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Memorandum

Date: June 2021 **Project No.:** 300041230.0000

Project Name: Niagara Village Development Feature-based Water Balance

Client Name: 2592693 Ontario Inc.

From: Steven Roorda

1.0 Background

Many of the natural heritage features and functions of the Study Area has been heavily modified due to the presence and maintenance of the TWGC; large areas of existing fairway and greens are comprised of manicured turf. Remnant deciduous / mixed forests and swamps are present, most of which occur within the eastern portion of the property. A section of woodlands within the western extent of the property has been designated as part of the Niagara Falls Slough Forest Complex Provincially Significant Wetland (PSW). A network of open drainage features is also present; these features are used both as water hazards for the golf course and as a source of water for irrigation of the grounds.

The Study Area and surrounding lands are located within the Niagara River Subwatershed and fall under the jurisdiction of the Niagara Peninsula Conservation Authority (NPCA). Two watercourses have been identified within the Study Area. The first, the Conrail Drainage Channel (an artificial linear watercourse), runs parallel and adjacent to the rail corridor that travels southwest to northeast; and the second is an unnamed intermittent watercourse that connects various water features on the golf course. The property is bisected by a Canadian Pacific Railway (CPR) and associated corridor allowances.

2.0 Water Balance

One of the most significant impacts to wetlands caused by land-use changes is the alteration of wetland hydrology. As natural cover is replaced by impervious cover and runoff is efficiently directed towards drainage conveyance systems, the components of a wetland's water balance may become highly altered, changing a wetland's natural hydrological regime. Similarly, large-scale groundwater withdrawals or aggregate extraction activities have the potential to reduce flows to wetlands with strong hydrological connections to aquifer.

A water balance accounts for the inflows and outflows of water in a system, which are attributed to the various components of the hydrological cycle. The water balance includes, for example, the amount and timing of surface and / or ground water flow that feed a wetland and allow it to function as habitat for flora and fauna. Changes to the wetland's hydrology can have negative impacts on the ecology of the wetland.

This feature-based water balance analysis was prepared due to the presence of wetlands and woodlands on and adjacent to the subject property, to demonstrate that development of the subject property will not have a negative impact on the function of these features. The overall purpose of a feature-based water balance is to maintain quantity of surface water that ensures the pre-development hydroperiod (seasonal pattern of water level fluctuation) of a feature of interest is protected.

The feature-based water balance analysis has modelled surface water contributions to these features under pre-development and post development conditions. The results of this analysis have been used to refine the design and associated storm drainage plan and to mimic the existing water balance to the greatest extent possible.

3.0 Approach and Methodology

The study was performed by utilizing a monthly soil-moisture balance as described in Thornthwaite and Mather (1957). Precipitation and evapotranspiration data were taken from the Environment Canada online database.

Estimates of surplus were provided using Thornthwaite and Mather approach where surplus is estimated based on precipitation minus evapotranspiration (Steenhuis and Van Der Molen, 1986). The infiltration portion of the surplus was estimated by applying the infiltration factors provided in the MECP's Stormwater Management Planning and Design Manual These factors considered slope, vegetation and soils. The remainder of surplus was considered to be runoff.

3.1 Feature-Based Approach

The analytical approach to calculate a water balance for the Subject Property involved monthly soil moisture- balance calculations to determine the pre-development (based on existing land use conditions) and post development- (based on the proposed development concept plan) infiltration volumes. A soil -moisture balance approach assumes that soils do not release water as "potential infiltration" while a soil moisture deficit exists. During wetter periods, any excess of precipitation over evapotranspiration first goes to restore soil moisture. Once the soil moisture deficit is overcome, any further excess water can then pass through the soil as infiltration and either become interflow (indirect runoff) or recharge (deep infiltration).

Considering the nature of the clay loam in the area, a soil moisture storage capacity of 200 mm was used for the predominantly short to moderate rooted fairways for wetland drainage areas. A soil moisture storage capacity of 400 mm was used for longer rooted vegetation, i.e., the wooded areas. Table 1 to 5 in the Attachment detail the monthly potential evapotranspiration calculations accounting for latitude and climate, and the actual evapotranspiration (AET) and water surplus components of the water balance based on the monthly precipitation and soil moisture conditions.

The MECP SWM Planning and Design Manual (2003) methodology for calculating total infiltration based on topography, soil type and land cover was used and a corresponding runoff component was calculated for five soil moisture storage conditions (i.e., for 100, 200 and

400 mm storage as well as post-development impervious and rooftop, as presented on Tables 1 to 5 in the Attachment).

The calculated water balance components from these tables are used to assess the pre-development infiltration volumes based on the existing land use characteristics (open space, wooded areas, etc.). A post-development water balance scenario is then calculated for each feature, if applicable, based on the proposed draft plan. The pre-and post-development calculations are provided in Tables 6 and 7 in the Attachment.

4.0 Existing Features

4.1 Feature 1 (F1)

4.1.1 Existing Conditions

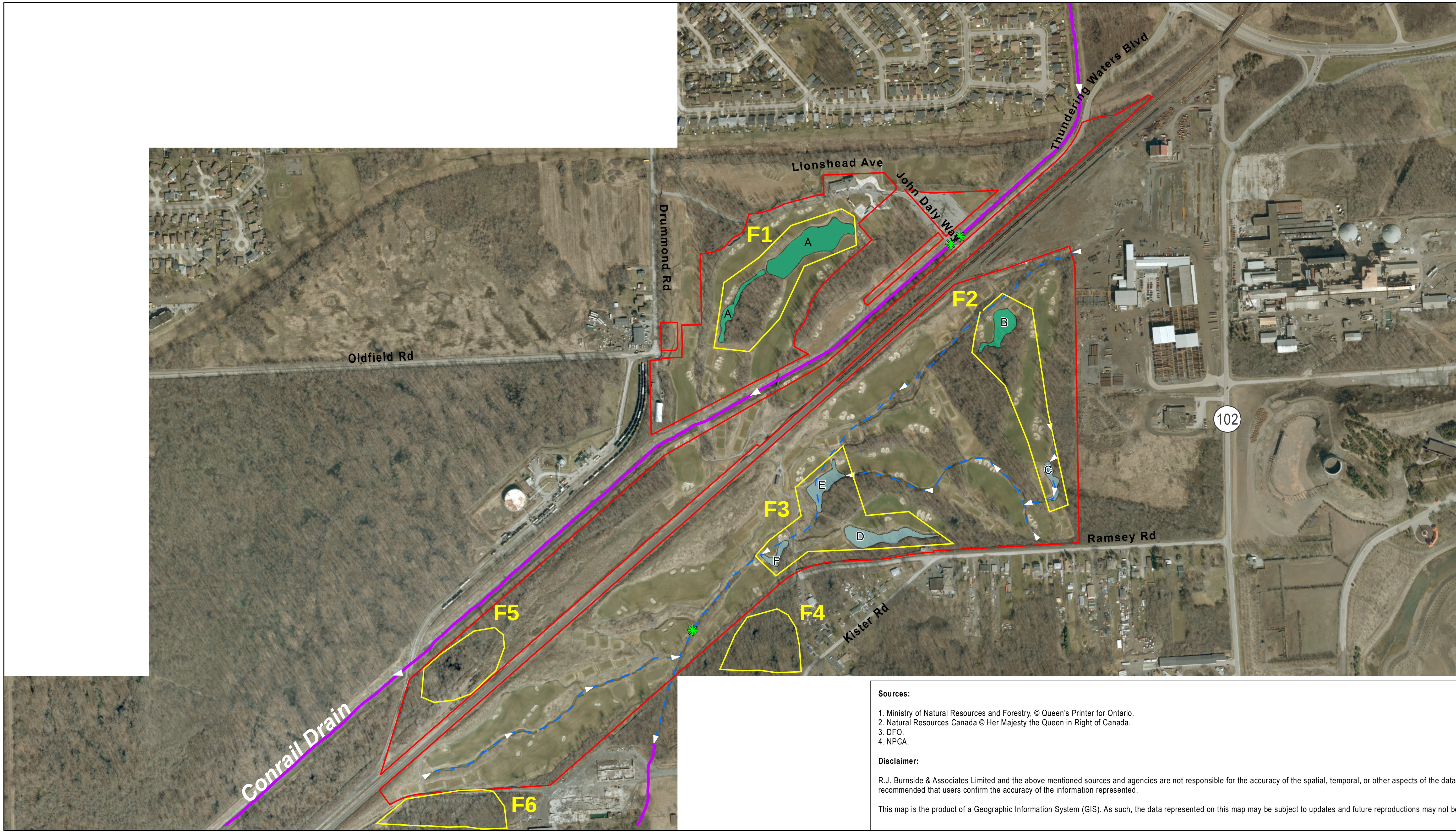
Feature 1 (also known as Pond A) is one of the two northernmost ponds within the Study Area and is not connected to any other ponds or watercourses. The pond is large and used by the golf course for irrigation purposes (OA areas on Figure 1).

Feature 1 is a large off-line pond that is comprised of two separate ponds which are connected to each other but do not connect to the other ponds or the watercourse. The larger portion of Pond A is northwest and downstream of the smaller portion of Pond A. The land surrounding the pond is currently comprised mostly of golf course fairway with a mature woodlot located on a small section of the south bank. The larger portion of Pond A was measured to be 187 m long and 75 m wide at maximum. The banks of the larger portion of Pond A were very steep (45 %) and majority of the surface area of the banks (80%) were vegetated with manicured grasses. The remainder of the banks were vegetated with mature riparian trees and rough hazards associated with the golf course. Cattail species were also present on the banks of the drain.

Feature 1 has an incoming storm sewer that serves the existing Thundering Waters Village development that is located at the northeast corner of the site. The west half of Lionshead Avenue drains to Feature 1 with a 675 mm diameter inlet into the pond. Feature 1 has a 600 mm outlet pipe connected to the Conrail Drainage Channel through an easement on the existing Green Vista condo site abutting the golf course.

4.1.2 Proposed Conditions

The draft plan proposes to eliminate Feature 1. According to EIS, as this feature is currently being fed using stormwater from the adjacent development it not considered a significant environmental feature. Storm sewer drainage that presently outlets to this pond will be redirected to connect to the Conrail drain.



Sources:

1. Ministry of Natural Resources and Forestry, © Queen's Printer for Ontario.
2. Natural Resources Canada © Her Majesty the Queen in Right of Canada.
3. DFO.
4. NPCA.

Disclaimer:

R.J. Burnside & Associates Limited and the above mentioned sources and agencies are not responsible for the accuracy of the spatial, temporal, or other aspects of the data represented on this map. It is recommended that users confirm the accuracy of the information represented.

This map is the product of a Geographic Information System (GIS). As such, the data represented on this map may be subject to updates and future reproductions may not be identical.

Datum: North American 1983	
Coord. System: NAD 1983 UTM Zone 17N	
Projection: Transverse Mercator	
Central Meridian: 81°0'0.00"W	
False Easting: 500,000m	False Northing: 0m
Rotation: 0	Scale Factor: 0.99960

N

True North

0 100 200 300 400 500

MetresAB

Barrier to Fish Movement

Intermittent Watercourse*

Site Boudary

Area within which one or more species listed under SARA may be found:

Extirpated, Endangered or Threatened (DFO, 2017)

Offline Pond*

Online Pond*

**Watercourse or Waterbody is a potential fish habitat*

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NIAGARA VILLAGE
Water Balance Features

Drawn	Checked	Date	Figure No.
		2021/06/08	1
Scale		Project No.	
H 1:7,500		300041230	

File Path: \\elmo\Shared Work Areas\041230-THUNDERING WATERS\GIS\Map\EIS Submission Feb 2020\041230 Watercourses.mxd Print Date: 2020/02/03 Time: 12:20 PM

4.2 Feature 2 (F2)

4.2.1 Existing Conditions

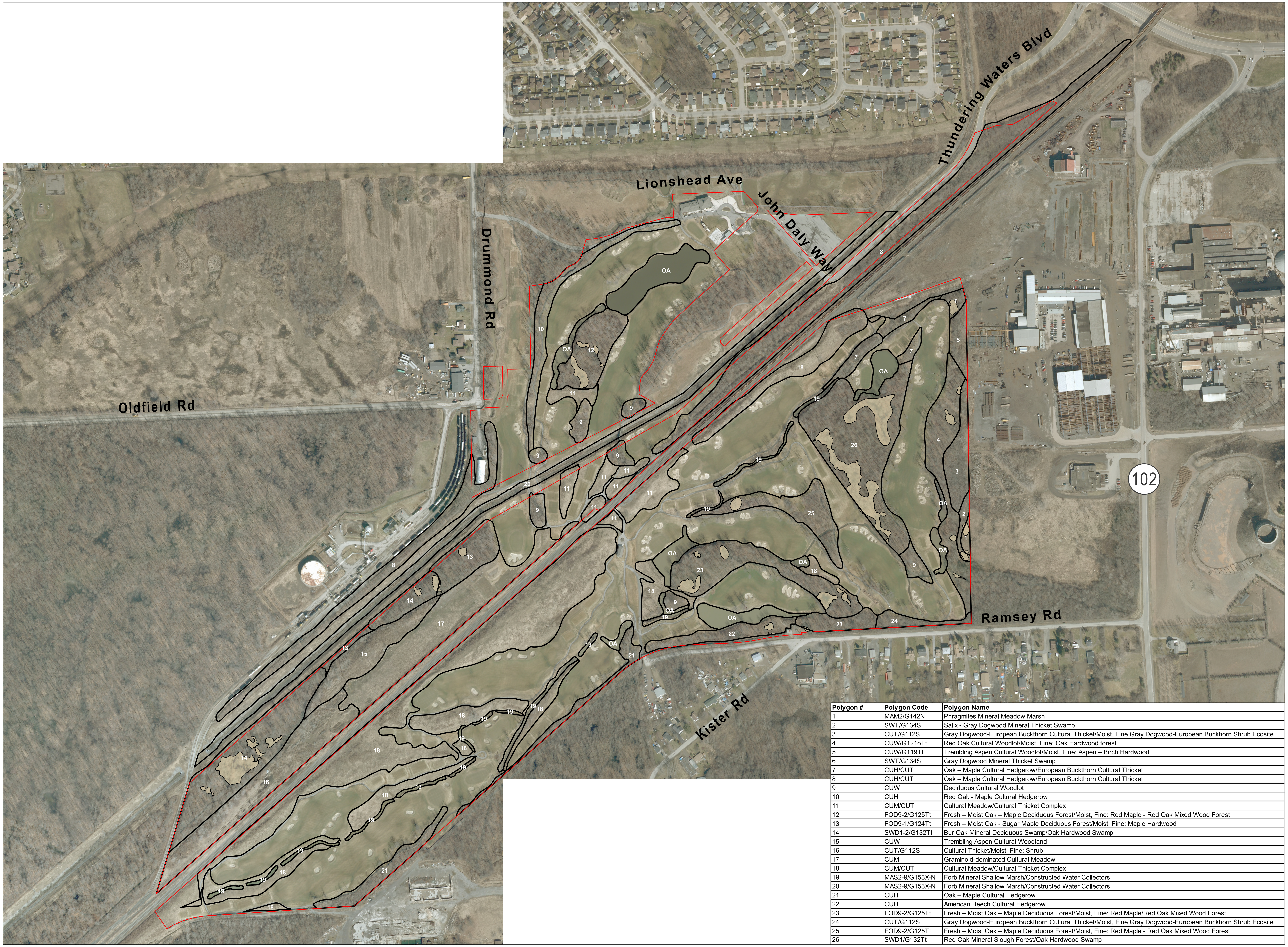
Pond B is one of the two northernmost ponds within the Study Area and is not connected to any other ponds or watercourses. The pond is used by the golf course for irrigation purposes (OA areas on Figure 1). Pond B is a round-shaped pond that is also offline and does not appear to outlet to the unnamed intermittent watercourse which connects most of the ponds within the Study Area. The maximum length and width of Pond B were measured to be 75 m and 45 m respectively. Nearshore slope was measured to range between 10-30%.

A wetland swamp associated with ELC polygon #26 is present behind the southwest bank of Pond B; it was observed that this pond flows, seasonally, into ELC polygon #26 (Figure 2).

Pond C is a 77m long approximately 10m wide pond located in the east boundary of the Study Area (Figure 1). The land surrounding the pond was comprised of golf course lands and a woodlot. This pond collects runoff from the surrounding lands and is connected to other ponds through the unnamed intermittent watercourse which flows within the Study Area.

4.2.2 Proposed Conditions

In the post-development condition, both Pond B and Pond C are proposed to remain. Drainage contributing to the woodlot known as Polygon #26 remains unchanged in the post-development scenario. The area surrounding Polygon #26 is not proposed to be developed as part of this application and a large part of the area is proposed to serve as an environmental compensation area. The areas that previously drained to the west will now be re-directed to the environmental compensation area. Refer to the Environmental Impact Study for additional details.



Site Boudary
ELC Boundary
Vernal Pool

Polygon #	Polygon Code	Polygon Name
1	MAM2/G142N	Phragmites Mineral Meadow Marsh
2	SWT/G134S	Salix - Gray Dogwood Mineral Thicket Swamp
3	CUT/G112S	Gray Dogwood-European Buckthorn Cultural Thicket/Moist, Fine Gray Dogwood-European Buckhorn Shrub Ecosite
4	CUW/G121oTt	Red Oak Cultural Woodlot/Moist, Fine: Oak Hardwood forest
5	CUW/G119Tt	Trembling Aspen Cultural Woodlot/Moist, Fine: Aspen – Birch Hardwood
6	SWT/G134S	Gray Dogwood Mineral Thicket Swamp
7	CUH/CUT	Oak – Maple Cultural Hedgerow/European Buckthorn Cultural Thicket
8	CUH/CUT	Oak – Maple Cultural Hedgerow/European Buckthorn Cultural Thicket
9	CUW	Deciduous Cultural Woodlot
10	CUH	Red Oak - Maple Cultural Hedgerow
11	CUM/CUT	Cultural Meadow/Cultural Thicket Complex
12	FOD9-2/G125Tt	Fresh – Moist Oak – Maple Deciduous Forest/Moist, Fine: Red Maple - Red Oak Mixed Wood Forest
13	FOD9-1/G124Tt	Fresh – Moist Oak - Sugar Maple Deciduous Forest/Moist, Fine: Maple Hardwood
14	SWD1-2/G132Tt	Bur Oak Mineral Deciduous Swamp/Oak Hardwood Swamp
15	CUW	Trembling Aspen Cultural Woodland
16	CUT/G112S	Cultural Thicket/Moist, Fine: Shrub
17	CUM	Graminoid-dominated Cultural Meadow
18	CUM/CUT	Cultural Meadow/Cultural Thicket Complex
19	MAS2-9/G153X-N	Forb Mineral Shallow Marsh/Constructed Water Collectors
20	MAS2-9/G153X-N	Forb Mineral Shallow Marsh/Constructed Water Collectors
21	CUH	Oak – Maple Cultural Hedgerow
22	CUH	American Beech Cultural Hedgerow
23	FOD9-2/G125Tt	Fresh – Moist Oak – Maple Deciduous Forest/Moist, Fine: Red Maple/Red Oak Mixed Wood Forest
24	CUT/G112S	Gray Dogwood-European Buckthorn Cultural Thicket/Moist, Fine Gray Dogwood-European Buckhorn Shrub Ecosite
25	FOD9-2/G125Tt	Fresh – Moist Oak – Maple Deciduous Forest/Moist, Fine: Red Maple - Red Oak Mixed Wood Forest
26	SWD1/G132Tt	Red Oak Mineral Slough Forest/Oak Hardwood Swamp

Sources:

1. Ministry of Natural Resources and Forestry, © Queen's Printer for Ontario
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Datum: North American 1983 CSRS	
Coord. System: NAD 1983 CSRS UTM Zone 17N	
Projection: Transverse Mercator	
Central Meridian: 81°0'0.00"W	
False Easting: 500,000m	False Northing: 0m
Page Orientation: 0°	Scale Factor: 0.99960

N
True North

0 50 100 150 200
Metres

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Client
2592693 ONTARIO INC.

Map Title
NIAGARA VILLAGE EIS
ECOLOGICAL LAND CLASSIFICATION

Drawn	Checked	Date	Map No.
HN	PD	2020/02/03	2
Scale		Project No.	
H 1:2,750		300041230	

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4.3 Feature 3 (F3)

4.3.1 Existing Conditions

An unnamed intermittent watercourse flows between four ponds (Ponds C-F) within the Study Area. This watercourse flows from northeast to southwest discharging into Pond E. Pond E outlets into a reach of the watercourse which flows generally from north to south out of the study area eventually discharging into the Welland River. It was observed that flows within the unnamed intermittent watercourse are controlled by the invert elevations of the culverts at the outlets of the ponds. This intermittent watercourse lacks diversity in channel bottom depth, substrate, and morphology.

4.3.2 Proposed Conditions

The ponds and intermittent watercourse will be impacted based on the proposed development and loss of water pumping that currently supports golf course operations. Ponds C-F are considered to provide marginal Fish Habitat and considered to provide low sensitivity fish habitat for warm water species. The ponds are man-made, augmented through pumping and drainage, and only outlet when water levels reach an elevation to outlet to the intermittent watercourse. Since the ponds and connectivity to the intermittent watercourse was designed and constructed approximately 15 years ago, the existing conditions are man-made and maintained through golf course operations. Generally, it has been assessed that the ecological integrity of these ponds is low, due mostly to operations of the golf course.

Considering that these ponds are not to be removed, no water balance will be required. It is noted that any areas that had previously drained to these features will now be directed to the southerly pond and ultimate outlet to the existing watercourse south of the site.

4.4 Feature 4 – Offsite (F4)

Based on a review of the existing drainage flow directions it does not appear that any of the existing golf course drainage is directed towards Feature 4. The on-site area adjacent Feature 4 flows towards the unnamed intermittent watercourse, which forms part of Feature 3. In post development, this drainage regime remains unchanged.

4.5 Feature 5 (F5)

4.5.1 Existing Conditions

This swamp features a Red Oak dominated canopy, with occasional representation of Red Maple, Silver Maple, and Bur Oak. This ecosite was noted as exhibiting the highest proportion of vernal pools following spring freshet with the exception of Polygon #14 (the southern portion of the PSW). It is estimated that up to 50% of the ecosite was flooded in the spring.

A slough-type microtopography is evident in this polygon, with upland and lowland habitats in close proximity to each other. The canopy in this swamp ecosite is dominated by Bur Oak and Red Oak, with high occurrence of Red/Silver/Freeman's Maple. As it is proposed that the drainage area to Feature 5 be altered based on the proposed development a pre-development water balance has been completed for this feature as described in the section below.

Pre-Development Water Balance

The pre-development water balance calculations for the woodlot/wetland features and external features are presented in Table 6 in the Attachment. A soil moisture storage capacity of 200 mm was used for the predominantly moderate-rooted wetland area and a soil moisture storage capacity of 400 mm was used for longer-rooted vegetation, i.e., the wooded areas (refer to Table 1 to 5 in the Attachment). In summary from these appendix tables, the total calculated pre-development infiltration and runoff volumes are summarized in Tables below.

Table 1: Summary of Estimated Infiltration, Runoff, and Evapotranspiration Rates

Land Use Area	Estimated Infiltration (mm/year)	Estimated Runoff (mm/year)	Estimated Evapotranspiration (mm/year)
Polygon #14 (the southern portion of the PSW)	247	326	640

Table 2: Summary of Pre-Development Runoff to Feature

Land Use Area	Estimated Pre-Development Infiltration (m^3/year)	Estimated Pre-Development Runoff (m^3/year)	Estimated Pre-Development Evapotranspiration (m^3/year)
Polygon #14 (the southern portion of the PSW)	14.5	15.99	46.8

Post Development Water Balance and Mitigation Strategies

The development of the area proposes to build houses and roads within features listed above eliminates infiltration and surface water contributions from the upland area and creating infiltration and runoff deficits.

Table 3: Summary of Post-Development Runoff to Woodlot/Wetland Features

Land Use Area	Estimated Post-Development Infiltration Volume (m^3/year)	Estimated Post-Development Runoff Volume (m^3/year)	Estimated Post-Development Evapotranspiration (m^3/year)
Polygon #14 (the southern portion of the PSW)	15.1	10.42	30.8

Therefore, the Net Surface Runoff Loss based on the above, would be 5.58 m3/year if no mitigation is considered (Scenario #1, see Table 6 in the Attachment).

One suggestion, as a mitigation measure, would be to direct the roof and rear lot run-off from the developed area in Polygon #14 to the wetland to compensate for the surface run-off loss in Scenario #1. The attached Fig 5 (markup) shows the areas that could be redirected to this feature. A review of the existing infrastructure and outlet elevations reveals that this scenario is possible, providing adequate cover to the proposed storm sewer system to outlet to this feature. An OGS would also be recommended to provide the appropriate level of quality control for the runoff expected from the road surfaces. It is recommended that this be added during detailed design. the Southerly SWM pond will also need to be updated, but with less contributing flows, the footprint would-be slightly larger than ultimately required. Again, this can be updated during detailed design.

Directing approximately 0% of the roof rare lot run-off would increase the post-development run-off volume to 17.5 m^3/year which would result in a net surface runoff ‘gain’ of 1.5 m^3/year (Scenario #2, see Table 7 in the Attachment).

4.6 Feature 6 – Offsite (F6)

Based on a review of the existing drainage flow directions, there appears to be a 0.49 ha drainage area at the south end of the site that drains to Feature 6. In post-development it is proposed that a portion of the 30 m buffer provided on the site from this feature continue to drain to Feature 6 with an equivalent area of 0.49 ha. By providing an equivalent area that will remain in an undeveloped condition it is expected that flows to Feature 6 will remain consistent with existing conditions. Refer to the Stormwater Management Report prepared R.J.Burnside for additional details on these drainage areas.

SR/ABJ:js

Enclosure(s) Attachment A

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Supporting Documents

WATER BALANCE CALCULATIONS
Niagara Village Development Lands
Niagara Region

PROJECT No.300041230

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TABLE 1

Water Balance Components for Woodlot

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 400 mm (mature forests in clayey loam)

Precipitation data from Niagara Falls NPCSH Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**	
Average Temperature (Degree C)	-4.1	-2.7	1.2	7.5	13.6	19.1	22.2	21.1	17.1	10.7	4.9	-0.7	**9.2**	<--From Environment Canada
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.12	1.85	4.55	7.61	9.55	8.85	6.43	3.16	0.97	0.00	**43.1**	
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	3.58	30.63	61.52	91.59	109.24	102.93	80.46	46.45	18.60	0.00	**545**	
Adjusting Factor for U (Latitude 43^o 44' N)	0.81	0.82	1.02	1.12	1.26	1.28	1.29	1.2	1.04	0.95	0.81	0.77		<--From J. M. Lorente (1961). pp. 206
Adjusted Potential Evapotranspiration PET (mm)	0	0	4	34	78	117	141	124	84	44	15	0	**640**	
PRE-DEVELOPMENT WATER BALANCE COMPONENTS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**	
Precipitation (P)	76	62	62	72	87	81	79	79	98	80	92	81	**948**	<--From Environment Canada
Potential Evapotranspiration (PET)	0	0	4	34	78	117	141	124	84	44	15	0	**640**	
P - PET	76	62	58	38	9	-36	-62	-44	15	36	77	81	**308**	
Change in Soil Moisture Storage	0	0	0	0	0	-36	-62	-44	15	36	77	16	**0**	
Soil Moisture Storage max 400 mm	400	400	400	400	400	364	302	257	272	307	384	400		
Actual Evapotranspiration (AET)	0	0	4	34	78	117	141	124	84	44	15	0	**640**	
Soil Moisture Deficit max 400 mm	0	0	0	0	0	36	98	143	128	93	16	0		
Water Surplus - available for infiltration or runoff	76	62	58	38	9	0	0	0	0	0	0	65	**308**	
Potential Infiltration (based on MOE metholodogy*; independent of temperature)	49	40	38	24	6	0	0	0	0	0	0	42	**200**	
Potential Direct Surface Water Runoff (independent of temperature)	26	22	20	13	3	0	0	0	0	0	0	23	**108**	
Recharge (deep infiltration-assume 50% of I)	25	20	19	12	3	0	0	0	0	0	0	21	**100**	
Interflow (indirect runoff-asume 50% of I)	25	20	19	12	3	0	0	0	0	0	0	21	**100**	
Total Runoff (direct and indirect components)	51	42	39	25	6	0	0	0	0	0	0	44	**208**	
IMPERVIOUS AREA WATER SURPLUS														
Annual Precipitation (P)	948	mm/yr												
Potential Evaporation (PE) from impervious areas (assume 15%)	142	mm/yr												
P-PE (surplus available for runoff from impervious areas)	806	mm/yr												

Assume January storage is 100% of Soil Moisture Storage		
Soil Moisture Storage	400 mm	<-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003
*MOECC SWM infiltration calculations		
topography - Flat/rolling land	0.25	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - Medium combinations of clay and loam	0.2	**<-- Infiltration Factors selected based on GRCA recomendation**
cover -Woodland	0.2	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
Infiltration factor	**0.65**	
Latitude of site (or climate station)	43 ^{O} N.	

WATER BALANCE CALCULATIONS
Niagara Village Development Lands
Niagara Region

PROJECT No.300041230

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TABLE 2

Water Balance Components for Wetland

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 200 mm (moderately-rooted crops in clayey loam)

Precipitation data from Niagara Falls NPCSH Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**	
Average Temperature (Degree C)	-4.1	-2.7	1.2	7.5	13.6	19.1	22.2	21.1	17.1	10.7	4.9	-0.7	**9.2**	<--From Environment Canada
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.12	1.85	4.55	7.61	9.55	8.85	6.43	3.16	0.97	0.00	**43.1**	
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	3.58	30.63	61.52	91.59	109.24	102.93	80.46	46.45	18.60	0.00	**545**	
Adjusting Factor for U (Latitude 43° 44' N)	0.81	0.82	1.02	1.12	1.26	1.28	1.29	1.2	1.04	0.95	0.81	0.77		<--From J. M. Lorente (1961). pp. 206
Adjusted Potential Evapotranspiration PET (mm)	0	0	4	34	78	117	141	124	84	44	15	0	**640**	
PRE-DEVELOPMENT WATER BALANCE COMPONENTS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**	
Precipitation (P)	76	62	62	72	87	81	79	79	98	80	92	81	**948**	<--From Environment Canada
Potential Evapotranspiration (PET)	0	0	4	34	78	117	141	124	84	44	15	0	**640**	
P - PET	76	62	58	38	9	-36	-62	-44	15	36	77	81	**308**	
Change in Soil Moisture Storage	0	0	0	0	0	-36	-62	-44	15	36	77	16	**0**	
Soil Moisture Storage max 200 mm	200	200	200	200	200	164	102	57	72	107	184	200		
Actual Evapotranspiration (AET)	0	0	4	34	78	117	141	124	84	44	15	0	**640**	
Soil Moisture Deficit max 200 mm	0	0	0	0	0	36	98	143	128	93	16	0		
Water Surplus - available for infiltration or runoff	76	62	58	38	9	0	0	0	0	0	0	65	**308**	
Potential Infiltration (based on MOE metholodogy*; independent of temperature)	42	34	32	21	5	0	0	0	0	0	0	36	**169**	
Potential Direct Surface Water Runoff (independent of temperature)	34	28	26	17	4	0	0	0	0	0	0	29	**138**	
Recharge (deep infiltration-assume 50% of I)	21	17	16	10	3	0	0	0	0	0	0	18	**85**	
Interflow (indirect runoff-asume 50% of I)	21	17	16	10	3	0	0	0	0	0	0	18	**85**	
Total Runoff (direct and indirect components)	55	45	42	27	7	0	0	0	0	0	0	47	**223**	
IMPERVIOUS AREA WATER SURPLUS														
Annual Precipitation (P)	948	mm/yr												
Potential Evaporation (PE) from impervious areas (assume 15%)	142	mm/yr												
P-PE (surplus available for runoff from impervious areas)	806	mm/yr												

Assume January storage is 100% of Soil Moisture Storage
Soil Moisture Storage 200 mm <-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003

*MOECC SWM infiltration calculations

topography - Flat/rolling land	0.25	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - Medium combinations of clay and loam	0.2	**<-- Infiltration Factors selected based on GRCA recomendation**
cover - predominantly cultivated land	0.1	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
Infiltration factor	**0.55**	

Latitude of site (or climate station) 43 ° N.

WATER BALANCE CALCULATIONS
Niagara Village Development Lands
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TABLE 3

Water Balance Components for Golf Course/Urban Lawn

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 100 mm (Urban Lawns/Shallow Rooted Crops in clayey loam)

Precipitation data from Niagara Falls NPCSH Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**	
Average Temperature (Degree C)	-4.1	-2.7	1.2	7.5	13.6	19.1	22.2	21.1	17.1	10.7	4.9	-0.7	**9.2**	<--From Environment Canada
Heat index: i = $(t/5)^{1.514}$	0.00	0.00	0.12	1.85	4.55	7.61	9.55	8.85	6.43	3.16	0.97	0.00	**43.1**	
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	3.58	30.63	61.52	91.59	109.24	102.93	80.46	46.45	18.60	0.00	**545**	
Adjusting Factor for U (Latitude 43^{o} 44' N)	0.81	0.82	1.02	1.12	1.26	1.28	1.29	1.2	1.04	0.95	0.81	0.77		<--From J. M. Lorente (1961). pp. 206
Adjusted Potential Evapotranspiration PET (mm)	0	0	4	34	78	117	141	124	84	44	15	0	**640**	
PRE-DEVELOPMENT WATER BALANCE COMPONENTS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**	
Precipitation (P)	76	62	62	72	87	81	79	79	98	80	92	81	**948**	<--From Environment Canada
Potential Evapotranspiration (PET)	0	0	4	34	78	117	141	124	84	44	15	0	**640**	
P - PET	76	62	58	38	9	-36	-62	-44	15	36	77	81	**308**	
Change in Soil Moisture Storage	0	0	0	0	0	-36	-62	-2	15	36	50	0	**0**	
Soil Moisture Storage max 100 mm	100	100	100	100	100	64	2	0	15	50	100	100		
Actual Evapotranspiration (AET)	0	0	4	34	78	117	141	81	84	44	15	0	**597**	
Soil Moisture Deficit max 100 mm	0	0	0	0	0	36	98	100	85	50	0	0		
Water Surplus - available for infiltration or runoff	76	62	58	38	9	0	0	0	0	0	27	81	**350**	
Potential Infiltration (based on MOE metholodogy*; independent of temperature)	42	34	32	21	5	0	0	0	0	0	15	45	**193**	
Potential Direct Surface Water Runoff (independent of temperature)	34	28	26	17	4	0	0	0	0	0	12	36	**158**	
Recharge (deep infiltration-assume 50% of I)	21	17	16	10	3	0	0	0	0	0	7	22	**96**	
Interflow (indirect runoff-asume 50% of I)	21	17	16	10	3	0	0	0	0	0	7	22	**96**	
Total Runoff (direct and indirect components)	55	45	42	27	7	0	0	0	0	0	19	59	**254**	
IMPERVIOUS AREA WATER SURPLUS														
Annual Precipitation (P)	948	mm/yr												
Potential Evaporation (PE) from impervious areas (assume 15%)	142	mm/yr												
P-PE (surplus available for runoff from impervious areas)	806	mm/yr												

Assume January storage is 100% of Soil Moisture Storage		
Soil Moisture Storage	100 mm	<-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003
*MOECC SWM infiltration calculations		
topography - Flat/rolling land	0.25	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - Medium combinations of clay and loam	0.2	**<-- Infiltration Factors selected based on GRCA recomendation**
cover - predominantly cultivated land	0.1	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
Infiltration factor	**0.55**	
Latitude of site (or climate station)	43^{O} N.	

WATER BALANCE CALCULATIONS
Niagara Village Development Lands
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BURNSIDE

TABLE 4

Water Balance Components for Impervious Area

Based on Thornthwaite's Soil Moisture Balance Approach with no Soil Moisture Retention

Precipitation data from Niagara Falls NPCSH Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**	
Average Temperature (Degree C)	-4.1	-2.7	1.2	7.5	13.6	19.1	22.2	21.1	17.1	10.7	4.9	-0.7	**9.2**	<--From Environment Canada
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.12	1.85	4.55	7.61	9.55	8.85	6.43	3.16	0.97	0.00	**43.1**	
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	3.58	30.63	61.52	91.59	109.24	102.93	80.46	46.45	18.60	0.00	**545**	
Adjusting Factor for U (Latitude 43^{o} 44' N)	0.81	0.82	1.02	1.12	1.26	1.28	1.29	1.2	1.04	0.95	0.81	0.77		<--From J. M. Lorente (1961). pp. 206
Adjusted Potential Evapotranspiration PET (mm)	0	0	4	34	78	117	141	124	84	44	15	0	**640**	
PRE-DEVELOPMENT WATER BALANCE COMPONENTS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**	
Precipitation (P)	76	62	62	72	87	81	79	79	98	80	92	81	**948**	<--From Environment Canada
Potential Evapotranspiration (PET)	0	0	4	34	78	117	141	124	84	44	15	0	**640**	
P - PET	76	62	58	38	9	-36	-62	-44	15	36	77	81	**308**	
Change in Soil Moisture Storage	0	0	0	0	0	-1	0	0	1	0	0	0	**0**	
Soil Moisture Storage max 1 mm	1	1	1	1	1	0	0	0	1	1	1	1		
Actual Evapotranspiration (AET)	0	0	4	34	78	82	79	79	84	44	15	0	**498**	
Soil Moisture Deficit max 1 mm	0	0	0	0	0	1	1	1	0	0	0	0		
Water Surplus - available for infiltration or runoff	76	62	58	38	9	0	0	0	14	36	77	81	**449**	
Potential Infiltration (based on MOE metholodogy*; independent of temperature)	38	31	29	19	5	0	0	0	7	18	38	41	**225**	
Potential Direct Surface Water Runoff (independent of temperature)	38	31	29	19	5	0	0	0	7	18	38	41	**225**	
Recharge (deep infiltration-assume 50% of I)	19	15	15	9	2	0	0	0	3	9	19	20	**112**	
Interflow (indirect runoff-asume 50% of I)	19	15	15	9	2	0	0	0	3	9	19	20	**112**	
Total Runoff (direct and indirect components)	57	46	44	28	7	0	0	0	10	27	58	61	**337**	
IMPERVIOUS AREA WATER SURPLUS														
Annual Precipitation (P)	948	mm/yr												
Potential Evaporation (PE) from impervious areas (assume 15%)	142	mm/yr												
P-PE (surplus available for runoff from impervious areas)	806	mm/yr												

Assume January storage is 100% of Soil Moisture Storage

Soil Moisture Storage	1	mm	<-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003
*MOECC SWM infiltration calculations			
topography - Flat/rolling land	0.2		<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - Medium combinations of clay and loam	0.2		**<-- Infiltration Factors selected based on GRCA recomendation**
cover - predominantly cultivated land	0.1		<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
Infiltration factor	**0.5**		
Latitude of site (or climate station)	43 ^{O}	N.	

WATER BALANCE CALCULATIONS
Niagara Village Development Lands
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BURNSIDE

TABLE 5

Water Balance Components for Rooftop Area

Based on Thornthwaite's Soil Moisture Balance Approach with a no Soil Moisture Retention

Precipitation data from Niagara Falls NPCSH Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**	Note
Average Temperature (Degree C)	-4.1	-2.7	1.2	7.5	13.6	19.1	22.2	21.1	17.1	10.7	4.9	-0.7	**9.2**	<--From Environment Canada
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.12	1.85	4.55	7.61	9.55	8.85	6.43	3.16	0.97	0.00	**43.1**	
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	3.58	30.63	61.52	91.59	109.24	102.93	80.46	46.45	18.60	0.00	**545**	
Adjusting Factor for U (Latitude 43^{o} 44' N)	0.81	0.82	1.02	1.12	1.26	1.28	1.29	1.2	1.04	0.95	0.81	0.77		<--From J. M. Lorente (1961). pp. 206
Adjusted Potential Evapotranspiration PET (mm)	0	0	4	34	78	117	141	124	84	44	15	0	**640**	
PRE-DEVELOPMENT WATER BALANCE COMPONENTS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**	
Precipitation (P)	76	62	62	72	87	81	79	79	98	80	92	81	**948**	<--From Environment Canada
Potential Evapotranspiration (PET)	0	0	4	34	78	117	141	124	84	44	15	0	**640**	
P - PET	76	62	58	38	9	-36	-62	-44	15	36	77	81	**308**	
Change in Soil Moisture Storage	0	0	0	0	0	-1	0	0	1	0	0	0	**0**	
Soil Moisture Storage max 1 mm	1	1	1	1	1	0	0	0	1	1	1	1		
Actual Evapotranspiration (AET)	0	0	4	34	78	82	79	79	84	44	15	0	**498**	
Soil Moisture Deficit max 1 mm	0	0	0	0	0	1	1	1	0	0	0	0		
Water Surplus - available for infiltration or runoff	76	62	58	38	9	0	0	0	14	36	77	81	**449**	
Potential Infiltration (based on MOE metholodogy*; independent of temperature)	42	34	32	21	5	0	0	0	7	20	42	45	**247**	
Potential Direct Surface Water Runoff (independent of temperature)	34	28	26	17	4	0	0	0	6	16	35	36	**202**	
Recharge (deep infiltration-assume 50% of I)	21	17	16	10	3	0	0	0	4	10	21	22	**124**	
Interflow (indirect runoff-asume 50% of I)	21	17	16	10	3	0	0	0	4	10	21	22	**124**	
Total Runoff (direct and indirect components)	55	45	42	27	7	0	0	0	10	26	56	59	**326**	
IMPERVIOUS AREA WATER SURPLUS														
Annual Precipitation (P)	948	mm/yr												
Potential Evaporation (PE) from impervious areas (assume 15%)	142	mm/yr												
P-PE (surplus available for runoff from impervious areas)	806	mm/yr												

Assume January storage is 100% of Soil Moisture Storage
Soil Moisture Storage 1 mm <-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003

*MOECC SWM infiltration calculations

topography - Flat/rolling land	0.25	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - Medium combinations of clay and loam	0.2	**<-- Infiltration Factors selected based on GRCA recomendation**
cover - predominantly cultivated land	0.1	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
Infiltration factor	**0.55**	

Latitude of site (or climate station) 43^{O} N.

WATER BALANCE CALCULATIONS
Niagara Village Development Lands
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BURNSIDE

TABLE 6

Surface Run-off: Feature 5 - Option 1

Pre-development				Post-development							Comments
				Pervious				Impervious			
Location	Area Draining to Location	Runoff Rate	Runoff Volume	Location	Area Draining to Location	Runoff Rate	Runoff Volume	Area Draining to Location	Runoff Rate	Runoff Volume	
	ha	*mm/year*	*m3/yr*		*ha*	*mm/year*	*m3/yr*	*ha*	*mm/year*	*m3/yr*	
Polygon 14 - Woodlot Portion	5.55	207.6842	11.52647	Polygon 14 - Woodlot Porion	4.16	207.6842	8.63966304			0	
Polygon 14 - Golf Course Portion	1.76	254	4.470492	Polygon 14 - Golf Course portion	0	254	0			0	
				Polygon 14 - Roof portion		326	0	0.19602	326	0.638594	
				Pervious Surface (Rear Lots)	0.4494	254	1.14149942			0	
Sub-total			15.99697				9.78116246			0.638594	
Total			15.99696525							10.41975683	

Net Loss Surface Runoff (m3/yr) 5.577208419

WATER BALANCE CALCULATIONS
Niagara Village Development Lands
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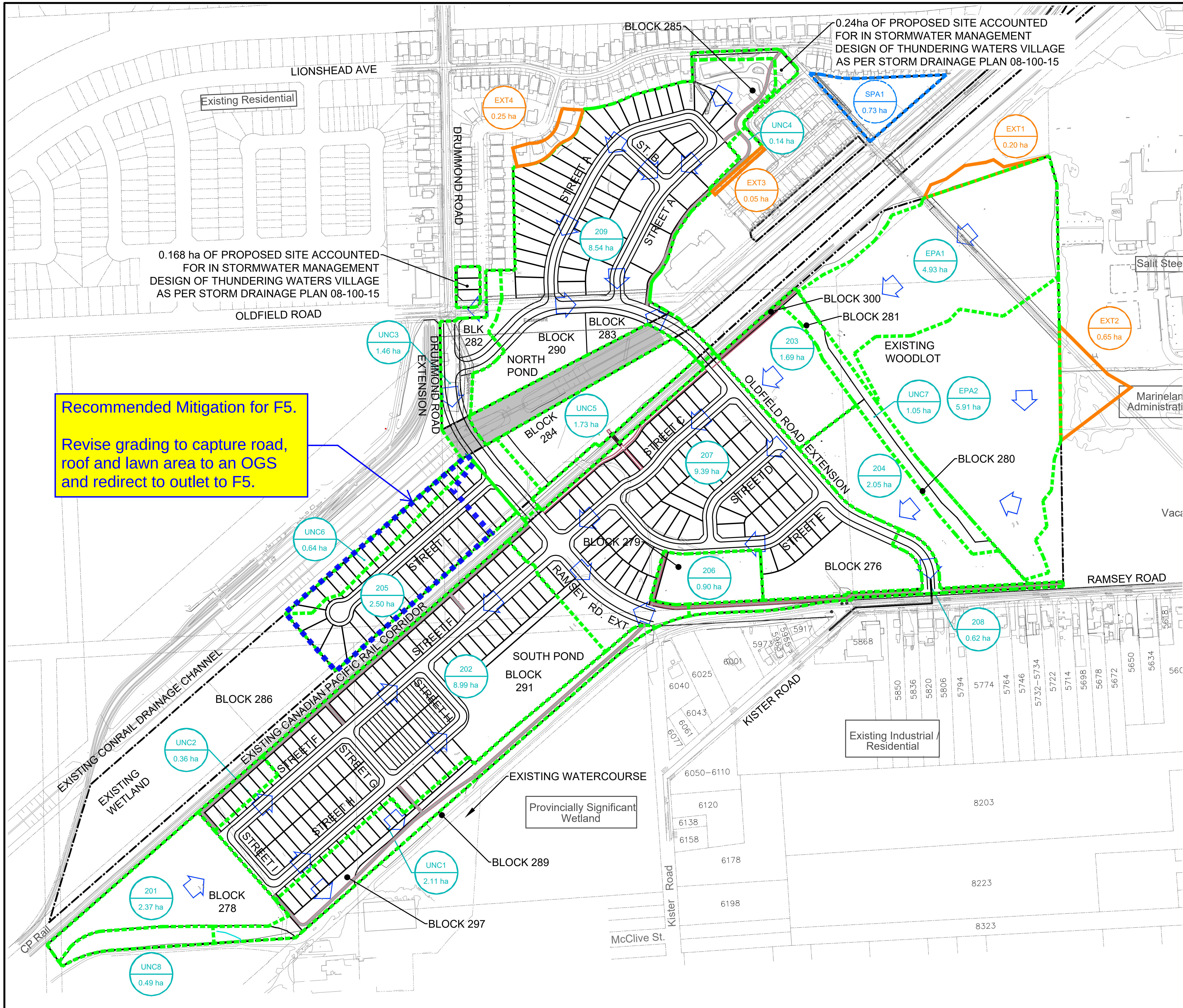
TABLE 7

Surface Run-off: Feature 5 - Option 2

Pre-development				Post-development							
				Pervious				Impervious			
Location	**Area Draining to Location**	**Runoff Rate**	**Runoff Volume**	**Location**	**Area Draining to Location**	**Runoff Rate**	**Runoff Volume**	**Area Draining to Location**	**Runoff Rate**	**Runoff Volume**	**Comments**
	ha	*mm/year*	*m3/yr*		*ha*	*mm/year*	*m3/yr*	*ha*	*mm/year*	*m3/yr*	
Polygon 14 - Woodlot Portion	5.55	207.6842	11.52647	Polygon 14 - Woodlot Porion	4.16	207.6842	8.63966304			0	
Polygon 14 - Golf Course Portion	1.76	254	4.470492	Polygon 14 - Golf Course portion	0	254	0			0	
				Polygon 14 - Roof portion		326	0	1.254744	326	4.087708	
				Pervious Surface (Rear Lots)	1.884	254	4.78545819			0	
Sub-total			15.99697				13.4251212			4.087708	
Total			15.99696525							17.51282888	

Net Loss Surface Runoff (m3/yr) -1.515863634



ON-SITE PEAK FLOW CONTROL REQUIREMENTS			
CATCHMENT	BLOCK AREA (ha)	BLOCK #	100-YR PEAK CONTROLLED FLOW (L/s)
201	2.37	278	420.43
203	1.85	281	328.19
204	2.42	280	429.30
206	0.87	279	154.34

NOTE: ALL CONTROLLED FLOWS BASED ON 5-YEAR RATIONAL METHOD FLOW IN ACCORDANCE WITH ANTICIPATED SPA REQUIREMENTS.

DRAINAGE AREAS ARE IN ACCORDANCE WITH BLOCK AREAS FROM THE DRAFT PLAN.

LEGEND

- PROPOSED OVERLAND FLOW DIRECTION
- PROPERTY BOUNDARY
- INTERNAL DRAINAGE BOUNDARY
- EXTERNAL DRAINAGE BOUNDARY
- FUTURE SITE PLAN DEVELOPMENTS
- CATCHMENT No. 101 / AREA 1.40 ha

N

0 50 100 200 300 400
Metres

BURNSIDE

Client
2592693 ONTARIO INC.

Figure Title
NIAGARA VILLAGE DEVELOPMENT

POST-DEVELOPMENT STORMWATER DRAINAGE AREA PLAN

Drawn	Checked	Date	Figure No.
BF	RS	21/06/09	FIG5
Scale		Project No.	
1:5000		041230.0500	

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