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Mr. Craig Rohe, M.Pl., MCIP, RPP
Senior Planner
Upper Canada Planning & Engineering Ltd.
30 Hannover Drive, Unit #3
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Re: Water Balance Study, Panoramic Properties Ltd., Lyons Narrows, Niagara Falls, ON

Dear Mr. Rohe,

1.0 Introduction and Background Information

Terra-Dynamics Consulting Inc. (Terra-Dynamics) respectfully submits this water balance study of Panoramic Properties Ltd.'s three Lyons Narrows properties located in Niagara Falls, Ontario (Properties, Figure 1). These properties include (i) a 25 hectare former campground (Property 1 – 9015 Stanley Avenue), (ii) a former 46 hectare golf course (Property 2 – 8970 Stanley Avenue) and (iii) 12 hectares of vacant land south of Lyons Creek Road (Property 3 – No municipal address, ARN 272513000300300000000) (Figure 2). Development of the Properties is proposed to be a mixture of single and multi-residential homes (Upper Canada Consultants, 2020, Appendix A).

The water balance is a Niagara Region (2021) requirement as an additional component of the Natural Heritage Constraints Terms of Reference (Colville Consulting Inc., 2021). The purpose of the water balance is to "*demonstrate no hydrological impacts to the wetlands and no net loss to productive capacity for fish habitat*" (Niagara Region, 2021). The water balance includes the following, as required by Niagara Region (2021):

1. Pre-development surface water drainage patterns; and
2. Assessment of potential impacts to the wetlands and fish habitat.

The suitability of the proposed wetland buffers was also reviewed as part of the water balance (Colville Consulting Inc., 2021). The '*high level*' (Niagara Region, 2021) feature-based water balance evaluated the possibility for future negative changes in hydrologic function of the Lyons Creek and Welland River East Provincially Significant Wetland Complexes (MNRF, 2009a, 2009b), and the fish habitat of the Welland River and Lyons Creek under developed conditions (Figure 2).

This report has been updated to include additional documentation requested by the Niagara Peninsula Conservation Authority (NPCA) specifically for submission of "*water balance data for the wetlands on Property 1, specifically provide an analysis for the unit of the Provincially Significant Lyons Creek Wetland Complex located on Property 1*" (NPCA, 2022). During this update some refinements to the water balances for Properties 2 and 3 have also occurred.

2.0 Methodology

Two primary tasks were completed for the water balance study:

A. The characterization of the physical setting using both published government agency information (e.g. Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), Ministry of Natural Resources and Forestry (MNRF) and the Ontario Geological Survey (OGS)) as well as on-site information collected by Colville Consulting Inc. and Terra-Dynamics Consulting Inc.

B. Modelling of pre-development and post-development water balance conditions through consideration of surface water catchments, buffers, land cover, soils, climate normals and wetland hydroperiods in order to determine if site design was sufficient.

3.0 Physical Setting

The three Properties are located in two subwatersheds: (i) the Welland River (WR) located to the north, and (ii) Lyons Creek (LC) located to the south (Figure 3). However, the lands of the Properties are primarily located within the Lyons Creek subwatershed (Table 1). A series of culverts allow surface water runoff from Properties 1 and 2 to cross Lyons Creek Road and reach Lyons Creek via southerly lands (Figure 3).

Table 1 – Subwatersheds

Property	Welland River Watershed		Lyons Creek Watershed	
	%	Hectares	%	Hectares
1	24%	6	76%	19
2	33%	15	67%	31
3	0%	0	100%	12
Total	25%	21	75%	62

The watershed boundary was determined by NPCA as part of their Source Water Protection Tier 1 water budget study (Figure 3, NPCA and AquaResource Inc., 2010). As shown on Figure 3, an additional 2.37 hectares of Property 2 may also be part of the Welland River Watershed that was previously mapped by NPCA as part of the Lyons Creek watershed.

3.1 Topography

At Property 1, the northern portion draining to the Welland River is fairly flat and gently slopes from 179 to 177 metres above sea level (m ASL), with a steepening slope within about 30 metres of the shoreline to 171 m ASL. The southern portion draining to Lyons Creek gently slopes to the south from 179 to 173-174 m ASL at Lyons Creek Road (Appendix A, Site Details).

At Property 2, the northern portion draining to the Welland River slopes from 178-176 to 171 m ASL at the Welland River. The southern portion draining to Lyons Creeks gently slopes to the southeast and Lyons Creek Road at 175 m ASL.

At Property 3, the ground surface topography slopes to the southeast from 173-175 m ASL at Lyons Creek Road to 171.35 m ASL at Lyons Creek.

3.2 Physiography and Soils

The Properties are within the Haldimand Clay Plain, which is the primary physiographic region south of the Niagara Escarpment in the Niagara Peninsula, and is comprised of glaciolacustrine clays and silts (Chapman and Putnam, 1984).

The soils at the Properties are derived from heavy lacustrine clay, with most soils classified as Niagara Loamy Phase, having 15-40 cm of loamy textures over the underlying clay (Figure 6, Kingston and Presant, 1989). These Niagara Loamy Phase soils are imperfectly drained, moderately to slowly permeable, with groundwater levels usually close to the surface until late spring (Kingston and Presant, 1989). Surface runoff ranges from slow on level topography to rapid on slopes, and surface cracking is common during dry summer periods. The hydrologic soil group (HSG) classification is 50% C (sandy clay loam) and 50% D (clay loam/silty clay loam/sandy clay/silty clay/clay) (OMAFRA, 2021, USDA, 1986). No tile-drainage is mapped on the Properties (OMAFRA, 2021).

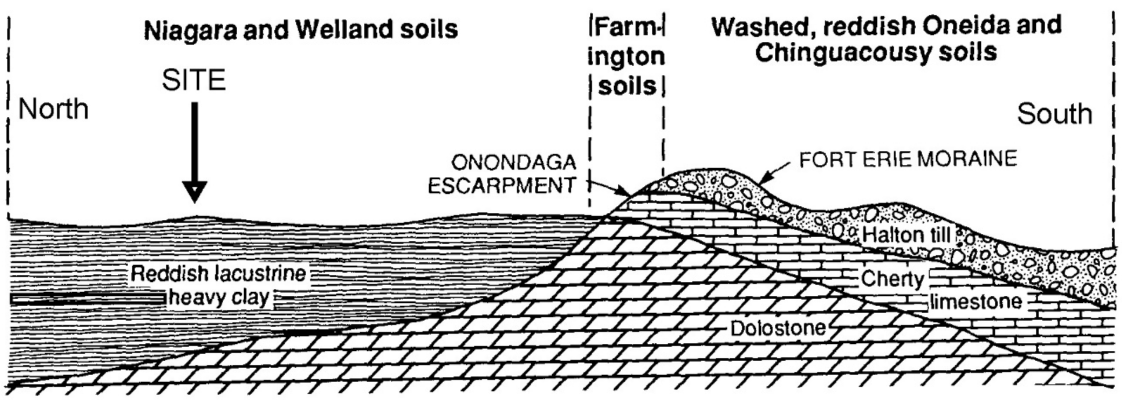

Figure 6 - Schematic landscape cross-section showing the relationship of soils to surficial geology and bedrock (Kingston and Presant, 1989)

It is noted that a portion of the on-site soils in the southwest corner of Property 1 are also mapped as the less permeable Niagara soils (i.e. non-loamy phase) (Figure 2), which encompass the area mapped as provincially significant wetland by the Ministry of Natural Resources and Forestry (Section 3.5) and are identified in the on-site Ecological Land Classification as woodland (Colville Consulting Inc., 2020).

Moderately well-drained Ontario soils are mapped at the northern extent of Property 1 at the Welland River and are classified as HSG C (Figure 2). Along the banks of the Welland River and Lyons Creek at Properties 1 and 2, silty clay loam alluvium soils are mapped (Figure 2) (OMAFRA, 2021).

3.3 Overburden

The Site's surficial geology is mapped as glaciolacustrine silty clay (Ontario Geological Survey (OGS), 2003), with modern alluvium along the banks of the Welland River and Lyons Creek. The thickness of the clay and silt underlying the Properties is between 15 to 25 m (NPSPA, 2013). Geologic cross-sections drawn for the Properties (Figures 4 and 5) visualize the extent of the underlying silty clay aquitards, and match the regional interpretation by the Ontario Geological Survey (OGS) (Figure 1, Section L-L', Appendix A).

3.3.1 Overburden Aquitard and Water Table

Multiple authors have mapped this silty clay as an aquitard (e.g. Burt, 2020 and Gartner Lee Limited (GLL), 1987). The limited groundwater flow in the overburden aquitard is expected to follow topography (Haitjema and Mitchell-Bruker, 2005), being limited in velocity by the low hydraulic conductivity.

Gartner Lee Limited (1987) provides a good description of the expected water table conditions within this overburden aquitard:

"*Detailed studies indicate that the water table fluctuates over the weathered/fractured upper two to three metres of the glaciolacustrine silts and clays comprising the overburden aquitard…flow in this shallow zone responds to daily climatic changes such that, during precipitation, the open fractures from weathering will quickly fill with water. The bulk of the discharge will then occur locally in swales that carry intermittent surface water…*"

Waterloo Hydrogeologic Inc. (2005) reported to NPCA for the area of the Properties that:
(i) it is not a potential groundwater recharge area; and
(ii) there is a downward vertical gradient from the water table to the potentiometric surface.

The downward vertical gradient between the aquitard and the bedrock aquifer was confirmed at two monitoring wells completed on-site (7345126/ 734527, Figures 4 and 5) with water table elevations observed to be above the deeper bedrock groundwater levels.

3.4 Surface Water

As introduced in Section 3.0, the Properties are bounded to the north by the Welland River/Chippawa Channel, and to the south by Lyons Creek (Figure 2). Lyons Creek flows to the northeast and into the Welland River/Chippawa Channel, and the Welland River/Chippawa Channel flows to the west away from the Niagara River.

Lyons Creek (*East*) receives a constant flow diversion from the Welland Canal at its headwaters, consisting of 0.283 m^3/s from April to November and 0.142 m^3/s from December to March (AquaResource Inc. and NPCA, 2009). The median monthly flows for the entire 136.5 km^2 South Niagara Falls (SNF) Watershed Planning Area (SNF WSPA, Appendix A) are presented below in Table 2 with estimated flows for Lyons Creek at 2/3 the amount as the Lyons Creek subwatershed is 91 km^2. However, this was not a hydraulic model and does not account for the potential additional water from the Chippawa Channel.

Table 2 - Modelled Lyons Creek Median Monthly Flows (m^3/s) (AquaResource Inc. and NPCA, 2009)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SNF WSPA Median Flow	0.73	0.91	1.64	1.04	0.57	0.39	0.34	0.32	0.32	0.34	0.61	0.82
Lyons Creek Flow	0.49	0.61	1.09	0.70	0.38	0.26	0.23	0.21	0.21	0.23	0.41	0.55

The Welland River receives continuous flow from the Niagara River as part of Ontario Power Generation operations, with daily Welland River/Chippawa Channel fluctuations affecting Lyons Creek (Philips Engineering Ltd., 2004) and being larger in fluctuation in the fall and winter (MNRF, 2009a, 2009b). The Welland River water level adjacent to the Properties, and Lyons Creek, has a diurnal cycle ranging between 170.7 and 171.6 m ASL (Philips Engineering Ltd., 2004). An example of the water level fluctuation is shown on Figure 7. Flow in the Welland River/Chippawa Channel is typically 1,980 m^3/s (McCorquodale, J.A. and Georgiou, 2008).

Philips Engineering Ltd. (2004) has also provided the following information regarding water level fluctuations in the area of the Properties:

"*the daily rise and fall of water levels has visibly impacted the shore area, with exposed tree roots and toppled trees in many locations, and base mud in many shallow nearshore areas. The submergent macrophytes observed here, were not found in very shallow water.*"; and

"the *River behaves in a hydraulically similar fashion to a tidal river; diurnal variations in water level create a 'pseudo-tidal wave' that progresses upriver*".

The Ministry of Natural Resources and Forestry (MNRF) has classified Lyons Creek as Type 1 Critical Fish Habitat, and the Welland River as Type 2 Important Fish Habitat (Yagi, 2016).

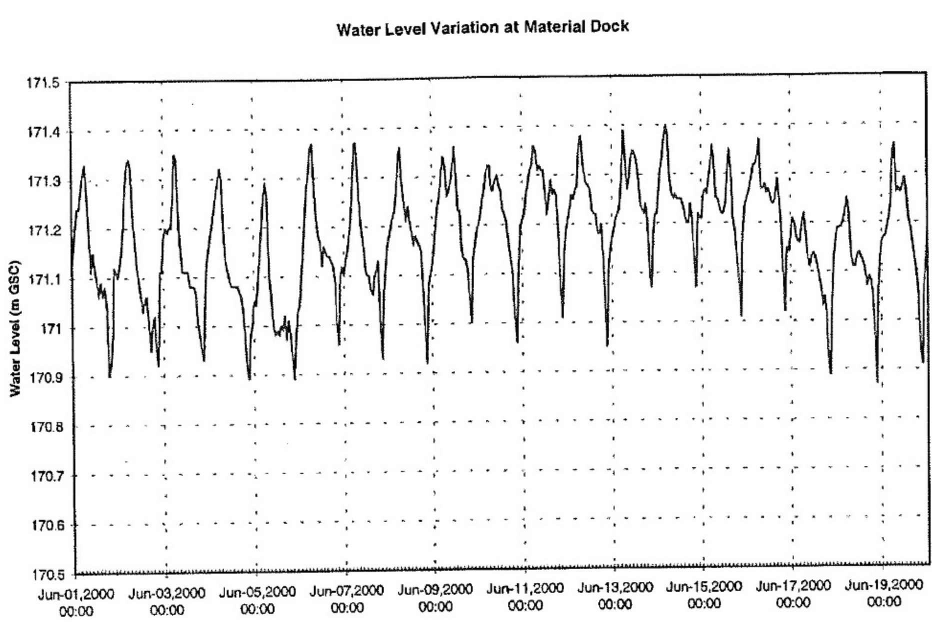

Figure 7 - Welland River Water Level Variations as measured upstream of the Properties

3.4.1 On-Site Surface Water Features

Watercourses mapped on-site are shown on Figure 3 and are summarized below (Table 3).

Table 3 – On-site Watercourses

Property	Watercourse Details (NPCA, 2017)
1	(i) Slough, intermittent/ephemeral within a portion of the Lyons Creek Wetland Complex; (ii) Constructed open ephemeral ditch at the southern end of property mapped to flow beneath Lyons Creek Road and eventually to Lyons Creek; and (iii) Natural intermittent or ephemeral seasonal waterbody.
2	(i) 9 constructed open permanent/intermittent ponds; (ii) 8 intermittent or ephemeral natural seasonal waterbodies; (iii) An ephemeral swale between constructed open ponds; and (iv) Ephemeral rural drainage at the southern end of the property mapped as flowing beneath Lyons Creek Road and eventually to Lyons Creek.
3	(i) Five southerly to southeastern flowing natural ephemeral open storm channels from Lyons Creek Road to Lyons Creek; and (ii) A small intermittent to ephemeral seasonal swamp within the Lyons Creek Wetland Complex.

Colville Consulting Inc. (2020) concluded "*small tributaries to Lyons Creek…were determined to be providing flow and nutrients to Lyons Creek, however this contribution is very limited*".

3.5 Provincially Significant Wetlands (PSWs)

The Ministry of Natural Resources and Forestry (MNRF) have mapped provincially significant wetlands (PSW) at each of the three Properties (MNRF, 2009a, 2009b) (Figure 2). MNRF details include:

(i) Swamp in the southwest corner of Property 1 as part of the Lyons Creek PSW. Colville Consulting Inc. (2020) has indicated that "*the vegetation community on the south end of the campground property is more consistent with a woodland than a wetland*";

(ii) Swamp along 800 metres of the Welland River shoreline immediately north of Property 2 as part of the Welland River East PSW Complex; and

(iii) Swamp and marsh along the entire shoreline of Property 3 as part of the Lyons Creek PSW Complex, with the marsh areas adjacent the creek.

Colville Consulting Inc. (2020) have recommended (Figure 3):

(i) a 15 m buffer from the Lyons Creek PSW at Property 1;
(ii) a 30 m buffer from the Welland River PSW at Property 2; and
(iii) a 30 m buffer from the Lyons Creek PSW at Property 3.

3.5.1 Wetland Ecological Land Classifications

Colville Consulting Inc. (2020) have completed Ecological Land Classifications (ELC) for the three Properties. ELC information is tabulated below (Table 4) for the areas on the Properties that are mapped by the MNRF as PSWs.

Table 4 - ELC Mapping of PSWs

Property	PSW	ELC Vegetation Community	
1	Lyons Creek	WODM5	Fresh-Moist Deciduous Woodland
2	Welland River East	SWD1-3	Pin Oak Mineral Deciduous Swamp
		FOD7	Fresh-Moist Lowland Deciduous Forest
3	Lyons Creek	SWD2-2	Green Ash Mineral Deciduous Swamp
		SWT2-8	Silky Dogwood Mineral Thicket Swamp
		FOD7	Fresh-Moist Lowland Deciduous Forest
		FOD7-3	Fresh-Moist Willow Lowland Deciduous Forest Type
		SWD1-3	Pin Oak Mineral Deciduous Swamp
		MAS2-3	Narrow-leaved Sedge Mineral Shallow Marsh Type
		MAS3-1	Cattail Organic Shallow Marsh Type

3.5.2 Wetland Characterization

The wetlands along the Welland River and Lyons Creek on the Properties can be classified as surface water slope wetlands (Figure 8). Surface water slope wetlands are summarized as:

"*…generally found in alluvial soil adjacent to a lake or stream and is fed, to some degree, by precipitation and surface runoff but, more important, by overbank flooding from the adjacent stream, river or lake. Hydroperiods of these wetlands match the seasonal patterns of the adjacent bodies of water, with relatively rapid wetting and drying.*" (Mitsch and Gosselink, 2007).

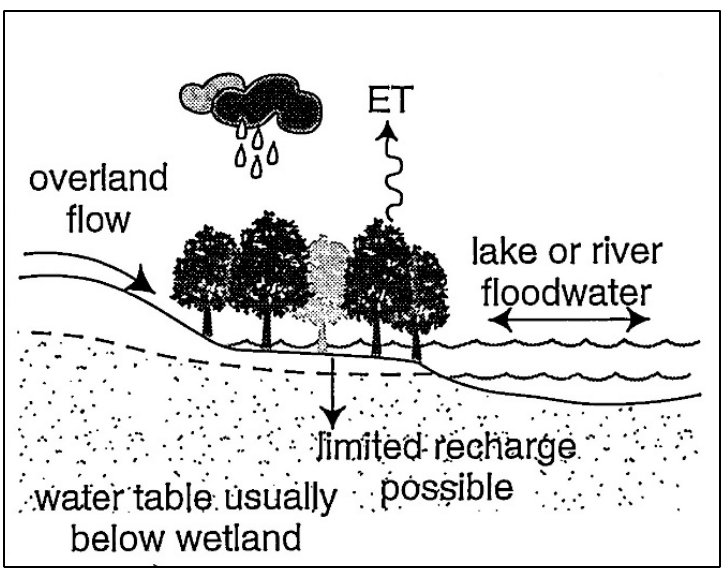

Figure 8 - Surface water slope wetland (Mitsch and Gosselink, 2007)

3.5.3 Wetland Hydroperiods

A hydroperiod is defined as "*the seasonal pattern of the water level of a wetland…It characterizes each type of wetland, and the constancy of its pattern from year to year ensures a reasonable stability for that wetland. It defines the rise and fall of a wetland's surface and subsurface water by integrating all of the inflows and outflows"* (Mitsch and Gosselink, 2007).
Hydroperiods for the MNRF wetlands at the Properties are classified as follows (Table 5):

Table 5 - Hydroperiod Classifications

Property	Wetland Hydroperiod (Mitsch and Gosselink, 2007)	ELC Classification (Colville Consulting Inc., 2020)
1	Bottomland hardwood forest	Woodland
2	Canadian swamp	Swamp
3	Canadian swamp	Swamp
	Great Lakes marsh/ regularly flooded 'tidal' marsh	Marsh

These hydroperiods are visualized below (Figure 9), with the shaded lower portion of the hydroperiod graph corresponding with the wetland ground surface and the months of the year listed along the x-axis. Mitsch and Gosselink (2007) report that the "*hydroperiods of many bottomland hardwood forests and swamps have distinct periods of surface flooding in the winter and early spring due to snow and ice conditions followed by spring floods but otherwise have a water table that can be a meter or more below the surface*". With respect to the Marsh areas, it is expected the hydroperiod will be similar to the Great Lakes marsh but with the regular "tidal" type influences of the varying water levels from the Welland River/Chippawa Channel.

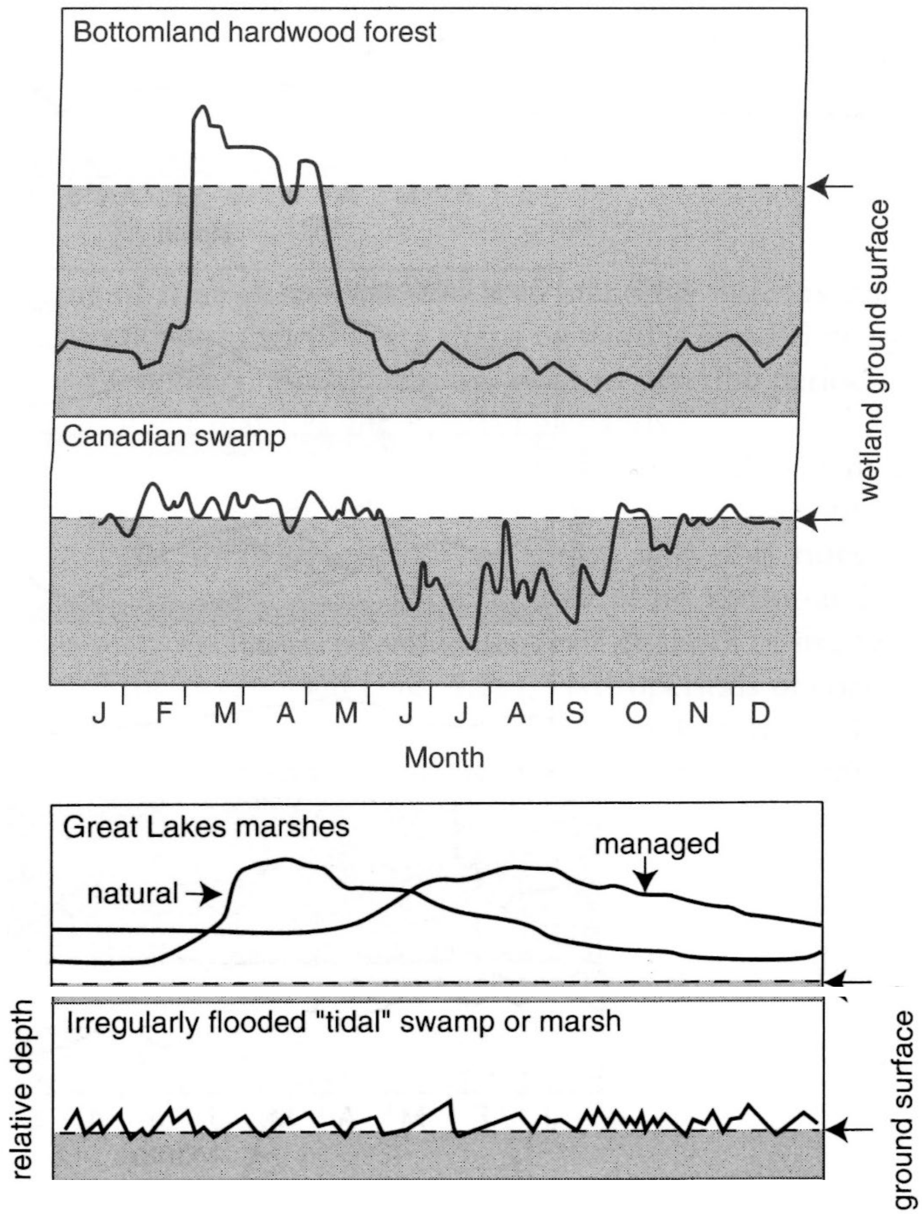

Figure 9 – Select Hydroperiods (Mitsch and Gosselink, 2007)

3.5.4 PSW Surface Water Catchments

The surface water catchment for the PSW mapped at Property 1 was delineated using a 2018 digital elevation model. The 1.93 hectare catchment upgradient of the mapped PSW within Property 1 is shown on Figure 3.

For Property 2, practically all of the lands north of the subwatershed divide (Figure 3) are modelled to drain to the Welland River PSW.

For Property 3, as the land slopes from Lyons Creek Road to Lyons Creek, the entire property is considered upgradient of the Lyons Creek PSW.

3.6 Land Cover and Soil Water Holding Capacity

NPCA mapped pre-development land cover types for their entire watershed derived from the Southern Ontario Land Resource Information System (SOLRIS) and the Southern Ontario Interim Landcover (SIL), current to 2000-2002 (Appendix A, NPCA and AquaResource Inc., 2010). This mapping was completed as part of the NPCA Tier 1 water availability modelling study at a 15 m by 15 m resolution (AquaResource Inc. and NPCA, 2009).

The land cover for the Properties is summarized below per catchment, with some land cover types grouped where having the same soil water holding capacity (Table 6).

Table 6 – Land Cover

Land Cover	Area (ha)	Percent Area
Property 1 – Welland River Subwatershed (North)		
Built-Up Pervious	5.69	95%
Deciduous Forest	0.22	4%
Open Water	0.09	1%
Property 1 – Lyons Creek Subwatershed (South)		
Built-Up Pervious	5.91	31%
Rural Land Use	4.04	21%
Mixed Agriculture/ Monoculture	7.53	40%
Forest/ Swamp	1.48	8%
Transportation	0.06	<1%
Property 2 – Welland River Subwatershed (North)		
Mixed Agriculture	13.59	89%
Built-up Pervious	1.19	8%
Swamp/ Forest	0.25	2%
Transportation/ Marsh	0.18	1%
Property 2 – Lyons Creek Subwatershed (South)		
Mixed Agriculture	23.25	75%
Deciduous Forest/ Forest/ Swamp	4.55	15%
Rural Land Use	2.27	7%
Transportation	0.63	2%
Built-Up Pervious	0.27	1%
Property 3 – Lyons Creek Subwatershed (South)		
Mixed Agriculture	5.56	48%
Deciduous Forest/ Swamp	2.67	23%
Marsh/ Transportation/ Open Water	2.03	17%
Idle Land/ Rural Land Use	1.42	12%

Soil water holding capacities (SWHC) for the evaluated wetlands were assigned based upon the OMAFRA soil information and existing NPCA water budgeting values (NPCA and AquaResource Inc., 2010). As a result, the Property 1 wetland as 50% Hydrologic Soil Group (HSG) C and 50% HSG D, was assigned a SWHC value of 375 mm, and the Property 2 and 3 wetlands mapped as silty clay alluvium (i.e. HSG D) were assigned a SWHC value of 350 mm.

3.7 Pre-development Subwatershed Water Balance Modelling

Subwatershed scale water balance modelling was previously completed by NPCA (NPCA and AquaResource Inc., 2010). The Properties are within two of the modelled catchments: (i) Lower Welland River – Welland River – W100 (LWR_WR_W100) and (ii) South Niagara Falls – Lyons Creek – W100 (SNF_LC_W100) (Appendix A, Figure 2.16). The subwatershed divide between these catchments is shown on Figure 3. The 15-year (1991-2005) average annual water balance results for these catchments are summarized in Table 7 and the average monthly water balance runoff results for SNF_LC_W100 are summarized in Table 8.

Table 7 - Subwatershed Water Balances

Catchment	Area	Precipitation	Evapotranspiration	Infiltration	Recharge	Runoff
	(km^2)	(mm/year)				
LWR_WR_W100	10.9	928	434	30	15	462
SNF_LC_W100	7.7	928	600	80	40	248

Notes: LWR – Lower Welland River, SNF – South Niagara Falls

Table 8 - Monthly Runoff and Recharge (Catchment SNF_LC_W100)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Runoff (mm)	27.4	34.1	50.9	39.5	27.9	8.9	3.8	3.6	4.5	5.5	16.2	25.5
Recharge (mm)	6.3	6.5	10.0	7.7	3.4	0.8	0.1	0.0	0.0	0.2	1.8	5.8

The runoff results for SNF_LC_W100 are similar to that for urban lawns on clay loam soils in the MECP Stormwater Management Planning & Design Manual (2003), and the 80 mm/year infiltration rates are reasonable given the silty clay surficial geology (MECP, 1995). However, runoff is much higher, and evapotranspiration much lower, for LWR_WR_W100 primarily because of differences in land cover, i.e. the higher percent of built-up impervious area (20.4%) in south Niagara Falls and Chippawa (within LWR_WR_W100) compared to SNF_LC_W100. As the SNF_LC_W100 results are more representative of current conditions at the Properties they will be used for modelling the pre-development water balances.

4.0 Water Balance Assessments

Monthly water balance assessments were completed for specific PSW features at the Properties, as informed by the Conservation Authority Guidelines for Development Applications (Conservation Ontario, 2013).

It is noted that the Conservation Ontario water balance approach (and the Ministry of the Environment, Conservation and Parks, 2003 approach it borrows from) is typically concerned with the evaluation of post-development to prevent (i) increased runoff, and/or (ii) reduction in groundwater recharge.

However, given the wetland characterization (Sections 3.5.2 and 3.5.3) and very low pre-development infiltration rates at the Properties (Sections 3.2, 3.3 and 3.7), any contribution to hydrologic function with respect to the wetlands, and permanent watercourses, is via additional surface water flow, not groundwater discharge, therefore maintenance of sufficient runoff to maintain the wetland hydroperiods is the criteria for the water balance assessment.

Proposed stormwater management for Properties 1 and 2 is via a stormwater management facility in the southwestern corner of Property 2 discharging ultimately to Lyons Creek (Upper Canada Consultants, 2020, Appendix A). Stormwater from Property 3 will be discharged to Lyons Creek via a stormwater management facility at that property.

4.1 Monthly Water Balance Example

An example of water balance modelling from the University of Waterloo is shown below (Figure 10). Annual groundwater recharge begins in the fall following '*soil water utilization*' and '*deficit*' in the summer. Soil water utilization corresponds with evapotranspiration exceeding the precipitation supply. Annual groundwater recharge occurs during the same time period that groundwater levels rise. However, in this example it is noted that the soil water holding capacity (SWHC) modelled was only 100 mm.

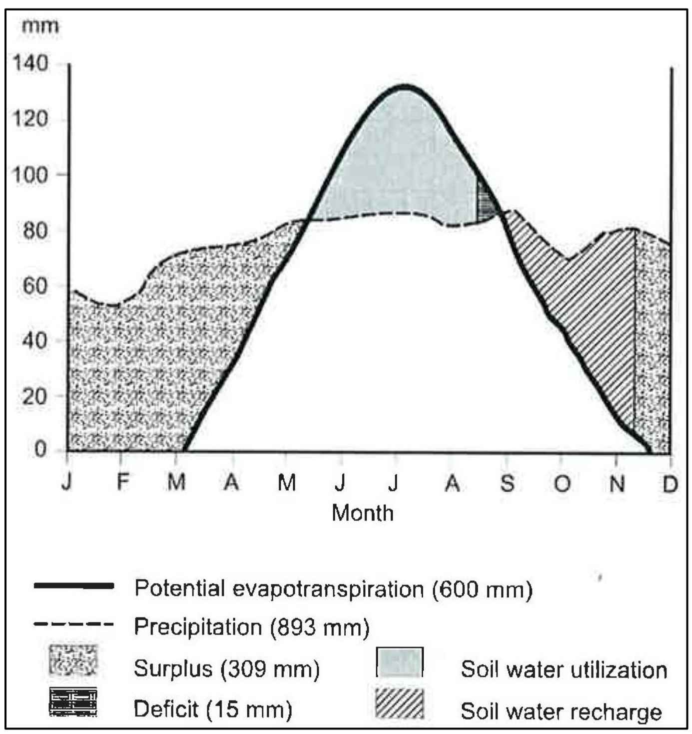

Figure 10 – Brantford Average Water Balance (Sanderson, 2004)

4.2 Wetland Water Balances

Monthly water balances for the downgradient wetlands were completed using the U.S. Geological Survey (USGS) Monthly Water Balance Model (McCabe and Markstrom, 2007), which considers direct precipitation only, not runoff to the wetland. For temperature and precipitation, climate normal inputs (1981-2010) from Niagara Falls NPCSH Station ID 6135657 were used (Environment Canada, 2021). The soil water holding capacities (i.e. soil moisture) per wetland were determined in Section 3.6.

The monthly modelling results are summarized below and presented in Tables 9, 10 and 11, in summary:

1. Potential evapotranspiration exceeded precipitation for June, July and August, i.e. soil water utilization occurred;
2. Swamp soil water holding capacities were less than saturated, for the summer months (June through September), as well as October; and
3. Soil water recharge occurred in September and October.

Table 9 – Property 1 Monthly Wetland Water Balance (mm)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation (mm)	76	62	62	72	87	81	79	79	98	80	92	81
Potential (mm) Evapotranspiration	10	12	22	40	73	108	130	103	62	33	18	11
Soil Moisture (mm)	375	375	375	375	375	**344**	**294**	**272**	**303**	**345**	375	375
Soil Water [1] Depletion (mm)						31	81	103	72	30		
Soil Water [2] Depletion (m^3)						288	753	959	670	276		
Upgradient area [3] required to produce saturated wetland (ha)						3.2	19.8	26.6	14.9	5.0		

Notes: [1] Difference between the SWHC (375 mm) and the modelled soil moisture
[2] Depletion depth multiplied by the downgradient area of PSW swamp (i.e. 0.93 hectares).
[3] Volume of soil water depletion (m^3) divided by monthly modelled runoff (mm) (from Table 8) converted to hectares

Table 10 – Property 2 Monthly Wetland Water Balance (mm)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation (mm)	76	62	62	72	87	81	79	79	98	80	92	81
Potential (mm) Evapotranspiration	10	12	22	40	73	108	130	103	62	33	18	11
Soil Moisture (mm)	350	350	350	350	350	**319**	**269**	**248**	**279**	**321**	350	350
Soil Water [1] Depletion (mm)						31	81	102	71	29		
Soil Water [2] Depletion (m^3)						47	121	154	107	43		
Upgradient area [3] required to						0.5	3.2	4.3	2.4	0.8		

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
produce saturated wetland (ha)												

Notes: [1] Difference between the SWHC (350 mm) and the modelled soil moisture
[2] Depletion depth multiplied by the downgradient area of PSW swamp above 172 m ASL (i.e. 0.15 hectares).
[3] Volume of soil water depletion (m^3) divided by monthly modelled runoff (mm) (from Table 8) converted to hectares

Table 11 – Property 3 Monthly Wetland Water Balance (mm)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation (mm)	76	62	62	72	87	81	79	79	98	80	92	81
Potential (mm) Evapotranspiration	10	12	22	40	73	108	130	103	62	33	18	11
Soil Moisture (mm)	350	350	350	350	350	**319**	**269**	**248**	**279**	**321**	350	350
Soil Water [1] Depletion (mm)						31	81	102	71	29		
Soil Water [2] Depletion (m^3)						174	452	573	399	162		
Upgradient area [3] required to produce saturated wetland (ha)						2.0	11.9	15.9	8.9	2.9		

Notes: [1] Difference between the SWHC (350 mm) and the modelled soil moisture
[2] Depletion depth multiplied by the downgradient area of PSW wetland (i.e. 0.56 hectares).
[3] Volume of soil water depletion (m^3) divided by monthly modelled runoff (mm) (from Table 8) converted to hectares

4.3 Property 1 Water Balance Discussion

4.3.1 Welland River

Development of Property 1 will reduce the amount of northerly runoff directed to the Welland River. Runoff will be directed to the stormwater management facility at Property 2 (Appendix A, Concept Plan of Subdivision), with some increase in flow to Lyons Creek. The direct loss in drainage area of Property 1 towards the Welland River is 4.3 hectares. However, no negative hydrologic impact to the Welland River is concluded based upon:

i. the reduction of annual surface water flow is very small (0.00002% of the Welland River flow, Section 3.4), based on an annual runoff value of 248 mm/year (Section 3.7); and

ii. Lyons Creek ultimately flows into the Welland River.

4.3.2 Lyons Creek PSW

The calculated area upgradient of the Property 1 wetland is 1.93 hectares. Consequently, it is not expected that saturated conditions are maintained during June to October from upgradient runoff, as between 3.2 and 26.6 hectares would be required (Table 9). Unsaturated conditions would therefore be expected under pre-development conditions for June, July, August, September and October at the downgradient wetland. This would be similar to the expected below ground surface water level for the swamp summer hydroperiod. Therefore, maintenance of the hydroperiod at the downgradient wetland area is primarily dependent upon direct precipitation not upgradient surface water supply via runoff.

The proposed development should not negatively affect the hydrology of the 0.93 hectares of Lyons Creek PSW at Property 1 because the amount of surface water provided will not be reduced but rather will be increased. The pre-development drainage area contributing to the PSW on-site is 1.93 hectares and is calculated to be 2.1 hectares after development. This conclusion and the associated calculations are based upon the following:

1. A minimum 15 m buffer from the PSW has been proposed by Colville Consulting Inc. (2020);
2. The proposed site design includes set-back distances from the PSW of between 15 and 35 m, averaging 24 m (Upper Canada Consultants, 2020, Appendix A); and
3. Read yard drainage of 23 m will be directed towards the PSW.

The proposed set-backs are sufficient for maintaining the monthly hydroperiod for the downgradient PSW.

4.4 Property 2 Water Balance Discussion

4.4.1 Welland River

Development of Property 2 will reduce the amount of northernly runoff directed to the Welland River PSW and the Welland River. Development of Property 2 will increase flow to Lyons Creek via the stormwater management facility. The change in drainage area is calculated as 11.4 hectares using the NPCA subwatershed divide (NPCA and AquaResource Inc., 2010). No negative hydrologic impact to the Welland River is concluded based upon:

i. the reduction of annual surface water flow is very small (0.00005% of the Welland River flow, Section 3.4), based on an annual runoff value of 248 mm/year (Section 3.7); and

ii. Lyons Creek ultimately flows into the Welland River.

4.4.2 Welland River East PSW

The proposed development is generally set-back greater than the recommended 30 m PSW buffer, ranging between 30 and 100 m, and averaging 55 m (Appendix A, Concept Plan of Subdivision). This greater distance is because of the set-back from the top of slope, as well as Ontario Hydro lands being on Property 2 and the PSW (Upper Canada Consultants, 2020, Appendix A).

Hydroelectric operations direct Niagara River flow to the west via the Welland River/Chippawa Channel. Within the diurnal cycle of flow, Ontario Power Generation surface water level restrictions are between 170.7 and 171.6 m ASL (Section 3.4). Most of the Welland River PSW north of Property 2 (~78%, the westerly portion), occurs at or close to 171 m ASL (Appendix A, Site Details). Consequently, for this portion of the surface water slope wetland (Section 3.5.2), Welland River/Chippawa Channel surface water flows meet the hydrologic needs of the PSW.

Although overall distributed (i.e. along the width of the PSW) post-development runoff volumes will be lower for the easterly portion of the PSW above 172 m ASL, distributed runoff will be maintained to the PSW as the land slopes towards it. This distributed runoff will be maintained through the minimum set-back of 30 m from the Welland River PSW, and larger where required by Ontario Hydro lands between the PSW and Property 2 (Appendix A, Concept Plan of Subdivision).

The downgradient Property 2 wetlands above 172 m ASL are 0.15 hectares in area. Consequently, saturated conditions under pre-development conditions are predicted during June, September and October from upgradient runoff given a pre-development catchment of 3.19 hectares for this portion of wetland (Table 10). The proposed set-backs are sufficient for maintaining the monthly hydroperiod for the downgradient PSW above 172 m ASL for June and October (Table 10). However to maintain saturated conditions in September it is recommended the stormwater management design for the multi-residential area include distributed rear yard and/or clean roof runoff, e.g. 0.05 ha of clean roof runoff would meet the runoff deficit.

4.5 Property 3 Water Balance Discussion

4.5.1 Lyons Creek

Development of Property 3 will increase the amount of runoff directed to Lyons Creek through the introduction of impervious areas. No negative hydrologic impact to Lyons Creek is concluded because:

i. The increase of annual surface water flow will be small compared to the average Lyons Creek flow. For example, if the 3.63 hectare development is 55% impervious, the increase in surface water flow to Lyons Creek would be 0.16% of the average Lyons Creek flow (Section 3.4), based on an annual runoff value of 248 mm/year (Section 3.7); and

ii. The drainage area will not change.

4.5.2 Lyons Creek PSW

The 3.63 hectares of development proposed in the northwest portion of Property 3 is along approximately 720 m of Lyons Creek. The amount of runoff to Lyons Creek will increase with development (Section 4.3.1), but the amount of distributed runoff along the Lyons Creek PSW will be reduced as the stormwater management facility is typically designed to outlet to a single location.

Although overall distributed runoff volumes will be lower in volume with development, distributed runoff will be maintained to the PSW as the land slopes to the PSW. This distributed runoff will be maintained through the minimum set-back of 30 m from the Lyons Creek PSW, and larger where existing stable top of bank considerations are required (Appendix A, Concept Plan of Subdivision). The downgradient Property 3 wetlands are 0.56 hectares in area. Consequently, saturated conditions under pre-development conditions are predicted during June and October, but not July through September, from upgradient runoff given a pre-development catchment of 5.65 hectates for this portion of the wetland (Table 11). The proposed buffer set-back of 2 ha is sufficient for maintaining the monthly hydroperiod in June (Table 11). However to maintain saturated conditions in October it is recommended the stormwater management design for this multi-residential area include distributed rear yard and/or clean roof runoff, e.g. 0.07 ha of clean roof runoff would meet the runoff deficit.

5.0 Conclusions and Recommendations

5.1 Conclusions

The following conclusions are provided:

1. A subwatershed divide exists through Properties 1 and 2, and most drainage is towards Lyons Creek.

2. The soils are derived from heavy lacustrine clay.

3. The Properties are on a regional aquitard.

4. The Welland River and Lyons Creek water levels have diurnal variations and behave in a hydraulically similar fashion to a tidal river.

5. The Provincially Significant Wetlands along the Welland River and Lyons Creek are surface water slope wetlands.

6. The reduction in surface water flow to the Welland River will be inconsequential.

7. Development of Property 3 should not negatively impact the hydrology of Lyons Creek.

8. The proposed development should not negatively impact the hydrology of the Lyons Creek Provincially Significant Wetland (PSW) at Property 1.

9. The proposed set-backs are sufficient for maintaining the monthly hydroperiod for the Welland River PSW at Property 2 for June and October. However, additional clean rear yard and/or roof runoff (e.g. 0.05 ha) will be required as part of the future stormwater management design to meet a modelled September deficit.

10. The proposed set-backs are sufficient for maintaining the monthly hydroperiod for the Lyons Creek PSW for June. However, additional clean rear yard and/or roof runoff (e.g. 0.07 ha) will be required as part of the future stormwater management design to meet a modelled October deficit.

5.2 Recommendations

The following recommendations are provided for your consideration:

1. Rear yard drainage of 23 m should drain to the Lyons Creek PSW at Property 1.

2. Future stormwater management design for the multi-residential portion of Property 2 should include additional clean rear yard and/or roof runoff (e.g. 0.05 ha) towards the wetland.

3. Future stormwater management design for the Property 3 multi-residential area should include additional clean rear yard and/or roof runoff (e.g. 0.07 ha) towards the wetland.

We trust this information is sufficient for your present needs. Please do not hesitate to contact us if you have any questions.

Yours truly,

TERRA-DYNAMICS CONSULTING INC.

Jayme D. Campbell, P. Eng.
Senior Water Resources Engineer

Annie Michaud, M.Eng., P. Eng.
Senior Water Resources Engineer

LICENSED PROFESSIONAL ENGINEER
July 25 2022
J. D. CAMPBELL
PROVINCE OF ONTARIO

cc. Ian Barrett, Colville Consulting Inc.

Attachments
Figure 1 – Location of Subject Lands
Figure 2 – Base Map
Figure 3 – Site Details
Figure 4 – Geologic Cross-Section A-A'
Figure 5 – Geologic Cross-Section B-B'
Appendix A – Supporting Information

6.0 References

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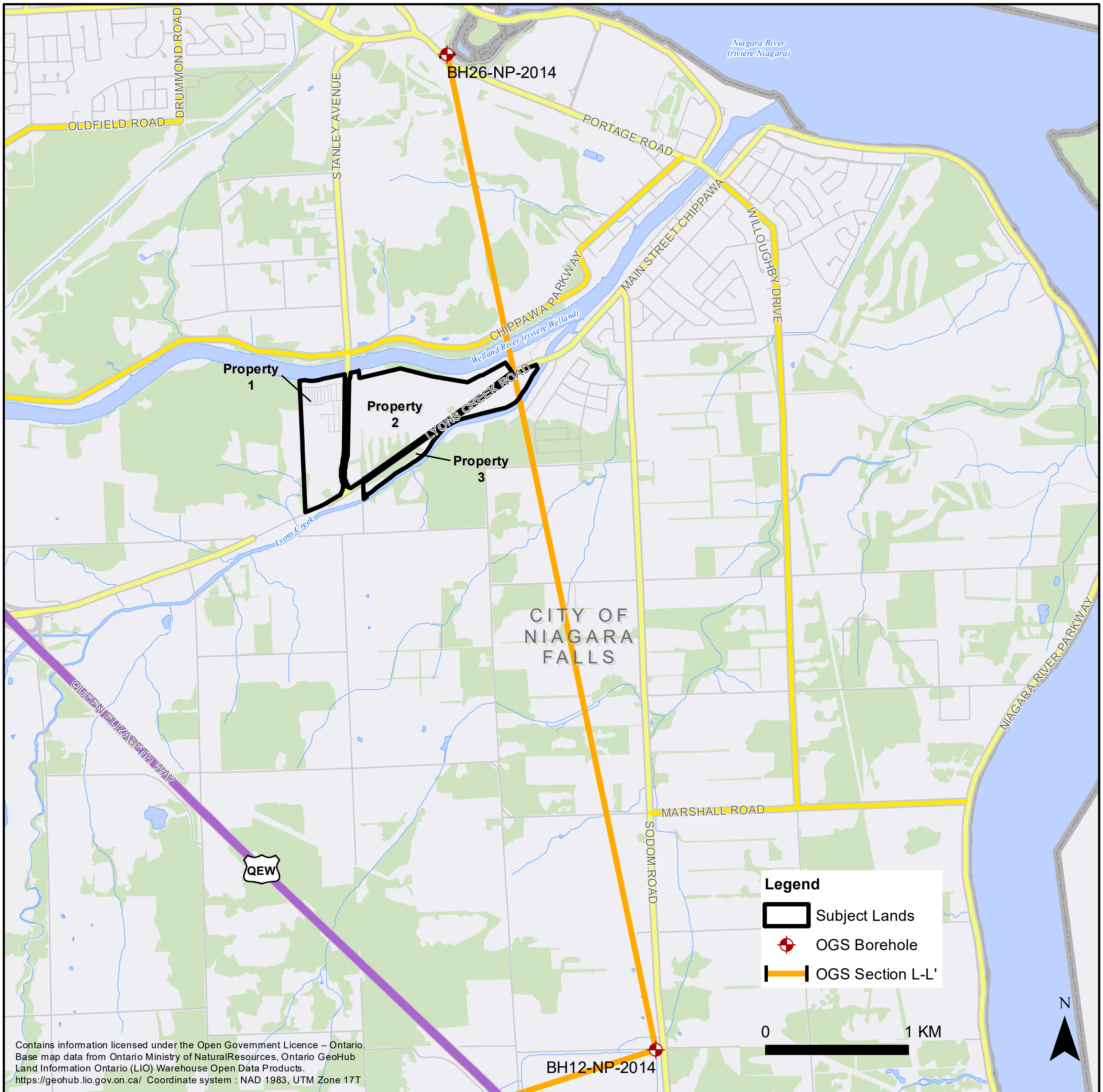
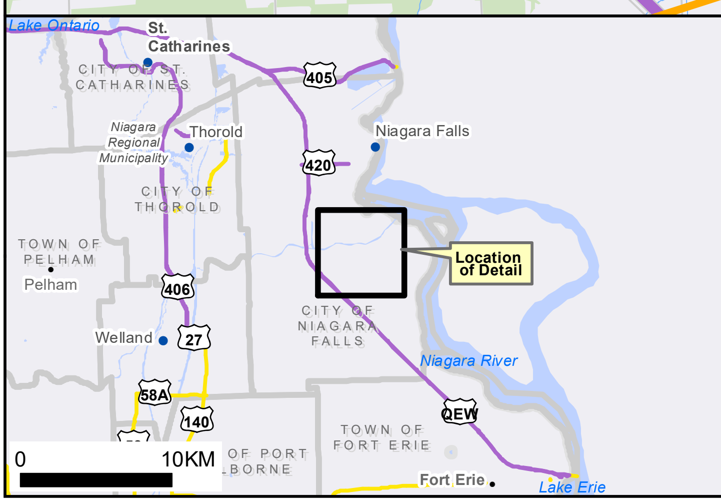




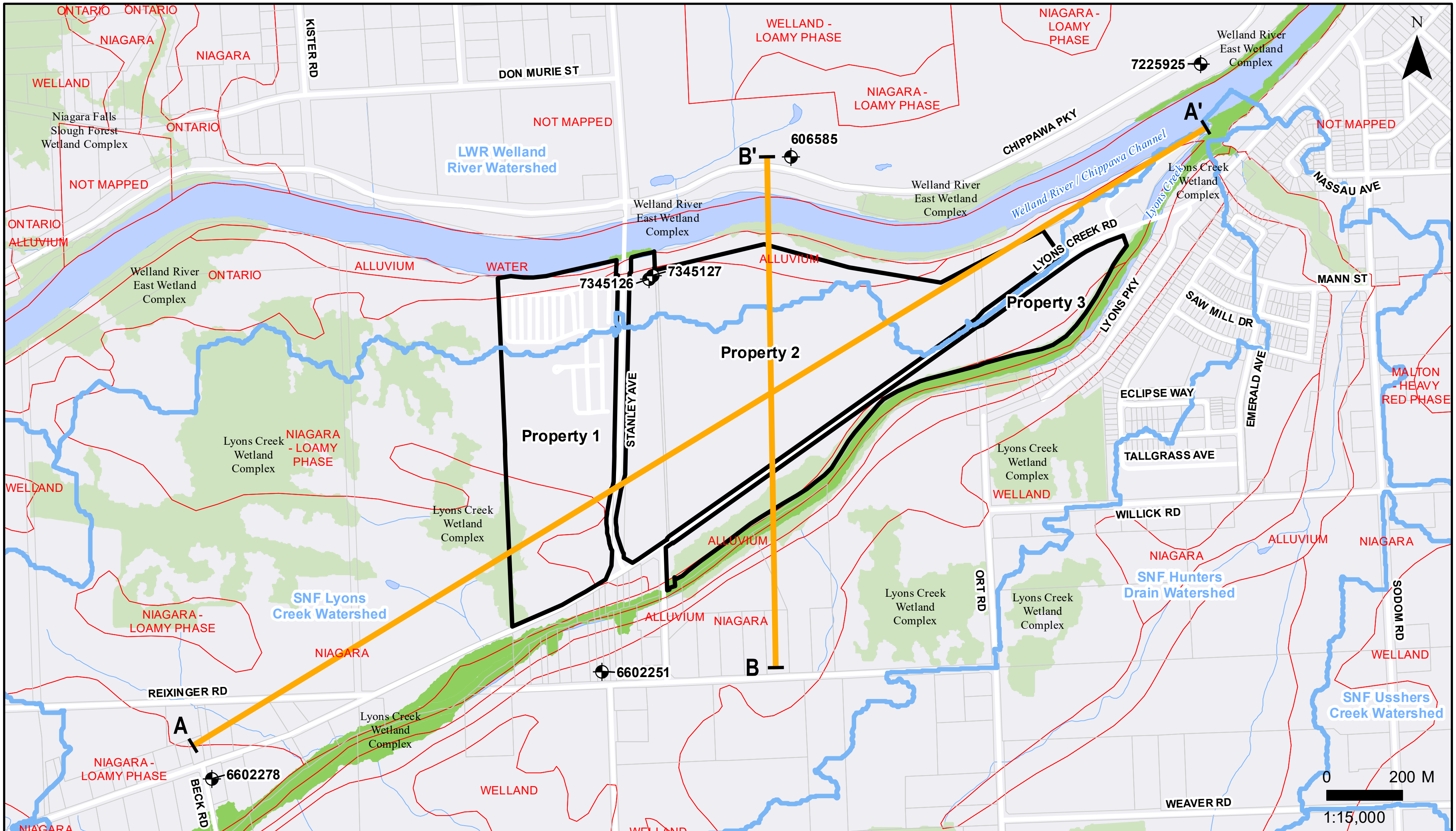
Location of Subject Lands

Lyons Narrows
Water Balance, Niagara Falls
Panoramic Properties Ltd.

TDC Terra-Dynamics Consulting Inc.

Figure 1

Path: H:\TERRA_DYNAMICS\9441 - TD ___ Lyons Narrows\gis\mxd\Figure 1 Location of Subject Lands.mxd Revised: July 25, 2022



Subject Lands

Watershed Boundary

Soil Survey Complex

MECP Water Well Records for Geologic Section

Geologic Cross-section

Wetland (Type)

Marsh

Swamp

Base Map

Lyons Narrows Water Balance,
Niagara Falls Panoramic Properties Ltd.

Terra-Dynamics Consulting Inc.

Figure 2

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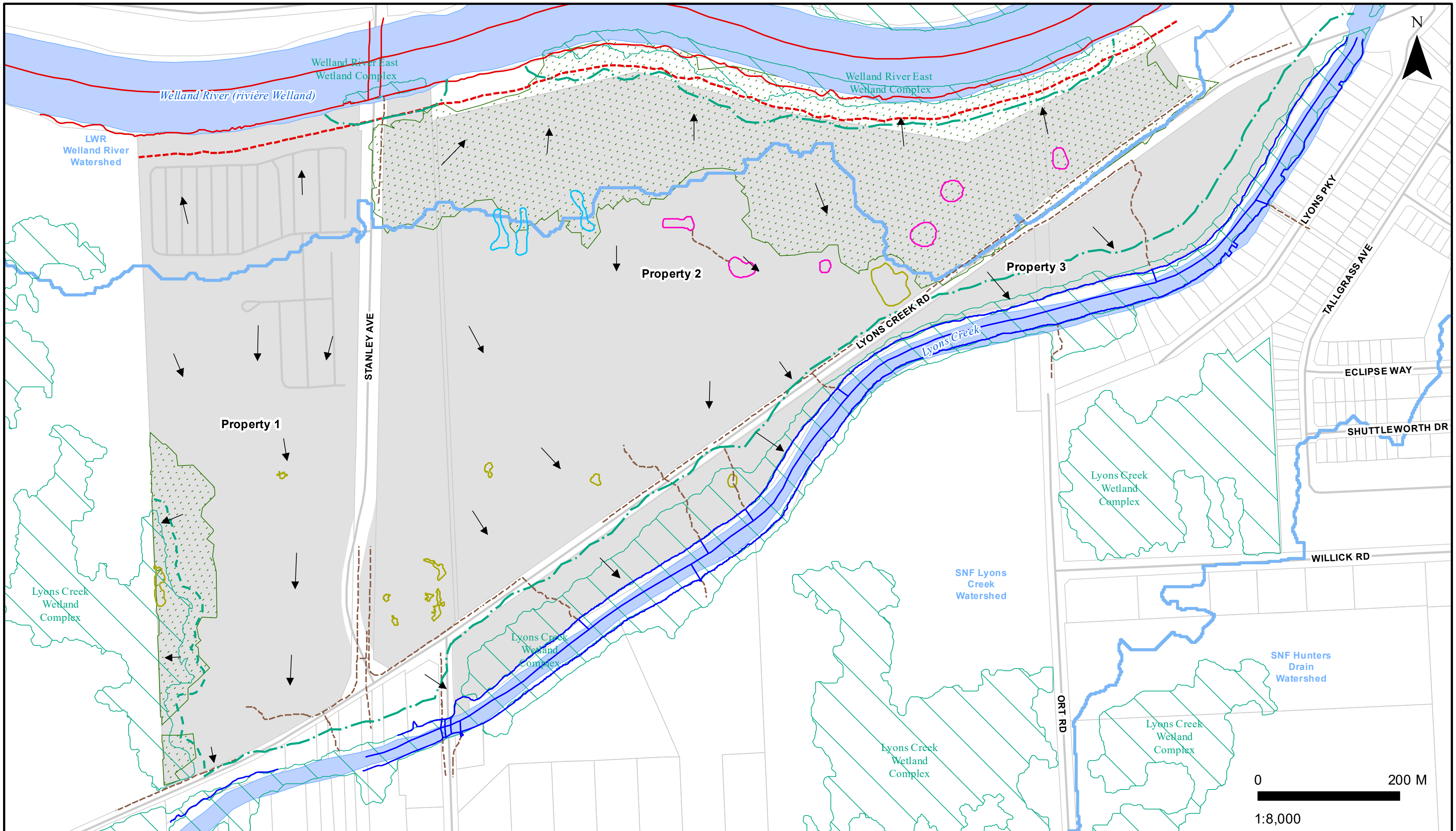

Subject Lands
Subwatershed Boundary
Upgradient Surface Water Basin
Provincially Significant Wetlands
On-land Surface Water Flow Direction

Buffers
Fish Habitat 30m Buffer
PSW 15 m Buffer
PSW 30 m Buffer

Watercourses (Permanency, Fish Habitat)
Ephemeral, Other
Intermittent or Ephemeral, Other
Permanent or Intermittent, Other
Permanent, Other
Permanent, Type 1 - Critical
Permanent, Type 2 - Important

Site Details

Lyons Narrows Water Balance,
Niagara Falls Panoramic Properties Ltd.

Terra-Dynamics Consulting Inc.

Figure 3

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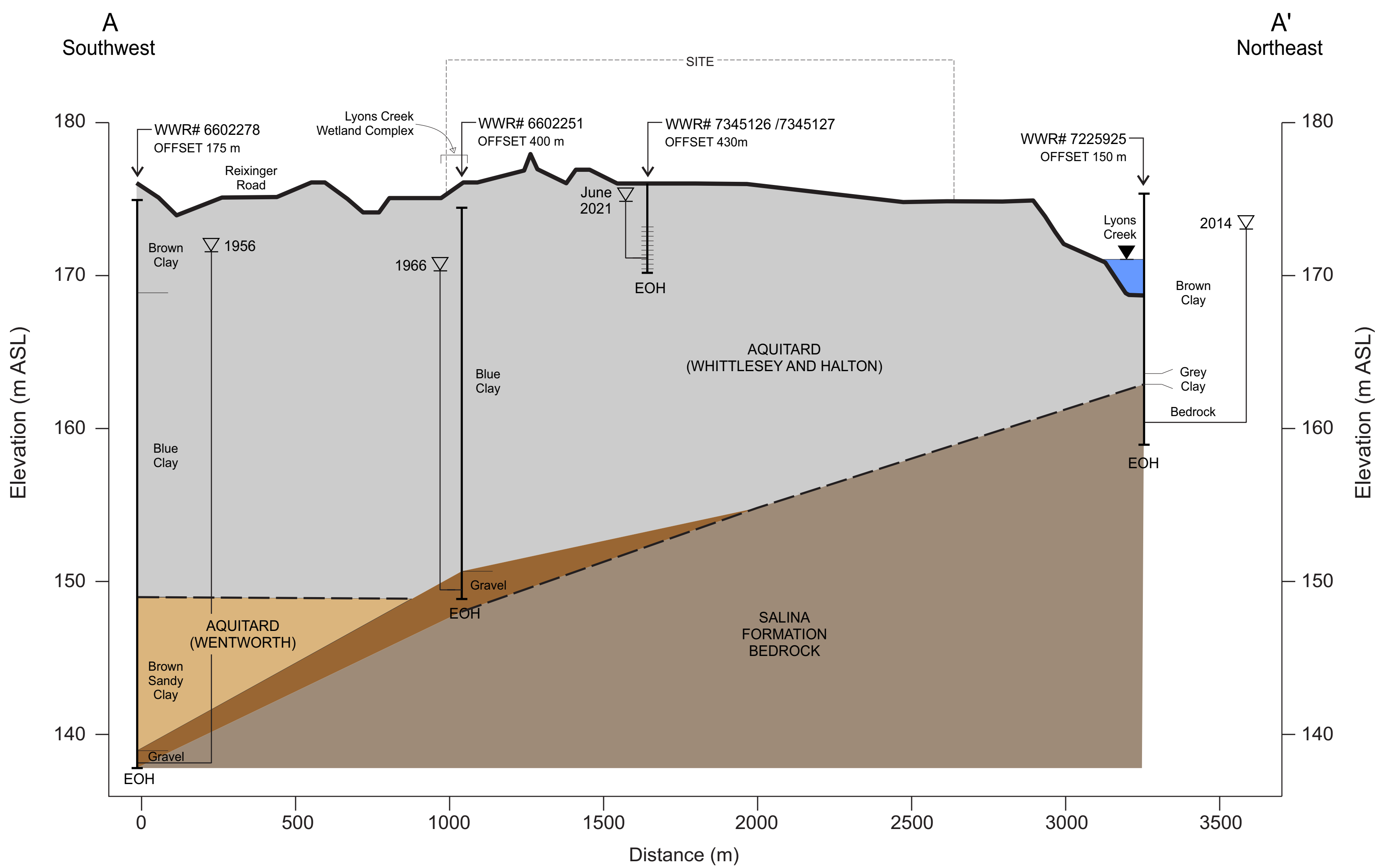


Water Level On Water Well Record and Year

Surface Water Level

EOH End of Hole

Well Screen

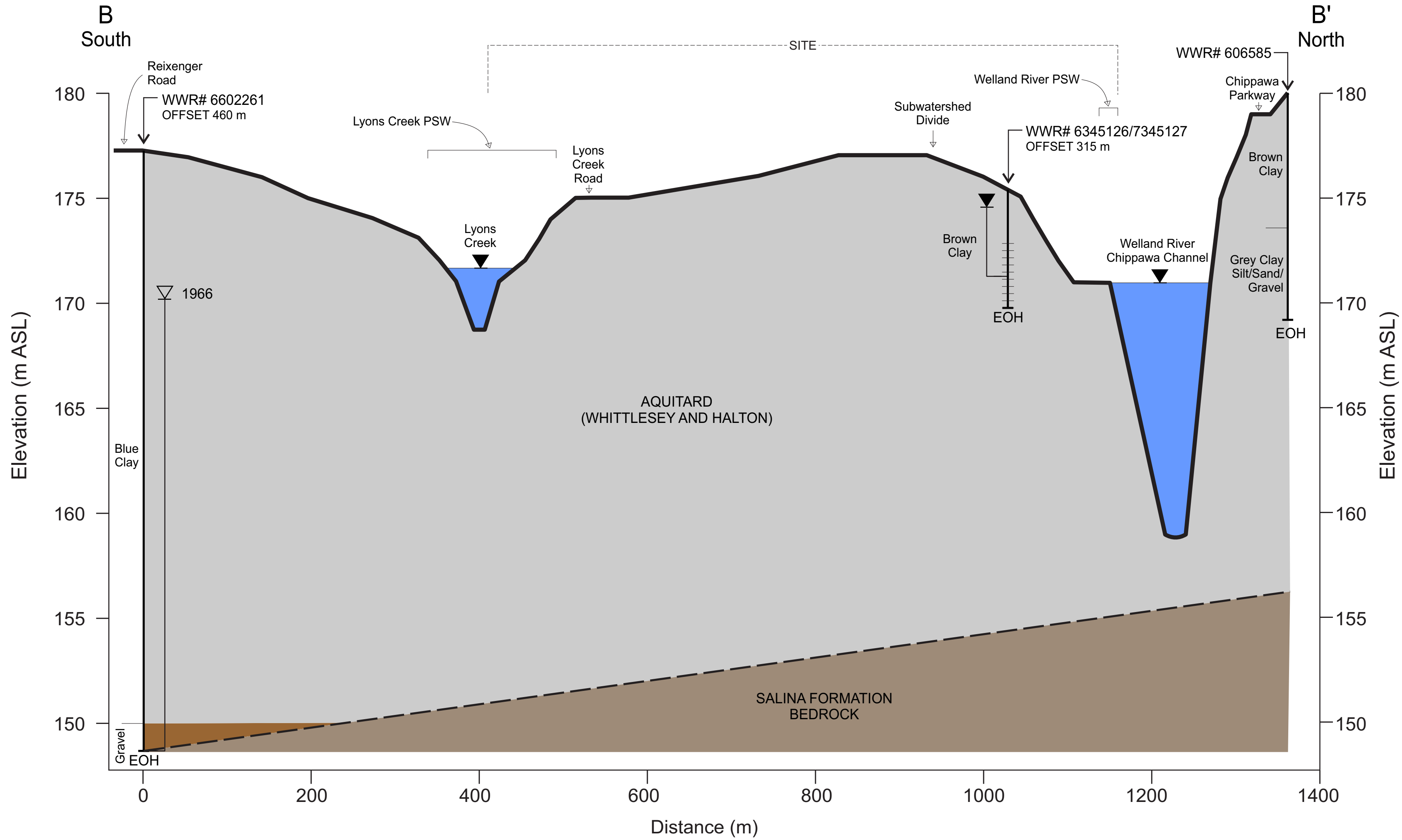
WWR# Water Well Record Number

Geologic Cross-section A-A'

Lyons Narrows Water Balance,
Niagara Falls Panoramic Properties Ltd.

TDC Terra-Dynamics Consulting Inc.

Figure 4



Water Level On Water Well Record and Year

Surface Water Level

EOH End of Hole

Well Screen

WWR# Water Well Record Number

Geologic Cross-section B-B'

Lyons Narrows Water Balance,
Niagara Falls Panoramic Properties Ltd.

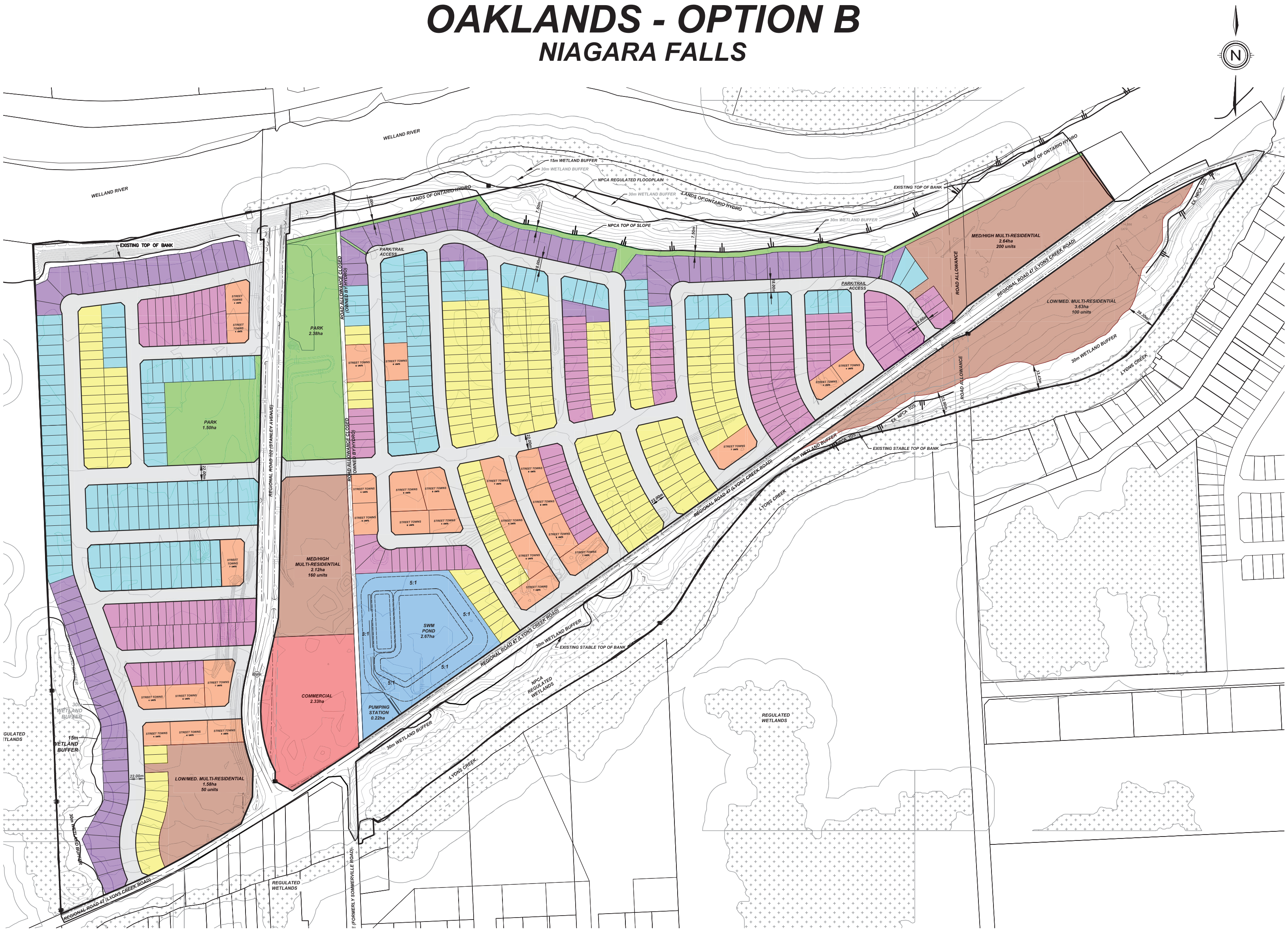
TDC Terra-Dynamics Consulting Inc.

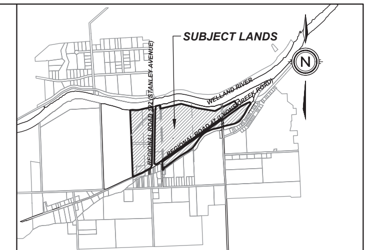
Figure 5

Appendix A

Supporting Information

OAKLANDS - OPTION B
NIAGARA FALLS





KEY PLAN
N.T.S.

CONCEPT PLAN OF SUBDIVISION

LEGAL DESCRIPTION

PART OF LOTS 1, 2 & 3
BROKEN FRONT CONCESSION WELLAND RIVER
and
PART OF THE ROAD ALLOWANCE BETWEEN
LOTS 2 & 3 (CLOSED BY BY-LAW)
BROKEN FRONT CONCESSION WELLAND RIVER
and
PART OF LOTS 19 & 20 - CONCESSION 3
all being in the former Township of Willoughby,
now the
CITY OF NIAGARA FALLS
REGIONAL MUNICIPALITY OF NIAGARA

- STREET TOWNS
- SINGLE RESIDENTIAL - 10.67m (35')
- SINGLE RESIDENTIAL - 12.20m (40')
- SINGLE RESIDENTIAL - 13.72m (45')
- SINGLE RESIDENTIAL - 15.24m (50')
- MULTI- RESIDENTIAL

LAND USE SCHEDULE

LAND USE	LOT/BLOCK	# OF UNITS	AREA(ha)	AREA(%)
SINGLE RESIDENTIAL 10.67m	LOT #-###	180	6.84	8.27
SINGLE RESIDENTIAL 12.20m	LOT #-###	217	9.01	10.90
SINGLE RESIDENTIAL 13.72m	LOT #-###	182	8.67	10.48
SINGLE RESIDENTIAL 15.24m	LOT #-###	100	5.91	7.15
STREET TOWNS	BLOCK #-#	155	4.68	5.66
MULTI-RESIDENTIAL	BLOCK #-#	510	10.02	12.12
STORMWATER MGMT FACILITY	BLOCK #-#		2.89	3.50
PARKS/TRAILS	BLOCK #-#		4.60	5.56
NEIGHBOURHOOD COMMERCIAL	BLOCK #-#		2.33	2.82
ROADWAY			13.92	16.83
ENVIRONMENTAL PROTECTION	BLOCK #-#		13.83	16.72
TOTAL		1344	82.7	100.00

DEVELOPABLE AREA = 68.87ha
DEVELOPABLE DENSITY = 19.52 units/ha

#	REVISION	DATE	INIT
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UPPER CANADA CONSULTANTS
ENGINEERS / PLANNERS

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	PRINTED FEBRUARY 6, 2020
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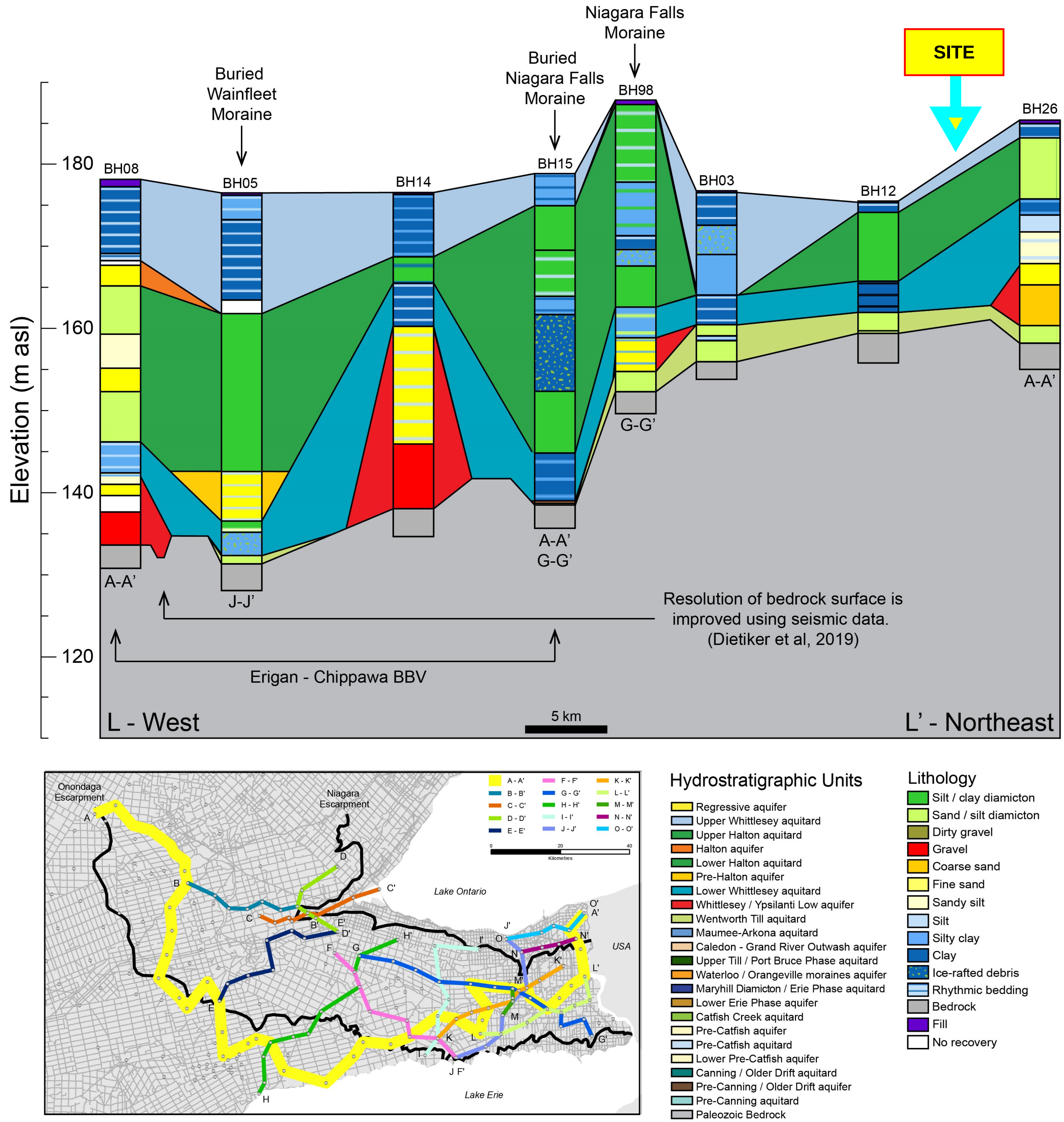
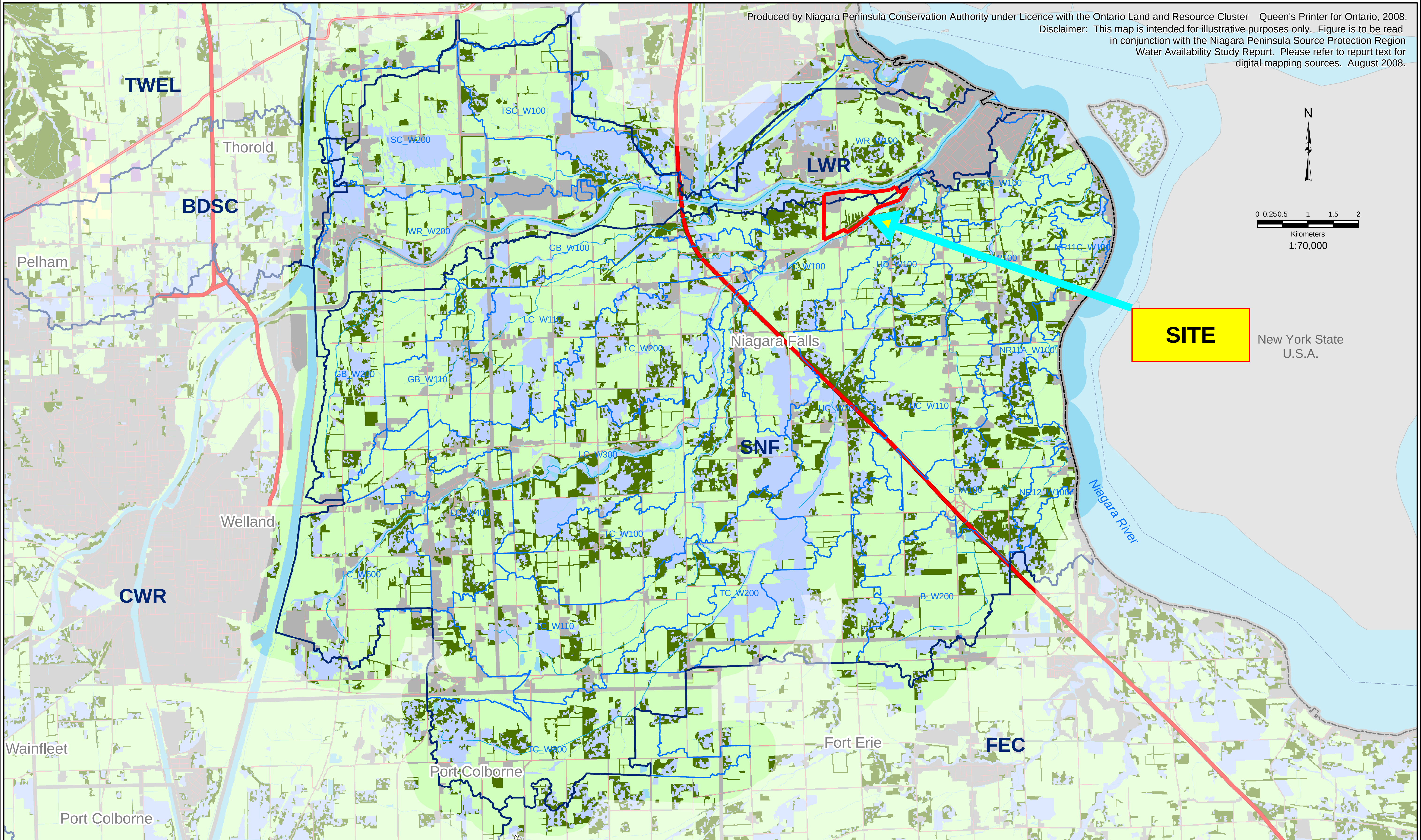

Niagara Falls Moraine
SITE
Buried Wainfleet Moraine
Buried Niagara Falls Moraine
BH08
BH05
BH14
BH15
BH98
BH03
BH12
BH26
180
160
140
120
Elevation (m asl)
A-A'
J-J'
A-A' G-G'
G-G'
A-A'
Resolution of bedrock surface is improved using seismic data. (Dietiker et al, 2019)
Erigan - Chippawa BBV
5 km
L - West
L' - Northeast
Onondaga Escarpment
Niagara Escarpment
Lake Ontario
Lake Erie
USA
A - A'
B - B'
C - C'
D - D'
E - E'
F - F'
G - G'
H - H'
I - I'
J - J'
K - K'
L - L'
M - M'
N - N'
O - O'
Kilometres
Hydrostratigraphic Units
Regressive aquifer
Upper Whittlesey aquitard
Upper Halton aquitard
Halton aquifer
Lower Halton aquitard
Pre-Halton aquifer
Lower Whittlesey aquitard
Whittlesey / Ypsilanti Low aquifer
Wentworth Till aquitard
Maumee-Arkona aquitard
Caledon - Grand River Outwash aquifer
Upper Till / Port Bruce Phase aquitard
Waterloo / Orangeville moraines aquifer
Maryhill Diamicton / Erie Phase aquitard
Lower Erie Phase aquifer
Catfish Creek aquitard
Pre-Catfish aquifer
Pre-Catfish aquitard
Lower Pre-Catfish aquifer
Canning / Older Drift aquitard
Pre-Canning / Older Drift aquifer
Pre-Canning aquitard
Paleozoic Bedrock
Lithology
Silt / clay diamicton
Sand / silt diamicton
Dirty gravel
Gravel
Coarse sand
Fine sand
Sandy silt
Silt
Silty clay
Clay
Ice-rafted debris
Rhythmic bedding
Bedrock
Fill
No recovery

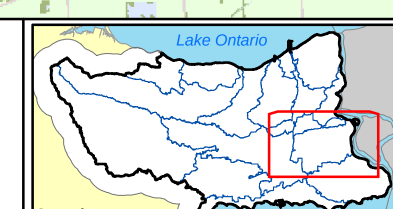


Legend

- Extended Context Area
- SPR Boundary
- Municipal Boundaries
- International Boundary
- Major Highways
- Highways
- Roads
- Rivers, Streams, Creeks
- Ponds, Reservoirs, Lakes
- NPCA Watershed Planning Area
- HMS Model Subcatchments
- HMS Model Reaches
- WR_W100: Subcatchment ID

Land Cover

- Agriculture
- Wetland
- Built Up / Transportation
- Forest
- Extraction
- Shoreline
- Water
- Orchards
- Vineyards



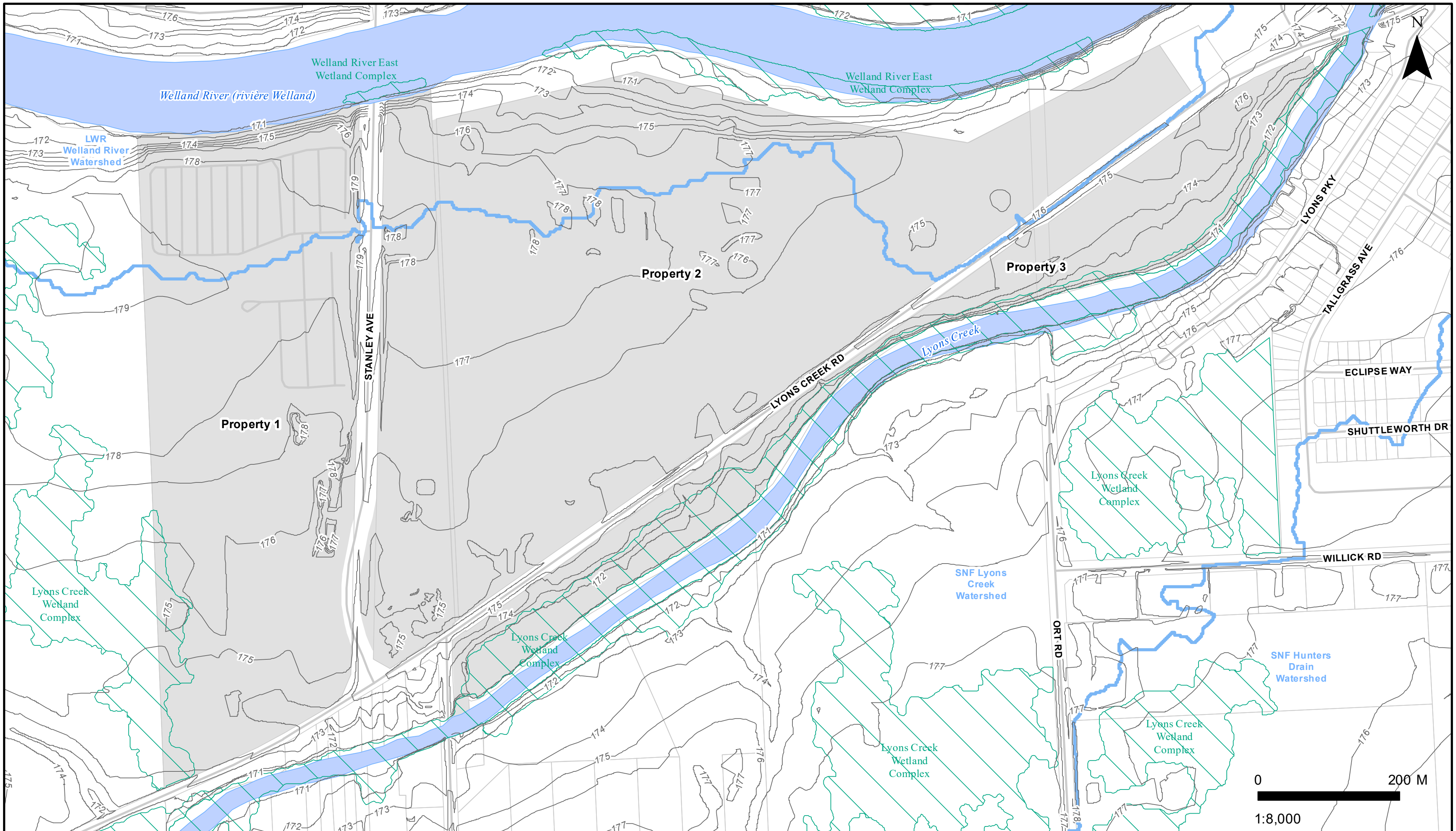
DRINKING WATER SOURCE PROTECTION
Niagara Peninsula Source Protection Region

Water Availability Study

Figure 2.16. SNF/LWR Land Cover

All Frames: North American Datum 1983, Universal Transverse Mercator 6° Projection, Zone 17N, Central Meridian 81° West.

Ontario



Subject Lands

Subwatershed Boundary

Provincially Significant Wetlands

Ground Surface Contour

Site Details

Stanley Avenue Properties Water Balance, Niagara Falls Panoramic Properties Ltd.

TDC Terra-Dynamics Consulting Inc.

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