Addendum to EARD

Sheet Harbour Quarry
Sheet Harbour, Halifax County

Dexter Construction Co. Ltd.

Table of Contents

Figure Index

Table Index

Appendix Index

1. Introduction

Dexter Construction Co. Ltd. is proposing the development of the Sheet Harbour Aggregate Quarry near Mushaboom, Halifax Regional Municipality, Nova Scotia. The purpose of the proposed undertaking is to develop a new rock quarry (up to 81.5 ha) to supply aggregate markets on the Eastern Shore and beyond with quality construction aggregate. The project is located within 81 hectares on PID 40832503 off Marine Gateway Road in Sheet Harbour, Nova Scotia. The project is anticipated to commence in 2020 with initial volumes of 50,000 tonnes per year. Depending on market demand the anticipated life of the project is 20 – 50 years. The scope of the proposed quarry is similar to other quarries in the area, and encompasses the activities associated with construction, operation, and decommissioning of a quarry.

Dexter Construction registered an Environmental Registration Document with Nova Scotia Environment (NSE) on January 31, 2019 for the Sheet Harbour Quarry for environmental assessment, in accordance with Part IV of the Nova Scotia *Environment Act* (https://novascotia.ca/nse/ea/SheetHarbourAggregateQuarry/). On March 22, 2019, the NS Minister of Environment requested additional information to support the Environmental Assessment of Dexter's proposed project (Appendix A). The methodology to be used for the response to the additional information request was discussed with NSE Environmental Assessment Branch on April 16, 2019 and a subsequent meeting with regulators was held to fully understand the requirements and adjust the methodology accordingly.

The responses are structured with the same order as the Minister's additional information request for ease of review.

2. Additional Information Requirements

2.1 Water Resources Assessment

"Provide additional details for the water resources assessment with accompanying discussion and analysis of potential effects to surface water resource quality and quantity (i.e. Big Eastern, East Mushaboom and Lawrence lakes and related watercourses and watersheds), wetlands and groundwater quality and quantity that includes the following":

a) *"An updated water balance based on appropriate and justified infiltration rates, evapotranspiration rates, groundwater-surface water flow interactions and site grading plans".*

An updated Preliminary Water Balance is provided in Appendix B. The work completed and the conclusions reached support the development of the quarry with negligible impacts to local surface water regimes.

When discussing the results of this water balance it should be noted that this quarry will be developed over the course of approximately 50+ years. The mid-life scenario is presented as the likely 20-year extent of the quarry. The lengthy duration of development will allow the surrounding environment to slowly adjust to changes in the hydrologic regime. Current conditions will be documented through monitoring and mitigated where necessary.

b) *"A quantitative groundwater numerical model for this site and surrounding area, including existing water supply wells and coastline within 2 km of the property boundaries. The model is to assess groundwater flows under the site development scenarios. The model should also integrate surface water features and properties, as well as the capability to assess density differences (seawater compared to freshwater/groundwater) and the process of seawater intrusion at the coastal groundwater-seawater interface. The model should provide a quantitative evaluation of the coastal seawater intrusion interface under the progressive site development scenarios, particularly in relation to the risk of seawater intrusion contamination to existing water supply wells along the coast. The groundwater model should be properly calibrated, include a sensitivity analysis, and be validated with water level observations."*

A review of groundwater data was conducted and the need for a groundwater quantitative model was reviewed. The additional analysis of surface water balance and available data shows that a groundwater model does not need to be conducted as the potential for the proposed quarry to affect groundwater is very low. Therefore, instead of attempting to predict impacts with a quantitative groundwater flow model, it is more appropriate to document current conditions and mitigate any gradual changes where necessary. The discussion can be found in Appendix C.

An Evaluation of Potential for Coastal Seawater Intrusion to Domestic Wells is provided in Appendix D. The work completed and the conclusions reached support the development of the quarry with no predicted impacts to domestic wells or increased risk of seawater intrusion affecting domestic wells as a result of the described and predicted changes in local surface water or groundwater regimes.

c) *"A surface water quality assessment based on the results of the revised water balance, in conjunction with applicable baseline surface water quality data from Big Eastern, East Mushaboom and Lawrence lakes and related watercourses and watersheds."*

Surface water samples were taken at 5 locations quarterly during 2017-2018 as part of the baseline survey for the environmental assessment. Subsequent samples were taken in area lakes during the fish habitat assessment. The analytical results are presented in Appendix E. The results from surface water analysis were compared to the Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Aquatic Life for Freshwater (FWAL). This criteria was used for baseline assessment since the Project site is on undisturbed ground. Future sampling, during development and operations, may be compared to other specified criteria as applicable. All lab analyzed samples show low pH conditions (range 4.62 - 6.32). Baseline conditions indicate that aluminum, cadmium and iron consistently exceed the CCME FWAL criteria for all samples. Analysis of samples from SW-3 indicates exceedance of lead (1.1 µg/L) criteria (1.0 µg/L) during two sampling events (December 2017 and June 2018)

d) *"A discussion of proposed mitigation measures and follow-up monitoring programs based on the results of the assessments."*

Surface Water Mitigation and Monitoring

Baseline water quality will be maintained through the use of re-vegetated slopes, drainage ditches and temporary settling ponds to capture, treat and re-direct surface water. Drainage ditches and swales will be utilized to the greatest extent practicable to divert surface water, originating upgradient of the property, around the quarry perimeter, thereby minimizing contact of water with the quarry floor and working faces. Settling ponds will capture surface flow and allow for suspended sediment to settle out of the water column. A spill way is constructed in the settling pond to allow treated water to return to the surrounding environment. No direct linkage, other than overland flow, will be developed between the settling ponds and the surrounding waterbodies.

The current baseline sampling locations will be used for long term monitoring and additional monitoring stations will be added for release points from the quarry to the environment (from a settling pond) as applicable. Samples will be analyzed for general chemistry (RCAp-MS), TSS, and field parameters. Visual monitoring of erosion and sedimentation control measures to identify pathways to surface water bodies and wetlands will be conducted through all phases of the Project.

A water level monitoring station will be located on Big Eastern Lake (SW-02). This station will be installed at least one month prior to the commencement of construction and will be monitored on a monthly basis. Water quality samples will also be collected from quarry discharge points to the Big Eastern or Lawrence Lake systems as appropriate to the development of the quarry (SW-01 and SW-08). Additional analysis will be conducted for BTEX-TPH at these two locations. Locations SW-03 and SW-04 are established baseline monitoring sites and the results of continued monitoring will provide commentary of conditions as compared to baseline. SW-07 is potentially only a drainage feature but is included for completeness. The SW-05 baseline monitoring station will continue to be used to monitor water quality on the stream that crosses the access road.

Table 2.1 provides rationale for the location of proposed monitoring stations and suggested parameters for analysis.

Table 2.1 Surface Water Monitoring Locations

Sample Location ID	Rationale	Parameters
SW-01	To monitor potential site run-off to Lawrence Lake tributary	RCAp-MS, TSS, Field (DO, pH, Temp.), BTEX-TPH
SW-02	To monitor water quality, quantity on Big Eastern Lake	RCAp-MS, TSS, Field, Water Levels
SW-03	To monitor water quality on in local area downgradient of site	RCAp-MS, Field
SW-04	To monitor water quality on in local area downgradient of site	RCAp-MS, TSS, Field
SW-05	To monitor water quality downgradient of Access road and upgradient of the Site	RCAp-MS, TSS, Field
SW-07	To monitor water quality on in local area downgradient of site	RCAp-MS, Field
SW-08	To monitor potential site run-off to Big Eastern Lake	RCAp-MS, TSS, Field, BTEX-TPH

Proposed surface water quality monitoring locations are shown on Figure 1.

Groundwater Mitigation and Monitoring

Lowering of the groundwater (GW) table and decreasing domestic well yield is not expected (either temporary or permanent) during the life of the project. The purpose of groundwater monitoring is to document baseline groundwater quality and to determine if there are changes in groundwater quantity and quality (e.g. SWI) associated with the Project. Water samples will be analyzed for general chemistry (RCAP-MS), BTEX-TPH and conductivity (Field parameter) as required by conditions of any environmental or industrial approval. It is proposed that samples will be collected quarterly for the first two years after well installation and then annually thereafter. Water level measurements will be recorded regularly.

Monitoring wells MW-1 and MW-2 will be installed prior to construction. MW-4 will be installed prior to commencement of operation of the quarry. MW-3 will be installed as the quarry approaches the 40 m contour. MW-5 will be installed prior to expanding beyond the proposed 20-yr block of aggregate. The monitoring wells will nested and be installed to top of bedrock/ weathered bedrock surface (estimated to 5 m) and in bedrock to a depth of approximately 20 m below ground surface. Wells will be installed to standard NSE requirements. Table 2.2 provides rationale for the location of proposed monitoring wells and suggested parameters for analysis.

Table 2.2 Groundwater Monitoring Locations

Sample Location ID	Rationale	Parameters
MW-1	To monitor GW quality/quantity adjacent to Big Eastern Lake	RCAp-MS, BTEX-TPH, Water levels, Field (Conductivity)
MW-2	To monitor GW quality/quantity upgradient of Lawrence Lake	RCAp-MS, BTEX-TPH, Water levels, Field
MW-3	To monitor GW quality/quantity upgradient of domestic wells	RCAp-MS, BTEX-TPH, Water levels, Field
MW-4	To monitor water quality/quantity adjacent to potable wells (SWI monitoring)	RCAp-MS, Water levels, Field
MW-5	To monitor GW quality/quantity upgradient of domestic wells	RCAp-MS, Water levels, Field

Water quantity impacts are not predicted for domestic wells. Select baseline domestic water quality surveys may be completed prior to construction to establish baseline conditions. Dexter Construction will maintain a clear line of communication through their Project Manager for domestic well complaints to be recorded and evaluated in accordance with legislation and NSE specific requirements.

Locations of proposed GW monitoring locations are shown on Figure 1.

2.2 Fish Habitat Assessment

"Provide a fish and fish habitat assessment of Big Eastern, East Mushaboom and Lawrence Lakes and related watercourses. Include accompanying discussion and analysis of potential effects on fish and fish habitat and proposed mitigation measures and follow-up monitoring programs based on the results of the assessments. If fish and fish habitat are identified within Big Eastern Lake, evaluate the potential for thermal charging impacts to the lake from settling pond and other stormwater management system discharges and identify and implement mitigation measures to reduce effects."

MacCallum Environmental Limited (MEL) completed additional work at the site and analysis for the additional information request items and prepared a report (Appendix F). Below is the summary and conclusions from the report.

"The Project Team has completed additional analysis to evaluate the hydrological effects of the proposed quarry expansion to fish and fish habitat within waterbodies and watercourses hydrologically connected to the proposed quarry development area. This was achieved through completion of a revised seasonal water balance, and prediction of surface water volume increases and decreases as a result of quarry development. Based on this information, an evaluation of potential effects to fish and fish habitat within down-gradient waterbodies and watercourses as a result of the quarry development was completed. This document discusses mitigation, expected residual effects and significance and recommended follow up monitoring measures.

The following conclusions were determined:

- Six watercourses (WC1-6) and three waterbodies (Big Eastern Lake, East Mushaboom Lake, and Lawrence Lake) receive a direct source of water from the proposed quarry development area.
- The watercourses and waterbodies are subject to predicted increases and decreases in surface water volume as a result of quarry development.
- Predicted changes in flow to WC4, WC5, and WC6 are not expected to negatively affect fish or fish habitat based on the absence of fish habitat and barriers to fish access.
- Based on the habitat conditions present within Big Eastern Lake and WC1, it has been determined that the increases in water flow volume will generate net benefits to fish and fish habitat.
- Predicted changes in flow to East Mushaboom Lake, WC3, and Lawrence Lake are negligible and are not expected to negatively affect fish or fish habitat.
- Although fish habitat quality present within WC2 is limited and potential mitigation of surface water reduction exists in the form of groundwater discharge and bi-directional flow, it has been determined that the proposed decreases in water quantity as a result of quarry development may trigger a Fisheries Authorization. Future consultation with FOC is recommended. However, since the Project will not interact with the East Mushaboom Lake Inlet (WC2) catchment area (CA) until a minimum of 20 years, it is proposed that monitoring of WC2 be initiated one year prior to quarrying extending into the CA, and continue concurrent to quarrying within the CA to further refine potential effects, modify mitigation methods and obtain approvals (if necessary).

Potential for thermal charging was evaluated and it is anticipated that thermal charging of quarry surface water discharge will not be of concern. This statement is based on the several factors:

1. Water balance assessment calculated no water surplus (runoff) during the warmest months of the year (June, July and August).
2. The quarry discharge channels migrate through vegetated areas prior to entering fish habitat, which will provide shading/cooling during the higher temperature months, should discharge occur.
3. Quarry discharge volume is a small percentage of the water bodies identified as potential fish habitat, such that any potential impacts from quarry discharge water will be significantly diluted to negligible levels.

However, through the development of the quarry, surface water monitoring will be completed to identify potential impacts before they become an issue. If thermal charging is identified as a potential issue then mitigation measures will included as part of the settling pond/discharge channel designs. Nova Scotia regulators and quarry operators have a good understanding of thermal charging and mitigative options such as discharge outlet controls (e.g. bottom withdrawal), shading and discharge channel aeration.

The surface water monitoring program will include field temperature recordings and this data can be used to evaluate if thermal charging potential changes as the quarry progresses.

2.3 Site Road Construction

"Provide a description of construction methods, widths and materials for the remainder of the site access road and include an assessment of potential effects to water resources, as well as proposed mitigation measures."

The quarry access road will be an approximately 15 m wide, 5 km long gravel road through a Right of Way (ROW) over Tusket owned lands, from Marine Gateway Drive to the project site (Figure 2). The access road will generally follow existing woods roads, which will be improved and expanded upon to support the operation thereby minimizing new disturbance in the ROW. The access road route includes consideration for avoiding wetlands and minimizing the number or watercourse crossings. A portion (2 km of the roughly 5 km) of the access road ROW has previously been cleared of vegetation, and in-situ materials have been used to construct approximately 2 km of the access road.

The remaining 3 km section of access road has previously been cleared of trees and will be grubbed to remove vegetation, stumps, and boulders prior to road construction. A qualified biologist will be employed to survey for nesting birds in the corridor if grubbing were to occur during the nesting season. Overburden from within the ROW will be used to shape and construct the road profile. Once the quarry has been developed, crushed aggregate will be placed and compacted on the access road for stabilization and to provide the final driving surface. Appropriate ditches and cross drainage culverts will be installed to manage drainage around and runoff from the access road.

Watercourse crossings will be installed at all defined watercourse locations along the access road. The watercourse crossings will be designed, sized, and installed in accordance with the Nova Scotia

Environment Watercourse Alteration Standard, and the established NSE Notification and/or Approval process will be followed.

2.4 Figure 3 Explanation

"Describe the intended use and development of the "Potential Aggregate Resource (above 25 masl)" area identified on Figure 3 of the EA Registration Document and include a discussion of related potential effects, proposed mitigation and follow-up monitoring measures (as necessary)".

Figure 3 in the EARD (and provided herein for completeness of discussion) demonstrates how the quarry footprint was designed based on the following criteria: property/lease boundaries; available aggregate resource given Dexter's quarrying plan; wetland/waterbody locations; and, distances to nearest structures. The criteria where setbacks are required are defined by the Pit & Quarry Guidelines (NSE 1999); namely no quarry works within 30 metres of a public road, property boundary, or watercourse; and no blasting within 800 m of an offsite structure, 30 m from a road or watercourse (high water mark), and 15 m from a property boundary where there is no structure on the abutting property. Water course in the guideline is defined as "the bed and shore of every river, stream, lake, creek, pond, spring, lagoon, or other natural body of water, and the water therein, within the jurisdiction of the Province, whether it contains water or not, and all ground water." It is generally accepted that wetlands also require a 30 m setback in the form of an undisturbed vegetative buffer between the demarcated wetland boundary and quarry operations.

In addition to the aforementioned setbacks, the aggregate resource in the leased area (Project Site), based on Dexter's proposed approach to the site, was identified on Figure 3 as "Potential Aggregate Resource (above 25 masl)" as a parameter to inform the "Quarry Extent (Final)".

There is no intention to quarry any aggregate outside of the proposed "Quarry Extent (Final)" as shown on the Figure and carried throughout the Environmental Assessment Registration Document.

All of Which is Respectfully Submitted,

GHD

Jeff Parks, P.Geo.

Peter Oram, P.Geo.

Source: Service Nova Scotia, GHD

0 250 500 750

Metres

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

N

GHD

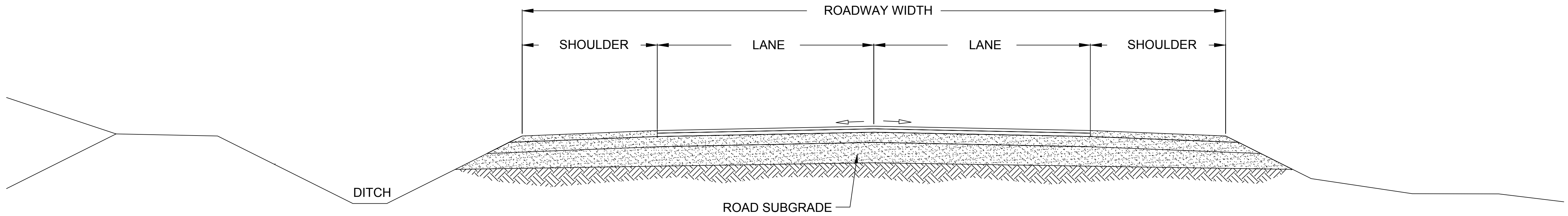
DEXTER CONSTRUCTION CO. LTD
SHEET HARBOUR, NOVA SCOTIA
EA ADDITIONAL INFORMATION

PROPOSED OPERATIONAL MONITORING LOCATIONS

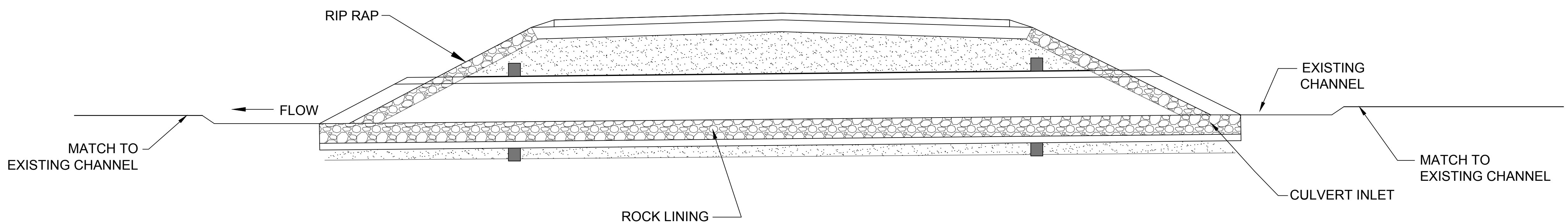
111411046 (003)
Sep 13, 2019

FIGURE 1

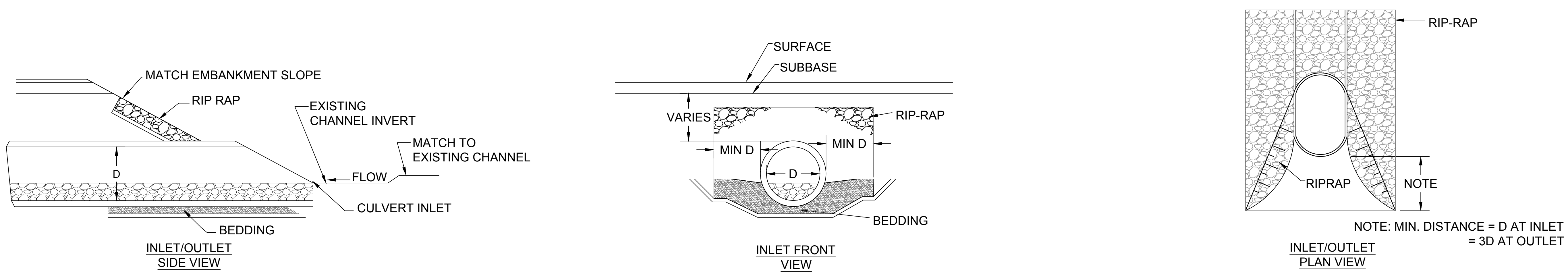
GIS File: I:\GIS_DATA\Projects\8-chars\1114----\11141046 Dexter\11141046-REPORTS\11141046(003)\11141046-14(003)_GIS-HX001.mxd



DETAIL 1 TYPICAL GRAVEL ACCESS ROAD CROSS SECTION
NOT TO SCALE



DETAIL 2 TYPICAL CULVERT PROFILE
NOT TO SCALE



DETAIL 3 TYPICAL CULVERT END TREATMENT DETAILS
NOT TO SCALE

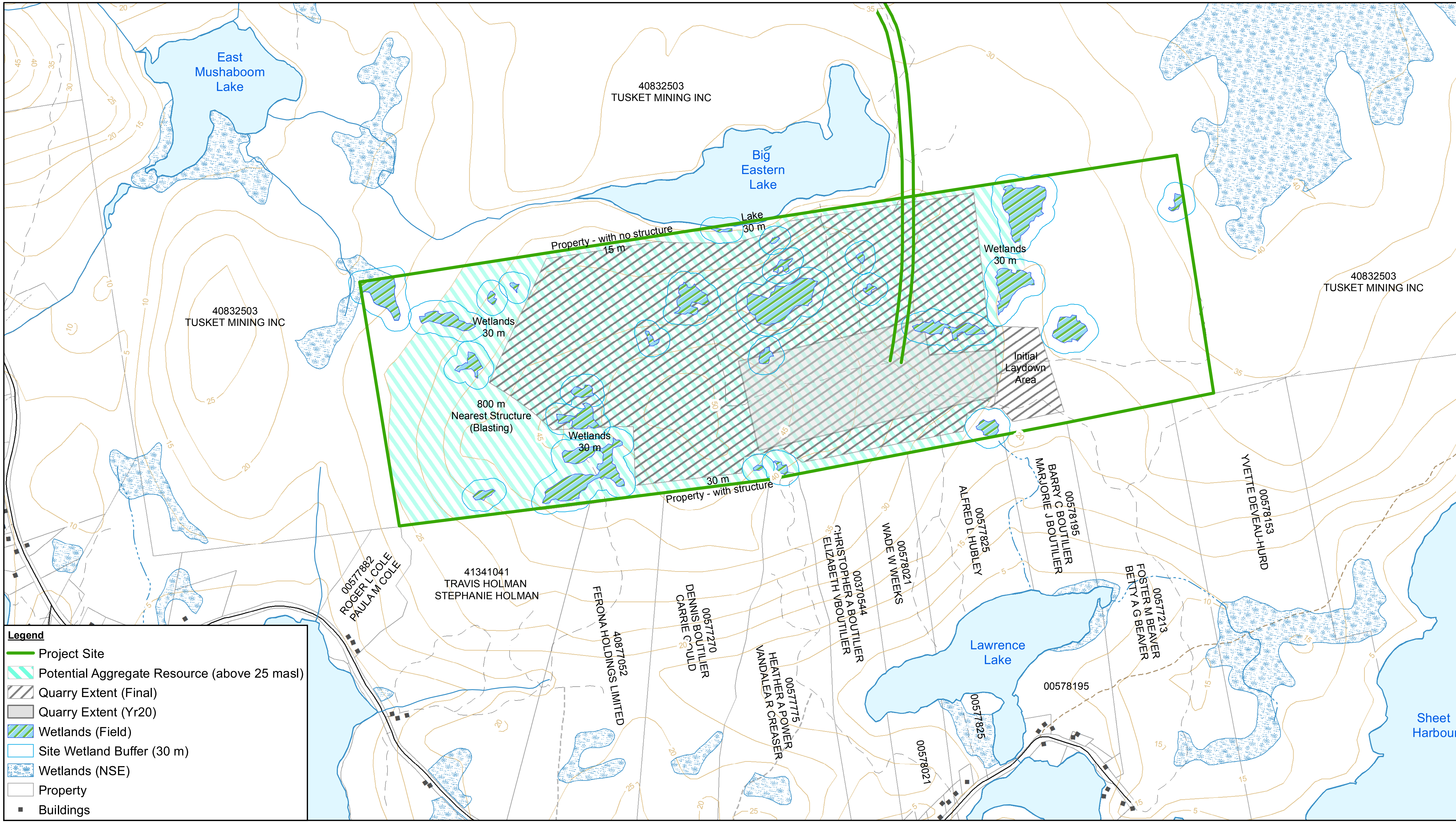
DEXTER CONSTRUCTION CO. LTD.
SHEET HARBOUR, NOVA SCOTIA
EA ADDITIONAL INFORMATION

TYPICAL ROAD AND CULVERT DETAILS

11141046-14
Jul 4, 2019

FIGURE 2

CAD File: I:\GIS_DATA\Projects\8-chars\1114----\11141046 Dexter\11141046-REPORTS\11141046(003)\11141046-14(003)GN-HX001.dwg



Source: Service Nova Scotia

0 100 200 300
Metres

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

N

GHD

DEXTER CONSTRUCTION COMPANY LIMITED
SHEET HARBOUR, NOVA SCOTIA
SHEET HARBOUR QUARRY EA

11141046 (001)
Jan 11, 2019

QUARRY RESOURCE AND SETBACKS

FIGURE 3

GIS File: I:\GIS_DATA\Projects\8-chars\1114----\11141046 Dexter\11141046-REPORTS\11141046(001)\11141046(001)_GIS-DA003.mxd

Appendices

Appendix A
Minister's Request for Additional Information

NOVA SCOTIA
Environment
Office of the Minister

PO Box 442, Halifax, Nova Scotia, Canada B3J 2P8 • www.gov.ns.ca/nse

our file number:
40100-30-292

MAR 2 2 2019

Gary Rudolph
Dexter Construction Company Limited
Box 48100
Bedford, Nova Scotia
B4A 3Z2

Dear Gary Rudolph:

Re: Environmental Assessment – Dexter Construction Company Limited
Sheet Harbour Aggregate Quarry Project, HRM, Nova Scotia

The environmental assessment (EA) of the proposed Sheet Harbour Aggregate Quarry Project (the Project) in Halifax Regional Municipality, Nova Scotia has been completed.

This letter is to advise that, pursuant to Section 13 (1)(a) of the Environmental Assessment Regulations, I have determined that the Registration Document provided is insufficient to allow me to make a decision, and that I require additional information. Specifically, the review determined that the following additional information is required in order to evaluate potential environmental effects that may be caused by the undertaking:

1. Provide additional details for the water resources assessment with accompanying discussion and analysis of potential effects to surface water resource quality and quantity (i.e., Big Eastern, East Mushaboom and Lawrence lakes and related watercourses and watersheds), wetlands and groundwater quality and quantity that includes the following:

    a. An updated water balance based on appropriate and justified infiltration rates, evapotranspiration rates, groundwater-surface water flow interactions and site grading plans.

    b. A quantitative groundwater numerical model for this site and surrounding area, including existing water supply wells and coastline within 2 km of the property boundaries. The model is to assess groundwater flows under the site development scenarios. The model should also integrate surface water features and properties, as well as the capability to assess density differences (seawater compared to freshwater/groundwater) and the process of seawater intrusion at the coastal groundwater-seawater interface. The model should provide a quantitative evaluation of the coastal seawater intrusion interface under the progressive site development scenarios, particularly in relation to the risk of seawater intrusion contamination to existing water supply wells along the coast. The groundwater model should be properly calibrated, include a sensitivity analysis, and be validated with water level observations.

c. A surface water quality assessment based on the results of the revised water balance, in conjunction with applicable baseline surface water quality data from Big Eastern, East Mushaboom and Lawrence lakes and related watercourses and watersheds.

d. A discussion of proposed mitigation measures and follow-up monitoring programs based on the results of the assessments.

2. Provide a fish and fish habitat assessment of Big Eastern, East Mushaboom and Lawrence lakes and related watercourses. Include accompanying discussion and analysis of potential effects on fish and fish habitat and proposed mitigation measures and follow-up monitoring programs based on the results of the assessments. If fish and fish habitat are identified within Big Eastern Lake, evaluate the potential for thermal charging impacts to the lake from settling pond and other stormwater management system discharges and identify and implement mitigation measures to reduce effects.

3. Provide a description of construction methods, widths and materials for the remainder of the site access road and include an assessment of potential effects to water resources, as well as proposed mitigation measures.

4. Describe the intended use and development of the "Potential Aggregate Resource (above 25 masl)" area identified on Figure 3 of the EA Registration Document and include a discussion of related potential effects, proposed mitigation and follow-up monitoring measures (as necessary).

This information must be submitted by Dexter Construction Company Limited within one year, as an addendum to the original Registration Document. Upon submission of the information, I will have 50 days to make my decision.

If you have any questions regarding this decision, please contact Helen MacPhail, Supervisor, Environmental Assessment Branch, at (902) 483-2696 or via email at Helen.MacPhail@novascotia.ca.

Sincerely,

Margaret Miller, MLA
Minister of Environment

c: Lynn Bowen
Helen MacPhail

Appendix B
Revised Sheet Harbour Water Balance Analysis

Memorandum

August 16, 2019

To:	Gavin Isenor, P.Geo.	Ref. No.:	11141046
From:	Andrew Betts/Chris Muirhead/aj/1	Tel:	519-340-4101
cc:	Jeff Parks, Peter Oram		

Subject: Revised Sheet Harbour – Water Balance Analysis

1. Background

The following technical memorandum summarizes the water balance assessment completed for the proposed Dexter Sheet Harbour Quarry (Project) located near Mushaboom, Nova Scotia. The proposed Project Site comprises 80 hectares (ha) of forested land that is in varying degrees of re-growth due to Hurricane Juan damage and historic logging activity. There are no streams within the Project Site, however, the Site is adjacent to Big Eastern Lake to the north and does contribute surface water runoff to surrounding wetlands and lakes (i.e., Lawrence Lake and East Mushaboom Lake).

The water balance presented here is a preliminary assessment of the predicted effects on surrounding surface waterbodies caused by development of the quarry area. Four site conditions were analyzed; existing (baseline) conditions; mid-life quarry conditions (~20 years into quarry operations); end-of-quarry (EOQ) conditions; and, reclamation conditions. In the mid-life quarry conditions, at 15 ha in developed area, the quarry is approximately 20% of the full proposed extent. EOQ conditions consider the quarry at full development of 81 ha. EOQ conditions are expected to occur at approximately 50 years. Reclamation conditions are representative of the site upon removal of all construction equipment and buildings and after re-contouring and introducing plant material to the seeding and planting of the property. As such these represent “worst case” as some degree of progressive reclamation will happen as site development occurs.

Due to the range of infiltration rates possible and associated changes in surface water movement caused by quarry development, the water balance assessment was completed for two infiltration potential scenarios for the mid-life quarry and EOQ situations. The two infiltration scenarios represent the range of possible outcomes from existing infiltration (most likely infiltration) to 100% impervious (worse-case no-infiltration).

1.1 Data Collection

1.1.1 Topographic Data

A 5 meter (m) contour dataset, collected from the Nova Scotia Enhanced Topographic Database – GeoNova, was used to delineate the watershed areas for the Project Site in combination with the Nova

GHD
455 Phillip Street Unit #100A Waterloo Ontario N2L 3X2 Canada
T 519 884 0510 **F** 519 884 0525 **W** www.ghd.com

Scotia Lake Survey Program (Nova Scotia, 2017). The contours were assessed manually and compared with existing watershed delineations from the Lake Survey Program to delineate watersheds during the four analyzed scenarios.

1.1.2 Climate Data

Precipitation totals were obtained from the Environment Canada Malay Falls Climate Station (Climate ID 8203400 and 8203405) from 1950-2007. Records from 1950-2000 were obtained from Station 8203400. The gauge was then replaced by Station 8203405 with a record from 2000-2007. These stations are in the same geographic location. These stations were selected based on its proximity to the Project Site, approximately 15 kilometres (km) from the Site, and relatively long record. Total monthly precipitation values for the period of record were averaged to determine the average precipitation depths for the Project area. Monthly lake evaporation normals were obtained from the Environment Canada Truro Station (Climate ID 8205990) for the period of 1981 to 2010. The Truro station is the closest climate station to the Project Site that collects lake evaporation data. The Truro station is approximately 82 km away from the project site. Monthly potential evapotranspiration normals were calculated using the Hamon equation (1961) (Lu et al., 2005). The Hamon equation requires monthly average hours of daylight and monthly average temperature as input. Monthly average hours of daylight were calculated for the Site using the Sunrise and Sunset Calculator (https://www.timeanddate.com/sun/, last accessed 24 May 2019). Monthly average temperature values were obtained from the Environment Canada Malay Falls Station.

Table 1.1 presents temperature, total precipitation, potential evapotranspiration and lake evaporation rates that are used in the analysis.

Table 1.1 Climate Normals (Data taken from Malay Falls and Truro Environment Canada Climate Stations)

	January	February	March	April	May	June	July	August	September	October	November	December
Temperature[1] (°C)	-5.50	-5.38	-1.41	3.72	8.95	14.13	18.00	18.18	14.66	8.9	3.98	-1.62
Precipitation[1] (mm)	140.3	126.8	133.0	123.4	125.2	67.1	94.3	92.9	112.1	140.6	170.4	143.3
Lake Evaporation[2] (mm)	0.0	0.0	0.0	0.0	89.9	102.0	117.8	96.1	69.0	40.3	0.0	0.0
PET[3] (mm)	0.0	0.0	0.0	36.6	56.2	77.7	98.2	91.0	63.4	40.1	25.7	0.0

Notes:
1 Values obtained from the Malay Falls climate station 8203400
2 Values obtained from the Truro climate station 8205990
3 Potential Evapotranspiration was calculated using the Hamon equation (1961), (Lu et al., 2005)

2. Methodology

GHD developed a preliminary water balance assessment to assess the potential environmental impacts of the proposed Project from existing conditions to mid-life of the quarry (20-year), EOQ conditions and reclamation conditions. The assessment was developed to determine the yearly changes to flow composition during an average year for the four site conditions, and two impervious scenarios mentioned previously.

2.1 Watershed Delineation

The area surrounding the Project site was delineated into five watersheds: Powers Cove SE (44.18 ha), Powers Cove NW (63.36 ha), Lawrence Lake (227.67 ha), Big Eastern Lake (187.56 ha), and East Mushaboom Lake (685.00 ha). Big Eastern Lake watershed is a subwatershed to the East Mushaboom Lake watershed.

The contributing watershed areas were delineated using manual methods within a GIS environment utilizing the 5 metre (m) topographic data set. Final watershed boundaries were verified through comparison with the East Mushaboom Lake watershed map from the Nova Scotia Lake Mapping tool (Nova Scotia, 2017). Watershed delineations are presented based on four life-cycle phases of the proposed quarry: Figure 1, Baseline Watershed Delineation; Figure 2, 20-Year (Mid-life) Quarry Life Cycle Watershed Delineation; Figure 3, 50-Year (End of Quarry); and Figure 4, Reclamation. It should be noted the drainage from EOQ conditions to Reclamation conditions is expected to remain constant. As such watershed areas from EOQ conditions to Reclamation conditions do not change.

During EOQ and reclamation conditions, water which falls on the quarry is split between Big Eastern Lake subwatershed and Lawrence Lake watershed. This watershed boundary was delineated to replicate existing conditions as much as possible and minimize the change to the hydrologic regime. If required, the quarry floor elevation can be contoured so that drainage flows to either Big Eastern Lake or Lawrence Lake watersheds as needed throughout quarry development in order to reduce the impact to the existing hydrologic regime.

2.2 Evaporation & Evapotranspiration Potential

Evaporation describes the process of the return of moisture to the atmosphere from open water and land surfaces. Evaporation from plant surfaces is called evapotranspiration. The magnitude of evaporation or evapotranspiration over time is a function of the climate, soil and the vegetation in the area. Evaporation rates tend to peak in the summer months when temperatures are highest, daylight hours are longest, sun intensity is greatest and the growing season is at its peak.

Lake evaporation is the amount of evaporation from an open water body. In Atlantic Canada, lake evaporation rate is greater than the standard evaporation rate because of the constant availability of water. For this analysis, lake evaporation rates from a weather station in Truro, Nova Scotia were used. The total annual lake evaporation rate is 515 millimetres (mm) per year. July represents the month with the highest lake evaporation rate on average, at 117.8 mm per month. Lake evaporation rates are only reported for the months of May to October. The temperature during the winter months of November, December, January, February and March are typically below zero degrees during which time there may be little to no evaporation.

Table 1.1 provides a summary of the lake evaporation rates used as a water loss parameter in the water balance assessment.

Evapotranspiration rates were calculated using the Hamon equation (1961) as described in Section 1.1.2 based on average monthly temperature and daylight hours. Potential evapotranspiration rates for the 5 months of December to March were set to zero due to low temperatures resulting in minimal potential for evapotranspiration. The total potential evapotranspiration rate used for this water balance is 488 mm per year. July represents the month with the highest lake evaporation rate on average, at 98.2 mm per month. Table 1.1 provides a summary of the potential evaporation rates used as a water loss parameter in the water balance assessment

Lake evaporation rates were applied to areas with year-round standing water while potential evapotranspiration rates were applied to all other areas. Year-round standing water was determined by analyzing aerial photographs and previously delineated wetlands and lakes near the project site.

2.3 Infiltration Factor

The water storage/infiltration has been estimated using the infiltration factors taken from Table 3.1 from the Ontario Ministry of Environment, Conservation and Parks (OMECP) SWM planning and Design Manual (2003). Calculations using OMECP (2003) Table 3.1 accounts for slope, soil types, and vegetation cover when estimating water holding capacity for an area. Each watershed was individually analyzed to determine the slope, land use and soil type drainage factors. If multiple slope or land use segments existed within a watershed an area-ratio method was used to determine the appropriate infiltration factor. During existing conditions the watersheds in the project site were determined to be hilly land (0.1 infiltration factor) with partial woodland (0.15) and imperfectly drained Sandy Loam soil (0.15). The soil in the area was determined through the Nova Scotia Soil Survey and imperfect drainage occurs due to the high elevation of bedrock in the area (Nova Scotia Museum, 1996).

Two scenarios were assessed for the infiltration conditions during mid-life and EOQ conditions; an impervious quarry floor where no infiltration occurred through the bed of the quarry; and a pervious quarry floor consisting of similar infiltration capabilities to existing surficial soils (imperfectly drained Sandy Loam). Due to the well-drained nature of the surficial soils and the presence of bedrock near the ground surface it is unlikely the soil will have greater infiltration at the base of the quarry than the existing surface. As such, these two scenarios present the maximum and minimum values for expected infiltration in the quarry. These two scenarios provide a range of potential outcomes as a result of quarry development. New infiltration parameters for these scenarios were computed based on an area-ratio method.

Reclamation conditions were expected to be similar to existing conditions with the exception of Flat Land (0.3) and Cultivated Land (0.1) in the area where the quarry was located. An area-ratio method was applied to determine the appropriate infiltration factor for slope and land use in the watersheds with multiple different slope and land use segments. This was mostly used for the watersheds containing the proposed quarry.

Runoff volumes for this water balance were assumed to equal the total precipitation less the potential evapotranspiration, lake evaporation and infiltration. Groundwater recharge was not included in this water balance.

3. Results

Table 3.1, Table 3.2, Table 3.3, Table 3.4, Table 3.5 and Table 3.6 present of the water balance analysis during existing, mid-life, EOQ and reclamation conditions respectively. Table 3.7, Table 3.8, Table 3.9, Table 3.10 and Table 3.11 display the percentage change in area, runoff and infiltration from existing conditions to mid-life, EOQ and reclamation conditions respectively. It can be noted during mid-life conditions Powers Cove SE and Powers Cove NW watersheds remain untouched from quarry activities and therefore do not experience any change to the area, runoff or infiltration. In Table 3.7, Table 3.8, Table 3.9, Table 3.10 and Table 3.11 a negative value represents a decrease in the value compared to existing condition and a positive value represents an increase in the value compared to existing conditions.

Table 3.1 Water Balance - Existing Conditions

Watershed	Area (ha)	Runoff (m^3)	Evaporation (m^3)	PET (m^3)	Infiltration (m^3)
Powers Cove SE	44.18	221,349	7,567	208,780	147,566
Lawrence Lake	227.67	1,140,700	117,618	1,001,311	760,467
Big Eastern Lake	201.15	1,007,817	143,723	846,889	671,878
Powers Cove NW	63.36	317,451	9,468	300,738	211,634
East Mushaboom Lake	683.45	3,424,274	376,538	2,983,577	2,282,849

Table 3.2 Water Balance - Mid-life Quarry Conditions – Impervious Floor

Watershed	Area (ha)	Runoff (m^3)	Evaporation (m^3)	PET (m^3)	Infiltration (m^3)
Powers Cove SE	44.18	221,349	7,567	208,780	147,566
Lawrence Lake	229.97	1,152,229	117,345	1,012,818	768,152
Big Eastern Lake	198.91	996,614	143,357	836,306	664,410
Powers Cove NW	63.36	317,451	9,468	300,738	211,634
East Mushaboom Lake	681.17	3,412,861	376,167	2,972,794	2,275,241

Table 3.3 Water Balance - Mid-life Quarry Conditions – Pervious Floor

Watershed	Area (ha)	Runoff (m^3)	Evaporation (m^3)	PET (m^3)	Infiltration (m^3)
Powers Cove SE	44.18	221,349	7,567	208,780	147,566
Lawrence Lake	229.97	1,133,002	117,345	1,012,818	787,379
Big Eastern Lake	198.91	996,614	143,357	836,306	664,410
Powers Cove NW	63.36	317,451	9,468	300,738	211,634
East Mushaboom Lake	681.17	3,412,861	376,167	2,972,794	2,275,241

Table 3.4 Water Balance - EOQ Conditions – Impervious Floor

Watershed	Area (ha)	Runoff (m^3)	Evaporation (m^3)	PET (m^3)	Infiltration (m^3)
Powers Cove SE	42.05	210,682	7,567	198,372	140,455
Lawrence Lake	236.38	1,184,329	114,775	1,046,577	789,553
Big Eastern Lake	211.02	1,057,269	133,025	905,290	704,846
Powers Cove NW	60.65	303,863	7,871	288,997	202,576
East Mushaboom Lake	679.82	3,406,077	364,670	2,977,086	2,270,718

Table 3.5 Water Balance - EOQ Conditions – Pervious Floor

Watershed	Area (ha)	Runoff (m^3)	Evaporation (m^3)	PET (m^3)	Infiltration (m^3)
Powers Cove SE	42.05	210,682	7,567	198,372	140,455
Lawrence Lake	236.38	1,099,537	114,775	1,046,577	874,346
Big Eastern Lake	211.02	991,540	133,025	905,290	770,575
Powers Cove NW	60.65	303,863	7,871	288,997	202,576
East Mushaboom Lake	679.82	3,340,348	364,670	2,977,086	2,336,447

Table 3.6 Water Balance - Reclamation Conditions

Watershed	Area (ha)	Runoff (m^3)	Evaporation (m^3)	PET (m^3)	Infiltration (m^3)
Powers Cove SE	42.05	210,682	7,567	198,372	140,455
Lawrence Lake	236.38	1,081,907	114,775	1,046,577	891,975
Big Eastern Lake	211.02	991,540	133,025	905,290	770,575
Powers Cove NW	60.65	303,863	7,871	288,997	202,576
East Mushaboom Lake	679.82	3,340,348	364,670	2,977,086	2,336,447

Table 3.7 Mid-life Impervious Quarry Conditions Comparison to Existing Conditions

Watershed	%Area Change	%Runoff Change	%Infiltration Change
Powers Cove SE	0.00%	0.00%	0.00%
Lawrence Lake	1.01%	1.01%	1.01%
Big Eastern Lake	-1.11%	-1.11%	-1.11%
Powers Cove NW	0.00%	0.00%	0.00%
East Mushaboom Lake	-0.33%	-0.33%	-0.33%

Table 3.8 Mid-life Pervious Quarry Conditions Comparison to Existing Conditions

Watershed	%Area Change	%Runoff Change	%Infiltration Change
Powers Cove SE	0.00%	0.00%	0.00%
Lawrence Lake	1.01%	-0.67%	3.54%
Big Eastern Lake	-1.11%	-1.11%	-1.11%
Powers Cove NW	0.00%	0.00%	0.00%
East Mushaboom Lake	-0.33%	-0.33%	-0.33%

Table 3.9 EOQ Impervious Conditions Comparison to Existing Conditions

Watershed	%Area Change	%Runoff Change	%Infiltration Change
Powers Cove SE	-4.82%	-4.82%	-4.82%
Lawrence Lake	3.82%	3.82%	3.82%
Big Eastern Lake	4.91%	4.91%	4.91%
Powers Cove NW	-4.28%	-4.28%	-4.28%
East Mushaboom Lake	-0.53%	-0.53%	-0.53%

Table 3.10 EOQ Pervious Conditions Comparison to Existing Conditions

Watershed	%Area Change	%Runoff Change	%Infiltration Change
Powers Cove SE	-4.82%	-4.82%	-4.82%
Lawrence Lake	3.82%	-3.61%	14.97%
Big Eastern Lake	4.91%	-1.62%	14.69%
Powers Cove NW	-4.28%	-4.28%	-4.28%
East Mushaboom Lake	-0.53%	-2.45%	2.35%

Table 3.11 Reclamation Conditions Comparison to Existing Conditions

Watershed	%Area Change	%Runoff Change	%Infiltration Change
Powers Cove SE	-4.82%	-4.82%	-4.82%
Lawrence Lake	2.79%	-5.15%	17.29%
Big Eastern Lake	6.09%	-1.62%	14.69%
Powers Cove NW	-4.28%	-4.28%	-4.28%
East Mushaboom Lake	-0.20%	-2.45%	2.35%

4. Conclusions

The results from the water balance analysis can be used to assess the potential impact of the proposed quarry development on the receiving environment in terms of the change in runoff volume discharged to Big Eastern Lake, East Mushaboom Lake and Lawrence Lake.

Powers Cove SE and Powers Cove NW are unaffected by quarry construction during the mid-life scenario and have 0% change in area, runoff and infiltration. Under EOQ and Reclamation conditions Powers Cove SE and Powers Cove NW watersheds experience a decrease in watershed area of 4.82% and 4.28% respectively. Infiltration parameters remain unchanged from existing. As such the percent change of runoff and infiltration remains proportional to percent area change, decreasing by 4.82% for Powers Cove SE and 4.28% for Powers Cove NW. These changes are not significant in terms of possible impacts to the lake's function.

Lawrence Lake experiences a 1.01%, 3.82% and 2.79% increase in area during the mid-life, EOQ and Reclamation scenarios respectively. The worst-case scenario for Lawrence Lake is an impervious floor during both mid-life and EOQ conditions. An impervious quarry floor results in a 1.01% increase in runoff during mid-life conditions and a 3.82% increase in runoff for EOQ conditions. Reclamation conditions result in a 5.15% decrease in runoff from existing conditions. These changes are not significant in terms of possible impacts to the lake's function. The increase in runoff volume may result in a peak monthly increase in lake levels of approximately 0.02 m and 0.06 m during mid-life and EOQ conditions, respectively.

Big Eastern Lake experiences a 1.11% decrease in area during the mid-life conditions, 4.91% increase for EOQ conditions and a 6.09% increase in area during reclamation conditions. The quarry extents do not drain to Big Eastern Lake subwatershed during mid-life conditions and as such % Runoff Change and % Infiltration Change are proportional to % Area Change at 1.11% decrease. The worse-case scenario for Big Eastern Lake is an impervious quarry floor during EOQ conditions. An impervious floor results in a 4.91% increase in runoff during EOQ conditions. Big Eastern Lake watershed also experiences a 1.62% decrease in runoff during reclamation conditions. These changes are not significant in terms of possible impacts to the lake's function. The decrease in runoff volume during mid-life conditions may result in a peak monthly decrease in lake levels of approximately 0.01 m. The increase in runoff volume during EOQ conditions may result in a peak monthly increase in lake levels of approximately 0.06 m.

East Mushaboom Lake watershed contains the Big Eastern Lake subwatershed and experiences similar trends. During mid-life conditions % Runoff Change and % Infiltration Change are proportional to % Area Change with a 0.33% decrease. During EOQ conditions East Mushaboom Lake experiences a 0.53% decrease in area. The pervious scenario is the worst-case scenario for East Mushaboom Lake EOQ conditions. A pervious quarry floor results in a 2.45% decrease in runoff to East Mushaboom Lake. During reclamation conditions East Mushaboom Lake watershed experiences a 0.2% decrease in area and a 2.45% decrease in runoff from existing conditions. These changes are not significant in terms of possible impacts to the watershed function. The increase in runoff volume may result in a peak monthly increase in lake levels of approximately 0.02 m and 0.03 m during mid-life and EOQ conditions, respectively.

It can be seen that the mid-life quarry operations have minimal impact on the receiving water bodies with a maximum change in runoff percentage of 1.11% in the Big Eastern Lake watershed. EOQ conditions impacts are also minimal with the largest runoff change occurring in the Big Eastern Lake watershed with a 4.91% decrease. The reclamation scenario also does not see significant changes to the hydrologic regime with the largest change occurring in the Lawrence Lake watershed at a 5.15% decrease in runoff.

When discussing the results of this water balance it should be noted that this quarry will be developed over the course of approximately 50 years. The mid-life scenario is presented as the likely 20-year extent of the quarry. The lengthy duration of development will allow the surrounding environment to slowly adjust to changes in the hydrologic regime.

5. References

Lu et al. (2005). A comparison of six potential evapotranspiration methods for regional use in the southeastern United States. Journal of the American Water Resources Association, 41, 621-633

Ministry of the Environment. (2003). Stormwater Management Planning and Design Manual.

Nova Scotia (2017). Nova Scotia Lake Survey Program: Lake Mapping Tool.

Nova Scotia Museum (1996). The Natural History of Nova Scotia, Volume 2: Theme Regions. Pg. 201-202.

Time & Date – Sunrise, Sunset and Daylength (2019, May 24). Retrieved from https://www.timeanddate.com/sun/@6084793

Appendix C
Groundwater Model Discussion

Memorandum

August 14, 2019

To:	Gavin Isenor, P.Geo.	Ref. No.:	11141046-14
From:	Alan Deal, P.Geo./tj/3	Tel:	902.814.3635
CC:	Jeff Parks, Peter Oram		

Subject: **Sheet Harbour Quarry – Groundwater Model Discussion**

1. Background

Concerns were raised by Nova Scotia Environment (NSE) during the public comment period with respect to impact to groundwater from the proposed quarry associated with potential for recharge reductions thereby increasing the potential for salt-water intrusion along the coast. These concerns have been examined in detail and in summary are valid and present but in a low concern category from a technical perspective as outlined below. A monitoring program has been developed that will help to confirm this through collection of data, analysis of the data and presentation of the data and analysis to NSE and other parties as requested.

2. Groundwater Model Discussion

NSE, in the Minister's Decision, identified a need to compete additional analysis and construct a quantitative groundwater flow model for the proposed quarry and surrounding area, including existing water supply wells and coastline within 2 km of the property boundaries. Our additional analysis of available data and the surface water balance (presented in Appendix C) shows that a groundwater model does not need to be completed as the potential for the proposed quarry to affect groundwater is very low.

Factors that mitigate any potential reduction in groundwater levels include:

- The proposed quarry will not extend below the water table
- There will be no groundwater extraction in the quarry
- The relatively low hydraulic conductivity of the Goldenville Group rocks will limit any change in groundwater elevations to the immediate vicinity of the quarry
- The surface water balance analysis predicts changes in infiltration will not be significant to surface water and groundwater regimes
- Ongoing monitoring during the relatively long time span of the quarry operation will permit implementation of mitigation measures to address any changes in groundwater levels, if identified through the monitoring program

These factors as discussed in more detail below.

The groundwater elevation near the proposed quarry is similar to the elevation of Big Eastern Lake, approximately 24 m above mean sea level (AMSL). The quarry will not extend below 25 m AMSL and there will be no groundwater extraction (pumping) in the quarry. Therefore, the quarry will not directly interact with the water table.

The relatively low yield of domestic water wells in the general site vicinity are consistent with regional trends and confirm the relatively low hydraulic conductivity of the Goldenville Group rocks. In general, low hydraulic conductivity limits the distance over which changes in groundwater levels can be induced. The closest domestic wells are more than 1 km from the proposed quarry. Any change in groundwater elevations will be restricted to the immediate vicinity of the proposed quarry. Given this separation and that no groundwater extraction is planned for the proposed quarry, it is more likely that the individual domestic wells in Mushaboom will interfere with each other than they will be impacted by the proposed quarry.

GHD completed a surface water balance analysis that included an assessment of the potential for the proposed quarry to alter infiltration. The analysis included a worst-case scenario where the end of quarry conditions consider the quarry at full development of 81.5 ha. This scenario does not include any progressive reclamation during the proposed 50+ years of operation. Under these conditions, the water balance analysis predicted that infiltration will be increased in some areas and decreased in others. The maximum predicted decrease in infiltration is less than 5 percent. The water balance analysis concludes, *"These changes are not significant in terms of possible impacts to the lake's function."* Conceptually the various lakes surrounding the quarry are expressions of the water table. Therefore, because of the interaction between groundwater and surface water, the minimal changes in infiltration mean that changes in groundwater recharge will also be minimal. In addition, if the levels in the lakes between the proposed quarry and the domestic wells are maintained, the groundwater-surface water interaction should continue unchanged and groundwater levels between the lakes and domestic wells will not be impacted.

Dexter is proposing to install nested monitoring wells in the immediate vicinity of the proposed quarry to monitor groundwater levels. If a reduction in groundwater levels is observed, mitigation measures such as re-contouring the quarry floor elevation to promote groundwater recharge and/or installing infiltration ponds can be implemented to reduce any identified impact to groundwater levels. In addition, portions of the quarry can be reclaimed during quarry operations if groundwater levels are observed to decrease.

3. Conclusion

Therefore, instead of attempting to predict impacts with a quantitative groundwater flow model, it is more appropriate to document current conditions and mitigate any gradual changes that might be observed.

Appendix D
Evaluation of Potential Coastal Seawater Intrusion to Domestic Wells

Memorandum

August 16, 2019

To:	Gavin Isenor, P.Geo.	Ref. No.:	11141046-14
From:	Alan Deal, P.Geo, Jeff Parks, P.Geo.	Tel:	902-334-1819
CC:	Peter Oram, P.Geo.		
Subject:	**Evaluation of Potential Coastal Seawater Intrusion to Domestic Wells**		

1. Introduction

Seawater (or saltwater) intrusion (SWI) is the movement of seawater (saline) into a freshwater aquifer. Under normal conditions, fresh water flows from inland aquifers and recharge areas, such as the proposed quarry location, to coastal discharge areas due to the difference in elevation of "upland" areas and the lower coastline. Seawater intrusion is common and affects many coastal communities, such as Mushaboom. This natural movement of fresh water towards the ocean prevents from entering freshwater coastal aquifers (Barlow, 2003). Freshwater is less dense than seawater so it will float on top, forming a lens. The boundary between salt water and fresh water is not distinct; the zone of dispersion, transition zone, or seawater interface is brackish with salt water and fresh water mixing. In fractured bedrock, such as at the Site, the interface is even more irregular and mainly dependent on fracture orientation and depth.

Groundwater extraction causes a lowering of water levels which draws the seawater – freshwater interface inland and potentially impacts near coast drinking water wells. SWI is also influenced by factors such as tidal fluctuations, long-term climate and sea level changes, fractures in coastal rock formations and seasonal changes in evaporation and recharge rates.

2. Hydrogeologic Conditions

Nova Scotia receives abundant precipitation (~1470 mm/a at Malay Falls - Climate Station 8203405) (Environment Canada 2019) and projections indicate that this may increase with the effects of climate change (Zhang et al 2019). Groundwater resources are not overly susceptible to seawater intrusion in Nova Scotia. Glacial till is present either near or at the surface in most areas of the province. The relatively low permeability of this material increases the slope of the water table, thus forcing the freshwater-seawater interface further seaward (Ferguson and Beebe 2013). The extent of SWI in the Goldenville Group rocks is dependent on the connectivity between seawater and the groundwater bearing fractures in the rocks. The model of vulnerability developed by the Province provides a snapshot of areas that may be at risk to seawater intrusion; however, the results of the model in some areas may be difficult to characterize due to the lack of available well water chemistry and water level monitoring data relative to the extent of unserviced coastline (Kennedy 2012).

The provincial SWI vulnerability model was developed on a 250 m grid and based on several input layers and rankings: distance to coastline, slopes calculated from the 20 m elevation, civic address (residential) locations, large groundwater users, and water level elevation relative to mean sea level (Kennedy 2012). In the area of the project at Mushaboom, the model does not provide conclusive results since the area around the quarry being classed as “Not evaluated” is due mostly to the lack of water level data (Figure 1). The model should be considered a screening tool in assessing the potential for SWI and not a definitive discussion on the subject (pers. comm. G. Kennedy May 31, 2019).

Figure 2 shows a cross section through the proposed quarry with the SWI index added (Kennedy & McKinnon 2013) (see also figure 10 of the EARD for the original drawing). The groundwater elevation at the proposed quarry is similar to the elevation of Big Eastern Lake, approximately 24 m above mean sea level (AMSL). The quarry will not extend below 25 m AMSL and there will be no groundwater extraction in the quarry. Precipitation that collects in the quarry will naturally drain to a settling pond(s) and either infiltrate into the subsurface or evaporate. Since no pumping of groundwater/quarry water will occur, site activities will not generally affect the groundwater level near the quarry. The relatively low hydraulic conductivity of the Goldenville Group rocks will also limit any change in groundwater elevations near the closest domestic wells at the coast, more than 1 km downgradient.

The cross section also shows an “average” (60 m deep) private drilled well at Mushaboom (range 26.5 to 90 m depth) (NSE 2017). The private wells drilled into the bedrock are located along the coast where ground surface elevations are approximately 5 to 10 m AMSL. Static groundwater level were reported in the range of 3 to 7 metres, or slightly above sea level. Groundwater flows from the vicinity of the quarry in a radial pattern and discharges into Big Eastern Lake, other surface water bodies, such as Lawrence Lake and the ocean.

Given the lateral separation, the poor hydraulic connection and the presence of surface water bodies between the quarry and the domestic wells, the quarry operations will have minimal, if any, impact on groundwater levels in Mushaboom. In fact, other factors such as sea level rise, changes in climate (primarily precipitation) and increased residential housing development and therefore more groundwater extraction is more likely to cause seawater intrusion than the proposed quarry.

3. Proposed Monitoring Program

GHD recommends the following groundwater monitoring program, to be implemented prior to construction, to measure baseline groundwater data (specifically GW elevation and water quality). The purpose of this monitoring is to document baseline groundwater quality and to determine if there are changes in groundwater quality indicative of SWI. Samples should be collected at a quarterly frequency and analyzed for general chemistry parameters and selected metals.

Three monitoring well nests (MW-1,-2, & -3) will be installed around the perimeter on the proposed quarry at the locations shown on Figure 2. Each monitoring well nest should include a shallow well installed in the first water bearing zone (overburden or bedrock) and another monitoring well in the deeper, fractured bedrock.

This will allow for the horizontal and vertical groundwater flow direction and the vertical hydraulic gradient to be monitored. The monitoring wells will be equipped with pressure transducers and data loggers so that continuous groundwater elevation data are collected. This monitoring well network will allow Dexter to determine if site activities are lowering groundwater levels near the proposed quarry.

GHD also recommends Dexter install a monitoring well nest (MW-4) in the community of Mushaboom. The purpose of this monitoring well nest is to document current conditions near the domestic wells that are closest to the proposed quarry and therefore the most vulnerable with respect to impact from the quarry. Similar to the proposed monitoring well nests at the quarry, this monitoring well nest should consist of two wells, one near the top of the water table and another in the same fractures that that supply the domestic wells. The monitoring well be equipped with pressure transducers equipped with temperature and salinity sensors. This will provide information with respect to the groundwater levels and salinity near the domestic wells.

4. References

Barlow, Paul M. 2003. Groundwater in Freshwater-Saltwater Environments of the Atlantic Coast. U.S. Geological Survey Circular: 1262

Environment & Climate Change Canada. 2019. Climate Normals 1950-2000 for Malay Falls, Station ID 8203405. http://climate.weather.gc.ca/historical_data/search_historic_data_e.html (accessed May 2019)

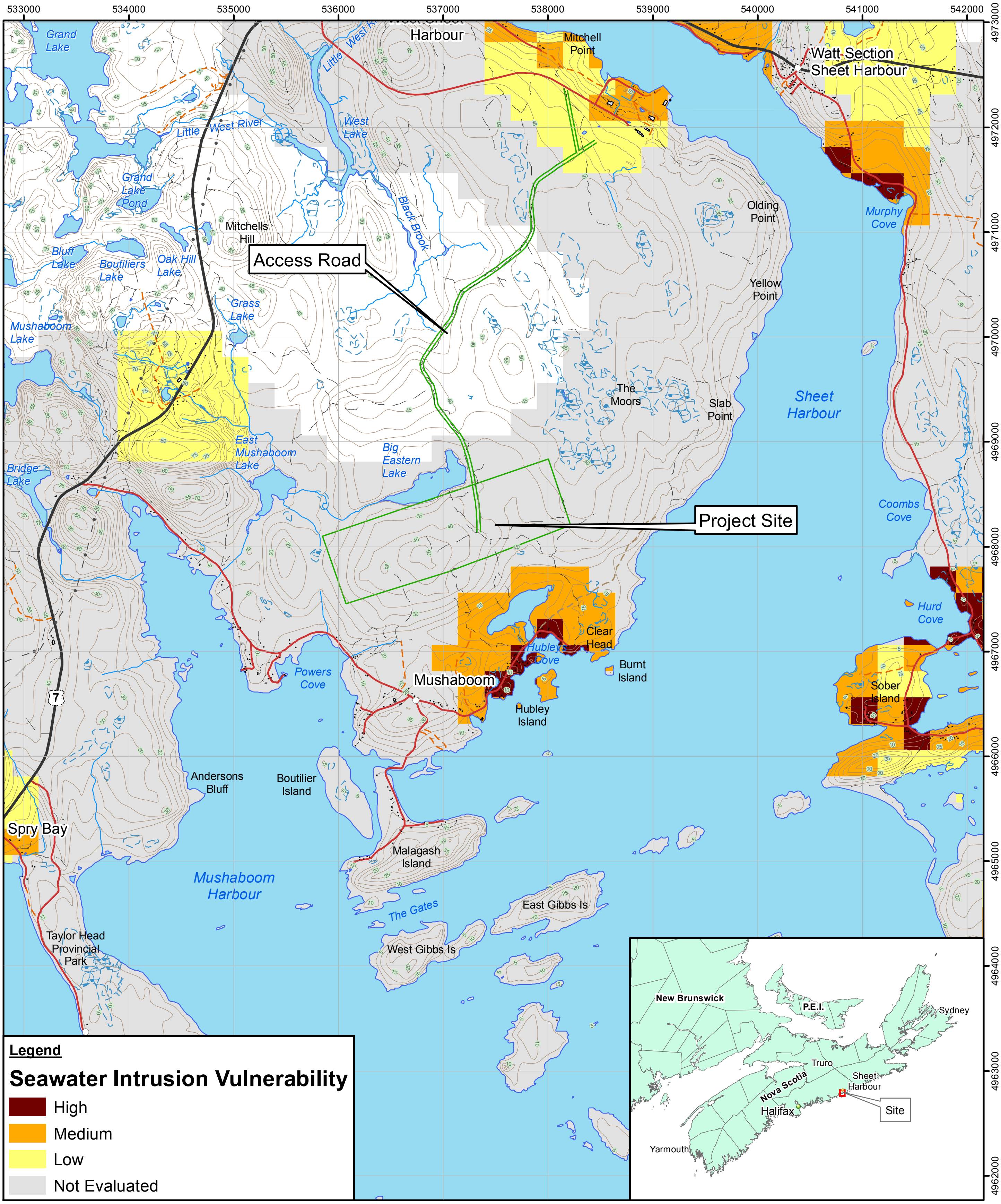
Ferguson, G. and Beebe, C. 2013. Vulnerability of Nova Scotia's coastal groundwater supplies to climate change, Atlantic Climate Adaptation Solutions Association, 10 p. https://atlanticadaptation.ca/en/islandora/object/acasa%253A572 (accessed May 2019)

Kennedy, G.W. 2012 Development of a GIS-based approach for the assessment of relative seawater intrusion vulnerability in Nova Scotia, Canada, Nova Department of Natural Resources https://novascotia.ca/natr/meb/data/pubs/cs/cs_me_2012-005.pdf (accessed May 2019)

Kennedy, G.W. and J. S. McKinnon, 2013. *Relative Seawater Intrusion Vulnerability* DP ME 483, Version 1. https://novascotia.ca/natr/meb/download/dp483.asp (accessed May 2019)

Nova Scotia Environment (NSE) 2017. *Nova Scotia Well Logs Database*, http://www.gov.ns.ca/nse/water/welldatabase.asp (accessed May 2019)

Zhang, X., Flato, G., Kirchmeier-Young, M., Vincent, L., Wan, H., Wang, X., Rong, R., Fyfe, J., Li, G., Kharin, V.V. (2019): Changes in Temperature and Precipitation Across Canada; Chapter 4 in Bush, E. and Lemmen, D.S. (Eds.) Canada's Changing Climate Report. Government of Canada, Ottawa, Ontario, pp 112-193



Source: Service Nova Scotia, NS Energy & Mines

0 500 1,000 1,500
Metres

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

GHD

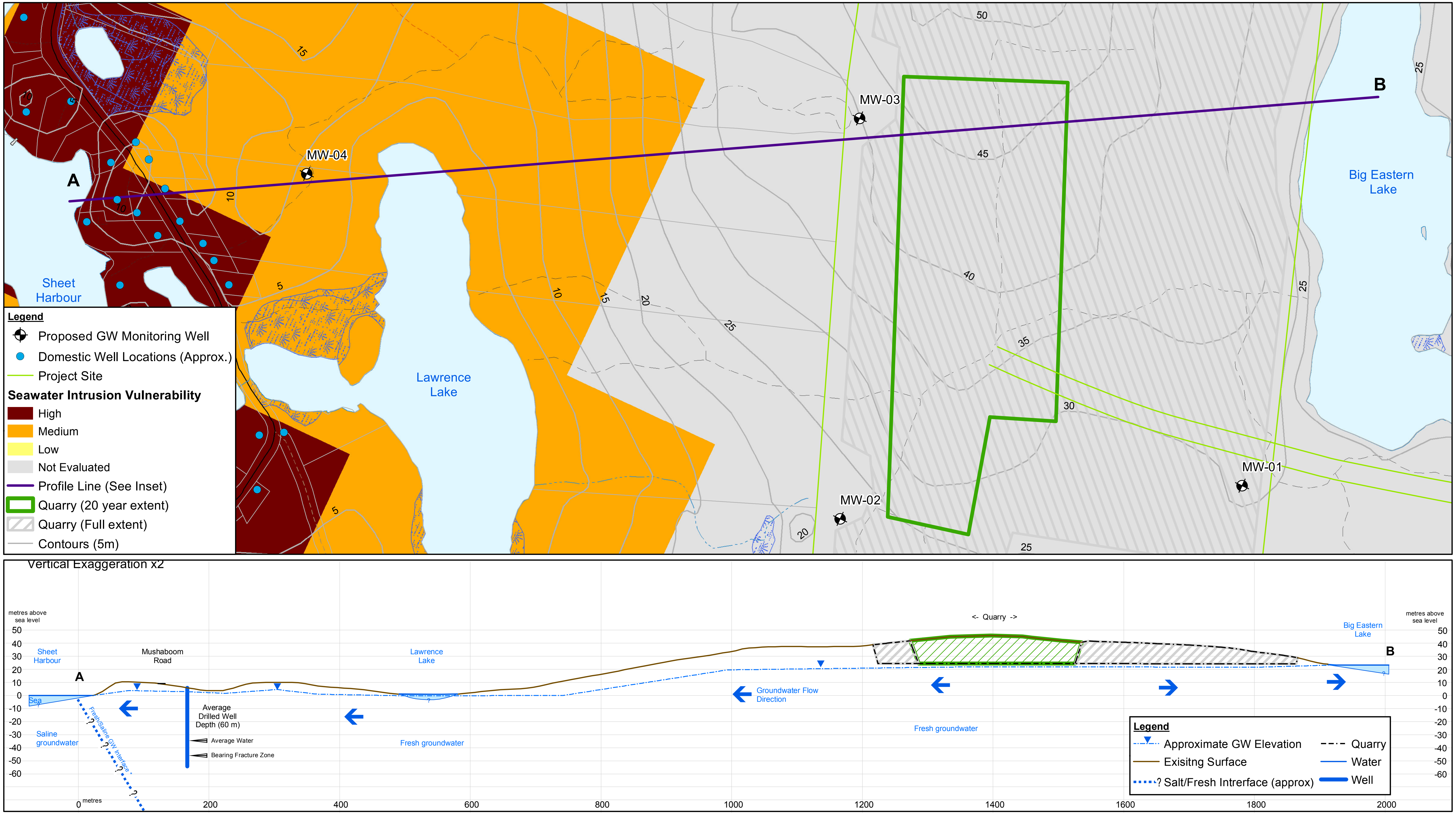
DEXTER CONSTRUCTION CO. LTD
MUSHABOOM, NOVA SCOTIA
SHEET HARBOUR QUARRY

SEAWATER INTRUSION VULNERABILITY

111411046-14
Aug 16, 2019

FIGURE 1

GIS File: I:\GIS_DATA\Projects\8-chars\1114----\11141046 Dexter\11141046-MEMO\11141046(Memo-2)\11141046(MEMO02)_GIS-HX001.mxd



Source: Service Nova Scotia, GHD, Dexter

0 55 110 165
Metres

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

DEXTER CONSTRUCTION COMPANY LIMITED
SHEET HARBOUR, NOVA SCOTIA
SHEET HARBOUR QUARRY EA - ADDITIONAL INFORMATION

QUARRY CROSS SECTION
WITH GROUNDWATER USERS

11141046-14
Sep 5, 2019

FIGURE 2

GIS File: I:\GIS_DATA\Projects\8-chars\1114----\11141046 Dexter\11141046-MEMO\11141046(Memo-2)\11141046(MEMO02)_GIS-HX002.mxd

Appendix E
Surface Water Quality Data

Appendix E
Water Quality Data - Surface Water

Sample					SW-2				SW-3				SW-4					
Sampling Date					25-Sep-17	11-Dec-17	13-Apr-18	28-Jun-18	25-Sep-17	11-Dec-17	13-Apr-18	28-Jun-18	25-Sep-17	25-Sep-17 SW-DUP	11-Dec-17	13-Apr-18	13-Apr-18 SW-DUP	28-Jun-18
Parameters	Units	RDL	CCME FWAL	NS Tier 1 EQS														
CALCULATED PARAMETERS																		
Anion Sum	me/L	NA	-	-	0.200	0.280	0.330	0.260	-	0.360	0.310	0.270	0.280	0.290	0.340	0.360	0.370	0.310
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	1.0	-	-	<1.0	<1.0	<1.0	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Calculated TDS	mg/L	1.0	-	-	16	22	23	18	-	25	22	23	22	23	25	25	25	22
Carb. Alkalinity (calc. as CaCO3)	mg/L	1.0	-	-	<1.0	<1.0	<1.0	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Cation Sum	me/L	NA	-	-	0.300	0.370	0.420	0.350	-	0.450	0.440	0.420	0.350	0.370	0.410	0.450	0.430	0.380
Hardness (CaCO3)	mg/L	1.0	-	-	3.7	5.7	6.2	4.5	-	7.8	5.2	4.9	4.1	4.2	5.8	5.4	5.2	4.3
Ion Balance (% Difference)	%	NA	-	-	20.0	13.9	12.0	14.8	-	11.1	17.3	21.7	11.1	12.1	9.33	11.1	7.50	10.1
Langelier Index (@ 20C)	NA		-	-	NC	NC	NC	NC	-	NC	NC	NC	NC	NC	NC	NC	NC	NC
Langelier Index (@ 4C)	NA		-	-	NC	NC	NC	NC	-	NC	NC	NC	NC	NC	NC	NC	NC	NC
Nitrate (N)	mg/L	0.050	-	-	<0.050	<0.050	<0.050	<0.050	-	<0.050	<0.050	<0.050	0.086	0.084	<0.050	<0.050	<0.050	<0.050
Saturation pH (@ 20C)	NA		-	-	NC	NC	NC	NC	-	NC	NC	NC	NC	NC	NC	NC	NC	NC
Saturation pH (@ 4C)	NA		-	-	NC	NC	NC	NC	-	NC	NC	NC	NC	NC	NC	NC	NC	NC
INORGANICS																		
Total Alkalinity (Total as CaCO3)	mg/L	5.0	-	-	<5.0	<5.0	<5.0	<5.0	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Dissolved Chloride (Cl)	mg/L	1.0	-	-	7.2	9.9	12	9.4	-	13	11	9.6	9.9	10	12	13	13	11
Colour	TCU	25	-	-	200	190	91	130	-	230	170	290	150	190	160	67	74	130
Nitrate + Nitrite (N)	mg/L	0.050	-	-	<0.050	<0.050	<0.050	<0.050	-	<0.050	<0.050	<0.050	0.086	0.084	<0.050	<0.050	<0.050	<0.050
Nitrite (N)	mg/L	0.010	-	-	<0.010	<0.010	<0.010	<0.010	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Nitrogen (Ammonia Nitrogen)	mg/L	0.050	-	-	<0.050	<0.050	<0.050	<0.050	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Total Organic Carbon (C)	mg/L	0.50	-	-	14	17	10	12	-	24	19	30	12	12	17	7.9	8.3	13
Orthophosphate (P)	mg/L	0.010	-	-	<0.010	<0.010	<0.010	<0.010	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
pH	pH	NA	6.0:9.5	-	5.04	5.61	5.73	5.87	-	4.94	4.62	5.39	5.90	5.24	5.02	5.66	6.01	5.71
Reactive Silica (SiO2)	mg/L	0.50	-	-	2.0	3.9	2.2	1.0	-	3.1	2.3	4.4	4.2	4.2	4.0	2.3	2.3	2.3
Dissolved Sulphate (SO4)	mg/L	2.0	-	-	<2.0	<2.0	<2.0	<2.0	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Turbidity	NTU	0.10	15	-	1.5	2.0	1.3	1.4	-	1.5	1.5	1.0	0.40	0.39	1.0	0.45	0.35	1.0
Conductivity	uS/cm	1.0	-	-	33	47	56	46	-	66	60	51	44	44	58	60	<1.0	50
INORGANICS - FIELD																		
Temperature	°C	-	-	-	23.04	6.17	7.82	20.43	-	7.42	3.74	12.03	18.3	-	6.08	7.48	-	18.05
pH	NA	-	6.0:9.5	-	4.55	4.17	2.81	4.71	-	3.76	2.26	4.25	4.18	-	4.13	3.41	-	3.6
Conductivity	uS/cm	-	-	-	16	25	30	23	-	35	31	26	22	-	29	31	-	26
Dissolved Oxygen	mg/L	-	-	-	5.13	27.5	21.81	7.47	-	28.09	21.93	9.11	3.45	-	24.02	24.97	-	9.45

Appendix E
Water Quality Data - Surface Water

Sample	SW-5					SW-6					Big Eastern Lake	Lawrence Lake	East Mushaboom Lake	
Sampling Date	25-Sep-17	11-Dec-17	11-Dec-17 SW-DUP	13-Apr-18	28-Jun-18	25-Sep-17	11-Dec-17	13-Apr-18	28-Jun-18	28-Jun-18 SW-DUP	19-Jun-19	14-Jun-19	14-Jun-19	19-Jun-14 SW-DUP
Parameters														
CALCULATED PARAMETERS														
Anion Sum	0.240	0.310	0.290	0.250	0.210	0.150	0.210	0.210	0.180	0.180	0.170	31.3	0.210	-
Bicarb. Alkalinity (calc. as CaCO3)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	11	<1.0	-
Calculated TDS	24	21	20	17	17	11	16	15	13	13	14	1800	15	-
Carb. Alkalinity (calc. as CaCO3)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-
Cation Sum	0.400	0.360	0.370	0.330	0.310	0.210	0.290	0.290	0.250	0.250	0.280	32.4	0.280	-
Hardness (CaCO3)	6.0	5.5	5.6	3.8	3.8	2.8	4.6	4.0	3.4	3.4	3.5	350	2.6	-
Ion Balance (% Difference)	25.0	7.46	12.1	13.8	19.2	16.7	16.0	16.0	16.3	16.3	24.4	1.63	14.3	-
Langelier Index (@ 20C)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	-2.92	NC	-
Langelier Index (@ 4C)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	-3.16	NC	-
Nitrate (N)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	-
Saturation pH (@ 20C)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	9.24	NC	-
Saturation pH (@ 4C)	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	9.48	NC	-
INORGANICS														
Total Alkalinity (Total as CaCO3)	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	11	<5.0	-
Dissolved Chloride (Cl)	8.6	11	10	8.8	7.4	5.1	7.3	7.4	6.3	6.3	6.2	1000	7.3	-
Colour	370	210	210	120	320	61	140	61	97	100	170	170	170	-
Nitrate + Nitrite (N)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	-
Nitrite (N)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	-
Nitrogen (Ammonia Nitrogen)	<0.050	<0.050	<0.050	<0.050	<0.050	0.095	<0.050	<0.050	<0.050	<0.050	0.090	<0.050	<0.050	<0.050
Total Organic Carbon (C)	31	22	23	15	33	6.4	17	7.1	10	9.7	18	17	14	-
Orthophosphate (P)	0.011	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	-
pH	5.46	5.29	4.70	4.89	5.62	6.01	5.18	6.19	5.58	5.93	5.36	6.32	5.39	-
Reactive Silica (SiO2)	6.9	2.2	2.1	1.6	2.9	1.6	2.4	1.8	1.1	1.2	1.5	1.6	1.9	-
Dissolved Sulphate (SO4)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	140	<2.0	-
Turbidity	0.92	1.5	1.1	0.87	1.2	0.59	0.90	0.43	0.92	2.0	1.4	0.84	0.88	-
Conductivity	44	59	64	51	45	23	44	<1.0	31	32	27	3200	31	-
INORGANICS - FIELD														
Temperature	15.63	5.70	-	5.07	14.58	19.33	5.85	7.80	20.06	-	18.5	16.1	15.9	-
pH	3.9	4.34	-	1.81	3.1	4.68	4.34	3.24	3.65	-	5.77	6.46	4.9	-
Conductivity	21	32	-	27	23	15	22	19	16	-	29	3750	35	-
Dissolved Oxygen	6.92	23.76	-	28.07	10.41	5.79	20.78	19.46	7.21	-	8.84	6.84	6.70	-

Appendix E
Water Quality Data - Surface Water

Sample					SW-2				SW-3				SW-4					
Sampling Date					25-Sep-17	11-Dec-17	13-Apr-18	28-Jun-18	25-Sep-17	11-Dec-17	13-Apr-18	28-Jun-18	25-Sep-17	25-Sep-17 SW-DUP	11-Dec-17	13-Apr-18	13-Apr-18 SW-DUP	28-Jun-18
Parameters	Units	RDL	CCME FWAL	NS Tier 1 EQS														
METALS																		
Total Aluminum (Al)	ug/L	5.0	-	5	**340**	**400**	**240**	**280**	-	**470**	**350**	**490**	**300**	**310**	**430**	**220**	**220**	**320**
Total Antimony (Sb)	ug/L	1.0	-	20	<1.0	<1.0	<1.0	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Arsenic (As)	ug/L	1.0	5	5	<1.0	<1.0	<1.0	<1.0	-	<1.0	<1.0	1.8	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Barium (Ba)	ug/L	1.0	-	1000	2.0	3.0	3.1	2.4	-	4.6	2.7	2.8	2.8	2.8	4.9	4.0	4.0	3.4
Total Beryllium (Be)	ug/L	1.0	-	5.3	<1.0	<1.0	<1.0	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Bismuth (Bi)	ug/L	2.0	-	-	<2.0	<2.0	<2.0	<2.0	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Boron (B)	ug/L	50	1500	1200	<50	<50	<50	<50	-	<50	<50	<50	<50	<50	<50	<50	<50	<50
Total Cadmium (Cd)	ug/L	0.010	0.01 / 0.12	0.01	**0.014**	**0.024**	**0.023**	**0.019**	-	**0.047**	**0.023**	**0.021**	**0.016**	**0.014**	**0.024**	**0.023**	**0.020**	**0.019**
Total Calcium (Ca)	ug/L	100	-	-	660	1000	980	750	-	1500	900	1000	750	780	1100	870	850	790
Total Chromium (Cr)	ug/L	1.0	-	-	<1.0	<1.0	<1.0	<1.0	-	<1.0	<1.0	1.4	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Cobalt (Co)	ug/L	0.40	-	10	0.45	0.50	0.45	0.48	-	1.1	0.73	0.86	0.50	0.48	0.56	0.48	0.41	0.43
Total Copper (Cu)	ug/L	2.0	2	2	<2.0	<2.0	<2.0	<2.0	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Iron (Fe)	ug/L	50	300	300	**1000**	**920**	**460**	**560**	-	**1200**	**960**	**1800**	**670**	**690**	**650**	270	260	**490**
Total Lead (Pb)	ug/L	0.50	1	1	0.55	0.63	<0.50	<0.50	-	**1.1**	0.73	**1.1**	<0.50	<0.50	0.64	<0.50	<0.50	<0.50
Total Magnesium (Mg)	ug/L	100	-	-	500	760	920	650	-	980	720	590	540	550	760	790	750	560
Total Manganese (Mn)	ug/L	2.0	-	820	58	77	79	64	-	130	95	87	44	47	62	56	55	42
Total Molybdenum (Mo)	ug/L	2.0	73	73	<2.0	<2.0	<2.0	<2.0	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Nickel (Ni)	ug/L	2.0	25	25	<2.0	<2.0	<2.0	<2.0	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Phosphorus (P)	ug/L	100	-	-	<100	<100	<100	<100	-	<100	<100	<100	<100	<100	<100	<100	<100	<100
Total Potassium (K)	ug/L	100	-	-	300	410	370	340	-	250	200	130	200	230	400	360	360	210
Total Selenium (Se)	ug/L	1.0	1	1	<1.0	<1.0	<1.0	<1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Silver (Ag)	ug/L	0.10	0.25	0.1	<0.10	<0.10	<0.10	<0.10	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Sodium (Na)	ug/L	100	-	-	3900	4800	6300	5200	-	5300	6300	5800	5400	5700	5700	7300	7000	6100
Total Strontium (Sr)	ug/L	2.0	-	21000	5.9	9.1	9.8	7.7	-	13	7.7	7.9	7.8	8.3	12	9.5	9.9	8.5
Total Thallium (Tl)	ug/L	0.10	0.8	0.8	<0.10	<0.10	<0.10	<0.10	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Tin (Sn)	ug/L	2.0	-	-	<2.0	<2.0	<2.0	<2.0	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Titanium (Ti)	ug/L	2.0	-	-	4.8	5.9	4.0	4.2	-	6.3	8.4	12	2.7	3.9	4.2	2.6	2.1	3.5
Total Uranium (U)	ug/L	0.10	15	300	<0.10	<0.10	<0.10	<0.10	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Vanadium (V)	ug/L	2.0	-	6	<2.0	<2.0	<2.0	<2.0	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Zinc (Zn)	ug/L	5.0	7.0	30	<5.0	<5.0	5.9	<5.0	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
PETROLEUM HYDROCARBONS																		
Benzene	mg/L	0.0010	-	2.1	-	-	-	-	-	<0.0010	-	-	<0.0010	-	-	<0.0010	-	<0.0010
Toluene	mg/L	0.0010	-	0.77	-	-	-	-	-	<0.0010	-	-	<0.0010	-	-	<0.0010	-	<0.0010
Ethylbenzene	mg/L	0.0010	-	0.32	-	-	-	-	-	<0.0010	-	-	<0.0010	-	-	<0.0010	-	<0.0010
Total Xylenes	mg/L	0.0020	-	0.33	-	-	-	-	-	<0.0020	-	-	<0.0020	-	-	<0.0020	-	<0.0020
C6 - C10 (less BTEX)	mg/L	0.010	-	-	-	-	-	-	-	<0.010	-	-	<0.010	-	-	<0.010	-	<0.010
>C10-C16 Hydrocarbons	mg/L	0.050	-	-	-	-	-	-	-	<0.050	-	-	<0.050	-	-	<0.050	-	<0.050
>C16-C21 Hydrocarbons	mg/L	0.050	-	-	-	-	-	-	-	<0.050	-	-	<0.050	-	-	<0.050	-	<0.050
>C21-<C32 Hydrocarbons	mg/L	0.10	-	-	-	-	-	-	-	<0.10	-	-	<0.10	-	-	<0.10	-	<0.10
Modified TPH (Tier1)	mg/L	0.10	-	-	-	-	-	-	-	<0.10	-	-	<0.10	-	-	<0.10	-	<0.10
Reached Baseline at C32	mg/L	NA	-	-	-	-	-	-	-	NA	-	-	NA	-	-	NA	-	NA
Hydrocarbon Resemblance	mg/L	NA	-	-	-	-	-	-	-	NA	-	-	NA	-	-	NA	-	NA

RDL = Reportable Detection Limit

NA = Not Applicable

- = no guideline/not analyzed

NC = not calculated

NS Tier 1 EQS = Nova Scotia Contaminated Site Regulations Tier 1 Environmental Quality Standards for Surface Water - Freshwater (Table 3), July 2013

Appendix E
Water Quality Data - Surface Water

Sample	SW-5					SW-6					Big Eastern Lake	Lawrence Lake	East Mushaboom Lake	
Sampling Date	25-Sep-17	11-Dec-17	11-Dec-17 SW-DUP	13-Apr-18	28-Jun-18	25-Sep-17	11-Dec-17	13-Apr-18	28-Jun-18	28-Jun-18 SW-DUP	19-Jun-19	14-Jun-19	14-Jun-19	19-Jun-14 SW-DUP
Parameters														
METALS														
Total Aluminum (Al)	**440**	**430**	**300**	**230**	**400**	**130**	**260**	**190**	**220**	**230**	**320**	**330**	**370**	-
Total Antimony (Sb)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-
Total Arsenic (As)	1.9	<1.0	<1.0	<1.0	1.2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.1	<1.0	-
Total Barium (Ba)	1.9	4.9	2.1	1.3	1.4	2.0	3.4	3.2	3.1	3.4	2.2	2.6	2.7	-
Total Beryllium (Be)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-
Total Bismuth (Bi)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	-
Total Boron (B)	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	250	<50	-
Total Cadmium (Cd)	**0.014**	**0.024**	**0.036**	**0.015**	**0.015**	<0.010	**0.025**	**0.019**	**0.016**	**0.018**	**0.026**	0.017	**0.013**	-
Total Calcium (Ca)	1400	1100	1100	650	780	560	960	730	670	670	740	23000	460	-
Total Chromium (Cr)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	7.4	<1.0	<1.0	<1.0	1.3	1.4	1.2	-
Total Cobalt (Co)	<0.40	0.56	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	0.49	<0.40	-
Total Copper (Cu)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	0.99	0.73	<0.50	-
Total Iron (Fe)	**1900**	**650**	**720**	**520**	**1200**	**310**	**460**	200	**370**	**380**	**590**	**560**	**520**	-
Total Lead (Pb)	**1.1**	0.64	0.75	<0.50	0.89	<0.50	0.57	<0.50	<0.50	<0.50	0.61	<0.50	<0.50	-
Total Magnesium (Mg)	600	760	700	530	450	340	540	520	420	430	400	71000	360	-
Total Manganese (Mn)	100	62	75	51	45	12	38	37	40	41	47	79	30	-
Total Molybdenum (Mo)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	-
Total Nickel (Ni)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	3.6	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	-
Total Phosphorus (P)	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	-
Total Potassium (K)	110	400	300	210	<100	270	340	260	240	260	470	21000	220	-
Total Selenium (Se)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-
Total Silver (Ag)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	-
Total Sodium (Na)	4700	5700	4800	4900	4300	3000	3800	4400	3700	3700	3900	570000	4600	-
Total Strontium (Sr)	10	12	9.5	5.5	6.6	5.6	9.5	8.0	7.0	7.6	6.0	400	5.3	-
Total Thallium (Tl)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	-
Total Tin (Sn)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	-
Total Titanium (Ti)	7.9	4.2	4.0	6.5	5.6	<2.0	2.7	3.6	<2.0	2.6	5.9	5.1	3.2	-
Total Uranium (U)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.16	<0.10	-
Total Vanadium (V)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	-
Total Zinc (Zn)	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	54	<5.0	<5.0	-
PETROLEUM HYDROCARBONS														
Benzene	-	<0.0010	-	-	-	<0.0010	-	<0.0010	<0.0010	-	-	-	-	-
Toluene	-	<0.0010	-	-	-	<0.0010	-	<0.0010	<0.0010	-	-	-	-	-
Ethylbenzene	-	<0.0010	-	-	-	<0.0010	-	<0.0010	<0.0010	-	-	-	-	-
Total Xylenes	-	<0.0020	-	-	-	<0.0020	-	<0.0020	<0.0020	-	-	-	-	-
C6 - C10 (less BTEX)	-	<0.010	-	-	-	<0.010	-	<0.010	<0.010	-	-	-	-	-
>C10-C16 Hydrocarbons	-	<0.050	-	-	-	<0.050	-	<0.050	<0.050	-	-	-	-	-
>C16-C21 Hydrocarbons	-	<0.050	-	-	-	<0.050	-	<0.050	<0.050	-	-	-	-	-
>C21-<C32 Hydrocarbons	-	<0.10	-	-	-	<0.10	-	<0.10	<0.10	-	-	-	-	-
Modified TPH (Tier1)	-	<0.10	-	-	-	<0.10	-	<0.10	<0.10	-	-	-	-	-
Reached Baseline at C32	-	NA	-	-	-	NA	-	NA	NA	-	-	-	-	-
Hydrocarbon Resemblance	-	NA	-	-	-	NA	-	NA	NA	-	-	-	-	-

RDL = Reportable Detection Limit

NA = Not Applicable

- = no guideline/not analyzed

NC = not calculated

NS Tier 1 EQS = Nova Scotia Contamina

Appendix F
Fish Habitat Assessment

McCallum Environmental Ltd.

August 19, 2019

Jeff Parks
GHD
Via email: jeff.parks@ghd.com

Re: Sheet Harbour Aggregate Quarry Project – Environmental Assessment.
Additional Information

1.0 INTRODUCTION

On March 22nd, 2019, Nova Scotia Environment (NSE) issued an Additional Information Request to Dexter Construction Company Ltd. in relation to the Sheet Harbour Aggregate Quarry Project Environmental Assessment (EA). The Minister of Environment has requested that the Proponent complete the following:

> *Provide a fish and fish habitat assessment of Big Eastern, East Mushaboom and Lawrence lakes and related watercourses. Include accompanying discussion and analysis of potential effects on fish and fish habitat and proposed mitigation measures and follow-up monitoring programs based on the results of the assessments. If fish and fish habitat are identified within Big Eastern Lake, evaluate the potential for thermal charging impacts to the lake from settling pond and other stormwater management system discharges and identify and implement mitigation measures to reduce effects.*

This report outlines the methods and results of the fish and fish habitat evaluations completed in response to the above Additional Information Request. The overall purpose of this document is to:

1) Describe current fish habitat conditions based on the results of fish and fish habitat evaluations completed for Big Eastern, East Mushaboom, and Lawrence lakes and related watercourses;
2) Evaluate the potential effects to fish and fish habitat as a result of the Sheet Harbour Quarry Project (the Project); and,
3) Describe recommended mitigation, potential residual effects and significance, and describe recommended follow-up and monitoring for the above discussed potential effects.

1.1 Project Team

A project team was assembled for the completion of this study. The team was selected based on level of proficiency in their respective roles. The team members and their individual roles are presented in Table 1.

Table 1: Project Team

Team Member	Role
Andy Walter, BSc. (Hort)	Senior Project Manager
Amber Stoffer, B.Sc., MREM Jeff Bonazza, B.Sc., MES	Biologists, Fish Habitat Evaluators, and Report Writers.

Curriculum Vitae for the above-mentioned team members are provided in Appendix B.

2.0 FISH AND FISH HABITAT EVALUATION

2.1 Methodology

2.1.1 Desktop Review

A desktop review for potential fish habitat within Big Eastern Lake, East Mushaboom Lake, and Lawrence Lake was completed using the Nova Scotia Topographic Water Features database, the NSE Wetlands database, and the Nova Scotia Wet Areas Mapping (WAM) database. This review also served to identify mapped watercourses associated with these aquatic features. Information on current fish presence and those species that may potentially access these systems, including Priority Species (as defined in Appendix C of the EA), was collected from the following sources:

- ACCDC Report (as presented in Appendix C of the EA)
- NSL&F Significant Species and Habitats database
- Fisheries and Oceans Stock Status Reports
- Description of Selected Lake Characteristics and Occurrence of Fish Species in 781 Nova Scotia Lakes (Alexander et al., 1986)
- Freshwater Fish Species Distribution Records (NSDFA, 2017)
- NSDFA Lake Inventory Maps
- Discussions with local residents

2.1.2 Field Surveys

The field program for fish and fish habitat was performed by MEL biologists from June 12 – 19, 2019, with follow-up surveys completed on July 26, 2019. Each component of the field program was designed based on the fish species expected to be present within the aquatic features of interest. The following sections provide details on the methodologies specific to each field component.

2.1.2.1 Waterbody Characterizations

MEL biologists completed biophysical characterisations of Big Eastern, East Mushaboom Lake and Lawrence Lake through visual assessments at multiple locations along the shoreline of each lake. These visual assessments were performed to obtain an understanding of littoral zone habitat, shoreline habitat and dynamics, adjacent land use, substrate, and the presence of species-specific habitat provisions (i.e. Brook Trout spawning).

2.1.2.2 Watercourse characterizations

A biophysical characterization was completed for each linear watercourse identified from the desktop review, encompassing the following:

- Tributary from Big Eastern Lake to East Mushaboom Lake (WC1);
- Headwater stream to East Mushaboom Lake (WC2);
- East Mushaboom Lake Outlet (WC3); and,
- Headwater stream to Lawrence Lake (WC4).

Based on the results of the revised water balance analysis (provided as Appendix B to the Additional Information Submission), two additional mapped watercourses (WC5 and WC6) were assessed for potential fish habitat. These watercourses are associated with the Powers Cove NW and SE drainage areas and are not associated with the waterbodies outlined in Section 2.1.2.1. All evaluated waterbodies and watercourses have been identified on Figure 1 (Appendix A of this document).

To support watercourse characterizations, MEL biologists walked the entire extent of each watercourse while taking note of physical parameters and fish habitat characteristics, including:

- Channel depths and widths;
- Flow characteristics;
- Substrate composition;
- Physical units (i.e. run, riffle, pool);
- In-stream vegetation;
- Cover (i.e. deep pools, woody debris, undercut banks, boulders, etc.);
- Riparian habitat;
- Potential barriers to fish passage; and,
- Identification of unique (high quality) fish habitat (i.e. suitable spawning habitat).

Linear watercourses were divided into reaches as required based on morphologically homogenous sections of the watercourse. Based on these observations, overall habitat quality and species-specific habitat provisions within the watercourses was inferred, as the biophysical features documented affect the ability of the watercourse and to support fish.

2.1.2.3 Fish Surveys

To establish species presence and community composition within Big Eastern Lake, East Mushaboom Lake, Lawrence Lake, and their associated watercourses, survey methods (electrofishing, and placement of eel pots, fyke nets, and minnow traps) were selected to maximize sampling efficacy while taking into account gear selectivity, habitat considerations for species potentially present within the aquatic features of interest, and access to those aquatic features. All fish captured were identified to species and measured for length and weight before being released back into the waterbody or watercourse. Fish surveys were completed under Fisheries and Oceans Canada Fishing License # 341208.

Electrofishing

Qualitative electrofishing surveys employed an "open" site methodology (no barrier nets) and a single pass. Fish were sampled using a Halltech Battery Backpack Electrofisher (HT-2000) with un-pulsed direct current (DC) and a single pass. The operator of the electrofisher waded upstream to eliminate the effects of turbidity caused by bottom sediment, while a second crew member walked alongside the operator to net any stunned fish using a D-frame landing net (1/8” mesh). Across the four watercourses evaluated for fish and fish habitat, only one site was considered suitable for electrofishing. Details of the survey are presented in Table 2. The sampling site of approximately 150 metres (m) in length was selected based on accessibility, habitat representation within the site, as well as safety of personnel.

Table 2. Electrofishing Details

Location	Survey Date	Reach Coordinates (UTM, NAD38)				Survey Effort (s)
		Upstream		Downstream		
		Easting	Northing	Easting	Northing	
WC 3.2 (East Mushaboom Lake Outlet)	June 14, 2019	535077	4967951	534977	4967850	620
	June 19, 2019					1173

Trapping

Within the shallow, inshore littoral zones of Big Eastern and Lawrence Lakes, MEL biologists deployed fyke nets, and baited eel pots and minnow traps at multiple shoreline locations based on accessibility and the variety of littoral habitats available to fish. Traps were set during the day, left overnight, and collected the following day. Details for each trap set are presented in Table 3. Traps have been grouped based on their relative shoreline location (e.g. Big Eastern Lake South vs. Big Eastern Lake East).

Table 3. Fish Trapping Details

Location	Survey Date	Trap	Reach Coordinates (UTM, NAD38)		Survey Effort
			Upstream		
			Easting	Northing	
Big Eastern Lake South	June 12 – 13, 2019	Fyke Net	537053	4968554	19h38m
		Eel Pot	537051	4968553	19h50m
		Minnow Trap 1	537040	4968547	19h10m
		Minnow Trap 2	537022	4968539	19h10m
		Minnow Trap 3	537068	4968554	19h05m
Big Eastern Lake East	June 12 – 13, 2019	Fyke Net	537148	4968808	20h14m
		Eel Pot	537215	4968735	19h44m
		Minnow Trap 1	537216	4968740	19h53m
		Minnow Trap 2	537215	4968759	20h00m
		Minnow Trap 3	537224	4968781	19h50m
Lawrence Lake South	June 13 – 14, 2019	Fyke Net	537845	4967128	18h37m
		Eel Pot	537834	4967115	18h19m
		Minnow Trap 1	537789	4967145	18h37m
		Minnow Trap 2	537808	4967111	18h40m
		Minnow Trap 3	537823	4967118	18h06m
Lawrence Lake East	June 13 – 14, 2019	Fyke Net	537975	4967484	18h25m
		Eel Pot	537973	4967477	18h33m
		Minnow Trap 1	537986	4967491	18h18m
		Minnow Trap 2	537978	4967485	18h18m
		Minnow Trap 3	537960	4967468	18h15m

Standardized data collection forms developed by the New Brunswick (NB) Aquatic Resources Data Warehouse, the NB Department of Natural Resources and Energy, and the NB Wildlife Council (2002, updated 2006) were adapted for use for field data collection during electrofishing and fish trapping surveys. Field data collected included the physical and chemical parameters of the survey site, survey methods and settings, and results of the surveys.

2.1.2.4 Water Quality

Water quality was measured concurrently with waterbody characterizations, watercourse characterizations, and fish surveys. Water quality measurements were recorded in the field using a YSI Professional Plus Multi-Probe water quality instrument at the time of the assessment. Parameters recorded include dissolved oxygen (mg/L), water temperature (°C), pH, specific water conductivity (mS/m), total dissolved solids (TDS, mg/L), and salinity (ppt). Water quality data was reviewed and compared to Canadian Council of Ministers of Environment (CCME) Water Quality for the Protection of Freshwater Aquatic Life guidelines, as well as species-specific water quality requirements drawn from the literature.

2.2 Results

2.2.1 Desktop Results

The three lakes and their related watercourses are all located within the Shore Direct secondary watershed (1EM-SD4), as described in the EA. Big Eastern Lake is hydrologically connected to East Mushaboom lake via a single, unnamed outlet stream, identified by field staff as WC1. NS topographic mapping reveals three additional, unnamed tributaries to East Mushaboom Lake, one of which extends from wetland habitat located within the quarry development area (WC2). Water from East Mushaboom Lake exits through one, unnamed third-order stream (WC3), eventually draining into the Atlantic Ocean just southwest of Mushaboom Road. Lawrence Lake has two mapped, unnamed tributaries. One of these first-order streams (WC4) is sourced water in part, by the quarry development area. Lawrence Lake has a single, ocean-direct outlet via culvert under Mushaboom Road. NS topographic mapping also shows two, ocean-direct headwater streams, located southwest of the original Study Area as identified on Figure 1 (Appendix A). These watercourses have been identified as WC5 and WC6.

No bathymetry, lake chemistry, or fish species occurrence data was available in regional literature or public databases for the aquatic features of interest.

Based on ACCDC report (described further in the EA) the 100 kilometre (km) buffer around the Study Area contains 143 records of 9 fish species. One SAR, the Atlantic Salmon (Inner Bay of Fundy population), was identified approximately 61 km from the Project. This population of Atlantic Salmon is restricted to rivers that drain to Bay of Fundy from mainland Nova Scotia and New Brunswick, and as such would not be present within the aquatic features of interest associated with the Project.

No priority fish species were identified by ACCDC within 5km of the Study Area. Atlantic Salmon (*Salmo salar*; S1), Alewife (*Alosa pseudoharengus*; S3), and Brook Trout (*Salvelinus fontinalis*; S3) were reported to be within 20 km of the Study Area.

Atlantic Salmon

Atlantic Salmon are an anadromous species with adults migrating from the ocean to spawn in freshwater rivers, generally in the same river where they were born. Salmon rivers or streams are generally large, clear, and cool, with riverbeds composed of gravel, cobble and boulder substrates (DFO, 2016). The Southern Uplands Population of Atlantic Salmon, whose habitat ranges along the extent of Nova Scotia's Atlantic coast and into the Bay of Fundy, has been assessed as endangered by COSEWIC (2010) and is considered imperiled provincially by the ACCDC (ranked S1). This population is not currently protected under SARA or NSESA. The waterbodies and watercourses within the Shore Direct secondary watershed 1EM-SD4 have not been identified to presently or historically support Southern Upland Atlantic Salmon (ASF, accessed 2019), nor are there any documented catches within these systems.

Alewife

Like the Atlantic Salmon, Alewife are anadromous fish that travel from the marine environment to freshwater to spawn. In the Maritimes, spawning occurs in lakes or slow-moving portions of rivers in late spring. Alewife are found mostly in larger rivers (DFO, 2016). Based on the size of the shore direct watershed in which the aquatic features lie, as well as through conservations with residents, Alewife is not documented or anticipated to utilize fish habitat within the waterbodies and watercourses evaluated.

Brook Trout

Brook Trout are known to inhabit a wide range of cool, freshwater environments, from small headwater streams to large lakes. Spawning sites are usually near groundwater upwelling or spring seeps and within a lake or stream with a gravel substrate (NSDFA, 2005).

American Eel

American Eel (*Anguilla rostrata;* COSEWIC Threatened) was also considered as a potentially present Priority Species based on its broad geographic range. Found throughout Nova Scotia, the catadromous species spends most of its lifecycle in freshwater, returning to the Sargasso Sea to spawn. American Eel are habitat generalists, showing no consistent preference for particular stream morphologies, physical characteristics, or temperatures in freshwater streams (Hawkins, 1995).

2.2.2 Field Results

The following sections outline the results of the field program for fish and fish habitat within Big Eastern Lake, East Mushaboom Lake, Lawrence Lake, and their related watercourses. Using information derived from biophysical characterizations, each waterbody and watercourse were evaluated for fish habitat potential based on the habitat requirements for Brook Trout, given that Alewife and Salmon are not expected to be present within this watershed. American Eel are considered, but are habitat generalists, and do not spawn in Canadian waters.

Brook Trout are known to inhabit a wide range of freshwater environments, including small headwater streams like those in proximity to the Project. As an indicator species that is sensitive to environmental stressors, Brook Trout help to determine the health or overall quality of the waters they inhabit. In addition, habitat suitability and limiting factors for all Brook Trout life stages have been well documented in the literature (Raleigh, 1982). However, it should be noted that no Brook Trout were caught during dedicated fish surveys, and that utilization of these features by the species discussed is based on potential access from other fish-bearing systems. Other species-specific habitat provisions have been discussed based on the results of fish surveys as detailed in Section 2.2.2.4.

2.2.2.1 Waterbody Characterizations

The biophysical characteristics observed for each waterbody are presented in Table 4. Bathymetry was not evaluated for these waterbodies as part of the field program, nor are bathymetric data available through the NSDFA Lake Inventory. However, shoreline depths observed while surveying and have been used to describe the littoral zone habitat.

Big Eastern Lake

Big Eastern Lake is a headwater lake located north of the quarry development area, its southern shoreline extending parallel to the Project area. With no mapped tributaries, surface water is sourced to this lake from overland drainage and precipitation. Outside of the noted riparian wetland habitat, which provides good cover and potential rearing habitat for fish, the littoral zone is narrow and highly sloped with depths of over 2 m occurring abruptly just off the shoreline. No suitable spawning habitat (gravel-cobble sized substrate) for Brook Trout was identified.

East Mushaboom Lake

East Mushaboom Lake receives water from Big Eastern Lake to the east, as well as inputs from three additional tributaries. One of these tributaries is a 3rd order stream sourced from smaller, headwater lakes (Grass Lake and Mud Lake) located north and northwest of East Mushaboom Lake. Wetlands comprise approximately one half of the shoreline habitat, with flooded swamp concentrated along its southern and western shores. Within this wetland habitat, muck and boulder substrate dominate. In contrast, the littoral zone along its eastern, upland shoreline is dominated by gravel-cobble sized substrate, which has been evaluated as potential spawning habitat for Brook Trout.

Lawrence Lake

Lawrence Lake, located south of the Study Area, is directly connected to the ocean via culvert under Mushaboom Road. In speaking with local residents, MEL biologists learned that culvert had replaced a former bridge crossing at the lake's outlet. This relatively narrow culvert has resulted in the flooding and expansion of the lake's southern lobe, in addition to restricting fish passage into the lake due to its high water velocity (Mr. Boutilier, personal communication, June 13, 2019). Still, exchange with seawater is ongoing as evidenced by seaweed washed up along the shoreline, brackish salinity levels (Section 2.2.2.3), and salinity tolerant/anadromous fish presence (Section 2.2.2.4).

Schools of minnow-sized fish (later confirmed as Banded Killifish) were observed frequently from the shoreline in the emergent grasses of the lake's littoral zone. The littoral zone is dominated by muck substrate and large boulders are scattered throughout. Along the its eastern shoreline, flooding of wetland habitat has formed secluded pools, surrounded almost completely emergent vegetation. These areas have been assessed as providing quality rearing and refuge habitat for fish. No suitable spawning habitat (gravel-cobble sized substrate) for Brook Trout was identified.

Representative shoreline and aerial photographs of each waterbody are presented in Appendix C.

Table 4. Lake Characteristics

Waterbody	Size (ha)	Inlets/Outlets (#)	Shoreline Characteristics	Littoral Zone Characteristics	Substrate
Big Eastern Lake	14.85	0/1	An ATV trail currently provides access to the southern and eastern edges of the lake but sees little use. Otherwise, the shoreline is completely undeveloped. Abrupt, upland habitat dominates the shoreline, which is dominated by mature Black Spruce with scattered Red Maple. Flooded, shrub swamps line the northeastern and southwestern edges of the lake, with vegetation dominated by Sweet Gale, Labrador Tea, and Leatherleaf.	Along the dominant upland shoreline, the littoral zone is narrow and sharply sloped, reaching a depth of over 1 m just 0.5 m from the shore. The littoral zone expands on the northeastern and southwestern edge of the lake through wetland habitat. Emergent vegetation is absent with the exception of shrubs within the flooded swamps. Submergent vegetation is infrequent but submerged, woody cover is common.	Littoral substrate is dominated by large boulders and muck, with cobble scattered throughout.
East Mushaboom Lake	9.62	4/1	East Mushaboom Lake is completely undeveloped and inaccessible – no trails exist within 500 m of the shoreline. NSE mapped treed swamps line the southern shoreline, while additional wetland habitat exists on the western edge of the lake. In total, wetland habitat comprises approximately 50% of the shoreline. Upland habitat is dominated by Black Spruce, Sheep Laurel, and Leatherleaf.	Along the eastern edge of the lake, the littoral zone is gently sloped and unshaded by any forest canopy cover. Submergent vegetation and woody debris is scattered throughout, while emergent vegetation is frequent along the southern shoreline.	Littoral substrate along the eastern edge of the lake is dominated by cobble-sized rock, interspersed with gravel and fines. Boulders and muck dominate the southern edge of the lake.
Lawrence Lake	12.21	2/1	The southern lobe and outlet of Lawrence Lake is impounded by Mushaboom Road. Here, the lake has a direct connection to the Atlantic Ocean via a single, concrete culvert. One residential property lies east of the southern lobe of Lawrence Lake but has left a 15 m strip of wetland shoreline intact. The remaining shoreline (approximately 90%) is undeveloped and inaccessible. Flooded peatland (flooding caused by the road impoundment) lines the southern lobe of the lake, while floating peatland fringes its eastern edge. Upland habitat is dominated by Black Spruce.	The littoral zone is moderately sloped and unshaded by any forest canopy cover. Flooded peatland surrounding the southern lobe comprises a narrow band of emergent grasses. Strips of grasses and shrubs emerge along the eastern edge of the lake, forming secluded pools. Bladderwrack seaweed (*Fucus vesiculosus)* is commonly washed up along the shoreline.	Littoral substrate is dominated by large boulders embedded in deep muck.

2.2.2.2 Watercourse Characterizations

As described in Section 2.1.2.2, six linear watercourses were evaluated for fish habitat based on predicted impacts from quarry expansion and hydrological connectivity with Big Eastern Lake, East Mushaboom Lake, or Lawrence Lake. Physical characteristics for each watercourse evaluated are presented in Table 5. Where applicable, these characteristics are described for each homogenous reach. Georeferenced photos for each watercourse are presented in Appendix C. WC3 and WC4 were evaluated during high flow conditions, while moderate flow was observed during the evaluation of WC1 and WC2. WC5 and WC6 did not receive full biophysical characterizations due to the absence of defined watercourse channels. Note that the labels of WC5 and WC6 do not indicate field-delineated watercourses but are used to identify watercourses as mapped through the NS Topographic Water Features database.

WC1

From the outflow at the western tip of Big Eastern Lake, WC1conducts surface water west, eventually draining into East Mushaboom Lake at its eastern shoreline. Three morphologically distinct reaches have been characterized for WC1.

The first 560 m of stream (WC1.1) is relatively confined, occasionally braiding through wooded swamps but predominantly flow is restricted to a single channel. Woody debris is prevalent throughout. Three barriers were observed that would seasonally/temporarily limit fish passage within this reach:

- A debris blockage resulting in a 20 cm falls, likely impassable during low-flow conditions;
- A stretch of boulder substrate exhibiting with subsurface flow, likely impassable during low-flow conditions; and
- Seasonally low water levels resulting in discontinuous, residual pools.

For the next 300 m, the watercourse deepens and expands into a shrub fen (WC1.2), with flooding caused by a beaver dam which spans the watercourse at the downstream end of the reach. Here, the water is relatively stagnant, with flooding expanding fish habitat into the riparian wetland. The beaver dam likely inhibits fish passage into this reach from downstream areas. Downstream of the beaver dam, the watercourse confines until it discharges into East Mushaboom Lake (WC1.3). The last 125 m of linear channel has been evaluated as potential Brook Trout spawning habitat based on the presence of suitable substrate. Overall, WC1 has been evaluated to provide seasonal passage, rearing, overwintering, and spawning habitat, with spawning habitat restricted to approximately 10% of its most downstream extent.

WC2

WC2 is a first-order, headwater stream that originates from pockets of surface water draining from Wetland 23, which is partially located in the northwest corner of the original Study Area (as identified in Appendix C in the EA).

For the first 300 m (WC2.1), the watercourse is intermittently channelized with hydrological connectivity maintained by stretches of subsurface flow during low-moderate flow conditions. Fish habitat within this reach was evaluated as marginal, with potential rearing and foraging habitat accessible only during periods of high flow.

The following 205 m of watercourse (WC2.2) is continuous, with beaver dams having created areas of localized flooding. Here, habitat complexity is improved through variable substrate, cover types, increased water depths, and greater accessibility. In this reach, WC2 has been evaluated to provide potential rearing and overwintering habitat. In addition, a 10 m stretch of potential spawning habitat was observed at the watercourse's most downstream extent and confluence with East Mushaboom Lake.

<u>WC3</u>

WC3is a third-order, perennial stream that drains East Mushaboom Lake southwest to the Atlantic Ocean via culvert under Mushaboom Road. The 675 m of mapped watercourse comprises two characterized reaches (WC3.1 and WC3.2).

Within the lower gradient WC3.1, surface water draining from the lake travels slowly and unconfined through wetland habitat; the watercourse first braids extensively through treed swamp, and then ponds into a shrub fen for approximately 150 m. Substrate within this reach is characterized by organic debris, muck, and boulders, with water depths reaching over 1 m.

The start of WC3.2 marks a gradient increase, linked to an increase in velocity, a diversification of substrate, and the presence of riffle-run habitat types. The watercourse confines intermittently but still displays extensive braiding through riparian swamp habitat. Water velocities over 1m/s and rapids were observed in areas of confined channel, and high amounts of woody debris have created debris jams which may be temporarily impassable to fish. Overall, WC3 has been evaluated to provide potential rearing and overwintering habitat, in addition to providing passage to upstream aquatic features. No spawning habitat was identified within the watercourse.

<u>WC4</u>

WC4 is a first-order, headwater stream that originates from a wetland approximately 360 m north of Lawrence Lake. The watercourse is seldom channelized; primarily, the watercourse exhibits as sheet flow through riparian habitat. Multiple physical barriers to fish passage were observed throughout the watercourse, with the most downstream barrier located approximately 10 m upstream from its discharge into Lawrence Lake. Here, surface flow appears absent throughout the year, as made evident by the absence of surface water during high flow conditions, the absence of surface scouring, and the presence of a heavy moss cover. This barrier excludes fish from upstream areas year-round; as such, the watercourse does not provide habitat for fish.

<u>WC5</u>

According to the NS Topographic Water Features database, a 430 m long unnamed, first-order stream flows from north to south within Powers Cove NW catchment area (Figures 1-4, Appendix C). Upon field verification, the culvert that would conduct a stream under Mushaboom Road to the ocean was observed to be ditch-fed only; a swamp (unmapped) north of the road passively feeds the ditch system west of the culvert via subsurface drainage. No channelized watercourse was identified nor any potential accessible fish habitat within the wetland. In addition, no upstream surface water feature was observed that could potentially support resident fish. Fish habitat is therefore absent within this catchment area.

WC6

Within the Powers Cove SW catchment area (Figures 1-4, Appendix D), the NS Topographic Water Features database shows a 480 m unnamed, first-order stream flowing from east to west, draining into the ocean at Mushaboom Road. Upon field verification, the culvert on Mushaboom Road was observed to be perched above high tide water levels. In addition, pooled surface water east of the road was observed to disappear underground through swamp habitat, with no evidence of potential channelized surface flow. In addition, no upstream surface water feature was observed that could potentially support resident fish. Fish habitat is therefore absent within this catchment area.

Table 5: Watercourse Characteristics

WC ID	Waterbody Association	Reference UTMs		Reach Length (m)	Stream Order	Velocity	Gradient	Bankfull Width (m)	Depth Range (cm)	Bank Height (cm)	Substrate (%)	Cover	Habitat	Barriers
		E	N											
1.1	Big Eastern Lake Outlet	Upstream		560	1	L-M	2%	0.75-4	10-50	20	Boulder = 35 Cobble = 35 Muck = 30	Boulder, CWD, Overhang	Run, Riffle, Pocket, Cascade, Flat	Debris blockage, Seasonal subsurface flow, Seasonal low flows
		536367	4968413											
		Downstream												
		535877	4968355											
1.2	Big Eastern Lake Outlet	Upstream		300	1	L	0.5%	Unconfined	50-150	N/A (flooded)	Boulder = 50 Muck = 50	Depth, Boulder, Vegetation, CWD	Glide	Beaver Dam
		535877	4968355											
		Downstream												
		535773	4968517											
1.3	Big Eastern Lake Outlet	Upstream		275	1	M	2%	2	10-50	40	Boulder (35 Cobble = 35 Gravel = 25 Sand = 5	Boulder, CWD, Overhang	Run, Riffle, Pool	None
		535773	4968517											
		Downstream												
		535519	4968510											
2.1	East Mushaboom Lake Inlet	Upstream		300	1	L-M	1.5%	0.3-4	10-25	10	Cobble = 5 Gravel = 10 Muck = 85	CWD, Overhang	Flat, Run, Riffle	Subsurface flow, Debris jams
		535826	4968167											
		Downstream												
		535604	4968326											

WC ID	Waterbody Association	Reference UTMs		Reach Length (m)	Stream Order	Velocity	Gradient	Bankfull Width (m)	Depth Range (cm)	Bank Height (cm)	Substrate (%)	Cover	Habitat	Barriers
		E	N											
2.2	East Mushaboom Lake Inlet	Upstream		205	1	L	0.5%	1-2.5	20-50	10	Cobble = 75 Gravel = 10 Sand = 5 Muck = 10	CWD, Overhang	Glide	Beaver dams
		535604	4968326											
		Downstream												
		535469	4968447											
3.1	East Mushaboom Lake Outlet	Upstream		230	3	L	0.5%	Unconfined	10-1.5	N/A (flooded)	Boulder = 40 Muck = 60	Boulder, CWD, Vegetation, Depth	Flat, Run, Pool	None
		535248	4968291											
		Downstream												
		535135	4968126											
3.2	East Mushaboom Lake Outlet	Upstream		445	3	M-H	1.5%	1 - Unconfined	10-1	10 – Flooded	Boulder = 40 Cobble = 45 Gravel = 5 Muck = 10	Boulder, CWD, Overhang	Riffle, Pool, Run, Rapid, Flat	Debris jams
		535135	4968126											
		Downstream												
		534891	4967773											
4	Lawrence Lake Inlet	Upstream		475	1	L-M	4%	1	10-40	20	Boulder = 35 Cobble = 15 Muck = 50	Boulder, CWD, Overhang	Flat, Run, Riffle, Pool	Subsurface flow, Seasonal low flows, Sheet flow
		537742	4967940											
		Downstream												
		537815	4967591											

2.2.2.3 Water Quality

Water quality measurements were recorded during the fish and fish habitat field program from June 12 – 19, 2019. Summaries of water quality measurements are presented in Table 6.

Table 6. Water Quality Measurements

Location	Coordinates (UTM, NAD83)	Date	Temp (°C)	pH	DO (mg/L)	Sp. Con (mS/cm)	TDS (mg/L)	Salinity (ppt)
Big Eastern Lake	537053, 4968553	June 12, 2019	18.5	**5.77**	8.84	0.029	20.15	0.01
Big Eastern Lake	537214, 4968757	June 12, 2019	18.2	**4.28**	8.49	0.031	20.15	0.01
WC1	536418, 4968434	June 19, 2019	18.4	7.12	6.89	0.030	19.50	0.01
WC1	536004, 4968254	June 19, 2019	17.8	**3.90**	8.18	0.029	19.50	0.01
WC2	535447, 4968436	June 19, 2019	13.1	**3.68**	6.63	0.032	20.80	0.01
East Mushaboom Lake	535244, 4968283	June 14, 2019	15.9	**4.90**	6.70	0.035	22.75	0.02
East Mushaboom Lake	535520, 4968506	June 19, 2019	19.7	**4.73**	6.98	0.032	23.4	0.02
WC3	534977, 4967850	June 14, 2019	18.8	**4.13**	8.66	0.034	22.40	0.01
WC3	534977, 4967850	June 19, 2019	18.3	**3.48**	6.87	0.037	24.05	0.02
Lawrence Lake	537827, 4967115	June 13, 2019	19.6	**6.12**	6.39	4.900	3,159	2.61
Lawrence Lake	537974, 4967482	June 14, 2019	16.1	**6.46**	6.84	3.75	2320.5	1.89

Notes: Values in bold indicate recorded water quality parameters below CCME guidelines for the protection of aquatic life.

While there are no CCME guidelines related to temperature and aquatic biota, water temperature preferences of fish have been well established for individual species, as well as for differences across lifecycle stages and seasons. Brook Trout, a cold-water species, have an optimal temperature range of 10-16°C, but can survive temperatures up to 23°C (Raleigh, 1982). All water temperatures recorded fell below the upper limit for Brook Trout; however, watercourses and waterbodies with elevated temperatures in June (e.g. East Mushaboom Lake) are likely to continue warming as the summer progresses. Notably, WC2 had a temperature recorded well below the ambient temperatures of other aquatic systems. This indicates a potential for groundwater discharge to the stream - a feature which is favourable for Brook Trout spawning, overwintering, and summer thermal refuge.

The CCME guidelines for the Protection of Aquatic Life establish a minimum recommended concentration of DO of 5.5 mg/L to sustain any life stage of warm or cold-water fish species (CCME, 1999). All DO levels recorded during the field program fell above the minimum CCME guideline. The CCME water quality guidelines for pH indicate a range from 6.5 to 9.0 is suitable within freshwater habitat. Levels of pH measured within 10 of the 11 sampling sites were below the suitable range, indicating the general presence of acidification within watercourses and waterbodies near the Project Area (typical for surface water systems within the southern uplands region of Nova Scotia). Brook Trout have a relatively wide tolerable pH range of 4.0-9.5, while optimal pH for the species ranges from 6.5 to 8.0 (Raleigh, 1982). Three watercourses (WC1, WC2, and WC3) were measured below the tolerable pH range for Brook Trout. Acidity levels within these areas likely pose a limiting factor for trout habitat viability.

Recorded measurements for salinity, conductivity, and total dissolved solids confirm brackish conditions within Lawrence Lake. All other salinity measurements recorded for the aquatic features of interest are indicative of freshwater conditions (<0.05 ppt).

2.2.2.4 Fish Surveys

A total of 116 individual fish across 6 species were captured as a result of fish survey efforts.

Table 7. Fish Species Captured - Trapping

Location	Species		Catch		Conservation Rank (ACCDC)
	Common	Scientific	Total #	% of Catch	
Big Eastern Lake	American Eel	*Anguilla rostrata*	9	17	S2
	Golden Shiner	*Notemigonus crysoleucas*	43	83	S5
Lawrence Lake	Banded Killifish	*Fundulus diaphanous*	43	88	S5
	Fourspine Stickleback	*Apeltes quadracus*	4	8	S5
	Rainbow Smelt	*Osmerus mordax*	1	2	S5
	White Perch	*Morone americana*	1	2	S5

Table 8. Fish Species Captured - Electrofishing

Survey	Species		Catch		Conservation Rank (ACCDC)
	Common	Scientific	Total #	% of Catch	
WC3.2 – July 14	American Eel	*Anguilla rostrata*	5	100	S2
WC3.2 – July 19	American Eel	*Anguilla rostrata*	10	100	S2

Two species of fish, Golden Shiner and American Eel, were caught in the Big Eastern Lake/East Mushaboom Lake system. Golden shiners are a schooling minnow that inhabits cool, vegetated areas of lake and slow-moving streams (Holm et al., 2009). Suitable habitat for American Eel (COSEWIC Threatened) is varied. As a catadromous species, eels spend the majority of their lives in freshwater, moving to the Sargasso Sea to spawn. Once hatched, American Eel larvae drift back to the coast, undergoing several phases of metamorphosis. By the time they reach freshwater, young glass eels have developed pigment and are now referred to as elvers (Scott and Crossman, 1973). In freshwater, elvers develop into yellow eels; growing immature adults and at which point sexual differentiation occurs. As growth proceeds, yellow eels metamorphose into Silver eels, or mature adults that are now physiologically prepared to return to the sea to spawn (COSEWIC, 2012). As can be noted in Figure 1, all three freshwater life stages of eel were captured during fish surveys in Big Eastern Lake and East Mushaboom Lake Outlet, with the majority of eels falling into the immature adult (yellow eel) life stage.

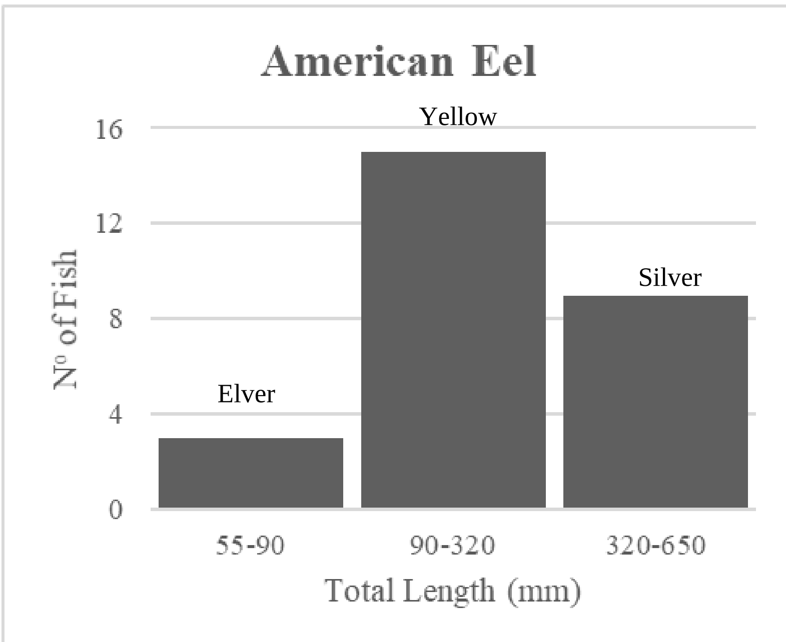


Figure 1. Length Frequency Analysis of American Eel (length at life stage referenced from Scott and Crossman, 1973; Jessop, 1987; Jessop, 2003; COSEWIC, 2012).

All four species of fish found in Lawrence Lake are known to inhabit brackish environments. Fourspine sticklebacks are typically a marine species, predominantly confined to coastal areas and commonly inhabiting brackish estuaries (Scott and Crossman, 1973). Unlike fourspine sticklebacks, banded killifish live in fresh and saltwater, but is most commonly found in freshwater lakes and streams (Scott and Crossman, 1973). White Perch use both brackish and freshwater, but in Nova Scotia are more commonly seen in freshwater habitats usually over mud substrate (Bigelow and Schroeder, 2002). Spawning occurs in June in shallow areas of either fresh or brackish water (Gilhen, 1974). They are typically resident species wherever they are found.

Rainbow smelt are anadromous, schooling fish that migrate to freshwater streams to spawn. Most commonly, rainbow smelt spawning takes place in lower reaches of streams, but shoreline spawning may also occur (Nellbring, 1989). Spawning along lake shorelines occur along gravel shoals (Scott and Crossman, 1973). Spawning may occur in slightly brackish water but saltwater flooding will kill the deposited eggs (Bigelow and Schroeder, 2002). The single rainbow smelt captured in Lawrence Lake was retrieved by a fyke net placed facing and surrounding the Mushaboom Road culvert opening. This capture methods reveals that smelt are able to make passage into Lawrence Lake from the coast during high tide, although likely in small numbers.

No Brook Trout were captured during fish surveys, nor were any observed during watercourse and waterbody characterizations. However, based on the results of the desktop review, the species' widespread occurrence throughout the province, and the availability of habitat within and surrounding the Study Area, it is anticipated that Brook Trout may be present within waterbodies and watercourses downgradient of the Study Area. As discussed in the sections above, habitat availability and quality for Brook Trout varies within each waterbody and watercourse evaluated and is limited based on a number of factors including pH and physical barriers to fish passage.

2.2.3 Water Balance Analysis

A revised water balance analysis was performed at six outfall locations (Big Eastern Lake Catchment Area [CA], East Mushaboom Lake CA, Lawrence Lake CA, Powers Cove NW CA, Powers Cove SE CA and East Mushaboom Lake Inlet CA) for the four quarry lifecycle stages:

- Baseline conditions;
- Mid-life quarry conditions;
- End-of-quarry conditions; and,
- Reclamation conditions.

A summary of the water balance analysis in the form of a technical memorandum is presented as Appendix B to the Additional Information Response document. It is important to note that the water balance analysis assesses the change in infiltration and surface runoff volume at the outfalls (i.e. the bottom) of each catchment and sub-catchment. These are identified on Figure 1 (Appendix A of this document) as Outfall Locations.

During the fish and fish habitat evaluation field study, it was determined that a tributary (WC2) currently draining into East Mushaboom Lake could potentially be affected by future development of the quarry. As result of the potential effects to this tributary and East Mushaboom Lake, a water balance analysis was completed for WC2 for its outfall location. This analysis was completed subsequent to the preliminary water balance being completed and was therefore not included in the revised water balance report completed for the additional information request.co. However, results of the evaluation for this CA (and subsequent discussions of effects to fish and fish habitat) are discussed in the following sections along with the other five outfall locations.

The following sections outline the predicted changes that can be expected in water quantity being sourced to Big Eastern Lake, East Mushaboom Lake, Lawrence Lake and their associated tributaries. It should be noted that these changes are based on <u>all phases of quarry development, and only the worst-</u>

case scenario predicted changes have been considered for the evaluation. **Since the calculated changes have been completed at the outfall of each catchment/sub-catchment area (i.e. the bottom), potential changes and associated effects to the upper portions (headwaters) of each aquatic feature have been qualitatively discussed. In some cases, this includes an extrapolation of predicted increases and reductions to these upper portions of each aquatic feature.**

Big Eastern Lake and Big Eastern Lake Outlet (WC1) – Outfall Location 1

- Based on impervious conditions, a 4.91% predicted increase in surface water volume.
- Based on a pervious condition scenario, a 1.62% reduction in surface water volume.
- Predicted increases in surface water volume are anticipated to be reduced as WC1 extends westward from Outfall Location 1; the effects are reduced the in lower portions of WC1 as water is sourced to it from the natural, undeveloped sub-catchment outside the quarry development.

East Mushaboom Lake Inlet (WC2) – Outfall Location 2

- A 27% predicted decrease in surface water volume.
- Predicted decreases in surface water volume are anticipated to be greater in the headwaters of WC2, as this portion of the sub-catchment area will be more heavily influenced by quarry expansion.

East Mushaboom Lake and East Mushaboom Lake Outlet (WC3) – Outfall Location 3

- A 2.45% predicted decrease in surface water volume.
- The predicted decrease in surface water volume is anticipated to be reduced in the lower portions of WC3 as water is sourced to it from overland drainage outside the impact of quarry development.
- **The two additional mapped tributaries that drain into the north and west of East Mushaboom Lake will not experience any changes in water quantity as a result of quarry development;** their contributing drainage areas will remain undisturbed and thus are not evaluated herein.

Powers Cove NW (WC5) – Outfall Location 4

- A 4.28% decrease in surface water volume.

Powers Cove SE (WC6) – Outfall Location 5

- A 4.82% decrease in surface water volume.

Lawrence Lake and Lawrence Lake Inlet (WC4) – Outfall Location 6

- A 5.15% predicted decrease in surface water volume.
- Predicted decreases in surface water volume are anticipated to be greater as WC4 extends north towards its headwaters. At its uppermost extent, WC4 is expected to have lost most of its water supply originally sourced from the Lawrence Lake LCA.

3.0 EFFECTS ASSESSMENT

Based on the results of the fish habitat evaluation and the water balance analysis, an effects assessment has been compiled to evaluate the predicted effects on fish and fish habitat within Big Eastern Lake, East Mushaboom Lake, Lawrence Lake, and their associated tributaries as a result of the predicted changes in surface water runoff.

The threshold for determination of significant adverse residual environmental effects for fish and fish habitat has been selected as an effect that is likely to cause serious harm to fish, without appropriate fish offsetting, as defined by the Government of Canada under the Fisheries Act (1985, Section 2(1)):

> *"serious harm to fish is the death of fish or any permanent alteration to, or destruction of, fish habitat," with fish habitat defined as "spawning grounds and any other areas, including nursery, rearing, food supply and migration areas, on which fish depend directly or indirectly in order to carry out their life processes."*

The following sections integrate the results of the water balance analysis and the fish and fish habitat assessments to discuss and evaluate the potential effects that are predicted in the downstream receiving aquatic features. Using this information, a prediction of potential residual effects and a determination of whether the effects meet the threshold defined above has been made. Planned mitigation and monitoring to offset and evaluate the potential effects are also discussed.

3.1 Surface Water and Fish and Fish Habitat

The predicted changes in water being sourced to each aquatic feature (as a result of changes to infiltration and surface runoff) can have implications for fish and fish habitat provided by these aquatic features.

The reader is reminded that the water balance completed for the Project is a predictive tool, based upon conservative assumptions, and does not incorporate field data (i.e. flows). As part of this assessment, the Project Team felt it important to highlight the unpredictability of determining effects to surface water flow (as well as groundwater). This effects assessment has been based on results of a water balance which utilized loss of catchment area and infiltration to the receiving aquatic system. This is in comparison to the use of stream flow data in downstream features, which one would expect would provide a more predictable effect. However, potential errors exist in the processes of stream flow measurement techniques as well. Notably, these potential errors pertain to water quantity predictions using the development of rating curves and other stream and river flow data derived from actual field measurements studies completed by (Harmel et al., 2006; Dibaldassarre and Montanari, 2009).

Based on the absence of viable fish habitat and barriers to fish access identified during the field program, in combination with small predicted changes to water quantity within these systems, predicted water quantity changes within the following systems will not trigger serious harm to fish:

- Powers Cove NW Mapped Watercourse (WC5): A 4.28% decrease in surface water volume;
- Powers Cove SW Mapped Watercourse (WC6): A 4.82% decrease in surface water volume; and,
- Lawrence Lake Inlet (WC4): A 5.15% decrease in surface water volume.

For the purposes of the evaluation of effects to fish and fish habitat, these features are not further discussed in this document.

3.1.1 Big Eastern Lake and Big Eastern Lake Outlet (WC1)

As noted in Section 2.2.3, Big Eastern Lake and its associated outflow watercourse (WC1) are expected to experience an increase in water quantity of 4.91%. The predicted increase in water quantity within these systems is expected to generate net benefits to fish and fish habitat within Big Eastern Lake and WC1, particularly to the upper reach of WC1 where several seasonal barriers (debris blockages, subsurface flows, low water levels) were identified. Benefits to fish and fish habitat may be achieved through the following pathways:

- Improvements to upstream and downstream fish passage;
- An increase in temporal accessibility to Brook Trout juvenile rearing habitat, and the expansion of potential Brook Trout juvenile rearing areas;
- An increase in pool depth, and the potential creation of new suitable overwintering, holding, and thermal refuge areas;
- A decrease in low-flow stranding and predation;
- A decrease in detrimental peak summer temperatures; and,
- An increase in accessible off-channel habitat.

Management of peak flow conditions within the quarry development area will be accomplished using re-vegetated slopes, ditching and settling ponds, as required. Big Eastern Lake and the large wetland floodplain located along WC1.2 (see Figure 1 Appendix A) provide additional, natural flood attenuation capacity within the system. Therefore, downstream flooding and erosion from the additional water is not expected in Big Eastern Lake or WC1. Furthermore, quality fish habitat (Brook trout spawning) identified in the lower reaches of WC1 are not anticipated to be impacted.

Based on the pervious condition scenario, a 1.62% reduction in surface water volume in Big Eastern Lake and Big Eastern Lake Outlet (WC1) – Outfall Location 1 is predicted. However, this minor loss of predicted water quantity change is not expected to trigger serious harm to fish.

3.1.2 East Mushaboom Lake Inlet (WC2)

As stated in Section 3.2.6, the predicted water quantity loss in WC2 is expected to be greatest in the upper portions of the stream (reach 2.1). Within this reach, potential Brook Trout juvenile rearing habitat (based on the physical characteristics of the watercourse) is intermittent and is spaced apart by spans of subsurface flow during low flow periods. Surface water connectivity, and thus fish accessibility, is limited to periods of high flow. Utilization of potential Brook Trout rearing habitat within the upper areas of the watercourse is therefore highly restricted; however, the predicted decrease in surface water quantity is predicted to further restrict fish access by increasing the magnitude and/or duration of low-flow periods.

Habitat complexity and fish habitat provisioning is enhanced in the lower portion of the stream (reach 2.2), as substrate and stream morphologies become more varied. Within this reach, potential Brook Trout spawning habitat is restricted to the most downstream 10 m of linear stream habitat, at its confluence with East Mushaboom Lake. As discussed in Section 2.2.3, water temperatures in this area suggest the presence of groundwater upwelling; the water balance analysis presented in Appendix D does not take into account existing contributions from groundwater seeps. In addition, the most downstream 150 m of linear stream habitat flows through fen-type riparian wetland which exhibits bi-directional flow (see Figure 1, Appendix A). The expected presence of groundwater discharge and inputs from riparian wetland habitat are predicted to reduce the overall effect of predicted reduced surface water quantity within the lower reaches of this system.

Trout habitat viability is limited by water quality, with pH recorded within WC2 as below the tolerable range for Brook Trout (3.68). No Brook Trout were observed during biophysical characterizations of watercourses and waterbodies, nor were any captured during electrofishing and trapping surveys. American Eel and Golden Shiner were the only species captured within the East Mushaboom Lake/Big Eastern Lake system. Based on the limiting pH factor and limited habitat availability, the watercourse is not likely to support a significant number of fish.

Overall, the effects of a 27% reduction in water quantity in WC2 is considered diminished based on limited habitat availability and barriers to fish access in the upper reach of the watercourse. In the lower reach, where potential spawning habitat was identified, the reduction in surface water it is anticipated to be mitigated by apparent groundwater discharge and bidirectional flow from the lake with the surrounding wetland.

3.1.3 East Mushaboom Lake and East Mushaboom Lake Outlet (WC3)

Based on the results of the water balance analysis, East Mushaboom Lake and WC3 are predicted to experience a maximum 2.45% decrease in water quantity. This predicted effect is anticipated to be reduced in the lower portions of WC3 as water is sourced to it is from the natural catchment outside the quarry development.

As detailed in Section 2.2.2.2, surface water within WC3 was observed to flow predominantly unconfined, frequently flooding its banks into riparian habitat. In the upper reaches of WC3, where the predicted decreases in water is expected to be greatest, the watercourse forms a deep pond, with surface water unconfined through wetland habitat. Even as it confines in its lower reaches, this third-order stream contains numerous braids and side channels which suggests a significant flow of water through this system. Due to the naturally high discharge through this system, the viability of potential Brook Trout rearing, overwintering, and fish passage within WC3 is not expected to be impacted by the minor predicted decrease in surface water runoff contribution. As habitat generalists, American Eel presence within this system as confirmed during fish surveys is not expected to be affected by quarry expansion. In addition, the predicted decrease is not expected to have an effect on fish habitat provided within East Mushaboom Lake, including within its littoral zone. The maximum predicted decrease in water quantity for Outfall Location 3 is not expected to produce an observable drop in lake water levels.

3.1.4 Lawrence Lake

Lawrence Lake is predicted to experience a maximum decrease in water quantity of 5.15%. However, the water balance analysis does not take into account saltwater inputs from the ocean, which was confirmed in Lawrence Lake by the presence of brackish salinity levels, seaweed, and anadromous Rainbow Smelt. In addition, the lake footprint has widened due to the installation of a culvert outflow, which has led to flooding of the lake's shoreline within its southern lobe. As such, the maximum predicted decrease in water quantity for Outfall Location 6 is not expected to affect the viability of available fish habitat within Lawrence Lake, nor is it expected to produce an observable drop in lake water levels.

3.2 Mitigation and Monitoring

As previously discussed, surface water management throughout the lifetime of the Sheet Harbour Quarry will be through direction to ditches and settling ponds as required. Mitigation for the effects to surface water quantity and quality is focused on the design and function of the settling pond during quarry operations.

The settling pond will be designed by a qualified engineer in consultation with NSE (through the IA process) to ensure the following:

- That pre-quarry expansion, and post-quarry expansion peak discharge rates are equal: This includes design of the settling pond to manage peak discharge to prevent scour and erosion in the downstream environment and to design the pond appropriately for storm events including climate change scenarios;
- To prevent additional flooding downstream;
- To prevent scour and erosion and sediment loading in the downstream environment;
- Potential thermal charging of water in the settlement pond will be considered in its design, and mitigation to reduce these potential effects will be implemented where warranted;
- To implement a surface water monitoring program (including sample locations from the outflow/downstream environment of the settling pond), to ensure water quality entering the downstream environment meets regulatory requirements and that potential impacts to aquatic life is not occurring. Details of the water quality program will be outlined in a Surface Water Quality Monitoring Program.

The Surface Water Monitoring Program will also be designed to evaluate the effects of increased and decreased flows to watercourses discussed in this document. This is likely to include baseline flow collection in watercourses subject to flow alterations, from which future data will be compared to.

3.3 Residual Effects and Significance

This document has evaluated the potential effects to fish and fish habitat as a result of expanding the Sheet Harbour Quarry over the period of 50+ years. The analysis completed confirms that there are predicted losses and increases in surface water runoff contributions to waterbodies and watercourses located down-gradient of the proposed quarry development area.

The following conclusions as it relates to residual effect and significance are provided:

- Big Eastern Lake and Watercourse 1: The effects of an increase in surface water runoff to Big Eastern Lake and WC1 are expected to generate net benefits to fish and fish habitat.
- Watercourse 2: The predicted decrease in water quantity in WC2 suggest that a drying effect is expected, however current fish habitat quality is currently limited by seasonal fish passage and high acidity levels. In addition, the decrease of water quantity within potential Brook Trout spawning habitat is thought to be mitigated by backwatering from the lake and expected groundwater discharge. Still, it is possible that the loss of habitat in WC2 may trigger a Fisheries Authorization and further consultation with Fisheries and Oceans Canada (FOC) is recommended.
- East Mushaboom Lake and Watercourse 3: The effects of a decrease in surface water runoff to the lake and WC3 are not expected to trigger serious harm to fish and fish habitat.
- Lawrence Lake: The effects of a decrease in surface water runoff to the Lawrence Lake is not expected to trigger serious harm to fish and fish habitat.
- The predicted losses and increases of water to WC4 (Lawrence Lake Inlet), WC5, and WC6 are negligible due to the absence of viable fish habitat and permanent barriers to fish access.

5.0 CONCLUSION

This document has been completed in response to the Additional Information Request issued by NSE on March 22, 2019 in association with the Sheet Harbour Aggregate Quarry Project EA registration document.

The Project Team has completed additional analysis to evaluate the hydrological effects of the proposed quarry expansion to fish and fish habitat within waterbodies and watercourses hydrologically connected to the proposed quarry development area. This was achieved through completion of a revised seasonal water balance, and prediction of surface water volume increases and decreases as a result of quarry development. Based on this information, an evaluation of potential effects to fish and fish habitat within downgradient waterbodies and watercourses as a result of the quarry development was completed. This document discusses mitigation, expected residual effects and significance and recommended follow up monitoring measures.

The following conclusions were determined:

- Six watercourses (WC1-6) and three waterbodies (Big Eastern Lake, East Mushaboom Lake, and Lawrence Lake) receive a direct source of water from the proposed quarry development area;
- The watercourses and waterbodies are subject to predicted increases and decreases in surface water volume as a result of quarry development;
- Predicted changes in flow to WC4, WC5, and WC6 are not expected to negatively affect fish or fish habitat based on the absence of fish habitat and barriers to fish access;

- Based on the habitat conditions present within Big Eastern Lake and WC1, it has been determined that the increases in water flow volume will generate net benefits to fish and fish habitat;
- Predicted changes in flow to East Mushaboom Lake, WC3, and Lawrence Lake are negligible and are not expected to negatively affect fish or fish habitat.
- Although fish habitat quality present within WC2 is limited and potential mitigation of surface water reduction exists in the form of groundwater discharge and bi-directional flow, it has been determined that the proposed decreases in water quantity as a result of quarry development may trigger a Fisheries Authorization. Future consultation with FOC is recommended. However, since the Project will not interact with the East Mushaboom Lake Inlet (WC2) CA until a minimum of 20 years, it is proposed that monitoring of WC2 be initiated one year prior to quarrying extending into the CA, and continue concurrent to quarrying within the CA to further refine potential effects, modify mitigation methods and obtain approvals (if necessary).

Please don’t hesitate to contact the undersigned with any questions you might have.

Sincerely,

Andy Walter
Senior Project Manager
McCallum Environmental Ltd.
902. 446-8252
andy@mccallumenvironmental.com

6.0 REFERENCES

Atlantic Salmon Federation (ASF). 2019 (accessed). Nova Scotia Salmon Rivers. Retrieved from: http://oldsalmon.ca/docs/uploads/rivers/novascotia.html

Bigelow, H.B., and W.C. Schroeder. 1953 (revised 2002). Fishes of the Gulf of Maine. Rev. ed. Washington (DC): US Government Printing Office. Fishery Bulletin no. 74 of the Fish and Wildlife Service, US Department of the Interior. Retrieved from: http://www.gma.org/fogm/.

Canadian Council of Resource and Environment Ministers (CCRME). 1987. Canadian Water Quality Guidelines. Retrieved from: https://www.ccme.ca/files/Resources/supporting_scientific_documents/cwqg_pn_1040.pdf.

Canadian Council of Ministers of the Environment (CCME). 1999. Canadian Water Quality Guidelines for the Protection of Aquatic Life. Updated 2001, 2002, 2003, 2005, 2006 and 2007. Retrieved from: http://ceqg-rcqe.ccme.ca/download/en/177/.

COSEWIC. 2010. COSEWIC assessment and status report on the Atlantic Salmon *Salmo salar* (Nunavik population, Labrador population, Northeast Newfoundland population, South Newfoundland population, Southwest Newfoundland population, Northwest Newfoundland population, Quebec Eastern North Shore population, Quebec Western North Shore population, Anticosti Island population, Inner St. Lawrence population, Lake Ontario population, Gaspé-Southern Gulf of St. Lawrence population, Eastern Cape Breton population, Nova Scotia Southern Upland population, Inner Bay of Fundy population, Outer Bay of Fundy population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xlvii + 136 pp. Retrieved from: https://wildlife-species.canada.ca/species-risk-registry/virtual_sara/files/cosewic/sr_Atlantic_Salmon_2011a_e.pdf.

COSEWIC. 2012. COSEWIC assessment and status report on the American Eel *Anguilla rostrata* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xii + 109 pp. Retrieved from: www.registrelep-sararegistry.gc.ca/default_e.cfm.

Dibaldassarre G., and A. Montanari. 2009. Uncertainty in river discharge observations: A quantitative analysis. Hydrology and Earth System Sciences 13, pp. 913-921.

Fisheries and Oceans Canada (DFO). 2016. Alewife. Retrieved from: https://dfo-mpo.gc.ca/species-especes/profiles-profils/alewife-gaspareau-eng.html

Gilhen, J. 1974. The fishes of Nova Scotia’s lakes and streams. Nova Scotia Museum, Halifax, NS.

Harmal, R.D., R.J. Cooper, R.M. Slade, R.L. Haney and J.G. Arnold. 2006. Cumulative Uncertainty in Measured Streamflow and Water Quality Data for Small Watersheds. Transactions of the ASABE, vol. 49(3), pp. 689-701.

Hawkins, C.M. 1995. Environmental habitat quality requirements/guidelines for American Eel *Anguilla rostrata*. Document prepared for Habitat Management Division, Department of Fisheries and Oceans, Maritimes Region.

Holm, E., Mandrak, N. E., & Burridge, M. 2009. The ROM field guide to freshwater fishes of Ontario. Toronto: ROM.

Jessop, B.M. 1987. Migrating American eels in Nova Scotia. Transactions of the American Fisheries Society 116: 161-170.

Jessop, B.M. 2003. The run size and biological characteristics of American eel elvers in the East River, Chester, Nova Scotia, 2000. Canadian Technical Report of Fisheries and Aquatic Sciences No. 2444. 42 p. Retrieved from: http://publications.gc.ca/collections/collection_2014/mpo-dfo/Fs97-6-2444-eng.pdf.

Nellbring, S. 1989. The ecology of smelts (genus *Osmerus*): a literature review. Nordic J, Freshwater Res, 65: 116-145.

Raleigh, R.F. 1982. Habitat suitability index models: Brook trout. United States Fish and Wildlife Service Biological Report 82 (10.24), Fort Collins, CO. Retrieved from: https://www.nwrc.usgs.gov/wdb/pub/hsi/hsi-024.pdf.

Nova Scotia Department of Agriculture and Fisheries (NSDFA). 2005. Nova Scotia Trout Management Plan. Retrieved from: https://novascotia.ca/fish/documents/special-management-areas-reports/NSTroutManplandraft05.pdf.

Scott, W.B., and E.J. Crossman. 1973. Freshwater fishes of Canada. Bulletin Fisheries Research Board of Canada 184:966 p.

APPENDIX A: FIGURES

Prepared For:

GHD

FIGURE 1

Fish and Fish Habitat Evaluation

Sheet Harbour, NS

- Photos
- Outfall Locations
- Study Area (EA)
- Field Verified Watercourses
- Mapped Watercourses
- Drainage
- Lakes
- Field Delineated Wetland
- Mapped Wetlands (NSE)

Coordinate System: NAD 1983 UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

0 125 250 500 m

1:10,000 Scale when printed @ 11" x 17"

Drawn By: AS

Date: 2019-07-27

McCallum Environmental Ltd.

Document Name: 190726_SH_FishIR

APPENDIX B: CURRICULUM VITAE

Andy Walter, BSc. (Hort)
andy@mccallumenvironmental.com
Senior Project Manager

Years in Practice

10

Certifications

Nova Scotia Advanced Wetlands Delineator and Evaluator

Memberships

Nova Scotia Wetlands Delineation, Maritime College of Forest Technology

Education

- BSc. (Horticulture), Essex University (UK), 2003-2005

Training

- Wetland Functional Assessment Training Workshop, NSE 2013
- Urban Wetland Restoration: A Watershed Approach, 2012
- Nova Scotia Advanced Wetlands Delineation and Evaluation Course, 2010;
- Water Management and Wetland Restoration Training Course, 2014;
- Identifying and Delineating Wetlands for Nova Scotia, 2009
- Watercourse Alteration Certification (Nova Scotia Environment) (2008)
- Saint John Ambulance Emergency First Aid, AED, CPR(C). 2016

Summary

Mr. Walter is a trained biologist and wetland specialist, and has extensive experience managing technical biophysical projects within Atlantic Canada. Mr. Walter is knowledgeable in federal, provincial, and municipal environmental regulations and guidelines applicable to Atlantic Canada, and works closely with all necessary regulatory agencies to facilitate project implementation. As senior project manager, Mr. Walter ensures biophysical field programs are tailored to the needs of the client and project, while meeting regulatory standards. Mr. Walter has provided environmental support to the planning process in a wide range of project types including residential development, industrial projects (mining, pit and quarry), transmission line and hydro dam infrastructure and highway construction to name a few. Mr. Walter has managed the environmental processes associated with multiple wind energy developments in Nova Scotia, including compilation of provincial environmental assessment (EA) documents, and implementation of associated EA biophysical field surveys, as well as acquiring pertinent environmental information required for regulatory permitting.

As a trained field biologist, Mr. Walter has completed terrestrial and stream habitat assessments, and flora and fauna surveys, including desktop reviews and characterization of biophysical environments. Mr. Walter also completes numerous fish habitat/watercourse assessments for effects monitoring, watercourse alteration, and HADD authorization projects. Assessments have also included water quality sampling, benthic sampling, and biophysical characterization (channel depth and width, stream velocity, fish habitat assessment) of water bodies.

As a qualified wetland delineator and wetland function evaluator for Atlantic Canada, Andy has completed delineation of hundreds of wetlands. Projects often involve the completion of species at risk assessments, functions assessments, and detailed wetland characterization in support of provincial wetland alteration applications. In addition, Mr. Walter assists in the identification of potential wetland restoration and creation sites for wetland and fish habitat alterations, reviews databases, mapping, and aerial imagery, completes ground truthing and consults with local environmental groups and government to identify potential sites. Following alteration approval, Mr. Walter supervises construction activities for numerous construction projects in wetland habitat ensuring that erosion and sedimentation control measures are implemented prior to construction, and monitors activities during construction to ensure wetland protection measures are effective.

Project Experience

- Managing, and currently in the process of implementing a new wetland functional assessment tool for use in Nova Scotia. This Project included the collection of baseline wetland information across Nova Scotia by completing 120 wetland functional assessments using the Wetland Ecosystem Services Protocol (WESP). Ongoing collaboration with Nova Scotia Environment to support the rolling out of this method to wetland practitioners.
- Management and implementation of a 18 hectare agricultural wetland restoration project in Middle Stewiacke, NS.
- Management and completion of terrestrial habitat mapping, wetland delineation and vegetation surveys in support of EA and regulatory permitting for the South Canoe Wind Project (80MW wind Project in Nova Scotia) 2011-2014.

Andy Walter, BSc. (Hort)
andy@mccallumenvironmental.com
Senior Project Manager

- Management of a multi-faceted avian study in support of a provincial EA at Aulds Cove, NS.
- Completion of six provincial environmental assessments and baseline surveys for community wind projects in Nova Scotia in 2012-2014.
- Terrestrial habitat mapping, wetland delineation and vegetation surveys in support of a 65km distribution transmission line in central Nova Scotia.
- Wetland delineation, species at risk, watercourses and flora surveys at the site of a proposed quarry in Nova Scotia. Subsequent facilitation of wetland alteration permit to alter in excess of 20 hectares of wetland.
- Implemented the passive wetland restoration strategy at a disturbed wetland on NSDNR property. Completed regular monitoring of vegetation, soil, and hydrology conditions and developed project recommendations accordingly (2009-2011).
- Wetland delineation, species at risk, watercourses and flora surveys at the site of a proposed 22km railway line and shipping container terminal in eastern Nova Scotia (2012-2014).
- Completion of wetland delineation and watercourse identification and associated regulatory permitting at multiple developments in Nova Scotia (2009-2016).

Work Experience

Strum Environmental Services Ltd., Nova Scotia 2008-2015

Environmental Specialist/Project Manager- provided project management expertise for development clients across Atlantic Canada. Projects included environmental assessment, large scale commercial, residential and wind power developments, wetland and watercourse alteration projects, wetland compensation planning and implementation, wetland restoration and creation projects, avian studies, and regulatory consultation.

Amber Stoffer, BSc., MREM
amber@mccallumenvironmental.com

Years in Practice
2

Education
B.Sc. (Honours, Biology), University of Ottawa, 2009-2013.

Master of Resource and Environmental Management, Dalhousie University, 2013-2015.

Training
- Fish Habitat Restoration Watercourse Alteration Installer, 2017
- Saint John Ambulance Standard First Aid, AED, CPR(C), 2017
- Marine Emergency Duties – A1, 2014
- W.H.M.I.S – 2013
- PADI Open Water Certified Suba Diver - 2013

Summary

Ms. Stoffer has worked in environmental consulting and research since 2014. She has worked on both project related and research related field assessments in Nova Scotia and Quebec.

Experience

McCallum Environmental Ltd. - Halifax, Nova Scotia
Junior Environmental Scientist:
July 2017-Present

Completing biophysical assessments, including flora and fauna surveys, with emphasis on species at risk. Completing wetland and watercourse delineations and assessments. Communicating field survey results and methodologies for environmental assessments and other provincial regulatory applications.

Tasks:

- Flora and fauna field surveys
- Species at risk assessments
- Watercourse and wetland identification and assessment
- Wetland delineation
- Reporting of methodology and results for environmental assessment
- Provincial regulatory applications
- Construction monitoring
- GIS

Clean Annapolis River Project – Annapolis Royal, Nova Scotia
Project Leader and Fisheries Technician:
July 2016 – July 2017

Led the planning, coordination, and implementation of fish passage and in-stream restoration work within the Annapolis River watershed. Conducted data collection through field surveys, ecological monitoring, and stakeholder consultation.

Tasks:

- In-stream and culvert restoration
- Fish habitat, water quality, and fish passage assessments
- Watershed management planning
- Staff and student training
- Community and stakeholder engagement

Stantec – Dartmouth, Nova Scotia

Environmental Scientist:

April – September 2014 (Student Contract)

Conducted and coordinated field studies as part of environmental impact assessments, including on-shore and vessel-based marine mammal surveys. Compiled, processed, and analyzed data for technical reports. Developed project work plans and training documents for field surveys.

Tasks:

- Marine mammal population and habitat utilization surveys
- Statistical analysis using R software
- Reporting of methodology and results for environmental assessment

Jeff Bonazza, BSc. MES
Jeffb@mccallumenvironmental.com

Years in Practice
4

Education

Master of Environmental Science, *Memorial University of Newfoundland* 2015

B.Sc. Major in Biology, *St. Francis Xavier University* 2010

Certifications

- Certified Environmental Professional in Training, ECO Canada
- Wetland Plants and Delineation, Fern Hill Institute

Training

- Landbird Species at Risk in Forested Wetlands Workshop, Jan. 2018
- Standard First Aid AED CPR "A", St. John Ambulance, Sept. 2015
- Construction Safety Training System, Sept. 2015
- Geographic Information System (GIS) Training, ESRI, Feb. 2015
- WHMIS, AIX Safety, Mar. 2013
- Green Defensive Driving, Canada Safety Council, July 2012

Experience

McCallum Environmental Ltd., Halifax, NS

Biologist and Intermediate Environmental Scientist

Sept 2015 - Present

- Flora and Fauna field surveys
- Biophysical assessments including species at risk assessments
  - Winter wildlife and birds
- Bird surveys for multiple wind projects – Alberta
  - Spring migratory bird surveys
  - Sharp-tailed Grouse Lek surveys
  - Raptor nest searches
- Watercourse and Wetland identification and assessment
- Wetland Delineation, functions assessments and alteration applications
- Construction Monitoring
  - Avifauna nest searches and buffering for transmission line construction
- Reporting of methodology and results
- Provincial regulatory applications
- GIS

Agriculture and Agri-Food Canada, NL and NS

Research Technician

2011- 2015.

- Led the collection of data in Newfoundland for a national research project
- Surveyed and staked research plots
- Entered and analyzed scientific data
- Conducted quadrat sampling and botanical separation
- Prepared samples for analysis
- Operated specialized laboratory instruments
- Entered and analyzed scientific data
- Supervised and trained laboratory visitors and volunteers
- Assisted research scientists and graduate students in their research
- Applied specialized laboratory procedures and techniques

Atlantic Developments Inc. - Halifax, NS

Office Manager & Assistant to Project Manager

Sept – Dec 2010

- Worked on site during the construction of a condominium complex
- Monitored construction progress
- Gave site tours to contractors and potential unit purchasers
- Assisted the project manager
- Organized and coordinated office operations and procedures

Jeff Bonazza, BSc. MES
Jeffb@mccallumenvironmental.com

- PADI Open Water certified scuba diver, Nov. 2010
- MED A1, Canadian Sailing Expeditions Inc. and Transport Canada, May 2008

UNESCO Southwest Nova Biosphere Reserve Association – Middleton, NS

Community Outreach Coordinator

May – Sept. 2010

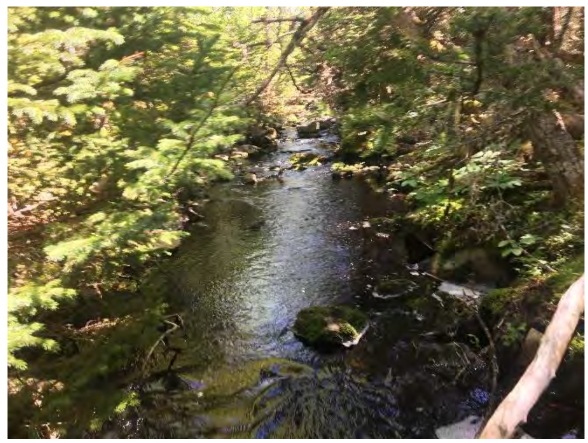
- Coordinated events and activities
- Developed and delivered educational programs
- Designed website and pamphlets

APPENDIX C: PHOTOLOG

P1: Big Eastern Lake – Eastern Shoreline

P2: Big Eastern Lake – Southern Shoreline

P3: Outlet of Big Eastern Lake (WC1)



P4: Representative habitat of WC1.1

P5: Representative habitat of WC1.2

P6: Representative habitat of WC1.3 (showing spawning substrate)

P7: East Mushaboom Lake – Eastern Shoreline (downstream end of WC1)

P8: Representative habitat of WC2.1

P9: Representative habitat of WC2.2

P10: Potential spawning gravels in WC2.2

P11: East Mushaboom Lake – Eastern Shoreline (downstream end of WC2)

P12: East Mushaboom Lake – Southern Shoreline

P13: Representative habitat of WC3.1

P14 Representative habitat of WC3.2

P15: Representative habitat of WC4

P16: Lawrence Lake – Eastern Shoreline

P17: Lawrence Lake – Southern Shoreline

P18a: Culvert at end of Powers Cove NW CA

P18b: Ditch drainage east of the culvert

P18c: Wetland north of road, draining into ditch

P19a: Culvert at end of Powers Cove SE CA

P19b: Ponded water east of the road

P19c: Channel lost underground 10 m east of Mushaboom Road.

Aerial 1: Big Eastern Lake

Aerial 2: East Mushaboom Lake

Aerial 3: Lawrence Lake

about GHD

GHD is one of the world's leading professional services companies operating in the global markets of water, energy and resources, environment, property and buildings, and transportation. We provide engineering, environmental, and construction services to private and public sector clients.

Jeff Parks
Jeff.Parks@ghd.com
902.334.1819

Peter Oram
Peter.Oram@ghd.com
902.334.1818

www.ghd.com