Final Report: Environmental Assessment Registration for the Envirosoil Facility: Addition of Stabilization/Solidification Technology (2016)

Project No. 121414234

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Table of Contents

LIST OF ACRONYMS iii

1.0 INTRODUCTION 1
1.1 FACILITY BACKGROUND 2
1.2 PROJECT OVERVIEW 2
1.3 PURPOSE AND NEED FOR THE PROJECT 6
1.4 PROPONENT IDENTIFICATION 7
1.5 REGULATORY CONTEXT 8
1.6 EXISTING ENVIRONMENT 8
1.6.1 Existing Facility 8
1.6.2 Treated Soil Fill Area 8

2.0 PROJECT DESCRIPTION 9
2.1 OVERVIEW 9
2.2 MATERIAL ACCEPTANCE CRITERIA (UPDATED) 10
2.2.1 General Acceptance Criteria – Inorganic Metals 11
2.2.2 General Acceptance Criteria - EC and SAR 11
2.2.3 General Acceptance Criteria – Petroleum Hydrocarbons and Polycyclic Aromatic Hydrocarbons 13
2.2.4 Summary of Material Acceptance Criteria for S/S Treatment 13
2.3 SITE PREPARATION AND CONSTRUCTION 14
2.4 OPERATION 15
2.4.1 Materials Receiving and Storage 16
2.4.2 Binder/Reagent Selection and Mix Design 16
2.4.3 Proposed Treatment Criteria and Performance Testing 18
2.4.4 Performance Testing Sampling Plan 24
2.4.5 Placement of Treated Materials 26
2.5 SCHEDULE/WORKFORCE 28
2.6 EFFLUENTS AND EMISSIONS 29
2.7 DECOMMISSIONING AND RECLAMATION 30

3.0 SCOPE OF THE ENVIRONMENTAL ASSESSMENT 30
3.1 FIELD STUDIES 30
3.2 VALUED COMPONENT (VC) IDENTIFICATION 31

4.0 CONSULTATION AND ENGAGEMENT 33

5.0 VALUED COMPONENT AND EFFECTS MANAGEMENT 33
5.1 EFFECTS ANALYSIS METHODS 33
5.2 GROUNDWATER RESOURCES 34
5.2.1 Description of Existing Conditions 34
5.2.2 Potential Effects and Proposed Mitigation 38
5.2.3 Monitoring and Follow-up 40
5.2.4 Summary 41

5.3 SURFACE WATER RESOURCES 42
5.3.1 Description of Existing Conditions 42
5.3.2 Potential Effects and Proposed Mitigation 43
5.3.3 Monitoring and Follow-up 45
5.3.4 Summary 45

6.0 OTHER APPROVALS REQUIRED 46

7.0 FUNDING 46

8.0 ADDITIONAL INFORMATION 46

9.0 SUMMARY 46

10.0 REFERENCES 47
10.1 LITERATURE CITED 47
10.2 PERSONAL COMMUNICATIONS 50

LIST OF APPENDICES

Appendix A S/S Equipment Design & Specifications
Appendix B 2015 Revised Site Monitoring Program (SLR 2015)
Appendix C Groundwater Flow Diagrams
Appendix D Additional Information

LIST OF TABLES

Table 1 Summary of Material Acceptance Criteria for S/S Treatment 13
Table 2 Typical Binders and Quantities 17
Table 3 Proposed Leachate Performance Criteria 19
Table 4 Summary of Proposed Treatment Criteria 20
Table 5 Summary of Acceptable Performance Criteria Deviations 21
Table 6 USEPA Typical Parameters for S/S treatment. 22
Table 7 Scoping of VCs 31

LIST OF FIGURES

Figure 1 Project Location and Overview 3
Figure 2 Site Plan – S/S Plant Location(s) 4
Figure 3 Treated Soils Fill Area 5
Figure 4 Pictures of Proposed S/S Equipment displaying the Pug Mill System 16
Figure 5 Conceptual Design and Placement Locations of Lined Cells in the Treated Soils Fill Area 27

List of Acronyms

ASTM	American Society for Testing and Materials
BMPs	Best Management Practices
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
C&D	Construction and Demolition
CCME	Canadian Council of Ministers of the Environment
CEAA, 2012	*Canadian Environmental Assessment Act, 2012*
EA	Environmental Assessment
EAC	Ecology Action Centre
EC	Electrical Conductivity
EQS	Environmental Quality Guidelines
ha	Hectares
HRM	Halifax Regional Municipality
KMKNO	Kwilmu'kw Maw-klusuaqn Negotiation Office
LTTD	Low Temperature Thermal Desorption
MBCA	*Migratory Birds Convention Act*
MW	Monitoring Well
NASGLP	North American Soil Geochemical Landscapes Project
NSSAM	Numerical Standards and Site Assessment Methodologies
NSAC	Nova Scotia Agricultural College
NSCSR	Nova Scotia Contaminated Site Regulations
NSE	Nova Scotia Environment
OSSGA	Ontario Sand, Soil and Gravel Association
PAHs	Polycyclic Aromatic Hydrocarbons
PERC	Perclororethylene
PHC	Petroleum Hydrocarbons
S/S	Stabilization/Solidification
SAR	Sodium Adsorption Ratio
TSFA	Treated Soils Fill Area
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
VCs	Valued Components
VOCs	Volatile Organic Compounds

1.0 INTRODUCTION

This document is the Environmental Assessment (EA) Registration document for the addition of Stabilization/Solidification (S/S) technology as a treatment process at the Envirosoil Limited (Envirosoil) facility in Bedford, Nova Scotia. The Project consists of the use of S/S technology as a treatment process, including the development of a Treated Soils Fill Area (TSFA).

This project was originally registered with Nova Scotia Environment (NSE) as a Class I Undertaking on May 26th, 2015. Following his review of the EA Registration document, the Minister of Environment released a decision that additional information was required in order to assess potential environmental effects. In response to this decision, an addendum with additional information was submitted on August 11th, 2015. On September 28th, 2015 the Minister issued a decision that the undertaking was not approved.

Subsequent to this decision, Envirosoil has had additional consultation with NSE and leading experts on solidification/stabilization, and has revised the proposed project to address potential concerns. The following substantive changes have been made to the original project proposal and EA Registration document to address concerns raised by NSE and stakeholders, which serve to increase effects prediction confidence and increase the overall conservatism in the design, monitoring and mitigation of this proposed project.

- An extremely low permeability high density polyethylene liner and cap system is being proposed for the encapsulation of the treated materials. This will include an integrated leachate collection and monitoring system.
- A network of groundwater wells has been installed surrounding the proposed area where treated materials will be deposited in the TSFA.
- A ditch and weir system has been proposed to surround the proposed area where treated materials will be deposited in the TSFA to control surface water flows and act as a compliance point for monitoring.
- Additional surface water points for monitoring have been proposed surrounding the TSFA.
- The monitoring and mitigation framework has been described in a greater level of detail.
- Specific material volume intervals for treatability testing have been established.
- Additional information about material storage and handling has been provided.
- Mass flux leachate testing is proposed to be used during the treatability testing program and during performance testing as an additional method to assess treatment performance.
- A monitoring point has been proposed within the HDPE lined cell.

1.1 FACILITY BACKGROUND

Envirosoil Limited (Envirosoil), was founded in 1992 in Bedford, Nova Scotia. Envirosoil designed and constructed a facility to provide a solution for the treatment and disposal of contaminated soil. The facility operates under Industrial Approval No. 2002-026440-A03 (the Approval) from NSE, which prescribes the criteria for material acceptance, treatment and reuse of treated material.

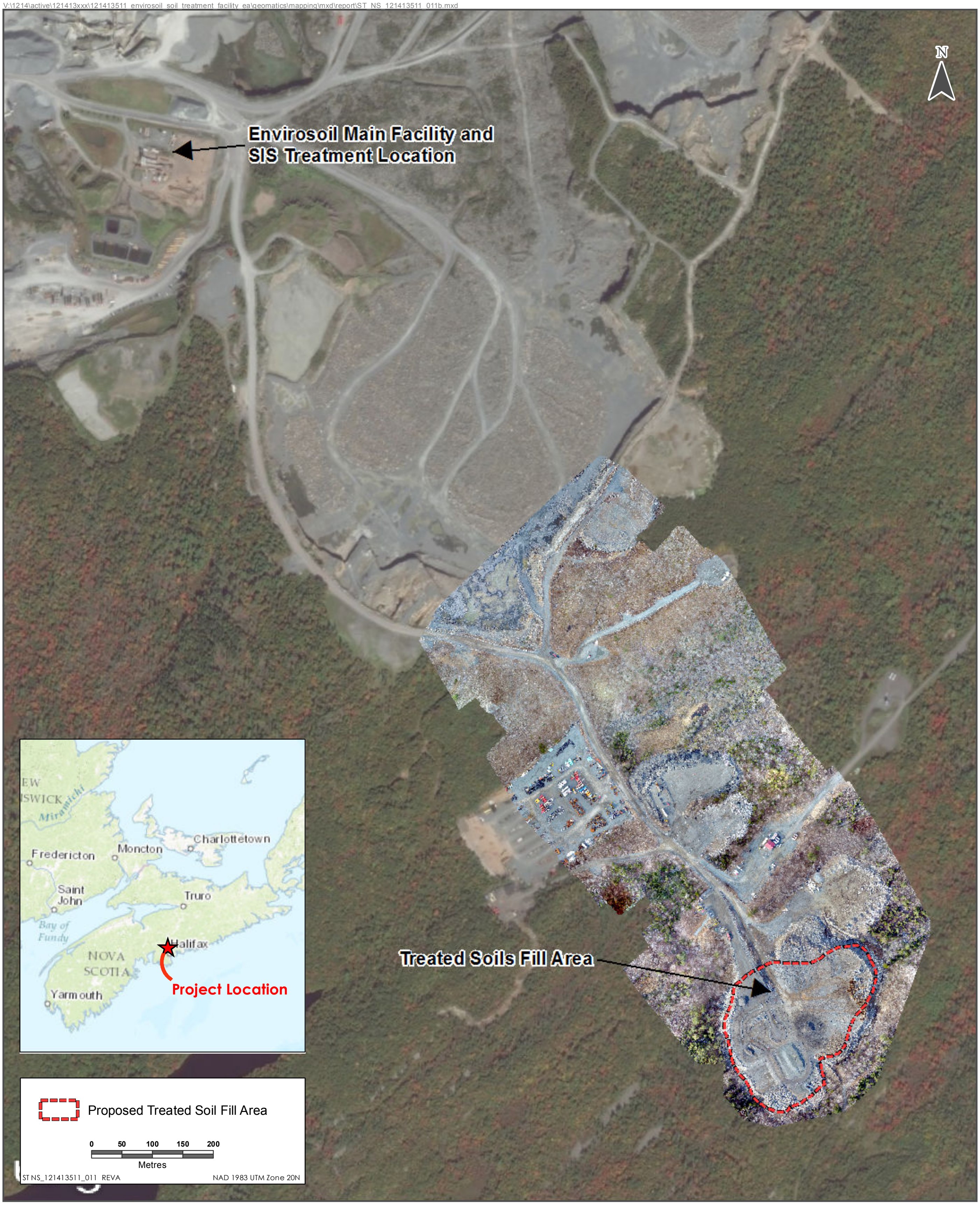
The facility initially provided bio-remediation services for contaminated soils. In 1995, permission was received to operate the Low Temperature Thermal Desorption (LTTD) unit. In 2003, an EA Approval was received to treat soils contaminated with perclororethylene (PERC) from dry cleaning fluids and related products. Additional information on the existing facility is provided in the 2003 EA (Envirosoil 2003).

1.2 PROJECT OVERVIEW

Envirosoil is proposing to add Stabilization/Solidification technology as a treatment process at its facility and to develop a Treated Soils Fill Area (TSFA) for the storage and placement of the final treated materials (*i.e.*, the Project). Therefore, the Project includes the following components and activities.

- The use of Stabilization/Solidification (S/S) technology as a method of treatment for materials with inorganic metals and low level organics; and
- The acceptance and treatment of materials containing elevated levels of metals, Petroleum Hydrocarbons (PHCs), Polycyclic Aromatic Hydrocarbons (PAHs), Electrical Conductivity (EC) and Sodium Adsorption Ratio (SAR) (or, salt impacted materials), using S/S technology.
- The addition of a pugmill system to the existing facility;
- The storage of untreated materials at the existing facility; and
- The development of the TSFA.

The Project location and overview is provided in Figure 1. The existing Envirosoil facility is located in Bedford, Nova Scotia, directly across from the Bedford Industrial Park at 48 Quarrystone Drive (PID #40237182). The existing facility and TSFA are located within the confines of the active quarry site. The existing Envirosoil facility is approximately 4 hectares (ha) in size and is accessed by existing quarry access roads. Figure 2 provides a schematic of the existing facility, and indicates options for the placement of the pugmill processing equipment. An overview of the TSFA is provided in Figure 3. The TSFA (PID# 00267864) is located approximately 2 km southeast of the Envirosoil treatment facility, within the quarry property boundaries (Figure 1). The Envirosoil facility and the TSFA are located on land that is zoned for industrial land use.



Imagery: Close range aerial imagery : Envirosoil; Bing: Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation

Disclaimer: This map is for illustrative purposes to support this project; questions can be directed to the issuing agency.

Project Location and Overview

Environmental Assessment Registration for the Envirosoil Facility: Addition of Stabilization/Solidification Technology and Treatment of Salt Impacted Materials

Figure 1

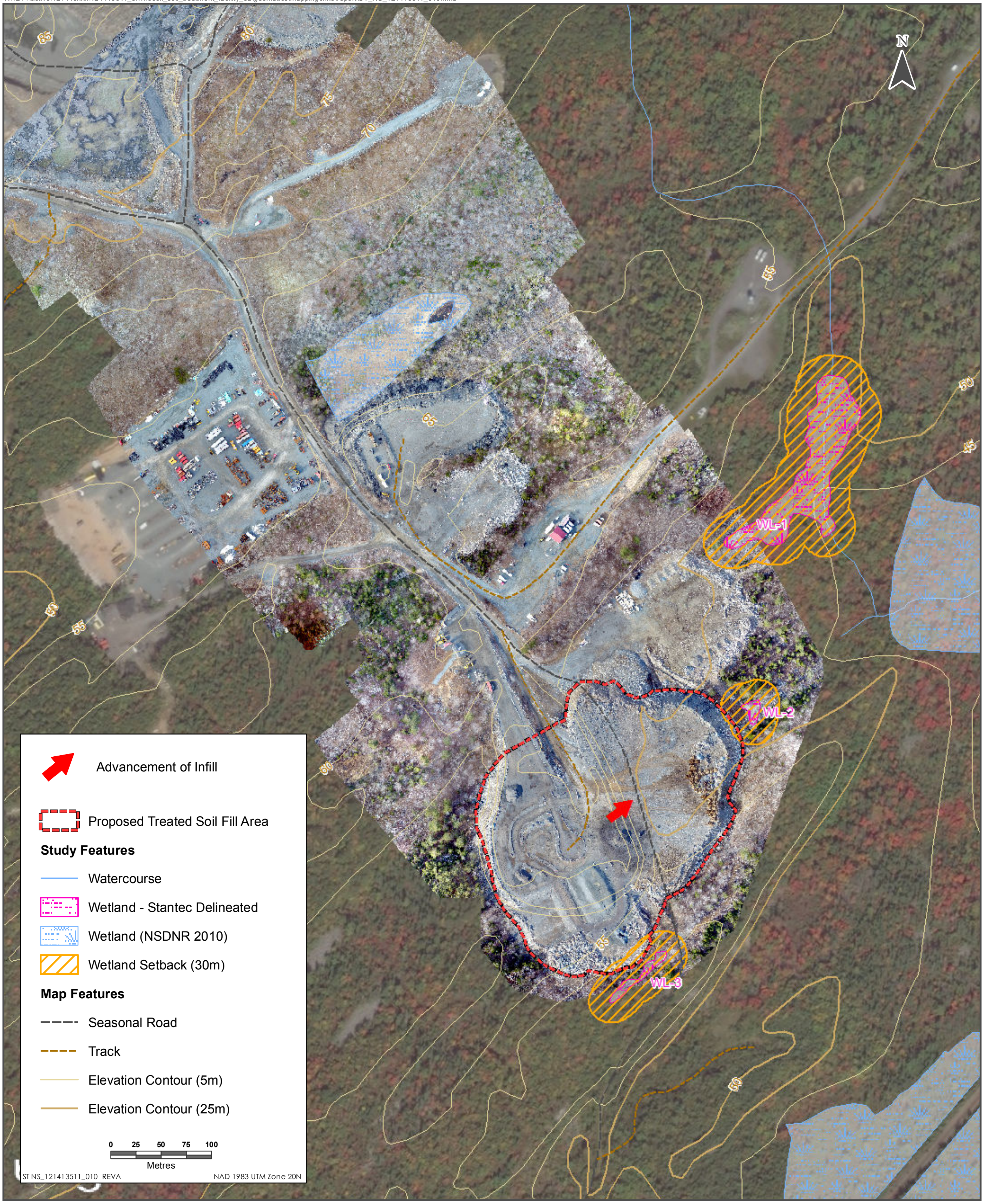
Sources: Base Data - Nova Scotia Geomatics Centre. Nova Scotia Department of Natural Resources.
Imagery: Bing: Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation

Disclaimer: This map is for illustrative purposes to support this project; questions can be directed to the issuing agency.

Existing Facility Site Plan - S/S Plant Location

Stantec

Figure: 2



Imagery: Close range aerial imagery : Envirosoil

Disclaimer: This map is for illustrative purposes to support this project; questions can be directed to the issuing agency.

envirosoil

Treated Soils Fill Area

Environmental Assessment Registration for the Envirosoil Facility: Addition of Stabilization/Solidification Technology and Treatment of Salt Impacted Materials

Figure 3

1.3 PURPOSE AND NEED FOR THE PROJECT

The Envirosoil facility has been in operation since 1992 under the existing Approval. The facility has successfully treated almost one million tonnes of impacted materials to the Canadian Council of Ministers of the Environment (CCME) Residential/Parkland criteria. The majority of materials have been treated to a non-detect level for petroleum hydrocarbons (PHC) and polycyclic aromatic hydrocarbons (PAHs).

The Project will allow Envirosoil to enhance treatment capabilities and extend current operations at their facility. The appropriate technology will be used to treat materials based on its physical and chemical characteristics, and the permitted acceptance criteria for each method: either LTTD (currently in use at the facility); or S/S. Materials will be treated via S/S technology if they meet the strict acceptance criteria detailed in Section 2.2. The use of S/S to treat contaminated soil is a mature and proven technology, which is used at 30% of all of Superfund sites in the United States. The United States Environmental Protection Agency (USEPA) has identified S/S as a Best Demonstrated Available Technology for more than 50 major industrial waste types and contaminants. The contaminants proposed to be treated via S/S at the Envirosoil facility have been successfully treated at many other sites using this method, including contaminated dredged materials with elevated chlorides and salinity (Bates and Hills, 2015).

Current options within Halifax Regional Municipality (HRM) for the treatment of materials impacted with inorganic metals are limited. The establishment of additional treatment capacity and technology for inorganic metals and EC/SAR impacted materials will present property developers with additional options for the disposal of impacted materials encountered during residential, commercial or industrial development projects.

Materials containing elevated levels of EC and SAR that are also impacted with hydrocarbons and metals, (*e.g.*, PAHs) can be generated in a variety of ways. They can be generated via the dredging of coastal harbors, the remediation of industrial sites such as salt storage depots, the drilling of wells through salt layers/domes, the drilling of hydrocarbon exploration wells in high saline environments, the application of road salt/brine, the use of saline based drilling muds, sludge generated from ship's bilge or the treatment of bilge waters. Materials generated via these activities will typically contain EC and SAR values above the CCME Industrial criteria.

Under existing environmental regulations and facility approvals, there are currently no disposal facilities within Nova Scotia that can accept materials having EC and SAR above the CCME Industrial criteria. The majority of treatment facilities are limited to accepting material containing EC and SAR values that are below the CCME Residential/Parkland criteria. As a result, these materials are technically required to be disposed of out of province at an approved disposal facility or by special permission obtained from NSE for alternate disposal options within the province. Under its existing Industrial Approval, Envirosoil cannot accept material having EC and SAR levels above the CCME Residential/Parkland criteria. Envirosoil is proposing that its Industrial Approval be amended to exempt the EC and SAR restrictions provided that all materials containing elevated EC and SAR are handled in accordance with the special procedures outlined in this EA Registration and only treated via S/S technology.

The amendment of Envirosoil's Industrial Approval to allow it to treat EC/SAR materials impacted with contaminants such as hydrocarbons, PAHs and metals will provide Nova Scotia with a reliable local option for the disposal of these types of materials.

It should be noted that the material Envirosoil is proposing to accept for treatment is not considered hazardous waste and/or dangerous goods, and if not treated, could remain in situ at industrial sites within Nova Scotia. Typically these materials are only removed during site redevelopment from the originating location.

1.4 PROPONENT IDENTIFICATION

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Signature of Company
Mr. Jerry Scott, General Manager

October 26, 2016
Date

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1.5 REGULATORY CONTEXT

Because these amendments are considered modifications to the existing facility, Envirosoil is required to register this Project as a Class I Undertaking pursuant to the Nova Scotia *Environment Act* and *Environmental Assessment Regulations*.

Envirosoil has conducted extensive consultation with NSE regarding this project, and has addressed technical comments received from NSE within the sections below.

There are no requirements under the *Canadian Environmental Assessment Act, 2012* (CEAA 2012) as the proposed Project is not listed as a designated project as per Section 2 of the *Regulations Designating Physical Activities* and the Project does not take place on federal lands.

1.6 EXISTING ENVIRONMENT

1.6.1 Existing Facility

The existing Envirosoil soil processing site (Figure 2) is located in a disturbed area, characterized by gravel pads, roads, and soil mounds. Much of the site is unvegetated; but native and exotic ruderal herbaceous plants such as Queen Anne's lace (*Daucus carota*) and Canada goldenrod (*Solidago canadensis*) provide cover on the soil mounds, and green alder (*Alnus viridis*) is scattered throughout the site. Although disturbed, the area has potential to provide habitat for several species of migratory birds that nest on the ground or are associated with open habitats. However, because of ongoing heavy equipment operations and other activities, species of migratory birds that are known to nest in open disturbed soils, such as common nighthawk (*Chordeiles minor*) and bank swallows (*Riparia riparia*) are unlikely to nest at the processing site. Site drainage is directed towards a settling pond, much of which is vegetated by broad-leaved cattail (*Typha latifolia*). Waterfowl, including Canada goose (*Branta canadensis*) and American Black Duck (*Anas rubripes*) were observed within the settling pond during the site visit on April 24, 2015, but are not expected to use the site for nesting purposes because of the lack of islands and vegetated areas buffering the settling pond from adjacent human activities. No other wetlands (naturally occurring or anthropogenic) are present on the site; because the settling pond lacks an outflow (water levels are managed through evaporation), it is isolated from downgradient water resources.

Additional information on the existing facility, environmental setting and surrounding area is provided in the 2003 EA (Envirosoil 2003).

1.6.2 Treated Soil Fill Area

Figure 3 provides a close range aerial photo and overview of the environmental features near the TSFA. The TSFA is located in a disturbed area characterized by exposed soils, and is elevated relative to the surrounding terrain. Upland forests of varying composition and structure surround the site. The majority of forest cover in the vicinity of the site is of well-drained immature to hardwood stands and are dominated by a mixture of red maple (*Acer rubrum*), paper birch (*Betula papyrifera*), and northern red oak (*Quercus rubra*) in the overstory, and an understory of sheep laurel (*Kalmia angustifolia*) and bracken fern (*Pteridium aquilinum*). A stand of red pine (*Pinus resinosa*) is present on the southern boundary of the existing footprint whereas eastern white pine (*Pinus strobus*) and red spruce (*Picea rubens*) are scattered throughout the surrounding forests. Black spruce (*Picea mariana*) is prevalent in relatively low-lying, imperfectly drained areas. The terrain within the surrounding forests is very rocky with boulders prevalent throughout and occasional bedrock outcropping. A variety of wildlife would use the area surrounding the TSFA, including migratory birds characteristic of forested and shrubby habitats. Because of ongoing heavy equipment operations and other activities, species of migratory birds that are known to nest in open disturbed soils, such as common nighthawk are unlikely to nest at the TSFA.

2.0 PROJECT DESCRIPTION

2.1 OVERVIEW

S/S is a well-established remediation technology for the treatment of soil, sediment and sludge contaminated with inorganic metals and various organic compounds. The USEPA has identified S/S with cement as a Best Demonstrated Available Technology for more than 50 major industrial waste types and contaminants. The Project consists of the following:

- The use of Stabilization/Solidification (S/S) technology as a method of treatment for materials with inorganic metals and low level organics; and
- The acceptance and treatment of materials containing elevated levels of metals, Petroleum Hydrocarbons (PHCs), Polycyclic Aromatic Hydrocarbons (PAHs), Electrical Conductivity (EC) and Sodium Adsorption Ratio (SAR) (or, salt impacted materials), using S/S technology.
- The addition of a pugmill system to the existing facility;
- The storage of untreated materials at the existing facility; and
- The development of the TSFA.

Typically, S/S includes the mixing of inorganic cementitious/pozzolanic reagents into contaminated material to transform it into a durable, solid, low–hydraulic conductivity material that reduces the risk of contaminant leaching. This is achieved as the cement chemically reacts with water in the material being treated, creating changes in the physical and chemical properties of the treated materials, thereby preventing the escape of contaminants into the environment.

Although solidification and stabilization are defined separately, they are often implemented simultaneously through a single treatment process. The USEPA defines each as follows.

- Stabilization involves the process whereby chemical reactions occur between the reagents and contaminated material to reduce the leachability of contaminated material or convert them into a more stable, insoluble and/or less toxic form.

- Solidification involves the process whereby the contaminated material is encapsulated to form a solid material that effectively restricts contaminant migration by decreasing the surface area exposed to leaching. Solidification effectively entraps the contaminated material within a granular or monolithic matrix.

S/S can be used to treat a wide variety of inorganic contaminants (*e.g.*, arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, antimony, uranium, and zinc), as well as organic contaminants such as petroleum hydrocarbons (PHCs) and polycyclic aromatic hydrocarbons (PAHs), and metals. Soil, sediment and sludge impacted with a variety of organic and inorganic contaminants have been treated successfully using this versatile technology. The contaminants proposed to be treated via S/S at the Envirosoil facility have been successfully treated at many other sites using this method, including: contaminated dredged materials with elevated EC/SAR; salinity; hydrocarbons. In many cases, these contaminants have been successfully treated at levels greatly exceeding the proposed acceptance criteria defined for this Project (Section 2.1).

Material will be accepted into the facility for S/S treatment if it meets the acceptance criteria described within Section 2.2 of this document. All material will be stored within the lined area of the Envirosoil facility. The material will then be stockpiled and homogenized. Treatability testing will be performed on each homogenized batch of material that will be treated via S/S (further described within Section 2.4 of this document). Using the mix design determined to meet the stringent performance criteria proposed in this submission, the material will be mixed with the selected reagents using an advanced, specially built pugmill-based system. Material will be collected for performance testing, and then the material will be taken to the TSFA for placement and compaction.

The S/S treated materials will be placed vertically within the TSFA, within lined cells at least 2 m above the water table. As the treated material is deposited, it will be compacted in approximately 30 – 50 cm lifts. The trench and surrounding fill material will be dynamically contoured to promote drainage as material is placed, to reduce standing water contact time with S/S treated materials prior to full curing. S/S operations will not take place during heavy rain events. At the end of each production season the deposited materials will be backfilled/covered with a minimum 1.2 m of fill to prevent frost cycling.

The deposition location for each treated batch of materials within the TSFA will be surveyed and recorded to facilitate action in the unlikely circumstance that the ongoing monitoring of the Envirosoil facility identifies an issue.

2.2 MATERIAL ACCEPTANCE CRITERIA (UPDATED)

With the addition of the cement based S/S process, Envirosoil is requesting that the current material acceptance criteria be amended to accept metals for treatment to reflect the additional treatment capability of the facility.

The criteria for the acceptance of this material is based on the Nova Scotia Contaminated Site Regulations (NSE, 2013) Tier 1 Environmental Quality Standards for soil at a Non-Potable Site (fine grained, industrial site) and the Nova Scotia Guidelines for Contaminated Solids in Landfills, Attachment C – Acceptance Parameters for Contaminated Soil (Leachate Results).

Envirosoil considers the proposed criteria inherently conservative for the following reasons:

- The Nova Scotia Guidelines for Contaminated Solids in Landfills, Attachment C – Acceptance Parameters for Contaminated Soil (Leachate Results) are based on disposal to an unlined, first generation landfill. As discussed in Section 2.4.5 of this document, the treated material will be deposited within a lined cell that contains a leachate collection system and a clay cap. In addition, the material will be treated through solidification/stabilization, which is treatment not considered in the development of these guidelines, providing an extra layer of protection. These criteria are commonly applied at treatment facilities across Nova Scotia.

- NSCSR Tier 1 EQS for soil at a Non-Potable Site (fine grained, industrial site) which have been proposed by Envirosoil as a standard for material acceptance. Tier 1 EQS were derived by the Numerical Standards and Site Assessment Methodologies (NSSAM) Working Group after a careful review of all relevant guidelines, legislation and benchmarks. The NSSAM Working Group have stated that these guidelines are "…adequately conservative and protective in nature and are thereby considered appropriate for use as EQS in Nova Scotia. Furthermore, the adoption of such guidelines into regulatory standards follows what is considered to be common industry practice currently in place in Nova Scotia."

Material that does not meet the proposed criteria will not be accepted into the facility for treatment via S/S technology.

2.2.1 General Acceptance Criteria – Inorganic Metals

Under the amendment, Envirosoil is proposing that the acceptance of inorganic metals impacted materials be based on the established NSCSR (2013) Tier 1 EQS for soil at a Non-Potable fine grained, industrial site. Acceptance of material containing metals concentrations in excess of the Tier I EQS will be based on the leachate criteria outlined in the Nova Scotia Guidelines for Contaminated Solids in Landfills, Attachment C – Acceptance Parameters for Contaminated Soil (NSE, 1994). These criteria have commonly been used as acceptance criteria for soil treatment facilities within Nova Scotia.

2.2.2 General Acceptance Criteria - EC and SAR

Under Envirosoil's existing approval, the facility is limited to accepting EC and SAR impacted materials not to exceed the Canadian Council of Ministers of the Environment (CCME) residential/parkland guidelines. Under this amendment, Envirosoil is proposing acceptance of soil with concentrations exceeding CCME Industrial guidelines.

Currently no disposal facilities in Nova Scotia can accept materials having EC and SAR above the CCME Industrial Guidelines. The majority of treatment facilities are limited to accepting material containing EC and SAR below CCME residential/parkland guidelines. As a result, these materials may be required to be disposed of out of province at a significant cost to developers, property owners and businesses.

Consultation with regulators and the public have resulted in comments regarding potential effects of elevated salt concentrations on the solidification process. While S/S has been used successfully worldwide to treat ocean sediments at locations such as London, New York and the ongoing STABCON project in Europe (which has successfully solidified contaminated sediments into blocks that can be used for construction), Envirosoil has sought further expert opinions. The following was provided by an expert in concrete applications (Langley, 2015) regarding the potential effect of materials containing salt being used in the solidification process. The full letter is available in Appendix D.

> *Sand and gravel removed from beaches was a primary source of concrete making materials in the metro area until about 1974, at which time sand removed from beaches was restricted. Up to this time the beach at Cow Bay (Trynor Construction) and Thrumpcap Shoal at the mouth of Halifax Harbour was the principal source of aggregate. These aggregates did not go through a wash plant, other than seawater. Seawater does not contain a harmful level of magnesium, sodium or calcium sulphate to cause harmful sulphate attack.*
>
> *For solidification/stabilization of materials, there is no rationalization to ban the use of marine sediments or saturated seawater materials from the solidification process. For reinforced concrete, the literature is split on the use of seawater for mixing concrete. The detrimental component of seawater with respect to its use in reinforced concrete is the Cl- component. Fifty percent of the available Cl- is tied up as chloro aluminates in the hydration products and not available as free ions to promote corrosion…There is no harm caused by chlorides to solidified cementitious materials, particularly in the absence of reinforcing steel. The sulphate from seawater in the solidified material would be partially combined in the mono-sulphate phase of cement hydration. This may cause a slightly earlier set than normal. There is not sufficient sulphate presence from seawater to cause internal sulphate attack such that the solidified material would deteriorate due to sulphate expansion.*

A recent solidification and stabilization guide commissioned by the USEPA (Bates and Hills, 2015), provides dozens of examples where cement based binders have been used with both ocean sediments and soil that has been exposed to salt water intrusion. The report references the Sydney Tar Ponds. No case studies could be found that showed that the presence of salt typical to ocean sediments posed an impediment to S/S performance.

2.2.2.1 General Acceptance Criteria – Dredgeate

EC/SAR materials will be accepted from a variety of sources which will dictate the level of saturation of the materials (e.g., dredged marine materials, drilling muds and roadside contaminated soils). Materials will be brought to site in sealed dump trucks that will prevent any spillage of liquid. No specific limits will be placed on the minimum solids contents, as the S/S process requires a certain level of material saturation for the solidification curing process, and as such the water contained in contaminated materials will assist with the solidification process. Therefore, wet materials arriving on site will immediately be mixed with dry materials as part of the homogenization process, prior to treatment. This process is commonly employed and will eliminate the risk of potential free water runoff from the material, and thus potential concerns associated with receiving materials with high moisture content. This will have the added benefit of reducing the water that will be required to be added during the solidification process.

As fully described in Section 2.4.1, the storage area for all untreated contaminated materials (included materials impacted by EC/SAR) is within the main Envirosoil facility, which is fully underlain by an impermeable compacted clay liner. The Envirosoil facility has the appropriate infrastructure to handle potential surface water runoff including ditching to direct water to the settling pond, and various monitoring points on site (Figure 2).

Additional description of the handling and storage of materials is provided in Section 2.4.1.

2.2.3 General Acceptance Criteria – Petroleum Hydrocarbons and Polycyclic Aromatic Hydrocarbons

Envirosoil is proposing that the acceptance of petroleum hydrocarbon and polycyclic aromatic hydrocarbon impacted materials for S/S treatment be based on the established criteria contained within the existing Industrial Approval No. 2002-026440-A03.

2.2.4 Summary of Material Acceptance Criteria for S/S Treatment

For the purposes of the proposed amendment, Table 1 summarizes the proposed acceptance criteria for S/S treatment.

Table 1 Summary of Material Acceptance Criteria for S/S Treatment

Parameter	Acceptance Criteria for S/S Treatment[1]
Metals	NSCSR Tier I EQS, fine grained, industrial land-use or leachate criteria as specified in this document
EC	Exceeding CCME Industrial criteria (4 dS/m), treated material must comply with specified performance criteria
SAR	Exceeding CCME Industrial criteria (12), treated material must comply with specified performance criteria
Petroleum Hydrocarbons	In accordance with existing approval
Polycyclic Aromatic Hydrocarbons	In accordance with existing approval

[1]This acceptance criteria is for materials that will be treated via S/S technology. The acceptance criteria for material treated via LTTD will remain the same as current approvals.

2.3 SITE PREPARATION AND CONSTRUCTION

The proposed S/S treatment site is the existing Envirosoil facility (Figure 2). This facility is approximately 4 ha in size and is located within the footprint of the quarry operations.

The topography of the treatment facility site is relatively flat and graded to drain overland surface water flow to an on-site storm water retention pond (Figure 2). The pond has no discharge outlet and water levels in the pond are controlled seasonally by evaporation. The storm water retention pond and associated infrastructure has already undergone an environmental assessment, and is permitted under the existing Approval. As part of the original requirements for the facility, the storm water retention pond was designed for a 100-year storm (1:100 year 24-hr Rainfall = 151.1mm). The proposed S/S activities will not change the requirements for this pond, as the surface area serviced by the storm water pond within the lined area is the same.

The site area is underlain by 400 mm thick compacted, clay liner with a hydraulic conductivity of 10^{-7} cm/sec limiting migration of potential impacts to offsite receptors. A groundwater monitoring network has been established. Groundwater is sampled and reporting is completed according to Envirosoil's existing Approval. The site location and general features are shown on Figure 2.

The TSFA is located approximately 2 km southeast of the Envirosoil treatment facility. The TSFA is located in an area of quarry restoration where excess virgin fill from quarry operations has been imported and graded flat and gently sloping to the northeast. In general, the fill material consists of coarse grained soils, gravel, cobbles and boulders. In some areas, fill thicknesses exceed 15 m. The proposed TSFA is shown in Figure 3.

Lined cells will be constructed for the deposition of the treated materials, as an extra safety measure. These cells will be comprised of a base layer fully lined with a high density polyethylene (HDPE) liner with full leachate collection and monitoring system, and a sloped HDPE lined cap with drainage functionality to ensure water does not pond on the completed cell. The conceptual design of the cells is described in Section 2.4.5 of this document.

Access to both the Envirosoil processing facility and TSFA is via existing roads.

Project activities have potential to cause erosion and deposition of sediment to downgradient surface water resources (including wetlands and watercourses), particularly during periods of heavy rainfall or snowmelt. Potential impacts to surface water resources will be reduced through site design and other mitigation techniques, including:

- grading of the TSFA surface so that surface water runoff is directed towards the south (*i.e.*, away from wetland and watercourse features located towards the north of the site; and
- maintaining buffers of natural vegetation between disturbed areas and wetlands.

A 30 m setback will be established between site activities and wetlands.

Migratory birds are protected under the federal *Migratory Birds Convention Act* (MBCA) which prohibits killing migratory bird species, their eggs or young. To comply with these regulations, clearing, grubbing and stripping of vegetated areas, if required, will be preferentially conducted outside of the breeding season of most bird species (April 1 to August 15) so that the eggs and flightless young of birds are not inadvertently destroyed.

2.4 OPERATION

The treatment of impacted material will follow a procedure similar to that already established for treatment of materials designated for the LTTD plant (*i.e.*, PHC/PAH materials). The material will be treated via the following sequence of activities.

- Material will be screened to remove oversize rocks and debris (oversize rock is not considered contaminated and will be segregated and disposed of separately).
- Material will be homogenized to provide an optimum feed material.
- Treatability testing will be completed to develop an optimum S/S reagent binder formulation, and to confirm that material can be treated to the specified performance criteria.
- Material will be mixed with the optimum S/S reagent binder formulation using a pugmill within the lined area at the Envirosoil facility.
- Samples will be taken from the treated material after being processed by the pugmill.
- Analytical data will be collected to confirm compliance with the appropriate treatment criteria.
- Treated material will be placed in the TSFA as described in Section 2.4.5.

Project activities will be consistent with the current facility operations approved by NSE (Approval No. 2002-026440-A03) and any future amendments.

The existing infrastructure at the Envirosoil facility will be used to support the S/S process. The only substantial addition is an automatic pugmill system. The system selected was chosen for its advanced pugmill design, its sophisticated level of automation, its automatic feeding and metering system and its proven reliability. The result is a final product that is highly homogeneous in composition.

Figure 4 shows the proposed equipment and Appendix A presents a specification and design data sheet for the proposed S/S plant.

Figure 4 Pictures of Proposed S/S Equipment displaying the Pug Mill System

2.4.1 Materials Receiving and Storage

Procedures established for contaminated material acceptance under the existing Approval will apply to the receipt and acceptance of metals, EC and SAR materials. Existing procedures require that receiving soils be characterized prior to acceptance, including: analytical data confirming the contamination type and concentration levels; originating site location; and quantities. All materials received must be detailed on Envirosoil's Bill of Lading/Manifest including: date and time of arrival; originating site location and address; description of material; quantity; name of transport company; and Generator declaration of the accuracy of information provided. Materials containing a high degree of water content will be homogenized immediately upon material receipt to prevent drainage runoff.

It is anticipated that when fully operational the facility will receive 30,000 – 70,000 tonnes of impacted material per year that will be treated using the S/S technology. This additional quantity of materials does not require an increase in the current storage capacity of the Envirosoil facility. All the requirements for analytical data, material receipt and tracking will be followed as required by the existing Industrial Approval.

All impacted materials will be stored within the confines of the Envirosoil facility and remain on the clay liner until treated. Monitoring points ES1, ES2 and ES3 (Holding Pond, Holding Pond Ditch, and Lily Lake) will be monitored for a full suite of general chemistry and total metals parameters, as well as for electrical conductivity and chloride to confirm that water meets established quality criteria. The geographic location of the deposited material within the TSFA will be recorded for every 1000 tonnes of placed material.

2.4.2 Binder/Reagent Selection and Mix Design

The S/S process involves the mixing of binders/reagents, additives, and water with impacted materials to produce a treated product having improved physical and chemical properties. A critical part of the S/S process is the development of an appropriate mix design of reagents and additives that will effectively achieve the treatment criteria.

The S/S process to be used by Envirosoil will include the use of cementitious and/or pozzolanic reagents to solidify and stabilize the impacted materials. These reagents are the most commonly used S/S reagents to treat a wide variety of impacted materials. Cementitious and/or pozzolanic reagents include Portland cement, fly ash, ground granulated blast furnace slag, silica fume, cement kiln dust, various forms of lime, and lime kiln dust. Although these reagents may be used singly or in various combinations, Portland cement is by far the most widely used. Fly ash is commonly used for the materials containing >50% peat.

Typical binder quantities vary from 75 kg/m^3 of contaminated soil up to 250 kg/m^3 of contaminated soil (*i.e.*, approximately 3% - 12% depending on soil density, contamination, binder type, *etc.*). Table 2 presents a general range of binder requirements for effective S/S of impacted materials. Although Table 2 presents quantities for individual binders, binder mixes consisting of two or more components are widely used and can be more versatile and effective in many cases. The quantities for multi-component binders are typically lower than for individual binders (*i.e.*, total binder quantities are not strictly additive).

Table 2 Typical Binders and Quantities

Binder Type	Required Quantity
Portland Cement	**2% - 10%**
Quicklime (calcium oxide)/Hydrated lime (calcium hydroxide)	**1% - 10%**
Cement kiln dust	**0.5% - 5%**
Blast furnace slag	**0.5% - 10%**
Fly Ash	**2% - 15%**
Water	**12% - 40%**
Carbon	**0.5% - 2%**
Calcium Bentonite	**1% - 10%**
Phosphates	**1% - 5%**

The binders proposed are typical of those used in the cement/concrete manufacturing process. They will be stored and managed in accordance with industry best management practices. Mixing of the binder with the contaminated materials is performed inside closed equipment using an automatic feeding and mixing system. For example, cement will be stored within a silo and fed directly via pipe into the S/S treatment process. Storage silos contain integrated bag filters to reduce dust exhaust during filling operations.

Prior to the treatment of impacted materials, a Treatability and Testing Program will be conducted. The program will be used to determine the optimal formulation of binders/reagents and design parameters to required so that the treated material meets the appropriate criteria. During the program, various potential binders/reagents will be identified and tested. Final binder/reagent selection will be based on the type of contaminants to be treated, the concentration of contaminants in the material and the material's geotechnical properties (*e.g.*, moisture, fines, particle size).

The Treatability and Testing Program will include:

- Description of program and number of samples for proposed tonnage to be treated;
- Selection of correct reagent(s);
- Optimization of the reagent(s) dosages and ratios;
- Identification of material handling issues;
- Assessment of the physical and chemical uniformity of the contaminated material;
- Confirmation of the volume increase due to addition of reagent(s);
- Conformance to the treatability and performance criteria (*e.g.*, strength, leachability); and
- Treated material physical parameters (*e.g.*, moisture content, slump).

The above parameters will be confirmed by analytical work to evaluate the following:

- Initial contaminant concentrations – both mass and leachate;
- Treated material contaminate leachate analysis (both mass flux and leachate concentration);
- Treated material compressive strength;
- Treated material hydraulic conductivity;
- Moisture cycling effects; and
- Temperature cycling effects.

To obtain representative samples of contaminated material for the Treatability and Testing Program, Envirosoil will be using the "Dutch" method of sampling (Lame et Al. 2005.) This method takes 50 smaller random samples, and integrates the samples together to provide representative sample of the overall material. This method has been proven to reduce uncertainty in sampling large volumes of soil and provide a sample representative of the soil being tested.

Results of the Treatability and Testing Program will be used to refine the final treatment mix designs so that the treatment criteria will be achieved. Treatability testing will be performed on homogenized batches of contaminated soil. To confirm that the final treatment mix meets applicable criteria, mass flux leachate (using American Nuclear Society 16.1 or equivalent), permeability, and strength testing will be performed every 5000 m^3 of homogenized material prior to treatment. These criteria and their selection and relevance are discussed further in the section below.

2.4.3 Proposed Treatment Criteria and Performance Testing

Upon consultation with NSE and their technical experts, leachate performance criteria have been proposed based upon the Nova Scotia Tier I EQS groundwater guidelines (NSE, 2015a) and the Nova Scotia Remediation Level Protocols (NSE, 2015b). These criteria are displayed in Table 3 below.

Table 3 Proposed Leachate Performance Criteria

Parameter	Units	Concentration	Parameter	Units	Concentration
Benzene	µg/L	5	***Aluminum***	µg/L	50
Toluene	µg/L	24	***Antimony***	µg/L	60
Ethylbenzene	µg/L	2	***Arsenic***	µg/L	50
Xylene	µg/L	300	***Barium***	µg/L	10,000
Modified TPH (gas)	µg/L	1,500	***Beryllium***	µg/L	40
Modified TPH (fuel)	µg/L	100	***Boron***	µg/L	12,000
Modified TPH (lube)	µg/L	100	***Cadmium***	µg/L	0.1
MTBE	µg/L	15	***Chromium (hexavalent)***	µg/L	10
1 - Methylnaphthalene	µg/L	20	***Chromium (total)***	µg/L	500
2- Methylnaphthalene	µg/L	20	***Cobalt***	µg/L	100
Acenaphthene	µg/L	58	***Copper***	µg/L	20
Acenapthylene	µg/L	45	***Cyanide***	µg/L	50
Anthracene	µg/L	0.12	***Iron***	µg/L	3,000
Fluoranthene	µg/L	0.4	***Lead***	µg/L	10
Fluorene	µg/L	30	***Manganese***	µg/L	8,200
Napthalene	µg/L	11	***Mercury (total)***	µg/L	0.26
Phenanthrene	µg/L	4	***Methylmercury***	µg/L	0.04
Pyrene	µg/L	0.25	***Molybdenum***	µg/L	700
Benz(a)anthracene	µg/L	0.18	***Nickel***	µg/L	250
Benzo(a)pyrene	µg/L	0.1	***Selenium***	µg/L	10
Benzo(b,j,k)fluoranthene isomers	µg/L	4.8	***Silver***	µg/L	1
Benzo(g,h,l,)perylene	µg/L	1.7	***Strontium***	µg/L	44,000
Chrysene	µg/L	14	***Thalium***	µg/L	8
Dibenz(a,h)anthracene	µg/L	2.6	***Tin***	µg/L	44,000
Indeno(1,2,3-c,d)pyrene	µg/L	2.1	***Uranium***	µg/L	200
-	-	-	***Vanadium***	µg/L	60
-	-	-	***Zinc***	µg/L	300
-	-	-	***Chloride***	µg/L	2,500,000
-	-	-	***Sodium***	µg/L	2,000,000

Table 4 includes proposed treatment criteria for stabilized and solidified material. Table 5 presents the variability criteria for each test parameter. These guidelines are conservative (*i.e.*, are protective) and are typically appropriate for most treatment and/or remedial activities.

Table 4 Summary of Proposed Treatment Criteria

Parameter	Test Description	Criteria
Leachate	Synthetic Precipitation Leaching Procedure (SPLP)	As displayed in Table 3 above
Mass Flux	ANS 16.1/USEPA 1315 or equivalent	As per ITRC2011, leachability criteria to be established based upon site specific conditions and final TSFA design.
Strength	UCS	344.7 kN/m^2 (50 psi) minimum
Hydraulic Conductivity (HC)	Falling Head Test	1 x 10^{-6} cm/sec for performance, 0.5 x 10^{-6} cm/sec for treatability
Moisture Cycling	Wet/Dry	Final placement minimum of 2 m above seasonal high groundwater table
Temperature Cycling	Freeze/Thaw	Final placement a minimum of 1.2 m (4 ft) below finished grade (*i.e.*, below the frost line) **or** to be completed where material is not covered Laboratory testing to ensure < 10% weight loss after 12 freeze/thaw cycles
Free Liquids	Free Liquids	US EPA Paint Filter Test. 5-min test period. If a portion of the material drops through the filter within the 5 min test the material is deemed to have free liquids.

The S/S performance objectives are to create a solidified mass that will no longer be prone to potential loss to the environment; this includes physically immobilizing the material and reducing potential loss through leaching. The S/S treatment is also designed to provide a solidified mass that has the geotechnical strength properties to accommodate future land use, although no change in land use is planned or anticipated for this project. For this program, four types of performance criteria were chosen to demonstrate the potential of the solidified mass to meet these objectives: unconfined compressive strength; hydraulic conductivity; leachability; and mass flux analysis. Leachability and mass flux are commonly excluded as specific performance objectives if hydraulic conductivity criteria are established. They are rarely both included as criteria. The leachate testing will be the primary method.

A low hydraulic conductivity of the solidified mass inhibits groundwater penetration/migration through the monolith, reducing the risk of leachate generation. Hydraulic conductivity is used as a performance criterion in lieu of leachability in other S/S processes. It should be noted that the treatability target for hydraulic conductivity is 50% lower than the performance criteria as displayed in Table 4. This added safety factor has been included based upon discussions with

NSE and their consultants, to ensure that the placed material will meet the performance specification when placed in the field.

For this Project, Envirosoil proposes to use all three performance criteria to provide conservative treatment endpoints. Hydraulic conductivity testing will be completed during the Testing and Treatability Program. Compressive strength and leachability testing will be conducted during both the Testing and Treatability Program and field execution phase.

Table 5 Summary of Acceptable Performance Criteria Deviations

Parameter	Test Description	Criteria
Leachate	SPLP	Average of all samples ≤ Table 3 Values No individual sample > 1.5 Table 3 Values Not more than 20% of all values shall be >Table 3 Values
Mass Flux	Tank Test	Performance Criteria (PC): Leachability Index ≥ 8 Average of all samples ≥ PC No individual sample < 6 Not more than 20% of the samples values shall be < PC
Strength	UCS	Average of all samples ≥ 344.7 kN/m^2 No individual sample < 275.8 kN/m^2 No more than 20% of the samples < 344.7 kN/m^2
Hydraulic Conductivity (HC)	Falling Head Test	Average of all samples ≤ 1×10^{-6} cm/sec No individual sample > 1×10^{-5} cm/s No more than 20% of the > 1×10^{-6} cm/s
Moisture Cycling	Wet/Dry If not buried > 1 m above seasonal groundwater	Performance Criteria (PC): < 10% weight loss after 12 cycles Average of all samples ≤ PC No individual sample > 20% weight loss Not more than 20% of the samples values shall be > PC
Temperature Cycling	Freeze/Thaw If not buried > 1.2 m below finished grade	Performance Criteria (PC) = < 10% weight loss after 12 cycles Average of all samples ≤ PC No individual sample > 20% weight loss Not more than 20% of the samples values shall be > PC

The performance criteria listed in Table 3, Table 4 and Table 5 are consistent with industry best practice standards, and guidance given by the USEPA (USEPA, 2009) and The Environment Canada Wastewater Technology Centre (Stegemann and Cote, 1996). These performance criteria are designed to be highly conservative, and are used in applications where S/S treated material is deposited in unlined areas. The proposed use of lined cells for S/S treated material deposition for this Project (described in detail with Section 2.4.5) adds another level of conservatism to these chosen performance criteria.

The mass flux criteria will require further development, as the leachability index is dependent on several factors such as the dilution attenuation factor, compliance point, flow regime (which is dependent on the liner design in this application) and the final design of the TSFA. Envirosoil will work with NSE during the industrial approval process to select appropriate criteria for mass flux performance and treatability testing, and will follow the criteria formulation guidance established in by the Interstate Technology and Regulatory Council (ITRC) in 2011 (ITRC, 2011). Envirosoil commits to selecting criteria for mass flux testing to meet the leachate performance criteria detailed in Table 3.

Table 6 illustrates typical performance criteria recommended by the USEPA for the major performance criteria of interest, which are consistent with the values chosen by Envirosoil.

Table 6 USEPA Typical Parameters for S/S treatment.

Parameter	Units	Average Value[1]	Test Method
Unconfined Compressive Strength	Pounds per Square Inch	>50	ASTM D1633
Hydraulic Conductivity	Centimeters pre Second	<1x10$^{(-6)}$	ASTM D5084
Leaching Tests	Milligrams per Liter	Site Specific	TCLP and SPLP
[1]-Usually stated as "the average value of all treated must equal (usually a 20% allowance is permitted for individual samples			
TCLP – Toxicity Characteristic Leaching Procedure SPLP - Synthetic Precipitation Leaching Procedure			

As shown in Table 6 , the USEPA states that it is industry best practice to allow 20% of individual samples to be less than the recommended 1x10^{-6} cm/s criteria (USEPA, 2009). This statistical approach recommended by the USEPA is consistent with guidance offered by the ITRC Solidification/Stabilization Team (ITRC, 2011).

This allows for the variability inherent to the treatment of soils, while maintaining a high overall performance standard. Envirosoil has exceeded industry standards in the selection of performance criteria by proposing to use hard performance testing criteria where no sample can fail (selected to be one order of magnitude less than the average criteria of each parameter). This is additional to the average performance criteria for each of the parameters. This provides an additional contingency measure to ensure the performance of S/S treated materials.

The leachate criteria were selected to be very conservative. Samples are fully crushed, and tested via the synthetic precipitation leaching procedure (SPLP). This testing does not account for one of the primary mechanisms of solidification treatment – permeability reduction – and therefore provides an extremely conservative measurement of the leachate generation potential of solidified materials. In field placement, there will be limited surfaces for leachate generation, whereas in the SPLP testing all surfaces are available for leachate generation.

It is common in industry to only conduct performance testing on two of the major three performance criteria listed in Table 6. Envirosoil will conduct performance testing for all three of the performance standards: unconfined compressive strength; hydraulic conductivity; and leaching tests for each homogenized batch of S/S treated materials. This performance testing will be completed upon samples collected during the S/S treatment process. This is a level of performance testing in excess of the industry best practice, which typically use a limited performance testing program coupled with a consistency testing program (*e.g.*, slump analysis and visual observations to ensure S/S treatment consistency) (ITRC, 2011). Sample collection will be undertaken as described within Section 2.4.4 below. The testing methods are further described below.

Compressive Strength

The cylinders will be tested using the *ASTM Method 39, Standard Test Method For Compressive Strength of Cylindrical Concrete Specimens* to evaluate the compressive strength of each candidate mix design. Multiple cylinders will be prepared to assess compressive strengths.

Hydraulic Conductivity

Cylindrical specimens will also be prepared for hydraulic conductivity tests using a uniaxial flow permeameter (flexible wall method). This apparatus was first developed by CANMET in the early 1980s (Canadian Journal of Civil Engineering, 1984) and was designed to accommodate portions of 150 mm diameter cylindrical concrete specimens. To facilitate these smaller diameter specimens in the apparatus, the soil mixture specimens will be placed in the centre of 150 mm diameter polypropylene cylindrical molds and the resulting annulus filled with a rapid setting high strength concrete repair material. After setting and curing, the resulting concrete cylinder will be assembled in the permeability cell.

The construction of the cell is such that water can flow only uniaxially through the specimen. Water at 1,000 kPa (150 psi) is introduced into the top of the permeability cell and allowed to saturate the soil sample. The quality of the surrounding concrete is considered impermeable relative to the stabilized soil mixture. Once water begins to flow through the sample, it will be collected in a sealed container where the volume per unit time is measured and recorded. Given the water pressure, the sample height and diameter, and the water volume per unit time, the hydraulic conductivity of the selected stabilized soil mixtures can be calculated.

Due to the low design compressive strength of S/S treated materials, extracting a core sample from deposited S/S material that is representative of the actual field hydraulic conductivity is difficult and may give inaccurate results (due to micro fracturing from the coring process). Therefore, hydraulic conductivity is tested on representative cylinders cast from processed materials. Leachability of placed materials provides a more accurate method of assessing S/S treatment performance.

Chemical Testing (Leachability)

Following solidification, leachate chemistry will be compared to the criteria displayed in Table 7 to assess effectiveness using the toxicity characteristic leaching procedure (SPLP, EPA Method 1312).

Chemical Testing (Mass Flux)

Following solidification, mass flux testing will be performed and the leachability of the material will be assessed compared to the performance criteria that will be developed as per ITRC 2011 guidelines. (Mass Flux Testing, ANS 16.1).

2.4.4 Performance Testing Sampling Plan

The goal Treatability and Testing program is to develop an appropriate mix design that will treat the contaminated material to the chosen criteria. The goal of the Performance Testing program is to ensure the treated material also meets the selected criteria.

In general, for ex situ treatment methods, a bulk sample is typically collected from the discharge of the pugmill. The bulk sample is collected in a 20-L bucket and relocated to the sample preparation area for further processing, testing and sample specimen preparation.

Many tests on treated material require curing cylinder molds of a specific geometry and for a minimum period of time for hydration reaction to occur and the material to solidify. Preparation of sample specimens will follow standard procedures such as those outlined by American Society for Testing and Materials (ASTM) to promote consistent specimen preparation for the tests specified. Bulk material will be initially screened through a 1.3-cm mesh to remove oversize particles that would interfere with the specimen testing due to the relatively small size of test specimens (screen mesh size may vary depending on the size of the mold). Established standards and best management practices will be followed to achieve accurate results. A sufficient number of replicate samples will be prepared in the field.

For this proposed Project the material expected to be treated by S/S is expected to have a density of 2 tonnes/m^3. Therefore Envirosoil proposes to use a sampling rate of 766 tonnes to 1530 tonnes for SPLP, UCS and permeability testing. Envirosoil's proposed sampling rate is conservative based on the most up to date recommended best practices regarding S/S treatment.

The frequency of sampling freshly treated material depends on the overall size of the S/S project, the daily treatment rate, the type of testing performed, the observed consistency of mixing by the treatment facility, observed changes in the impacted material properties, and other factors. It is recommended that performance sampling of treated material be conducted considering the following guidance from the ITRC (2011).

- Sample every 1000 tonnes of treated material (alternate frequencies may be appropriate based on overall volume to be treated for a site, anticipated contaminated material characteristics heterogeneity, and review of tests resulltsas project progresses).
- Sample any time the impacted material or blended material physical characteristics appear to change significantly (*e.g.*, greater contaminant level, significant variation in moisture content, significant variation in material gradation).

The sampling frequency was derived from guidance provided by the USEPA and the ITRC. They recommend sampling every 400–800 m^3 of material (ITRC, 2011) for assessing the performance of materials treated via S/S. Envirosoil is using a similar frequency but is using a different unit of measurement, and sampling once every 1000 tonnes of material. Assuming an average density of 2 tonnes/m^3, the Envirosoil sampling schedule is approximately once every 500 m^3, on the conservative side of the USEPA recommended frequency schedule.

This sampling frequency meets industry best practices and was detailed with the USEPA's recently released manual of practice (Bates and Hills, 2015.) which provide a sampling range of 383-765 m^3.

While Envirosoil has proposed to use mass flux testing (ANS 16.1) as an additional performance criterion, the Mass Flux test requires 90 days to complete. This limits the utility of mass flux testing as an ongoing method of performance testing. For example, if material was found to exceed criteria, it would have already been placed within the completed cell, making removal and retreatment of the material difficult. Envirosoil is therefore proposing to use SPLP as the primary method of leachate analysis using the above described schedule, while using mass flux testing as a method of confirmatory performance sampling every 5000 m^3 using the ANS 16.1 mass flux testing method. This will allow rapid adjustment of treatment by early detection of issues by SPLP testing, and also provides an important secondary measurement of long term leachability via the mass flux testing. The standard industry practice uses SPLP only, therefore the proposed approach is considered conservative.

If material fails performance criteria, modifications to the mix design or the homogenization process may be implemented depending on test results, and the sampling frequency will be increased until the performance criteria can be reliably met. In the unlikely event the performance criteria cannot be achieved, the material will be reworked and re-solidified using S/S treatment until it meets performance criteria.

In the highly unlikely event that Envirosoil cannot successfully treat the materials using S/S or existing approved treatment methods, then the materials will be sent to an approved, offsite facility for final treatment/disposal. Envirosoil will maintain the appropriate bonding and security required by NSE to ensure that sufficient financial resources are available to handle any unforeseen circumstances. S/S will not be deposited in the TSFA unless the S/S treatment process has proven adequate based on the testing and treatability program.

2.4.5 Placement of Treated Materials

Envirosoil proposes that the treated materials be placed at a lined site within the quarry property boundaries (Figure 5). This figure displays a conceptual drawing of the proposed containment storage area for the S/S treated materials. This lined area will include the following design features:

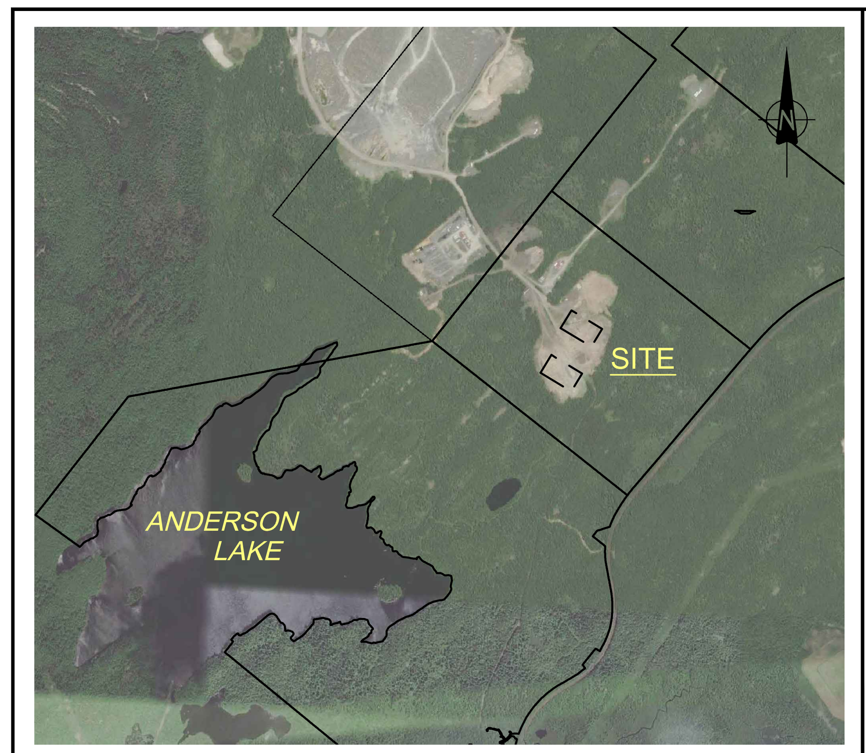
- 1.5 mm thick HDPE liner forming the base (design hydraulic conductivity of 10^{-8} cm/s);
- 300 mm thick leachate collection layer (with collection system) above the HDPE liner;
- 1.5 mm thick HDPE liner forming the cover cap (design hydraulic conductivity of 10^{-8} cm/s with a 2% grade to promote drainage and reduce standing water);
- a leachate monitoring point located at the base of the monolith;
- at least 1.2 m of compacted fill above the monolith (to prevent frost cycling);
- a French drain at the toe of the cover cap to collect clean runoff water, which will include a 150 mm perforated pipe surrounded by clearstone at the toe of the cover cap collection trench; and
- a runoff collection ditch located at the toe of the TSFA, which will collect clean runoff water from the French drain. This trench will contain multiple discharge weirs, to provide a specific sample point for ongoing water quality monitoring.

Prior to the placement of S/S materials, the receiving area will be suitably prepared (*e.g.*, site grading, removing any large boulders). Each lined cell will be constructed within the TSFA as it is required.

As displayed in Figure 3, the TSFA is currently a deposited mass of unconsolidated clean fill and surface grubbing from quarry operations. Each lined cell will be placed within an excavated area within this mass of clean fill. S/S material will be placed at the base of each lined cell a minimum of 2 m above the water table to prevent moisture cycling in the unsaturated zone. Groundwater levels within the TSFA will be confirmed via monitoring well installation prior to material placement, so that the treated materials are placed at the correct distance above the water table. This is an extra safety measure, as the monoliths are fully capable of being submerged while maintaining containment (in marine or inland waters); subaqueous placement is a common practice in other locations where this treatment method has been used.

Treated material will also be placed on a minimum base soil thickness of 1 m above bedrock. Solidified material will be placed in lined cells in 30 cm to 50 cm thick lifts, which is consistent with industry best practices (Bates and Hills, 2015). Once placed, the S/S material will be compacted with a standard sized roller. Compaction requirements will be assessed and confirmed as standard practice during the treatability testing program and confirmed during treatment operations. The location of the placed material will be recorded every 1000 m^3 of placed material.

Field compaction testing methods will be employed to confirm that the material placed within the cells has been adequately compacted as compared to the performance testing samples.



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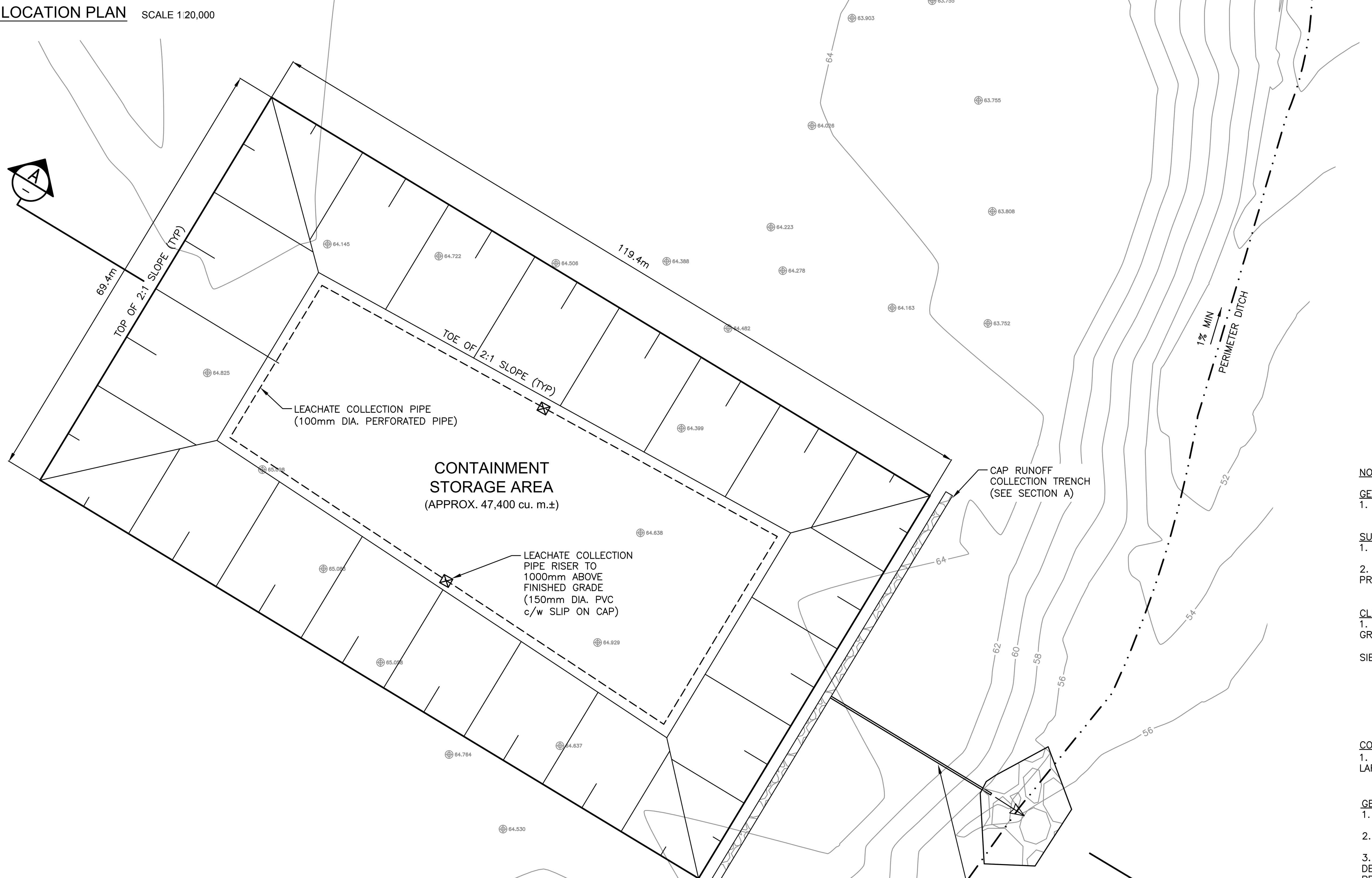

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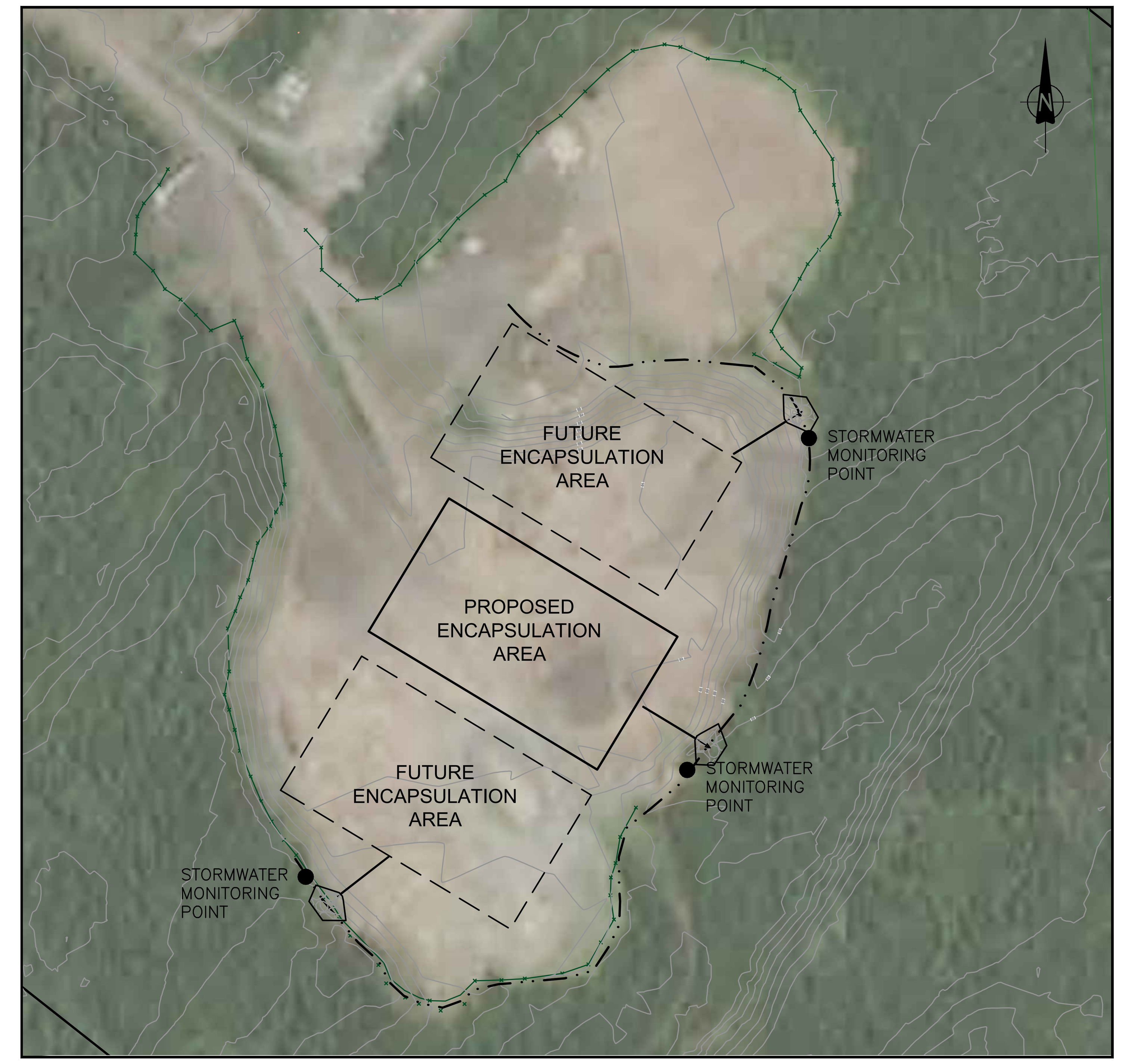


□EY PLAN SCALE 1□2000

LEGEND

EXISTING GROUND SURFACE CONTOUR (GEODETIC CGVD28) (m)

NOTES:

GENERAL:
1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE NOTED.

SUBGRADE:
1. THE SUBGRADE SHALL BE REVIEWED AND APPROVED BY QUALIFIED GEOTECHNICAL PERSONNEL.

2. THE SUBGRADE SHALL BE UNIFORM, WELL-COMPACTED AND FREE OF DELETERIOUS MATERIAL SUCH AS TREE ROOTS AND LARGE OR PROTRUDING CONSTRUCTION DEBRIS.

CLEAR STONE (SURGE):
1. CLEAR STONE SHALL BE AN APPROVED CRUSHED AND SCREENED, HARD, DURABLE STONE, FREE FROM CLAY AND ORGANIC MATTER AND GRADED AS FOLLOWS:

SIEVE DESIGNATION (mm)	PERCENT PASSING (%)
200	100
150	90-100
112	20-35
80	0-20
20	0-10

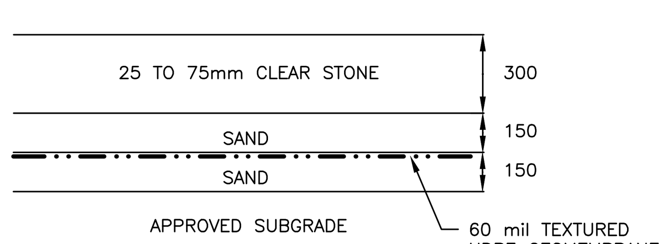
COMACTED FILL:
1. COMPACTED FILL SHALL BE WELL-COMPACTED AND FREE FROM: STUMPS, TREES, ROOTS, SOD; ROCKS, BOULDERS, AND MASONRY LARGER THAN 100mm IN ANY DIMENSION: AND OTHER DELETERIOUS MATERIAL.

GEOMEMBRANES:
1. GEOMEMBRANE SHALL BE SOLMAX HDPE, 460T - 2000, 60mil (1.5mm) LINER OR APPROVED EQUIVALENT.

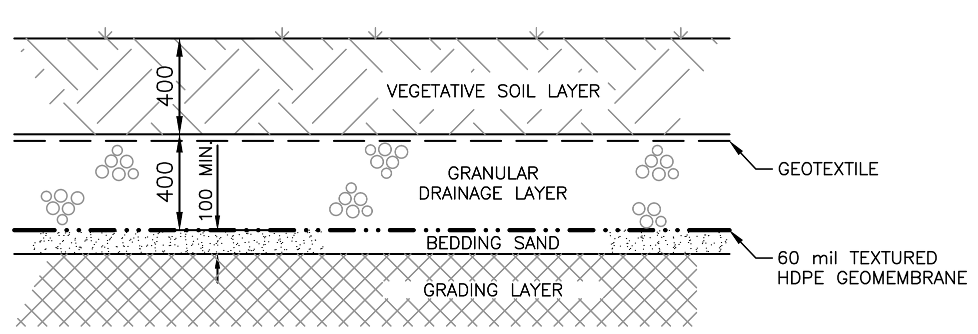
2. GEOMEMBRANE SHALL HAVE A ROUGHENED/TEXTURED SURFACE (BOTH SIDES) ON SLOPES.

3. INSTALLATION OF GEOMEMBRANES SHALL BE PERFORMED IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS. DETAILS AND PROCEDURES OF INSTALLATION (INCLUDING CONNECTION DETAILS) SHOULD BE SUBMITTED TO THE ENGINEER PRIOR TO THE START OF CONSTRUCTION.

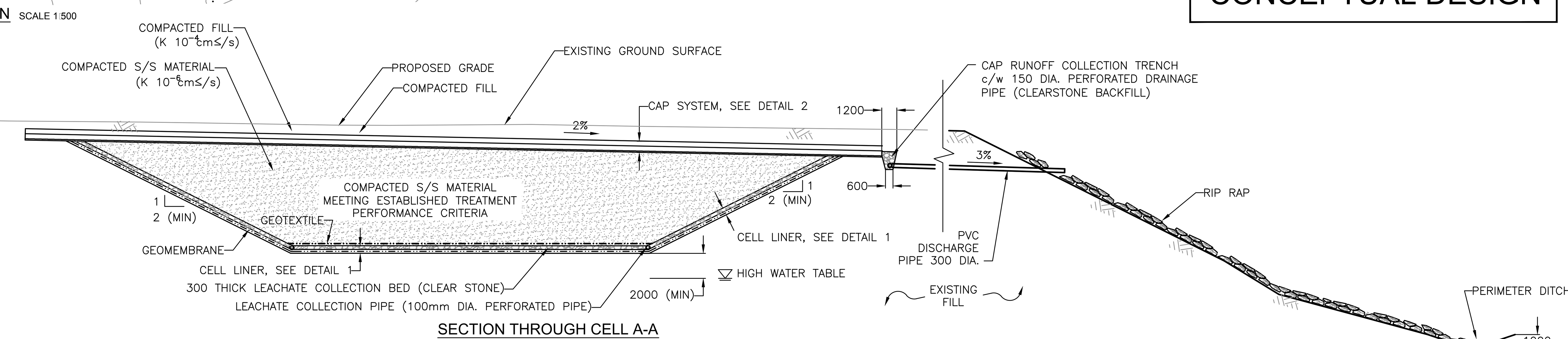
REVISED DRAFT CONCEPTUAL DESIGN



CELL LINER DETAIL 1
NTS



CAP SYSTEM DETAIL 2
NTS



SECTION THROUGH CELL A-A
SCALE 1:200

STAMP

STAMP

NOTE□ THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD PRO□ECT AND MUST NOT BE USED FOR OTHER PURPOSES.

APP'D	NO.	DETAILS	DATE
DM	1	ISSUED FOR REVIEW	OCT 25 2016

REVISIONS

DWG. NO.	DESCRIPTION	DATE
CAD FILE	En□iro□oil Cell, PROVIDED BY CLIENT	13 OCT 2015

REFERENCES

PROJECT: SOIL TREATMENT FACILITY

SITE ADDRESS: BEDFORD, NOVA SCOTIA

CLIENT: ENVIROSOIL LIMITED

JOB No.:	SCALE:	DATE:
121413511	AS SHOWN	2015□10□15
DRAWN BY	DESIGNED BY:	APPROVED BY
BSP	DM	DM

DRAWING TITLE: SOLIDIFICATION ENCAPSULATION CELL

FIGURE No.: 5

REVISION No.: 1

Stantec

When the material has been placed, the HDPE cap system will be installed and sloped to reduce ponding and promote drainage away from the covered material. A French drain will be installed along the toe of the sloped cover, to collect clean runoff that flows off the cover cap. This drain will discharge along the slope of the TSFA, which will be stabilized with Rip Rap.

Water will not be allowed to pond on the surface of the S/S materials during deposition. Deposition will not take place during significant rain events. The S/S treated material will be at least two orders of magnitude less permeable than the surrounding TSFA matrix. If water flows through the matrix, there is no opportunity for a driving head on top of the monoliths to form. Any water that contacts the material during placement will be collected and sent to an appropriate approved facility for disposal if required.

The HDPE liner will provide an extra level of conservatism for the reduction of groundwater infiltration into the monolith. Groundwater modelling was undertaken to quantify the effect of the lined cell within the TSFA on groundwater flow.

The proposed design for the HDPE lined area for treated material deposition includes leachate monitoring and collection systems, which will remove any leachate in the event leachate is generated, thus preventing any theoretical breakthrough. Combined with the low permeability of the monolith and the HDPE cap it is extremely unlikely that there will be any leachate collected on the bottom liner of the cell.

At the end of each production season (*i.e.*, late fall) the deposited S/S material will be backfilled/covered with a minimum of 1.2 m of fill so that the entire S/S monolith is below the local frost line to prevent temperature cycling. Interim covers may be placed to prevent material from being exposed for long periods of time. The fill cover will meet a hydraulic conductivity of 10^{-5} cm/sec (consistent with NSE Industrial Approvals for select Construction and Demolition (C&D) facilities in Nova Scotia). When used in conjunction with the requirement that the treated material be placed a minimum of 2 m above the seasonal high groundwater table, this will further help protect material from potential degradation due to moisture or temperature cycling.

2.5 SCHEDULE/WORKFORCE

Envirosoil operates on a year-round basis and maintains a full-time office with 24-hour accessibility. The new treatment options are proposed to commence in the summer of 2017 pending regulatory approval. Treatment operations are normally confined to the months of May to October, unless dictated by project-specific requirements. During the operating season, the equipment will operate five days per week, 10 hours per day, unless project-specific requirements require longer operational times.

Envirosoil employs 12-15 permanent staff and seasonal employees at the existing facility during the operational season. During the off-season, Envirosoil employs four to five full time employees. If volume increases, there will be a need to add further hourly workers and employees. This number can fluctuate depending on the activities taking place on-site. Employment levels are expected to remain the same following the addition of the new treatment options.

2.6 EFFLUENTS AND EMISSIONS

Project activities (operation of the S/S equipment and the storage and treatment of EC/SAR impacted materials) will be consistent with the current facility operations approved by NSE (Approval No. 2002-026440-A03) and any subsequent amendments . The Project will not generate dust or noise at levels beyond those of the current Envirosoil operations.

Any monitoring of airborne particulate emissions (dust) is conducted at the request of NSE and in accordance with the Nova Scotia Air Quality Regulations and the facility's existing Approval (or future amendments). Emissions shall not exceed the following limits at the property boundaries:

- Annual Geometric Mean 70 µg/m^3; and
- Daily Average (24 hrs) 120 µg/m^3.

Cement dust will be controlled with appropriate filter mechanisms installed on the cement storage silos. These filters are industry standard equipment on all cement storage silos at cement plants and/or production facilities.

The Project will not generate noise at levels beyond those of the current Envirosoil operations. As per the requirements of the existing Approval and standard provincial guidelines, sound levels from the operation will be maintained at the following sound levels (Leq) at the property boundaries:

• L_{eq}	65 dBA	0700-1900 hours (Days);
	60 dBA	1900-2300 hours (Evenings); and
	55 dBA	2300-0700 hours (Nights).

Envirosoil has handled PHC/PAH impacted materials for over 12 years without any issues related to odour.

All of the requirements for groundwater and surface monitoring, reporting and criteria will continue to be strictly followed. Details of the requirements are in the existing Approval . Groundwater analysis will be expanded to include dissolved chlorides whenever there is high EC/SAR materials stored on-site (Section 5.2.2).

The only solid materials generated by the S/S plant will consist of treated materials. The only solid materials generated by the impacted EC/SAR materials will consist of treated EC/SAR materials.

Combustion emissions will be generated from the operation of vehicles and equipment during Project activities. These emissions will be similar in quantities to the current operation. Emissions will be reduced through proper equipment maintenance and inspection practices for efficient operation. Consideration will be given to methods to reduce truck and equipment idling, as feasible.

Refuelling of equipment used to transport material to the TSFA will continue to be conducted on-site on a regular basis. Refuelling activities will not be conducted within 30 m of any active stream or wetlands identified in the field surveys. Other control measures include implementing Envirosoil's existing best practices for handling of materials as well as established contingency plans. All spills will be reported to the 24-hour environmental emergencies reporting system (1-800-565-1633) in accordance with the Emergency Spill Regulations.

2.7 DECOMMISSIONING AND RECLAMATION

The Envirosoil facility is expected to be in operation for the foreseeable future with proper maintenance and according to market requirements. When permanent shut down of the facility is planned, Envirosoil will work with NSE to prepare a final decommissioning and reclamation plan according to regulations at the time. Post-closure monitoring requirements will be addressed with the NSE at closure, along with the other expected regulatory requirements at that time. In general, it is expected that the equipment at the processing facility will be removed and any required site remediation will be conducted. The TSFA will be closed, graded and re-vegetated. Sufficient financial bonding/security will be provided to NSE to cover these costs.

3.0 SCOPE OF THE ENVIRONMENTAL ASSESSMENT

As indicated in Section 1.5, the Project is subject to registration as a Class I Undertaking under the Environmental Assessment Regulations. This report fulfills the requirements for Project registration under this legislation, as well as requirements outlined by NSE during the Project planning stages (NSE, pers comm, April 1, 2015).

3.1 FIELD STUDIES

Field reconnaissance was conducted by Stantec on April 24, 28 and 29, 2015 to investigate and establish the existing conditions at the Envirosoil facility and the TSFA location, and to determine appropriate mitigation, if necessary, to manage environmental effects from the Project. Information on the location and character of wetlands, watercourses, and general habitat conditions in and near the Envirosoil facility and TSFA was also gathered during the site visits.

The existing processing facility site is located in a disturbed area, characterized by gravel pads, roads, and soil mounds. The TSFA is located in an area within the Municipal Quarry property boundaries. Exposed soils and elevated terrain characterize the TSFA. An approximate 50 m area surrounding the current disturbed footprint of the TSFA was searched for wetlands and watercourses. Surveys extended to beyond 100 m from the edge of the current footprint when features of interest were encountered.

To assess the groundwater flow surrounding the TSFA, a network of wells were installed. These wells are shown in Appendix C, Figures E1 and E2. These figures display the monthly calculated groundwater flow direction between October, 2015 and March, 2015. The installed wells range from approximately 5 m below ground surface to approximately 18 m below ground surface. These wells are being monitored automatically using independent water level sensing instrumentation. Full discussion of this study and the results are contained within Section 5.2

3.2 VALUED COMPONENT (VC) IDENTIFICATION

The scope of the EA for the Project has been determined by the Proponent and Stantec, and is based on the Project components and activities, the professional judgment of the study team, consultation with NSE, previous site information and reporting, and the results of three site visits conducted in April, 2015 in support of this EA. Additional information on the facility, environmental setting and surrounding area is provided in the 2003 EA (Envirosoil, 2003).

This EA focuses the evaluation of potential environmental effects of the Project on Valued Components (VCs). VCs are broad components of the biophysical and socio-economic environments that, if altered by the Project, may be of concern to regulatory agencies, the Mi'kmaq of Nova Scotia, scientists, and/or the general public.

Table 7 indicates scoping considerations and selection of VCs used in this EA.

Table 7 Scoping of VCs

Component	Scoping Considerations	VC
	Biophysical Environment	
Groundwater	The Project has the potential to interact with groundwater resources. The Project could potentially affect down-gradient groundwater and surface water quality . Effects on groundwater resources are discussed in the VC.	Groundwater Resources
Surface Water, Fish and Fish Habitat	The S/S process does not generate any wastewater that would require dedicated collection and/or treatment. All operational aspects of the S/S process will occur within the confines of the current Envirosoil facility and within the boundary of the existing clay liner system. The storage of impacted EC/SAR materials has the potential to generate runoff high in dissolved chlorides due to the percolation of rainwater over and through the stockpiled material during periods of heavy rainfall or snowmelt. No fish and fish habitat will be affected by the Project. The Project could affect groundwater at the Envirosoil facility and potentially affect groundwater and surface water quality down-gradient. Effects on surface water resources are discussed in the VC.	Surface Water Resources

Table 7 Scoping of VCs

Component	Scoping Considerations	VC
Wetlands	Wetlands are valued resources, protected by the Nova Scotia *Environment Act* and Regulations. No wetlands (naturally occurring or anthropogenic) are present on the processing site. As the settling pond lacks an outflow, it is isolated from downgradient water resources. Three wetland areas were identified in the surrounding area around TSFA. Surface runoff at the TSFA will be directed away from wetlands and a 30 m setback will be maintained. Potential for groundwater flows to enter wetlands will be discussed in the context of interactions with surface water. No alterations to wetlands are anticipated.	Surface Water Resources
Flora and Fauna	There will be no new ground disturbance of greenfield areas. The existing processing site is confined to the land parcel on which current activities are restricted. The existing processing site is located in a disturbed area, characterized by gravel pads, roads, and soil mounds. The TSFA is also in a highly disturbed area. No direct habitat loss and disturbance to wildlife is expected.	N/A
Atmospheric Conditions/Air Quality	Envirosoil is situated in an industrial area that is separated from residential areas and sensitive land uses. Envirosoil is an existing operation that has procedures for the handling of materials designated for LTTD treatment. These materials have been handled for over 12 years without any issues related to dust or other air emissions. Cement dust will be controlled with appropriate filter mechanisms installed on the cement storage silos. These filters are industry standard equipment on all cement storage silos at cement plants and/or production facilities. Emissions are further discussed in Section 2.6. Envirosoil will continue to comply with existing permit conditions.	N/A
Acoustic Environment	Envirosoil is situated in an industrial area that is separated from residential areas and sensitive land uses. S/S operations and the handling and treatment of impacted EC/SAR materials will not generate noise at levels beyond those of the current Envirosoil operations at the industrial site. Emissions are further discussed in Section 2.6. Envirosoil will continue to comply with existing permit conditions.	N/A
	Socio-economic Conditions	
Land Use	The Project will not interact with surrounding land uses including residential and recreational land use. The Envirosoil facility and TSFA are located on private land with restricted access.	N/A
Transportation	The Project will not substantially increase traffic on public roads. Transportation of materials will be along existing private access roads in the quarry.	N/A
Cultural and Heritage Resources	There will be no new ground disturbance. The existing processing site is confined to the land parcel on which current activities are restricted. The existing processing site is located in a disturbed area, characterized by gravel pads, roads, and soil mounds. Existing permit conditions will continue to be followed should there be a chance find of an archeological or heritage resource.	N/A

4.0 CONSULTATION AND ENGAGEMENT

Envirosoil has extensively consulted with NSE, including multiple in-person meetings and information submissions in response to NSE inquires. Comments received from the public and stakeholders during the previous Environmental Assessment process were considered during the development of this document.

The existing Envirosoil facility has been in operation since 1992 and there have been no known issues or complaints to date. The facility operates under an existing Approval and is on privately owned lands that are not open to the public for recreational use.

This EA Registration document will be subject to a public review process as required under provincial legislation. Copies of the EA Registration document will also be provided by NSE to Mi'kmaq organizations. The document will be posted on the NSE website http://www.novascotia.ca/nse/ea/), with paper copies available at several locations including near the Project area. Publication dates and Registration document locations will be advertised in one Province-wide newspaper and one local newspaper. Public and Mi'kmaq comments regarding the EA Registration will be collected and reviewed by NSE to inform the Minister's decision regarding the Project.

5.0 VALUED COMPONENT AND EFFECTS MANAGEMENT

5.1 EFFECTS ANALYSIS METHODS

A focused approach is used for the EA using the VCs identified in the scoping process described in Section 3.0. EA is used as a planning tool not only to identify predicted Project effects, but also to design mitigation strategies to reduce adverse environmental effects and propose monitoring programs where substantial risk or uncertainty remains.

For the selected VCs, existing conditions in the facility area and TSFA are described. Potential Project-VC interactions are identified and effects, including proposed mitigation, are predicted. Effects are analyzed qualitatively, and, where possible, quantitatively, using existing knowledge, professional judgment and other analytical tools, where appropriate.

To assess the potential environmental effects of the Project and determine the significance of an effect, the study team has considered the magnitude, frequency, duration, geographical extent and reversibility of the potential effect, where applicable. In particular, regulatory standards were used, where appropriate, to determine thresholds of significance for predicted environmental effects after application of mitigation (*i.e.*, residual effects).

Requirements for follow-up and monitoring are linked to the potential sensitivity of the VC to predicted environmental effects as well as levels of uncertainty with respect to the prediction of effectiveness of mitigation.

5.2 GROUNDWATER RESOURCES

Groundwater is an integral component of the hydrologic cycle that originates from the infiltration of precipitation or surface water into the ground. Within the subsurface, the upper surface of the saturated zone is called the water table. The water table intersects the surface at springs, lakes, streams where interaction between groundwater and surface water resources can occur. There is a dynamic interaction between groundwater resources and surface water resources in Nova Scotia. Groundwater generally sustains the base flow of springs, streams and wetlands during dry periods of the year. More rarely, surface water bodies can contribute to groundwater storage under certain hydrogeological conditions.

Aquifers are saturated geological formations or groups of formations that can store or yield useable bodies of permeable rock or unconsolidated material capable of storing or yielding useable volumes of groundwater to wells or springs. The yield of dug or drilled wells can vary greatly, depending on the hydraulic properties of overburden and bedrock aquifers into which wells are constructed. Natural groundwater quality is directly influenced by the geochemical composition of the aquifer materials through which it passes, and the length of time the water resides within those materials.

Groundwater has been selected as a VC because of its importance to local ecosystems (*e.g.*, wetlands and watercourses) and as a local private potable water supply. Groundwater Resources will be assessed in the context of potential Project-related effects on groundwater quality and quantity and will consider the Envirosoil facility and TSFA.

5.2.1 Description of Existing Conditions

5.2.1.1 Physiography and Drainage

The Envirosoil facility is located within the footprint of the existing quarry which is situated in the watershed of Rocky Lake (5.11 km^2). The TSFA is located along the southwest border of the Lake William watershed (22 km^2) and is within a sub-catchment of Marshall Brook. Lake William is one of the headwater lakes for the Shubenacadie Canal System and receives water from Rocky Lake and six other inlets along the south and west shores. Surface topography is primarily bedrock controlled.

5.2.1.2 Surficial Geology

Surficial geology within the vicinity of the TSFA at higher elevations primarily consists of a thin veneer of glacial till and exposed bedrock outcrop. A quartzite till surrounds the till veneer and is approximately 1-10 m thick along Rocky Lake Road. The quartzite till consists of a light bluish-grey, loose matrix of angular clasts comprised of approximately 80% sand, 15% silt and 5% clay with large cobbles (Stea and Fowler, 1981). Detailed Quaternary maps of the area (Utting, 2011) show thin glacial veneer overlying most of the area, with small zones of glacial till immediately northeast and southwest of the fill materials between the bedrock ridges.

Recent drilling near the TSFA indicates variable glacial till thickness, ranging from nil along bedrock ridges to approximately 6 m along intervening swale.

5.2.1.3 Bedrock Geology

The bedrock in the vicinity of the TSFA consists of Cambrian-Ordovician aged (510 to 545 million years) fractured meta-sandstone (greywacke) and minor slate of the Goldenville Formation of the Meguma Group (Keppie, 2000). This bedrock is described as a greywacke and minor slate turbidite sequence laid down in a continental rise prism sub-aqueous depositional environment, and is in places metamorphosed to schist and gneiss, and is commonly described as greenish-gray greywacke and minor slate.

The bedrock structure in the TSFA consists of a series of tightly folded, northeast to southwest trending anticlines and synclines. The TSFA is situated on the southeast limb of the Bedford Syncline. The dominant direction of bedding (and bedrock ridge) strike is northeast along the structural trend, with bedding dips averaging 30 degrees to the northwest in the immediate area of the TSFA. No major faulting or fracture trends are noted from available topographic and Lidar mapping.

Bedrock in the TSFA dominates the local topography, forming a series of northeast to southwest trending rock ridges with intervening glacial till infilled swales. The highly detailed LIDAR mapping of the area clearly shows the dominance of these ridges. The ridges are comprised of more competent meta-sandstones and can locally control drainage and surface water features. The TSFA is bordered to the north and south by such ridges (the intervening swale is being filled) which extend 730 m southwest to Anderson Lake and northeast to Marshall Brook.

The Goldenville Formation is not generally considered to be acid generating, except in the vicinity of mineralized zones in Gold Districts where natural arsenic, in the form of arsenopyrite, is well known and documented (Grantham, 1976; Grandtham and Jones, 1977). The Goldenville Formation hosts the numerous Gold Districts of Nova Scotia, which tend to occur along the crests of anticline axis. Arsenopyrite mineralization associated with extension fracturing along the mineralized anticlines results in arsenic concentrations in groundwater above the Canadian Drinking Water Guideline of 10 micrograms per litre (Bottomley, 1984; Nova Scotia Department of Health, 1986; Nova Scotia Department of Natural Resources, 2005). The nearest gold mining area is located at Waverley 5.3 km to the north, and at Montague Gold Mines, 7.4 km to the east (Nova Scotia Department of Natural Resources, 2005)

Mineralized zones may also occur near contacts between Meguma bedrock and the granite intrusive, where local bedrock is more highly altered. The nearest contact with granite occurs 7.8 km to the northeast (north end of Lake Major) and 10 km to the north (Long Lake). The combination of bedrock structure in the immediate area (syncline), distance to granite contacts (> 7.5 km) and absence of apparent mineralized zones (nearest Gold District >5 km from site) suggest a low probability of encountering mineralized zones.

5.2.1.4 Bedrock Permeability

Three hydrostratigraphic units are typically considered in this type of terrain when conducting a high level assessment of bedrock permeability. The top unit is the glacial till. In this case the till is considered to be a sand-phase (hydraulic conductivity is expected to be 1×10-4 to 1×10-3 cm/s, which is a low typical hydraulic conductivity for surface bedrock in this geological domain). The unit below is weathered bedrock which may have enhanced permeability due to glaciation. In many cases the permeability of the till and weathered bedrock are about the same.

The lower unit is the competent bedrock which is of lower permeability (geometric mean of hydraulic conductivity from 100s of individual pumping tests in the Meguma Terrain is 2.5×10-5 cm/s) derived from the Nova Scotia pumping test inventory (Nova Scotia Department of Natural Resources, 2015). Fracturing is dominantly sub-vertical and poorly inter-connected; hence the lower yield in bedrock wells in this terrain.

5.2.1.5 Groundwater Flow

The possible mechanisms for flow out of the TSFA include: seepage out of the toe of the fill at the fill-glacial till interface due to the contrast in permeability with direct discharge to surface water; recharge into the till and upper weathered rock beneath the fill which is part of interflow with discharge to surface water features within close proximity; and recharge into the deeper bedrock system beneath the pile due to a downward vertical gradient with more distal discharge to surface water features.

Solinst water level loggers were deployed in three monitoring wells adjacent to the TSFA (15MW-01, 15MW-02, and 15MW-03S) for continuous water level logging (logging interval set at 15 minutes) and an on-site barologger to allow water level data to be corrected for changes in atmospheric pressure. Well locations are displayed within Figures E1 through E6 in Appendix C. Water level and barometric pressure data has been tabulated and barometric pressure compensation applied to all water level data. Water level data were corrected using manual water level readings collected during download events.

Elevation surveys of the top of well PVC casing and ground surface for each on-site monitoring well was performed. Top of casing elevations and corrected water level data were used to calculate groundwater elevations. The average water level elevation for each month from October 2015 to March 2016 was calculated for 15MW-01, 15MW-02, and 15MW-03S. These monthly averages were used to generate an approximate direction of shallow groundwater flow for each month.

Groundwater elevations varied on average 1.69 m from October 2015 to March 2016. Monthly groundwater elevations varied a maximum of 4.43 m in December 2015 at 15MW-02 to a minimum of 0.07m in January 2016 at 15MW-03S.

Triangulation was used to determine the approximate direction of shallow groundwater flow. This method uses the following equation (Sanders, 1998):

$$\frac{Distance\ from\ low\ point\ to\ selected\ point}{Distance\ from\ low\ point\ to\ high\ point} = \frac{difference\ between\ water\ levels\ at\ low\ point\ and\ selected\ point}{difference\ between\ water\ levels\ at\ low\ point\ and\ high\ point}$$

Based on the average monthly groundwater elevation from the above three monitoring wells, the approximate direction of shallow groundwater flow was determined to be northwest for each month between October 2015 to March 2016. This is consistent with local topography. The groundwater flow direction for each month is displayed within Appendix C.

Shallow groundwater flow within the Lake William watershed is expected to mimic topography, move northeasterly, and discharge to streams other surface water features and Lake William. The large lobe of fill underlying the TSFA could induce groundwater mounding within its footprint and result in local radial outward groundwater flow; however the groundwater monitoring completed to date shows that the measured groundwater flow direction has been consistent.

5.2.1.6 Water Wells

A survey of domestic water wells was previously conducted in 2005 as part of the Quarry Modification Project Environmental Assessment Registration (Jacques Whitford 2005). Domestic water supply in the vicinity of the TSFA would be derived from dug or drilled wells. Water supply for the Lakeview Area, across Rocky Lake, is mainly provided by Halifax Water. The closest residential wells are located on Rocky Lake Road (unknown type) and Lakeview Drive (dug) approximately 1.7 km north of the Envirosoil facility. The closest commercial well is a drilled bedrock well reportedly in shale (Goldenville Formation) and is on Municipal Quarry property.

The TSFA is bounded by forested area, which includes a rail line. No confirmed commercial or residential properties with dug or drilled wells are located within 1.5 km based on the data available in the Nova Scotia Interactive Groundwater Map (NSDNR 2014).

5.2.1.7 Water Quantity

Yields from dug wells are not reported but are expected to be relatively low. The glacial tills in the vicinity of the TSFA have high silt and clay content and thus have a relatively low hydraulic conductivity on the order of 10^{-5} to 10^{-7} cm/s (Freeze and Cherry 1979). Low hydraulic conductivity would result in low rates of groundwater infiltration and high potential for surface water retention (and wetland formation where drainage is poor).

Jacques Whitford (2005) compiled information from 38 available NSE well records for drilled bedrock wells that are reportedly located along Rocky Lake Drive or in Lakeview in the vicinity of the TSFA. While the well locations have not been verified, the compilation of well construction details provides in indication of likely drilled well conditions. The average well depth is 64 m. Well yields range from nil to 36.4 L/min, with a median yield of 4.5 L/min which is relatively low but suitable for domestic use.

5.2.1.8 Water Quality

The water quality from wells constructed in the Goldenville Formation is expected to be good, with most parameters meeting the Canadian Drinking Water Guidelines (Health Canada 2014). Arsenic in excess of drinking water guidelines is possible as a naturally-occurring water quality issue. Other potential aesthetic problems such as iron, manganese and moderate hardness have occasionally been reported (Jacques Whitford, 2005).

The Envirosoil facility has an on-going groundwater quality monitoring program established under the current operating permit. The current groundwater quality monitoring for wells MW1-MW9 occurs bi-monthly for BTEX (benzene, toluene, ethylbenzene, and xylene)/TPH and quarterly for PAHs. Monitoring wells MW1, MW2, MW8R and MW9 are also sampled quarterly for metals, pH, phenols, conductivity, sulfate, and TSS. Water quality is not currently monitored at the TSFA.

5.2.2 Potential Effects and Proposed Mitigation

Envirosoil Facility

Project activities at the existing Envirosoil facility are limited to impacted materials being stored and handled, and a new S/S operation and the associated equipment. Both of these activities are similar to current operations covered under the existing Approval.

Potential groundwater quantity effects are expected to remain unchanged from existing conditions. The footprint of future operations remains with the confines of the lined Envirosoil facility.

Project-related contamination could affect groundwater at the Envirosoil facility and potentially affect well water and surface water quality down-gradient. This could result from the release of fuel, lubricants and other industrial fluids associated with operations. It could also result from the infiltration of rain water or snow melt into stockpiles and the leaching and mobilization of salt, metals and organics. This water would have to breach the confines of the liner by leaking though or spilling over it, and migrate to the water table. The current Envirosoil facility is designed to prevent this from occurring.

Groundwater elevation contours and inferred flow lines developed by SLR (2015) show that the local groundwater flow spreads radially to the south of the lined area towards other parts of the quarry facility. Thus, contaminated groundwater could be captured by the quarry sump system. The regional flow direction is interpreted as being north towards Rocky Lake. In either case, the nearest water well is greater than 800 m away and is not likely in the flow path of groundwater moving from this location. This remains unchanged from existing and approved site conditions.

The proposed mitigation measures include following Best Management Practices (BMPs) for handling and storing all treated and untreated waste materials in addition to the BMPs already established for operations under the existing Approval. Operation of the Project will remain within the confines of the lined Envirosoil facility. The Envirosoil facility will continue to be operated above the water table to retard the movement of contaminants into the groundwater system. Existing procedures established for waste acceptance under the existing Approval will apply to the receipt and acceptance of metals, EC and SAR materials.

Treated Soils Fill Area

The TSFA is designed to receive S/S monoliths of organics and salt and metals-impacted soils. The TSFA is constructed of poorly-sorted geologic materials on the order of 15 m thick.

Potential groundwater quantity effects are expected to remain unchanged from existing conditions.

Without design-mitigation or additional site-specific mitigation and best management practices, Project-related activities could result in an adverse change to groundwater at the TSFA and down-gradient groundwater and surface water receptors. Contamination could enter the shallow groundwater system under the pile as interflow and discharge to proximal surface water. It could migrate deeper into bedrock and discharge to surface water at more distal points such as Marshall Brook. The mechanism depends on the hydraulic characteristics of the fill, the glacial till and bedrock. Groundwater flow direction characterization has been undertaken at the TSFA (as detailed in Section 5.2.1). The measured groundwater flow direction is approximately northwest. This scenario is presented because of concerns raised during consultation; however for such a scenario to occur, the following components would all need to fail simultaneously:

- failure of the surface cap;
- failure of the S/S monolith;
- failure of the cell leachate collection system; and
- failure of the bottom liner.

This scenario is not considered to be reasonable given the redundant design-mitigation and site-specific mitigation that is planned for the Project.

The proposed mitigation measures include following BMPs for handling and storing all treated and untreated waste materials outlined in this document in addition to the BMPs already established for operations under the existing Approval. Typically, S/S treated materials with concentrations Envirosoil is proposing to accept are deposited and compacted without any external lining system; however, Envirosoil will be using a fully lined cell, with a leachate collection system and a system for reducing standing water on the cell. The TSFA will be operated above the water table. The position of the water table in the fill has not yet been characterized, however Envirosoil commits to characterizing the water table location within the TSFA prior to any deposition of treated materials. The magnitude of the potential effect would depend on mass loading at the source, the amount of dispersion and retardation in the environment, and the transit time. It should be noted that application of S/S technology to treat materials is using conservative acceptance and performance criteria, combined with a fully lined cell system (with leachate and runoff control features), which taken together would mean it is highly unlikely there is any effluent discharged from the TSFA.

There have been questions regarding Anderson Lake raised during consultation with regulators and the public. Anderson Lake is a large waterbody located south of the TSFA. Anderson Lake is located in the Wrights Brook Watershed, while the Envirosoil Facility and the TSFA are located in the Shubenacadie River Watershed. This has been confirmed by groundwater flow delineation (Section 5.2.1). Water leaving the facility will therefore not enter the Wright Brook watershed as there is no physical flow path. This predicted lack of interaction with Anderson Lake means there is no potential risk and/or effect to the Atlantic Whitefish (*Coregonus huntsman*) resident in Anderson Lake from any potential effluents from the TSFA. The proposed monitoring program will verify this prediction.

In the unlikely event that concentrations of parameters indicate potential leaching after on-site activity commences, appropriate interception contingency measures will be taken if site monitoring indicates a potential issue with the exceedance of relevant groundwater quality guidelines. Contingency measures will need to be dynamic to properly respond to an issue. In the unlikely event of contaminant impacts to groundwater, the following contingency measures may be used if required to prevent contaminant migration off-site:

- groundwater interception and management;
- physical removal of materials from the TSFA;
- ditching, swaling and ground contouring to collect surface water.

Due to the strict acceptance criteria for soil, the selected treatment and performance criteria, and the TSFA design, it is considered extremely unlikely the above measures would have to be enacted. If required and depending on the nature and extent of the impacts, the contingency measure best suited to intercepting and containing the contaminant migration would be chosen, and discussions regarding preferred strategies would occur with NSE if such measures were required.

5.2.3 Monitoring and Follow-up

Envirosoil Facility

It is recommended that the 10 existing perimeter groundwater monitoring wells at the Envirosoil facility continue to be used for obtaining groundwater elevation and groundwater samples. The revised sampling frequency and analyte list proposed by SLR (2015) at the facility is appropriate for monitoring during operation (Appendix B). The monitoring program should be reviewed every two years.

Treated Soils Fill Area

Monitoring wells are needed to characterize the groundwater system around the TSFA. Wells have been installed as detailed within Figures E1 through E6 in Appendix C. The wells range in depth from approximately 5 m to 18 m below ground surface, with a multilevel well pair installed between the TSFA and Anderson Lake (MW15-03S and MW15-03D). In addition to these monitoring wells, drive point wells will be installed in the toe of the fill at local lows where seepage might occur prior to the deposition of treated materials. Manual groundwater level measurements should be conducted in all wells on a quarterly basis.

Envirosoil will include a leachate monitoring point at the base of the monolith, within the lined cell. This point will be monitored monthly, as per the groundwater wells above, and be used as an early indicator for the performance of treated materials. The results from the monitoring of this point will be communicated with NSE.

Quarterly groundwater samples will be collected and analyzed for the same parameters as at the Envirosoil facility (RCAp-MS, Volatile Organic Compounds or VOCs, BTEX/TPH, PAH, TSS and phenols, as detailed in the frequency and analyte list proposed by SLR(2015)). One down-gradient surface water sampling location will also be established (see Section 5.3, Surface Water Resources). If concentrations are observed to increase in relation to on-site activity, appropriate interception schemes alternative may be considered depending on the CCME guidelines for the receiving environment.

The water level measurement and chemical sampling programs should be reviewed after two years. The scope of the monitoring program will be evaluated in conjunction with the plan for on-site activity.

5.2.4 Summary

S/S is a proven technology that is widely used and is designed to reduce leaching of inorganic and organic contaminants, and is designed specifically as an environmental protection measure.

The USEPA has identified S/S with cement as a Best Demonstrated Available Technology for more than 50 major industrial waste types and contaminants. There are no confirmed commercial or residential properties with dug or drilled wells located within 1.5 km of the TSFA, based on the data available (NSDNR 2014). The closest residential wells are approximately 1.7 km north of the Envirosoil facility. The proposed monitoring will determine if there are any residual concerns, and adaptive management will be applied as necessary so that all applicable criteria are maintained.

The Envirosoil facility is lined and S/S operations will continue to be operated above the water table. Existing procedures established for waste acceptance under the existing Approval will apply to the receipt and acceptance of metals, EC and SAR materials.

The material Envirosoil is proposing to accept for treatment is not considered hazardous waste and/or dangerous goods, and if not treated, could remain in situ at industrial sites within Nova Scotia, or be disposed of at an approved appropriate landfill.

As noted above in this submission, the stringent acceptance and performance criteria, combined with a full lined cell system for deposited materials and the rigorous proposed monitoring system make it extremely unlikely there would be any discharges to the environment from the deposited treated material.

With the application of proposed mitigation, monitoring and adaptive management measures,, significant Project-related effects on groundwater resources are not predicted to occur.

5.3 SURFACE WATER RESOURCES

5.3.1 Description of Existing Conditions

Surface water resources, including surface water quality and quantity, are included as a VC because of the potential interactions with the Project. Surface water resources are also affected by changes in associated wetlands and hydrology.

Envirosoil Facility

The S/S process at the Envirosoil facility does not generate any wastewater that would require dedicated collection and/or treatment. All operational aspects of the S/S process will occur within the confines of the current Envirosoil facility and within the boundary of the existing clay liner system. The on-site settling pond has already been approved as part of the existing Approval. Due to the strict material acceptance standards and treatment performance criteria, Envirosoil does not believe there will be substantial input of contaminants into the settling pond from the Project. The proposed monitoring of the on-site settling pond extends the current monitoring to contaminants that will be treated via S/S. To date, there has been no issue operating the on-site settling pond within the bounds of the existing Approval.

Treated Soils Fill Area

The watercourse located to the north of the TSFA (Figure 3) is a tributary to Lake William. As a result of the rocky nature of the terrain, the majority of the length of watercourse that is located proximate to the site (*i.e.*, which runs through Wetland 1, which is displayed in Figure 4) runs below ground surface and would not be considered fish habitat. Channelized flow is occasionally visible amongst the large boulders; but the watercourse is largely subterranean until it enters the boundary of the NSDNR-identified swamp and a forms a pronounced surface channel through organic substrate (reference to aerial imagery indicates that surface channeling is also prevalent up gradient). This surface channel is located approximately 200 m from the edge of the TSFA and would be considered potential fish habitat. Additional subterranean drainages are present throughout the forests at the northern end of the TSFA and feed into the provincially mapped watercourse.

Several wetlands were identified in the vicinity of the TSFA (Figure 3). The largest wetland is located to the north of the site. In this area, a treed swamp (Wetland 1) is located in association with a provincially mapped watercourse. This wetland drains towards the north and feeds into a large swamp that has been identified through aerial imagery by NSDNR. The approximate location of its southern boundary was confirmed during the site visit. A small patch of remnant swamp (Wetland 2) is located on the eastern border of the TSFA. This wetland lacks a channelized outflow but drains towards the north via subterranean flow. A small basin swamp, Wetland 3, which lacks an inlet or outlet is also present on the eastern side of the site and is located within a linear depression caused by bedrock ridges. Field delineated wetlands were comprised of deciduous and mixedwood treed swamp. Red maple and black spruce formed the majority of the tree canopy within these wetlands, which typically had a well-developed tall shrub understory of mountain holly (*Nemopanthus mucronatus*), common winterberry (*Ilex verticillata*), speckled alder (*Alnus incana*) and regenerating tree species. Ground vegetation was limited at the time of visit but cinnamon fern (*Osmunda cinnamomea*), manna grass (*Glyceria sp.*), and peatmoss (*Sphagnum spp.*) provide important components to this layer.

5.3.2 Potential Effects and Proposed Mitigation

Envirosoil Facility

Potential effects on surface water resources will be reduced through site design and other mitigation. The S/S process at the Envirosoil facility does not generate any wastewater that would require dedicated collection and/or treatment. All operational aspects of the S/S process will occur within the confines of the current Envirosoil facility and within the boundary of the existing clay liner system.

Treatment of impacted materials will not be performed during periods of inclement weather involving the potential for significant rainfall. Any water collected within the storage cells/lagoons will be handled as per the requirements of the existing Approval. All of the requirements for surface water monitoring, reporting and criteria, and any further amendments, will continue to be adhered to.

As noted above and displayed in Figure 2 the existing Envirosoil facility is underlain by a 400 mm compacted clay liner, with a hydraulic conductivity of 10-7 cm/s. This low permeability layer prevents groundwater and surface water runoff from infiltrating into the groundwater below the liner. As described in the Approval No. 2002-026440-A03, the entire facility drains towards an evaporative pond located in the center of the facility above the liner. No fluid has been discharged from this pond in over a decade, and it is not anticipated to require active discharging.

If exceedances or an upwards trend in monitored parameters are observed, mitigation measures will be immediately implemented. Water will not be discharged from the evaporative collection pond if it exceeds criteria. Any water exceeding criteria will be removed and treated at an approved facility.

As the evaporative pond does not discharge to the collection ditch (ES2) or Lily Lake (ES3) with current operations, and has not discharged for well over a decade, it is not anticipated that there will be any exceedances at these points. If an exceedance is observed, Envirosoil will work with their technical team to delineate the source of the contamination, and implement mitigative measures such as the removal of water exceeding criteria, the isolation of any identified sources, and the containment and treatment of contaminated water.

Treated Soils Fill Area

Prior to the placement of S/S materials, the TSFA will be suitably prepared (*e.g.*, site grading, removing any large boulders). S/S material will be placed at the base of the lined cell so that materials are a minimum of 2 m above the water table. Solidified material will be placed in lined cells in 30 to 50 cm thick lifts and covered. The lined cells will be constructed within the mound of deposited clean fill material already in place at the TSFA location. Figure 5 displays the TSFA and the associated infrastructure for the placement of treated materials.

Project activities have potential to cause erosion and deposition of sediment to down-gradient surface water resources (including wetlands and watercourses), particularly during periods of heavy rainfall or snowmelt. Potential effects to surface water resources will be reduced through site design and other mitigation techniques, including:

- the construction of a drainage ditch along the toe of the TSFA, to provide a consistent monitoring location and controlled clean runoff discharge;
- grading of the TSFA surface so that surface water runoff is directed towards the south (*i.e.*, away from wetland and watercourse features located towards the north of the site);
- maintaining existing buffers of natural vegetation between disturbed areas and wetlands; and
- the construction of weirs along the toe of the drainage ditch to provide sampling locations and clear discharge points for runoff.

If an exceedance is observed, Envirosoil will work with their technical team to delineate the source of the contamination, and implement mitigative measures. Contingency measures will need to be dynamic to properly respond to an issue. In the unlikely event of contaminant impacts to groundwater, the following contingency measures may be used if required to ensure there is no contaminant migration off-site:

- surface water interception and management;
- physical removal of materials from the TSFA;
- ditching, swaling and ground contouring to collect surface water; and
- the use of silt fencing and other mitigative interceptions measures.

No wetland alterations are expected and surface water drainage will be directed away from wetlands. A 30 m setback will be established between site activities and wetlands.

5.3.3 Monitoring and Follow-up

It is proposed that the existing groundwater and surface water monitoring locations at the Envirosoil facility continue to be used for obtaining samples. The sampling frequency and analyte list proposed by SLR (2015) for the existing facility is appropriate for monitoring proposed operations (Appendix B). The monitoring program will be reviewed every two years. As per the current approval, there are three current surface water monitoring points within the main facility. These locations are monitored for general chemistry, metals, PAHs and TPH/BTEX. They are located as follows:

- ES1 – The evaporative collection pond
- ES2 – The ditch beside the collection pond
- ES3 – Lily Lake

The proposed groundwater monitoring program for the TSFA, described in Section 5.2 and Appendix B, will also detect changes in shallow groundwater potentially discharging to surface water flows. There will be four additional surface water sampling points established. The first additional monitoring point will be a down-gradient surface water sampling location, the location of which will be selected in conjunction with consultation with NSE. The remaining monitoring points will be located at the discharge weirs of the clean runoff drainage ditch at the toe of the TSFA. The approximate locations of these sample points are located in Figure 5; the final locations will be placed based upon detailed engineering and consultations with NSE.

If concentrations are observed to increase in relation to on-site activity, appropriate interception schemes or alternatives may be considered depending on the CCME guidelines for the receiving environment. The water quality of the effluent exiting any site will continue to meet parameters as stated in the facility's existing Approval and future amendments. This includes any surface water quality and quantity monitoring required by NSE.

5.3.4 Summary

S/S is a proven technology that is widely used for treating contaminated soil through a cement-based process, and is designed specifically as an environmental protection measure. Potential effects on surface water resources will be further reduced through site design and other mitigation techniques. The S/S process at the Envirosoil facility does not generate any wastewater that would require dedicated collection and/or treatment. All operational aspects of the S/S process will occur within the confines of the current Envirosoil facility and within the boundary of the existing clay liner system.

At the proposed TSFA, the nearest fish habitat is located approximately 200 m from the edge of the proposed infill area. No wetland alterations are expected and surface water drainage will be directed away from wetlands. A 30 m setback will be established between site activities and wetlands. At the TSFA, soils will be stripped systematically to a pre-determined depth below ground surface. S/S material will be placed at the base so that materials are a minimum of 1 m above the water table. Solidified material will be placed in lined cells in 30 to 50 cm thick lifts and covered and locations will be monitored.

Anderson Lake is located within a different watershed than the TSFA, and this fact, combined with the S/S treatment performance criteria and fully lined cell system for deposited materials, mean that there is little risk of effluent from treated materials entering Anderson Lake.

Based on the results of the surface water assessment, existing mitigation, and the mitigation, monitoring and adaptive management measures proposed, significant Project-related effects on surface water resources are not predicted to occur.

6.0 OTHER APPROVALS REQUIRED

As stated in Section 2.0, the Proponent is required to register this Project as a Class I Undertaking pursuant to the Nova Scotia *Environment Act* and Environmental Assessment Regulations.

Other relevant provincial regulations include the Activities Designation Regulations, which requires an amendment to the existing Industrial Approval (No.2002-026440-A03) from NSE for construction and operation of the Project.

Requirements under the *Canadian Environmental Assessment Act, 2012* (CEAA 2012) are not anticipated as this type of soil treatment operation is not listed as a designated project as per Section 2 of the *Regulations Designating Physical Activities* and does not occur on federal lands.

7.0 FUNDING

The proposed Project will be 100 percent privately funded.

8.0 ADDITIONAL INFORMATION

As part of Envirosoil's commitment to due diligence and undertaking the best possible project, Envirosoil commissioned an independent peer review from a recognized expert in the field of solidification and stabilization treatment of contaminated materials. Mr. Ed Bates was commissioned to undertake this independent peer review. Mr. Ed Bates is a highly qualified professional, who is one of the two authors of the recently released USEPA manual of practice for solidification and stabilization (Bates and Hills, 2015). The independent review is available within Appendix D of this submission.

9.0 SUMMARY

S/S is a proven and widely used method for treatment of impacted soils and is designed specifically as an environmental protection measure. All operational aspects of the S/S process, as well as operational aspects of the receipt, handling, storage and treatment of impacted materials will occur within the confines of the current Envirosoil facility and within the boundary of the existing clay liner system. The proposed TSFA is located approximately 2 km southeast of the Envirosoil treatment facility, within the Municipal Quarry property boundaries. Access to the existing the Envirosoil processing facility and proposed TSFA is along existing roads. Solidified material at the TSFA will be placed in lined cells in 30 to 50 cm thick lifts and covered. No wetland alterations are expected and surface water drainage will be directed away from wetlands. A 30 m setback will be established between site activities and wetlands.

The material Envirosoil is proposing to accept for treatment is not considered hazardous waste and/or dangerous goods.

Activities associated with the proposed Project, including requirements for groundwater and surface monitoring, reporting and criteria, will be conducted in accordance with terms and conditions of the existing Approval pursuant to Division V of the Activities Designation Regulations, as well as future amendments to the Industrial Approval.

With the application of the mitigation measures, monitoring and adaptive management (if required) specified in this EA, and the continued operation of the facility according to existing and any future provincial guidelines and approvals, significant Project-related effects are not likely to occur.

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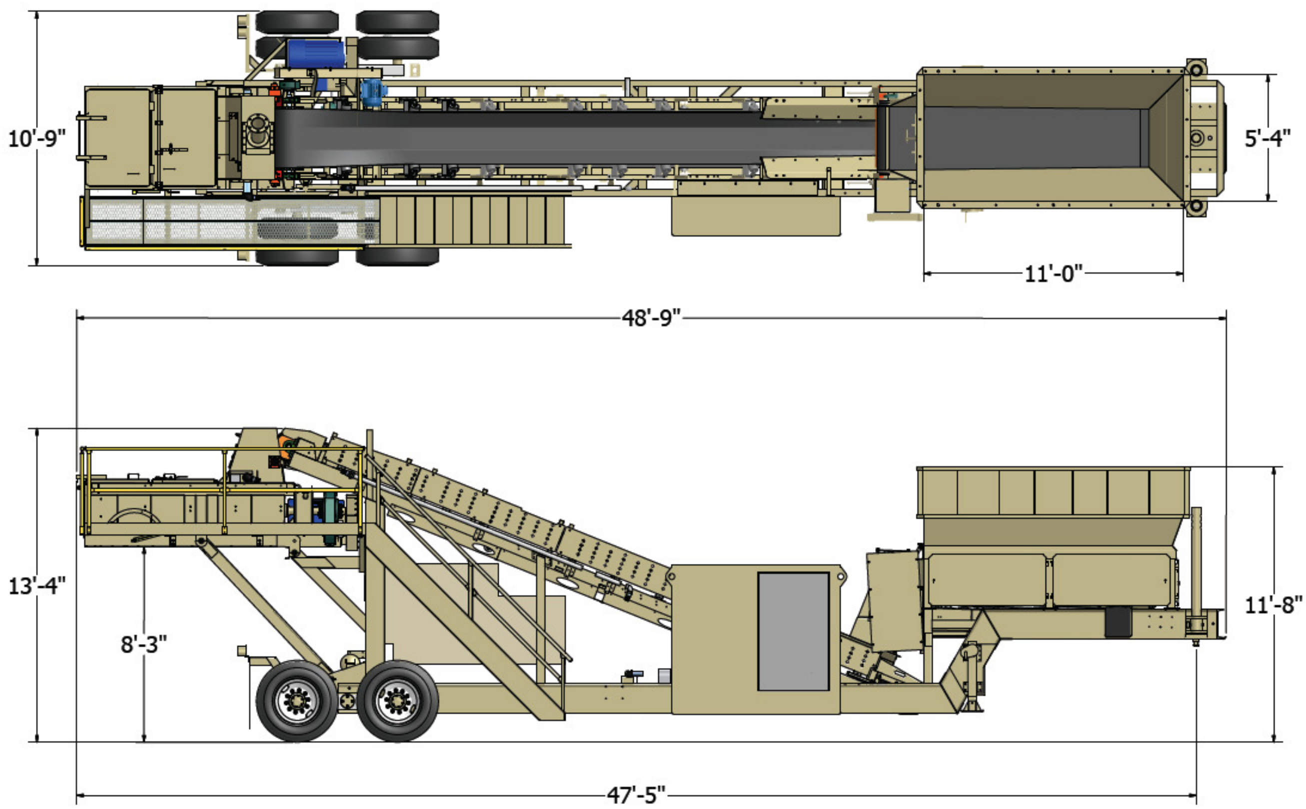
Appendix A
S/S Equipment Design & Specifications



Primary Hopper Belt Feeder:

The primary hopper has a nine cubic yard capacity with an 11' x 5'-4" top opening. The sides of the hopper have a 70 degree slope and are constructed of 3/16" thick A-36 steel.

The primary belt feeder is positioned underneath the primary feed hopper. The belt feeder is powered with a 5 hp variable speed electric drive. The feeder has a belt-width of 36" and is 11'-6" long.

Feed Conveyor:

The feed conveyor transfers material from the feed hoppers to the pugmill mixing box. It has a heavy duty channel-type frame, and is powered with a 7.5 hp electric head end drive. The conveyor is 27'-6" long and has a belt width of 30".

Pugmill:

The twin shaft pugmill consists of an enclosed 4' x 6' mixing box with AR steel liners. Enclosed in the mixing box are two heavy-duty 6" XH counter rotating shafts. These shafts push 40 double tip paddles in an overlapping spiral arrangement. The paddles are 4 ¾" x 5 ¼" x 1" Ni-hard tips set at a 45 degree pitch. Paddle tips have an adjustable wall clearance range of ¾" to 2".

Power is transferred to the rotating shafts from a 60 hp electric motor through a v-belt/gear reducer drive. The reducer drives a single shaft which in turn powers the other shaft. The shafts are coupled with 3" timing gears that rotate in an oil bath.

The mixing box has an adjustable dam gate, a receiving hood, a spray bar, inspection doors, and a drop out bottom for easy clean out.

NOTE: Specifications are subject to change without notice.

Chassis:

The pugmill plant's portable chassis consists of a heavy duty channel-style frame with a gooseneck and kingpin located at the feed end of the plant. The chassis utilizes a walking beam-type tandem axle with dual 11.0 x 22.5 tires (8 total) located at the discharge end. The kingpin area of the chassis is supported with hand crank landing gear during storage and two pin lock tube style support legs during operation.

Secondary Hopper:

The optional secondary hopper has a six cubic yard capacity with an 10' x 5' top opening. The sides of the hopper have a 60 degree slope and are constructed of 3/16" thick A-36 steel.

The secondary belt feeder is positioned underneath the secondary feed hopper. The belt feeder is powered with a 5 hp variable speed electric drive. The feeder has a belt-width of 30" and is 8' long.

Water System:

The pugmill plant's optional water system includes a 150 gpm pump (powered by a 3 HP motor), a flowmeter, and a valve. The system can be configured per customer request to be adjusted manually or to be automatically proportioned.

Asphalt System:

The optional asphalt system includes a 100 gpm pump (powered by a 10 hp motor), a flowmeter, and a valve. The system can be configured per customer request to be adjusted manually or to be automatically proportioned.

Walkway:

The 24" wide walkway gives the operator access to the pugmill mixing chamber. It consists of an operator's platform and a stairway (with handrail) to provide access to the platform from the ground.

Automatic Proportioning:

Automatic Proportioning is an optional feature that utilizes feedback from a belt scale to automatically adjust the amount of additives (e.g. water, asphalt, fly ash) that will be combined with varying amounts of material being fed to the pugmill mixing box.

Controls:

Controls for the pugmill plant are located on a ground accessible panel mounted to the side of the plant. Operators have start/stop capability for the plant as well as the ability to vary both the speed of the belt feeder and the rate at which any additives will be blended into the feed material.

Physical / Operating Characteristics:

Overall Length .... 48'-9"
Travel Length; kingpin to tail: .... 47'-5"
Travel Height .... 13'-4"
Travel Width .... 10'-9"
Feed Height .... 11'-8"
Discharge Height .... 8'-3"
Travel Weight (kingpin) .... 10,400 lbs
Travel Weight (axle) .... 26,400 lbs

Mixing Capacities (100 pcf material):

Dry Material Throughput .... 300 TPH
Water System (Optional) .... 150 GPM
Asphalt System (Optional) .... 100 GPM

Options:

Secondary Feed Hopper (6 yd^3)
Belt Scale
Dry Solids Flowmeter
Diesel Genset (95 KW)
Hydraulic Dribble Gate with Power Pack
Manual Water System
Automatic Water System
Manual Asphalt System
Automatic Asphalt System
Discharge Hood

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NOTE: Specifications are subject to change without notice.

Because KPI-JCI may use in its catalog & literature, field photographs of its products which may have been modified by the owners, products furnished by KPI-JCI may not necessarily be as illustrated therein. Also continuous design progress makes it necessary that specifications be subject to change without notice. All sales of the products of KPI-JCI are subject to the provisions of its standard warranty. KPI-JCI does not warrant or represent that its product meet and federal, state, or local statures, codes, ordinances, rules, standards or other regulations, including OSHA and MSHA, covering safety, pollution, electrical wiring, etc. Compliance with these statutes and regulations is the responsibility of the user and will be dependent upon the areas and the use to which the product is put by the user. In some photographs, guards may have been removed for illustrative purposes only. This equipment should not be operated without all guards attached in their normal position. Placement of guards and other safety equipment is often dependent upon the area and the use to which the product is put. A safety study should be made by the user of the application, and, if required additional guards, warning signs and other safety devices should be installed by the user, wherever appropriate before operating the products.

Appendix B
2015 Revised Site Monitoring Program (SLR 2015)

March 27th, 2015

Jerry Scott
Envirosoil Limited
P.O. Box 48100
927 Rocky Lake Drive
Bedford, NS
B4A 3Z2

CONFIDENTIAL

SLR Project No.: 210.05726.00015

RE: 2015 REVISED SITE MONITORING PROGRAM, ENVIROSOIL RECYCLING FACILITY, 48 QUARRYSTONE DRIVE, BEDFORD, NS

Dear Mr. Scott,

SLR Consulting (Canada) Ltd. (SLR) is providing the following letter in accordance with Nova Scotia Environment's (NSE) requirement for a revised site monitoring program to address Envirosoil Limited's (Envirosoil) Request for Amendments Related to Approval No. 2002-026440-R01, dated December 5, 2014. Features of the site, including monitor wells, surface water sampling locations, groundwater elevations and flow plan, are shown in **Drawing 1**.

Current Monitoring Program

SLR collects groundwater and surface water samples at a monthly frequency for various parameters in accordance with NSE approval 2002-026440-R01 for the Construction, Operation and Reclamation of a Soil Recycling Facility including preparation of quarterly monitoring reports and one annual report. The current monitoring program schedule is outlined in **Table 1**, attached, including specified parameters at each sample location.

Proposed Site Monitoring Program

NSE is requesting a revised monitoring program encompassing aspects associated with the proposed stages of a soil Solidification/Stabilization (S/S) process and the handling of salt impacted soils, including disposal on site.

Pending approval, the proposed changes would take effect for the next regularly scheduled monitoring event. Quarter 1 (January, February and March 2015) monitoring events have been completed in accordance with the current Approval (No. 2002-026440-R01). The current and proposed monitoring plans are outlined in **Table 1** & **2**. The proposed changes are highlighted and the rationale for each change is provided in reference to the proposed amendments. Detailed information for each proposed amendment at the Envirosoil facility is found in **Appendix A**.

Amendment #1 – Solidification/Stabilization (S/S)

Envirosoil is requesting that the current approval be expanded to allow for the installation and operation of a cement-based Stabilization/Solidification process to treat soils impacted with low level organics and inorganic metals. The proposed monitoring program includes additional PAH, phenols and metals sampling based on Amendment #1 (**Appendix A**):

1.) ES1 (Holding Pond, Surface Water) and ES2 (Lily Lake, Surface Water)

Each surface water sampling location will continue to be monitored monthly; however, more parameters will be added for each sample. A full suite of general chemistry and total metals parameters will be collected from each location including electrical conductivity, chloride, a metals scan among other parameters. Additional analysis of phenols and PAH's have been added to ES1 due to its proximity to the proposed S/S equipment location at the Envirosoil site.

Note that phenols and PAH are currently collected from ES2 (Lily Lake) at a monthly frequency as outlined with the current approval and will remain the same in the proposed site monitoring program.

2.) Groundwater (Monitor Wells: MW1, MW2, MW3, MW4A, MW5, MW5A, MW6R, MW7R, MW8R, MW9)

Currently, all wells are monitored bi-monthly for benzene, toluene, ethylbenzene, xylenes and Total Petroleum Hydrocarbons (BTEX/TPH) and quarterly for polycyclic aromatic hydrocarbons (PAH). Under the proposed changes, all wells will be monitored quarterly for BTEX/TPH and polycyclic aromatic hydrocarbons PAH aligning sampling event frequency with those for other approvals (see Item 3, below) and monitoring potential groundwater impacts from materials with low level organics.

3.) Additional Groundwater Analysis (Monitor Wells: MW1, MW2, MW8R, MW9)

In addition to the above mentioned analysis for all monitor wells, quarterly monitoring also occurs at wells MW1, MW2 and MW9 for select dissolved metals, pH, phenols, conductivity, sulfate and total suspended solids (TSS). This program was part of the compliance monitoring required by the expired approval for sulphite-bearing materials. Due to their proximity to the proposed S/S and PERC storage areas, it is proposed that monitor wells MW1, MW2, MW9 and an additional well, MW8R, will be monitored for Volatile Organic Compounds (VOCs) to assess water quality from the acceptance of materials containing low level organics for the proposed S/S process.

Amendment #5 – Treatment of Salt Impacted Materials

Under the current approval, Envirosoil cannot accept salt-impacted materials. Envirosoil is proposing to treat EC/SAR materials in accordance with the established procedure, mix-bury-cover (MBC) method (**Appendix A**). Changes to water quality monitoring based on proposed site activities include the following:

1.) Additional Groundwater Analysis (Monitor Wells: MW1, MW2, MW8R, MW9)

In addition to BTEX/TPH and PAH analysis, monitor wells MW1, MW2 and MW9 are currently monitored quarterly for select dissolved metals, pH, phenols, conductivity, sulfate and total suspended solids (TSS).

Due to the proximity to the proposed EC/SAR storage cell and site features, select monitor wells (MW1, MW2, MW9 and an additional well, MW8R) will be sampled for additional parameters, collected at a quarterly frequency to align with the program described in Items 2 and 3, above. A full suite of general chemistry and dissolved metals parameters will be collected from each location, including electrical conductivity and chlorides among other parameters, to assess potential impacts from salt impacted materials.

Closing

Site monitoring in accordance to NSE approval 2002-026440-R01 for the Construction, Operation and Reclamation of a Soil Recycling Facility is ongoing at the Envirosoil facility until further notice from NSE. Modifications to the site monitoring plan discussed in this letter report reflect Envirosoils proposed impacted material disposal methodologies.

Please contact the undersigned should you have any questions or comments.

Yours sincerely,
SLR Consulting (Canada) Limited

Ashley Gould, B.Sc., CET, EP
Project Scientist

Craig Chandler, MSc, PEng, LEED AP
Senior Project Manager

Enc.

Drawing 1 – Site Plan and Groundwater Flow Plan

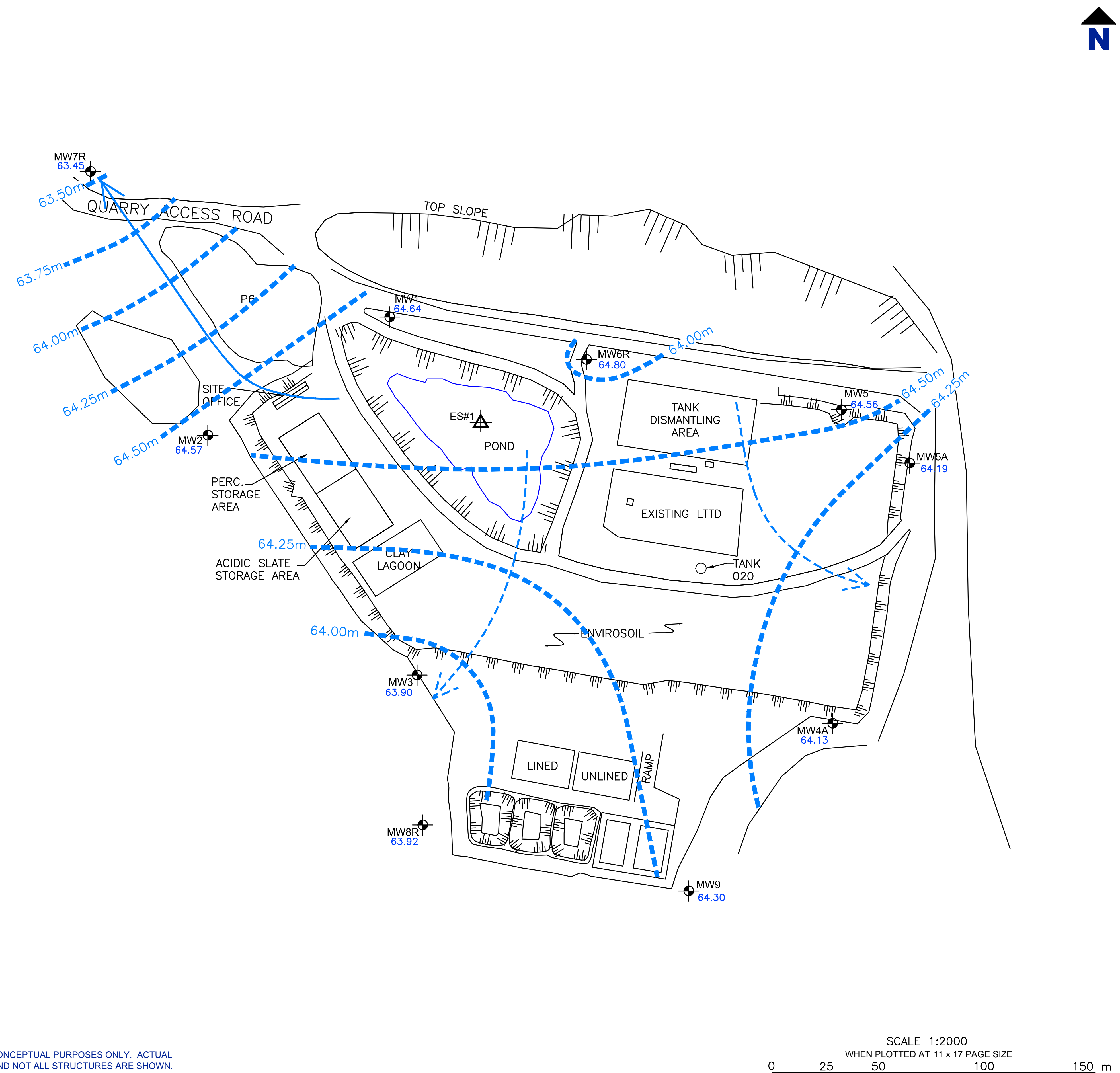
Table 1 – 2015 Current Site Monitoring and Sampling Program
Table 2 – Proposed 2015 Monitoring Program

Appendix A – Request for Amendments Related to Approval No. 2002-02640-R01

cc: Robert Cuthburt, NSE

DRAWING

2015 Revised Monitoring Program
48 Quarrystone Drive, Bedford, NS
SLR Project No.: 210.05726.00015



THIS DRAWING IS FOR CONCEPTUAL PURPOSES ONLY. ACTUAL LOCATIONS MAY VARY AND NOT ALL STRUCTURES ARE SHOWN.

NOTES

DRAWING COMPILED FROM ENVIROSOIL LIMITED.

ALL GROUNDWATER ELEVATIONS RELATIVE TO AN ARBITRARY DATUM OF 100.00m

INFERRED GROUNDWATER CONTOURS AND FLOW DIRECTIONS SHOWN AS BASED ON THE ASSUMPTION OF SIMILAR STRATIGRAPHY AND WELL COMPLETION DETAILS ACROSS THE AREA OF INVESTIGATION. NO BOREHOLE LOGS AVAILABLE AT THE TIME OF THIS REPORT PREPARATION

LINED CONTAINMENT POND ASSUMED TO NOT BE HYDRAULICALLY CONNECTED TO GROUNDWATER

LEGEND

- SLOPE
- BOREHOLE LOCATION COMPLETED AS A MONITORING WELL (OTHERS)
- SURFACE WATER SAMPLE LOCATION (OTHERS)
- 65.08 — GROUNDWATER ELEVATION (m)
- 64.50m — INFERRED GROUNDWATER ELEVATION CONTOUR (INTERVAL 0.25m)
- REGIONAL GROUNDWATER FLOW DIRECTION
- POTENTIAL SITE GROUNDWATER FLOW DIRECTION (INFLUENCED BY WEIGHT LOAD OF ADJACENT GRAVEL PILES)
- NOT MONITORED OR DATA NOT INCLUDED IN CONTOUR DUE TO REASONS PROVIDED BELOW

MUNICIPAL CONTRACTING LTD.
ENVIROSOIL
48 QUARRYSTONE DRIVE
BEDFORD, NS

Report: 2014 ANNUAL MONITORING REPORT

Drawing: INFERRED GROUNDWATER CONTOUR PLAN - OCTOBER 9, 2014

Date December 17, 2014	Scale AS SHOWN	Drawing No. 1
File Name S_210-05726-00013-E1	Project No. 210.05726.00013	

SLR

TABLES

2015 Revised Monitoring Program
48 Quarrystone Drive, Bedford, NS
SLR Project No.: 210.05726.00015

Table 1
2015 Current Site Monitoring and Sampling Program, Envirosoil Recycling
48 Quarrystone Drive, Bedford

Month	Sample Location			
	ES1	ES2	MW1-MW9	MW1, MW2, MW9[1]
January	Metals, pH, TSS, Sulfate, conductivity, BTEX/TPH	Metals, pH, TSS, sulfate, conductivity, BTEX/TPH, PAH, phenols	N/A	N/A
February	Metals, pH, TSS, Sulfate, conductivity, BTEX/TPH	Metals, pH, TSS, sulfate, conductivity, BTEX/TPH, PAH, phenols	BTEX/TPH[2], PAH	Metals, pH, phenols cond, sulfate,TSS
March	Metals, pH, TSS, Sulfate, conductivity, BTEX/TPH	Metals, pH, TSS, sulfate, conductivity, BTEX/TPH, PAH, phenols	N/A	N/A
April	Metals, pH, TSS, Sulfate, conductivity, BTEX/TPH	Metals, pH, TSS, sulfate, conductivity, BTEX/TPH, PAH, phenols	BTEX/TPH	N/A
May	Metals, pH, TSS, Sulfate, conductivity, BTEX/TPH	Metals, pH, TSS, sulfate, conductivity, BTEX/TPH, PAH, phenols	PAH	Metals, pH, phenols cond, sulfate,TSS
June	Metals, pH, TSS, Sulfate, conductivity, BTEX/TPH	Metals, pH, TSS, sulfate, conductivity, BTEX/TPH, PAH, phenols	BTEX/TPH	N/A
July	Metals, pH, TSS, Sulfate, conductivity, BTEX/TPH	Metals, pH, TSS, sulfate, conductivity, BTEX/TPH, PAH, phenols	N/A	N/A
August	Metals, pH, TSS, Sulfate, conductivity, BTEX/TPH	Metals, pH, TSS, sulfate, conductivity, BTEX/TPH, PAH, phenols	BTEX/TPH, PAH	Metals, pH, phenols cond, sulfate,TSS
September	Metals, pH, TSS, Sulfate, conductivity, BTEX/TPH	Metals, pH, TSS, sulfate, conductivity, BTEX/TPH, PAH, phenols	N/A	N/A
October	Metals, pH, TSS, Sulfate, conductivity, BTEX/TPH	Metals, pH, TSS, sulfate, conductivity, BTEX/TPH, PAH, phenols	BTEX/TPH	N/A
November	Metals, pH, TSS, Sulfate, conductivity, BTEX/TPH	Metals, pH, TSS, sulfate, conductivity, BTEX/TPH, PAH, phenols	PAH	Metals, pH, phenols cond, sulfate,TSS
December	Metals, pH, TSS, Sulfate, conductivity, BTEX/TPH	Metals, pH, TSS, sulfate, conductivity, BTEX/TPH, PAH, phenols	BTEX/TPH	N/A

Notes:

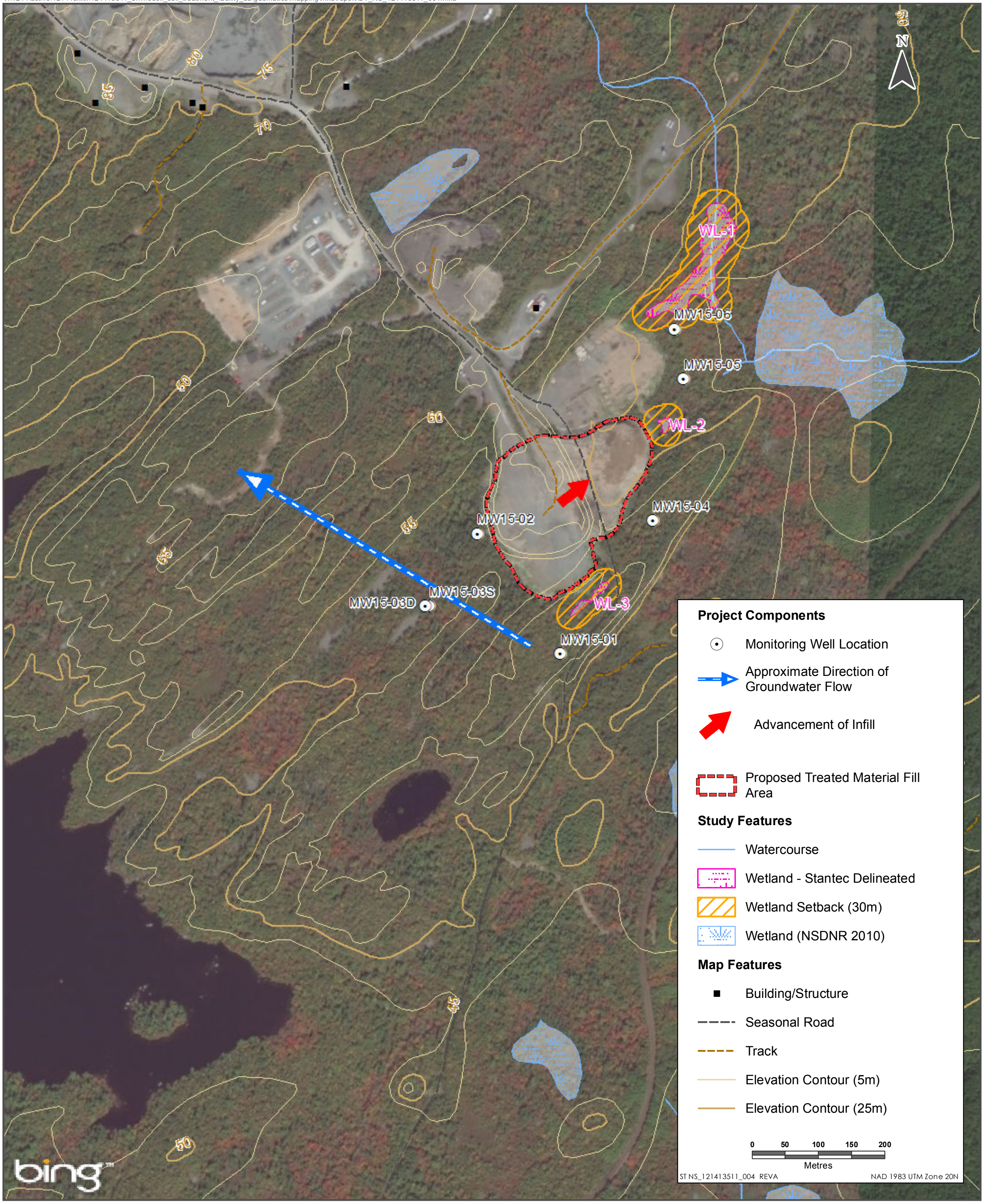
N/A - Not Applicable, laboratory analysis for applicable not required as outlined in NSE approval

Table 2
Proposed 2015 Monitoring Program, Envirosoil Recycling Facility
48 Quarrystone Drive, Bedford

Month	Sample Location				Proposed Changes & Rationale		
	ES1[2]	ES2[2]	MW1-MW9	MW1, MW2, MW8R, MW9[1]			
January	RcapMS (general chem + metals), BTEX/TPH, TSS, Phenols[7], PAH[5]	RcapMS (general chem + metals), TSS, BTEX/TPH, PAH, Phenols	N/A	N/A	**Amendment #1, 2, & 5** (S/S, Metals & Salt Impacted Materials) RcapMS (metals, conductivity, chloride + other parameters) and Phenols (ES1)	**Amendment #1 (S/S) -** PAH (ES1)	
February	RcapMS (general chem + metals), BTEX/TPH, TSS, Phenols[7], PAH[5]	RcapMS (general chem + metals), TSS, BTEX/TPH, PAH, Phenols	BTEX/TPH[3] & PAH[4]	RcapMS (gen chem + metals, VOCs[6], Phenols, TSS	**Amendment #1, 2, & 5** (S/S, Metals & Salt Impacted Materials) RcapMS (metals, conductivity, chloride + other parameters) and Phenols (ES1)	**Amendment #1,4 & 6** (S/S,SBM & PERC) Impacted Materials. Additional analysis at MW1, MW2, MW8R, MW9 for RCapMS, VOC's	**Amendment #1 (S/S) -** PAH & BTEX/TPH (all sample locations, quarterly frequency)
March	RcapMS (general chem + metals), BTEX/TPH, TSS, Phenols[7], PAH[5]	RcapMS (general chem + metals), TSS, BTEX/TPH, PAH, Phenols	N/A	N/A	**Amendment #1, 2, & 5** (S/S, Metals & Salt Impacted Materials) RcapMS (metals, conductivity, chloride + other parameters) and Phenols (ES1)	**Amendment #1 (S/S) -** PAH (ES1)	
April	RcapMS (general chem + metals), BTEX/TPH, TSS, Phenols[7], PAH[5]	RcapMS (general chem + metals), TSS, BTEX/TPH, PAH, Phenols	N/A	N/A	**Amendment #1, 2, & 5** (S/S, Metals & Salt Impacted Materials) RcapMS (metals, conductivity, chloride + other parameters) and Phenols (ES1)	**Amendment #1 (S/S) -** PAH (ES1)	
May	RcapMS (general chem + metals), BTEX/TPH, TSS, Phenols[7], PAH[5]	RcapMS (general chem + metals), TSS, BTEX/TPH, PAH, Phenols	BTEX/TPH[3] & PAH[4]	RcapMS (gen chem + metals, VOCs[6], Phenols, TSS	**Amendment #1, 2, & 5** (S/S, Metals & Salt Impacted Materials) RcapMS (metals, conductivity, chloride + other parameters) and Phenols (ES1)	**Amendment #1,4 & 6** (S/S,SBM & PERC) Impacted Materials. Additional analysis at MW1, MW2, MW8R, MW9 for RCapMS, VOC's	**Amendment #1 (S/S) -** PAH & BTEX/TPH (all sample locations, quarterly frequency)
June	RcapMS (general chem + metals), BTEX/TPH, TSS, Phenols[7], PAH[5]	RcapMS (general chem + metals), TSS, BTEX/TPH, PAH, Phenols	N/A	N/A	**Amendment #1, 2, & 5** (S/S, Metals & Salt Impacted Materials) RcapMS (metals, conductivity, chloride + other parameters) and Phenols (ES1)	**Amendment #1 (S/S) -** PAH (ES1)	
July	RcapMS (general chem + metals), BTEX/TPH, TSS, Phenols[7], PAH[5]	RcapMS (general chem + metals), TSS, BTEX/TPH, PAH, Phenols	N/A	N/A	**Amendment #1, 2, & 5** (S/S, Metals & Salt Impacted Materials) RcapMS (metals, conductivity, chloride + other parameters) and Phenols (ES1)	**Amendment #1 (S/S) -** PAH (ES1)	
August	RcapMS (general chem + metals), BTEX/TPH, TSS, Phenols[7], PAH[5]	RcapMS (general chem + metals), TSS, BTEX/TPH, PAH, Phenols	BTEX/TPH[3] & PAH[4]	RcapMS (gen chem + metals, VOCs[6], Phenols, TSS	**Amendment #1, 2, & 5** (S/S, Metals & Salt Impacted Materials) RcapMS (metals, conductivity, chloride + other parameters) and Phenols (ES1)	**Amendment #1,4 & 6** (S/S,SBM & PERC) Impacted Materials. Additional analysis at MW1, MW2, MW8R, MW9 for RCapMS, VOC's	**Amendment #1 (S/S) -** PAH & BTEX/TPH (all sample locations, quarterly frequency)
September	RcapMS (general chem + metals), BTEX/TPH, TSS, Phenols[7], PAH[5]	RcapMS (general chem + metals), TSS, BTEX/TPH, PAH, Phenols	N/A	N/A	**Amendment #1, 2, & 5** (S/S, Metals & Salt Impacted Materials) RcapMS (metals, conductivity, chloride + other parameters) and Phenols (ES1)	**Amendment #1 (S/S) -** PAH (ES1)	
October	RcapMS (general chem + metals), BTEX/TPH, TSS, Phenols[7], PAH[5]	RcapMS (general chem + metals), TSS, BTEX/TPH, PAH, Phenols	N/A	N/A	**Amendment #1, 2, & 5** (S/S, Metals & Salt Impacted Materials) RcapMS (metals, conductivity, chloride + other parameters) and Phenols (ES1)	**Amendment #1 (S/S) -** PAH (ES1)	
November	RcapMS (general chem + metals), BTEX/TPH, TSS, Phenols[7], PAH[5]	RcapMS (general chem + metals), TSS, BTEX/TPH, PAH, Phenols	BTEX/TPH[3] & PAH[4]	RcapMS (gen chem + metals, VOCs[6], Phenols, TSS	**Amendment #1, 2, & 5** (S/S, Metals & Salt Impacted Materials) RcapMS (metals, conductivity, chloride + other parameters) and Phenols (ES1)	**Amendment #1,4 & 6** (S/S,SBM & PERC) Impacted Materials. Additional analysis at MW1, MW2, MW8R, MW9 for RCapMS, VOC's	**Amendment #1 (S/S) -** PAH & BTEX/TPH (all sample locations, quarterly frequency)
December	RcapMS (general chem + metals), BTEX/TPH, TSS, Phenols[7], PAH[5]	RcapMS (general chem + metals), TSS, BTEX/TPH, PAH, Phenols	N/A	N/A	**Amendment #1, 2, & 5** (S/S, Metals & Salt Impacted Materials) RcapMS (metals, conductivity, chloride + other parameters) and Phenols (ES1)	**Amendment #1 (S/S) -** PAH (ES1)	

Notes:
1 -Additional analysis for monitor wells MW1, MW2, MW8R, MW9
2 - Surface water sampling locations ES1 and ES2 proposed sampling for RcapMS as it includes parameters previously monitored plus chloride.
3 - BTEX/TPH monitoring frequency changed from bi-monthly to quarterly to coincide with PAH sampling.
4 - PAH currently monitored quarterly from all wells, unchanged from current monitoring plan.
5 - PAH sample collection proposed from ES1 (holding pond) at a monthly frequency
6 - VOC's and Rcap (general chemistry and dissovled metals) proposed for a quarterly sampling frequency from the following: MW1, MW2, MW8R, MW9
7 - Phenols samples proposed at ES1, monthly
Quarter 1 2015 (January, February & March) completed as shown in Table 1, former monitoring schedule.
S/S - Solidification/Stabilization
SBM - Sulfide Bearing Materials
PERC - Percholoroethylene

Appendix C
Groundwater Flow Diagrams



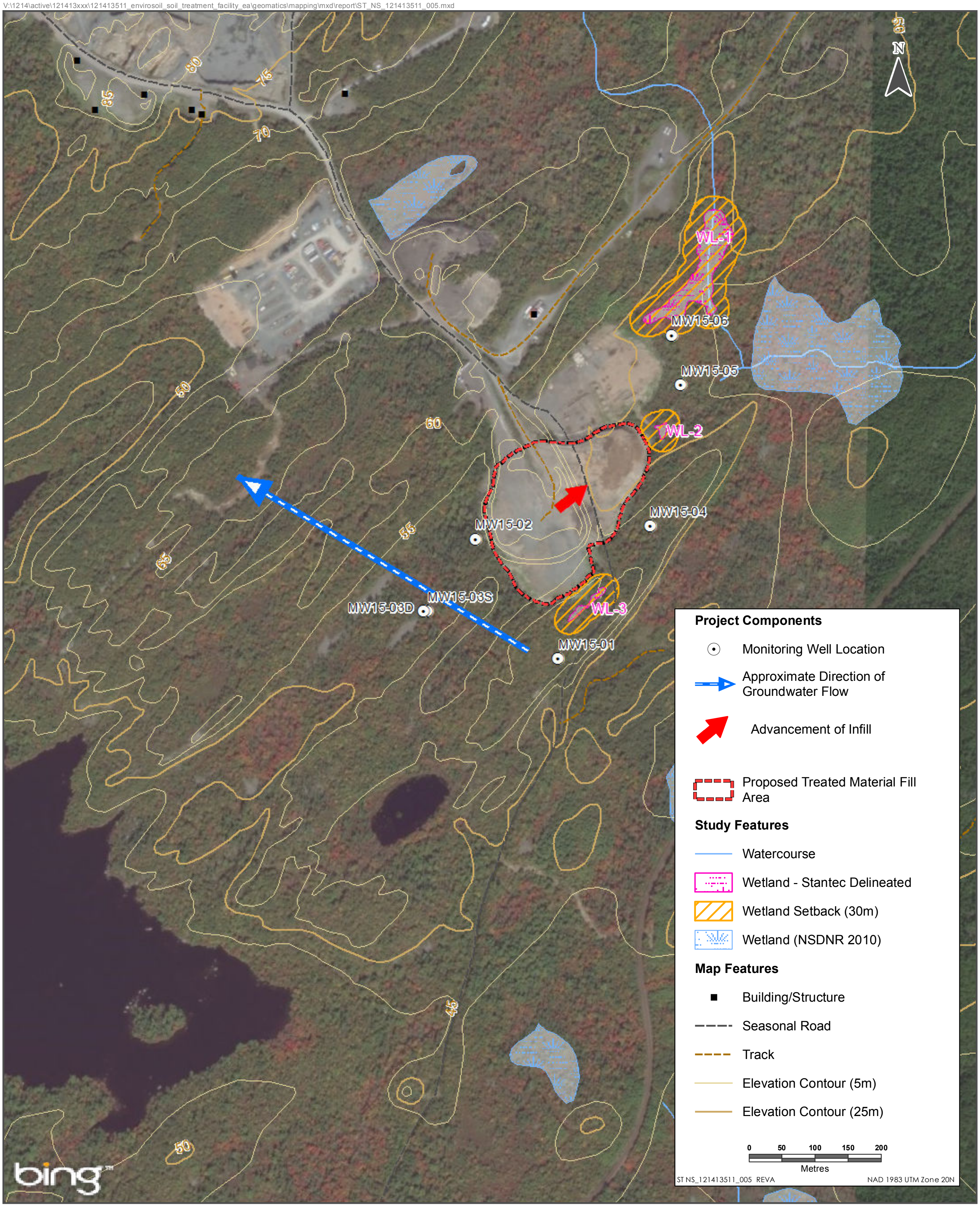
Sources: Base Data - Nova Scotia Geomatics Centre (NSGC), Nova Scotia Topographic Database (NSTDB).
Wetlands - Nova Scotia Dept. of Natural Resources (NSDNR), Wetland Mapping Inventory
Imagery: Bing: Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation

Disclaimer: This map is for illustrative purposes to support this Stantec project; questions can be directed to the issuing agency.

Approximate Direction of Groundwater Flow

October 2015

envirosoil ISO 14001 • ISO 9001



Sources: Base Data - Nova Scotia Geomatics Centre (NSGC), Nova Scotia Topographic Database (NSTDB).
Wetlands - Nova Scotia Dept. of Natural Resources (NSDNR), Wetland Mapping Inventory
Imagery: Bing: Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation

Disclaimer: This map is for illustrative purposes to support this Stantec project; questions can be directed to the issuing agency.

Approximate Direction of Groundwater Flow

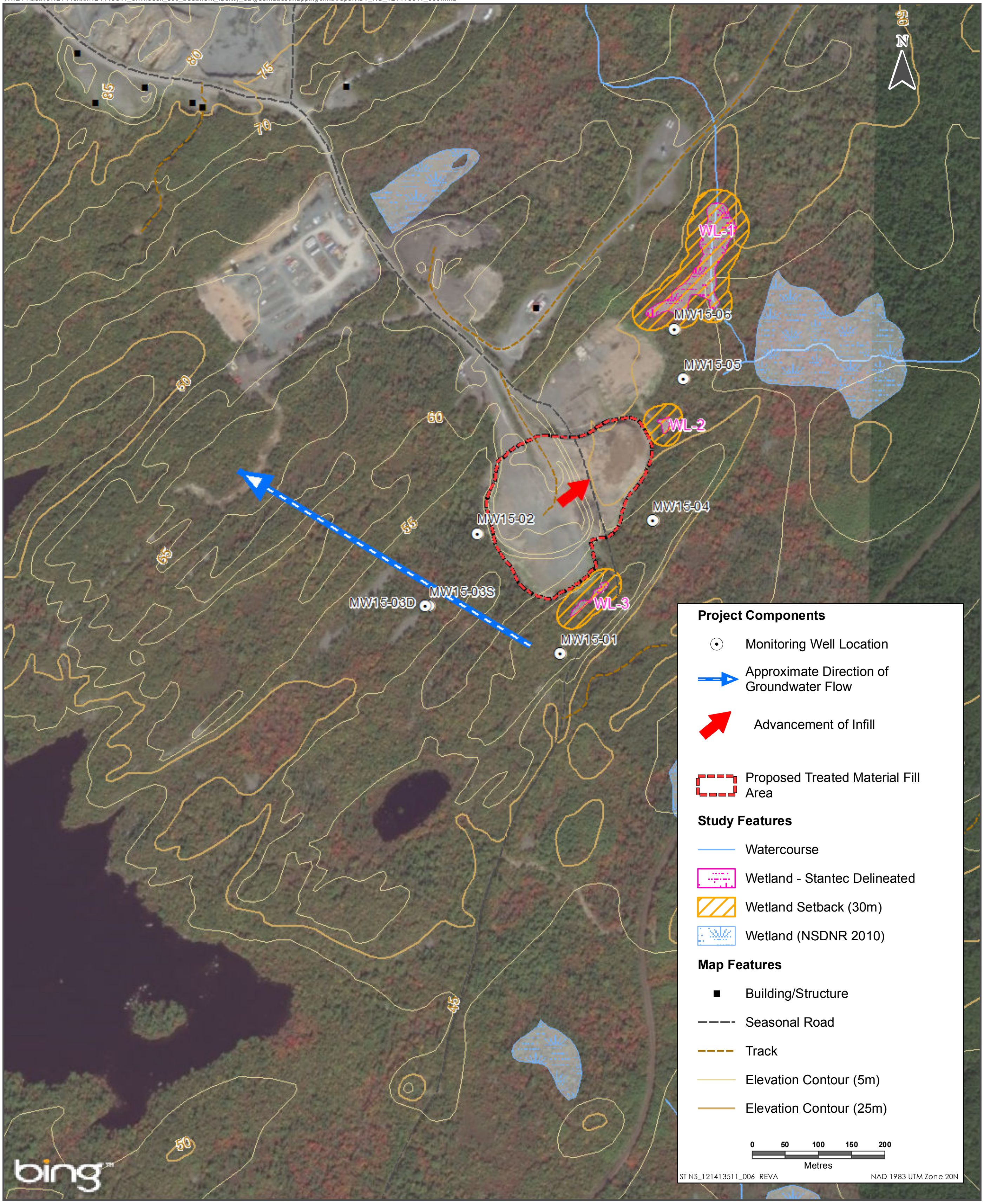
November 2015

envirosoil
ISO 14001 • ISO 9001

Environmental Assessment Registration for the Envirosoil Facility: Addition of Stabilization/Solidification Technology and Treatment of Salt Impacted Materials

Figure E2

V:\1214\active\121413xxx\121413511_envirosoil_soil_treatment_facility_ea\geomatics\mapping\mxd\report\ST_NS_121413511_006.mxd



Sources: Base Data - Nova Scotia Geomatics Centre (NSGC), Nova Scotia Topographic Database (NSTDB). Wetlands - Nova Scotia Dept. of Natural Resources (NSDNR), Wetland Mapping Inventory. Imagery: Bing: Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation

Disclaimer: This map is for illustrative purposes to support this Stantec project; questions can be directed to the issuing agency.

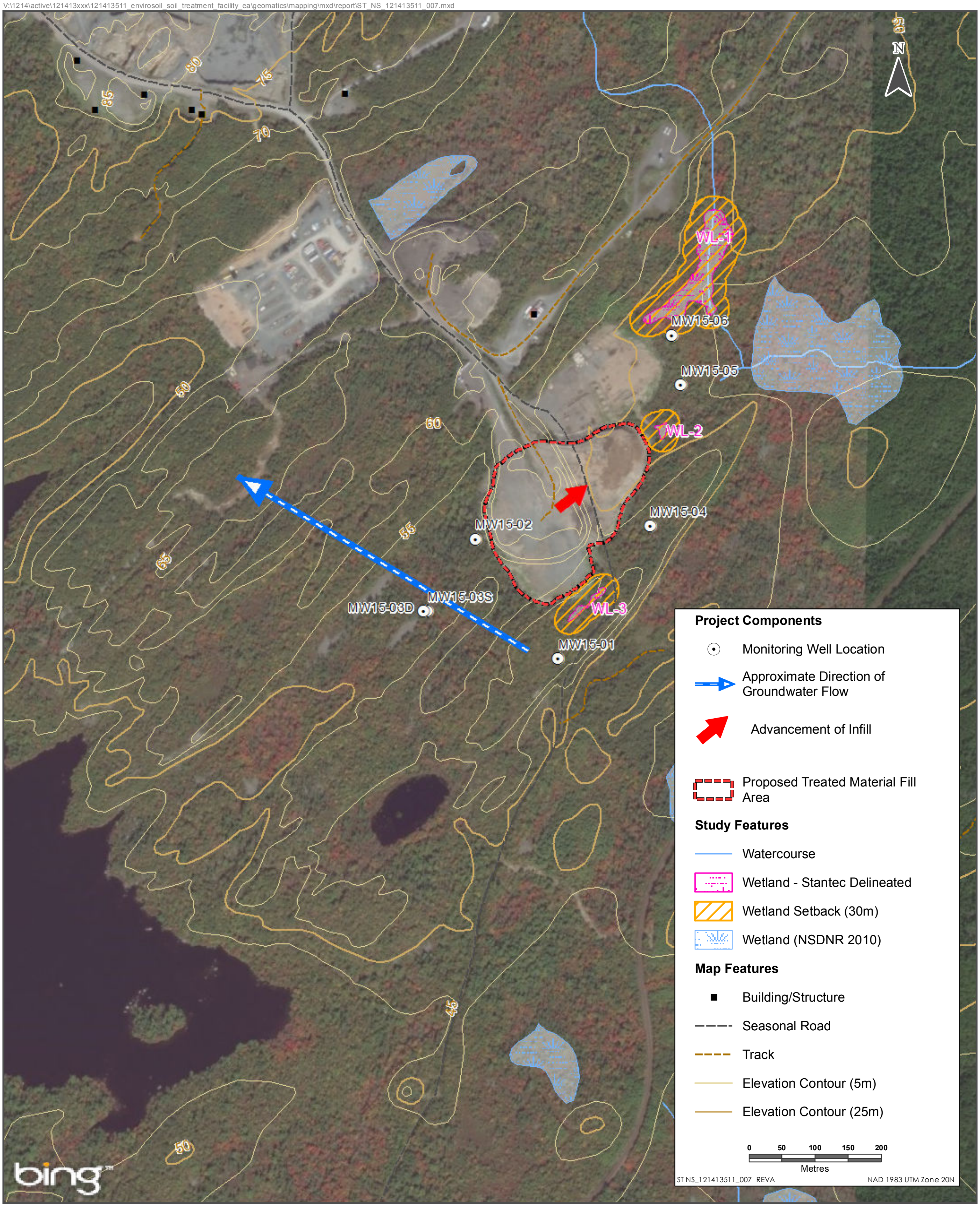
Approximate Direction of Groundwater Flow

December 2015

envirosoil ISO 14001 • ISO 9001

Environmental Assessment Registration for the Envirosoil Facility: Addition of Stabilization/Solidification Technology and Treatment of Salt Impacted Materials

Figure E3



Sources: Base Data - Nova Scotia Geomatics Centre (NSGC), Nova Scotia Topographic Database (NSTDB).
Wetlands - Nova Scotia Dept. of Natural Resources (NSDNR), Wetland Mapping Inventory
Imagery: Bing: Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation

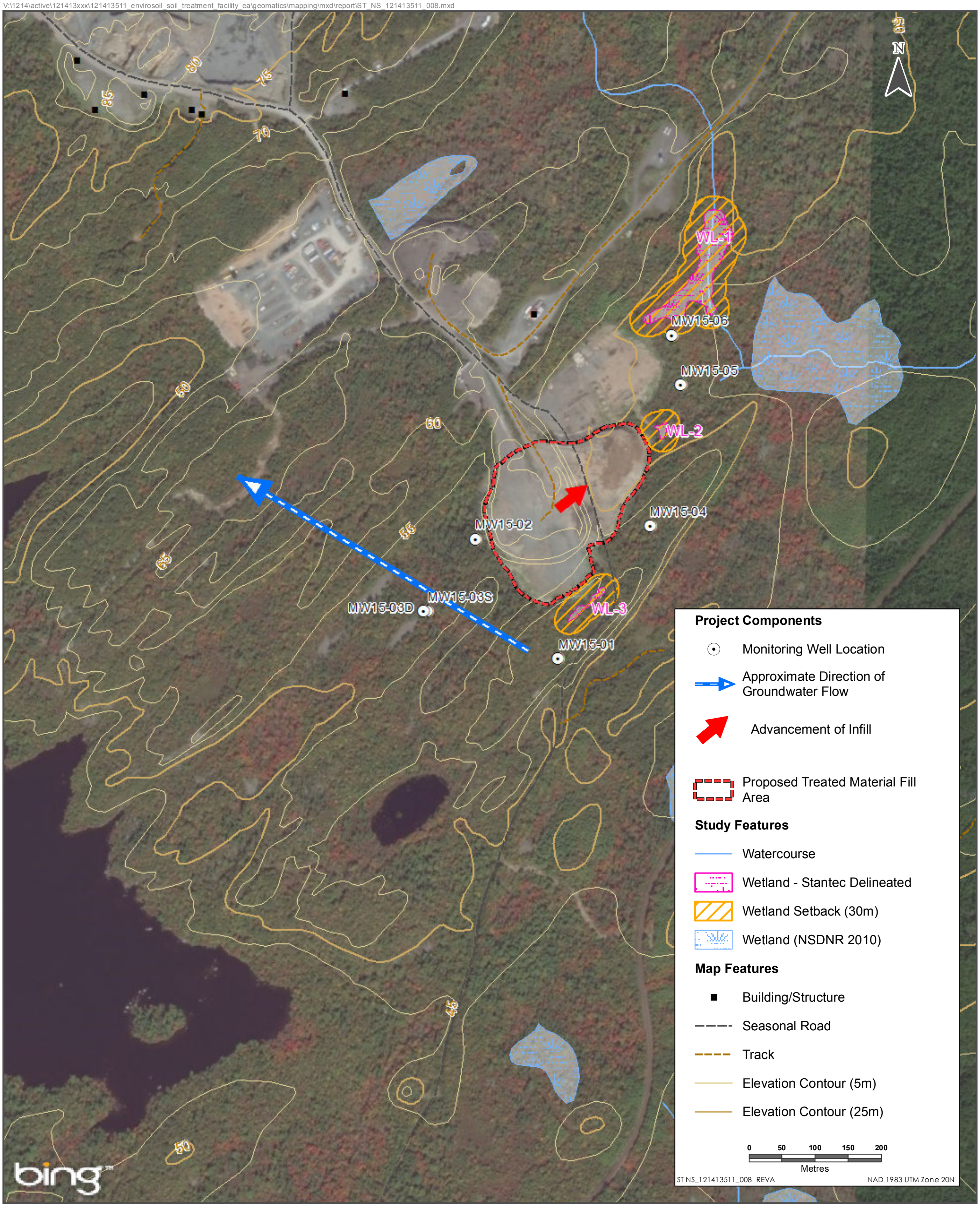
Disclaimer: This map is for illustrative purposes to support this Stantec project; questions can be directed to the issuing agency.

Approximate Direction of Groundwater Flow

January 2016

envirosoil ISO 14001 • ISO 9001

Figure E4



Sources: Base Data - Nova Scotia Geomatics Centre (NSGC), Nova Scotia Topographic Database (NSTDB). Wetlands - Nova Scotia Dept. of Natural Resources (NSDNR), Wetland Mapping Inventory Imagery: Bing: Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation

Disclaimer: This map is for illustrative purposes to support this Stantec project; questions can be directed to the issuing agency.

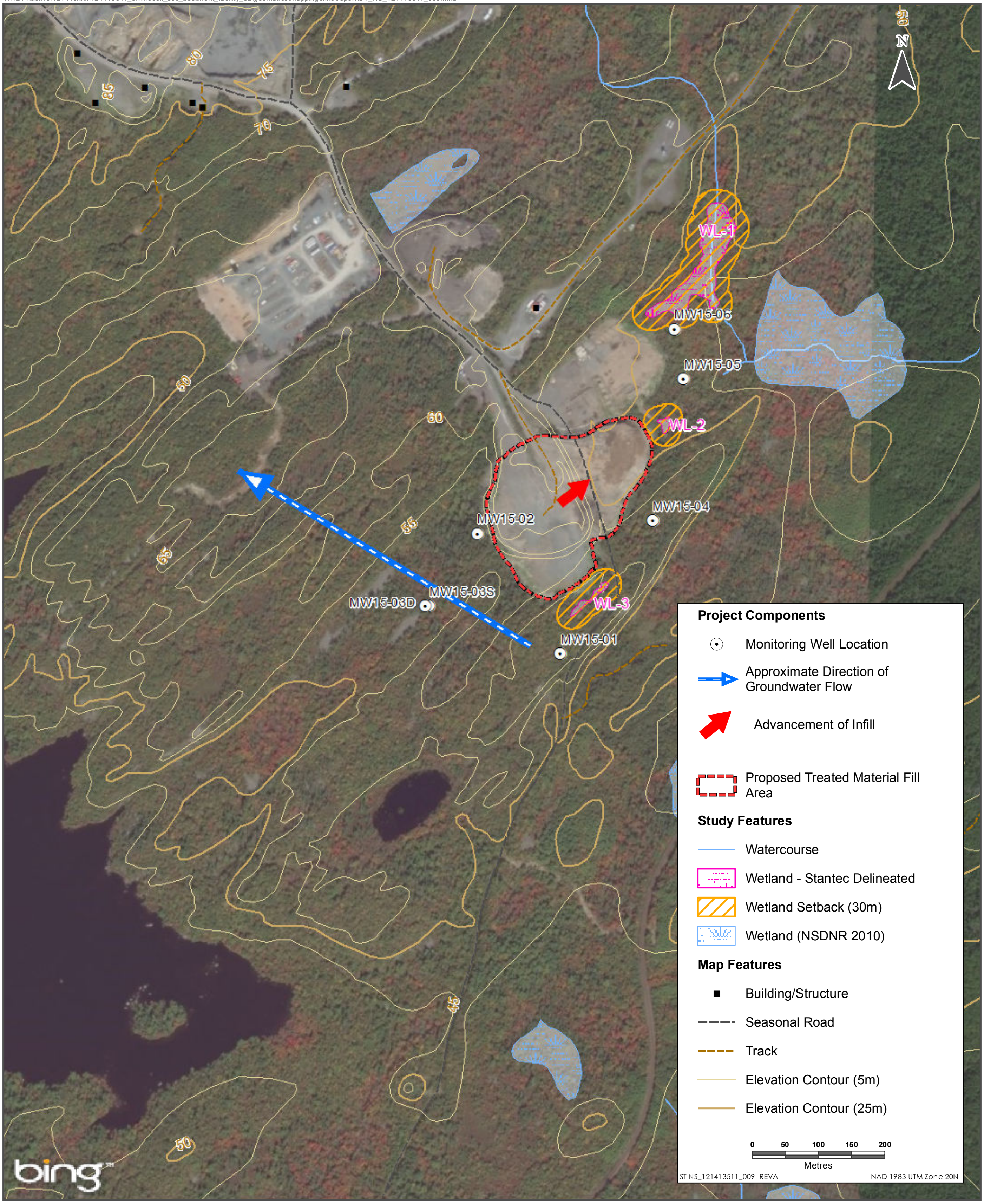
Approximate Direction of Groundwater Flow

February 2016

envirosoil ISO 14001 • ISO 9001

Figure E5

V:\1214\active\121413xxx\121413511_envirosoil_soil_treatment_facility_ea\geomatics\mapping\mxd\report\ST_NS_121413511_009.mxd



Sources: Base Data - Nova Scotia Geomatics Centre (NSGC), Nova Scotia Topographic Database (NSTDB).
Wetlands - Nova Scotia Dept. of Natural Resources (NSDNR), Wetland Mapping Inventory
Imagery: Bing: Microsoft product screen shot(s) reprinted with permission from Microsoft Corporation

Disclaimer: This map is for illustrative purposes to support this Stantec project; questions can be directed to the issuing agency.

Approximate Direction of Groundwater Flow

March 2016

envirosoil ISO 14001 • ISO 9001

Environmental Assessment Registration for the Envirosoil Facility: Addition of Stabilization/Solidification Technology and Treatment of Salt Impacted Materials

Figure E6

Appendix D
Additional Information

W.S. Langley
Concrete & Materials Technology Inc.

September 17, 2015

Mr. Dan Morehouse
Stantec

Dear Mr. Morehouse:

The use of salt water (seawater) for mixing and curing concrete has been in use for in excess of 150 years. Early marine structures and light stations used seawater exclusively for concrete work. Codes and standards have discouraged the use of salt water in reinforced concrete due to the depassivation effect of the chloride on unprotected reinforcing steel. There is a renewed interest in the use of contaminated water (seawater, bog water, mine water, etc.) to promote sustainability in concrete and avoid a world water shortage by the year 2025.

Sand and gravel removed from beaches was a primary source of concrete making materials in the metro area until about 1974, at which time sand removed from beaches was restricted. Up to this time the beach at Cow Bay (Trynor Construction) and Thrumpcap Shoal at the mouth of Halifax Harbour was the principal source of aggregate. These aggregates did not go through a wash plant, other than seawater. Seawater does not contain a harmful level of magnesium, sodium or calcium sulphate to cause harmful sulphate attack.

For solidification/encapsulation of landfills, there is no rationalization to ban the use of marine sediments or saturated seawater materials from the landfill. For reinforced concrete, the literature is split on the use of seawater for mixing concrete. The detrimental component of seawater with respect to its use in reinforced concrete is the Cl^- component. Fifty percent of the available Cl^- is tied up as chloro aluminates in the hydration products and not available as free ions to promote corrosion.

All of the elements contained in Table 2 can be tied up in cementitious materials. An exception is vanadium; however, this is below CCME guidelines. While the vanadium cannot be tied up in the calcium silicate hydrate (CSH) of cement hydration, the low permeability of the concrete would slow its migration from the solidification. Also, arsenic must consider the pH of the solidification medium.

If you have any further questions or comments please do not hesitate to contact me at your convenience.

Yours truly,

W.S. LANGLEY CONCRETE & MATERIALS TECHNOLOGY INC.

Wilbert Langley

Dr. Wilbert S. Langley, M.Eng., P.Eng., FACI, FCSCE

WSL:hmg
C:\Users\Heather\Documents\client correspondence\stantec\Ltr Morehouse 17 Sept 2015.docx

Unit 106, 51 Cobequid Road
Lower Sackville, Nova Scotia
Canada B4C 2N1
tel: (902) 865-3177
fax: (902) 865-7252
www.langleyconcrete.com wlangley@accesscable.net

FINAL

Technical Review of:

Environmental Assessment Registration and Related Documents for the Envirosoil Facility: Addition of Stabilization/Solidification Technology, Project No. 121413511, Bedford, Halifax County, Nova Scotia, Canada

<u>Prepared for:</u>

Stantec Consulting Ltd.

102-40 Highfield Park Drive

Dartmouth NS B0A 0A3

<u>Review prepared by:</u>

Edward R. Bates

26 Springfield Pike

Cincinnati, Ohio 45215

Phone: 513-317-9691

February 05, 2016

Technical Review of: Environmental Assessment Registration and Related Documents for the Envirosoil Facility: Addition of Stabilization/Solidification Technology, Project No. 121413511, Bedford, Halifax County, Nova Scotia, Canada

Preface:

This technical review was prepared by Edward R. Bates at the request of Stantec Consulting Ltd. of Dartmouth, NS. The views, opinions, comments, and statements included are solely those of the author. Stantec requested a completely unbiased review of documents previously submitted by Stantec along with associated comments and responses. The author has had no previous involvement with this project or any prior involvement in review/comment/response on this project. This review will not deal with previous specific comments, responses, or actions. Rather this review will focus upon the entire project as proposed including modifications in response to previous reviews and comments.

It is noted that over the course of previous review and comment, more detail was included, and some additional features were incorporated. The most significant of these were adding compaction of the disposal cell base to include approval of the base by a geo-technical professional, including complete clay encapsulation (1 X 10-7 cm/sec) of the treated material disposal cell, adding a leachate collection system (though very little if any leachate is expected), and including a sentinel monitoring well system around the disposal cell. Envirosoil had already included a treated material permeability specification of 1 X 10-6 cm/sec. Collectively these features provide for a very secure treated material disposal area and exceed best industry practice.

<u>The objective of this review of the proposed project, prior review comments, and associated responses is to provide an independent assessment of:</u>

1. Whether the proposed project is consistent with industry best practices;

2. Whether the environmental effects described in the environmental assessment are reasonable given the proposed design and mitigation measures;

3. Provide any guidance and recommendations, as may be appropriate, to improve the proposed project.

The documents which were reviewed consist of:

1. Environmental Assessment Registration for the Envirosoil Facility: Addition of Stabilization/Solidification Technology Project No. 121413511, dated May 2015.

2. Environmental Assessment Registration Addendum - Envirosoil Facility: Addition of Stabilization/Solidification Technology Project No. 121413511, dated August 2015

3. Table 1 Consolidated EA Review Comments and Envirosoil Responses – Submission 1, September 18, 2015

4. Solidification Encapsulation Cell drawing, issued October 15, 2015

Review Comments and Recommendations

1. Is the proposed project consistent with industry best practices?

To evaluate this I have considered the following:

1) Can and have the described soils and marine dredge spoils been successfully treated using solidification/stabilization (S/S)?
2) Does the proposed Envirosoil process comply with the best industry practice for using S/S to treat the described materials?
3) Are the proposed quality control/quality assurance features appropriate and adequate?

1) Can and have the described soils and marine dredge spoils been successfully treated using Solidification/stabilization (S/S)?

Dredge Spoils and Saline Materials

It is noted that the material being treated by Envirosoil will be substantially less contaminated than material that has typically been successfully treated by S/S technologies, providing an extra safety factor to the proposed treatment process. Soils and marine dredge spoils containing low levels of salt and many organic compounds have been successfully treated using S/S and many successfully completed site remediations testify to this. Refer to my recent publication listing hundreds of such successful S/S treatments and containing case studies for many of these sites (Bates and Hills, 2015). I agree with Dr. Wilbert Langley (Langley, 2015) that the salts in marine dredge spoils will not provide any issues for S/S treatment.. The low level of salts contained in marine sediments and sometimes drilling muds will have no effect on the proposed S/S treatment process or product. A detailed discussion regarding salts in marine dredge spoils and how these are incorporated into the S/S treatment process is presented in my letter to Jerry Scott on this subject (Bates, 2016). Unlike situations where high concentrations of salt are repeatedly applied to a cement product causing deleterious effects, the relatively small amount of salt that could be included in the S/S treatment process for sediments should cause no harm. This small amount of salt will not be enough to seriously compromise the integrity of the treated product. Nova Scotia was one of the principal parties who recently demonstrated successful treatment of marine sediments contaminated with organics during the Sydney Tar Ponds Project.

Bellegarde, is an example of a large TSDF operation in Southern France described in the recent multinational PASSiFY (Performance Assessment of Solidified/Stabilised Waste-Forms) report. "*The Bellegarde site is located in the south of France, near Nimes. Until 1979 this was the site of a quarry. The extraction of marls left a pit underlain by 500 m of impermeable natural clay. In 1993, part of the site was licensed for the disposal of hazardous waste, with a stabilisation unit being operational from 1995. Disposal activities ceased in 2001 and the site has been subject to restoration and redevelopment, partially for the biological treatment of organically contaminated soil.*
A second area of the site, covering 36 ha has been actively receiving S/S waste since 2001. The wastes treated were mainly ashes from MSW incineration, which contained high levels of chloride, sulfate, lead and zinc." (PASSiFY Project, 2010).

<u>Treatment of Organics</u>

S/S has been used for decades to successfully treat soils contaminated with organics. A recent publication (Hills, Gunning, and Bates, 2015) contains an entire chapter discussing S/S of organic contaminated soils. The Interstate Technology and Regulatory Council published a guidance document "Development of Performance Specifications for Solidification/Stabilization". This document states "Early literature concerning effectiveness of S/S on organic hazardous constituents noted the possibility of the interference by organics with the setting of cement-based mixtures, and as a result, a majority of S/S remedies were used for source control of inorganic contaminants (EPA 2007b), possibly leading readers to conclude that S/S treatment is not effective on organics. However, current published case studies and other literature indicate that S/S technology can be effective or potentially effective for a wide range of contaminants (see Table 2-1)" (ITRC, 2011, p 7). This same ITRC document cites references for demonstrated effectiveness of S/S treatment for: VOCS, SVOCs, PCBs, pesticides, dioxins/furans, organic cyanides, organic corrosives, pentachlorophenol, creosotes, coal tar, and heavy oils (ITRC, 2011, p 8). A recent publication (Bates and Hills, 2015) includes over 25 case studies documenting successful S/S treatment of a wide range of organics, including: PAHs, PCP, Dioxins, creosote, hydrocarbons, BTEX, TPH, TCE, coal tars and others. In almost all of these cases, no pretreatment was required.

Long-Term Permanence of S/S Treated Material.

By far the best and most comprehensive evaluation of the long term performance of S/S treated materials is presented in the multi-nation study , Performance Assessment of Solidified/Stabilized Waste-forms, An Examination of the Long-term Stability of Cement-treated Soil and Waste (Final Report), that not only included examination of the available literature but also included sampling and analysis of several completed S/S remediations (PASSiFy Project, 2010). This report, the most comprehensive study to date on the long term performance of S/S treated materials concluded "it is the opinion of the authors that treated material from all the sites sampled performed well and met the objectives of the original remedial treatment. This opinion is reinforced by the post treatment 5-year reviews conducted by the USEPA on three of the sites and the 10 and 15-year reviews for one of the sites investigated" (PASSiFy Project, 2010, p 13). It is noted that the sites investigated included S/S treatment of TPH, weathered waste oils, creosote, dioxin, and pentachlorophenol, along with lead, arsenic, zinc, and copper.

2) Does the proposed Envirosoil process comply with the best industry practice for using S/S to treat the described materials?

I have personally worked on over 14 successful applications of S/S to remediate sites with organics and have completed successful treatability studies for many others. The key to success is the same in all cases. First, have a good characterization of what you are planning to treat, including both the chemical characterization and the physical properties including particle size distribution. The characterization should represent either a sample from a well homogenized source material, or a reasonable worst case for treatment. Then conduct a treatability study based upon experience with these contaminants and available literature. Locate the best local sources for the reagents in the quantity to complete the job. Initially develop several formulations and test/compare to desired physical properties. Adjust and re-test as necessary, then evaluate against any leaching requirements. Adjust reagent dose rate or add additional reagents as necessary to achieve leaching requirements to produce a successful reagent formula. Then, when treating the target material, collect performance samples of the treated product about every 500-1000 cubic meters to document successful treatment. Lastly, implement ground water monitoring near the treated product disposal area. The Envirosoil proposed process calls for characterization before acceptance (I recommend particle size analysis be included), and the conduct of treatability tests to develop and document an effective treatment formula. Performance sampling is included in the plan as is groundwater monitoring near the disposal area. As each batch, represented by a performance sample, is placed, the physical location of that batch should be recorded. This is so that in the unlikely event that a performance sample indicates failure to meet one or more criteria, then the location of that material in known. I recommend referring to Bates and Hills, 2015, for a discussion of what constitutes a failure and options to correct. It should be noted that failure of a single performance sample does not necessarily mean that the field placed treated product did not meet specifications. It is not unusual for a specific performance coupon to have been prepared incorrectly, or for the testing laboratory to have made an error. Thus failure by a single coupon should always be verified by testing a replicate coupon from the same batch. If failure is confirmed, then there are several options including removing/retreating that batch, removing and sending the failed material off-site, or taking a compensating action such as collecting and removing leachate or adding additional isolation from the environment. The Envirosoil proposed process includes all the required elements described above and meets the standard of complying with the industry best practice. More detailed discussion of these elements follows.

Equipment. Pugmills are commonly used whenever it is desired to rapidly mix large quantities of soil like materials to achieve a very uniform blended product. They have been a mainstay for exsitu S/S treatment of contaminated soils on hazardous waste sites due the outstanding uniformity of the treated product and dependability of the equipment. Envirosoil is proposing to use a modern pugmill similar to those I have successfully used on many sites.

The use of specific targeted treatability tests on the soils to be treated is standard industry practice both on contaminated sites and at TSDF (temporary storage and disposal facilities) in the USA and worldwide. Standard practice is to collect soils, or waste materials, into stock piles, of practical size, (say 10,000 cubic meters), homogenize the material, select several random samples, blend the samples, and conduct the treatability test on this blended sample to document that the reagent mix will produce a treated product meeting design (permit) specifications. Then the targeted pile is treated and a sample of the treated product is collected from the discharge of the pugmill, cured, and tested for compliance with specifications. Pugmills can more easily produce a uniform treated product than the insitu excavator mixing used for treating contaminated brackish and marine sediments at the Sydney, NS Tar Ponds project. Some recent examples of the use of pugmills in the USA include the MRI site near Tampa (Pb over 880 ppm), Brunswick Wood site in Georgia (creosote and PCP), Escambia Wood Site in Florida (creosote and PCP), United Metals Site in Florida (lead from battery acids), and American Creosote Site in Tennessee (creosote, dioxins, and PCP). The equipment and processes proposed by Envirosoil comply with the best industry practice.

Treatability Testing. Treatability testing to develop and validate an appropriate formula that can produce a S/S product meeting agreed upon performance criteria is standard industry practice. Envirosoil has committed to implement such a treatability program, to be approved by

NSE. The treatability program process as described in the EA Addendum conforms to the best industry practice, and is the process I have used successfully for many sites. For a detailed discussion on S/S treatability testing, one should refer to my recent publication (Bates and Hills, 2015). In general, one develops formulas that meet the physical properties first, and then tweaks the formula as necessary to meet any leachate criteria.

Performance Criteria. S/S industry practice is to establish performance criteria to be met by all treated material, before treatment begins. Standard criteria include performance specifications for strength, permeability, and sometimes leachate quality. Freeze/thaw and wet/dry criteria are only rarely used. The preference is to place and cap the treated material so that freeze/thaw and wet/dry stressors are not present, save briefly during the placement operation. The Envirosoil proposal complies with these best industry practices.

I have either created, or been a major contributor to, the S/S performance standards for about 20 sites, most USEPA Superfund sites. The specifications I have written over the course of 30 years have essentially become the industry best practice standard for S/S treatment.

Of these, permeability is often the most important as a low permeability of 1 X 10-6 cm/sec severely limits of amount of leachate, thus loading, that could potentially leave the treated material to enter the environment. Usually ASTM D 5084 is used as the test method.

Strength is usually set for 50 psi using ASTM D 1633 as the test method. The value of 50 psi is to assure that a competent solidified monolith is created. In some cases a higher value may be set if the proposed future use requires it.

A leachate value, concentration of principal contaminants, is sometimes, but not always used. USEPA SW846, Method 1312 (SPLP) is generally used. Sometimes an existing regulatory standard is used. Otherwise the leachate values are set at low enough levels so that if the maximum amount leachate is generated, as limited by permeability, and this leachate enters the ground water of surface water, then the resulting concentration of contaminants in that water will not exceed an established environmental criterion at the site boundary or point of compliance. This requires site specific modeling as described in the ITRC guidance document (ITRC, 2011).

The Envirosoil proposal includes all three criteria, low permeability, strength, and leachate quality used appropriately and meets standards for industry best practice.

Post Treatment (Performance) Testing. The best industry practice has been shown to be to collect treated samples immediately after treatment, as the material exits the pugmill, screen to remove particle larger than ½ inch, load into right cylinder molds, and cure under humid conditions at ambient temperatures. Such samples have been documented to accurately represent in place cured material. After curing for 28 days, sometimes less, the samples are tested for conformance with the performance criteria. Sampling frequency should be approximately once for every 500-1000 cubic yards (500-1000 cubic meters), but include at least one sampling event for each day of significant production. This is the process proposed by Envirosoil (EA, May, 2015, page 210). It is the process that I personally developed and have successfully used on many USEPA Superfund sites. Please note USEPA SW846 Method 1311, TCLP, was developed for, and is intended for, determining if a material is characteristically "hazardous" by leaching characteristic. It is not appropriate for use in assessing the environmental mobility (leaching impact potential) for a material being disposed as described in the Envirosoil proposal. USEPA SW846 Method 1312, SPLP, was developed and should be used for this purpose. *I understand that Envirosoil plans to use Method 1312, SPLP, (Table 3, page 2.8 of the EA, not Method 1311, (as was erroneously stated on page 13 of the EA Addendum),* to evaluate leaching potential both pre and post treatment of materials. I have documented in a number of cases that using Method 1311 can lead to development of a formula that performs well under the highly acid conditions of Method 1311, but the formula performs poorly under actual environmental conditions.

Envirosoil is proposing (EA Addendum) to use ASTM Method 39 for strength and a method I am not familiar with for permeability. The methods most commonly used are ASTM D 1633 for strength and ASTM D 5084 for permeability. However, I have no specific issues with the methods proposed.

Treated Material Placement. To comply with best industry practice, immediately after exiting the pugmill, the treated material should be transported to the final placement location, spread in lifts about 2 feet (0.6 meters) thick, and compacted. Envirosoil has proposed placing and compacting the treated material immediately after treatment. Placement/compaction will be in 30-50 cm lifts, following the accepted best industry practice. (Also see "recommendations" regarding the method of compaction). Placement of treated material above the water table, as proposed by Envirosoil, complies with the most conservative industry practice, as it prohibits groundwater from contacting the treated material. Note that insitu S/S has often been conducted below the water table, and yet no adverse impacts to groundwater have been observed. Covering the treated material to assure that it is below the frost line is standard best practice and negates the need for freeze/thaw testing as the material will not be exposed to this stressor.

It is noted that the placed location of each day's production, or batch, within the fill will be recorded so that in the event that performance samples indicate failure, the material can be recovered and retreated. Envirosoil has also committed to compacting the native soil base below the fill and obtaining the approval of a geo-technical professional for this surface before constructing the fill. This conforms to the best industry practice for this type of S/S treated waste fill.

It is noted (per the October 15, 2015 Solidification Encapsulation Cell drawing) that the treated material containment cell is lined on the bottom and sides with 300 mm of clay. Upon cell completion, the top will also have a clay cap. In addition to the clay liner, the bottom of the cell has a perforated leachate collection pipe bedded in gravel with a means provided to sample and remove leachate, should there be any leachate. These features substantially exceed the best industry practice for disposal of far more highly contaminated material that has been treated by S/S so as to meet the stated treatment specifications. By way of comparison, I have developed treatment specifications for many Superfund sites that employed S/S to treat truly hazardous soils. A common permeability specification has been 1 X 10-6 cm/sec. The soils were treated to this specification and disposed with no added liner, both above and below, the water table and there have been no issues. Note that I prefer disposal above the water table, as proposed by Envirosoil, whenever feasible.

3) Is the proposed quality control/quality assurance appropriate and adequate?

Quality assurance and quality control (QAQC) are defined and discussed in some detail in my recent publication (Bates and Hills, 2015). For the following discussion we will define quality assurance as the activity conducted by an outside party to assure that the process, procedures and quality control are conducted according to plans and are able to achieve the project objectives and requirements, and are in compliance with regulations. The remainder of this discussion will concern quality controls employed by the proposed project operator to make certain that treatment and disposal operations will be successful and that any potential environmental impacts are mitigated.

A detailed QAQC program has not yet been prepared by Envirosoil. This is appropriate as a detailed QA/QC document can, and should be, prepared during the industry approval stage. A detailed QAQC document with the detailed procedures, forms, reporting, and cross checks that will be employed, and presenting exactly who is responsible for each activity, how the activity is to be done, what testing laboratories will be used, the timelines, etc. can only effectively be prepared later in the permitting/final design process. What is important at this stage is to assure that the critical elements for successful S/S QAQC are included in the proposed project. These critical elements are: define the nature/ maximum contamination levels of the materials to be treated, define the acceptable treated soil specifications and test methods, include homogenization of materials prior to treatment, include a provision for treatability testing to develop an appropriate S/S formula, include provision for collecting, curing, and testing the treated product, and provide for recording the location of placement for each batch of treated material. Envirosoil has included all these critical elements of best industry practice for S/S QAQC.

2. Are the environmental effects described in the environmental assessment and related documents reasonable given the proposed design and mitigation measures?

To evaluate this we will look at possible environmental impacts in both the soils/spoils storage/treatment area and in the treated materials disposal area.

Potential environmental impacts include odors and air emissions from the waste and dust from the reagent handling, potential precipitation runoff and leachate from untreated soils/spoils in the process area if these entered surface or ground waters, potential runoff from the treated materials in the disposal cell prior to capping if it entered surface or ground water, and possible longer term generation of leachate from treated soils/spoils in the disposal cell if the leachate contains a significant contaminant load and reached these waters. Noise could also be considered an environmental impact, but will be no different than current operations which are well removed from potential receptors.

Storage/Treatment Area

Soils and dredge spoils that meet the acceptance criteria and are brought onto the site will be stored, homogenized, and treated within the current LTTD storage and processing facility. This area is clay lined and any runoff is directed to the lined storage pond which was designed for a 100 year storm. The S/S treatment facility, pugmill, silos, etc., will also be within this current lined facility. Thus any runoff, free drainage waters, etc. will be contained. The S/S treatment facility itself will have a pugmill with closed covered mix chamber and reagent silos with baghouses to control dust. I have worked with this type equipment for 30 years, and the equipment is quite capable of controlling emissions/dust. The brief failures I have seen were all human related and due to failure to maintain the bag filters on the silos, not watching to assure that pneumatic trucks off-loading reagents into silos do not exceed acceptable pressures, failing to close the pugmill mix box cover, etc. The solution is a daily maintenance check at the end of the day, and monitoring the pneumatic truck off-loading. There should be no environmental issues from the storage/treatment area, but a daily maintenance check, with checklist, is recommended for all critical equipment, operational as well as environmental.

Treated Materials Disposal Area

Envirosoil has committed to installing and monitoring several shallow wells and one deep well in the disposal cell area and periodic sampling of Anderson Lake. In the unlikely event of any, even slight, impact on water resources, this monitoring should provide early detection, allowing for corrective action to be implemented. Envirosoil has committed to the monitoring of ground water wells and taking appropriate corrective in the unlikely event that waste contaminants are detected in the monitoring wells. This follows best industry practice and the number of wells also complies with best industry practice. The proposed Envirosoil S/S treatment and disposal project is not intended to treat/dispose of Hazardous wastes (per USEPA definition of hazardous wastes), yet the new monitoring well system proposed for the treated soil disposal area is equivalent to what would be installed at a USEPA Superfund hazardous waste site remediated by S/S. The frequency of sampling is also similar.

Envirosoil has stated that detailed drawings and maps for the treated materials disposal area will be included as part of the Part V application process. However the drawings already provided, especially the Solidification Encapsulation Cell Conceptual Design, dated October 15, 2015, provide important detail. This drawing shows that the treated material will be encapsulated by 1 X 10-7 cm/sec clay on the bottom, sides, and upon completion by a clay cap. This exceeds the industry best practice for S/S treated soils at USEPA Superfund hazardous waste sites. Note that a leachate collection system is also shown above the clay liner on the drawing, so that in the unlikely event that there is any leachate, it can be detected and removed.

Potential routes for contaminant release, potential receptors, and the mitigation provisions to monitor, protect, and prevent such releases have been described by Envirosoil throughout the reviewed documents. The analyses and mitigation methods described are appropriate and meet, or exceed, best industry practice.

3. Suggested guidance and recommendations to improve the proposed project and alieve any concerns.

The following suggestions are offered to potentially improve process operations and in some cases add additional reassurance that there will be no significant environmental impacts.

Process Operations.

For planning purposes, one should be aware that the actual realized throughput from most pugmills treating contaminated soil is about 50% of the manufactures rated throughput. For this project, one could consider creating 5,000 to 10,000 cubic meter stockpiles, screen each pile using either a power screen or trommel to remove oversize material (generally over 2 inches, but depends on pugmill specification), use an excavator to initially homogenize the material, collect say 5 random aliquots to be blended into the treatability sample, conduct the treatability test to develop the successful formula, treat the pile by blending in the S/S reagents in the pugmill, collect a performance sample for compliance testing from the pugmill discharge, transport the treated material to the disposal cell, then spread and compact in place to cure. Note that the compliance sample results will not be available for several days after the treated material was placed in the cell. Hence the importance, as proposed by Envirosoil, to record the exact position of placement for each batch treated and disposed. Then in the unlikely event that the performance sample fails to meet criteria, the treated material represented by that sample can be excavated and retreated. In my experience, the most likely problem areas are to closely monitor the baghouses on the reagent silos, off-loading of dry reagents into the silos, and making sure to frequently check/adjust the water addition rate into the pugmill. Daily calibration checks may also be necessary for the reagent metering systens.

Solidification Encapsulation Cell Drawing, issued October 15, 2015.

This “Revised draft Conceptual Design” drawing has included substantial additional environmental elements including full clay encapsulation of the S/S treated material, a leachate collection system, and a runoff collection system for the completed cell. These additional protective features should go a long way in alleviating concerns expressed by some reviewers. I suggest that some text be prepared to describe these added protective features and also to describe how the disposal cell will be constructed. For example the following might be used, though other construction approaches are certainly possible.

1. Excave the trench to an elevation about 2 feet below the intended elevation of the bottom of the clay bottom liner.

2. Screen the excavated soils so as to obtain enough fine, but well graded soil, to fill the 2 feet of over excavation with a compacted soil layer free of any cobbles/stones, so that it can be approved by the geo-tech professional.

3. Install the clay liner and then the leachate collection stone bed, pipe and geotextile

4. Begin construction of the clay side walls by constructing the first lift (maybe 3 feet?) of the side walls.

5. Place and compact S/S treated material to within 1 foot of the top of the clay sidewalls. (Remaining 1 foot of freeboard will assure that there is no runoff from freshly placed treated material due to precipitation event).

6. Continue raising the clay side walls and placing S/S material in lifts until the cell is full, then proceed to construct the clay cap, evaporative soil cover, and final runoff collection system.

There are other ways this could be done, but the point really is **to explain it in a way that reviewers can see it being built in their mind, and *realize how many protections have been built into the disposal cell design.***

I suggest that any storm water collected from the cell during filling operations, be used as make water in the pugmill. This not only will dispose of the water, but will also assure that it is “treated”. This is common practice with ex-situ S/S operations and has never caused any issues.

Material Placement in Landfill.

I recommend the following refinements to the placement procedure. The freshly treated, as yet uncured material should be placed in lifts about 0.6 meters thick, and compacted by the tracks of the dozer spreading the material. This will produce a rough, corrugated surface, suitable for bonding with the next lift, and avoid creating smooth planer surfaces between lifts. (See picture below.) The final top lift of the cell should be compacted with a smooth drum roller to prepare the top of the cell for installation of the final cap.

Each lift is dozer compacted leaving corrugated surface to bond with the next layer

Modeling the Potential Impact of Leachate

Some simple modeling of the possible mass flux of contaminates into the groundwater flow below the treated soil disposal cell may help alleviate concerns of some reviewers. First one must determine the approximate volume of groundwater flow below the cell per unit of time (say per year). Probably best to express in cubic meters or hectare-meters. Then calculate the maximum volume of leachate that could be produced from the disposal cell by using the design maximum permeability, 1 X 10-6 cm/sec, the cell geometry (surface area exposed to precipitation), duration of the probable available infiltration time (how long the treated soil surface is wet, cumulative over a year, and the retardation due to the clay cap and clay liner, to generate a maximum volume of leachate per year. Or for an easy and very worst case, assume the surface is continuously wet all year and the clay cap has failed, so infiltration is controlled by the permeability of the treated material. Also assume that the clay liner has failed. Having determined the volume of leachate per year, assume the worst case scenario that the leachate quality equals the maximum limits allowed. (It will not be greater than this because the formula developed to treat the waste soils has to achieve this criterion, or better.) Now one can calculate the mass flux of contaminate into the groundwater, and thus the worst case for groundwater quality. Due to the low permeability of the treated and disposed materials, it is very likely that the modelling will show very little impact upon groundwater quality even if the cay cap fails, the clay liner fails, the proposed leachate collection system fails, and the surface of the fill is saturated 365 days/year.

Note that this same process can be used to determine the maximum allowable concentration of a contaminant in the leachate, if the maximum allowable concentration in the ground water is specified. This approach has been used at hazardous waste sites in the USA and is described in the ITRC document on Development of Performance Specifications for Solidification/Stabilization (ITRC, 2011).

S/S Performance Test Methods.

Please note USEPA SW846 Method 1311, TCLP, was developed for, and is intended for, determining if a material is characteristically "hazardous" by leaching characteristic. It is not appropriate for use in assessing the environmental mobility (leaching impact potential) for a material being disposed as described in the Envirosoil proposal. USEPA SW846 Method 1312, SPLP, was developed and should be used for this purpose. *I understand that Envirosoil plans to use Method 1312, SPLP, (Table 3, page 2.8 of the EA, not Method 1311, (as was erroneously stated on page 13 of the EA Addendum),* to evaluate potential both pre and post treatment of materials. Method 1312 is the appropriate method.

Envirosoil is proposing (EA Addendum) to use ASTM Method 39 for strength and a method I am not familiar with for permeability. The methods most commonly used are ASTM D 1633 for strength and ASTM D 5084 for permeability. I have no specific issues with the proposed methods, but recommend considering the industry standard practice of using methods ASTM D 1633 and ASTM D 5084.

Appendix C-Proposed Pugmill

A pugmill is the best type of equipment for the described treatment operation and the model proposed appears to be up to date and very suitable. Experience with assorted pugmills when treating soils with S/S indicates that the actual expected production rate is about 50% of the manufactures stated rate for soils, hence about 150 tons/hour. You will want to set the clearance gap between the paddle tops and wall for the maximum 2 inches. I recommend use of the automatic proportioning system to control reagent feed using feedback from the weigh belt. Unclear in the description is exactly how the reagent feed is controlled, and how many reagent feed material streams can be controlled using the automated system. If it cannot separately control at least two dry reagent streams, this could be an issue. Ability to control 3 dry reagent streams would be ideal. Water addition can best be adjusted by the pugmill operator so as to achieve the correct moisture content in the treated material to allow for cement hydration reactions, while not making the treated product too wet which would interfere with placement and compaction. Moisture sensors and moisture tests are not as effective in this regard as having the pugmill operator occasionally grab and squeeze a hand full of product and visually observe for moisture beads, but no dripping water. Also the placement operation should be in communication with the pugmill operator to suggest adjusting water addition based on field placement conditions.

Update the S/S Proposal

Since first submitting the Environmental Assessment registration in May of 2015, many changes have been incorporated in response to the excellent comments received. Many of these changes have a profound effect on environmental protection and alleviate concerns expressed. Yet these changes proposed are scattered among several documents, so may not be fully appreciated by all reviewers. Among the most important are adding a maximum permeability specification of 1 X 10-6 cm/sec for the S/S treated material, compaction of the disposal cell base to include approval of the base by a geo-technical professional, including complete clay encapsulation (1 X 10-7 cm/sec) of the treated material disposal cell, adding a leachate collection system, and including a sentinel monitoring well system around the disposal cell. It may be useful at this point to provide at least a summary update to highlight all the protect features that have been added.

Notes and Corrections

Regarding Treatment of Some Metals and Organics:

Envirosoil is proposing that its Industrial Approval be amended to exempt the EC and SAR restrictions provided that all materials containing elevated EC and SAR are handled in accordance with the special procedures outlined in this EA Registration. (EA, May, 2015, Page 1.7).

"The proposed amendments for this project focus on the following:
Amendment to add S/S technology to allow treatment of materials with inorganic metals and organics; and

Amendment to allow for the acceptance and treatment by S/S technology, materials containing elevated levels of EC and SAR (or, salt impacted materials)." (EA May, 2015, Page 2.1).

"The popularity of S/S is due to the fact that it can be used to treat a wide variety of inorganic contaminants such as arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, antimony, uranium, and zinc as well as organic contaminants such as petroleum hydrocarbons and PAHs, etc. Soil, sediment and sludge impacted with an array of organic and inorganic contaminants have been treated successfully using this versatile technology." (EA, May, 2015, Page 2.1)

Though the above is generally true, there are some special considerations. Amphoteric metals such as lead and arsenic exhibit increased solubility at both high and low pH values. Hence one must be careful not to exceed the higher pH solubility point when adding alkaline reagents, including cement. For many lead compounds, leaching increases above pH of about 11.5 and for many arsenic compounds this point is reached at a pH of about 10.5. However these pH points can vary some depending on the specific compounds. Thus for a specific material, treatability/leaching tests are recommended, using tests such as the USEPA SW846 method 1312, SPLP. By employing treatability tests in conjunction with an appropriate leaching test like SPLP, as Envirosoil has proposed, any potential leaching issues can be identified, and appropriate adjustments made to the formulation. Note that SW846 Method 1311, TCLP, cannot be used for this as it will produce erroneous results due to the acids used and the acid addition rates called for by the method.

Some organics are not well suited to treatment by S/S. These include volatile compounds, common solvents such as benzene, toluene, xylene, and lighter weight oils if the oils are present in high enough concentration to be free flowing. This does not preclude treating soils with these contaminants in low concentration. Oils in low concentrations will adhere to the surface of soil particles and become bound in the low permeability matrix. Low concentrations of solvents and volatiles can often be adsorbed into the surface of activated carbon, added as a special reagent, and the carbon in turn is bound into the matrix. Material specific treatability tests can often produce a cost and performance effective formulation to treat these contaminants in low concentrations.

I would add activated carbon to table 2, page 2.7 of the EA. Typical quantity 0.5% - 2%. Activated carbon is particularly useful for binding small quantities of volatile organics when present in soils/sediments that are being treated for other contaminants. The granulated form is preferred to the powdered form, to eliminate dusting issues. I suggest adding phosphates to the reagent table as they are often very effective in treating lead. Typical quantity 1-5%. Quicklime is difficult and hazardous to store/handle. It's OK to include in the table but I would avoid storing and using it if possible. Its primary use is for treating soils/sludges that have a substantial mobile oil component (saturated with oils) that would interfere with the setting of the cement. From the acceptance criteria, this does not seem likely.

Importance of the Low Permeability Criterion.

The treated material will have a permeability of 1 X 10-6 cm/sec, or lower, permeability per the Envirosoil proposal. This is a very low permeability equal to about 0.31536 meters/year, or about 1.0346 feet/year of water movement thru the treated soil fill. However the pore space that could be occupied by water is very small. In untreated soils one might expect 30% pore space; but in S/S treated soils/spoils most of the pore space has been filled with the products of cement hydration (hence the low permeability). The expected available pore space is likely much less than 5%. However if one assumed 5% pore space and a shallow pond directly on top of the treated material for 365 days of the year and no clay cap (though one is proposed), then a square meter of surface area would produce 0.015768 cubic meters of leachate (0.31536 X 0.05) per year, or 0.0000432 cubic meters of leachate per day. This is with ponded water sitting directly on top of the fill for 365 days/year. However, the proposed landfill will be sloped to prevent ponding and have a clay cap of 1 X 10-7 cm/sec maximum permeability to prevent infiltration. So the proposed treated soil is simply not capable of producing a significant volume of leachate. Looking even beyond that, the formula developed during treatability testing, and the performance sample collected at the time of treatment have to meet strict limits regarding the concentration of a contaminate in the leachate. Thus the loading (flux) of contaminate that could enter the groundwater, even without the proposed clay liner and leachate collection system, would be extremely small compared to the volume of groundwater that will be flowing past the site. Some basic modelling might help in understanding the important role of the treated soil low permeability value in protecting ground and surface waters.

Corrections:

1. The following is not a USEPA document, although the USEPA helped fund and write the document. It is an ITRC document and the correct citation is:

~~USEPA. 2011. Development of Performance Specifications for Solidification/Stabilization. Prepared by The Interstate Technology & Regulatory Council Solidification/Stabilization Team. July 2011. (Page 10.2)~~

ITRC, (2011). Development of Performance Specifications for Solidification/Stabilization, Interstate Technology Regulatory Council, ITRC, 50 F Street, NW, Suite 350 Washington, DC 20001, http://www.itrcweb.org/gd.asp

2. The Bates and Hills Manual of Practice (Bates and Hills, 2015) is also not an EPA document, although EPA chose to post it on the EPA website due to the value of its content.

References Cited

Bates and Hills, 2015, Stabilization and Solidification of Contaminated Soil and Waste: A Manual of Practice, USEPA website clu-in, https://clu-in.org/download/techfocus/stabilization/S-S-Manual-of-Practice.pdf

Bates, 2016, "Impact of Salt Content in Marine Dredge Spoils on the Solidification/Stabilization Treatment Proposed by Envirosoil Limited, Bedford, Nova Scotia", Letter from Edward R. Bates to Jerry Scott, General Manager, Envirosoil Limited, dated January 21, 2016

EA, May, 2015, Environmental Assessment Registration for the Envirosoil Facility: Addition of Stabilization/Solidification Technology Project No. 121413511, dated May 2015.
EA Addendum, August, 2015, Environmental Assessment Registration Addendum - Envirosoil Facility: Addition of Stabilization/Solidification Technology Project No. 121413511, dated August 2015

Hills, Gunning, and Bates, 2015. Stabilisation/Solidification of Contaminated Soil and Waste: Science, Colin Hills, Peter Gunning and Edward Bates, 106 pages, August 2015, Hygge Media, http://www.hyggemedia.com/shop/

ITRC, 2011. Development of Performance Specifications for Solidification/Stabilization, Interstate Technology & Regulatory Council (ITRC), http://www.itrcweb.org/GuidanceDocuments/solidification_stabilization/ss-1.pdf

Langley, (2015), Letter from Dr. Wilbert Langley, Concrete and Materials Technology, Inc., addressed to Mr. Dan Morehouse of Stantec, September 18, 2015, previously provided to Nova Scotia Environment.

PASSiFY Project, 2010, Performance Assessment of Solidified/Stabilized Waste-forms, An Examination of the Long-term Stability of Cement-treated Soil and Waste (Final Report, 2010), CL:AIRE, RP16.
http://www.claire.co.uk/index.php?option=com_cobalt&view=record&cat_id=23:stabilization-solidification&id=298:performance-assessment-of-stabilizedsolidified-waste-forms-passify&Itemid=61