



**Solid Waste Management Facility
Operation and Maintenance (O&M) Plan
Hamlet of Arviat**

Prepared by

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Executive Summary

The Hamlet of Arviat provides Solid Waste Management Services for the community.

The facility operates under NWB License NWB3ARV03018, which expired in December 2008. Application for a new Type “A” license is in progress.

A Solid Waste Management Facility O&M Plan dated January 2009 was prepared by Nuna Burnside, as required by the original license and submitted in support of the application for a new license.

As noted in the January 2009 O&M Plan, as per the NWB license, the Plan is to be reviewed and updated annually. This May 2010 update of the Plan also addresses comments provided by review agencies during the Type A license application process, in particular the Compilation of Issues from the Technical Meeting/Pre-Hearing Conference conducted in March 2010.

The following items have been identified by regulatory agencies and documented in the Compilation of Issues during the Technical Meeting/Pre-Hearing Conference in March 2010:

- As-built plans for the bulky waste and hazardous waste storage area
- O&M Plan for the interim management of facilities
- Environmental assessment of the soil, surface water, and shallow groundwater in the active layer
- Lack of monitoring and reporting.

In the areas of the landfill, bulky metals, and hazardous waste storage:

- Evaluating and addressing the storage of contaminated soil at the bulky metals area
- Future method and process of disposal of sewage sludge
- Control and management of leachate discharge from the landfill bulky metals and hazardous waste storage areas
- Development and management of a landfarm to handle stockpiled hydrocarbon contained soil
- Abandonment and restoration plans
- As-built (or currently constructed) plans
- Burning control as per GN-DOE policy document “Municipal Solid Wastes Suitable for Open Burning”
- Adding a landfarm facility to the NWB license to handle hydrocarbon impacted soil.

It is recognized that there is significant work required, including studies, engineering, and training to bring the Solid Waste Management Facility into compliance. A New Solid Waste Management Facility design was completed in the May of 2009, however the Hamlet has not

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confirmed a location. It is suggested that the non-compliance items be included as “Conditions” in the new license, with study/reporting requirements due by December 31, 2010, which would include a timetable to bring all aspects into compliance during the first year or two of the license.

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1.0 Introduction

1.1 Overview

This Operation and Maintenance Plan has been prepared to assist the Hamlet of Arviat in the operation of their Solid Waste Management Facility. The Operation and Maintenance Plan applies to the Solid Waste Management Facility as it currently exists. A new Solid Waste Management Facility is currently being designed for a different location. Following development of the new site, the current site will close.

The Hamlet of Arviat Solid Waste Management Facility consists of the following components:

- Landfill (also referred to as the Municipal Solid Waste Disposal Area)
- Bulky Waste Area (also referred to as the Bulk Metals Area) located north of the fill area
- Hazardous Waste Area (currently next to the Hamlet garage).

1.2 Design, Construction, and Operation History

The original NWB License (#NWB3ARV0308) was issued September 2003 for 5 years. It expired in 2008. No as-built drawings or Operations and Maintenance Plan (O&M Plan) are known to exist. The landfill is nearing capacity and an expansion or a new site will be required in the next few years.

Figure 1 displays the location of the community. Figure 2 displays the layout of Arviat.

The waste in the current landfill generally consists of domestic wastes, construction debris, fuel drums, scrap wood, and animal carcasses. It is not clear how the existing site was selected, given its proximity to Hudson Bay, and the airport.

Figure 3 displays the Solid Waste Management Facility. The Bulky Metals area is located north of the fill area. There is no reference to the separate bulky metals area in the license.

There is no reference in the license or approval for the storage of waste oil and hazardous materials at the Public Works garage.

This is not an ideal location for a landfill site. It is too close to the airport and the take off and landing path for aircraft. This is a potential bird hazards to aircraft, as the site attracts birds. The site is also close to the Hudson Bay, with the potential for leachate migration to Hudson Bay. No documentation or design drawings were available to address this issue. There is no information available to indicate how the original designers planned to operate the site.

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Presently, the landfill in Arviat is operated as an open dump. There is no compaction of waste and the landfill is covered infrequently with fill. Burning is used to reduce volumes of waste and is uncontrolled with no segregation of combustible material from non-combustible materials. There was no NWB license amendment submission for the site following its construction.

Currently the fill area is next to the sewage lagoon within a bermed and fenced enclosure (Figures 3 and 4). The Bulky Metals Area is in a separate location to the north (Figure 3). The waste oil and hazardous materials is currently stored at the Hamlet Public Works Garage.

A new landfill site is currently being designed for a location west of the community, as shown on Figure 3. As per MWB requirements, a Closure Plan will be prepared and submitted 6 months prior to the closure of the existing site. This is currently estimated to occur in 2010/2011.

1.3 Maximizing the Use of the Site

In spite of the above noted issues, this O&M Plan has been created to maximize the effectiveness of the site from an environmental and O&M perspective.

A new landfill site location has been selected and the current site is expected to close within 2 years.

This O&M Plan has been prepared to assist in maximizing the site while minimizing the environmental impacts. It is recognized that a number of compliance issues may not be able to be addressed at this point in the landfill's life.

2.0 Hamlet Description

2.1 Infrastructure

The Hamlet of Arviat is located on the northern shore of a peninsula on the west coast of Hudson Bay. Arviat is located at 61° 05' N and 94° 00' W, and is 241 km southwest of Rankin Inlet and 265 air km north of Churchill Manitoba (Figure 1).

The community has a population of approximately 2,167 (2009), with an approximate 1.7 percent projected growth rate. This is taken from available statistics data, as shown in Appendix B. Information provided by the Hamlet suggests the population currently exceeds 2,500. Given that the site is scheduled to close in the next 2 years, the population difference between the government statistics and Hamlet information will not significantly impact the O&M Plan. Hamlet infrastructure includes:

- A Water Reservoir
- Trucked water is supplied to holding tanks in each building
- A Sewage Disposal Facility consisting of a 55,000 m³ single-cell exfiltration lagoon. The effluent from this lagoon proceeds downstream to the marine environment through an undefined, natural wetland along a 200 m flow path prior to entering Hudson Bay
- A Solid Waste Management Facility, that includes a Municipal Solid Waste Disposal Area (landfill) and a Bulky Waste Area
- An airstrip beside the sewage lagoon and landfill site
- Diesel powered generators.

Key features of the community are shown on Figure 1.

The Hamlet of Arviat is predominately residential with a few small commercial establishments. Hunting and fishing in the traditional manner is still a prime occupation for many of the inhabitants. A layout of the entire community and infrastructure is displayed on Figure 1.

2.2 Climate

Arviat is affected by arctic air masses, and experiences a maritime arctic climate characterized by short cool summers, and long cold winters. Arviat receives an average of 16 cm of rainfall and 118 cm of snowfall per year. July mean high and low temperatures are 13.1 °C and 4.5 °C, respectively. In January, the mean high is -27.9 °C and a mean low of -35 °C. Winds are generally north-west (Environment Canada, 2009).

2.3 Geology and Morphology

Arviat is located on the northern shore of a peninsula on the west coast of Hudson Bay. The Hamlet is located in a zone of continuous permafrost, extending from 30 m to over 100 m. The active layer varies between 0.5 and 0.3 m. The predominant local vegetation consists of mosses and lichens on rocky outcrops, with hardy grasses and sages in swampy and/or more sheltered areas (FSC, 2001).

2.4 Nunavut Water Board License

The Solid Waste Management Facility operates under Nunavut Water Board License Number NWB3ARV0308, issued January 9, 2004. It expired December 31, 2008 (Appendix A). An application for a renewal/amendment of the licence has been made. This O&M Plan has been prepared for due diligence purposes, to assist in meeting the anticipated requirements of the new license.

Typically Water Licenses require:

- Operation and Maintenance Plan
- Environmental Emergency Contingency Plan – separate document
- Monitoring Program and Quality Assurance/Quality Control Plan – separate document.

2.5 Health and Safety

Health and Safety of workers and the public is the first priority during the operation of the Solid Waste Management Facility. The requirements of the Nunavut Safety Act must be followed at all times. All actions and operations must be undertaken with human safety as the first priority.

2.6 Training

Staff training is an important aspect of operating a Solid Waste Management Facility. Staff must be adequately trained to follow this O&M Plan and operate the facility. This O&M Plan depends on effective site specific training.

2.7 Design of the Solid Waste Management Facility

The current landfill is located 2.0 km southeast of Arviat and less than 0.6 km east of the community airstrip. The landfill is located along the south esker, less than 1 km north of the Hudson Bay. The location of the landfill is displayed on Figure 2. The landfill area consists of a 160 x 200 m area measured from the inside of the containment berms and a 170 x 210 m area including the berms. An area for general solid waste disposal (landfill) is located on the south of the access road. A sewage lagoon is located immediately east of the fill area. On the

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east side of the access road, 250 m, away from the landfill is an area for Bulky Metals. A three meter containment berm is constructed around the landfill area between the solid waste fill area to prevent impacted water from flowing into the Hudson's Bay (Figure 4). This area is off limits for all other land uses. Any land use development in the surrounding area must be reviewed to ensure it does not conflict with site operations.

The bulky waste area is located along an esker, 0.5 km south of the town. Vehicles, heavy equipment, 45 gallon drums and other metal wastes are disposed/stored at this site. Historical records indicate some burial occurred during the mid-1970's until 1977, when the area was used as a disposal area for domestic wastes. The filled area has been closed with a layer of fill. Seven hundred and fifty cubic meters of contaminated soil were reportedly removed from the N.W.T. Power Corporation (NWTPC) tank farm and brought to the Bulky Waste site for landfarming. Some of the soil has been spread over the former landfill with approximately 300 m³ still in piles. The soil is believed to be contaminated with diesel.

The proposed new landfill site will have an area set aside for bulky metals and a landfarm. It is proposed that the contaminated soil at the bulky metals site be evaluated and handled according to regulations. No time table has been set to address this issue.

3.0 Operation and Maintenance

3.1 Overview

The Hamlet of Arviat Solid Waste Management facility consists of the following components:

- Landfill (solid waste disposal area)
- Bulky Metals Area
- Hazardous Waste Storage Area.

The site is designed as a natural attenuation landfill. It does not have a liner, so small amounts of contaminants are able to leach from the waste and enter the natural environment. In a natural attenuation landfill the discharge of contaminants is expected to occur at a rate that can be attenuated (broken down and diluted) by the natural environment. The design also relies on permafrost gradually migrating into the waste at depth as it is covered over. In order to protect the environment, the facility is designed to divert as much waste as possible from landfilling. This is especially important for hazardous wastes such as batteries, waste oil, waste antifreeze, and other materials that could harm the environment if landfilled. These items are diverted to the Hazardous Waste Storage Area.

The waste quantity calculations table in Appendix B includes estimates of the current volume of waste in the landfill and projected waste generation for the next 20 years.

Site operations must comply with the Nunavut Safety Act. The health and safety of workers and the public must be the first priority.

3.2 Material Arrival

3.2.1 Material Assessment

Material will arrive at the facility either by a garbage compactor truck owned by the Hamlet or by private individual or company drop-off. After Hamlet staff collects waste, the collection vehicles will progress to the landfill. Wastes will be tipped into the landfill burn pile. After being tipped (or during collection), staff will perform an inspection of the waste to ensure that it does not contain visible hazardous waste or bulky metals. If such waste is noted, it will be segregated in the appropriate locations of the approved Hazardous Waste Storage Area or the Bulky Metals Area. Members of the community may drop off materials directly at the facility. The public is required to place materials in the appropriate location; generally bulky metals within the Bulky Metals Area, wood in the wood pile, etc. The layout of the site is displayed in Figure 3. Effective placement of bilingual signage encourages diversion and directs the public to the appropriate areas within the facility. Materials are

assessed prior to disposal in the landfill. If the material is something other than municipal solid waste, it is assessed according to the following criteria:

- Canadian Environmental Quality Guidelines
- Environmental Guideline for Industrial Waste Discharges.

If the material meets the industrial land use criteria for disposal in the landfill, it is landfilled. If not, it must be treated (land farmed) or stored as hazardous waste. Suitability for land farming will be based on the volume, type of contaminants, and concentration of contamination. A cost/benefit analysis is done to determine if land farming is a better alternative than storage as hazardous waste and eventually shipped out of the community. The staff will record the number of trips to the Solid Waste Disposal Facility per day and estimate the approximate quantity in cubic meters (based on the volume of the truck) on the Waste Placement Forms included as Appendix C. If waste is present on site that has been tipped by others, an estimate of the quantity shall be made and recorded. Records are to be delivered to the Hamlet office once per week where they will be retained on file for inclusion in the Annual Report.

3.2.2 Wood

Wood materials that may have reusable value are placed in the wood pile in the reuse/recycle area that is part of the Bulky Metals Area. The wood pile should be burned on occasion when quantities build up. Burning should take place when wind and climate conditions are favorable. Burning should only be done when the smoke will not drift towards the community or airport.

3.2.3 Bulky Metals Area

The Bulky Metals Area consists of a segregation area for reuse and recycling of materials such as metals, tires, vehicles, and equipment. Bulky metals are segregated and stockpiled until there is a sufficient quantity that warrants a burial event. Non-bulky metals (waste) is commonly disposed of in the Bulky Metals Area, so regular maintenance is required to keep it clean.

Staff should inspect the Bulky Metals Storage Area on a regular basis to check for new materials. Fluids (oil, antifreeze) should be drained from vehicles; batteries should be removed and transferred to the Hazardous Waste Storage Area. Vehicles should then be tagged to indicate that they have been inspected and cleaned. Bulky metals should be moved to the appropriate location to maximize segregation of the materials. These groupings can be developed by the operation staff based on needs and materials, but are anticipated to consist of tires, appliances, bicycles, ATV's, snowmobiles and miscellaneous materials. Appropriate signage will direct the segregation.

3.2.4 Hazardous Waste

Material not confirmed to be acceptable for the landfill or the Bulky Metal area, will be stored in the Hazardous Waste area, currently next to the Public Works garage. This area is out of compliance with regulations. A new facility is to be included in the design for the new landfill.

3.3 Landfill Operation

Site operations include potentially hazardous practices such as burning and operation of heavy equipment. All work is to be conducted only by staff with the appropriate training to conduct the work safely. The health and safety of workers and the public takes precedence at all times.

It has been indicated that the burning of clean burnable waste is a necessity to prevent odour, eliminate flies, and to reduce potential problems with scavengers, such as bears and foxes (since the ability to cover waste is limited due to the short operational season). In order to minimize the potential for impacts from fires the following procedures are to be followed:

- Burn only in the established burn area
- Materials should not be tipped directly onto burning or smoldering waste; it is preferable to not ignite the waste until it has all been collected for the day
- Ensure that the weather is acceptable for burning.

The following process is recommended:

- Wind speed should be checked. If loose paper or debris can be lifted and carried off site (moderate breezes or greater), burning shall be avoided. The wind direction should be checked, to ensure that smoke does not drift towards the Hamlet, or workers in the vicinity. If heavy rain is present, burning should be avoided (as it may result in poor combustion and greater potential to generate deleterious by-products). The site operators shall stay upwind of the fire at all times. Prior to waste handling, the equipment operator will confirm that the waste is no longer hot or burning. As required, using a dozer or a loader, the ash and unburnt municipal wastes will be pushed away from the burn pit and along the active face, observing the following operating principles:
 - All waste shall be removed from the tipping and burn areas
 - The waste shall be pushed and spread along the disposal area at a maximum 3:1 grade (shallower grades result in the need for too much cover; steeper grades are typically not stable).

Burning should follow the protocols outlined in detail in the GN policy document “Municipal Solid Wastes Suitable for Open Burning”. Materials suitable for burning must be segregated from those that are not, prior to placing them in the burn pile.

The following operational procedures are based on continuing to operate the landfill as an “area fill” landfill, with waste being spread over the fill area footprint, compacted, and covered prior to the next lift (layer) being added.

The recommendations made in this report are based on the Municipal and Community Affairs “*Guidelines for the Planning, Design, Operation and Maintenance of Solid Waste Modified Landfill Sites in the N.W.T.*”.

- Compact the wastes at the landfill.

Compaction of wastes can significantly reduce the volumes of materials in a landfill. The steps involved in properly compacting wastes along the southern slope of the esker is as followed.

Step 1 – Allow loose wastes to accumulate

Step 2 – Spread the waste for compaction

Step 3 – Work the material across the fill area a little at a time, to form compacted layers of waste

Step 4 – Cover and compact a layer of fill over the exposed waste.

- Cover the wastes.

Local borrow areas of sandy and sandy material north and northeast of the fill area. Operations are made easier by stocking cover material close to the landfill.

After the garbage has been compacted a layer of fill approximately 0.15 m to 0.2 m should be placed upon the compacted garbage. The fill should be spread over the entire pile and then compacted again to prevent erosion. It is recommended that the landfill in Arviat be compacted and covered with a layer of fill at least four times a year subject to financial ability.

- Minimize the scatter of wastes by maintaining signs and fencing around the waste disposal area.
 - Divert hazardous material, bulky metals, and reusable/recyclable materials
 - Drop off waste at the designated area at the end of the access road
 - Close the fill area once final grades (maximum 3:1 slopes) are achieved.

3.4 Hazardous Waste

Although reuse of the material is possible, there are materials that will have no potential future life. It is recommended that periodically (i.e., every 3 to 5 years), bulky metals with no further recyclable value be removed and buried.

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Minimize the amount of hazardous wastes entering the landfill. Residents should be discouraged from disposing of used oil in the landfill. Used oil is a hazardous waste and placement in the landfill should be avoided. Used oil accounts for approximately 70 percent of the hazardous waste produced in Nunavut municipalities account for half of this production. Eskimo Point Lumber has a waste oil burner. Residents in Arviat should be encouraged to take their waste oil to Eskimo Point Lumber for disposal.

Other hazardous wastes that should not be allowed to enter the landfill are acid batteries, antifreeze, solvents, and waste paints.

The Hazardous Waste area next to the Public Works building will be operated using the following procedures:

- Any hazardous materials brought to the site should be transferred to the Hazardous Waste Storage Area
- Batteries must be stored upright. Oils, lubricants and antifreeze may be bulked together in common drums, preferably remaining in their original packaging
- Unknown substances should remain in their packages and placed into drums for assessment
- Hazardous wastes will be labeled and assigned for removal from the community to a licensed receiver in the south when the storage area nears capacity or when a cost effective volume to warrant shipping has accumulated
- Medical and biological wastes are stored at the nursing station and removed from the community
- Only persons with the appropriate skills and training are permitted to handle hazardous wastes
- In the event of a spill refer to the Environmental Emergency Contingency Plan (a separate document) for details on dealing with a spill of hazardous materials.

The DOE monitors the movement of hazardous wastes from generators, carriers to receivers of the wastes, through the use of a tracking document known as a Waste Manifest. A Waste Manifest must accompany all movements, and all parties must register with DOE by contacting:

- Robert Eno (867) 975-7729
reno@gov.nu.ca
- Ian Rumbolt (867) 975-7748
irumbolt@gov.nu.ca

A new Hazardous Waste Facility was included in the design of the new Solid Waste Management Facility in May 2009. A site has not yet been approved by the Hamlet. The O&M Plan for the new site including Hazardous Waste Storage and control protocols.

In the interim until the new site is constructed, hazardous waste is stored on pallets next to the Public Works garage. The area has not been officially designated, designed, or controlled. There are no formal O&M procedures.

The Environmental Guidelines for General Management or Hazardous Waste should be used as a reference for hazardous waste identification, storage, and control until an approved facility can be constructed.

3.5 Maintenance

Operations staff will perform weekly site inspections and maintenance. During these inspections, weekly site inspection forms (Appendix C) will be completed. These forms are designed to note the standard items requiring inspection and maintenance at the site, as well as other relevant information, such as weather. Health and safety concerns will also be noted. They are also used to document the response to any incidents that affect site operations such as accidents, injuries, fires, flooding, or chemical spills. The following maintenance should be carried out monthly:

- The tipping area and roadways shall be maintained by snow clearing in the winter and grading in the summer, and repaired as necessary
- Ditches and drainage channels shall be inspected for erosion, and repaired as necessary
- Site warning signage, which identifies the boundaries of the Solid Waste Management Facility (which includes the landfill, Hazardous Waste Storage Area, and the Bulky Metals Area) shall be inspected, and repaired or replaced as necessary
- Any airborne litter outside of the litter-control fences (which are located on top of the berms) shall be removed, and deposited in the landfill
- Litter that has accumulated against the fences shall be removed and placed into the landfill
- After rain events and following the spring thaw, the site shall be inspected for leachate breakout. If leachate breakouts are identified, cover the waste face where leachate is seeping if possible and ensure that leachate is being contained
- Control leachate through effective ditching and drainage control
- The berms and final cover at the landfill shall be inspected for erosion and settlement
- The fences shall be inspected for damage, and repaired as necessary. Inspection results and maintenance conducted shall be reported in the Annual Report. Staff will place hazardous materials, such as oil or solvents into drums located in the Hazardous Waste Disposal Area. Materials should be left in their original container and placed into the drums, sorted according to contents (i.e., waste oils stored with oils, solvents with solvents, cleaners with cleaners).

3.6 Health and Safety

Health and safety of the public and site staff is to be considered the first priority all the times. Site staff must conduct their jobs on site safely and in accordance with the Nunavut Safety Act. Close attention should be given to the unique hazards of this site including:

- Scavenging bears and other wildlife
- Open burning
- Moving equipment
- Adverse weather conditions
- Hazardous materials.

Staff must be aware of these issues and operate the site in a manner that protects other staff and the public. Complaints from the public should be recorded and reported to the Public Works Supervisor. Complaints and the responses to complaints should be documented in the Annual Report for the site.

3.7 Special Wastes

On occasion, the Hamlet may be faced with a waste material of an unusual nature (contaminated soil, ship ballast, sand blasting waste, etc.). Since the landfill is designed and licensed to accept only municipal waste, an assessment process is followed to determine if the special waste is suitable for disposal at the facility. As a general protocol, any solid material which meets the Canadian Environmental Quality Guidelines for Soil Industrial Land Use Criteria is likely acceptable. If the material cannot be sampled and tested in this fashion, outside expertise should be brought in to make an evaluation and recommendation to the Hamlet. When in doubt, the safest practice is to:

- Not accept the material
- Store it in the Hazardous Waste Storage Area
- Designate special location in the waste disposal area for storage until a final decision as to its final disposal can be made.

3.8 Site Closure and Restoration

There is available land around the proposed landfill location (Figure 1) which may permit site expansion and continued use beyond the current design. This will require a design modification and a NWB License amendment. Closure will include:

- Creation of an Abandonment and Restoration Plan at least two years prior to closure, for which a new submission for a water license amendment will be required
- Long term monitoring
- Surficial inspections and cover maintenance as required

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- Restoration of the surface to match the surrounding natural tundra.

Figure 2 displays the location of a proposed new landfill site.

3.9 Reuse Recycle

A reuse/recycle area has been established in the Bulky Metals Area. The Bulky Metals Area is used to segregate materials for landfilling and materials that may have future use. The Bulky Metals Area must be kept neat and organized for safety (i.e. do not pile up vehicles). It must be expected the public will access this area, so signage and regular separation of materials will assist in reuse of materials.

Hazardous waste such as waste oil, paint and batteries are separated from the garbage and placed in the Hazardous Waste Storage Area.

3.10 Landfarm

Approximately 750 m³ of hydrocarbon (diesel) impacted soil from the NWT Power Corporation tank farm, was reportedly placed at Bulky Metals Site for landfarming. Some of soil was spread out on the site and approximately 300 m³ remains in piles. The new landfill design for Arviat completed in May 2009 included a landfarm of sufficient size to handle this material. Construction of the new facility has been delayed awaiting Hamlet approval of the location. In the interim, the soil remains at the Bulky Metals site, which is not in compliance with regulations. There are no available reports regarding the degree of contamination or the impact to the environment. The material needs to be characterized and placed in a licensed landfarm facility for treatment. Guidelines on the siting, design, and operation of landfarms in Nunavut are included in Appendix E.

4.0 Contingency Measures

4.1 General Contingencies

Contingency plans are designed so that site operators are prepared in the event of an accident or occurrence. The contingency measures described below are generic in nature since they must address a wide variety of issues.

4.2 Environmental Emergency Contingency Plan

A separate document entitled Environmental Emergency Contingency Plan, Hamlet of Arviat, has been prepared as part of a submission for renewal of the NWB license. Refer to that document for the response to spills and environmental contingencies.

4.3 Injuries

In the event of an injury to workers or members of the public:

- Apply first aid
- Seek medical assistance, if necessary
- Report the injury to the supervisor
- Document the incident and all response measures on the Weekly Waste Management Facility Inspection Form (Appendix B).

4.4 Fires

In the event of a fire, assess the situation. Do not attempt to fight a fire if it cannot be done safely. Standard fire fighting equipment that can manage most small fires should be available in a shed near the Hazardous Waste Storage area. Alternatively, cover soils can be thrown onto the fire either by hand, or by using available equipment (i.e. bulldozer). Obtain help as necessary. Document the incident and all response measures on the Weekly Site Inspection Form and Supplementary Site Inspection Form (Appendix C).

4.5 Erosion

Erosion may become a problem if runoff rates exceed expectations or cover soils and vegetation are not well established. The preferred contingency measure for this is to repair the area of erosion with available materials and cover with cobbles, blast rock, or other stabilizing materials.

4.6 Accumulation of Impacted Water

At some point, for a variety of reasons, impacted water may accumulate in the landfill, Hazardous Waste Storage Area, or the Bulky Metals area.

The water may or may not be impacted by leachate, hazardous wastes or contaminants from land farmed soil. Given the climate, this is not anticipated to be a significant problem; however, in the event this occurs, the following procedures will be followed:

- Collect samples as outlined in the Environmental Monitoring Program and QA/QC
- Plan (separate document)
- It is recognized that it may take some time for results to be received from the accredited laboratory
- Analyze samples for parameters of concern and compare the results to the relevant Canadian Water Quality Guidelines
- If waiting for analytical results and the water retention area fills to the top of the culvert, it should be inspected for odours, stain, or signs of visible impact (sheens, floating scum). The culvert may be blocked to facilitate additional water accumulation, until the sampling results are received
- Dispose of the water. Disposal options are dependent on the water quality and could include: Transportation and disposal in the sewage lagoon— direct discharge to the environment is discouraged. Pre-treatment (filter, chemical, etc.) prior to discharge to the sewage lagoon. Containment and storage if deemed to be hazardous waste. Direct discharge, if sampling results indicate no exceedances of discharge criteria Pre-treatment (filter, chemical, etc.) prior to direct discharge providing the discharge meets the water quality guidelines.

5.0 Solid Waste Management Facility Monitoring Procedures

As outlined in the NWB water license, regular monitoring of runoff from the Solid Waste Management Facility is required. Refer to the monitoring program, as described in the Environmental Monitoring Program and QA/QC Plan (Nuna Burnside 2009, revised 2010). Results of analytical testing and monitoring are to be recorded on a regular basis by the staff. Copies of the Certificates of Analysis and Chain of Custody forms are to be kept for future reference. Monthly and annual quantities of solid waste offloaded will be estimated and recorded on the Waste Placement Form (Appendix C).

Monitoring Station ARV-2 is located in the southeast corner of the site in a low area, to monitor discharge towards the ocean and the abandoned sewage lagoon to the east.

No recent monitoring data is available regarding the impact of the landfill site, bulk metals area, or the hazardous waste storage area next to the Hamlet garage, other than that recorded in the 2008 and 2009 INAC inspection reports. The INAC reports document a wide range of compliance issues.

6.0 Reporting

The Nunavut Water Board License, Part B: General Conditions, includes the requirement to file an Annual Report with the NWB no later than March 31st of the year following the calendar year reported, which shall include:

- Tabular summaries of all data generated under the “Monitoring Program”
- The monthly and annual quantities in cubic metres of fresh water obtained from all sources
- The monthly and annual quantities in cubic metres of each and all waste discharged
- A summary of modifications and/or major maintenance work carried out on the Water Supply and Waste Disposal Facilities, including all associated structures and facilities
- A list of unauthorized discharges and summary of follow-up action taken
- A summary of any abandonment and restoration work completed during the year and an outline of any work anticipated for the next year
- A summary of any studies, reports and plans (i.e. Operation and Maintenance, Abandonment and Restoration, QA/QC) requested by the Board that relate to waste disposal, water use or reclamation, and a brief description of any future studies planned
- Any other details on water use or waste disposal requested by the Board by November 1st of the year being reported
- The format of the NWB Annual Report is included in Appendix D
- The creation of the report can be greatly simplified by regularly filling out the Site Forms included in Appendix D. The forms include:
 - Form 1, Waste Placement Form — describing the day to day delivery of waste and site activities
 - Form 2, Weekly Waste Management Facility Inspection Form, to document the weekly inspection and observation of the site operation and infrastructure
 - Form 3, Solid Waste Management Facility Planning Form — which provides a list of items to be discussed by the Public Works Supervisor, SAD, and Hamlet Council related to short term and long term solid waste decision making. In addition to these forms, there would be sampling information and analytical data. Using the forms and following the procedures provided herein should make submitting the NWB Annual Report relatively straight forward.

7.0 Summary

7.1 Overview

This Operation and Maintenance Plan has been prepared for the Hamlet of Arviat, to assist Hamlet staff to operate the Solid Waste Management Facility as safely and effectively as possible, based on the current design and layout of the site. Safety of staff and the public is the first priority at all times. The landfill was sited, designed, and constructed prior to the preparation of this O&M Plan. There is no record of an O&M Plan prepared by the original designer or constructor, and there is no documentation available indicating how they planned the facility to operate. This O&M Plan has been prepared to maximize the use of the site in the most safe and environmentally sound manner as possible.

A Solid Waste Planning form has been included in Appendix C, to allow the Hamlet to track and evaluate the various aspects of their Solid Waste Management Facility. The form is designed to be used by the Public Works Supervisor/Site Foreman and Hamlet Council, when evaluating and planning solid waste management over both the short term (1 to 5 years), as the plan is to close the site as soon as the new site is operational. It will assist in identifying issues and developing the strategies and budgets to deal with them. The Operation and Maintenance Plan has been prepared to allow operational flexibility, so site staff can maximize efficiency with the changing seasons and available equipment. Appropriate training for site staff is necessary as part of the implementation of this O&M Plan. This document should be reviewed and updated annually, and whenever the NWB Water License is amended or new relevant legislation is issued.

This O&M Plan recognizes that the current hazardous waste storage area is out of compliance with regulations, and requires immediate attention and the creation of an interim facility until the new landfill site is constructed and licensed. Ideally, all of the stockpiled hazardous materials should be shipped out of the community during the summer.

7.2 Outstanding Issues

A new Solid Waste Management Facility was designed for the Hamlet of Arviat in May 2009 by Nuna Burnside. To date, the Hamlet has not reached a decision on the location of a new facility.

The new facility was designed to operate in compliance with regulations and NWB license requirements. Currently the landfill, bulky metals area, and hazardous waste storage area are not in compliance. The O&M Plan outlined herein, is a “best efforts plan” to work with the current facilities until a new facility is constructed.

Solid Waste Management Facility
Operation and Maintenance (O&M) Plan

January 2009
Revised May 2010

The following items have been identified by regulatory agencies and documented in the Compilation of Issues during the Technical Meeting/Pre-Hearing Conference in March 2010:

- As-built plans for the bulky waste and hazardous waste storage area
- O&M Plan for the interim management of facilities
- Environmental assessment of the soil, surface water, and shallow groundwater in the active layer
- Lack of monitoring and reporting.

In the areas of the landfill, bulky metals, and hazardous waste storage:

- Evaluating and addressing the storage of contaminated soil at the bulky metals area
- Future method and process of disposal of sewage sludge
- Control and management of leachate discharge from the landfill bulky metals and hazardous waste storage areas
- Development and management of a landfarm to handle stockpiled hydrocarbon contained soil
- Abandonment and restoration plans
- As-built (or currently constructed) plans
- Burning control as per GN-DOE policy document “Municipal Solid Wastes Suitable for Open Burning”
- Adding a landfarm facility to the NWB license to handle hydrocarbon impacted soil.

It is recognized that there is significant work required, including studies, engineering, and training to bring the Solid Waste Management Facility into compliance. A New Solid Waste Management Facility design was completed in the May of 2009, however the Hamlet has not confirmed a location. It is suggested that the non-compliance items be included as “Conditions” in the new license, with study/reporting requirements due by December 31, 2010, which would include a timetable to bring all aspects into compliance during the first year or two of the license.

8.0 Reference Documents

The following documents provide a resource of information to deal with specific issues:

- Canadian Council of Ministers of the Environment (CCME), 2007. Canadian Water Quality Guidelines for the Protection of Aquatic Life: Summary table. Updated September, 2007. In: Canadian environmental quality guidelines, 1999, Canadian Council of the Environment, Winnipeg
- Guidelines for the Planning, Design, Operations, and Maintenance of Modified Solid Waste Sites in the Northwest Territories, prepared by Northwest Territories, Municipal and Community Affairs
- Consolidation of General Sanitation Regulations under the Public Health Act
- Nunavut Safety Act
- Nunavut Waters and Nunavut Rights Tribunal Act.

The following guidelines prepared by the Department of Sustainable Development:

- Development: General Management of Hazardous Waste
- Environmental Guidelines for Waste Antifreeze
- Guidelines for Dust Suppression
- Environmental Guideline for Industrial Waste Discharges
- Environmental Guidelines for Ozone Depleting Substances
- Environmental Guidelines for Waste Asbestos
- Environmental Guidelines for Waste Batteries
- Environmental Guidelines for Waste Paint
- Environmental Guidelines for Waste Solvent.

The following policies prepared by the Government of Nunavut:

- Waste Lead (Draft), Policies Regarding Open Burning
- Management of Fluorescent Lamp Tubes
- Spill Contingency Planning and Reporting Regulations, Government of the Northwest Territories, 1998
- Municipal Solid Wastes Suitable for Open Burning
- Environmental Guideline for General Management of Hazardous Waste.

Hamlet specific documents include:

- The amended Nunavut Water Board License which may have additional specific requirements
- Environmental Emergency Contingency Plan, Hamlet of Arviat, Nuna Burnside Engineering and Environmental Ltd. (May 2008, revised May 2010)

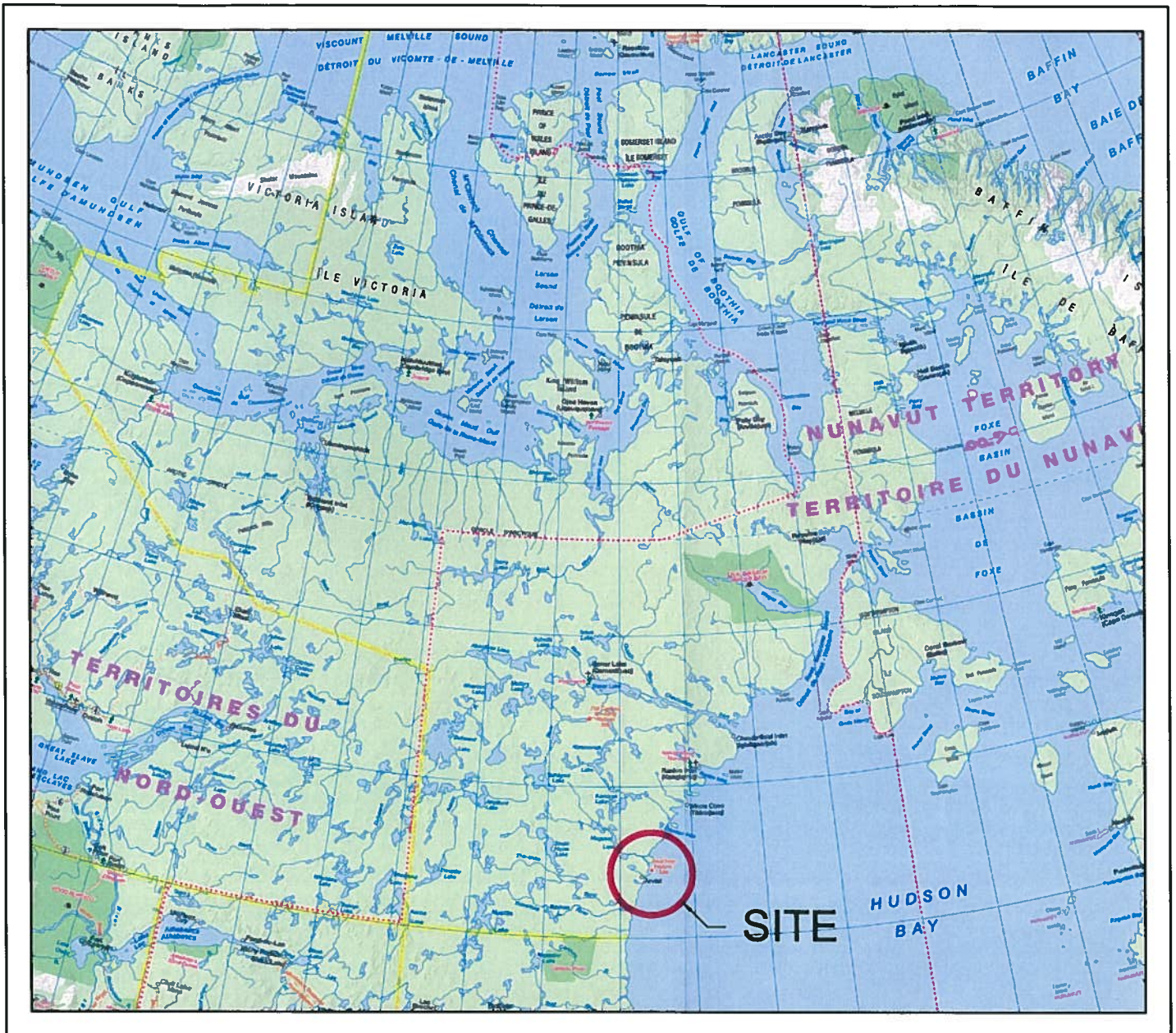
Solid Waste Management Facility
Operation and Maintenance (O&M) Plan

January 2009
Revised May 2010

- Monitoring Program and QA/QC Plan, Hamlet of Arviat, Nuna Burnside Engineering and Environmental Ltd. (May 2008, revised May 2010)
- Canadian Climate Data 1985-2007, Arviat A Weather Station, Environment Canada.



Figures



Map Reference:
Map Art Publishing

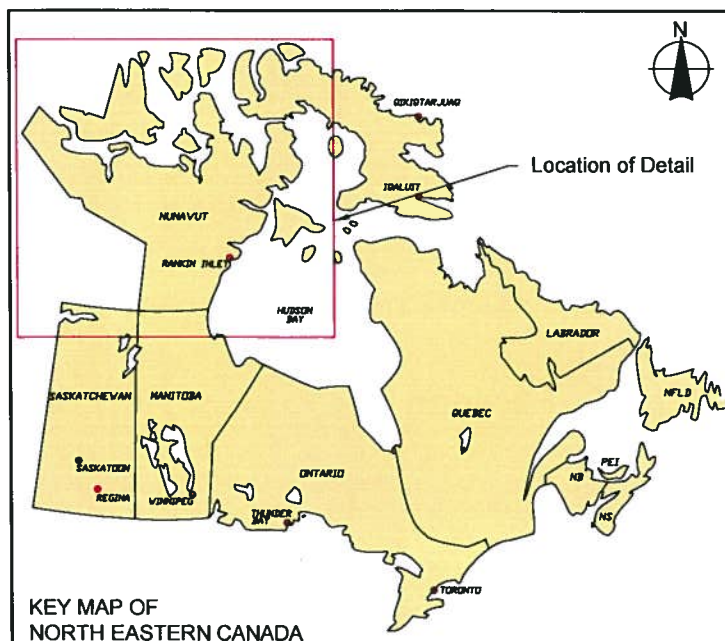


FIGURE 1 - SITE LOCATION MAP

HAMLET OF ARVIAT HAMLET OF ARVIAT, NUNAVUT

SOLID WASTE FACILITY OPERATIONS & MAINTENANCE PLAN

May 2009

Project Number: N-O15746

Prepared by: C. Sheppard

Verified by: J. Walls

burnside

N-O15746 EXISTING SWF O&M PLAN SL.dwg

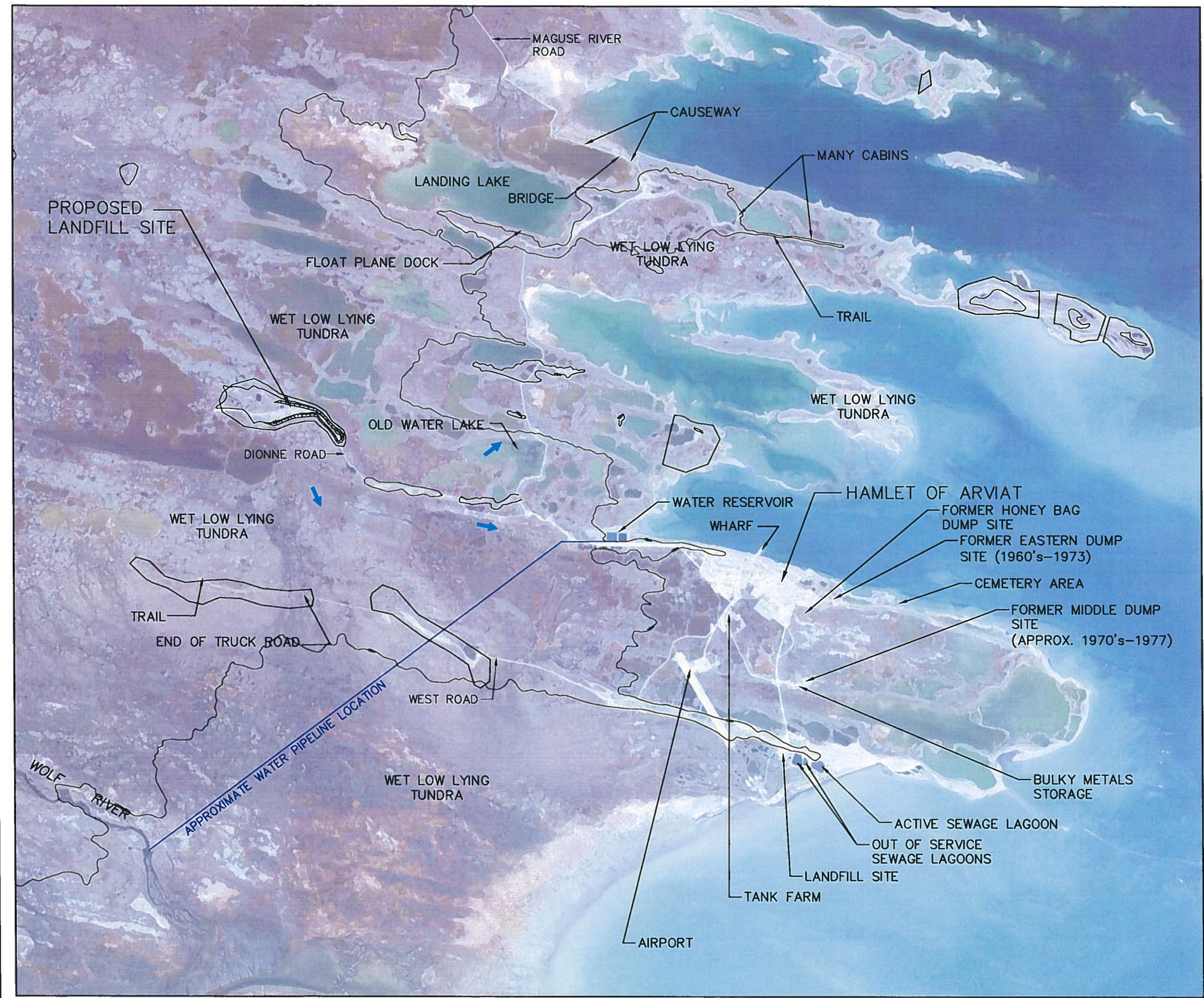


FIGURE 2
HAMLET OF ARVIAT
HAMLET OF ARVIAT, NUNAVUT
SOLID WASTE MANAGEMENT FACILITY O&M PLAN

COMMUNITY PLAN

Satellite Image Source:
Background colour satellite image obtained from Google Earth Pro.

Map Source:
Background physical features obtained from the National Topographic Database Website.

0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
Kilometres

1:50,000
May 2009
Project Number: N-015746
Prepared by: C. Sheppard

Projection: UTM Zone 15
Datum: NAD83
Verified by: J. Walls





FIGURE 3
HAMLET OF ARVIAT
HAMLET OF ARVIAT, NUNAVUT
SOLID WASTE MANAGEMENT FACILITY O&M PLAN

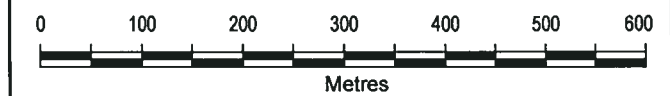
SOLID WASTE MANAGEMENT FACILITY

LEGEND

➡ INTERPRETED SURFACE WATER FLOW DIRECTION

Satellite Image Source:
Background colour satellite image obtained from Google Earth Pro.

Map Source:
Background physical features obtained from the National Topographic Database Website.



1:7,500
May 2009
Project Number: N-015746
Prepared by: C. Sheppard
Projection: UTM Zone 15
Datum: NAD83
Verified by: J. Walls



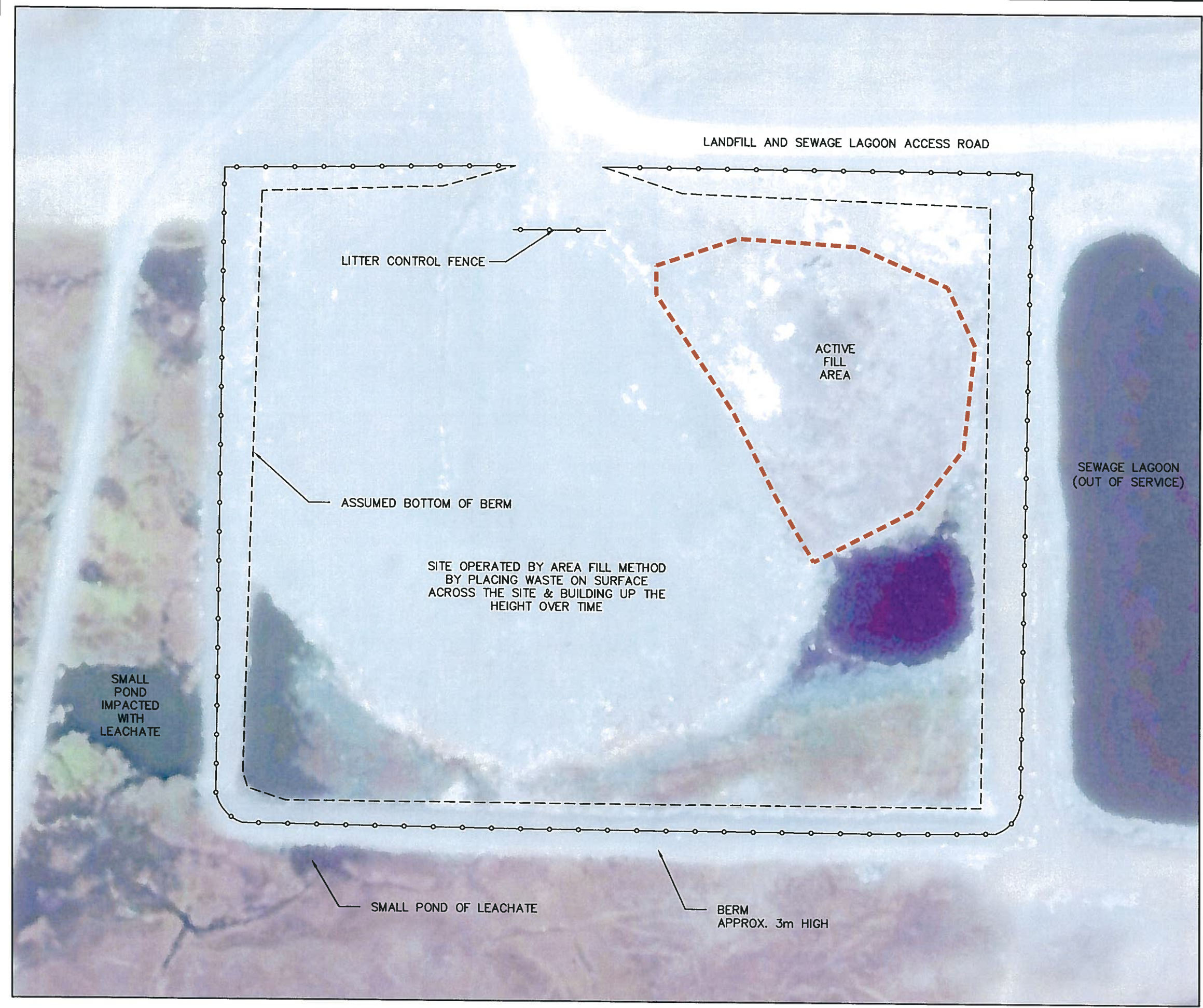


FIGURE 4

HAMLET OF ARVIAT
 HAMLET OF ARVIAT, NUNAVUT
 SOLID WASTE MANAGEMENT FACILITY O&M PLAN

EXISTING SITE
 CONDITIONS - FALL 2008

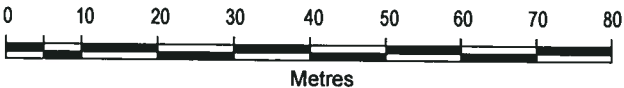
LEGEND

—○—○—○— APPROXIMATE LOCATION OF CHAIN LINK FENCE

Notes

- No Design or As Built drawings available
- No previous Operations & Development Plan available
- Site in use from approximately 1977
- Internal area approximately 28,423 m²
- Based on 2m of waste disposal depth, Landfill capacity is approximately 56,846 m³

Satellite Image Source:
 Background air photo obtained from Google Earth Pro.



1:1,000
 June 2009
 Project Number: PIO15746
 Prepared by: C. Sheppard
 Projection: UTM Zone 15
 Datum: NAD83
 Verified by: J. Walls

ᑎᓂᓂᓂᓂ **BURNSIDE**



Appendix A

Nunavut Water Board License



P.O. Box 119
GJOA HAVEN, NU X0B 1J0
TEL: (867) 360-6338
FAX: (867) 360-6369

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NUNAVUT WATER BOARD
NUNAVUT IMALIRIYIN KATTMAYINGI

DECISION

LICENCE NUMBER: NWB3ARV0308

This is the decision of the Nunavut Water Board (NWB) with respect to an application for a Licence dated September 2, 2003, made by:

Hamlet of Arviat

to allow for the use of water and disposal of waste by the Hamlet of Arviat, Nunavut. With respect to this application, the NWB gave notice to the public that the Hamlet had filed an application for a water licence.

DECISION

After having been satisfied that the application was exempt from the requirement for screening by the Nunavut Impact Review Board in accordance with S. 12.3.2 of the *Nunavut Land Claim Agreement* (NLCA), the NWB decided that the application could proceed through the regulatory process. After reviewing the submission of the Applicant and written comments expressed by interested parties, the NWB, having given due regard to the facts and circumstances, the merits of the submissions made to it and to the purpose, scope and intent of the *Nunavut Land Claims Agreement* and of the *Nunavut Waters and Nunavut Surface Rights Tribunal Act* (NWNSRTA), decided to waive the requirement to hold a public hearing and furthermore to delegate its authority to approve the application to the Chief Administrative Officer pursuant to S. 49(a) of the NWNSRTA and determined that:

Licence Number NWB3ARV0308 be issued subject to the terms and conditions contained therein. (Motion #: 2003-39)

SIGNED this 9th day of January 2004 at Gjoa Haven, NU.



Philippe di Pizzo
Chief Administrative Officer

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I. BACKGROUND

The Hamlet of Arviat is located on the northern shore of a peninsula on the west coast of Hudson Bay. Arviat is located at 61°05' N and 94° 00'W, and is 241 km southwest of Rankin Inlet and 265 air km north of Churchill, Manitoba. The topography of Arviat, which is located on a low and narrow coastal strip, is characterized by low topographic variations, occasional bedrock outcrops and a thick mantle of glacio- fluvial debris. Features include till, fine- grained marine deposits, and extensive beaches. The permafrost is continuous, extending to depths from 30 m to over 100 m. The active layer varies between 0.5 m and 0.3 m. Numerous ponds and lakes are present in the vicinity of the Hamlet, making drainage difficult. The average annual precipitation in Arviat consists of 16 cm of rainfall and 118 cm of snowfall. The mean high in July is 13.1 degrees with a mean low of 4.5 degrees. In January, the mean high is -27.9 degrees and a mean low of -35.0 degrees. The predominant local vegetation consists of mosses and lichens on rocky outcrops, with hardy grasses and sages in swampy and/or more sheltered areas.

II. PROCEDURAL HISTORY

On September 2, 2003, an application for a water licence was filed by the Hamlet of Arviat, which was previously un-licensed by the NWB. The Nunavut Water Board publicly posted notice of this application, in accordance with the *Nunavut Waters and Nunavut Surface Rights Tribunal Act* S.55.1 and Article 13 of the *Nunavut Land Claims Agreement*, on October 7, 2003. An assessment of the Hamlet's request for a municipal water licence for water use and waste disposal activities within the Hamlet was then undertaken, so that the Board could make a fully informed decision on the merits of application. This assessment process included the referral of the application to a variety of Federal, Territorial and local organizations for their review and comment. As no public concern was expressed, the NWB waived the requirement to hold a public hearing for the application.

Based upon the results of the detailed assessment, which was completed, including consideration of any potential accidents, malfunctions, or cumulative environmental effects that the overall project might have in the area, the Board delegated to the Chief Administrative Officer authority to approve the application pursuant to S. 13.7.5 of the *Agreement*.

III. ISSUES

Term of the Licence

In accordance with the *Nunavut Waters and Nunavut Surface Rights Tribunal Act* S. 45, the NWB may issue a licence for a term not exceeding twenty-five years. In determining an appropriate term of a water licence, the Board considers a number of factors, including the results of the annual Department of Indian Affairs and Northern Development (DIAND) site inspection and the

compliance record of the Applicant. Specifically, the August 12, 2002 DIAND Inspection Report indicated:

1. The lagoon currently in operation does not have sufficient freeboard, and capacity should be increased;
2. Concentrations of ammonia exceeded the levels recommended in the *Canadian Guidelines for the Protection of Freshwater Aquatic Life*; and
3. Levels of Total Suspended Solids and BOD exceeded the *Municipal Wastewater Effluent Quality Guidelines*.

The NWB has imposed the requirement to produce an Annual Report. These Reports are for the purpose of ensuring that the NWB has an accurate annual update of municipal activities during a calendar year. This information is maintained on the public registry and is available to any interested parties upon request. The Licensee's attention is drawn to the attached standard form for completing the Annual Report (see Attachment I).

The NWB has also imposed on the Licensee the requirement to produce an Operations and Maintenance Manual for their sewage and solid waste operations. The purpose of an Operation and Maintenance Manual is to assist Hamlet staff in the proper operation and maintenance of their waste disposal facilities. The manual should demonstrate to the Nunavut Water Board that the Hamlet is capable of operating and maintaining all waste disposal sites adequately. The Plan should be completed using the *Guidelines for the Preparation of an Operations and Maintenance Manual for Sewage and Solid Waste Disposal Facilities in the Northwest Territories* (Duong and Kent, 1996; see Attachment II). Additionally, the Plan shall address the operational issues identified at the Sewage Disposal Facility in the July 11, 2002 DIAND Inspection Report

The NWB believes that a term of five (5) years is appropriate, and will allow enough time for the Hamlet to establish a consistent compliance record with the terms and conditions of its licence. It will also ensure that sufficient time is given to permit the Licensee to develop, submit, and implement the plans required under its licence to the satisfaction of the NWB.

Water Use

The Municipality currently receives water from the Wolf Creek water supply located 8.0 km southwest of the Hamlet. Water is stored in a 57,000 m³, 2-cell reservoir located 1.5 km west of the Hamlet, adjacent to the truck fill station. The water receives a chlorine treatment and is then distributed to the community by truck. Water requirements for 2003 were reported as 64,871 m³. Demand for 2008 was not reported in application. Utilizing the water demand formula developed by the Department of Municipal and Community Affairs (Government of the Northwest Territories), projected demand requirements for 2008 was calculated at 78,273 m³.

No concerns were expressed by the parties in their written submissions as to the amount of water required by the Applicant or the manner in which this water will be used. Based upon the projected requirements of the Hamlet, the Board has set the terms and conditions in the water licence, which govern water usage. Accordingly, and based upon the projected requirements of the Hamlet, the Board has set the terms and conditions in the water licence, which govern water usage and which are contained herein. The maximum permitted usage of water by the Hamlet of Arviat, over the term of the water license and for all purposes, has been set at 81,000 m³ *per annum*.

Deposit of Waste

Sewage

The Hamlet of Arviat utilizes a Sewage Disposal Facility approximately 2.8 km southeast of the Municipality. This Sewage Disposal Facility is located in an area adjacent to the Solid Waste Disposal Facility, and consists of a 55,000 m³ single-cell exfiltration lagoon. The effluent from this lagoon proceeds downstream to the marine environment through an undefined, natural wetland along a 200 m flow path prior to entering Hudson Bay.

Specific comments relevant to sewage disposal operations in the Hamlet were provided by DIAND, and Environment Canada. DIAND and Environment Canada recommended that the Hamlet develop appropriate Operations and Maintenance and Spill Contingency Plans. DIAND and Environment Canada further recommended that the Hamlet take steps to remedy capacity and effluent quality issues currently evidenced at the Sewage Disposal Facility.

Additionally, DIAND provided recommendations concerning effluent discharge criteria, which are consistent with the *Guidelines for the Discharge of Treated Municipal Wastewater in the Northwest Territories* (Northwest Territories Water Board; 1992), as well as specific recommendations concerning the Monitoring Program. This Program is established to collect data on water quality to assess the effectiveness of treatment for protection of public health and to assess potential impacts to the environment associated with the municipal facilities. The Board concurs with these recommendations, which are reflected in the terms and conditions of the Water Licence. The Board also draws the attention of the Licensee to their requirements to implement the Quality Assurance/Quality Control (QA/QC) Plan to be provided by the NWB. The purpose of the QA/QC Plan is to ensure that samples taken in the field as part of the Monitoring Program will maintain a high quality, so as to accurately represent the physical and chemical nature of the samples being taken. It should also be noted that while minimum sampling requirements have been imposed, additional sampling may be requested by an Inspector.

Solid Waste

The Hamlet's solid waste management site is located adjacent to the Sewage Disposal system, approximately 2.8 km southeast of the community. Waste is segregated, with a generic landfill area,

a bulky wastes area, and an area segregated for hazardous wastes. Combustible wastes are burned regularly, and the landfill is compacted and covered annually.

Recommendations relevant to solid waste disposal operations in the Hamlet were provided by DIAND, DFO and Environment Canada. DIAND and Environment Canada recommended that the Hamlet develop appropriate Operations and Maintenance and Spill Contingency Plans. DIAND further recommended that the Hamlet segregate hazardous materials such as waste oils and batteries from municipal solid waste, and that these materials be disposed of off-site in an approved facility. DIAND, Environment Canada and DFO recommended the appropriate management of waste oil at the solid waste site, so as to prevent the deposition of hydrocarbons into water in contravention of the *Fisheries Act*. The Board concurs with these recommendations, which are reflected in the terms and conditions of the Water Licence.

LICENCE NWB3ARV0308

Pursuant to the *Nunavut Waters and Nunavut Surface Rights Tribunal Act* and the *Agreement Between the Inuit of the Nunavut Settlement Area and Her Majesty the Queen in Right of Canada*, the Nunavut Water Board, hereinafter referred to as the Board, hereby grants to

HAMLET OF ARVIAT

(Licensee)

of

ARVIAT, NUNAVUT, X0A 0J0

(Mailing Address)

hereinafter called the Licensee, the right to alter, divert or otherwise use water for a period subject to restrictions and conditions contained within this licence:

NWB3ARV0308

Licence Number

NUNAVUT 06

Water Management Area

ARVIAT, NUNAVUT

Location

WATER USE AND WASTE DISPOSAL

Purpose

MUNICIPAL UNDERTAKINGS

Description

81,000 CUBIC METRES ANNUALLY

Quantity of Water Not to be Exceeded

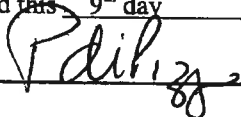
JANUARY 9, 2004

Date of Licence

DECEMBER 31, 2008

Expiry Date of Licence

Dated this 9th day of January 2004 at Gjoa Haven, NU.



Philippe di Pizzo
Chief Administrative Officer

Philippe di Pizzo
Chief Administrative Officer

PART A: SCOPE AND DEFINITIONS

1. Scope

- a. This Licence allows for the use of water and the disposal of waste for municipal undertakings at the Hamlet of Arviat, Nunavut (63°21' N; 90° 42'W);
- b. This Licence is issued subject to the conditions contained herein with respect to the taking of water and the depositing of waste of any type in any waters or in any place under any conditions where such waste or any other waste that results from the deposits of such waste may enter any waters. Whenever new Regulations are made or existing Regulations are amended by the Governor in Council under the *Nunavut Waters and Nunavut Surface Rights Tribunal Act*, or other statutes imposing more stringent conditions relating to the quantity or type of waste that may be so deposited or under which any such waste may be so deposited, this Licence shall be deemed, upon promulgation of such Regulations, to be subject to such requirements; and;
- c. Compliance with the terms and conditions of this Licence does not absolve the Licensee from responsibility for compliance with the requirements of all applicable Federal, Territorial and Municipal legislation.

2. Definitions

In this Licence: **NWB3ARV0308**

“Act” means the *Nunavut Waters and Nunavut Surface Rights Tribunal Act*;

“Amendment” means a change to original terms and conditions of this licence requiring correction, addition or deletion of specific terms and conditions of the licence; modifications inconsistent with the terms of the set terms and conditions of the Licence;

“Analyst” means an Analyst designated by the Minister under Section 85 (1) of the *Act*;

“Appurtenant undertaking” means an undertaking in relation to which a use of waters or a deposit of waste is permitted by a licence issued by the Board;

“Average Concentration” means the arithmetic mean of the last four consecutive analytical results for contained in composite or grab samples collected from the Waste Disposal Facility’s final discharge point;

“Average Concentration For Faecal Coliforms” means the geometric mean of the last four consecutive analytical results for faecal coliforms contained in composite or grab samples collected from the Waste Disposal Facility’s final discharge point;

“Board” means the Nunavut Water Board established under the *Nunavut Land Claims Agreement*;

“Chief Administrative Officer” means the Executive Director of the Nunavut Water Board;

“Commercial Waste Water” means water and associated waste generated by the operation of a commercial enterprise, but does not include toilet wastes or greywater;

“Composite Sample” means a water or wastewater sample made up of four (4) samples taken at regular periods over a 24 hour period;

“Effluent” means treated or untreated liquid waste material that is discharged into the environment from a structure such as a settling pond or a treatment plant;

“Final Discharge Point” means an identifiable discharge point of a Waste Disposal Facility beyond which the Licensee no longer exercises care and control over the quality of the Effluent;

“Freeboard” means the vertical distance between water line and crest on a dam or dyke’s upstream slope;

“Grab Sample” means a single water or wastewater sample taken at a time and place representative of the total discharge;

“Greywater” means all liquid wastes from showers, baths, sinks, kitchens and domestic washing facilities, but does not include toilet wastes;

“Inspector” means an Inspector designated by the Minister under Section 85 (1) of the *Act*;

“Licensee” means the holder of this Licence;

“Modification” means an alteration to a physical work that introduces new structure or eliminates an existing structure and does not alter the purpose or function of the work, but does not include an expansion, and changes to the operating system that are consistent with the terms of this Licence and do not require amendment;

“Monitoring Program” means a monitoring program established to collect data on surface water and groundwater quality to assess impacts to the freshwater aquatic environment of an appurtenant undertaking;

“Nunavut Land Claims Agreement” (NLCA) means the *“Agreement Between the Inuit of the Nunavut Settlement Area and Her Majesty the Queen in right of Canada”*, including its preamble and schedules, and any amendments to that agreement made pursuant to it;

“Sewage” means all toilet wastes and greywater;

“Sewage Disposal Facilities” comprises the area and engineered lagoon and decant structures designed to contain and treat sewage as described in the Application for Water Licence filed by the Applicant on September 2, 2003 and illustrated in Drawing # 2003-0440-04/1-3;

“Solid Waste Disposal Facilities” comprises the area and associated structures designed to contain solid waste as described in the Application for Water Licence filed by the Applicant on September 2, 2003 and illustrated in Drawing # 2003-08-26;

“Toilet Wastes” means all human excreta and associated products, but does not include greywater;

“Waste” means, as defined in S.4 of the *Act*, any substance that, by itself or in combination with other substances found in water, would have the effect of altering the quality of any water to which the substance is added to an extent that is detrimental to its use by people or by any animal, fish or plant, or any water that would have that effect because of the quantity or concentration of the substances contained in it or because it has been treated or changed, by heat or other means;

“Waste Disposal Facilities” means all facilities designated for the disposal of waste, and includes the Sewage Disposal Facilities and Solid Waste Disposal Facilities, as described in the Application for Water Licence filed by the Applicant on September 2, 2003 and illustrated in Drawing # 2003-0440-04/1-3; and

“Water Supply Facilities” comprises the area and associated intake infrastructure at the Wolf Creek Water Supply, as described in the Application for Water Licence filed by the Applicant on September 2, 2003 and illustrated in Drawing # 1998-08-24/2.

PART B: GENERAL CONDITIONS

1. The Licensee shall file an Annual Report with the Board not later than March 31st of the year following the calendar year reported which shall contain the following information:

- i. tabular summaries of all data generated under the "Monitoring Program";
 - ii. the monthly and annual quantities in cubic metres of fresh water obtained from all sources;
 - iii. the monthly and annual quantities in cubic metres of each and all waste discharged;
 - iv. a summary of modifications and/or major maintenance work carried out on the Water Supply and Waste Disposal Facilities, including all associated structures and facilities;
 - v. a list of unauthorized discharges and summary of follow-up action taken;
 - vi. a summary of any abandonment and restoration work completed during the year and an outline of any work anticipated for the next year;
 - vii. a summary of any studies, reports and plans (e.g., Operation and Maintenance, Abandonment and Restoration, QA/QC) requested by the Board that relate to waste disposal, water use or reclamation, and a brief description of any future studies planned;
 - viii. any other details on water use or waste disposal requested by the Board by November 1st of the year being reported; and
2. The Licensee shall comply with the "Monitoring Program" described in this Licence, and any amendments to the "Monitoring Program" as may be made from time to time, pursuant to the conditions of this Licence.
 3. The "Monitoring Program" and compliance dates specified in the Licence may be modified at the discretion of the Board.
 4. Meters, devices or other such methods used for measuring the volumes of water used and waste discharged shall be installed, operated and maintained by the Licensee to the satisfaction of an Inspector.
 5. The Licensee shall, within ninety (90) days after the first visit of the Inspector, post the necessary signs, where possible, to identify the stations of the "Monitoring Program." All signage postings shall be in the Official Languages of Nunavut, and shall be located and maintained to the satisfaction of an Inspector.

6. The Licensee shall immediately report to the 24-Hour Spill Report Line (867-920-8130) any spills of Waste, which are reported to or observed by the Licensee, within the municipal boundaries or in the areas of the Water Supply or Waste Disposal Facilities.
7. The Licensee shall ensure a copy of this Licence is maintained at the municipal office at all times.
8. Any communication with respect to this Licence shall be made in writing to the attention of:

(i) Chief Administrative Officer:

Executive Director
Nunavut Water Board
P.O. Box 119
Gjoa Haven, NU X0B 1J0
Telephone: (867) 360-6338
Fax: (867) 360-6369

(ii) Inspector Contact:

Water Resources Officer
Nunavut District, Nunavut Region
P.O. Box 100
Iqaluit, NU X0A 0H0
Telephone: (867) 975-4298
Fax: (867) 979-6445

(iii) Analyst Contact:

Taiga Laboratories
Department of Indian and Northern Affairs
4601 - 52 Avenue, P.O. Box 1500
Yellowknife, NT X1A 2R3
Telephone: (867) 669-2781
Fax: (867) 669-2718

9. The Licensee shall submit one paper copy and one electronic copy of all reports, studies, and plans to the Board. Reports or studies submitted to the Board by the Licensee shall include a detailed executive summary in Inuktitut.

PART C: CONDITIONS APPLYING TO WATER USE

1. The Licensee shall obtain all fresh water from the Wolf Creek Water Supply using the Water Supply Facilities or as otherwise approved by the Board.
2. The annual quantity of water used for all purposes shall not exceed 81,000 cubic metres.
3. The Licensee shall maintain the Water Supply Facilities to the satisfaction of the Inspector.
4. The water intake hose used on the water pumps shall be equipped with a screen with a mesh size sufficient to ensure no entrainment of fish.

PART D: CONDITIONS APPLYING TO WASTE DISPOSAL

1. The Licensee shall direct all Sewage to the Sewage Disposal Facilities or as otherwise approved by the Board.
2. All Effluent discharged from the Sewage Disposal Facilities at Monitoring Program Station ARV-4 shall meet the following effluent quality standards:

Parameter	Maximum Average Concentration
Faecal Coliforms	1×10^4 CFU/dl
BOD ₅	80 mg/L
Total Suspended Solids	100 mg/L
Oil and grease	No visible sheen
pH	between 6 and 9

3. A Freeboard limit of 1.0 metre, or as recommended by a qualified geotechnical engineer and as approved by the Board, shall be maintained at all dams, dykes or structures intended to contain, withhold, divert or retain water or wastes.
4. The Licensee shall advise an Inspector at least ten (10) days prior to initiating any decant of the sewage lagoon.

5. The Sewage Disposal Facility shall be maintained and operated, to the satisfaction of an Inspector in such a manner as to prevent structural failure.
6. The Licensee shall dispose of and contain all solid wastes at the Solid Waste Disposal Facilities or as otherwise approved by the Board.
7. The Licensee shall implement measures to ensure hazardous materials and/or leachate from the Solid Waste Disposal Facility does not enter water.
8. The Licensee shall submit to the Board for review within six (6) months of the issuance of this license a report identifying each Final Discharge Point. The report shall at least include:
 - a. Plans, specifications and a general description of each Final Discharge Point together with its specific geo-referenced location;
 - b. A description of how each Final Discharge Point is designed and maintained.
9. If, during the term of this Licence, additional Final Discharge Points are identified, the Licensee shall submit the information as required by Part D, Item 8 for each new Final Discharge Point within 30 days after the discharge point is identified and at least 60 days prior to depositing Effluent from the new Final Discharge Point and/or proposed changes are made to a Final Discharge Point.

PART E: CONDITIONS APPLYING TO MODIFICATION AND CONSTRUCTION

1. The Licensee shall submit to the Board for approval design drawings stamped by a qualified engineer registered in Nunavut prior to the construction of any dams, dykes or structures intended to contain, withhold, divert or retain water or wastes.
2. The Licensee may, without written approval from the Board, carry out modifications to the Water Supply and Waste Disposal Facilities provided that such modifications are consistent with the terms of this Licence and the following requirements are met:
 - i. the Licensee has notified the Board in writing of such proposed modifications at least sixty (60) days prior to beginning the modifications;
 - ii. said modifications do not place the Licensee in contravention of the Licence or the *Act*;

- iii. the Board has not, during the sixty (60) days following notification of the proposed modifications, informed the Licensee that review of the proposal will require more than sixty (60) days; and
 - iv. the Board has not rejected the proposed modifications.
- 3. Modifications for which all of the conditions referred to in Part E, Item 1, have not been met may be carried out only with written approval from the Board.
 - 4. The Licensee shall provide as built plans/drawings of the modifications referred to in this Licence within ninety (90) days of completion of the modifications.

PART F: CONDITIONS APPLYING TO OPERATION AND MAINTENANCE

- 1. The Licensee shall, within 6 months of the issuance of this license, submit to the Board for approval, a Plan for the Operation and Maintenance of the Sewage and Solid Waste Disposal Facilities in accordance with "*Guidelines for Preparing an Operation and Maintenance Manual for Sewage and Solid Waste Disposal Facilities*" (October 1996). This Plan shall specifically address hazardous waste disposal and operational issues at the Solid Disposal Facility.
- 2. The Licensee shall implement the Plan specified in Part F, Item 1 as and when approved by the Board.
- 3. The Licensee shall revise the Plan referred to in Part F, Item 1, if not acceptable to the Board. The revised Plan shall be submitted to the Board for approval within thirty (30) days of notification of the Board decision
- 4. If, during the period of this Licence, an unauthorized discharge of waste occurs, or if such a discharge is foreseeable, the Licensee shall:
 - i. employ the appropriate contingency plan as provided for in the Operation and Maintenance Plan;
 - ii. report the incident immediately via the 24-Hour Spill Reporting Line at (867) 920-8130 and to an Inspector; and
 - iii. submit to an Inspector a detailed report on each occurrence not later than thirty (30) days after initially reporting the event.
- 5. In the absence of a contingency plan contained within an approved Operation and Maintenance Plan, and should during the period of this Licence an unauthorized discharge of

waste occur, or if such a discharge is foreseeable, the Licensee shall:

- i. take whatever steps are immediately practicable to protect human life, health and the environment;
- ii. without delay seek guidance from the Departments of Community Government and Transportation and Sustainable Development with regards to mitigation and remedial actions required to address the discharge;
- ii. report the incident immediately *via* the 24-Hour Spill Reporting Line at (867) 920-8130 and to an Inspector; and
- iii. submit to an Inspector a detailed report on each occurrence not later than thirty (30) days after initially reporting the event.

PART G: CONDITIONS APPLYING TO ABANDONMENT AND RESTORATION

1. The Licensee shall submit to the Board for approval an Abandonment and Restoration Plan at least six (6) months prior to abandoning any facilities and the construction of new facilities to replace existing ones. The Plan shall include, but not be limited to where applicable:
 - i. water intake facilities;
 - ii. the water treatment and waste disposal sites and facilities;
 - iii. petroleum and chemical storage areas;
 - iv. any site affected by waste spills;
 - v. leachate prevention;
 - vi. an implementation schedule;
 - vii. maps delineating all disturbed areas, and site facilities;
 - viii. consideration of altered drainage patterns;
 - ix. type and source of cover materials;
 - x. future area use;
 - xi. hazardous wastes; and
 - xii. a proposal identifying measures by which restoration costs will be financed by the Licensee upon abandonment.
2. The Licensee shall implement the plan specified in Part G, Item 1 as and when approved by the Board.
3. The Licensee shall revise the Plan referred to in Part G, Item 1 if not approved. The revised Plan shall be submitted to the Board for approval within thirty (30) days of receiving notification of the Board's decision.
4. The Licensee shall complete the restoration work within the time schedule specified in the Plan, or as subsequently revised and approved by the Board.

PART H: CONDITIONS APPLYING TO THE MONITORING PROGRAM

1. The Licensee shall maintain Monitoring Stations at the following locations:

<u>Monitoring Station</u>	<u>Description</u>
ARV-1	Raw water supply at the Wolf Creek Water Supply prior to treatment
ARV-2	Effluent discharge from the Final Discharge Point of the Solid Waste Disposal Facilities
ARV-3	Raw Sewage at truck offload point
ARV-4	Effluent discharge from the Final Discharge Point of the Sewage Disposal Facilities

2. The Licensee shall sample monthly at Monitoring Station ARV-2 and ARV-4 during the months of May to August, inclusive. Samples shall be analyzed for the following parameters:

BOD	Faecal Coliforms
pH	Conductivity
Total Suspended Solids	Ammonia Nitrogen
Nitrate-Nitrite	Oil and Grease (visual)
Total Phenols	Sulphate
Sodium	Potassium
Magnesium	Calcium
Total Arsenic	Total Cadmium
Total Copper	Total Chromium
Total Iron	Total Lead
Total Mercury	Total Nickel
Total Zinc	

3. The Licensee shall measure and record in cubic metres the monthly and annual quantities of water pumped from Monitoring Station ARV-1 for all purposes.
4. The Licensee shall measure and record in cubic metres the monthly and annual quantities of raw sewage offloaded from trucks at Monitoring Station ARV-3 for all purposes.

5. Additional sampling and analysis may be requested by an Inspector.
6. The Licensee shall conform to the Quality Assurance/Quality Control (QA/QC) Plan which shall be provided to the Licensee by the NWB within 120 days of the issuance of this license.
7. All sampling, sample preservation and analyses shall be conducted in accordance with methods prescribed in the current edition of *Standard Methods for the Examination of Water and Wastewater*, or by such other methods approved by the Board.
8. All analyses shall be performed in a Canadian Association of Environmental Analytical Laboratories (CAEAL) Certified Laboratory, or as otherwise approved by an Analyst.
9. The Licensee shall measure and record the annual quantities of sewage solids removed from the Sewage Disposal Facility.
10. The Licensee shall, unless otherwise requested by an Inspector, include all of the data and information required by the "Monitoring Program" in the Licensee's Annual Report, as required *per* Part B, Item 1.
11. Modifications to the Monitoring Program may be made only upon written approval of the Chief Administrative Officer.



Appendix B

Waste Quantity Calculations

Waste Quantity Calculations - Hamlet of Arviat, Nunavut

Planning Year	Calendar Year	Projected Population [people]	Annual Volume of Solid Waste [m ³]	Cumulative Volume of Solid Waste [m ³]	Annual Volume of Combustible Solid Waste [m ³]	Annual Volume of Combustible Solid Waste After Burning [m ³]	Annual Volume of Uncombustible solid waste [m ³]	Volume of Uncombustible and Combusted Solid Waste [m ³]	Annual Volume of Compacted Waste [m ³]	Annual Volume of Cover Material [m ³]	Total annual volume of compacted waste and cover material [m ³]	Cumulative Landfill Volume [m ³]
	2006	2060	11279	11279	2256	677	9023	9700	6790	1358	8148	
	2007	2095	11470	22749	2294	688	9176	9864	6905	1381	8286	
	2008	2131	11665	34414	2333	700	9332	10032	7022	1404	8427	
	2009	2167	11864	46278	2373	712	9491	10203	7142	1428	8570	
0	2010	2204	12065	58343	2413	724	9652	10376	7263	1453	8716	8614
	2011	2241	12270	70613	2454	736	9816	10552	7387	1477	8864	17478
	2012	2279	12479	83092	2496	749	9983	10732	7512	1502	9015	26493
	2013	2318	12691	95783	2538	761	10153	10914	7640	1528	9168	35661
	2014	2357	12907	108690	2581	774	10325	11100	7770	1554	9324	44985
5	2015	2397	13126	121816	2625	788	10501	11289	7902	1580	9482	54467
	2016	2438	13349	135165	2670	801	10679	11480	8036	1607	9644	64111
	2017	2480	13576	148742	2715	815	10861	11676	8173	1635	9808	73918
	2018	2522	13807	162549	2761	828	11046	11874	8312	1662	9974	83893
	2019	2565	14042	176591	2808	843	11233	12076	8453	1691	10144	94036
10	2020	2608	14281	190871	2856	857	11424	12281	8597	1719	10316	104353
	2021	2653	14523	205395	2905	871	11619	12490	8743	1749	10492	114844
	2022	2698	14770	220165	2954	886	11816	12702	8892	1778	10670	125514
	2023	2744	15021	235186	3004	901	12017	12918	9043	1809	10851	136366
	2024	2790	15277	250463	3055	917	12221	13138	9197	1839	11036	147401
15	2025	2838	15536	265999	3107	932	12429	13361	9353	1871	11223	158625
	2026	2886	15800	281800	3160	948	12640	13588	9512	1902	11414	170039
	2027	2935	16069	297869	3214	964	12855	13819	9674	1935	11608	181648
	2028	2985	16342	314211	3268	981	13074	14054	9838	1968	11806	193453
	2029	3036	16620	330831	3324	997	13296	14293	10005	2001	12006	205460
20	2030	3087	16903	347734	3381	1014	13522	14536	10175	2035	12210	217670

Notes and Assumptions:

2006 population obtained from Hamlet population and dwelling counts, Statistics Canada, www.statcan.gc.ca

1.7 % Population growth rate per annum obtained from Hamlet population and dwelling counts, Statistics Canada, www.statcan.gc.ca

0.015 m³ / cd Cold Climate Utilities Delivery Design Manual - Alaskan Communities Average

20 % of waste is combustible

30 % of combustible waste is remaining after burning

30 % decrease in volume after compaction



Appendix C

Site Forms

Form 1
Waste Placement Form
Hamlet of Arviat

Time Period			Waste Delivered by Hamlet Staff		Waste Delivered by Others	Total (m ³)	Waste Activities (i.e. burning, compacting, covering, etc.)	Staff Initials
From	To	Number of Days	Number of Loads	Estimated Quantity (m ³)	Estimated Quantity (m ³)	Volume		
Totals								

Form 2
Weekly Landfill Inspection Form
Hamlet of Arviat

Inspected By: _____ Date: _____

Wind Direction: _____ Temperature: _____

Precipitation: _____ Ground Cover: _____

Issues and Conditions	Description/Condition/Problems	Action/Maintenance Required
Health and Safety (dangers and concerns)		
Wildlife		
Entrance Road and Site Roads (condition, ditches, snow, surface, etc.)		
Signs		
Litter (fences, on site, off site, etc.)		
Berms and Fences		
Waste Diversion Area		

Issues and Conditions	Description/Condition/Problems	Action/Maintenance Required
Bulky Metals		
Hazardous Waste Storage		
Landfill Area		
Waste Drop Off		
Burning		
Waste Placement and Compaction		
Waste Materials (hazardous wastes, damaged materials, etc.)		
Cover Material (stockpile, exposed waste, etc.)		
Waste Compaction and Placement		

Issues and Conditions	Description/Condition/Problems	Action/Maintenance Required
Surface Drainage (water flow, erosion, waste in ditches, etc.)		
Leachate Seepage from Waste		
Environmental Impacts (litter on tundra, impacted water escaping site, etc.)		
Equipment (garbage trunk, loader, bulldozer, dump truck, etc.)		
Cell/Layer Construction (slopes, cover, etc.)		
Site Planning		
Other Issues and Concerns		

Form 3
Solid Waste Management Facility Planning Form
Hamlet of Arviat

Prepared By: _____

Date: _____

Solid Waste Planning Issue	Current Operations	To Do Items and Schedule
Health and Safety		
Site Inspection Results/Concerns		
Waste Placement and Filling Summary		
Hazardous Waste Storage Summary		
Bulky Metals Summary		
Environmental Monitoring		

Solid Waste Planning Issue	Current Operations	To Do Items and Schedule
Annual Reporting		
Nunavut Water Board License Requirements		
Staffing		
Equipment		
Costs		
Other Issues/Concerns		



Appendix D

Annual Monitoring Report Format

NWB Annual Report

Year being reported: ▼

License No: Issued Date:
Expiry Date:

Project Name:

Licensee:

Mailing Address:

Name of Company filing Annual Report (if different from Name of Licensee please clarify relationship between the two entities, if applicable):

General Background Information on the Project (*optional):

Licence Requirements: the licensee must provide the following information in accordance with

▼ ▼

A summary report of water use and waste disposal activities, including, but not limited to: methods of obtaining water; sewage and greywater management; drill waste management; solid and hazardous waste management.

Water Source(s):	<input type="text"/>
Water Quantity:	Quantity Allowable Domestic (cu.m)
	Actual Quantity Used Domestic (cu.m)
	Quantity Allowable Drilling (cu.m)
	Total Quantity Used Drilling (cu.m)

Waste Management and/or Disposal

- ☐ Solid Waste Disposal
- ☐ Sewage
- ☐ Drill Waste
- ☐ Greywater
- ☐ Hazardous
- ☐ Other:

Additional Details:

A list of unauthorized discharges and a summary of follow-up actions taken.

Spill No.: (as reported to the Spill Hot-line)
 Date of Spill:
 Date of Notification to an Inspector:
 Additional Details: (impacts to water, mitigation measures, short/long term monitoring, etc)

Revisions to the Spill Contingency Plan

Select

Additional Details:

Revisions to the Abandonment and Restoration Plan

Select

Additional Details:

Progressive Reclamation Work Undertaken

Additional Details (i.e., work completed and future works proposed)

Results of the Monitoring Program including:

The GPS Co-ordinates (in degrees, minutes and seconds of latitude and longitude) of each location where sources of water are utilized;

Select

Additional Details:

The GPS Co-ordinates (in degrees, minutes and seconds of latitude and longitude) of each location where wastes associated with the licence are deposited;

Select

Additional Details:



Appendix E

Landfarm Guidance Documents

Results of any additional sampling and/or analysis that was requested by an Inspector

Select ▼

Additional Details: (date of request, analysis of results, data attached, etc)

Any other details on water use or waste disposal requested by the Board by November 1 of the year being reported.

Select ▼

Additional Details: (Attached or provided below)

Any responses or follow-up actions on inspection/compliance reports

Select ▼

Additional Details: (Dates of Report, Follow-up by the Licensee)

Any additional comments or information for the Board to consider

Date Submitted:

Submitted/Prepared by:

Contact Information:

Tel:

Fax:

email:



Environment Canada
Prairie and Northern Region
Nova Plaza
P.O. Box 2310
Yellowknife, NT X1A 2P7

February 24, 2010

Your File: 3AM-ARV ---
Our File: 4782 047

David Hohnstein
Director, Technical Services
Nunavut Water Board
PO Box 119
Gjoa Haven, NU X0B 1J0

Re: Hamlet of Arviat – Application for Type A Water Licence - 3AM-ARV

On behalf of Environment Canada (EC), I have reviewed the information and supporting materials submitted with the above-mentioned application. The following specialist advice has been provided pursuant to the *Canadian Environmental Protection Act*, and Section 36(3) of the *Fisheries Act*.

The Hamlet of Arviat is applying for a Type A Water Licence for a 5 year term to allow for the municipal use of water and deposit of waste. The Hamlet's previous Type B Water Licence (3AM-ARV0308) expired in 2008.

The Hamlet's Water Supply is pumped from Wolf River into a 2-cell water lined water reservoir which is expected to meet demands throughout the requested 5 years of this Water Licence.

The Solid Waste Facility consists of an open dump that is managed by natural attenuation and burn and bury techniques. Although the Facility is separated from the surrounding environment by a berm and fence, the wet, marshy area is likely affected by leachate, especially given the absence of a liner and presence of pooled water onsite. The natural attenuation that the Facility is said to rely on has not been verified and, as such, the extent of environmental impact is unknown. Separate to this main Solid Waste Facility site is a Bulky Metal and Contaminated Soil Site. This second landfill location was previously used as a domestic landfill 40 years ago, with some burial events on record. However, there is no active management of the bulky metal nor landfarming of the contaminated soil.

The Sewage Disposal Facility consists of a single engineered cell, discharging by seepage through the berm, with effluent flowing through a wetland prior to its marine discharge to Hudson's Bay. In the absence of design documents, it is unclear whether the effluent is intended to seep at the locations and rates that are described in the application documents. Adjacent to the current Sewage Disposal Facility are two abandoned lagoon cells. Although not in use, there has been no abandonment or restoration work on the old lagoon cells.

General

- The Hamlet must ensure that any effluent discharged from a system's final discharge point is in compliance with Section 36(3) of the *Fisheries Act*. According to the *Fisheries Act*, Section 36(3), the deposition of deleterious substances of any type in water frequented by fish, or in any place under any conditions where the deleterious substance, or any other deleterious substance that results from the deposit of the deleterious substance, may enter any such water, is prohibited.

- The application documents contain conflicting information on many matters, and clarification was sought in the letter previously submitted to the Nunavut Water Board (NWB) by Environment Canada as part of the Board's Completeness Check. Information that remains outstanding include:
 - Number of sewage lagoons currently in use, and status of those not in use, if any.
 - Confirmation on the current sewage lagoon wetland flow path(s)
 - Sewage Lagoon discharge time, duration and method.
 - Identification of SNP ARV-2 location
- EC recommends that design drawings be submitted to the Board for approval prior to construction of the new Solid Waste Facility. Furthermore, EC recommends that As Built Drawings be submitted for the new Sewage Lagoon and the new Solid Waste Facility when it is completed.
- EC recommends that Abandonment and Restoration Plans be submitted to the Board for approval for the old Sewage Lagoons if not in use and the current Solid Waste Facility.

Monitoring

- No water quality results have been provided with the application, and no sampling is known to have taken place in the community, though monitoring was required under the expired licence. With regards to sludge accumulation, the application indicates that "the sludge has not interfered with the efficiency of the lagoon," yet no water samples have been submitted to verify this statement. Furthermore, in the Supplementary Questionnaire, the wastewater wetland is described as utilizing "complex physical and biological processes to treat the wastewater," yet no work or sampling has been done to verify this statement. Therefore, EC recommends that a thorough lagoon discharge and wetland hydrology study which includes water samples be completed as one of the licence conditions to ascertain this information.
- In order to monitor the whole effluent effect on the receiving environment, EC recommends including a Pass/Fail Bioassay Toxicity test at an appropriate sampling location prior to effluent discharge to the receiving environment. Toxicity testing provides an evaluation of effluent quality that integrates all the measured parameters, and provides the proponent with an indication of overall effluent characterization with respect to deleteriousness.

Solid Waste Facility

Plans for a new Solid Waste Facility have been described in the application documents with commissioning planned for in the next few years. EC's Solid Waste comments herein apply to the current Solid Waste Facility that requires a Water Licence while it remains in use. EC recognizes that design, operational and management improvements are planned for the new Solid Waste Facility and commends to Hamlet for pursuing these improvements. However, for the purpose of this water licence renewal application, EC's comments seek to prevent pollution from the existing facility.

- Hazardous Waste Storage - Hazardous Waste is stored beside the Public Works Garage. Very little detail is provided about this site except the descriptions that "the area is not fenced or controlled" and that it "is out of compliance with regulations." EC recommends that the site be improved to control the access to the Hazardous Waste and that appropriate containment be in place to reduce spills or leaching into the natural environment. Reference to appropriate management of Hazardous Waste can be found in the GN-DOE Environmental Guideline for General Management of Hazardous Waste.

- Bulky Metal Storage and Contaminated Soil Site - A separate Solid Waste site has been identified at 500m south of the community containing vehicles, heavy equipment, tires, appliances, snowmobiles, and 45 gallon drums as well as hydrocarbon contaminated soil. Leachate from this site is unmanaged. EC recommends that this site be captured by this new Type A water licence and require appropriate Bulky Waste management as well as landfarming and monitoring of the contaminated soil. EC recommends decommissioning and restoring this site as soon as an appropriately lined site becomes available. In the meantime, leachate sampling would provide useful information to identify the geographical extent of environmental impact.

Comments on the Supporting Materials Documents

Environmental Monitoring Program and Quality Assurance / Quality Control Plan (EMP and QA/QC Plan)

EC considers this document to be a detailed and complete plan to achieve the objectives of high quality sampling, sample transportation and best management practices. In order to ease the interpretation of sample data results, the Monitoring Station Name (ex. ARV-1, ARV-2) should be specifically identified on the sample label. EC suggests that the words "sample name" in section 4.1.7 be replaced with "Monitoring Station Name." The EMP and QA/QC Plan should be revised and resubmitted for approval upon issuance of a new Water Licence.

Environmental Emergency Contingency Plan (EEC Plan)

Environment Canada considers this Plan to be a comprehensive and well written plan. The EEC Plan should be revised and resubmitted for approval upon issuance of a new Water Licence.

Section 2.2.4, pg 5: This section should be revised to clarify whether or not spills from 'Other Hamlet Activities' are covered by this contingency plan. As this section is written, it could be understood that this EEC Plan, and those responsible for implementing the plan, applies to any spill that occurs in the municipality, whether or not it is related to activities described in the Water Licence.

Appendix A, Contact Information: EC suggests that the Government of Nunavut, Department of Environment, Environmental Protection Division be added to this list.

Solid Waste Facility Operation and Maintenance (O&M) Plan

EC considers this document to contain pertinent information and references. The Solid Waste O&M Plan should be revised and resubmitted for approval upon issuance of a new water licence.

3.3 Landfill Operation (Burning)

In the Water Licence Application, it is stated that "the Hamlet does not conduct burning." However, the O&M Plan explains that "Burning is used to reduce volumes of waste and is uncontrolled with no segregation of combustible material from non-combustible materials." Furthermore, explicit directions on conditions and methods of burning are provided in the O&M Plan.

If burning is not a practice at this landfill, EC recommends that all reference to burning should be removed from the O&M Plan. If burning is indeed occurring as a management measure at the Solid Waste Facility, the following comments are provided:

- In order to provide clear operational instruction regarding material suitable for burning, EC recommends including lists of material that are suitable or non-suitable for open burning.
- A reference should be made in this section to the Government of Nunavut Department of the Environment (GN-DOE) Policy entitled "Municipal Solid Wastes Suitable for Open Burning."

Section 3.4 Hazardous Waste

In order to provide clear operational instruction regarding Hazardous Waste, EC recommends including a list of typical Hazardous Wastes as well as a reference to the location of the Hazardous Waste Disposal Area. Furthermore, the GN-DOE Environmental Guideline for General Management of Hazardous Waste should be referenced in this section.

Section 3.9 Reuse Recycle

This section contains one paragraph relating to a Reuse Recycle Area followed with a section relating to Hazardous Waste. EC recommends moving the Hazardous Waste information to Section 3.4 Hazardous Waste.

Landfarming of Contaminated Soil

The application documents indicate that 750m³ of diesel contaminated soil is present at the Bulky Metals Sites. However, no operational instruction is given on the proper handling of hydrocarbon contaminated soil. EC recommends including landfarming methods, containment, and sampling as part of this O&M Plan. Please find attached EC's Landfarming Recommendations for your consideration.

Sewage Treatment Facility Operation and Maintenance (O&M) Plan

EC considers this document to contain pertinent information and references. The Sewage Treatment Facility O&M Plan should be revised and resubmitted for approval upon issuance of a new water licence.

Section 3.1.2 Lagoon Storage Capacity

This section indicates that sludge removal should be considered starting in 2014. Prior to sludge removal, sludge blanket thickness will need to be assessed. EC recommends including details on how to monitor or assess sludge thickness as part of the O&M Plan.

Please do not hesitate to contact me with any questions or comments with regards to the foregoing at (867) 669-4715 or by email at mary.kelly@ec.gc.ca

Yours truly,

Mary Kelly
Physical Science Officer – Wastewater Specialist
Environmental Protection Operations
Environment Canada

cc: Carey Ogilvie, Head, Environmental Assessment-North, EC, Yellowknife
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Many of the recommendations relative to design, siting, operation, monitoring, sampling and analytical methods, decommissioning and closure as well as record keeping and reporting can be referenced in the following guidance documents:

- ***Federal Guidelines for Landfarming Petroleum Hydrocarbon Contaminated Soils.*** SAIC Canada (Science Applications International Corporation), December 2005
- ***Bioremediation of Petroleum Hydrocarbons in Soil and Groundwater Under Cold Climate Conditions: A Review, Implications for Applications in Canada***, Dale Van Stempvoort and Pamela Grande, National Water Research Institute in Burlington, December 2005
- ***Cold Climate Bioremediation: A Review of Field Case Histories.*** Pamela Rogers, Research Assistant, Department of Civil & Environmental Engineering, University of Alberta, July 2005

Environment Canada urges the proponent to follow environmental site assessment steps as established by the following standards:

- **Canadian Council of Ministers of the Environment (CCME) *Canada-Wide Standard for Petroleum Hydrocarbons in Soil* (CWS-PHC) (CCME, 2001);**
- **Canadian Standards Association (CSA) *Environmental Site Assessment Standards Z768-01* (2001) and *Z769-00* (2000), for Phase 1 and Phase 2; and,**
- ***Subsurface Assessment Handbook for Contaminated Sites* (CCME, 1994).**

As these documents are updated periodically, please consult the CCME and CSA for the most recent versions.

Assuming that the soils to be remediated are known to contain primarily petroleum hydrocarbon contamination, following the procedure in the CWS-PHC is recommended. The CWS-PHC allow for a risk-assessment approach. This could take the form of the CWS-PHC Tier 2 or 3 or, other tools to ensure equal or better protection, for example, the Risk-Based Corrective Action (RBCA) process. For information on the CWS-PHC and related documentation, consult with the on-line information available from CCME at <http://www.ccme.ca/ourwork/standards.html>.

The characterization of the contaminants and contaminant levels in the soil determined during the environmental site assessment may be used to determine landfarming applicability. An evaluation of the type and degree of contamination helps to exclude soil material that might be toxic to certain species of microorganisms and also helps to determine if landfarming would be the appropriate remediation technology to be employed for the contaminants of concern. Although landfarming is recommended for petroleum hydrocarbon contaminated soils only, it is understood that other contaminants may also be present. **Table 1** indicates, through shaded selections, the type of analyses recommended for contaminated soil characterization.

Table 1 Recommended Analyses Based on Suspected Soil Contaminationⁱ

Contaminant Source	Parameters Analyzed							
	CWS – PHC fractions	BTEX	TPH	Lead	Total Heavy Metals ⁱⁱ	Chromium/Cadmium	PCBs	Phenols

unleaded gasoline									
leaded gasoline, aviation gasoline									
fuel oil, diesel, kerosene, jet fuel, mineral oil/spirits, motor oil									
petroleum solvents									
crude oils, hydraulic fluids									
waste petroleum products									

Please note that if any of the levels detected exceed these maximums, the contaminated soil should be considered hazardous waste and handled accordingly. Landfarming is not recommended for such contaminated soils.

- Total petroleum hydrocarbon (TPH) or total extractable hydrocarbons (TEH) < 3% (Yukon, 2004a and 2004b);
- total heavy metal concentrations < 2500 mg/L (USEPA, 1994)¹;
- electrical conductivity (EC) < 4 dS/m; and
- sodium adsorption ratio (SAR) < 6 (Alberta EUB, 1996).

Site Characterization

Prior to landfarm design, a characterization of the site where the landfarm is to be placed should be conducted such that the following parameters are identified and respected:

- groundwater flow, direction and baseline chemical analysis;
- native soil hydraulic conductivity determination;
- Microbial identification determination and population.
- A landfarm should be sited greater than 500 m from a permanent surface water body. This restriction applies to both potable and non-potable surface waters.
- A landfarm should be sited greater than 500 m from a potable groundwater well.
- The geology of the site needs to be considered (e.g. thickness of underlying soil, the presence of bedrock, degree of fracturing) to determine the need a liner/barrier (see Section 8.3.9). It is recommended that at landfarm sites with less than 5 m of low hydraulic conductivity ($<10^{-6}$ cm/s) native underlying soil, a liner/barrier be used.
- The landfarm should be sited at a location with a natural slope of less than 5 %; otherwise the site will require grading.
- The landfarm should be sited where the groundwater table is greater than 3 m from the surface. When there is a need to excavate during landfarm construction, cultivation no closer than 3 m above the groundwater table must be ensured. Using groundwater flow direction and rate data, the landfarm should be sited such that groundwater contamination is avoided (otherwise, a barrier to groundwater flow is necessary).
- A landfarm should not be sited on land within a 50 year floodplain.
- Adequate volumes of clean topsoil should be available at the site to effectively manage and operate this facility.

Prior to landfarm design, an evaluation of the soil characteristics provided in **Table 2** will ensure that the contaminated soil is well-suited to landfarming.

Table 2: Optimal Soil Characteristics for Landfarming

Landfarming Parameter	Optimal Characteristics
Microbial population density:	For landfarming to be effective, the minimum heterotrophic plate count should be 10^3 CFU/g (colony forming units/gram). Below this minimum, landfarming may still be effective provided the existing bacteria are stimulated using nutrients or the soil is amended to increase the bacteria population (USEPA. 1994) In the latter case, adding non-indigenous bacteria to a site has had limited success in enhancing degradation of petroleum hydrocarbons. There are also regulatory restrictions associated with the addition of bacteria to sites.
Soil pH:	To support bacterial growth, soil pH should be between 6 and 8. Outside this range, landfarming may still be effective through soil amendments.
Moisture content:	Bacterial growth requires moisture, optimally between 40-85% of field capacity ² (USEPA, 1994) Periodically, moisture may be added to landfarmed soil to maintain this moisture level. Excess moisture due to periods of high precipitation, during spring thaw or due to poor site drainage may need to be addressed. Site drainage may be improved through landfarm design, but uncontrollable influx of moisture may simply mean that longer operating times will be required for the landfarm.
Nutrient concentration:	For proper growth, micro-organisms require inorganic nutrients that may be naturally-occurring in the soil. Nitrogen and phosphorous may be added in the form of commercial fertilizer. For effective biodegradation, carbon:nitrogen:phosphorus ratios need to be between 100:10:1 and 100:1:0.5 (USEPA. 1994). This ratio may be calculated from the soil bulk density and the total hydrocarbon concentration.
Soil Type:	Clayey soils hamper biodegradation because of difficulties in aeration and the distribution of nutrients and moisture. Soil amendments such as gypsum and bulking agents such as sawdust, may be required. Clumpy soils may also require pre-treatment in the form of shredding, in order for landfarming to be effective. Very coarse soils are not suitable to landfarming as they do not retain moisture and nutrients (University of Saskatchewan, 2002). Volatile compounds will also volatilize more readily from coarse-grain soils than from fine grain soils. Typically, large diameter soil particles have a low contamination concentration due to their low surface area. As such, these particles can be screened out prior to placing soils in the landfarm.

Once a landfarm is operating, generic or site-specific remediation limits as per the CCME Environmental

² The most reliable measure of moisture content is expressed as a percent of field capacity (also referred to as "soil capacity"). Field capacity itself is the maximum %-weight of moisture the unconfined, gravity-drained soil can retain. An example would be a sandy soil with a field capacity of 25%, meaning a maximum of 250 grams of water retained in 1,000 grams (dry wt.) of unconfined soil. Typically the target moisture content is expressed as a percent of the field capacity; for example, 50% of field capacity for the above sandy soil would be 125 grams water per 1,000 grams dry soil.

Quality Guidelines (EQGs) or CWS-PHC should be used to monitor the extent to which the soil has been remediated to acceptable levels. The parameters analyzed during the environmental site assessment should be evaluated using these guidelines to determine chemicals of concern (CoCs) and those identified should be tracked during the remediation process.

Leachate Control

Groundwater and leachate criteria become applicable once the landfarm location is sited. One approach is to follow the **Environment Canada Contaminated Sites Management Working Group (CSMWG) policy: A Federal Approach to Contaminated Sites (CSMWG, 1999)**. This policy recommends the use of appropriate provincial/territorial guidelines or criteria when there is an absence of similar guidelines/criteria available.

Groundwater sampling and analysis should adhere to the CCME sampling procedures (CCME, 1993). Leachate monitoring performed during the landfarm operations is primarily for characterization purposes only, as leachate is often recirculated over the landfarm as a means of irrigation (or stored in a tank in the event that irrigation may be required at some point in the landfarming season). If this tank is discharged into the environment, the CCME EQGs apply as a standard.

A means to collect and treat run-off from the landfarm may be necessary. A leachate control system capable of handling a 24 hour duration, 1:10 year frequency storm is required in such a case. Leachate may be recirculated over the landfarm soil surface as a means of irrigation to maintain optimal biodegradation rates, or discharged if surface water analyses indicate contaminant levels are within CCME EQGs. **Environment Canada strongly recommends a containment system where all leachate from the facility is fully controlled.**

Barriers/Liners

When native soils at the landfarm site have high conductivity (see Section 8.2.5), a barrier or liner having a maximum seepage rate equivalent to clay liner under 0.3 m head of water or a 10^{-7} cm/s hydraulic conductivity at a thickness of 0.6 m, should be used beneath the soil to be treated.

Placement of Soil in Landfarm

A contaminated soil depth less than 0.5 m within cell(s) or in windrows is recommended. However, the type of equipment available for tilling, as well as the land availability, will dictate soil depth. Typically, landfarming is practiced with soil depths between 0.30 and 0.45 m. Contaminated soil should not be applied on a continuous layer of snow or ice or when the existing soil base is saturated with moisture.

Landfarm Design/Operational Requirements

Land Availability

Please note that the expected landfarm soil depth of between 0.30 and 0.45 m and a maximum soil thickness of 0.5 m is recommended. Therefore, a single plot or multiple plots may be required. Additional area surrounding the plot(s) for berms and leachate control should be considered.

Microbial Population Density Monitoring

If microbial amendments are being considered, the user should be aware that products containing microorganisms, biochemicals (such as enzymes) or biopolymers, are "biotechnology products" and may be subject to the New Substances Notification (NSN) Regulations, pursuant to the Canadian Environmental Protection Act, 1999 (CEPA, 1999). (Contact the New Substances Division of Environment Canada and http://www.ec.gc.ca/substances/nsb/eng/index_e.htm for more information.)

Although a few petroleum hydrocarbon-degradable micro-organisms have been found to be active at temperatures below 0°C (Whyte and Greer, 1999; Whyte, *et al.* 2001 and 2003; Rike, *et al.* (2003)), most biodegradation occurs above freezing. Research has shown appreciable biodegradation may occur after one summer season, additional biodegradation over a second season is usually required. Therefore, it is recommended that the landfarm should operate for a minimum between 6 months to 2 years. This operation period assumes optimal conditions are maintained (i.e. regular tilling; moisture control; nutrient amendment, if required). Please note that soil sampling and analyses are required to confirm remediation progress and completion.

pH Maintenance

The optimal pH for landfarming operations is between 6 and 8. The soil pH may be increased with the addition of lime and decreased with the addition of elemental sulphur.

Moisture Content Monitoring

The amount of moisture in the landfarm soil impacts biodegradation and, therefore, should be monitored and adjusted if possible and necessary. If moisture levels are too high, the movement of air through the soil is restricted thereby reducing oxygen availability. Effective moisture levels are 40 - 85 % of water-holding capacity in the soil, but 20 – 85 % will support microbes. Water spraying is often needed during summer months, particularly prior to tilling, in order to reduce wind erosion. Soil may be amended with organic matter to increase moisture retention. A rule of thumb is the soil should be moist, not dry and dusty or dripping wet.

Nutrient Amendments Requirements

Biodegradation requires that micro-organisms are meeting nutritional requirements. The optimal range of carbon:nitrogen:phosphorus (C:N:P) is 100:10:1 to 100:1:0.5. If the available nutrients are not sufficient, soil amendment in the form of commercial fertilizers, is required. Note that the addition of nitrogen may inadvertently lower the pH. Nutrients can be supplied to the soil in either liquid or solid form. Solid nutrients can be added directly to the soil when the soil is mixed prior to placement in the landfarm or during tilling events once the landfarm is operational. Liquid nutrient can be added to watering or irrigation systems. The frequency of nutrient addition can be reduced by using slow release nutrients.

Tilling

Tilling, with a rototiller or turning over the soil with a backhoe or other similar equipment, is a means of aerating the soil. This provides oxygen for the micro-organisms as well as distributes nutrients and moisture in the soil, thereby aiding biodegradation. Tilling is recommended once per month during the operating season of the landfarm, provided the soil is uniformly moist but not saturated. Tilling when soil is excessively wet is unproductive, whereas tilling while the soil is excessively dry may erode the soil and cause wind-blown dust problems. Tilling must be carefully carried-out by an experienced operator, since it is possible to disturb or damage the liner placed under the contaminated soil.

System Maintenance

Maintenance of the landfarm is essential in ensuring its effectiveness. At some appropriate point during landfarm construction, inspection of the synthetic liner(s) should be conducted to ensure that the seams and joints are tight, and that there is the absence of punctures, blisters or tears. Imperfections (e.g. lenses, cracks, channels) can occur in soil and clay liners. Weekly, during landfarm operations, and immediately after a major storm or catastrophic event, inspections should be conducted on the:

- (i) drainage control systems for evidence of deterioration, malfunction, leaks or improper operation, and

- (ii) leachate collection systems to ensure proper functioning and to determine if leachate is being generated or is accumulating.

If any defects or malfunctioning works are detected, immediate repair is required to maintain the integrity of all works.

The drainage control system should be inspected as necessary/required during periods of precipitation or spring thaw to ensure control measures are taken if the system is approaching its capacity.

Closure Procedures

During the system design phase, it is important to determine the requirements for closing the sites once remediation is complete. By laying out the closure procedures at this time, the responsible party or site sponsor can reviewed and endorsed them prior to proceeding with the system construction. This closure plan must be consistent with the current land use and will need to recognize how future land use changes or ownership will be taken into consideration after landfarm closure.

Monitoring and Record Keeping Requirements

For the purpose of monitoring the performance of the land treatment process, soil samples should be taken no less frequently than once every four months, during the period of active land treatment to monitor contamination levels until analytical results are below acceptable levels as set forth in the CCME's Canadian Soil Quality Guidelines (CSQG).

For the purpose of monitoring for potential impact of the facility on groundwater quality in the active layer, groundwater samples should be taken from the down gradient monitoring wells no less frequently than twice per year and analyzed for indicators of petroleum hydrocarbon contamination. Should analytical results indicate groundwater contamination associated with the land treatment facility, corrective action should be taken as soon as possible.

A sampling plan should include sampling methods (grid, composite) and frequency (number of samples per surface area). Since the landfarmed material is relatively thinly applied and homogenized through tilling, only one depth of sample collection is required. The samples should then be analyzed for the contaminants of interest and compared with the remediation guidelines presented in the CCME EQG and the CWS-PHC documentation. These protocols are recommended for the landfarm soils to determine at which point the soils have been remediated and the landfarm can be closed. Monitoring of contaminant levels in the leachate is only required prior to discharge to the environment; during recirculation, testing may be done for purposes of tracking remediation progress. It is also recommended that groundwater on-site be monitored and compared to the appropriate CCME EQGs. **Table 3** summarizes the criteria that should be used for the various media involved in landfarming operations.

The landfarm soils may be considered remediated once analyses confirms these soils are within the CCME EQGs or CWS-PHC for the particular land use of the property. The remediated soil may then be used in a manner that is consistent and appropriate with the site use. If other contaminant levels (such as heavy metals, PCBs, etc.) exceed CCME EQGs, the landfarmed materials should be then further remediated using an alternative remediation technique.

Accurate records should be maintained by the owner/operator which contain the following information:

- A detailed description of the size and location of the land treatment facility
- Quantitative and qualitative data on the soil treated at the site
- Monitoring data as set forth above
- The final destination of the treated soil and its intended use.

Table 3: Summary of Landfarming Standards for Federal Contaminated Sites

Media Monitored	Criteria
Landfarm soil and soil remaining at the delineated (excavation) site	Canada Wide Standard for Petroleum Hydrocarbons (CWS-PHC) (CCME, 2003)
	Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (CCME, 2003)
Groundwater	Non-potable - none; as per <i>A Federal Approach to Contaminated Sites</i> (CSMWG, 1999) whereby provincial/territorial guidelines are recommended. Potable - Guidelines for Canadian Drinking Water Quality (Health Canada, 1996)
Leachate	For recirculation – none (operations monitoring only) For discharge to environment <ul style="list-style-type: none"> Into surface water: CCME Environmental Quality Standard (EQS) for Freshwater Aquatic Life (CCME, 2003) for surface water reception; and Into groundwater: none, as per <i>A Federal Approach to Contaminated Sites</i> (CSMWG, 1999) whereby provincial/territorial guidelines are recommended
Surface Water	CCME Environmental Quality Standard (EQS) for Freshwater Aquatic Life (CCME, 2003) or, for potable water, the Guidelines for Canadian Drinking Water Quality (Health Canada, 1996)
Ambient Air	Canadian National Ambient Air Quality Objectives: Process and Status (CCME, 2003)

Modified from: Environment Canada. 1993. "Appendix 3: Guidelines on the Ex-Situ Bioremediation of Petroleum Hydrocarbon Contaminated Soils on Federal Crown Land" in the *Study on the Use of Landfarming and Surface Impoundments in the Management of Hazardous and Non-Hazardous Waste*. Conservation and Protection. June 23, 1993.

ⁱⁱ Heavy metal analyses required to determine if constituents are not present at levels toxic to micro-organisms (>2500 mg/L) (USEPA. 1994). (Soils with heavy metal concentrations below this level but above remediation criteria, will have to undergo further treatment following landfarming to reduce heavy metal concentrations.)