FUNCTIONAL SERVICING AND STORMWATER REPORT

OAK RIDGES SEATON INC. SP-2009-02 & PRE-07/23

NEIGHBOURHOOD 18 - SEATON COMMUNITY

CITY OF PICKERING

Prepared by: Sabourin Kimble & Associates Ltd.
110 Old Kingston Road
Ajax, Ontario
L1T 2Z9

Prepared for: DG Group
30 Floral Parkway
Concord, Ontario
L3K 4R1

Project No.: 08:178

Date: July 2023 Latest Revision: October 2024

SKA SABOURIN KIMBLE & ASSOCIATES LTD. CONSULTING ENGINEERS

ACKNOWLEDGEMENT AND DIRECTION

This Functional Servicing and Stormwater Report ('FSSR') has been prepared in conjunction with a team of consultants for the Land Ownership Group within FSSR #3 as follows:

Land Ownership Group

Oak Ridges Seaton Inc. (ORSI) Draft Approved Plan SP-2009-02

Prime Consultant:	Sabourin Kimble & Associates Ltd.
Sub-Consultants:	Beacon Environmental
	Matrix Solutions (formerly Parish Geomorphic Ltd.) (Geomorphology)
	exp (Geotechnical)

This FSSR has been prepared by Sabourin Kimble & Associates Ltd. on the basis of the engineering information produced by Sabourin Kimble & Associates Ltd., and the information provided by their sub-consulting team.

Sabourin Kimble & Associates Ltd. has not reviewed the accuracy or completeness of engineering information provided by external land consultants' and their sub-consulting teams input towards the production of this FSSR, but has relied solely on the other consultants' production and review of the material provided for its accuracy and completeness.

FUNCTIONAL SERVICING AND STORMWATER REPORT

OAK RIDGES SEATON INC. (SP-2009-02)

TABLE OF CONTENTS

FUNCTIONAL SERVICING AND STORMWATER REPORT

OAK RIDGES SEATON INC. (SP-2009-02)

LIST OF TABLES

FUNCTIONAL SERVICING AND STORMWATER REPORT

OAK RIDGES SEATON INC. (SP-2009-02)

LIST OF FIGURES

FUNCTIONAL SERVICING AND STORMWATER REPORT

OAK RIDGES SEATON INC. (SP-2009-02 and PRE-07/23)

LIST OF APPENDICES

1.0 INTRODUCTION

1.1 Purpose and Scope of Work

As part of the Neighbourhood Planning process, the Seaton Community was broken down into six (6) neighbourhoods denoted as Neighbourhoods 16, 17, 18, 19, 20 and 21. As outlined in the Master Environmental Servicing Plan Amendment, Seaton Community, Final July 2013 ('MESPA') and as stated in the City of Pickering Official Plan Amendment No. 22 ('OPA No. 22', Policy 11.73), Neighbourhood Functional Servicing and Stormwater Reports ('NFSSR') were required for each of the six (6) neighbourhoods in support of draft plan of subdivision and/or site plan applications.

The purpose of the NFSSRs was to provide more detailed information and confirm the servicing routes, environmental constraints, and stormwater management ('SWM') works including low impact development ('LID') measures, end of pipe stormwater management facility ('SWMF') locations and sizes, and outfall locations presented in the MESPA. NFSSRs were prepared as a collaboration of information from each landowner's consultant within each respective neighbourhood plan. These reports were submitted numerous times with comments received from approving agencies leading up to Ontario Municipal Board settlement hearings conducted in the summer and fall of 2013. Through the settlement hearing process draft plan approval of all subdivision plans was obtained with specific draft plan conditions. One of the draft plan conditions from the City of Pickering sets out the requirement for individual Functional Servicing and Stormwater Reports ('FSSR') as follows:

> *That the owner will be required to submit a Functional Servicing and Stormwater Report (FSSR) to the City of Pickering that is consistent with the final approved MESPA and the previously submitted Neighbourhood Functional Servicing and Stormwater Report (NFSSR), especially as it relates to the servicing and stormwater management issues within and between Neighbourhoods that will ensure that the separate FSSR's will combine to form a complete NFSSR as required, to the satisfaction of the City of Pickering.*

This FSSR utilizes and refines the information provided in the NFSSR to provide a clear and concise representation of the servicing and stormwater management works that will be provided in support of the Oak Ridges Seaton Inc. ('ORSI') (SP-2009-02 and PRE-07/23) subdivision located within Neighbourhood 18.

An annotated Table of Contents was developed for the NFSSRs through consultation with both Toronto and Region Conservation Authority ('TRCA') and the City of Pickering to establish the

scope of work required. In addition to following the annotated Table of Contents, the NFSSRs were completed in accordance with OPA No. 22 and relevant guidelines including, but not limited to, City of Pickering's Stormwater Management Design Guidelines, TRCA's Stormwater Management Criteria (August 2012), Region of Durham's Design and Construction Specifications for Regional Services, and the Ministry of Environment Conservation and Parks' ('MECP') Stormwater Management Planning and Design Manual (2003).

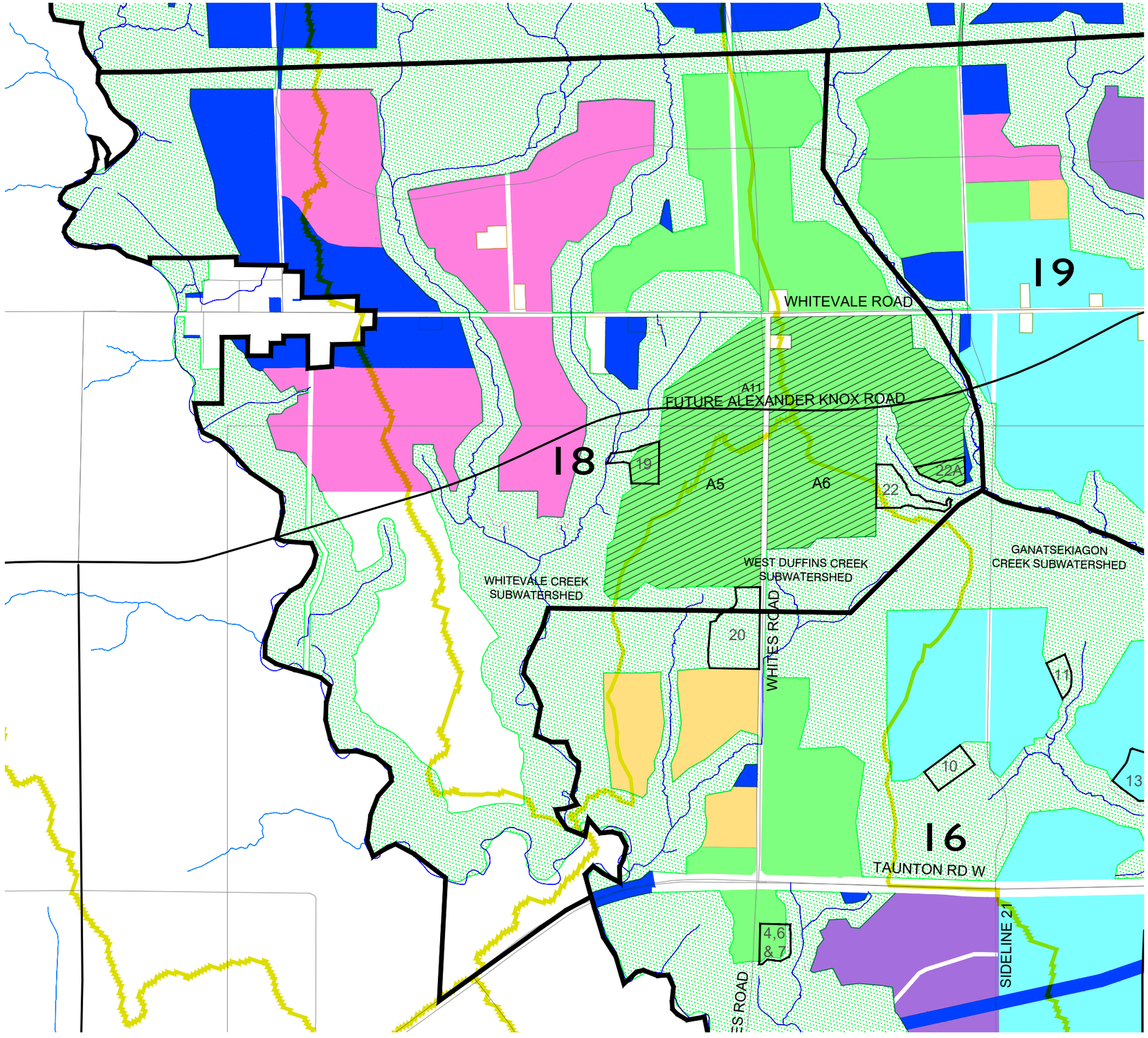
The NFSSR's annotated Table of Contents, agency guidelines and comments were utilized to develop the content of this FSSR. This FSSR addresses the municipal servicing, grading and SWM requirements in accordance with the annotated Table of Contents for Neighbourhood 18. It also includes a summary of the NFSSR findings and direction pertaining specifically to the Oak Ridges Seaton Inc. ('ORSI') subdivision, SP-2009-02, and a future subdivision, PRE-07-23. A summary of existing conditions as per the MESPA and further field work completed for Neighbourhood 18 including assessment of endangered species; conceptual servicing and grading; preliminary analysis of all local road crossings of the Natural Heritage System ('NHS'); conceptual grading of SWMFs; and locations of required LID measures.

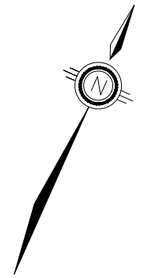
1.2 Study Area

As illustrated in **Figure 1A**, the Study Area is comprised of one draft plan of subdivision, Oak Ridges Seaton Inc., SP-2009-02, and one future plan, City of Pickering File PRE-07/23. SP-2009-02 covers lands known as A5 (west of Whites Road) and A6 (east of Whites Road). File PRE-07/23 covers land known as A11 (northwest of Whites Road and Alexander Knox Road). These lands are located in the southeastern corner of Neighbourhood 18 of the Seaton Community.

As illustrated on **Figure 1B,** the Study Area is bound on the south by NHSA lands, on the west by the Whitevale Creek, and on the north by Whitevale Road, and on the east by Ganatsekiagon Creek. The Study Area is bisected by Whites Road (Sideline 26) and by the proposed Alexander Knox Road. Topographic surveys are enclosed in **Appendix B**.

The Study Area is located within the Whitevale Creek Subwatershed, West Duffins Creek Subwatershed, and the Ganatsekiagon Creek Subwatershed. Per the NFSSR, four storm water management facilities, one located in Catchment 31, one located in Catchment 32 and two located in Catchment 34, will treat post development surface drainage from the proposed development area. Pond 19 will discharge to the east branch of Whitevale Creek (Catchment 31). Pond 20 will discharge to a tributary of the West Duffins Creek (Catchment 32). Ponds 22 and 22A will discharge to Ganatsekiagon Creek (Catchment 34).





LEGEND:

- ZAVALA DEVELOPMENTS INC.
- OAK RIDGES SEATON INC. (ORSI)
- MATTAMY (SEATON) LIMITED
- LEBOVIC ENTERPRISES LIMITED
- WHITE SUN DEVELOPMENTS LTD.
- OLIC LANDS
- NON-PARTICIPANTS
- NATURAL HERITAGE SYSTEM LIMIT
- WATERCOURSE
- PROPOSED ROAD
- EXISTING ROAD
- RAILROAD
- 18 — NEIGHBORHOOD BOUNDARY & ID
- STUDY AREA
- 20 — SWM POND BLOCK & ID
- A5 — PARCEL NAME
- EXISTING CONDITIONS SUBWATERSHED BOUNDARY

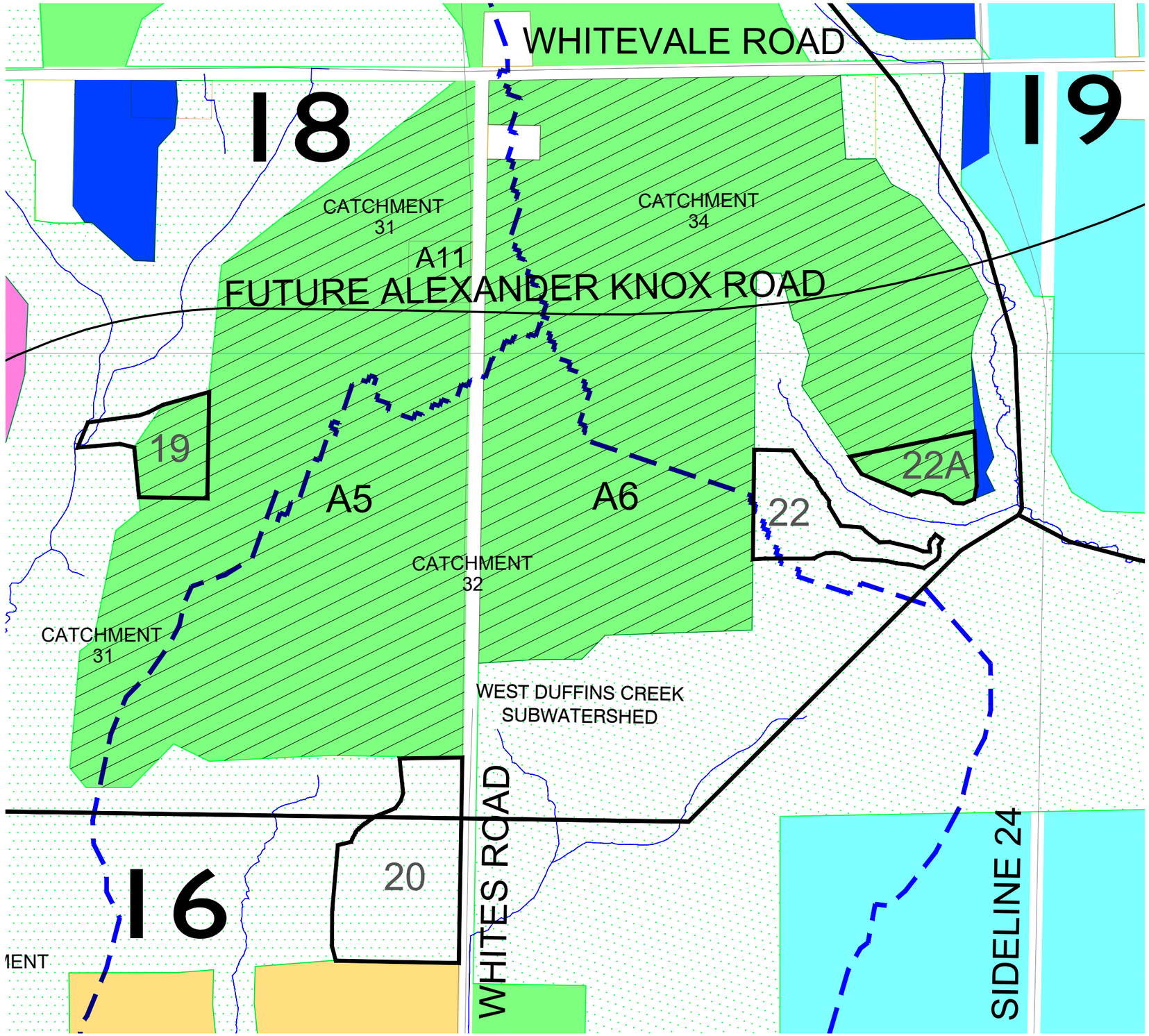
SCALE: 1:15 000

STUDY AREA

SABOURIN KIMBLE & ASSOCIATES LTD. CONSULTING ENGINEERS

PROJECT NUMBER	FIGURE NO.
08:178	1A

CAD FILE: P:\08\178\Drawing Files\A5 A6\Figures\FSR Figures 1st Submission\178 A5 A6 Fig 01A 01B - Study Area.dwg



LEGEND:

- ZAVALA DEVELOPMENTS INC.
- OAK RIDGES SEATON INC. (ORSI)
- MATTAMY (SEATON) LIMITED
- LEBOVIC ENTERPRISES LIMITED
- WHITE SUN DEVELOPMENTS LTD.
- OLIC LANDS
- NON-PARTICIPANTS
- NATURAL HERITAGE SYSTEM LIMIT
- WATERCOURSE
- PROPOSED ROAD
- EXISTING ROAD
- RAILROAD
- 18 NEIGHBORHOOD BOUNDARY & ID
- STUDY AREA
- 20 SWM POND BLOCK & ID
- A5 PARCEL NAME
- CATCHMENT BOUNDARY

SCALE: 1:6000

STUDY AREA

SABOURIN KIMBLE & ASSOCIATES LTD. CONSULTING ENGINEERS

PROJECT NUMBER	FIGURE NO.
08:178	1B

CAD FILE: P:\08\178\Drawing Files\A5 A6\Figures\FSR Figures 1st Submission\178 A5 A6 Fig 01A 01B - Study Area.dwg

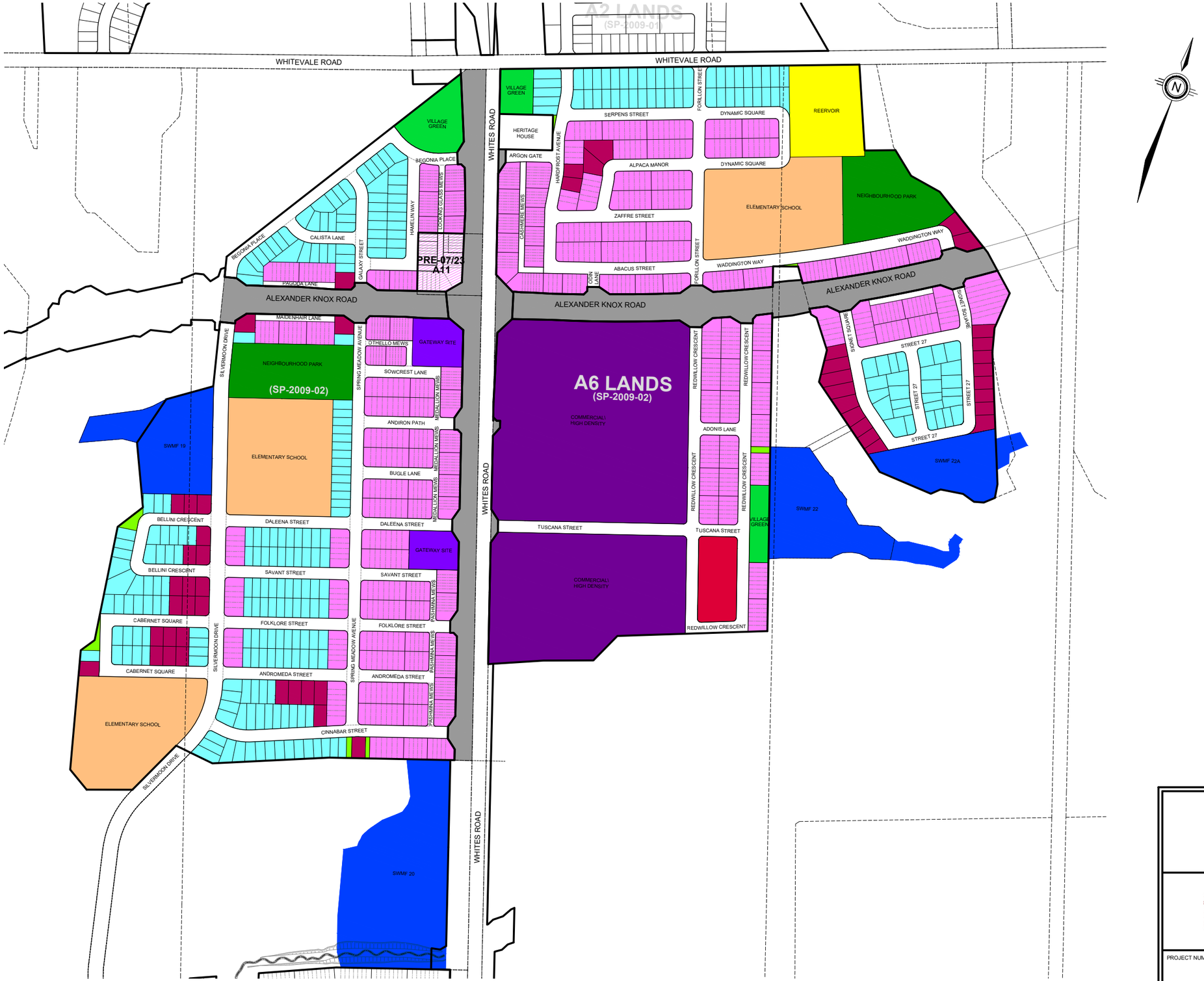
1.3 Development Plans

The subject draft plan of subdivision is illustrated on **Figure 2**. The proposed Oak Ridges Seaton Inc. subdivision, including both SP-2009-02 and PRE-07/23, is 84.37 ha in area.

The proposed land use within the draft plan is summarized in **Table 1**.

Table 1: Proposed Land Use

Land Use	Draft Plan SP-2009-02 (ha)	File PRE-07/23 (ha)
Single Family Detached	9.73	
Semi-Detached	4.13	
Townhouses	17.85	0.45
Stacked Townhouse	0.66	
Neighborhood Park	2.80	
Reservoir	1.35	
Village Green	1.24	
Open Space	0.16	
Elementary School	7.36	
Gateway Site	0.85	
Commercial/High Density	12.47	
Roads	21.82	0.07
Road Widening	0.65	0.02
Stormwater Management Facility	2.54	
Subtotal	83.84	0.53
Total	**84.37**	



SUBJECT DRAFT PLANS

SABOURIN KIMBLE & ASSOCIATES LTD.
CONSULTING ENGINEERS

PROJECT NUMBER	FIGURE NO.
08:178	2

N.T.S.

CAD FILE: P:\08\178\Drawing Files\A7 A8 A9 B2 B3 B4\Figures\FSR 2 A7-9 B2-4\FSR 2 Figure December 2008\Fig 02 - Subject Draft Plan.dwg

2.0 SUMMARY OF MESPA FINDINGS AND DIRECTION

The MESPA provided conclusions and recommendations on a range of items relevant to this FSSR. The MESPA provided a summary table of the components and their implications specific to Neighbourhood 18 (MESPA Table B11.9), reproduced in **Table 2**, below, to be specific to this FSSR: **Figure 3** (back pocket) illustrates the locations of the NHS features.

Table 2: Summary of MESPA Recommendations for the Study Area

Study/Design Component	West Duffins Creek	Whitevale Creek	Ganatsekiagon Creek
Stormwater Management Facilities (SWMFs)	SWMF20	SWMF19	SWMF22, 22a
On-Site Control Areas (OSCAs)	NA	NA	NA
Feature-Based Water Balance			
- Roof and/or Rear-yard Runoff to Wetland	WD9, WD10*	NA	NA
- SWMF Discharge to Wetlands	NA	NA	NA
- Roof and/or Rear-yard Runoff to Woodlands	FC17	NA	NA
- Roof and/or Rear-yard Runoff to Headwater Drainage Features	HDFC24 on Reach DB7-1	NA	NA
LID Measures	5mm requirement	5mm requirement	5mm requirement
Watercourses for Further Study	NA	NA	NA
Areas of Interest	NA	NA	NA
Reduced Buffer Areas	NA	NA	NA
Crossings of the NHS	NA	NA	San Crossing

* Refer to Section 2.1 for the removal of WD10 from the requirements.

2.1 Natural Heritage System

Neighbourhood 18 is approximately 595 ha in size with approximately 42% (248 ha) of this area being identified as NHS. The NHS features within the Neighbourhood 18 consist of West Duffins ('WD') Creek, wetlands, watercourses and headwater drainage features ('HDF'), Iroquois shoreline locations, erosion sites, and woodlands. As per the MESPA some of these features require special consideration with respect to water balance, crossing configuration, etc. **Table 3** summarizes the various features within the study area which require special consideration and **Figure 3** (back pocket) illustrates the location of the NHS features.

Table 3: Natural Heritage System Features Requiring Special Consideration

NHS Feature	Special Consideration
Wetland WD9	Drainage Supplement
Wetland WD10 (Northwest)*	Drainage Supplement
Woodland FC17	Drainage Supplement
HDFC24	Drainage Supplement

* Drainage to WD10 was later confirmed by TRCA to be isolated from the subject site and is not discussed further.

The existing contributing drainage area for Wetland WD10 (Northwest) was subsequently examined by TRCA using lidar who acknowledged that the contributing drainage area for WD10 does not extend into the subject site. Any NHS feature based requirements for WD10 are therefore beyond the scope of this report and Wetland WD10 (Northwest) is not discussed any further. Refer to Figure 3 (back pocket), for NHS feature locations adjacent to the subject lands.

2.2 Endangered Species Act (ESA) Specific Requirements

Three species at risk were identified within the Seaton Community in the MESPA that would require further attention through the development process. These included Redside Dace (Clinostomus elongatus), Bobolink (Dolichonyx oryzivorus), and Butternut (Juglans cinerea). The presence of these species requires consideration of current federal and provincial species at risk legislation. Discussion on these species and the relevant regulations were presented in the MESPA. Furthermore, in support of this functional servicing and stormwater management report, Beacon Environmental Limited prepared a scoped Environmental Impact Study in July 2013, which they updated in 2023. The scoped EIS is enclosed in **Appendix C**. The Beacon report confirmed the presence of the three above noted species at risk and also identified Eastern Meadowlark (Sturnella magna) and Little Brown Myotis (Myotis lucifugus). These studies do not

preclude other endangered species not identified to date; however, only these five will be discussed as part of this FSSR. Site specific assessments for other ESA species will occur as part of detail site work, in accordance with Ont. Reg. 242/08 (or as modified from time to time).

Overall benefit plans are outlined in detail in the MESPA for Redside Dace, Bobolink and Butternut. The following provides an outline of the MESPA findings and recommendations relevant to Neighbourhood 18.

2.2.1 Redside Dace

Ganatsekiagon Creek throughout the majority of the Seaton Community was identified in the MESPA as being Redside Dace habitat. As such, the eastern portion of the lands within Neighbourhood 18 which are in Ganatsekiagon Creek subwatershed will be required to provide appropriate mitigation and obtain an Overall Benefit Permit(s) from the Ministry of the Environment, Conservation and Parks (MECP) in support of the proposed development application. The overall permit process for all the draft plan approved lands within the Seaton land area is underway and will follow a schedule and critical path outside that of this FSSR.

2.2.2 Bobolink and Eastern Meadowlark

Bobolinks have been identified as nesting in areas established for development within Neighbourhood 18. To allow development to proceed, permit(s) from MECP will be required; as part of the permitting process, it will be necessary to have an Overall Benefit Plan which MNR indicated should be comprehensive for the Seaton Community MESPA lands.

The proposed Overall Benefit Plan for Bobolink in the Seaton Community as per the MESPA identified areas for habitat installation and the implementation requirement for this installation, along with on-going management to provide an overall benefit to the species, as required by the ESA. There are four areas identified in the MESPA for habitat installation, one of which is located within Neighbourhood 18; however, this area is outside of the subject lands of this FSSR.

The overall net benefit plan is currently being updated and has been expanded to include the Eastern Meadowlark. This overall plan will address all the draft plan approved lands within the Seaton Community. The schedule and critical path for this plan is outside that of this FSSR.

2.2.3 Butternut

For the road alignments that were shown in the Central Pickering Development Plan ('CPDP'), a 100m swath centred on all the road alignment locations was inventoried as part of the MESPA. Those alignments were determined to be free of Butternut trees.

As outlined in the MESPA, the NFSSR is required to investigate for the presence of Butternut trees in the tableland areas identified for development, and in NHS areas where any development-related activities may intrude. This includes infrastructure (e.g. stormwater management facilities, low impact development measures, outfalls, etc.), modified road locations and grading. Where Butternut trees are identified in these areas, the ESA applies.

In 2023, Beacon surveyed the existing footprints of interim SWMF's 20 and 22, as well as areas within 30 metres of the proposed footprints of SWMF's 19 and 22A and the proposed sanitary crossing of G14-2. No Butternut trees were identified.

2.2.4 Bats

Little Brown Myotis has been identified within the DG Group owned Seaton lands. In 2023, Beacon surveyed the areas around SWMF's 19, 20, 22 and 22A, and the proposed sanitary sewer crossing of G14-2. Beacon concluded that there is suitable SAR bat habitat in the areas of the outfalls for SWMF19 and SWMF 22A. Acoustic monitors have been deployed in these areas to determine if species at risk bats are associated with these areas.

2.3 SWM and Infrastructure Direction from the MESPA

Multiple SWMFs were recommended in the MESPA, SWMF 19, 20, 22 and 22A. Pond 19 is located in Parcel A5 and discharges to the east branch of Whitevale Creek (Catchment 31). Pond 20 is located Parcel A5 and discharges to an un-named tributary of the West Duffins Creek (Catchment 32). Ponds 22 and 22A are located in Parcel A6 and will discharge to a branch of Ganatsekiagon Creek (Catchment 34).

The SWM requirements for Neighbourhood 18, as established in the MESPA are as follows:

- Quality Control: Enhanced Protection Level (80% TSS removal) as per Table 3.2 in the MECP (formerly MOE) Manual;
- Erosion Control: Runoff from a 25 mm 4-hour Chicago storm shall be detained and released over 120 hours. This corresponds to a unitary discharge rate of 0.6 l/s/ha and a unitary volume of 250 m^3/imp ha; and

- Quantity Control: Control post development release rates for the 2-year to 100-year storm events to the unit release rates presented in Table 5.2 of the 2012 Duffins Creek Hydrology Update for all Seaton Community subcatchments with the exception of areas draining directly to West Duffins Creek.

LID measures are required to address water balance conditions for natural features as well as for maintaining overall groundwater recharge and providing surface water runoff volume reductions in the developed areas. LID measures will provide treatment of 5mm of runoff over certain impervious areas as discussed below.

1. All residential roof areas and roofs in the employment areas will provide the equivalent of 5mm runoff volume through LID measures that can be provided communally and/or on individual lots.
2. Parking lots (retail/employment) to provide 5mm volume control;
3. The 5mm requirement does not apply to driveways;
4. LID measures are not required for local roads, except for local roads that extend through the NHS or where they abut (i.e. physically touch) the NHS and where technically feasible.

One sanitary servicing crossing of the NHS is required within the A6 lands.

During the design of NHS servicing crossings, the following factors should be considered: hydraulics, fluvial geomorphology, stormwater management, fisheries, geotechnical and hydrogeology, wildlife passage, vegetation management, species at risk, road design, and trails. There are no road crossings of the NHS within the study area.

All infrastructure crossings of NHS areas where diverse natural heritage features are present (i.e. excluding agricultural lands) are proposed to be constructed using appropriate trenchless technology when warranted. The exact type of construction will be determined during the detailed design phase considering subsurface ground conditions, natural heritage conditions, and development requirements.

3.0 EXISTING CONDITIONS

3.1 Topographical Surveys

All topographical surveys were completed by Holding Jones Vanderveen Inc. (HJV). Multiple surveys were required to capture the subject lands and surrounding areas of interest. All surveys reference City of Pickering Bench Mark No. 3-027, Elevation 165.085 metres. All files have been provided in **Appendix B**.

3.2 Hydrology/Hydraulics

An existing conditions hydrologic analysis for the Duffins Creek watershed was completed by Aquafor Beech (May 2002) as part of the Duffins Creek Hydrology Update. This update did not discretize the Seaton Community lands into smaller subwatersheds to the extent necessary to perform a complete impact analysis of the proposed Seaton Community. Consequently, the existing conditions model required an update. In 2012, the City of Pickering and the TRCA had Aquafor Beech update the existing conditions West Duffins watershed hydrology model. A post development conditions scenario model established unit storage and outflow rates for the development areas within Seaton. The post development model assumed one (1) SWMF in each catchment, and thus established specific unit rates for each catchment separately. These unit rates have been used to size the proposed stormwater management facilities within the Seaton Community.

In July 2013, as part of the MESPA, the hydraulics model was updated. The updated hydraulics model utilized the flows generated from the Duffins Creek Hydrology Update. The existing conditions flows for the 2-year through 100-year storm events were used and the future official plan land use (including Seaton Community without Airport lands) was used for the Regional Storm flow. The floodplain mapping has been updated to include this new Regional Storm flood line.

3.3 Channel Morphology and Stream Bank Erosion

Channel morphology and stream bank erosion was studied in depth for existing conditions in the Seaton MESP Phase 1 Existing Conditions Report (Sernas et. al., 2008) and the MESPA. Meander belt widths for existing conditions were presented in the individual SWM Matrices available in Chapter B, Appendix B6-B of the MESPA. A summary of the field work, and characterization of the findings and constraints is provided in Section 4.0 of the Phase 1 MESP and Chapter B, Section 5.9.1 of the MESPA.

In support of the NFSSR, Parish Geomorphic completed a *Meander Belt Width and Erosion Risk Assessment* (January 2012) within Neighbourhood 18 for those reaches of watercourse adjacent to, and running through, lands controlled by DG Group. Field reconnaissance was conducted in order to update previous work and consisted of Rapid Assessments (Rapid Geomorphic Assessment – RGA, and Rapid Stream Assessment Technique – RSAT), which were utilized to characterize overall channel conditions and ecological health. In Neighbourhood 18, the analysis described the characteristics of Whitevale Creek, West Duffins Creek and Ganatsekiagon Creek, which are the receiving waters for the four DG Group stormwater management ponds. The *Meander Belt Width and Erosion Risk Assessment* is enclosed in **Appendix N**. Geomorphic conditions at the outfall locations are described in **Section 6.6**.

Through the MESPA commenting process, the City of Pickering identified "Watercourses of Concern" due to the proposed stormwater management plan and the potential erosion issues at multiple stormwater management facilities' outlets. Ganatsekiagon Tributary Reach G14-1, the proposed outlet for SMWFs 22 and 22A, was identified by the City of Pickering and as a result, GEO Morphix Limited was retained by Sabourin Kimble & Associates Limited to carry out a detailed field investigation assessing the erosion threshold of Reach G14-1. A copy of their original study *Watercourse Erosion Assessment in Support of Functional Servicing and Stormwater Management Plan Report for Draft Plan of Subdivision SP-2008-05, SP-2008-06 and SP-2009-02*, dated January 11, 2015, along with their update *Response to TRCA and City of Pickering Comments – SWMF 4, 20, 22 and 36* dated October 12, 2018, can be found in **Appendix Q**.

This study found that reach G14-1 is an unconfined channel consisting of mostly sand and gravel as the bed material with dense shrubbery lining the channel and frequent trees and shrubs on the bank. Due to these characteristics, little to no evidence of erosion was observed in the channel. An erosion threshold assessment was completed to determine the flow conditions under which channel bed and bank materials can potentially be eroded, identified as the "critical discharge". Full details on how this discharge was determined can be found in Geo Morphix Ltd.'s report in **Appendix Q**.

The critical discharge was used in the design of stormwater management facility outlet controls. Once the pond curve was established, a continuous model was run to generate a hydrograph in reach G14-1 for six (6) consecutive years of data. These hydrographs were provided to GEO Morphix, who then used them in their modelling to determine the cumulative effective discharge,

cumulative effective work index, duration of exceedances and number of exceedance events. These results can be found in their updated analysis which has been included in **Appendix Q**. Details on the continuous model used to generate the hydrographs in reach G14-1 can be found in **Section 6.6**.

GEO Morphix's analysis found that the proposed 120 hour extended detention in SWMF 22 is more than sufficient to mitigate potential erosion to Reach G14-1. Therefore, no systemic instream works will be required.

The *Meander Belt Width and Erosion Risk Assessment* also analysed the DB2 reach of the branch of West Duffins Creek, which is downstream of the outlet of Pond 20. (This report referred to MESP reach DB2 as being part of DB1.) The assessment concluded that the state of the channel is transitional and has a low critical discharge value of 0.005 m^3/s. As a result, Matrix Solutions Inc. (formerly Parish Geomorphic) was retained by Sabourin Kimble & Associates Limited to carry out a detailed erosion threshold analysis was completed to determine the "critical discharge" of Reach DB2. A copy of their study *Seaton Land Development – Reach DB-2 Erosion Analysis* can be found in **Appendix O**.

The critical discharge was used in the design of stormwater management facility outlet controls. Once the pond curve was established, a continuous model was run to generate a hydrograph in reach DB2 for six (6) consecutive years of data. These hydrographs were provided to Matrix, who then used them in their modelling to determine the cumulative effective discharge, cumulative effective work index, duration of exceedances and number of exceedance events. These results can be found in their analysis which has been included in **Appendix O**. Details on the continuous model used to generate the hydrographs in reach DB2 can be found in **Section 6.6**.

Matriix's analysis found that the proposed 120 hour extended detention of 9,000 m^3 in SWMF 22 is more than sufficient to mitigate potential erosion to Reach DB2. Therefore, no systemic instream works will be required.

3.4 Geotechnical Conditions

Geotechnical investigations involving borehole drilling and monitoring well installations were completed within Neighbourhood 18 by AME (2006, 2011), Trow Associates (2009a, b, c, 3d, e, f, g, h), V.A. Woods (2009a, b), Golder Associates (2011), and exp Services Inc. (formerly Trow Associates; 2011, 2013a, b, c, d, e, f, g, h, i). exp Services Inc. has prepared soils reports specifically for the Study Area lands which are enclosed in **Appendix D**.

The on-site soils vary across the Study Area from silty sand to clayey silt till. The predominant soil on both parcels is sandy silt till as outlined in each report. These deposits were brown and grey in colour and contained scattered gravel and cobbles. The relative density varied from loose to very dense depending on depth. Refer to **Appendix D** for specific soil details.

The geotechnical investigation specific to each of the SWMF blocks made recommendations regarding pond excavation and groundwater control, soil permeability and pond grading/surface treatment. A copy of these reports is provided in **Appendix E.** The following recommendations for all SWMF's are based on their assessment of the borehole and monitoring well data**:**

- No major groundwater control requirements are anticipated during pond construction;
- Due to the relatively low coefficient of hydraulic conductivity of the sandy silt till, a clay liner is not required;
- The pond bottom and upper portion of the pond slopes to be surface compacted with a heavy vibratory roller; and
- Side slopes are not to be steeper than 3:1 horizontal to vertical.

3.5 Slope Stability

Slope stability assessments were completed for the Study Area lands by exp Services Inc. and are included in **Appendix F**. The reports provide detailed slope conditions surveying, stability analyses and setback assessment of the critical slopes. The purpose of the slope stability evaluations was to determine the long-term stable top of slope, which is defined as an imaginary slope with a factor of safety of 1.5 (static) and 1.1 (seismic) along with an allowance for erosion if required.

The reports concluded that construction of the residential developments is feasible and will not negatively affect the stability of the slope. The reports also provided conclusions on the erosion

allowance. A more elaborate summary for each studied area is summarized below with locations shown on the figures in the exp Services Inc. reports, in **Appendix F**.

3.5.1 Slope Stability Summary, Oak Ridges Seaton Inc., SP-2009-02

The subject slopes are located along the West Duffins Creek valley. The field work for this slope stability study consisted of a site walk as well as the drilling of two boreholes for each parcel of land. Site visits were conducted between May 3rd and July 1st, 2013, to record the general slope condition, including signs of instability, if any, vegetation cover, internal and surface erosion.

Parcel A5

Section 1-1

Along the west side of the site, the slope is approximately 5m high. The slope gradient at Section 1-1 is about 12 degrees to the horizontal or less. The minimum calculated factors of safety for this section are 2.80 and 2.14 under static and seismic conditions, respectively. The long-term stable top of slope is located at the physical top of slope, with a minimum F.S. of 1.5.

Section 2-2:

The slope along this area is about 9m high and the slope gradient is about 23 degrees to the horizontal or less. The minimum calculated factors of safety for this section are 1.73 and 1.45 under static and seismic conditions, respectively. The long-term stable top of slope is located at the physical top of slope, with a minimum F.S. of 1.5.

Parcel A6

Section 1-1 (SWM Pond 22A)

Slope stability analysis was carried out for SWMF 22A for the case of after construction in static condition, seismic condition, and rapid drawdown. In all cases, the calculated minimum F.S. for the slope meet or exceed the requirement specified in the Ontario Dam Safety Guidelines.

Parcel A5 & A6 Conclusions

Based on the results of the slope stability study, it is exp Services' opinion that the proposed construction of residential development for A5 and A6 is feasible and will not negatively affect the stability of the slope.

3.6 Hydrogeological Conditions

Groundwater levels have been measured in monitoring wells, stream piezometers and wetland piezometers across the Neighbourhood 18 area to characterize the depth to water table, shallow groundwater flow directions and recharge and discharge conditions. Field tests have also been completed to assess the soil hydraulic conductivity and the potential for use of LID measures for stormwater infiltration. Details of the hydrogeological investigations and findings are provided in the Seaton Neighbourhood 18 Hydrogeological Assessment (Burnside, 2013) This report was prepared as part of, and included in, the NFSSR for Neighbourhood 18 and will not be repeated in this document.

The groundwater flow patterns are interpreted to essentially follow the surface water drainage patterns, with flow generally moving from topographically higher areas to lower areas, i.e., southwards across the Neighbourhood with convergence towards the watercourse valleys. The depth to the water table varies across the study area and is generally found at depths greater than 2 m below grade in the upland areas (recharge areas) and seasonally at or above grade along the incised watercourse valleys (discharge areas).

Field testing results have shown that the till overburden deposits in the northwestern area of the Neighbourhood have relatively low hydraulic conductivity. This generally limits the groundwater movement through the thick surficial till sediments such that groundwater recharge and discharge volumes tend to be quite low. Much of the interaction between groundwater and surface water in the till areas is interpreted to occur very locally and at shallow depths.

There are two local areas where more permeable shallow sand layers at surface may affect local lateral movement of groundwater, however, the more substantial lateral flows occur regionally in the higher hydraulic conductivity sand sediments of the underlying Thorncliffe Aquifer Complex. The deeper Thorncliffe Aquifer Complex sands do not intersect the Creek valleys in the Neighbourhood 18 study area.

The groundwater flow modelling found that groundwater contributions to the wetlands within Neighbourhood 18 accounted for less than 5% of the net wetland water budget. It was concluded

that wetlands in the study area generally rely on surface water contributions (precipitation and surface water runoff). Therefore, the MESPA also presented detailed surface water balance assessments and modelling for the natural features (wetlands, woodlands and headwater drainage features) in the Neighbourhood and provided feature-based target water volumes to maintain the natural features. The MESPA findings and water volume targets for the features in Neighbourhood 18 are summarized in the Hydrogeological Assessment.

It was envisioned in the MESPA that clean roof drainage from the development lands could be conveyed to the features to maintain the water balance conditions. Distribution of surface water inputs to the natural features through the use of swales, shallow infiltration trenches or other spreading techniques located in the feature buffers is generally recommended. The proposed roof water collection systems designed to maintain the features within the subject lands are described in **Section 7.3**.

The use of LID measures across the Neighbourhood was also recommended in the MESPA to minimize, where possible, the volumes of runoff in the developed areas. Techniques considered are outlined in **Section 7.1**

3.7 Feature Based Water Balance

The MESP and subsequent MESPA identified three sub-watersheds within Neighbourhood 18, Whitevale Creek, Ganatsekiagon Creek, and West Duffins Creek. All of these creeks are tributary to Duffins Creek, which outlets to Lake Ontario. There are several identified natural heritage features within these sub-watersheds including:

- Woodlands;
- Wetlands;
- Headwater Drainage Features;
- Whitevale Creek and its tributaries;
- Ganatsekiagon Creek and its tributaries; and
- West Duffins Creek and its tributaries.

As noted previously, some of these natural features require runoff loss mitigation under post development conditions.

The MESPA prepared a water balance assessment on some of these features under existing and proposed development conditions. The QUALHYMO hydrology model was utilized in the MESPA.

For the NFSSR, however, the existing and proposed water balance assessment was completed using the PCSWMMM model. The proposed development conditions models included scenarios with and without runoff loss mitigation. The proposed mitigation method is to direct supplemental roof top drainage to the features. The location of the features with respect to the subject site is shown in **Figure 3** (back pocket). The NFSSR provided a summary table of the features within Neighbourhood 18 that will be impacted by the development as well as their existing, proposed and supplemental roof drainage areas (NFSSR Table 3.1). This table has been reproduced in **Table 4**, below, to be specific to this FSSR.

Table 4: Natural Feature Pre-Development and Post Development Drainage

Natural Feature	Drainage Area (ha)					
	MESPA Existing Drainage Area	NFSSR Existing Drainage Area	MESPA Proposed Remaining Ex Drainage Area	NFSSR Proposed Remaining Ex Drainage Area	MESPA Required Supplemental Roof Drainage	NFSSR Required Supplemental Roof Drainage
Wetlands WD9	7.6	7.6	0.7	0.7	0.9	2.3
Woodlands FC17	6.6	6.6	3.7	4.3	0.4	1.3
Headwaters HDFC24	13.9	13.9	5.9	5.8	1.0	2.5

3.8 ESA Conditions - Butternut Trees

Under existing conditions as inventoried in the Niblett Environmental Associated Inc. - Butternut Health Assessment Memo, no retainable butternut trees were located in the study area.

4.0 MUNICIPAL SERVICING AND GRADING

4.1 Conceptual Grading Plan

Preliminary road design and lot grading design has been completed for the Study Area, in accordance with City of Pickering criteria, and is shown on **Figures 4A and 4B (back pocket)**.

As shown on **Figures 4A and 4B**, a minimum gradient of 0.5% and a maximum gradient of 8.0% for up to and including 9.75 metre pavement widths and 6% for pavement widths over 9.75 metres. In accordance with City of Pickering design criteria, vertical curves will be implemented during detailed design where road gradient changes greater than or equal to 1.0% occur.

Roads have been designed as major system flow paths to convey overland storm drainage in accordance with the SWM requirements for each development area. Where possible, roads follow the existing site topography to minimize the amount of cut and/or fill and to maintain existing grades at site boundaries, reducing the quantity of grading within the adjacent NHS Buffers. Grading encroachments into the NHS Buffers are discussed in further detail in **Section 4.3**.

Residential lots have been designed as either front draining, split draining, or walk-out type configurations, all in accordance with City of Pickering criteria. Lot grading principles were used to direct overland drainage away from the proposed dwellings to adjacent lots, roads or rear lot catchbasins. Lot and swale grades between 2.0% and 5.0% have been implemented and in areas where greater grade differentials are required a maximum slope of 3 horizontal to 1 vertical were used.

4.2 Areas where Major Storm Drainage Capture is Required

The MESPA identifies that an assessment of the major/minor system design is required where piping of 100-year flows to consolidate SWMFs or to convey 100-year flows under roadways is proposed. Within the Study Area there are areas that require capture of 100-year flows, primarily due to Region of Durham criteria that does not allow overland flow to cross a regional road. The MESPA outlined a 2-staged approach to address design requirements for 100-year capture.

At the FSSR stage, the feasibility of 100-year capture is to be demonstrated by the following:

- Delineate drainage areas to 100-year capture points;
- Determine 100-year flows from these areas using the Rational Method;
- Using Manning's equation, determine approximate pipe size for free flow;
- Identify emergency overland flow routes should blockage occur (assume 50% blockage at road inlets and 100% blockage at sags and low points); and
- Delineate areas on the draft plans which will become the schedules of "No Pre-Sale Agreements" in which the owner of the areas delineated will agree not to sell lots within such areas until the major/minor system assessment for such areas is submitted at the detailed design stage.

At the detailed design stage, areas where the major system flows are to be captured and conveyed by the minor system are subject to a specific detailed design modeling protocol to ensure adequate operation and safety of the system. All criteria used in this analysis must satisfy

City of Pickering standards unless otherwise noted. It was determined that the following design and modeling criteria must be followed:

General Criteria

- Design storm for capture purposes to be the 1-hour AES 100-year storm;
- Continuous major system flow routes to be provided;
- Adequate and safe overflows to be provided at the outlet of all major system routes.
- Safe overflow defined as passage of overland flow assuming system failure without flooding impacts on private property;
- Safe overflow rates will be defined as the greater of the 100-year storm or Regional storm as per Section 3.2 of the City of Pickering Stormwater Management Guidelines;
- City standard hydraulic grade line requirements to be satisfied; and
- Any discharge to Region of Durham roadways must satisfy Region of Durham criteria.

Specific Criteria

- A dual drainage model is to be used – PCSWMMM preferred;
- Alternative modeling approaches and models may be utilized after approval by the City as per the City of Pickering Stormwater Management Guidelines;
- The assessment is to be based on detailed engineering design information and on a segment by segment basis as per standard modeling practice;
- External areas may be considered on a lumped basis with supporting assumptions;
- All road and sag inlets to be modeled based on approach flow (depth), inlet capture capabilities and sag storage characteristics;
- All inlets at sags and low points to assume 50% blockage;
- Variations from standard inlet spacing and types to be documented and approved by the City;
- Volume and flow continuity to be maintained and documented according to modeling results;
- Maximum ponding depths at sags and low points prior to overtopping to be below the private property line elevation;

- For sizing of the safety overflow, road inlets must be assumed to be 50% blocked and sag/low point inlets must be assumed to be 100% blocked;
- When overflowing onto a Regional road, the maximum lateral spread criteria outlined in MTO's Highway Drainage Design Standards, SD-3, be applied and satisfied in the system failure analysis; and
- Impervious coverage values utilized within the model to be as per Table 18 (page 67) of the City of Pickering Stormwater Management Guidelines unless otherwise calculated according to actual lot coverage and approved by the City of Pickering.

4.2.1 Drainage to SWMF 19

Major storm (100-year) capture is required for all of the north drainage to SWMF 19 due to the inability to convey overland flows on Alexander Knox Road per Region of Durham criteria. The 100-year drainage areas have been delineated on **Figure 5**. During detailed engineering design, the major system will be analysed utilizing PCSWMMM and the number and location of 100-year capture points within each catchment will be identified. As shown on **Figure 5**, there are 2 emergency overland flow spillways as summarized below:

- Capture Areas 19-Ov1 and 19-Ov2, are on local roads north of Alexander Knox Road. Should the 100-year pipes surcharge, an emergency overland flow spillway is provided onto Alexander Knox Road and the spillway flows will be conveyed to a tributary of Whitevale Creek.

Preliminary supporting calculations can be found in **Appendix G**.

4.2.2 Drainage to SWMF 20

Major storm (100-year) capture is required for all of the drainage from A5 and a small portion of A6 to SWMF 20 due to the fact the pond is south of the site with no direct overland flow channel. The 100-year drainage areas have been delineated on **Figure 5**. During detailed engineering design, the major system will be analysed utilizing PCSWMMM and the number and location of 100-year capture points within each catchment will be identified. As shown on **Figure 5**, there are 2 emergency overland flow spillways as summarized below:

- Capture Areas 20-Ov1 and 20-Ov2 accept storm flows from Parcel A5 and A6, respectively. Should the 100-year pipes surcharge, an emergency overland flow spillway

is provided at the low points/open space blocks for both parcels and the spillway flows will be conveyed directly to tributaries of West Duffins Creek;

Preliminary supporting calculations can be found in **Appendix G**.

4.2.3 Drainage to SWMF 22

Major storm (100-year) capture is required for all of the north drainage to SWMF 22 due to the inability to convey overland flows on Alexander Knox Road per Region of Durham criteria. The 100-year drainage areas have been delineated on **Figure 5**. During detailed engineering design, the major system will be analysed utilizing PCSWMMM and the number and location of 100-year capture points within each catchment will be identified. As shown on **Figure 5**, there are 2 emergency overland flow spillways as summarized below:

- Capture Areas 22-Ov1 and 22-Ov2, are on local roads north of Alexander Knox Road. Should the 100-year pipes surcharge, an emergency overland flow spillway is provided onto Alexander Knox Road and the spillway flows will be conveyed to tributaries of West Duffins Creek;

Preliminary supporting calculations can be found in **Appendix G**.

4.2.4 Drainage to SWMF 22A

Major storm (100-year) capture is required for all of the north drainage to SWMF 22A due to the inability to convey overland flows on Alexander Knox Road per Region of Durham criteria. The 100-year drainage areas have been delineated on **Figure 5**. During detailed engineering design, the major system will be analysed utilizing PCSWMMM and the number and location of 100-year capture points within each catchment will be identified. As shown on **Figure 5**, there is 1 emergency overland flow spillways as summarized below:

- Capture Area 22A-Ov1 is on a local road north of Alexander Knox Road. Should the 100-year pipes surcharge, an emergency overland flow spillway is provided onto Alexander Knox Road and the spillway flows will be conveyed to tributaries of Ganatsekiagon Creek;

Preliminary supporting calculations can be found in **Appendix G**.

19-OV2
2.85 ha
0.69
12.00 min
0.397 cms

19-OV1
2.45 ha
0.57
12.60 min
0.274 cms

22-OV2
10.06 ha
0.73
13.00 min
1.412 cms

22A-OV1
2.89 ha
0.52
11.80 min
0.307 cms

22-OV1
3.15 ha
0.65
12.27 min
0.410 cms

20-OV2
1.41 ha
0.69
11.00 min
0.205 cms

~~20-OV1~~
20.00 ha
0.71
14.33 min
2.616 cms

ALEXANDER KNOX ROAD

WHITES ROAD

A5 LANDS
(SP-2009-02)

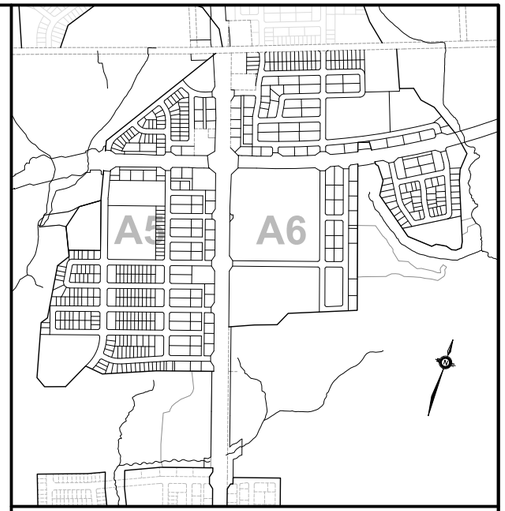
A6 LANDS
(SP-2009-02)

SWMF #19

SWMF #20

SWMF #22

SWMF #22A



KEYMAP N.T.S.

LEGEND:

PROPOSED 100 YEAR CAPTURE AREA

19-OV1
9.01 ha
0.62
15.13 min
0.986 cms

SUB BASIN NUMBER
AREA (Ha)
RUNOFF COEFFICIENT
TIME OF CONCENTRATION (MINUTES)
FLOW (CUBIC METRES PER SECOND)

POTENTIAL LOCATION OF POND BLOCK IN LIEU OF 100 YEAR CAPTURE AREAS (7% OF DRAINAGE AREA)

OVERLAND FLOW DIRECTION

EMERGENCY OVERLAND FLOW SPILLWAY

100 YEAR STORM DRAINAGE AREA TO SWMF 19, 20, 22 22A

SABOURIN KIMBLE & ASSOCIATES LTD.
CONSULTING ENGINEERS

PROJECT NUMBER 08:178

FIGURE NO. 5

SCALE: 1:5000

CAD FILE: P:\08\178\Drawing Files\A7 A8 A9 B2 B3 B4\Figures\FSR 2 A7-9 B2-4\FSR 2 Figures December 2018\Fig 02 - Subject Draft Plan.dwg

4.3 Grading & Servicing within the Natural Heritage System

Road elevations and slopes have been designed to match existing ground wherever possible to reduce the amount of grading required in the NHS Buffer. Lot grading has also been utilized to reduce any vertical differential at property limits and match existing grade at the boundary. Due to existing site topography, road grading, servicing and SWM constraints require some works in the designated Buffer area.

In areas where existing elevations could not be met at the limit of development, grading is proposed within the 30 m NHS Buffer. These grading intrusions are also shown on **Figure 4A** to **4B** (back pocket). Maximum sloping of 3 horizontal to 1 vertical will be used to minimize the area of disturbance.

In some instances, LID measures are proposed to be located within the 30 metre NHS buffer. These proposed works are summarized in detail throughout **Section 7.0**.

During detailed design, all intrusions into the NHS and surrounding NHS Buffers will be minimized as best as possible and impact mitigation will be detailed further for discussion with TRCA and the City of Pickering. Restoration to the area of disturbance will also be discussed with TRCA and the City of Pickering on a case by case basis during detailed design.

4.4 Conceptual Servicing Plan

The following sections outline the preliminary design of the storm, sanitary and water supply services required to service the subject lands.

4.4.1 Storm Sewer System

Storm sewer layout and obverts have been designed and are shown on **Figure 6** (back pocket). Appropriate depth has been provided on storm sewers to allow gravity connections to residential dwellings. During detailed design, storm sewers will be sized to convey the 5-year storm and will be designed based on the City of Pickering design criteria. Calculations will also be completed to ensure all dwellings are hydraulically protected during large storm events in accordance with City of Pickering standards. Storm runoff will be captured in the storm sewer system using street catchbasins; rear-yard catchbasins will be used for areas where rear lot drainage cannot be conveyed overland to adjacent roads.

The design of the storm sewer system will be based on City of Pickering design standards for a 5-year return frequency storm. Design flows are calculated using the Rational formula,

$$Q = 0.002778 \times A \times I \times R,$$

Where, Q is the peak runoff rate (m^3/s)

A is the contributing area in (ha);

I is the rainfall intensity (mm/hr); and

R is the run-off coefficient.

Rainfall intensities are based on City of Pickering's IDF curves and are expressed as follows:

$$I = \frac{A}{(t_c + B)^{C}}$$

where t_c is the time of concentration in minutes and the IDF parameters are outlined in **Table 5**.

Table 5: Pickering IDF Parameters

Parameter	Return Period					
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
A	715.076	1082.901	1313.979	1581.718	1828.009	2096.425
B	5.262	6.007	6.026	6.007	6.193	6.485
C	0.815	0.837	0.845	0.848	0.856	0.863

Run-off coefficients in accordance with City of Pickering criteria will be utilized, when detailed calculations have not been completed, and are shown in **Table 6**.

Table 6: Pickering Standard Runoff Coefficients by Land Use

Land Use	Run-off Coefficient
Parks over 4 hectares	0.20
Unimproved	0.20
Parks 4 hectares and under	0.25
Railroad Yard	0.35
Single Family Residential	0.65
Single Family Residential (Frontage less than 12.2m)	0.70
Semi-detached Residential	0.70
Street Townhouses	0.75
Laneway Townhouses	0.85
Back-to-Back Townhouses	0.90
Apartments	0.85

Table 6: Pickering Standard Runoff Coefficients by Land Use

Land Use	Run-off Coefficient
Schools and Churches	0.85
Industrial	0.90
Commercial	0.90
Heavily Developed Areas	0.95
Paved Areas	0.95

As discussed in **Section 4.1 to 4.2.4**, 100-year storm capture is required for all of the drainage to SWMF 19, 20, 22, and 22A. To ensure the storm sewers located within Whites Road and conveying flows from the Study Area to SWMF 20 were adequately sized, 100-year flow capture information was calculated and provided to Morrison Hershfield as part of Spine 4 works. The 100-year capture locations by Spine 4 storm sewers and flow information are shown on **Figure 5**.

4.4.1.1 Inlet Structure Criteria

The criteria for the maximum number of catchbasins located at the lowest area on the road to achieve the major system capture requirement shall be as specified below:

- The maximum number of catchbasins at low points along any roads capturing the major storm event shall be limited to four (4) double catchbasins (2 on each side of the road);
- Additional single catchbasins shall be installed on both sides of the double catchbasins located at a distance calculated by a maximum height of 0.15m above the lowest double catchbasin; and
- All lots in a subdivision shall not have more than one single or double catchbasin within its frontage.

The number, size, and final spacing of catchbasins will be determined at detailed design through the major system capture assessment following the criteria outlined in **Section 4.2** above.

4.4.2 Major System Conveyance

Local roads have been designed as major system flow paths to convey overland storm drainage to 100-year capture points. During detailed design, calculations will be completed to ensure overland flow depths during large storm events meet City of Pickering standards.

4.4.3 Roof Drain Collector System

In accordance with the recommendations of the MESPA, a roof drain collector system is to be designed in specified areas to supply supplemental runoff to Woodland FC17, Wetland WD9 and Headwaters HDFC24. The roof drain collector pipes, including proposed obverts, are shown on **Figure 6** (back pocket). The roof drain collector pipes will collect roof drainage from proposed residential dwellings and convey the water to the identified features. Foundation drains will connect to the minor system storm sewer and not the roof drain collector system. During detailed design, the roof drain collector pipes will be sized based on the corresponding contributing roof area.

4.4.4 Sanitary Sewer System

Sanitary sewer layout and obverts have been designed and are shown on **Figure 7** (back pocket). Local sanitary sewers have been designed to connect to the trunk sanitary sewers running through the A5 lands as well as Whites Road.

Appropriate depth on local sewers has been provided to allow gravity connections to basements of residential dwellings. During detailed design local sanitary sewers will be sized based on the design flow, detailed below, and using Manning's Formula on the basis of full flow pipes.

In accordance with Region of Durham design guidelines, residential sewage flows shall be calculated on the basis of the following for residential areas.

- Residential Average Flow – 364 litres/person/day
- Infiltration – 22,500 litres/gross hectare/day when foundation drains are not connected to the sanitary sewer. Calculated on the number of gross hectares of residential lands tributary to the sanitary sewer systems. Foundation drains within all areas of the Study Area are connected to the storm sewer system.

All sanitary sewers shall be sized to handle the theoretical daily peak flow, where the peaking factor for sanitary drainage is calculated as follows:

$$\text{Peaking Factor, } K_H = \frac{1 + 14}{}$$

$$4 + P^{1/2}$$

Where, P is population in thousands; and

K_H is the Harmon peaking factor, maximum of 3.8 and minimum of 1.5.

In accordance with Region of Durham design guidelines, when lands are zoned for a specific residential use and detailed information is not available, the following population densities shall apply in accordance with **Table 7**.

Table 7: Sanitary Population Densities - Unknown Lot Configuration

Type of Housing	Persons/Hectare
Single Family Dwellings	60
Semi-detached Dwellings	100
Street Townhouses	125
Apartment	--
Low Density (62 units/ha)	150
Med-Low Density (86 units/ha)	210
Med Density (124 units/ha)	300
High Density (274 units/ha)	600

When the number and type of housing units within the proposed development is known, the calculation of population for the proposed development shall be based on the population densities shown in **Table 8**.

Table 8: Sanitary Population Densities - Known Lot Configuration

Type of Housing	Persons/Unit
Single Family Dwellings	3.5
Townhouses, Semi-Detached, Duplex	3.5
Apartment	--
Bachelor	1.6
1 Bedroom	1.6
2 Bedroom	2.7
3 Bedroom	2.7
Average (apartment)	2.2

In accordance with Region of Durham standards, commercial design flow shall be 180m^3/gross floor area in hectares/day including infiltration and peaking effect.

4.4.5 Water Supply

As shown on **Figure 8** (back pocket), local water mains have been designed to provide individual service connections for future residential lots. During detailed design, hydrants will be spaced on local water mains to provide adequate fire protection in accordance with City of Pickering and Region of Durham standards. As development progresses, water modelling will be completed on a subdivision basis to size local water mains for appropriate domestic and fire loading requirements.

Feeder mains, pumping stations and reservoirs to service the Seaton Community, including the Study Area, are currently being designed as part of Durham Region's EA. The results of the EA and design of the above mentioned Regional infrastructure will serve as the basis for future water modelling and water supply for individual developments.

The subject lands are within Zone 4 & Zone 5 pressure districts and are, at a minimum, dependent on the following works:

i. Construction of the Zone 4 and Zone 5 watermains along Alexander Knox Road.

Provision will be made for looping Zone 4 and Zone 5 water mains to provide security of supply and circulation within each subdivision respectively.

5.0 TRANSPORTATION

5.1 System Design

The transportation system for the Study Area is illustrated on the Preliminary Grading Plans (**Figures 4A** and **4B**) including all roads, and future trailheads. A sidewalk analysis will be provided at detailed design outlining the single and dual sidewalk roads. The transit system (where applicable), trails, and bike lanes will be developed during detailed design and will follow the recommendations of the MESPA. It is anticipated that there will be additional review and discussions with the City related to the exact cross sections that will be used within the subject lands as the FSSR is reviewed and approved. Currently, appropriate road allowance widths have been used within each Draft Plan that are suitable for the class and function of each roadway.

5.2 NHS Road and Infrastructure Crossings

As discussed in **Section 2.3,** within the Study Area, there is one (1) infrastructure crossings of the NHS, Sanitary NHS Crossing. This crossing was not identified previously and has not been numbered. The crossing location is shown on **Figure 9** (back pocket) and the NHS crossing is shown in detail in **Figure 10**. The figure contains the following information:

- The location and alignment of the infrastructure within the NHS, its relationship to the existing watercourse/wetland; and
- Proposed infrastructure elevations

5.2.1 Sanitary NHS Crossing

The proposed crossing is an NHS infrastructure crossing. It is comprised of a sanitary sewer crossing of Reach G14-2 (unnamed tributary of the Ganatsekiagon Creek), refer to **Figure 10**. As shown in **Appendix H** - *Comprehensive Aquatic Framework – Trustee Proposed Works in Regulated Redside Dace Habitat (2017-2020),* Reach G14-2 is classified as “Simple Contributing (Not Regulated)” habitat.

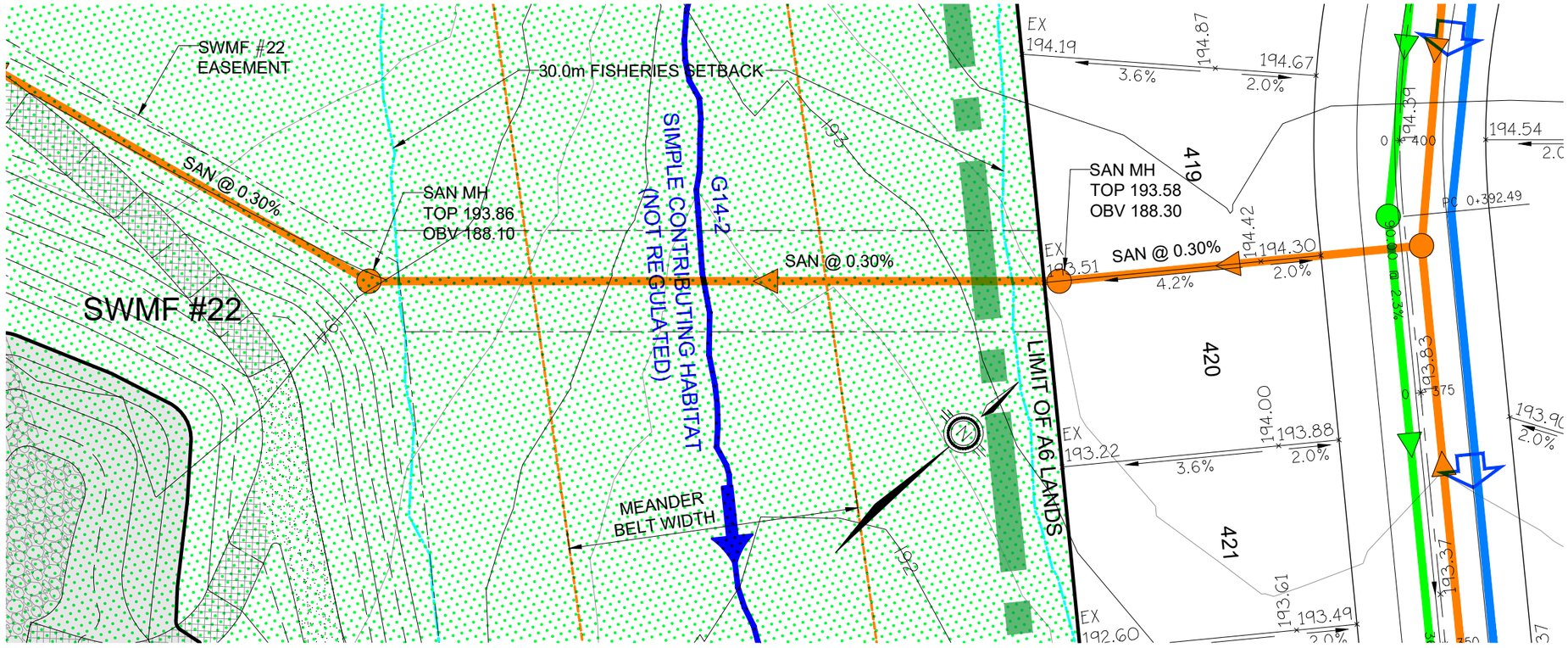
Beacon Environmental provided an *Input to Functional Servicing and Stormwater Management Report - Scoped Environmental Impact Study* in which they identified redside dace habitat. Beacon identified relevant natural feature buffers and evaluated the potential impacts of the proposed crossing on the surrounding terrestrial and aquatic habitat. Beacon concluded that with appropriate construction mitigation measures and replanting, the sanitary crossing can be

constructed without adversely affecting the Natural Heritage System. The *Scoped Site Environmental Impact Study* is enclosed in **Appendix C**.

The infrastructure crossing spans a sparsely treed stream corridor. There are no provincially or municipally designated features or significant habitat associated with the vegetation communities. No wildlife species or related habitat, nor historic records, within or adjacent to the proposed crossing were identified.

The sanitary sewer will be installed by open trench. During construction, the area of disturbance will be minimized as much as possible. Following construction, the watercourse will be restored to post re-alignment conditions; therefore, there will be no adverse impacts to the creek or the Regional Storm Water Surface Elevations. Areas of open soils will be revegetated immediately with native wetland seed mix and/or plantings with mulch to prevent erosion and establishment of invasive species. Cut woody material can be left in situ to provide habitat and cover, or chipped and used on site as ground mulch unless diseased.

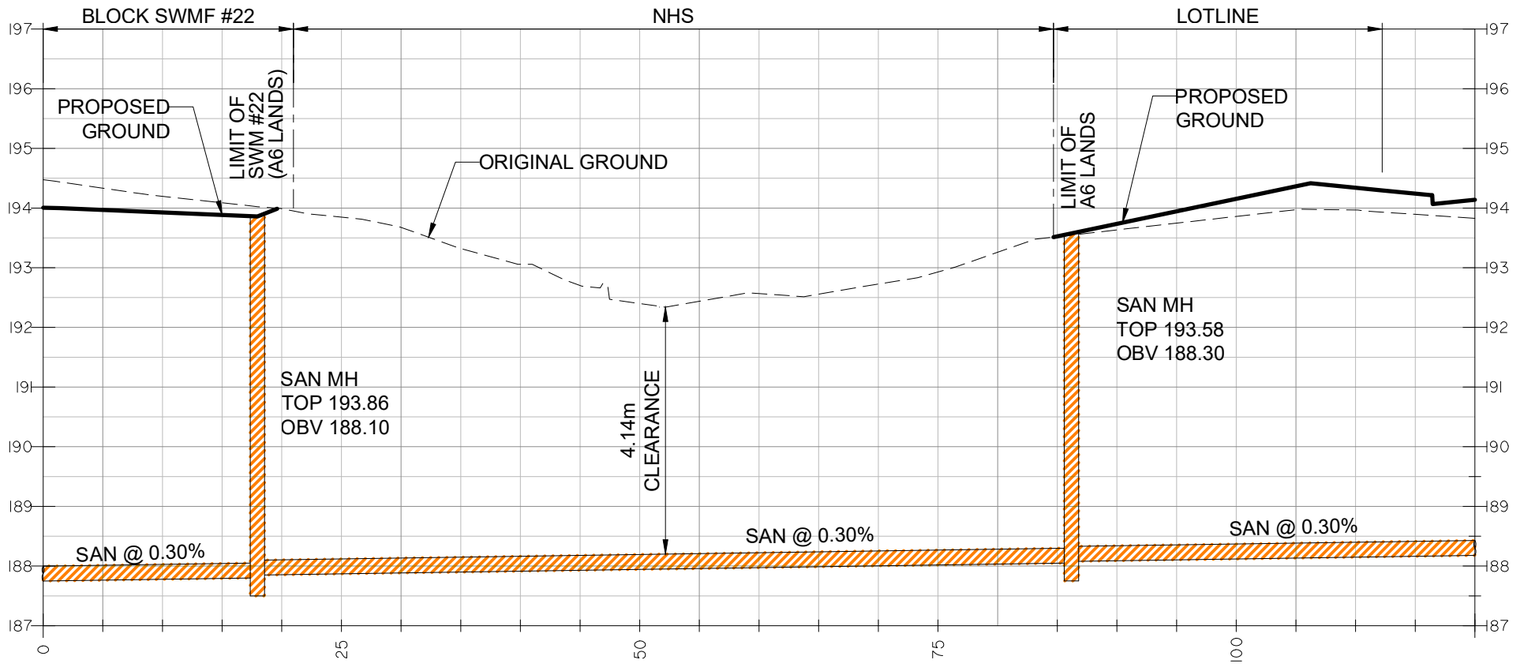
A nine metre wide easement is required over the sanitary sewer in favour of the Region of Durham wherever the sanitary sewer lies outside a municipal road allowance.



KEYMAP N.T.S.

LEGEND:

- NATURAL HERITAGE SYSTEM LIMIT
- WOODLANDS LIMIT
- WETLAND LIMIT (TRCA ELC)
- EXISTING CONTOUR
- PROPOSED STORM MANHOLE
- PROPOSED STORM SEWER AND FLOW DIRECTION
- PROPOSED SANITARY MANHOLE
- PROPOSED SANITARY SEWER AND FLOW DIRECTION
- PROPOSED WATERMAIN
- OVERLAND FLOW DIRECTION
- WATERCOURSE
- FLOODLINE
- FISHERIES SETBACK (30m)
- MEANDER BELT WIDTH
- BIORETENTION SWALE



SCALE: HOR. 1:500 VER. 1:100

SANITARY SEWER CROSSING ON NHS

SABOURIN KIMBLE & ASSOCIATES LTD. CONSULTING ENGINEERS

PROJECT NUMBER	FIGURE NO.
08:178	10

CAD FILE: P:\08\178\Drawing Files\A5 A6\Figures\FSR Figures 1st Submission\178 A5 A6 Fig 10 NHS Crossing.dwg

6.0 STORMWATER MANAGEMENT STRATEGY

6.1 Stormwater Management Plan

As discussed previously, the MESPA recommended multiple SWMFs in the Study Area, SWMF 19, 20, 22, and 22A. Pond 19 is located within Catchment 31 and discharges to a minor tributary of the east branch of Whitevale Creek. Pond 20 is located within Catchment 32 and discharges to an un-named tributary of the West Duffins Creek. Ponds 22 and 22A are located within Catchment 34 and will discharge to Ganatsekiagon Creek.

As part of Spine 4, SWMF 20 and 22 were initially designed as interim facilities to provide the required quality, erosion and quantity control for stormwater runoff from the widened and urbanized Whites Road. Preliminary designs are documented in the Region of Durham Owner Constructed Design Assignment 4, Stormwater Management Report, SWMF 20/SWMF 22, prepared by Sabourin Kimble & Associates Ltd., dated February 2019 which has been approved by applicable regulatory agencies. Detailed design parameters for the Spine 4 versions of SWMFs 20 and 22 are documented in separate approved stormwater management reports for each pond.

In support of part of Spine 7A, SWMF19 and 22A were initially designed as interim facilities to provide the required quality, erosion and quantity control for stormwater runoff from proposed Alexander Knox Road. A minor orifice modification to the Spine 4B version of the interim SWMF 22 was also required for Spine 7A. Preliminary design parameters are documented in the Region of Durham Owner Constructed Design Spine Assignment 7A, 100% Design & Stormwater Management Report, prepared by Sabourin Kimble & Associates Ltd., dated April 2022 and has been approved by applicable regulatory agencies. Detailed design parameters for the Spine 7A versions of SWMFs 19, 22 and 22A are documented in separate approved stormwater management reports for each pond.

The preliminary SWMF designs for SWMF's 19, 20, 22 and 22A presented herein, represent the four preliminary pond designs for their ultimate drainage scenarios, which will accept post development drainage from the entire Study Area. The preliminary designs incorporate any criteria identified to date through the MESPA process, the Duffins Creek Hydrology Update, their supporting studies and other more recent studies.

6.2 Stormwater Management Design Criteria

The required stormwater management criteria have been established through the development of the MESPA. All development areas have the same quality control requirements. They also

have the same basic unitary erosion control requirements, however some drainage areas have been identified as “Watercourses of Concern” by the City of Pickering and are subject to a more stringent analysis. At the NFSSR stage, additional watercourses were also identified for erosion analysis. Erosion analyses for pond discharge from SWMF’s 20, 22 and 22A are discussed further in **Section 6.6.** The quantity control requirements vary by subwatershed. All requirements are summarized below.

Quality Control

Enhanced fisheries protection, as per MOE guidelines, is to be provided for all development areas. This is 80% total suspended solids (TSS) removal from stormwater effluent.

Erosion Control

The MESPA established unit storage and outflow rates based on contributing drainage area and percent impervious. Unit storage of 250 m^3/imp.ha is to be provided with a unit outflow rate of 0.0006 m^3/s/ha. This roughly corresponds to 120 hour extended detention of runoff from a 25 millimetre storm. Through the MESPA commenting process, Ganatsekiagon Creek reach G14-2 was identified by the City of Pickering as a “Watercourse of Concern” with respect to erosion potential. require a detailed erosion control analysis. Parish Geomorphic also identified West Duffins tributary reach DB2 as requiring a detailed erosion control analysis.

Quantity Control

As outlined in Section 2.3, the quantity control requirement established by the MESPA, and further refined in the *2012 Duffins Creek Hydrology Update (DCHU)*, varies based on subwatershed. unitary storage volumes and discharge rates have been established for Catchments 31, 32 and 34 for all storms, up to and including the 100-year storm event. The values were calculated and presented by two methods; discharge and storage per overall hectare, and discharge and storage per impervious hectare. The unitary rates for the stormwater facilities in each catchment area are shown in **Table 9**. In the following table, the unitary values per impervious hectare which were established in the DCHU assumed that each catchment will have impervious percentages as follows; Catchment 31 – 84%, Catchment 32 – 87%, and Catchment 34 – 81%. The actual percent impervious values based on the proposed draft plans will be less than the assumed DCHU values, therefore the unitary rates per overall hectare apply. Additionally, discharge rates are based on each tributary areas which are within the same subcatchment as each outlet. Areas diverted from a neighbouring sucatchment do not count toward the allowable discharge rate. A plan comparing subcatchment and post development drainage boundaries is included in **Appendix J**.

Table 9: DCHU Stormwater Management Unit Storage and Discharge Rates

Return Period	Unitary Discharge		Unitary Storage	
	(L/s/ha)	(L/s/Imp-ha)	(m^3/ha)	(m^3/Imp-ha)
Catchment 31, Pond 19				
2 Year	2.38	2.83	302	359
5 Year	3.80	4.51	391	464
10 Year	4.80	5.39	445	529
25 Year	6.19	7.36	517	615
50 Year	7.27	8.64	569	676
100 Year	8.42	10.00	620	738
Catchment 32, Pond 20				
2 Year	5.62	6.44	272	311
5 Year	8.84	10.13	349	400
10 Year	11.10	12.72	393	450
25 Year	14.23	16.31	451	517
50 Year	16.63	19.07	494	566
100 Year	19.17	21.97	536	614
Catchment 34, Ponds 22 and 22A				
2 Year	2.86	3.53	282	349
5 Year	4.56	5.63	367	454
10 Year	5.76	7.11	419	518
25 Year	7.44	9.18	486	600
50 Year	8.74	10.79	535	660
100 Year	10.11	12.49	584	722

6.3 Stormwater Management Facility Design Requirements

There are a total of eleven stormwater management facilities proposed within Neighbourhood 18. This FSSR addresses lands which are tributary to four facilities, SWMF's 19, 20, 22, and 22A. The design details for these facilities are provided in the following sections.

6.3.1 SWM Pond Grading Criteria

The stormwater facilities are required to be designed in accordance with MECP, TRCA and City of Pickering Design criteria, a summary of these criteria are as follows:

- Minimum Length to Width Ratio of 4:1;
- Side Slopes:
    - 3:1 from the bottom of the permanent pool to 500 mm below the normal water level (NWL)
    - 6:1 within 3.0m on either side of NWL
    - 4:1 where the slope backs on to the rear yard lot line or an adjacent valley system
    - 4:1 where the pond is adjacent to a municipal boundary
    - 5:1 where the slope backs on to an adjacent road system
    - 3:1 if necessary, where the pond will be fenced
- Water Levels:
    - Permanent Pool: 1.0 to 2.0 m deep
    - Permanent Pool at Outlet: 2.5m max depth
    - Extended Detention Storage: 1.5 m max depth
    - Quantity Control Storage: 2.0m max depth
- Berming:
    - Max berm height: 3m
    - Where berm >2m it must be designed by a geotechnical engineer
- Maintenance access road/walking trail;
- Emergency spillway.

The ponds will be generally designed to adhere to the design criteria presented above. In some situations, maintaining the City of Pickering Design Criteria noted above may not be feasible due to either topographic constraints or location of established roads whether existing or future. Any variation from these guidelines will require acceptance by the City of Pickering. Requirements for pond liners will be further analyzed by a geotechnical engineer during detailed design.

6.3.2 SWM Redside Dace Criteria

Through the MESPA process, the Ministry of Natural Resources and Forestry (MNRF) identified reaches containing Redside Dace regulated habitat in Seaton. The Seaton Environmental Consulting team has prepared a report detailing works for the Seaton Community within Regulated Redside Dace habitat entitled *Comprehensive Aquatic Framework* (*CAF).* The *CAF* has identified all regulated Redside Dace watercourses in Drawing 1 – Trustee Proposed Works in Regulated Redside Dace Habitat (2017-2020) from their report, which has been included in **Appendix G**. SWMFs 22 and 22A will discharge to Ganatsekiagon Creek Reach G14-1, which has been identified as regulated Redside Dace Contributing. This is defined as an upstream watercourse/wetland that contributes to habitat conditions within occupied/recovery reaches. SWMFs 22 and 22A will therefore adhere to the following MNRF Redside Dace criteria for stormwater management facilities as found in Section 3.2.1 of *Section 17(2)(c) Aquatic ESA Permit Applications Seaton Secondary Planning Area:*

1. Discharge from SWM facilities not to exceed 25mg/l of TSS.
2. Discharge temperatures to be below 24°C.
3. Post development water balance to match pre-development water balance, with the recommendation of no storm runoff from rainfall events in the range of 10 to 15mm.
4. Ponds to be located outside of the Redside Dace Regulated habitat.
5. Discharge not to be directly to the watercourse.
6. Areas disturbed by construction to be restored to pre-development conditions.
7. Access to be vegetated where long-term access is necessary.
8. Thermal mitigation to be achieved in the pond by the use of:
    a. Average permanent pool depth (excluding forebay) to be a minimum of 3 metres.
    b. Bottom draw outlet to be located a minimum of 2.5 metres below permanent pool.
    c. Pond perimeter at the permanent pool elevation to have a minimum 3 metre wide flat shelf 0.3 metres deep as a wetland planting area and should include 0.3 metres of topsoil and to be planted with native emergent species.

d. Side slopes below the permanent pool to be 4:1.
e. The volume of water in the permanent pool between 1.5 and 3.0 metres depth to be at least equivalent to the volume of runoff generated by a 10mm storm event.
f. The calculated volume below 1.5 metre depth to be discharged over a minimum 24 hour period.

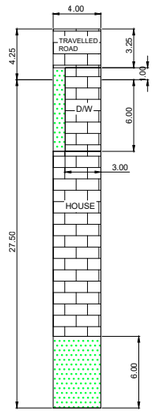
6.3.3 Impervious Coverage

To determine the quality and erosion storage requirements, a weighted percent impervious value was calculated based on the land use presented in the draft plans. The percent impervious for various land use types was calculated based on City of Pickering by-laws for Seaton Community regarding lot set back requirements for residential land uses. For residential lands, details of the imperious area coverage assumed for the various typical lot sizes are presented in **Figure 11,** detailed calculations can be found in **Appendix I**. These coverage calculations for residential lots compare favourably to the typical percentage impervious values provided in the City of Pickering SWM Guidelines. The percent impervious utilized as part of this FSSR are provided in **Table 10**.

Table 10: Percent Impervious Based on Land Use

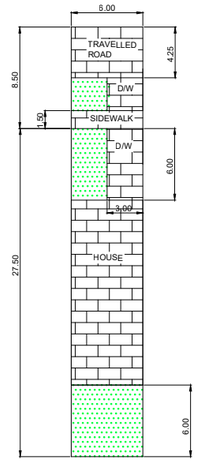
Land Use	Percent Impervious
4.0m Townhouse Residential	76%
6.0m Townhouse Residential	71%
Semi-detached Residential	68%
Single Residential	68%
Medium Density Residential	70%
High Density Residential	85%
Gateway Site	95%
Commercial	95%
School	90%
Local Road	70%
Whites Road	90%
Alexander Knox Road	90%
Park/Village Green (less than 4ha)	25%
SWM Pond Block	50%
Water Supply Reservoir	57%

14' TH
4.0m FRONTAGE - TOWNHOUSE



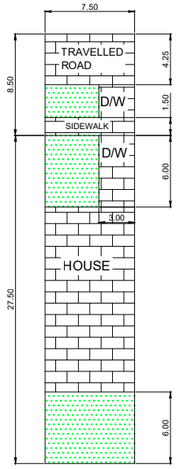
ROOF AREA	= 62.00
LOT AREA	= 110.00
TOTAL AREA (INCL. ROW)	= 127.00
IMPERVIOUS AREA	= 96.00
TOTAL IMPERVIOUS	= 76%

17' TH
6.0m FRONTAGE - TOWNHOUSE



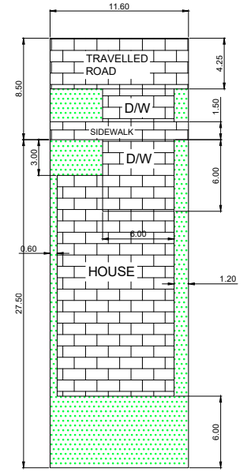
ROOF AREA	= 93.00
LOT AREA	= 165.00
TOTAL AREA (INCL. ROW)	= 216.00
IMPERVIOUS AREA	= 153.75
TOTAL IMPERVIOUS	= 71%

25' TH
7.5m FRONTAGE - TOWNHOUSE



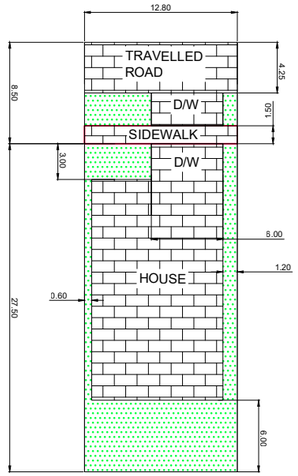
ROOF AREA	= 116.25
LOT AREA	= 206.25
TOTAL AREA (INCL. ROW)	= 270.00
IMPERVIOUS AREA	= 185.63
TOTAL IMPERVIOUS	= 69%

39'
11.6m FRONTAGE



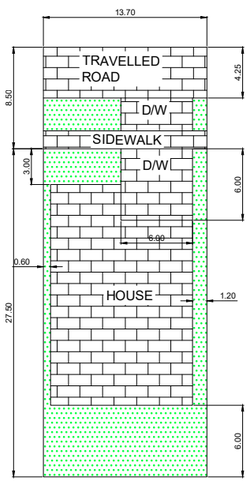
ROOF AREA	= 163.30
LOT AREA	= 319.00
TOTAL AREA (INCL. ROW)	= 417.60
IMPERVIOUS AREA	= 282.50
TOTAL IMPERVIOUS	= 68%

43'
12.8m FRONTAGE



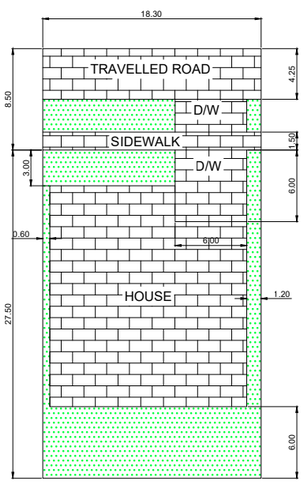
ROOF AREA	= 185.50
LOT AREA	= 352.00
TOTAL AREA (INCL. ROW)	= 460.80
IMPERVIOUS AREA	= 311.60
TOTAL IMPERVIOUS	= 68%

46'
13.7m FRONTAGE



ROOF AREA	= 202.15
LOT AREA	= 376.75
TOTAL AREA (INCL. ROW)	= 493.20
IMPERVIOUS AREA	= 333.43
TOTAL IMPERVIOUS	= 68%

61'
18.3m FRONTAGE



ROOF AREA	= 287.25
LOT AREA	= 503.25
TOTAL AREA (INCL. ROW)	= 658.80
IMPERVIOUS AREA	= 444.98
TOTAL IMPERVIOUS	= 68%

NON-IMPERVIOUS AREA

IMPERVIOUS AREA

ALL DIMENSIONS IN METRES, AND AREAS IN SQUARE METRES UNLESS OTHERWISE NOTED

SCALE: N.T.S.

TYPICAL LOT IMPERVIOUS COVERAGE

SABOURIN KIMBLE & ASSOCIATES LTD.
CONSULTING ENGINEERS

PROJECT NUMBER
08:178

FIGURE NO.
11

CAD FILE: P:\08\178\Drawing Files\A7 A8 A9 B2 B3 B4\Figures\FSR 2 A7-9 B2-4\FSR 2 Figures December 2018\Fig 16 - Typical Lot Impervious Coverage.dwg

6.4 Regional Road Drainage

The extent of Regional Road drainage that is to be accommodated in the proposed stormwater management facilities within the Seaton Community boundary was originally identified in the MESPA and subsequent NFSSR process. These documents identified the limits of Regional Roads that could either drain to a specific SWMF or have water quantity accounted for through over-control within a nearby and appropriate SWMF. This approach was further refined through the Central Pickering Development Plan Class Environmental Assessment (Regional EA) process. Ultimately, the Regional EA identified those roads that would either drain to a specific SWMF or have over-controlled provided for in a specific SWMF. The Regional EA also identified those sections of road that would not drain to a SWMF and would require further consideration with respect to the provision of adequate stormwater management controls. The Regional EA also included an outline of various techniques to provide specific stormwater controls both within and adjacent to the Regional road right-of-way.

Alexander Knox Road and the widening/extension of Whites Road are the two Regional Roads within the Study Area. **Figure 12** (back pocket) illustrates the portions of Whites Road which are tributary to SWMF 20 and 22, as well as the portions of Alexander Knox Road tributary to SWMF 19, 22, and 22A. At the time of writing this report, the widening /extension of Whites Road has been constructed and Alexander Knox Road is under construction.

6.5 Stormwater Management Facility Design Details

The stormwater management design requirements and criteria (outlined in previous sections) have been utilized during the preliminary design of SWMF 19, 20, 22 and 22A. Preliminary design details for this facility are outlined in the following sections.

6.5.1 Stormwater Management Facility 19

SWMF19 has a total contributing drainage area of 16.55 ha. Drainage boundaries are illustrated on **Figure 12** (back pocket). Based on the proposed land use, the contributing drainage area has an impervious coverage of 67%. The pond's permanent pool will provide Enhanced Protection Level (80% TSS removal) quality control. The extended detention volume will have a drawdown time greater than 120 hours. The required quantity control volume will be stacked on top of the extended detention volume.

The preliminary design storage volumes for the two through 100-year storms are slightly less than the DCHU criteria for Catchment 31 because the runoff coefficient for the proposed development

is significantly lower than the coefficient assumed in the DCHU. The release rates, however, satisfy the DCHU criteria for the 2 through 100-year storm events. An overflow weir will allow passage of the 1:100 Year storm flow if the outlet structure is blocked. Grading, outfall and access characteristics have been designed to satisfy the City of Pickering's stormwater facility design criteria. SWMF 19 preliminary design calculations are provided in **Appendix J**. Preliminary pond plan view, outfall and profiles are shown on **Figures 13** to **15**, respectively. Operating characteristics of the facility are presented in **Table 11**.

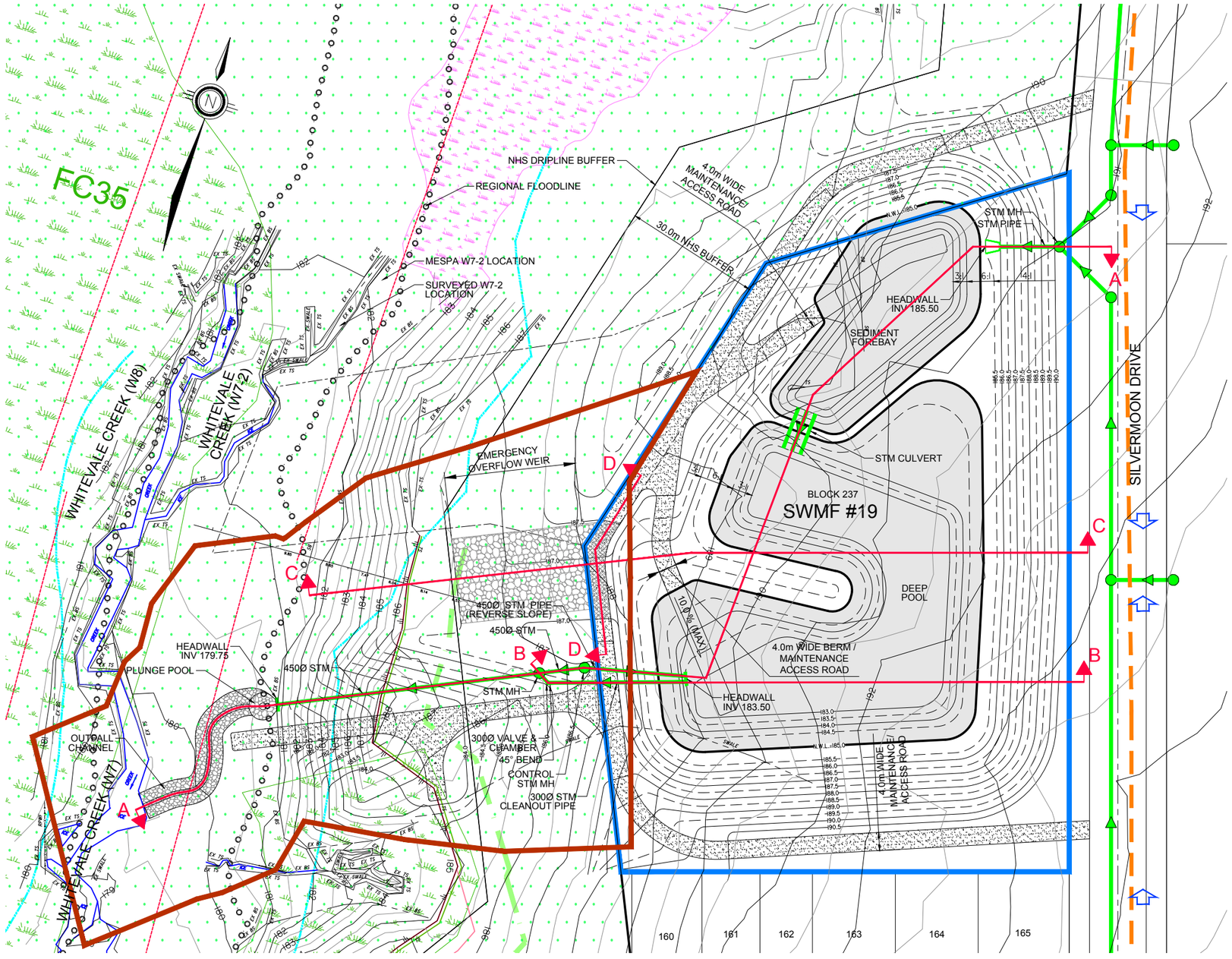
Table 11: SWMF19 Operating Characteristics

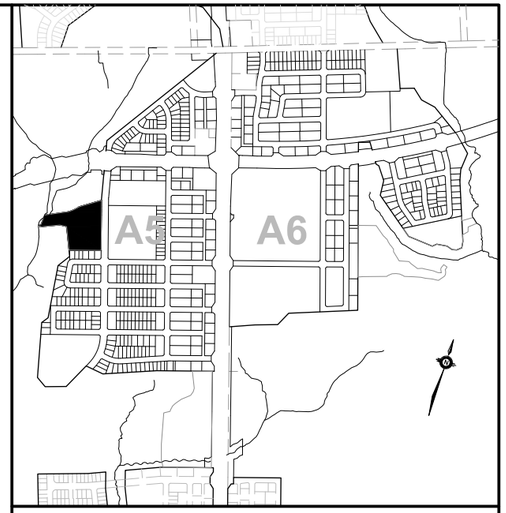
SWM Characteristic	Allowable Discharge (m^3/sec)	Design Discharge (m^3/sec)	Required Storage (m^3)	Provided Storage (Excl. Ext. Det.) (m^3)	Provided Storage (Incl. Ext. Det.) (m^3)	Elevation (m)
Perm Pool	N/A	N/A	2,930	-	12,634	185.50
Ext Detention	0.010	0.010	2,775	-	2,775	185.80
2 Yr Stm	0.035	0.024	4,998	4,250	7,025	186.23
5 Yr Stm	0.057	0.027	6,471	5,790	8,565	186.37
10 Yr Stm	0.072	0.028	7,365	6,800	9,575	186.47
25 Yr Stm	0.092	0.034	8,556	8,120	10,895	186.59
50 Yr Stm	0.108	0.037	9,417	9,100	11,875	186.68
100 Yr Stm	0.126	0.039	10,261	10,100	12,875	186.77

As shown in the above table, the extended detention fluctuation is within City of Pickering guidelines. Further, excess storage volume is available for the extended detention which will allow for refinements during detailed design.

SWM FACILITY OPERATING CHARACTERISTICS				
	DISCHARGE (m^3/s)	REQUIRED STORAGE* (m^3)	PROVIDED STORAGE* (m^3)	ELEVATION (m)
PERMANENT POOL	N/A	2,976	6,897	185.00
EXTENDED DETENTION	0.010	2,811	2,811	185.43
100 YEAR (STACKED)	0.038	12,891	12,891	186.68

*BASED ON 69% IMP AND DRAINAGE AREA 16.29 HA.





KEYMAP N.T.S.

LEGEND:

- NATURAL HERITAGE SYSTEM LIMIT
- WOODLANDS LIMIT
- WETLANDS LIMIT
- WATERCOURSE
- EXISTING CONTOUR
- WETLANDS SETBACK
- FISHERIES SETBACK (30m)
- MEANDER BELT WIDTH
- 100-YR FLOODPLAIN
- TOE EROSION
- WOODSTAKES LIMIT
- PHYSICAL TOP OF SLOPE (EXP.)
- LONG TERM STABLE TOP OF SLOPE (EXP.)
- EROSION ALLOWANCE (EXP.)
- EROSION HAZARD BUFFER (10m) (EXP.)
- SWMF BLOCK
- PROPOSED POND CONTOUR
- PROPOSED STORM MANHOLE
- PROPOSED STORM SEWER AND FLOW DIRECTION
- OVERLAND FLOW DIRECTION
- EXISTING 10 LICENSE LIMIT

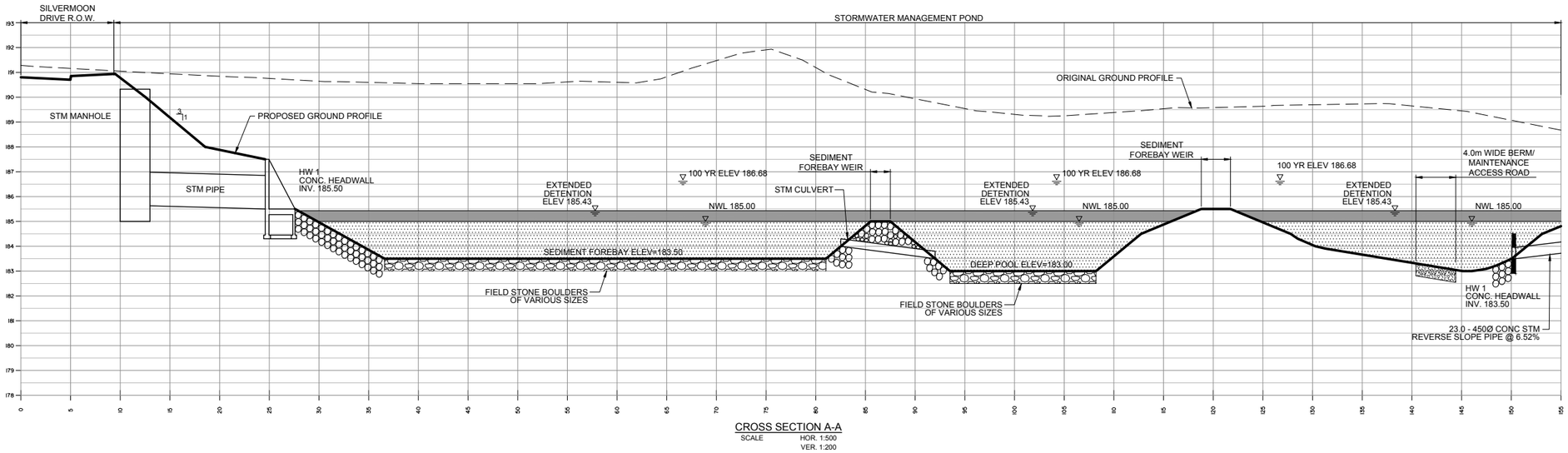
SWMF 19 PLAN VIEW

SABOURIN KIMBLE & ASSOCIATES LTD. CONSULTING ENGINEERS

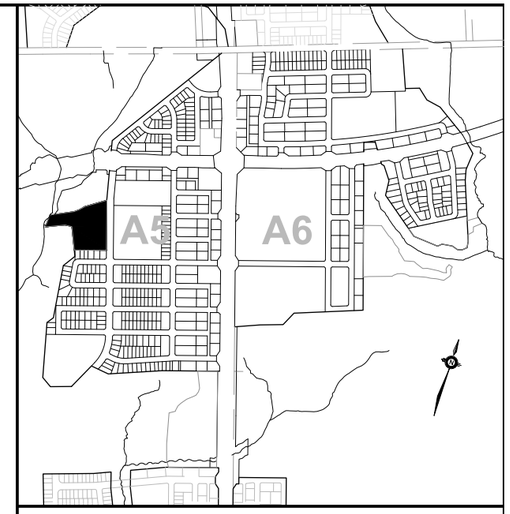
PROJECT NUMBER	FIGURE NO.
08:178	13

SCALE: 1:1000

CAD FILE: P:\08\178\Drawing Files\A5 A6\Figures\FSR Figures 1st Submission\178 A5 A6 Fig 13-15 - SWMF 19 Outfall And Cross Sec.dwg

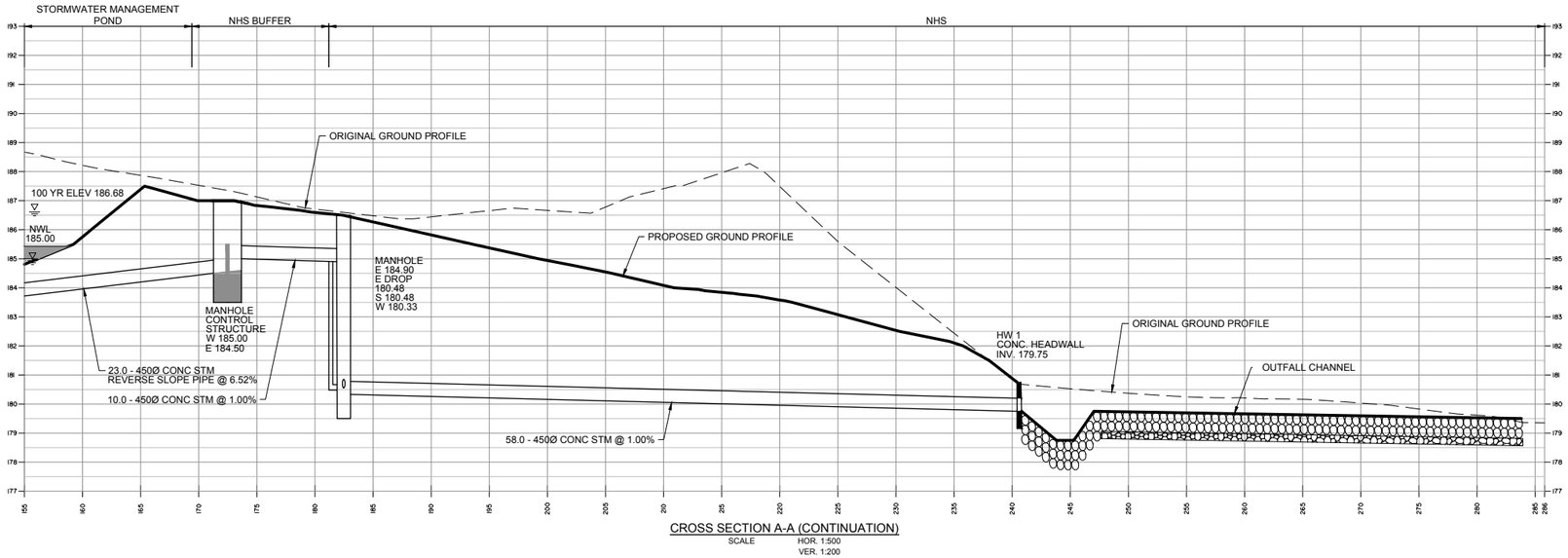


CROSS SECTION A-A
SCALE HOR. 1:500
VER. 1:200



KEYMAP N.T.S.

100-YEAR (STACKED) PONDING ELEVATION (m)	186.68
EXTENDED DETENTION ELEVATION (m)	185.43
PERMANENT POOL ELEVATION (m)	185.00



CROSS SECTION A-A (CONTINUATION)
SCALE HOR. 1:500
VER. 1:200

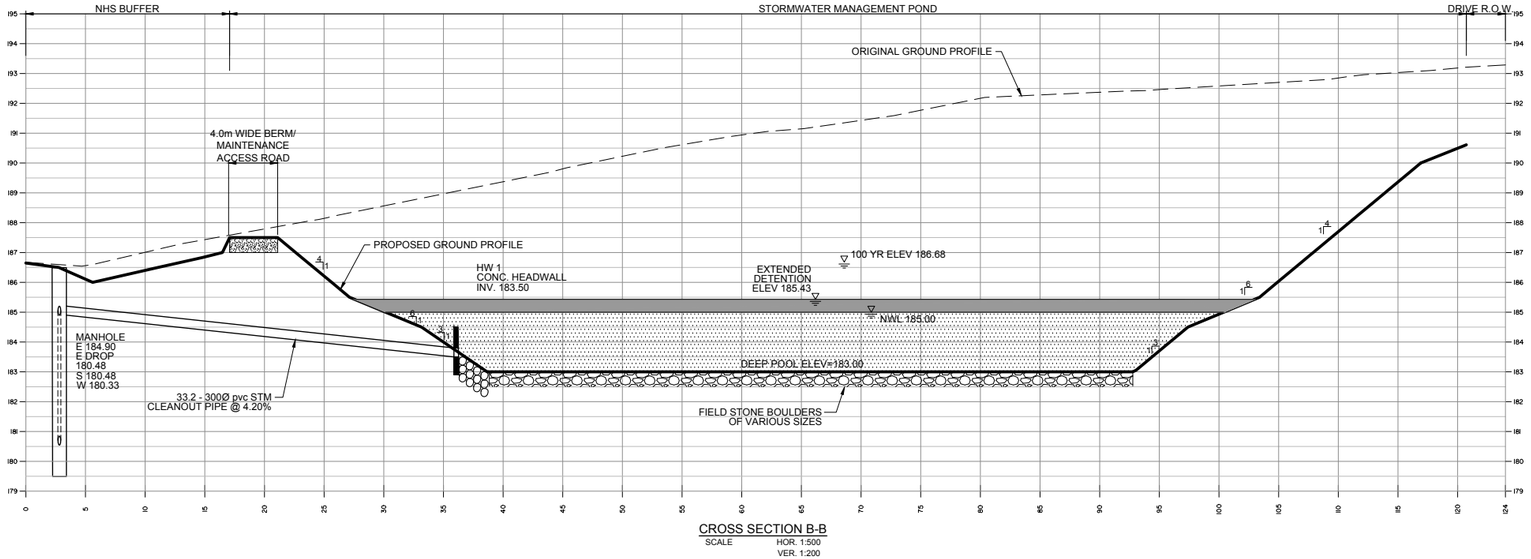
CROSS SECTION D-D
(EMERGENCY OVERFLOW WEIR)
SCALE HOR. 1:500
VER. 1:200

SWMF 19 OUTFALL

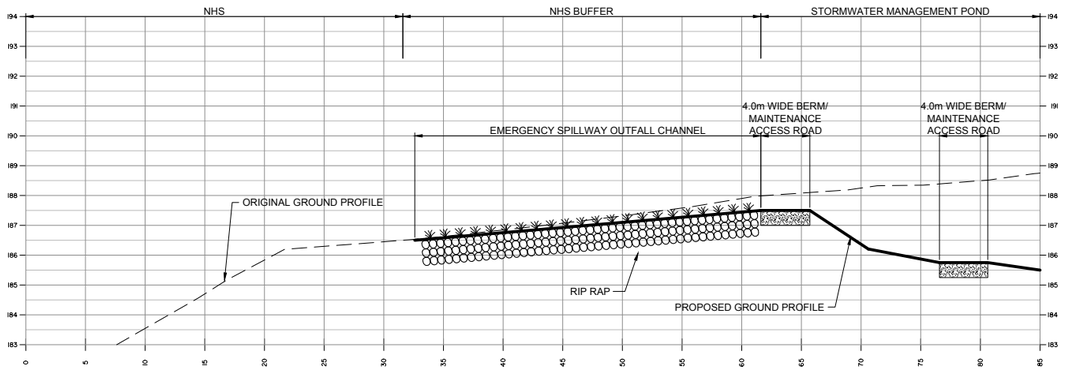
SABOURIN KIMBLE & ASSOCIATES LTD.
CONSULTING ENGINEERS

PROJECT NUMBER	FIGURE NO.
08:178	14

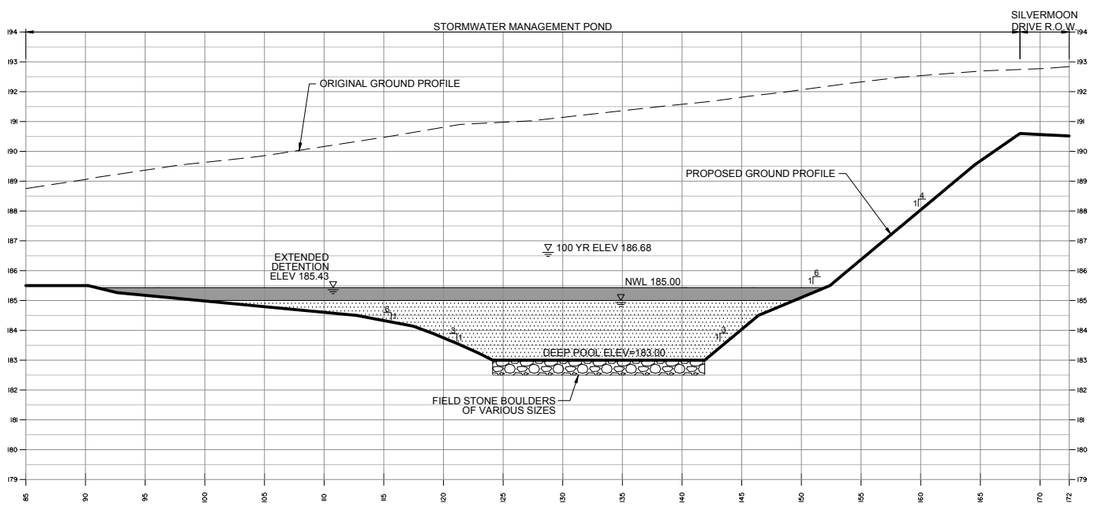
CAD FILE: P:\08\178\Drawing Files\A5 A6\Figures\FSR Figures 1st Submission\178 A5 A6 Fig 13-15 - SWMF 19 Outfall And Cross Sec.dwg



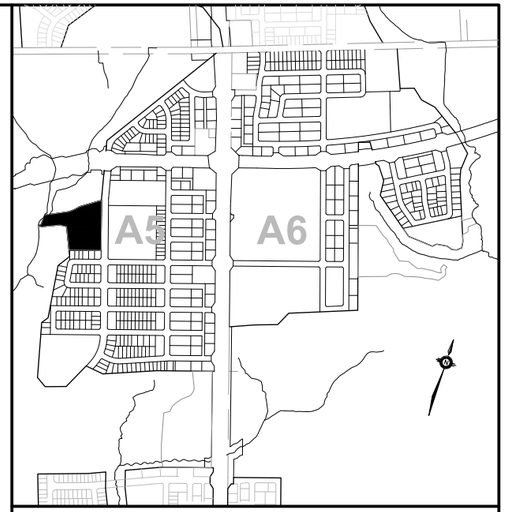
CROSS SECTION B-B
SCALE HOR. 1:500 VER. 1:200



CROSS SECTION C-C
(EMEREGENCY OVERFLOW WEIR)
SCALE HOR. 1:500 VER. 1:200



CROSS SECTION C-C (CONTINUATION)
(EMEREGENCY OVERFLOW WEIR)
SCALE HOR. 1:500 VER. 1:200



KEYMAP N.T.S.

100-YEAR (STACKED) PONDING ELEVATION (m)	186.68
EXTENDED DETENTION ELEVATION (m)	185.43
PERMANENT POOL ELEVATION (m)	185.00

SWMF 19
CROSS SECTIONS

SABOURIN KIMBLE & ASSOCIATES LTD. CONSULTING ENGINEERS

PROJECT NUMBER 08:178

FIGURE NO. 15

CAD FILE: P:\08\178\Drawing Files\A5 A6\Figures\FSR Figures 1st Submission\178 A5 A6 Fig 13-15 - SWMF 19 Outfall And Cross Sec.dwg

6.5.2 Stormwater Management Facility 20

SWMF20 is an existing interim facility that was constructed in support of the Whites Road construction. The pond was graded to its ultimate configuration with interim controls in place, however the control structure will be modified to address the ultimate post development drainage conditions. The storage fluctuation will be adjusted accordingly. The pond has a total contributing drainage area of 38.72 ha. Drainage boundaries are illustrated on **Figure 12** (back pocket). Based on the proposed land use, the contributing drainage area has a 79% impervious coverage.

The pond's permanent pool will provide Enhanced Protection Level (80% TSS removal) quality control. Due to downstream erosion concerns discussed in **Section 6.6.3**, the extended detention volume is more than required by the unitary criteria and will have a drawdown time greater than 120 hours. The required quantity control volume will be stacked on top of the extended detention volume. The preliminary design will provide storage volumes and release rates that satisfy the DCHU criteria for Catchment 32 for the 2 through 100-year storm events. An overflow weir will allow passage of the 1:100 Year storm flow if the outlet structure is blocked. Grading, outfall and access characteristics have been designed to satisfy the City of Pickering's stormwater facility design criteria. SWMF 20 preliminary design calculations are provided in **Appendix K**. The preliminary pond plan view, outfall and profiles are shown on **Figure 16** to **18**, respectively. Operating characteristics of the facility are presented in **Table 12**.

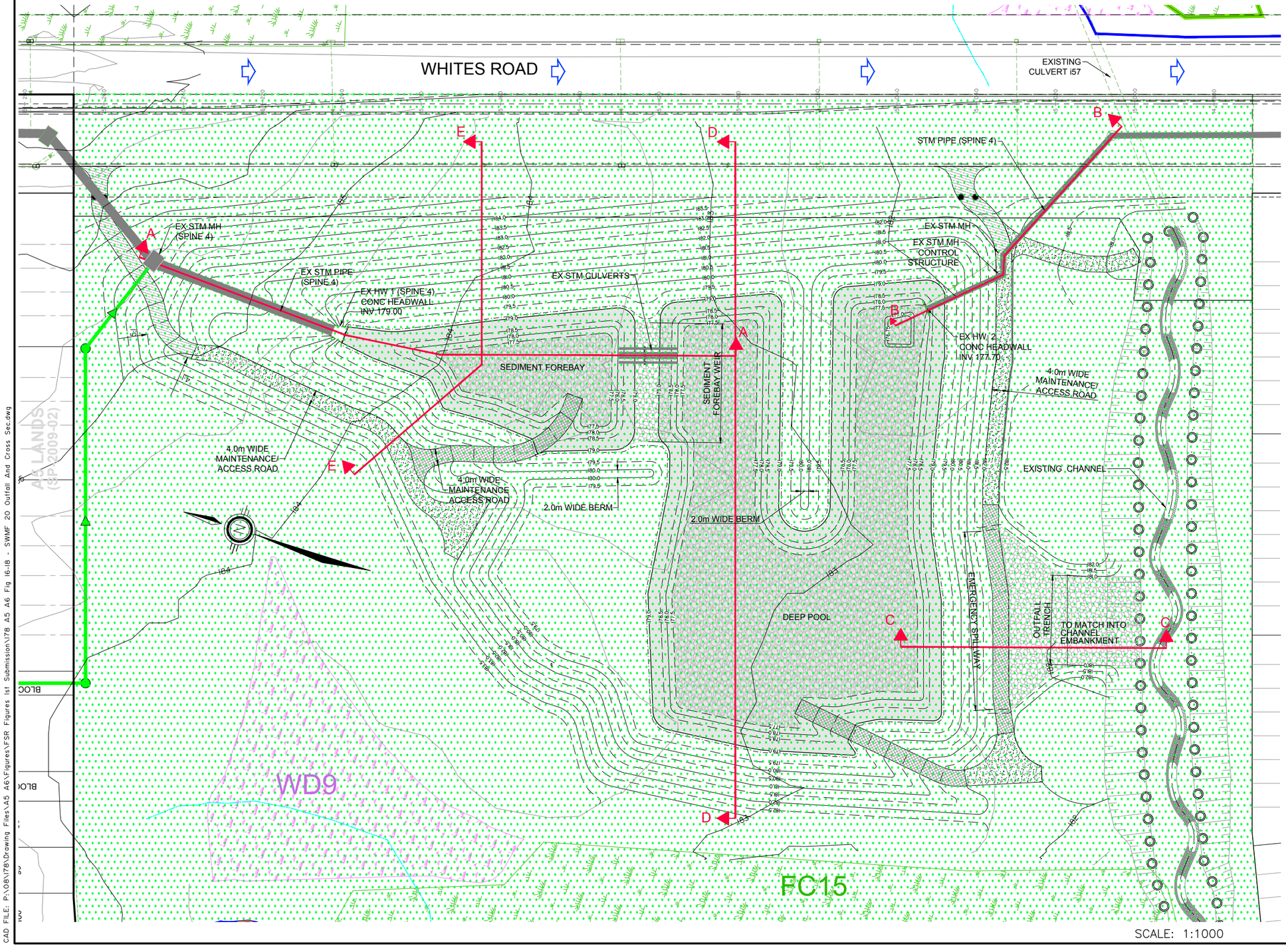
Table 12: SWMF20 Operating Characteristics

SWM Characteristic	Allowable Discharge (m^3/sec)	Design Discharge (m^3/sec)	Required Storage (m^3)	Provided Storage (Excl. Ext. Det.) (m^3)	Provided Storage (Incl. Ext. Det.) (m^3)	Elevation (m)
Perm Pool	N/A	N/A	7,729	-	9,919	179.00
Ext Detention	0.018	0.004	9,000	-	9,000	179.77
2 Yr Stm	0.196	0.126	10,532	10,532	19,532	180.51
5 Yr Stm	0.308	0.145	13,513	14,130	23,130	180.73
10 Yr Stm	0.386	0.156	15,217	16,480	25,480	180.88
25 Yr Stm	0.495	0.286	17,463	18,790	27,790	181.02
50 Yr Stm	0.579	0.457	19,128	20.070	29,070	181.09
100 Yr Stm	0.667	0.635	20,754	21,120	30,120	181.15

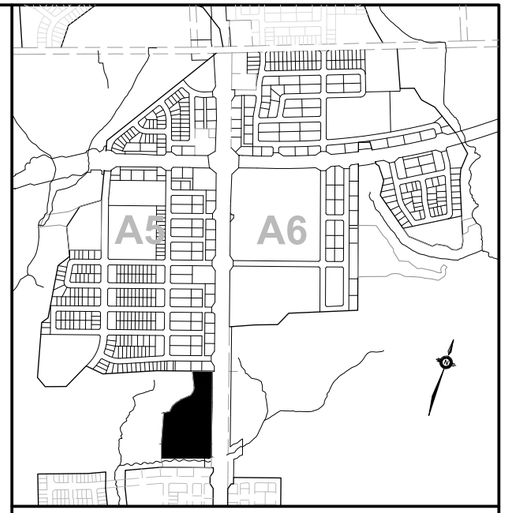
As shown in the above table, the extended detention fluctuation is within City of Pickering guidelines. Further, excess storage volume is available for the extended detention which will allow for refinements during detailed design.

SWM FACILITY OPERATING CHARACTERISTICS				
	DISCHARGE (m^3/s)	REQUIRED STORAGE* (m^3)	PROVIDED STORAGE* (m^3)	ELEVATION (m)
PERMANENT POOL	N/A	7,979	9,919	179.00
EXTENDED DETENTION	0.020	7,878	9,000	179.77
100 YEAR (STACKED)	0.635	30,630	30,630	181.18

*BASED ON 79% IMP AND DRAINAGE AREA 39.90 HA.



SCALE: 1:1000



KEYMAP N.T.S.

LEGEND:

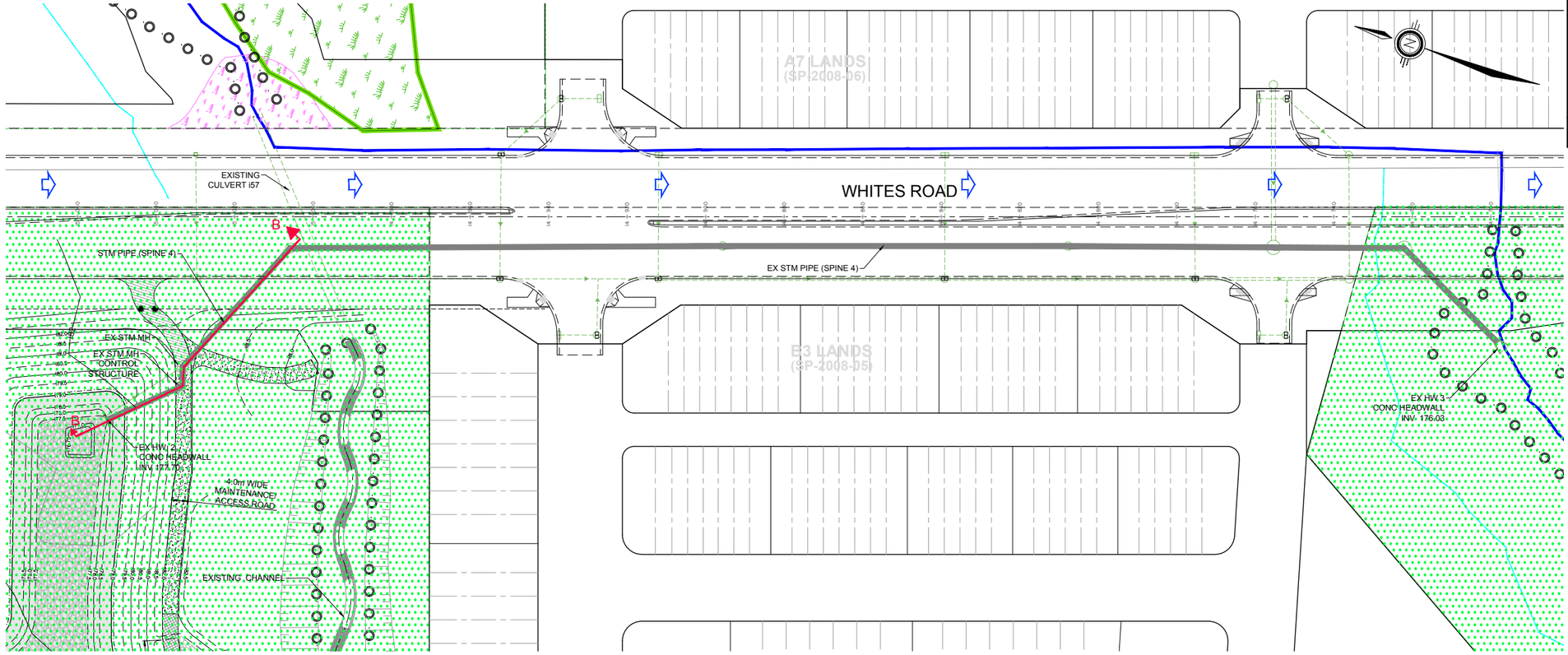
- NATURAL HERITAGE SYSTEM LIMIT
- WOODLANDS LIMIT
- WETLANDS LIMIT
- WATERCOURSE
- EXISTING CONTOUR
- WETLANDS SETBACK
- FISHERIES SETBACK (30m)
- MEANDER BELT WIDTH
- REGIONAL STORM FLOODPLAIN
- TOE EROSION
- WOODSTAKES LIMIT
- SWMF BLOCK
- PROPOSED POND CONTOUR
- PROPOSED STORM MANHOLE
- PROPOSED STORM SEWER AND FLOW DIRECTION
- EXISTING SPINE 4 STORM MANHOLE
- EXISTING SPINE 4 STORM SEWER AND FLOW DIRECTION
- OVERLAND FLOW DIRECTION

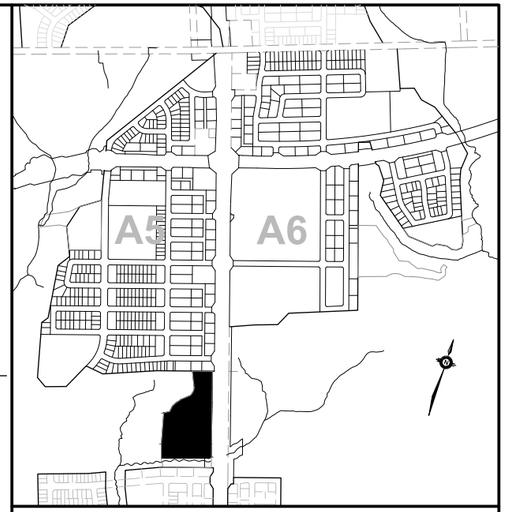
EXISTING SWMF 20 PLAN VIEW

SABOURIN KIMBLE & ASSOCIATES LTD. CONSULTING ENGINEERS

PROJECT NUMBER	FIGURE NO.
08:178	16

CAD FILE: P:\08\178\Drawing Files\A5 A6\Figures\FSR Figures 1st Submission\178 A5 A6 Fig 16-18 - SWMF 20 Outfall And Cross Sec.dwg





KEYMAP N.T.S.

LEGEND:

- NATURAL HERITAGE SYSTEM LIMIT
- WOODLANDS LIMIT
- WETLANDS LIMIT
- WATERCOURSE
- 161 EXISTING CONTOUR
- WETLANDS SETBACK
- FISHERIES SETBACK (30m)
- MEANDER BELT WIDTH
- REGIONAL STORM FLOODPLAIN
- TOE EROSION
- WS #105 WOODSTAKES LIMIT
- SWMF BLOCK
- 163.5 PROPOSED POND CONTOUR
- PROPOSED STORM MANHOLE
- PROPOSED STORM SEWER AND FLOW DIRECTION
- EXISTING SPINE 4 STORM MANHOLE
- EXISTING SPINE 4 STORM SEWER AND FLOW DIRECTION
- OVERLAND FLOW DIRECTION

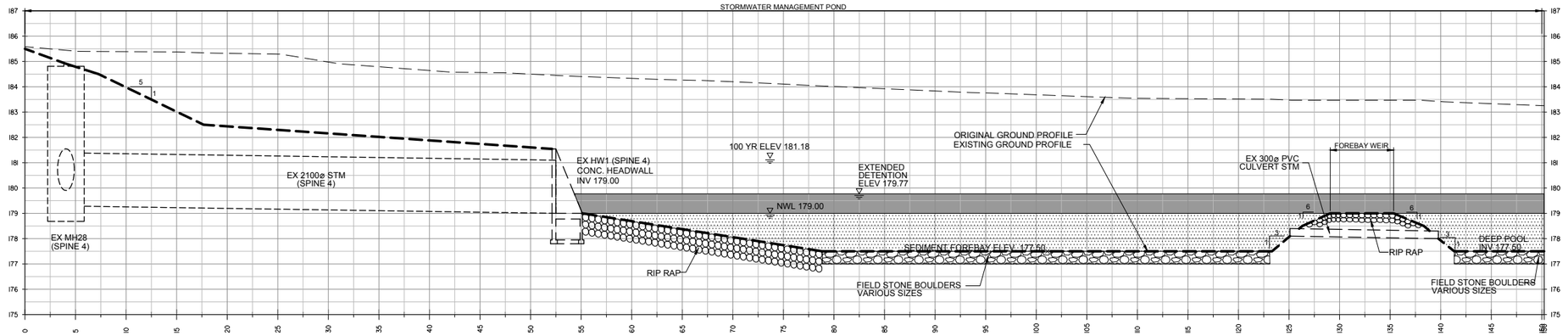
SCALE: 1:1250

EXISTING SWMF 20 OUTFALL

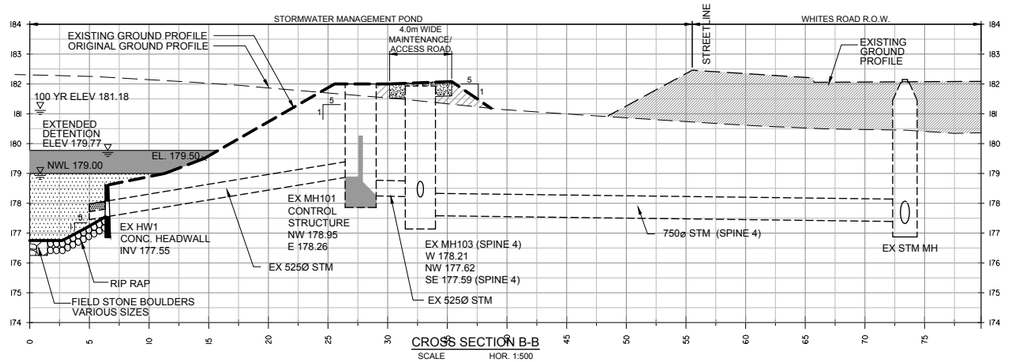
SABOURIN KIMBLE & ASSOCIATES LTD. CONSULTING ENGINEERS

PROJECT NUMBER	FIGURE NO.
08:178	17

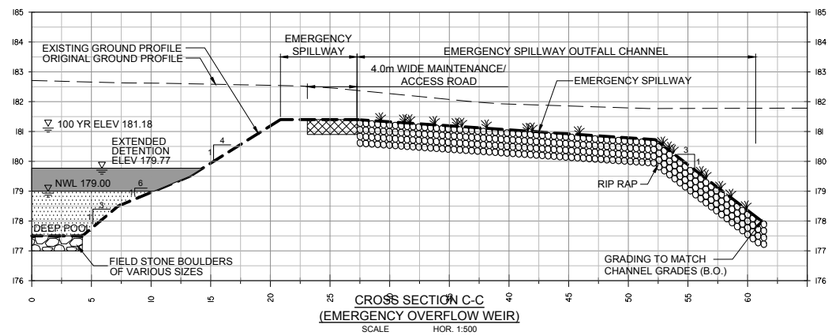
CAD FILE: P:\08\178\Drawing Files\A5 A6\Figures\FSR Figures 1st Submission\178 A5 A6 Fig 16-18 - SWMF 20 Outfall And Cross Sec.dwg



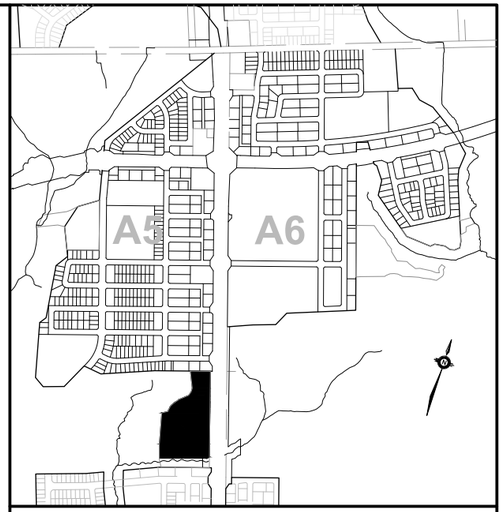
CROSS SECTION A-A
SCALE HOR. 1:500 VER. 1:200



CROSS SECTION B-B
SCALE HOR. 1:500 VER. 1:200

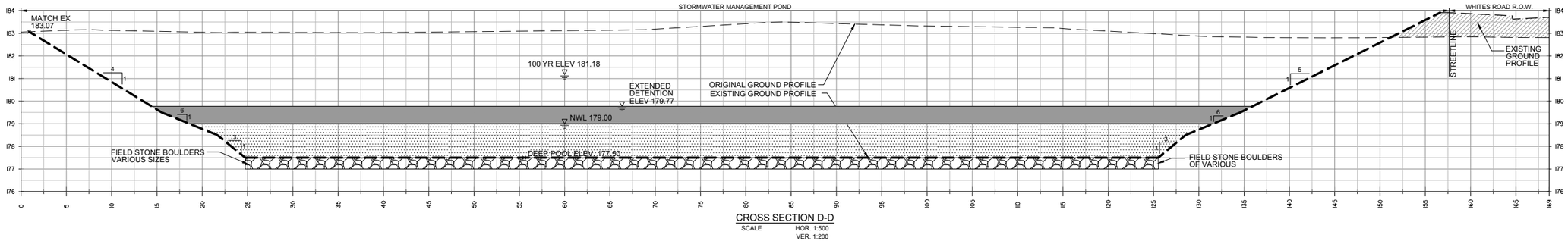


CROSS SECTION C-C
(EMERGENCY OVERFLOW WEIR)
SCALE HOR. 1:500 VER. 1:200

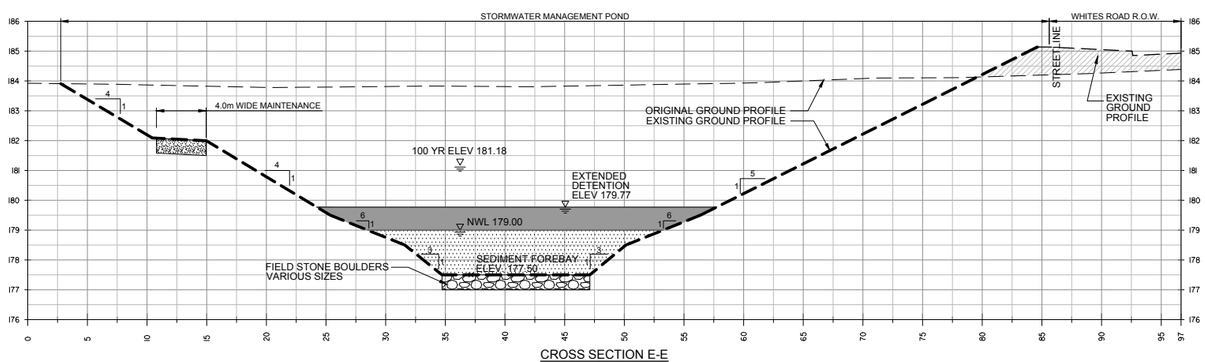


KEYMAP N.T.S.

100-YEAR (STAKED) PONDING ELEVATION (m)	181.18
EXTENDED DETENTION ELEVATION (m)	179.77
PERMANENT POOL ELEVATION (m)	179.00



CROSS SECTION D-D
SCALE HOR. 1:500 VER. 1:200



CROSS SECTION E-E
SCALE HOR. 1:500 VER. 1:200

EXISTING SWMF 20 CROSS SECTIONS

SABOURIN KIMBLE & ASSOCIATES LTD. CONSULTING ENGINEERS

PROJECT NUMBER	FIGURE NO.
08:178	18

CAD FILE: P:\08\178\Drawing Files\A5 A6\Figures\FSR Figures 1st Submission\178 A5 A6 Fig 16-18 - SWMF 20 Outfall And Cross Sec.dwg

6.5.3 Stormwater Management Facility 22

SWMF22 is an existing interim facility that was constructed in support of the Whites Road construction. The pond was graded to its ultimate configuration with interim controls in place, however the control structure will be modified to address the ultimate post development drainage conditions. The storage fluctuation will be adjusted accordingly. SWMF22 has a total contributing drainage area of 25.38 ha. Drainage boundaries are illustrated on **Figure 12** (back pocket). Based on the proposed land use, the contributing drainage area has an impervious coverage of 72%.

The pond's permanent pool will provide Enhanced Protection Level (80% TSS removal) quality control. The extended detention volume will have a drawdown time greater than 120 hours. The required quantity control volume will be stacked on top of the extended detention volume. The preliminary design will provide storage volumes and release rates that satisfy the DCHU criteria for Catchment 34 for the 2 through 100-year storm events. Grading, outfall and access characteristics have been designed to satisfy the City of Pickering's stormwater facility design criteria. An overflow weir will allow passage of the 1:100 Year storm flow if the outlet structure is blocked. Grading and outfall characteristics also satisfy the design criteria for discharge to redside dace habitat. SWMF 22 preliminary design calculations are provided in **Appendix L**. Preliminary Pond plan view, outfall and profiles are shown on **Figure 19** to **21**, respectively. Operating characteristics of the facility are presented in **Table 13**.

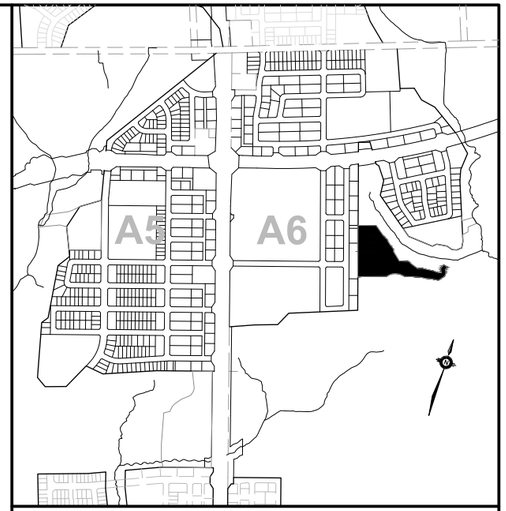
Table 13: SWMF22 Operating Characteristics

SWM Characteristic	Allowable Discharge (m^3/sec)	Design Discharge (m^3/sec)	Required Storage (m^3)	Provided Storage (Excl. Ext. Det.) (m^3)	Provided Storage (Incl. Ext. Det.) (m^3)	Elevation (m)
Perm Pool	N/A	N/A	4,798	-	8,976	189.50
Ext Detention	0.011	0.010	4,595	-	4,595	190.03
2 Yr Stm	0.038	0.034	7,157	7,157	11,752	190.70
5 Yr Stm	0.091	0.038	9,314	9,550	14,145	190.92
10 Yr Stm	0.115	0.057	10,634	11,000	15,595	191.04
25 Yr Stm	0.149	0.120	12,335	12,550	17,145	191.17
50 Yr Stm	0.175	0.157	13,576	13,680	18,275	191.26
100 Yr Stm	0.202	0.185	14,822	14,890	19,485	191.36

As shown in the above table, the extended detention fluctuation is within City of Pickering guidelines. Further, excess storage volume is available for the extended detention which will allow for refinements during detailed design.

LEGEND:

- NATURAL HERITAGE SYSTEM LIMIT
- WOODLANDS LIMIT
- WETLANDS LIMIT
- WATERCOURSE
- EXISTING CONTOUR
- WETLANDS SETBACK
- FISHERIES SETBACK (30m)
- MEANDER BELT WIDTH
- REGIONAL STORM FLOODPLAIN
- TOE EROSION
- WOODSTAKES LIMIT
- SWMF BLOCK
- PROPOSED POND CONTOUR
- EXISTING STORM MANHOLE
- EXISTING STORM SEWER AND FLOW DIRECTION
- PROPOSED STORM MANHOLE
- PROPOSED STORM SEWER AND FLOW DIRECTION
- PROPOSED SANITARY MANHOLE
- PROPOSED SANITARY SEWER AND FLOW DIRECTION
- OVERLAND FLOW DIRECTION



KEYMAP N.T.S.

SWM FACILITY OPERATING CHARACTERISTICS

	DISCHARGE (m^3/s)	REQUIRED STORAGE* (m^3)	PROVIDED STORAGE* (m^3)	ELEVATION (m)
PERMANENT POOL	N/A	4,816	8,976	189.50
EXTENDED DETENTION	0.008	4,622	4,622	190.03
100 YEAR (STACKED)	0.185	19,562	19,562	191.36

*BASED ON 73% IMP AND DRAINAGE AREA 25.39 HA.

REDWILLOW CRESCENT
BLOCK 409
BLOCK 410
BLOCK 470
BLOCK 411
A6 LANDS (SP-2009-02)
EX 4.0m WIDE MAINTENANCE/ ACCESS ROAD
STM PIPE
HW 1 CONC. HEADWALL INV 189.50
SEDIMENT FOREBAY
EX 450Ø STM CULVERTS
SEDIMENT FOREBAY WEIR
2.0m WIDE BERM
DEEP POOL
EX HW 2 CONC. HEADWALL INV 187.00
G14-2
SIMPLE CONTRIBUTING HABITAT (NON-REGULATED)
MEANDER BELT WIDTH
30.0m FISHERIES SETBACK
EMERGENCY OVERFLOW WEIR
EX 450Ø STM PIPE (REVERSE SLOPE)
EX MH 1 2400Ø PC WITH ULTIMATE CONC CONTROL WALL STRUCTURE W 189.00 E 189.50
EX COOLING TRENCH
EX HW 2 CONC. HEADWALL INV 189.30
EX 600Ø STM PIPE
EX 4.0m WIDE MAINTENANCE/ ACCESS ROAD
EX SWALE
REGULATED REDSIDE DACE HABITAT (CONTRIBUTING)
G14-1
GANATSEKIAGON CREEK
FC17
WD10

SCALE: 1:1000

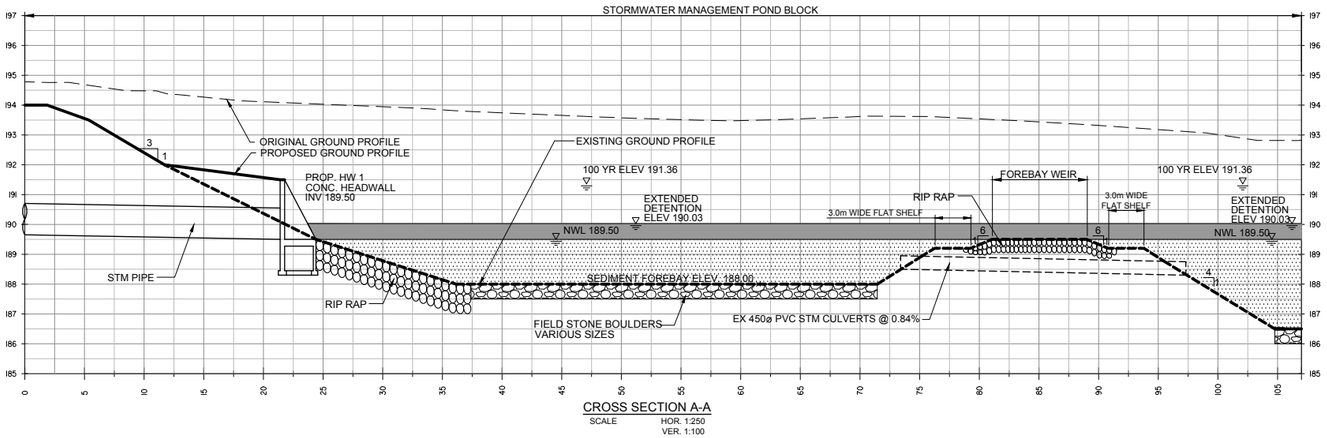
EXISTING SWMF 22 PLAN VIEW

SABOURIN KIMBLE & ASSOCIATES LTD. CONSULTING ENGINEERS

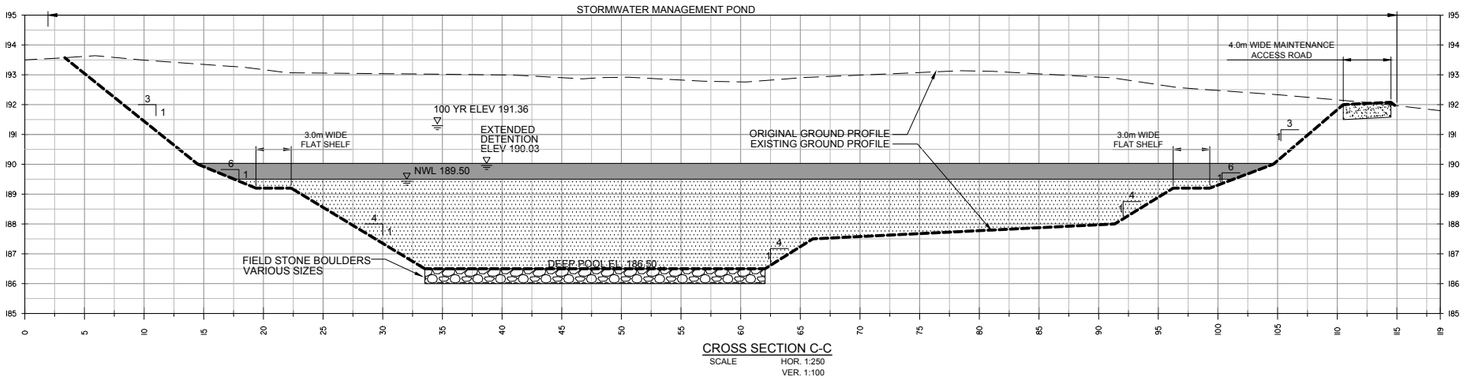
PROJECT NUMBER 08:178

FIGURE NO. 19

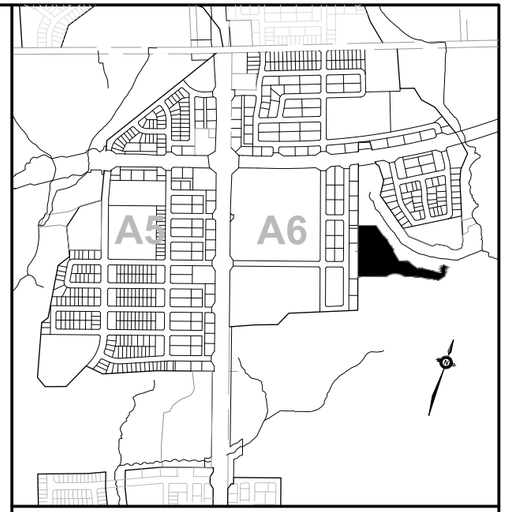
CAD FILE: P:\08\178\Drawing Files\A5 A6\Figures\FSR Figures 1st Submission\178 A5 A6 Fig 19-21 - SWMF 22 Outfall And Cross Sec.dwg



CROSS SECTION A-A
SCALE HOR. 1:250
VER. 1:100



CROSS SECTION C-C
SCALE HOR. 1:250
VER. 1:100



KEYMAP N.T.S.

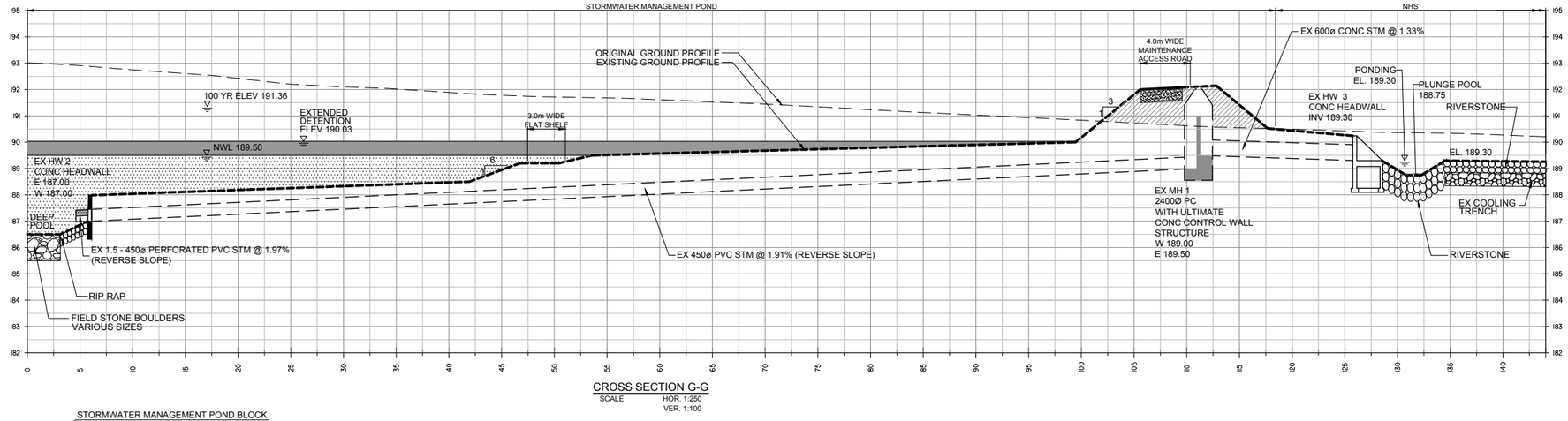
100-YEAR (STACKED) PONDING ELEVATION (m)	191.35
EXTENDED DETENTION ELEVATION (m)	190.03
PERMANENT POOL ELEVATION (m)	189.50

EXISITNG SWMF 22 CROSS SECTIONS

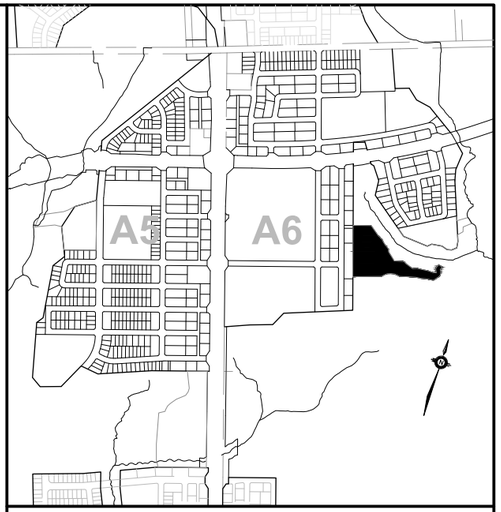
SABOURIN KIMBLE & ASSOCIATES LTD. CONSULTING ENGINEERS

PROJECT NUMBER	FIGURE NO.
08:178	20

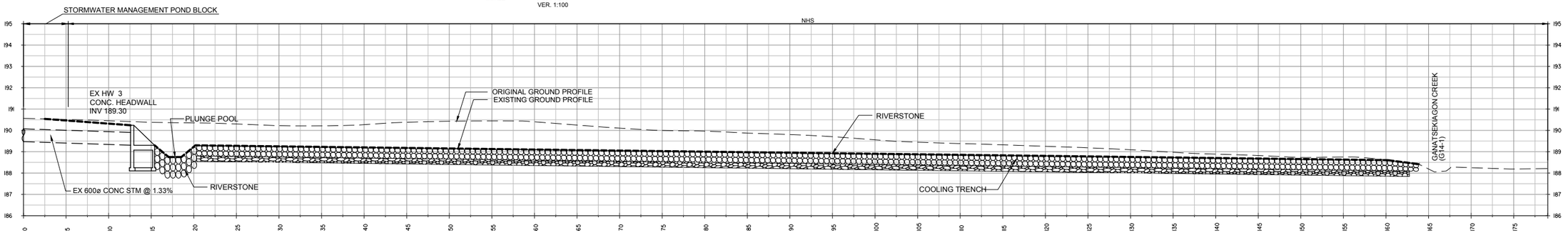
CAD FILE: P:\08\178\Drawing Files\A5 A6\Figures\FSR Figures 1st Submission\178 A5 A6 Fig 19-21 - SWMF 22 Outfall And Cross Sec.dwg



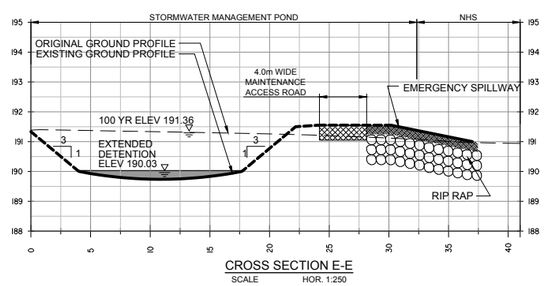
CROSS SECTION G-G
SCALE HOR. 1:250
VER. 1:100



KEYMAP N.T.S.



CROSS SECTION H-H
(COOLING TRENCH)
SCALE HOR. 1:250
VER. 1:100



CROSS SECTION E-E
SCALE HOR. 1:250
VER. 1:100

100-YEAR (STACKED) PONDING ELEVATION (m)	191.35
EXTENDED DETENTION ELEVATION (m)	190.03
PERMANENT POOL ELEVATION (m)	189.50

EXISTING SWMF 22
CROSS OUTFALL

SABOURIN KIMBLE & ASSOCIATES LTD.
CONSULTING ENGINEERS

PROJECT NUMBER
08:178

FIGURE NO.
21

CAD FILE: P:\08\178\Drawing Files\A5 A6\Figures\FSR Figures 1st Submission\178 A5 A6 Fig 19-21 - SWMF 22 Outfall And Cross Sec.dwg

6.5.4 Stormwater Management Facility 22A

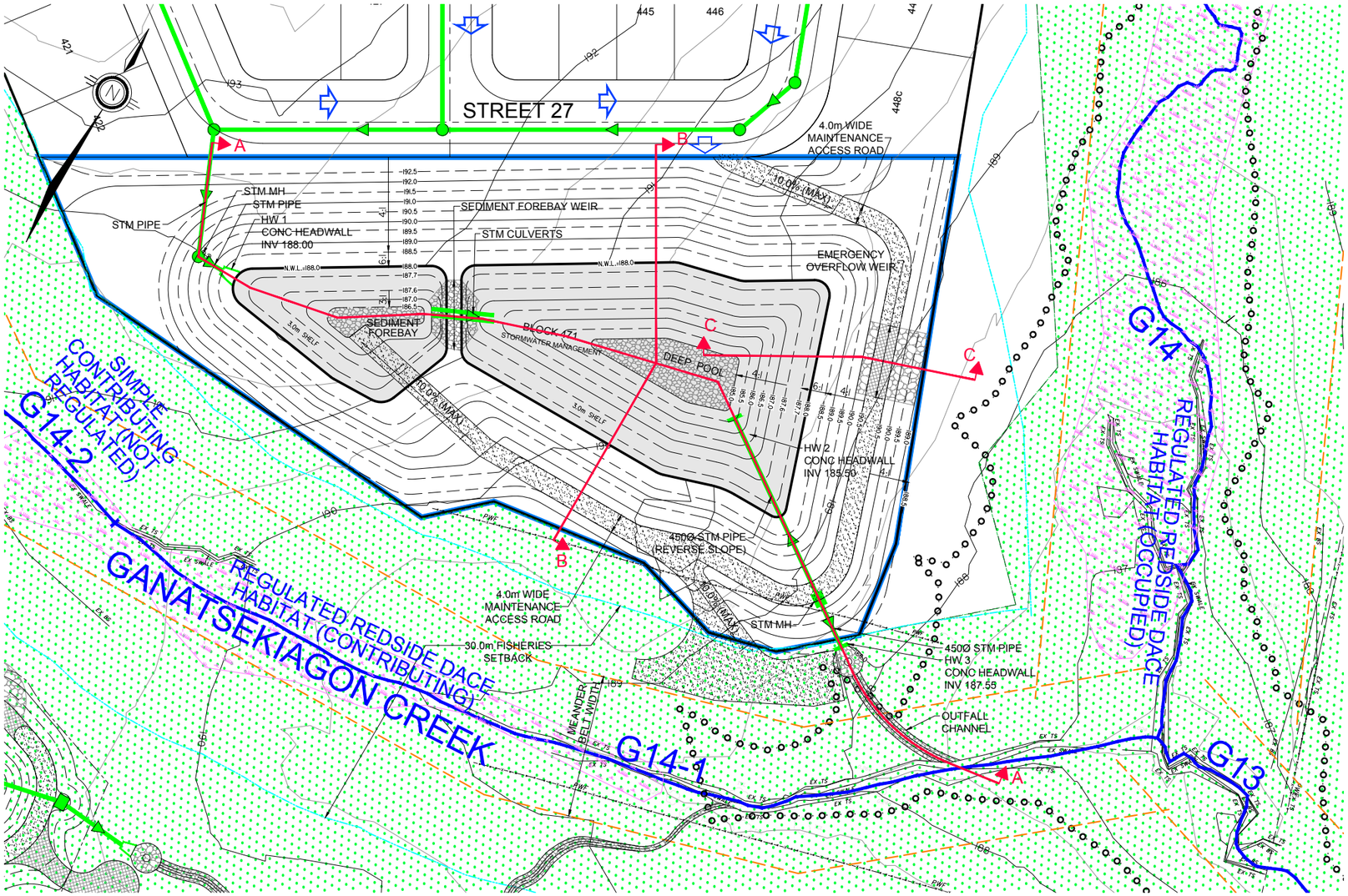
SWMF22A has a total contributing drainage area of 9.47 ha. Drainage boundaries are illustrated on **Figure 12** (back pocket). Based on the proposed land use, the contributing drainage area has an impervious coverage of 62%. The pond's permanent pool will provide Enhanced Protection Level (80% TSS removal) quality control. The extended detention volume will have a drawdown time greater than 120 hours. The required quantity control volume will be stacked on top of the extended detention volume.

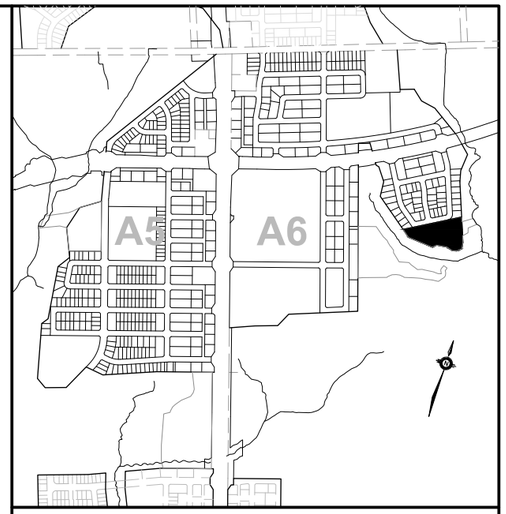
The preliminary design storage volumes for the two through 100-year storms are slightly less than the DCHU criteria for Catchment 31 because the runoff coefficient for the proposed development is significantly lower than the coefficient assumed in the DCHU. The release rates, however, satisfy the DCHU criteria for the 2 through 100-year storm events. Grading, outfall and access characteristics have been designed to satisfy the City of Pickering's stormwater facility design criteria. An overflow weir will allow passage of the 1:100 Year storm flow if the outlet structure is blocked. Grading and outfall characteristics also satisfy the design criteria for discharge to redside dace habitat. The permanent pool is designed to provide Level 1 (Enhanced) SWMF 22A preliminary design calculations are provided in **Appendix M**. Preliminary Pond plan view, outfall and profiles are shown on **Figure 22** to **24**, respectively. Operating characteristics of the facility are presented in **Table 14**.

Table 14: SWMF22A Operating Characteristics

SWM Characteristic	Allowable Discharge (m^3/sec)	Design Discharge (m^3/sec)	Required Storage (m^3)	Provided Storage (Excl. Ext. Det.) (m^3)	Provided Storage (Incl. Ext. Det.) (m^3)	Elevation (m)
Perm Pool	N/A	N/A	1,567	-	3,400	188.00
Ext Detention	0.006	0.005	1,459	-	1,459	188.39
2 Yr Stm	0.016	0.017	2,671	2,200	3,659	188.89
5 Yr Stm	0.018	0.019	3,475	3,030	4,489	189.05
10 Yr Stm	0.019	0.023	3,968	3,580	5,039	189.15
25 Yr Stm	0.024	0.027	4,602	4,290	5,749	189.28
50 Yr Stm	0.027	0.029	5,066	4,820	6,279	189.38
100 Yr Stm	0.029	0.031	5,530	5,360	6,819	189.47

As shown in the above table, the extended detention fluctuation is within City of Pickering guidelines. Further, excess storage volume is available for the extended detention which will allow for refinements during detailed design.





KEYMAP N.T.S.

LEGEND:

- NATURAL HERITAGE SYSTEM LIMIT
- WOODLANDS LIMIT
- WETLANDS LIMIT
- WATERCOURSE
- 161 EXISTING CONTOUR
- WETLANDS SETBACK
- FISHERIES SETBACK (30m)
- MEANDER BELT WIDTH
- REGIONAL STORM FLOODPLAIN
- TOE EROSION
- WS #105 WOODSTAKES LIMIT
- SWMF BLOCK
- 163.5 PROPOSED POND CONTOUR
- PROPOSED STORM MANHOLE
- PROPOSED STORM SEWER AND FLOW DIRECTION
- OVERLAND FLOW DIRECTION

SWM FACILITY OPERATING CHARACTERISTICS				
	DISCHARGE (m^3/s)	REQUIRED STORAGE* (m^3)	PROVIDED STORAGE* (m^3)	ELEVATION (m)
PERMANENT POOL	N/A	1,700	3,566	188.00
EXTENDED DETENTION	0.005	1,592	1,592	188.43
100 YEAR (STACKED)	0.029	7,292	7,292	189.55

*BASED ON 64% IMP AND DRAINAGE AREA 9.89 HA.

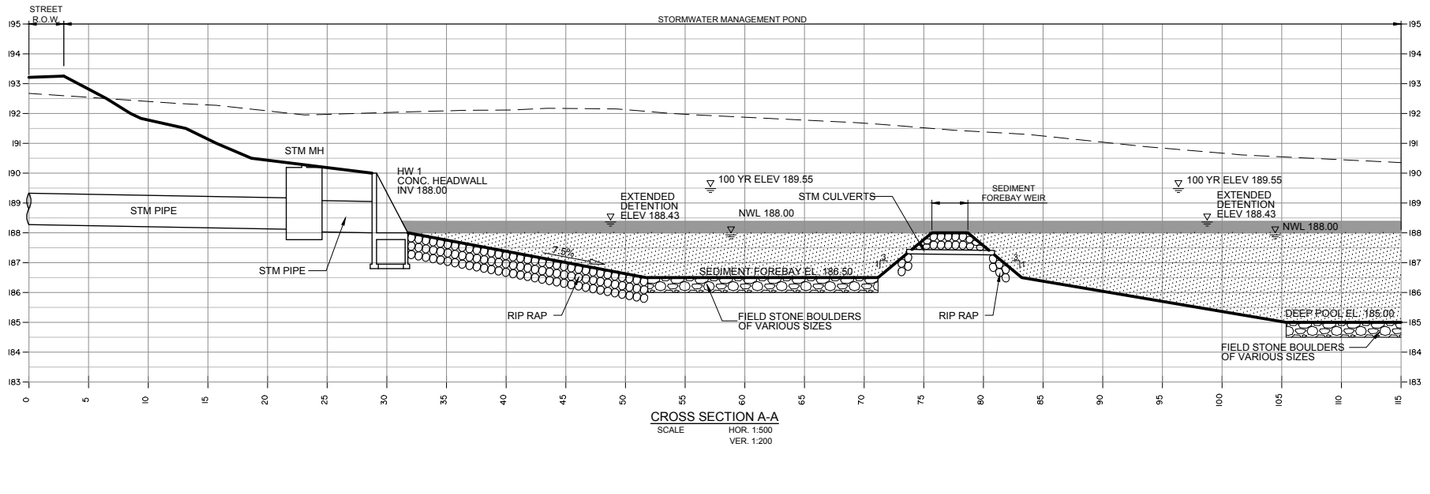
SWMF 22A PLAN VIEW

SABOURIN KIMBLE & ASSOCIATES LTD. CONSULTING ENGINEERS

PROJECT NUMBER 08:178

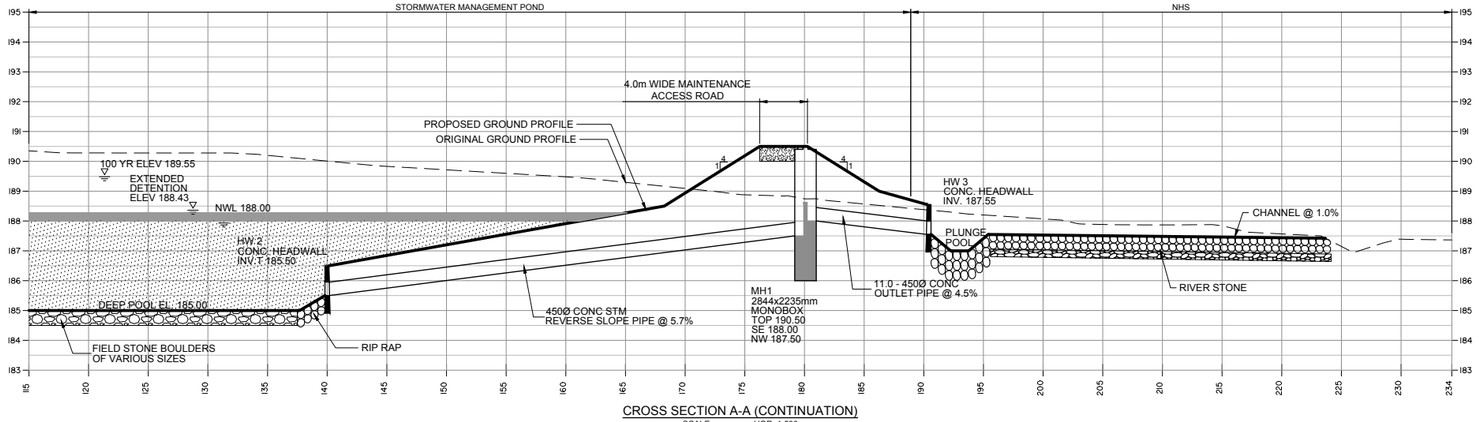
FIGURE NO. 22

CAD FILE: P:\08\178\Drawing Files\A5 A6\Figures\FSR Figures 1st Submission\178 A5 A6 Fig 22-24 - SWMF 22A Outfall And Cross Sec.dwg



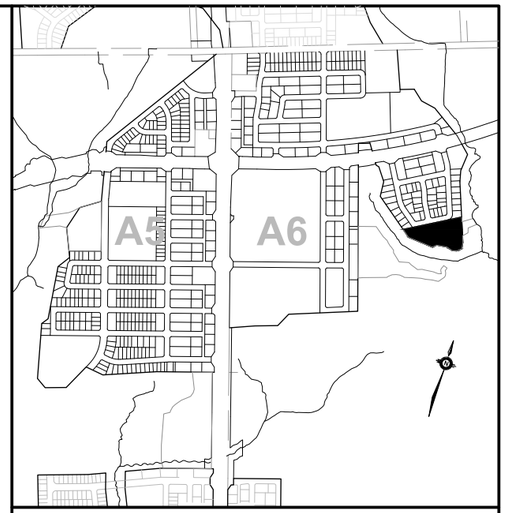
CROSS SECTION A-A

SCALE HOR. 1:500
VER. 1:200



CROSS SECTION A-A (CONTINUATION)

SCALE HOR. 1:500
VER. 1:200



KEYMAP N.T.S.

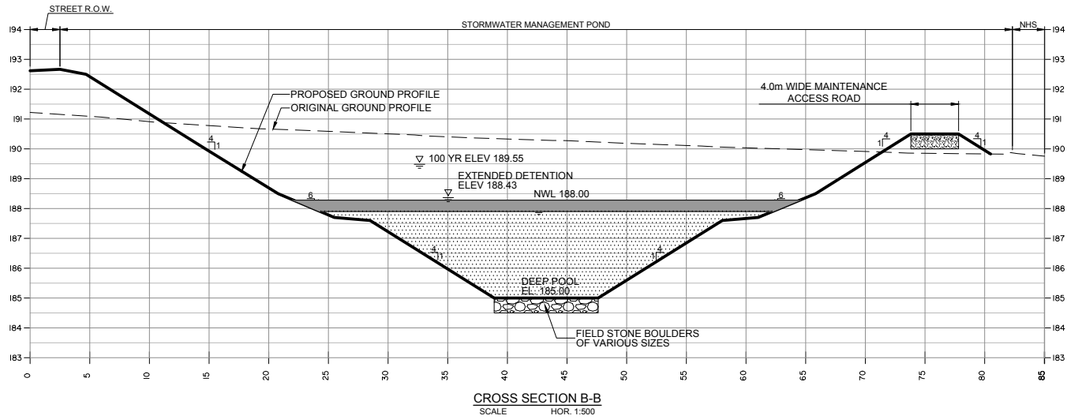
100-YEAR (STACKED) PONDING ELEVATION (m)	189.55
EXTENDED DETENTION ELEVATION (m)	188.43
PERMANENT POOL ELEVATION (m)	188.00

SWMF 22A OUTFALL

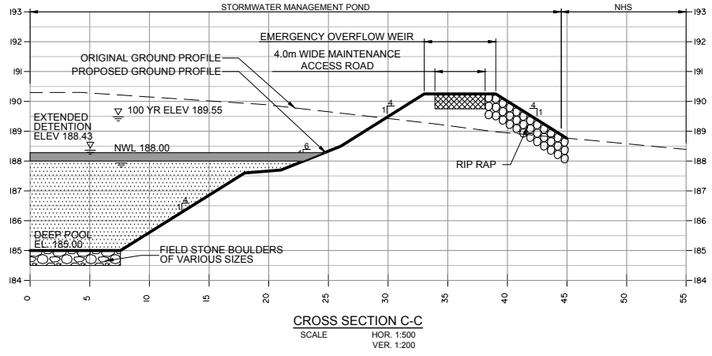
SABOURIN KIMBLE & ASSOCIATES LTD.
CONSULTING ENGINEERS

PROJECT NUMBER	FIGURE NO.
08:178	23

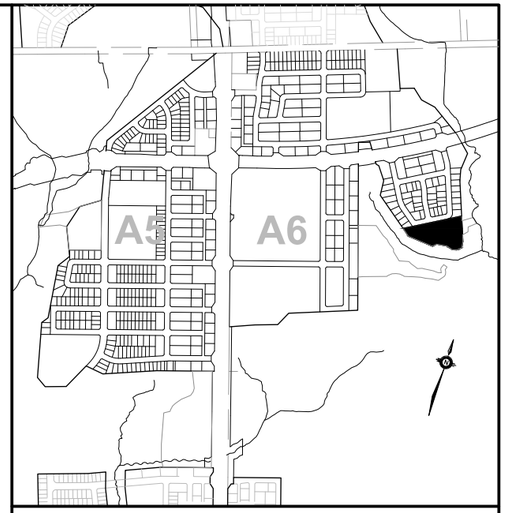
CAD FILE: P:\08\178\Drawing Files\A5 A6\Figures\FSR Figures 1st Submission\178 A5 A6 Fig 22.24 - SWMF 22A Outfall And Cross Sec.dwg



CROSS SECTION B-B
SCALE HOR. 1:500 VER. 1:200



CROSS SECTION C-C
SCALE HOR. 1:500 VER. 1:200



KEYMAP N.T.S.

100-YEAR (STACKED) PONDING ELEVATION (m)	189.55
EXTENDED DETENTION ELEVATION (m)	188.43
PERMANENT POOL ELEVATION (m)	188.00

SWMF 22A CROSS SECTIONS

SABOURIN KIMBLE & ASSOCIATES LTD. CONSULTING ENGINEERS

PROJECT NUMBER	FIGURE NO.
08:178	24

CAD FILE: P:\08\178\Drawing Files\A5 A6\Figures\FSR Figures 1st Submission\178 A5 A6 Fig 22-24 - SWMF 22A Outfall And Cross Sec.dwg

6.6 Stormwater Management Pond Outfalls

6.6.1 SWMF19 Outfall

The outfall from SWMF 19 is located on the east side of a minor tributary of the east branch of Whitevale Creek as far back from the channel as possible to limit the potential for erosion concerns. The outfall is required to convey the 100-year pond outflow to reach W7-2. In the HEC RAS model for Whitevale Creek, the outfall headwall is located near section 31.110 where the 100-year water surface elevation is 180.64. The outfall headwall elevation will be set at elevation 182.00, to blend in with the existing toe of slope and to ensure that the water level in Whitevale Creek will not impact the outflow from the pond. The headwall will discharge to a rip rap plunge pool and outfall channel which will withstand and dissipate the pond outlet flows prior to them reaching the W7-2 channel. An easement over the outfall and channel in favour of the City of Pickering is required wherever this infrastructure is located on provincially owned land.

As part of the Seaton Community NFSSR *Meander Belt Width and Erosion Risk Assessment,* which is enclosed in **Appendix N**, Parish Geomorphic analysed hydraulic geometry, sediment characterization and erosion threshold and assessed this portion of the creek as transitional and did not identify any erosion concerns.

Beacon Environmental provided an *Input to Functional Servicing and Stormwater Management Report - Scoped Environmental Impact Study* in which they identified the relevant natural feature buffers and evaluated the potential impacts of the proposed stormwater management facilities on the surrounding terrestrial and aquatic habitat. Beacon concluded that with appropriate construction mitigation measures and replanting, SWMF19 can be constructed without adversely affecting the Natural Heritage System. Monitors are currently in place to determine the presence of any Species at Risk bats. Removal of any vegetation considered to be Suitable SAR Bat Habitat should not occur between April 15 to October 1. The *Scoped Site Environmental Impact Study* is enclosed in **Appendix C**.

6.6.2 SWMF20 Outfall

SWMF20 discharges to an existing storm sewer on Whites Road which was constructed solely for the pond outlet. The storm sewer and the outfall were constructed in conjunction with Whites Road. The outfall is located on the west side of Whites Road, approximately 300m south of the pond block, adjacent to the upstream end of a remnant of a tributary of West Duffins Creek. The

outfall conveys the 100-year pond outflow to reach DB2-5. Easements in favour of the City of Pickering are required for any outfall related infrastructure located on provincially owned land.

As part of the Seaton Community NFSSR *Meander Belt Width and Erosion Risk Assessment*, (**Appendix N**), Parish Geomorphic analysed hydraulic geometry, sediment characterization and erosion threshold. They assessed the location of the proposed outfall to be transitional and did not identify any erosion concerns.

Beacon Environmental provided an *Input to Functional Servicing and Stormwater Management Report - Scoped Environmental Impact Study* (**Appendix C)** in which they identified the relevant natural feature buffers and evaluated the potential impacts of the proposed stormwater management facilities on the surrounding terrestrial and aquatic habitat. Beacon concluded that with appropriate design features and construction mitigation measures, SWMF20 can be constructed without adversely affecting the Natural Heritage System.

6.6.3 Duffins Branch Erosion Analysis – SWMF 20

The *Meander Belt Width and Erosion Risk Assessment* carried out by Parish analysed the DB2 reach of the branch of Duffins Creek, which is downstream of the outlet of Pond 20. (This report referred to MESP reach DB2 as being part of DB1.) The assessment concluded that this reach has a low critical discharge value of 0.005 m^3/s. Matrix Solutions was therefore retained to carry out a detailed erosion threshold analysis was completed to determine the "critical discharge" of Reach DB2. A copy of their study *Seaton Land Development – Reach DB-2 Erosion Analysis* can be found in **Appendix O**.

The critical discharge was used in the design of stormwater management facility outlet controls. In order to mitigate erosion in DB2, Pond 20's erosion control volume was designed to provide 9,000 m^3, which is more than required by the DCHU unit rates. Once the pond curve was established, a continuous model was run to generate a hydrograph in reach DB2 for six (6) consecutive years of data. These hydrographs were provided to Matrix, who then used them in their modelling to determine the cumulative effective discharge, cumulative effective work index, duration of exceedances and number of exceedance events. These results are presented in **Table 15**. The continuous model used to generate the hydrographs in reach DB2 can be found in **Appendix P**.

Table 15: Post-Development vs. Pre-Development Erosive Flows for DB2

Parameter	Existing Conditions	Proposed Conditions	Percent Change
Time of Events Exceeding 0.005 m^3/sec (hrs)	974	1,914	1,202
Cumulative Erosion Index	0.93	0.70	-33
Cumulative Effective Work Index	74	52	-47

As shown in the above table, based on six years of rainfall data, the total hours of flow above the erosive threshold will be greater under proposed conditions than under existing conditions. The longer time of exceedance is attributed to the long release time from the stormwater management facility and a very low threshold. Matrix concluded however, that the proposed conditions Cumulative Erosion Index and Cumulative Effective Work Index will both be lower under proposed conditions than existing conditions, the erosive potential will also be less. Matrix recommends that the stream stability be monitored after development in accordance with TRCA protocol.

6.6.4 SWMF22 Outfall

The outfall from SWMF22 and a related cooling trench were constructed in conjunction with Whites Road. It is located on the south side of a tributary of Ganatsekiagon Creek as far back from the channel as possible to limit the potential for erosion concerns and to maximize cooling of the pond discharge. The outfall is required to convey the 100-year pond outflow to reach G14-1. The outfall headwall elevation has been set at elevation 189.30 and the channel outlets to the creek at elevation 188.42. The design grade of the 140-metre-long channel is 0.60% and the channel is constructed with 450mm deep riverstone over a 500 mm deep clear stone gallery wrapped in filter fabric. Easements in favour of the City of Pickering are required for any pond related infrastructure which is located on provincially owned land.

As part of the approved Whites Road Pond design, GEO Morphix Ltd. assessed the erosion potential within reach G14-1, which is the most critical reach near the pond outlet. GEO Morphix determined that the reach has an erosion threshold of 0.4 m^3/s. The erosion potential of the pond discharge is discussed further in **Section 6.6.6**. The erosion analysis is enclosed in **Appendix Q**.

Beacon Environmental provided an *Input to Functional Servicing and Stormwater Management Report - Scoped Environmental Impact Study* (**Appendix C**) in which they identified redside dace habitat. Beacon identified relevant natural feature buffers and evaluated the potential impacts of the proposed stormwater management facilities on the surrounding terrestrial and aquatic habitat. Beacon concluded that appropriate design features and construction mitigation measures, were incorporated such that SWMF20 was constructed without adversely affecting the Natural Heritage System.

6.6.5 SWMF22A Outfall

The outfall from SWMF22A is located on the north side of a tributary of Ganatsekiagon Creek as far back from the channel as possible to limit the potential for erosion concerns and to maximize cooling of the pond discharge. According to the MESP, the outfall was originally proposed to convey the 100-year pond outflow to reach G14, however the preliminary design presented herein proposes to discharge the pond to reach G14-1 due to habitat considerations. The outfall headwall elevation has been set at elevation 187.55 and the channel outlets to the creek at elevation 188.40. The design grade of the 30-metre-long channel is 0.50% and the channel is constructed with 450mm deep riverstone over a 500 mm deep clear stone gallery wrapped in filter fabric. An easement is required for any part of the outfall which is located on provincially owned land.

As part of the approved Whites Road Pond design, GEO Morphix Ltd. assessed the erosion potential within reach G14-1, which is the most critical reach near the pond outlet (**Appendix Q**). GEO Morphix determined that the reach has an erosion threshold of 0.04 m^3/s. The erosion potential of the pond discharge is discussed further in **Section 6.6.6**.

Beacon Environmental provided an *Input to Functional Servicing and Stormwater Management Report - Scoped Environmental Impact Study* (**Appendix C**) in which they identified redside dace habitat. Beacon identified relevant natural feature buffers and evaluated the potential impacts of the proposed stormwater management facilities on the surrounding terrestrial and aquatic habitat. Beacon concluded that with appropriate pond design features, construction mitigation measures and replanting, SWMF22A can be constructed without adversely affecting the Natural Heritage System. Monitors are currently in place to determine the presence of any Species at Risk bats. Removal of any vegetation considered to be Suitable SAR Bat Habitat should not occur between April 15 to October 1.

6.6.6 Ganatsekiagon Creek Erosion Analysis – SWMF 22 and 22A

Through the MESPA commenting process the City of Pickering identified "Watercourses of Concern" due to the proposed stormwater management plan and the potential erosion issues at multiple stormwater management facilities' outlets. Ganatsekiagon tributary reach G14-1, the proposed outlet for SMWF22, was identified by the City of Pickering. As a result, GEO Morphix Limited was retained by Sabourin Kimble & Associates Ltd. to carry out a detailed field investigation assessing the erosion threshold of reach G14-1. GEO Morphix determined that the erosive threshold flow in G14-1 is 0.04 m^3/s. A copy of their original study *Watercourse Erosion Assessment in Support of Functional Servicing and Stormwater Management Plan Report for Draft Plan of Subdivision SP-2008-05, SP-2008-06 and SP-2009-02*, dated January 11, 2015 along with their update *Response to TRCA and City of Pickering Comments – SWMF 4, 20, 22 and 36* dated October 12, 2018 can be found in **Appendix O**.

The critical discharge was used in the design of stormwater management facility outlet controls. In order to mitigate erosion in G14-1, Pond 22's two year storm release rate was designed to be 0.038 m^3/s instead of 0.057 m^3/s as required by the DCHU unit rate criteria. Once the pond curve was established, a continuous model was run to generate a hydrograph in reach G14-1 for six (6) consecutive years of data. These hydrographs were provided to GEO Morphix, who then used them in their modelling to determine the cumulative effective discharge, cumulative effective work index, duration of exceedances and number of exceedance events. These results are presented in **Table 16**.

Table 16 Post-Development vs. Pre-Development Erosive Flows for One Pond Outlet to G14-1

Parameter	Existing Conditions	Proposed Conditions	Percent Change
Cumulative Effective Discharge (m^3/sec)	99.72	21.21	-79%
Cumulative Effective Work Index (N/m)	8,810,344	1,218,432	-86%
Time of Events Exceeding 0.04 m^3/sec (hrs)	241.33	104.00	-57%
Number of Events Exceeding 0.04 m^3/sec	77	50	-35%

As shown in the above table, all parameters for post-development conditions are less than the parameters for predevelopment conditions, therefore no further erosion study was recommended.

Following the completion of the GEO Morphix erosion analysis, which reflected the discharge of SWMF22 into G14-1, Sabourin Kimble examined the potential merits of also discharging SWMF 22A to G14-1. The proposed outfall location would discharge to Redside Dace Contributing habitat instead of Redside Dace Occupied habitat and would allow for more favorable pond grading. Sabourin Kimble therefore examined the potential effects on stream erosion within reach G14-1 by comparing occurrences of erosive flows under existing conditions to proposed conditions including two pond outlets. The erosion assessment consisted of preparing continuous SWMHYMO models using six years of rainfall data, to be consistent with prior hydrologic studies for the area. The resulting hydrographs for each year were compared to determine the total hours of erosive flow and number of erosive events. Existing conditions, the single pond outlet option and the two pond outlet option are compared in **Table 17**.

Table 17: G14-1 Post-Development vs. Pre-Development Erosive Flows for Two Pond Outlets to G14-1

Parameter	Existing Conditions	Proposed Conditions	
		Pond 22 Outlet	Ponds 22 and 22A Outlets
Time of Events Exceeding 0.04 m^3/sec (hrs)	241.33	104.00	82.35
Number of Events Exceeding 0.04 m^3/sec	77	50	47

As shown in the above table, under proposed development conditions, which includes the pond discharge from both SWMF 22 and 22A, the number of events with erosive flows, and the total duration of those events, will be less than for existing conditions. The decrease in values from one pond outlet to two can be attributed to a more accurate delineation between the drainage areas for the two ponds and the remaining natural area contributing flow to G14-1. It is therefore recommended that the outlet from SWMF 22A be located on reach G14-1 to avoid discharging to Redside Dace Occupied Habitat. The existing and proposed conditions SWMHYMO erosion models are included in **Appendix R**.

7.0 LOW IMPACT DEVELOPMENT MEASURES

Throughout the Seaton Community, LID measures are required to address surface water balance mitigation to natural features as well as maintaining overall ground water recharge and surface water runoff reductions in the developed areas.

Through the MESPA and NFSSR processes, as discussed in **Section 3.7**, it was determined that LID measures are required to ensure that post-development hydrologic conditions continue to feed specific identified natural features in a manner similar to existing conditions.

The MESPA and NFSSR processes also determined that LID measures for each development will be required to provide treatment of the equivalent of 5mm of runoff from the following impervious areas:

- All residential and employment area rooftops.
- Parking lots (retail/employment).
- Local roads that extend through or about the NHS (where feasible).

This criteria will be applied to those areas which are not being utilized to supplement surface water runoff volumes to natural features.

For specific land uses that will be subject to a site plan process, the method for satisfying the 5mm treatment criteria will be demonstrated at the site plan stage. These land uses include schools, commercial blocks, high density residential blocks, and the future water supply reservoir.

Additionally, the *Comprehensive Aquatic Framework* developed by the Seaton environmental team identified watercourses containing redside dace habitat which include Ganatsekiagon Creek. The post development water balance for the contributing drainage area is required to match the existing conditions water balance, with the recommendation of no runoff from 10 to 15mm rainfall events.

In the following sections, a variety of LIDs which are applicable to the low-rise residential portions of the study area are summarized and assessed qualitatively to establish a hierarchy for consideration.

7.1 Alternative LID Works

7.1.1 Natural Feature Water Balance Systems

The MESPA process identified a number of natural features that would require the provision of supplemental drainage to offset losses associated with development of table lands. It is anticipated that the supplemental runoff volume will be provided by a roof drain collector system collecting 5mm of runoff from residential roofs. The roof drain collector system should outlet to the natural feature in a diffuse manner, typically through a granular exfiltration gallery. Overflow bypasses should be incorporated where possible to permit the diversion of excess flows into the adjacent storm sewer system.

7.1.2 Enhanced Grass Swales in NHS or Public Space

Enhanced grass swales are open channels designed to convey, treat and attenuate stormwater runoff. They may be more pronounced in depth and width and drain areas that are typically larger than an ordinary grass swale. Check dams and plantings may be used to attenuate flows. The surface swale may be supplemented with a subsurface clear stone gallery that stores runoff and drains down in a 24 to 48-hour period. Depending on the space available, these facilities may be designed to above average volumes of rainfall to compensate for areas that fall short of the 5mm criteria. Clear stone galleries may receive untreated drainage from clean sources, or pre-treatment may be required for runoff from sources like road drainage. These facilities may be located in the NHS or any available public space. Incorporation of enhanced grass swales into a public space will require the input and approval from the City of Pickering.

7.1.3 Rear Yard Infiltration Galleries

These facilities are intended to service individual roof areas and will be constructed in the rear yard of the residential lot. The gallery will consist of clear stone with sufficient void space to store at least 5 mm of runoff from the roof. They will be designed to drain down within a 24 to 48-hour period. The gallery will receive drainage from the roofs via direct connection of roof downspouts to the gallery. An overflow pipe discharging to the surface will be provided in the event that the infiltration gallery becomes full or clogged. In this study area, Infiltration galleries are not proposed for townhouses due to the limited space along the rear lot line.

7.1.4 Rain Barrels

This LID involves collecting stormwater runoff from roofs via rear yard downspouts connected to the rain barrel(s) and retaining it for future use on-site. The number of rain barrels per unit and depth of rainfall captured depends on the lot frontage, roof area, and number of units grouped together. For the study area, typically one rain barrel is specified per rear building corner, plus one or two more along the back wall of the block of units where space permits. Two barrels are proposed per single unit, three barrels per pair of semi-detached units or townhouse blocks of up to five units, and four barrels for a block of six townhouses or more. TRCA has expressed concern with the implementation of rain barrels as these works are located on private property and may be subject to removal by the homeowner. For this reason, TRCA will only give 50% credit up to 2.5mm of runoff for those areas utilizing rain barrels as a suitable LID over long term.

7.1.5 Roof Downspout Disconnection

The City of Pickering will allow lots with greater than 12.0 metres of frontage to have downspouts discharge to the surface instead of connecting to the storm sewer connection. Additionally, for lots with less than 12 metres of frontage, discharge of the rear downspouts to the surface may be permitted if there are no adverse drainage effects on other properties. Therefore, units of this size that back onto the NHS, parks or open space may be permitted to discharge to the surface. TRCA will give credit for treatment of 2.5mm of runoff for roof downspouts discharging to the surface.

7.1.6 Extra Depth Topsoil

This LID involves the placement of engineered topsoil on residential lots at a depth of 300mm or greater. The topsoil must consist of a combination of sand or other approved additives and topsoil with sufficient organic composition to promote growth. The intent of this LID is to provide a porous growing medium that will store roof top storm runoff for an extended period and make it available for plant uptake or infiltration into shallow ground water. Historically, the TRCA has expressed concern with the implementation of extra depth topsoil as these works are located on private property and may be subject to partial removal by the installation of personal amenity areas (pools, decks, patios, etc.). Therefore, TRCA credits 2.5mm of infiltration for 50% of impervious tributary area. In the Seaton study area, extra depth topsoil may be applied across a broad range of residential unit densities. Larger lots typically have sufficient space for more effective LID measures, therefore extra depth topsoil calculations have only been applied as part of a treatment train for lots with offsite measures, or as part of a treatment train for smaller lots to supplement a lower yield LID such as rain barrels.

7.1.7 Plantings within the NHS

This LID option may not be directly attributive to the LID objectives of the Seaton Stormwater Management Plan however, it is worthy of discussion as it relates to indirect benefits to the plan. For this LID, appropriate plantings would be provided within areas of the NHS currently devoid or lacking plantings. The plant material would provide an enhanced interception and evapo-transpiration function to offset roof areas that may not be serviced by conventional LID measures. TRCA has expressed concern that these possible works do not directly receive runoff from impervious areas and as such, will not achieve the objective of retention of the 5mm of runoff from those surfaces. However, it is arguable that sufficient plantings will offset the response of the roof areas by retarding runoff from other sources. In this regard the TRCA issued a guideline in that a maximum of 25% of the total required roof top areas can be compensated for by plantings (if other LID measures have been exhausted) with a 3:1 ratio (i.e. for every 100 m^2 of roof top not accounted for in the LID strategy, 300 m^2 of NHS will be planted to TRCA standards).

7.2 LID Hierarchy

An LID hierarchy was developed that considers the multiple criteria that apply to the study area, the effectiveness, accessibility by the municipality, maintainability, and concerns that TRCA has expressed previously regarding some LID measures. The hierarchy is as follows:

1. Natural Feature Water Balance System
2. Enhanced Grass Swales in the NHS
3. Enhanced Grass Swales in Public Space
4. Rear Yard Infiltration Galleries
5. Roof Downspout Disconnection
6. Extra Depth Topsoil to supplement 2, 3 and 5.
7. Rain Barrels
8. Plantings in the NHS

7.3 Proposed LID Works

A complete LID approach has been developed based on the hierarchy of methods outlined in **Section 7.2**. Based on other constraints within the proposed draft plans (lot locations, lot sizes, proposed grading, etc.) it was difficult to provide higher ranking LID measures for each lot;

therefore, the proposed LID approach utilizes a combination of available roof areas and other appropriate impervious surfaces to satisfy the LID volume (5mm) requirement.

There are several instances where the front roof and back roof of a particular group of units may have different treatment systems, due to topography, space availability, or the practicality of implementing each type of LID. For instance, a natural feature roof drain collector system may be capable of collecting the front roofs only, leaving the back roofs to discharge to an enhanced grass swale or other method. In such cases, townhouse roofs are split 50 percent to the front and the remainder to the back, while single and semidetached units are split 25 percent to the front and 75 percent to the back.

The following approach was used in consideration of the LID hierarchy.

1. Roof areas required to augment flow to natural features.
2. Roof areas readily available to high-ranking LID works.
3. Other impervious surfaces (roads) available to high-ranking LID works to replace roof areas which are difficult to service.
4. Other roof areas which may be tributary to lower ranking LID works.

To ensure that adequate LID works have been provided, a total contributing impervious area (LID volume) was determined based on the proposed draft plan, typical lot coverages for low rise residential development, and the capture of some street impervious areas adjacent to NHS lands. The impervious roof calculation omits any blocks that will be subject to a later site plan process, including schools, commercial, high density residential and the Region's proposed water supply reservoir.

The resulting LID features and contributing areas are outlined in the following sections.

7.3.1 Natural Feature LID Measures

As discussed in **Section 3.7**, the MESPA and NFSSR identified four natural features to be addressed through feature-based water balance modeling, however TRCA has since confirmed that only three features are within the scope of this report. These features are Wetland WD9, Woodland FC17 and Headwaters HDFC24. For the NFSSR assessment the existing and proposed water balance assessment was completed using the PCSWMMM model.

In order to confirm the roof areas required to augment the post development drainage to the natural features, a Water Augmentation Feasibility Analysis (WAFA) was performed using the most current topographic information. The calculations confirmed the existing and proposed remaining drainage areas as presented in the NFSSR. Existing and proposed conditions models were created using PCSWMM and six years of continuous rainfall data from 1998 to 2003, to be consistent with the MESPA and the NFSSR. Please note the rainfall dates were adjusted to 1994 to 1999 to be consistent with earlier models, due to the date limitations of those models.

Based on the PCSWMM models, tables and graphs were prepared for existing and proposed conditions that indicated the total precipitation for each month in each year, the average precipitation for each month, and the variability for each month. These tables and graphs were prepared for the total year, and for the rainy months only (March – October). The results of the initial post development PCSWMM models for each feature were compared to the existing conditions models to determine if post-development monthly rainfall would fall within the variability range of the existing conditions models. If required, the post development contributing roof areas in the PCSWMM model were increased incrementally until the post development rainfall results fell within the desired range. The final results of the post development model support the findings of the NFSSR. The results for each feature are presented in detail in the following sections.

TRCA has requested that the modelled roof augmentation areas be increased by thirty percent to provide flexibility for field monitoring and adjustment of flows via valves on the roof drain collector system. For each natural feature drainage area to be augmented, the WAFA calculations, modelled areas and thirty percent supplement are presented in **Table 18**. The WAFA calculations, and PCSWMM model results are enclosed in **Appendix S**.

Table 18: Natural Features Augmentations Results

Natural Feature	Drainage Area (ha)				
	Updated Existing Drainage Area	Proposed Remaining Drainage Area	WAFA Augmentation Roof Area	PCSWMM Augmentation Roof Area	Roof Area Enlarged 30 Percent
Wetlands WD9	10.40	4.30	0.78	1.25	1.63
Woodlands FC17	14.90	5.80	1.16	2.50	3.25
Headwaters HDFC24	8.80	0.70	1.03	2.25	2.93

Wetland WD9

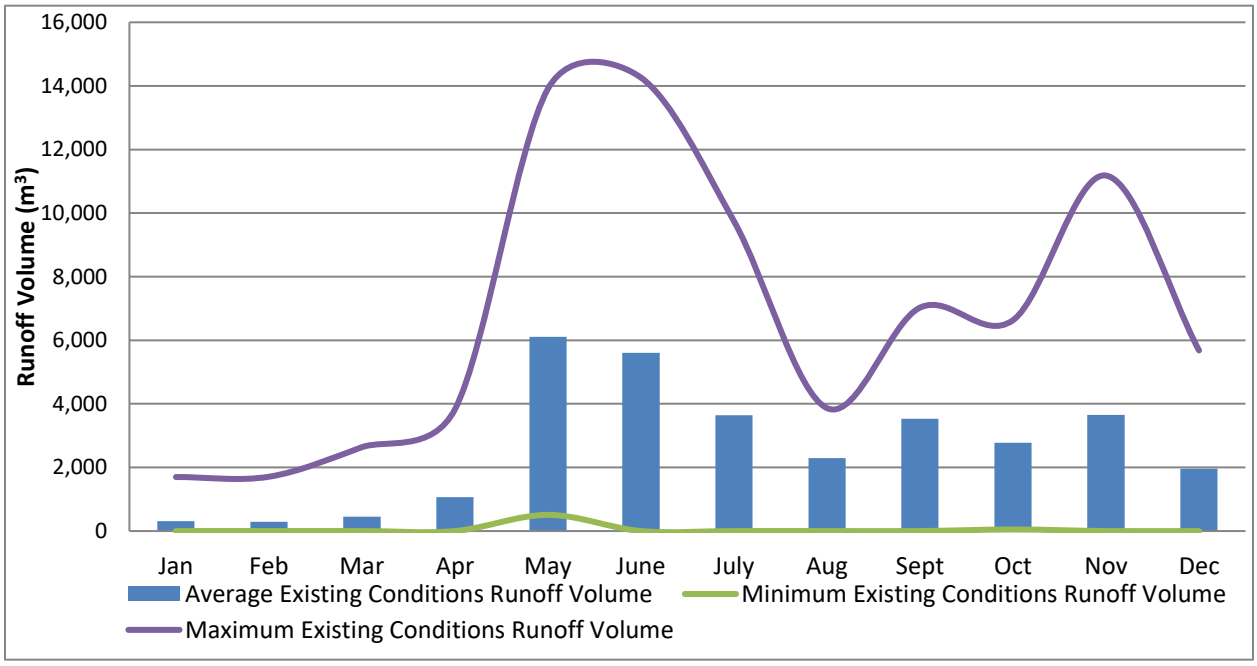
Wetland WD9 is located west of Whites Road, south of the proposed development, north of SWMF20, and east of Reach DB2 of an unnamed West Duffins Creek tributary. The total existing surface area draining to WD9 is approximately 8.8 ha of agricultural drainage. WD9's location and existing contributing drainage area is illustrated on **Figure 3** (back pocket).

The wetland is characterized as a mineral meadow marsh with small reed canary grass, with some woody species dominated by exotics. It is a relatively dry and poorly drained corner in an agricultural field that primarily receives overland flow from the adjacent farm field.

A water balance analysis is required by the MESPA because the development of Parcel A5 will eliminate approximately 8.1 ha or ninety percent of the wetland's existing drainage area. Without infrastructure to support augmentation, the post development drainage area to WD9 would only be 0.7 ha, refer to **Figure 9** (back pocket).

Runoff volumes for the existing condition were computed using PCSWMMM. Results are summarized into monthly totals over six (6) years of rainfall data from 1998 to 2003 and are shown in **Table 19**.

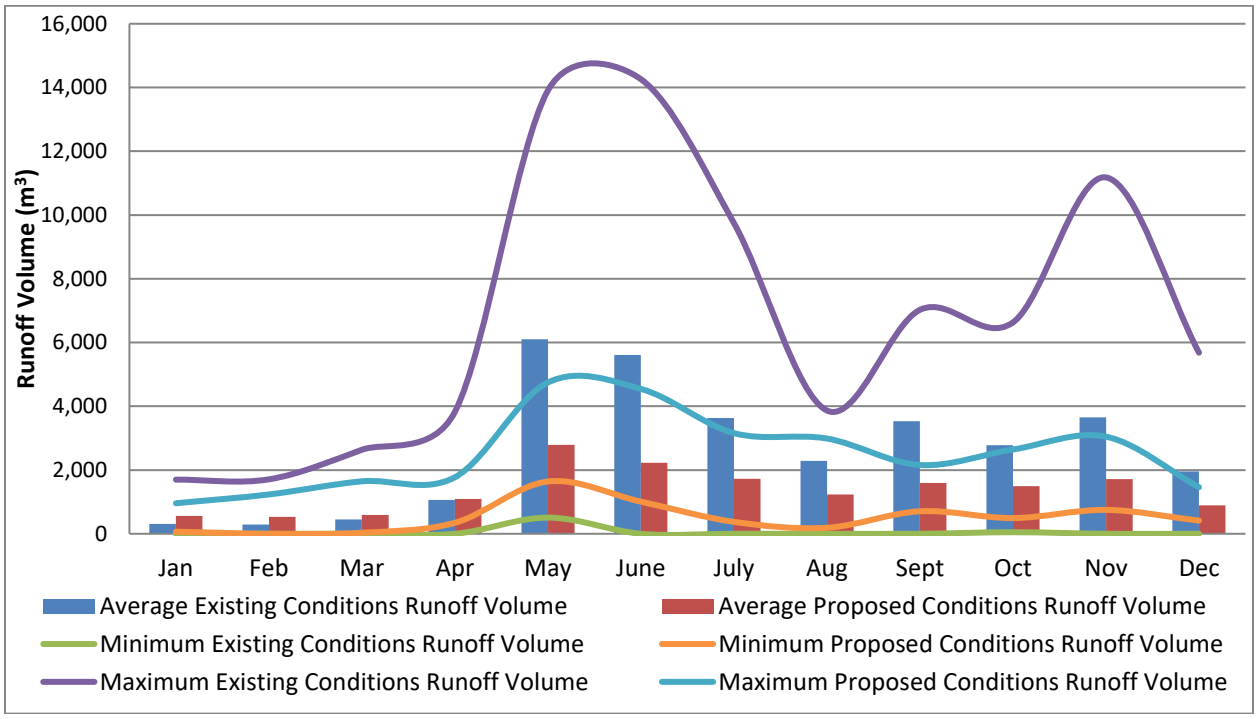
Table 19: WD9 Existing Conditions Runoff Volumes



As can be seen in **Table 19**, the magnitude of the natural variability of the monthly runoff is large. The largest quantities of runoff come during the late spring and early summer months. Every month has a zero (0) runoff year in the six years of data.

Water Augmentation Feasibility Analysis (WAFA) findings were used as a starting point to calculate an appropriate roof drainage supplement to the 0.7 ha of pervious drainage to offset the deficit. Iterative modelling demonstrated that approximately 2.25 ha of roof drainage would replicate the existing conditions runoff behaviour. With this supplement, monthly runoff volumes fall within the range of natural variability experienced in the existing condition, and closely match the average runoff trend in summer months, refer to **Table 20.**

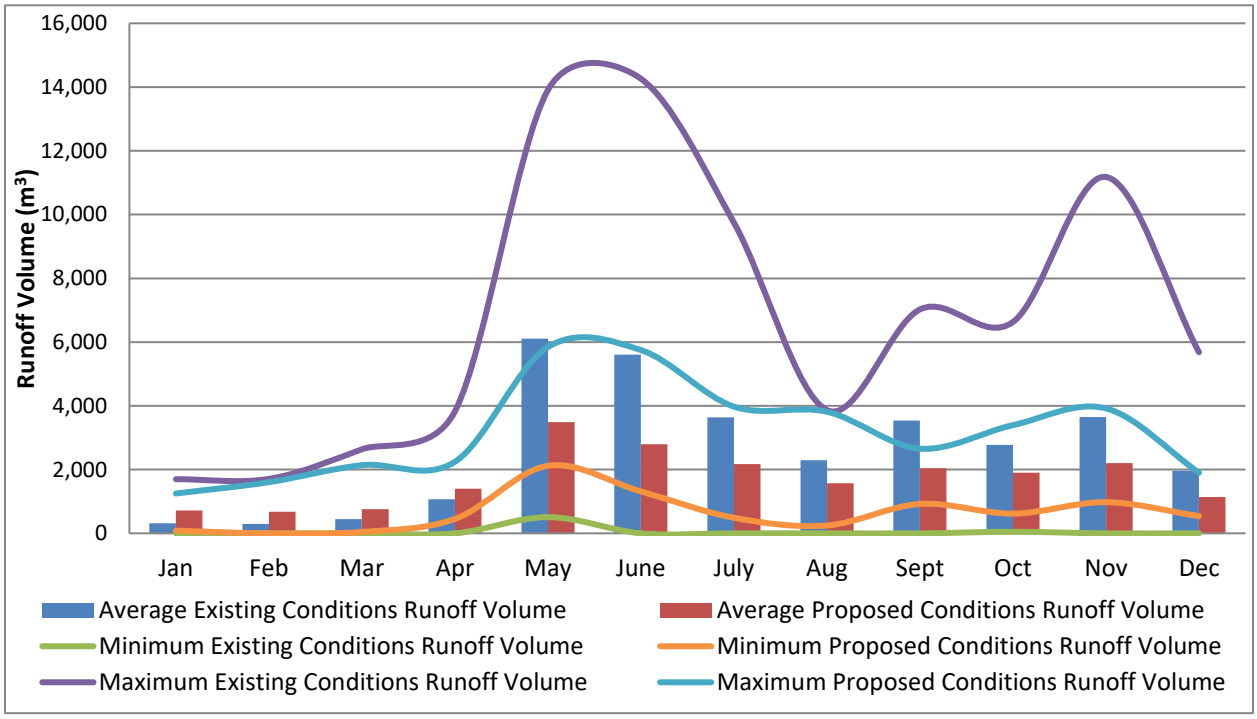
Table 20: WD9 Existing and Proposed Conditions Monthly Runoff Volumes



As requested by TRCA, an additional 30% of supplemental roof drainage area is to be provided to the wetland. The total supplemental roof drainage area should therefore be 2.93 ha. Based on a realistic roof drain collector layout and preliminary estimates of roof areas, the actual contributing roof area is currently estimated to be 2.90 ha. As shown in **Table 21**, with the supplemental area, monthly runoff volumes continue to fall within the range of natural variability experienced under existing conditions, however they are close to exceeding the range for August. The average proposed monthly runoff volumes more closely resemble existing conditions. A plan

of the proposed drainage to the feature is presented in **Figure 9** (back pocket). Tables supporting the water balance are presented in **Appendix S**.

Table 21: WD9 Existing and Proposed Conditions Monthly Runoff Volumes With Contingency Area



Clean water drainage will be collected by a roof drain collector system from the subdivision area immediately north of WD9. The system is designed to follow the proposed topography of the development, however in some areas only the front halves of the roofs can be captured. A flow split structure will be installed at the downstream end of the roof drain collector system and provide an overflow to the storm sewer, which will ultimately outlet to SWMF20. The outlet pipes will be equipped with sluice gates which can be opened and closed as required to control runoff to Wetland WD9. Design details and a post development monitoring program will be provided during detailed design.

A plan of the proposed drainage to the feature is presented in **Figure 9** (back pocket). Tables supporting the water balance are presented in **Appendix S**.

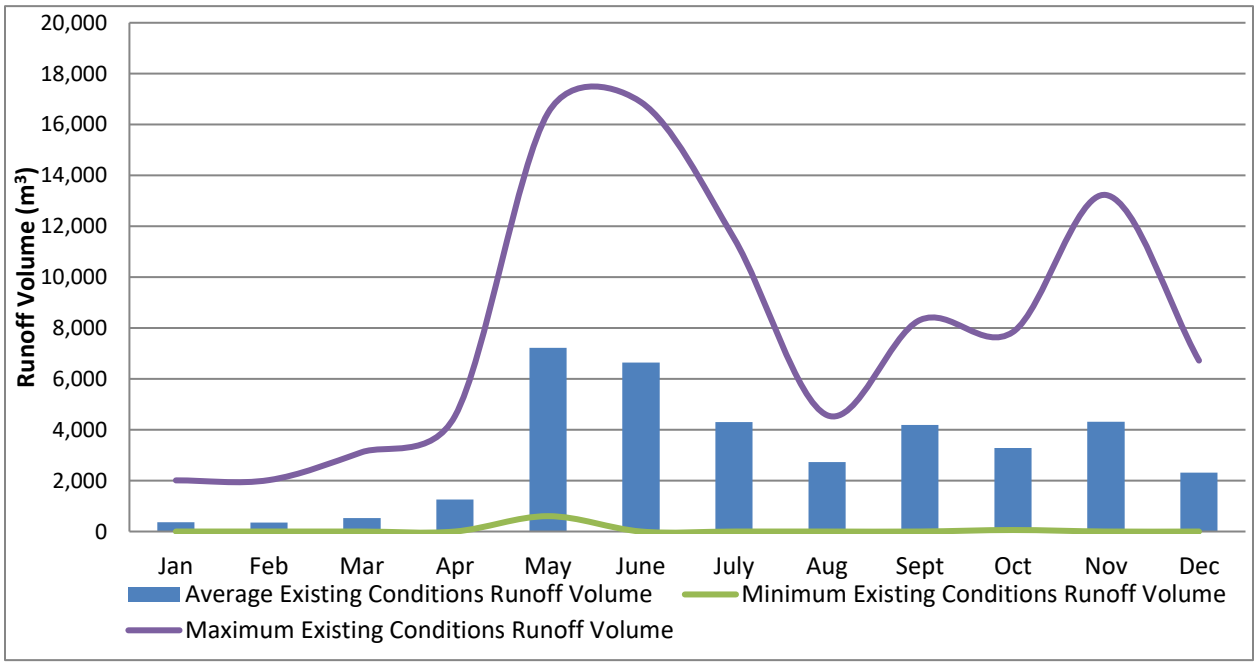
Woodland FC17

Woodland FC17 is located south of the proposed development, east of HDFC24 and north of an unnamed tributary of West Duffins Creek. The total existing surface area draining to FC17 is approximately 10.4 ha of agricultural drainage. FC17's location and existing contributing drainage area is illustrated on **Figure 3** (back pocket). The woodland consists of fresh-moist poplar and dry-fresh beech.

A water balance analysis is required by the MESPA because the development of Parcel A6 will eliminate approximately 6.1 ha or sixty percent of the woodland's existing drainage area. Without infrastructure to support augmentation, the post development drainage area to FC17 would only be 4.3 ha, refer to **Figure 9** (back pocket).

Runoff volumes for the existing condition were computed using PCSWMMM. Results are summarized into monthly totals over six (6) years of rainfall data from 1998 to 2003 and are shown in **Table 22**.

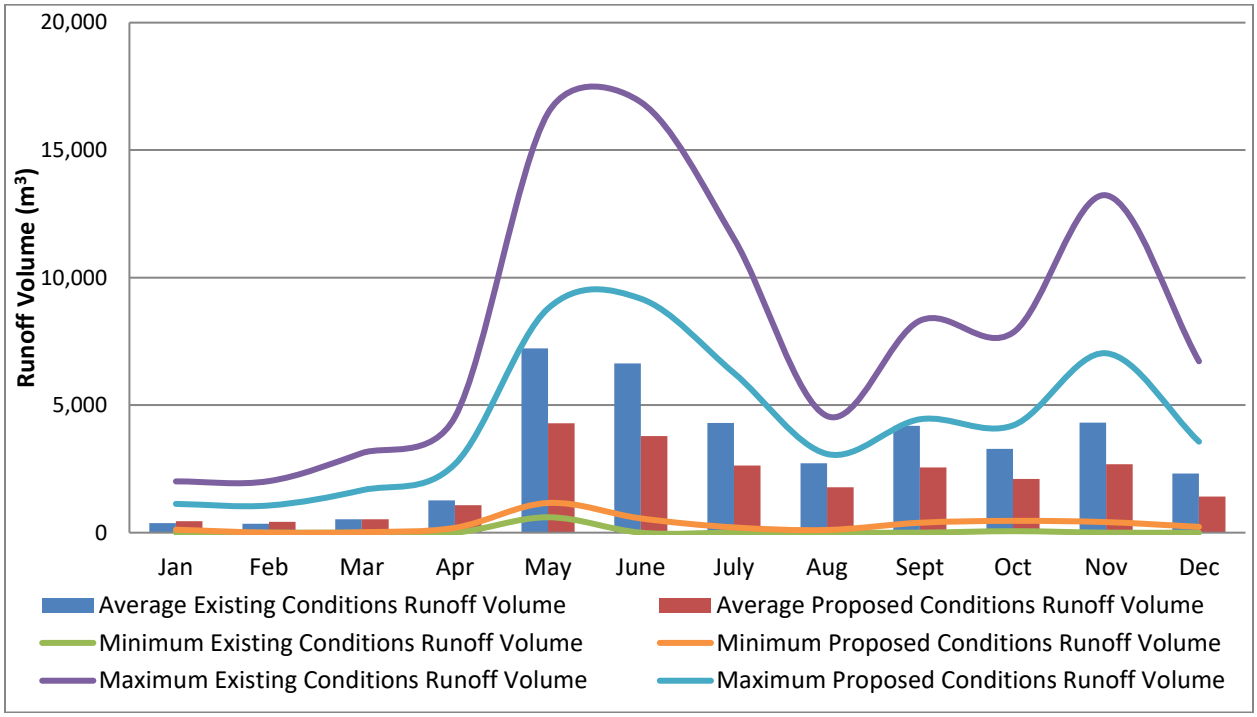
Table 22: FC17 Existing Conditions Monthly Runoff Volumes



As can be seen in **Table 22**, the magnitude of the natural variability of the monthly runoff is large. The largest quantities of runoff come during the late spring and summer months. Every month has a zero (0) runoff year in the six years of data.

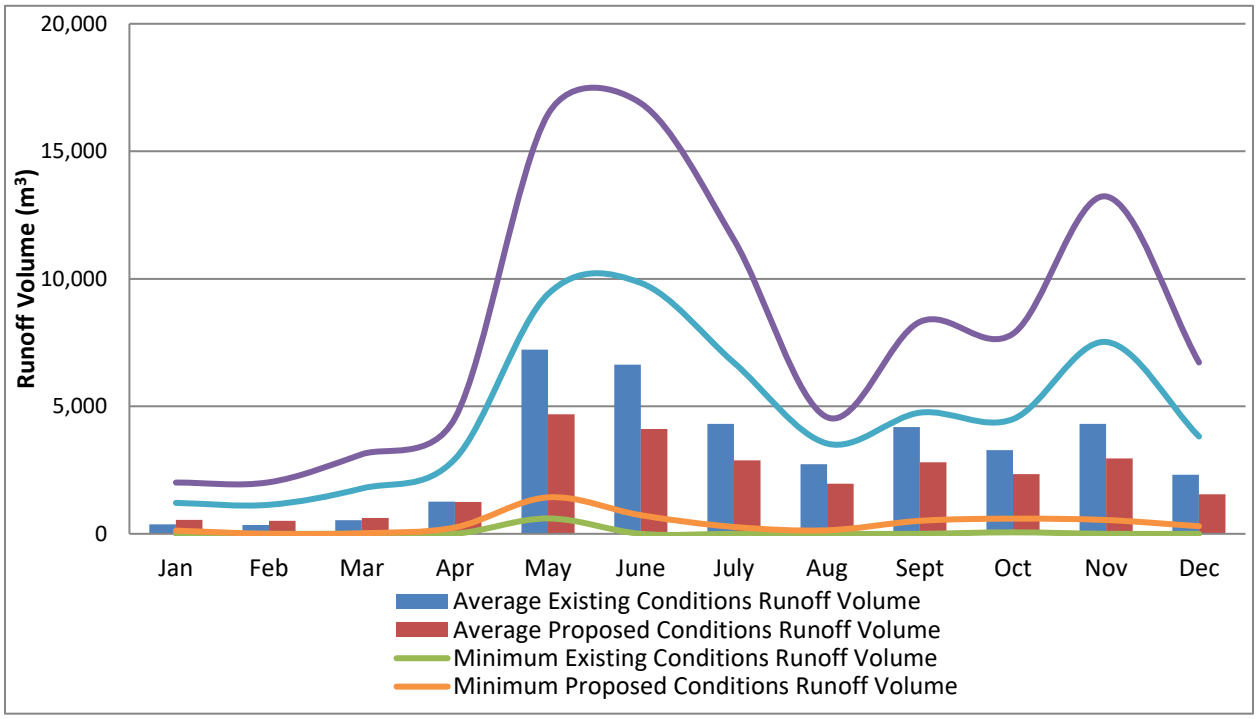
WAFA findings were used as a starting point to calculate an appropriate roof drainage supplement to the 3.7 ha of pervious drainage and offset the deficit. Iterative modelling demonstrated that approximately 1.25 ha of roof drainage best replicated the existing conditions runoff behaviour. With this supplement, monthly runoff volumes fall within the range of natural variability experienced in the existing condition, and closely match the average runoff trend summer months. shown in **Table 23**.

Table 23: FC17 Existing and Proposed Conditions Monthly Runoff Volumes



As requested by TRCA, an additional 30% of supplemental roof drainage area is to be provided to the wetland. The total supplemental roof drainage area should therefore be 1.63 ha. Based on a realistic roof drain collector layout and preliminary estimates of roof areas, the actual contributing roof area is currently estimated to be 1.73 ha. As shown in **Table 24**, with the supplemental area, monthly runoff volumes continue to fall within the range of natural variability experienced under existing conditions, however they are close to exceeding the range for August. The average proposed monthly runoff volumes more closely resemble existing conditions. A plan of the proposed drainage to the feature is presented in **Figure 9** (back pocket). Tables supporting the water balance are presented in **Appendix S**.

Table 24: Existing and Proposed Conditions Monthly Runoff Volumes With Contingency Area



Clean water drainage will be collected by a roof drain collector system from the subdivision area immediately north of FC17. The system is designed to follow the proposed topography of the development. Approximately twenty-five percent of a large high-density block is included in the drainage area, therefore the actual roof area captured will be 1.73 hectares. Without this block, the captured roof area would not meet the minimum augmentation requirement.

In order to better distribute the roof drainage, two outlets are proposed. One outlet will be located along the south side of SWMF22, and the second one will be located at the south limit of the development. Flow split structures will be installed at the downstream ends of the roof drain collector system, providing overflows to the storm sewer, with one ultimately outletting to SWMF20, and the other to SWMF22. The outlet pipes will be equipped with sluice gates which can be opened and closed as required to control runoff to Woodland FC17. Design details and a post development monitoring program will be provided during detailed design.

A plan of the proposed drainage to the feature is presented in **Figure 9** (back pocket). Tables supporting the water balance are presented in **Appendix S**.

Headwater HDFC24

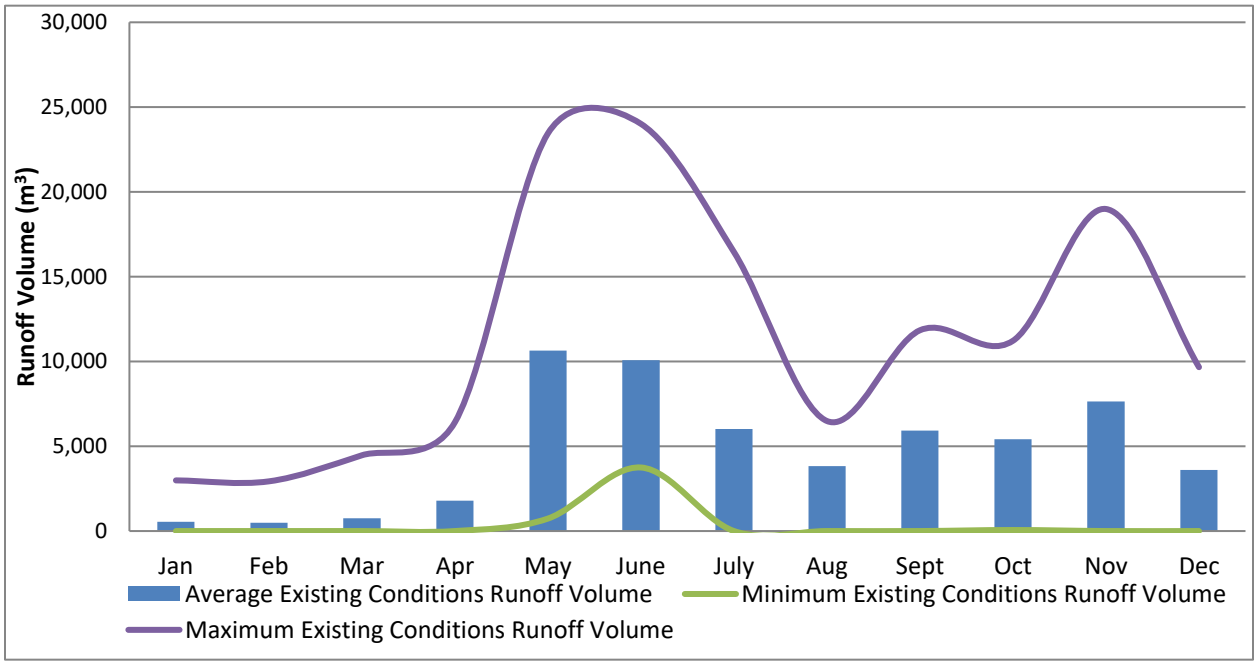
Headwater HDFC24 is located south of the proposed development, east of Whites Road, west of Woodland FC17, and north of an unnamed tributary of West Duffins Creek. The total existing surface area draining to HDFC24 is approximately 14.9 ha of agricultural drainage. FC17's location and existing contributing drainage area is illustrated on **Figure 3** (back pocket).

The upstream portion of the headwater feature consists of fresh-moist sugar maple, characterizing the area adjacent to FC17 as a hardwood deciduous forest. The downstream portion consists of reed canary grass meadow marsh.

A water balance analysis is required by the MESPA because the development of Parcel A6 will eliminate approximately 9.1 ha or sixty percent of the woodland's existing drainage area. Without infrastructure to support augmentation, the post development drainage area to HDFC24 would only be 5.8 ha, refer to **Figure 9** (back pocket).

Runoff volumes for the existing condition were computed using PCSWMMM. Results are summarized into monthly totals over six (6) years of rainfall data from 1998 to 2003 and are shown in **Table 25**.

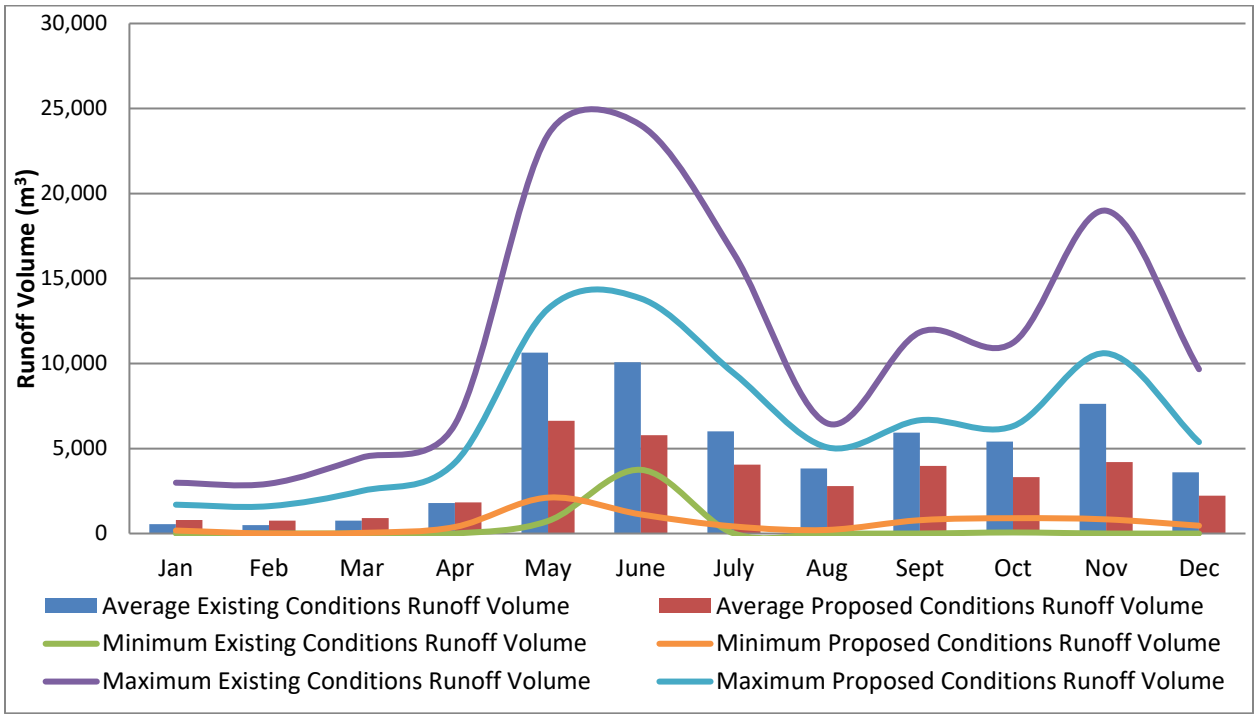
Table 25: HDFC24 Existing Conditions Monthly Runoff Volumes



As can be seen in **Table 25**, the magnitude of the natural variability of the monthly runoff is large. The largest quantities of runoff come during the late spring and summer months. Every month has a zero (0) runoff year in the six years of data.

WAFA findings were used as a starting point to calculate an appropriate roof drainage supplement to the 5.8 ha of pervious drainage and offset the deficit. Iterative modelling demonstrated that approximately 2.5 ha of roof drainage best replicated the existing conditions runoff behaviour. With this supplement, monthly runoff volumes fall within the range of natural variability experienced in the existing condition, and closely match the average runoff trend summer months. shown in **Table 26**.

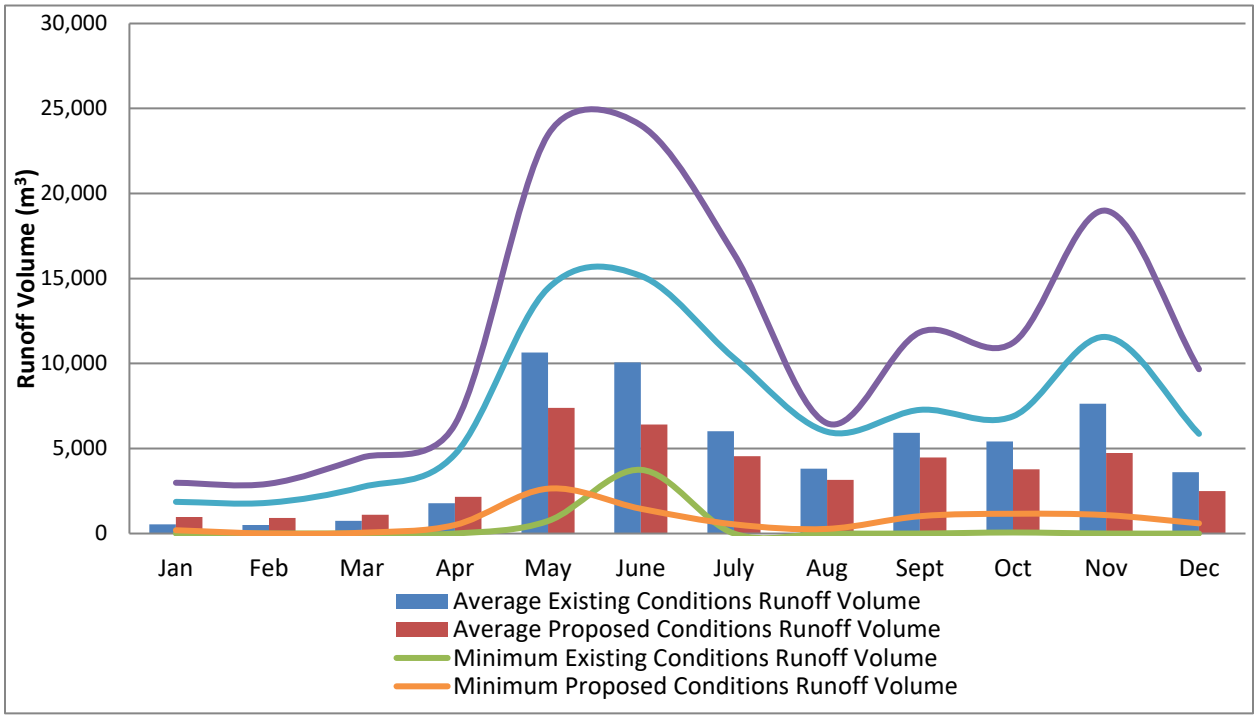
Table 26: HDFC24 Existing Conditions and Proposed Conditions Monthly Runoff Volumes



As requested by TRCA, an additional 30% of supplemental roof drainage area is to be provided to the wetland; the total supplemental roof drainage area is therefore 3.25 ha. This area corresponds to the high-density block and the remaining seventy-five percent of the commercial/high density block. As shown in **Table 27**, with this supplemental area, monthly runoff volumes continue to fall within the range of natural variability experienced in the existing condition. The average proposed monthly runoff volumes more closely resemble existing conditions. It should be noted that the drainage areas for FC17 and HDFC24 are bounded by Regional Roads

which are either existing or under construction, therefore any attempt to enlarge the augmentation area for one natural feature would compromise the adjacent augmentation area for the other feature. A plan of the proposed drainage to the feature is presented in **Figure 9** (back pocket). Tables supporting the water balance are presented in **Appendix S**.

Table 27: HDFC24 Existing and Proposed Conditions Monthly Runoff Volume with Contingency Area



A flow split structure will be installed at the downstream end of the roof drain collector system and provide an overflow to the storm sewer, which will ultimately outlet to SWMF20. The outlet pipes will be equipped with sluice gates which can be opened and closed as required to control runoff to HDFC24. Design details and a post development monitoring program will be provided during detailed design. Tables supporting the water balance are presented in **Appendix S**.

7.3.2 Neighbourhood LID Measures

The required neighbourhood LID volume was determined based on the lot distribution and coverage characteristics of the subject lands. The total required LID storage was calculated by taking 5 mm of runoff over the area of proposed low rise residential roofs and feasible roads (i.e. roads adjacent to the NHS) within the subdivision plan. Low rise roof area captured for features WD9, FC17 and HDFC24 was subtracted from the total area in establishing a LID target. It should

be noted that runoff from some high density and commercial roof areas will be captured for discharge to the natural features, however the credits for these blocks will be applied to their respective development proposals at the site plan stage. The calculation of the overall subdivision 5mm volume target is presented in **Table 28**.

Table 28: Total LID 5mm Volume Targets

Description	Drainage Area (ha)	Required LID Volume (m^3)
Roads Adjacent to NHS	0.28	14.0
Low Rise Residential Roofs	15.27	763.7
Low Rise Roofs to Features*	(4.19)	(209.5)
TOTAL	**11.36**	**568.4**

* Roof area to Features WD9, FC17 and HDFC24 are subtracted from the total.

The proposed LID concept presented in **Figure 25** (back pocket), was developed using the hierarchy discussed in Section 7.2 and also recognizes several on-site restrictions. The native till across the majority of the site has a low infiltration capability. The depth of any subsurface infiltration facilities is therefore limited by the requirement to drain down within 48 hours. Subsurface infiltration measures need to avoid high groundwater areas. Some areas around the perimeter of the proposed development will be constructed in fill which will reduce the impact of existing groundwater levels, however significant portions of the interior land must be constructed in cut due to grading concerns, which will bring the finished grade closer to the observed water table. Surface infiltration measures, however, are impacted by the density of development and the availability of usable permeable space. Lots with frontages greater than twelve metres may have downspouts disconnected from the storm sewer system, making them available for discharge to the surface. Lots with frontages less than twelve metres are required to have downspouts connected to the storm sewer system, where rain barrels may be more appropriate. Exceptions may be given for small lots with rear yards that drain directly to NHS, parks or open space. In order to maximize infiltration potential wherever possible, there are several areas where the methods implemented for the front roofs differ from the methods implemented for the rear roofs. Extra depth topsoil may be added across the entire subdivision, however for purposes of calculating infiltration, extra depth topsoil is only proposed as a treatment train approach for lots where roof leaders will discharge to the surface, including lots that ultimately drain to enhanced grass swales.

The runoff volume accounting is provided in **Table 29**, and a detailed breakdown of LID accounting is presented in **Appendix T**. As shown in **Figure 25** (back pocket), the proposed LIDs are summarized as follows:

- Feature WD9, FC17 and HDFC24 LID lots are shown in pink. Roof drain collector sewers will direct 100% of this roof drainage to the features. (Some commercial and high-density site plan areas are included; however they have been netted out of the subdivision calculations). Downspouts must connect to the roof drain collector system.
- Roads capable of discharging near side catchbasins to enhanced grass swales located in the NHS are shown in orange. Road drainage will be collected by catchbasins with goss traps to prevent contamination. A typical enhanced grass swale detail is shown in **Figure 26**.
- Split draining, back splits or walkout lots draining onto public space or NHS lands, where space is available for enhanced grass swales, are shown in blue. Extra depth topsoil will be added within the lots. Rear downspouts should discharge to the surface.
- Split draining lots where drainage will be captured along the rear lot lines in infiltration galleries are shown in yellow. Rear downspouts will connect to the gallery with overflows to the surface. A typical infiltration gallery detail is shown in **Figure 25.**
- Lots with small frontages (less than twelve metres) with roof downspouts connected to rain barrels (240 litre capacity per barrel) are shown in green. The number of barrels for each unit or block of units varies. The number is based on one per exterior building corner plus additional barrels along the rear exterior wall where space permits. It is therefore assumed that single detached units will have two barrels, pairs of semidetached, and blocks of four or five townhouses will have three, and blocks of six or more townhouses will have four barrels.
- Lots with larger frontages (greater than twelve metres) with roof downspouts discharging to the surface are shown with a diagonal hatch pattern.
- Any units, or parts of units, for which no measures are proposed are shown in white.
- Townhouse roofs are considered to be split fifty percent to the front and fifty percent to the back. Single and semidetached units are considered to be split twenty-five percent to the front and seventy-five percent to the back.

Table 29: Proposed Neighbourhood LID Works

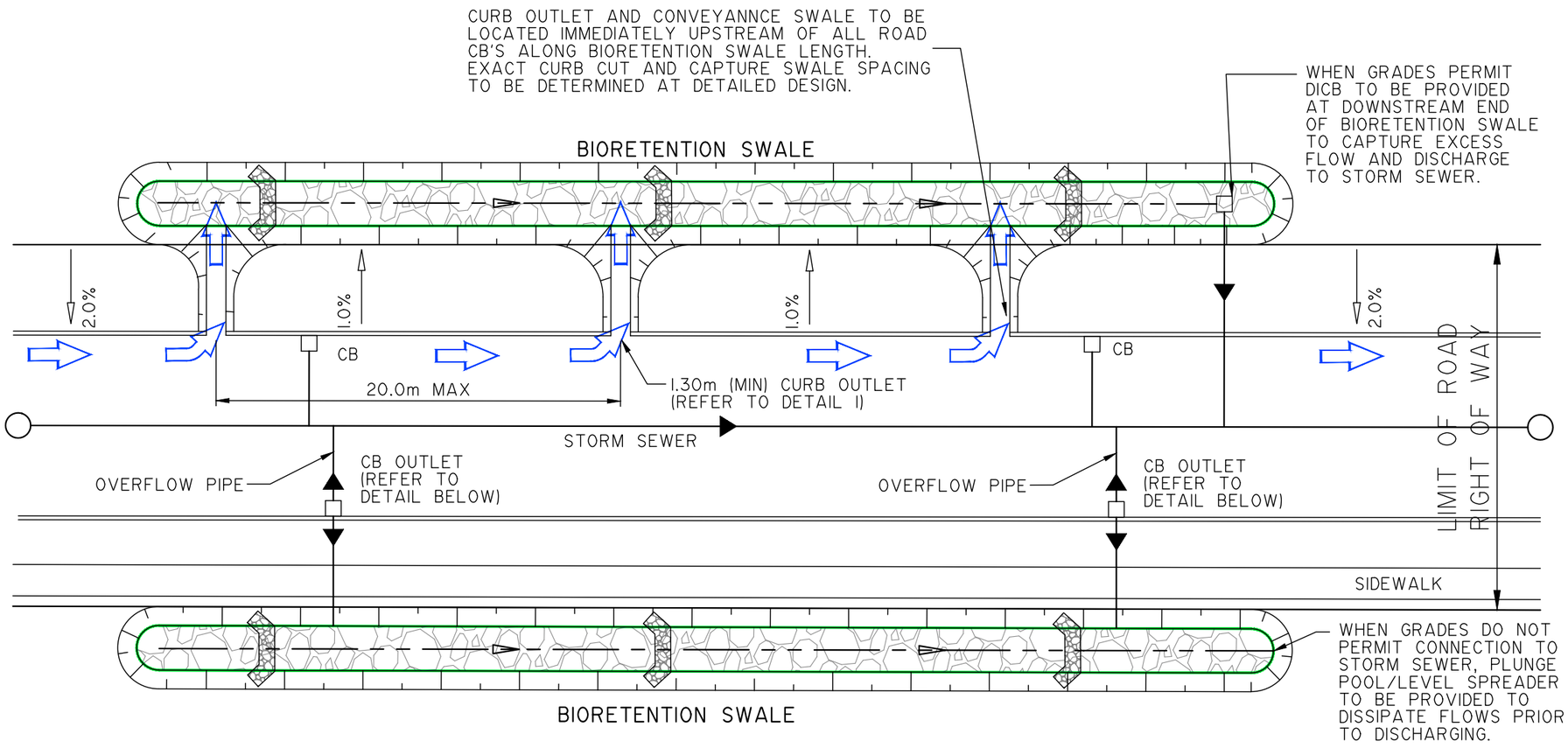
LID Type	Contributing Area (ha)	Portion of Roof	Depth (mm)	Volume Captured (m^3)
Road Drainage to Enhanced Grass Swale in NHS Buffer	0.28	-	35.8	100.2
Enhanced Grass Swale in NHS Buffer	0.70	50-75%	24.0	167.7
Rear Yard Infiltration Gallery	3.67	50-75%	13.4	491.3
Rain Barrel Lots (240L)	2.24[a]	50-75%	1.7	38.8
Downspout Disconnection	1.46	25-75%	2.5	36.6
Extra Depth Topsoil	1.08[ab]	50-75%	2.5	27.0
Total Provided	**8.35**	**25-75%**	**10.4**	**861.7**

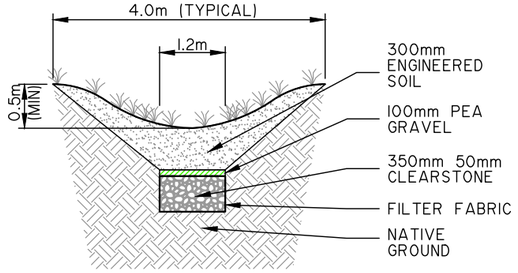
[a] Only 50% of the contributing roof area is used in the Extra Depth Topsoil calculations.

[b] Extra Depth Topsoil area is not included in the Total Provided due to overlapping area with other LIDs.

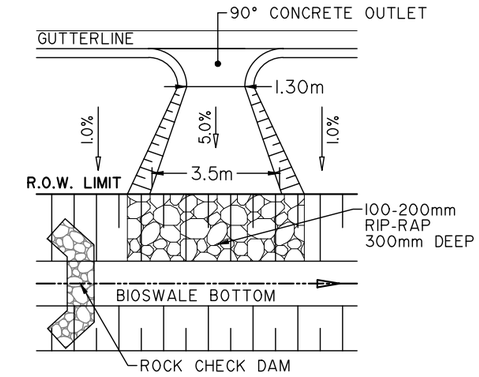
As shown in the above table, the runoff volume captured from some roof areas falls short of the 5mm target, however due to overcontrol in other areas, the overall runoff volume captured is 10.4 mm, which satisfies the Seaton 5mm criteria across the whole subdivision. **Table 29** shows that the proposed LID strategy satisfies approximately 152 percent of the total LID volume required to address the 5mm roof runoff requirement. A total volume of 568.2 m^3 is required and 861.7 m^3 is provided. Furthermore, the LID strategy satisfies the more stringent redside dace 10mm capture criteria.

It is understood that averaging overcontrol in some areas with a shortfall in others does not directly equate to an average level of capture across the entire catchment area. There are other factors, however that should be considered in support of the LID capture calculations. Although an extra depth topsoil credit has been calculated in the table above for fifty percent of the Enhanced Grass Swale and Downspout Disconnection tributary areas, extra depth topsoil will be spread across all grassed areas regardless of LID type. Furthermore, an annual water balance has been prepared, as discussed in **Section 7.3.3**, that demonstrates that the proposed development will balance annually to approximately ninety percent of the existing conditions water balance. Calculations in support of the proposed LID works are included in **Appendix T**.

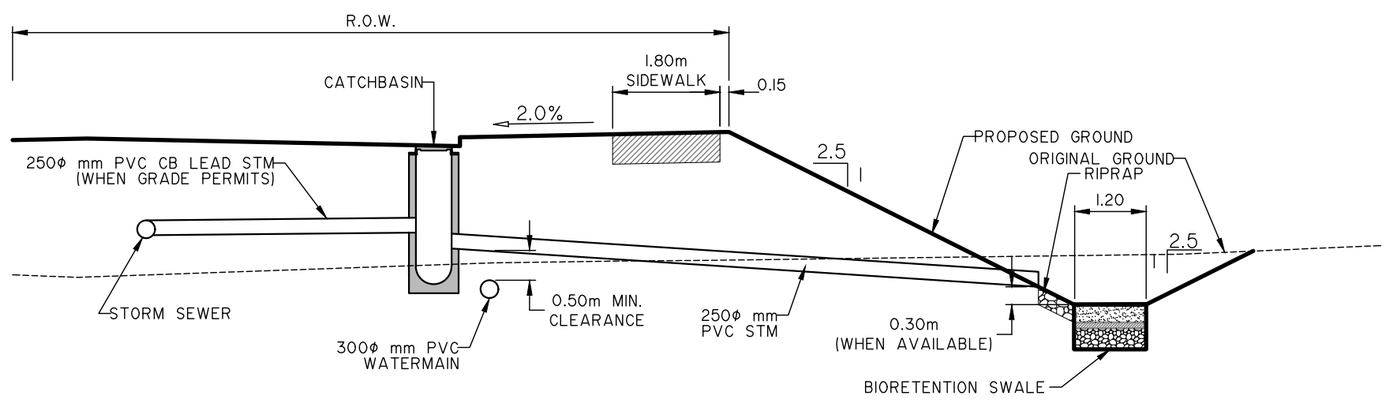




TYPICAL ROADSIDE BIORETENTION SWALE CROSS SECTION



TYPICAL CURB OUTLET AND CAPTURE SWALE DETAIL I (WITHOUT SIDEWALK)



TYPICAL CATCHBASIN OUTLET DETAIL

SCALE: N.T.S.

LEGEND:

- PROPOSED STORM MANHOLE
- PROPOSED STORM SEWER AND FLOW DIRECTION
- ROAD LOW IMPACT DEVELOPMENT BIORETENTION SWALE
- FLOW DIRECTION
- ROCK CHECK DAM

TYPICAL ENHANCED GRASS SWALE DETAIL

SABOURIN KIMBLE & ASSOCIATES LTD. CONSULTING ENGINEERS

PROJECT NUMBER	FIGURE NO.
08:178	26

CAD FILE: P:\08\178\Drawing Files\A7 A8 A9 B2 B3 B4\Figures\FSR 2 A7-9 B2-4\FSR 2 Figures December 2018\Fig 22 - Typical Bio-Retention Swale Detail.dwg

7.3.3 Overall Annual Water Balance

Ganatsekiagon Creek has been identified as Redside Dace Habitat, therefore MECP requires that the annual water balance in Subcatchment 34 for post development conditions to match the water balance for existing conditions. As discussed in the previous section, TRCA requires a 5mm capture analysis of the LID strategy across the entire site. The LID strategy prepared by Sabourin Kimble & Associates satisfies the TRCA criteria, however the strategy includes a blend of higher capture and lower capture areas. As additional support for the site wide 5mm analysis, Sabourin Kimble also extended the annual water balance across the entire development.

Sabourin Kimble & Associates Ltd. prepared a Thornthwaite water balance analysis for the entire development using climate information from Oshawa and Toronto. The analysis applies to the 88.94 hectare draft plan area, excluding any blocks which will be subject to a further site plan application process, any Regional Road and widenings, and any roof areas which will provide drainage directly to the three natural features described earlier. The analysis therefore applies to a net 48.57 hectare area. The calculation of the net area is shown in **Appendix U**.

As shown in the appendix, average annual precipitation and evapotranspiration amounts of 900 and 608 millimetres per annum respectively were determined from the Oshawa climate station (recorded from 1981 to 2010), which generated an annual water surplus of 292 millimetres per annum. Precipitation factors for the existing topography, soil types and topography determined that fifty percent (146 millimetres per annum) of the surplus is infiltrated, while the remaining fifty percent becomes runoff.

The annual precipitation, evapotranspiration, infiltration and runoff rates were applied to the subject area to determine existing conditions annual volumes for each parameter. The existing conditions water balance parameters are summarized in **Table 30**.

Table 30: Existing and Proposed Conditions Water Balance Parameters

Conditions	Net Area (ha)	Water Balance Parameter			
		Precipitation (m^3/a)	Evapotransp. (m^3/a)	Infiltration (m^3/a)	Runoff (m^3/a)
Existing	**48.57**	**437,130**	**295,306**	**70,912**	**70,912**
Proposed w/o Mitigation	48.57	437,130	139,885	27,106	270,139
Proposed with LIDs	**48.57**	**437,130**	**139,885**	**63,205**	**234,040**
Existing Less Proposed with LIDs			**(155,421)**	**(7,707)**	**163,128**

For the post-development analysis, the overall drainage area was separated into the expected proposed impervious and pervious areas. Evapotranspiration, infiltration and runoff values were recalculated assuming no mitigation measures are implemented. Under proposed conditions, annual runoff will be approximately 381 percent of existing conditions, and infiltration will be approximately 38 percent of existing conditions. The annual values are shown in **Table 30**.

To determine the effects of incorporating Low Impact Development Measures on the overall annual water balance, Figure 1a of the City of Toronto Wet Weather Flow Management Guidelines, which is enclosed in **Appendix U**, was referenced. This chart relates daily rainfall depths to the corresponding percentage of total average annual rainfall depths. The LID accounting calculations discussed in Section 7.3.2 were expanded upon. The event-based depth of rainfall capability of each LID was converted into a percentage of the total average annual rainfall volume using the City of Toronto chart. These percentages were then applied to the annual rainfall falling on the impervious areas being directed to the LIDs, to determine the annual volume of runoff being converted to infiltration by each LID. This volume was then applied to the unmitigated characteristics to reduce annual runoff and increase annual infiltration for the mitigated scenario.

Mitigation by the proposed LID measures will reduce proposed conditions runoff from approximately 381 percent of the existing conditions runoff, to approximately 330 percent. It

should be noted that the surplus runoff shown in the LID calculations will be tributary to the four stormwater management ponds described previously, therefore surplus runoff is addressed by the DCHU storage and discharge criteria.

Infiltration is therefore the more significant parameter for the annual water balance analysis. As shown in **Appendix U**, mitigation by the proposed LID measures will increase proposed conditions infiltration (without LIDs), from 38.2 percent of existing conditions infiltration, to 89.3 percent of existing conditions infiltration.

Based on the foregoing analysis, the proposed LID strategy greatly reduces the proposed conditions overall infiltration deficit in comparison to existing conditions. Given the densities of the proposed land uses within the drainage area, the proposed LID strategy maximizes the space available for infiltration. The infiltration values resulting from LID implementation more closely resembles existing conditions.

7.3.4 Easements for LID Measures

Several of the LID facilities described above will be located outside the development limits on provincially owned NHS lands. As such, easements in favour of the City of Pickering are required for any stormwater management related infrastructure which is located on provincial lands. They include:

- enhanced grass swales which are adjacent to roads along the site perimeter, including Silvermoon Drive and Begonia Place
- enhanced grass swales which are located behind lots, including the lots on the west side of Bellini Crescent and Cabernet Square, the south side of Cinnabar Square, and the west side of Signet Square
- roof drain collector outfalls and flow spreaders located behind the lots on the south side of Cinnabar Street, south of the high density block on Tuscana Street, south of Redwillow Crescent, and south of SWMF22A.

8.0 EROSION, SEDIMENT AND TOPSOIL CONTROL STRATEGY

Erosion and sediment control will be implemented for all construction activities, including topsoil stripping, earth moving operations, and the servicing/building program. Detailed erosion and sediment control plans and reports will be prepared during detailed design of each individual development, in support of necessary permit applications. Erosion and sediment control plans will be designed in conformance with the City of Pickering, TRCA, and Ministry of the Environment guidelines and the Greater Golden Horseshoe Conservation Authorities Erosion and Sediment Control Guideline for Urban Construction (GGHCA ESC guideline).

The erosion and sediment control strategies will include the following:

- Immediately following construction for all permanent works, all disturbed areas to be graded to design, organic soil added and re-vegetated as soon as conditions allow.
- Rough grading for residential and commercial projects shall be undertaken in such a manner as to limit the extent and duration of open excavation as much as possible.
- Rapid establishment of vegetation on any channel banks and adjacent floodplains to minimize potential erosion, where applicable.
- Temporary sediment control measure at construction limits, and/or downstream of any disturbed areas prior to grading.
- Gravel mud mats at construction vehicle access points to minimize off-site tracking of sediments.
- Material stockpiles located an appropriate distance from watercourses, stabilized and bordered by temporary sediment control works.
- Vehicle and equipment re-fuelling and/or maintenance conducted in a specified, controlled area.
- Temporary sediment ponds as required, utilizing the permanent stormwater management facilities, where possible.
- Sediment laden unwatering discharge pumped to a stilling basin, or filtering system well away from the watercourse, and allowed to settle and/or filter through the riparian vegetation before re-entering the watercourse, downstream of the construction area.
- Check dams for erosion/velocity control.

- Sediment traps in catch-basins.
- Routine inspection, monitoring, and repair as necessary of all temporary erosion and sediment control measures during construction.
- Removal of temporary controls once the areas they serve are restored and stable.
- In-Water Works, if necessary, will occur during the allowable fisheries window, or as otherwise directed by the MNR.

It is recognized that individual site development may proceed in multiple phases. In cases where sites involve multiple phases of construction, efforts will be made to minimize disturbed areas in adjacent phases as site specific conditions warrant. It must be noted, however, that disturbance in future phases to allow a practical earth moving program may be required. In such cases, disturbed areas in future phases will follow the erosion and sediment control strategies outlined above and be stabilized immediately after construction with an appropriate seed mix.

In December 2014, TRCA issued a memo outlining the comprehensive erosion and sediment control strategy for the Seaton Community. In keeping with that strategy, all erosion and sediment control reports and plans shall be prepared by a Certified ESC Designer. Separate and distinct ESC plans will be prepared and implemented for topsoil stripping/earth moving operations and site servicing/building programs.

During construction, contract administration supervisors will be Accredited Erosion and Sediment Installers or Canadian Certified Inspectors of Sediment and Erosion Control. Appropriate inspection and reporting protocols will be established and agreed upon with the City of Pickering and TRCA.

9.0 CONCLUSIONS

Based On the findings of this FSSR, the following conclusions may be reached:

1. The MESPA and NFSSR processes have provided sufficient direction and background information to advance this FSSR.
2. An overall Seaton-wide benefit plan is being carried out for Redside Dace, Bobolink and Eastern Meadowlark outside of this FSSR terms of reference.
3. Any on-site butternut trees have previously been compensated for.
4. A detailed slope stability analysis adjacent to each draft plan of subdivision was carried out and concluded that the proposed construction of the residential development is feasible without negatively affecting the stability of adjacent slopes.
5. The proposed subdivision roads and lots may be graded to meet City of Pickering design criteria.
6. Sanitary sewage disposal and water supply may be provided to the site according to Region of Durham and City of Pickering design criteria with appropriate connections to trunk services.
7. Minor system storm drainage from the subject site is tributary to SWMF's 19, 20, 22, and 22A.
8. Major system flows will be captured prior to discharge to Alexander Knox Road or Whites Road and as such are subject to the modeling protocol as determined by the City of Pickering and Region of Durham.
9. All four stormwater ponds will be wet ponds with permanent pools that provide Level 1 (Enhanced) water quality control, and erosion control storage with a 120-hour or greater drawdown time.
10. SWMF 19 will provide water quantity control as required for DCHU Catchment 31. The quantity control volume will be stacked on top of the erosion control volume. This pond will discharge to a minor tributary of the east branch of Whitevale Creek.
11. SWMF 20 will provide water quantity control as required for DCHU Catchment 32. The quantity control volume will be stacked on top of the erosion control volume. This pond will discharge to an unnamed tributary of West Duffins Creek.
12. SWMFs 22 and 22A will provide water quantity control as required for DCHU Catchment 34. The quantity control volumes will be stacked on top of the erosion control volumes. These ponds will discharge to the West Branch of Ganatsekiagon Creek.

13. The preliminary designs of all four SWMFs meet the City of Pickering, MECP, and TRCA design guidelines and provide sufficient storage capacity to satisfy the water quality and erosion control criteria. SWMFs 22 and 22A will also contain features that satisfy requirements for discharge to redside dace habitat.
14. A hierarchy for consideration of use of specific LIDs was established to reflect several criteria and prior feedback from TRCA.
15. Runoff to wetland WD9, woodland FC17 and headwater feature HDFC24 will be supplemented by roof drain collector systems from approximately 2.93 ha, 1.63 ha and 3.25 ha of roof respectively.
16. The collector systems will be designed to outlet to each feature with standard headwalls and flow spreaders. Systems will be able to be controlled via sluice gates and overflow connections will direct surplus flow to the adjacent storm sewer system, for discharge to a stormwater pond.
17. The remaining roof area within the subject lands was utilized to determine the total volume of LID works required to satisfy the Seaton 5mm volume criteria, the redside dace habitat 10 to 15mm volume criteria, and the annual water balance criteria.
18. LIDs were chosen based on their expected effectiveness, accessibility and maintainability. LID measures include enhanced grass swales in NHS lands and public parkland, rear yard infiltration galleries, rain barrels and downspout disconnection where applicable. Extra depth topsoil will be used throughout the development.
19. The overall subdivision LID strategy will capture 11.36 mm of runoff, which satisfies the 5mm runoff criteria for developments in Seaton and the 10 to 15 mm runoff criteria for redside dace habitat.
20. An annual water balance was prepared by converting millimetres of runoff infiltrated per event, to amount of runoff infiltrated per annum. By maximizing all available LID options, the proposed LID strategy will reduce the annual post development infiltration deficit from 43,806 m^3 per annum to 7,558 m^3 per annum. Implementation of LIDs increases post development infiltration (without LIDs) from 38.2 percent of predevelopment levels to 89.3 percent of predevelopment levels.
21. Appropriate erosion and sediment control strategies will be developed through the detailed design stage. Design, inspection and reporting protocols will be developed in cooperation with the TRCA and City of Pickering.

APPENDIX A

SITE WALK MEETING MINUTES, CITY OF PICKERING MINUTES

APPENDIX B

TOPOGRAPHIC SURVEYS

HOLDING JONES VANDERVEEN INC.

APPENDIX C

SCOPED ENVIRONMENTAL IMPACT STUDY

BY BEACON ENVIRONMENTAL LIMITED

APPENDIX D

STUDY AREA SOILS REPORTS

APPENDIX E

POND BLOCK SOILS REPORTS

APPENDIX F

SLOPE STABILITY ASSESSMENTS WITHIN STUDY AREA

APPENDIX G

MAJOR SYSTEM CAPTURE CALCULATIONS

APPENDIX H

COMPREHENSIVE AQUATIC FRAMEWORK –

TRUSTEE PROPOSED WORKS IN REGULATED REDSIDE DACE HABITAT

(2017-2020)

APPENDIX I

RESIDENTIAL LOT IMPERVIOUS CALCULATIONS

APPENDIX J

SWMF19 DESIGN DETAILS

AND VO5 OUTPUT

APPENDIX K

SWMF20 DESIGN DETAILS

AND VO5 OUTPUT

APPENDIX L

SWMF22 DESIGN DETAILS

AND VO5 OUTPUT

APPENDIX M

SWMF22A DESIGN DETAILS

AND VO5 OUTPUT

APPENDIX N

MEANDER BELT WIDTH AND EROSION RISK ASSESSMENT

BY PARISH GEOMORPHIC

APPENDIX O

EROSION ASSESSMENT REPORT FOR REACH DB2

BY MATRIX SOLUTIONS INC.

APPENDIX P

EROSION MODEL SWMHYMO OUTPUT FOR REACH DB2

APPENDIX Q

EROSION ASSESSMENT REPORT FOR REACH G14-1

BY GEO MORPHIX LTD.

APPENDIX R

EROSION MODEL SWMHYMO OUTPUT FOR REACH G14-1

APPENDIX S

NATURAL FEATURE PC SWMM OUTPUT

AND WATER BALANCE CALCULATIONS

APPENDIX T

OVERALL LID CALCULATIONS

APPENDIX U

ANNUAL WATER BALANCE CALCULATIONS

BACK POCKET FIGURES