonal (i.e., spring, summer, and fall) surface water and sediment sampling to fully characterize contaminant distribution in peak and low flow situations; and
- Hazardous waste materials sampling and characterization.

12.0 LIMITATIONS

The conclusions in this report are based on information collected from the investigation locations chosen for this study. The locations were selected based on the best information available to us at the time of this study. This does not preclude the possibility that different conditions may be present elsewhere on the property. No investigative method can completely eliminate the possibility of obtaining partially imprecise or incomplete information; it can only reduce this possibility to an acceptable level.

Professional judgement was exercised in gathering and analysing the information obtained. Like all professional persons rendering advice, we cannot act as absolute insurers of the conclusions we reach; we commit ourselves to care and competence in reaching those conclusions. Our undertaking therefore, is to perform our work, within the limits prescribed by our client, with the usual thoroughness and competence of the profession. No other warranty or representation, expressed or implied, is included or intended in this report.

Sincerely,

Franz Environmental Inc.

Ryan Fletcher C.Tech, CEPIT
Field Supervisor

Marta Rosa, B.Sc.
Environmental Geoscientist

Tamra Reynolds, P.Geo.
Environmental Geologist

Steve Livingstone, M.Sc., P.Geo(I).
Vice-President

Richard Wells, P.Eng.
Senior Environmental Engineer