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Phosphorus Net Loading Assessment

Fall River Site C

Proposed Ingram Drive Development

Prepared by:

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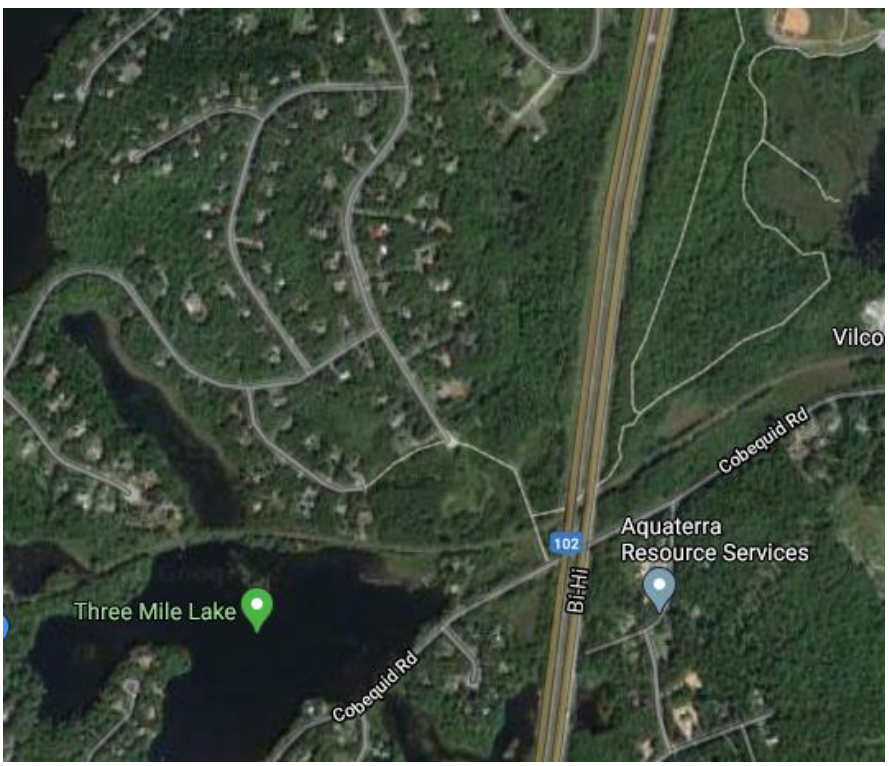
April 2020



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Project Description

The proposed project will see the development of three – 40 unit, two-bedroom residential apartment buildings on PIDs 40844375, 40551277, 00472910, 00472902, and 40551558 at the end of Ingram Drive, Fall River, Nova Scotia.

There have been several revisions to this plan over the years with varying numbers of units proposed. The latest plans for the development have been drawn by Marco Visentin P. Eng. of Able Engineering Services Inc., dated April 9, 2020. These plans (6 total) are included in Appendix A. The plans include the Phosphorus Net Loading Assessment Plan, Site Concept Plan, Water Service Site Concept Plan, Sanitary Service Concept Plan, Stormwater Management Plan, and the Erosion and Sedimentation Control Plan.

The size of the footprint of this project has been reduced in order to limit the impact on the environment. This has been done by keeping all three of the buildings at one end of the lot and away from a sensitive wetland area located on the property. This allows the site development to be directed to one large stormwater infiltration and retention feature before any waters are discharged offsite.

Parking is provided to tenants underground below each building with only a few designated visitor parking areas out front of each building, thereby, limiting the footprint of impermeable parking areas.

Water will be provided to the units by an existing 300mm watermain that runs through the property near the proposed buildings. Sewer services will be provided with a combination of primary septic tanks, secondary biofilters, electrostatic phosphorus removal, and tertiary treatment in infiltration trenches, similar to what was outlined in a report done by A. W. Dewar P. Eng. in August 14, 2019 (see Appendix B) but revised and updated in the most recent drawings dated April 9, 2020 by M. Visentin P.Eng. included in Appendix A.

The requirement for this Phosphorus Net Loading Assessment comes from Halifax Regional Municipality's (HRM) desire to protect the water quality in the Shubenacadie Lake water system and the need for all development in the area to adhere to the "no net increase in phosphorus" export policy (HRM, Policy RL-22). A previous study was completed for this property by Strum Consulting on June 23, 2016 (see Appendix B) and was found by HRM to be lacking in some areas. This was brought to the attention of WM Fares Architects in a letter dated October 30, 2019 (See Appendix B).

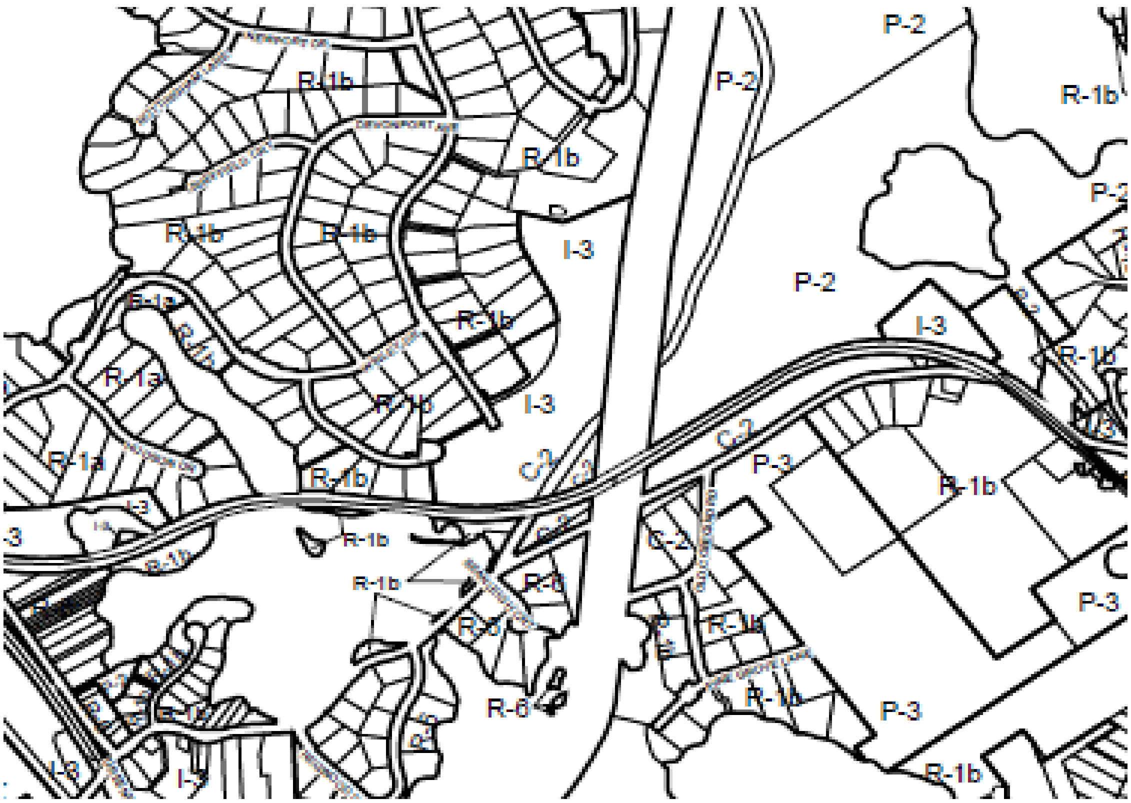
This report will attempt to add to the information provided in the previous report published by Strum in hopes of further clarifying how this development can proceed without increasing the trophic state of the receiving waters. This is a very stringent requirement for developers that will require special measures to be used during construction, and in the treatment of stormwater and runoff and onsite sewage treatment. In addition, after the lot is developed, best management practices will need to be followed to ensure phosphorus export levels are kept low.

Site Conditions

Land Use Past, Present and Proposed.

The property is in the Shubenacadie Lakes Plan Area (Planning Districts 14 &17) and is zoned C-2 and I-3, which are Community Commercial Zone and Light Industry Zone, respectfully.

The east side of the property is bounded by Highway 102 and on the south side of the highway by the railway right-of-way and tracks. To the west is all R-1b zoning, or Suburban Residential Zone. Historically, the property was used as a gravel or borrow pit for extracting soils and aggregates. It has also been used as a place to store or stockpile fill and soils from other excavations in the area.



As mentioned previously, the plan is to develop the lot for multi-unit residential apartment buildings as shown on the Proposed Site Concept Plan C100 in Appendix A. This will involve the construction of three 40- unit buildings on the southern half of the lot.

Roads

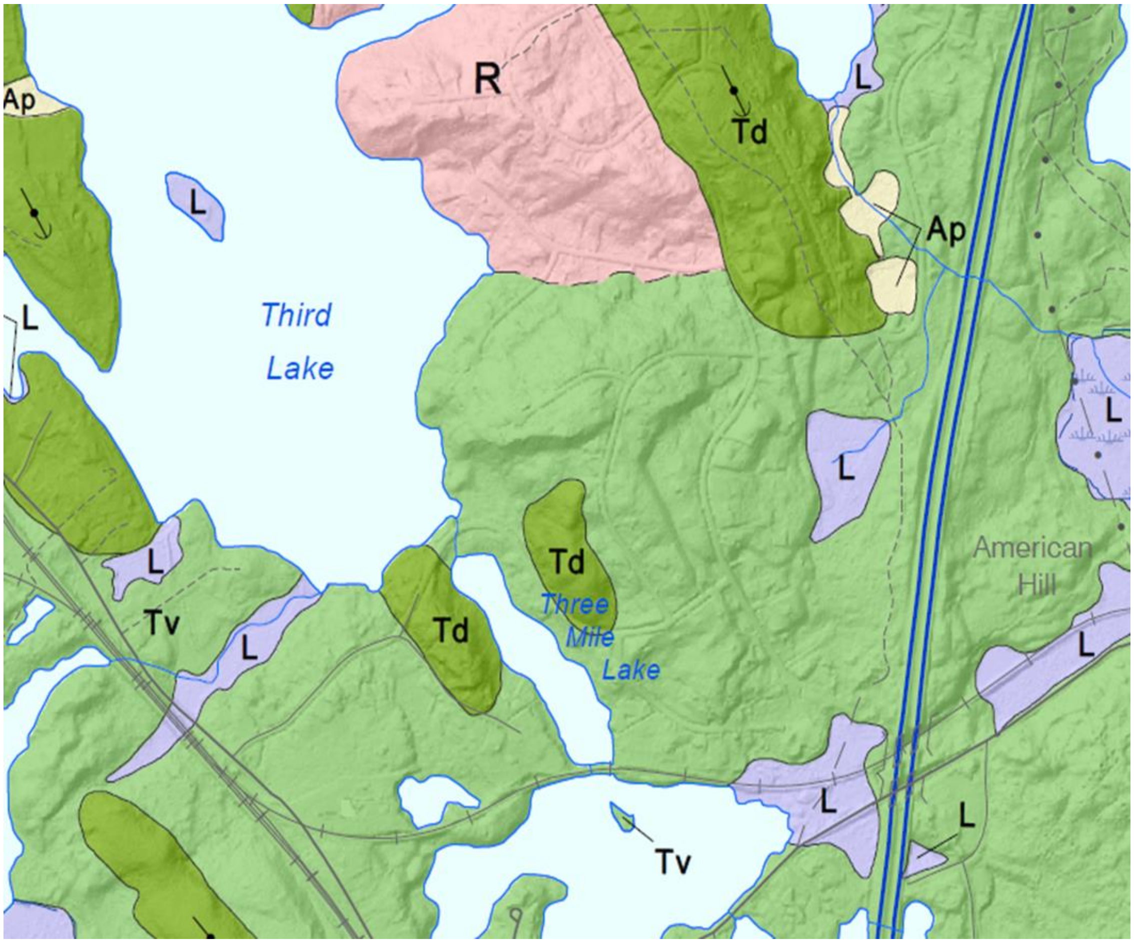
Access to the site is provided via Ingram Drive and this development is at the end of this street. From the site, it is approximately 0.2 km up Ingram Drive to Windley Dr. and then about 1.3 km to Windsor Junction Road. Bolton Drive also dead ends on the west side of the property but this road will not be utilized.

On the east side of the property is the limited access to Highway 102 and no access is available directly from this property to this main highway. The property also has a hiking trail which runs parallel to Highway 102, which will be maintained for use by residents and others in the community.

Figure 1 Ingram Drive Access to Site

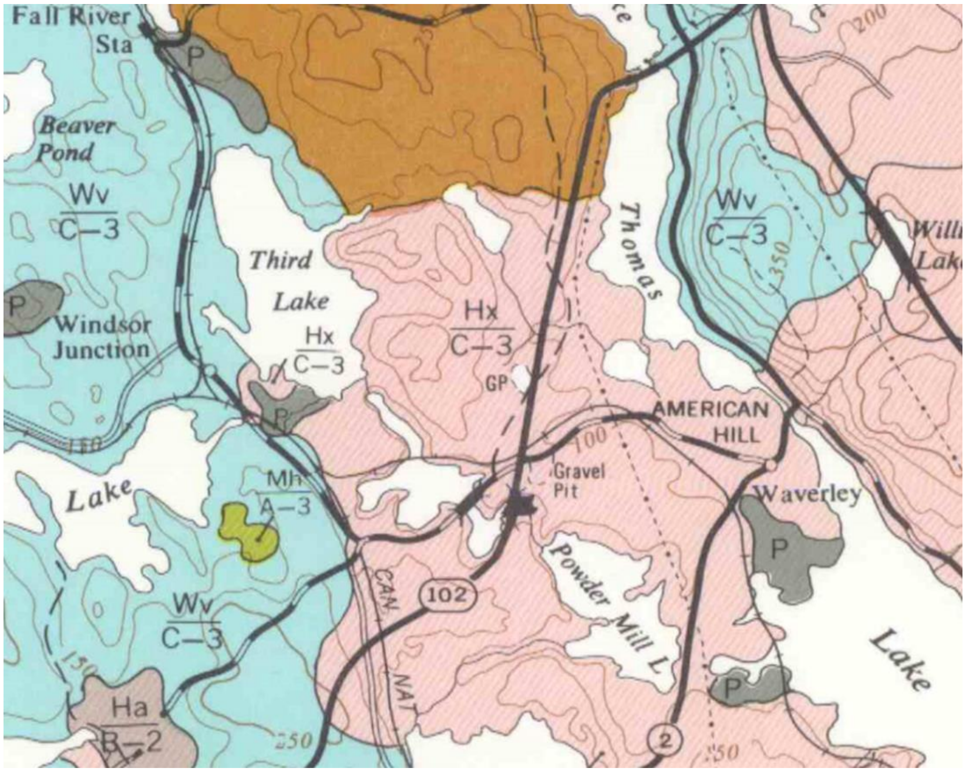
Surficial Geology

The surficial geology is a till veneer (Tv), known as the Beaver River Till, which is a diamicton (a sediment resulting from dry land erosion) with a sandy matrix and locally-derived clasts. Sediments are deposited by ice and derived from subglacial erosion. The thickness of the deposits is estimated to be between 0.5 to 5.0 meters.



The area of the proposed development shown above also has some Lacustrine (L) deposits. These are sand, silt, clay, and organic deposits formed from suspension in freshwater lakes, ponds, and wetlands and includes shoreline materials deposited or those reworked by wave action. These deposits may be underlain by till or glacio-lacustrian materials with a thickness of 1-5 meters. This area of the property is going to remain undisturbed, as it includes a wetland. It will also function as a final filter of any phosphorus that may runoff from the property.

From the Halifax West Soils Maps (shown below), the site is known to have soils from the Halifax Series Soils. These are described as brown sandy loam over yellowish sandy loam. It is olive to yellowish-brown stony sandy loam till derived from quartzite. Terrain is generally rolling 9-16% grade and very stony, limiting its use for cultivation, however, these soils are well-drained and suitable for onsite sewage disposal systems. Specifically, the yellowish-brown sandy soils usually are rich in iron which will help to precipitate phosphorus from the sewage effluent in the disposal trenches that have been proposed.



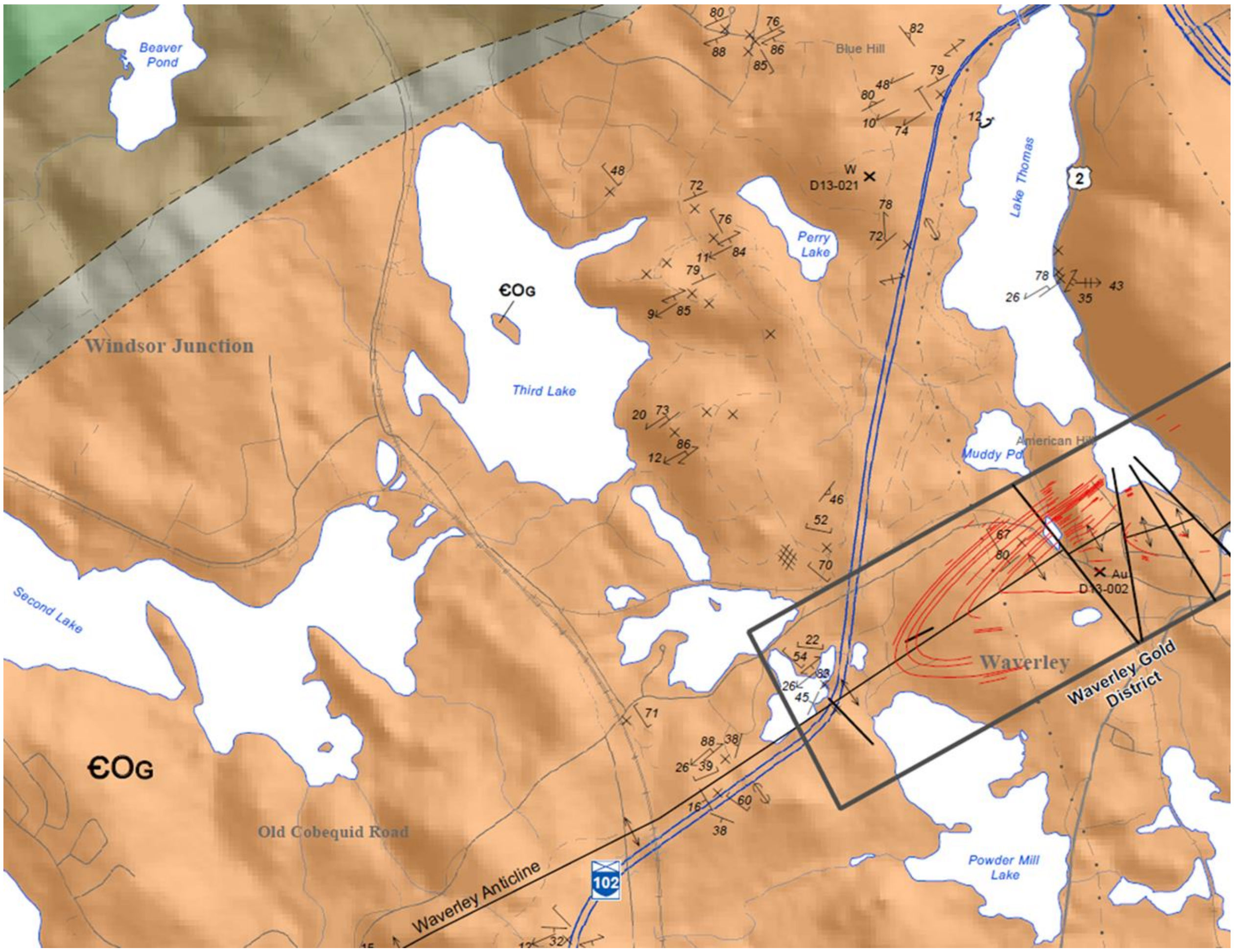
In the past, some areas of the site have been used to extract this resource, however, extraction operations ceased several years ago, and the land is now revegetating with birch, alders and other small trees.

Figure 2 Old pit area showing vegetative regrowth

The area dug out for the pit left large boulders behind around the sides of the pit, and small trees and bushes are now growing up.

Bedrock Geology

The underlying bedrock is from the Goldenville Group formed during the Cambrian Ordovican era. The Goldenville group consists of undivided greenish grey metasandstone and minor interbedded green laminated metasiltstone and dark grey-black slate. There is also some cataclastic texture fault breccia with inclined shear and inclined veins as shown in the plan below from the Nova Scotia Department of Lands and Forests



This site is in the "Low Risk" category for the potential for radon in indoor air (as is shown below), so this does not require extra considerations during the construction of these apartment buildings. With indoor underground parking being provided, the ventilation system for the vehicle exhausts will more than be adequate for any radon gas removal.

radon in indoor air.

Potential for Radon in Indoor Air

- High Risk
- Medium Risk
- Low Risk

Testing is the only way to find out how much radon is in your home, so it is important to test no matter where you live. Some areas of Nova Scotia have a higher risk of radon because of the local geology. The radon risk map for Nova Scotia from the Department of Natural Resources shows areas with high, medium and low risk. Test results have shown that 40% of buildings in the high risk areas exceed the radon guideline. In the medium risk areas, 14% of buildings exceed the guideline and in the low risk areas 5% exceed the guideline. These results tell us that even homes in low risk areas should be tested.

Do-it-yourself radon testing kits can be ordered on-line from the Lung Association of Nova Scotia

You can also hire a C-NRPP Certified Professional for radon testing and mitigation. Find one here.

For further information on radon please click here.

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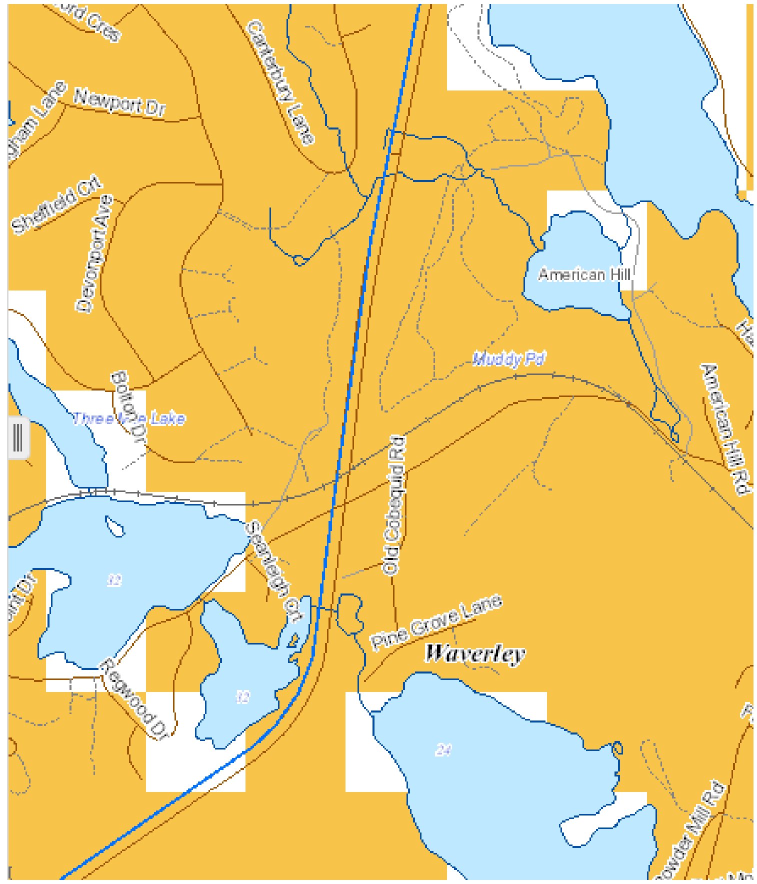
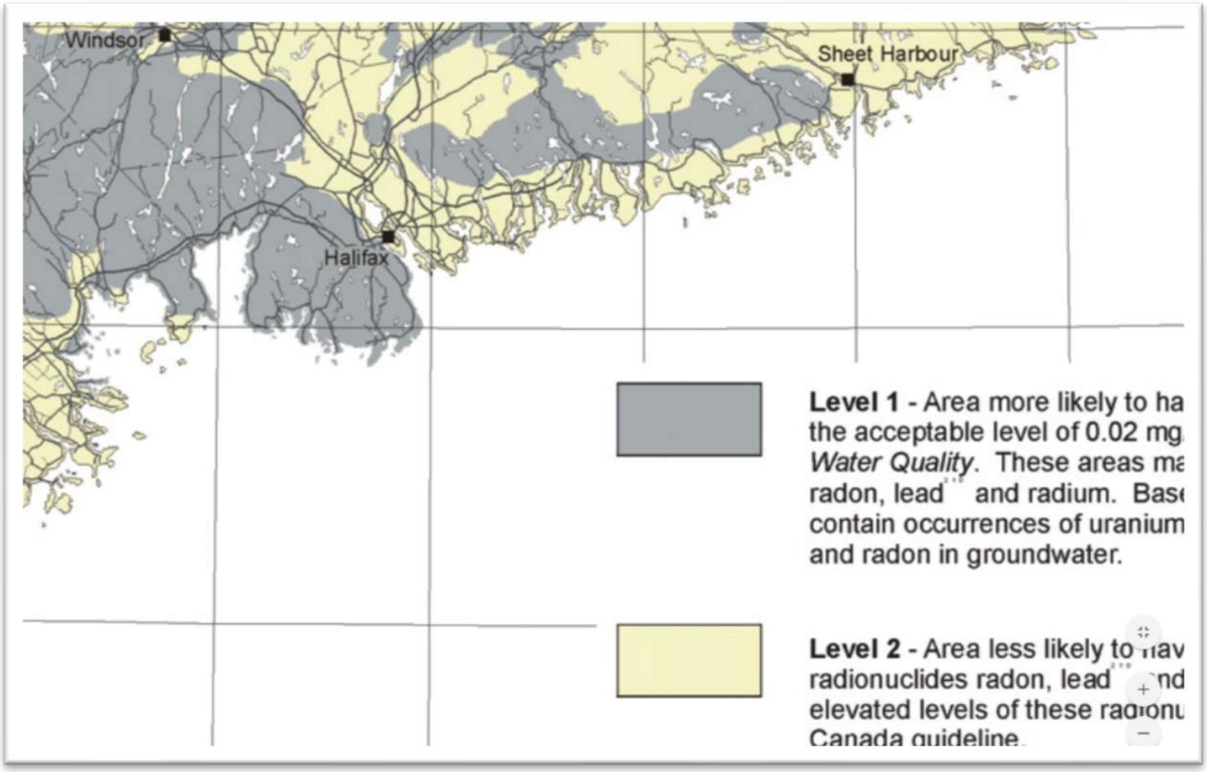


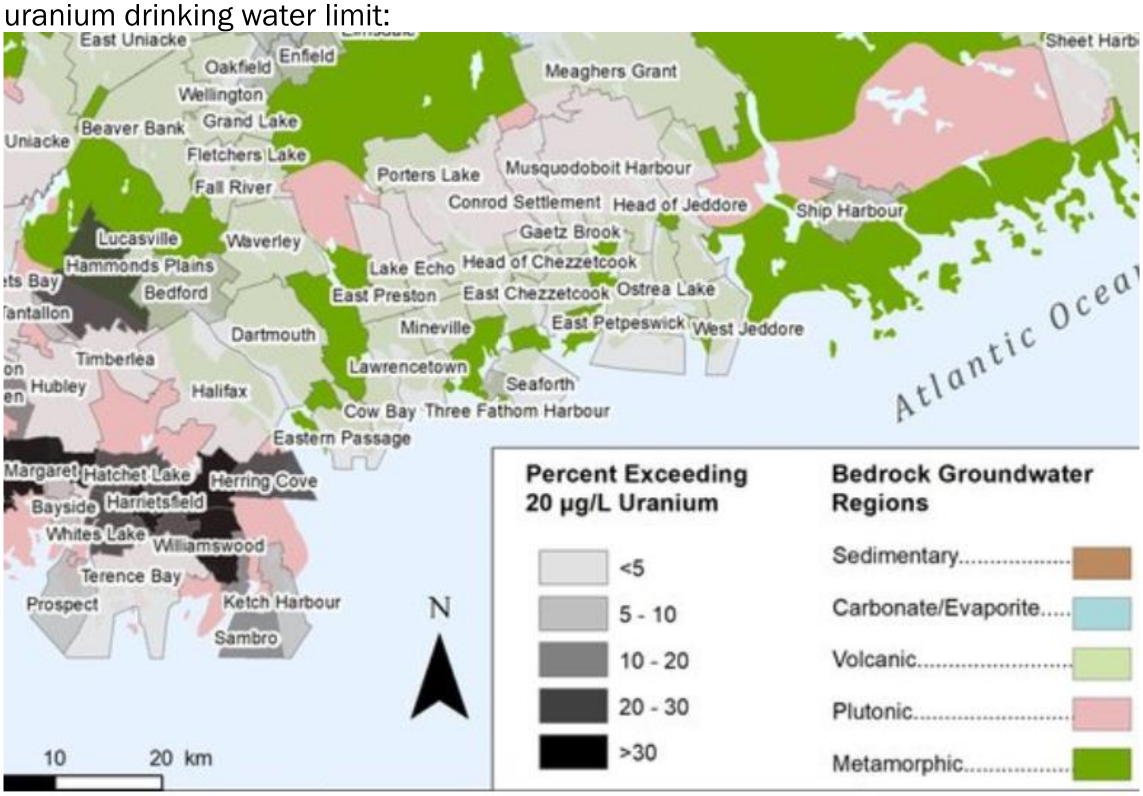
Groundwater Resources

Groundwater will not be negatively impacted by this development as none will be withdrawn from the aquifer, and treated potable water is available on site from the Pockwock water system that will eventually find its way into the groundwater after undergoing tertiary treatment with the proposed sewage treatment system, and filtering down through the overlying soils described above.

The map below provided by the Department of Natural Resources' website shows that the area of this development is less likely to have uranium and other radionuclides naturally occurring in the groundwater.



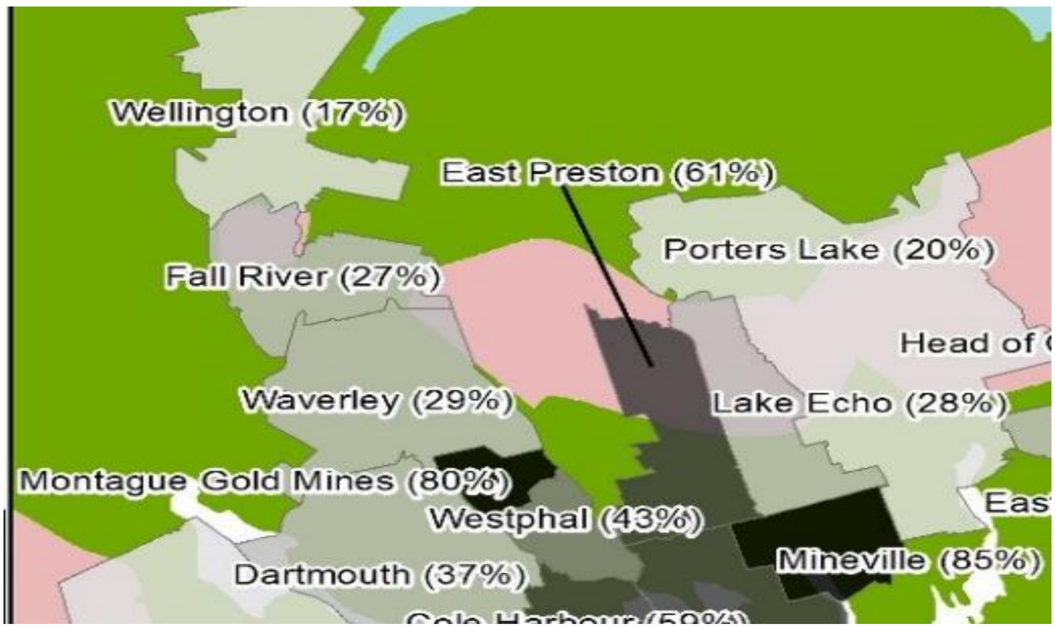
The more detailed map below shows less than 5% of samples would exceed the 20 ug/l of uranium drinking water limit:



Well logs in the area found in Appendix C show that the three closest wells to the site yielded between 1.25 and 1.75 igpm with depths of 128 to 260 ft. This would have been insufficient water for the size of this development.

Arsenic in groundwater is another naturally occuring problem in many parts of Nova Scotia and this has been studied fairly extensively over the years. The Fall River area is known to have some naturally-occuring arsenic in the groundwater.

A report from (Kennedy and Drage, 2016) shows the percentage of samples that exceed the level of 10 ug/l of arsenic in the water, which was the drinking water limit at the time. For the Fall River area 27% of wells sampled exceeded this level of arsenic:



Rainfall Information

Rainfall information for the area was obtained from weather records kept by Environment Canada at the Halifax Stanfield International Airport (HIAA) which is located less than 20km from the site. The total average rainfall per year is 1.4 meters, or 1396 mm/year, in this area. Rainfall intensity and duration information is included in a report by A. W. Dewar P.Eng. dated Aug. 3, 2019 found in Appendix B. The highest rainfall in a single day at the HIAA was 83.8 mm in 2016. This information is required for stormwater runoff calculations and sizing of containment measures.

Vegetation

The vegetation on the site has been somewhat disturbed by the presence of a working gravel pit on the property and a walking trail through the property.

In addition, on the northern lower areas of the property there is a small pond and wetland surrounding it. This area has a much more diverse set of plants. The plan is to leave this area mostly untouched. The wastewater effluent disposal beds, which will be up above this closer to the hiking trail, will add additional treated water to this area. The shallow groundwater will help to enhance the growth of wetland plants and vegetation as this supplemental water source will be available year round. Vegetation around the hiking trail is a mix of older hardwoods and softwood trees.

Figure 3 Hiking Trail

Surface Drainage and Wetlands

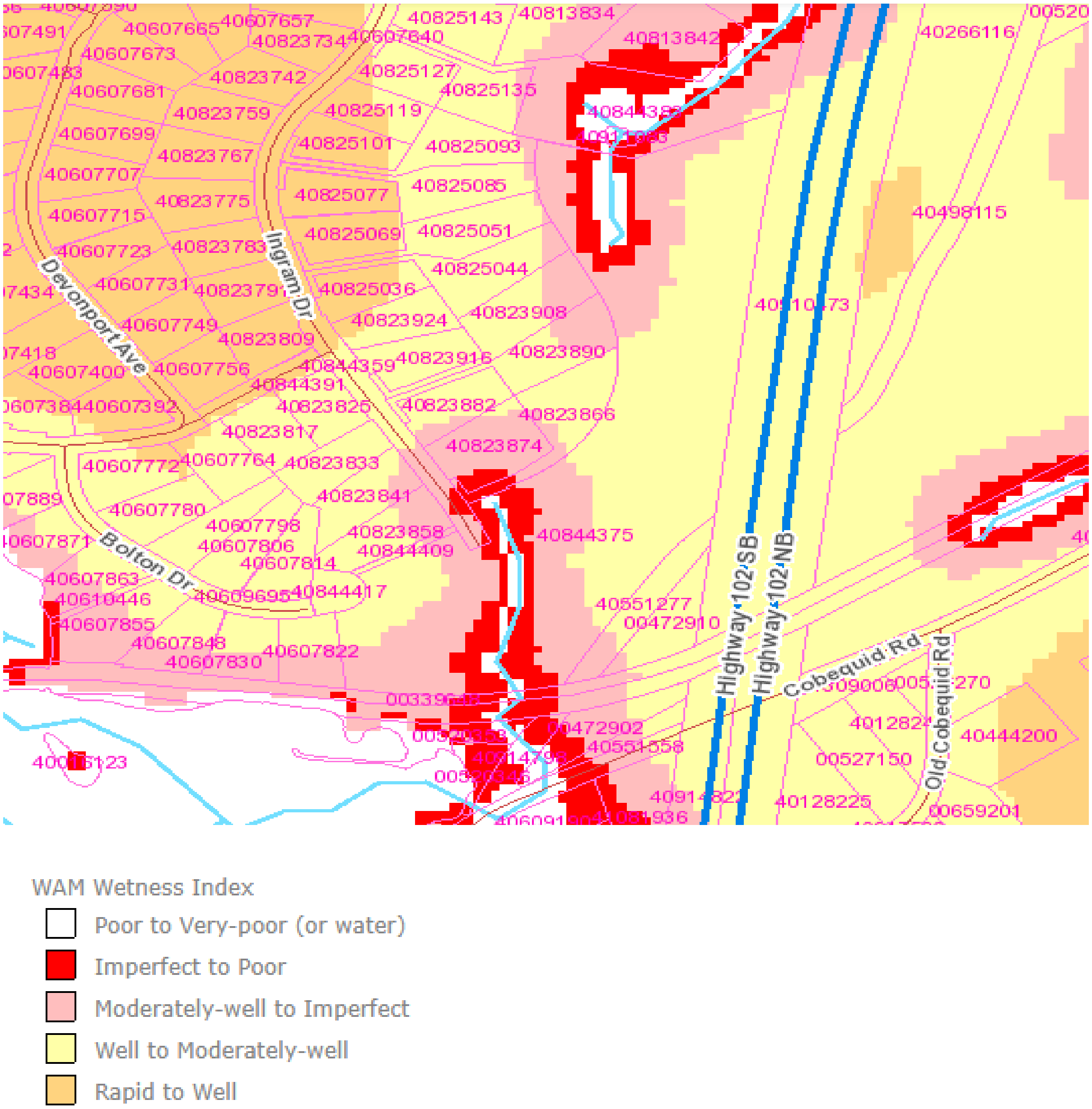
Stormwater runoff and surface drainage calculations have been completed in a report by A.W. Dewar P. Eng. Aug. 3, 2019 and are included in Appendix B. This gives the amount of storage that is needed to result in a no net increase in runoff from the property.

We have also included, in the latest Stormwater Management Concept Plan by Marco Visentin P. Eng. C103, a large bioretention ponding area that will hold approximately 1000 cubic meters of stormwater and then drain through the underlying soils and the sand bermed dike on the south side of the property. This is a key component in the removal of silt, sediment and phosphorus from the stormwaters before running off into Three Mile Lake. The benefit of this will become apparent in the phosphorus loading calculations, as it takes and treats runoff not only from this property but from other lots upgradient on Ingram Drive.

The Wet Areas Mapping (provided below) shows that the waters on this lot drain in two directions to two different watersheds, but both eventually end up in the Shubenacadie River System. The waters on the northern half of the lot run towards Perry Lake and the waters on the southern half run towards Three Mile Lake.

The southern area, as mentioned previously, will be modified with the proposed development of three apartment buildings, and has already been changed, to a certain extent, by stockpiling fill in this area years ago. Extensive use of bioswales and ditching will direct the water around buildings and roadways.

Wet Areas Mapping shows the following wet areas on the property:



The areas proposed for the sewage disposal system infiltration trenches are in category of "Well to Moderately-well" drained soils.

Sensitive Natural Areas and Buffers

The only undisturbed sensitive natural area on this lot is in the northern part of the property where a small pond and wetland are located. This area serves as a headwater to a small natural watercourse that helps to retain water during peak flow events, and maintain flows to Perry Lake during dry times. This area would also improve water quality as wetlands are natural filters that help to prevent erosion downstream and to remove phosphorus and other nutrients from the water. Additionally, wetland serves as important wildlife habitant for birds and other amphibians and mammals if left undisturbed. The Phosphorus Net Loading

Assessment Plan C99 shows a minimum 30 meter buffer all around the wetland to help preserve the natural area.

Water and Sewer Services

Water services to the three new proposed buildings will be provided by the existing 300 mm waterline, which runs right through the property, coming in under the railway tracks to the south, and up to Ingram Dr. This watermain will provide fire protection with sprinkler services to the buildings and fire hydrants as well as potable drinking water for the occupants. See Plan C101 in Appendix A for more details of the water system.
Luckily, the groundwater will not be required to be used for drinking water, which is good because the amount of water produced from wells is not sufficient and may have elevated concentrations of arsenic.

Sewer Services

For this project the volume of sewage = 120 units x 750 l/day/unit (2 bedroom apartment) + 15% safety factor for multiple units = 90,000x 1.15 = 103,500 l/day is the design load for the sewage disposal system (SDS). Meters should be installed on each of the three buildings to regularly monitor the water flows, as flows can be higher than this where municipal water systems are provided (Onsite Sewage Disposal System Technical Guidelines, April 2013 Appendix F).

Sewer services will be provided with onsite sewage disposal systems utilizing septic tanks at each building then secondary treatment with advanced filtration from a Waterloo biofilter or Advantex treatment unit, followed by an electrostatic phosphorus precipitation system, and finally, infiltration ditches as shown on drawing C102 in Appendix A. This is the same basic concept with the addition of the extra phosphorus removal unit, as was earlier proposed by A.W. Dewar P. Eng. in August 2019 for a slightly different development, and no restrictions as to the phosphorus loading being considered at the time (See Appendix B).

The disposal trenches have been moved back away from the wet area leaving more of a buffer and giving less chance of overland flow of sewage effluent directly to the wetland. By keeping the trenches up on higher and drier land and lengthening the contour disposal systems, the effluent will be dispersed into the soils uniformly where the phosphorus will be adsorbed by the soils.

Phosphorus attenuation in septic system drainfields utilizes a combination of biotic and abiotic processes including sorption/precipitation reactions, plant uptake, and mineralization/immobilization by microbes [8, 9]. Researchers agree the dominant P attenuation mechanisms in drainfields are sorption/ precipitation reactions. Phosphorus attenuation can occur throughout the drainfield, but researchers have observed rapid attenuation within proximity (1±3 m) of the infiltration pipes [10] due to the reduction/oxidation (redox) changes resulting in precipitation of P minerals [11]. Wilhelm et al. [8] found that septic tank effluent (STE) oxidation and the soils buffering capacity influenced the pH and redox potential in the drainfield, which in turn, affected the P species, solubility, and charge of cations (Al, Fe, Ca, and Mg) associated with P minerals, effectively controlling whether P will remain mobile in the drainfield ([9]. (Septic Systems Contribution to Phosphorus in Shallow Groundwater: Field-Scale Studies Using Conventional Drainfield Designs Sara Mechtensimer, Gurpal S. Toor)

The Waterloo Biofilter system with the electrostatic precipitators, has been shown to remove 95% of the phosphorus from the sewage, so this unit will be added to the selected treatment unit (Advantex or Waterloo Biofilter). Without this added to the treatment process to help remove the excess phosphorus, we would not be able to conclude a no net increase in phosphorus, as the calculations below will show.

Wetlands only remove 40 - 60% of the phosphorus and this will serve as an extra layer of protection to meet the no net increase in phosphorus requirement to help preserve the Shubenacadie watershed in its present trophic state.

Setbacks from Onsite Septic Systems

The onsite sewage disposal trenches for the treated effluent from the biofilters will be a minimum of 31 meters from any wetland or watercourse, and in most cases almost twice that limit. From side property lines they will be at least three (3) meters, and 10 meters from downslope areas. There are no wells on the property or adjoining properties to be contaminated as the area is serviced with a central water system. A search of well records did show some older wells within a kilometer of the site, these were generally low yielding bedrock wells. The well logs are included in Appendix C.

Phosphorus Loading Calculations

Surface Water Contributions

The amount of phosphorus is calculated using the model from Minnesota which is used on small properties of less than 640 acres. The model is included in Appendix D of this report along with the excel spreadsheet of the areas of impermeable surfaces, etc.

The pre-development load was determined by using a constant for phosphorus loading on woodlands of 0.5 lbs/acre/year multiplied by the number of acres of the property (26.6 acres):

Lpre = 0.5A
= 0.5 x 26.6 = 13.3 lbs/year

This is approximately the equivalent of spreading 2 – 25 kg bags of 6-12-12 fertilizer on the entire property and it running off within a year. 13.2 lbs of phosphorus would be found in this amount of a common lawn or garden fertilizer. Therefore, the use of best management practices on the property need to be emphasized, as it will not take much to undo or defeat all the management steps taken to develop this lot to limit phosphorus runoff.

Lpost =0.2xPxRvxCxA
= 0.2x54.97”x0.16826x0.3x26.6
Lpost = 14.76 lbs/year will result from the reduction in woodlands and permeable surfaces and resulting increased runoff.

Where:
0.2 is a constant
P is depth of rainfall in inches (1396 mm =54.97 inches)
Rv = runoff coefficient = (0.05+0.009 I) , where I is site imperviousness as a % of total area (See excel spreadsheet of areas from the proposed plans in Appendix D)
I in this case is 13.14% of the site will be impervious after development.

Therefore Rv = 0.05=0.009(13.14) =0.16826

Removal Requirement to achieve no net increase in phosphorus.
RR = Lpost -0.9Lpre, RR = 14.76-0.9x13.3

RR= 14.76-11.97= **2.79 lbs/year** from surface water is required to be removed due to the development on the southern half of the lot and the loss of infiltrative and forest cover.

In order to remove this extra phosphorus and to comply with the net zero storm water impact, we have incorporated a few measures to slow, adsorb and catch any storm water events. These include: a stormwater detention basin, vegetative swales to redirect water to the biodetention area.

The biodetention basin has been designed to collect the storm water from 13.5 acres (some of this stormwater comes from lots to the west of this property). Stormwater storage requirements were calculated in a report dated Aug. 3, 2019 by A. W. Dewar P. Eng. This report showed an area of 31, 656 cubic feet, or approximately 900 cubic meters, is required. The plan by Marco Visentin P. Eng. (C103 dated April 9, 2020) shows these features along with a 1000 cubic meter stormwater bioretention area, and how it will effectively redirect the water flows from the original wet areas as shown on the wet areas mapping in the previous section, and settle out any silt load and the associated phosphorus loads.

This will remove 13.5 acres X 0.5 lb/acre/year = **6.75 lbs/year of phosphorus**. This exceeds the removal requirement of **2.79 lbs/year** for the development of impervious surfaces on the lot. Therefore, we have excess phosphorus removal of 6.75-2.79 = **3.96 lbs/year**, however, we have not yet considered the contributions of the onsite sewage disposal system to the development of this lot.

Onsite Sewage Phosphorus Contributions

Onsite sewage systems can also contribute a significant amount of phosphorus to the environment. With an onsite septic system much of the phosphorus is removed in the septic tank (20-50%) however, the remaining phosphorous is released into the environment where it is adsorbed in infiltration trenches.

The solids in the septic tank are pumped out and hauled away every two to three years which eliminates this portion of the phosphorus. Effluent from the septic tanks still contains approximately 8.6 mg/l of Total Phosphorus and 6.0 mg/l of Soluble phosphorus that needs to be removed. (Reference: Domestic Wastewater Phosphorus Concentration Report

Phosphorus Concentration of Residential Clarified Effluent by the State of Idaho Department of Environmental Quality, August 2012)

Other studies show higher levels of phosphorus of over 18-20+ mg/l from septic tanks that they were using their trademarked electrochemical technology to remove. (Economical and effective phosphorus removal for septic systems By Craig Jowett, Yanqing Xu, Christopher James, Glenn Pembleton & Christopher Jowett).

In order to calculate the phosphorus loading rates we have selected a value of **14.2 mg/l** , which should provide a safety factor from the lower number found in the more widespread Idaho study and the higher number done in systems by Craig Jowett and others.
This would mean that we have 103,500 liters of sewage per day at 14.2mg/l of phosphorus. 103,500x14.2/1000 = 1,470 g/day. (536.4 kg/year of phosphorus to manage on the proposed development)

Technology such as Waterloo Biofilters EC-P (Electrochemical Phosphorus removal technology) will remove 95% of the phosphorus from the wastewater.

See the brochure by Waterloo Biofilter on Phosphorus Removal Systems in Appendix D.
This technology will be used to bring the level of phosphorous to a more manageable level in the disposal bed (0.05 x 536.4 = 26.82 kg/year). This is still not close to meeting the no net phosphorus requirement of HRM.

Onsite sewage disposal beds remove between 23% - 99% of phosphorus. The wide range of variability is due to different conditions and soil characteristics, pH levels, iron content of soils, and $CaCo_3$ content found in onsite systems. Saturated flow conditions will result in removals towards the lower range; therefore, we have selected a trench design that will spread the effluent out over more than 600 meters to lower the loading rate per meter.

The design of the trench has been modified from what is normally utilized under the Provincial Onsite Sewage Disposal System Technical Guidelines based on a design that was tested by the University of Florida and found to remove greater than 97% of phosphorus. (Reference: Septic Systems Contribution to Phosphorus in Shallow Groundwater: Field-Scale Studies Using Conventional Drainfield Designs **Sara Mechtensimer, Gurpal S. Toor**).

This bed is constructed with only 6” of cover over the drainpipes, which are underlain by 12” of clean stone and further underlain by 12” of clean fast-draining sand. See the cross-section below of the selected trench.

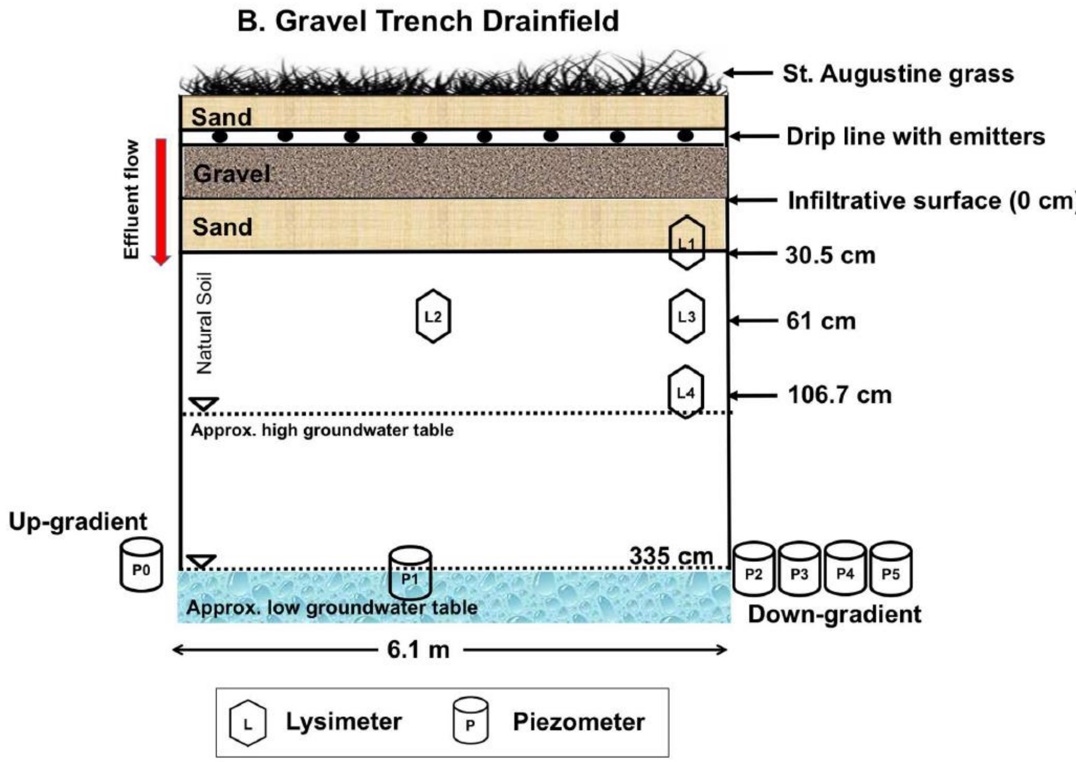


Fig 1. A north-south longitudinal cross-section (not to scale) of the drainfields showing vadose zone and groundwater monitoring instruments: (A) drip dispersal and (B) gravel trench systems.

Phosphorus reduction in the disposal bed now must remove the 26.82 kg/year that comes from the pre-treatment units. With this bed design, the phosphorus remaining or potentially discharging to the environment = 26.82 kg/year X 0.03 = 0.805kg/year or **1.77 lb/year)**
Net load after development = 2.79 lb/yr + 1.77 lb/yr = 4.56 lb/yr less the credit for catching the runoff from 13.5 acres x 0.5 =6.75 lb/yr for a net load of – 2.19 lb/yr.

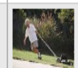
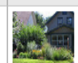
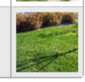
In summary, in order to meet the phosphorus no net increase in loading there will need to be extensive surface water and erosion control plans as well as an advanced sewage treatment and disposal system designed specifically to treat the phosphorus in the sewage discharges from the residents of the proposed 120 apartments.

During construction, in order to not exceed the phosphorus loading to the watershed, maintaining strict adherence to the Erosion and Sediment Control Plan C104 drawn by Marco Visentin P. Eng. dated April 9, 2020, as shown in Appendix A, is crucial.

In order to not in advertently cause excess phosphorus loading from the developed site, best management practices must be followed (for example, the simple practice of fertilizing the lawn could potentially cause an exceedance in the allowable phosphorus discharge).

The following table is taken from the Minnesota Storm Water Manual. It outlines practices that should be followed to help mitigate the presence of phosphorous:

Residential pollution prevention methods effective for controlling or reducing phosphorus.
Link to this **table**

Practice	Relative effectiveness	Method	Image[1]
Fertilizer and pesticide management	High	Reduce or eliminate the need for fertilizer and pesticides by practicing natural lawn care, planting native vegetation, and limiting chemical use; follow Minnesota Statutes Chapter 18C and federal regulatory requirements on fertilizer and pesticide storage and application if used.	
Litter and animal waste control	High	Properly dispose of pet waste and litter in a timely manner and according to local ordinance requirements.	
Yard Waste Management	High	Prevent yard waste from entering storm sewer systems and water bodies by either composting or using curbside pickup services and avoiding accumulation of yard waste on impervious surfaces; keep grass clippings and leaves out of the street.	
Better Car and Equipment Washing	Moderate	Wash cars less often and on grassy areas using phosphorus free detergents and non-toxic cleaning products or use commercial car washes to prevent dirty wash water from flowing to storm sewer systems and water bodies.	
Septic tank maintenance	High		
Native Landscaping	High	Reduce turf areas by planting native species to reduce and filter pollutant-laden runoff and prevent the spread of invasive, non-native plant species into the storm sewer system.	
Better Sidewalk and Driveway Deicing	Moderate	Reduce or eliminate the need for deicing products by manually clearing sidewalks and driveways prior to deicer use; use environmentally-friendly deicing products when possible, apply sparingly and store properly if used.	
Exposed Soil Repair	High	Use native vegetation or grass to cover and stabilize exposed soil on lawns to prevent sediment wash off.	
Healthy Lawns	Moderate	Maintain thick grass planted in organic-rich soil to a height of at least 3 inches to prevent soil erosion, filter stormwater contaminants, and absorb airborne pollutants; limit or eliminate chemical use and water and repair lawn as needed	

Conclusion

The no net phosphorus contribution to nearby lakes and streams leading to the Shubenacadie River System will require some extensive planning and sitework around the proposed facilities and a specially designed onsite sewage disposal system in order to meet this stringent requirement. Plans have been prepared by Able Engineering Services Inc. for how this should be achieved. In addition, once the site has been developed, the buildings constructed and tenants are occupying the apartments, long-term best management practices, such as those outlined above, have been recommended to be strictly followed.

References

Mapping by Property online Nova Scotia

Surficial Geology, Bedrock Geology, and Soils Mapping from Nova Scotia Dept of Natural Resources

Soils Mapping from Agriculture Canada online at http://sis.agr.gc.ca/cansis/publications/ns/index.html

Mapping by Google Maps

Mapping of wetlands(Wet areas Mapping) by Nova Scotia Dept of Natural Resources
http://www.gov.ns.ca/natr/forestry/gis/wamdownload.asp

Nova Scotia Dept of Natural Resources Radon Risk Mapping.

GeoNova Nova Scotia Data Mapping for Well Logs, Uranium in Groundwater, Arsenic in Groundwater
https://geonova.novascotia.ca/base-mapping

Environment Canada Weather Records for Halifax International Airport

Septic Systems Contribution to Phosphorus in Shallow Groundwater: Field-Scale Studies Using Conventional Drainfield Designs Sara Mechtensimer, Gurpal S. Toor

Waterloo Biofilter systems Phosphorus Removal technology available at
https://waterloo-biofilter.com/wp-content/uploads/2017/05/PhosphorousRemovalBrochure.pdf

The simple model for estimating Phosphorus Export from Minnesota Storm Water Manual available at
https://stormwater.pca.state.mn.us/index.php/The_Simple_Method_for_estimating_phosphorus_export

Domestic Wastewater Phosphorus Concentration Report Phosphorus Concentration of Residential Clarified Effluent by the State of Idaho Department of Environmental Quality, August 2012)

Economical and effective phosphorus removal for septic systems By Craig Jowett, Yanqing Xu, Christopher James, Glenn Pembleton & Christopher Jowett 2014

Onsite Sewage disposal System Technical Guidelines, Nova Scotia, April 2013

Septic Systems Contribution to Phosphorus in Shallow Groundwater: Field-Scale Studies Using Conventional Drainfield Designs Sara Mechtensimer, Gurpal S. Toor.

Appendix A

Phosphorus Net Loading Assessment Plan

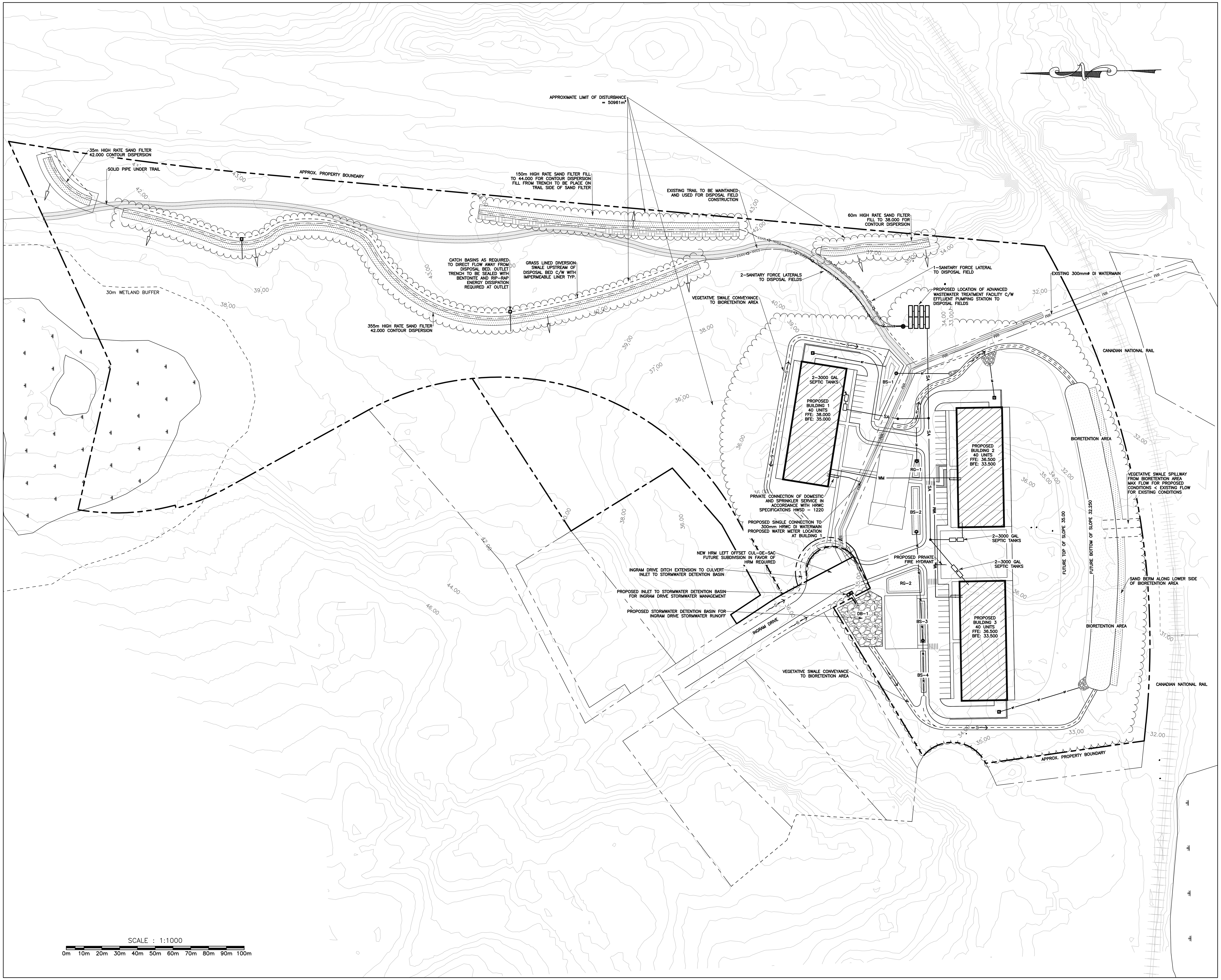
Site Concept Plan

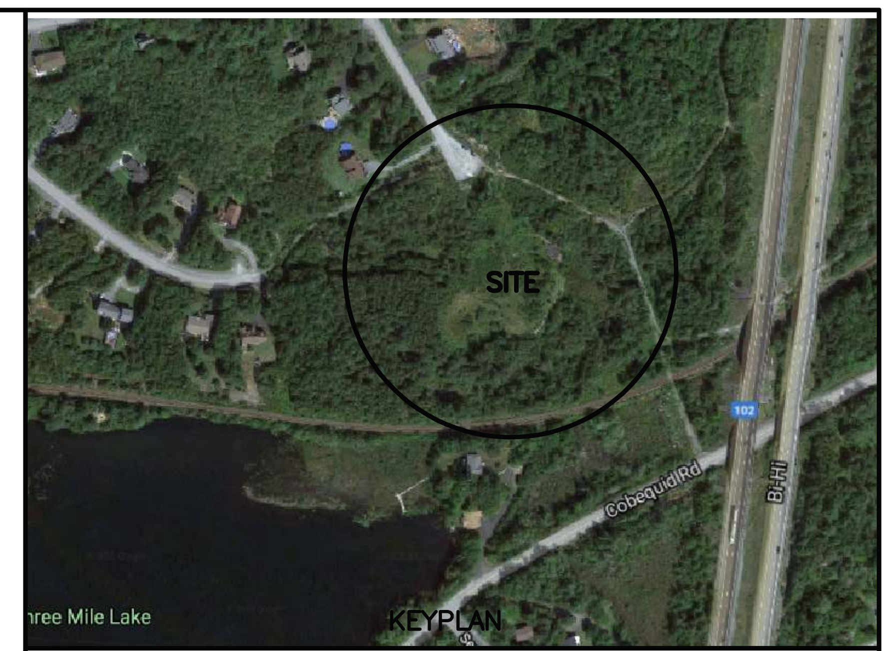
Water Service Site Concept Plan

Sanitary Service Concept Plan

Stormwater Management Plan

Erosion and Sedimentation Control Plan





LEGEND

EXISTING		PROPOSED
	GATE/BUTTERFLY VALVE	
	STREET SIGN	
	POWER POLE/LIGHT POLE	
	CATCHBASIN	
	CULVERT	
158.5	ELEVATION	158.5
	HYDRANT	
	PROPERTY BOUNDARY	
	OVERHEAD LINE	
—SA—□—SA—	SANITARY MANHOLE & PIPE	—SA—■—SA—
—ST—○—ST—	STORM MANHOLE & PIPE	—ST—●—ST—
—WM——WM—	WATERMAIN	—WM——WM—
⊗——WM——	WATER SERVICE	⊗——WM——
—FM——FM—	FORCEMAIN	—FM——FM—
—C——C—	UNDERGROUND CONDUIT	—C——C—
	CONCRETE THRUST BLOCK	
	CURB AND DRIVEWAY CUT	
	SIDEWALK	
	STREET LINE	
	DRAINAGE DIRECTION	
—S→	SWALE FLOW	—S→
346	CONTOUR LINES	346
—GAS——GAS—	GAS LINE	—GAS——GAS—
	TREE	
	BOTTOM OF SLOPE	
	TOP OF SLOPE	
	GUARD RAIL	
	SILT FENCE	—SF——SF—

NOTES:

1. TOPOGRAPHIC SURVEY DATA SHOWN HAS BEEN PRODUCED BY ABLE ENGINEERING SERVICES INC.. VALUES SHOWN ARE OBTAINED FROM THE NOVA SCOTIA LiDAR POINT CLOUD (RAW LiDAR) AND THE NOVA SCOTIA ELEVATION DATASET REFERENCED TO THE COORDINATE SYSTEM NAD83 CSRS 2010 CGVD2013.
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3. PLAN TO BE READ IN CONJUNCTION WITH PHOSPHORS NET LOADING ASSESSMENT REPORT.

LOW IMPACT DEVELOPMENT PRIMARY CONTROLS
BS – BIOSWALE
RG – RAIN GARDEN
DB – DETENTION BASIN
VS – VEGETATIVE SWALE
FS – FILTER STRIP

LOW IMPACT DEVELOPMENT SECONDARY CONTROLS
BR – BIORETENTION AREA

NOT FOR CONSTRUCTION

No.	Date	Revision Description	Appr'd
2	09/04/2020	ISSUED FOR REVIEW	
1	03/04/2020	ISSUED FOR REVIEW	

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DATE 09/04/20
Original Signed
M.A. Visentin
12358
REGISTERED PROFESSIONAL ENGINEER
PROVINCE OF NOVA SCOTIA

ABLE
ENGINEERING SERVICES INC
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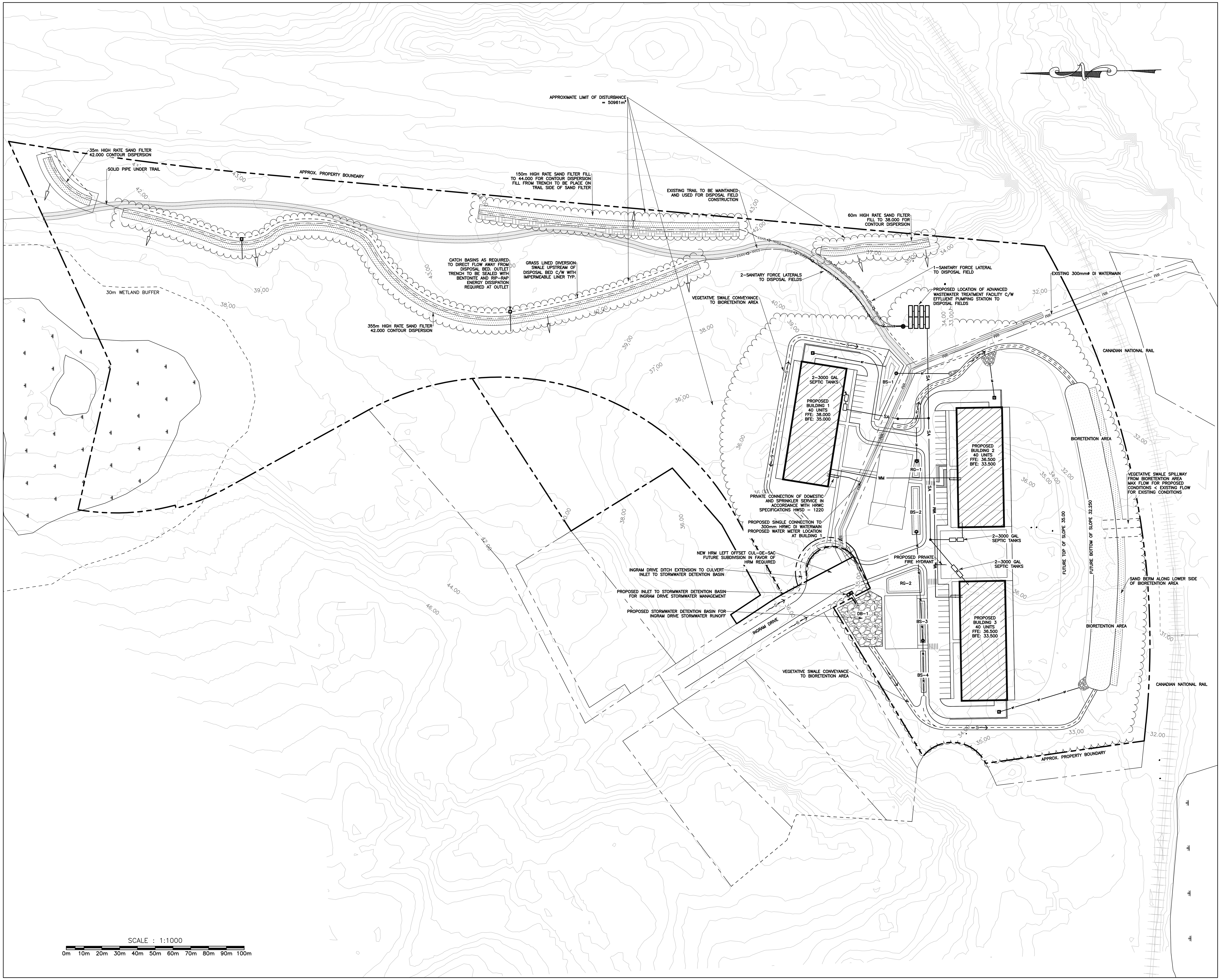
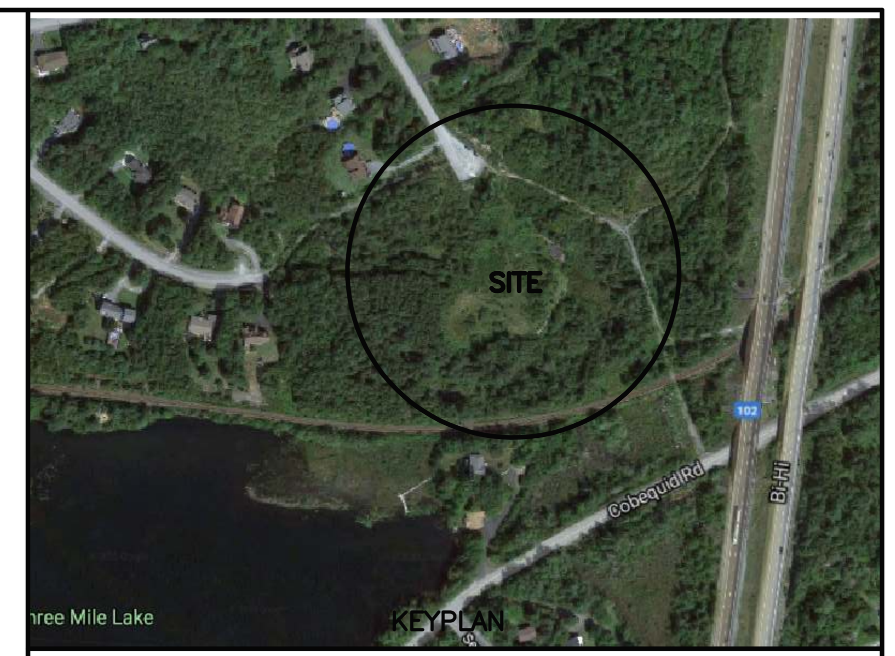
FALL RIVER SITE C

PROPOSED INGRAM DRIVE DEVELOPMENT

PHOSPHORUS NET LOADING ASSESSMENT PLAN

Date MARCH 13, 2020	Drawn J.HENMAN	Project No.
Scale 1:1000	Engineer M.VISENTIN	Plan No. C–99





LEGEND

EXISTING		PROPOSED
	GATE/BUTTERFLY VALVE	
	STREET SIGN	
	POWER POLE/LIGHT POLE	
	CATCHBASIN	
	CULVERT	
158.5	ELEVATION	158.5
	HYDRANT	
	PROPERTY BOUNDARY	
	OVERHEAD LINE	
—SA—◻—SA—	SANITARY MANHOLE & PIPE	—SA—■—SA—
—ST—◯—ST—	STORM MANHOLE & PIPE	—ST—●—ST—
—WM—WM—	WATERMAIN	—WM—WM—
—WM—	WATER SERVICE	—WM—
—FM—FM—	FORCEMAIN	—FM—FM—
—C—C—	UNDERGROUND CONDUIT	—C—C—
	CONCRETE THRUST BLOCK	
	CURB AND DRIVEWAY CUT	
	SIDEWALK	
	STREET LINE	
	DRAINAGE DIRECTION	
—S→	SWALE FLOW	—S→
346	CONTOUR LINES	346
—GAS—GAS—	GAS LINE	—GAS—GAS—
	TREE	
	BOTTOM OF SLOPE	
	TOP OF SLOPE	
	GUARD RAIL	
	SILT FENCE	—SF—SF—

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DATE 09/04/20 Original Signed M.A. Visentin 12358 REGISTERED PROFESSIONAL ENGINEER PROVINCE OF NOVA SCOTIA

ENGINEERING SERVICES INC
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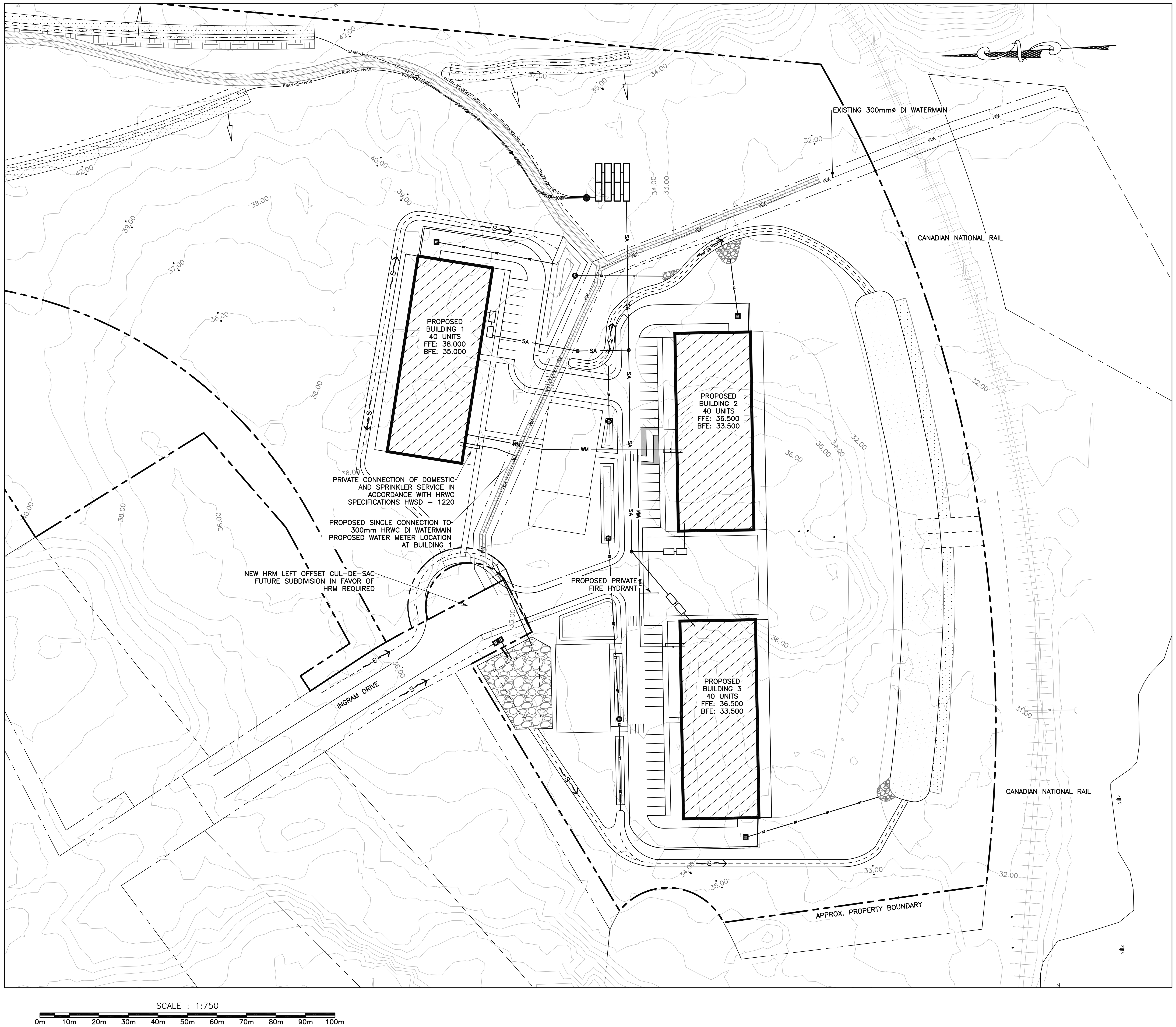
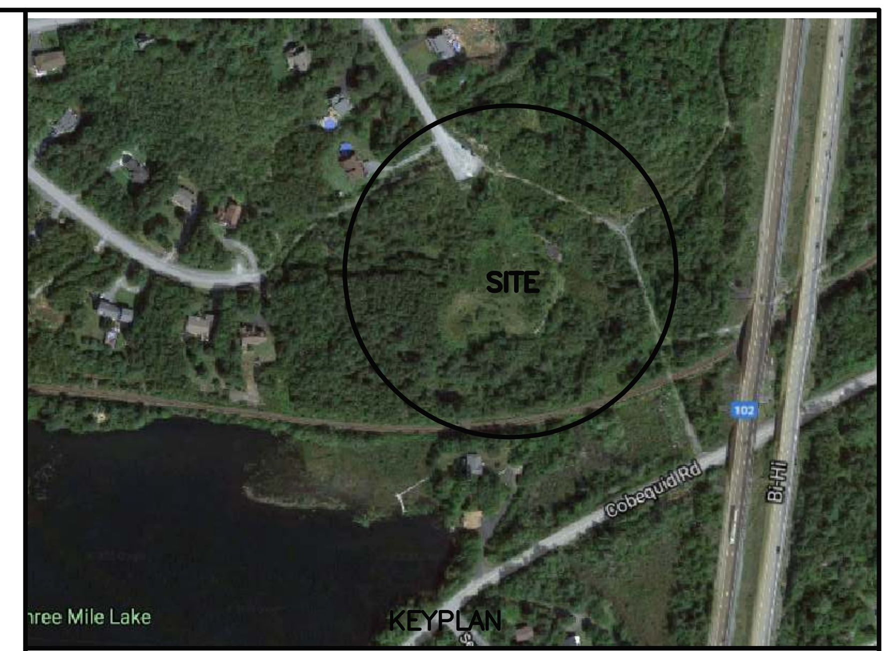
FALL RIVER SITE C

PROPOSED INGRAM DRIVE DEVELOPMENT

PROPOSED SITE CONCEPT PLAN

Date	Drawn	Project No.
MARCH 13, 2020	J.HENMAN	
Scale 1:1000	Engineer M.VISENTIN	Plan No. C–100





LEGEND

EXISTING		PROPOSED
	GATE/BUTTERFLY VALVE	
	STREET SIGN	
	POWER POLE/LIGHT POLE	
	CATCHBASIN	
	CULVERT	
158.5	ELEVATION	158.5
	HYDRANT	
	PROPERTY BOUNDARY	
	OVERHEAD LINE	
—SA—□—SA—	SANITARY MANHOLE & PIPE	—SA—■—SA—
—ST—○—ST—	STORM MANHOLE & PIPE	—ST—●—ST—
—WM—WM—	WATERMAIN	—WM—WM—
⊗—WM—	WATER SERVICE	⊗—WM—
—FM—FM—	FORCEMAIN	—FM—FM—
—C—C—	UNDERGROUND CONDUIT	—C—C—
	CONCRETE THRUST BLOCK	
	CURB AND DRIVEWAY CUT	
	SIDEWALK	
	STREET LINE	
	DRAINAGE DIRECTION	
~S→	SWALE FLOW	~S→
346	CONTOUR LINES	346
—GAS—GAS—	GAS LINE	—GAS—GAS—
	TREE	
	BOTTOM OF SLOPE	
	TOP OF SLOPE	
	GUARD RAIL	
	SILT FENCE	—SF—SF—

NOTES:

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3. WATER SERVICE TO PROPOSED DEVELOPMENT TO BE COMPLETED WITH A SINGLE CONNECTION TO THE 300mm HRWC WATERMAIN. WATER METER TO BE INSTALLED IN BUILDING 1. ALL WORK TO BE IN ACCORDANCE WITH THE LATEST VERSION OF THE HRWC SPECIFICATIONS AND STANDARD DETAILS.

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No.	Date	Revision Description	Appr'd
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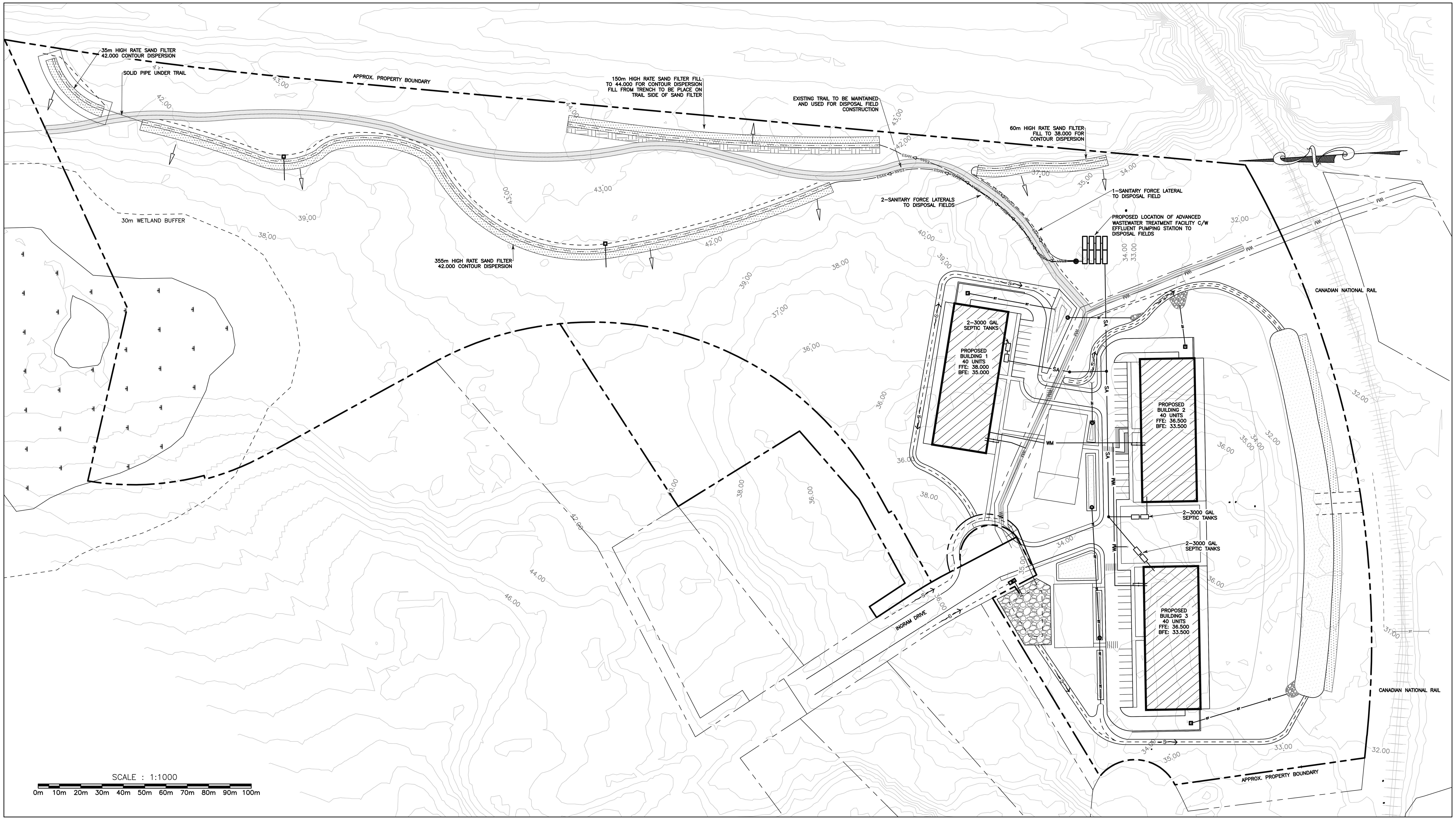
civil@ableinc.ca www.ableinc.ca

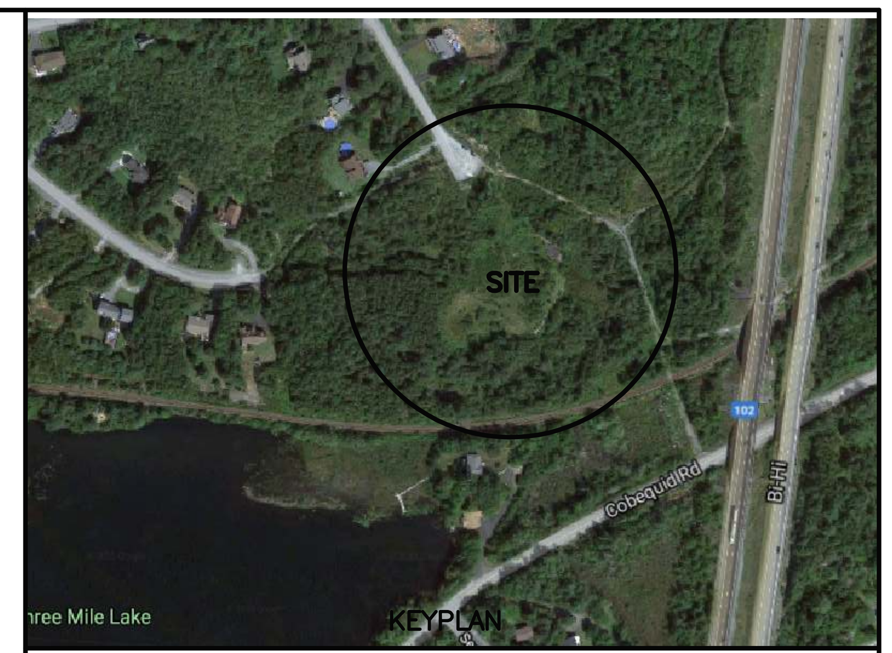
FALL RIVER SITE C

PROPOSED INGRAM DRIVE DEVELOPMENT

PROPOSED WATER SERVICE SITE CONCEPT PLAN

Date: MARCH 13, 2020	Drawn: J.HENMAN	Project No.
Scale: 1:750	Engineer: M.VISENTIN	Plan No. C–101





LEGEND

EXISTING		PROPOSED
⊗	GATE/BUTTERFLY VALVE	⊗
	STREET SIGN	
	POWER POLE/LIGHT POLE	
	CATCHBASIN	
	CULVERT	
158.5	ELEVATION	158.5
	HYDRANT	
	PROPERTY BOUNDARY	
	OVERHEAD LINE	
—SA—□—SA—	SANITARY MANHOLE & PIPE	—SA—■—SA—
—ST—○—ST—	STORM MANHOLE & PIPE	—ST—●—ST—
—WM——WM—	WATERMAIN	—WM——WM—
⊗——WM——	WATER SERVICE	⊗——WM——
—FM——FM—	FORCEMAIN	—FM——FM—
—C——C—	UNDERGROUND CONDUIT	—C——C—
	CONCRETE THRUST BLOCK	
	CURB AND DRIVEWAY CUT	
	SIDEWALK	
	STREET LINE	
	DRAINAGE DIRECTION	
~S→	SWALE FLOW	~S→
346	CONTOUR LINES	346
—GAS——GAS—	GAS LINE	—GAS——GAS—
	TREE	
	BOTTOM OF SLOPE	
	TOP OF SLOPE	
	GUARD RAIL	
	SILT FENCE	—SF——SF—

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3. WASTEWATER TREATMENT DETAILED DESIGN TO MEET OR EXCEED REQUIREMENTS OF NOVA SCOTIA ENVIRONMENT AND PHOSPHORUS NET LOADING ASSESSMENT.

NOT FOR CONSTRUCTION

No.	Date	Revision Description	Appr'd
2	09/04/2020	ISSUED FOR REVIEW	
1	03/04/2020	ISSUED FOR REVIEW	

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REGISTERED PROFESSIONAL ENGINEER — DATE 09/04/20 — Original Signed — M. A. Visentin — 12358 — PROVINCE OF NOVA SCOTIA

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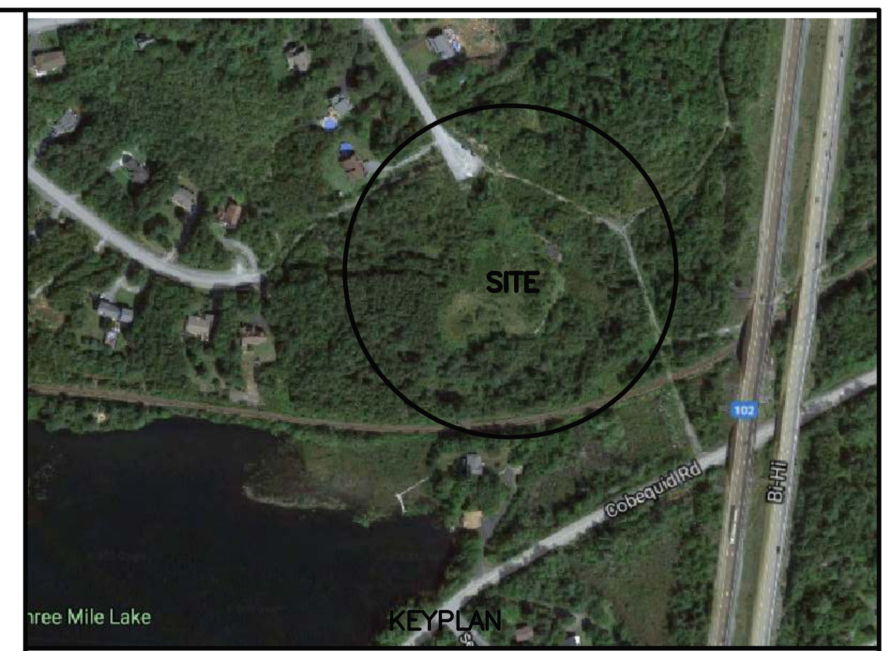
FALL RIVER SITE C

PROPOSED INGRAM DRIVE DEVELOPMENT

PROPOSED SANITARY SERVICE SITE CONCEPT PLAN

Date	Drawn	Project No.
MARCH 13, 2020	J.HENMAN	
Scale	**Engineer**	**Plan No.**
1:1000	M.VISENTIN	C-102



LEGEND

EXISTING		PROPOSED
⊗	GATE/BUTTERFLY VALVE	⊗
	STREET SIGN	
	POWER POLE/LIGHT POLE	
	CATCHBASIN	
	CULVERT	
158.5	ELEVATION	158.5
	HYDRANT	
	PROPERTY BOUNDARY	
	OVERHEAD LINE	
—SA—□—SA—	SANITARY MANHOLE & PIPE	—SA—■—SA—
—ST—□—ST—	STORM MANHOLE & PIPE	—ST—●—ST—
—WM——WM—	WATERMAIN	—WM——WM—
—WM—	WATER SERVICE	—WM—
—FM——FM—	FORCEMAIN	—FM——FM—
—C——C—	UNDERGROUND CONDUIT	—C——C—
	CONCRETE THRUST BLOCK	
	CURB AND DRIVEWAY CUT	
	SIDEWALK	
	STREET LINE	
	DRAINAGE DIRECTION	
—S→	SWALE FLOW	—S→
346	CONTOUR LINES	346
—GAS——GAS—	GAS LINE	—GAS——GAS—
	TREE	
	BOTTOM OF SLOPE	
	TOP OF SLOPE	
	GUARD RAIL	
	SILT FENCE	—SF——SF—

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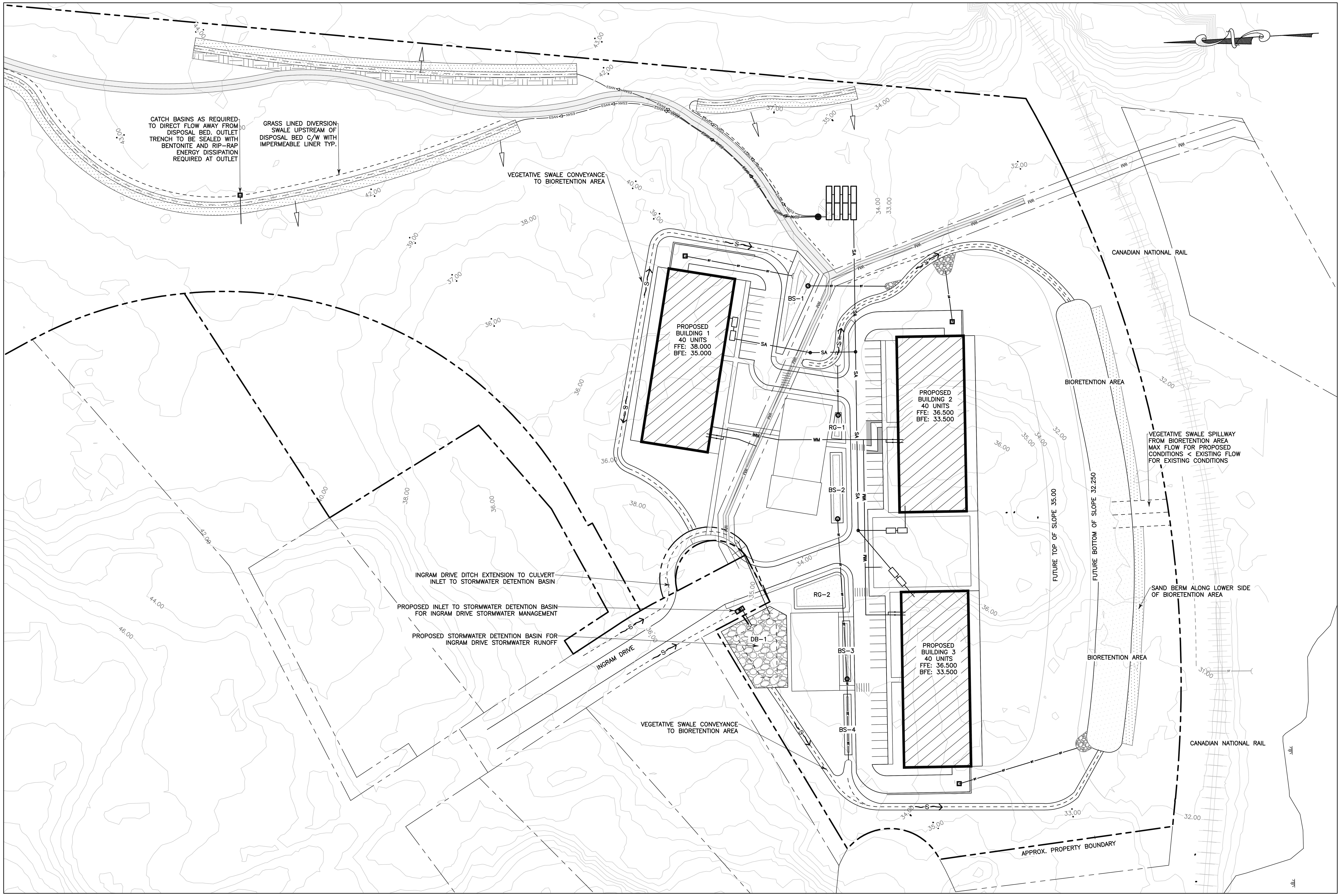
3. THE PROPOSED STORMWATER MANAGEMENT FOR THE SITE WILL FOLLOW A LOW IMPACT DEVELOPMENT APPROACH. DETAILED DESIGN OF STORMWATER MANAGEMENT WILL BE IN ACCORDANCE WITH HRWC SPECIFICATIONS AND PHOSPHORUS NET LOADING ASSESSMENT.

LOW IMPACT DEVELOPMENT PRIMARY CONTROLS
BS – BIOSWALE
RG – RAIN GARDEN
DB – DETENTION BASIN
VS – VEGETATIVE SWALE
FS – FILTER STRIP

LOW IMPACT DEVELOPMENT SECONDARY CONTROLS
BR – BIORETENTION AREA

NOT FOR CONSTRUCTION



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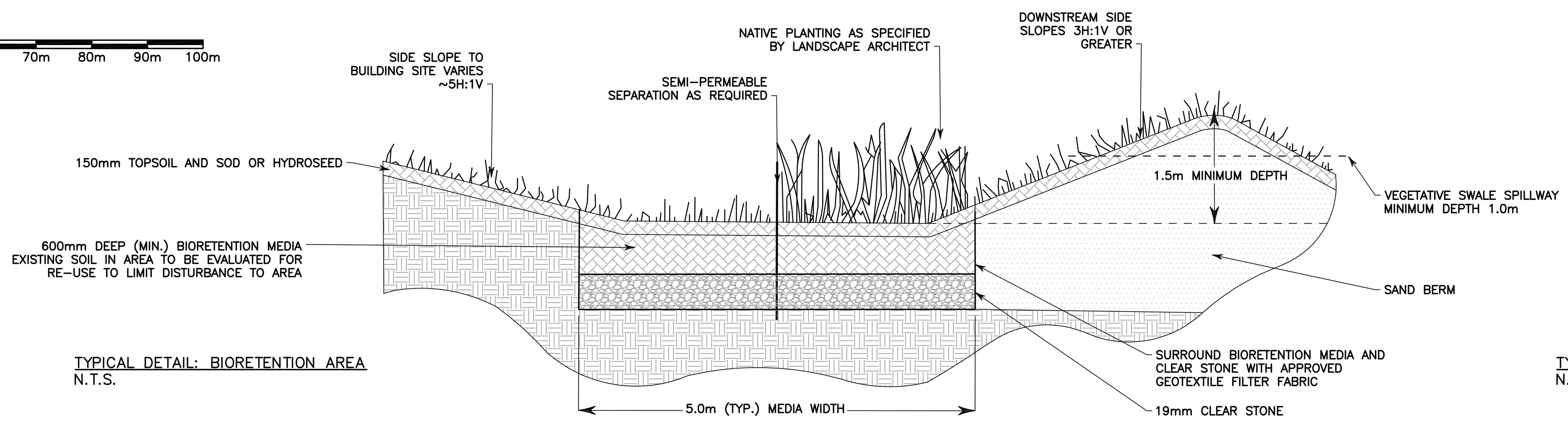
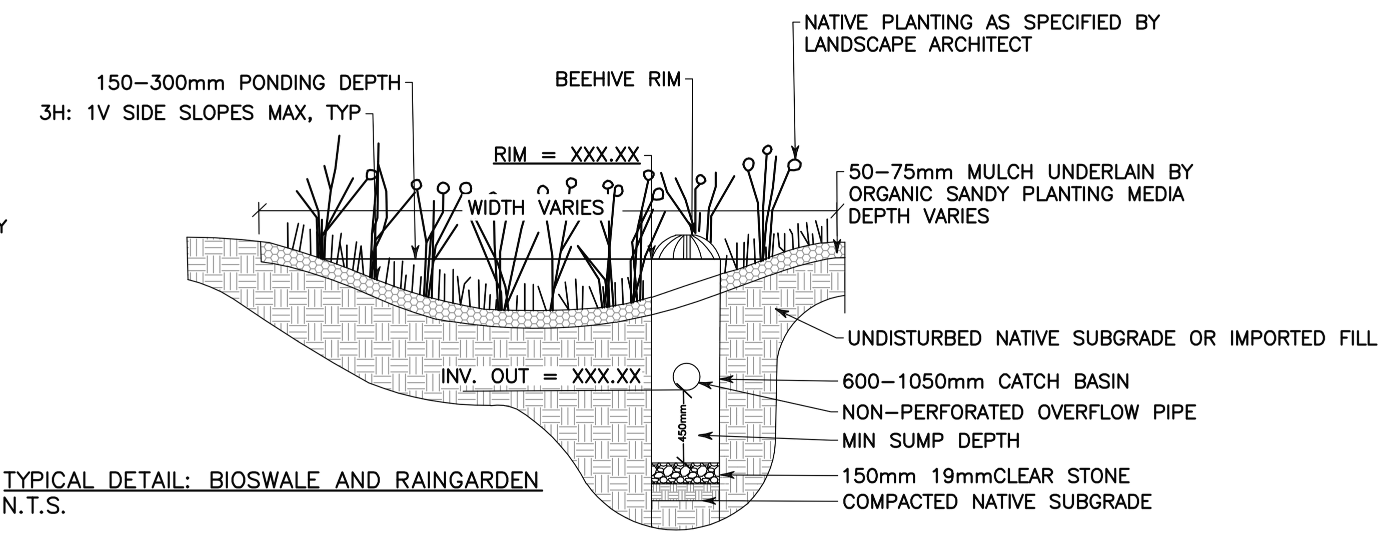


TYPICAL DETAIL: BIORETENTION AREA
N.T.S.



TYPICAL DETAIL: BIOSWALE AND RAINGARDEN
N.T.S.

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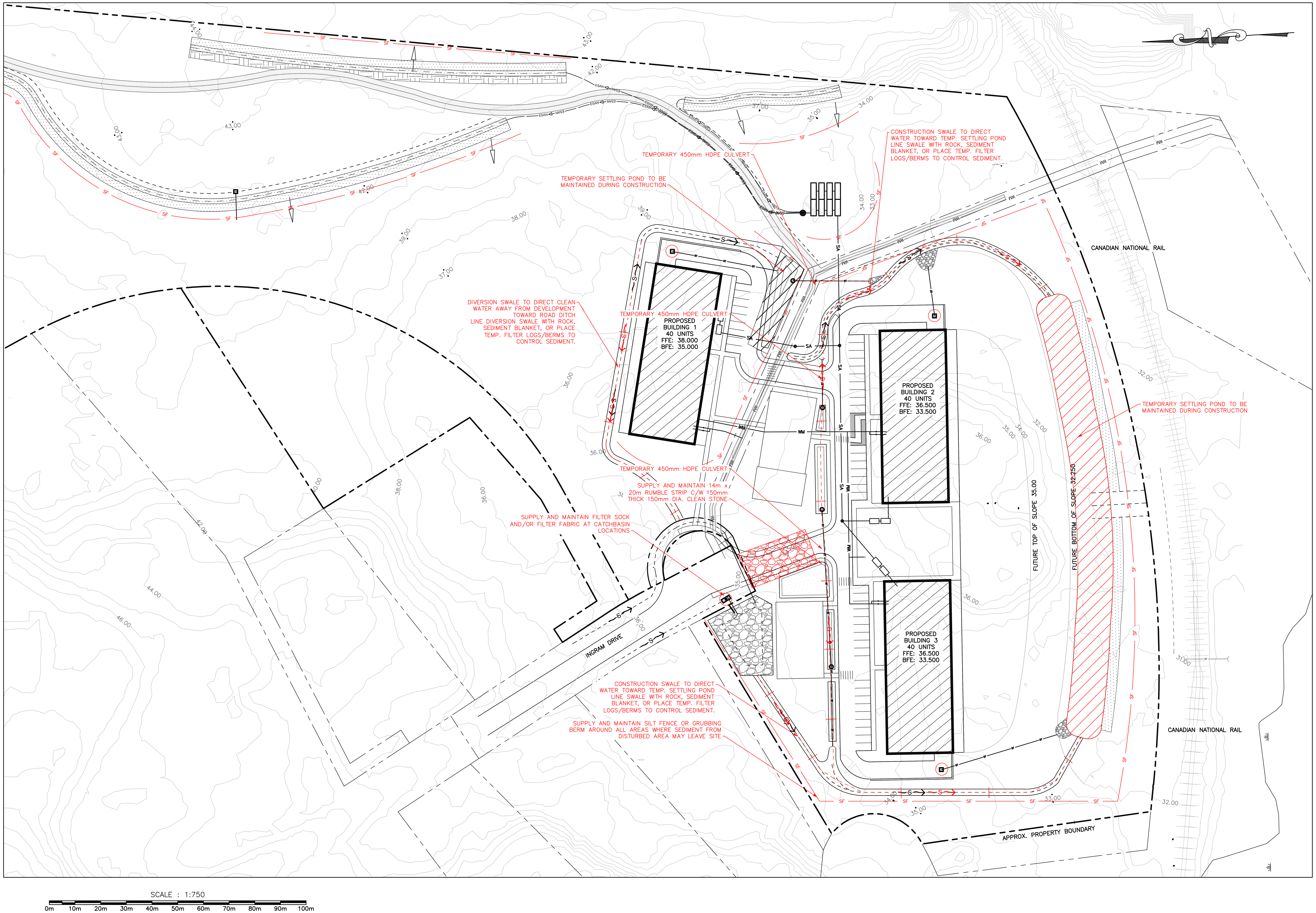
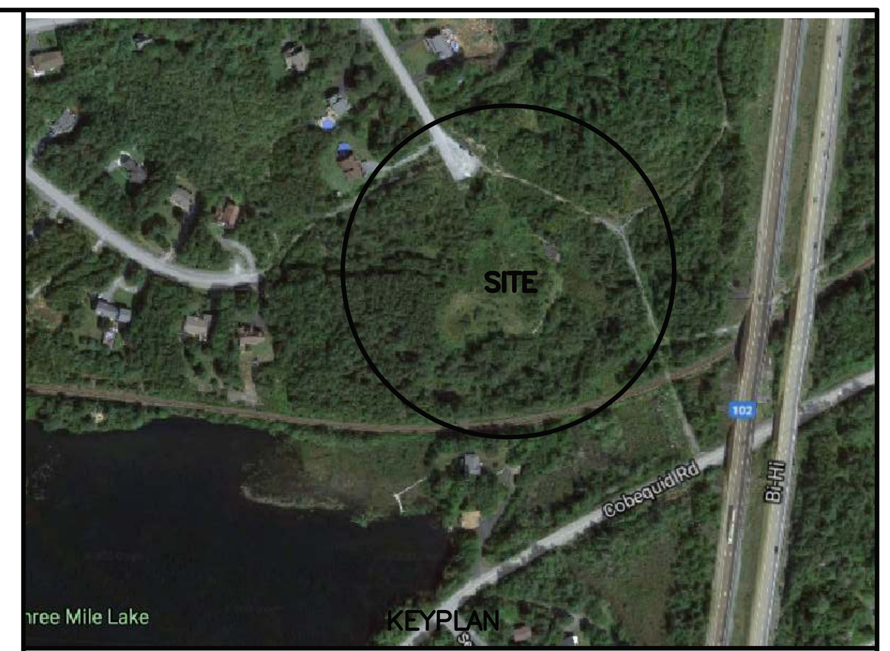
FALL RIVER SITE C

PROPOSED INGRAM DRIVE DEVELOPMENT

PROPOSED STORMWATER MANAGEMENT CONCEPT PLAN

Date	Drawn	Project No.
MARCH 13, 2020	J.HENMAN	
Scale	Engineer	Plan No.
1:750	M.VISENTIN	C-103





LEGEND

EXISTING		PROPOSED
	GATE/BUTTERFLY VALVE	
	STREET SIGN	
	POWER POLE/LIGHT POLE	
	CATCHBASIN	
	CULVERT	
158.5	ELEVATION	158.5
	HYDRANT	
	PROPERTY BOUNDARY	
	OVERHEAD LINE	
—SA—□—SA—	SANITARY MANHOLE & PIPE	—SA—■—SA—
—ST—○—ST—	STORM MANHOLE & PIPE	—ST—●—ST—
—WM——WM—	WATERMAIN	—WM——WM—
⊗——WM—	WATER SERVICE	⊗——WM—
—FM——FM—	FORCEMAIN	—FM——FM—
—C——C—	UNDERGROUND CONDUIT	—C——C—
	CONCRETE THRUST BLOCK	
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	SIDEWALK	
	STREET LINE	
	DRAINAGE DIRECTION	
~S→	SWALE FLOW	~S→
346	CONTOUR LINES	346
—GAS——GAS—	GAS LINE	—GAS——GAS—
	TREE	
	BOTTOM OF SLOPE	
	TOP OF SLOPE	
	GUARD RAIL	
	SILT FENCE	—SF——SF—

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3. EROSION AND SEDIMENT CONTROL MEASURES MAY DIFFER, BASED ON CONSTRUCTION PHASING.
4. CONTRACTOR TO ISOLATE STRIPPING TO MINIMUM AREA REQUIRED TO FACILITATE CONSTRUCTION.
5. ALL STOCKPILES MUST BE COVERED AND PROTECTED FROM PRECIPITATION EVENTS.
6. INSPECT EROSION AND SEDIMENT CONTROL FEATURES FREQUENTLY TO ENSURE PROPER FUNCTIONING OF THE SYSTEM.
7. ALL EROSION AND SEDIMENT CONTROL MEASURES MUST MEET OR EXCEED THE RECOMMENDATIONS OF THE EROSION AND SEDIMENTATION CONTROL HANDBOOK FOR CONSTRUCTION SITES PREPARED BY NOVA SCOTIA ENVIRONMENT.

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civil@ableinc.ca www.ableinc.ca

FALL RIVER SITE C

PROPOSED INGRAM DRIVE DEVELOPMENT

EROSION AND SEDIMENT CONTROL CONCEPT PLAN

Date MARCH 13, 2020	Drawn J.HENMAN	Project No.
Scale 1:750	Engineer M.VISENTIN	Plan No. C-104

Appendix B

Drainage Report prepared by A.W. Dewar, August 3rd, 2019

On-site Design prepared by A.W. Dewar, August 14th, 2019

Previous Study by Strum Consulting, June 23rd, 2016

Letter to WM Fares Architects from Halifax Regional Municipality, October 23rd, 2019

ABLE
Engineering Services Inc.

4 Calkin Drive
Kentville, NS B4N 3V7
Phone: (902) 678-2774

4073 Highway #3
Chester, NS B0J 1J0
Phone: (902) 273-3050

5209 St. Margaret's Bay Road
Upper Tantallon, NS B3Z 1E3
Phone: (902) 820-3255

August 3, 2019

Perry Lake Developments
31 Sterns Court
Dartmouth, NS
B3B 1W7
Attention: Mr. Larry Gibson

RE: PROPOSED SUBDIVISION - DRAINAGE REPORT - INGRAM DRIVE, FALL RIVER, NOVA SCOTIA

Dear Larry:

Further to our conversations, we have prepared drainage report for the proposed Fall River South Development.

We have examined pre and post development drainage scenarios using the NRCS (SCS) method, with curve numbers ranging from 75 to 90. We evaluated 2, 5, 10, 50 and 100-year storms in our preliminary analysis; and a 100-year storm for the storm water runoff leaving the property. Peak flows for the 100-year storm range from 32.64 cfs (pre) to 65.41 cfs (post), based on IDF curves from Halifax International Airport.

Since the post-development storm flows exceed the pre-development flow and a "net zero" flow is required, we will have to use mitigations methods to achieve our goal. The primary mitigation method is detention in some form, either at surface (pond) or underground storage. This decision will be made during the final design process.

I trust this is the information you require, but should you have any questions please contact me at 902-678-2774.

Yours truly,

Original Signed

A. W. Dewar, P. Eng.
AWD/ajs
s:\projects\ingram\traffic\ingram drive letter august 3, 2019

INGRAM DRIVE

Drainage Report

ABLE Engineering Services Inc.
4 Calkin Drive, Kentville, NS B4N 3V7
Phone: 902-678-2774

A. W. (Sandy) Dewar, P. Eng.
a.dewar@ableinc.ca

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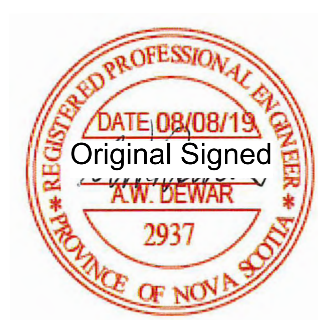


1.0 INTRODUCTION

The proposed development by Perry Lake Developments is located in the south end of the community of Fall River, Nova Scotia. It is bound on the north and west by private lands, on the east by Highway 102, and on the south by CNR railway. The total drainage area is approximately 29 acres. The drainage catchment area consists of two (2) separate sub catchment areas, one (Pre A1) to the northeast (15.5 acres), the second (Pre A2) to the south (13.5 acres).

Although the development consists of two separate drainage areas, we need to examine the whole development in order to get a clear picture of how the rainfall runoff flow patterns change from pre-development to post-development. This information is essential for stormwater management and mitigation of development challenges. This information will also allow the allocation of drainage sub-areas to be directed to the most beneficial outlet from the development.

The primary cover of the property is presently treed. The area Pre A1 is relatively flat land and slopes slightly to the north boundary. The area Pre A2 slopes moderately to the south towards the CNR right-of-way.

Presently, the storm water runoff flows overland to existing drainage areas, to a wetland in the north (Pre A1), and to CNR drainage system and Three Mile Lake in the south (Pre A2). Given these are normal runoff flow conditions, we have concentrated our drainage evaluation to pre and post development flows during 2, 5, 10, and 100-year storms.

2.0 Present Condition

The present contours of the property separate it into two sub-drainage areas, labelled Pre A1 and Pre A2 (ABLE #Y2019-059-02 Drainage Plan - Pre-Development).

- Drainage area Pre A1 is 15.5 acres in size, and lies in the northeast portion of the property. This portion slopes slightly to the north into an unnamed wetland.

- Drainage area Pre A2 is 13.5 acres in size, and it lies in the southern portion of the property, and it slopes moderately to the south, eventually into Three Mile Lake.

During a rainfall event storm water runoff will flow as above.

3.0 FUTURE CONDITIONS

The future drainage patterns will be very similar to the existing patterns, except the topography will change slightly due to development. The storm water from the northerly (Post B1) area will continue to drain into the existing wetland to the north. The only development change in Post B1 will be two 30-foot wide strips 600 feet long; otherwise, the area will be undisturbed. See ABLE plan #Y2019-059-03 Drainage Plan - Post-Development.

The South (Post B2) catchment area will be developed (143 residential units), roadways, parking, and lawn areas. The roof drains and roadway/parking will drain into a collection system and eventually to the CNR drainage ditches, and then to Three Mile Lake.

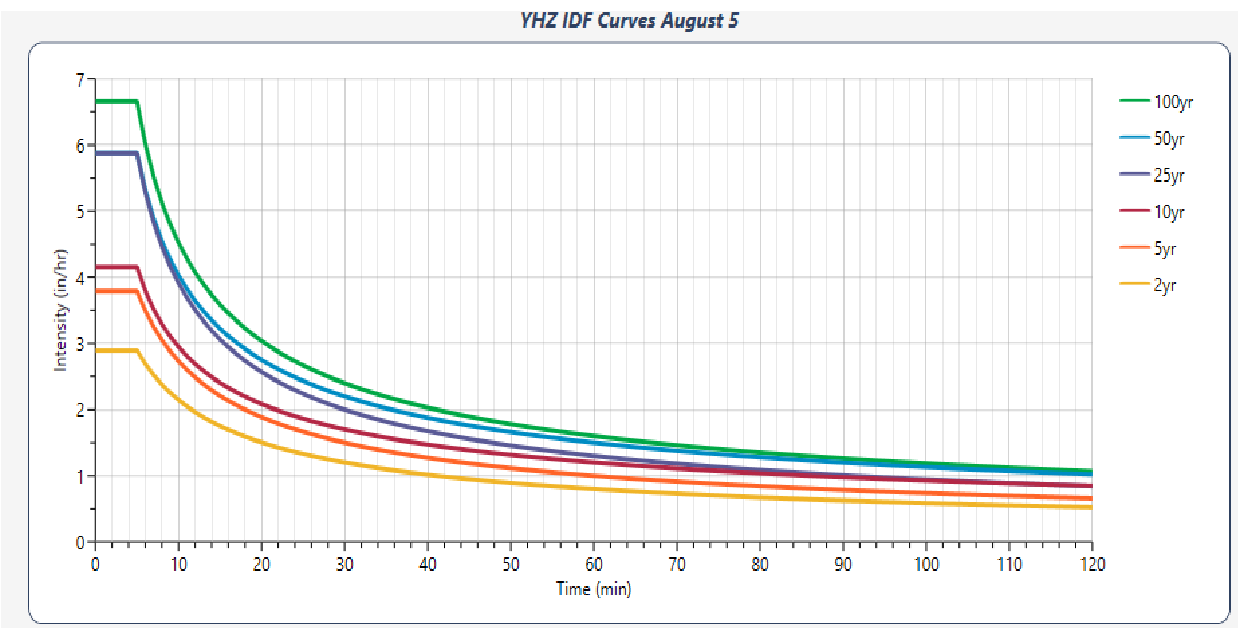
As with any large residential development, when there is a significant difference (23.4 cfs) between pre and post storm runoff, detention is usually recommended. Detention is sized to store storm runoff for such a time as to have a “net zero affect” between pre and post-development storm water runoffs, in order to release storm water at a flow rate of not greater than before development. This is achieved by controlling stormwater released using small diameter pipes and/or weirs. The recommended detention pond volume was estimated to be 31,656 cu ft), and is to be built when full development warrants.

4.0 FLOW EVALUATIONS ASSUMPTIONS

Hydrology Studio, a computer modelling program was used to evaluate the Pre and Post development stormwater flows and conditions, and the development of a detention pond. The following assumptions were used in our evaluation:

- Method of calculation – SCS Method
- Units of measure - imperial
- Runoff Curve Number (CN) vary from 75 to 90
- Rainfall intensity based on Halifax International Airport IDF curves derived from Environment Canada Data – Short Duration Rainfall Intensity – Duration – Frequency Data (2019/02/27)
- Net-zero run off

Halifax International Airport IDF Curves



Hydrograph by Return Period

Hydrology Studio v 3.0.0.11

Project Name:

08-07-2019

Hyd. No.	Hydrograph Type	Hydrograph Name	Peak Outflow (cfs)							
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
1	NRCS Runoff	Pre A1		3.531		9.641	20.18			37.47
2	NRCS Runoff	Pre A2		3.075		8.397	17.58			32.64
3	NRCS Runoff	Post B1		5.232		12.16	23.12			42.02
4	NRCS Runoff	Post B2		20.16		30.53	39.76			65.41

Runoff Curve Numbers

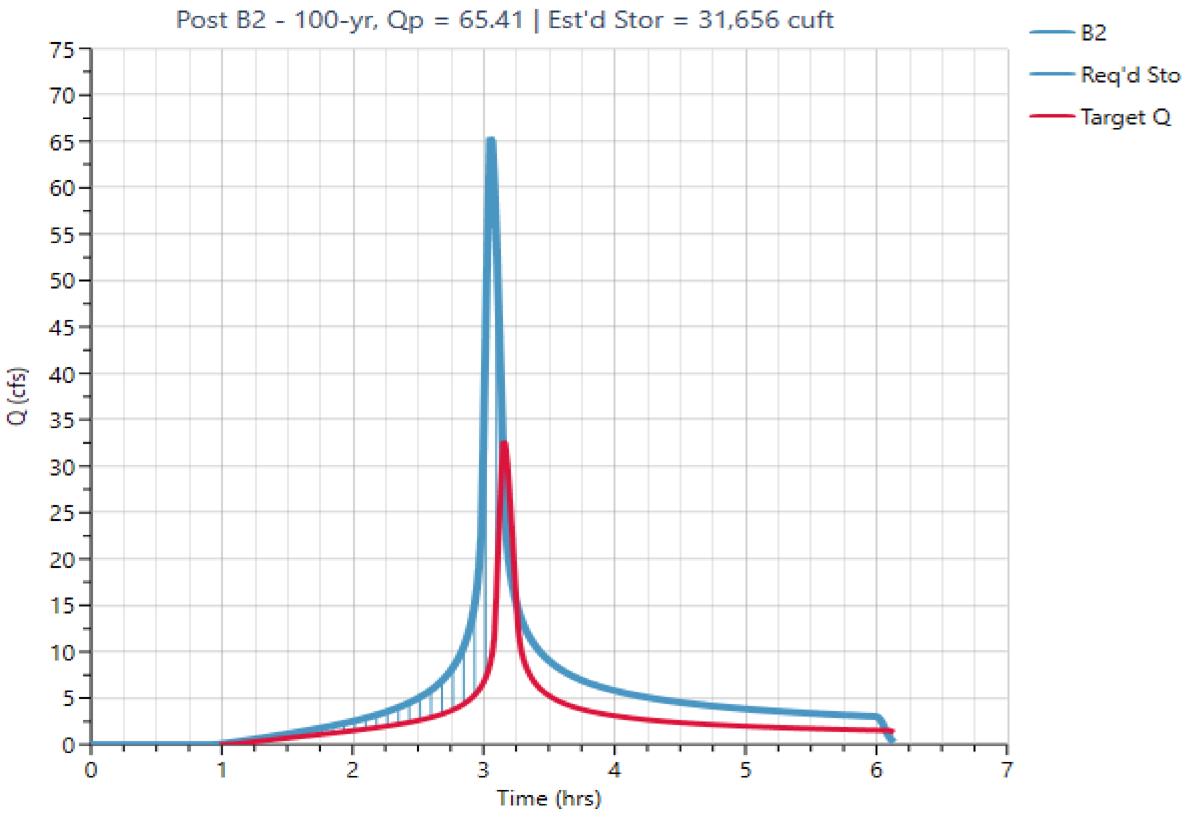
	Area (ac)	C value	Comments
Pre A1	15.5	75	Unimproved, treed
Pre A2	13.5	75	medium slope, treed
Post B1	15.5	77	weighted residential
Post B2	13.5	90	weighted residential

Peak Flow Summary

Since the 100-year storm is the most significant, we have used this storm data to determine the difference between pre and post development storm water runoff. The post development peak flow is 65.41 cfs, whereas the pre development peak flow is 42.02 cfs, a difference of only 23.39 cfs. This difference would necessitate the construction of a detention storage for this project. However, we feel the detention could be constructed in phases as the project progresses.

Stormwater Storage Estimate

The diagram below is used to determine the size of storage that could needed to provide a truly "net zero" effect. The estimated storage required is 31,656 cubic feet.



5.0 MITIGATION MEASURES

Given the large volume of residual rainfall, the very short time of concentration and the non-linear relationship of rainfall intensity to time, regulating agencies have dictated a "net zero" mitigation response. "Net zero" means the post-development rainfall runoff cannot exceed the pre-development rainfall runoff.

5.1 *EROSION AND SEDIMENTATION CONTROLS*

Although we feel the proposed development will cause an increase in drainage flows, concentration, erosion, and sedimentation this impact can be eradicated by proper mitigation techniques; therefore, we are recommending the following course of action be taken:

1) Ensure that all construction is in accordance with the terms and procedures in the NSDOE Erosion and Sedimentation Control Handbook. All silt and sedimentation must be contained on-site during development and construction.
2) Any open ditches or channels shall be rock lined, complete with the appropriate number of ditch plugs (control dams).
3) Siltation fencing shall be placed at the disturbed area boundaries of the property, checked regularly; the silt removed and disposed of off-site.
4) During construction, all storm sewer grates on the site shall have filter fabric placed between the frame and grate to stop all siltation from entering the any watercourse.
5) All slopes steeper than 2:1 from the construction shall be stabilized with 6 inch minus rock.
6) The increased runoff concentration from the proposed development should be collected in a new stormwater collection system, and connected detention storage facility, which will then exit the property.
7) Inform the HRM and NSDOE immediately whenever any siltation flows from the project to unnamed watercourse.
8) ***All the above measure shall be in place BEFORE construction starts.***

6.0 CONCLUSION

Due to topographical changes on the final development, there will be an increase in the total storm runoff discharge. All storm water that is collected from the development will be routed to the detention storage areas and the exit the property.

Given the existing pipe layout, the increase in stormwater runoff, and the estimated storage volume a detention structure is necessary for this project. However, we feel the detention storage could be partially constructed as the progress of the development continues. The increase in runoff could be mitigated with the use of ditch plugs in the armoured ditch.

Both erosion and sedimentation control measures have been accounted for in the management plan to minimize the impact of this development on the existing and future environmental features, on or near the property.

7.0 RECOMMENDATIONS

Although the overall storm flows will increase with development, this impact can be eradicated by proper mitigation and storage techniques. It is our recommendation the following action is taken:

1. The Developer shall ensure that all construction is in accordance with the terms and procedures in the NSDOE Erosion and Sedimentation Control Handbook. Efforts to contain silt and sedimentation onsite during development and construction shall be undertaken.

2. Any open ditches or channels shall be rock lined, complete with the appropriate number of ditch plugs (control dams). Detailed construction plans will identify the location and quantity of the ditch plugs.

3. A detention pond need not be constructed during the early stages of construction; but could be partially constructed and expanded as the subdivision develops. However, we will restrict the flow to pre-development levels by installing ditch plugs in any armoured ditches.

Appendix "A"

Basin Model

Hydrograph Summary

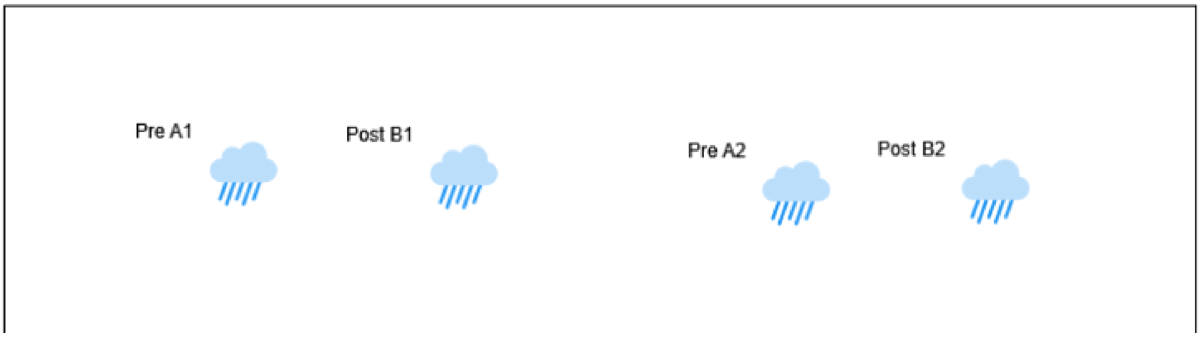
Environment Canada Rainfall Data

Basin Model

Hydrology Studio v 3.0.0.11

Project Name:

08-08-2019



Hydrograph 2-yr Summary

Hydrology Studio v 3.0.0.11

Project Name:

08-08-2019

Hyd. No.	Hydrograph Type	Hydrograph Name	Peak Flow (cfs)	Time to Peak (hrs)	Hydrograph Volume (cuft)	Inflow Hyd(s)	Maximum Elevation (ft)	Maximum Storage (cuft)
1	NRCS Runoff	Pre A1	3.531	3.12	11,747	----		
2	NRCS Runoff	Pre A2	3.075	3.12	10,231	----		
3	NRCS Runoff	Post B1	5.232	3.10	14,506	----		
4	NRCS Runoff	Post B2	20.16	3.07	38,365	----		

Hydrograph 5-yr Summary

Hydrology Studio v 3.0.0.11

Project Name:

08-08-2019

Hyd. No.	Hydrograph Type	Hydrograph Name	Peak Flow (cfs)	Time to Peak (hrs)	Hydrograph Volume (cuft)	Inflow Hyd(s)	Maximum Elevation (ft)	Maximum Storage (cuft)
1	NRCS Runoff	Pre A1	9.641	3.08	22,983	----		
2	NRCS Runoff	Pre A2	8.397	3.08	20,017	----		
3	NRCS Runoff	Post B1	12.16	3.08	26,967	----		
4	NRCS Runoff	Post B2	30.53	3.07	56,613	----		

Hydrograph 10-yr Summary

Hydrology Studio v 3.0.0.11

Project Name:

08-08-2019

Hyd. No.	Hydrograph Type	Hydrograph Name	Peak Flow (cfs)	Time to Peak (hrs)	Hydrograph Volume (cuft)	Inflow Hyd(s)	Maximum Elevation (ft)	Maximum Storage (cuft)
1	NRCS Runoff	Pre A1	20.18	3.07	52,809	----		
2	NRCS Runoff	Pre A2	17.58	3.07	45,995	----		
3	NRCS Runoff	Post B1	23.12	3.07	59,028	----		
4	NRCS Runoff	Post B2	39.76	3.05	96,655	----		

Hydrograph 100-yr Summary

Hydrology Studio v 3.0.0.11

Project Name:

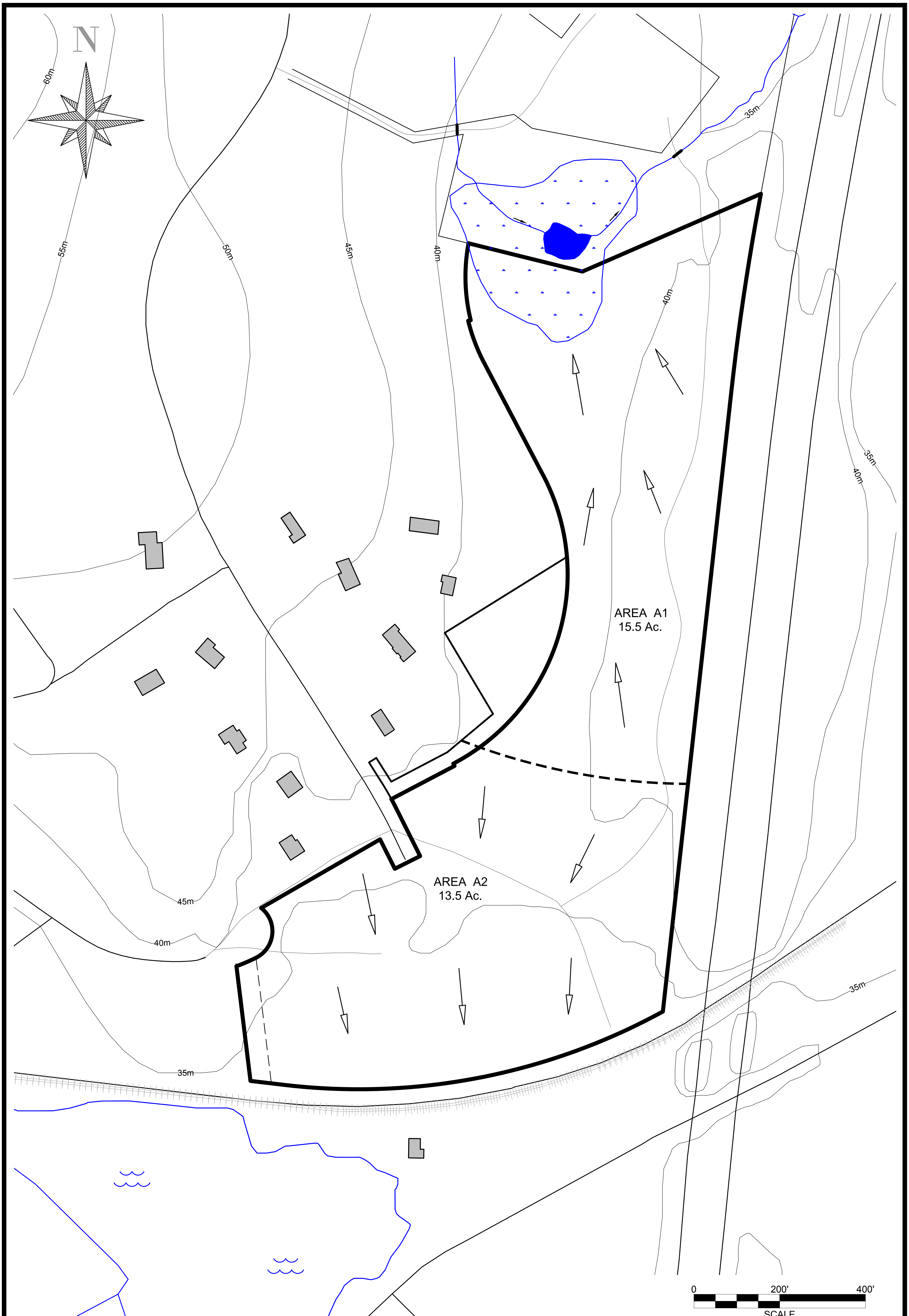
08-08-2019

Hyd. No.	Hydrograph Type	Hydrograph Name	Peak Flow (cfs)	Time to Peak (hrs)	Hydrograph Volume (cuft)	Inflow Hyd(s)	Maximum Elevation (ft)	Maximum Storage (cuft)
1	NRCS Runoff	Pre A1	37.47	3.07	69,153	----		
2	NRCS Runoff	Pre A2	32.64	3.07	60,230	----		
3	NRCS Runoff	Post B1	42.02	3.07	76,296	----		
4	NRCS Runoff	Post B2	65.41	3.05	116,300	----		

Appendix B

Plan #Y2019 059-02
Drainage Plan - Pre - Development

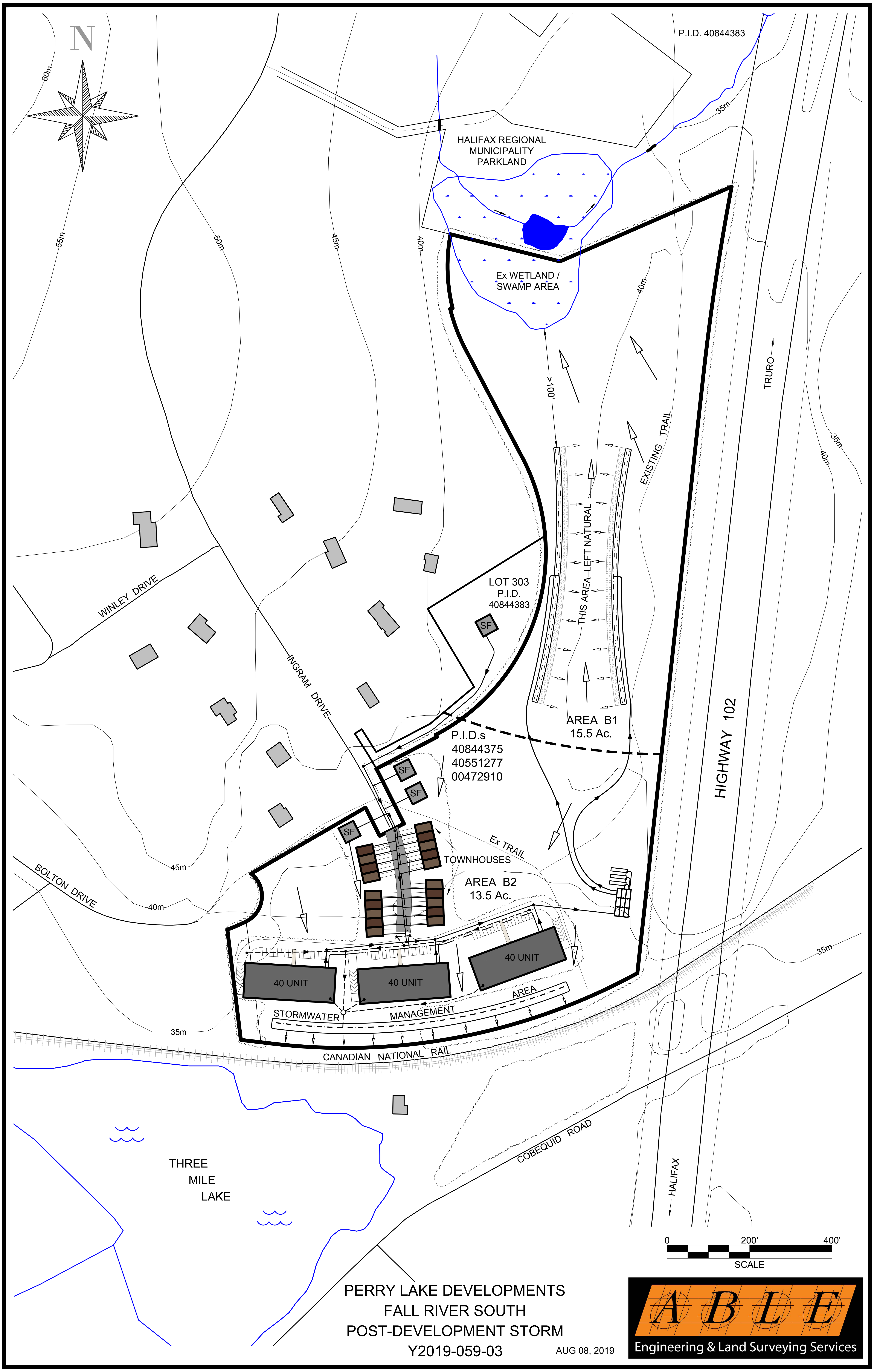
Plan #Y2019-059-03
Drainage Plan - Post - Development



PERRY LAKE DEVELOPMENTS
FALL RIVER SOUTH
PRE-DEVELOPMENT STORM
Y2019-059-02

AUG 08, 2019

A B L E
Engineering & Land Surveying Services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MUNICIPALITY
PARKLAND
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TRURO
EXISTING TRAIL
THIS AREA LEFT NATURAL
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P.I.D.
40844383
SF
WINLEY DRIVE
INGRAM DRIVE
AREA B1
15.5 Ac.
P.I.D.s
40844375
40551277
00472910
HIGHWAY 102
Ex TRAIL
TOWNHOUSES
AREA B2
13.5 Ac.
BOLTON DRIVE
40 UNIT
STORMWATER
MANAGEMENT
AREA
CANADIAN NATIONAL RAIL
THREE
MILE
LAKE
COBEQUID ROAD
HALIFAX
0
200'
400'
SCALE
PERRY LAKE DEVELOPMENTS
FALL RIVER SOUTH
POST-DEVELOPMENT STORM
Y2019-059-03
AUG 08, 2019
ABLE
Engineering & Land Surveying Services

ABLE Engineering Services Inc.

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4073 Highway #3
Chester, NS B0J 1J0
Phone: (902) 273-3050

5209 St. Margaret's Bay Road
Upper Tantallon, NS B3Z 1E3
Phone: (902) 820-3255

August 14, 2019

Perry Lake Developments
31 Sterns Court
Dartmouth, NS
B3B 1W7
Attention: Mr. Larry Gibson

RE: PROPOSED SUBDIVISION – ON-SITE REPORT - INGRAM DRIVE, FALL RIVER, NOVA SCOTIA

Dear Larry:

Further to our conversations, we have updated the on-site sewage treatment report for the proposed Fall River South Development, Mac Williams Engineering Limited dated June 22, 2016.

Listed are some of the differences and improvements of the latest site layout:

- The latest site layout plan is not similar to the former layout in the Williams Report.
- Occupancy only increased by 1 unit.
- Less land will be disturbed during and after development.
- The sanitary treatment on this newer phase uses a large 9 compartment septic tank to provide primary treatment.
- Secondary treatment is achieved using 3–40,000L/Day Waterloo BioFilters.
- Tertiary treatment when the effluent is filtered through high rate sand filters.
- The treatment system is somewhat modular, and can easily be expanded in the future.

Based on the above, we are confirming that the proposed sewage treatment is adequate and shall be adopted for this development.

I trust this is the information you require, but should you have any questions please contact me at 902-678-2774.

Yours truly,

Original Signed

A. W. Dewar, P. Eng.
AWD/ajs
s:\projects\ingram\onsite\ingram drive onsite letter august 14, 2019

INGRAM DRIVE

Updated On-Site Sewage Treatment Assessment

Newly Proposed Development

A. W. (Sandy) Dewar, P. Eng.
ABLE Engineering Services Inc.
a.dewar@ableinc.ca

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REGISTERED PROFESSIONAL ENGINEER * PROVINCE OF NOVA SCOTIA *
DATE 08/14/19
Original Signed
A.W. DEWAR
2937

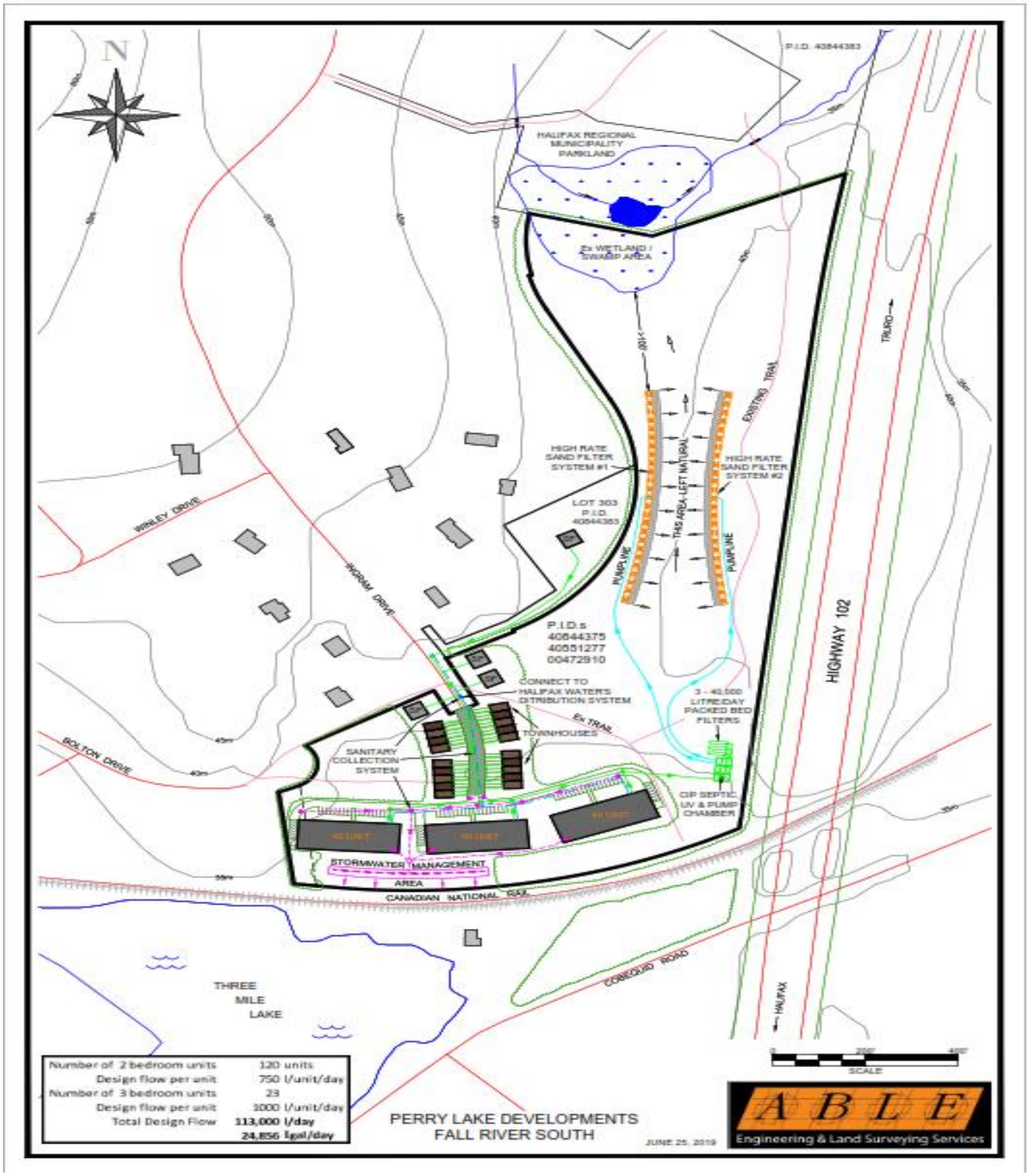
1.0 INTRODUCTION

This updated On-Site Sewage Treatment Assessment was carried out in support of the planning application process for a proposed residential development located on Ingram Drive (PID's #40844375, #40551277, #00472910, #00472902, and #40551558) in the community of Windsor Junction, Halifax Regional Municipality (HRM).

The newly proposed development will be comprised of eleven buildings containing 143 medium density residential units. This includes three low-rise buildings (120 total units), and four low-rise condominium/townhome buildings (19 total units), and four single family (4 units).

Each building will send its effluent to central septic tankage, which will allow the solid to settle out and produce a filtered clear effluent. All effluent from the septic tanks will be sent for further secondary and tertiary sewage treatment. Secondary treatment will be media-based Waterloo BioFilter, and the tertiary treatment will be high rate sand filtration as shown in figure 1.

Figure 1 – Sewage Treatment Layout



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Phone: (902) 820-3255

2.0 FLOW ESTIMATES

The estimated flows are in accordance with the *Atlantic Canada Wastewater Guidelines Manual for Collection, Treatment, and Disposal.*

Table 1 - Multi Unit Residential Flows

Buildings	Unit Type Being Built	Unit Flow (L/Day)	Average Daily Flows (L/Day)
Buildings 1 - 4	Low-rise Condominiums/ townhouses (19 units)	1,000	19,000
Buildingd 5-8	Low-rise rental apartments (120 units)	750	90,000
Buildings SF 1 - 4	Single Family Dwellings (4 units)	1,000	4,000

Based on the above table the total average daily flows for this development is 113,000 L/Day (24,860 Igpd). Applying a Harmon peaking factor of 4.31 the peak flows will be 338 L/minute (74.4 Igpd).

3.0 PRIMARY/SECONDARY/TERTIARY TREATMENT DESCRIPTION

3.1 Primary Tankage

Effluent from the dwelling units is collected and delivered to a large septic tank (60' x 30' x 8'), divided into compartments for total septic storage of 339 cubic metres (74,580 Ig). Primary treatment is applied to the septic waste, and the effluent is filtered, de-odorised, and proceeds to the next phase.

3.2 Secondary BioFilters

Effluent from the septic tankage is further treated in 3 parallel – 40,000 L/Day Waterloo Bio-mass filters. The wastewater is distributed over large bio-mass where it attaches to the media, filtering the wastewater even further. As the effluent drips down the media, the liquid becomes clearer and is collected at the bottom of the unit, where it is pumped back to the last compartment in the septic tank. This compartment is isolated from the rest of the septic tank compartments.

In this chamber, the effluent is disinfected passing through an Ultraviolet Disinfection unit.

3.3 Tertiary High Rate Sand Filter System

After the UV unit, the effluent is pumped to the High Rate Sand Filter System, which consists of two 180 metre (600 ft) long contour beds. Here, the effluent permeates into the beds and into the soil; and eventually flowing sub-surface in a northerly direction to an existing wetland, where it assimilates into the wetland.

The use of a subsurface infiltration trench can be used on-site for final wastewater dispersal, and is dependant on local soil conditions. Based on our knowledge of the local soil conditions and the fact that wastewater has been filtered, treated (Bio Filtration), and disinfected, we have used a hydraulic loading rate of 27 L/Day/m^2.

4.0 CONCLUSION

The proposed 142 multi unit development will create considerable wastewater that needs to be treated in such a way that it does not negatively affect the proposed and surrounding environment. To ensure the environment is not affect by the wastewater produced, we have incorporated the following treatment processes:

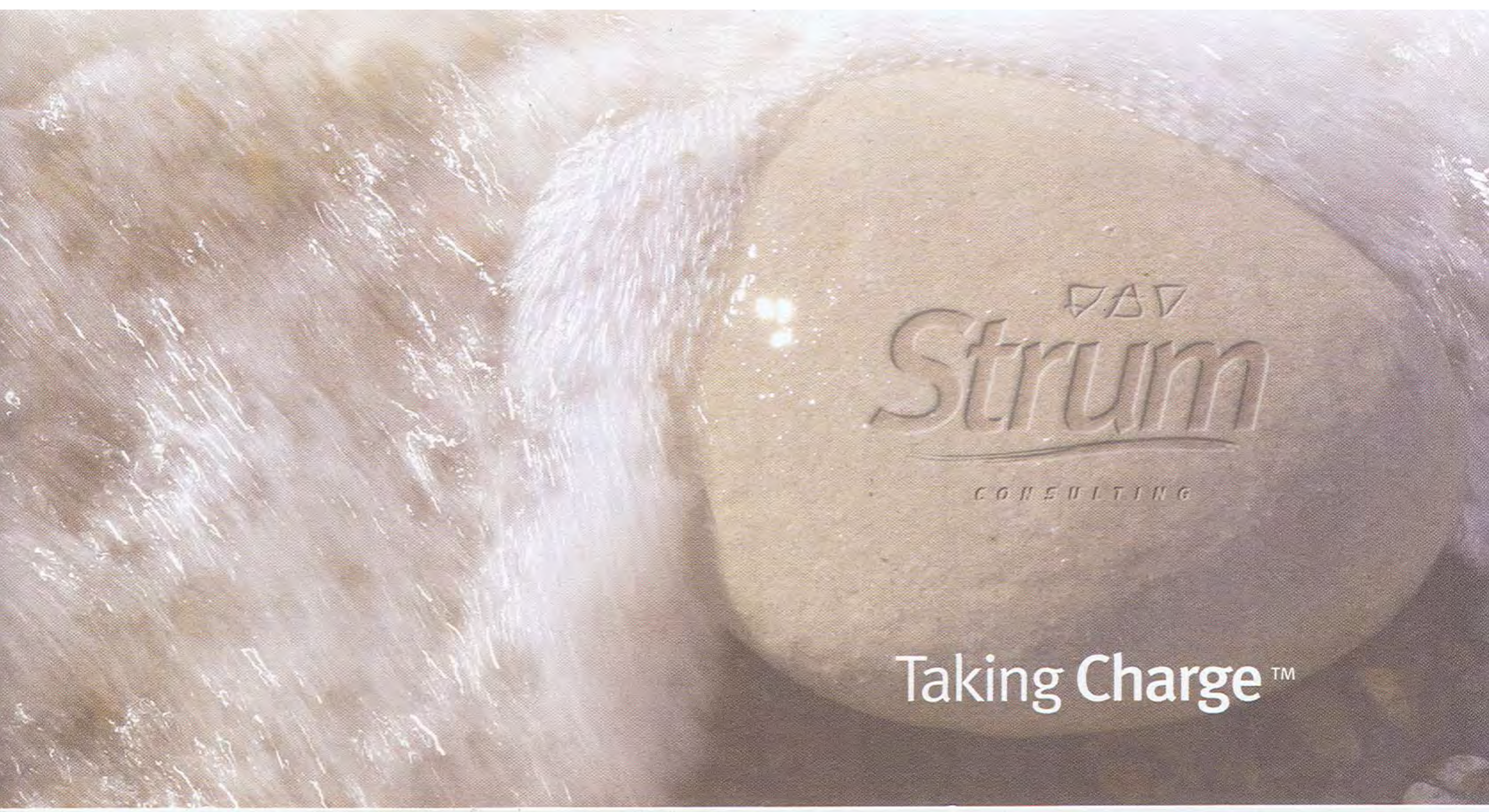
- Primary – Septic tankage to separate the wastewater into sludge and effluent.
- Secondary – Bio mass filtration and Ultraviolet disinfection to provide a 95% treated effluent.
- Tertiary – High rate sand filter to filter the effluent even further and to introduce it into the subsurface regime for underground dispersal.

Strum

CONSULTING

PHOSPHOROUS LOADING STUDY
Fall River South Development

June 23, 2016



June 23, 201□

Mr. Larry Gibson
Perry Lake Developments
31 Sterns Court
Dartmouth, NS B3B 1W7

Dear Mr. Gibson

Re: Phosphorous Loading Study, Fall River South Development

Attached is the Phosphorous Loading Study prepared for the Fall River South Development.

This report documents our observations, findings, and recommendations.

We trust this report to be satisfactory at this time. Once you have had an opportunity to review this correspondence, please contact us to address any questions you may have.

Thank you,

Original Signed

Chris Boudreau, P.Eng.
Manager, Civil Engineering
cboudreau□ strum.com

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Page

1.0 INTRODUCTION

As part of the development agreement application for the Fall River South development in Fall River, Nova Scotia, a stormwater phosphorus loading study was completed by Strum Consulting. The proposed Fall River South development contains an extension of Ingram Drive to Cobequid Road, three multi-unit residential buildings, a commercial building, and a self storage facility. This rural development will manage its stormwater through surface conveyance and will not have central stormwater servicing. Refer to Site Development Plan prepared by WM Fares June, 2016 for an overview of the proposed site layout and use.

The need for this study arose through section RL-22 of Halifax's Municipal Planning Strategy for Planning Districts 14/17 (Shubencadie Lakes). This sub-section states:

> *The River-lakes Secondary Planning Strategy shall establish a no net increase in phosphorus as the performance standard for all large scale developments […] A study prepared by a qualified person shall be required for any proposed development pursuant to these policies to determine if the proposed development will export any greater amount of phosphorus from the subject land area during or after the construction of the proposed development than the amount of phosphorus determined to be leaving the site prior to the development taking place. If the study reveals that the phosphorus levels predicted to be exported from the proposed development exceed the phosphorus levels currently exported from the Planning Districts 14 and 17 MPS Page 129 site, then the proposed development will not be permitted to take place unless there are reductions in density or other methods that reduce phosphorus export levels to those current before the proposed development. Any stormwater management devices designed to treat phosphorus must be located on the privately-owned land included in the proposed development agreement.*

The purpose of this study was to estimate the total phosphorus (TP) that is expected to discharge into the site's surrounding water system under pre-development and post-development conditions. In addition to modeling the post-development conditions several best management practices (BMP) were investigated to provide balanced TP values in pre and post-development conditions.

It is expected that through the development of most sites the overall phosphorus loadings would typically increase as more areas are expected to receive fertilizers, biosolids, and industrial discharge, which are large contributors to the production of TP. This increase is mitigated through the use of stormwater treatment BMPs.

This report presents the findings of the water quality analysis conducted in May and June 2016.

1.1 Design Criteria

With the introduction of future development in the area of Fall River South, stormwater management features must be considered in order to adequately maintain water quality and not adversely affect the surrounding water systems. Proposed stormwater management features must:

- Maximize removal of TP from runoff generated within the developed area
- Minimize the potential for flooding
- Minimize the creation of sediment and erosion

This water quality study follows the guidelines put forth in the Halifax Regional Municipality Stormwater Management Guidelines published by Dillon Consulting in March 200□.

2.0 SCOPE AND METHODOLOGY

2.1 Scope

The purpose of this water quality study is to analyze the proposed Fall River South development's pre-development TP loadings, estimate post-development TP loadings, and propose stormwater BMPs to provide a balanced site (i.e. match pre-development TP loading during construction as well as in the fully developed condition). Stormwater peak-flow management design is outside the scope of this report and is covered in other project documentation.

2.2 Methodology

The methodology undertaken for this analysis consisted of three primary elements listed below. More detailed information on each is contained in Section 3.0.

<u>2.2.1 Historical Data Review</u>

Historical records relating to the site and its surrounding climatic data were reviewed as part of the Study. The primary sources of information included aerial photographs, topographic maps (5 m HRM LiDAR), registered survey plans, and Environment Canada's 1□□1-2001 Canadian Climate Normals for Halifax Stanfield International Airport, NS (□202250). Strum staff also visited the site during our analysis to gather photographic and topographical (survey) information to help determine drainage divides, hydrological features, and outlet control structures.

<u>2.2.2 Hydrological Model</u>

The upstream watershed was delineated for the proposed Fall River South development. It was assumed that areas within the delineated watershed that were not to be altered throughout the development process would be ignored while modeling water quality. This left only the developed portion to be considered throughout the analysis. Existing and developed surface characteristics were classified and are discussed further in section 3.1.3.

<u>2.2.3 Water Quality Analysis</u>

Through the use of desktop modeling processes a simulation of TP production for the proposed development was completed in both the pre-development and post-development conditions. Considerations for accurate calculation included:

- Accurately identifying ground surface characteristics
- Assigning TP pollutant washoff values
- Removal rates for a range of different stormwater BMPs

3.0 MODEL CONFIGURATION

The site in question exists within a watershed that contains an existing residential development, upland forest, and a portion of Nova Scotia Highway 102. There is a defined outlet for the watershed and an ultimate discharge point exists, which directs water toward Three Mile Lake. A model was created that simulated a full year of precipitation and calculated the resulting anticipated TP transported in the yearly runoff volume.

3.1 Hydrology

3.1.1 Rainfall

Average annual precipitation data was collected from Environment Canada□s 1□□1-2001 Canadian Climate Normals for Halifax Stanfield International Airport, NS (□202250). To represent the winter months adequately, both average annual rainfall and average annual snowfall were used as contributors to the production of TP throughout a full year. Table 3.1 below outlines the precipitation values used during the analysis.

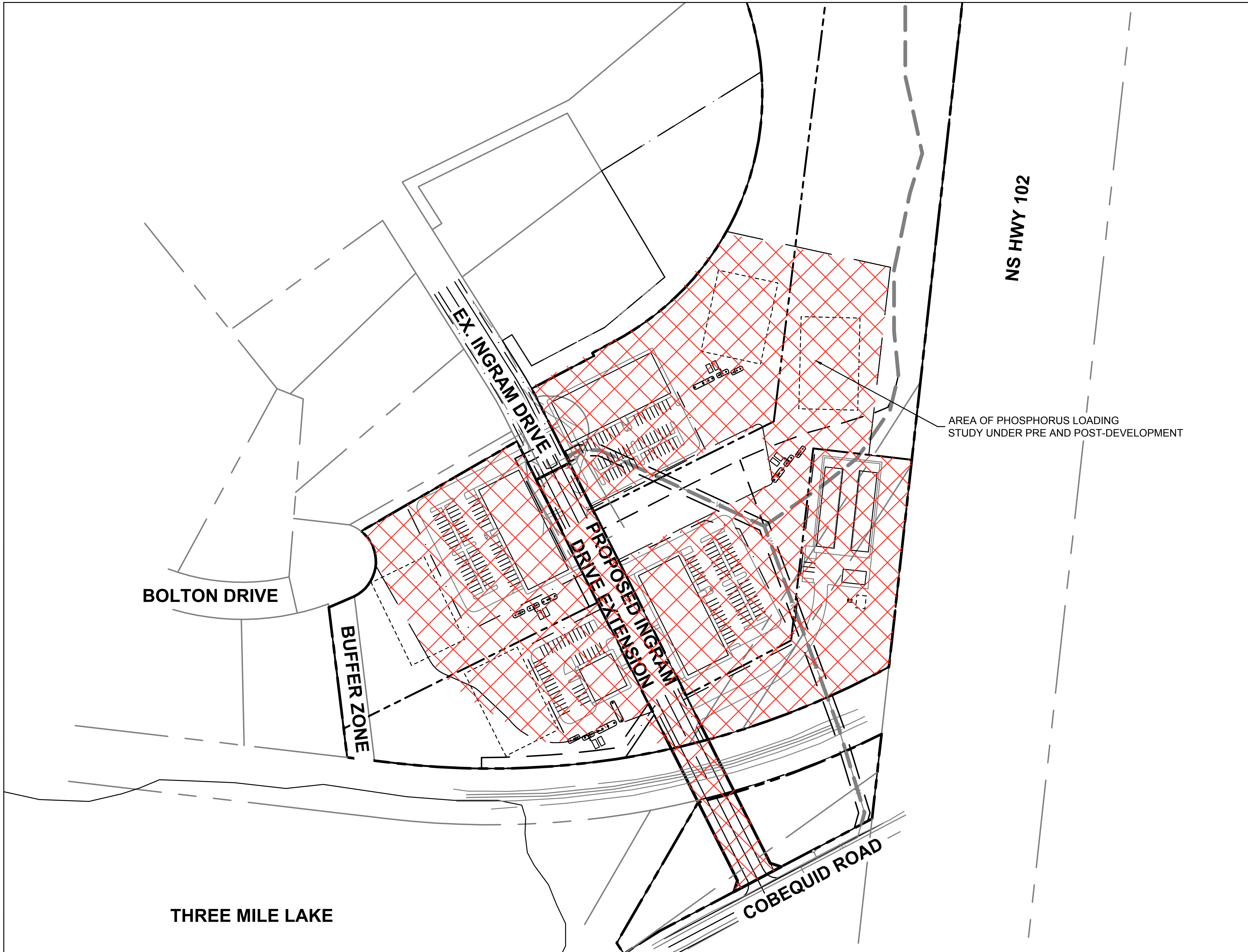
Table 3.1: 1981-2001 Canadian Climate Normals, Halifax Stanfield Int'l A

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall (mm)	□3.5	□5.0	□□.□	□□.2	10□.□	□□.2	□5.5	□3.5	102.0	124.□	13□.1	101.□	11□□.1
Snowfall (cm)	5□.5	45.4	37.1	15.□	2.0	0.0	0.0	0.0	0.0	0.4	1□.□	45.4	221.2
Precipitation (mm)	134.3	105.□	120.1	114.5	111.□	□□.2	□5.5	□3.5	102.0	124.□	154.2	143.3	13□□.2

Due to the relatively small catchment area on the site, we do not anticipate significant locali□ed evaporation to occur and therefore evaporation was not considered during the analysis.

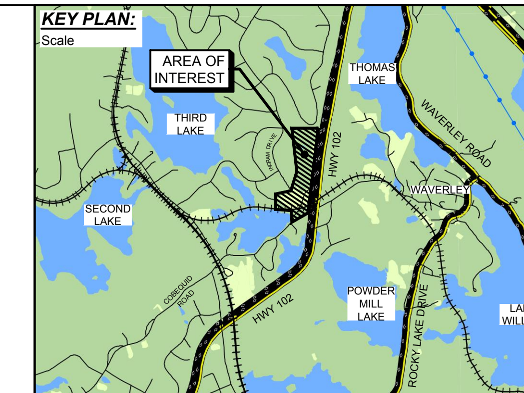
3.1.2 Catchment Delineation

Catchment delineation was completed using HRM LiDAR data and AutoCAD Civil3D. Existing road divides, topographical ridges, and road ditches helped define the overall catchment. A stormwater structure, which passes beneath the existing CN Rail line in the southwestern corner of the site was determined to be the ultimate discharge location for the site to the downstream watershed. Refer to drawing C-102 Preliminary Stormwater Management Plan prepared by Strum Consulting dated June 22, 201□ for defined catchment boundaries and outlet location. The water quality model consists only of areas that will experience a change in land-use or surface type. This means that areas within the catchment area but outside of the proposed development will not be considered in the model as the TP production in these areas will not change throughout the life of the development. Considering the excluded areas, the development area including the road extension was calculated to be 50,□00m^2. The developed portion of the site are shown in Figure 1.



KEY PLAN:

Scale



GENERAL NOTES:

0 20 40 60 80 100 metres

Scale 1:2000

CLIENT:

PERRY LAKE DEVELOPMENTS LTD.

PROJECT:

FALL RIVER SOUTH DEVELOPMENT

LOCATION:

FALL RIVER, NOVA SCOTIA

TITLE:

AREA OF STUDY

CONSULTANT:

Strum CONSULTING 20 YEARS Taking Charge

Engineering * Surveying * Environmental
Bedford * Antigonish * Moncton * Deer Lake

SCALE: H: 1:2000	V:	
DATE: 2016-06-20		DRAWN: RW
DESIGNED: RW	CHECKED: CB	APPR'D: CB
PROJECT No.: 15-5497		
DRAWING No.: FIGURE 1		

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3.1.3 Land Use and Surface Cover

The following land use scenarios were used during analysis:

- Scenario 1: Pre-development conditions
- Scenario 2: Post-development conditions, no BMPs
- Scenario 3: Post-development conditions, with BMPs

As discussed in Section 3.1.2, only the areas within the delineated watershed that will be altered during the development construction process have been considered. Refer to Figure 1 for the areas included in the water quality model. TP loading from undeveloped areas is expected to remain unchanged in the pre and post-development conditions.

Pre and post-development land uses and their corresponding phosphorus loading concentrations for the site were assigned using the land uses outlined in the Halifax Regional Municipality Stormwater Management Guidelines, see Appendix A for portions of the HRM report including land use table of values. Pre-development conditions were estimated using a combination of aerial photography as well as data collected during site visits. Table 3.2 below summari□es the land uses utili□ed throughout the modelling process.

Table 3.2 below summari□es the land uses that were selected for the site and corresponding phosphorus loading values.

Table 3.2: Summary of Pre and Post-Development Land Uses

Development Condition	Land Use	Area (ha)	TP (mg/L)	Notes
Pre-Development	Forested Wetland	1.14	0.2	
	Upland Forest	3.□3	0.2	
Post-Development	Medium-Density Residential	1.□7	0.2	
	Highways	0.33	0	*Proposed road extension*
	Urban Open	3.07	0.2	*Remaining grassed/landscaped areas*

3.1.4 Runoff Coefficients

Runoff coefficients were used in determining the annual volume of rainfall that runs off of the site. These runoff coefficients are commonly used in rational stormwater models and are also known as rational C values. The runoff coefficient is essentially a ratio of runoff to rainfall and varies based on land use, soil type, and land slope. Runoff coefficients are a value between 0 and 1 that can be taken directly from published tables or used aggregately as a weighted value to represent an area which incorporates multiple land uses. The closer the value is to 1, the more runoff is expected to occur, so for an area covered in asphalt, which would see large quantities of runoff and little infiltration, a runoff coefficient of 0.7-0.□5 would be expected.

Table 3.3 below summari□es the runoff coefficients used for each land use outlined in Section 3.1.3.

Table 3.3: Site Runoff Coefficients

Development Condition	Land Use	Runoff Coefficient
Pre-Development	Forested Wetland	0.15
	Upland Forest	0.1
Post-Development	Medium-Density Residential	0.□4□
	Highways	0.7
	Urban Open	0.15

□Weighted runoff coefficient based on multiple land uses

3.2 Water Quality

A water quality model was prepared to estimate the proposed development□s annual generation of TP in kilograms.

TP loading is dependant on the land use of a particular area. Based on the land uses outlined in Section 3.1.3 corresponding TP concentrations were selected from the Halifax Regional Municipality Stormwater Management Guidelines.

The TP values used are solely the result of runoff. This means that any pollutants derived directly from rainwater, groundwater, and any other water sources are not considered in the model.

Using the provided TP concentrations, an annual mass of phosphorus in kilograms was calculated using the estimated annual rainfall for the area. The estimated pre-development annual mass was used as the target values during pre and post-development balancing.

3.3 Best Management Practices

Stormwater best management practices (BMPs) are devices or features included in a stormwater system with the goal of improving water quality. Typically, BMPs are introduced in areas that experience a change in land use and have an increased percentage of impervious area, causing more direct runoff to occur. The performance of various BMPs has been monitored in studies across North America and published values for removal efficiency are widely available. Values signify their ability to remove pollutants, one being TP. BMP removal efficiencies used during analysis were retrieved from:

- Standard and Guidelines for Municipal Waterworks, Wastewater, and Storm Drainage Systems published by Alberta Environment in March 2013
- New Jersey Stormwater Best Management Practices Manual published in February 2004

Refer to Appendix B and C respectively for portions of the reports stated above.

BMPs can act as stand alone features which will remove a defined percentage of waterborne pollutants but they can also be arranged in a series configuration, known as a train, to increase the overall removal efficiency.

Equation 3-1 below is used to determine the removal efficiency of BMPs in series:

BMPs in Series

$$R = A + B - \frac{AB}{100}$$ **Equation 3-1**

Where,

R = Total aggregate removal rate
A = TSS removal rate of the upstream BMP (%)
B = TSS removal rate of the downstream BMP (%)

With the introduction of residential/commercial areas in the Fall River South development, a treatment train of BMPs is being proposed to balance pre and post-development water quality values.

Table 3.4 outlines some of the potential BMPs that are often introduced to the development along with their pollutant removal efficiency based on values outlined in the Alberta Environment and New Jersey BMP Manual.

Table 3.4: BMPs and Related TP Removal Efficiency Ranges

	Alberta Environment	**New Jersey Stormwater**
Best Management Practice	**TP Removal Efficiency (%)**	**TP Removal Efficiency (%)**
Wet Pond	45	50
Grass Swale	20	-
Vegetated Filter Strip	40	30
Permeable Pavement	5	□0
Constructed Stormwater Wetland	25	50
Sand Filter	50	50
Infiltration Trench	□0	-

The BMPs listed above can be incorporated into the design topography of most developments but they will need special consideration for placement due to size requirements (i.e. the wet pond may require a minimum plan area for effective removal).

An alternate option that would require less consideration for size and location is a combination of a pre-fabricated vault and engineered phosphorus removing media. Imbrium Systems has developed a product called Sorbtive Media which absorbs and retains large amounts of dissolved phosphorus. Sorbtive Media can be implemented in one of two ways□within a flow profile filter inside a pre-cast vault where water passes through and phosphorus binds to the Sorbative material, or it can be simply added to soils within a surface trench, sand filter, or permeable pavement.

4.0 MODEL RESULTS

The water quality model was initially run in the pre-development scenario to determine the base-line values. Then, a model was created that did not include any pollutant loading attenuation features (BMPs) to understand how the expected pollutant loading would be affected by a developed site. Table 4.1 summarizes the pre and post-development (uncontrolled) TP values.

Table 4.1: TP loadings for Pre and Post-Development (Uncontrolled)

Development Scenario	Annual TP Loading (kg)
Pre-Development	1.[illegible]
Post-Development [illegible] Uncontrolled	5.20

Based on the values stated above it was determined that stormwater BMPs are required in order to achieve a balanced site. Comparing the pre-development and the uncontrolled post-development values shows the sites require the implementation of measures with a [illegible]4[illegible] removal efficiency of TP in order to achieve Halifax's bylaw requirement of no increased phosphorus loading. To satisfy these removal efficiencies, several BMPs were investigated to help produce a post-development site that would meet this requirement.

Several iterations of the water quality model were run in the controlled post-development case to find the best pollutant loading attenuation methods. Table 4.2 below summarizes the BMPs investigated to create a balanced post-development site.

Table 4.2: BMP TSS and TP Removal Efficiencies

BMP	TP Removal Efficiency (%)
Wet Pond	45
Grass Swale	20
Vegetated Filter Strip	35
Permeable Pavement	25
Constructed Stormwater Wetland	35
Sand Filter	50
Infiltration Trench	[illegible]0

Due to the provision for "*Any stormwater management devices designed to treat phosphorus must be located on the privately-owned land included in the proposed development agreement"* outlined in section RL-22 of Halifax's Municipal Planning Strategy for Planning Districts 14/17, all BMPs must be contained on each individual site. Therefore, each developed site is investigated as a stand-alone post-development area, and having the sum of all TP from each area being less than or equal to the pre-development TP value stated in Table 4.1.

Investigating each post-development site independently ensures that the future developers and designers can design and implement stormwater BMPs as required.

As an alternate to the above stated BMPs Sorbative Media can be used as a highly effective method for removing TP. When the Sorbtive media is blended with bioretention soil at 3-5□ volume it can be expected to have a TP removal efficiency of □□0□, which more than satisfies the □4□ removal that is required. Additionally, Imbrium Systems reports that the Sorbative Media□s design life is typically 10-50 years depending on site removal requirements and runoff characteristics. For design purposes, a TP removal rate of □0□ was used for calculations using Sorbative Media.

Post-development pollutant loadings with the use of BMPs are summari□ed for each proposed site in Table 4.3, with detailed calculations and model results presented in Appendix D.

Table 4.3: Post-Development Pollutant Loading Summary

Development Scenario	BMPs Used	Annual TP Loading (kg)
Pre-Development	**N/A**	**1.96**
Post-Development □The Rylan	Grass Swale & Infiltration Trench	0.31
Post-Development □The Morgan		0.1□
Post-Development □The Addison		0.40
Post-Development □The Chloe		0.35
Post-Development □Fall River Storage		0.24
Post-Development □Ingram Drive Extension	None	0.00
Post-Development – Total	**Various**	**1.49**
Post-Development □The Rylan	Sorbative Media vault	0.24
Post-Development □The Morgan		0.11
Post-Development □The Addison		0.25
Post-Development □The Chloe		0.2□
Post-Development □Fall River Storage		0.1□
Post-Development □Ingram Drive Extension	None	0.00
Post-Development – Total	**Various**	**1.07**

Alberta Environment recommends that for grass swales to achieve the published TP removal efficiency the swale must be 5 to □0 m long. Using the upper end of this range it was assumed that for every □0 m of grass swale that was designed, 20□ removal of TP is achieved. For design purposes, it was decided grass swales would only be used in multiples of □0 m and the remainder of the ditching would be used as an infiltration trench (i.e. 140 m of ditch available would have two □0 m grass swales and 20 m of infiltration trench). Infiltration trenches were limited to a single 20 m length for each site. Equation 3-1 was applied to calculate the aggregate removal efficiency as they will act as BMPs in series.

4.1 Construction Period

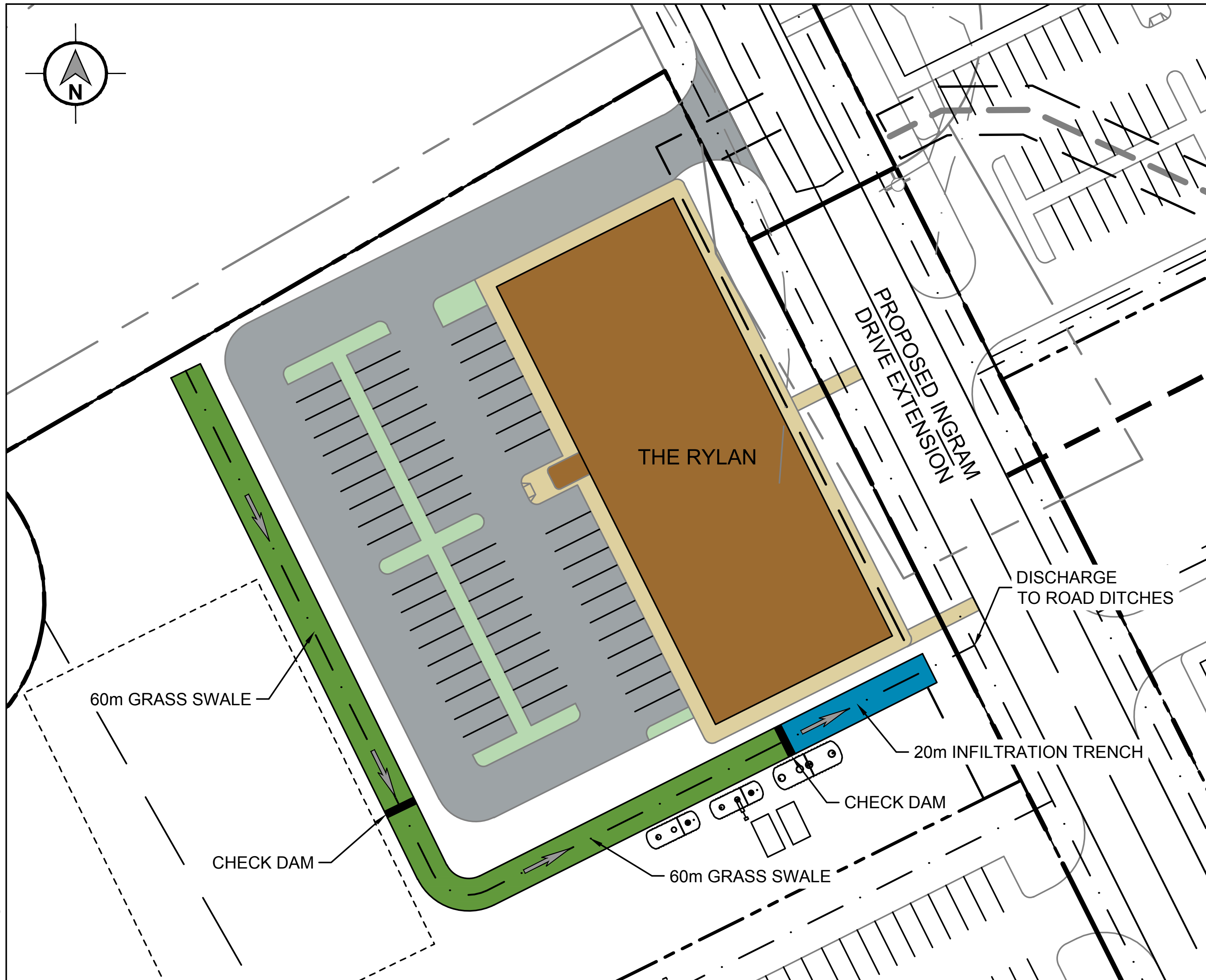
During construction of the development, it will be important to monitor how and where material stockpiles are stored. If topsoil and grubbings are stored on-site during construction, there is potential that increased phosphorus concentrations could be generated in surface water that contacts those materials.

To mitigate this potential concern, topsoil and grubbings piles on the site shall be removed from the site prior to rainfall events, or will be covered with tarps to limit exposure to precipitation and surface water. Additionally, other erosion and sedimentation controls (e.g. sediment fence) shall be installed and maintained on the site during construction, which will limit the transport and loss of sediment from topsoil or grubbings that may contain elevated phosphorus concentrations.

Other than topsoil and grubbings, the main sources of increased phosphorus loading are through the introduction of fertili□ers, biosolids, or other concentrated organics, and industrial wastes. As these main sources of phosphorus will not be present during the construction phase, it is not expected that there will be a net increase of phosphorus through the construction phase of the development. Since no increase in phosphorus is anticipated during the construction phase, it was not included in site modeling.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the data collected above, it is recommended that BMPs be introduced into the final site design to treat site runoff and pollutants in order to achieve a balanced water quality site. Refer to Figure 2 for a typical natural feature BMP layout as well as a table summari□ing each sites BMP design criteria. For design information of Sorbative Media and vaults please consult an Imbrium representative to acquire typical si□ing and layout requirements for their systems. A schematic view of a Sorbative Media layout is shown in Figure 3.



1 C101 **TYPICAL BMP LAYOUT - PLAN**
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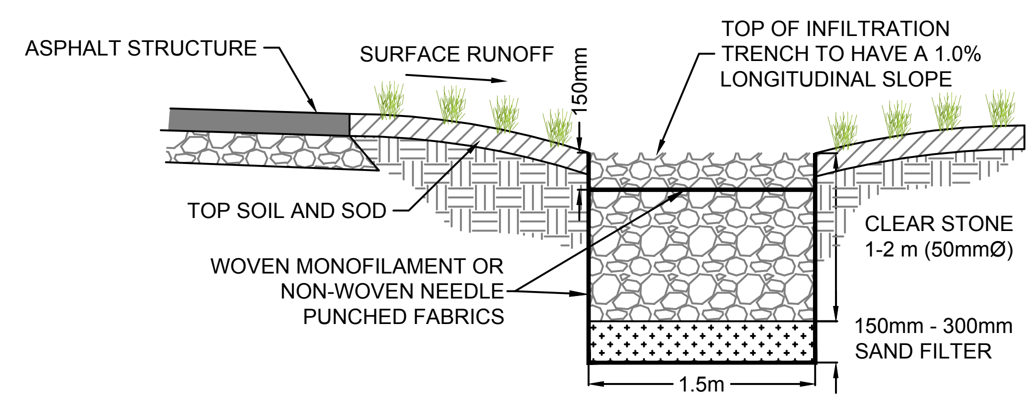

1 C101 **INFILTRATION SWALE - SECTION**
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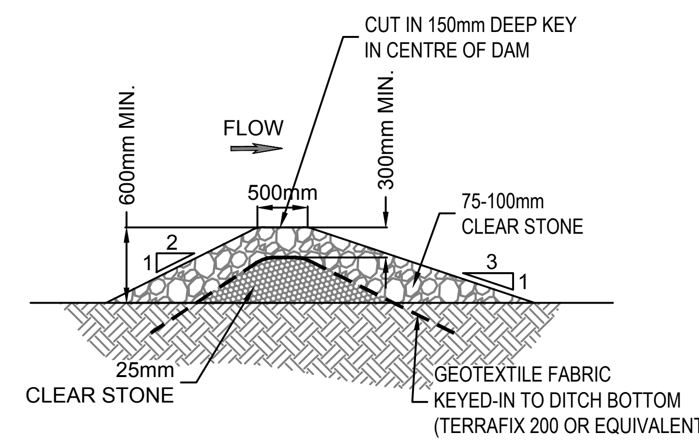

1 C101 **CHECK DAM - PROFILE**
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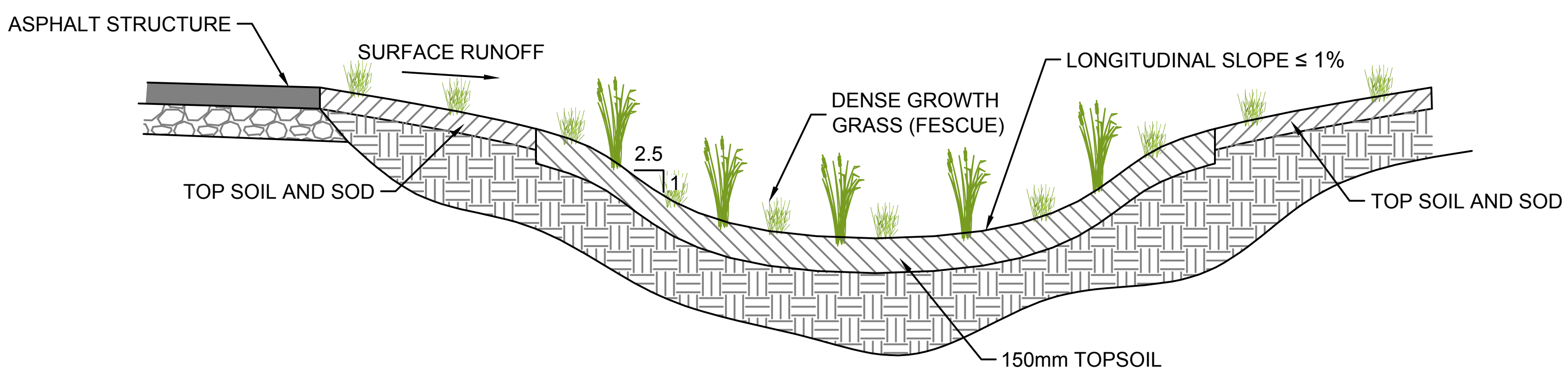
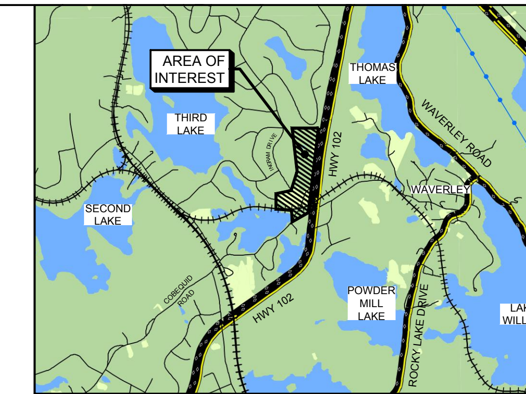


1 C101 **GRASS SWALE - SECTION**
NTS

SUMMARY OF PROPOSED BMPS			
SITE	LENGTH OF GRASS SWALE (m)	LENGTH OF INFILTRATION TRENCH (m)	WEIGHTED TP REMOVAL EFFICIENCY (%)
THE RYLAN	120	20	74.4
THE ADDISON	60	20	68.0
THE CHLOE	120	20	74.4
THE MORGAN	60	20	68.0
SELF STORAGE	120	20	74.4



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CLIENT:
PERRY LAKE DEVELOPMENTS LTD.

PROJECT:
FALL RIVER SOUTH DEVELOPMENT

LOCATION:
FALL RIVER, NOVA SCOTIA

TITLE:
TYPICAL BMP LAYOUT AND DETAILS

CONSULTANT:
Strum Consulting 20 Years Taking Charge
Engineering * Surveying * Environmental
Bedford * Antigonish * Moncton * Deer Lake

SCALE: H: AS NOTED V:
DATE: JUNE 2016
DRAWN: RW
DESIGNED: RW
CHECKED: CB
APPR'D: CB
PROJECT No.: 15-5497
DRAWING No.:

FIGURE 2

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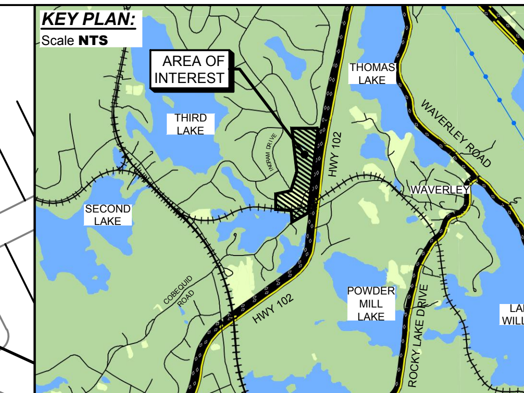

GENERAL NOTES:

1. SORBATIVE MEDIA VAULT SHOWN IS AN APPROXIMATE REPRESENTATION ONLY. FOR DESIGN DETAILS CONSULT AN IMBRIUM SOLUTIONS REPRESENTATIVE.

0 5 10 15 20 25 metres

Scale 1:500

CLIENT:

PERRY LAKE DEVELOPMENTS LTD.

PROJECT:

FALL RIVER SOUTH DEVELOPMENT

LOCATION:

FALL RIVER, NOVA SCOTIA

TITLE:

TYPICAL SORBATIVE VAULT LAYOUT

CONSULTANT:

Strum 20 YEARS Taking Charge CONSULTING

Engineering * Surveying * Environmental
Bedford * Antigonish * Moncton * Deer Lake

SCALE: H: 1:500	V:	
DATE: JUNE 2016		DRAWN: RW
DESIGNED: RW	CHECKED: CB	APPR'D: CB
PROJECT No.: 15-5497		
DRAWING No.: **FIGURE 3**		

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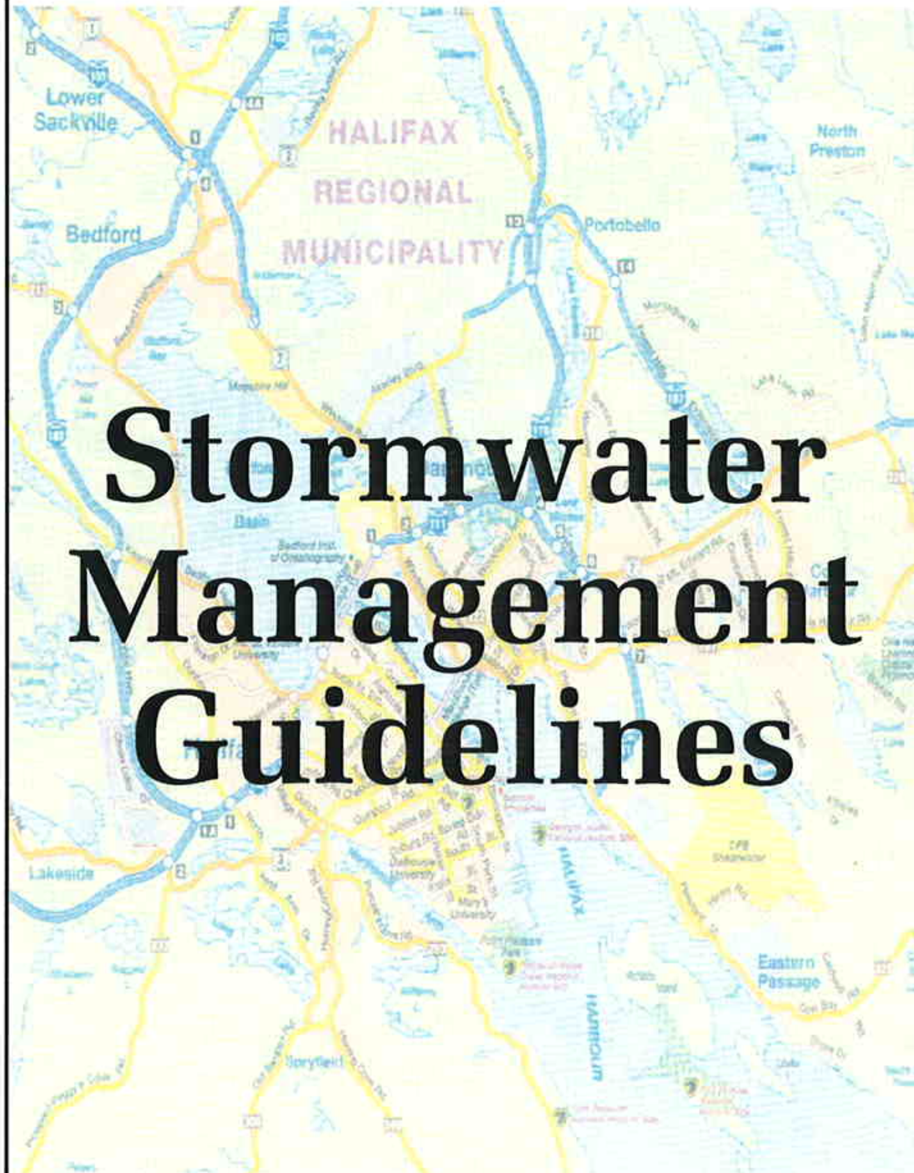
APPENDIX A
PORTIONS OF HALIFAX REGIONAL MUNICIPALITY STORMWATER MANAGEMENT GUIDELINES □ MARCH 200□

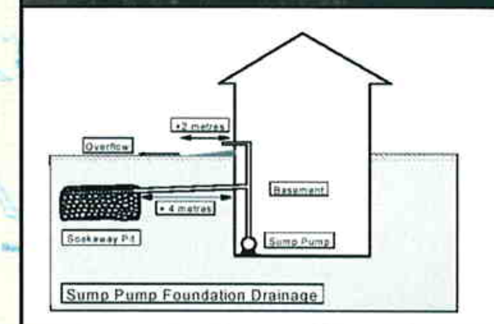
HALIFAX
REGIONAL MUNICIPALITY

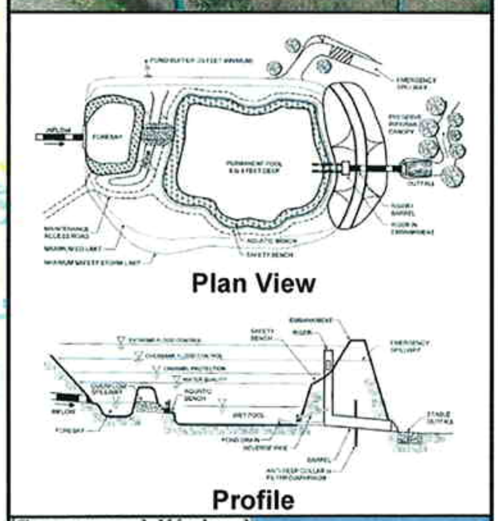


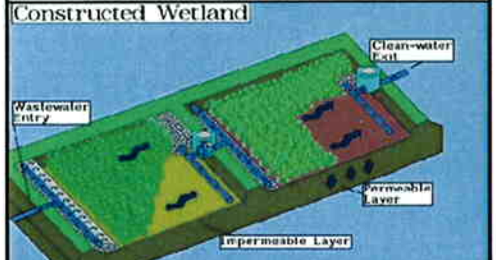
Stormwater Management Guidelines

March 2006

DILLON
CONSULTING







Stormwater Management Guidelines

March 2006

Halifax Regional Municipality

05-4680-0400

Submitted by:

Dillon Consulting Limited

Executive Summary

The purpose of the Stormwater Management Guidelines is to describe a set of criteria for the design of stormwater management practices to protect the environment of the Halifax Regional Municipality from adverse impacts of urban storm water runoff. The Guidelines describe Best Management Practices (BMPs), techniques and methods of managing stormwater drainage for adequate control and pollutant reduction by using the most effective and practical means that are economically acceptable to the community.

The ultimate selection of recommended stormwater BMPs is dependent on the tributary-specific and in some instances, the reach-specific characteristics, sensitivities and functionalities present within the watershed. Ideally, all BMP design criteria should be based on recommendations developed as part of a comprehensive watershed or subwatershed plan prepared for the subject location's basin. These plans are produced through the study of the environmental and land use features of a watershed. The purpose of the plan is to identify those areas that should be protected and preserved as part of the land use planning process, to evaluate the impact of future land use changes and to develop criteria to mitigate potential cumulative impacts in the watershed.

In the absence of watershed/subwatershed study recommendations, the Guidelines provide general design criteria that should be used in HRM for quantity, quality, erosion, and base flow control. The use of this unified approach should result in a design of stormwater management practices that would meet the flood, water quality, erosion control and groundwater recharge criteria adopted until the completion of the watershed and subwatershed studies.

The overall objectives of introducing BMPs are to minimize the adverse effects on and off the development site. An important part of the selection of BMPs is to preserve the sensitive, natural features and to develop a new stormwater system that can reproduce, as closely as possible, the natural conditions of the undeveloped state. This approach stresses the importance of preserving natural storage, infiltration and pollutant filtering functions where feasible, thus reducing the lifecycle cost for stormwater management and minimizing the need for costly capital improvements to the existing system.

There is no single BMP that suits every development, and a single BMP cannot satisfy all stormwater control objectives. Therefore, cost-effective combinations of BMPs may be required that will achieve the objectives.

These Guidelines are intended to be a tool to be used by HRM to guide developers and their designers toward the selection and design of appropriate stormwater management facilities. It will also be used by HRM staff for the review and design of facilities. It is intended that it will be used in combination with the Regional Plan and other planning and design tools already in place to achieve HRM's long-term goals and objectives.

March 29, 2006

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P. O. Box 1749
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ATTENTION: Tony Blouin
Manager of Environmental Performance (Water)

Stormwater Management Guidelines
Final Report

Please find enclosed the Stormwater Management Guidelines. This report provides guidance to the selection and use of Best Management Practices (BMPs) for stormwater management within HRM. The BMPs recommended have been based on a review of practices within HRM and in other jurisdictions in Canada and the United States. It provides a list of alternatives and a methodology for selecting appropriate BMPs for different situations. It must be understood that when the BMPs are utilized, in order for them to operate efficiently, they must be maintained. HRM must endeavour to develop maintenance plans for the BMPs to achieve the stormwater management objectives.

It has been a pleasure to work with HRM and we hope we can be of further service in the future. Please do not hesitate to contact the undersigned if you have any questions concerning this report.

Yours truly,

DILLON CONSULTING LIMITED

Original Signed

Sarah Devereaux, M.Eng., P.Eng.
Project Manager

Original Signed

F. Ivan Lorant., P.Eng.
Water Resource Specialist

SLD:jep
Our File: 05-4680-0400

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Acronyms

BMP	Best Management Practice
HRM	Halifax Regional Municipality
MGA	Municipal Government Act
MSS	Municipal Services System
NP	Not practical
NSEL	Nova Scotia Environment and Labour
OP	Operating Procedure
SWM	Stormwater Management
SUDS	Sustainable Urban Drainage Systems
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
US	United States
USEPA	United States Environmental Protection Agency

5.0 Design Criteria For Best Management Practices

5.1 Introduction

Ideally all BMP design criteria should be based on recommendations developed as part of a comprehensive watershed or subwatershed plan prepared for the subject location's basin. These plans are produced through the study of the environmental and land use features of a watershed. The purpose of the plan is to identify those areas that should be protected and preserved as part of the land use planning process, to evaluate the impact of future land use changes and to develop criteria to mitigate potential cumulative impacts in the watershed. A list of Watershed and Subwatershed Study components relevant to the selection and design of BMPs is presented in ***Appendix D***.

There is a degree of uncertainty associated with the prediction of pollutant retention, especially in parts of Canada where there is a lack of BMP performance monitoring data. The absence of local information on the pollutant retention process and inflow characteristics makes it difficult to verify criteria developed in other parts of the continent. This makes long–term performance monitoring in HRM essential to identify refinements, if needed, to improve design and construction techniques.

In the absence of watershed/subwatershed study recommendations, the following set of design criteria should be used in HRM for quantity, quality, erosion, and base flow control. The use of this unified approach should result in a design of stormwater management practices that would meet the flood, water quality, erosion control and groundwater recharge criteria. The criteria developed in this chapter is partially based on the review of international practices provided in ***Appendix B***.

In the selection of design criteria, local rainfall characteristics should be taken into consideration. ***Appendix E*** presents the findings of the precipitation analysis undertaken for the study area. As a result of the analysis two factors have been incorporated in the selection of design rainfall events for HRM area: i) the unique rainfall pattern observed in the area which is different from other parts of Canada, and ii) the winter rainfall, or snowmelt and rain combination which could produce unique runoff conditions.

5.2 Design Criteria for Water Quantity Control

The intent of quantity control is to manage flood hazards by preventing or reducing damages associated with large, infrequent storm events. By controlling flood flow rates, flood plain and hazard limits in existing development areas can be maintained and the physical integrity of drainage infrastructure (e.g., bridges, culverts and stormwater management facilities) can be protected.

Ideally, watershed or subwatershed studies should evaluate requirements for post-development water quantity controls based on the potential cumulative impacts of development and potential flood hazards. Where such studies do not exist, requirements for water quantity control should be based on potential downstream flooding hazard. Generally, the criteria are to control post-development peak flows for the 2, 5, 25, 50 and 100–year storms to pre-development levels. If a proposed development is located in the lower reaches of a watershed or subwatershed discharging to coastal waters or large lakes with no downstream developments, quantity control may not be required.

For sizing wet ponds and constructed wetlands, a 24-hour duration event should be selected, as shorter rainfall durations may under-estimate design runoff volumes and associated storage volume requirements. Hydrographs for the individual return period events should be generated by hydrologic models using the Shearwater gauge Intensity-Duration-Frequency data. A more detailed discussion on design storms is presented in ***Appendix E.***

5.3 Design Criteria for Water Quality Control

Maintenance of healthy aquatic ecosystems requires that pre-development water quality be maintained and enhanced where feasible. The goal is to restore, protect and enhance water quality and associated aquatic resources and water supplies of the receiving watercourse. This goal mandates the prevention of contamination of streams and lakes from urban runoff containing nutrients, pathogenic organisms, organic substances, heavy metals and toxic substances.

Similar to the quantity criteria, water quality criteria should be based on the premise that where feasible the post-development water quality should be similar to the pre-development water quality.

The selection of water quality criteria is influenced to a great extent by the receiving system environment. Protection of receiving waters from impacts of sediments generated by urban development construction and post construction periods have been recommended by most provincial and municipal agencies across the North American continent. In Canada the Federal Government prepared guidelines on the potential impacts of sediment on aquatic organisms and their habitat.

In controlling the pollutant efficiency of a BMP, it is recommended that Total Suspended Solids (TSS) be adopted as a primary indicator. As a rule of thumb, when rural land use becomes urbanized, the resulting runoff volume could double. At the same time the TSS loads from urban land uses are twice as high as from rural land uses. Therefore, the combined effect could be a fourfold increase in the TSS loads caused by urbanization. To match the pre-urbanized TSS loading, the selected BMP should reduce the post-development load by approximately 75%. Wet ponds and constructed wetlands are capable of removing 80% of TSS or higher.

The design criteria selection should start by assessing the state of the environment in the downstream receiving water bodies. There are two alternative indicators of the downstream water quality that could be considered in the selection of design criteria: 1) fish habitat, and/or 2) the nutrient concentration in the receiving system.

For the first alternative indicator, consideration should be given to the selection of design criteria based on the potential effects of urban runoff on the aquatic habitats of the receiving system streams and lakes. A simple classification is presented in ***Table 5-1*** to describe the downstream habitat:

Table 5-1
Classification of Downstream Habitat

Category	Fishery	Type of species	Suggested TSS control
I	Cold water fishery	Salmonids, lobster fishery, aquaculture	80%
II	Warm water fishery	Perch, minnows, suckers and urbanized lakes	70%
III	No existing or prospect of future habitat	Habitat in ditches, intermittent streams, stream with blockage	60%

The TSS indicator could also be used to assess receiving system impacts of the health on existing or potential future fish habitat. Impacts on this health can be measured by the relative changes in in-stream fish population or by the severity of impacts due to sediment concentration and duration of exposure.

The following table compares the suspended solids concentration guidelines prepared by the European Inland Fisheries Advisory Commission and the Government of Canada, in the Yukon Placer Authorization 1993, document, based on suspended solids increases.

Table 5-2
Risk to Fish Habitat by Increase in TSS

European Commission		Canada	
TSS – mg/L	**Risk Level**	**TSS – mg/L**	**Risk Level**
<25	Not harmful	<25	Very low risk
25-80	Somewhat diminished yield	25-100	Low risk
80-400	Unlikely to support fisheries	100-200	Moderate risk
>400	Only poor fisheries	200-400	High risk

Researchers on fish and exposure to increases in sediment concentration identified that most species of fish can withstand higher exposure of elevated levels of TSS, but impairment will occur when sediment exposure increases beyond threshold values which are a function of both the sediment concentration and its duration. According to Ward (1992) sediment concentration in the receiving stream below 25 mg/L would result in few ill effects regardless of the duration. For typical runoff events lasting less than 4 hours, moderate impacts would occur at about 200 mg/L. For duration of more than 10 hours, a concentration of 1,000 mg/L could result in major impacts.

Where body contact recreation, aesthetic or other uses require the control of nutrients entering the receiving system, it is recommended that Total Phosphorus (TP) removal be adopted as an alternative or as an additional primary design criterion. The following general relationship exists between TSS and TP removal rates:

TSS %	TP %
80	50
70	45
60	35

Based on estimated 50% higher TP concentration and 100% increase in runoff caused by urbanization, there could be an associated 150% increase in the TP loads. To match the pre-urbanized TP loads, the selected BMP should reduce the post-development load by approximately 67%. Wet ponds and constructed wetlands TP removal capability is limited to approximately 45% to 50%. Therefore, where the TP design criteria requires a reduction in excess of that range, additional BMPs would be required to meet the desired level of control. There is extensive background information available on the water quality of local lakes and rivers in the HRM area (http://lakes.chebucto.org), assembled by the Soil and Water Conservation Society of Metro Halifax.

Just as comprehensive watershed studies may include flood control requirements based on cumulative effects of multiple developments, nutrient loading and trophic status modelling may be required to determine TP removal requirements. These studies may even identify linkages between nutrient levels and fish habitat as excessive algae and plant growth can result in the depletion of dissolved oxygen as plant material decomposes.

The water quality criterion for sizing stormwater management facilities has two components: 1) for sizing storage facilities a volume criterion; and 2) for flow-through BMPs a peak flow criterion is recommended. Water quality control BMPs use primarily sedimentation processes to remove pollutants, through settling and/or filtering. Particulate pollutants such as sediment and metals are relatively easy to remove, while soluble pollutants such as nitrates and phosphates are more difficult to remove. A volume generated by a relatively low rainfall and runoff design event generally defines the detention volume requirement for water quality control with a storage facility. Design criteria for BMPs that permit runoff to a flow-through filtration or settling system are related to flow rates and velocities.

When managing runoff for water quality impacts, the control of more frequent and smaller rainfall events are selected. This approach is based on the fact that the percentage of annual precipitation for very large events is relatively small, and the construction cost of storage facilities based on extreme rainfall events would be prohibitive. This approach can still provide partial benefit for larger storms as the BMP can continue to control pollutants from the first portion of the larger storm’s runoff.

The water quality volume criteria for sizing BMPs for the HRM area was determined from an analytical model as described in ***Appendix F***. Long-term local rainfall data was analyzed to determine storage requirements for different impervious conditions and TSS removal efficiencies. The total storage volume in a wet pond or in a constructed wetland consisting of a permanent pool and an extended detention should generally be equivalent to the runoff volume generated by 90% of the long-term rainfall events observed in HRM. (For rainfall information see ***Appendix E***)

An example of the relationship between permanent pool storage and TSS removal efficiency as described in ***Appendix F*** is reproduced on ***Figure 5-1***. Increasing the active storage over 40 m^3/ha would only marginally increase the TSS removal.

The peak flow water quality criterion is based on a statistical analysis of local precipitation data. It is recommended that a 25 mm winter rain event should be used to estimate the peak flow generated by the proposed land use.

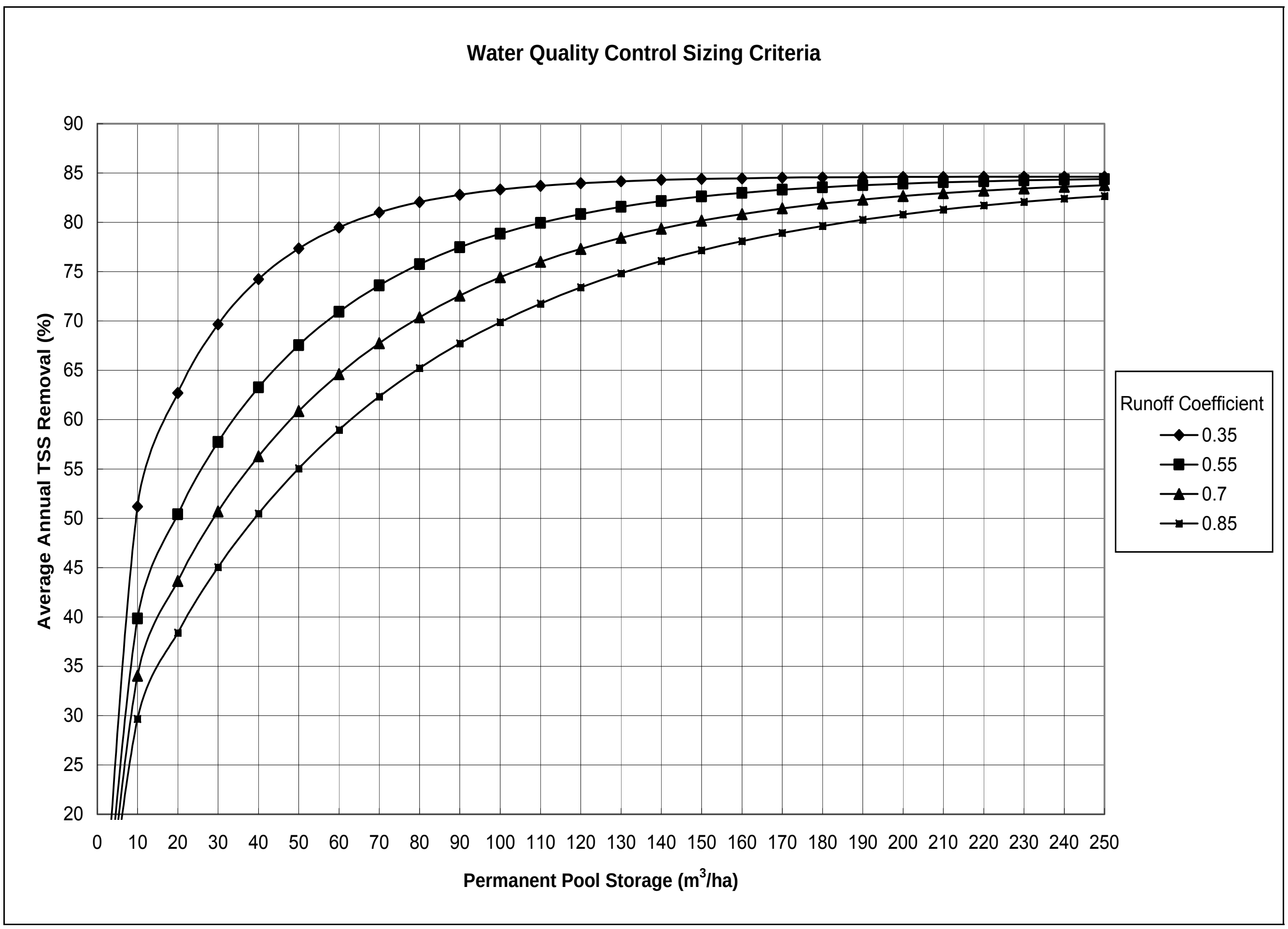

Figure 5-1 Example of Sizing Permanent Pool Storage for Water Quality Control

5.4 Design Criteria for Erosion Control

The preferred approach for addressing erosion concerns is at the watershed/subwatershed planning level. During watershed/subwatershed planning, pre and post-development exceedance erosive index values are computed for a watercourse to determine the need for and the magnitude of erosion control measures.

To select the erosion criterion when no such information is available, it is recommended to undertake an analysis of downstream channel conditions to assess the potential effects of post-development flows, water levels, and velocities on erosion. Such an analysis of erosion potential should extend downstream to a point where the runoff from the upstream drainage area controlled by the pond represents only 10% of the total drainage area.

In the absence of information on downstream channel conditions, a 25 mm winter storm is recommended for the erosion control design event. This storm should be based on a 6 hour Chicago distribution event and should be routed through a storage facility assuming a gradual release rate with a drawdown time of 24-48 hours. For sensitive streams, the longer drawdown time should be used. The required storage is then compared to the extended quality control storage, and the greater of the two is used for design.

For BMPs other than wetpond/wetland, the analysis of downstream channel conditions should determine the need for flow control or erosion protection requirements based on velocities and erosive forces generated by a 25 mm winter rain.

5.5 Recharge and Base Flow Maintenance

The need for providing groundwater recharge at a particular site will depend on the use of local aquifers. Where there is a potential risk of adversely affecting groundwater supply (quantity or quality) in the area, or the risk of reduction in base flow, the recharge from a proposed development should attempt to match the pre-development recharge. The pre- and post-development recharge can be estimated by a simple computation of the hydrologic cycle components.

The local average annual precipitation and evaporation components of the hydrological cycle in the HRM area are:

Precipitation	1421 mm
Evapotranspiration	552 mm
Surplus	869 mm (made up of recharge/base flow and surface runoff)

The recharge and base flow components of the surplus can be estimated by an infiltration factor determined by summing the following factors for topography, soils and cover (Ontario Ministry of the Environment, Stormwater Management Planning and Design Manual (2003)):

Topography	**Factor**
Flat Land, average slope <0.6 m/km	0.3
Rolling Land, average slope 2.8 m to 3.8 m/km	0.2
Hilly Land, average slope 28 m to 47 m/km	0.1
Soils	
Tight impervious clay	0.1
Medium combinations of clay and loam	0.2
Open sandy loam	0.3
Cover	
Cultivated Land	0.1
Woodland	0.2

The range of infiltration factor to be applied is 0.3 to 0.8, therefore the minimum recharge and base flow component of the hydrological cycle could be 260 mm (= 0.3 x 869 mm). For post-development conditions when an area is paved and becomes impermeable, the infiltration/base flow and evapotranspiration components are removed from the hydrologic cycle.

Infiltration through BMPs can provide groundwater recharge by diverting runoff from small and moderate storms into an infiltration facility. An additional benefit is achieved by providing opportunities for a number of physical, chemical and biological processes that remove pollutants from the recharge water. A general guideline for recharge and base flow maintenance is to capture where feasible the first 5 mm of rainfall.

A summary of the recommended design criteria for BMPs is listed in ***Table 5-3.***

Table 5-3
Summary of Design Criteria

Control	Criteria	Comments
Flood and water quantity control	Control peak discharges from the 2, 5, 25, 50 and 100-year storms to pre-development rates	• Downstream system analysis may reveal that flood control criterion may not be required. • Should consider the cumulative effects of development and controls.
Water quality	Volume control for storage facilities, or control of peak flow from a 25 mm winter rainfall	• Compute storage from design graphs, or generate hydrographs for the single event design storm
Stream channel erosion	Control of peak flows	• 24 hour-48 hour extended detention of post-development 25 mm winter storm event. • Should consider the cumulative effects of development and controls.

Control	Criteria	Comments
Baseflow	Infiltrating the first 5 mm rainfall	• Where feasible, the pre-development hydrologic cycle components should be maintained.

5.6 Municipal Infrastructure Criteria

A set of storm drainage guidelines was released by HRM in 2005 as part of the Municipal Services Systems Design Guidelines. This municipal document describes the guidelines to be used in the design of municipal storm sewer pipes, ditches and other appurtenances. In particular, the document deals with the design of the major-minor drainage components of urban drainage systems, such as sewers, catch basins, and foundations drains. The stormwater sections of the Guideline document, reproduced in ***Appendix G,*** contains information on:

- Design parameters for the Minor Drainage system;
- Storm sewer system design: pipes, catchbasins, street drainage, ditches, culverts;
- Minor drainage system connections, roof leaders, foundation drains; and
- Erosion and sediment control.

Table 5-4 summarizes the various guidelines listed in the Municipal document. It also details design requirements in addition to those outlined in the Municipal Services System Guidelines.

Table 5-4
Summary of Existing HRM Storm Drainage Design Guidelines

System Component	Guideline	Additional Requirements
Minor System		
Design flow	• Larger of the winter or annual flow. • Where time of concentration >6 hours use winter precipitation and ice/snowmelt. • Where significant portion of area is underdeveloped use annual and winter data. • Piped systems and driveway culverts: minor storm. • Combined capacity of major and minor systems: major storm. • Watercourses, culverts, roadside ditches, in absence of minor system: major system. • Road culverts: 1:10 year storm.	• As recommended in watershed or subwatershed plans. • In absence of such plans the sewer sizing should be based on 1 in 5 year storm without surcharge.
Downstream effects	• Have capacity to convey discharge from fully developed watershed.	
Rainfall data	• Historical data IDF curves for nearby station. • Synthetic storms, Chicago distribution of 2 and 24 hours, r=0.5, discretization 5	• Storm discretization be selected considering basin size. Five minutes is less than the minimum Tc for

System Component	Guideline	Additional Requirements
	minutes and 1 hour for the two storms. • Historical storms used for verification of storage pond performance.	most rational method design – it can lead to very high peaks in small basins.
Runoff computation	• Model must be calibrated and verified. • Rational method for preliminary design for <20 ha, but not for storage.	
Hydraulic design of sewer pipe	• Manning formula, based on published roughness coefficients. • Minimum pipe size is 300 mm diameter. • No decrease in size in the downstream direction, except at intakes.	
Catch basins	• Located in the gutter line, should minimize ice accumulation and ponding. Double catch basins may be required at locations to prevent by-pass of storm flows. • Spacing not to exceed 120 m. • Interception capacity be compatible with the storm drainage capacity. • Where potential for contamination inverted siphons or separators may be required.	• For more details see Appendix G.
Catch basin leads	• Minimum size 200 mm. • Minimum cover 1 m at construction and 1.2 m at completion of construction. • Minimum slope 1%. • Incorporate flexible joint. • Generally, catch basin connection to another catch basin is not permitted.	• For more details see Appendix G
Storm sewer leads	• Connected from the building foundation should be PVC DR35, 150 mm diameter or less.	
Foundation drains	• Normally drained by gravity to storm sewers and located above the hydraulic grade of major storms, or above the major storm flood if connected to a watercourse.	• No connection permitted to sanitary sewers. Basement floor >1m above 100 year hydraulic grade line.
Roof drains	• May be connected to the storm sewer system if capacity available. • Discharge to a dry well normally not permitted. • Under the Lot Grading bylaw, roof drains are not permitted to be connected to the storm sewer except at discretion of HRM.	• Infiltration of roof runoff to be encouraged subject to soil conditions. Roof leaders should discharge to splash pads 4 m away from building.
Institutional, commercial and industrial connections	• Limit flow to 40% of uncontrolled fully developed flow.	
Major System		
Street and overland flow routes	• Minor storms, depth of flow in gutters <50 mm. • Major storms, depth of flows <50 mm at	• For major system use 100 year return storm event.

System Component	Guideline	Additional Requirements
	crown. • No overtopping of curbs and gutter enter driveways, except where a major system is provided. • Open ditches should not be overtopped and enter driveways.	
Ditches and open channels	• Minimum grade 1%. • For rural roads ditch capacity based on major storm. • Depth at bank full conditions <1.2 m, side slopes not steeper than 2H:1V. • Wetted perimeter stabilized above 4% grade. • Maximum velocity at unlined.	
Culverts	• Grade, obverts of outfalls <150 mm above minor storm level, above normal ice level, allowance for accumulation of debris at the outfall. Minimum grade 1%. • Hydraulic capacity to determined by inlet and outlet control computation. • Headwater depth <2 x diameter of pipe. No inundation of buildings. • Grates if structure >30 m long. • Inlet and outlet structure if piped diameter >375 mm extended >600 mm beyond toe of slope. • Minimum diameter for driveway culvert diameter 450 mm, or not smaller than upstream culvert. • Minimum diameter for roads 525 mm. • Culvert materials: reinforced concrete CSA 257.2 and STM C-76 or high-density polyethylene pipe CSA B182.6. ASTM F-667, and have a minimum stiffness of 320 kPa. • Watercourses with drainage area > 40 ha to be maintained as open.	Culvert design capacities: • Urban arterial road, 50-100 year return frequency. • Rural arterial road, 25 – 50 year return frequency. • Local road, 10-25 year return frequency.

5.7 Pollutant Loads

The goal in selecting the best BMP for a site is to minimize the adverse effects of the proposed development on the environment. The aim is to match predevelopment conditions in the receiving system. A list of pollutant loads generated by different land uses based on CH2M Hill is presented in ***Table 5-5*** to assist the designer in estimating pre and post development pollutant

Table 5-5
Mean Pollutant Concentration Generated by Different Land Uses

Land Use	Primary Indicators		Secondary Indicators					Metals						
	TSS (mg/L)	TP (mg/L)	BOD (mg/L)	COD (mg/L)	TKN (mg/L)	TDS (mg/L)	TN (mg/L)	Cd (ug/L)	Cr (ug/L)	Cu (ug/L)	Pb (ug/L)	Ni (ugL)	Zn (ug/L)
Forested wetland	19.0	0.2	4.1	29.4	0.6	52.0	1.1	0.5	2.8	5.3	3.0	4.7	22.9
Cropland and Pasture	19.2	0.2	4.2	29.7	0.6	52.0	1.1	0.5	2.9	5.4	3.1	4.7	23.5
Upland forest	19.7	0.2	4.3	30.4	0.7	52.0	1.1	0.5	2.9	5.6	3.2	4.7	24.8
Urban open	20.0	0.2	4.4	30.7	0.7	52.0	1.1	0.5	2.9	5.7	3.2	4.7	25.4
Communication and utilities	20.7	0.2	4.6	31.7	0.7	52.0	1.2	0.5	3.0	6.0	3.4	4.8	27.5
Low-density Residential	22.1	0.2	5.0	33.4	0.8	52.0	1.2	0.5	3.1	6.5	3.8	4.8	31.2
Medium-density residential	30.5	0.2	7.5	43.5	1.1	52.0	1.7	0.6	3.8	9.7	6.1	5.0	59.4
Institutional	41.9	0.3	11.3	56.7	1.5	52.0	2.4	0.6	4.5	14.7	9.9	5.3	112.9
High-density residential	47.7	0.3	13.3	63.1	1.7	52.0	2.7	0.7	4.9	17.3	12.0	5.4	145.9
Multifamily residential	47.7	0.3	13.3	63.1	1.7	52.0	2.7	0.7	4.9	17.3	12.0	5.4	145.9
Commercial	54.2		15.7	70.1	2.0		3.1	0.7	5.3	20.4	14.5	5.5	188.7
Highways	57.8		17.0	74.0	2.1	1.3	3.3	0.7	5.5	22.1	16.0	5.5	214.6
Industrial	57.8		17.0	74.0	2.1	1.3	3.3	0.7	5.5	22.1	16.0	5.5	214.6

loads for selected parameters. The data represents event mean concentrations monitored across North America. Generally, in the design of stormwater management facilities, only one or two key indicators, such as TSS and TP are considered. Runoff from impervious surfaces has a high potential for introducing pollutants to surface waters. Suspended solids, dissolved nutrients and oil/grease cause the most common water quality concerns. The existing and future pollutant loads could be estimated to provide an indication to the desired level of control. This early estimate will assist in the selection of the most appropriate alternative BMPs.

The portion of the HRM Waste Water Discharge by-law related to stormwater is presented in ***Appendix H***. This by-law describes limits for chemicals discharged to the municipal storm sewer system.

5.8 Exemptions From Runoff Control

Stormwater control would not normally be required for:

- Single lot development of one family dwelling should apply, as a minimum, basic source control measures, such as reduced lot grades and disconnection of roof leaders. Additional stormwater management measures may also be needed subject to local conditions;
- Addition to existing commercial buildings, provided the total impervious area is not increased, and the existing stormwater management facilities are adequate and are not altered; and
- Runoff from a development if it will be controlled by an external regional stormwater facility.

It is recommended that recognition should be given to any non-structural facility when selecting and sizing BMPs for a particular site. For example, appropriate reduction in the design volume or peak flow should be permitted for conservation of natural areas, disconnection of roof runoff if diverted to an infiltration facility, or use of vegetated swales with an infiltration function which will reduce the effective drainage area contributing to the BMP.

APPENDIX B
PORTIONS OF STANDARD AND GUIDELINES FOR MUNICIPAL WATERWORKS, WASTEWATER, AND STORM DRAINAGE SYSTEMS PUBLISHED BY ALBERTA ENVIRONMENT IN MARCH 2013

Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems

Part 5
Stormwater Management Guidelines
of a Total of 5 Parts

March 2013

Alberta Government

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Part 5 STORMWATER MANAGEMENT GUIDELINES
March 2013

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Additional Parts published separately are:

Part 1 Standards for Municipal Waterworks
Part 2 Guidelines for Municipal Waterworks
Part 3 Wastewater Systems Standards for Performance and Design
Part 4 Wastewater System Guidelines for Design, Operating and Monitoring

FOREWORD TO PART 5 STORMWATER MANAGEMENT GUIDELINES (2013)

Alberta Environment and Sustainable Resource Development (AESRD) has the regulatory mandate, in accordance with the Environmental Protection and Enhancement Act and Regulations, for the Drinking Water, Wastewater and Storm Drainage serving large public systems in Alberta. AESRD considers the establishment of standards and guidelines for municipal waterworks, wastewater and storm drainage facilities an integral part of our regulatory program directed at ensuring public health and environmental protection. AESRD's objective is to develop comprehensive and scientifically defensible standards and guidelines that are effective, reliable, achievable and economically affordable.

Since publication of the last revision of the Standards and Guidelines, Alberta Environment and Sustainable Resource Development has embarked on a process of "decoupling" the various components of the January 2006 document into functionally-associated sections to aid those using the document. This process started with the publication of the January 2006 version of the Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems in the Alberta Gazette. A program of separating the component parts of this document is under way and new parts will eventually replace the corresponding sections in the January 2006 Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems. Until the process of "decoupling" is completed with new "Parts" the existing sections of the 2006 Standards and Guidelines document will remain in operation. This Part (Part 5) details system components that are guidance to best practices in providing well designed and managed Storm Drainage System.

Engineering consultants and / or the system owners / utilities are responsible for the detailed project design and satisfactory construction and operation of the Storm Drainage systems.

In accordance with the Wastewater and Storm Drainage Regulation (119/1993) storm drainage will be designed so that it meets, as a minimum, the applicable standards set out in the Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems, published by AESRD, as amended or replaced from time to time, or, any other standards and design requirements specified by the Regional Director.

AESRD last revised its Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems in January 2006.

This present part is intended to provide general guidance on for storm drainage management. Good engineering and best management practices are included in this Part. These are not mandatory requirements but they establish the minimum expectation when the system owner / utility applies for registration.

The only change from the January 2006 version of the Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems is the numbering of Section 6 – Stormwater Management Guidelines. This document, Part 5 – Stormwater Management Guidelines is now numbered 5.0 through 5.3.6.4.

DEFINITIONS / ABBREVIATIONS

AO	-	Aesthetic Objectives
AESRD	-	Alberta Environment and Sustainable Resource Development
AWWA	-	American Water Works Association
BDOC	-	Biodegradable Dissolved Organic Carbon
BNR	-	Biological Nutrient Removal
BPJ	-	Best Professional Judgement
BPR	-	Biological Phosphorus Removal
BPT	-	Best Practicable Technology
CBOD	-	Carbonaceous Biochemical Oxygen Demand at 5 days and 20 °C
CFID	-	Continuous feed and intermittent discharge
DAF	-	Dissolved Air Flotation
DBP	-	Disinfection By-product
DCS	-	Distributed Control System
DO	-	Dissolved Oxygen
DOC	-	Dissolved Organic Carbon
DWSP	-	Drinking Water Safety Plan
EPEA	-	Environmental Protection and Enhancement Act
F/M	-	Food to Microorganism ratio
G	-	Velocity Gradient
GCDWQ	-	Guidelines for Canadian Drinking Water Quality
GWUDI	-	Groundwater under the direct influence of surface water
HPC	-	Heterotrophic Plate Count
HRT	-	Hydraulic Retention Time
IFID	-	Intermittent feed and intermittent discharge
MAC	-	Maximum Acceptable Concentration
MLSS	-	Mixed Liquor Suspended Solids
NH_3-N	-	Ammonia nitrogen
NSF	-	National Sanitation Foundation
NTU	-	Nephelometric Turbidity Unit
ORP	-	Oxidation Reduction Potential
OU	-	Odour Unit
PLC	-	Programmable Logic Controllers
QA/QC	-	Quality Assurance/Quality Control
RBC	-	Rotating Biological Contactor
SAR	-	Sodium Adsorption Ratio
SBR	-	Sequencing Batch Reactor
SRT	-	Sludge Retention Time
TBOD	-	Total Biochemical Oxygen Demand at 5 days and 20 °C
TOC	-	Total Organic Carbon
TP	-	Total Phosphorus
TSS	-	Total Suspended Solids
TTHM	-	Total Trihalomethanes
UC	-	Uniformity Coefficient
USEPA	-	United States Environmental Protection Agency
UV	-	Ultraviolet
WHO	-	World Health Organization

Average daily design flow (water and wastewater) - The product of the following:

- design population of the facility, and
- the greatest annual average per capita daily flow which is estimated to occur during the design life of the facility.

Co-op - An organization formed by the individual lot owners served by a waterworks system, wastewater system or storm drainage system.

Granular filter media:

1. Effective Size (D_{10}) - Size of opening that will just pass 10% of representative sample of the granular filter media.
2. Uniformity Coefficient - A ratio of the size opening that will just pass 60% of the sample divided by the opening that will just pass 10% of the sample.

Groundwater - All water under the surface of the ground.

Maximum daily design flow (water) - Maximum three consecutive day average of past-recorded flows, times the design population of the facility. If past records are not available, then 1.8 to 2.0 times the average daily design flow.

Maximum hourly design flow (water) - 2.0 to 5.0 times the maximum daily design flow depending on the design population.

Maximum monthly average daily design flow (wastewater) - The product of the following:

1. design population of the facility, and
2. the greatest monthly average per capita daily flow which is estimated to occur during the design life of the facility.

Owners - Owners of the waterworks or wastewater systems as defined in the regulations.

Peak demand design flow (water) - the maximum daily design flow plus the fire flow.

Peak wastewater design flow (wastewater) - The sum of the peak dry weather flow rates as generated by population and land use, and the rate of all extraneous flow allowances, as determined for the design contributing area (see Section 4.1.1).

Potable water – As defined in the EPEA. Other domestic purposes in the EPEA definition include water used for personal hygiene, e.g. bathing, showering, washing, etc.

Sodium adsorption ratio - A ratio of available sodium, calcium and magnesium in the soil solution which can be used to indicate whether or not the accumulation of sodium in the soil exchange complex will lead to a degradation of soil structure.

$$SAR = \frac{Na}{\left[\frac{Ca}{2} + \frac{Mg}{2}\right]^{\frac{1}{2}}}$$

Note : All concentrations expressed in milliequivalents per litre

Surface water - Water in a watercourse.

Watercourse - As defined in the EPEA.

TABLE 5.3 PHYSICAL BMP CONSTRAINTS					
BMP	Criteria				
	Topography	Soils	Bedrock	Groundwater	Area
On-Lot BMP					
Flat lot grading	<5%	none	none	none	none
Soak-away pit	none	loam (min. infiltration rate ≥15 mm/h)	>1 m below bottom	>1 m below bottom	<0.5 ha
Rear yard infiltration	<2%	loam (min. infiltration rate ≥15 mm/h)	>1 m below bottom	>1 m below bottom	<0.5 ha
Conveyance BMP					
Grassed swales	<5%	none	none	none	none
Perforated pipes	none	loam (min. infiltration rate ≥15 mm/h)	>1 m below bottom	>1 m below bottom	none
Pervious catch basins	none	loam (min. infiltration rate ≥15 mm/h)	>1 m below bottom	>1 m below bottom	none
End-of-Pipe BMP					
Wet pond	none	none	none	none	>5 ha
Dry pond	none	none	none	none	>5 ha
Wetland	none	none	none	none	>5 ha
Infiltration basin	none	loam (min. infiltration rate ≥15 mm/h)	>1 m below bottom	>1 m below bottom	<5 ha
Infiltration trench	none	loam (min. infiltration rate ≥15 mm/h)	>1 m below bottom	>1 m below bottom	<2 ha
Filter strips	<10%	none	none	>0.5 m below bottom	<2 ha
Sand filters	none	none	none	>0.5 m below bottom	<5 ha
Oil / grit separators	none	none	none	none	<1 ha

5.3.6.3 Final Screening

In the initial screening phase the options for BMPs were limited by particular disadvantages and site constraints. The list of BMP options that are still considered feasible are further screened by the application of specific objectives that must be met as part of the development including:

- water quality
- flooding
- erosion
- recharge.

The performance of BMPs in regard to the objectives for stormwater management are shown in Table 5.4.

TABLE 5.4
POTENTIAL BMP OPPORTUNITIES

Stormwater BMP	Water Quality	Flooding	Erosion	Recharge
Lot Level BMPs				
Lot grading	♦	♦	♦	•
Roof leader ponding	♦	♦	♦	•
Roof leader soak-away pits	♦	♦	♦	•
Conveyance BMPs				
Pervious pipes	•*	♦	♦	•
Pervious catch basins	•*	♦	♦	•
Grassed swales	•	♦	•	♦
End-of-Pipe BMPs				
Wet pond	•	•	•	❍
Dry pond	♦	❍	•	❍
Dry pond with forebay	•	•	•	❍
Wetland	•	•	•	❍
Sand filter	•	♦	♦	❍
Infiltration trench	♦*	♦	♦	•
Infiltration basin	♦*	♦	♦	•
Vegetated filter strip	•	❍	♦	♦
Buffer strip	♦	❍	♦	♦
Special purpose BMP				
Oil / grit separator	♦	❍	❍	❍

• Highly effective (primary control)
♦ Limited effectiveness (secondary control)
❍ Not effective
* May have adverse effects
From MOEE, 1994

5.3.6.4 Water Quality Control and Enhancement Opportunities

In many areas of development, stormwater management practices must meet stringent water quality objectives to protect sensitive receiving waters. Water quality objectives can be defined for a stormwater management system and then appropriate BMPs can be selected from the pre-screened list that will meet the water quality objectives.

The reported effectiveness of a number of BMPs to remove pollutants are shown in Table 5.5.

TABLE 5.5
EFFECTIVENESS OF BEST MANAGEMENT PRACTICES FOR CONTROL OF RUNOFF FROM NEWLY DEVELOPED AREAS

Management Practice		Removal Efficiency (%)						Factors	References
		TSS	TP	TN	COD	Pb	Zn		
Infiltration Basin	Average:	75	65	80	65	65	65	Soil percolation rates Basin surface area Storage volume	NVPDC, 1979; EPA, 1977; Schueler, 1967; Griffin et al, 1980; EPA, 1963; Woodword-Clyde, 1966
	Reported Range:								
	SCS Soil Group A	60-100	60-100	60-100	60-100	60-100	60-100		
	SCS Soil Group B	50-80	50-80	50-80	50-80	50-80	50-80		
	No. of Values Considered:	7	7	7	4	4	4		
Infiltration Trench	Average:	75	60	55	65	65	65	Soil Percolation rates Trench surface area Storage volume	NVPDC, 1979; EPA, 1977; Schueler, 1967; Griffin et al, 1980; EPA, 1963; Woodword-Clyde, 1966; Kuo et al 1968; Lugbill, 1990
	Reported Range:	45-100	40-100	(110)-100	45-100	45-100	45-100		
	Probable Range:								
	SCS Soil Group A	60-100	60-100	60-100	60-100	60-100	60-100		
	SCS Soil Group B	50-90	50-90	50-90	50-90	50-90	50-90		
	No. of Values Considered:	9	9	9	4	4	4		

TABLE 5.5 continued
EFFECTIVENESS OF BEST MANAGEMENT PRACTICES FOR CONTROL OF RUNOFF FROM NEWLY DEVELOPED AREAS

Management Practice		Removal Efficiency (%)						Factors	References
		TSS	TP	TN	COD	Pb	Zn		
Vegetated Filter Strip	Average:	65	40	40	40	45	60	Runoff volume Slope Soil infiltration rates Vegetative cover Buffer length	IEP, 1991 Casman, 1990 Glick et al, 1991 VADC, 1987 Minnesota PCA, 1989 Scheuler, 1967 Hartigan et al 1969
	Reported Range:	20-80	0-95	0-70	0-60	20-90	30-90		
	Probable Range:	40-90	30-80	20-60	-	30-80	20-50		
	No. of Values Considered:	7	4	3	2	3	3		
Grass Swale	Average:	60	20	10	25	70	60	Runoff volume Slope Soil infiltration rates Vegetative cover Swale length Swale geometry	Yousel et al, 1965 Dupuls, 1985 Washington State, 1968 Schuerer, 1967 British Columbia Res. Corp, 1991 EPA, 1983 Whelen et al, 1988 PIN, 1966 Caeman, 1990
	Reported Range:	0-100	0-100	0-40	25	3-100	50-80		
	Probable Range:	20-40	20-40	10-30	-	10-20	10-20		
	No. of Values Considered	10	8	4	1	10	7		

TABLE 5.5 continued
EFFECTIVENESS OF BEST MANAGEMENT PRACTICES FOR CONTROL OF RUNOFF FROM NEWLY DEVELOPED AREAS

Management Practice		Removal Efficiency (%)						Factors	References
		TSS	TP	TN	COD	Pb	Zn		
Porous Pavement	Average:	35	5	20	5	15	5	Maintenance Sedimentation storage volume	Pitt, 1965 Field, 1985 Schueler, 1967
	Reported Range:	0-95	5-10	5-55	5-10	10-25	5-10		
	Probable Range:	10-25	5-10	5-10	5-10	10-25	5-10		
	No. of Values Considered:	3	1	2	1	2	1		
Concrete Grid Pavement	Average:	90	90	90	90	90	90	Percolation rates	Day, 1961 Smith et al, 1961 Schueler, 1967
	Reported Range:	65-100	65-100	65-100	65-100	65-100	65-100		
	Probable Range:	60-90	60-90	60-90	60-90	60-90	60-90		
	No. of Values Considered:	2	2	2	2	2	2		
Sand Filter / Filtration Basin	Average:	80	50	35	55	60	65	Treatment volume Filtration media	City of Austin, 1986 Environmental and Conservation Service Department, 1990
	Reported Range:	60-95	0-90	20-40	45-70	30-90	50-80		
	Probable Range:	60-90	0-80	20-40	40-70	40-80	40-80		
	No. of Values Considered:	10	6	7	3	5	5		

TABLE 5.5 continued
EFFECTIVENESS OF BEST MANAGEMENT PRACTICES FOR CONTROL OF RUNOFF FROM NEWLY DEVELOPED AREAS

Management Practice		Removal Efficiency (%)						Factors	References
		TSS	TP	TN	COD	Pb	Zn		
Water Quality Inlet	Average:	35	5	20	5	15	5	Maintenance Sedimentation storage volume	Pitt, 1965 Field, 1965 Schueler, 1967
	Reported Values:	0-95	5-10	5-55	5-10	10-25	5-10		
	Probable Values:	10-25	5-10	5-10	5-10	10-25	5-10		
	No. of Values Considered:	3	1	2	1	2	1		
Water Quality Inlet with Sand Filter	Average:	80	NA	35	55	80	65	Sedimentation storage volume Depth of media	Shaver, 1991
	Reported Range:	75-85	NA	30-45	45-70	70-90	50-80		
	Probable Range:	70-90	–	30-40	40-70	70-90	50-80		
	No. of Values Considered:	1	0	1	1	1	1		
Oil / Grit Separator	Average:	15	5	5	5	15	5	Sedimentation storage volume Outlet configurations	Pitt, 1965 Schueler, 1967
	Reported Range:	0-25	5-10	5-10	5-10	10-25	5-10		
	Probable Range:	10-25	5-10	5-10	5-10	10-25	5-10		
	No. of Values Considered:	2	1	1	1	1	1		

TABLE 5.5 continued
EFFECTIVENESS OF BEST MANAGEMENT PRACTICES FOR CONTROL OF RUNOFF FROM NEWLY DEVELOPED AREAS

Management Practice		Removal Efficiency (%)						Factors	References
		TSS	TP	TN	COD	Pb	Zn		
Extended-Detention Dry Pond	Average:	45	25	30	20	50	20	Storage volume Detention time Pond shape	MWCOG, 1983 City of Austin, 1990 Schueler and Heinrich, 1965 Pope and Hess, 1989 OWML, 1967 Wollnold and Stack, 1990
	Reported Range:	5-90	10-55	20-60	0-40	25-65	(-40)-65		
	Probable Range:	70-90	10-60	20-60	30-40	20-60	40-60		
	No. of Values Considered:	6	6	4	5	4	5		
Wet Pond	Average:	60	45	35	40	75	80	Pond volume Pond shape	Wotzka and Oberta, 1966 Yousel et al, 1968 Cullum, 1985 Driscoll, 1983 Driscoll, 1986 MWCOG, 1963 OWML, 1963 Yu and Benemouflok, 1986 Hother, 1989 Martin, 1966 Dowman et al, 1969 OWML, 1962 City of Austin, 1990
	Reported Range:	(-30)-91	10-85	5-85	5-90	10-85	10-95		
	Probable Range:	50-90	20-90	10-90	10-90	10-95	20-95		
	No. of Values Considered:	18	18	9	7	13	13		

TABLE 5.5 continued
EFFECTIVENESS OF BEST MANAGEMENT PRACTICES FOR CONTROL OF RUNOFF FROM NEWLY DEVELOPED AREAS

Management Practice		Removal Efficiency (%)						Factors	References
		TSS	TP	TN	COD	Pb	Zn		
Extended-Detention Wet Pond	Average:	80	65	55	NA	40	20	Pond volume Pond shape Detention time	Ontario Ministry of the Environment, 1991 cited in Schueler et al 1992
	Reported Range:	50-100	50-60	55	NA	40	20		
	Probable Range:	50-95	50-90	10-90	10-90	10-95	20-95		
	No. of Values Considered:	3	3	1	0	1	1		
Constructed Stormwater Wetlands	Average:	65	25	20	50	65	35	Storage volume Detention time Pool shape Wetlands biota Seasonal variation	Harper et al, 1966 Brown, 1985 Wotzka and Oberta, 1966 Hickock et al, 1977 Burten, 1967 Martin, 1966 Morris et al, 1961 Sherberger and Davis, 1962 ABAG, 1979 Oberts et al, 1969 Rushton and Dye, 1990 Hay and Barrett, 1991 Martin and Smool, 1986 Ralnelt et al, 1990 cited in Woodward and Clyde, 1991
	Reported Range:	(-20)-100	(-120)-100	(-15)-40	20-80	30-95	(-30)-60		
	Probable Range:	50-90	(-5)-80	0-40	-	30-95	-		
	No. of Values Considered:	23	24	6	2	10	8		

NA - Not available

[a] Design criteria: storage volume equals 80% avg. runoff volume, which completely drains in 72 hours; maximum depth = 6 ft.; minimum depth = 2 ft.

[b] Design criteria: storage volume equals 90% avg. runoff volume, which completely drains in 72 hours; maximum depth = 5 ft.; minimum depth = 3 ft.; storage volume = 40% excavated trench volume

[c] Design criteria: flow depth < 0.3 ft.; travel time > 5 min.

[d] Design criteria: Low slope and adequate length

[e] Design criteria: minimum extended detention time 12 hours

[f] Design criteria: minimum area of wetland equal 1% of drainage area

[g] No information was available on the effectiveness of removing oil and grease

[h] Also reported as 90% TSS removed

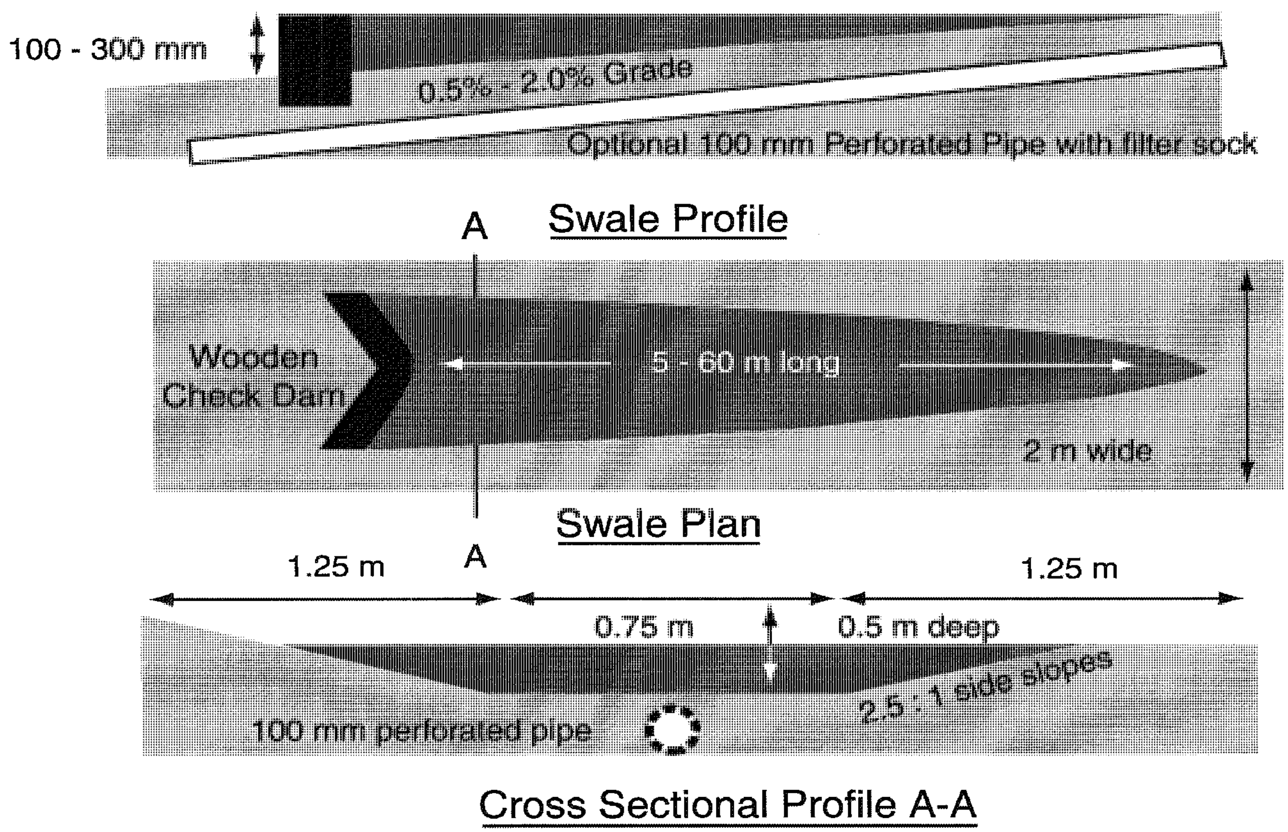


Figure 5.8
Grass Swale Design

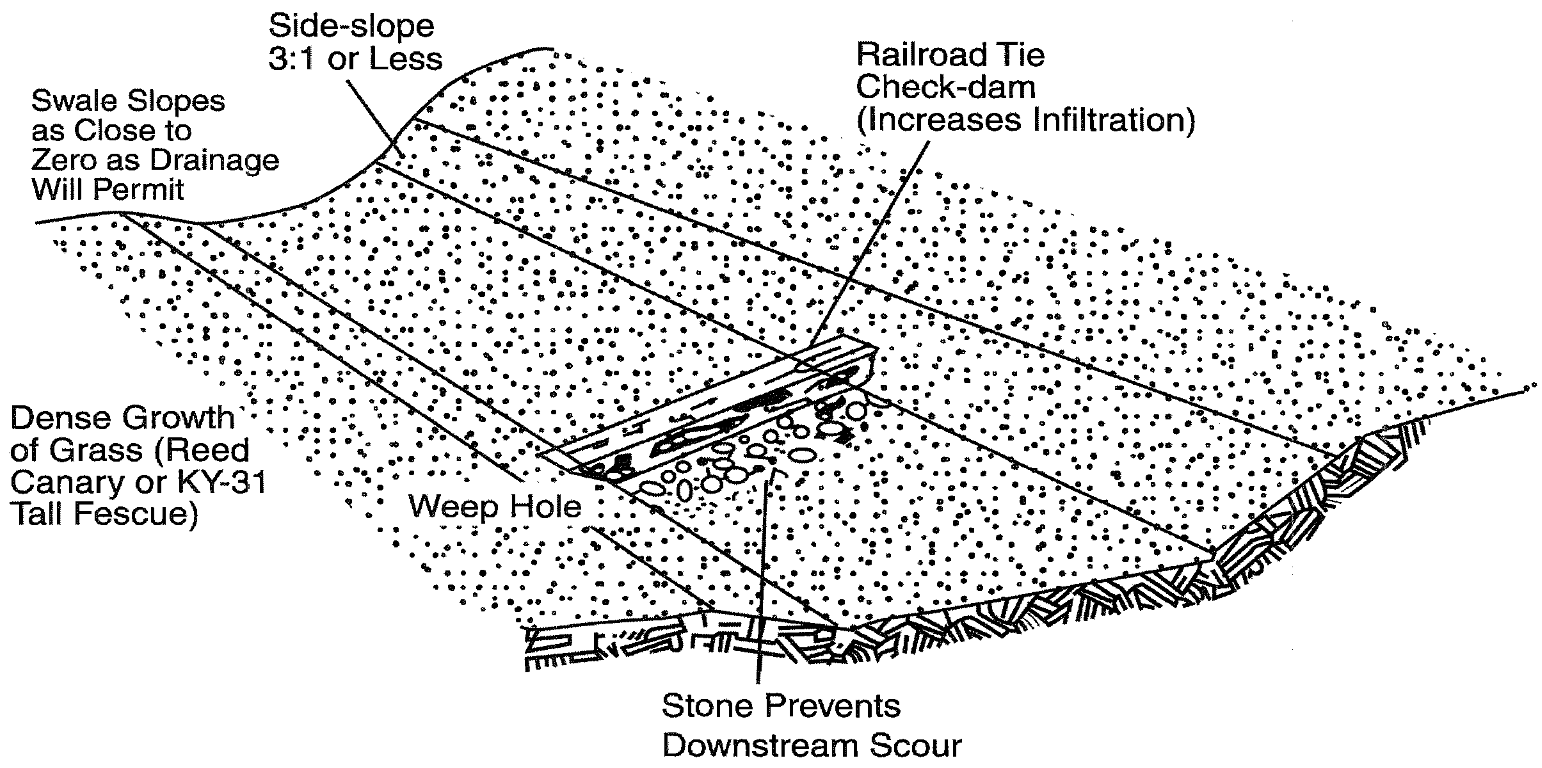


Figure 5.9
Grass Swale with Check Dam

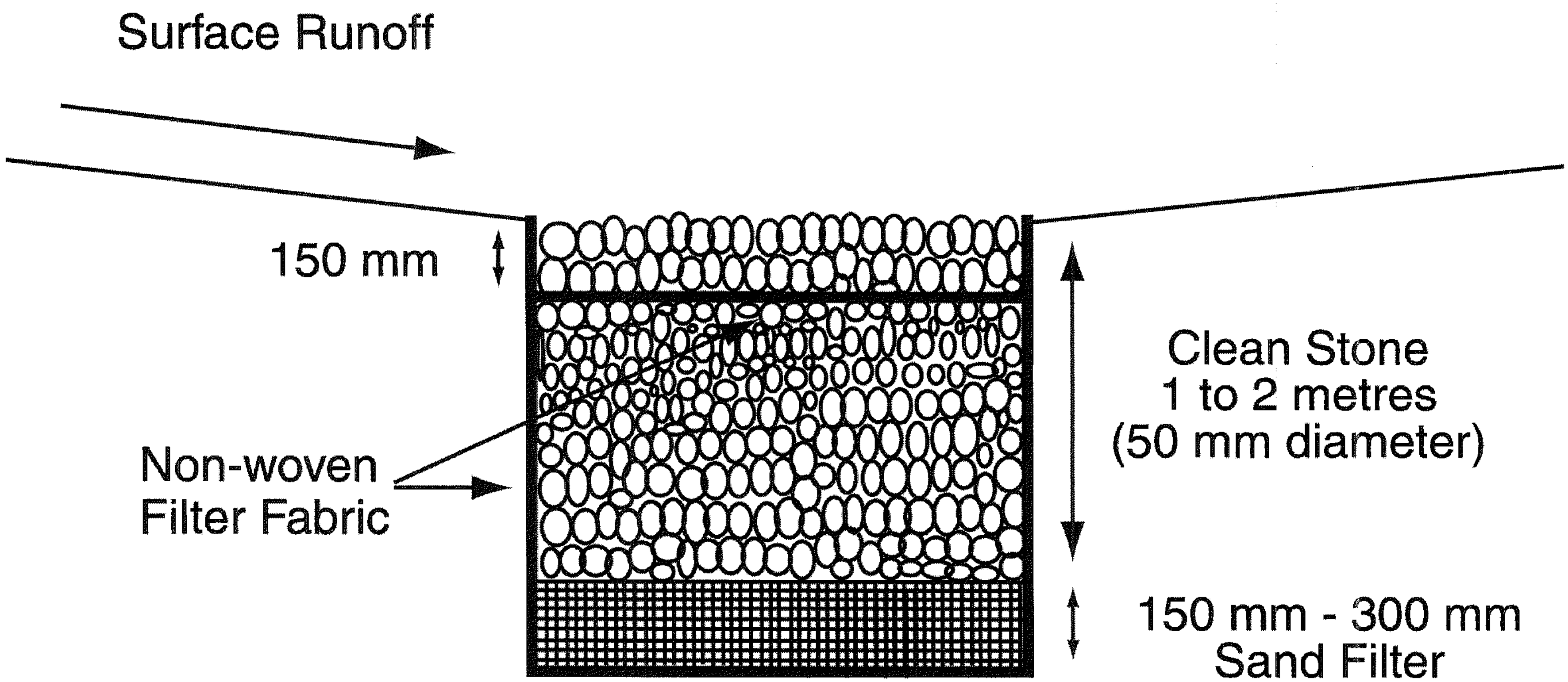


Figure 5.13
Surface Infiltration Trench

APPENDIX C
NEW JERSEY STORMWATER BEST MANAGEMENT PRACTICES MANUAL PUBLISHED IN FEBRUARY 2004

C H A P T E R 4

Stormwater Pollutant Removal Criteria

This chapter presents the criteria and methodologies necessary to determine the pollutant removal rates of stormwater management measures used individually and in series to meet the stormwater quality requirements of the Stormwater Management Rules at N.J.A.C. 7:8. According to these Rules, a “major development” project that creates at least 0.25 acres of new or additional impervious surface must include stormwater management measures that reduce the average annual total suspended solids (TSS) load in the development site’s post-construction runoff by 80 percent. This 80 percent requirement has been based, in part, upon Section 6217(g) of the 1990 Coastal Zone Management Act Reauthorization Amendments as enforced by the U.S. Environmental Protection Agency. In addition, these stormwater management measures must reduce the average annual nutrient load in the post-construction runoff by the maximum extent feasible. This requirement has been included in the Stormwater Management Rules because nutrients, consisting primarily of various forms of nitrogen and phosphorous, are recognized as a major class of stormwater pollutants from land development.

The stormwater management measures used to reduce the average annual TSS and nutrient loads can be structural and/or nonstructural in nature. To achieve the reduction requirements, they must be designed to treat the runoff from the stormwater quality design storm, a 1.25-inch/2-hour variable rate rainfall event. Details of the stormwater quality design storm are presented in *Chapter 5: Computing Stormwater Runoff Rates and Volumes*. Details of nonstructural and structural stormwater management measures, also known as Best Management Practices (BMPs), are presented respectively in *Chapter 2: Low Impact Development Techniques* and *Chapter 9: Structural Stormwater Management Measures.*

TSS Removal Rates for Individual BMPs

As noted above, the Stormwater Management Rules require an 80 percent TSS reduction in the post-construction runoff from a land development site that increases impervious surface by 0.25 acres or more. This reduction is to be achieved by conveying the site's runoff through one or more onsite BMPs that have the ability to remove a portion of the TSS load. To demonstrate compliance with this requirement, the NJDEP has adopted official TSS removal rates for each of the BMPs described in detail in Chapter 9. These BMPs and their adopted TSS removal rates are presented below in Table 4-1. Different removal rates and BMPs may be utilized if supporting information is provided and accepted by the applicable review agencies.

It is important to note that the TSS removal rates shown in Table 4-1 have been based upon several sources of BMP research and monitoring data as well as consultation with numerous stormwater management experts. As demonstrated by that research, actual TSS removals at specific BMPs during specific storm events will depend upon a number of site factors and can be highly variable. As such, the TSS removal rates presented in Table 4-1 are considered representative values that are based upon a recognition of this variability and the state's need to develop and implement a statewide stormwater management program. Furthermore, the TSS removal rates are also considered to accurately represent the relative TSS removal efficiencies of the various BMPs listed in the table.

Table 4-1: TSS Removal Rates for BMPs

Best Management Practice (BMP)	Adopted TSS Removal Rate (%)
Bioretention System	90
Constructed Stormwater Wetland	90
Dry Well	Volume Reduction Only[1]
Extended Detention Basin	40 to 60[2]
Infiltration Structure	80
Manufactured Treatment Device	See N.J.A.C. 7:8-5.7(d)[3]
Pervious Paving System	Volume Reduction Or 80[4]
Sand Filter	80
Vegetative Filter	60-80
Wet Pond	50-90[5]

[1] See text below.
[2] Final rate based upon detention time. See Chapter 9.
[3] To be determined through testing on a case-by-case basis. See text below.
[4] If system includes a runoff storage bed that functions as an infiltration basin. See Chapter 9.
[5] Final rate based upon pool volume and detention time. See Chapter 9.

As shown in Table 4-1, a dry well and certain types of pervious paving do not have an adopted TSS removal rate. This is due to the fact that, as described in Chapter 9, a dry well is intended to infiltrate runoff only from a roof and other impervious area with minimal TSS loading. A pervious paving system without a runoff storage bed can reduce the runoff volume from standard paving, but is not used to treat runoff from other impervious areas. As such, these systems are not considered to be effective in reducing the overall TSS load from a development site. However, in recognition of their infiltration ability, both BMPs can be used to reduce the volume of development site runoff and, consequently, the size and cost of other onsite BMPs. Use of these "volume reduction" BMPs are illustrated in Example 4-2 below and described in detail in Chapter 5.

In addition, Table 4-1 also indicates that the adopted TSS removal rates for manufactured treatment devices must be determined on a case-by-case basis. Manufactured treatment devices are proprietary water quality devices that use a variety of stormwater treatment techniques. They have and continue to be developed by a variety of companies. As such, the actual TSS removal rate for a specific device will depend on a number of factors, and a single representative TSS removal rate cannot be developed. Instead, the NJDEP's Division of Science, Research & Technology (DSRT) is responsible for certifying final pollutant removal rates for all manufactured treatment devices. This certification process is described in detail in Chapter 9.

Finally, as noted in Table 4-1, the adopted TSS removal rates for extended detention basins and wet ponds will vary depending on such specific features as detention time and permanent pool volume. Details for each BMP are also provided in Chapter 9.

TSS Removal Rates for BMPs in Series

The TSS removal rates specified in Table 4-1 for certain BMPs range as low as 40 percent, which indicates that these BMPs will not be able to meet the 80 percent TSS reduction requirement by themselves. As such, it will be necessary at times to use a series of BMPs in a treatment train to achieve the required 80 percent TSS removal rate. In such cases, the total removal rate of the BMP treatment train is based on the removal rate of the second BMP applied to the fraction of the TSS load remaining after the runoff has passed through the first BMP (Massachusetts DEP, 1997).

A simplified equation for the total TSS removal rate (R) for two BMPs in series is:

$$R = A + B - [(A \times B) / 100] \qquad \text{(Equation 4-1)}$$

Where:

R = Total TSS Removal Rate

A = TSS Removal Rate of the First or Upstream BMP

B = TSS Removal Rate of the Second or Downstream BMP

The use of this equation is demonstrated in Example 4-1 below.

Example 4-1: Total TSS Removal Rate for BMPs in Series

A stormwater management system consists of both a vegetative filter and an extended detention basin to collect and treat runoff from a small commercial parking lot. Runoff from the parking lot will sheet flow off the parking lot through the filter strip, which will have a turf grass surface cover, before being discharged to the extended detention basin. The extended detention basin will have a detention time of 18 hours.

From Table 4-1 and Chapter 9, the adopted TSS removal rates for these individual BMPs are:

Turf Grass Vegetative Filter = 60%

Extended Detention Basin with 18-Hour Detention Time = 50%

From Equation 4-1,

$$R = A + B – [(A X B) / 100]$$

$$R = 60 + 50 – [(60 X 50) /100] = 110 - 30 = 80\% \text{ Total TSS Removal Rate}$$

It should be noted that the total TSS removal rate of the stormwater management system described in Example 4-1 above can also be computed by the following technique:

Initial TSS Load Upstream of Vegetated Filter Strip = 1.0

TSS Load Removed by Vegetated Filter Strip = 1.0 X 60% Removal Rate = 0.6

Remaining TSS Load Downstream of Vegetated Filter Strip = 1.0 – 0.6 = 0.4

TSS Load Removed by Extended Detention Basin = 0.4 X 50% Removal Rate = 0.2

Final TSS Load Downstream of Extended Detention Basin = 0.4 – 0.2 = 0.2

Total TSS Removal Rate = 1.0 – 0.2 = 0.8 or 80%

This technique can also be used in place of Equation 4-1 when there are more than two BMPs in series.

Guidelines for Arranging BMPs in Series

As described in Example 4-1, it may be necessary or desirable to use a series of BMPs in a treatment train to provide adequate TSS removal. In selecting the order or arrangement of the individual BMPs, the following general guidelines should be followed:

1. Arrange the BMPs from upstream to downstream in ascending order of TSS removal rate. In this arrangement, the BMP with the lowest TSS removal rate would be located at the upstream end of the treatment train. Downstream BMPs should have progressively higher TSS removal rates.
2. Arrange the BMPs from upstream to downstream in ascending order of nutrient removal rate. Similar to 1 above, the BMP with the lowest nutrient removal rate would be located at the upstream end of the treatment train in this arrangement. Downstream BMPs should have progressively higher nutrient removal rates.
3. Arrange the BMPs from upstream to downstream by their relative ease of sediment and debris removal. In this arrangement, the BMP from which it is easiest to remove collected sediment and debris would be located at the upstream end of the treatment train. In downstream BMPs, it should be progressively more difficult to remove sediment and debris.

In applying these guidelines, it is recommended that they generally be applied in the order presented above. As such, a series of BMPs would be preliminarily arranged in accordance with their relative TSS removal rates (Guideline 1). This preliminary arrangement would then be refined by the BMPs' relative nutrient removal rate (Guideline 2) and then their ease of sediment and debris removal (Guideline 3). Two or more iterations may be necessary to select the optimum arrangement, which should also include consideration for site conditions and the abilities and equipment of the party responsible for the BMPs' maintenance.

Finally, it should be noted that, unless otherwise approved by the applicable reviewing agencies or specifically indicated in the certification of a specific manufactured treatment device, all manufactured treatment devices that achieve TSS removal primarily through swirling and/or baffles should be placed at the upstream end of a treatment train.

Sites with Multiple Discharge Points and Subareas

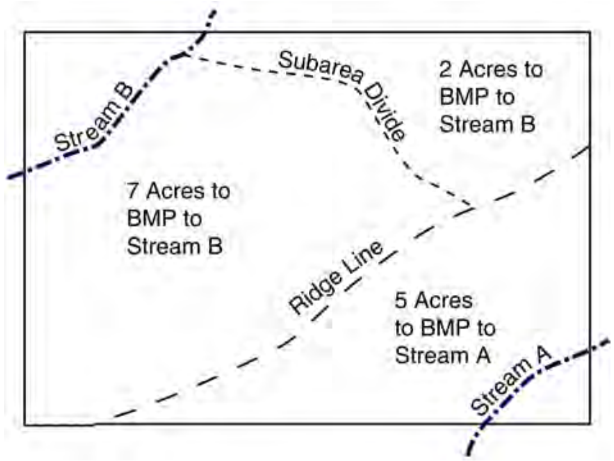
In general, if runoff is discharged from a site at multiple points, the 80 percent TSS removal requirement will have to be applied at each discharge point. However, the application of this requirement will depend upon the exact amount of physical and hydraulic separation between the various discharge points. If the runoff from two or more discharge points combine into a single waterway or conveyance system before leaving the site, these separate discharge points can be considered as a single one for purposes of computing TSS removal.

In addition, where there are multiple onsite subareas to a single discharge point, the removal rates for the subareas can be combined through a weighted averaging technique. It should be noted that the averaging of TSS removal rates is applicable only where the anticipated pollutant loadings from each of the subareas are similar. As such, the TSS removal rate for an onsite BMP receiving runoff from a commercial parking lot cannot be averaged with a second onsite BMP serving a lawn or landscaped area.

Example 4-2 below provides further explanations of the procedures described above for computing TSS removal rates at sites with both multiple discharge points and subareas.

Example 4-2: TSS Removal Rates at Sites with Multiple Discharge Points and Subareas

A 15-acre site has a ridge running through it from northeast to southwest. Five acres of the site drain in a southeasterly direction to Stream A, while the remaining 10 acres drain in a northwesterly direction to Stream B. Since Stream A and B do not join on the site, each portion of the site will have to be evaluated separately for compliance with the 80 percent TSS removal requirement.



Southeast Drainage to Stream A

The site runoff to Stream A will first be routed through a bioretention system.

The bioretention system TSS removal rate is 90 percent. This exceeds the 80 percent removal requirements and meets the TSS removal requirement for the southeast drainage area.

Northwest Drainage to Stream B

One acre of rooftop runoff from the stormwater quality design storm will be directed to dry wells, thereby reducing the drainage area to be served by other BMPs by 1 acre. The remaining 9 acres to Stream B are divided into two subareas of 2 and 7 acres, respectively. A vegetative filter will treat the runoff from one of the subareas, while a constructed stormwater wetland will treat the runoff from other. The anticipated pollutant loadings from each subarea are similar.

The TSS removal rate for a vegetative filter with meadow is 70 percent, which is not sufficient by itself to meet the 80 percent TSS removal requirement. However, the constructed stormwater wetland TSS removal rate is 90 percent, which exceeds the 80 percent TSS removal requirement. By averaging of removal rates, the use of these two BMPs may be sufficient to meet the 80 percent removal requirement for this portion of the site.

Two alternatives to address the TSS load in the runoff from the northwest portion of the site to Stream B are presented below.

OPTION A: The meadow vegetative filter will be used to treat the runoff from the 7 acre subarea, while the constructed stormwater wetland will be used in the 2 acre subarea.

Apply the various TSS removal rates to the areas to be treated by each BMP and determine the average TSS removal rate for the entire northwest portion of the site.

7 Acres X 70% TSS Removal for Vegetative Filter= 4.9

2 Acres X 90% TSS Removal for Wetland = 1.8

Total Acreage-Removal Rate = 4.9 + 1.8 = 6.7

6.7 Total Acreage-Removal Rate / 9 Acres = 0.74 or 74% Average TSS Removal Rate

Therefore, for Option A, the northwest portion of the site does not meet the 80 percent TSS removal requirement.

OPTION B: The vegetative filter will be used to treat the runoff from the 2 acre subarea, while the constructed stormwater wetland will be used in the 7 acre subarea.

Once again, apply the various TSS removal rates to the areas to be treated by each BMP and determine the average TSS removal rate for the entire northwest portion of the site.

2 Acres X 70% TSS Removal for Vegetative Filter = 1.4

7 Acres X 90% TSS Removal for Wetland = 6.3

Total Acreage-Removal Rate = 1.4 + 6.3 = 7.7

7.7 Total Acreage-Removal Rate / 9 Acres = 0.86 or 86% Average TSS Removal Rate

Therefore, for Option B, the northwest portion of the site does meet the 80 percent TSS removal requirement.

Nutrients

In addition to TSS removal, the Stormwater Management Rules also require the reduction of post-construction nutrients to the maximum extent feasible. In general, to demonstrate compliance with this requirement, a two step approach should be used. First, the input of nutrients to the drainage area should be limited as much as feasible. Second, when selecting a stormwater management measure to address the TSS removal requirement, the measure with the best nutrient removal rate that also best meets the site's constraints should be chosen. Details of each step in this approach are provided below.

Reducing Nutrient Input

A significant amount of nutrients are in stormwater runoff due to fertilization of lawns. As described in Chapter 2, lawns should be minimized in favor of other vegetated cover. Existing site areas with desirable vegetation communities should be left in a natural state and forested areas and meadows should be considered as alternatives to the standard lawn. Ground covers provide aesthetically pleasing, innovative landscapes that are adaptable to the local environment. These types of land cover reduce lawn area and the consequent need for fertilization. A landscape design that minimizes the use of lawn can be beneficial in preventing pesticides, as well as nutrients from fertilizers, from stormwater runoff.

Soil testing determines the soil nutrient level as well as pH. Using the test results to determine the appropriate application of lime and fertilizer required for lawn areas will increase efficient uptake and decrease associated costs of lawn maintenance as well as minimize nutrient input. Low or no phosphorous fertilizers may be adequate to maintain the health of the landscape after the vegetation has fully established. Soil test kits are available at most lawn and garden care centers as well as through the Rutgers Cooperative Extension county offices. Fertilization specifications must be included in the maintenance manual.

Pet waste is another source of nutrients in stormwater runoff. To prevent or minimize pet waste problems, residents must be required to pick up after their animal and dispose of the material in the toilet or garbage. Homeowner associations must include this condition in homeowner's agreements. Signage should be located strategically throughout the development to reinforce this criterion. Education is critical to successful pet waste management.

Nutrient Removal Rates

Site conditions and the need to reduce post-construction TSS by 80 percent are primary factors in the selection of appropriate BMPs for a development site. However, removal of nutrients such as phosphorous and the various forms of nitrogen must also be considered in this selection process. The chosen BMP must meet the TSS criteria, but must also maximize nutrient removal for the site. To assist with the selection of BMPs for nutrients, information regarding estimated nutrient removal rates is provided in Table 4-2.

Table 4.2 – Typical Phosphorous and Nitrogen Removal Rates for BMPs

Best Management Practice (BMP)	Total Phosphorous Removal Rate (%)	Total Nitrogen Removal Rate (%)
Bioretention Basin	60	30
Constructed Stormwater Wetland	50	30
Extended Detention Basin	20	20
Infiltration Basin	60	50
Manufactured Treatment Devices	See N.J.A.C. 7:8-5.7(d)	See N.J.A.C. 7:8-5.7(d)
Pervious Paving[2]	60	50
Sand Filter	50	35
Vegetative Filter	30	30
Wet Pond	50	30

The nutrient removal rates presented in Table 4-2 should be considered typical values based upon data from a range of research studies. Due to the multiple forms and complex behavior of nutrients in stormwater runoff and the similarly complex processes by which nutrient loading is altered by BMPs, actual removal rates for specific BMPs and development sites may vary.

The nutrient removal data in Table 4-2 is intended to assist designers in the selection of appropriate BMPs to meet both the 80 percent TSS and maximum feasible nutrient removal requirements in the NJDEP Stormwater Management Rules. During this selection process, primary consideration should be given to achieving the Rules' 80 percent TSS removal requirement with one or more BMPs that are compatible with and responsive to site conditions and constraints, maintenance needs, and safety concerns. The selection process should then be further refined to achieve the Rules' maximum feasible nutrient requirement utilizing the structural BMP data in Figure 4.2 and, as necessary, other appropriate resources. In doing so, it should be remembered that many nonstructural BMPs can also help achieve the nutrient removal requirement, and must be considered prior to the use of structural BMPs.

The nutrient removal data in Table 4-2 can also be used to optimize existing BMP retrofits.

Additional Considerations

From the information presented in this chapter, it should be evident that BMPs are intended to reduce the pollutants in stormwater runoff. However, sometimes an unintended consequence of stormwater management facilities is their attractiveness to waterfowl, such as Canada geese. Canada geese are attracted to lawn areas adjacent to water bodies. As such, wet ponds and other stormwater management structures can appeal to these waterfowl, whose resulting fecal input can result in an increase in nutrient loading to systems that are intended to reduce such pollutants. As a result, adjustments to a BMP's design and/or maintenance plan may be necessary to discourage waterfowl from contributing pollutants to the stormwater measure. Additional guidance on Canada geese is available in Management of Canada Geese in Suburban Areas: A Guide to the Basics, available at http://www.state.nj.us/dep/watershedmgt/DOCS/BMP_DOCS/Goosedraft.pdf.

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APPENDIX D
DETAILED MODEL RESULTS

15-5497 - Fall River South Development - Water Quality Model (Pre-Development) 6/22/2016

Pre-Development Conditions									
Land Use	**Area m^2**	**Area-ha**	**Avg Annual Precipitation (m)**	**Runoff C**	**Total Runoff (m^3)**	**TSS - mg/L**	**TSS - kg**	**TP-mg/L**	**TP-kg**
Upland Forest	39,290	3.929	1.40	0.15	8228.50	19.7	162.10	0.2	1.65
Forested Wetland	11,400	1.14	1.40	0.1	1591.67	19	30.24	0.2	0.32
Total	**50,690**	**5.069**			**9820.17**		**192.34**		**1.96**

Post-Development Conditions									
Land Use	**Area m^2**	**Area-ha**	**Avg Annual Precipitation (m)**	**Runoff C**	**Total Runoff (m^3)**	**TSS - mg/L**	**TSS - kg**	**TP-mg/L**	**TP-kg**
Medium-Density Residential	16,700	1.67	1.40	0.84	19585.89	30.5	597.37	0.2	3.92
Highways	3,331	0.3331	1.40	0.7	3255.52	57.8	188.17	0	0.00
Urban Open	30,659	3.0659	1.40	0.15	6420.91	20	128.42	0.2	1.28
Total	**50,690**	**5.069**			**29262.33**		**913.96**		**5.20**

Effect of urbanization with no control

	Existing Land Use	**Future Land Use**	**Net Change**
Annual TP Loading (kg)	1.96	5.20	Increase

Runoff Coefficients

Land Type	% Land	Runoff C
Residential Impervious	90%	0.9
Residential Pervious	10%	0.3

Weighted Residential Runoff C **0.84**

15-5497 - Fall River South Development - Water Quality Model (Natural BMPs) 6/22/2016

The Rylan - Post-Development Conditions									
Land Use	**Area m^2**	**Area-ha**	**Avg Annual Precipitation (m)**	**Runoff C**	**Total Runoff (m^3)**	**TSS - mg/L**	**TSS - kg**	**TP-mg/L**	**TP-kg**
Medium-Density Residential	4,333	0.4333	1.40	0.84	5081.78	30.5	154.99	0.2	1.02
Urban Open	4,794	0.4794	1.40	0.15	1004.01	20	20.08	0.2	0.20
Total	**9,127**	**0.9127**			**6085.78**		**175.07**		**1.22**

Land Use	TP - mg/L	TP - kg Uncontrolled	TP - kg Grass Swale	TP - kg Infiltration Trench
Medium-Density Residential	0.2	1.02	0.65	0.26
Urban Open	0.2	0.20	0.13	0.05
Total	**0.40**	**1.22**	**0.78**	**0.31**

Length of Ditch (m)	146
Length of Grass Swale (m)	120
Length of Infiltration Trench (m)	20
Multiples of 60m swales	2.00
Weighted TP Removal efficiency (%)	36.00

The Addison - Post-Development Conditions									
Land Use	**Area m^2**	**Area-ha**	**Avg Annual Precipitation (m)**	**Runoff C**	**Total Runoff (m^3)**	**TSS - mg/L**	**TSS - kg**	**TP-mg/L**	**TP-kg**
Medium-Density Residential	3,942	0.3942	1.40	0.84	4623.21	30.5	141.01	0.2	0.92
Urban Open	7,664	0.7664	1.40	0.15	1605.07	20	32.10	0.2	0.32
Total	**11,606**	**1.1606**			**6228.28**		**173.11**		**1.25**

Land Use	TP - mg/L	TP - kg Uncontrolled	TP - kg Grass Swale	TP - kg Infiltration Trench
Medium-Density Residential	0.2	0.92	0.74	0.30
Urban Open	0.2	0.32	0.26	0.10
Total	**0.40**	**1.25**	**1.00**	**0.40**

Length of Ditch (m)	107
Length of Grass Swale (m)	60
Length of Infiltration Trench (m)	20
Multiples of 60m swales	1.00
Weighted TP Removal efficiency (%)	20.00

The Chloe - Post-Development Conditions									
Land Use	**Area m^2**	**Area-ha**	**Avg Annual Precipitation (m)**	**Runoff C**	**Total Runoff (m^3)**	**TSS - mg/L**	**TSS - kg**	**TP-mg/L**	**TP-kg**
Medium-Density Residential	4,263	0.4263	1.40	0.84	4999.68	30.5	152.49	0.2	1.00
Urban Open	9,096	0.9096	1.40	0.15	1904.98	20	38.10	0.2	0.38
Total	**13,359**	**1.3359**			**6904.66**		**190.59**		**1.38**

Land Use	TP - mg/L	TP - kg Uncontrolled	TP - kg Grass Swale	TP - kg Infiltration Trench
Medium-Density Residential	0.2	1.00	0.64	0.26
Urban Open	0.2	0.38	0.24	0.10
Total	**0.40**	**1.38**	**0.88**	**0.35**

Length of Ditch (m)	140
Length of Grass Swale (m)	120
Length of Infiltration Trench (m)	20
Multiples of 60m swales	2.00
Weighted TP Removal efficiency (%)	36.00

The Morgan - Post-Development Conditions									
Land Use	**Area m^2**	**Area-ha**	**Avg Annual Precipitation (m)**	**Runoff C**	**Total Runoff (m^3)**	**TSS - mg/L**	**TSS - kg**	**TP-mg/L**	**TP-kg**
Medium-Density Residential	1,900	0.19	1.40	0.84	2228.34	30.5	67.96	0.2	0.45
Urban Open	2,681	0.2681	1.40	0.15	561.48	20	11.23	0.2	0.11
Total	**4,581**	**0.4581**			**2789.82**		**79.19**		**0.56**

Land Use	TP - mg/L	TP - kg Uncontrolled	TP - kg Grass Swale	TP - kg Infiltration Trench
Medium-Density Residential	0.2	0.45	0.36	0.14
Urban Open	0.2	0.11	0.09	0.04
Total	**0.40**	**0.56**	**0.45**	**0.18**

Length of Ditch (m)	100
Length of Grass Swale (m)	60
Length of Infiltration Trench (m)	20
Multiples of 60m swales	1.00
Weighted TP Removal efficiency (%)	20.00

Self Storage - Post-Development Conditions									
Land Use	**Area m^2**	**Area-ha**	**Avg Annual Precipitation (m)**	**Runoff C**	**Total Runoff (m^3)**	**TSS - mg/L**	**TSS - kg**	**TP-mg/L**	**TP-kg**
Medium-Density Residential	3,050	0.305	1.40	0.84	3577.06	30.5	109.10	0.2	0.72
Urban Open	5,636	0.5636	1.40	0.15	1180.35	20	23.61	0.2	0.24
Total	**8,686**	**0.8686**			**4757.41**		**132.71**		**0.95**

Land Use	TP - mg/L	TP - kg Uncontrolled	TP - kg Grass Swale	TP - kg Infiltration Trench
Medium-Density Residential	0.2	0.72	0.46	0.18
Urban Open	0.2	0.24	0.15	0.06
Total	**0.40**	**0.95**	**0.61**	**0.24**

Length of Ditch (m)	170
Length of Grass Swale (m)	120
Length of Infiltration Trench (m)	20
Multiples of 60m swales	2.00
Weighted TP Removal efficiency (%)	36.00

Road Extension - Post-Development Conditions									
Land Use	**Area m^2**	**Area-ha**	**Avg Annual Precipitation (m)**	**Runoff C**	**Total Runoff (m^3)**	**TSS - mg/L**	**TSS - kg**	**TP-mg/L**	**TP-kg**
Highways	3,331	0.3331	1.40	0.7	3255.52	57.8	188.17	0	0.00
Total	**3,331**	**0.3331**			**3255.52**		**188.17**		**0.00**

	Total Area	**Total TP** Infiltration Trench
Pre-Development	50,690	1.96
Post-Development	50,690	1.49
Net Change	**N/A**	**Decrease**

15-5497 - Fall River South Development - Water Quality Model (Sorbative Vault) 6/22/2016

The Rylan - Post-Development Conditions									
Land Use	**Area m^2**	**Area-ha**	**Avg Annual Precipitation (m)**	**Runoff C**	**Total Runoff (m^3)**	**TSS - mg/L**	**TSS - kg**	**TP-mg/L**	**TP-kg**
Medium-Density Residential	4,333	0.4333	1.40	0.84	5081.78	30.5	154.99	0.2	1.02
Urban Open	4,794	0.4794	1.40	0.15	1004.01	20	20.08	0.2	0.20
Total	**9,127**	**0.9127**			**6085.78**		**175.07**		**1.22**

Land Use	TP - mg/L	TP - kg	TP - kg
		Uncontrolled	Sorbative Media
Medium-Density Residential	0.2	1.02	0.20
Urban Open	0.2	0.20	0.04
Total	**0.40**	**1.22**	**0.24**

The Addison - Post-Development Conditions									
Land Use	**Area m^2**	**Area-ha**	**Avg Annual Precipitation (m)**	**Runoff C**	**Total Runoff (m^3)**	**TSS - mg/L**	**TSS - kg**	**TP-mg/L**	**TP-kg**
Medium-Density Residential	3,942	0.3942	1.40	0.84	4623.21	30.5	141.01	0.2	0.92
Urban Open	7,664	0.7664	1.40	0.15	1605.07	20	32.10	0.2	0.32
Total	**11,606**	**1.1606**			**6228.28**		**173.11**		**1.25**

Land Use	TP - mg/L	TP - kg	TP - kg
		Uncontrolled	Sorbative Media
Medium-Density Residential	0.2	0.92	0.18
Urban Open	0.2	0.32	0.06
Total	**0.40**	**1.25**	**0.25**

The Chloe - Post-Development Conditions									
Land Use	**Area m^2**	**Area-ha**	**Avg Annual Precipitation (m)**	**Runoff C**	**Total Runoff (m^3)**	**TSS - mg/L**	**TSS - kg**	**TP-mg/L**	**TP-kg**
Medium-Density Residential	4,263	0.4263	1.40	0.84	4999.68	30.5	152.49	0.2	1.00
Urban Open	9,096	0.9096	1.40	0.15	1904.98	20	38.10	0.2	0.38
Total	**13,359**	**1.3359**			**6904.66**		**190.59**		**1.38**

Land Use	TP - mg/L	TP - kg	TP - kg
		Uncontrolled	Sorbative Media
Medium-Density Residential	0.2	1.00	0.20
Urban Open	0.2	0.38	0.08
Total	**0.40**	**1.38**	**0.28**

The Morgan - Post-Development Conditions									
Land Use	**Area m^2**	**Area-ha**	**Avg Annual Precipitation (m)**	**Runoff C**	**Total Runoff (m^3)**	**TSS - mg/L**	**TSS - kg**	**TP-mg/L**	**TP-kg**
Medium-Density Residential	1,900	0.19	1.40	0.84	2228.34	30.5	67.96	0.2	0.45
Urban Open	2,681	0.2681	1.40	0.15	561.48	20	11.23	0.2	0.11
Total	**4,581**	**0.4581**			**2789.82**		**79.19**		**0.56**

Land Use	TP - mg/L	TP - kg	TP - kg
		Uncontrolled	Sorbative Media
Medium-Density Residential	0.2	0.45	0.09
Urban Open	0.2	0.11	0.02
Total	**0.40**	**0.56**	**0.11**

Self Storage - Post-Development Conditions									
Land Use	**Area m^2**	**Area-ha**	**Avg Annual Precipitation (m)**	**Runoff C**	**Total Runoff (m^3)**	**TSS - mg/L**	**TSS - kg**	**TP-mg/L**	**TP-kg**
Medium-Density Residential	3,050	0.305	1.40	0.84	3577.06	30.5	109.10	0.2	0.72
Urban Open	5,636	0.5636	1.40	0.15	1180.35	20	23.61	0.2	0.24
Total	**8,686**	**0.8686**			**4757.41**		**132.71**		**0.95**

Land Use	TP - mg/L	TP - kg	TP - kg
		Uncontrolled	Sorbative Media
Medium-Density Residential	0.2	0.72	0.14
Urban Open	0.2	0.24	0.05
Total	**0.40**	**0.95**	**0.19**

Road Extension - Post-Development Conditions									
Land Use	**Area m^2**	**Area-ha**	**Avg Annual Precipitation (m)**	**Runoff C**	**Total Runoff (m^3)**	**TSS - mg/L**	**TSS - kg**	**TP-mg/L**	**TP-kg**
Highways	3,331	0.3331	1.40	0.7	3255.52	57.8	188.17	0	0.00
Total	**3,331**	**0.3331**			**3255.52**		**188.17**		**0.00**

	Total Area	**Total TP**
Pre-Development	50,690	1.96
Post-Development	50,690	1.07
Net Change	**N/A**	**Decrease**

October 30, 201□

Cesar Saleh
WM Fares Architects
34□0 Joseph Howe Drive
Suite 500
Halifax, NS B3L 4H7

Sent via email to cesar.saleh@wmfares.com

Dear Mr. Saleh:

Re: Phosphorus Study Requirement

Within the River-Lakes Secondary Planning Strategy, discretionary planning applications are sub□ect to Policy RL-22 (see attached). Policy RL-22 states "*A study prepared by a qualified person shall be required for any proposed development pursuant to these policies to determine if the proposed development will export any greater amount of phosphorus from the subject land area during or after the construction of the proposed development than the amount of phosphorus determined to be leaving the site prior to the development taking place."* To assist in the creation of this study, HRM has developed PNLA (Phosphorus Net Loading Assessment) Guidelines (see attached). These guidelines are designed to ensure a consistent approach is taken and that there is sufficient information received to allow for HRM's review and assessment of the proposal to ensure the development is reasonable consistent with the intent of policy RL-22.

All PNLA studies must consider all the following conditions (Section 5.4.1 of attached Guidelines):

- Land-use
- Buildings
- Roads
- Vegetation
- Slope
- Soil cover texture
- Depth to bedrock
- Rainfall
- Surface drainage
- Buffers
- Setbacks of septic systems from lakes
- Wetlands
- Sensitive natural features
- Groundwater

Please be advised that the phosphorus study submitted in support of Case 21460 has been deemed incomplete as it does not consider all the conditions listed above. Please refer to the attached guidelines for further information on what is required to satisfy the requirements under Policy RL-22 of the River-Lakes Secondary Planning Strategy of the Municipal Planning Strategy for Planning District 14 and 17 (Shubenacadie Lakes).

If you have any questions or concerns, please do not hesitate to contact me.

Yours Truly,

Original Signed

Stephanie Salloum
Planner
Planning & Development
Halifax Regional Municipality
Tel □02.4□0.4223
Email sallous□ halifax.ca

Attachment A
Policy RL-22 of the River-Lakes Secondary Planning Strategy

Water Quality Objectives

Given the environmental sensitivity of the Shubenacadie Lakes and the desire of residents to preserve and protect its water quality, the Study recommends an oligotrophic status with an upper limit of 10µg/L should be maintained for Grand Lake. This is also desirable since Grand Lake is a municipal water supply for the Municipality of East Hants. Trophic Status limits should also be set for the lakes upstream from Grand Lake, Lake Fletcher, Lake Thomas, Kinsac, William and Charles - to ensure that this objective is maintained.

The Study recommends an upper limit of 20µg/L for Lake Thomas and Lake Fletcher which are within the River-lakes Secondary Planning Strategy Area. It also recommends 20µg/L for Lake William which may be impacted by future developments in the southern portion of the Plan Area that is within the Lake William Sub-watershed. Although a limitation of 20µg/L will maintain Lake William, Lake Thomas and Lake Fletcher at the upper range mesotrophic level in the long-term, this Secondary Planning Strategy has no control over the developments that are in the portions of these sub-watersheds that area outside of this Plan Area.

The proposed regulations for the River-lakes Village Centre Designation will significantly reduce the permitted floorspace and amount of impervious surface within the River-lakes Village Centre Designation from the previous regulations under the C-2 (Community Commercial) and C-4 (Highway Commercial) Zones. The new regulations proposed under the River-lakes Village Centre Designation Zones require the retention of a minimum of 50% of each site as pervious surface. The permitted building footprint for all buildings permitted within the various zones has been reduced from 10,000 square feet to anywhere between 2000 to 4000 square feet depending on the zone. The Regional Plan requires the retention of riparian buffers and wetlands which will also aid in the uptake of phosphorus and ameliorate its impacts. However, there is a substantial amount of housing development proposed within the southern and northern portions of the Secondary Planning Strategy Area which should be assessed to ensure that it does not exceed the capacity of the receiving waters to assimilate phosphorus without exceeding the water quality objectives established under this Secondary Plan.

In order to maintain the health and resilience of these receiving waters, this Secondary Planning Strategy will establish a no net increase phosphorus export policy for any future residential developments exceeding 8 units/lots within the River Lakes Secondary Planning Strategy Area. Pursuant to the Regional Plan, any development requiring a new road for the development of more than 8 lots is only allowed to proceed under the provisions of a development agreement. As part of the assessment process for a development agreement, applicants shall be required to submit a study by a qualified person demonstrating that the proposed development will not export any more phosphorus from the site than what may be exported from the site prior to the development taking place. The total amount of phosphorus that is expected to be exported from the site prior to the undertaking of a development shall in effect become the phosphorus budget or limit for the amount of phosphorus that may be allowed to be exported from the site under the proposed development for that area. If the amount of phosphorus for a proposed development exceeds the phosphorus budget for the site, then the density of development will have to be adjusted to reduce the phosphorus impacts on the receiving environment. The feasibility of continuing development in the northern portion of the Secondary Planning Strategy Area should be reviewed during the Phase II planning process.

In order to achieve an appropriate balance of development throughout the Shubenacadie Lakes System and to maintain an oligotrophic level for Grand Lake, water quality objectives should be established for each contributing sub-watershed after HRM adopts a water quality monitoring functional plan. HRM is currently undertaking a watershed study of the Shubenacadie Lakes Watershed to assess the impacts of potential future development in the Port Wallis area within the Lake Charles Sub-watershed. It would be appropriate to review the River-lakes Secondary Planning Strategy when setting targets for future growth in the Lake Charles or Lake William sub-watersheds that are upstream from Fall River. At this time, threshold values should be set for the Shubenacadie Lakes System against which to regulate the density of all future development.

RL-22 The River-lakes Secondary Planning Strategy shall establish a no net increase in phosphorus as the performance standard for all large scale developments considered through the provisions of policy RL-13 and development agreement (RC-Mar 5/19;E-Apr 6/19) policies RL-4, RL-5, RL-11, RL-12, RL-14 and RL-15 of this Secondary Plan. This Policy shall also apply to proposed developments pursuant to policies S-15 and S-16 of the Regional Municipal Planning Strategy. A study prepared by a qualified person shall be required for any proposed development pursuant to these policies to determine if the proposed development will export any greater amount of phosphorus from the subject land area during or after the construction of the proposed development than the amount of phosphorus determined to be leaving the site prior to the development taking place. If the study reveals that the phosphorus levels predicted to be exported from the proposed development exceed the phosphorus levels currently exported from the site, then the proposed development will not be permitted to take place unless there are reductions in density or *other methods that* (RC-Feb 23/16;E-Apr 2/16) to reduce phosphorus export levels to those current before the proposed development. *Any stormwater management* *devices designed to treat phosphorus must be located on the privately-owned land included in the proposed development agreement.* (RC-Feb 23/16;E-Apr 2/16) The cost of the study shall be borne by the applicant. The study may rely on phosphorus export coefficients derived from existing studies if they can be justified for application to local environmental conditions. All existing and proposed development within the affected area shall be taken into account and the consultant shall undertake Wet Areas Mapping to help define the ecological boundaries associated with the flow channels, accumulation points, and riparian zones to restrict any high impact development in those areas.

RL-23 The following measures shall be incorporated into the provisions for Opportunity Site B and (RC-Mar 5/19;E-Apr 6/19) all development agreements in the River-lakes Secondary Planning Strategy Area:

(a) A site non- disturbance area of a minimum of 50% of the site or greater if required pursuant to any other policies within this Secondary Planning Strategy or the Regional Municipal Planning Strategy; and

(b) Stormwater management and erosion and sedimentation control plans are in place to minimize impact on receiving waters.

Appendix C
Well Logs

Well Log Record: # 580095

Well Number: 580095
Type: DRILLED
Date Well Completed (mm-dd-yyyy): 12-31-1958

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Well Owner/Contractor and Location

Well Drilled for: D.R. DRISCOLL
or Contractor/Builder/Consultant: n/a

Civic Address of Well: n/a
Lot #: n/a
Subdivision: n/a
County: HALIFAX
Postal Code: n/a
Nearest Community in Atlas/Map Book: FALL RIVER

Certified Well Contractor

Driller Name: BOWMASTER
Certificate No: 3
Company: WILLIAM BOWMASTER, SR.

Well Status / Water Use

Final Status of Well: Water Supply Well
Water Use: Domestic
Method of Drilling: Rotary

Well Location

Nova Scotia Atlas or Map Book Reference

Atlas or Map Book: NTS
Map Page No.: n/a
Reference Letter: n/a
Reference Number: n/a
Roamer Letter: n/a
Roamer Number: n/a

NTS Map Reference

Map Sheet: 11D13
Reference Map: A
Tract No.: 30
Claim: E

GPS (WGS84 UTM)

Northing (m): 4959032
Easting (m): 450761
Property (PID): n/a
Well Location Sketch Available: n/a

Stratigraphy Log

Geology	Colour	Description	Lithology	Water Found
From (depth in ft): 0 to: 128				
Primary Geology	n/a	n/a	UNKNOWN	n/a
Secondary Geology	n/a	n/a	n/a	

Geology	Colour	Description	Lithology	Water Found
From (depth in ft): 128 to: 128				
Primary Geology	n/a	n/a	MINE ROCK	n/a
Secondary Geology	n/a	n/a	n/a	

Well Construction Information

Total Depth Below Surface (ft): 128
Depth to Bedrock (ft): n/a
Water Bearing Fractures Encountered at (ft): n/a
Outer Well Casing: From (ft): n/a To: 66
Diameter (in): n/a
Length of Casing Above Ground (ft): n/a and (in): n/a
Driveshoe Make: n/a

Water Yield

Estimated Yield (igpm): n/a
Method: AIR LIFT
Rate (igpm): 1.75
Duration (hrs): n/a
Depth to Water at end of Test (ft): n/a
Total Drawdown (ft): n/a
Water Level Recovered to (ft): n/a
Recovery Time (hrs): n/a
Depth to Static Level (ft): n/a
Overflow: n/a

Comments

n/a

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Well Log Record

Well Log Record: # 741678

Well Number: 741678
Type: DRILLED
Date Well Completed (mm-dd-yyyy): 4-29-1974

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Well Owner/Contractor and Location

Well Drilled for: NOVA PROJECT MANAG LTD
or Contractor/Builder/Consultant: n/a

Civic Address of Well: n/a
Lot #: n/a
Subdivision: EAGLE POINT
County: HALIFAX
Postal Code: n/a
Nearest Community in Atlas/Map Book: LOWER SACKVILLE

Certified Well Contractor

Driller Name: BOWMASTER, W. L.
Certificate No: 70
Company: W. L. BOWMASTER WELL DRILLING LTD.

Well Status / Water Use

Final Status of Well: n/a
Water Use: Domestic
Method of Drilling: Rotary

Well Location

Nova Scotia Atlas or Map Book Reference

Atlas or Map Book: NTS
Map Page No.: n/a
Reference Letter: n/a
Reference Number: n/a
Roamer Letter: n/a
Roamer Number: n/a

NTS Map Reference

Map Sheet: 11D13
Reference Map: A
Tract No.: 31
Claim: J

GPS (WGS84 UTM)

Northing (m): 4959420
Easting (m): 450352
Property (PID): n/a
Well Location Sketch Available: n/a

Stratigraphy Log

Geology	Colour	Description	Lithology	Water Found

Geology	Colour	Description	Lithology	Water Found
From (depth in ft): 0 to: 27				
Primary Geology	n/a	n/a	BOULDERS & CLAY	n/a
Secondary Geology	n/a	n/a	n/a	
From (depth in ft): 27 to: 260				
Primary Geology	n/a	n/a	GRANITE	n/a
Secondary Geology	n/a	n/a	n/a	

Well Construction Information

Total Depth Below Surface (ft): 260
Depth to Bedrock (ft): 27
Water Bearing Fractures Encountered at (ft): 250
Outer Well Casing: From (ft): 7 To: 31
Diameter (in): 6
Length of Casing Above Ground (ft): n/a and (in): n/a
Driveshoe Make: unknown

Water Yield

Estimated Yield (igpm): n/a
Method: PUMPED
Rate (igpm): 1.25
Duration (hrs): 1
Depth to Water at end of Test (ft): n/a
Total Drawdown (ft): n/a

Water Level Recovered to (ft): n/a
Recovery Time (hrs): n/a
Depth to Static Level (ft): 100
Overflow: n/a

Comments

n/a

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Well Log Record

Well Log Record: # 993277

Well Number: 993277
Type: DRILLED
Date Well Completed (mm-dd-yyyy): 4-29-1999

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Well Owner/Contractor and Location

Well Drilled for: HYDROGEOLOGY FIELD SCHOOL DEMO WELL #1 (DW-1)
or Contractor/Builder/Consultant: AQUATERRA RESOURCE SERVICES LIMITED

Civic Address of Well: 21 OLD COBEQUID ROAD
Lot #: n/a
Subdivision: n/a
County: HALIFAX
Postal Code: n/a
Nearest Community in Atlas/Map Book: WAVERLEY

Certified Well Contractor

Driller Name: EDWARDS, HARRY A.
Certificate No: 83
Company: H. J. EDWARDS WELL DRILLING LTD.

Well Status / Water Use

Final Status of Well: Observation Well
Water Use: Observation
Method of Drilling: Rotary

Well Location

Nova Scotia Atlas or Map Book Reference

Atlas or Map Book: ATLAS
Map Page No.: 58
Reference Letter: Y
Reference Number: 5
Roamer Letter: G
Roamer Number: 2

NTS Map Reference

Map Sheet: n/a
Reference Map: n/a
Tract No.: n/a
Claim: n/a

GPS (WGS84 UTM)

Northing (m): 4958996
Easting (m): 451255
Property (PID): 40128241
Well Location Sketch Available: n/a

Stratigraphy Log

Geology	Colour	Description	Lithology	Water Found

Geology	Colour	Description	Lithology	Water Found
From (depth in ft): 0 to: 11				
Primary Geology	n/a	n/a	SAND & GRAVEL	n/a
Secondary Geology	n/a	n/a	n/a	
From (depth in ft): 11 to: 15				
Primary Geology	n/a	n/a	GRAVEL	Yes
Secondary Geology	n/a	n/a	WATER	
From (depth in ft): 15 to: 200				
Primary Geology	See Comments	See Comments	QUARTZITE	n/a
Secondary Geology	n/a	See Comments	SLATE	

Well Construction Information

Total Depth Below Surface (ft): 200
Depth to Bedrock (ft): 15
Water Bearing Fractures Encountered at (ft): 20, 58, 70, 82, 112, 189
Outer Well Casing: From (ft): 0 To: 20
Diameter (in): 6
Length of Casing Above Ground (ft): 1.05 and (in): n/a
Driveshoe Make: unknown

Water Yield

Estimated Yield (igpm): n/a
Method: AIR LIFT
Rate (igpm): 0.5
Duration (hrs): 1
Depth to Water at end of Test (ft): n/a
Total Drawdown (ft): n/a
Water Level Recovered to (ft): n/a
Recovery Time (hrs): n/a
Depth to Static Level (ft): 4.76
Overflow: n/a

Comments

WELL DRILLED FOR DEMO & STUDENT ACTIVITIES FOR FIELD SCHOOL 1999. STATIC LEVEL 4.76 FT (FROM TOP CSG) DEC 9, 2010. FRACT (CAMERA LOG) 20, 58, 70, 78, 82, 112-113, 189 FT. MOST OF WATER FROM SHALLOW FRACTURE SYSTEM. STRAT: 15-200 FT MAINLY GREY TO DARK

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Appendix D

Report: The Simple Method for Estimating Phosphorus Export

Excel Spreadsheet: Infiltrative and Impermeable Areas

The Simple Method for estimating phosphorus export

The Simple Method for estimating phosphorus export □ Main Page □ Calculator □ Main Page □ The Simple Method for estimating phosphorus export

The Simple Method is a technique used for estimating storm pollutant export delivered from urban development sites. The method was developed to provide an easy yet reasonably accurate means of predicting the change in pollutant loadings in response to development. This information is needed by planners and engineers to make rational non-point source pollution decisions at the site level.

The Simple Method calculation is intended for use on development sites less than a square mile in area. As with any simple model, the method to some degree sacrifices precision for the sake of simplicity and generality. Even so, the Simple Method is still reliable enough to use as a basis for making non-point pollution management decisions at the site level. Phosphorus pollutant loading (L, in pounds per year) from a development site can be determined by solving equation 1, shown below.

Factors used in calculating phosphorus pollutant loading

Depth of rainfall (P)

The value of P represents the number of inches of precipitation that falls during the course of a normal year of rainfall. Long-term weather records around the state of Minnesota suggest that the average annual rainfall depth is about 2□ inches. This can be used to estimate P or a user can substitute the average annual rainfall depth from the closest National Weather Service long-term weather station or other suitable locations for which a reliable record can be demonstrated (□ 10 years).

Correction factor (P)

The $P_{□}$ factor is used to account for the fraction of the annual rainfall that does not produce any measurable runoff. Many of the storms that occur during the year are so minor that all of the rainfall is stored in surface depressions and eventually evaporates. As a consequence, no runoff is produced. An analysis of regional rainfall/runoff patterns indicates that only □0 percent of the annual rainfall volume produces any runoff at all. Therefore, $P_{□}$ should be set at 0.□.

Runoff coefficient (R_v)

The runoff coefficient (R_v) is a measure of the site response to rainfall events, and in theory is calculated as R_v □ r/p, where *r* and *p* are the volume of storm runoff and storm rainfall, respectively, expressed as inches. The R_v for the site depends on the nature of the soils, topography, and cover. However, the primary influence on the R_v in urban areas is the amount of imperviousness of the site. Impervious area is defined as those surfaces in the landscape that cannot infiltrate rainfall consisting of building rooftops, pavement, sidewalks, driveways, etc. In the equation R_v □ 0.05 □ 0.00□(I), *I* represents the percentage of impervious cover expressed as a whole number. A site that is 75□ impervious would use *I* □ 75 for the purposes of calculating R_v. To see runoff coefficients for different land uses, link here.

Site area (A)

The total area of the site (in acres) can be directly obtained from site plans. If the total area of the site is greater than one square mile (□40 acres), the Simple Method may not be appropriate and applicants should consider utili□ing other approaches, such as modeling or monitoring.

Pollutant concentration (C)

Statistical analysis of several urban runoff monitoring datasets has shown that the average storm concentrations for total phosphorus do not significantly differ between new and existing development sites. Therefore, a pollutant concentration, *C*, of 0.30 milligrams per liter (mg/l) should be used in this equation as a default. However, if good local data are available or an adjustment is needed, this factor can be customized for local condition.

The phosphorus pollutant export calculation is described by

$$L = 0.227 P P_j R_v C A$$

where

- L = Load of a pollutant in pounds per year;
- P = Rainfall depth per year (inches);
- P_j = Fraction of rainfall events that produce runoff;
- R_v = Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff. $R_v = 0.05 + 0.009(I)$;
- I = Site imperviousness (i.e., $I = 75$ if site is 75% impervious);
- C = Flow-weighted mean concentration of the pollutant in urban runoff (mg/l); and
- A = Area of the development site (acres).

The above equation can be simplified to

$$L = 0.20 P R_v C A$$

Calculating pre-development and post-development phosphorus load

The methodology for comparing annual pre-development pollutant loads to post-development pollutant loads is a six-step process:

1. Calculate site imperviousness;
2. Calculate the pre-development phosphorus load;
3. calculate post-development pollutant load;
4. Calculate the pollutant removal requirement;
5. Identify feasible BMPs; and
6. Select off-site mitigation option.

Step 1: Calculate site imperviousness

In this step, the applicant calculates the impervious cover of the pre-development (existing) and post-development (proposed) site conditions.

Impervious cover is defined as those surfaces in the landscape that impede the infiltration of rainfall and result in an increased volume of surface runoff. As a simple rule, human-made surfaces that are not vegetated will be considered impervious. Impervious surfaces include roofs, buildings, paved streets and parking areas and any concrete, asphalt, compacted dirt or compacted gravel surface.

Step 2: Calculate pre-development phosphorus load

Caution: The following equations use default values for phosphorus loading. It is best to use site-specific data if possible. If site-specific data are not available, values from the literature can be used for loading from specific land uses. For more information and phosphorus load information for different land uses, see Phosphorus in stormwater.

In this step, the applicant calculates stormwater phosphorus loadings from the site prior to development. Loading estimates in a new development situation utili□es a benchmark load for undeveloped areas based on average phosphorus loadings for a typical mix of undeveloped land uses and is given by

$$L_{pre} = 0.5A$$

Lpre□0.5A

where

L_{pre} □ Average annual load of total phosphorus exported from the site prior to development (lbs/year)□

0.5 □ Annual total phosphorus load from undeveloped lands (lbs/acre/year)□and

A □ Area of the site (acres).

The equation to determine phosphorus loading in a redevelopment situation is based on the Simple Method and is given by

$$L_{pre} = 0.20PR_vCA$$

Lpre□0.20PRvCA

where□

L_{pre} □ Average annual load of total phosphorus exported from the site prior to development (lbs/year)□

P □ Rainfall depth over the desired time interval (inches)□

R_v □ Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff □ 0.05 □ 0.00□(Ipre)□

I_{pre} □ Pre-development (existing) site imperviousness (i.e., I □ 75 if site is 75□ impervious)□

C □ Flow-weighted mean concentration of the pollutant (total P)□

A □ Area of the development site (acres)□and

0.20 is a regional constant and unit conversion factor

Step 3: Calculate post-development pollutant load

In this step, the applicant calculates stormwater phosphorus loadings from the post-development, or proposed, site. Again, an abbreviated version of the Simple Method is used for the calculations, and the equation is the same for both new development and redevelopment sites.

$$L_{post} = 0.20PR_vCA$$

Lpost□0.20PRvCA

where:

L_{post} □ Average annual load of total phosphorus exported from the post-development site (lbs/year)□

P □ Rainfall depth over the desired time interval (inches)□

R_v □ Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff □ 0.05 □ 0.00□(I_{post})□

I_{post} □ Post-development (proposed) site imperviousness (i.e., I □ 75 if site is 75□ impervious)□

C □ Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l)□ 0.30 mg/l□

A □ Area of the development site (acres)□and

0.20 is a regional constant and unit conversion factor.

Step 4: Calculate the pollutant removal requirement

The phosphorus load generated from the post-development site must be reduced so that it is □0 percent or less of the load generated prior to development. In this example, a 10 percent reduction in phosphorus loading from pre-development conditions is used. This should not be construed as a recommended reduction for the State of Minnesota. Applicants should check with local stormwater authorities to determine if specific pre- to post-development phosphorus reduction requirements exist. The amount of phosphorus that must be removed through the use of stormwater BMPs is called the Pollutant Removal Requirement (RR) and is given by

$$RR = L_{post} - 0.9 L_{pre}$$
RR=Lpost−0.9Lpre

where

RR□ Pollutant removal requirement (lbs/year)□

L_{post} □ Average annual load of total phosphorus exported from the post-development site (lbs/year)□

L_{pre} □ Average annual load of total phosphorus exported from the site prior to development (lbs/year)□and

0.□0 is suggested post-development phosphorus load reduction. Local requirements may vary.

Step 5: Identify feasible BMPs

Step 5 looks at the ability of the chosen BMP to meet the site's pollutant removal requirements. The pollutant load removed by each BMP is calculated using the average BMP removal rate, the computed post-development load, and the drainage area served. If the load removed is equal to or greater than the pollutant removal requirement computed in Step 4, then the on-site BMP complies. If not, the designer must evaluate alternative BMP designs to achieve higher removal efficiencies, add additional BMPs, design the pro□ect so that more of the site is treated by the proposed BMPs, or design the BMP to treat runoff from an off-site area.

$$LR = L_{post} BMP_{RE} DA$$
LR□LpostBMPREDA

where

LR □ Annual total phosphorus load removed by the proposed BMP (lbs/year)□

L_{post} □ Average annual load of total phosphorus exported from the post-development site prior to development (lbs/year)□

BMP_{RE} □ BMP removal efficiency for total phosphorus (□)□and

DA □ Fraction of the drainage area served by the BMP (□)

Step 6: Select off-Site mitigation option

If the pollutant removal requirement has been met through the application of on-site stormwater BMPs, the process is complete.

In the event that on-site BMPs cannot fully meet the pollutant removal requirement and on-site design cannot be changed, an offset fee should be charge (e.g. □X per pound of phosphorus).

General summary of comparative BMP phosphorus removal performance[a,e,f]
Link to this table

BMP Group	BMP Design Variation	Average TP Removal Rate (%)[b]	Maximum TP Removal Rate (%)[c]	Average Soluble P Removal Rate (%)[dg]
Bioretention	Underdrain	see Phosphorus credits for bioretention systems with an underdrain	see Phosphorus credits for bioretention systems with an underdrain	see Phosphorus credits for bioretention systems with an underdrain
	Infiltration	• 100 for infiltrated portion • 0 for non-infiltrated portion	• 100 for infiltrated portion • 0 for non-infiltrated portion	• 100 for infiltrated portion • 0 for non-infiltrated portion
Filtration	Media Filter	50	55	0
	Vegetative Filters (dry)	50	55	0
	Wet Swale	0	35	0
Infiltration[f,i]	Infiltration Trench	• 100 for infiltrated portion • 0 for non-infiltrated portion	• 100 for infiltrated portion	• 100 for infiltrated portion • 0 for non-infiltrated portion

BMP Group	BMP Design Variation		Average TP Removal Rate (%)[b]	Maximum TP Removal Rate (%)[c]	Average Soluble P Removal Rate (%)[dg]
				• 0 for non-infiltrated portion	
		Infiltration Basin	• 100 for infiltrated portion • 0 for non-infiltrated portion	• 100 for infiltrated portion • 0 for non-infiltrated portion	• 100 for infiltrated portion • 0 for non-infiltrated portion
	Stormwater Ponds	Wet Pond	50	75	0
		Multiple Pond	60	75	0
	Stormwater Wetlands	Shallow Wetland	40	45	0
		Pond/Wetland			0

[a] Removal rates shown in table are a composite of five sources: ASCE/EPA International BMP Database Caraco (CWP), 2001 MDE, 2000 Winer (CWP), 2000 and Issue Paper D P modeling
[b] Average removal efficiency expected under MPCA Construction General Permit si ing requirements
[c] Upper limit on phosphorus removal with increased si ing and design features, based on national review
[d] Average rate of soluble phosphorus removal in literature
[e] See also Calculating stormwater volume and pollutant reductions and credits
[f] Note that the performance numbers apply only to that portion of total flow actually being treated it does not include any runoff that by-passes the BMP
[g] Note that soluble P can transfer from surface water to ground water, but this column refers only to surface water
[h] Note that 100 is assumed for all infiltration, but only for that portion of the flow fully treated in theinfiltration facility by-passed runoff or runoff diverted via underdrain does not receive this level of treatment

Caution: Removal rates shown here are composite averages intended solely for use in comparing performance between BMP designs and for use in calculating load reduction in site-based TP models. They have been adapted, rounded and slightly discounted from statistical values published in BMP performance databases.

References

Caraco, D. 2001. *Managing Phosphorus Inputs Into Lakes III: Evaluating the Impact of Watershed Treatment.* Watershed Protection Techniques. 3 (4): 7□1-7□□. Center for Watershed Protection. Ellicott City, MD.

Maryland Department of the Environment (MDE). 2000. 2000 Maryland Stormwater Design Manual. MDE. Baltimore, MD.

Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices. 2nd Edition. Center for Watershed Protection. Ellicott City, MD.

LID BMP - PROPOSED				
ITEM	TYPE	AREA (m^2)	DEPTH (m)	
BS-1	BIOSWALE	275		
BS-2	BIOSWALE	125		
BS-3	BIOSWALE	65		
BS-4	BIOSWALE	65		
RG-1	RAINGARDEN	30		
RG-2	RAINGARDEN	220		TOTAL
BR-1	BIORETENTION	2373		**3153**

IMPERVIOUS SURFACES - PROPOSED				
AREA	IMPERVIOUS AREA	SURFACE MATERIAL	AREA(m^2)	
1	ROAD AND PARKING (ALL)	ASPHALT	3613	
2	BUILDINGS (3)	ROOF (UNKNOWN)	5151	
3	WALKWAY (ALL)	CONCRETE (ASSUMED)	1252	
4	RECREATION (2)	UNKNOWN SURFACE	1336	TOTAL
5	TRAIL (ALL)	GRAVEL (PACKED)	2470	**13822**
Estimated Total Area of Property for Future Development 26.6acres = 107646.5m^2				

IMPERVIOUS SURFACE EXISTING		
ITEM	TYPE	AREA (m^2)
1	TRAIL	2470

PERVIOUS SURFACE PROPOSED	
CALCULATION	TOTAL (m^2)
= 107646.5m^2 - 13822m^2	93824.5

PERVIOUS SURFACE EXISTING	
CALCULATION	TOTAL (m^2)
= 107646.5m^2 - 2470m^2	105176.5

WETLAND (APPROX.) FROM MAPPING
AREA (m^2)
3890