RESEARCH & DEVELOPMENT AND SOIL TREATMENT FACILITY

REGISTRATION DOCUMENT FOR A CLASS I UNDERTAKING

Submitted by
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1.0 INTRODUCTION

CleanEarth Technologies Incorporated (CleanEarth) has developed a patent pending soil washing process to remediate contaminated properties. This is a "made in Nova Scotia" technology having been developed and field tested within Nova Scotia over the past four years. Over this time a number of successful projects have been completed including soil remediation projects involving the treatment of properties contaminated with lead, copper, arsenic, zinc, thallium, cadmium, selenium, polycyclic aromatic hydrocarbons (PAHs), total petroleum hydrocarbons and a water treatment project involving the treatment of approximately 4,500,000 liters of water contaminated with metals. These projects were completed using the patent pending mobile treatment process where the contaminated soil was treated at the contaminated property itself.

Based on these successes using the mobile treatment process, CleanEarth applied to the Nova Scotia Department of Environment and Labour (NSDEL) for approval to construct and operate a fixed facility at 203 Aerotech Drive in Enfield, Nova Scotia for the treatment of TPH, PAH and metal contaminated soils that are not classified as a waste dangerous good. The approval was granted on March 3, 2006 with the facility constructed and opened shortly thereafter. The rationale behind the opening of the fixed facility was to allow CleanEarth to provide treatment for both smaller volume projects where mobilization of a treatment process to a contaminated property is not feasible, as well as projects that require remediation at an off-site location due to logistical or weather related issues.

Since opening the soil treatment facility CleanEarth has been approached regarding the treatment of a number of properties with contamination that would be classified as waste dangerous goods. These properties have included contaminated soil and other mineral substances contaminated with leachable metals, polychlorinated biphenyls, chlorinated solvents and hydrocarbon contaminated soil at concentrations that would classify the material as a waste dangerous good. Based on these identified needs, the purpose of this document is to amend CleanEarth's existing operating approval to include the treatment of contaminated material classified as waste dangerous goods.

1.1 Company Operations

CleanEarth has been successfully operating at the facility located at 203 Aerotech Drive since May, 2006. This has provided an important opportunity to view the technology at work in a permanent site application. These operations have been characterized as highly successful providing a venue to treat contaminated soil and to demonstrate the viability of the process and its positive impact in environmental terms. This period of successful operation can give all stakeholders comfort that CleanEarth has designed its system to ensure that it is able to operate safely in accordance with the terms of its approval and that the principals of CleanEarth put a premium on safe, effective and environmental responsive operations.

In addition to the operational aspect of the facility located at 203 Aerotech Drive, CleanEarth is currently constructing an administration building, maintenance warehouse and a research and development laboratory. The R&D lab is of central importance to the future development of a Center of Excellence that will allow Clean Earth to continue with the development of the baseline soil washing process as well as provide a facility to test other innovative solutions to environmental problems that are currently being developed but now require specialized laboratory facilities in order to complete the testing phase. The company is committed to a philosophy of continuous improvement and long term evolutionary approaches building on its proprietary technology.

Over the past year CleanEarth has also been vigorously working to expand the use of its technology to other markets, starting in Canada. Over the past several months, CleanEarth has been working with officials of the Ontario Ministry of the Environment to obtain certification to operate in the Province of Ontario. The company has been successful in these efforts and has been approved for a *Certificate of Approval* to apply the CleanEarth technology to remediation opportunities in that Province.

In addition, Clean Earth has negotiated a contract to complete our inaugural project in Ontario with an important Federal Government client. This Project will commence early in 2007.

This latter opportunity was made possible as a result of the Company having had a very favorable assessment of its' technology completed by a senior official of Public Works and Government Services Canada (PWGSC). This assessment was very thorough and consisted of the assessor taking samples at various stages of the patented CleanEarth treatment process and having the results verified by an independent lab.

Longer term plans for the Aerotech property include the construction of a manufacturing facility where the soil washing and other environmental technologies can be constructed. This longer term plan is predicated on the interest received to date by CleanEarth from the European, Canadian and American markets in either purchasing or licensing the soil washing technology. The complete CleanEarth facility as described above would allow CleanEarth a location to bring prospective clients to demonstrate the technology on "real world" contaminated soils and upon receipt of orders, manufacture the process to the client's specifications in-house and in Nova Scotia.

Nova Scotia has developed a well-deserved international reputation for leadership in environmental matters, particularly, waste management and recycling. The facility that CleanEarth is developing can be a new chapter in that story of environmental innovation and leadership. We want to make our facility, the research and development lab and our technology available to visiting delegations and share with them the effectiveness of this approach. This development will also assist in the continuing effort to achieve critical mass in our environmental industries.

The following sections of this report outline in more detail the nature of the undertaking, the process to be employed to treat the contaminated soil, treatment schedules, the proposed location of the treatment and the monitoring and contingency plans that will be implemented during the course of the project.

Registration for a Class I Undertaking CleanEarth Technologies Inc.

1.2 Registration

Name of Undertaking:	Research and Development and Soil Treatment Facility
Location of Undertaking:	203 Aerotech Drive, Enfield, Nova Scotia
Proponent:	CleanEarth Technologies Incorporated
Chief Executive Officer:	Mr. Glenn Clark - President
Contact Person:	Mr. Colin Morrell V.P. Operations CleanEarth Technologies Phone: 902-835-9095 Fax: 902-85-9010 Email: colin@cleanearthtechnologies.ca

Signature of the Signing Officer:

Glenn Clark, President CleanEarth Technologies

October 1, 2006

Date

1.3 Public Funding

The project will be privately funded.

1.4 Applicable Acts, Regulations and Programs

The proposed amendment to the current operating approval is either subject to the following Acts, Regulations and Programs or may be subject to dependent on conditions such as the volume and type of contaminated material received:

FEDERAL

Interprovincial Movement of Hazardous Waste Regulations (for transport across provincial boundaries)
Transportation of Dangerous Goods Act and Regulations
National Pollutant Release Inventory
Storage of PCB Material Regulations
Fisheries Act
Species at Risk Act
Migratory Birds Convention Act

PROVINCIAL

Environment Act
Approvals Procedures Regulations
Activities Designation Regulations
Environmental Assessment Act
Dangerous Goods Management Regulations
Petroleum Management Regulations
Dangerous Goods Transportation Act and Regulations

In addition to the above provincial acts and regulations it should be noted that the origin of some of the waste dangerous goods requiring treatment will be outside of Nova Scotia. In these instances the Nova Scotia Department of the Environment's Waste Dangerous Goods Policy would also be applicable. This policy relates to procedures to be followed for the management of waste dangerous goods generated either inside or outside of Canada.

2.0 PROJECT DESCRIPTION

2.1 Nature of the Undertaking

This application outlines CleanEarth's intention to amend its existing operating approval to store, treat and dispose of contaminated soil or polluted mineral substances classified as waste dangerous goods. Specifically, CleanEarth is applying to treat soil or mineral substances contaminated with leachable metals, PCBs, and chlorinated solvents.

2.2 Purpose and Need of the Undertaking

There are currently no treatment or disposal options for soil or mineral matter classified as waste dangerous goods in the Maritimes. Current practices to remediate properties contaminated with waste dangerous goods involve the transport of the polluted materials to hazardous waste landfills or incinerators located in Quebec or Ontario. The combined cost of transporting the contaminated material and associated tipping fees at the receiving facility often render the cleanup of these contaminated properties cost prohibitive. The high costs of treatment can result in the properties being abandoned or risk managed. In both these scenarios the liability associated with the contamination remains at the property and any future redevelopment of the property is either precluded or restricted by the presence of the contaminants.

Given the current options, the addition of a regional cost effective treatment option that would eliminate the liability associated with these properties while allowing unrestricted redevelopment would represent a significant advancement in addressing properties contaminated with waste dangerous goods in the Maritime region. Our technology has the ability to change the economics of Brownfield site development.

2.3 Site Location

The proposed location for the soil treatment facility is Lot 15 of the AeroTech Business Park. The property is located within the Halifax Regional Municipality and is currently developed as a soil treatment facility for the treatment of hydrocarbon, metals and PAH contaminated soils that are not classified as waste dangerous goods. The property is approximately 8.14 acres and is serviced by municipal sewer and water.

2.3.1 Confirmation of Municipal Approval

Appendix A contains a letter from the Halifax Regional Municipality confirming the zoning permits the operation of a soil remediation facility in the AeroTech Business Park.

In addition, for purposes of absolute clarity on the matter of municipal approval relative to the land use by-law for Shebenacadie Lakes Plan Area (Planning Districts 14 &17) (the area in which the Aero-Tech Business Park is located), CleanEarth has sought further specific clarification relative to the explicit reference in the by-law (Clause 2.51) in regard to the treatment of Waste Dangerous Goods. This clause, under heading of “Obnoxious Use” allows for the treatment of waste dangerous goods providing that is not the primary use of the facility. The clause is outlined below.

> *2.51 OBNOXIOUS USE means a use which, from it nature or operation creates a nuisance or is offensive by the creation of noise or vibration, or by reason of the emission of gas, fumes, dust, oil or objectional odour, or by reason of the unsightly storage of goods, wares, merchandise, salvage, refuse matter, waste or other material and shall include, in unserviced areas, operations which produce wastes which cannot be disposed of by means of an on-site sewage disposal system or which involves, as the primary function, the processing, production, or warehousing of dangerous goods or hazardous wastes.*

CleanEarth sought a further specific interpretation of the definition of “primary” and were advised, through an inquiry to Development Officer Trevor Creaser, as follows: “I understand you were looking for clarification as the what is considered "primary" under the Obnoxious Use Definition as it pertains to the handling, processing etc. of dangerous or hazardous goods.

In the past we have measured these activities as a percentage. If the percentage of hazardous or dangerous goods does not exceed 49% of the total then it is not considered to be "primary".”

The email from Mr. Creaser is also included in **Appendix A**.

2.3.2 Surrounding Properties

The property is located within the AeroTech Business Park and is accessed via Highway 102 and AeroTech Drive. Currently the AeroTech Business Park is largely undeveloped. The nearest developed properties are located at 209, 249 and 252 AeroTech Drive. The properties at these locations are described below:

209 AeroTech Drive

This property is located approximately 100 meters northeast of Lot 15 and is a multi-tenant building currently occupied by Enterprise Rent-A-Car, Aerotech Engines Limited, The Tank Doctor, Worldwide Perishables Canada Co. and Aerotech Developments.

249 and 252 AeroTech Drive

These properties are approximately 500 meters northeast of Lot 15 and are occupied by L3 Communications (249) and Ocean Case Co. Limited (252).

Other developed properties in the area are Pratt and Whitney Canada and the Hilton Hotel which are located greater than 1 kilometer north of Lot 15.

The nearest residences to the CleanEarth Facility are located approximately 6.0 kilometers to the northeast along Oldham Road and approximately 4.5 kilometers to the southwest along Perrin Drive near Millar Lake. Both of these areas do not have municipal services and obtain drinking water from groundwater sources.

Figures 1, 2, 3 and 4 show the regional, location, surrounding area and water courses/residences, respectively. Figure 5 presents a detail of the 203 Aerotech Drive Property showing construction details of the containment and process areas as well as the location of an unnamed stream that intersects the northwest corner of the property and drains to Preepers Pond.

Figure 1 Regional Setting of the CleanEarth Technologies Inc. Facility in Enfield, Nova Scotia

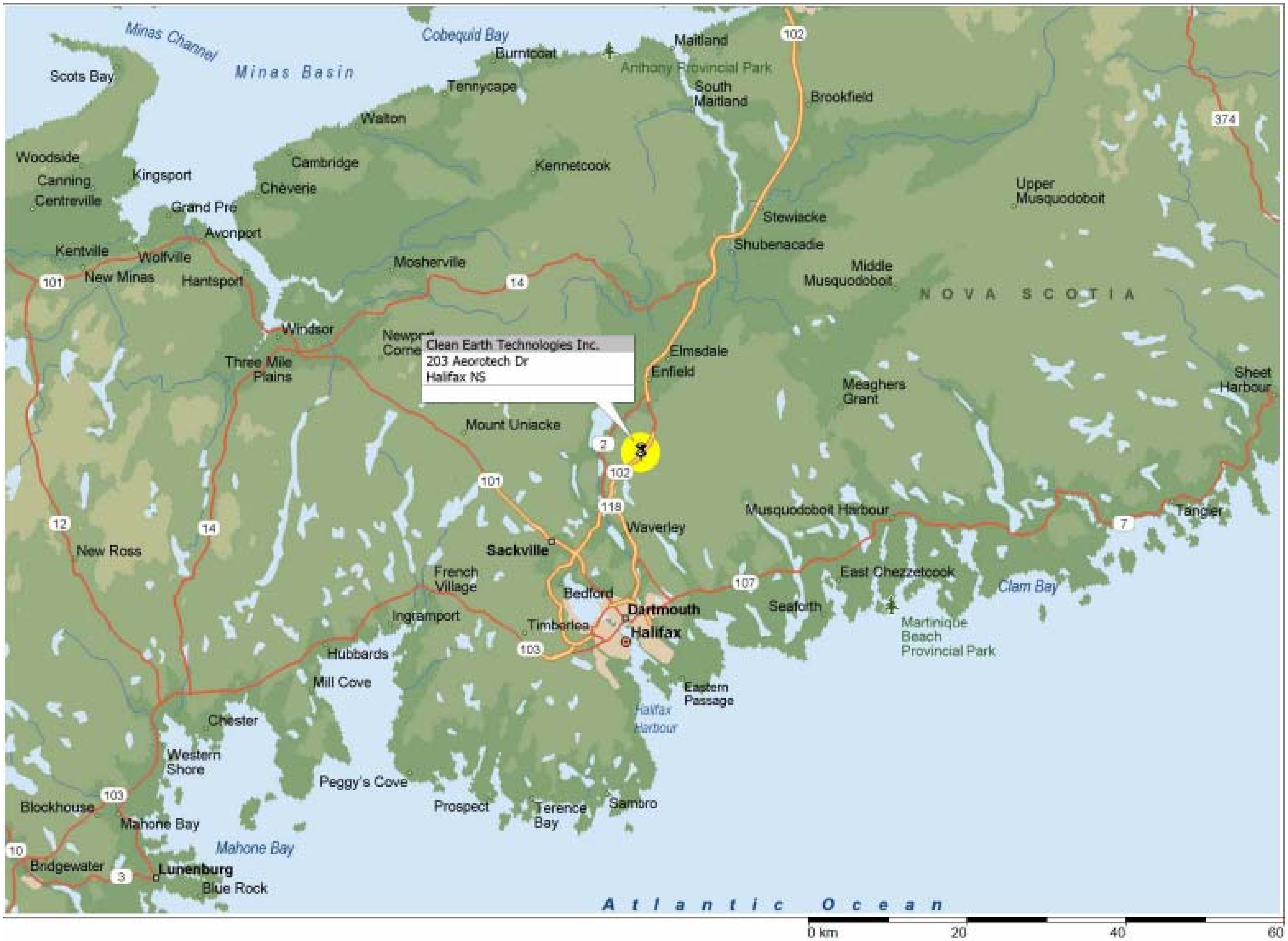


Figure 2 Location Plan of the CleanEarth Technologies Inc. Facility in Enfield, Nova Scotia

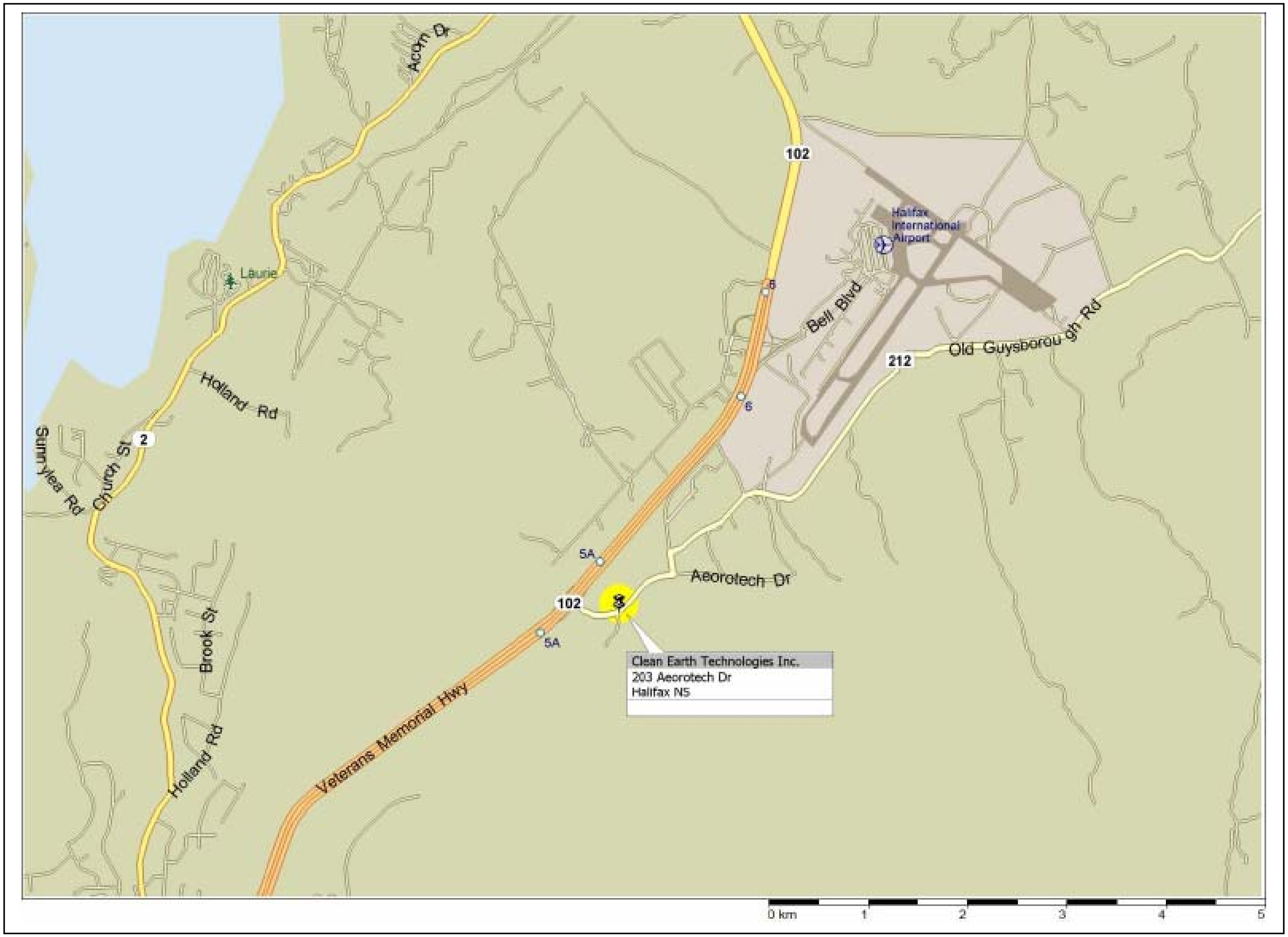


Figure 3 Aerial Photograph of the Subject Site and Surrounding Area

Figure 4 Location Plan of Soil Washing Facility Showing Surrounding Watercourses and Residences

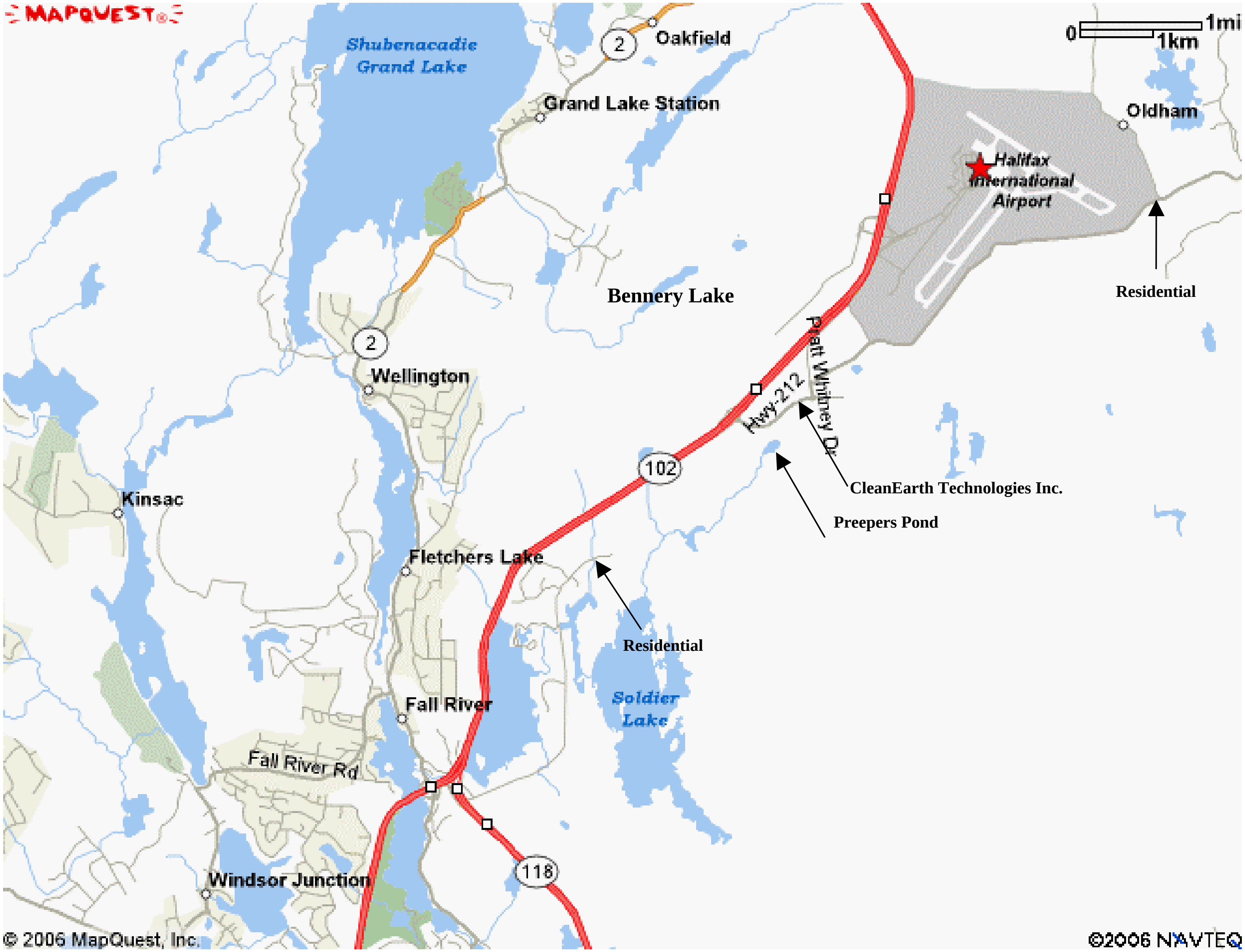
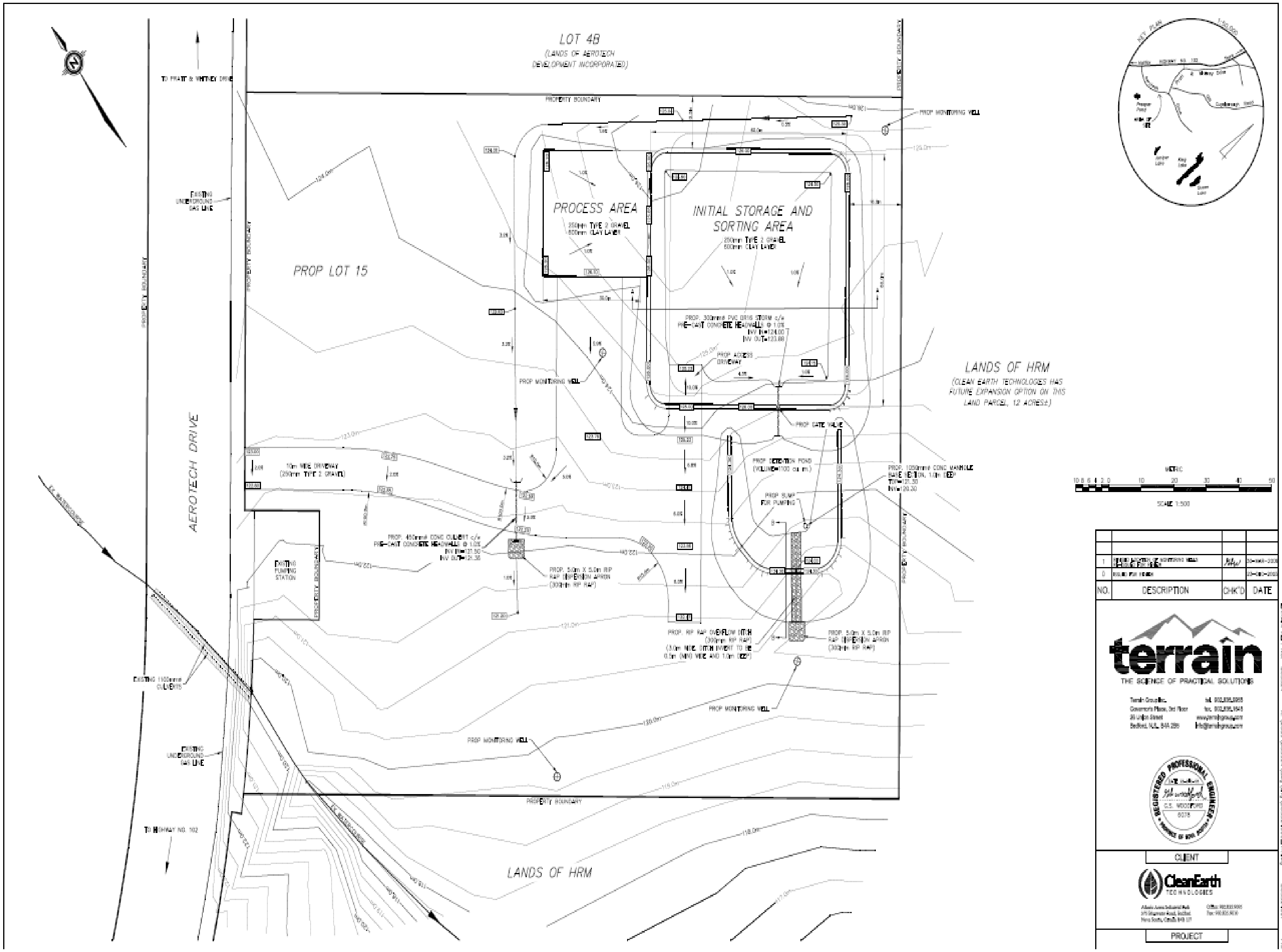


Figure 5 CleanEarth Technologies Inc. Site Plan and Sections Showing Site Topography, Unnamed Stream and Site Construction Details



2.4 Site Facilities

The subject property is currently developed as a soil treatment facility for the treatment of TPH, PAH and metal contaminated soils that are not classified as waste dangerous goods. Main features of the facility include the following:

- An 18,000 square foot administration and research and development laboratory building and associated maintenance warehouse. At the time of the writing of this document these buildings were currently under construction with scheduled completion for October, 2006.
- A 30 m x 30 m process area constructed of a minimum thickness of 600 mm of clay with an associated minimum hydraulic conductivity of 1x 10^{-6} cm/s covered with a 200 mm thick layer of sand/gravel. This area is scheduled for construction following the construction of the administration, R&D and maintenance warehouse. If the permit amendment is granted then the liner will be upgraded to a minimum of 1000 mm of clay with an associated hydraulic conductivity of $1x10^{-7}$ cm/s or equivalent and covered with a 500 mm layer of sand/gravel.
- A 60 m x 60 m storage and operation pad constructed of a minimum of thickness of 600 mm of clay with a minimum hydraulic conductivity of 1x 10^{-6} cm/s covered with a 200 mm thick layer of sand/gravel. The storage and operation area is surrounded by a 1.2 m high berm that controls runoff onto and off of the storage and operational pad. The storage area has the capacity to store 30,000 tonnes of contaminated material
- An 1100 cubic meter retention pond designed to contain the runoff from the storage and operation pad from a 1 in 100 year storm event.
- Monitoring well network designed to monitor the upgradient and downgradient groundwater conditions at the property.
- A 100 to 200 tonne per hour soil washing process capable of treating TPH, PAH and metal contaminated soil.
- A 75 gallon per minute water treatment system capable of treating water contaminated with suspended solids, organic and inorganic contamination.
- Municipal water and sewer service. Water for the property is provided by the Halifax Regional Municipality from the water treatment plant located at Bennery Lake. Wastewater discharges from the property are treated at the Aerotech WPCP and are treated by primary clarification, rotating biological contactors, secondary clarifiers, and post chlorination. Other features of the Aerotech WPCP include aerobic sludge digestion, nitrification, and phosphorus removal. The effluent from the plant effluent is discharged to the Johnson River system.

Further details on the construction of the storage pad and retention pond are shown in Figure 5 and included in **Appendix B.**

Information on the soil washing process and water treatment system is provided in section 2.7.

2.5 Treatability Testing

The first stage in ultimately treating contaminated material that would be classified as a waste dangerous good involves treatability testing in the CleanEarth Technologies Laboratories. The treatability testing typically involves analysis of a 20 liter sample or samples of soil obtained from one or more locations from the impacted property or the contaminated material. The selection of the samples is completed following a review of any environmental reports prepared for the property or waste stream and in consultation with the environmental professional or owner responsible for the analysis of the waste dangerous good. The samples are taken from representative areas of the property that will allow analysis of the “worst case” contaminated areas at the property and/or areas that are representative of the overall contamination present.

Testing in the CleanEarth Laboratory involves simulated unit process treatment at a bench scale level on a representative sample in order to predict remedial performance and optimize the treatment system configuration. This involves simulation of the size, density and washing solution parameters that will be implemented on a full scale treatment. Following evaluation of the treatment process at the bench scale level, the treated samples are sent to a third party CAEL certified laboratory for analysis of the contaminants of concern and evaluation of the expected remedial performance. This is an important risk management and risk mitigation process. By conducting this initial evaluation before agreeing to accept any soil at the treatment facility the ultimate treatment of the soil is predictable and ensures that only contaminated materials that can be treated to required levels are received at the facility.

The goals of treatability testing performed to support a project at the CleanEarth Treatment Facility are as follows:

- Determine process feasibility
- Select physical separation approach
- Optimize washing solution parameters
- Determine design parameters
- Finalize cost of Treatment

Process feasibility is determined by the ability to meet the contaminant specific limits established on total and/or leachable contaminants remaining in the soil.

2.6 Transportation and Receipt of Contaminated Material

If the treatability testing returns positive results, then the next stage in the treatment process will involve the signing of a contract and a technical document detailing the nature of the contaminated material to be transferred to the facility. The content of the draft technical document will include the following content:

- Origin of the Waste Dangerous Goods
- Quantity to be Delivered
- List of Contaminants and Waste Classes
- Number of Samples Taken to Characterize the Waste Dangerous Goods
- Attached Analytical Results from a CAEL Certified Laboratory
- Description of the Material
- Site history/Origin of the Contamination
- Generator or Generator Representative Declaration of the Accuracy of the Information Provided

If the permit amendment is granted a draft of the technical document will be submitted to the NSEL containing as a minimum the above content for review and comment in prior to the final version being submitted to potential clients. This approach provides assurance that CleanEarth is getting exactly the materials that have been subjected to the antecedent treatability assessment and have been the subject of the design of a viable treatment plan. It is also a newly added “check and balance” that is being applied to ensure quality control. The addition of this step provides an important risk mitigation/management strategy to ensure that CleanEarth receives the same material for which the treatability assessment has been completed and underscores the company’s commitment to absolute transparency and accountability.

Following the signing of the contract and technical document the contaminated material will be transported and received at the CleanEarth Soil Treatment Facility. Transportation of the contaminated material will be conducted by third parties. A typical scenario will involve one of consultants, contractors or owners coordinating the transport of the contaminated material from the originating property via an independent trucking company. Upon receipt of the contaminated material a composite sample will be obtained for QA/QC purposes and submitted to a CAEL certified laboratory to verify the quality of the material being transported. QA/QC samples will be obtained at a frequency of one sample for every 1000 tonnes delivered to the facility.

The actual route of transport will be dependent on the location of the originating property and will have to be conducted on roads or highways designated for the transport of waste dangerous goods. As the shipment of contaminated material enters the regional vicinity of CleanEarth’s Treatment Facility in the AeroTech Park it will be transported along Highway 102 to Aerotech Drive. The transportation of dangerous goods and waste dangerous goods are already occurring along Highway 102 and Aerotech Drive. In addition, Highway 102 is designed to accommodate the transport of high traffic volumes while Aerotech Drive is a collector road designed to accommodate traffic volumes within an industrial park. Impacts from increased traffic hauling waste dangerous goods to CleanEarth’s treatment facility are expected to be negligible on both roadways.

It should be noted that the transportation of waste dangerous goods is regulated federally under the Interprovincial Movement of Hazardous Waste Regulations and Transportation of Dangerous Goods Act and Regulations and provincially under the Dangerous Goods Transportation Act and Regulations. These Acts and Regulations outline minimum requirements to transport material of this nature including manifesting and safety requirements. Any shipment of contaminated material trucked to CleanEarth’s Treatment Facility by a third party transport company will have to be conducted in accordance with these Acts and Regulations.

Following the arrival of the contaminated material shipment at the Treatment Facility it is scaled to confirm the quantity of material being shipped, the sections of the manifest requiring completion by the receiving facility are completed and the material is stockpiled in the storage and operational cell to await treatment.

2.7 Soil and Water Treatment

After the contaminated material has been delivered to the treatment facility, the next stage of the process involves the treatment of the contaminated material and any process residuals generated during the treatment processes. The following sections present the flowsheet for the equipment that will be used to treat the contaminated material and to treat the process water and any surface water that may require treatment after collection in the on-site retention pond from processing or rainfall events.

2.7.1 Soil Treatment

The soil treatment process involves the physical separation of particles from each other based on particle characteristics such as size, shape and density.

Soil washing is an ex situ process in which contaminated soil is treated through the physical separation of particles from each other based on particle characteristics such as size, shape and density. It operates on the principal that contaminants are associated with certain size fractions of soil particles and that these contaminants can be dissolved or suspended in an aqueous solution, removed by separating out clay and silt particles from the bulk material matrix or separated through physical differences between the contaminant and the bulk matrix. Amendments are sometimes added to the washwater to aid in the separation process. Table 1 in section 2.10 lists the potential additives that can be added for either the soil or water treatment activities. These additives are utilized on an as needed basis and if required are typically added in the part per million concentration range.

The CleanEarth soil washing process is a closed loop system that recycles the water used within the circuit following an initial charge of water prior to beginning operations. The initial volume of water for the soil washing process will be obtained from the municipal water source that services the Aerotech Business Park. As discussed in section 2.4 this water source originates from Bennery Lake.

Most organic and inorganic contaminants bind chemically or physically to clay or silt particles which in turn adhere to larger sand and gravel particles primarily by the relatively weak forces of compaction and adhesion. Typically 99% of the contaminants in soil are associated with particles of less than 60um in diameter. Particle size separation by washing enables the contaminated clay and silt particles and the bound contaminants to be concentrated.

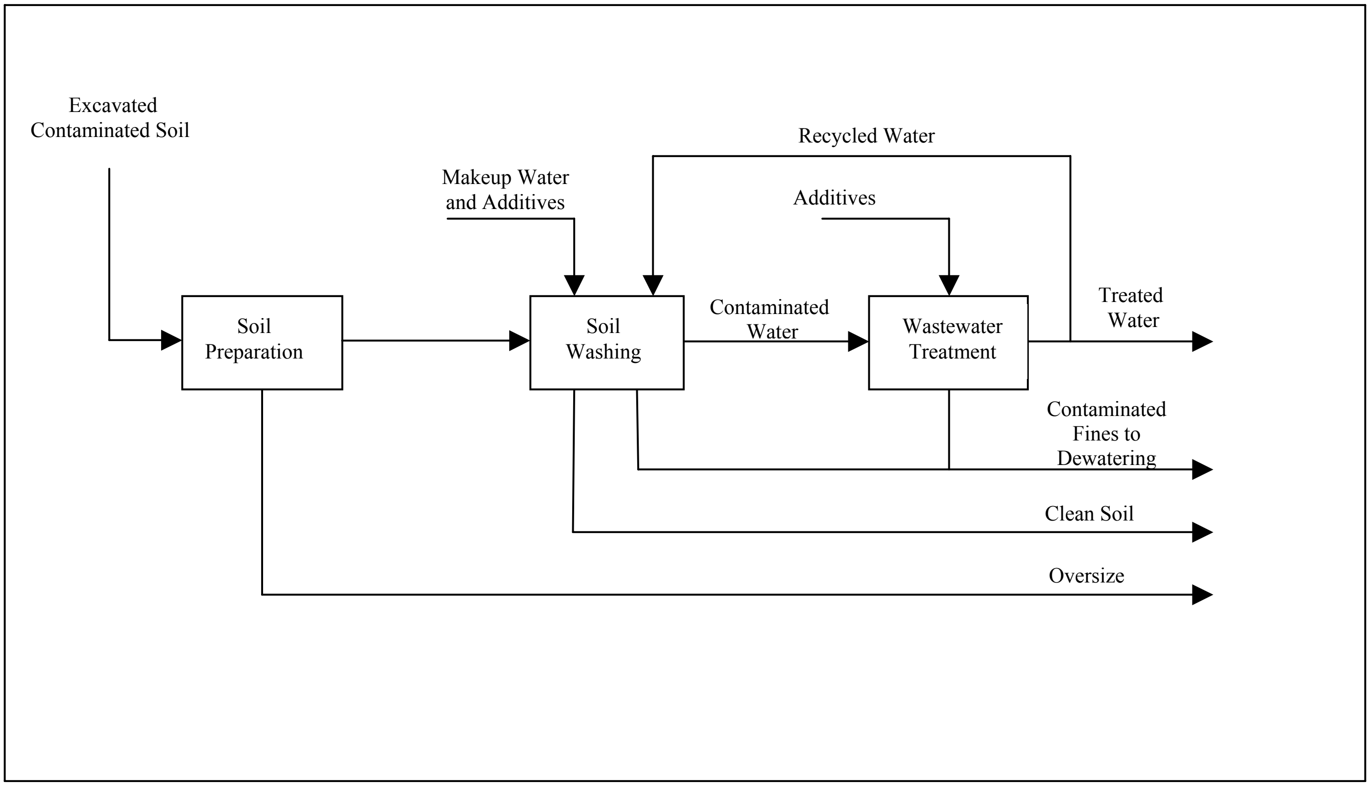
Figure 1 shows a process diagram of a generalized soil washing process. Removal of debris and large objects precedes the soil washing process to prepare the soil for treatment. After the soil is prepared it is mixed with washwater and enters into a number of unit treatment processes the selection of which is dependent on the treatability testing previously conducted on the soil. At this point four potential separation processes can occur:

1. water-soluble contaminants are transferred to the washwater;
2. contaminants are suspended in the washwater;
3. clay and silt particles to which contaminants are adhered are separated from the larger soil particles; and
4. contaminants are separated and concentrated from the bulk matrix based on physical differences.

The water soluble contaminants transferred to the washwater and contaminants suspended in the washwater are sent to the wastewater treatment circuit where the contaminants are removed from the water. The treated water is typically recycled back to the soil washing process for further treatment of soils or is transferred to a holding tank where it can be analysed to evaluate compliance with regulatory levels before being discharged.

The contaminated fines (clay and silt particles) and/or the concentrated contaminates are sent to the dewatering modules where the free water is removed and the concentrated contaminants are prepared either for further treatment or for off-site disposal at an appropriate licensed facility.

Figure 6 Soil Washing Flow Sheet



Each stage in the soil washing process is described in more detail below.

Soil Preparation

As shown in Figure 1 the first stage of the process involves soil preparation. The CleanEarth Soil Washing Process is capable of treating material up to 24 inches in size. Rock and debris greater in size than this maximum limit are separated from the bulk soil using a dry screening technique and, if required, subsequently treated using a hand held high pressure water spray device to clean the surface of the oversize material. The water spray will be conducted on the treatment pad so that the wash water will drain and collect in the retention pond for subsequent treatment.

For the purposes of treating the oversize material a clean surface will be defined as free from all visible contaminated soil except that residual staining from soil consisting of light shadows, slight streaks, or minor discolorations. Soil may be present in cracks, crevices, and pits provided that such staining and soil is limited to no more than 5% of each square inch of surface area.

The ability to further treat the oversize that has been screened is an extremely important feature. Dry screening techniques work well when the feed soil contains very little moisture. Since in reality this is rarely the case, dry screening operations often result in significant quantities of contaminated fines carrying over with the oversize material.

Soil Washing Process

The actual configuration of the soil washing process will be determined based on the treatability testing. However, the unit process employed will be a combination of the following treatment modules described in the sections below:

- Size Separation Modules – particle size separations are conducted on the bulk contaminated material through the use of physical or hydrodynamic separation techniques. Examples of equipment utilized include multi deck screeners, hydrocylones and rising current classifiers.
- Density Separation Modules – particles with different densities respond differently to gravity and to one or more other forces applied simultaneously in opposition to gravity. Although density difference is the main criterion for gravity separation, particle size and shape also influence the separation. Utilizing these techniques contaminants with a density difference from the bulk matrix can be effectively separated and concentrated. Examples of equipment used in density separation include spirals, shaking tables and froth floatation.
- Dewatering Modules – the dewatering modules are used to separate the washwater from the treated soil and contaminated sludge. These modules allow the washwater to be recycled and utilized in a continuous closed loop process. Examples of dewatering equipment include filter presses, linear motion screens and centrifuges.

Since each soil and contaminant combination is unique, the exact treatment circuit and any potential amendments added to the washwater are determined on a case by case basis from the results of the treatability testing a specific flowsheet is not offered. However, case studies illustrating specific projects are provided in Section 9.0 to illustrate the abilities of the process.

Wastewater Treatment

The wastewater treatment system is described in section 2.7.3

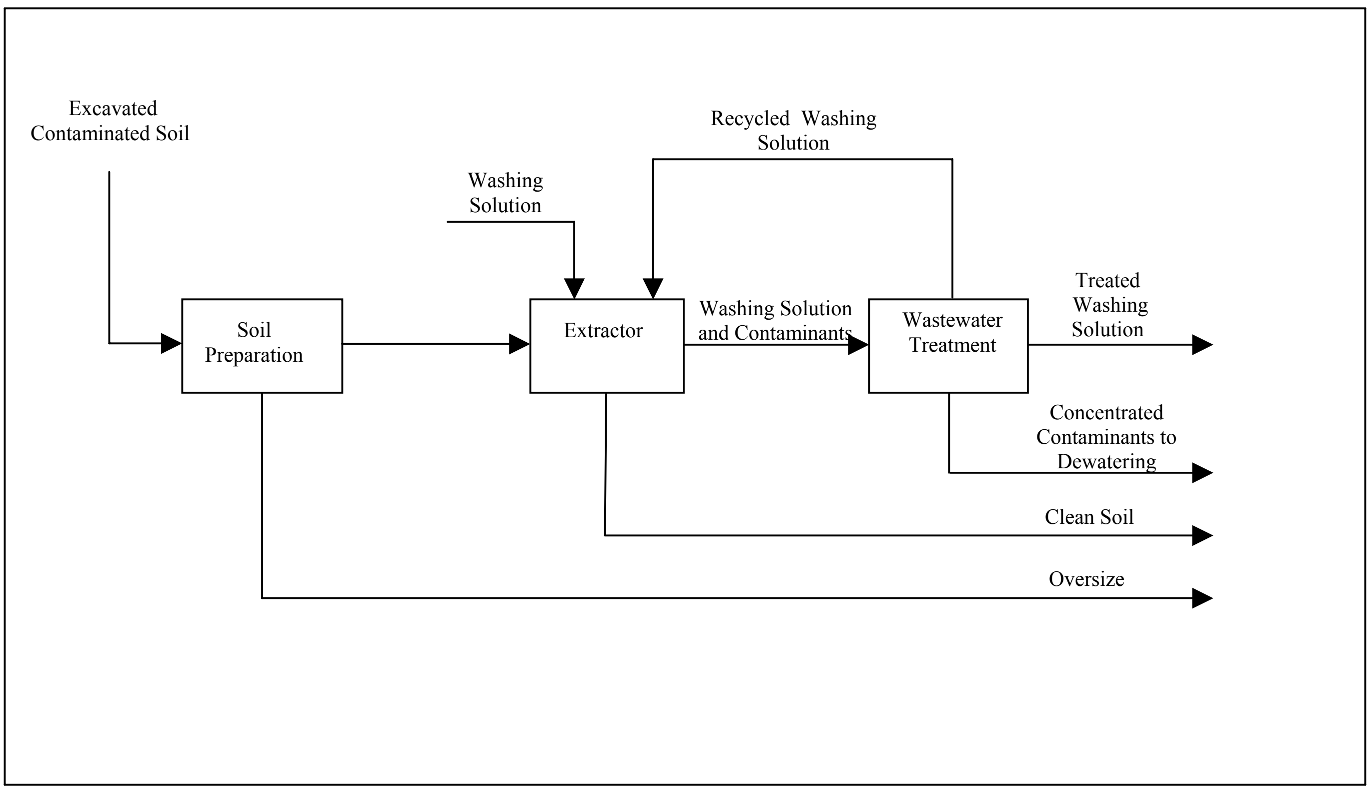
2.7.2 Leaching/Extraction

Leaching or extraction differs from soil washing in that it employs a leachant or extractant to separate the contaminants from the bulk matrix. Like soil washing, it is a separation process that utilizes an amended washwater to extract the contaminants from the soil, however, it differs from soil washing in that the residence time within the extraction system is in the order of magnitude of hours as opposed to minutes allowing for greater contact times and extraction efficiencies.

The technique operates on the principal that the contaminants will have a greater solubility in the washwater solution than in the soil or mineral matter matrix. The equilibrium concentration gradient drives the mass transport process such that the contaminant transfers from the soil to the washwater. When the soil is separated from the amended washwater, the contaminant concentrations present in the soil or mineral matrix are reduced relative to the concentrations prior to the extraction process.

Figure 2 shows a process diagram of the leaching/extraction process. The remediation process begins with excavating the contaminated material and passing it through a dry screen to remove large or oversized objects. In the extractor the washing solution is mixed with the contaminated material and mixed over a period of minutes to hours to promote the transfer of the contaminants to the amended washwater. After the washing solution and contaminated material have been contacted for the appropriate period of time the leachant/extractant is separated from the treated solids and pumped to the wastewater treatment circuit to remove the contaminants from the washing solution. Two process streams are produced at the wastewater treatment stage. The treated washing solution is either recycled for further soil treatments or held for analysis to ensure regulatory compliance levels have been met prior to discharge. The concentrated contaminants removed from the washing solution are pumped to the dewatering module to remove the free water and prepare the contaminants for disposal at an appropriate licensed off-site facility.

Figure 7 Leaching/Extraction Process Flowsheet



Key to this process is the treatability testing conducted in the laboratory prior to the acceptance of the contaminated soil at the treatment facility. The upfront laboratory testing determines the required amendments to the washwater and the residence time required to effectively transfer the contaminants from the solid phase to the washwater phase. Table 1 in section 2.10 lists the potential chemical reagents used for the soil and wastewater treatment activities including the leachant/extractant agents that may be used in the soil treatment.

Like the soil washing process, each soil and contaminant combination is unique with the leaching solution determined on a case by case basis from the results of the treatability testing. Case studies illustrating the treatment of specific contaminants using these techniques are presented in section 9.0.

2.7.3 Water Treatment

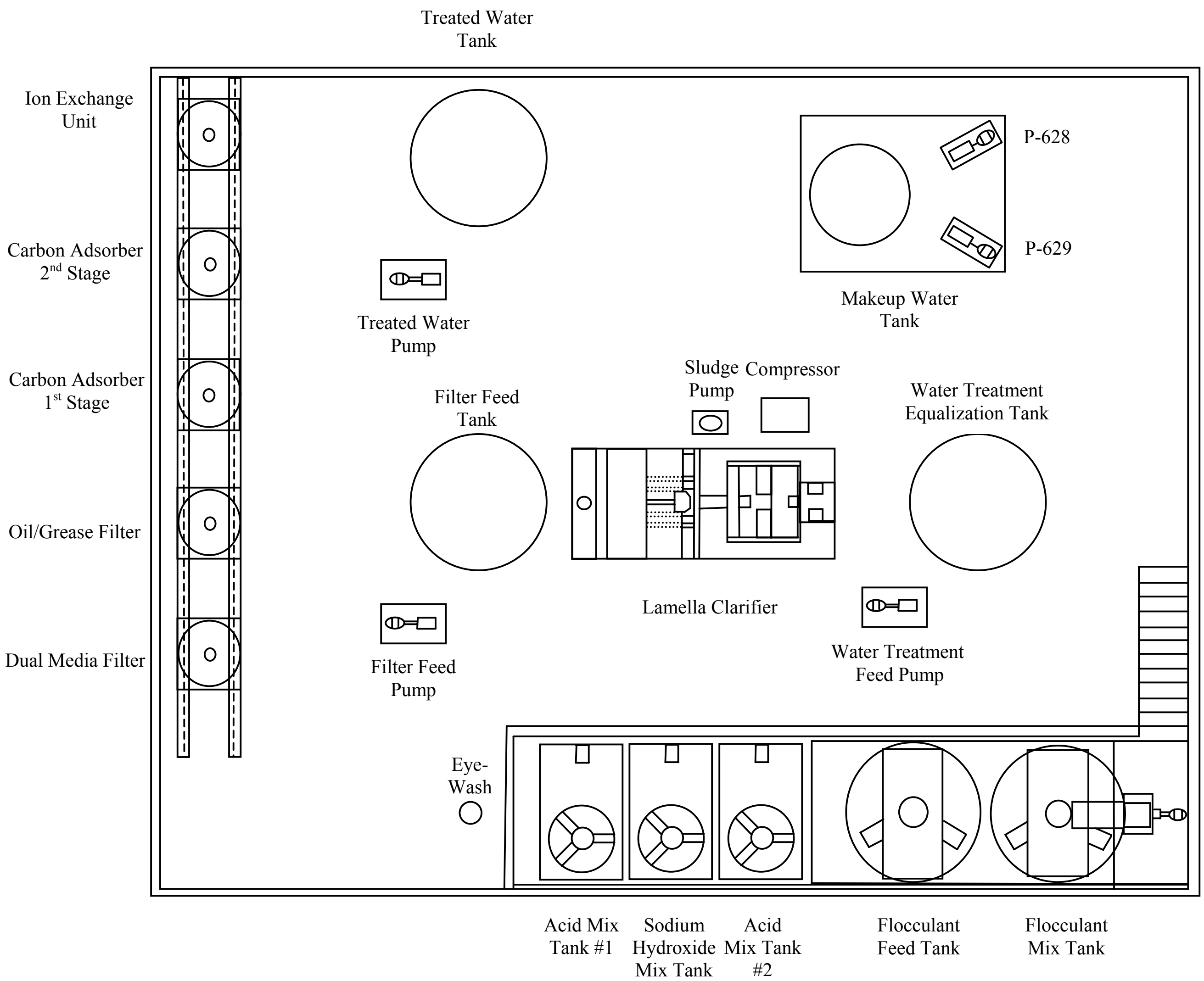
The water treatment equipment is used on an as needed basis to treat the process water used in the soil washing or leaching/extraction processes as well as any surface water that may collect in the retention basins used to control run-off from the treatment and storage pads at the facility.

While the majority of the soil processed at the facility will have contaminants that are either insoluble or possess trace solubility, the water treatment equipment will allow the flexibility to handle contaminant forms that will partition to the aqueous phase. The following plan view and equipment description provides more detail on each of the unit processes.

The process begins by pumping water to the Water Treatment Equalization Tank. Influent is then pumped from the Water Treatment Equalization tank to the Lamella Clarifier where acid/base adjustments can be made to precipitate heavy metals. Flocculant is added to the Lamella Clarifier and the stream flows by gravity into an inclined plate section of the clarifier. A liquid-solid-free phase hydrocarbon separation is completed in this portion of the Clarifier where flocculated precipitates and fine suspended solids report to the underflow for intermittent transfer by a pneumatic diaphragm pump. The Clarifier overflow passes into the Filter Feed Tank for blending and intermittent storage. The wastewater is pumped from the Filter Feed Tank to the filters for polishing. Downstream filters operate in series and include the Dual Media Filter, Oil/Grease Filter, two-stage Carbon Adsorbers, Ion Exchange Unit and Treated Water Tank. Backwash for the Dual Media Filter is pumped from the Treated Water Tank as required.

This water treatment configuration offers the ability to reduce organic or inorganic contaminants present in a wastewater stream to below detection limits.

Figure 8 Water Treatment Process Plan View



2.10 Chemical Storage

Table 1 lists some of the treatment reagents that may be used during the course of the soil treatment and water treatment activities. It should be noted that few chemicals will be stored on-site at any one time. The required treatment reagents will be brought on-site following identification during the treatability testing as required for the treatment of soil using the soil washing or leaching/extraction processes. Chemicals will be brought on-site in quantities required for the completion of a specific project and will typically involve the storage of between 1 to 4 drums of material at any one time.

Table 1 Soil Washing, Leaching/Extraction and Water Treatment Reagents

Reagent	CAS No.
Surfactants	N/A
Ammonium Sulfate	7783-20-2
Ammonium Phosphate (Monobasic)	7722-76-1
Anionic and Cationic Floculants	None
Aquaset	14808-60-7
Aquaset II	14808-60-7
Aquaset II-H	None
Calcium Hypochlorite	7778-54-3
Calcium Superphosphate	None
Calcium Sulfate	10101-41-4
Calcium Bisulfite	1344-81-6
Calcium Polysulfide (Lime, sulfurated)	None
Calcium Dimethyldithiocarbamate	20279-69-0
Calcium Dimethyldithiocarbonate	None
Calcium Chloride	10043-52-4
Calcium Tetrathiocarbonate	None
Calcium Superphosphate	None
Calcium Polysulfide (Lime, sulfurated)	None
Carbon	7440-44-0
Cellulose Xanthanide	None
Cement (Portland)	65997-15-1
Cement Kiln Dust	None
Copper	None
Ferric Oxide	1309-37-1
Ferrous Oxide	1345-25-1
Ferrous Sulfate	7720-78-7
Ferrous Ammonium Sulfate	10045-89-3
Fly Ash (Class C & F)	None
Green Phosphate (Triple Superphosphate)	7664-38-2
Hg Buster 72	None
Hydrochloric Acid	7647-01-0
Hydrogen Peroxide	7722-84-1

Reagent	CAS No.
Iron Chips	None
Lime	1305-78-8
Magnesium Oxide	1309-48-4
Methanol (when used with Petroset II or II-H)	67-56-1
Nickel	None
Petroset	1318-93-0
Petroset II	None
Petroset II-H	1318-93-0
Potassium Permanganate	7722-64-7
Potassium Phosphate (Monobasic)	7778-77-0
Salt Water (˜ 8%)	None
Selenium	7782-49-2
Sodium Sulfate	7757-82-6
Sodium Percarbonate	15630-39-4
Sodium Sulfonate	None
Sodium Metabisulfite	7681-57-4
Sodium Thiosulfate	7772-98-7
Sodium Dimethyldithiocarbamate	128-04-1
Sodium Sulfide (Flake)	16721-80-5
Sodium Hydroxide	1310-73-2
Sodium Silicate	1344-09-8
Sodium Dimethyldithiocarbonate	None
Sodium Aluminate	1302-42-7
Sodium Carbonate	497-19-8
Sodium Hydrosulfite (Sodium Bisulfite)	7631-90-5
Sodium Hypochlorite	7681-52-9
Sodium Tetrathiocarbonate	7345-69-9
Starch Xanthate	None
Sulfur (elemental)	7704-34-9
Sulfuric Acid	7664-93-9
Tin	7440-31-5
Zeolites (Clinoptilolites, Aluminum Silicates)	None
Zinc	None

As stated previously treatment reagents will only be brought onto site on an as needed basis based on the results of the treatability testing. All chemicals stored at the facility will be stored in accordance with the Nova Scotia Dangerous Goods Management Regulations, but will generally be contained within a secondary containment according to conditions identical to the already approved procedure outlined in CleanEarth's existing approval, namely:

- Single tanks or containers will be stored in a secondary containment area consisting of a minimum 110% of the single storage tank container; or
- Multiple tanks included in the same containment area will be stored in a secondary containment area with 110% of the volume of the largest tank or

100% of the largest tank plus 10% of the aggregate capacity of all other tanks, whichever is greater.

MSDS sheets for all chemicals stored on-site will be maintained in a single binder with copies maintained at the location of chemical storage and chemical use.

3.0 Environmental Setting

The following sections summarize the environmental conditions present at the 203 Aerotech Drive property.

3.1 Atmospheric Conditions

At the Halifax Airport, which is in close proximity to the CleanEarth Soil Treatment facility, atmospheric conditions are described as a modified continental climate with average low temperatures varying from -11 degrees Celsius in January and February to average high temperatures of 23 degrees Celsius in July and August. Yearly precipitation at the airport averages approximately 1500 millimeters including about 260 cm of snowfall. Wind directions are typically southerly and northwesterly and depend largely on the season. Winter winds blow predominantly from the west or northwest and tend to be stronger than during other times of the year. During the summer months, the prevailing winds typically blow from the south.

3.2 Geology, Hydrogeology and Hydrology

3.2.1 Soil, Bedrock and Groundwater Conditions

Surficial geology in the area of the site is reported by others to consist predominantly of Lawrencetown till. This unit is described as moderately compact clay till consisting of approximately 25% sand, 40% silt and 25% clay with variations to a compact sand silt till consisting of approximately 50% sand, 35% silt and 15% clay. At the time of construction of the existing soil treatment facility site specific sampling was conducted on the soil and bedrock present at 203 AeroTech Drive. A sample of soil was obtained as a composite from the area where the storage/operational pad was constructed. The soil is described as 10% gravel, 44% sand and 46% silt and clay. The test results are presented in **Appendix C**.

During initial site development work, a series of soil samples were retrieved and analyzed in order to determine baseline conditions on the property. Although the presence of some trace metals was detected, these are believed to represent baseline conditions in the natural soils in this area and are not expected to be become an environmental concern.

Bedrock at the 203 Aerotech Drive property and immediately surrounding area is underlain by Goldenville formation undivided metasandstone, green siltstone and minor slate of the Meguma Group. As this area of Nova Scotia is known to contain acid producing pyritic slate, a sample of the bedrock was submitted to the Dalhousie Minerals Engineering Center for analysis of total sulphur and acid producing potential in order to verify the absence slate. The results were reported as 0.002% total sulphur with an acid producing potential of 0.061 kg/t. Given these results the soil treatment facility is not within the zone of pyritic slate bedrock and is not anticipated to have issues related to acidic runoff during the course of operations.

Four groundwater monitoring wells were also installed on the site which are to be analyzed on a quarterly basis. Initial baseline data have indicated elevated levels of aluminum, iron and manganese and are indicative of regional background conditions.

The monitoring wells installed at the property indicate that the groundwater table varies from just below grade to approximately 4.5 m below grade. The direction of groundwater flow follows the general topography of the property and flows to the south/southwest towards the unnamed stream that intersects the western corner of the 203 AeroTech lot.

Falling head permeability testing conducted on the soils present at the property indicate a measured value of 2.0×10^{-6} cm/s. The test results are included in **Appendix C**.

Original laboratory reports on the soil and groundwater baseline conditions are presented in **Appendix D.**

3.2.2 Surface Water and Site Drainage

The site is broadly level, occurring or as a result of filling which was conducted during site development. There is a slight slope to the west toward the small creek that crosses the property in the north west corner and a prominent drop along the western limit of the lot. Operating areas of the site appear to be sloped outward and since no surfaces are paved at the present time, rainwater would be expected to percolate the ground with excess running off toward the site perimeter and particularly in a westerly direction toward the creek.

A clay lined water retention pond is located on the south western portion of the site. Rainwater that collects inside the bermed processing area is pumped to this pond for use in the process. There are no storm sewers or other drainage works located on the site.

3.3 Watercourses

There are no major watercourses within 500 meters of 203 AeroTech Drive. The nearest waterbody is an intermittent unnamed stream that intersects the western edge of Lot 15 and is located approximately 150 meters away from the location of the operation/storage pad. This detail is shown in Figure 5 and in **Appendix B**. In addition to the unnamed stream the nearest waterbodies are:

- Preeper Pond - 0.7 kilometers to the southwest;
- Juniper Lake - 1.2 kilometers to the southeast;
- King Lake - 2.0 kilometers to the southeast;

- Holland Brook - 1.25 kilometers to the south;
- Soldier Lake - 3.25 kilometers to the southwest;
- Preeper Big Lake - 2.0 kilometers to the southeast;
- Bug Lake - 3.5 kilometers to the south;
- Bennery Lake – 3.75 kilometers to the northwest;
- Shubenacadie Grand Lake – 5 kilometers to the northwest;
- Little Red Trout Lake - 4.0 kilometers to the south; and
- Kelley Long Lake - 2.25 kilometers to the northwest.

In the above list Bennery Lake and Shubenacadie Grand Lake are used as drinking water sources. Figure 4 shows the relation of these watercourses to the CleanEarth Faciltiy.

3.5 Ecological Survey

CEF Consultants (CEF) were contracted to conduct an ecological survey of the 8.14 acre property at 203 AeroTech Drive. The purpose of the survey was to establish baseline ecological conditions and evaluate whether or not the property supported any species of concern or listed on the Species at Risk Act (SARA) that would require special precautions or mitigation measures as related to the proposed amendment to the existing Approval for the treatment facility.

CEF specifically surveyed the following ecological elements at the property:

- Botanical Resources;
- Water Courses;
- Fish Habitat;
- Wildlife;
- Ornithological Resources;
- Species at Risk; and
- Wetlands

Following the completion of the survey CEF concluded the following:

> *The Species At Risk Act (SARA) is the official list of wildlife species that are extirpated, threatened, endangered or of special concern. No species of concern, or listed in SARA were found in Lot 15, nor is the lot considered prime habitat for any of these species. The habitat assessment showed no major concerns that would affect the development of the area.*

The complete CEF report is presented in **Appendix E**.

3.6 Archeological Resources

This project only involves an amendment to the existing operating approval and will not involve the disturbance of any ground to the existing footprint of the operating facility. Since there will be no disturbance to the property there is no risk to any potential archeological resources and an impact assessment is not required.

4.0 POTENTIAL ENVIRONMENTAL IMPACTS AND IMPACT MITIGATION

This section outlines the potential environmental impacts and the mitigation measures that will be put in place during the course of the treatment of the contaminated soil.

4.1 Potential Impacts

The environmental issues associated with the operation of the treatment facility for the treatment of Waste Dangerous Goods involve the following potential impacts. The identification of these impacts is based on CleanEarth's experience as well as third party experience at similar facilities:

- Dust Emissions;
- Groundwater Impacts;
- Surface Water Impacts;
- Solid Waste;
- Vehicle Tracking of Contaminants off-site;
- Noise Emissions; and
- Volatile Emissions.

Impacts from dust emissions, groundwater impacts and surface water impacts can occur during the storage and the processing phases of the treatment cycle. Potential noise emissions are restricted to the processing stage of the project.

4.2 Mitigation and Contingency of Potential Impacts

The following sections outline the measures that will be put in place to mitigate the potential impacts identified above.

4.2.1 Inspections and Monitoring

Daily inspections will be conducted throughout the course of the storage and treatment activities to confirm that the storage and operation of the treatment processes have not adversely affected the local surface soils, surface water or groundwater. Inspections will ensure that the integrity of all control features is maintained.

4.2.2 Dust Emission, Groundwater/Surface Water Impacts During Storage

Potential impacts to groundwater and surface water during storage of the contaminated soil will be controlled through the existing operation/storage pad and retention pond. As described previously, the main design parameters for the storage pad and retention pond include:

- The storage pad is constructed using a base consisting of a minimum thickness of 600 mm of clay with a minimum hydraulic conductivity of 1x 10^{-6} cm/s covered with a 200 mm thick layer of sand/gravel..
- The retention pond is designed to contain the runoff of the storage and treatment pads from a 24 hour 1 in 100 year storm or approximately 1100 cubic meters of storage capacity.

Further details on the construction of the storage pad and retention pond are provided in **Appendix B**.

The potential to generate dust emissions will be controlled through a combination of smooting the sidewalls and wetting the stockpiled material. The stockpiles will be inspected on a daily basis to ensure that this procedure is remaining effective in controlling any dust emissions. If required, additional water or a polymer based solution will be applied to the pile to on an as needed basis to prevent any airborne dispersal.

4.2.3 Dust Emissions During Operation of the Process

The initial feeding and conveying of the contaminated soil has the potential to generate dust emissions. The treatment processes described in this document are wet processes, and therefore dust emission will be insignificant once the soil has entered into the treatment system. If the soil is too dry and can generate dust emissions during the initial feeding operations a water spray will be applied to the soil prior to processing to eliminate any dust emissions.

In addition to the above measures, the treatment activities will not be conducted in high wind conditions.

4.2.4 Groundwater/Surface Water Impacts During Operation of the Process

Potential impacts to groundwater/surface water can occur in the event of a spill of process water during processing. If a spill were to occur, the process water would be contained, collected and recovered via the clay lined operation/storage pad that is graded to drain to the retention pond. Details of construction are provided in **Appendix B.**

Prior to the discharge of any water collecting in the retention pond, the water will be tested for total metals, PAHs, TPH, PCBs and chlorinated solvents. Contaminant concentrations will be compared against the Halifax Municipal Discharge Criteria (HRM By-Law Number W-101) prior to discharge to the municipal sewer system or the applicable CCME or Provincial criteria if discharged to the unnamed streamn that intersects the northwest corner of the 203 Aerotech Drive property.

If the Target discharge criteria are exceeded the water will be treated using the on-site water treatment equipment outlined in section 2.9. If contaminant concentrations still exceed the Target Criteria following treatment using on-site methods, the water will be disposed off-site via an NSDEL approved hazardous waste disposal company, such as Barrington Industrial Services or Atlantic Industrial Cleaners.

If in the unlikely event that a spill of process water escapes the implemented containment features, potential impacts to groundwater will be monitored through the groundwater wells that will be installed at the property. If the groundwater sampling identifies a contaminant impact to the groundwater, the well(s) will be resampled to confirm the result. If the results confirm the impact, additional well(s) will be installed to delineate the impacts and the downgradient water courses will be sampled to determine potential impacts. Once delineated an active remediation program of groundwater and/or surface water recovery and treatment using the on-site water treatment system will be implemented. Any soil that has come in contact with the contaminated process water will be excavated and processed through the treatment system or disposed at a licensed facility if the wet-screening process has been demobilized. Boundary samples will be obtained to confirm all impacted soil has been removed.

In addition to the containment features listed above, if the amended permit is issued, a contingency plan developed in accordance with the Nova Scotia Department of Environment and Labour's Guideline for Contingency Planning dated September, 2004 will be submitted prior to receipt of waste dangerous goods at the facility.

4.2.5 Solid Waste Disposal

Contaminated material such as disposable coveralls, gloves, boots, etc. will be collected and stored in specified drums in a drum storage area at the operational area of the property prior to disposal at a licensed facility.

Other solid waste streams such as spent carbon, sand filters, resins, etc. will also be stored in drums or equivalent container and stored in a specified area of the property. The disposal of the material will be dependent on the nature of the solid waste stream and will be disposed at a facility licensed to receive the contaminated materials.

4.2.6 Vehicle Washing and Decontamination Area

All vehicles leaving the CleanEarth Facility will be washed to remove any adhered contaminated soils or material prior to leaving the property. The decontamination will be conducted at the existing washdown area that is located at the entrance of the operational/storage pad of the facility. The water generated from the washdown will be collected and treated to meet the discharge limits for the property. In the event that the washdown water can not be treated to discharge limits then it will be disposed at a licensed facility.

4.2.7 Noise Emission Control During Operation of the Process

Significant noise sources from the project are restricted to the diesel generator that will be used on-site to provide power for the process. The generator will be utilized on an interim basis until the operational area of the property is serviced with power. In the interim, the potential noise generated from the generator is mitigated through the use of an insulated generator during the course of the treatment activities.

4.2.8 Volatile Emissions

The emissions of concern from soil remediation activities in general are typically related to volatile organic compounds (VOCs), semi-volatile organic compounds and particulate matter and associated metals. Particulate matter and associated metals are addressed in section 4.2.4.

The magnitude of VOC emissions depends on a number of factors, including the type of compounds present in the waste, the concentration and distribution of the compounds, and the porosity and moisture content of the soil.

To date emissions from the soil washing process have not been an issue during operations. The mobile soil washing process incorporates a number of wet treatment modules that ultimately concentrate the bulk of the contamination into the fines fraction of the soil that comprises a particle size of less than 15 um. Following dewatering, this fraction contains approximately 20% to 25% moisture by weight as well as a polymer that is used to condition the fines for the dewatering module. The combination of moisture content and polymer addition results in very low volatile emissions.

The low volatile emissions qualitatively observed during the operation of the process is based on the rationale that wet soils generally have relatively low levels of volatile emissions, even if the soil VOC concentrations are high. This is based on the wet to saturated soils having little air-filled porosity and therefore the rate of diffusion of VOCs through wet soils is relatively low.

The existing control techniques will be utilized to control any potential VOC emissions that may result from contaminated soils brought to the facility. The controls that can be implemented include:

- Temporary and long term foams;
- Covers and physical barriers;
- Water sprays; and
- Wind barriers

5.0 MONITORING PLAN

This section establishes the requirement for collecting and analyzing confirmation samples collected to monitor system performance, process water, groundwater and surface water quality. The required sampling frequency and analyses are summarized below.

5.1 Remediation Criteria

The following criteria will be applied to evaluate the treatment of the soil.

- Chlorinated Solvents, Metals, PCBs and PAHs - CCME Residential Criteria
- TPH - Atlantic Canada Tier I Residential Nonpotable RBSL Table

5.2 Treated Material Sampling

Following treatment in the soil washing or leaching/extraction process, the treated material will be sampled as a minimum according to the following frequencies:

Soil Volume (Tonnes)	No. of Composite Samples
1-50	1
50-500	2
500-1000	3
1000-2000	4
2000-5000	5
Each Additional 2000	1

Each individual confirmation sample will be formed as a composite of ten subsamples collected at random locations with the sample tested for the applicable contaminant in accordance with PIRI or CCME analytical requirements at a CAEL certified laboratory.

5.3 Soil and Groundwater Chemistry Baseline Information

Prior to the original development of 203 AeroTech Drive into the current soil treatment facility subsurface baseline information was obtained on the soil, surface water and groundwater conditions, to serve as the basis for future comparisons.

If the existing approval is amended to include contaminated materials classified as waste dangerous goods, then additional baseline soil, groundwater and surface water information will be obtained for the contaminants where baseline information does not currently exist.

For each contaminant baseline sampling will consist of four (4) soil samples, one (1) groundwater sample from each monitoring well and two surface water samples (upstream and downstream) of the unnamed stream that intersects the 203 AeroTech Drive property.

5.4 Sample Container Labeling

A label will be applied to the sample container before the sample is collected. The label will be completely filled out with permanent ink and will contain the following information:

- Sample number
- Sample matrix
- Preservative used, if any
- Sampling location
- Analysis required
- Initials of the sampler
- Date and time of sample collection.

5.5 Final Disposal of Treated Soil and Process Residuals

The intent of the project is to treat the bulk of the soil to the CCME or Atlantic Canada Tier I criteria residential criteria with the concentrated contamination separated from the bulk of the soil sent to an off-site biroremediation facility, thermal desorption facility, landfill or secure landfill depending on the levels and types of contamination. According to the actual level of treatment achieved during the treatment activities, the final disposal will be conducted according to the following:

- Below residential criteria - Disposal at a property with background levels of the applicable contaminant concentrations higher than the levels reported in the treated soil.
- Below residential criteria – Reuse on 203 AeroTech Drive as fill.
- Below landfill criteria and above residential criteria - Disposal at a licensed treatment facility or solid waste landfill.
- Above landfill criteria - Disposal at a licensed in-province or out-of-province disposal/treatment facility

5.6 Groundwater Monitoring

Groundwater samples will be obtained from the monitoring wells and submitted for analysis at a CAEL certified laboratory for the following:

- TPH;
- PAHs;
- total metals;
- PCBs;
- General Chemistry; and
- Volatile Organic Compounds (VOCs)

In addition to the above the monitoring wells will be monitored in the field for static water level and flow direction.

Samples will be obtained on a quarterly basis while the facility is operational and will be compared to the initial baseline groundwater conditions and the appropriate Provincial or CCME criteria.

5.7 Wastewater Collection, Storage and Discharge

Wastewater streams generated at the facility include process water, rainfall that has come into contact with contaminated soils and washwater generated from the vehicle washing and decontamination area. All treated wastewaters requiring discharge from the facility will be discharged to the unnamed watercourse on the site leading to Preepers Pond or to the municipal sanitary sewer. Wastewater is collected in the retention pond shown in Figure 5 prior to treatment and discharge.

Prior to discharge, collected wastewater will be treated using the water treatment circuit described in section 2.7.3 to meet the CCME aquatic life criteria. Samples of the treated water will be collected and tested at a CAEL certified laboratory to verify compliance with the CCME levels. In addition to testing for the contaminants of concern being treated at the property, testing will also be conducted for any specific treatment reagents utilized at the facility during the period in which the wastewater collected in the on-site retention pond.

5.8 Surface Water Monitoring

Surface water is currently monitored at two monitoring stations located upgradient and downgradient of the 203 Aerotech Drive property. If the amendment to the current operating permit is granted, then the stations will be sampled quarterly for analysis at a CAEL certified laboratory for the following parameters:

- TPH;
- PAHs;
- total metals;
- PCBs;
- General Chemistry; and
- Volatile Organic Compounds (VOCs)

6.0 REPORTING

A summary report will be submitted to the NSDEL on a quarterly basis outlining the previous quarters monitoring data.

In addition, an annual report will be submitted to the NSDEL that will summarize all the monitoring results for groundwater and surface water with an analysis of any seasonal or temporal trends, quantities of untreated soil in storage, sources and quantities of all soils received, the final disposition and quantities of all treated materials, quantities of untreated wastewater in storage and the quantity and results of wastewater treated.

7.0 PROJECT SCHEDULE

The anticipated project only involves an amendment to the existing operating approval and will not require minimal upgrades to the existing infrastructure. As such, the following outlines the schedule for the project.

- Regulatory Permits (Envionmental Assessment and Operational Permit) – 83 days
- Liner upgrade – 14 days

The facility will be open year round to receive contaminated soils with an operational period of soil treatment conducted typically between April to December.

8.0 PUBLIC CONSULTATION

The immediate area of the treatment facility is located in a sparsely populated area both in terms of residential and commercial development. In order to address any potential concern CleanEarth contacted three parties to discuss any potential concerns that may be present for any stakeholders in the area. Contact was made with Mr. Doug McRae who owns the multi-unit commercial building adjacent to the CleanEarth property, Mr. Brooke Taylor the MLA for Colchester-Musquodoboit Valley and Ms. Krista Snow the District 2 Regional Councilor for the Halifax Regional Municipality. Their comments are outlined below:

Mr. Doug McRae – President Aerotech Developments Inc. (Owner of 209 AeroTech Drive)

Mr. McRae was pleased that another business had located into the AeroTech Business Park. His concerns around the operation of a treatment facility next to his operations centered on issues related to odours and noise. During the discussions the control features in place to mitigate these issues were described. As well it was noted that currently 8,000 tonnes of contaminated soil was currently being stored and processed at the facility with 80% of the stored material being a hydrocarbon contaminated soil that could potentially cause odour problems. Mr. McRae indicated that he was not aware that CleanEarth had been storing and treating contaminated soil over the previous month and that he had not received any complaints from his tenants or had any of his own. It was agreed that the current mitigation measures for the odour and noise issues were effective.

Mr. Brooke Taylor – MLA Colchester-Musquodoboit Valley

A meeting was held between Mr. Taylor and CleanEarth personnel at the CleanEarth office located at 203 AeroTech Drive. Mr. Taylor was given an introduction to the company and the facility and treatment process was described. Mr. Taylor indicated that he had not known the nature of the CleanEarth operations prior to the meeting and was pleased to hear that the facility is involved in the treatment of contaminated material and is not a facility that will simply landfill contaminated material.

Ms. Krista Snow – District 2 Regional Councilor

Krista Snow recently toured the CleanEarth Facility located at 203 Aerotech Drive. During the tour Ms. Snow was shown the various control features that have been implemented to ensure that the operation of the facility will have minimal impacts on the surrounding area. Following the completion of the tour Ms. Snow expressed that she was impressed with the facility and would be contacting other city officials to come and tour the facility in order to better understand how CleanEarth can help HRM with their environmental management issues.

9.0 CASE STUDIES

The following outline the results of projects that were successfully completed by CleanEarth in various locations of Nova Scotia.

Fairmount Project – Soil Washing

The Fairmount project was completed on a 33 acre Brownfield site in Halifax, Nova Scotia being redeveloped into a high-end residential subdivision. Contamination at the property resulted from uncontrolled historical dumping activities resulting in TPH, PAH and metal impacts at select areas of the property. Results of the project are summarized below.

- 10,000 tonne project
- Contaminated with PAHs, lead, arsenic, zinc, copper and low levels of TPH
- **Achieved variable processing rate: 175 to 250 tonnes/hour**
- 97% of soil treated to residential criteria and reused as clean fill at the property
- 3% residual of concentrated PAHs and metals

The following table presents the polycyclic aromatic hydrocarbon and metal results obtained over the duration of the Fairmount project. The results presented in the table are the mean contaminant concentrations ± the standard error.

Table 2 Mean Contaminant Concentrations (mg/kg)

Contaminant	Fractions (mg/kg)			Treated Moisture %	Residual Moisture %
	Feed	Treated	Residual		
Naphthalene	0.42 ± 0.07	0.01 ± 0.00	0.68 ± 0.18	5 to 20	20 to 25
Phenanthrene	6.32 ± 0.88	0.31 ± 0.06	12.4 ± 1.01		
Pyrene	5.94 ± 0.67	0.31 ± 0.06	13.1 ± 0.82		
Benzo(a)anthracene	3.06 ± 0.31	0.15 ± 0.04	7.31 ± 0.44		
Benzo(b)fluoranthenes	2.45 ± 0.24	0.10 ± 0.03	5.63 ± 0.36		
Benzo(k)fluoranthenes	2.45 ± 0.24	0.10 ± 0.03	5.63 ± 0.36		
Benzo(a)pyrene	3.15 ± 0.30	0.11 ± 0.04	6.72 ± 0.41		
Indeno(1,2,3-cd)pyrene	1.92 ± 0.15	0.06± 0.02	4.45 ± 0.29		
Dibenzo(a,h)anthracene	0.45 ± 0.05	0.00 ± 0.0	1.01 ± 0.10		
Benzo(g,h,i)pyrene	1.35 ± 0.11	0.04 ± 0.02	3.31 ± 0.20		
Arsenic	12.5 ± 0.60	8.64 ± 0.53	16.0 ± 0.73		
Copper	71.6 ± 4.50	28.6 ± 2.65	93.4 ± 4.31		
Lead	173 ± 8.0	10.8 ± 0.82	279.6 ± 14.6		
Zinc	273 ± 33.2	69.7 ± 5.93	235 ± 10.7		

Photos of the circuit designed for the property are shown below.

All Saints Project – Soil Washing

The All Saints project was completed in downtown Halifax, Nova Scotia on a property being developed into residential apartment units. Timelines for the development were aggressive and remedial activities were conducted concurrently with other site construction activities.

- 5000 tonne project
- Contaminated with PAHs, lead and arsenic
- **Achieved processing rate: 100 to 120 tonnes/hour**
- 85% of soil treated to residential standards and removed off-site as clean fill
- 15% residual material containing elevated levels of metals and PAHs following treatment

Photos from the project are displayed below. The final photo shows the construction at the current stage of development.

Former Halifax Infirmary Project – Soil Washing

The former Halifax Infirmary project involved the treatment of five separate areas of contamination each with unique soil and contaminant characteristics. The original remedial plan specified the off-site treatment of hydrocarbon and PAH contamination with on-site containment cells constructed to contain the metal contamination identified at the property. In order to ensure ongoing integrity pf the containment cells, monitoring of the metals was scheduled into the foreseeable future. Upon CleanEarth becoming involved in the project the concept of on-site containment was abandoned with CleanEarth contracted to treat all of the contaminant types.

- Phase I was completed during the fall of 2005 and involved the onsite treatment of:
    - 700 tonnes of soil contaminated with leachable lead and PAHs;
    - 200 tonnes of soil contaminated with PAHs;
    - 350 tonnes of soil contaminated with leachable metals; and
    - 410 tonnes of soil contaminated with nonleachable metals

- Processing rates greater than 100 tonnes/hour were achieved in all of the contaminated areas.

- 92% to 99% of the soil volume was treated to levels below the CCME residential criteria for each of the respective contaminants

This particular project showcases the flexibility of the CleanEarth process to mobilize to a particular property and treat multiple types of contamination within a mobile configuration.

Water Treatment Project

A water treatment project was completed in Nova Scotia during the summer of 2005. A total of 4,500,000 liters of water with metallic contamination were treated to near non-detect levels within a timeframe of approximately 1 month upon arrival at the property. Photos taken during the course of the remedial effort are presented below.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Polychlorinated Biphenyls – Soil Washing

An understanding of the fate of PCBs within once released to the soil system is a key to effectively treating soil contaminated with PCBs. Table 4 presents the environmental fate of PCBs present in soil, water and the atmosphere.

Table 3 presents the results of a bench scale test on a PCB contaminated soil from a contaminated property located in Newfoundland. As the results show approximately 95% of the soil mass is treated to concentration levels below the CCME residential criteria. The concentrated residual represents approximately 5% of the total soil volume.

The management plan for this particular site involved the on-site treatment of the soil with the residual contamination to be sent to a third party facility for further management.

Table 3 Results of Bench Scale Testing on PCB Contaminated Soil

Contaminant	Untreated (mg/kg)	Treated (mg/kg)	Residual (mg/kg)	Treated Percent
PCB (Arcolor-1260)	15	0.44	44	95

The treatment for this particular soil involved the use of the soil washing system utilizing a wash solution containing a blend of ionic and nonionic surfactants and wetting agents.

Table 4 Environmental Fate of PCBs in the Environment

Terrestrial Fate	Aquatic Fate	Atmospheric Fate
The terrestrial fate of PCBs is dependent on the degree of chlorination in the specific congener mixture. In general, the persistence of PCB congeners increases with an increase in the degree of chlorination. PCBs are resistant to biodegradation. Although biodegradation of PCBs may occur very slowly on an environmental basis, no other degradation mechanisms have been shown to be important in soil systems. The Koc value (309000 l/kg) indicates that PCBs will be tightly adsorbed in soil with adsorption generally increasing as the degree of chlorination of the individual congeners increase. PCBs should not leach significantly in most aqueous soil systems although the most water soluble PCBs will be leached preferentially. While the volatilization rate of PCBs may be low from soil surfaces due to the tight adsorption, the total loss by volatilization over time may be significant because of the persistence and stability.	Higher chlorinated congeners in PCBs are susceptible to reductive dechlorination by anaerobic microogranisms found in aquatic sediments. No other degradation mechanisms have been shown to be important in environmental aquatic systems. In water, adsorption to sediments and organic matter is a major fate process for PCBs. Strong PCB absorption to sediment significantly decreases the rate of volatilization. Aquatic hydrolysis and oxidation are not important processes with respect to PCBs. PCBs have been shown to bioconcentrate significantly in aquatic organisms.	The vapor pressures of the PCB congeners indicate that they will exist primarily in the vapor phase in the ambient atmosphere with PCBs with the highest vapor pressures (low chlorination). Physical removal of PCBs in the atmosphere is accomplished by wet and dry deposition processes; dry deposition will be important only for the PCB congeners associated in the particulate-phase. The relatively long degradation half-lives in air indicates that physical removal is more important than chemical transformation.

Chlorinated Solvents – Leaching/Extraction

The most common way that chlorinated solvents enter the environment is through fugitive air emissions from dry cleaning and metal degreasing industries or by spills and accidental releases to air, soil, or water. If released to soil, solvents such as tetrachloroethylene (PCE) will be subject to evaporation into the atmosphere and leaching to the groundwater. Biodegradation may occur in anaerobic soils with slow biodegradation occurring in groundwater where acclimated populations of microorganisms exist.

The biodegredation process relies on microorganisms (soil bacteria) that are stimulated by adding electron donors changing, prevailing redox conditions where necessary, and leading to biological contaminant degradation. Highly oxidized chlorinated aliphatic hydrocarbons (CAHs) such as tetrachloroethene (PCE) and lower CAHs are used as electron acceptors in the anaerobic process of biologically mediated reductive dechlorination. During the anaerobic biological process, hydrogen substitutes for a chlorine ion on the PCE molecule forming trichloroethylene (TCE), which can be further reduced to dichloroehtylene (DCE) and vinyl chloride (VC).

The following table presents the environmental fate of some representative chlorinated solvents typically encountered at properties contaminated with dry cleaning fluid. The understanding of the fate and chemical characteristics is a key element in ultimately treating soil contaminated with chlorinated solvents.

Table 5 Environmental Fate of Chlorinated Solvents Typically Encountered at Contaminated Sites

Chlorinated Solvent	Terrestrial Fate	Aquatic Fate	Atmospheric Fate
Perchloroethylene	If tetrachloroethylene (PCE) is released to soil, it will evaporate fairly rapidly into the atmosphere due to its high vapor pressure and low adsorption to soil. It can leach rapidly through sandy soil and therefore may reach groundwater. Biodegradation may be an important process in anaerobic soils based on laboratory tests with methanogenic columns. Slow biodegradation may occur in groundwater where acclimated populations of microorganisms exist. There is some evidence of slow degradation in subsurface soils. PCE should not hydrolyze under normal environmental conditions.	If tetrachloroethylene (PCE) is released in water, the primary loss will be by evaporation. The half-life for evaporation from water will depend on wind and mixing conditions and is estimated to range from 3 hours to 14 days in rivers, lakes and ponds. Chemical and biological degradation are expected to be very slow. PCE will not be expected to significantly bioconcentrate in aquatic organisms or to adsorb to sediment. Volatilization was the major removal process during all seasons and seasonal differences can be explained by hydrodynamics and the measured half-lives were 25 days in spring, 11 days in winter and 14 days in summer .	If tetrachloroethylene (PCE) is released to the atmosphere, it will be expected to exist in the vapor phase based on a reported vapor pressure of 18.47 mm Hg at 25 deg C . Vapor phase PCE will be expected to degrade by reaction with photochemically produced hydroxyl radicals or chlorine atoms produced by photooxidation of PCE. Estimated photooxidation time scales range from an approximate half-life of 2 months to complete degradation in an hour . Some of the PCE in the atmosphere may be subject to washout in rain based on the solubility of PCE in water (150 ppm); PCE has been detected in rain.
Trichloroethylene	A relatively high vapor pressure and low adsorption coefficient to a number of soil types indicates ready transport through soil and low potential for adsorption to sediments. The mobility in soil is confirmed in soil column studies and river bank infiltration studies. Four to six percent of environmental concentrations of trichloroethylene adsorbed to two silty clay loams (Koc = 87 and 150).	The high Henry's Law Constant indicates rapid evaporation from water. Half-lives of evaporation have been reported to be on the order of several minutes to hours, depending upon the turbulence. Field studies also support rapid evaporation from water. Trichloroethylene is not hydrolyzed by water under normal conditions. It does not adsorb light of less than 290 nm and therefore should not directly photodegrade. However, slow (half-life -l0.7 months) photooxidation in water has been noted. Marine monitoring data only suggest moderate bioconcentration (2-25 times). Bioconcentration factors of 17 to 39 have been reported in bluegill sunfish and rainbow trout.	Trichloroethylene is relatively reactive under smog conditions with 60% degradation in 140 min and 50% degradation in 1 to 3.5 hours reported. Atmospheric residence times based upon reaction with hydroxyl radical is 5 days (6-8) with production of phosgene, dichloroacetyl chloride, and formyl chloride.
1,2-Dichlorethane	Smaller releases on land will evaporate fairly rapidly because of 1,2-dichlorethane's moderately high vapor pressure. Larger releases may leach	When 1,2-dichloroethane is released to surface water, its primary loss will be by evaporation. The half-life for evaporation will depend on wind and mixing conditions and was of the	When released to the atmosphere, 1,2-dichloroethane will degrade by reaction with hydroxyl radicals which are formed photochemically in the atmosphere with a

Chlorinated Solvent	Terrestrial Fate	Aquatic Fate	Atmospheric Fate
	rapidly through sandy soil into groundwater.	order of hours in the laboratory.The half-life for evaporation would be much less in a river or stream. Chemical and biological degradation is expected to be very slow. Adsorption to sediment is not expected.	half-life of a little over a month. One would expect the chemical to be transported long distances and be washed out in rain.
Vinyl Chloride	If vinyl chloride is released to soil, it will be subject to rapid volatilization based on a reported vapor pressure of 2660 mm Hg at 25 deg C ; half-lives of 0.2 and 0.5 days were reported for volatilization from soil incorporated into 1 and 10 cm of oil, respectively . Any vinyl chloride which does not evaporate will be expected to be highly mobile in soil. It may be subject to biodegradation under anaerobic conditions such as exists in flooded soil and groundwater; however, existing data indicate that vinyl chloride is can biodegrade in aerobic systems and therefore, it may be subject to biodegradation in natural waters. It will not be expected to hydrolyze in soils under normal environmental conditions.	If vinyl chloride is released to water, it will not be expected to hydrolyze, to bioconcentrate in aquatic organisms or to adsorb to sediments. It will be subject to rapid volatilization with an estimated half-life of 0.805 hr for evaporation. In waters containing photosensitizers such as humic acid, photodegradation will occur fairly rapidly. Dissolved vinyl chloride in water will readily escape into the gas phase, but chemical reactions can occur with water impurities which may inhibit its release. Many salts have the ability to form complexes with vinyl chloride and can increase its solubility. Therefore, the amounts of vinyl chloride in water could be influenced significantly by the presence of salts.	If vinyl chloride is released to the atmosphere, it can be expected to exist mainly in the vapor-phase in the ambient atmosphere based on a reported vapor pressure of 2660 mm Hg at 25 deg C . Gas phase vinyl chloride is expected to degrade rapidly in air by reaction with photochemically produced hydroxyl radicals with an estimated half-life of 1.5 days. Products of reaction in the atmosphere include chloroacetaldehyde, HCl, chloroethylene epoxide, formaldehyde, formyl chloride, formic acid, and carbon monoxide . In the presence of nitrogen oxides, eg photochemical smog situations, the half-life would be reduced to a few hours.

Based on the above understanding of the properties of chlorinated solvents, CleanEarth conducted a bench scale test on soil contaminated from a former dry cleaning operation located within the Halifax Regional municipality. The results from the testing are presented below.

Table 6 Bench Scale Results of Testing on Chlorinated Solvent Contaminated Soil

Contaminant	Untreated (mg/kg)	Treated (mg/kg)	Percent Reduction
PCE	33	0.061	99.8
TCE	1.8	nd	>99.9
DCE	nd	nd	na
VC	nd	nd	na

Notes: nd = nondetect, *na = not applicable*

The treatment procedure utilized during this test involved an leaching/extraction procedure with a residence time of 70 minutes and a wash solution amended primarily with a chemical oxidant with minor additions of three other chemicals listed in Table 1.

Leachable Metals – Soil Washing and Leaching/Extraction

Table 7 presents bench scale results from testing conducted on a soil obtained from a rifle range located in Nova Scotia. The soil contained pockets of lead with concentrations ranging up to 5% and leachable levels significantly in excess of 5 mg/L. The speciation of lead encountered at properties utilized as rifle ranges can vary dependent on how the characteristics of the native soil effect the weathering of the elemental lead over time. This results in soils that can be treated using soil washing techniques alone or requiring soil washing followed by leaching/extraction techniques to reduce lead concentrations below CCME residential levels.

Contaminant	Untreated (mg/kg)	Treated (mg/kg)	Residual (mg/kg)	Treated Percent
Lead	50,000	<100 mg/kg	300,000	99.8

The treatment circuit in this instance involved preliminary treatment using the soil washing process to remove the metallic species followed by an acid leach to remove the molecular and ionic lead species. The residual contamination which consists primarily of bullet fragments and lead hydroxide will be sent to an off-site smelter where the residual can be used as feed stock.