APPENDIX C
Surface Water Assessment Technical Report (2015)

Black Point Quarry Project
Guysborough County, NS
SLR Project No.: 210.05913.00000

global environmental solutions

Surface Water Assessment

Black Point Quarry, Nova Scotia

SLR Project No.: 7CA.19025.00003

January 2015

Vulcan Materials Group and Morien Resources Corp

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SURFACE WATER ASSESSMENT

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SURFACE WATER ASSESSMENT

1 INTRODUCTION

1.1 BACKGROUND

SLR Consulting was retained by Vulcan Materials Group and Morien Resources Corporation (the Proponent) to conduct a hydrologic assessment of a proposed Black Point aggregate quarry in Guysborough County, Nova Scotia. The assessment and description of hydrologic conditions within the vicinity of the site is a requirement outlined in the *Guide to Preparing an EA Registration Document for Pit and Quarry Developments in Nova Scotia* (NSE 2009).

1.2 SITE DESCRIPTION

The proposed Black Point Quarry Project is located on a 354.5 ha property along the south shore of Chedabucto Bay, approximately 4.0 km east of Fox Island in Guysborough County, Nova Scotia.

The proposed quarry land is currently zoned by the MODG as Industrial Heavy (I-2).

The site is greenfield (undeveloped) and covered by thin soils, which sustain tall shrub and some coniferous forest. The site features several wetlands and a lake (Fogherty Lake). Topography on the site slopes in all directions away from a granite hill, located within the southern central part of the site.

1.3 PROPOSED DEVELOPMENT

The proposed quarry is located on the abovementioned hill which has minimal overburden on top of the granite. The base of the quarry will be at approximately 30 m below mean seal level (<130 m deep) and will occupy a footprint of 180 ha. Processing including secondary crushing, screening, and washing will be undertaken on a 28 ha “lower platform” situated between the quarry and the coastline. The aggregate will be exported by ship via a marine terminal and load-out facility, north of the processing platform.

1.4 OBJECTIVES

The objectives of this hydrologic assessment are based on Section 6.1.2 of the *Nova Scotia Pit and Quarry Guidelines*:

1. Provide a general description of the hydrologic conditions and water quantity and quality for all surface waters in the vicinity of the proposed quarry;

2. Discuss and quantify the predicted effects the quarry activity may have on existing surface water quantity, both on-site and downstream of the quarry area;
3. Estimate the total change in surface water runoff amounts for the existing and proposed quarry development;
4. Estimate the total required capacity of the detention/siltation facilities (i.e. detention ponds) for the existing and proposed conditions (i.e. full quarry expansion) in order to meet acceptable liquid effluent discharge concentrations as defined in the *Guidelines*; and
5. Assess any potential impacts of the proposed quarry expansion on downstream surface water components with respect to water quantity and quality and propose mitigation measures to minimize any potential effects.

2 BASELINE HYDROLOGY

The following section provides a description of baseline hydrological conditions of the site including rainfall, evaporation, storm intensities, catchments and watercourse network.

2.1 CLIMATE

Climate data including historical average total monthly precipitation and average monthly temperature were obtained from Government of Canada Climate website[1]. Deming Station, located approximately 15 km south of the proposed quarry, was chosen due to the large amounts of continuously recorded data dating between 1954 and 2011. This station (station 8201410) is located at coordinates 45.22N, -61.18W. Average climate conditions for the site were calculated using 30 year averages for data from 1975 to 2005. Data for years subsequent to 2005 were incomplete and not used in the calculation. A summary of climate norms is presented in Table 2-1.

As common on the eastern coast of Canada, the region's climate is influenced by the Atlantic Ocean and is characterised by mild winters and cool summers. Average monthly temperatures range from -0.5^{o}C to -4.4^{o}C from December to the end of March and from 11.1^{o}C to 17.3^{o}C from June through September.

The Deming, NS Climate Station recorded an average annual total precipitation of 1426.17 mm over a thirty year period consisting of 1311.8 mm of rain and 114.3 cm of snow.

[1] http://climate.weather.gc.ca/climate_normals/index_e.html

TABLE 2-1: SUMMARY OF CANADA CLIMATE NORMS FOR STATION 8201410, DEMING, NS (1975-2005)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave.
Mean Temp (°C)	-4	-4.4	-1.4	2.5	6.6	11.1	14.7	17.3	15	10	4.9	-0.5	6.0
Mean Max Temp (°C)	-0.5	-1.1	1.4	5.3	9.7	14.3	17.4	20.2	18	12.7	7.6	2.7	9.0
Mean Min Temp (°C)	-7.5	-7.6	-4.3	-0.3	3.5	7.8	11.8	14.5	12	7.2	2.1	-3.7	3.0
Extreme Max Temp (°C)	10.5	10	11	20	24	31.1	30	28.5	26	20.5	18.5	12	20.2
Extreme Min Temp (°C)	-25	-23	-19	-11	-3.5	1	4.5	7	2	-2.2	-12	-23.5	-8.7

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Average Total Rain (mm)	90.4	66.5	97.1	121.9	112.9	99.8	103.2	93.3	115.5	149.5	140.9	120.7	1311.7
Average Total Snow (cm)	29.1	27.7	21.2	9.4	0.6	0	0	0	0	0	4.6	21.7	114.3
Average Total Precipitation(mm)	119.5	94.2	118.3	131.3	113.5	99.8	103.2	93.3	115.5	149.5	145.6	142.4	1426.1

Table 2-2 presents Depth Duration Frequency (DDF) rainfall data for the site, which is taken as the average of Sable Island and Shearwater stations abstracted from the Government of Canada Climate DDFv2 dataset[2]. These weather stations were selected from the database because of the long records used for estimation of the DDF data. The 1:100 year 24 hour rainfall depth averaged from Sable Island and Shearwater stations was compared against the average 1:100 year 24 hour depths for the three stations nearest to the site, which had over 40 years of data as provided by Environment Canada[3], which gave a similar result (<0.5% difference).

TABLE 2-2: DEPTH DURATION FREQUENCY (DDF) RAINFALL – PROJECT SITE

Duration	Rainfall Depth (mm) and Frequency					
	1:2 years	1:5 years	1:10 years	1:25 years	1:50 years	1:100 years
5 minutes	6.3	8.3	9.6	11.3	12.6	13.8
10 minutes	9.2	11.8	13.6	15.8	17.5	19.1
15 minutes	11.5	14.6	16.7	19.4	21.3	23.2
30 minutes	16.1	20.5	23.3	27.0	29.7	32.3
1 hour	22.2	28.1	32.1	37.1	40.8	44.5
2 hour	30.3	39.2	45.2	52.7	58.2	63.7
6 hour	49.8	62.9	71.7	82.7	90.8	98.9
12 hour	60.9	77.5	88.5	102.5	112.8	123.1
24 hour	68.7	89.6	103.4	120.9	133.8	146.7
2 Day	79.5	108.0	127.0	150.9	168.6	186.3
5 Day	98.6	127.9	147.4	171.9	190.1	208.2

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[2] http://climate.weather.gc.ca/prods_servs/engineering_e.html and ftp://ftp.tor.ec.gc.ca/Climate_Services/

[3] Email from climate.atlantic@ec.gc.ca dated 26 January 2015

10 Day	127.2	163.8	188.1	218.8	241.5	264.1
15 Day	154.5	194.5	221.0	254.5	279.3	303.9
30 Day	221.0	270.0	302.5	343.5	373.9	404.1

Storm intensities are predicted to increase in this region due to the effects of climate change (Richards and Daigle 2001) as follows:

- 1980s – 0% (1980 is the base decade against which increases are compared).
- 2020s – 5% above 1980s values.
- 2050s – 9% above 1980s values.
- 2080s – 16% above 1980s values.

2.2 EVAPOTRANSPIRATION

Evapotranspiration has been calculated at 549 mm/year calculated using the Thornthwaite equation requiring mean monthly temperature and latitude. Mean temperature and a factor for latitude combine to reflect the amount of energy available to contribute to potential evapotransporation (PET).

2.3 TOPOGRAPHY

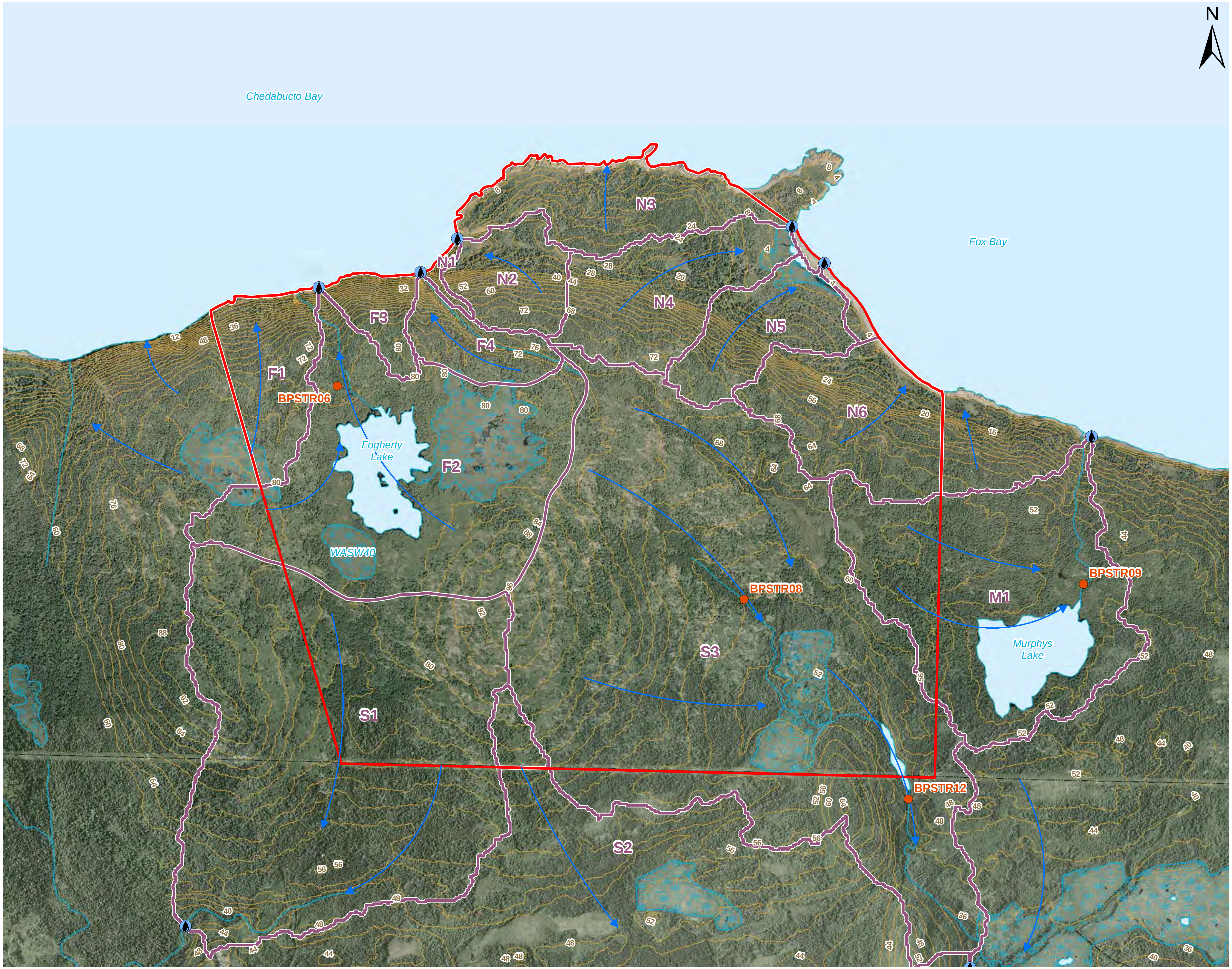
The topography of the site and surroundings is presented on Figure 2-1 which shows that site topography slopes in all directions away from a granite hill, located within the southern central part of the site. The granite hill has a maximum elevation of approximately 97 m above mean sea level (amsl).

There is a marked break in slopes between the headland containing both Black Point and Fogerty Head, which forms a level plateau, and the rest of the site which raises sharply from 20-30 m amsl to 60 – 80 m amsl within just over 100 m. With the exception of this steep slope, the rest of the site is gently undulating.

2.4 WATER FEATURES AND CATCHMENTS

As presented on Figure 2-1 the site features numerous wetlands and a lake (Fogherty Lake), suggesting that relatively low infiltration rates are typical. This is supported by considering the elevation of Fogherty Lake, in which water levels are sustained at approximately 80m amsl and in relatively close proximity to the coast line.

Fogherty Lake is a shallow waterbody surrounded by trees, barrens and exposed rock. The water is clear but darkly tea-coloured, and visibility is nil at approximately one metre depth. The lake substrate is exposed bedrock and large boulders. There is some woody organic debris on the lake bed, which has a strong sulfurous smell. Lake water is to be very acidic (pH in field=2.94) (AMEC 2011).



LEGEND

- Stream Sample Location
- Point of Catchment Calculation
- Direction of Surface Flow
- Property Boundary
- Catchment Boundaries
- Waterbody
- Wetland
- Watercourse
- Utility Line
- Contour (4m, LIDAR)

* Catchment Bondaries are based on LiDAR data
Flow through wetlands is difficult to predict without onsite investigation. Catchment boundaries are an estimate only.

0 125 250 500 Meters

SCALE: 1:12,000
WHEN PLOTTED CORRECTLY AT 11 x 17
NAD 1983 UTM Zone 20N

NOTES

This map is for conceptual purposes only and should not be used for navigational purposes.
Basedata: Nova Scotia Natural Resources, downloaded, June 2014; Orthoimagery from GeoNOVA, 2007.

MORIEN RESOURCES CORP.

BLACK POINT SURFACE WATER ASSESSMENT

WATER FEATURES, SAMPLING LOCATIONS, TOPOGRAPHY AND CATCHMENTS

September 3, 2014	Rev 1.0	Figure No.
Project No.	210.05913.00000	2.1

SLR Consulting (Canada) Ltd.

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Three watercourses are identified within the site boundary and are described in full in AMEC's report (AMEC 2011), a summary of which is as follows:

- Watercourse 1 – flows from Fogherty Lake northwards into Chedabucto Bay. A beaver dam is located near the upstream end of the watercourse. Upstream of the dam, the channel is deep and wide and the substrate largely fines; downstream, the channel is a relatively narrow and shallow run with one area of natural deadwater. The northernmost 150m of this watercourse was not surveyed, as it flows down a steep dropoff; however, the dimensions and substrate of the downstream reaches appeared to be similar to the run portions of the channel (AMEC 2011). Flow was measured and water quality monitored approximately 10 m downstream from the discharge of Fogherty Lake at location BPSTR06. The channel varied from approximately 0.50 to 1.0 m wide and had a moderate slope. The stream bed consisted of gravel and varied sized boulders scattered throughout.
- Watercourse 2 – flows within a steep valley from the centre of the site in a north-westerly direction into Chedabucto Bay. There was a great deal of deadfall in the channel valley. The upstream reaches were dry at the time of the 2011 survey, and further downstream the stream was very shallow; this watercourse is probably ephemeral. The stream was dry in July and August, 2014. The last 220 m of this watercourse was inaccessible, as it flows down a steep slope to the ocean, as does Watercourse 1. However, the dimensions and substrate of the downstream reaches appeared to be similar to the rest of the channel (AMEC 2011).
- Watercourse 3 – flows south from the wetlands in the southeast part of the site, across the transmission line cut and towards another wetland system southeast of the site. This in turn is the headwaters of Reynolds Brook, which drains in a south-westerly direction, eventually discharging through Hendsbee and Cooeycoff Lakes into Tor Bay. The downstream portion of the assessed section is a large pool resulting from a beaver dam on the watercourse just south of the Site property line. Flows were measured and water quality monitored at two locations; BPSTR12 which is downstream of wetland 17, and BPSTR08 which is upstream of wetland 17. The discharge measurement at BPSTR12, also on Watercourse 3, was measured at the outflow of Wetland 1. The channel is 2.0 to 10.0 m wide with low, gradual banks, and moderate slope. The stream bed consisted primarily of a mix of small and large boulders. The discharge measurement was located at a narrow, well-contained section 1.0 m wide with large boulders on each side, and consistent flow throughout the section.

In addition to the abovementioned watercourses, the following significant off-site surface water resources are noted in close proximity to the site:

- South-West (off-site) Watercourse – runoff from the south-west of the site drains towards a watercourse (Reynolds Brook) which flows to the south-west into Hendsbee Lake, approximately 1.3km form the site.

- Murphys Lake (Sample ID BPSTR09) - runoff from the east of the site drains towards Murphys Lake which is located approximately 100 m east of the site. Murphys Lake drains to the north into Chedabucto Bay. The discharge measurement at BPSTR09 was measured approximately 20 m downstream from the discharge from Murphys Lake. The typical channel width was 1.0 m or less and had a moderate slope. The stream bed was muddy with fine gravel. The discharge measurement section was 0.80 m wide, had well-defined banks on each side, and had consistent flow throughout the entire section.
- Fox Island Main Creek (Sample ID BPRST10) - Fox Island Main creek drains a large wetland southeast of the Property and discharges north to Indian Cove approximately located 2.0 km east of the Property boundary. Water samples and discharge measurements were taken approximately 10 m upstream from the bridge crossing at Starks Road, Fox Island Main. The typical full-bank channel width is approximately 3.0 m wide, with high banks and a moderate slope. The stream was in low-flow conditions at the time of July and August, 2014 measurements. The stream bed consisted of a mix of gravel and small boulders. The discharge measurement section was 1.1 m wide, well-defined with boulders at each bank, with flow concentrated primarily in middle of the cross-section and negligible at the banks.

As presented in Figure 2-1 the site can be split into 13 catchments which drain to the above mentioned receptors or directly to the ocean.

As presented in Table 2-3, flow measurements were taken in five watercourses at the end of July 2014 and end of August 2-14 (AECOM 2014). The July flows were considered representative of dry (baseflow) conditions (no precipitation for the three days prior to measurements), showed flow out of Fogherty Lake in Watercourse 1 to be 0.03 L/s and flow out of the southeast wetland in Watercourse 3 to be 7.7 L/s. The August flows were also considered representative of low flow conditions and measured flows were consistently lower than during the July round of measurements.

For comparison, estimates of mean annual runoff for these locations suggest higher flows would be more common at other, wetter, times of the year, in the order of 15 L/s in Watercourse 1 and 31 L/s in Watercourse 3.

Table 2-3: Stream discharge summary

Sample ID	Location Description	Discharge (L/s)	Dates Measured (2014)
BPSTR06	Fogherty Lake Outflow Watercourse 1	0.031 / 0	July 30 / Aug 27
None	Watercourse 2	0 / 0	July 30 / Aug 26
BPSTR08	Wetland 17 Inflow Watercourse 3 Upstream	0 / 0	July 30 / Aug 26
BPSTR09	Murphys Lake Outflow	0.170 / 0	July 31 / Aug 27
BPSTR12	Wetland 1 Outflow (Watercourse 3 downstream)	7.73 / 0.325	July 31 / Aug 27

2.5 Mean Annual Runoff

Rain falling onto a catchment either evaporates, infiltrates to groundwater, or runs off as storm water. Undertaking a basic water balance allows the mean annual runoff from the site to be estimated as detailed below:

- Mean Annual Precipitation – 1426 mm (as presented in section 2.1).
- Mean Annual Evapotranspiration – 549 mm (as presented in section 2.2).
- Mean Annual Infiltration – adopting factors to account for the slope, soils types, and vegetation cover (OMOE 2003), allows an infiltration factor to be estimated:
    - Topography is classified as rolling to hilly, with an infiltration factor of 0.15.
    - Soils are shallow and peaty, with an infiltration factor of 0.1.
    - Vegetation is thicket and shrub, with an infiltration factor of 0.15.
- From the above, an infiltration factor of 0.4 is estimated (the sum of each of the above components). When this factor is multiplied by the net precipitation (calculated as precipitation – evapotranspiration), an annual infiltration of 351 mm is derived.
- Mean Annual Runoff – calculated to be 526 mm based on the net precipitation (877 mm) minus infiltration (351 mm). When applied to the entire 354.5 ha site, this gives an annual runoff of 1 865 592 m^3 which equates to an average flow of 59 L/s leaving the site.

2.6 Peak Flow Rates and Flood Volumes

The peak flows and flood volumes generated by the site during baseline and developed conditions were estimated using the SCS Method within the HydroCAD software package. The following parameters were used:

- Rainfall – 24 hour storm depths were adopted based on the DDF storm data presented in Table 2-2, and a Type II storm profile was adopted which is considered applicable for most parts of Canada (LSRCA 2013).

- Catchment Area – the total site area of 354.5 ha is used.
- Curve Number – taking into account the shallow soils over much of the site, which readily generate runoff, and the shrub vegetation coverage, a curve number of 82 is used.
- Time of Concentration – estimated from longest flow pathway (approximately 1,000 m) and average gradient (0.03) to be 44.5 minutes for the pre-development site.

The peak flows and flood volumes for the site are presented in Table 2-4.

TABLE 2-4: PEAK FLOWS RATES AND FLOOD VOLUMES

Flood Hydrograph	1:25 years	1:100 years
Peak Flow (m^3/s)	47	62
Flood Volume (m^3)	258 000	341 000

2.7 WATER QUALITY

Water quality monitoring was undertaken at 5 locations on 31st July 2014 and is described in detail in Section 6.2 and Appendix A of the Main Report; a summary of the key findings are presented below. The analytical results were compared against Canadian Water Quality Guidelines (CWQG) for the Protection for Aquatic Life (PAL) Freshwater Guideline Update 7.0 (CCME 2007). The results indicate:

- pH was low (4.33 – 4.70) in all 5 samples and is outside of the acceptable CWQG PAL guideline range (6.5-9.0).
- Lead slightly exceeded the CWQG PAL guidelines at two locations.
- Iron was elevated (320 – 1600 ug/L) in all 5 samples and exceeded the CWQG PAL guidelines (300 ug/L).
- Cadmium was above the CWQG PAL guidelines at one location (0.09 ug/L).
- Ammonia was elevated (0.08 – 0.086 mg/L) in 2 samples and exceeded the CWQG PAL guidelines.
- Aluminium was elevated (270 – 820 ug/L) in all 5 samples and exceeded the CWQG PAL guidelines (5 ug/L).

The pH of surface water features is low and colour of water is typically dark brown, both characteristics are thought to be attributable to the peaty soils which are common across the site. The high pH is likely to be the cause of the elevated concentrations of dissolved metals within the samples.

2.8 SOILS AND GEOLOGY

The regional geology consists of Ordovician-age metamorphosed sedimentary rocks of the Halifax and Goldenville formations that were intruded by Devonian-age granite (Stea and Dickie 1977). The granite will be quarried to produce crushed-stone aggregate.

Based on information collected from 11 boreholes completed within the granite, this unit is fractured to approximately 15 m below ground level (bgl) and groundwater levels are shallow, generally found between 2 and 4.5 m bgl.

Soils in this area belong to the Rockland series and are described as having “excessive to poor” drainage and characterised as having “extreme shallowness” (Hilchey 1964).

2.9 VEGETATION

Most of the area is covered by a mosaic of barren vegetation, tall shrub barren, and some coniferous forest. There are also patches of mixed forest, and wetlands such as treed bog, open bog, fen, and swamp scattered throughout the site. A number of other habitat types are also present, including beaches, coastal barren headlands, coastal cliffs, regenerating forests, and lakes.

3 POTENTIAL POST DEVELOPMENT CHANGES

The quarry development has the potential to affect the baseline hydrology in the following ways:

- Mean Annual Runoff – alteration of topography / drainage routes, removal of topsoil / vegetation, and use of water for processing requirements may impact the volumes of runoff discharged from the site thereby affecting flow dependent receptors within the downstream environment.
- Peak Flow – alteration of topography / drainage routes and removal of topsoil / vegetation may increase the peak flow of runoff discharged from the site thereby increasing the risk of flooding within the downstream environment.
- Water Quality – the use of chemicals, fuels, lubricants and explosives at the site and disturbance of soils, and rock has the potential to detrimentally impact upon the quality of water discharged from the site thereby affecting downstream environmental receptors.

These points are described in more detail below.

3.1 EFFECT ON MEAN ANNUAL RUNOFF

Following full development (50+ years) and without accounting for re-vegetation that will occur during progressive rehabilitation, the quarry and much of the lower platform will not retain any soils or vegetation, reducing the infiltration factor from 0.4 to 0.3 across approximately 57% of the total site. This reduction in infiltration will increase the runoff by 17% in these areas (208 ha), which equates to a 10% increase from the entire 354.5ha site to a mean annual runoff of 2 043 906m^3 following development.

As discussed further in Section 4.1, measures are recommended to convey runoff from operational areas to one of two stormwater retention ponds, from where runoff will either be re-used on site or discharged to Chedabucto Bay, meaning that post development the mean annual runoff of several catchments will be reduced whilst runoff from N2, N3 and N4 will be substantially increased. The impact of full development on the mean annual runoff from the site is presented in Table 3-1.

TABLE 3-1: IMPACT OF DEVELOPMENT ON MEAN ANNUAL RUNOFF

Catchment	Baseline Scenario (Pre Development)		Post Development Scenario		% of Baseline Runoff
	Area (ha)	Mean Annual Runoff (m^3)	Area (ha)	Mean Annual Runoff (m^3)	
F1	14.4	75 573	14.4	75 573	100%
F2	61.5	323 504	36.8	193 743	60%
F3	5.8	30 387	5.8	30 387	100%
F4	8.7	45 767	3.9	20 621	45%
M1	13.2	69 481	4.6	24 237	35%
N1	1.0	5 401	1.0	5 238	97%
N2	11.0	57 684	27.8	169 414	294%
N3*	19.9	104 481	8.4	44 296	42%
N4*	21.5	113 040	91.3	557 914	494%
N5	14.4	75 632	93.8	571 322	755%
N6	22.4	118 041	5.7	30 193	26%
S1	31.9	168 101	17.4	91 373	54%
S2	2.9	15 100	1.5	8 053	53%
S3	126.1	663 399	42.1	221 542	33%
Total	**354.5**	**1 865 592**	**354.5**	**2 043 906**	**110%**

**Stormwater Discharge Point*

It should be noted that this estimated impact on mean annual runoff discharged from the site does not take account of any collection and re-use of runoff for processing requirements at the site. However, since the processing water will be recycled and given the relatively low evaporation rates at the site, losses of processing water and consequent impact upon mean annual runoff will be minimal.

The estimated mean annual runoff from the quarry and lower platform areas which will drain into the stormwater ponds and will be available for re-use is likely to be 1 248 202 m^3, which equates to an average flow of 40 L/s during the fully developed site. However, volumes of runoff are likely to be much lower during the initial stages of site development and prior to excavation of the quarry, the mean annual runoff from the lower platform only is likely to be 161 467 m^3 (5 L/s).

3.2 EFFECT ON PEAK FLOW RATES AND FLOOD VOLUMES

Of the total site area, the development will feature approximately 180 ha of quarry while the processing plant and stockpiles will occupy the 28 ha lower platform. Most of the vegetation and soils in these areas are likely to be removed and stockpiled, leaving bare rock surfaces. This tends to increase runoff volume and runoff velocity, which is represented as follows:

- Curve Number – for 208 ha of the site, an increased curve number of 91 is used.
- Time of Concentration – a reduced time of concentration of 37.4 minutes is used.

The hydrographs for the site during 1:25 year and 1:100 year events for pre-development and post development scenarios are presented in Figure 3-1 and Figure 3-2. The post-development hydrographs do not take into account the retention ponds discussed in Section 4.1 and are therefore representative of an un-mitigated scenario.

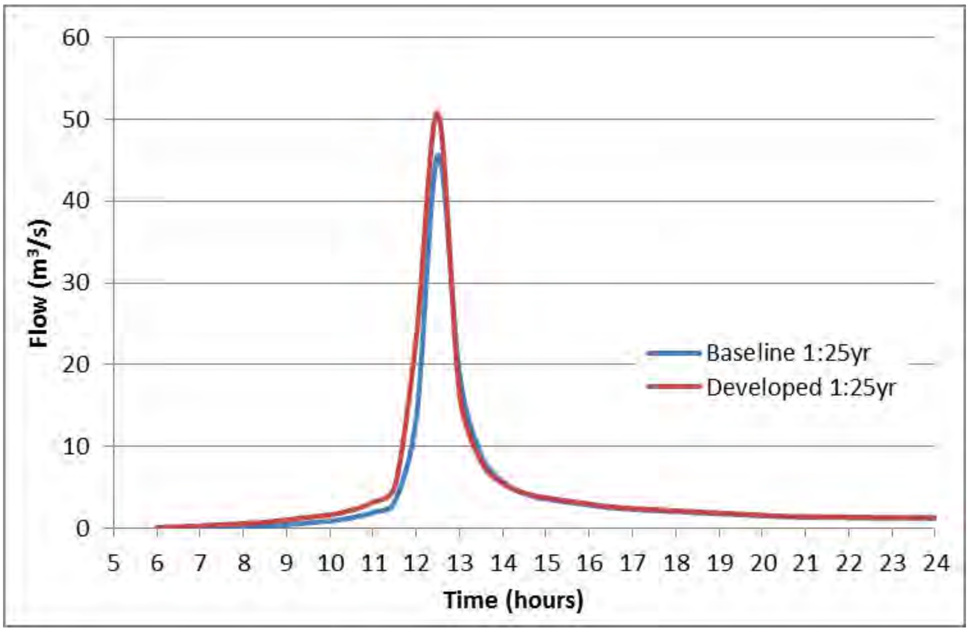


FIGURE 3-1: HYDROGRAPHS FOR BASELINE AND DEVELOPED SITE DURING A 1:25 YEAR EVENT

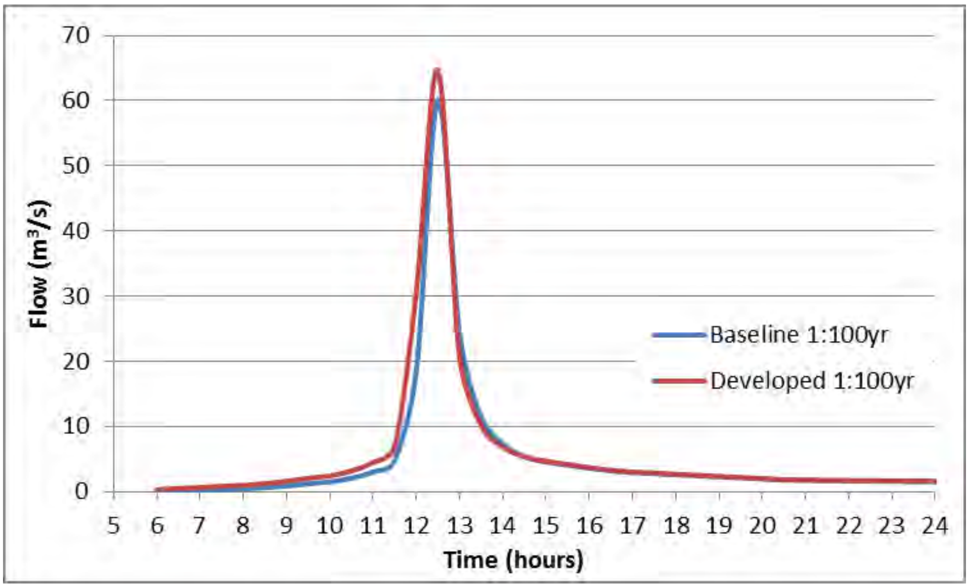


FIGURE 3-2: HYDROGRAPHS FOR BASELINE AND DEVELOPED SITE DURING A 1:100 YEAR EVENT

As can be observed in the un-mitigated post-development scenario, peak flows will increase by 11% for a 1:25 year event and 8% for a 1:100 year event while the volume of runoff generated post development will be increased by 17% for a 1:25 year event and 13% for a 1:100 year event.

It is considered that the increase in peak flow and flood volumes attributable to the development are relatively minor and given that there are no downstream receptors susceptible to flooding, these increases are not considered significant. Therefore, it is not considered necessary to attenuate peak flows on-site to ensure that the pre-development discharge rates are not exceeded.

3.3 Effect on Water Quality

It is not possible to quantitatively assess the un-mitigated impact of the development upon the baseline water quality conditions. Nonetheless qualitatively the impacts could be as follows:

- Geochemistry – quarrying activities may expose elements naturally occurring within soils and geology to rainfall and oxidation, potentially mobilising these elements into discharge from the site. From the water quality monitoring it can be seen that pH is low and aluminum, iron and lead are already found at elevated levels within the surface water environment.
- Ammonia and Nitrate - the use of Ammonium Nitrate-Fuel Oil (ANFO) blasting agents (consisting of inorganic nitrates and petroleum-based fuels) may leave explosives residues, high in ammonia and nitrate, within areas where blasting has occurred. These residues may be mobilised by runoff. From the water quality monitoring it can be seen that ammonia is already found at elevated levels within the surface water environment.

- Suspended Solids – quarrying activities will include stripping of vegetation and soils, as well as washing of crushed aggregate. These activities have the potential to increase the concentrations of suspended solids and silts within runoff discharges from the site.

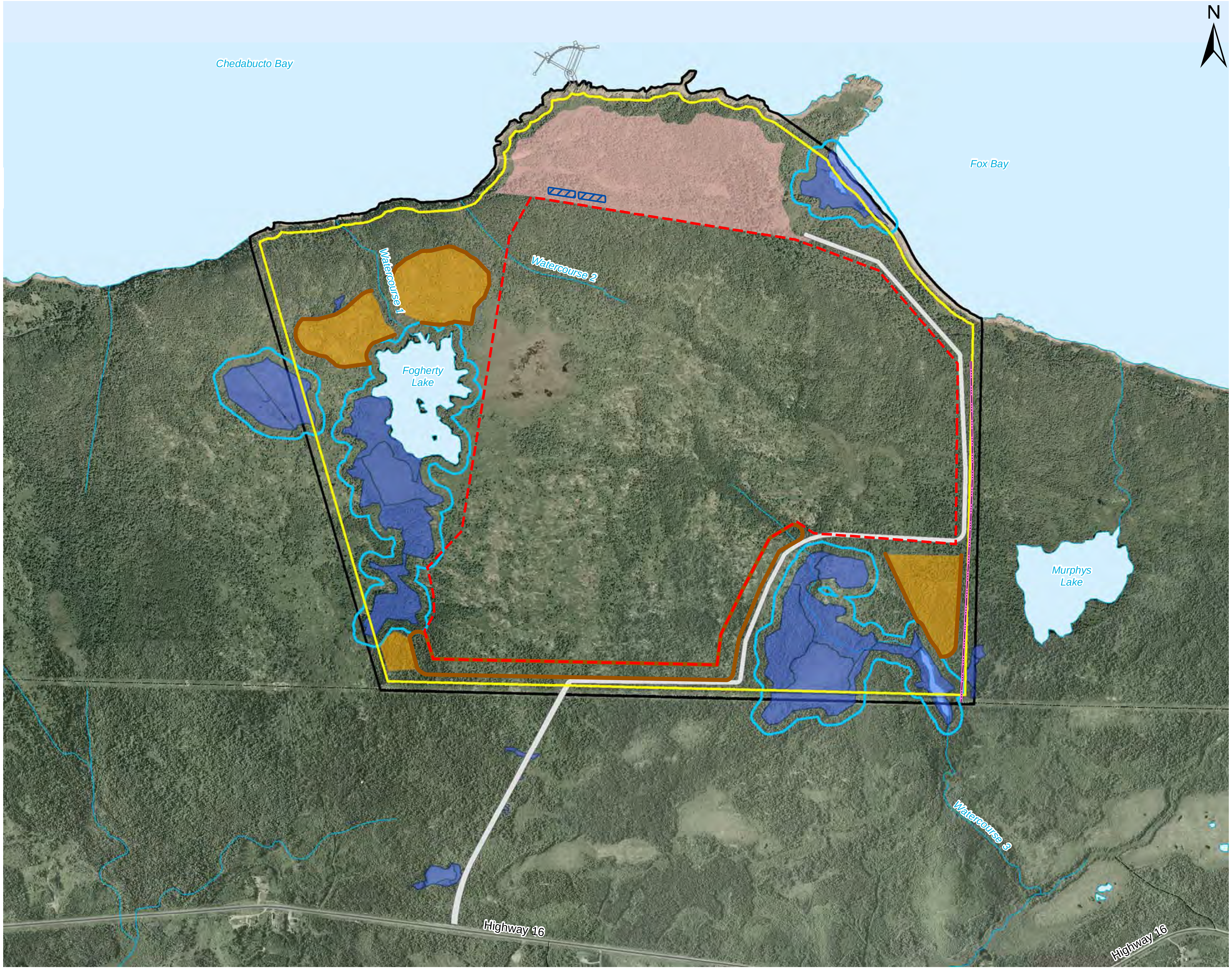
4 MITIGATION MEASURES

In order to reduce the potential impacts of the development on the baseline surface water environment as identified in Section 2, the following is recommended:

- Stormwater Retention Ponds;
- Fuel and Chemical Storage; and
- Discharge Monitoring.

4.1 Stormwater Retention Ponds

Runoff from the working areas of the quarry and associated infrastructure will be conveyed to flow stormwater retention ponds as shown in Figure 4-1. These ponds should be constructed upstream of the final discharge point to improve the quality of water discharged from the site.



LEGEND

- Property Boundary
- Property Boundary Buffer (-30m)
- Ultimate Pit Boundary
- Waste Rock Storage
- Plant Location - Lower Platform
- Proposed Retention Ponds
- Berms
- Power Line
- Current Utility Line
- Entrance Road
- Undifferentiated Wetlands
- 30m Buffer
- Waterbody
- Watercourse

0 125 250 500 Meters

SCALE: 1:12,000
WHEN PLOTTED CORRECTLY AT 11 x 17
NAD 1983 UTM Zone 20N

NOTES

This map is for conceptual purposes only and should not be used for navigational purposes.

Basedata: Nova Scotia Natural Resources, downloaded, June 2014; Orthoimagery from GeoNOVA, 2007.

MORIEN RESOURCES CORP.

BLACK POINT SURFACE WATER ASSESSMENT

CONCEPTUAL SITE PLAN AND PROPOSED RETENTION PONDS

September 4, 2014	Rev **1.0**	Figure No.
Project No. 210.05913.00000		**4.1**

SLR

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It is recommended that retention ponds are designed in accordance with Nova Scotia Department of the Environment Guidelines (NSE 1988) to intercept sediment laden runoff and allow sediment to settle out, thereby reducing the amount of sediment leaving the disturbed area, and protecting local watercourses from excessive sedimentation.

The recommended design features are as follows:

- Permanent Pool – a permanent volume of water is to be retained within the pond at all times to ensure treatment of all stormwater discharged from the site. It is recommended the permanent pool is sized to contain at least 190 m^3 per ha of catchment (NSE 1988). Based on the mean annual runoff, this equates to 11 days of residence time within the pond prior to discharge.
- Flood Conveyance – flood events up to and including a 1:100 year event + 16 % for climate change should be conveyed through the pond and discharged via a spillway.

The following stormwater retention ponds are proposed:

- Process Water Ponds – during construction of the lower platform and access road, a series of process water ponds will be constructed to store runoff from the entire lower platform area. Once complete the entire lower platform will drain to these ponds and will be re-used for processing where required or discharged to Chedabucto Bay.
- In-Pit Drainage Sump – during the initial stages of quarrying a drainage sump will be created to intercept runoff generated within the footprint of the quarry in addition to any groundwater inflows to the pit, and water will either be used for processing where required or discharged to Chedabucto Bay.

The catchment areas, recommended retention pond sizes, and outflow controls are presented in Table 4-1 below:

TABLE 4-1: RECOMMENDED RETENTION POND DETAILS

Parameters	Process Water Ponds	In-Pit Drainage Sump
Catchment Area is (ha)	28	180
Mean Annual Runoff (L/s)	5.5	35.0
Permanent Pool Volume (m^3)	5 320	34 200*
Flood Conveyance – 1:100yr + 16% (m^3/s	7.5	33.0

*Theoretical design volume; the actual sump will have a smaller volume since any overflow would be contained within quarry limits

At this stage of the project, the above measures and design detail are considered indicative and as such, it is recommended that the drainage strategy be revisited during further design of the site.

4.2 FUEL AND CHEMICAL STORAGE

All fuels and chemicals stored or used on site should be contained within fit-for-purpose containers and stored within designated storage areas. In order to prevent pollution of the surrounding environment during an accidental spillage, the designated storage areas should be situated on an impermeable surface and should feature a perimeter bund and a drainage sump. The volume of the bund and sump should be sized to contain at least 110% of the total volume of the fuel and chemicals being stored within the designated storage area. The storage areas should feature a roof to prevent inflow of rainwater, which would require the sump to be emptied frequently.

4.3 DISCHARGE MONITORING

It is recommended that water quality monitoring is undertaken on the discharge from the retention ponds on a monthly basis and results compared against the baseline conditions.

Where guideline values and baseline are exceeded, it is recommended that a review of site activities should be undertaken to identify the source of pollution and remedial measures should be implemented to ensure that the quality of the discharge is improved.

5 CONCLUSIONS AND RECOMMENDATIONS

The site is 354.5 ha in area features 3 watercourses, numerous wetlands and a lake. The existing topography divides the site into 13 catchments. The mean annual runoff for the site is 1 865 592 m^3 and the peak flows leaving the site are 34 m^3/s for a 1:25 year event and 42 m^3/s for a 1:100 year event. The baseline water quality shows low pH, elevated iron and aluminium concentration across all sampling locations.

Unless appropriately mitigated, the proposed quarry development has the potential to impact upon the baseline surface water quantity and quality.

It is proposed that runoff is from the site is conveyed to stormwater retention ponds, to improve the quality of water discharged from the site and allow for settlement of suspended solids prior to discharge to the receiving environment. This will significantly reduce the mean annual runoff in some of the catchments identified at site and increase mean annual runoff at the discharge points.

The proposed development will increase peak flows by up to 16% during a 1:100 year event however, it is not considered necessary to attenuate peak flows on-site as no receptors susceptible to flooding because of the slightly increased peak flows were identified.

The following monitoring and maintenance is recommended during construction and operational phases of the site:

- Water Quality Monitoring – discharge from the retention ponds should be monitored to demonstrate compliance with the Nova Scotia Pit and Quarry Guidelines (NSEL 1999).
- Maintenance Retention Ponds – in order to maintain the function of the ponds as outlined above, it is recommended that silt is removed and the outflow controls are routinely checked for any potential blockages.

It should be noted that the above strategy is indicative only and should be revisited to take account of more detailed information which may be forthcoming during later stages of design or during the operational phases of the site, as detailed below:

- Site Development Phasing – as the site develops, catchment areas and drainage pathways will need to be considered and additional berms or ponds maybe required to prevent direct discharge of runoff from working areas to any surrounding receptors.
- Site Water Requirements – water will be required for operational and processing activities at the site. It is recommended that this is considered through an operational water balance for the site, to confirm whether the operation is water positive and excess water needs to be discharged, or whether the operation is water negative and further makeup water will need to be abstracted.
- Groundwater Inflow – in addition to runoff collecting within the pit, it is anticipated that groundwater seepage into the pit may need to be managed. Given the close proximity to the coastline and the deep nature of the quarry, it may be that seawater seeps into the pit, which may impact upon the natural salinity of surface water receptors if pumped out alongside runoff.
- Settlement Velocities – during initial phases of construction, samples of the runoff entering the stormwater ponds should be taken during storm events. Samples should be left to stand and the settlement velocity should be observed to confirm the design of the retention ponds.

6 REFERENCES

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