McCallum Environmental Ltd.

July 14, 2019

Nova Scotia Environment
Office of the Minister
PO Box 442
Halifax, Nova Scotia
B3J 2P8

Re: Birette's East Uniacke Quarry Expansion Project – Environmental Assessment. Additional Information

## 1.0 INTRODUCTION

On May 8th, 2019 Nova Scotia Environment (NSE) issued an Additional Information Request to Bio Design Earth Products Inc. in relation to the Birette's East Uniacke Quarry Expansion Project Environmental Assessment (EA).

In order to meet the requests, Bio Design Earth Products Inc. engaged McCallum Environmental Ltd. (MEL) and GHD (*the Project Team*) to respond to the Additional Information request. This included a comprehensive review of individual NSE EA reviewer comments and assimilation of information and methods of approach discussed at a meeting with NSE held on 27th, May 2019.

The Additional Information Request presents two questions for the Project Team to respond to. The two questions and the methods by which the Project Team have responded to the questions in this document are provided in Table 1 (below).

The overall purpose of this document is to:

1) Provide the methods and results of the additional analysis completed to evaluate potential effects to water quantity and water quality as a result of the Project;
2) Based on the results of the above analysis, re-evaluate the potential effects to fish and fish habitat as a result of the Project; and
3) Describe recommended mitigation; potential residual effect and its significance and describe recommended follow-up and monitoring for the above discussed potential effects.

**Table 1: Additional Information Questions and Methods of Response**

| QUESTION | RESPONSE DETAILS | SECTION IN REPORT |
|---|---|---|
| 1. Provide additional information for the water resources assessment with accompanying analysis and discussion of potential effects to surface water quality and quantity and of the proposed mitigation measures and follow-up monitoring programs, that includes the following: Analysis of flows and discharges under current and post-development conditions with considerations for seasonal variation and an assessment of impacts on the watercourses and wetland identified in the Registration Document resulting from this analysis. This analysis should include delineation of watersheds for current and post-development conditions, modelling of flows and discharges using information currently available and considerations for validation through monitoring; | N/A | N/A |
| *a) Re-delineation of the drainage area for unnamed Tributary B to determine whether it will be potentially affected by the proposed project. The Unnamed Tributary B catchment area was estimated to be outside the project development area. However, based on contour mapping (Figure 7 - Appendix A) it could be interpreted that, a portion of the Unnamed Tributary B catchment area is within the project development area.* | Field verification was completed to determine whether unnamed Tributary B lies within, or beyond the proposed development area. | Section 2.1.3 |
| *b) A consistent analysis of the project's activities and potential interactions with changes to the surface water quality and quantity. The EA registration document has conflicting information regarding the project's activities potentially interacting with surface water. For example, the activities and their potential interactions with surface water quantity and quality in Tables 32 and 33 are not the same* | A review of proposed project activities and potential Project interactions and changes to water quality and quantity was completed. The revised analysis is included in this document. | Section 2.0 |
| *c) Detailed rationale to support the general water balance approach, assumptions and results. There is insufficient information provided to support the setup and assumptions made in the water balance approach and some information provided conflicts with the assumptions. For example, an increase of surface water runoff within the quarry floor is predicted, but the water balance approach assumes the quarry floor will no longer be contributing to downstream watercourse flows. Additionally, groundwater is currently not mentioned as part of the water balance methodology with no details as to why it has been omitted and the reasonableness of this assumption.* | A new monthly water balance has been completed for the Project. The water balance incorporates seasonal effects, and takes into consideration predicted infiltration rates, evaporation and evapotranspiration and changes in landcover.<br><br>In addition, the water balance calculations have been predicted within the three different catchment areas within the Development Area. Each catchment area has been assigned an estimated duration for quarrying activities (i.e. Phase).<br><br>Predicted effects to surface water drainage patterns are provided and the potential interaction with shallow groundwater and lateral flow. These predictions have been calculated as per the above catchment area extents. | Water Balance Methodology: Section 3.1<br><br>Water Balance Results and predicted effects to streamflow contribution: Section 3.2 |

| QUESTION | RESPONSE DETAILS | SECTION IN REPORT |
|---|---|---|
| *d) A new water balance scenario representing the reclamation phases of the project. The water balance presented in the EA Registration Document considered the pre-development and end of quarry scenarios only. The reclamation scenario, which would represent different infiltration rates and drainage routing, was not modeled where the land cover within the development area would be changed. Land use changes and the potential for increased water flows to Watercourse 2 between the project's operating and reclamation phases were not considered in the water balance.* | A preliminary description of the methods by which water will be managed during the reclamation phase of the quarry is provided, and the associated predicted water balance scenario during reclamation and quarry closure is discussed. | Section 3.2.3 |
| 2. Provide a new assessment of the potential effects on fish and fish habitat within all watercourses to be affected by the project. Results of the water balance scenarios and predicted surface water flow changes should be considered in the assessment. Include accompanying discussion and analysis of proposed mitigation measures and follow-up monitoring programs based on the results of the assessments. The Ecological Maintenance Flow (EMF) approach within the EA registration document, correlating predicted streamflow reductions with EMF criteria outlined in the "Nova Scotia Guide to Surface Water Withdrawal Approvals" is not appropriate. This guide is applicable to withdrawals from water bodies (i.e. lake or river) and not to water flow reductions due to alteration of the drainage area, as anticipated from the quarry expansion. Should the Ecological Maintenance Flow (EMF) be considered in the analysis, its approach and methods must be submitted to NSE and Fisheries and Oceans Canada for prior approval. | Based on the revised results of the water balance, an additional evaluation of habitat present within Watercourse 2, Watercourse 3 and Wetland 7 was completed. This was completed to support the effects assessment process discussed below.<br><br>A revised Effects Assessment to fish and fish habitat has been provided in this document. The Effects Assessment utilizes the calculations presented in the Water Balance to determine the potential effect to fish and fish habitat in watercourses affected by the Project including the immediately adjacent Wetland 7. This process included the use of a "Threshold" to determine significance of potential effects, and a discussion of potential mitigation and monitoring that could be implemented to reduce the effects. | Fish Habitat: Section 4<br><br>Fish and Fish Habitat: Section 5.1<br><br>Wetlands: Section 5.2 |

## 2.0 HYDROLOGICAL INTERACTIONS

As part of the Effects Assessment in the original EA Registration document, potential interactions with surface water quantity and quality were analyzed, and effects were evaluated for surface water and fish and fish habitat. Inconsistencies in this approach have been reviewed by the Project Team and updated below (Table 2). For ease of comparison, the interactions and potential effects for surface water and fish and fish habitat have been compiled into one table.

**Table 2: Interactions by Project Phase on Surface Water and Fish and Fish Habitat**

| Project Activities and Physical Works | Changes in Water Quality | | Changes in Water Quantity | |
|---|---|---|---|---|
| | Surface Water Interaction | Fish and Fish Habitat Interaction | Surface Water Interaction | Fish and Fish Habitat Interaction |
| **Construction** | | | | |
| Site preparation/clearing | X | X | | |
| Grubbing | X | X | | |
| Watercourse/wetland alteration | X | X | X | X |
| Removal of overburden | X | X | | |
| Waste management | | | | |
| Expansion of storage areas for grubbings and overburden soils | X | X | | |
| **Operation and Maintenance** | | | | |
| Rock Blasting | X | X | | |
| Rock Transfer | | | | |
| Sorting and Crushing | | | | |
| Management of surface water | X | X | X | X |
| Trucking/Transport of product | | | | |
| **Decommissioning** | | | | |
| Re-grading of rock face | X | X | | |
| Reclamation/re-vegetation | X | X | X | X |
| **Accidents, Malfunctions and Unplanned Events** | | | | |
| Erosion and sediment control failure | X | X | | |
| Fuel spill from machinery/trucks | X | X | | |
| Fire | | | | |

Effects, mitigation, monitoring and residual effects for the above described interactions are explored further in Section 5.1.

## 3.0 HYDROLOGICAL ASSESSMENT

Based on the detailed comments provided by NSE, and individual comments provided by EA reviewers, a revised hydrological assessment was completed for the Project. The revised hydrological assessment was completed by MEL and Senior Water Resources Engineer Andrew Betts (GHD).

The objective of the hydrological assessment is to determine the potential indirect impact of a change in water quantity during development of the Birette's East Uniacke Quarry (BEUQ).

### 3.1 Methodology

The hydrological assessment included the completion of a monthly water balance assessment. General tasks completed as part of this assessment are indicated in Table 3. A detailed description of each task is provided in the sections that follow.

Utilizing the methodology described below, the water balance assessment can be used to evaluate the following:

1) Predicted monthly changes in surface water runoff quantity to downstream receiving aquatic features (i.e. WC2, WC3, Unnamed Tributary A, O'Hearn Flowage, and WL7);
2) Predicted monthly surface water runoff changes at different phases of the quarry development (i.e. within the three LCA boundaries);
3) Predicted changes to shallow groundwater through calculation of infiltration loss;
4) Predicted changes to surface water quantity during the reclamation phase/closure of the quarry.

**Table 3: Hydrological Assessment Tasks**

| Task | Details |
|---|---|
| 1. Quarry Development Assumptions | Assumptions associated with the development of the Project were identified in support of the hydrological assessment. See Section 3.1.1. |
| 2. Create DEM of Study Area | A Digital Elevation Model was created. See Section 3.1.2. |
| 3. Identify Catchment Areas | Catchment areas were re-defined. See Section 3.1.3. |
| 4. Perform monthly water balance analysis | A monthly water balance analysis was completed to assess the impact of the proposed quarry expansion on the receiving aquatic features in terms of water quantity for each development stage. See Section 3.1.4. |

Using this information, the Project Team has completed a revised effects assessment to fish and fish habitat within WC2, WC3, O'Hearn Flowage and WL7 as a result of quarry expansion across all quarry development phases.

In support of the methodology discussed below, please refer to Figures 1 and 2 (Appendix A).

3.1.1 Assumptions

In order to complete the hydrological assessment, a number of assumptions were identified to support the monthly water balance exercise. The assumptions listed below are specific to the proposed expansion of BEUQ over the next 25 years, and the management of water during development and post quarry reclamation/closure.

**1)** As discussed in the EA Registration document, the BEUQ will initially expand southward from the existing quarry footprint. Subsequently, the quarry will expand westward into the existing quarry face, throughout the Development Area. The quarry floor will be sloped from the quarry face downgradient eastward at a 2:1 slope, and surface water will be directed to the on-site settling pond located at the eastern extent of the Development Area. **Surface water within the Development Area will be directed eastward to the location of the on-site settling pond throughout the lifetime of the BEUQ and post quarry closure.** This has been taken into consideration within the water balance results (Section 3.2) and the predicted conditions during the reclamation and quarry closure phase of the Project (Section 3.2.8).

2) All inflow to the settling pond is assumed to discharge to lower portions of WC2 (via the Quarry Discharge Flow) at a controlled discharge rate (i.e., the water balance calculations assume that within the quarry no water will infiltrate into the quarry floor and groundwater system). Elsewhere, within land surrounding the quarry, infiltration was calculated as part of the water balance assessment). This represents a conservative "worst case scenario".

3) Catchment areas existing and/or potentially affected by the proposed Project have been identified and are discussed further in Section 3.1.3. Four aquatic features (3 watercourses and one wetland) which have been identified to directly receive water from each of the catchments, have been assessed as part of the water balance and associated Effects Assessment. The four aquatic features (Watercourse 2, Watercourse 3, Unnamed Tributary A, O'Hearn Flowage and Wetland 7) are identified on Figure 2 (attached). These aquatic features are subject to direct reductions and/or increases in surface water flow as a result of the proposed Development. It should be noted that WC2 is subject to a reduction in water flow in its upper reaches. Water draining from the settling pond to lower reaches of WC2 (via the Quarry Discharge Flow) will be done so at a controlled discharge rate, therefore surface water volume in expected to change but peak flow volume is not expected at this location of WC2.

4) For the purposes of the water balance assessment, the model integrates two land drainage characteristics; pervious and non-pervious.
   - Pervious applies to land which is natural/undisturbed; and
   - Impervious applies to land which has been developed into the Quarry footprint.

5) For the purposes of this assessment the effects to shallow ground water is being assessed as a reduction to groundwater recharge/infiltration within the quarry area as a result of the quarry expansion.

6) Changes to surface water runoff within the quarry area as a result of the quarry expansion is calculated after infiltration, evaporation and evapotranspiration have occurred.

3.1.2 Creation of a DEM

A Digital Elevation Model (DEM) of the Study Area was created based on source data obtained from the Nova Scotia Topographic Database (NSTDB). The topographic contour, spot elevation, and water feature data was inputted into the 'Topo to Raster' tool in ArcGIS which generated a DEM with a 1 m cell size.

3.1.3 Catchment Areas

The three Local Catchment Areas (LCA) identified for the initial EA Registration Document were reviewed as part of this Additional Information Response. The LCA's were identified based on three (3) tributaries to the O'Hearn Flowage that are within and adjacent to the Development Area (Figures 1 and 2, Appendix A). In addition, one broader catchment area (the O'Hearn Flowage Catchment Area), and two sub catchment areas (O'Hearn Brook upstream of O'Hearn Flowage and WC2 upstream of the confluence with Quarry discharge flow) were identified and used in the assessment to quantity impacts within these reaches.

The northern boundary of LCA Central is located on relatively flat land, and topographical contour mapping suggests that Unnamed Tributary B is in close proximity to it. As part of the Additional Information request, NSE questioned whether Unnamed Tributary B lies within catchment LCA Central (and therefore subject to water quality/quantity effects as a result of the Project). The boundary of) LCA Central was field truthed in June 2019 by MEL personnel. As part of this process, the surveyor walked the LCA boundary and identified elevated land using a handheld GPS. In addition, the surveyor walked to the headwater of Unnamed Tributary B to confirm that it was at a lower elevation than the boundary of LCA Central located to its south. As a result, water flow volume and water quality in Unnamed Tributary B is not expected to be affected by the quarry expansion.

Natural baseline flow directions within each LCA are presented in Figure 2 (Appendix A).

3.1.4 Monthly Water Balance

The following provides a summary of the methodology that has been implemented to assess the potential impact to water quantity in receiving aquatic features to the Project. The water balance assessment was based on meteorological data obtained from Environment Canada from the Mount Uniacke Climate station (ID 8203600) from 1981 – 2010. Water balance calculations are based on the following equation:

$$P = S + ET + R + I$$

Where:

P = Precipitation

S = change in soil water storage

ET = evapotranspiration

R = Surface runoff

I = infiltration (interflow and groundwater recharge)

### *3.1.4.1 Overview*

A monthly water balance analysis was completed to assess the impact of the BEUQ on the receiving aquatic features. In order to do this, modelled predictions of increases and decreases in infiltration and surface water runoff was performed at multiple outfall locations within the LCA's and the O'Hearn Flowage LCA including:

- WC2 at the confluence with the Quarry Discharge Flow. This is indicated on Figure 2 (Appendix A) as Outfall Location 1;
- WC2 at its confluence with O'Hearn Flowage at the outfall of the Eastern LCA. This is indicated on Figure 2 (Appendix A) as Outfall Location 2;
- WC3 at its confluence with O'Hearn Brook/O'Hearn Flowage at the outfall of the Central LCA. This is indicated on Figure 2 (Appendix A) as Outfall Location 3;
- O-Hearn Flowage Catchment Area at its confluence with WC2. This is indicated on Figure 2 (Appendix A) as Outfall Location 2;
- Unnamed Tributary A at the outfall of the Western LCA. There are no direct watercourse connections between the future quarry expansion area and Unnamed Tributary A; therefore, no distinct outfall location is identified. Rather, for the purposes of the water balance modelling the extent of Unnamed Tributary A located directly west of the quarry expansion area has been considered; and
- O'Hearn Brook upstream of O'Hearn Flowage and the confluence with WC3. This is indicated on Figure 2 (Appendix A) as Outfall Location 3.

<u>Data Inputs</u>

Data inputs for the monthly water balance analysis included LCA's, precipitation data, potential evapotranspiration (PET), topography and soil, and land cover data which was used to calculate monthly infiltration for pervious surfaces:

- LCA's for the Eastern LCA, Central LCA, Western LCA, and the O'Hearn Flowage Catchment Area were delineated;
- 30-year precipitation normals (1981 – 2010) were obtained from the Environment Canada Mount Uniacke Climate Station (ID 8203600); and
- Potential evapotranspiration (PET) was calculated using Hamon Equation (1961) as described in *A Monthly Water Balance Model Driven By a Graphical User Interface* (USGS Report No. 2007-1088;
- Surveyed topographic data was provided by the Proponent (190228_EUQ_topo_NAD83);
- Soil information was obtained from the Soil Survey of Hants County from the Canadian Soil Information Service (<u>http://sis.agr.gc.ca/cansis/publications/surveys/ns/ns5b/index.html</u>, last accessed June 2019); and
- Land cover was determined from aerial imagery in Google Earth.

### *3.1.4.2 Water Balance Methodology*

The monthly water balance analysis follows the methodology by Thornthwaite (1948) and Mather (1978). For pervious areas (natural/undisturbed), infiltration and surface runoff depths are calculated as fractions of the 'surplus' of water from the soil storage, while for impervious areas (quarry), direct runoff depth is assumed to be equal to precipitation depth. The calculations are performed at a monthly time step from April to March for a unit area, and the final results are multiplied by catchment area to determine infiltration and surface runoff volumes.

Short-term or seasonal changes in soil water storage are anticipated to occur on an annual basis as demonstrated by the typically dry conditions in the summer months and the wet conditions in the winter and spring. Long-term changes (e.g. year-to-year) in soil water storage are considered negligible in this assessment. For pervious areas, precipitation is added to the soil storage and actual evapotranspiration (AET) is subtracted from the soil storage. AET is equal to PET when precipitation is greater than PET (i.e. for all months except July). AET is equal to precipitation plus the amount of water that can be withdrawn from the soil storage when precipitation is less than PET (i.e. for July). Surplus is calculated as the excess water from the soil storage (i.e., the amount that precipitation – AET + soil storage of the previous month exceeds the soil storage capacity):

- A soil storage capacity of 150 mm is applied in this analysis as recommended in USGS Report Number 2007-1088
- An initial soil storage depth of 150 mm for April was determined using a one-year spin up period
- Soil storage for the dry months of July and August drop to 141.9 and 144.1 respectively, based on loss caused by PET being higher that precipitation during those months.

Infiltration depth is calculated as the product of the surplus, and an infiltration factor for each month, assuming that the pervious portion of the catchment area is homogeneous in terms of topography, soil type, and land cover:

- The infiltration factor was determined from Table 3.1 of the Stormwater Management Planning & Design Manual (MOE, 2003).
- An infiltration factor of 0.6 was selected for the undisturbed area based on the hilly topography (i.e., average slope of 2.8 - 4.7%), covered sandy loam soil, and woodland cover.

Pervious surface runoff depth is calculated as the difference between the surplus and the infiltration depth for each month. Quarry areas are assumed to be impervious, where direct runoff is equal to precipitation depth.

Infiltration volume is calculated as the product of infiltration depth, catchment area, and the percentage of pervious area. Surface runoff volume is calculated as the product of pervious runoff depth, catchment area, and percentage of pervious area plus the product of direct runoff, catchment area, and percentage of impervious area.

The water balance modelling approach does not quantify recharge to the groundwater system, baseflow, or total streamflow, rather it calculates infiltration and surface runoff volumes. The infiltration component combines both interflow and groundwater recharge. The results of this analysis are used to assess the monthly change in infiltration and surface runoff volume to the four aquatic features between baseline conditions and the three stages of quarry expansion, as well as the reclamation stage.

**3.2 Results**
Results of the water balance are provided below. Prediction of potential environmental effects as a result of this analysis are discussed in Section 4.0.

The water balance analysis was performed at seven locations (Eastern LCA, Central LCA, Western LCA, O'Hearn Flowage Catchment, Settling Pond, WC2 upstream of Quarry Discharge flow, and O'Hearn Brook upstream of O'Hearn flowage) for five life cycle stages (baseline conditions, the three phases of quarry expansion as defined by the LCA boundaries, and reclamation). The quarry expansion phases are shown on Figure 2 (Appendix A).

- Phase 1 of quarry development extends from the current quarry footprint to the western extent of the Eastern LCA. Eastern LCA is expected to be developed over a period of four (4) years;
- Phase 2 of quarry development exists within Central LCA. Central LCA is expected to be developed over a period of 5-10 years; and
- Phase 3 of quarry development exists within Western LCA. The Western LCA is expected to be developed over a period of 11-25 years.

Surface runoff from the quarry area discharges to a settling pond within the Eastern LCA which discharges via a culvert to off-site lands which drains water to WC2 (Outfall Location 2) approximately 360 m downstream of WL7 (known as the Quarry Discharge Flow).

As the quarry expands, the area and the fraction of impervious surface area in each of the individual development phases will increase. Additionally, the fraction of impervious surface area in the O'Hearn Flowage Catchment Area increases. Until development encroaches a development Phase, land cover and permeability remain unchanged within it.

Table 1 in Appendix B summarizes the change in land cover (pervious and impervious) within each LCA between the four phases of quarry expansion including baseline conditions. It should be noted that the change in land cover results from the development of the quarry (converting pervious land to impervious land), and all quarry development becomes part of the Eastern LCA (i.e. discharged through the settling pond).

The results of the water balance analysis (increases and reductions to surface water volume and infiltration) are provided in Table 2 (Appendix B).

The following sections provide an overview of the results based on **the entire development of the BEUQ (i.e. all three Phases)**.

<u>3.2.2 Eastern LCA – Outfall Location 2</u>
The results for the Eastern LCA show that infiltration (and its contribution to shallow groundwater and lateral flow) volume decreases by 15.0% from baseline conditions for all stages of quarry development. The 15.0% reduction in infiltration volume is equal to the reduction in natural area due to the quarry expansion within the LCA. The results also show that surface runoff volume increases by 42.0%, 133.2%, and 255.6% from baseline conditions to Phase 1, Phase 2, and Phase 3 of quarry

expansion, respectively. The increase in surface runoff volume is attributed to the increase in catchment areas associated with all Phases of the quarry expansion and the increase in the fraction of impervious surface area due to the quarry footprint. These calculations assume that there is no change in storage due to the quarry expansion (i.e., quarry pits are pumped to the settling pond, or have been filled with water). The quarry settling pond outfall will be designed to mitigate the increased peak flows from the quarry expansion (see Section 4.1.1).

3.2.2 Central LCA - Outfall Location 3

The quarry will be developed within the Central LCA during Phase 2 of the quarry expansion; therefore, there is no change in infiltration (and its contribution to shallow groundwater and lateral flow) or surface runoff volume from baseline conditions during Phase 1 at the Central LCA outfall. There is a 20.9% reduction in infiltration and surface runoff volume from baseline conditions to Phase 2 of the quarry expansion at the Central LCA. The 20.9% reduction in infiltration and surface runoff volume is equal to the reduction in natural area. The reduction in area is due to the quarry footprint which will direct surface water discharge to the settling pond within the Eastern LCA, and the area to the north of the quarry that will be cut off from sourcing water to WC3. As indicated on Figure 2 (Appendix A), during Phases 2 and 3, the northern extent of the Central LCA will be separated from the quarry area by a berm and diverted to the Western LCA. The reduction in infiltration and surface runoff volumes can be related to the change in catchment area because there are no changes in climate, topography, soil type, or land cover in the Central LCA as a result of the quarry expansion. There are no changes within the Central LCA between Phase 2 and Phase 3 of quarry expansion.

3.2.2 Western LCA - Outfall to Unnamed Tributary A

During Phase 3 of the expansion, the quarry will be developed within the Western LCA; therefore, there are no changes to infiltration (and its contribution to shallow groundwater and lateral flow) or surface runoff volumes in the Western LCA during baseline conditions to Phase 1 of the quarry expansion. There is, however, a 0.9% increase in infiltration and surface runoff volume in the Western LCA during Phase 2 of the expansion. This is attributed to the small portion of the Central LCA located north of the quarry footprint that will be diverted to the Western LCA. There is a 2.7% reduction in infiltration and surface runoff volume from baseline conditions to Phase 3 of the quarry expansion, which is equal to the percent reduction in natural area.

3.2.2 O'Hearn Flowage Catchment Area - Outfall Location 2

There is a 0.4%, 1.1%, and 2.1% reduction in infiltration (and its contribution to shallow groundwater and lateral flow) volume from baseline conditions to Phase 1, Phase 2, and Phase 3 of quarry expansion, respectively, in the O'Hearn Flowage Catchment. This reduction in infiltration volume is equal to the reduction in natural area due to the quarry expansion within the catchment area.

There is a 1.2%, 3.2%, and 5.8% increase in surface runoff volume from baseline conditions to Phase 1, Phase 2, and Phase 3 of quarry expansion, respectively in the O'Hearn Flowage Catchment Area. This increase in surface runoff volume is attributed to the increase in the fraction of impervious surface area due to the quarry expansion.

3.2.3 O'Hearn Brook Catchment Area – Outfall Location 3

There is a 0%, 0.8%, and 1.9% reduction in infiltration (and its contribution to shallow groundwater and lateral flow) volume from baseline conditions to Phase 1, Phase 2, and Phase 3 of quarry expansion, respectively, at O'Hearn Brook upstream of O'Hearn Flowage. This reduction in infiltration volume is equal to the reduction in natural area due to the quarry expansion.

There is a 0%, 0.8%, and 1.9% decrease in surface runoff volume from baseline conditions to Phase 1, Phase 2, and Phase 3 of quarry expansion, respectively.

3.2.4 WC2 Upstream of Quarry Discharge Flow – Outfall Location 1

The results for the WC2 upstream of the Quarry Discharge flow show that infiltration (and its contribution to shallow groundwater and lateral flow) volume and surface water runoff both decrease by 25.1% from baseline conditions for all stages of quarry development. The 25.1% reduction in infiltration volume is equal to the reduction of the contributing drainage area due to the quarry expansion within the original catchment area.

3.2.5 Settling Pond

As a result of quarry expansion, surface water will be re-directed into the on-site settling pond at the eastern extent of the Quarry Development Area. As a result, the increases in surface water run-off volume being drained to the settling pond have been calculated at 40.1%, 63.6% and 76% during Phase 1, Phase 2 and Phase 3 respectively.

3.2.6 Aquatic Features

It is important to note that this analysis assesses the change in infiltration and surface runoff volume at the outfalls of the LCA's, sub-catchments and within the O'Hearn Flowage Catchment. As such, the predicted losses and increases have been done so at the bottom of each of the aquatic features receiving water from the quarry development area. These are identified on Figure 2 (Appendix A) as Outfall Locations.

The predicted changes in water being sourced to each downstream aquatic feature (either as a result of changes to infiltration or surface runoff) can have implications to the viability or habitat conditions in them.

Utilizing the calculations presented in the sections above, the following section outlines the predicted changes that can be expected to each aquatic feature. It should be noted that these changes are based on all three phases of the BEUQ being developed. **Since the calculated changes have been done so at the outfall of each LCA/sub-catchment (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.**

- *Watercourse 2:* The quarry footprint removes a large portion of the contributing drainage area to the headwaters of WC2 and diverts it to downstream portions of WC2 after its flow through the settling pond (Outfall Location 1). The water balance results show that the settling pond discharge represents a significant portion of the total surface runoff volume at the Eastern LCA outfall; however, the upper portion of WC2 will not receive this water. As a result, the following surface water run-off volume changes and changes to infiltration in the Eastern LCA which sources water to WC2 can be expected <u>at full quarry development (Phase 3).</u>

<u>Watercourse 2, Downstream of the Quarry Discharge Flow – Outfall Location 2:</u>

- A 255.6% predicted increase in surface-water volume.
- A 15% decrease in infiltration.
- Predicted increases in surface-water volume are anticipated to be greater as WC2 extends from Outfall Location 2 northwest toward the Quarry Discharge Flow. The effects are reduced the in lower portions of WC2 as water is sourced to it from the natural, undeveloped sub-catchment outside the quarry development.

<u>Watercourse 2 Up-Stream of the Quarry Discharge Flow – Outfall Location 1</u>:

- A 25.1% predicted decrease in surface-water volume.
- A 25.1% decrease in infiltration.
- Predicted decreases in surface water volume are anticipated to be greater as WC2 extends northwest towards its headwaters and WL7. At its intersection with WL7, WC2 is expected to have lost the majority of its water supply originally sourced from the Eastern LCA.

- *<u>Watercourse 3 – Outfall Location 3:</u>* The quarry expansion will also impact the upper portions of WC3. The impacts will be most significant at the headwaters of WC3 (WL7) and will become less significant downstream due to additional contributing area which provides water to WC3 and is unaffected by the quarry development. As a result, the following surface water run-off volume changes, and changes to infiltration in the Central LCA which sources water to WC3 can be expected <u>at full quarry development (Phase 3).</u>

  - A 20.9% predicted decrease in surface-water volume.
  - A 20.9% decrease in infiltration.
  - Predicted decreases in surface water volume are anticipated to be greater as WC3 extends northwest towards its headwaters and WL7. Upper portions of WC3 are likely to run dry due to the loss of water originally sourced from the Central LCA. However, the role of WL7 and its ability to provide a source of water from groundwater discharge to WC3 is currently limited and could counterbalance some of the drying effects (more discussion provided in Section 4.1.1).

- *<u>Un-named Tributary A:</u>* Unnamed Tributary A will see a small increase (0.9%) in water and infiltration during the development of Phase 2 (sourced from northern, unaffected portions of Central LCA), followed by a reduction (2.7%) of water and infiltration during Phase 3. Surface water located in the Western LCA but beyond the northern quarry development area boundary will be re-directed westward, around the quarry and toward Unnamed Tributary A (Figure 2, Appendix A).

- *O'Hearn Brook – Outfall Location 3*: O'Hearn Brook, above Outfall Location 3 was modelled to predict the effects to surface water volume and infiltration at full quarry development (Phase 3). These results indicate that there will be a:

    - A 0%, 0.8% and 1.9% predicted decrease in surface-water volume.
    - A 0%, 0.8% and 1.9% predicted decrease in infiltration.
    - These predicted decreases are expected to be greater further upstream, however, will not exceed the decrease of 2.7% of water and infiltration calculated at Unnamed Tributary A (see above).

- *Wetland 7:* Wetland 7 extends across a portion of the Eastern LCA and the Central LCA. Therefore, WL7 will see reductions of water during Phase 1 of the development, but the largest reduction of water to it will be during Phase 2 of the quarry expansion. These reductions can be quantified by the calculated losses of infiltration and surface water volume at Outfall Locations 1 and 3 and the extrapolated up to the headwaters. For the purposes of this assessment surface water run-off volume changes, and predicted changes to infiltration in water being sourced to WL7 has been displayed below for the eastern extent of WL7 (located within Eastern LCA) and the western extent of WL7 (Central LCA):

    - Eastern extent of WL7: The predicted reduction of 25.1% of surface water run-off volume and 25.1% infiltration at Outfall Location 1 are anticipated to be greater as WC2 extends northwest towards its headwaters and WL7. Therefore, the eastern extent of WL7 is predicted to loose most of its catchment area and may experience a drying effect; and
    - Western extent of WL7: The predicted reduction of 20.9% of surface water run-off volume and 20.9% infiltration at Outfall Location 3 are anticipated to be greater as WC3 extends northwest towards its headwaters and WL7. Therefore, the western extent of WL7 is predicted to loose the majority of its catchment area and may experience a drying effect.

    The extent of potential drying within WL7 will depend on the supply of water to it from groundwater discharge throughout quarry expansion (See Section 4.2.2).

- *O'Hearn Flowage Catchment – Outfall Location 2*: This catchment area was modelled to represent the broader O'Hearn flowage system upstream from Outfall Location 2. The predicted changes in surface water volume and infiltration as a result of full quarry development is as follows:

    - There is a maximum 5.8% predicted increase in surface-water volume attributed to the increase in the fraction of impervious surface area due to the quarry expansion.
    - There is a maximum 2.1% decrease in infiltration which is equal to the reduction in natural area due to the quarry expansion within the catchment area.

3.2.8 Reclamation

Water balance calculations were performed to represent the reclamation stage of the quarry. To model the reclamation stage, it was assumed that the total quarry footprint would be re-vegetated so that it would have similar infiltration characteristics to baseline conditions. As such, infiltration and surface runoff volumes for the Eastern LCA and O'Hearn Flowage Catchment change compared to the Phase 3 results as a result of them receiving additional water from the entire extent of the quarry development.

Infiltration (and its contribution to shallow groundwater and lateral flow) and surface runoff volumes at the Central and Western LCA's are the same as for Phase 3.

At the Eastern LCA outfall, infiltration volume increases by 56.2% from baseline conditions. This increase is attributed to the change in contributing drainage area due to the quarry expansion, because it is assumed that the reclaimed quarry infiltration characteristics will be similar to baseline conditions. There is also an increase in surface runoff volume at the Eastern LCA outfall of 56.2% compared to baseline conditions as a result of the re-direction of water which will remain permanent.

All losses and reductions of water experienced in aquatic features receiving water from the entire development area of the BEUQ would have equaled out at the O'Hearn Flowage outfall. Therefore, there are no changes in infiltration or surface water runoff volume from baseline conditions and the effects of the quarry development are not seen downstream of Outfall Location 2 within the O'Hearn Flowage.

## 4.0 FISH HABITAT EVALUATION

In support of the effects assessment for fish and fish habitat as a result of the proposed quarry expansion and the associated revised water balance, MEL biologists completed a detailed fish habitat evaluation within WC2, WC3 and WL7 on July 10, 2019. These additional fish habitat assessments expanded upon the initial watercourse characterizations through the continued delineation and identification of habitat features that could be utilized by the fish species expected to be present within downgradient aquatic receptors. For these species, the availability and condition of habitat features were considered for all life stages and processes. This information was used to further analyse the potential effects of predicted reductions and increases in water to fish and fish habitat.

The fish habitat assessments focused on aquatic receptors with predicted changes in contributing surface water run-off, encompassing WC2, WC3, and Wetland 7. Additional assessments for O'Hearn Brook and Un-named Tributary A were not conducted as the predicted changes in water quantity within these catchment areas as a result of quarry expansion are considered to be negligible.

Through a review of physical watercourse characteristics presented in the EA registration document and confirmation of habitat availability during the July 2019 field assessment, it was determined that WC2, WC3, and Wetland 7 do not provide suitable habitat for Atlantic Salmon for any life processes (migration, spawning, rearing). Habitat suitability for Striped Bass was not evaluated as only one river system in Nova Scotia, Shubenacadie/Stewiacke, is currently known to support Striped Bass spawning

(COSEWIC, 2012a). American Eel are habitat generalists, showing no consistent preference for particular stream morphologies, physical characteristics, or temperatures in freshwater streams (Hawkins, 1995). At present, overwintering requirements for American Eel are poorly understood (COSEWIC, 2012b). Habitat requirements for American Eel were therefore not reassessed and are not further discussed in the sections below; still, they are considered to potentially inhabit any accessible freshwater habitat provided by WC2, WC3, and WL7. The additional fish habitat assessments focused on the identification of suitable Brook Trout habitat. Brook Trout are known to inhabit a wide range of freshwater environments, including small headwater streams like the downstream aquatic receptors included in the following effects assessment. However, it should be noted that no fish were caught in these streams during dedicated fish surveys in 2018, and that utilization of these features by the species discussed is based on potential access from downstream, fish-bearing systems.

### 4.1 Results

The following provides the results of the habitat assessments in WC2, WC3 and Wetland 7.

#### 4.1.1 Watercourse 2

As noted in Section 3.2.6, WC2 is expected to experience a reduction in water quantity in its upper extent (*i.e.* above the Quarry Discharge Flow – Outfall Location 1). Field observations confirmed that immediately upstream of the confluence of the Quarry Discharge Flow and WC2, WC2 disperses into wetland habitat, draining subsurface between pockets of standing water for 118 m before re-channelizing at the downstream end of the wetland (Figure 3, Appendix A). Surface flow appears absent throughout the year, as made evident by the absence of surface scouring and the presence of a heavy moss cover. This barrier excludes fish from upstream areas year-round, including potential fish access and habitat noted in WL7. The slope of WC2 as it enters the wetland and confluence with the Quarry Discharge Flow is such that water provided from the Quarry Discharge Flow will not backwater and create a fish passage connection to upper portions of WC2.

As discussed in Section 3.2.4, downstream of the Quarry Discharge Flow, water quantity in WC2 is expected to increase. The approximately 500 m of linear watercourse reach downstream of the Quarry Discharge Flow (at which point it intersects O’Hearn Flowage) provides 273 m of potential Brook Trout juvenile rearing habitat. This habitat is comprised of:

- adequate in-stream and overhead cover;
- approximately 20 m of shallow pool habitat with residual depths less than 20 cm; and,
- 5.5 m of off-channel habitat (Note: this habitat is currently inaccessible due to low water levels.

Currently, accessibility to the potential habitat areas listed above is restricted by two seasonal barriers and insufficient water depths and is therefore considered accessible only during periods of high flow. No potential Brook Trout spawning, or overwintering habitat was identified within WC2.

#### 4.1.2 Watercourse 3

As stated in Section 3.2.6, the predicted water quantity loss in WC3 is expected to be greatest in the upper portions of the stream, near its headwaters and WL7. Upstream of the forestry road which bisects WC3 from north to south (Figure 3, Appendix A), a 245 m expanse of noncontiguous/subterranean flow poses a permanent barrier to fish passage; the channel dissolves into wetland habitat with water draining subsurface. Similar to WC2, subsurface flow is present in WC3 throughout the year, as made evident by the absence of surface scouring and the presence of heavy moss cover. This barrier excludes fish from accessing the upstream half of the mapped watercourse, as well as WL7.

The remaining 675 m of linear watercourse downstream of the barrier was predominantly dry with negligible flow during the July 2019 evaluation. Standing water remaining in residual, isolated pools was measured to a maximum depth of 12 cm. Potential Brook Trout juvenile rearing habitat within the watercourse is intermittent, comprising a 74 m and 62 m reach of potential cover in the form of boulder-sized substrate, large woody debris and overhanding vegetation (Figure 3, Appendix A). These potential juvenile rearing areas occur intermittently along the channel, being spaced apart by 240 m of extremely poor-quality habitat in the form of unconfined, wetland sheet flow (completely dry at the time of the evaluation with no discernable bankful height). Multiple seasonal barriers also exist that impede fish passage under low-moderate flow conditions, particularly concentrated along the 200 m stretch from O'Hearn flowage to the first rearing habitat. Evidence of a flashy hydrological regime was also noted through the identification of siltation of the stream bed from bank scouring and downed riparian trees. No areas of potential Brook Trout spawning, or overwintering habitat were identified within WC3. These conditions are consistent with the hydrological conditions observed during the September 2018 survey, as reported in the original EA Registration document.

Fish passage into WC3 from O'Hearn Brook, as well as fish passage through the watercourse, is restricted to periods of high flow as determined by the dry channel conditions and barriers to downstream passage observed during the July 2019 evaluation. Utilization of potential Brook Trout rearing habitat within the upper areas of the watercourse is therefore highly restricted; furthermore, habitat quality has been evaluated as poor due to limiting factors to trout survival such as a lack of pool density and pool depth during low-flow periods (Meehan, 1991), and the absence of spawning and overwintering habitat. Based on these limiting factors, the watercourse does not currently provide ideal conditions upon which Brook Trout depend, and based on the limited habitat availability, is not likely to support a significant number of fish. Habitat availability and complexity is considerably improved at the confluence of WC3 with O'Hearn Brook, where overwintering pools and accessible off-channel habitat were locally identified.

## 5.0 EFFECTS ASSESSMENT

Based on the results of the water balance modelling exercise, and in conjunction with the development plan for the BEUQ, and the detailed fish habitat evaluation, a revised effects assessment has been compiled to evaluate the predicted effects on fish and fish habitat (surface water systems) as a result of the predicted changes in surface water runoff. In addition, due to its proximity to proposed quarrying, potential effects to Wetland 7 have also been further explored.

As per the original EA Registration methodology, a threshold for determination of significant adverse residual environmental effects for these components have been defined in Table 4 (below).

**Table 4. Component Threshold for Determination of Significance**

| Components | Threshold for Determination of Significance |
|---|---|
| **Fish and Fish Habitat** | An effect that is likely to cause serious harm to fish, as defined by the Government of Canada (1985, Section 2(1)) without appropriate compensation offsetting<br><br>*“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.”* |
| **Wetlands** | An effect to wetlands that is likely to cause an adverse change to the functional characteristics of the wetland and/or its downgradient aquatic receptors (i.e. watercourses, additional wetlands etc) without appropriate wetland compensation offsetting |

The following sections integrate the new water balance results and expand upon the potential effects that which are predicted in the downstream receiving aquatic features. Utilizing this information, a prediction of potential residual effects and a determination of whether the effects meet the Thresholds presented in Table 4 has been made. Planned mitigation and monitoring to offset and evaluate the potential effects are also discussed.

### 5.1 Surface Water/Fish and Fish Habitat

As discussed in Section 3.2.6, development of the BEUQ is predicted to cause reductions and increases in surface water runoff to downstream aquatic features. These changes in water quantity being sourced to downstream watercourses and wetlands, have the potential to impact surface water systems and fish and fish habitat.

Potential Project interactions and effects to water quality were discussed in the initial EA Registration document and were also updated in this document (Section 2.0).

For the purposes of evaluating potential effect to fish and fish habitat as a result of the BEUQ, the Project Team reviewed the detailed fish habitat characteristics of each water feature being affected and compared these conditions to the predicted effects of the future quarry development. It should be acknowledged that there are no standardized methodologies to quantitatively evaluate the potential effects to downstream aquatic fish habitat. Therefore, the approach being implemented below is based on predicted changes in surface water run off volumes (as per water balance results) to the physical dynamics and baseline fish habitat characteristics within the receiving watercourses.

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. In studies completed by Harmel et al

(2006) and Dibaldassarre G., and A. Montanari 2009 however, it was determined that 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. The Dibaldassarre G., and A. Montanari 2009 report concludes that errors in river discharge observations are significant and can heavily impact the output of hydrological and hydraulic studies. The Harmel report concluded that the calculated cumulative probable uncertainty (±%) contributed under typical scenarios ranged from 6% to 19% for streamflow measurement. The Dibaldassarre G., and A. Montanari 2009 indicate that overall error affecting river discharge observations averaged over the river reach that they studied was found to range from 6.2% to 42.8%, at the 95% confidence level, with an average value of 25.6%.

The reader is reminded that the water balance completed for the BEUQ is also a predictive tool, based upon conservative assumptions (i.e. no infiltration occurring within the quarry floor), and does not incorporate field data (i.e. flows). As such, the margin of error identified in the literature above suggests that the predicted reductions and increases at the following listed outfall locations fall well below the margins of error for determining water quantity predictions noted in the two studies:

- Unnamed Tributary A: A maximum 2.7% decrease in surface water volume;
- O'Hearn Flowage Catchment: A maximum 5.8% increase in surface water volume; and,
- O'Hearn Brook Catchment Area: A maximum 1.9% decrease in surface water volume;

Furthermore, predicted water quantity changes of these magnitudes are not expected to cause adverse effect to fish and fish habitat in these systems. So, for the purposes of this evaluation, these features are not further evaluated in this document.

As discussed in Section 4, fish access is only present in the lower half of WC2 (~500m), and restricted and seasonal fish access is present within the lower portion of WC3 (~675m). Therefore, the potential indirect effects to fish habitat as a result of the predicted infiltration and surface water runoff changes associated with the quarry expansion are provided for these reaches of each stream.

<u>Watercourse 2</u>
Due to the absence of accessible fish habitat upstream of the Quarry Discharge Flow, the predicted water quantity loss in upper portions of WC2 will not alter fish or fish habitat.

The predicted increases in water quantity provided by the Quarry Discharge Flow is expected to generate net benefits to fish and fish habitat within these lower portions of WC2. This 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 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.

The quarry settling pond will be designed to manage the peak flow conditions being discharged to the Quarry Discharge Flow and WC2. Therefore, downstream flooding, and/or erosion from the additional water is not expected in lower portions of WC2.

Watercourse 3

Due to the stream characteristics currently present (*i.e.* intermittent and frequent dry conditions and residual, isolated and intermittent shallow pools), it is possible predicted water quantity reductions could strand fish and lead to possible mortality if the flow reductions were rapid. However, it is important to note that the rate of quarry expansion within the Central LCA (which sources water to WC3) is planned over a long timeline (5-10 years) and the predictions made are based on a total worse case scenario (i.e. no infiltration occurring in the quarry). As well, the rate of quarry expansion and associated predicted loss of water quantity to WC3 is not expected to influence temporal variability in flow regimes.

The potential juvenile rearing areas for Brook Trout present are infrequent and separated by extents of extremely poor-quality habitat in the form of unconfined, wetland sheet flow. As such, although drying of this habitat as a result of future quarry expansion is likely, loss of quality fish habitat will not occur as it is currently not present.

The following sections provide an update on methods by which effects will be mitigated and the monitoring that can be completed in association with potential water quality and water quantity effects as a result of the quarry expansion.

5.1.1 Mitigation and Monitoring

As previously discussed, water management throughout the lifetime of the BEUQ will be through direction of surface water to an on-site settling pond. Therefore, mitigation for the effects to surface water quantity and quality is focused on the design and function of the settling pond during quarry operations.

As discussed in Section 4.1, as a result of the re-direction of water to the settling pond, a reduction of surface water flow volume will occur to WC2 upstream of the Quarry Discharge Flow (Outfall Location 1), WC3, Unnamed Tributary A, and O'Hearn Brook. Predicted increases in water flow volume will occur to lower portions of WC2 (below the Quarry Discharge Flow) and within the O'Hearn Flowage Catchment generally. As the quarry expands into its respective catchment areas (Eastern, Central, and Western LCAs), although infiltration is proposed to match baseline conditions as a result of revegetation, <u>the surface water volume losses are considered permanent and mitigation for the losses in water quantity cannot be applied</u>. The primary function of the settling pond will be to mitigate effects to the downstream environment (i.e. offsite wetlands and drainage features via the Quarry Discharge Flow), lower portion of the Watercourse 2 and the O'Hearn Flowage. 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. Altered flow within receiving waterbodies is predicted to occur in upper portions of WC2 during latter stages of Phase 1 (i.e. 1-4 years) of the BEUQ expansion. However, predicted increases in water flow volume will continue to occur to lower portions of WC2 (via the settling pond).

5.1.2 Residual Effects and Significance

This document has evaluated the potential effects to fish and fish habitat as a result of expanding the BEUQ over the period of 25 years. The analysis completed confirms that there are predicted losses and increases in surface water runoff contributions to watercourses located down-gradient of the quarry area.

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

- Watercourse 3: The predicted decrease in water quantity to lower portions of WC3 suggest that a drying effect is expected, however current fish habitat quality is generally poor and restricted to seasonal potential juvenile areas for Brook Trout. It is possible that the loss of habitat in WC3 will trigger a Fisheries Authorization and further consultation with Fisheries and Oceans Canada (FOC) is recommended.
- Watercourse 2: The effects of an increase in water to downstream portions of WC2 are expected to generate net benefits to fish and fish habitat.
- The predicted losses and increases of water to O'Hearn Brook, Unnamed Tributary A and the O'Hearn Flowage Catchment are negligible, and in all cases, represent changes which are equivalent to natural variation in aquatic systems and fall below expected margins of error for water quantity predictions.

**5.2 Wetland 7**

The water balance analysis has identified predicted effects to WL7 as the quarry expands from the Eastern LCA into the Central LCA. These two catchment areas source surface water to Wetland 7;

therefore, a drying trend is likely to occur over time which is predicted to alter WL7 and its functional characteristics. It should be noted however that WL7 is likely also sourced water through groundwater discharge, and therefore the full extent of effect to the wetlands hydrological regime as a result of the quarry expansion is not fully understood. It is possible the supply of groundwater discharge to WL7 will be affected (i.e. through loss of groundwater seepage into the adjacent quarry), however this effect can be determined through monitoring as the quarry expands (refer to Section 5.2.2).

More specifically, the water balance predicts that during Phase 1 of quarry expansion the southeastern lobe of WL7 (which drains water to the headwaters of WC2), may see an effect as a result of reduced water volume being sourced to it. The loss of water flow volume calculated at the Quarry Discharge Flow within WC2 (approximately 480m south of WL7) is 25%. Therefore, extrapolation of this reduction from the Quarry Discharge Location to the headwaters of WC2 and WL7 would result in a higher percentage of loss. This loss is anticipated to be representative of the majority of the catchment area sourcing WL7 its surface water flow.

During Phase 2 of the quarry expansion, the water balance analysis predicts that the remainder of lands sourcing water flow to WL7 will be removed from the landscape (i.e. Central LCA). This prediction is supported by the predicted effects for WC3 (which WL7 drains into) which is predicted to loose a maximum of 20.9% flow at Outfall Location 3 (confluence with the O'Hearn Flowage).

As well as providing habitat for wildlife and songbirds, the primary functions of WL7 are hydrological. WL7 stores and detains water sourced from the Eastern LCA and the Central LCA and discharges it to the receiving WC2 and WC3. In addition, WL7 provides support to aquatic life as it is directly contiguous with WC2 and WC3. It should be noted however that WL7 does not provide habitat for fish due to non-connectivity via surface water with the downstream WC2 and WC3. Therefore, quarry expansion and the potential effects to aquatic life are expected to be more relevant in the connected watercourses and the habitat which they provide rather than WL7 itself.

It has been noted earlier that a drying effect is expected in the headwaters of both Watercourses 2 and 3, and therefore WL7 which sources water to them. As such, the aquatic support functions being affected by the loss of predicted flow to WL7 becomes insignificant due to the anticipated effects to WC2 and WC3 discussed in Section 5.1.

#### 4.2.2 Mitigation and Monitoring

Mitigation methods discussed in the EA Registration document will be employed to prevent indirect effects during the quarry expansion (i.e. erosion and sediment, water quality issues, contamination as a result of malfunctions and accidents etc); however, the predicted surface water flow volume changes to WL7 discussed in this document are unavoidable as the quarry expansion progresses. <u>That said, the extent of effect to WL7 is unknown due to the contribution of water to this wetland via groundwater discharge, and the potential loss of this contribution as a result of adjacent quarrying.</u>

It is therefore recommended that baseline hydrological and vegetative monitoring is completed during 2019 in WL7 and annually thereafter in order to determine if alteration to wetland functions are occurring. The monitoring timeline and implementation plan can be further defined through the IA process.

Should monitoring results indicate that wetland function has been altered, the Proponent will obtain a provincial wetland alteration permit for WL7, which would require a commitment to compensate for the loss of wetland habitat.

4.2.3 Residual Effects and Significance

Should WL7 be subjected to the drying trend that has been predicted, the effect is likely to cause an adverse change to the functional characteristics of the wetland (i.e. loss of water storage, aquatic support and wildlife/songbird habitat). In an alteration scenario, wetland compensation offsetting can be implemented. Furthermore, due to the size of alteration, relative intactness of the surrounding landscape and provision of additional similar habitat, no significant residual environmental effects are expected.

## 5.0 CONCLUSION

This document has been completed in response to the Additional Information Request issued by NSE on May 8, 2019 in association with the Birette's East Uniacke Quarry Expansion 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 watercourses and a wetland hydrologically connected to the Birette's East Uniacke Expansion Development Area. This was achieved through completion of a revised Hydrological Assessment (seasonal water balance), and prediction of surface water volume increases and decreases as a result of quarry expansion. Based on this information, an evaluation of potential effects to watercourses and a wetland as a result of the quarry expansion was completed. The effects have been analyzed for three quarry development phases (1-4 years, 5-10 years and 11-25 years). This document discusses mitigation, expected residual effects and significance and recommended follow up monitoring measures.

The following conclusions were determined:

- Water from within the quarry development area will be directed eastward into an on-site settling pond throughout the lifetime of the quarry and beyond;
- Three watercourses (WC2, WC3 and Unnamed Tributary A) receive a direct source of water from the proposed quarry expansion area;
- The watercourses are subject to predicted increases and decreases in surface water volume as a result of quarry expansion;
- Altered flow within receiving watercourses is predicted to occur in upper portions of WC2 during latter stages of Phase 1 (i.e. 1-4 years). Altered flow is expected to occur within WC3 and Unnamed Tributary A during Phases 2 and 3 (5-25 years);
- Predicted changes in flow to Unnamed Tributary A, the O'Hearn Flowage Catchment and O'Hearn Brook are negligible and not expected to negatively affect fish or fish habitat;

- Based on the habitat conditions present within WC2, it has been determined that the increases in water flow volume will generate net benefits to fish and fish habitat;
- Although fish habitat quality present within lower portions of WC3 is generally poor, it has been determined that the proposed decreases in water quantity as a result of quarry expansion, may trigger a Fisheries Authorization. Future consultation with FOC will determine this.
- One wetland (WL7) lies at the headwaters of WC2 and WC3 and adjacent to future quarrying activity;
- Wetland 7 does not provide access to fish due to fish barriers in WC2 and WC3;
- Altered flow sourcing water to the eastern lobe of WL7 is expected to occur during latter stages of Phase 1 (1-4 years). Altered flow sourcing water to the western lobe of WL7 is expected to occur during Phase 2 (5-10 years);
- Although direct alteration to the wetland will be avoided, quarry expansion is predicted to alter the hydrological inputs sourcing the wetland as a result of removing upstream catchment;
- The extent of water sourced to WL7 via groundwater discharge, and the effect the quarry may have on the wetland is not fully understood;
- A wetland monitoring plan will be implemented to determine the potential changes to wetland function as the quarry expands;
- Should it be determined that the wetland functions have been altered, a provincial wetland alteration permit will be obtained, and associated wetland compensation offsetting completed; and,
- Potential effects during the reclamation stage of the quarry were considered as part of this evaluation. Although infiltration rates are proposed to match baseline conditions (through revegetation of the quarry floor), water will continue to be directed eastward post quarry closure. As such, predicted effects discussed in this document are expected to be permanent and irreversible.

We look forward to your attention to this Additional Information Request response.

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

Sincerely,

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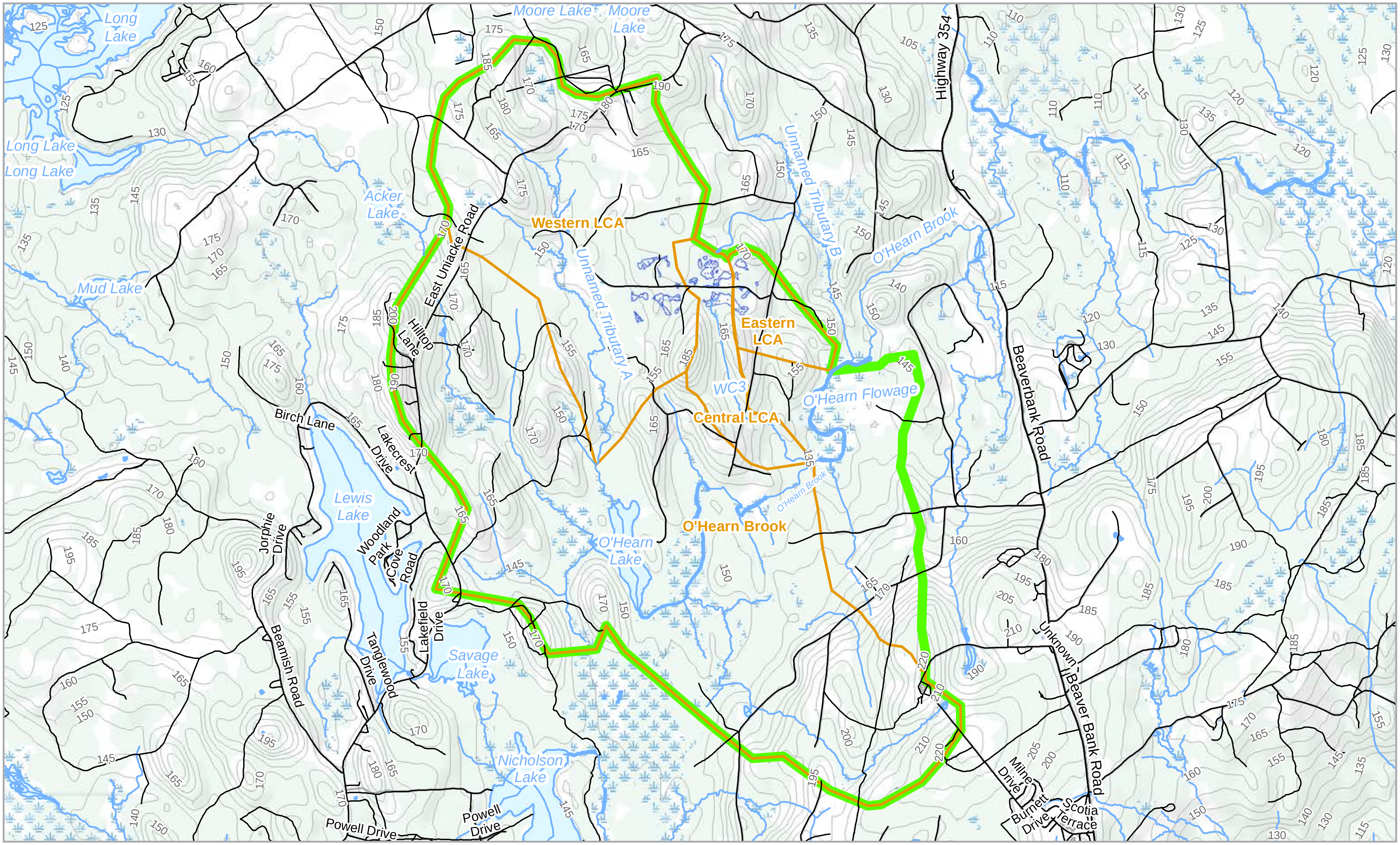
McCallum Environmental Ltd.

# APPENDIX A: FIGURES




Legend

Local Catchment Area (LCA)

O'Hearn Flowage Catchment

Paper Size ANSI A

0 400 800 1,200 1,600

Meters

N

Map Projection: Transverse Mercator
Horizontal Datum: North American 1983 CSRS
Grid: NAD 1983 CSRS UTM Zone 20N

GHD

BIRETTE'S EAST UNIACKE QUARRY
EXPANSION PROJECT
ENVIRONMENTAL ASSESSMENT

**BASELINE CONDITIONS**

Project No. **11198304**
Revision No. **-**
Date **Jul 9, 2019**

# FIGURE 1

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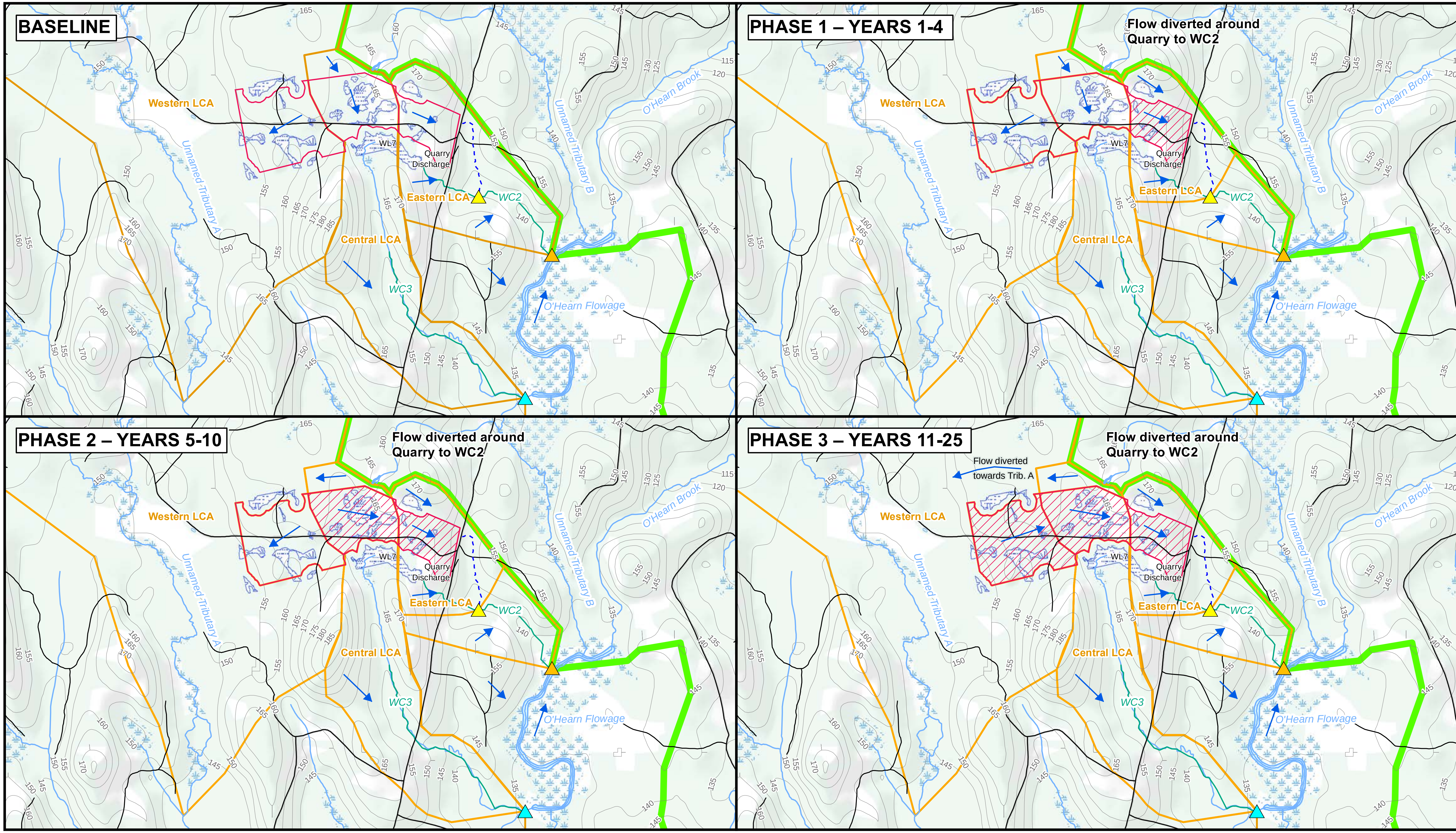
Data source: Basemap data from Nova Scotia Topographic Database. Contours derived from Natural Resources Canada Canadian Digital Elevation Model (CDEM). Open Government Licence - Canada




**Legend**

- Future Quarry Expansion
- Local Catchment Area (LCA)
- O'Hearn Flowage Catchment
- Development Area
- Flow Direction
- Field Delineated Watercourse
- Quarry Discharge
- Outfall Location 1
- Outfall Location 2
- Outfall Location 3

Paper Size ANSI B

0 200 400 600 800

Meters

Map Projection: Transverse Mercator
Horizontal Datum: North American 1983 CSRS
Grid: NAD 1983 CSRS UTM Zone 20N

N

**BIRETTE'S EAST UNIACKE QUARRY EXPANSION PROJECT ENVIRONMENTAL ASSESSMENT**

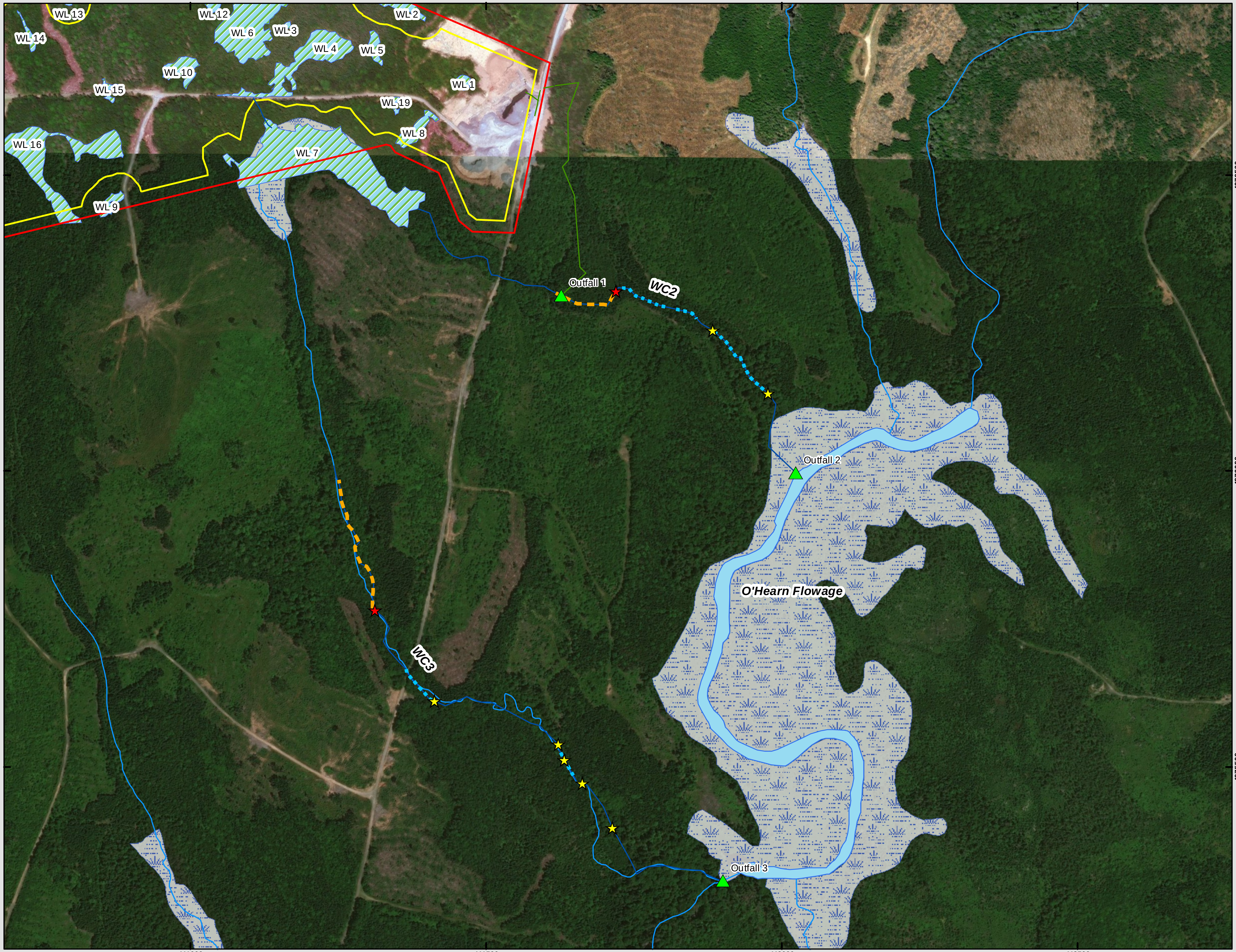
**LOCAL CATCHMENT AREA FLOW DIRECTION**

Project No. **11198304**
Revision No. **-**
Date **Jul 17, 2019**

**FIGURE 2**

Q:\GIS\PROJECTS\11198000s\11198304\Layouts\MEMO001\11198304-00(MEMO001)GIS-WA005.mxd

Data source: Basemap data from Nova Scotia Topographic Database. Contours derived from Natural Resources Canada Canadian Digital Elevation Model (CDEM). Open Government Licence - Canada




Prepared For:

BIRRETTE'S QUARRY

**FIGURE 3**

**Additional Fish Habitat Evaluations**

**Proposed Birrette's East Uniacke Quarry Expansion PID 45405388**

**East Uniacke, Nova Scotia**

- Permanent Barrier
- Seasonal Barrier
- Subterranean Flow
- Seasonal Brook Trout Rearing Habitat
- Outfall Locations
- Field Delineated Watercourses
- Mapped Watercourses
- Approximate Quarry Discharge Flow
- Field Delineated Wetlands
- NSE Mapped Wetlands
- Lakes
- Working Area
- Study Area


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

0 62.5 125 250 m

1:6,000 Scale when printed @ 11" x 17"

Drawn By: AS

Date: 2019-07-15

McCallum Environmental Ltd.

# APPENDIX B: WATER BALANCE RESULTS

**Table 1: Birette’s East Uniacke Quarry:**
**Catchment Area Permeability Changes During Quarry Development**

McCallum Environmental Ltd.

| Catchment Area ($m^3$) | | Baseline | Phase 1 | Phase 2 | Phase 3 | Notes |
|---|---|---|---|---|---|---|
| Eastern LCA | Total | 424,266 | 424,266 | 526,024 | 662,555 | Pervious area increases after Phase 1. Impervious area increases during quarry expansion as Eastern LCA becomes larger. |
| | Pervious | 424,266 | 360,674 | 360,674 | 360,674 | |
| | Impervious | 0 | 63,592 | 165,350 | 301,881 | |
| Central LCA | Total | 650,957 | 650,957 | 514,748 | 514,748 | Central LCA becomes smaller as does its permeability during quarry expansion. Impervious does not increase as the Central LCA becomes part of the Eastern LCA as quarry expands. |
| | Pervious | 650,957 | 650,957 | 514,748 | 514,748 | |
| | Impervious | 0 | 0 | 0 | 0 | |
| Western LCA | Total | 3,825,345 | 3,825,345 | 3,859,796 | 3,723,265 | Western LCA gets larger in Phase 2 due to water redirected to it from Central LCA. Reduces in Phase 3 due to it becoming part of Eastern LCA. |
| | Pervious | 3,825,345 | 3,825,345 | 3,859,796 | 3,723,265 | |
| | Impervious | 0 | 0 | 0 | 0 | |
| O’Hearn Flowage Catchment | Total | 14,552,777 | 14,552,777 | 14,552,777 | 14,552,777 | Pervious surface decreases and impervious increases as quarry expands. |
| | Pervious | 14,552,777 | 14,489,185 | 14,387,427 | 14,250,896 | |
| | Impervious | 0 | 63,592 | 165,350 | 301,881 | |

**Table 2: Birettes East Uniacke Quarry Expansion Project: Water Balance Inputs and Results**

| Eastern LCA Monthly and Annual Infiltration Volumes ($m^3$) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Annual | Percent Change from Baseline Conditions |
| Baseline | 21,318 | 14,485 | 3,104 | -2,063 | -1,510 | 15,588 | 25,007 | 36,786 | 36,124 | 41,008 | 28,949 | 31,165 | 253,534 | - |
| Phase 1 | 18,123 | 12,314 | 2,639 | -1,754 | -1,284 | 13,251 | 21,259 | 31,272 | 30,710 | 34,862 | 24,610 | 26,494 | 215,533 | -15.0% |
| Phase 2 | 18,123 | 12,314 | 2,639 | -1,754 | -1,284 | 13,251 | 21,259 | 31,272 | 30,710 | 34,862 | 24,610 | 26,494 | 215,533 | -15.0% |
| Phase 3 | 18,123 | 12,314 | 2,639 | -1,754 | -1,284 | 13,251 | 21,259 | 31,272 | 30,710 | 34,862 | 24,610 | 26,494 | 215,533 | -15.0% |
| Reclamation | 33,291 | 22,620 | 4,847 | -3,221 | -2,358 | 24,343 | 39,052 | 57,447 | 56,414 | 64,041 | 45,209 | 48,669 | 395,932 | 56.2% |
| Eastern LCA Monthly and Annual Surface Runoff Volumes ($m^3$) | | | | | | | | | | | | | | |
| | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Annual | Percent Change from Baseline Conditions |
| Baseline | 14,212 | 9,656 | 2,069 | -1,375 | -1,007 | 10,392 | 16,671 | 24,524 | 24,083 | 27,339 | 19,299 | 20,777 | 169,023 | - |
| Phase 1 | 19,560 | 15,611 | 8,010 | 5,076 | 4,842 | 16,453 | 22,312 | 31,048 | 30,120 | 34,033 | 24,292 | 26,655 | 240,037 | 42.0% |
| Phase 2 | 31,527 | 27,456 | 18,013 | 15,068 | 13,960 | 28,643 | 35,337 | 47,370 | 45,557 | 51,301 | 36,910 | 41,043 | 394,210 | 133.2% |
| Phase 3 | 47,583 | 43,348 | 31,434 | 28,476 | 26,193 | 45,000 | 52,813 | 69,270 | 66,269 | 74,470 | 53,840 | 60,349 | 601,068 | 255.6% |
| Reclamation | 22,194 | 15,080 | 3,231 | -2,147 | -1,572 | 16,228 | 26,035 | 38,298 | 37,609 | 42,694 | 30,139 | 32,446 | 263,954 | 56.2% |

| Central LCA Monthly and Annual Infiltration Volumes ($m^3$) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Annual | Percent Change from Baseline Conditions |
| Baseline | 32,709 | 22,224 | 4,762 | -3,165 | -2,317 | 23,917 | 38,369 | 56,441 | 55,426 | 62,920 | 44,417 | 47,817 | 389,001 | - |
| Phase 1 | 32,709 | 22,224 | 4,762 | -3,165 | -2,317 | 23,917 | 38,369 | 56,441 | 55,426 | 62,920 | 44,417 | 47,817 | 389,001 | 0.0% |
| Phase 2 | 25,864 | 17,574 | 3,766 | -2,503 | -1,832 | 18,912 | 30,340 | 44,631 | 43,829 | 49,754 | 35,123 | 37,812 | 307,605 | -20.9% |
| Phase 3 | 25,864 | 17,574 | 3,766 | -2,503 | -1,832 | 18,912 | 30,340 | 44,631 | 43,829 | 49,754 | 35,123 | 37,812 | 307,605 | -20.9% |
| Reclamation | 25,864 | 17,574 | 3,766 | -2,503 | -1,832 | 18,912 | 30,340 | 44,631 | 43,829 | 49,754 | 35,123 | 37,812 | 307,605 | -20.9% |
| Central LCA Monthly and Annual Surface Runoff Volumes ($m^3$) | | | | | | | | | | | | | | |
| | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Annual | Percent Change from Baseline Conditions |
| Baseline | 21,806 | 14,816 | 3,175 | -2,110 | -1,544 | 15,944 | 25,579 | 37,627 | 36,951 | 41,946 | 29,611 | 31,878 | 259,334 | - |
| Phase 1 | 21,806 | 14,816 | 3,175 | -2,110 | -1,544 | 15,944 | 25,579 | 37,627 | 36,951 | 41,946 | 29,611 | 31,878 | 259,334 | 0.0% |
| Phase 2 | 17,243 | 11,716 | 2,510 | -1,668 | -1,221 | 12,608 | 20,227 | 29,754 | 29,219 | 33,169 | 23,415 | 25,208 | 205,070 | -20.9% |
| Phase 3 | 17,243 | 11,716 | 2,510 | -1,668 | -1,221 | 12,608 | 20,227 | 29,754 | 29,219 | 33,169 | 23,415 | 25,208 | 205,070 | -20.9% |
| Reclamation | 17,243 | 11,716 | 2,510 | -1,668 | -1,221 | 12,608 | 20,227 | 29,754 | 29,219 | 33,169 | 23,415 | 25,208 | 205,070 | -20.9% |

**Table 2: Birettes East Uniacke Quarry Expansion Project: Water Balance Inputs and Results**

| Western LCA Monthly and Annual Infiltration Volumes ($m^3$) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Annual | Percent Chanage from Baseline Conditions |
| Baseline | 192,212 | 130,600 | 27,985 | -18,598 | -13,614 | 140,545 | 225,472 | 331,675 | 325,712 | 369,747 | 261,017 | 280,997 | 2,285,961 | - |
| Phase 1 | 192,212 | 130,600 | 27,985 | -18,598 | -13,614 | 140,545 | 225,472 | 331,675 | 325,712 | 369,747 | 261,017 | 280,997 | 2,285,961 | 0.0% |
| Phase 2 | 193,943 | 131,776 | 28,237 | -18,766 | -13,736 | 141,811 | 227,503 | 334,662 | 328,645 | 373,077 | 263,368 | 283,528 | 2,306,549 | 0.9% |
| Phase 3 | 187,082 | 127,115 | 27,238 | -18,102 | -13,250 | 136,795 | 219,456 | 322,824 | 317,020 | 359,880 | 254,052 | 273,498 | 2,224,960 | -2.7% |
| Reclamation | 187,082 | 127,115 | 27,238 | -18,102 | -13,250 | 136,795 | 219,456 | 322,824 | 317,020 | 359,880 | 254,052 | 273,498 | 2,224,960 | -2.7% |

| Western LCA Monthly and Annual Surface Runoff Volumes ($m^3$) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Annual | Percent Chanage from Baseline Conditions |
| Baseline | 128,141 | 87,067 | 18,657 | -12,399 | -9,076 | 93,697 | 150,315 | 221,117 | 217,141 | 246,498 | 174,012 | 187,331 | 1,523,974 | - |
| Phase 1 | 128,141 | 87,067 | 18,657 | -12,399 | -9,076 | 93,697 | 150,315 | 221,117 | 217,141 | 246,498 | 174,012 | 187,331 | 1,523,974 | 0.0% |
| Phase 2 | 129,295 | 87,851 | 18,825 | -12,511 | -9,157 | 94,541 | 151,669 | 223,108 | 219,097 | 248,718 | 175,579 | 189,018 | 1,537,699 | 0.9% |
| Phase 3 | 124,722 | 84,743 | 18,159 | -12,068 | -8,834 | 91,197 | 146,304 | 215,216 | 211,347 | 239,920 | 169,368 | 182,332 | 1,483,307 | -2.7% |
| Reclamation | 124,722 | 84,743 | 18,159 | -12,068 | -8,834 | 91,197 | 146,304 | 215,216 | 211,347 | 239,920 | 169,368 | 182,332 | 1,483,307 | -2.7% |

| O'Hearn Flowage Catchment (Downstream) Monthly and Annual Infiltration Volumes ($m^3$) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Annual | Percent Chanage from Baseline Conditions |
| Baseline | 731,303 | 496,890 | 106,473 | -70,760 | -51,795 | 534,729 | 857,850 | 1,261,916 | 1,239,228 | 1,406,767 | 993,086 | 1,069,103 | 8,697,346 | - |
| Phase 1 | 728,108 | 494,719 | 106,008 | -70,451 | -51,569 | 532,393 | 854,101 | 1,256,402 | 1,233,814 | 1,400,620 | 988,747 | 1,064,431 | 8,659,344 | -0.4% |
| Phase 2 | 722,995 | 491,245 | 105,264 | -69,956 | -51,207 | 528,654 | 848,104 | 1,247,579 | 1,225,150 | 1,390,784 | 981,804 | 1,056,957 | 8,598,535 | -1.1% |
| Phase 3 | 716,135 | 486,584 | 104,265 | -69,293 | -50,721 | 523,638 | 840,056 | 1,235,742 | 1,213,525 | 1,377,588 | 972,488 | 1,046,927 | 8,516,947 | -2.1% |
| Reclamation | 731,303 | 496,890 | 106,473 | -70,760 | -51,795 | 534,729 | 857,850 | 1,261,916 | 1,239,228 | 1,406,767 | 993,086 | 1,069,103 | 8,697,346 | 0.0% |

| O'Hearn Flowage Catchment (Downstream) Monthly and Annual Surface Runoff Volumes ($m^3$) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Annual | Percent Chanage from Baseline Conditions |
| Baseline | 487,535 | 331,260 | 70,982 | -47,174 | -34,530 | 356,486 | 571,900 | 841,277 | 826,152 | 937,844 | 662,058 | 712,735 | 5,798,230 | - |
| Phase 1 | 492,884 | 337,215 | 76,923 | -40,723 | -28,681 | 362,547 | 577,541 | 847,802 | 832,189 | 944,538 | 667,050 | 718,613 | 5,869,244 | 1.2% |
| Phase 2 | 501,442 | 346,743 | 86,430 | -30,400 | -19,323 | 372,245 | 586,567 | 858,242 | 841,850 | 955,249 | 675,039 | 728,018 | 5,982,879 | 3.2% |
| Phase 3 | 512,924 | 359,528 | 99,185 | -16,550 | -6,765 | 385,257 | 598,678 | 872,249 | 854,812 | 969,621 | 685,759 | 740,638 | 6,135,344 | 5.8% |
| Reclamation | 487,535 | 331,260 | 70,982 | -47,174 | -34,530 | 356,486 | 571,900 | 841,277 | 826,152 | 937,844 | 662,058 | 712,735 | 5,798,230 | 0.0% |

**Table 2: Birettes East Uniacke Quarry Expansion Project: Water Balance Inputs and Results**

| Settling Pond Discharge Volumes ($m^3$) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Annual | Percent of Surface Runoff at Eastern LCA Outfall |
| Baseline | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0% |
| Phase 1 | 7,478 | 7,402 | 6,251 | 6,245 | 5,698 | 7,618 | 8,140 | 10,200 | 9,647 | 10,792 | 7,885 | 8,992 | 96,348 | 40.1% |
| Phase 2 | 19,445 | 19,247 | 16,254 | 16,237 | 14,815 | 19,809 | 21,165 | 26,522 | 25,084 | 28,060 | 20,503 | 23,380 | 250,522 | 63.6% |
| Phase 3 | 35,501 | 35,139 | 29,675 | 29,645 | 27,049 | 36,165 | 38,641 | 48,422 | 45,795 | 51,229 | 37,433 | 42,686 | 457,380 | 76.1% |
| Reclamation | 10,079 | 6,848 | 1,467 | -975 | -714 | 7,370 | 11,823 | 17,392 | 17,079 | 19,388 | 13,687 | 14,734 | 119,868 | 45.4% |

| WC2 U/S of Pond Discharge Point Monthly and Annual Infiltration Volumes ($m^3$) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Annual | Percent Change from Baseline Conditions |
| Baseline | 12,707 | 8,634 | 1,850 | -1,229 | -900 | 9,291 | 14,905 | 21,926 | 21,532 | 24,443 | 17,255 | 18,576 | 151,119 | - |
| Phase 1 | 9,511 | 6,463 | 1,385 | -920 | -674 | 6,955 | 11,157 | 16,412 | 16,117 | 18,296 | 12,916 | 13,905 | 113,117 | -25.1% |
| Phase 2 | 9,511 | 6,463 | 1,385 | -920 | -674 | 6,955 | 11,157 | 16,412 | 16,117 | 18,296 | 12,916 | 13,905 | 113,117 | -25.1% |
| Phase 3 | 9,511 | 6,463 | 1,385 | -920 | -674 | 6,955 | 11,157 | 16,412 | 16,117 | 18,296 | 12,916 | 13,905 | 113,117 | -25.1% |
| Reclamation | 9,511 | 6,463 | 1,385 | -920 | -674 | 6,955 | 11,157 | 16,412 | 16,117 | 18,296 | 12,916 | 13,905 | 113,117 | -25.1% |

| WC2 U/S of Pond Discharge Point Monthly and Annual Surface Runoff Volumes ($m^3$) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Annual | Percent Change from Baseline Conditions |
| Baseline | 8,471 | 5,756 | 1,233 | -820 | -600 | 6,194 | 9,937 | 14,617 | 14,355 | 16,295 | 11,503 | 12,384 | 100,746 | - |
| Phase 1 | 6,341 | 4,308 | 923 | -614 | -449 | 4,636 | 7,438 | 10,942 | 10,745 | 12,198 | 8,611 | 9,270 | 75,411 | -25.1% |
| Phase 2 | 6,341 | 4,308 | 923 | -614 | -449 | 4,636 | 7,438 | 10,942 | 10,745 | 12,198 | 8,611 | 9,270 | 75,411 | -25.1% |
| Phase 3 | 6,341 | 4,308 | 923 | -614 | -449 | 4,636 | 7,438 | 10,942 | 10,745 | 12,198 | 8,611 | 9,270 | 75,411 | -25.1% |
| Reclamation | 6,341 | 4,308 | 923 | -614 | -449 | 4,636 | 7,438 | 10,942 | 10,745 | 12,198 | 8,611 | 9,270 | 75,411 | -25.1% |

| O'Hearn Brook (Upstream of O'Hearn Flowage) Monthly and Annual Infiltration Volumes ($m^3$) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Annual | Percent Change from Baseline Conditions |
| Baseline | 623,388 | 423,566 | 90,762 | -60,319 | -44,152 | 455,821 | 731,260 | 1,075,700 | 1,056,360 | 1,199,175 | 846,541 | 911,339 | 7,413,912 | - |
| Phase 1 | 623,388 | 423,566 | 90,762 | -60,319 | -44,152 | 455,821 | 731,260 | 1,075,700 | 1,056,360 | 1,199,175 | 846,541 | 911,339 | 7,413,912 | 0.0% |
| Phase 2 | 618,275 | 420,092 | 90,017 | -59,824 | -43,790 | 452,083 | 725,262 | 1,066,877 | 1,047,696 | 1,189,340 | 839,597 | 903,864 | 7,353,103 | -0.8% |
| Phase 3 | 611,414 | 415,431 | 89,018 | -59,160 | -43,304 | 447,067 | 717,215 | 1,055,039 | 1,036,071 | 1,176,143 | 830,281 | 893,835 | 7,271,514 | -1.9% |
| Reclamation | 611,414 | 415,431 | 89,018 | -59,160 | -43,304 | 447,067 | 717,215 | 1,055,039 | 1,036,071 | 1,176,143 | 830,281 | 893,835 | 7,271,514 | -1.9% |

| O'Hearn Brook (Upstream of O'Hearn Flowage) Monthly and Annual Surface Runoff Volumes ($m^3$) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Annual | Percent Change from Baseline Conditions |
| Baseline | 415,592 | 282,377 | 60,508 | -40,212 | -29,435 | 303,881 | 487,507 | 717,133 | 704,240 | 799,450 | 564,360 | 607,559 | 4,942,608 | - |
| Phase 1 | 415,592 | 282,377 | 60,508 | -40,212 | -29,435 | 303,881 | 487,507 | 717,133 | 704,240 | 799,450 | 564,360 | 607,559 | 4,942,608 | 0.0% |
| Phase 2 | 412,183 | 280,061 | 60,011 | -39,883 | -29,193 | 301,388 | 483,508 | 711,251 | 698,464 | 792,893 | 559,731 | 602,576 | 4,902,069 | -0.8% |
| Phase 3 | 407,610 | 276,954 | 59,346 | -39,440 | -28,869 | 298,044 | 478,143 | 703,359 | 690,714 | 784,095 | 553,521 | 595,890 | 4,847,676 | -1.9% |
| Reclamation | 407,610 | 276,954 | 59,346 | -39,440 | -28,869 | 298,044 | 478,143 | 703,359 | 690,714 | 784,095 | 553,521 | 595,890 | 4,847,676 | -1.9% |