Terra-Dynamics Consulting Inc.
432 Niagara Street, Unit 2 St. Catharines, ON L2M 4W3

January 11, 2023

Empire (Grand Niagara) GP Inc.
c/o Jeffrey Swartz, VP Land Development
125 Villarboit Crescent
Vaughan, ON L4K 4K2

Re: Preliminary Hydrogeologic Assessment and Water Balance Study, Grand Niagara Residential Subdivision, 8547 Grassy Brook Road, Niagara Falls ON

Dear Mr. Swartz,

1.0 Introduction and Background Information

Terra-Dynamics Consulting Inc. (Terra-Dynamics) respectfully submits this preliminary hydrogeologic assessment and water balance study of Empire (Grand Niagara) GP Inc.'s Grand Niagara Residential Subdivision, located at 8547 Grassy Brook Road in Niagara Falls, Ontario (Site) (Figure 1). The Site is presently part of a golf course and is approximately 210 ha in size.

A water balance assessment, of both Site and feature-based wetlands, is required for development of the Site (NPCA, 2022 and City of Niagara Falls, 2022 and Savanta, 2017). Agency water balance requirements include the following:

1. Submit the water balance study Terms of Reference to NPCA prior to proceeding (NPCA, 2022);

2. "*Ensure no negative impacts to the natural heritage system*" (City of Niagara Falls, 2022);

3. Inform stormwater management design at the Site "*in such a manner that pre-development water balance conditions are maintained for all wetlands in the Natural Heritage System Designation. A detailed water balance will be required as part of a stormwater management plan*" submission (City of Niagara Falls, 2019); and

4. "*Provincially Significant Wetlands (PSW) …be conserved, with the successful matching of pre and post development water balances*" (Savanta, 2017). Savanta (2017) identified for particular consideration a feature-based water balance for the "*treed swamp north of Grassy Brook Road*".

Historically, Niagara Region (Appendix A) has also required water balances to demonstrate:

1. *"No hydrologic impacts to wetlands"*; and

2. *"No net loss to productive capacity for fish habitat.*"

The NPCA has also recently been requesting wetlands be placed within their larger watershed context with respect to changes in overall drainage.

This water balance assessment includes:

1. An assessment of the water balance of the wetlands, specifically analyzing the role of the Site in supplying the wetlands with water; and

2. An overview of potential impacts, discussion of potential alternatives and proposed mitigation measures.

This water balance exceeds the requirements for "low risk" evaluation as specified by the TRCA (2017) and was also completed to generally conform to the Conservation Authority Guidelines for Development Applications (Conservation Ontario, 2013).

2.0 Methodology

Primary tasks completed as part of the water balance study to this point have included:

A. Submission of a water balance Terms of Reference (TofR) to NPCA and Niagara Region for comment. This was provided to NPCA and Niagara Region on April 6, 2022. Niagara Region offered "*no objection to the work plan proposed*" by e-mail May 4, 2022. NPCA responded that "*NPCA staff are generally supportive of the proposed scope of work*" by e-mail May 4, 2022 but requested some additional details be provided in the TofR. This additional information was provided May 10, 2022 by e-mail May 10, 2022 and accepted by NPCA June 2, 2022 by email. This correspondence record and the TofR are located in Appendix A.

B. Characterization of the physical setting using published information from the following government agencies: (i) the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), (ii) the Ministry of Natural Resources and Forestry (MNRF), (iii) the Ministry of the Environment, Conservation and Parks (MECP), (iv) the Niagara Peninsula Conservation Authority (NPCA), and (v) the Ontario Geological Survey (OGS). Existing on-site investigation reports were reviewed (e.g. GeoTerre Limited, 2021, Savanta Inc., 2017, Dillon Consulting Inc., 2022, Terrapex Environmental Limited, 2022) as well as a historic hydrogeological study of the Site was reviewed (Gartner Lee Limited (GLL), 1985);

C. Field Investigations have thus far included: (i) manual groundwater level measurements, (ii) datalogger monitoring of select groundwater monitoring wells, (iii) wetland hydrologic monitoring both by manual water levels and dataloggers, and (iv) surface water level monitoring both manual water levels and dataloggers. Future field investigations will include (a) additional monitoring of shallow monitoring wells, (b) hydraulic conductivity testing of monitoring wells, and (c) continued hydrologic (wetlands, surface water and groundwater) monitoring;

D. Modelling of pre-development and post-development monthly water balance conditions through consideration of: surface water catchments, land cover, soils, climate normals and wetland hydroperiods in order to determine if the site design is sufficient; and

E. A preliminary Wetland Risk Evaluation (TRCA, 2017).

3.0 Physical Setting

The Site is located on the Haldimand Clay Plain (Chapman and Putnam, 1984, Figure 3b regional cross section below). Aerial photos indicated the Site was developed as a golf course between 2000 and 2006 (Niagara Navigator, 2022). The Site is within the historic Crowland Township, part of Lot 1 and 2 and Lots 3 and 4 of Broken Front Concession, City of Niagara Falls, Regional Municipality of Niagara within the Niagara Peninsula Conservation Authority. The Site is bounded by Biggar Road to the south, Crowland Avenue to the west, Montrose Road to the East and the Welland River to the north. A Canadian Pacific Railway line bisects the Site from southwest to northeast (Figure 2).

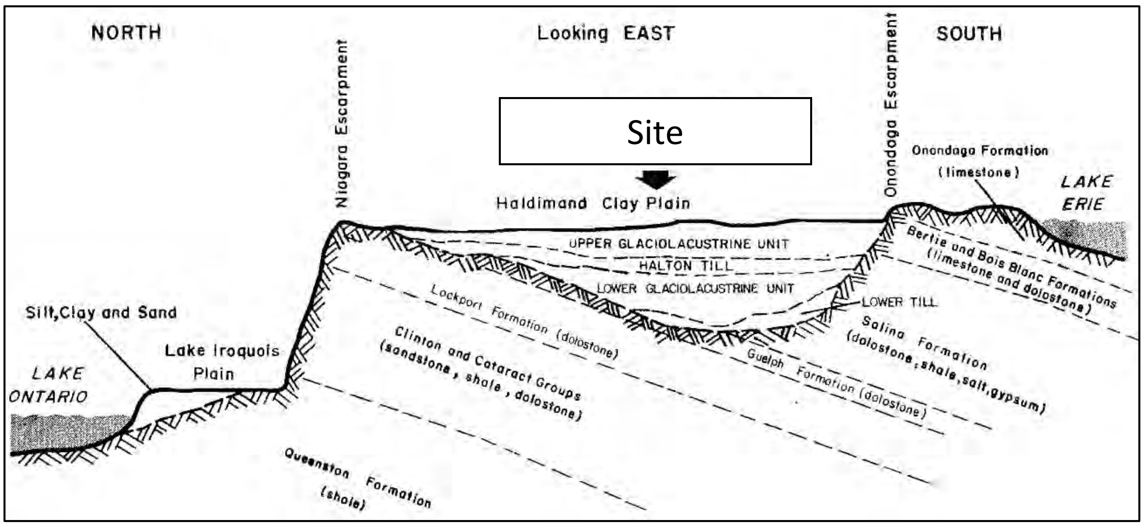


Figure 3b - Cross-Section Sketch Through the Eastern Niagara Peninsula (GLL, 1985)

3.1 Surface Water

3.1.1 Watercourses and Subwatersheds

There are three primary watercourses at/adjacent the Site; from north to south they are: (i) the Welland River, (ii) Grassy Brook and (iii) Lyons Creek (Figure 1). Adjacent, or within, the Site they have reaches of approximately 1.5, 2.0 and 2.1 km, respectively. These three watercourses originate over 110, 9 and 5 km upstream of the Site, respectively (Figure 3, Welland River watershed not shown). The Niagara Peninsula Conservation Authority Tier 1 water budget catchments for these three watercourses in relation to the Site are LWR_WR_W200, SNF_GB_W100 and SNF_LC_W110, respectively (AquaResource Inc. and NPCA, 2009, Figure 3, and Figure A-1, Appendix A).

Approximately 700 m downstream of the Site, the Welland River flows north to the Ontario Power Generation (OPG) Chippawa Power Canal No.1 and the Sir Adam Beck (SAB) Generating Station (Figure 3). The total drainage area of the Welland River is 921 km^2 and the portion on-site is 0.59 km^2 or <0.1% of the total Welland River watershed. It should be noted that the Welland River has a diurnal water level cycle making for an estuary-type environment, 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*" (Philips Engineering Ltd., 2004).

Approximately 1.7 km downstream of the Site, Grassy Brook enters the Welland River and also flows north to the SAB Generating Station via Chippawa Power Canal No. 1 (Figure 3). The total drainage area of Grassy Brook is 13.16 km^2 and the portion on-site is 0.77 km^2 or 6% of its watershed. Although NPCA have classified Grassy Brook in the area of the Site as permanent flow, Savanta (2017) have identified it as an intermittent or discontinuously flowing watercourse into summer and early fall, which has been confirmed by current surface water levels at Station SG-4 (Section 3.5.4, Figure 2). However, surface water level monitoring suggests the fluctuating water levels of Welland River are noted at the outlet of Grassy Brook from the Site (Section 3.1.2, Station SW1), however additional water level monitoring during the non-irrigation season should more confidently determine this influence.

Downstream of the Site, Lyons Creek flows 6.4 km east and northeast into the Welland River, and then the Welland River flows 4.5 km west (backwards compared to natural flow) before also flowing north to the SAB Generating Station via Chippawa Power Canal No. 1 (Figure 3). This 'backwards flow' is possible because the Welland River between the Niagara River and the north flowing Chippawa Power Canal No.1, was deepened to reverse the flow of the river for hydroelectric operations. The total drainage area of Lyons Creek is 45.08 km^2 and the portion on-site is 0.75 km^2 or 2%. The Ontario Hydro Network have classified Lyons Creek in the area of the Site as intermittent warmwater flow, which will be confirmed by future monitoring at SW2 as surface water levels were nearly dry at the last field visit in mid-August (Section 3.1.2).

3.1.2 Surface Water Monitoring

Historic Welland River surface water levels at Niagara Falls (referenced as 'Material Dock') show a diurnal fluctuation in water levels (Figure 3c, ranging from 170.7 and 171.6 m ASL) as larger volumes are directed over Niagara Falls during the day-time. Similar variations in surface water levels at wetland staff gauge station SG9 (Appendix C) adjacent the Welland River have been noted (Figure 2). Updated Welland River surface water levels at Niagara Falls have been requested from Ontario Power Generation but no response has yet been received. The NPCA have provided Welland River water levels to the west and upstream of the Site at the Welland River East Siphon (Appendix B, Figure B-1) which showed the summer 2022 diurnal fluctuations as ranging from 170.8 to 171.2 m ASL.

Surface water level Site monitoring of Grassy Brook and Lyons Creek began in May 2022 at the eastern downgradient outlets along Montrose Road at Stations SW1 and SW2, respectively (Figure 2).

Grassy Brook water levels at Montrose Road (SW-1, Figure 2) were (i) responsive to precipitation events, (ii) exhibited an overall seasonal decreasing trend of approximately 10 cm from May to August 2022 and (iii) displayed daily short-term rises in water levels (e.g. 15 cm) beginning at 6:30 am, peaking at 8:30 a.m. decreasing until the next daily rise (SW-1, Appendix C). These daily water level fluctuations correlate with NPCA reported Welland River water levels (Appendix B) from Ontario Power Generation flow changes in the Chippawa Channel. Additional monitoring will be completed to confirm the flow direction (e.g. flow/velocity measurements at the station) as there is reversal of flow in the Welland River from these activities.

The Lyons Creek water levels at Montrose Road (SW-2, Figure 2) were (i) responsive to precipitation events, (ii) exhibited an overall seasonal decreasing trend of approximately 30 cm from May to August 2022, (iii) were nearly dry (i.e. only 2 cm depth) by mid-August and (iv) displayed daily short-term drops in water levels (<1 cm) at approximately 10 a.m. (SW-2, Appendix C). These water level fluctuations may be related to Ontario Power Generation flow changes in the Chippawa Channel and/or irrigation activities at the Site. Additional monitoring during the non-irrigation season will be required to confirm.

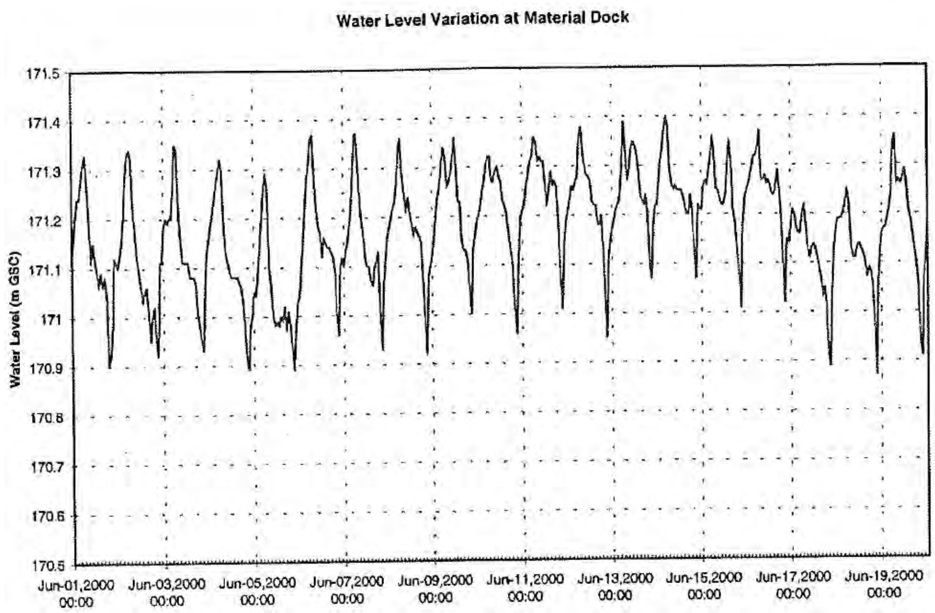


Figure 3c - Welland River Water Level Variations (Philips Engineering Ltd., 2004)

It is noted that during the May to August 2022 monitoring period that monthly precipitation was 62 to 88% below average, with similar or warmer air temperatures than average (Environment Canada and Climate Change, 2022a), resulting in less water for runoff and increased evapotranspiration. It is noted that a number of the surface water level monitoring stations (e.g. SW-1 and SW-2) indicated a rise in water levels not shown at the nearby Environment Canada climate station (2022a) on June 22, 2022. A review of radar data indicates between 3 to 4 inches of rain fell within 5 hours at the Site (Appendix B).

3.1.3 Waterbodies

NPCA's Contemporary Mapping of Watercourses (2017) provides an overview of the waterbodies at the Site. These are listed in Table 1 per subwatershed, and shown on Figure 2.

Table 1 – Summary of Waterbody Information (NPCA, 2017)

Subwatershed	Constructed Waterbodies	Natural Waterbodies within or partially with a PSW
Welland River	Six ponds: 3.03, 1.11, 0.50, 0.17, 0.02 & 0.01* ha	Three intermittent/ephemeral sloughs: 0.05, 0.05 & 0.04 ha
Grassy Brook	Seven ponds: 2.43, 0.16, 0.11, 0.08, 0.06, 0.03 and 0.02* ha	
Lyons Creek	1.49, 1.16, 1.16**, 0.23, 0.14, 0.11, 0.11, 0.07* (intermittent/ephemeral)	Three intermittent/ephemeral sloughs: 0.61, 0.18, 0.11, 0.60***

Table Notes: *reclassified as 'constructed' from NPCA desktop classification of natural as not present prior to golf course construction, ** - partially in Grassy Brook, *** - noted as seasonal waterbody not slough by NPCA

3.1.4 Surface Water Permit to Take Water

Water is added to the Site from the Welland River as part of golf course operations via a Permit To Take Water (PTTW 6133-98BMFV) with the Ministry of the Environment, Conservation and Parks (MECP). During 2021, takings from the Welland River to the Main Irrigation Pond occurred during May to August with on-site irrigation occurring from April to November 2021. Most irrigation occurs at night (e.g. 9 p.m. to 4 a.m.) with some occasional irrigation during daytime hours. The PTTW allows for the six largest ponds on-site (outlined on Figure 6) to be used for irrigation filled with Welland River water to a maximum permitted daily taking from the Welland River of 2,192,000 Litres/day for 214 days of the year, and a maximum taking from the main irrigation pond of 3,818,400 Litres/day. However, it is our understanding only the main irrigation pond is currently used and is approximately 6.1 metres (20 feet deep) (Figure 6, Grand Niagara Golf Club, 2022). A topographic survey of the Main Irrigation Pond in 2022 reported pond base elevations from 172 to 172.5 m ASL (Figure 6), with its northern extension at 170.5 to 171.5 m ASL and also reported on the base of the eastern pond north of Grassy Brook Road as at 172 to 172.5 m ASL. The water level elevations of these ponds from topographic mapping are suggested as ranging from 174.6 to 176.7 m ASL placing the ponds as higher in elevation than the deeper groundwater levels (Figure 6).

3.1.5 Floodplain Mapping

The NPCA Regulated Floodplain extent along the Welland River and Grassy Brook are fairly similar to the extent of the provincially significant wetlands (Figure 7, Appendix B, Figure F3, Dillon Consulting 2022). Also, the NPCA Regulated Floodplain along Lyons Creek is also fairly similar to the extent of the unevaluated wetlands identified by Savanta Inc. (2017) and Dillon (2022) to be preserved (Figure 7). Storm-event surface water flows are predicted to be greater along Grassy Brook than Lyons Creek as shown by historic flow flood estimates (Table 2).

Table 2 - Storm Event Flows (m^3/s), (Marshall Macklin Monaghan, 1989)

	Grand Niagara Drive			Montrose Road		
Watercourse	**2-year**	**5-year**	**10-Year**	**2-year**	**5-year**	**10-year**
Grassy Brook	6.6	9.0	10.6	6.8	9.2	10.9
Lyons Creek	1.9	2.6	3.0	2.3	3.1	3.6

3.2 Soils

The Site is primarily underlain by low permeability silty clay. The primary mapped soils include Niagara, Welland, Cashel - Heavy Red Phase and Alluvium (Figure 7). Details on these low permeability soil types include (Kingston and Presant, 1989):

i. Niagara (58% of Site, 120.79 ha throughout the Site): imperfectly drained, moderately to slowly permeable, groundwater levels are usually close to surface until late spring, moderate to high water-holding capacities, and surface runoff ranges from slow on level topography to rapid on slopes, Hydrologic Soil Group (HSG) ranges from 100% C to HSG 50% C/50% D and has an area-weighted average of 79% C and 21% D for the Site (see Table 3 for description of soils).

ii. Welland (19% of Site, 39.94 ha, central and southern portions of Site): poorly drained, slowly permeable except during the summer when surface cracking increases the permeability, groundwater levels remain close to the surface most of the year except during the summer, high water holding capacity, water runoff is slow to moderate (Hydrologic Soil Group D, Table 3).

iii. Cashel – Heavy Red Phase (20.46 ha, 10% of Site, limited to along Grassy Brook): moderately well-drained, moderately to slowly permeable, groundwater may perch near the surface for brief periods of time, high moisture-holding capacities, but during dry periods droughtiness can be a problem, surface runoff is generally rapid (Hydrologic Soil Group C, Table 3).

iv. Silty clay alluvium (9% of Site, 19.13 hectares, along the Welland River, upper Grassy Brook and central to east Lyon's Creek) correlating well with many of the wetlands at the Site (Figure 7). The hydrologic soil group for this alluvium, where classified, is HSG C (Table 3).

Less than 4 percent of the Site was not mapped as a soil type.

Table 3 - Hydrologic Soil Groups (USDA, 1986)

HSG Group	Soil description
A	sand, loamy sand or sandy loam
B	silt loam or loam
C	sandy clay loam
D	clay loam, silty clay loam, sandy clay, silty clay or clay

The area-weighted division of HSG for the Site is 67% HSG C and 33% HSG D.

3.3 Surficial Geology

The surficial geology of the Site is primarily low permeability clay and silt (Feenstra, 1984). This upper surficial unit, the Whittlesey Aquitard (Burt, 2020) consists of a "*massive or stratified (varved in places) silty clay… with generally more than 50% clay…*" (Feenstra, 1981). A series of geotechnical holes completed at the Site (GeoTerre Limited, 2021) indicated this silty clay (also called the "upper glaciolacustrine unit") as generally 12 to 15 m thick over the underlying clayey till as shown on the hydrogeologic cross-sections provided on Figures 4 and 5. The hydrogeologic cross-sections through the Site also include deeper borehole records previously completed by Gartner Lee Limited (1985). Within the silty clay were occasional, although sometimes noted as frequent, horizontal layers of silt at over half of the geotechnical boreholes (GeoTerre Limited, 2021) boreholes, sometimes including the screened interval. Vertical sand filled joints were also noted at many boreholes in the shallowest soil zones (GeoTerre, 2021).

Alluvial deposits also occur in association with the Welland River floodplain and as discontinuous deposits along Grassy Brook and Lyons Creek. The alluvium is confined laterally, and from below, by the silty clay Whittlesey Aquitard, and the alluvium tends to be fine-textured reflecting the available source materials and low to moderate stream gradients (GLL, 1985).

A previous hydrogeologic investigation of the Site determined the depth to bedrock as 17 to 30 metres below ground surface (GLL, 1985), which is similar to regional modelling of the overburden thickness as 17 to 28 metres over bedrock, averaging 24 metres (NPSPA, 2013).

3.4 Hydrogeologic Setting

The Whittlesey Aquitard (Upper Glaciolacustine Unit, Figure 3b) beneath the Site is a confining layer that also includes beneath it low permeability units associated with the clayey Halton Till, and a Lower Glaciolacustrine unit characterized by "*fine-textured materials with low hydraulic conductivities*". The hydraulic conductivity has been previously reported as between $1x10^{-8}$ and $3x10^{-10}$ m/s for the surficial fractured/weather zone of the silty clay and the unfractured zones of the silty clay, respectively (GLL, 1985). The upper 1 to 2 metres of the Whittlesey Aquitard "*is the most severely fractured, however fracture frequency declines rapidly with depth as fractures become more tightly closed and fewer… Fracturing and groundwater flow diminish rapidly to the base of the fractured zone which extends to a depth of about 5 m on the site… The surficial fractured zone of the confining layers is about 5 m thick*" (GLL, 1985).

The low permeability of the silty clay overburden will be further confirmed by hydraulic conductivity testing of select monitoring wells to further confirm previous reporting (GLL, 1985) for the future dewatering assessment and the OGS classification of the underlying silty clay as an aquitard.

3.4.1 Groundwater levels - Overburden

Gartner Lee Limited (1987) provides a description of the expected water table conditions within the 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.*"

Similar conditions were indicated by the initial assessment by GeoTerre Limited (2021) "*that the water table is generally quite shallow, i.e., typically 2 to 3 m below existing grades*", which was qualified as the "*measurements over quite a limited period of time and as such, may not represent fully stabilized values… some seasonal variation should be expected*".

Additional measurements collected during 2022 by Terra-Dynamics indicate groundwater levels generally rose since the 2021 study, the range of increase being from 0.3 to 1.9 m, with an average increase of 0.7 m (Tables 4a and 4b). This observed increase may be due to groundwater level recovery since monitoring well construction in low permeability units can be slow. Groundwater levels continued to generally be between 2 to 3 m below existing ground surface, becoming shallower from south to north, however these levels are from the unfractured silty clay. Additional monitoring wells will be added into the monitoring program in the shallower fractured silty clay. Groundwater level details from 2022 are provided as follows:

(a) groundwater levels south of Grassy Brook were generally 2.5 to 3 m BGS;
(b) groundwater levels north of Grassy Brook were generally 1 to 2.5 m BGS; and
(c) groundwater levels were less than 1 m BGS at BH20-3, BH20-10 and BH20-18 near the Welland River and the eastern boundary of the Site.

Manual groundwater levels will continue to be collected to refine this characterization, particularly with respect to Spring 2023 and the shallower fractured silty clay.

At the beginning of our study we were aware of sixteen monitoring wells already constructed at the Site, which were generally screened from 9 to 12 m BGS with five locations also deeper from 15 to 18 m BGS (GeoTerre Limited, 2021, Tables 4a and 4b). These monitoring wells are screened below the 5 m BGS upper '*fractured zone*' identified by Gartner Lee Limited (1985) and monitoring groundwater levels within the unfractured silty clay. Additional monitoring wells screened within, or partially within, the upper '*fractured zone*' for monitoring of the water table (Terrapex Environmental Limited, 2022, WSP, 2015) have been identified. These will be included in the quarterly manual groundwater level monitoring program for water table monitoring, and select monitoring wells be chosen for datalogging pressure transducers and hydraulic conductivity testing.

Five groundwater monitoring wells originally chosen for installation of datalogging pressure transducers in May 2022 in order to record water levels at 15-minute intervals in close proximity to the provincially significant wetlands on-site (Figure 2). These monitoring wells are BH20-2, BH20-4, BH20-8, BH20-13 and BH20-18 for their proximity to provincially significant wetlands (Figure 2). Additional shallow groundwater monitoring wells will be added to the monitoring program near the wetland along Lyons Creek which will also be preserved under post-development conditions. In summary between May and August 2022 (i.e. approximately 3 months) water level observations included (Appendix C):

(i) BH20-2: Groundwater levels showed little fluctuation, or influence of precipitation, but with a small seasonal decline of 5 cm. However, daily short-term (2.5 hours in the morning) water level reductions of less than 1 cm were noted; this may be related to on-site irrigation pond withdrawals or Welland River fluctuations, further monitoring during the non-irrigation season is required. This monitor is screened deeper than the other four monitoring wells installed with dataloggers and is adjacent to the Welland River.

(ii) BH20-4: Groundwater levels showed some regular minor fluctuation (less than 5 cm), with limited response to precipitation and an overall seasonal decline of 5 cm. The water level fluctuations may be related to on-site irrigation and/or irrigation pond withdrawals, further monitoring during the non-irrigation season is required.

(iii) BH20-8: Groundwater levels showed some response to precipitation and an overall seasonal decline of 35 cm. This greater water level decline may be from evapotranspiration at the nearby wetland, further monitoring during the non-growing season should clarify this interpretation.

(iv) BH20-13: Groundwater levels did not display a seasonal decline but did include regular fluctuations on the order of a couple centimeters. The water level fluctuations may be related to on-site irrigation and/or also operations of the adjacent railway line (i.e. the monitoring well water level changes in response to the weight of the train on the tracks), further monitoring during the non-irrigation season is required.

(v) BH20-18: Groundwater levels showed some response to precipitation and an overall seasonal decline of 18 cm. Daily short-term (3 hours in the morning) water level reductions of less than 1 cm were noted which may be related to on-site irrigation pond withdrawals or Welland River fluctuations, however further monitoring during the non-irrigation season is required. This monitor is less than 250 metres from the Welland River.

3.4.2 Groundwater Flow

Previous groundwater flow reporting on the Site has included the following:

"*Infiltration is the source of groundwater and differences in hydraulic head provide the driving force for groundwater flow systems…shallow lateral flow is considered to exist in the saturated portion of the fractured zone… Groundwater flow tends to be mainly vertical in fine-textured materials and lateral in granular deposits which have lateral continuity…Downward gradients exist …however ground-water flow rates and quantities are very small*" (GLL, 1985).

"*The water table occurs in the fractured zone and its shape is a reflection of topography. Fracturing and groundwater flow diminish rapidly to the base of the fractured zone which extends to a depth of about 5 m on the site*." (GLL, 1985)

"*…the water levels within the surface silty clay materials are marginally higher than that of the underlying deep soils… groundwater flows seems to be predominantly north to south with a small downward component*" (GeoTerre Limited, 2021)

The directions of groundwater flow within the unfractured silty clay at the Site is shown on Figure 6 using the manual water level measurements collected in August 2022. The groundwater level elevation was about 176 m ASL at the southern boundary (BH19-2) to 172 m ASL along the Welland River (BH20-3). The south to north gradient was calculated as 0.002 for the unfractured portion of the Whittlesey Aquitard which is close to that previously reported gradient of 0.003 for the fractured portion of the Whittlesey Aquitard at the Site (GLL, 1985).

In the northwestern portion of the Site, groundwater flow is primarily towards the Welland River, while a component of groundwater flow at the Site is towards the east and Lyons Creek. However, the amount of flow would be very small based on the low hydraulic conductivity. It is also noted that the manual water levels at BH20-8 were not included in the groundwater flow map at this time as they appear anomalously low in elevation and may be a function of the well being screened partially in sand and silt below the Whittlesey Aquitard.

The water level surface elevations of the on-site ponds are shown on Figure 6 based upon the NPCA digital elevation model and are above nearby groundwater levels. It is expected in most cases that the depths of the ponds are below some of the horizontal silt layers identified during the geotechnical investigation (Section 3.3) providing a possible hydrologic connection.

Future reporting will include water table mapping using Terrapex (2022) and WSP (2015) monitoring wells completed in the fractured silty clay.

3.4.3 Groundwater levels – Bedrock (Starzynski, 2017)

The Niagara Peninsula Conservation Authority (NPCA) operates a bedrock monitoring well (named Baden Powell, OGS BH31-NP-2014) less than 200 m northeast of the Site and 250 m from the Welland River (Figure 1, Appendix B). This bedrock well is screened 15 m below the base of the Welland River and vertically separated from the base of the Welland River by 15 m of silty clay. The bedrock groundwater levels at this location have been previously documented to (a) reflect the fluctuating stages of the Welland River by 10% (presumed to be a function of loading of the weight of water), and (b) were consistently above the water level elevation of the Welland River at the NPCA Siphon East Station indicating an upward gradient.

3.5 Wetlands

There are 26 hectares of provincially significant wetlands (PSWs) at the Site, which accounts for approximately 12% of the Site area. These PSWs were mapped by the province as swamps associated with the Welland River East Wetland Complex (MNRF, 2009b), and the Lower Grassy Brook Wetland Complex (MNRF, 2009a). Additional non-PSW wetlands have also been identified at the Site (Savanta 2017) and the additional wetlands to be protected account for another 9 hectares (Appendix B, Figure 3, Dillon, 2022). The wetlands (PSWs and non-PSWs) are summarized in Table 4 with the Ecological Land Classifications (ELCs) provided by Savanta (2017). The wetlands mapped along the Welland River, Grassy Brook and Lyons Creek closely match that of the NPCA flood plain extents (Figure 7, Appendix B, Figure 3, Dillon, 2022).

Table 4 – Wetland Summary Information

<table>
<tr><th>Site Sub-watershed</th><th>PSW Complex</th><th>Wetland Type</th><th>Wetland Area (hectares)</th><th>HSG (Section 3.2)</th><th>ELC** (Savanta, 2017)</th><th>Catchment</th></tr>
<tr><td rowspan="2">Welland River</td><td>Welland River East</td><td>Riverine</td><td>5.95</td><td>C</td><td>SWD2-2 (some MAS2-1, MAS2-10, FOD)</td><td>1</td></tr>
<tr><td>Lower Grassy Brook</td><td>Palustrine</td><td>3.36</td><td>70%C/ 30% D</td><td>SWD3</td><td>4</td></tr>
<tr><td rowspan="3">Grassy Brook</td><td rowspan="3">Lower Grassy Brook*</td><td>Riverine West</td><td>1.90</td><td rowspan="3">C</td><td>SWD2-2 (some MAS2-1)</td><td>5/7</td></tr>
<tr><td>Riverine Central</td><td>4.07</td><td>SWD2-2 (some MAM2-11, MAM2-10, SWD3-5)</td><td>5/7</td></tr>
<tr><td>Riverine East</td><td>4.86</td><td>SWD2-2 (some SWT2-9)</td><td>6/9</td></tr>
</table>

Site Sub-watershed	PSW Complex	Wetland Type	Wetland Area (hectares)	HSG (Section 3.2)	ELC** (Savanta, 2017)	Catchment
		Palustrine	6.22	19% C/ 81% D	SWD3-5 (some MAM2-10)	11
Lyons Creek	Lower Grassy Brook*	Palustrine	4.81	D	SWD3-5 (minor MAM2-2 and SWD1-6)	12
	Not PSW	Riverine West	0.73	70% C/ 30% D	SWD1-5	14
		Riverine Central	0.57	70% C/ 30% D	SWD1-3 (minor MAM2-2)	15
		Riverine East	2.95	C	SWD2-2 (minor MAM2-2)	15, 17, 18, 20 & south off-site

Note: * - Some non-PSW wetlands included, ** - ELC Codes explained in Table 5 (below),

Savanta's (2017) Ecological Land Classification (ELCs) of the Site (Appendix B) also refined the PSW wetland details, e.g. identification of marsh where previously regionally classified by the MNRF as only swamp. The wetland communities to be reviewed as part of the wetland water balance are listed in Table 5 with their hydrological sensitivities for the future wetland risk assessment (Section 4.4).

Table 5 - Ecological Land Classifications (ELCs) (Savanta, 2017) and Hydrological Sensitivity

ELC Code	Description	Hydrological Sensitivity (TRCA, 2017*)
	MARSH	
MAM2-2	Reed-canary Grass Mineral Meadow Marsh	Low
MAM2-10	Forb Mineral Meadow Marsh	Low
MAM2-11	Mixed Mineral Meadow Marsh	Low*
MAS2-1	Cattail Mineral Shallow Marsh	Medium*
MAS2-10	Common Reed Mineral Shallow Marsh	Low*
	SWAMP	
SWD1-3	Pin Oak Mineral Deciduous Swamp	Medium*
SWD1-5	Green Ash-Pin Oak Mineral Deciduous Swamp	Medium*
SWD1-6	Pin Oak-Ash-Maple Mineral Deciduous Swamp	Medium*
SWD2-2	Green Ash Mineral Deciduous Swamp	Medium
SWD3	Maple Mineral Deciduous Swamp	Medium*
SWD3-5	Maple Mineral Deciduous Swamp	Medium*
SWT2-9	Grey Dogwood Mineral Thicket Swamp	Low*

Note: * - where no direct correlation with TRCA (2017) communities hydrologic sensitivity assigned by Dillon (2022)

3.5.1 Wetland Characterization

The on-site wetlands are currently classified as either (a) *surface water depression wetlands or (b) surface water slope wetlands* (Figures 8a and 8b) (Mitsch and Gosselink, 2007).

A surface water depression wetland is summarized as a: "*wetland…dominated by surface runoff and precipitation, with little groundwater outflow due to a layer or low-permeability soils*…". Low permeability soils have been noted at the Site (Sections 3.2 and 3.3) and the palustrine wetlands at the Site fit this description.

A surface water slope wetland is summarized as a: "*wetland…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*." The riverine wetlands along the Welland River, Grassy Brook and Lyons Creek fit this description.

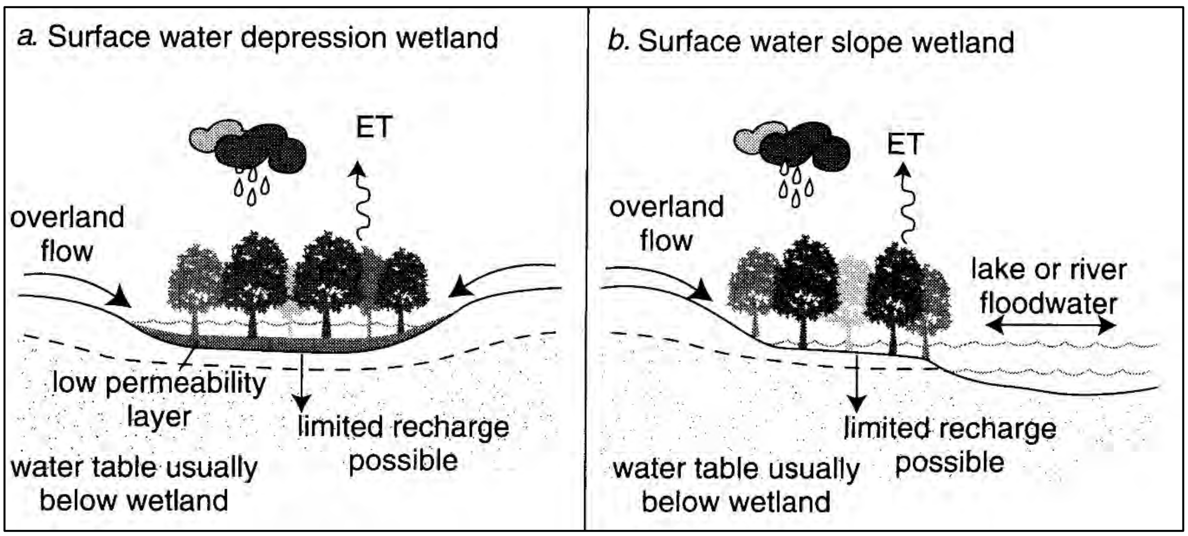


Figure 8a - Surface water depression and surface water slope wetlands (Mitsch and Gosselink, 2007)

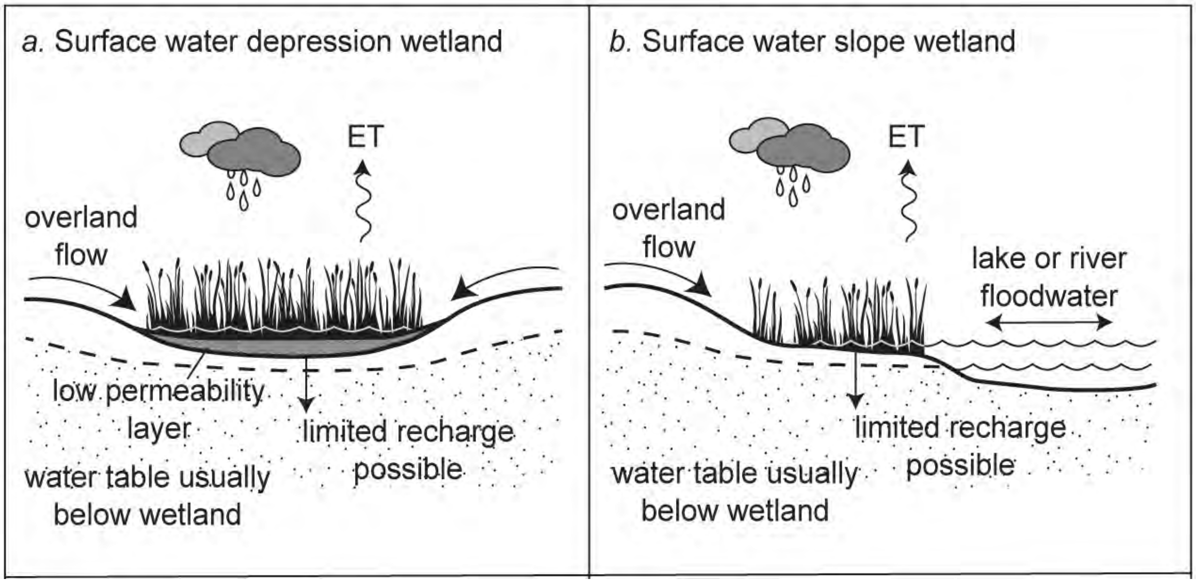


Figure 8b - Surface water depression and surface water slope wetlands (Mitsch and Gosselink, 2007)

3.5.2 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).

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*" (Figure 9).

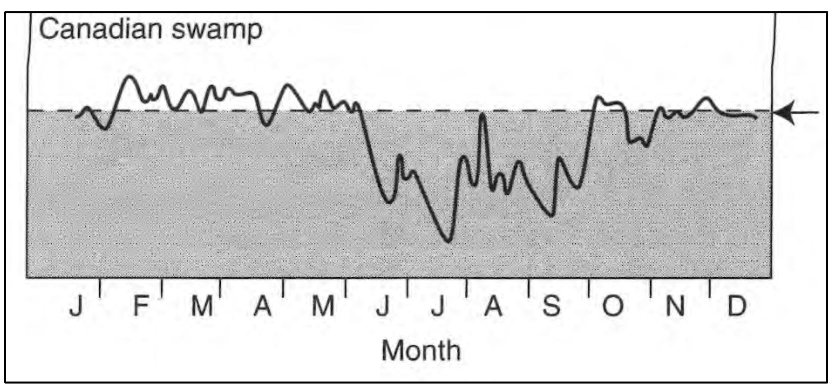


Figure 9 – Canadian Swamp Hydroperiod (Mitsch and Gosselink, 2007)
Note: arrow indicates wetland ground surface

Wetland staff gauges were installed at nine locations (Figure 2, Table 6) as per the agreed upon Terms of Reference (TofR) with NPCA and Niagara Region (Appendix A). These stations were determined based upon the provincially significant wetlands at the Site. As non-PSW wetlands along Lyons Creek are being preserved three additional staff gauges will be placed along Lyons Creek. The staff gauges were installed to measure surface water levels but also allow for measurement of water levels 0.1 to 0.3 metres below ground surface. Wetland water levels have been monitored from May to August 2022, and is continuing as per the TofR indicates monitoring for at least one year. A brief description of the surface water levels per station is presented below with site visit photos provided in Appendix D.

Table 6 – Wetland Staff Gauge Monitoring Locations

ID	Wetland Type	ELC* Code
SG-1	Palustrine Swamp Slough	SWD3-5
SG-2		
SG-3		
SG-4	Grassy Brook Riverine Swamp	SWD2-2
SG-5		SWD3-5
SG-6		SWD2-2
SG-7	Palustrine Swamp Slough	SWD3
SG-8		
SG-9	Welland River Riverine Swamp	SWD2-2

Note: * - For ELC codes see Table 5

SG-1/SG-2/SG-3 (Grassy Brook Palustrine Slough Swamp): Surface water levels were recharged by precipitation, with a summer decline to dry conditions in August. A downward vertical water gradient was noted comparing these surface water levels to nearby groundwater monitoring well BH20-13 (Appendix C).

SG-4/SG-5/SG-6 (Grassy Brook Riverine Swamp): Surface water levels were very responsive to precipitation events at SG-4, and the average seasonal summer water level decline was ~20 cm with dry conditions in mid-July and mid-August. Surface water levels at SG-5 were less responsive to precipitation (but SG-4 was installed closer to the Grassy Brook channel) and SG-5 showed more stable surface water levels, e.g. less summer decline with a seasonal decline closer to 10 cm although with frequent dry conditions in mid-July and mid-August. SG-5 water level fluctuations may be an upgradient effect of the Welland River with daily fluctuations similar to that observed at SW1 (Section 3.1.2). Surface water levels at SG-6 were not very responsive to precipitation (SG-4 was installed closer to the Grassy Brook channel), with no clear summer decline as surface water levels were commonly dry, and daily fluctuations noted (Appendix C). Although groundwater levels at BH20-18 were higher than surface water levels at SG-4, dry surface water conditions in July and August and the temperature profiles (Appendix B) support the interpretation that the silty clay soils are confining groundwater levels from the surface water system at SG-4. This will be further confirmed with future groundwater monitoring at a fractured clay shallow monitoring well (Appendix B, Figure 2, Terrapex, 2022). Groundwater levels were also generally higher at BH20-8 than surface water levels at SG-5 and SG-6, but summer dry conditions and the temperature profiles (Appendix B) support the interpretation that the silty clay soils are confining groundwater levels from the surface water system at SG-5 and SG-6. This will be further confirmed with future groundwater monitoring at a fractured clay shallow monitoring well (Appendix B, Figure 2, Terrapex, 2022).

SG-7/SG-8 (Grassy Brook Road North Palustrine Slough Swamp): Surface water levels were recharged by precipitation, and declined during summer to dry conditions in August in a similar manner at both SG-7 and SG-8 (Appendix C). A downward vertical water gradient is noted comparing these surface water levels to nearby groundwater levels at BH20-4 and BH20-8. Daily minor water level reductions (<1 cm) were commonly noted at SG-8 in the morning between 9:30 a.m. and 10:30 a.m.; further monitoring in the non-irrigation season will likely clarify the source of the daily water level change.

SG-9 (Welland River Riverine Wetland): These water levels fluctuated from approximately 10 cm above, to 10 cm below, ground surface (Appendix C). The water level peaks are caused by estuary-type Welland River water level fluctuations from flow changes in the Chippawa Channel from Ontario Power Generation operations putting larger flows to the Beck Power Plant at night and larger flows over Niagara Falls in the daytime (Section 3.1). Peak water levels tended to occur close to 8:15 a.m., but could occur later in the morning. In order to improve comparison to groundwater levels the datalogger pressure transducer will be moved to BH20-3 from BH20-2, and an additional datalogger will be placed in a shallow fractured clay monitoring well (Appendix B, Terrapex, 2022).

3.5.3 Soil Water Holding Capacity

The soil water holding capacities (SWHC) for the wetland polygons were calculated based upon the mapped OMAFRA hydrologic soil group (Section 3.2, Figure 7) and values from previous wetland SWHC designations used by NPCA in their water budgeting study (AquaResource Inc. and NPCA, 2009).

Table 7 – Wetland Soil Water Holding Capacities (SWHC)

Site Subwatershed	PSW Complex	Wetland Type	HSG (Section 3.2)	SWHC (mm)
Welland River	Welland River East	Riverine	C	400
	Lower Grassy Brook	Palustrine	70%C/30% D	385
Grassy Brook	Lower Grassy Brook	Riverine	C	400
		Palustrine	19% C/ 81% D	360
Lyons Creek	Lower Grassy Brook	Palustrine	D	350
	Not PSW – Lyons Creek West	Riverine	70%C/30% D	385
	Not PSW – Lyons Creek Central		70%C/30% D	385
	Not PSW – Lyons Creek East		C	400

3.5.4 Surface Water and Wetland Catchments

A digital terrain model from NPCA (2018) was processed in a Geographic Information System (GIS) to determine pre-development surface water catchments for the Site with particular focus on lands draining to on-site watercourses, waterbodies and wetlands (Figure 10). Relevant catchment information is summarized in Table 8.

Table 8 - Surface Water Catchment Summary

Catchment ID	Description	Area (ha)
1	Welland River Riverine Wetland	23.38
2	Main Irrigation Pond	22.30
3	Pond	4.71
4	Palustrine Wetland Grassy Brook North	4.39
5	Lower Grassy Brook North	28.19

Catchment ID	Description	Area (ha)
6	Lower Grassy Brook Northeast	3.51
7	Lower Grass Brook South	17.40
8	Pond	4.50
9	Lower Grassy Brook Southwest	10.04
10	Pond	7.32
11	Palustrine Wetland Railway North	9.82
12	Palustrine Wetland Railway South	9.00
13	West Lyons Creek North	8.06
14	West Lyons Creek South	5.60
15	Central Lyons Creek North	11.34
16	Pond	5.07
17	East Lyons Creek North	5.40
18	Central Lyons Creek South	15.60
19	Pond	5.61
20	East Lyons Creek South	26.69
21	Central Lyons Creek South	4.72

3.6 Pre-development Subwatershed Water Balance Modelling

NPCA previously completed water balance modelling for 1991-2005, as part of provincial water budgeting for the source water protection program (AquaResource Inc. and NPCA, 2009). This modelling was completed at 1-hour time steps with a filled-in meteorological dataset including solar radiation and a crop coefficient for improved calculation of evapotranspiration.

Modelled annual and monthly water balance results were obtained for the South Niagara Falls Grassy Brook Catchment W100 (SNF_GB_W100, Figure 3) (Tables 9 and 10, respectively) (AquaResource Inc. and NPCA, 2009). This catchment covers over a 1/3 of the Site and is the most appropriate of the three NPCA modelling catchments that cover the Site (Figure 3), e.g. similar percent of HSG C (60%) and D (36%) to the Site. Also, the Site's average modelled infiltration rate is 97 mm (NPCA and AquaResource Inc., 2009), which is close to that of the modelled Grassy Brook catchment. The annual surplus available for runoff and recharge is precipitation minus evapotranspiration.

Table 9 - Water Balance 15-year (1991-2005) Averages

Catchment	Precipitation	Actual Evapotranspiration	Annual Surplus	Infiltration*	Recharge	Runoff
	(mm/year)					
SNF_GB_W100	968	592	376	114	57	263

Notes: * - Infiltration is interflow plus recharge

Table 10 - Monthly Runoff and Recharge (Catchment SNF_GB_W100)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Runoff (mm)	38.4	28.9	49.6	43.7	19.4	11.8	3.0	3.1	4.3	6.0	26.1	28.1
Recharge (mm)	8.9	9.0	15.0	10.7	3.6	1.1	0.2	0.0	0.0	0.4	2.9	7.2

4.0 Water Balance Assessment

A monthly water balance assessment has been completed of the Site's wetlands, as informed by the Conservation Authority Guidelines for Development Applications (Conservation Ontario, 2013) and TRCA's guidance for water balances (2012).

It is noted that the MECP (2003) water balance approach is typically concerned with the evaluation of post-development conditions to prevent (i) increased runoff, and/or (ii) reduction in groundwater recharge. However, given the wetland surface water characterizations (Section 3.5.1), any contribution to hydrologic function with respect to the wetlands is via additional surface water flow, not groundwater discharge. Consequently, '*maintenance of pre-development monthly saturated conditions via runoff to maintain the wetland hydroperiod*' is the criteria for the water balance assessment.

4.1 Monthly Water Balance Example

An example of water balance modelling from the University of Waterloo is shown below (Figure 12). 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 very low at only 100 mm compared to the higher SWHC of the wetlands of between 350 to 400 mm.

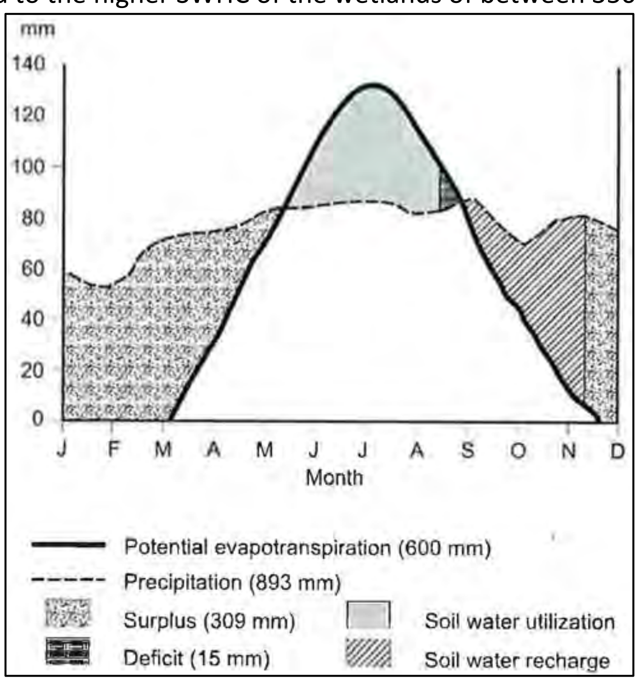


Figure 12 – Brantford Average Water Balance (Sanderson, 2004)

4.2 Wetland Water Balances

Monthly wetland water balances were completed using the U.S. Geological Survey (USGS) Monthly Water Balance Model (McCabe and Markstrom, 2007), which considers direct precipitation to the wetland. For temperature and precipitation, 30-year climate normal inputs (1981-2010) from the average of the two closest weather stations with climate normals were used as the Site is midway between two weather stations, 6139445 Welland and 6135657 Niagara Falls NPCSH (Environment Canada, 2022b, 2022c). Monthly wetland water balance modelling results (Tables 11a, 11b, 11c and 11d) were produced for the wetland Soil Water Holding Capacities at the Site (Section 3.5.3) and are summarized below in Table 12 (however without decimal places). Similar trends were noted in each case as:

1. Potential evapotranspiration exceeded precipitation for June, July and August, i.e. soil water utilization occurred;
2. Soil water holding capacities were less than saturated for the months of June through October;
3. The highest soil water deficit was in August; and
4. Soil water recharge occurred in September and October as shown by the increase in soil moisture and reduced deficit.

Table 12 – Monthly Wetland Water Balance (mm)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation (mm)	77	62	66	74	86	82	82	81	98	85	95	87
Actual (mm) Evapotranspiration	10	12	22	40	72	107	123	97	61	33	17	11
Hydrologic Soil Group C (SWHC 400 mm)												
Soil Moisture (mm)	400	400	400	400	400	**371**	**325**	**305**	**336**	**384**	400	400
Soil Water [1] Depletion (mm)	0	0	0	0	0	**29**	**75**	**95**	**64**	**17**	0	0
Hydrological Soil Group 70% C/ 30% D (SWHC 385 mm)												
Soil Moisture (mm)	385	385	385	385	385	**356**	**311**	**290**	**321**	**369**	385	385
Soil Water [1] Depletion (mm)	0	0	0	0	0	**29**	**75**	**95**	**64**	**16**	0	0
Hydrological Soil Group 19% C/ 81% D (SWHC 360 mm)												
Soil Moisture (mm)	360	360	360	360	360	**331**	**286**	**266**	**297**	**344**	360	360
Soil Water [1] Depletion (mm)	0	0	0	0	0	**29**	**74**	**94**	**63**	**16**	0	0
Hydrological Soil Group D (SWHC 350 mm)												
Soil Moisture (mm)	350	350	350	350	350	**321**	**276**	**256**	**287**	**335**	350	350
Soil Water [1] Depletion (mm)	0	0	0	0	0	**29**	**74**	**94**	**63**	**15**	0	0

Note: [1] Difference between the SWHC and the modelled soil moisture

4.3 Wetland Water Balance Assessment

As introduced in Section 4.0, "*maintenance of pre-development monthly saturated conditions via runoff, to maintain the wetland hydroperiod, is the criteria for the water balance assessmen*t". Consequently, the wetland water balance assessment is an evaluation to determine if there are catchments where upgradient runoff provides saturated conditions to wetlands during June to October when soil water holding capacities are expected to be less than saturated (Section 4.2).

Wetlands not requiring this evaluation include:

A. Palustrine wetlands within catchments 4, 11 and 12 as they were determined during the catchment delineation process not to receive upgradient runoff but are sustained by precipitation (Figure 11).

B. Wetland catchments preserved as open space, (i.e. with no change to their pre-development catchments): (i) Grassy Brook Riverine Central Catchment 7, (ii) Grassy Brook Riverine East Catchment 6 and (iii) Lyons Creek Riverine East Catchments 18 and 20.

C. Riverine wetlands sustained by surface water flow (Figure 11), not overland runoff; these wetlands include: (i) Grassy Brook Riverine West and Central and (ii) Northern swamp (SWD2-2) and marsh (MAS2-1 and MAS2-10) portions of the Welland River Riverine Wetland. This classification was determined through an analysis of the creek elevations, wetland extent elevations, surface water and wetland water level monitoring and evaluation of expected rooting depths per ELC mapped (Savanta, 2017). It is noted that a portion of the Grassy Brook Riverine Central wetland does include 150 m along the railway that is not riverine, however it's location within a larger protected development area between adjacent wetlands protects its pre-development hydrologic regime.

The required set-backs provided from wetlands and forest for these features will also provide additional hydrologic benefit, with any excess water running off to the nearby watercourse.

However, portions of four 'riverine' wetlands were identified to potentially require runoff to maintain their hydroperiods, these include, from north to south: (a) Forest (FOD) portion of the Welland River Riverine Wetland, (b) Grassy Brook Riverine East Catchment 9, (c) Lyons Creek Riverine Central and (d) Lyons Creek Riverine East. Analyses were completed (Sections 4.3.1 to 4.3.4) of these four wetland catchments to determine if average June to October runoff would be expected to maintain saturated soils under pre-development conditions.

4.3.1 Wetland Runoff Assessment – Northwest Welland River Wetland

A portion of the PSW Welland River Riverine Wetland is located above the inferred water level influence of the Welland River, labelled as "Northwestern Welland River Wetland" (Figure 11). This area is 0.86 ha, approximately 290 metres long and on average 30 m wide. It is noted that although these lands are within the MNRF PSW polygon, Savanta (2017) previously identified the vegetation as deciduous forest (FOD), not wetland. During the 2022 NPCA wetland staking (Dillon Consulting Inc., 2022), this was staked as wetland. Consequently, development restrictions for this area include a 30 m set-back (Appendix B, Figure 3, Dillon Consulting Inc.).

The upgradient area modelled to runoff to this area is 3.84 ha in Catchment 1 (Figure 11). Modelling of the June to October monthly pre-development runoff (Table 13a) identified only sufficient runoff to address the natural soil water deficit in June and October, but not during July, August and September.

However, the 30 m wetland set-back is not sufficient to maintain the pre-development June and October modelled saturated conditions (Table 13a). The addition of increased wetland buffer is not recommended, as it is very inefficient and would require an additional 55 m to be added. However, additional clean roof runoff (as an impervious surface) can provide most received precipitation to the 'wetland', and consequently a minimum of 1,790 m^2 of impervious roof area directed towards the 'wetland' can address the June and October deficit.

4.3.2 Wetland Runoff Assessment – Grassy Brook Riverine East Catchment 9

Wetland above 173 m ASL at the Grassy Brook Riverine East Wetland in Catchment 9 (i.e. south of Grassy Brook) is expected to be above the rooting depth (i.e. max 0.65 m for Green Ash Mineral Deciduous Swamp) of allowing vegetation to access soils saturated by Grassy Brook. Nearby wetland staff gauge SG-6 recorded an average surface water level of 172.5 m ASL in summer 2022. Thie area of wetland believed to need runoff for its hydroperiod is 0.52 ha and the upgradient area in Catchment 9 is 2.09 ha, however this does not include the portion of the upgradient area already developed as Industrial Lands as that land use is not changing (Figure 11).

The June to October monthly pre-development runoff (Table 13b) is modelled to only provide sufficient volume to address the natural soil water deficit in June and October, but not during July, August and September. As this wetland feature is located within a woodland, the exterior woodland dripline was staked and a 10 m buffer was placed on this feature in order to protect both the woodland and internal wetland features.

However, the buffer set-back and preserved open space of 0.63 ha is not sufficient to maintain pre-development June and October saturated conditions at the wetland. It is estimated that an additional 0.85 ha spread along the wetland boundary would be required to maintain saturated conditions in June and October. However additional clean roof runoff, as an impervious surface, can provide most precipitation received, consequently a minimum of 932 m^2 of impervious roof area directed towards the wetland can address the June and October deficit (Table 13b). As the wetland area slopes towards Grassy Brook and the soils are of low permeability, additional water not needed will runoff to Grassy Brook.

4.3.3 Wetland Runoff Assessment – Lyons Creek Riverine Central

Wetland above 177 m ASL at the Lyons Creek Riverine Central Wetland in Catchment 15 (i.e. north of Lyons Creek) may be above the rooting depth (i.e. max 0.65 m for Pin Oak Mineral Deciduous Swamp) of allowing vegetation to access soils saturated by Lyons Creek. A staff gauge was installed in fall 2022 to further confirm surface water levels as the creek base elevation is approximately 176 m ASL. The area of wetland is 0.19 ha assumed to require runoff for its hydroperiod and the upgradient area in Catchment 15 is 0.18 ha (Figure 11).

However, the June to October monthly pre-development runoff (Table 13c) is modelled to not provide sufficient volume to address the natural soil water deficit in June through October. This means under pre-development conditions the current hydrologic regime is modelled not to create saturated conditions during the summer deficit period. Consequently, additional buffer is not required to maintain the pre-development wetland hydroperiod.

4.3.4 Wetland Runoff Assessment – Lyons Creek Riverine East

Wetland above 176 m ASL at the Lyons Creek Riverine East Wetland in Catchments 15 and 17 (i.e. north of Lyons Creek) may be above the rooting depth (i.e. max 0.65 m for Green Ash Mineral Deciduous Swamp) of allowing vegetation to access soils saturated by Lyons Creek. The creek base elevation is between 174.9 and 175.3 m ASL, and SW-2 to the east had average surface water levels of between

175.1 to 175.3 m ASL in summer 2022. A staff gauge was installed in fall 2022 to further confirm surface water levels in order to refine the extent of riverine water supply to the wetland. The area of the wetlands are 0.20 ha and 0.13 ha estimated to receive runoff to sustain their hydroperiod, and the upgradient runoff areas in Catchments 15 and 17 are 1.75 ha and 0.37 ha, respectively (Figure 11).

The June to October monthly pre-development runoff (Tables 13d and 13e) are modelled to only provide sufficient volume to address the natural soil water deficit in June and October, but not during July, August and September. As this wetland feature is located within a woodland, the exterior woodland dripline was staked and a 10 m buffer was placed on this feature in order to protect both the woodland and internal wetland features.

However, since the buffer set-back and preserved open space of 0.25 ha and 0.14 ha, for the Catchment 15 and 17 wetlands, respectively, are not sufficient to maintain pre-development June and October saturated conditions at the wetland, an additional 0.35 ha and 0.23 ha would be required. However additional clean roof runoff, as an impervious surface, can provide most precipitation received, consequently a minimum of 348 m^2 and 258 m^2 of impervious roof area directed towards the wetland can address the June and October deficits (Tables 13d and 13e).

4.4 Wetland Risk Evaluation

4.4.1 Magnitude of Hydrological Change

TRCA's wetland risk evaluation (2017) decision tree (Figure 12) includes four key hydrological change criteria:

1) Impervious cover in catchment;
2) Change in catchment size;
3) Dewatering; and
4) Impact to recharge areas.

With respect to item #1, an initial estimate of the amount of impervious cover upon development will range from 42% to 64% within the areas proposed for development (WSP, 2022).

With respect to item #2, surface water catchments will be changed through development. The change to wetlands requiring direct runoff was assessed in Section 4.3 and stormwater management recommendations provided to maintain wetland pre-development conditions.

With respect to item #3, construction dewatering is not expected to affect wetlands as the wetlands are either perched systems or fed by surface water. The aquitard underlying the Site is of sufficiently low permeability that overburden dewatering may not be feasible and/or necessary (Preene, 2020).

With respect to item #4, no impacts to wetland recharge areas are predicted as TRCA (2017) defines this as "*replacement of existing soils with significantly less permeable materials*" and the on-site soils are already of low permeability. In addition, there are no locally significant recharge areas to be impacted as these are defined by TRCA (2017) as "*highly porous sedimentary deposits or otherwise having high hydraulic conductivity*".

"*The highest magnitude category with one or more criteria satisfied determines the potential magnitude of change*" with the magnitude thresholds of less than 10% change as low, 10-25% medium and greater than 25% high (TRCA, 2017). Therefore, a high hydrologic risk is assigned based upon the magnitude of impervious cover in catchments. However, as discussed in Section 4.3, negative hydrologic impacts to the downgradient wetlands are not predicted with the limited recommended measures for select wetlands requiring additional runoff for June and October to maintain hydroperiods.

4.4.2 Sensitivity of the Wetlands

The risk assignment (Figure 12) is to consider the type of wetlands, and their hydrological sensitivity (TRCA, 2017). These are listed for the Site in Table 5 and include medium and low hydrological sensitivities.

4.4.3 Risk Assignment

As per Figure 12, a medium risk is assigned based upon a (i) high magnitude of hydrological change and (ii) a medium wetland sensitivity. The TRCA recommended study, modelling and mitigation requirements are listed below and our current work program includes most, if not all, the expected risk assignment recommendations, such as:

(i) Pre-development monitoring as outlined in the Wetland Water Balance Monitoring Protocol (TRCA, 2016).
- This has been occurring since late spring 2022.

(ii) Continuous hydrological modelling at daily aggregated to weekly resolution.
- Existing modelling (completed at 1-hour time steps) completed by NPCA was utilized for this report (AquaResource Inc. and NPCA, 2009) as part of a monthly analysis. This existing work could be re-visited to extract weekly results, however this would appear to have no benefit.

(iii) Design of a mitigation plan to maintain the wetland water balance, in some cases an interim mitigation plan may also be required.
- Evaluation of the proposed set-backs was completed as part of this report.

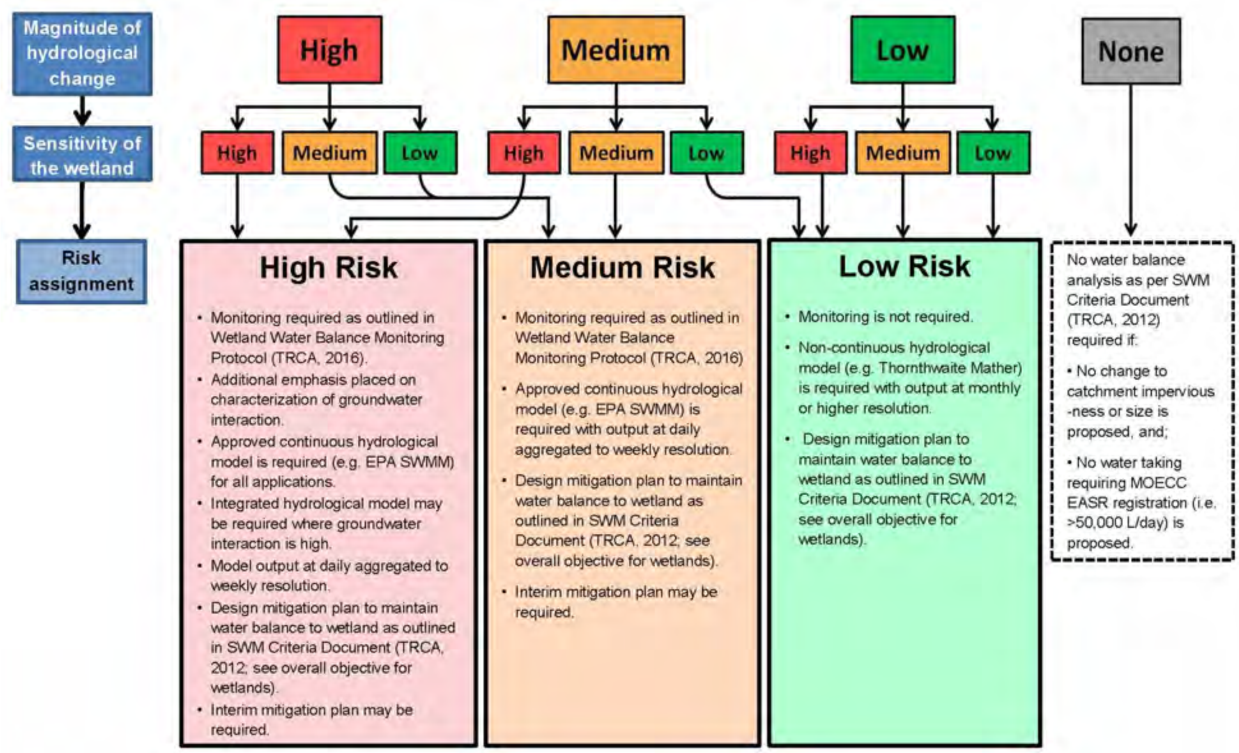


Figure 12 - Wetland Risk Evaluation Decision Tree (TRCA, 2017)

5.0 Conclusions and Recommendations

The following conclusions are provided:

1. The Site is located on the Haldimand Clay Plain on a regional aquitard of silty clay soils.

2. The wetlands are both palustrine and riverine, perched on low permeability silty clay, consisting of either surface water depression or surface water slope wetlands.

3. A monthly water balance for the wetlands identified potential evapotranspiration as exceeding precipitation for June, July, and August, with soil water holding capacities less than saturated for June through October.

4. Monthly runoff modelling completed by NPCA reported runoff amounts for June, July, August, September and October of 11.8, 3.0, 3.1, 4.3 and 6.0 mm/month, respectively.

5. Pre-development monthly water balance modelling for the wetlands indicates most are not dependent upon upgradient runoff.

6. Residential development of the Site should not negatively impact the hydrology of the wetlands. However, three areas have been identified to need an increase to the amount of clean runoff to maintain pre-development June and October hydroperiods.

The following recommendations are provided:

1. Implement rear yard and roof lot drainage towards wetlands for lots adjacent to wetlands; and
2. Implement the wetland, woodland, top of slope and floodplain buffers as recommended by Dillon Consulting Inc. (2022).
3. In addition to the proposed buffers, design additional clean runoff to flow to (a) the Northwest Welland River Wetland, (b) Grassy Brook River East Wetland within Catchment 9 and (c) the Lyons Creek East Wetland within Catchments 16 and 17.
4. Continue the groundwater level monitoring program, including the additional manual and datalogger measurements and hydraulic conductivity testing at select shallow monitoring wells.
5. Implement three new staff gauge stations along Lyons Creek to further characterize the wetland hydroperiods.
6. Complete flow monitoring at the Grassy Brook outlet to determine if flow changes are related to Welland River fluctuations from Ontario Power Generation operations.

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

cc. John Castro, Empire
Michael Audoung, Armstrong

PROFESSIONAL ENGINEER
J. D. CAMPBELL
PROVINCE OF ONTARIO

Attachments
Figure 1 – Location of Subject Lands
Figure 2 – Monitoring Base Map
Figure 3 – Subwatersheds
Figure 4 – Geologic Cross-Section A-A' south-north
Figure 5 – Geologic Cross-Section B-B' west-east
Figure 6 – Potentiometric Surface
Figure 7 – Soils
Figure 10 – Surface Water and Wetland Catchments
Figure 11 – Wetland Hydrologic Classifications
Table 11 – USGS Monthly Wetland Water Balances
Table 13 – Wetland Runoff Water Balances
Appendix A – Terms of Reference
Appendix B – Supporting Information
Appendix C – Hydrographs
Appendix D - Photographs

6.0 References

AquaResource Inc. and Niagara Peninsula Conservation Authority (NPCA), 2009. Water Availability Study for South Niagara Falls and Lower Welland River Watershed Plan Areas, Niagara Peninsula Source Protection Area.

Burt, A.K., 2020. Results of the 2014-2017 drilling programs on the Niagara Peninsula: Graphic logs, descriptions and analytical data; Ontario Geological Survey, Miscellaneous Release – Data 383.

Chapman, L.J., and Putnam, D.F., 1984. The Physiography of Southern Ontario. Ontario Geological Survey, Special Volume 2, 270 p.

City of Niagara Falls, 2022. Pre-consultation, 8547 Grassy Brook Rd & unaddressed parcels on Grassy Brook Rd, ECMI LP, Armstrong Planning.

City of Niagara Falls, 2019. Official Plan for the City of Niagara Falls.

Conservation Ontario, 2013. Hydrogeological Assessment Submissions, Conservation Authority Guidelines for Development Applications.

Dillon Consulting Limited, 2022. Draft EIS Addendum, Empire Grand Niagara.

Environment and Climate Canada, 2022a. Monthly Daily Precipitation and Temperature, Welland Station, ID 6139445.

Environment and Climate Change Canada, 2022b. Climate Normals 1981-2010 Niagara Falls NPCSH Station, ID 6135657.

Environment and Climate Change Canada, 2022c. Climate Normals 1981-2010 Welland Station, ID 6139445.

Feenstra, B.H., 1984. Quaternary Geology of the Niagara-Welland Area, Map 2496. Ontario Geological Survey.

Feenstra, B.H., 1981. Quaternary Geology and Industrial Minerals of the Niagara-Welland Area, Southern Ontario, Ontario Geological Survey OFR 5361, 260 pages.

Gartner Lee Limited (GLL), 1987. Water Resources of the Niagara Frontier and the Welland River Drainage Basin. Prepared for the Ontario Ministry of the Environment.

Gartner Lee Limited (GLL), 1985. Site Selection Process – Phase 4A, Technical Appendix PI-27E, Geologic, Hydrogeologic, and Geotechnical Considerations. Prepared for the Ontario Waste Management Corporation.

GeoTerre Limited, 2021. Preliminary Geotechnical Investigation Report, Proposed Grand Niagara Residential Subdivision, 8547 Grassy Brook Road, Niagara Falls, Ontario. Prepared for Grand Niagara, c/o Rand Engineering Corporation.

Grand Niagara Golf Club, 2022. Re: Grand Niagara – Existing Permit to Take Water, e-mail from John Taylor (Property Manager) to Jayme Campbell (Senior Water Resource Engineer, Terra-Dynamics).

Kingston, M.S. and Presant, E.W., 1989. The Soils of the Regional Municipality of Niagara, Report No.60 of the Ontario Institute of Pedology, Volume 1.

Marshall Macklin Monaghan, 1989. Watershed Hydrology Study, completed for the Niagara Peninsula Conservation Authority.

McCabe, G.J., and Markstrom, S.L., 2007. A monthly water-balance model driven by a graphical user interface. U.S. Geological Survey Open-File report 2007-1008, 6p.

Ministry of the Environment, (Conservation and Parks), 2003. Stormwater Management Planning and Design Manual.

Ministry of Natural Resources and Forestry (MNRF), 2009a. Lower Grassy Brook Wetland Complex, Wetland Evaluation Edition 3rd.

Ministry of Natural Resources and Forestry (MNRF), 2009b. Welland River East Wetland Complex, Wetland Evaluation Edition 3rd.

Mitsch, W.J., and Gosselink, J.G., 2007. *Wetlands*, 4th Edition.

Niagara Navigator, 2022. Aerial photography.

Niagara Peninsula Conservation Authority (NPCA), 2022. E-mail to the City of Niagara Falls (c/o Ms. Julie Hannah), RE: Empire precon comments.

Niagara Peninsula Conservation Authority (NPCA), 2018. Digital Elevation Model.

Niagara Peninsula Conservation Authority (NPCA), 2017. Contemporary Watercourse Mapping.

Niagara Peninsula Conservation Authority and AquaResource Inc., 2010. Niagara Peninsula Tier 1 Water Budget and Water Quantity Stress Assessment Final Report, Niagara Peninsula Source Protection Area.

Niagara Peninsula Conservation Authority and AquaResource Inc., 2009. Significant Groundwater Recharge Area Delineation, Niagara Peninsula Source Protection Area.

Niagara Peninsula Source Protection Authority, 2013. Assessment Report.

Ontario Geological Survey (OGS), 2003. Surficial geology of southern Ontario. Miscellaneous Release Data – 128. Project Summary and Technical Document, 53 pp.

Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), 2022. AgMaps https://www.gisapplication.lrc.gov.on.ca/AIA/index.html?viewer=AIA.AIA&locale=en-US

Philips Engineering Ltd., 2004. Welland River Fluctuation Study, Draft Final Report. Prepared for the Niagara Peninsula Conservation Authority.

Preene, M., 2020. Conceptual modelling for the design of groundwater control systems. Quarterly Journal of Engineering Geology and Hydrogeology.

Sanderson, M., 2004. Weather and Climate in Southern Ontario. Department of Geography, University of Waterloo, Publication Series Number 58.

Savanta Inc., 2017. Environmental Impact Study, Grand Niagara, Niagara Falls, ON.

Starzynski, H., 2017. Factors affecting water level fluctuations in NPCA monitoring wells. Prepared for the Niagara Peninsula Conservation Authority.

Terrapex Environmental Limited, 2022. Groundwater levels, borehole logs and borehole plan.

Toronto and Region Conservation Authority (TRCA), 2017. Wetland Water Balance Risk Evaluation.

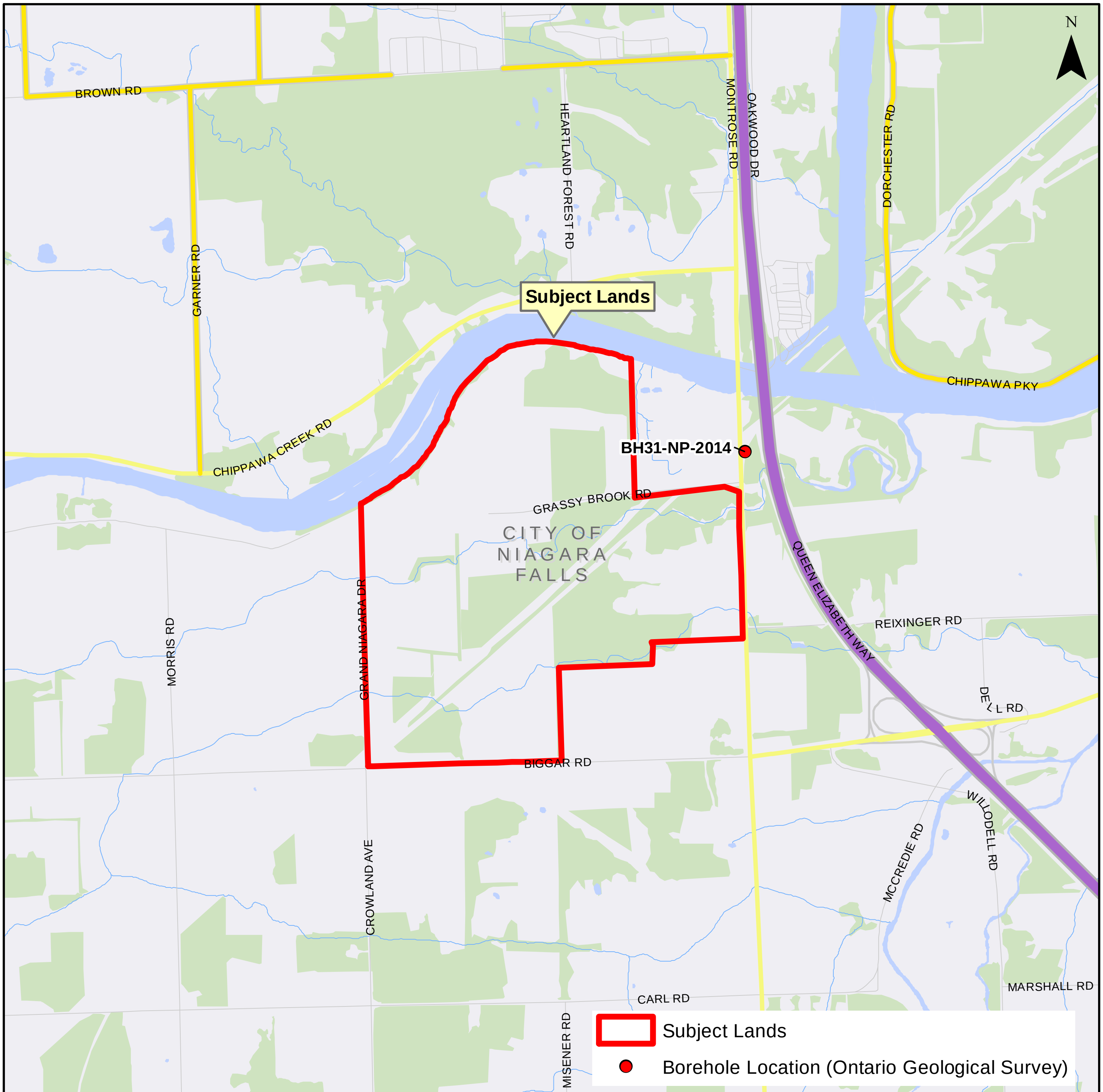
Toronto and Region Conservation Authority (TRCA), 2016. Wetland Water Balance Monitoring Protocol.

Toronto and Region Conservation Authority (TRCA), 2012. Water Balance Guidelines for the Protection of Natural Features.

United States Department of Agriculture (USDA), 1986. Urban Hydrology for Small Watersheds.

WSP, 2022. DRAFT Hydrologic Modelling Results, Draft Plan of Grand Niagara Residential Subdivision, Empire (Grand Niagara) GP Inc.

WSP, 2015. Summary of Findings from Initial Investigation and Proposed Supplementary Phase Two Environmental Site Assessment – Grand Niagara Golf Course, Niagara Falls, Ontario.



Location of Subject Lands

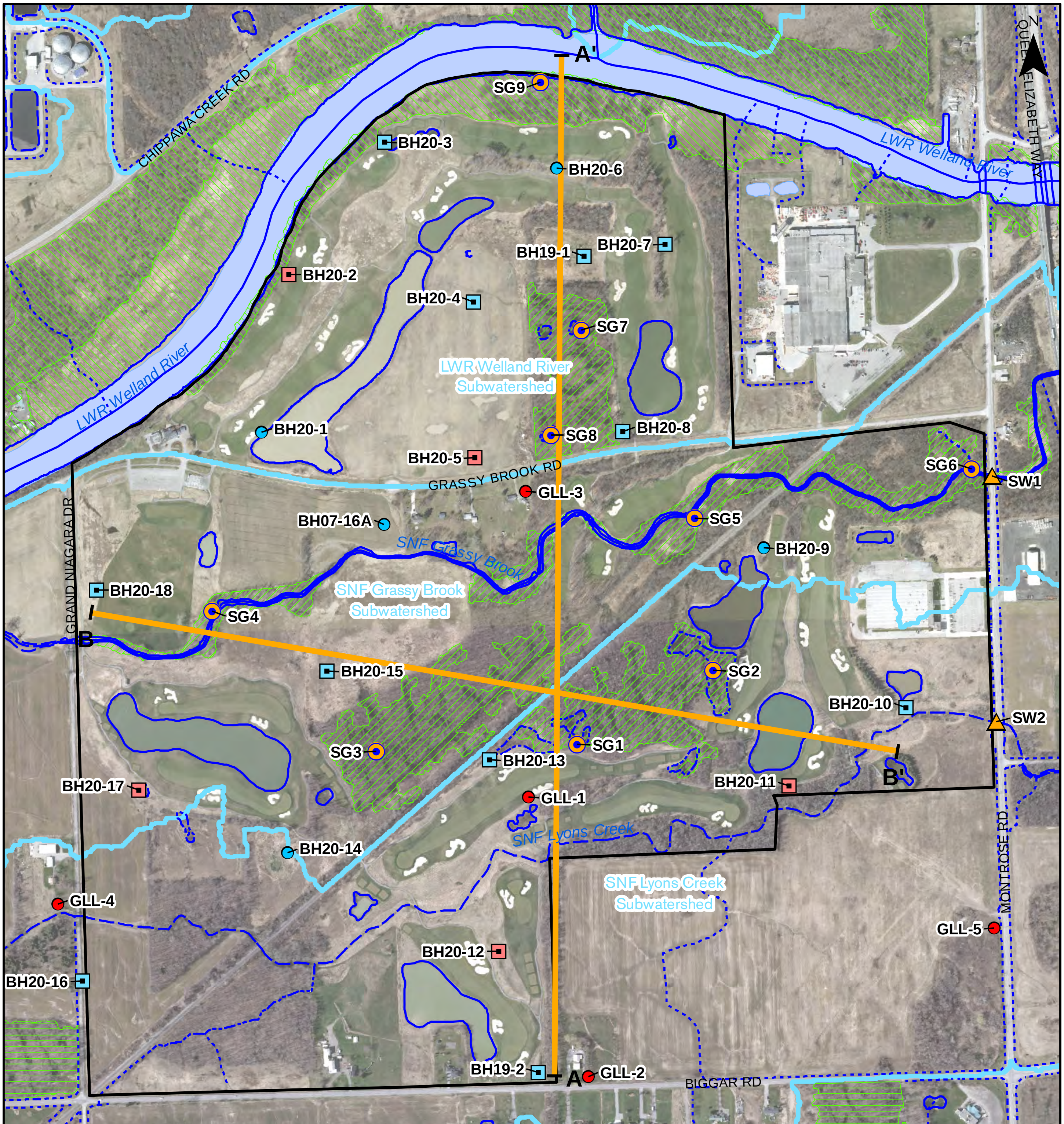
Grand Niagara, Empire (Grand Niagara) GP Inc.
8547 Grassy Brook Road, Niagara Falls, ON.

Terra-Dynamics Consulting Inc.

0 500 Meters
1:25,000

Figure 1

Path: H:\TERRA_DYNAMICS\9559 - TD 8547 Grassy Brook Rd\gis\mxd\Figure 1 Location of Subject Lands.mxd Revised: October 13, 2022



Subject Lands
Borehole (Gartner Lee)
Borehole (GeoTerre)
Surface Water Monitoring
Wetland Staff Gauge
Groundwater Monitoring - Deep
Groundwater Monitoring - Shallow
Subwatershed
Location of Cross-section

Watercourse (NPCA)
Permanent
Permanent or Intermittent
Intermittent or Ephemeral
Ephemeral

Provincially Significant Wetlands
Lower Grassy Brook Wetland Complex
Lyons Creek North Wetland Complex
Welland River East Wetland Complex

Monitoring Base Map

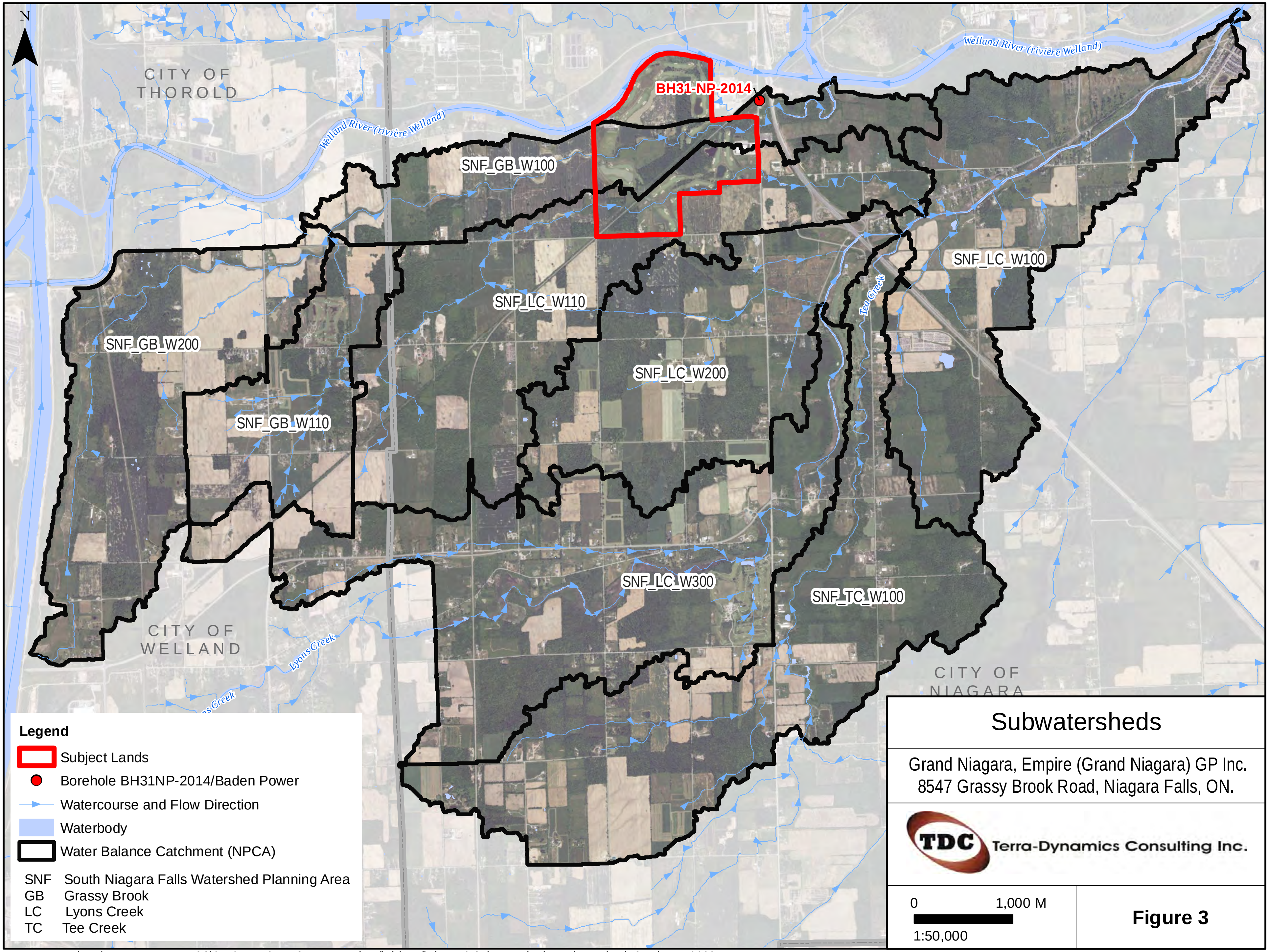
Grand Niagara, Empire (Grand Niagara) GP Inc.
8547 Grassy Brook Road, Niagara Falls, ON.

TDC Terra-Dynamics Consulting Inc.

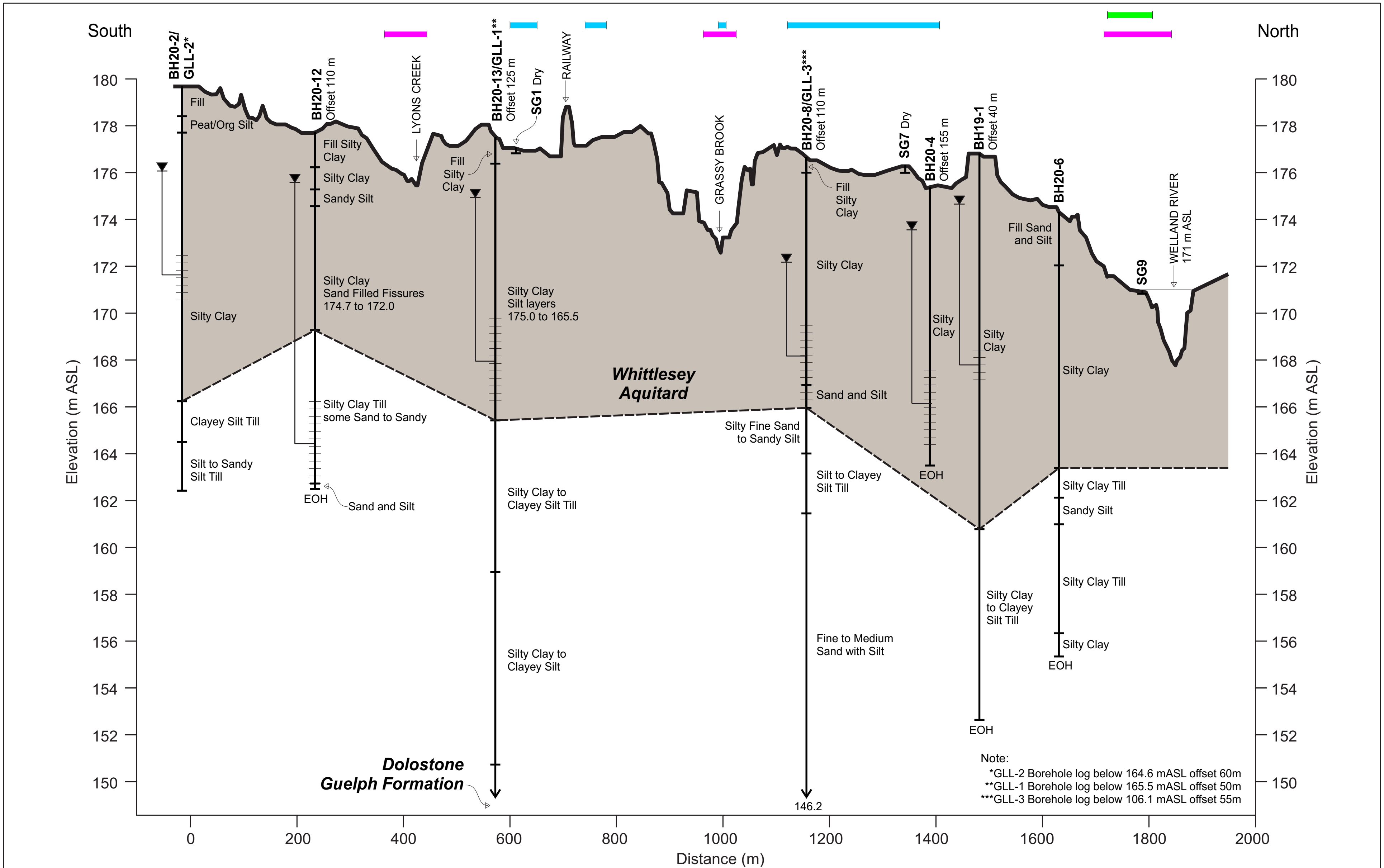
0 200 M
1:10,000

Figure 2

Path: H:\TERRA_DYNAMICS\9559 - TD 8547 Grassy Brook Rd\gis\mxd\Figure 2 Monitoring Base Map.mxd Revised: October 3, 2022



Path: H:\TERRA_DYNAMICS\9559 - TD 8547 Grassy Brook Rd\gis\mxd\Figure 3 Subwatersheds.mxd Revised: October 4, 2022



Borehole
Well Screen
EOH End of Hole
Upper Whittlesey Aquitard
Water Level (August 18, 2022)
Lower Grassy Brook Wetland Complex
Welland River East Wetland Complex
Regulated Floodplain (NPCA)

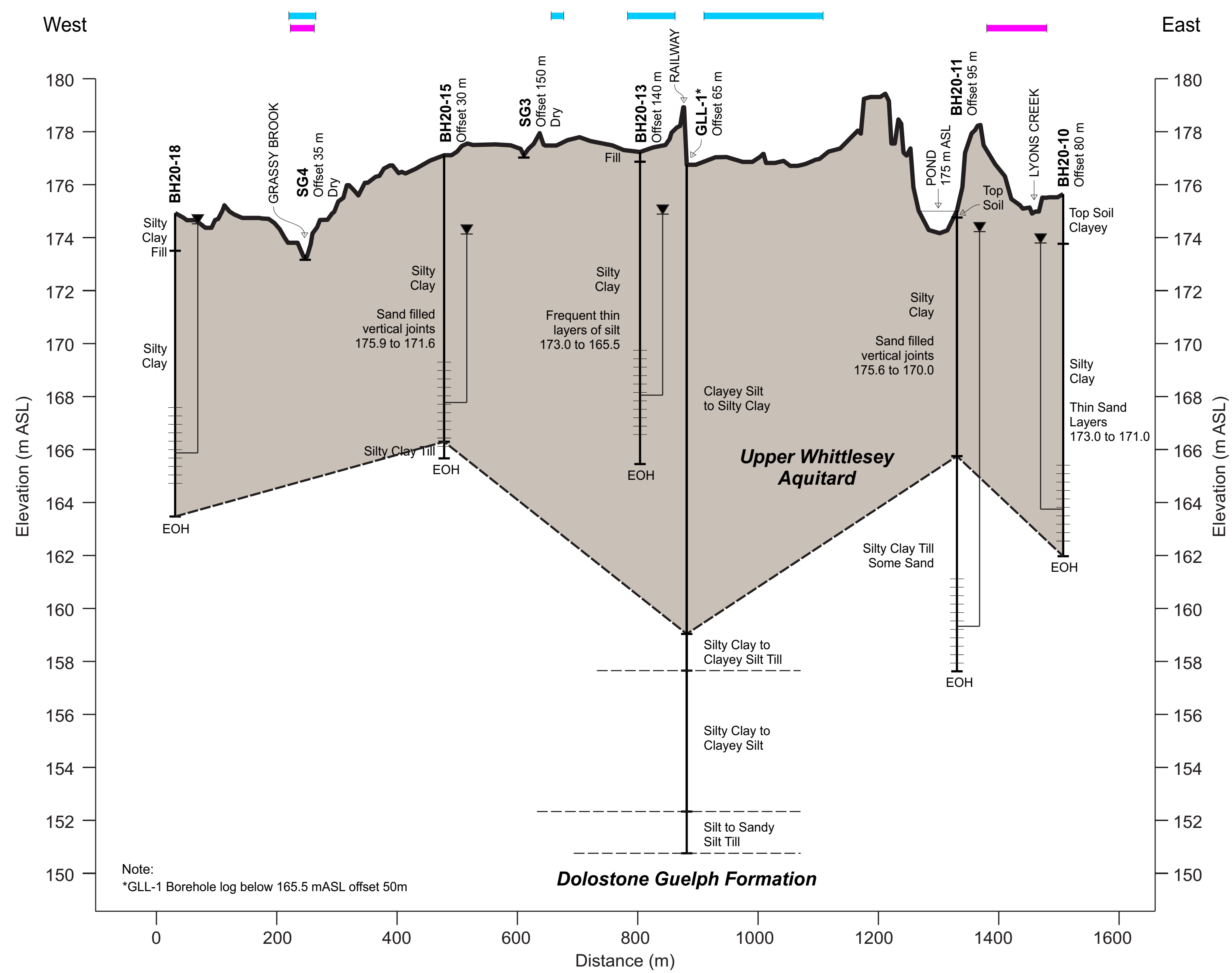
Hydrogeologic Cross-section A-A'

Grand Niagara 8547 Grassy Brook Rd, Niagara Falls ON

TDC Terra-Dynamics Consulting Inc.

Figure 4

H:\TERRA_DYNAMICS\9559 - TD 8547 Grassy Brook Rd\corel\Figure 4 Geologic Cross-section A-A' south-north.cdr Revised: September 30, 2022



Borehole	Water Level (August 18, 2022)		
Well Screen	Lower Grassy Brook Wetland Complex		
EOH End of Hole	Regulated Floodplain (NPCA)		
Upper Whittlesey Aquitard			

Hydrogeologic Cross-section B-B'

Grand Niagara 8547 Grassy Brook Rd, Niagara Falls ON

TDC Terra-Dynamics Consulting Inc.

Figure 5

H:\TERRA_DYNAMICS\9559 - TD 8547 Grassy Brook Rd\corel\Figure 4 Geologic Cross-section B-B' west-east.cdr Revised: September 26, 2022

Appendix A

Terms of Reference

TDC Terra-Dynamics Consulting Inc.
432 Niagara Street, Unit 2 St. Catharines, ON L2M 4W3

Niagara Peninsula Conservation Authority
Regional Municipality of Niagara

April 6, 2022

Re: Hydrogeologic and Water Balance Assessment Proposed Terms of Reference, Grand Niagara Residential Subdivision, 8547 Grassy Brook Road, Niagara Falls, ON

1.0 Introduction and Background Information

Terra-Dynamics Consulting Inc. respectfully submits this proposed Terms of Reference to complete a Hydrogeological and Water Balance Assessment for the proposed Grand Niagara Subdivision (the Site).

The Site is presently part of a golf course and is approximately 170 hectares in size with 110 hectares planned for development. This scope of work is based upon pre-consultation records (NPCA, 2022 and City of Niagara Falls, 2022), correspondence with Armstrong Planning and our experience in the Niagara Peninsula with the physical environment. Our current understanding of study requirements are detailed below per topic after an initial review of information provided by Armstrong Planning including a geotechnical investigation report (GeoTerre, 2021) and an Environmental Impact Study (Savanta, 2017).

2.0 Scope of Work

2.1 Hydrogeological Assessment

A hydrogeological assessment will be completed following the Conservation Authority Guidelines for Hydrogeological Assessments (see attached Table 1, Conservation Ontario, 2013).

The hydrogeological assessment will include (i) a description of existing conditions, (ii) an impact assessment and (iii) recommended mitigation measures for a subdivision on municipal servicing. However, it is proposed at this time to not include a private well survey as Niagara Region mapping shows the Site as having municipal servicing. However, the need for a water well survey can be determined as part of future dewatering analyses. The Site's geologic and hydrogeologic setting will be described. Available geologic information will be summarized and documented from existing and future geotechnical investigations as well as historic studies of the Site.

The following features require particular attention in the hydrogeological assessment:

(i) Provincially significant swamp wetland areas associated with the Lower Grassie Brook Wetland Complex as well as portions of the Welland River East Wetland Complex (MNRF, 2009); and

(ii) Watercourses including Grassy Brook, Lyons Creek and the Welland River.

Groundwater levels will be manually measured at the existing on-Site sixteen (16) monitoring wells in the spring, summer and fall for the hydrogeological assessment. Water levels will also be measured using datalogging pressure transducers at the wetland and surface water level locations required for the wetland water balance assessment.

2.2 Water Balance Assessment

A water balance assessment, both Site and feature-based wetland, is required for development of the Site (NPCA, 2022 and City of Niagara Falls, 2022 and Savanta, 2017). Agency water balance requirements include to:

1. Submit the water balance study Terms of Reference to NPCA prior to proceeding (NPCA, 2022);

2. "*Ensure no negative impacts to the natural heritage system*" (City of Niagara Falls, 2022);

3. Inform stormwater management design at the Site "*in such a manner that pre-development water balance conditions are maintained for all wetlands in the Natural Heritage System Designation. A detailed water balance will be required as part of a stormwater management plan*" submission (City of Niagara Falls, 2019); and

4. "*PSW Wetlands …be conserved, with the successful matching of pre and post development water balances*" (Savanta, 2017). Savanta (2017) identified for particular consideration a feature-based water balance the "*treed swamp north of Grassy Brook Road*".

2.2.1 Field Investigation

Wetland hydroperiod characterization from hydrologic field monitoring will include:

a) nine (9) wetland monitoring staff gauges with datalogging pressure transducers;
b) datalogging pressure transducers installed in five (5) on-site shallow monitoring wells; and
c) surface water monitoring level gauges with datalogging pressure transducers at the two Site outlets on Lyon's Creek and Grassy Brook intermittent watercourses (Savanta, 2017).

Summer period hydrologic monitoring is expected to be the most critical to observe with respect to the swamp wetlands given typical summer dry periods.

2.2.2 Water Balance/Wetland Modelling

The water balance assessment will use existing long-term water balance modelling by NPCA (AquaResource Inc. and Niagara Peninsula Conservation Authority (NPCA), 2009). This modelling was completed at an hourly interval over a fifteen-year period (1991-2005) providing baseline pre-development water balance values. This approach exceeds the minimum requirements for a "low risk" water balance (Figure 1). Results will be refined with using the information obtained during the geotechnical investigations to provide a more detailed hydrogeological characterization.

A water balance model will be completed for the wetland using the United States Geological Survey (USGS) Thornthwaite Monthly Water Balance (McCabe and Markstrom, 2007). The model provides:

i. A number of adjustable parameters for calibration of pre-development conditions to Niagara Peninsula Conservation Authority (NPCA) water balance modelling (AquaResource Inc. and NPCA, 2009); and

ii. A monthly water balance, as this is commonly sufficient detail for assessing wetland hydrologic function during summer months on low permeability soils.

2.2.3 Wetland Risk Evaluation

Since early 2021, NPCA has been requiring water balances conform to the guidelines (2012), monitoring protocols (2016) and risk evaluations (2017) developed by the Toronto Region Conservation Authority (TRCA). This work program will exceed the requirements for "low risk" evaluation as specified by the TRCA and include completion of a risk evaluation (Figure 1, 2017).

2.2.4 Mitigation

The post-development water balance will consider the proposed storm drainage plan and recommendations provided for the Stormwater Management Plan to improve post-development water management completing the water balance requirement for a "mitigation plan" (Figure 1, TRCA, 2017). It is expected that a mitigation plan can be developed to avoid any requirements for new continuous water balance modelling.

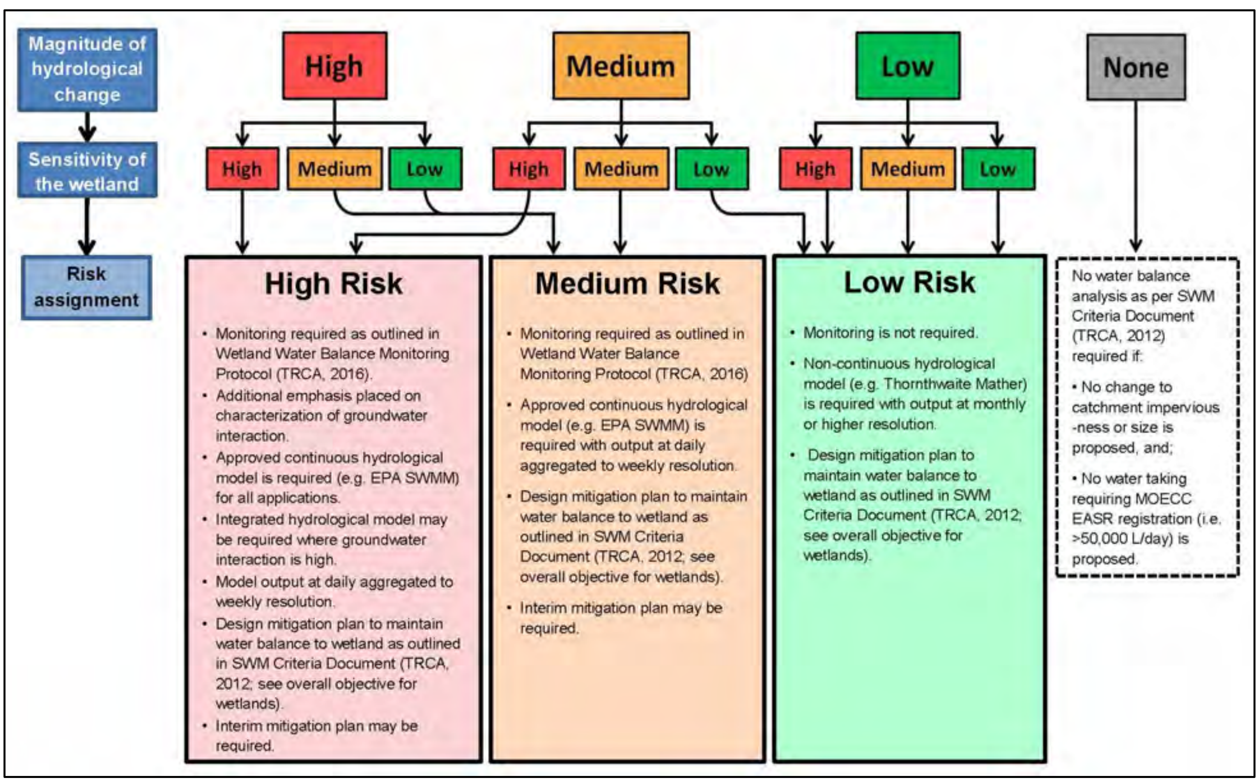


Figure 1 – Wetland Risk Evaluation Decision Tree (TRCA, 2017)

We trust this information is sufficient for your present needs. Thank you for the opportunity to submit this proposed Terms of Reference. 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

cc. Michael Audoung, Armstrong Planning & Project Management
John Castro, Empire Communities
Jeffrey Swartz, Empire Communities
Adele Mochrie, Dillon Consulting Limited

Attachments

Table 1 – Hydrogeological Assessment Check List intended to Support Development Applications

3.0 References

AquaResource Inc. and Niagara Peninsula Conservation Authority (NPCA), 2009. Water Availability Study for South Niagara Falls and Lower Welland River Watershed Plan Areas, Niagara Peninsula Source Protection Area.

City of Niagara Falls, 2022. Pre-consultation, 8547 Grassy Brook Rd & unaddressed parcels on Grassy Brook Rd, ECMI LP, Armstrong Planning.

City of Niagara Falls, 2019. Official Plan for the City of Niagara Falls.

Conservation Ontario, 2013. Hydrogeological Assessment Submissions, Conservation Authority Guidelines for Development Applications.

GeoTerre Limited, 2021. Preliminary Geotechnical Investigation Report, Proposed Grand Niagara Residential Subdivision, 8547 Grassy Brook Road, Niagara Falls, Ontario. Prepared for Grand Niagara, c/o Rand Engineering Corporation.

McCabe, G.J., and Markstrom, S.L., 2007. A monthly water-balance model driven by a graphical user interface. U.S. Geological Survey Open-File report 2007-1008, 6p.

Ministry of Natural Resources and Forestry (MNRF), 2009. Lower Grassy Brook Wetland Complex, Wetland Evaluation Edition 3rd.

Ministry of Natural Resources and Forestry (MNRF), 2009. Welland River East Wetland Complex, Wetland Evaluation Edition 3rd.

Niagara Peninsula Conservation Authority (NPCA), 2022. E-mail to the City of Niagara Falls (c/o Ms. Julie Hannah), RE: Empire precon comments.

Niagara Peninsula Conservation Authority and AquaResource Inc., 2010. Niagara Peninsula Tier 1 Water Budget and Water Quantity Stress Assessment Final Report, Niagara Peninsula Source Protection Area.

Savanta, 2017. Environmental Impact Study, Grand Niagara, Niagara Falls, ON.

Toronto and Region Conservation Authority (TRCA), 2017. Wetland Water Balance Risk Evaluation.

Toronto and Region Conservation Authority (TRCA), 2016. Wetland Water Balance Monitoring Protocol.

Toronto and Region Conservation Authority (TRCA), 2012. Water Balance Guidelines for the Protection of Natural Features.

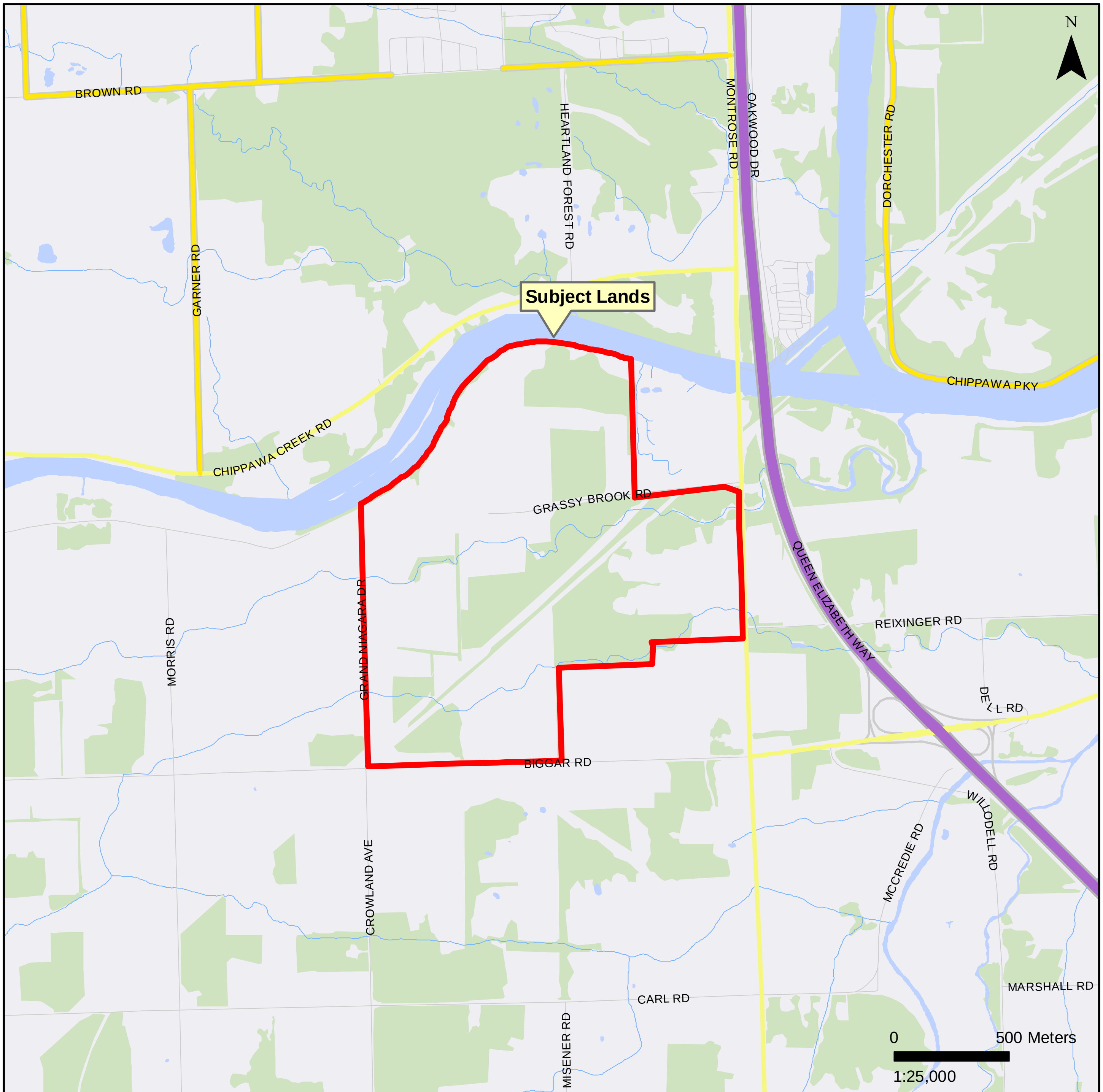
Table 1: Hydrogeological Assessment Check List intended to Support Development Applications

Groundwater Assessment	Master Environmental Servicing Plan or Equivalent	Environmental Assessment (EA)	Site Plan Commercial, Institutional, or Industrial	Subdivision or Condominium Development		Single lot Residential	Dewatering
				Municipal Servicing	Private Servicing		
1. EXISTING CONDITIONS:							
Introduction and background	☐	☐	☐	☐	☐	☐	☐
Site location and description	☐	☐	☐	☐	☐	☐	☐
Description of: • Topography & Drainage • Physiography • Geology & Soils	☐	☐	☐	☐	☐	☐	☐
Test pits/Boreholes	☐	☐	☐	☐	☐	GNR	☐
Monitoring Wells	☐	☐	☐	☐	☐	GNR	☐
Private Well Survey	☐	☐	☐	☐	☐	GNR	☐
Hydrostratigraphy/Hydrogeology: • Aquifer properties • Groundwater Levels • Groundwater flow direction	☐	☐	☐	☐	☐	☐	☐
Description of surface water features and functions	☐	☐	☐	☐	☐	☐	☐
Water Taking Permit details	GNR	GNR	GNR	GNR	GNR	GNR	☐
Water Quality	☐	☐	☐	☐	☐	GNR	☐
D-5-5 (Water Supply)	GNR	GNR	GNR	GNR	☐	GNR	GNR

Groundwater Assessment	Master Environmental Servicing Plan or Equivalent	Environmental Assessment (EA)	Site Plan Commercial, Institutional, or Industrial	Subdivision or Condominium Development		Single lot Residential	Dewatering
				Municipal Servicing	Private Servicing		
2. IMPACT ASSESSMENT:							
Groundwater Levels	☐	☐	☐	☐	☐	GNR	☐
Pumping Tests*	☐	☐	GNR	GNR	☐	GNR	☐
Groundwater Discharge (Baseflow)	☐	☐	☐	☐	☐	GNR	☐
Water Balance	☐	☐	☐	☐	☐	GNR	GNR
Groundwater Quality	☐	☐	☐	☐	☐	GNR	☐
D-5-4 (Onsite Sewage Systems)	GNR	GNR	GNR	GNR	☐	GNR	GNR
3. MITIGATION MEASURES:							
Maintenance of Infiltration/Recharge	☐	☐	☐	☐	☐	GNR	GNR
Maintenance Groundwater Quality	☐	☐	☐	☐	☐	GNR	☐
Monitoring Program	☐	☐	☐	☐	☐	GNR	☐
Contingency Plans**	GNR	GNR	GNR	☐	☐	GNR	☐

NOTES: This table outlines the type of planning application and associated requirements most commonly required by Conservation Authorities in the review of Hydrogeological Assessments. This table is not a complete list of all types of applications dealt with by each Conservation Authority nor is the checklist appropriate for every development situation. Individual Conservation Authorities should be consulted with for specific requirements.

☐ - *Recommended*
GNR – Generally Not Required
** Where development is municipally serviced, these tests will be necessary on a case by case basis (sensitive aquifer/ aquatic considerations).*
***May be scoped, Contingency Plans will not be needed in most cases.*



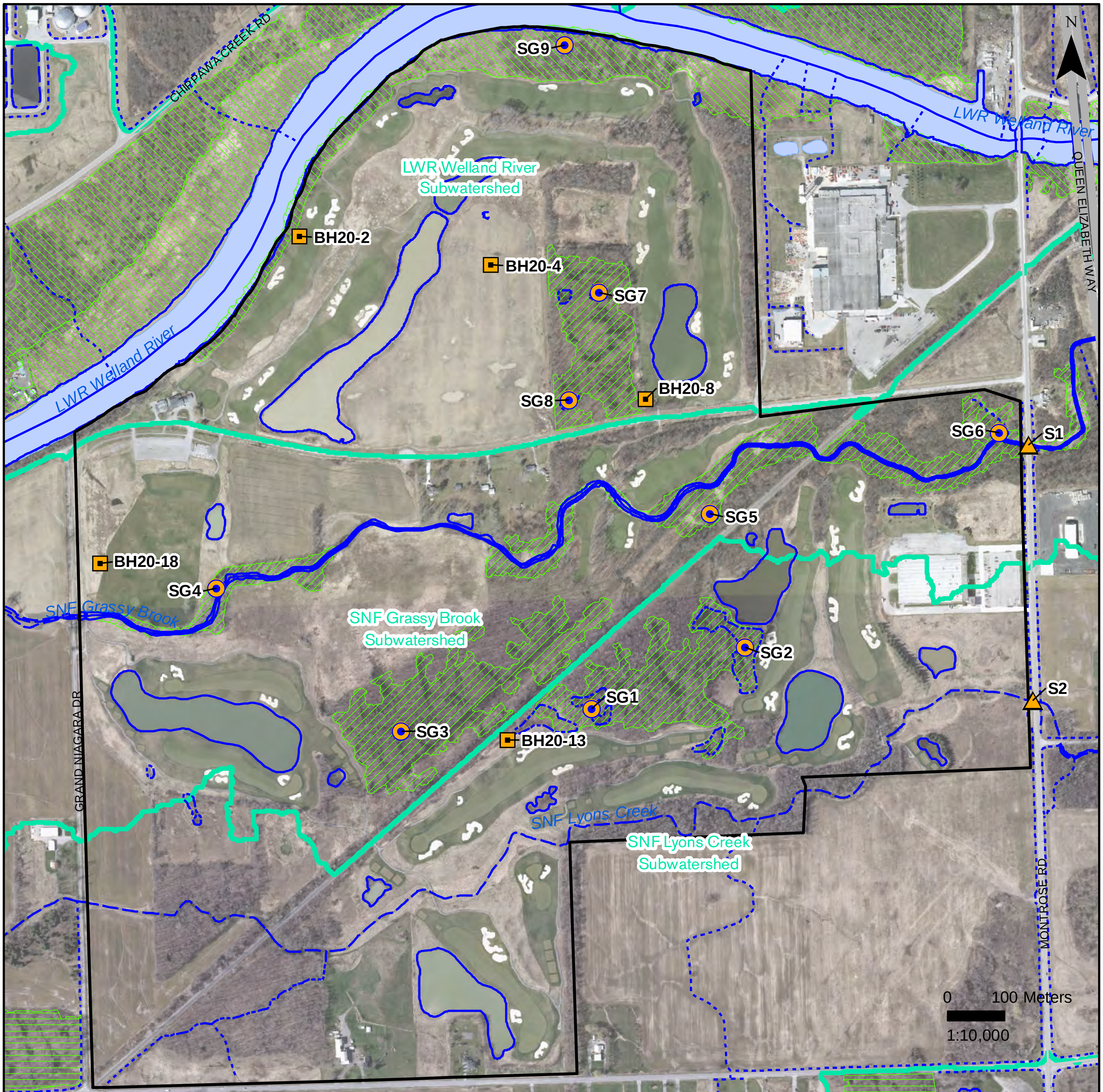
Location of Subject Lands

Grand Niagara, Empire (Grand Niagara) GP Inc.
8547 Grassy Brook Road, Niagara Falls, ON.

TDC Terra-Dynamics Consulting Inc.

Figure 1

Path: H:\TERRA_DYNAMICS\9559 - TD 8547 Grassy Brook Rd\gis\mxd\Figure 1 Location of Subject Lands.mxd Revised: May 10, 2022



Subject Lands

Surface Water Monitoring

Wetland Staff Gauge

Groundwater Monitor

Subwatershed

Watercourse (NPCA)

Permanent

Permanent or Intermittent

Intermittent or Ephemeral

Ephemeral

Provincially Significant Wetlands

Lower Grassy Brook Wetland Complex

Lyons Creek North Wetland Complex

Welland River East Wetland Complex

Monitoring Base Map

Grand Niagara, Empire (Grand Niagara) GP Inc.
8547 Grassy Brook Road, Niagara Falls, ON.

Terra-Dynamics Consulting Inc.

Figure 2

Path: H:\TERRA_DYNAMICS\9559 - TD 8547 Grassy Brook Rd\gis\mxd\Figure 2 Monitoring Base Map.mxd Revised: May 10, 2022

jcampbell@terra-dynamics.com

From:	Boudens, Adam <Adam.Boudens@niagararegion.ca>
Sent:	May 4, 2022 1:34 PM
To:	jcampbell@terra-dynamics.com; Lampman, Cara
Cc:	'Michael Auduong'; 'John Castro'; JSwartz@empirecommunities.com; 'Mochrie, Adele'; D Deluce; Sarah Mastroianni; Loiacono, Johnpaul
Subject:	RE: Grand Niagara Hydrogeological Water Balance Terms of Reference
Attachments:	Grand Niagara Hydrogeological Water Balance Terms of Reference 2022-04-06.pdf

Hi Jayme,

Thanks for your patience. Regional Environmental Planning staff have reviewed the Hydrogeological Water Balance Terms of Reference and offer no objection to the work plan proposed.

Please do not hesitate to reach out with any questions.

Best regards,
Adam

Adam Boudens
Senior Environmental Planner/Ecologist

Planning and Development Services, Niagara Region
1815 Sir Isaac Brock Way, P.O. Box 1042
Thorold, ON L2V 4T7
Phone: **905-980-6000 ext. 3770** Toll-free: 1-800-263-7215
Adam.Boudens@niagararegion.ca

From: jcampbell@terra-dynamics.com <jcampbell@terra-dynamics.com>
Sent: Wednesday, April 6, 2022 1:23 PM
To: 'Jessica Abrahamse' <jabrahamse@npca.ca>; Lampman, Cara <Cara.Lampman@niagararegion.ca>; Boudens, Adam <Adam.Boudens@niagararegion.ca>
Cc: 'Michael Auduong' <michael@armstrongplan.ca>; 'John Castro' <JCastro@empirecommunities.com>; JSwartz@empirecommunities.com; 'Mochrie, Adele' <amochrie@dillon.ca>
Subject: Grand Niagara Hydrogeological Water Balance Terms of Reference

Good afternoon Jessica, Cara and Adam,

Please find attached as requested during pre-consultation, a proposed hydrogeology water balance terms of reference regarding the Grand Niagara site for your review and comment.

If you have any questions regarding the attached please feel free to contact me directly.

Jayme D. Campbell, P.Eng.
Senior Water Resource Engineer
Terra-Dynamics Consulting Inc.
432 Niagara Street, Unit 2, St. Catharines, Ontario L2M 4W3
Phone: 289-407-0915
https://terra-dynamics.com/

Common sense solutions to environmental challenges

---

jcampbell@terra-dynamics.com

From:	Nicholas Godfrey <ngodfrey@npca.ca>
Sent:	May 4, 2022 3:03 PM
To:	jcampbell@terra-dynamics.com
Cc:	Sarah Mastroianni; Boudens, Adam
Subject:	RE: Grand Niagara Hydrogeological Water Balance Terms of Reference

Good afternoon Jayme,

Our office has reviewed the Hydrogeologic and Water Balance Assessment Proposed Terms of Reference, Grand Niagara Residential Subdivision prepared by Terra-Dynamics Consulting Inc., dated April 6, 2022. NPCA staff are generally supportive of the proposed scope of work. We note the following comments to incorporate into a revised ToR:

1. The Terms of Reference has identified that 9 wetland monitoring stations, 5 shallow groundwater monitoring wells and 2 surface water monitoring stations will be established and/or instrumented with datalogging pressure transducers within the study area. Please provide a figure which identifies the proposed monitoring locations.
2. The Terms of Reference does not specify the intended duration of monitoring. Please identify the duration of monitoring.
3. The Terms of Reference does not discuss catchments of the wetlands and watercourses present within the study area. Pre and post development catchments must be clearly identified and documented in the report and within a figure.

Please let me know if you require further information or clarification.

Best,

Nicholas Godfrey, M.A.
Watershed Planner
Niagara Peninsula Conservation Authority (NPCA)
250 Thorold Road West, 3rd Floor, Welland, ON, L3C 3W2
905-788-3135, ext. 278
ngodfrey@npca.ca
www.npca.ca

From: jcampbell@terra-dynamics.com <jcampbell@terra-dynamics.com>
Sent: Wednesday, May 4, 2022 1:36 PM
To: 'Boudens, Adam' <Adam.Boudens@niagararegion.ca>; 'Lampman, Cara' <Cara.Lampman@niagararegion.ca>

Cc: 'Michael Auduong' <michael@armstrongplan.ca>; 'John Castro' <JCastro@empirecommunities.com>; JSwartz@empirecommunities.com; 'Mochrie, Adele' <amochrie@dillon.ca>; David Deluce <ddeluce@npca.ca>; Sarah Mastroianni <smastroianni@npca.ca>; 'Loiacono, Johnpaul' <Johnpaul.Loiacono@niagararegion.ca>
Subject: RE: Grand Niagara Hydrogeological Water Balance Terms of Reference

Good afternoon Adam,

Thank you for your reply.

Do you know if NPCA will be providing their own review? I understand you are separate agencies but perhaps you know?

Thank you.

Jayme D. Campbell, P.Eng.
Senior Water Resource Engineer
Terra-Dynamics Consulting Inc.
432 Niagara Street, Unit 2, St. Catharines, Ontario L2M 4W3
Phone: 289-407-0915
https://terra-dynamics.com/

Common sense solutions to environmental challenges

From: Boudens, Adam <Adam.Boudens@niagararegion.ca>
Sent: May 4, 2022 1:34 PM
To: jcampbell@terra-dynamics.com; Lampman, Cara <Cara.Lampman@niagararegion.ca>
Cc: 'Michael Auduong' <michael@armstrongplan.ca>; 'John Castro' <JCastro@empirecommunities.com>; JSwartz@empirecommunities.com; 'Mochrie, Adele' <amochrie@dillon.ca>; D Deluce <ddeluce@npca.ca>; Sarah Mastroianni <smastroianni@npca.ca>; Loiacono, Johnpaul <Johnpaul.Loiacono@niagararegion.ca>
Subject: RE: Grand Niagara Hydrogeological Water Balance Terms of Reference

Hi Jayme,

Thanks for your patience. Regional Environmental Planning staff have reviewed the Hydrogeological Water Balance Terms of Reference and offer no objection to the work plan proposed.

Please do not hesitate to reach out with any questions.

Best regards,
Adam

Adam Boudens
Senior Environmental Planner/Ecologist

Planning and Development Services, Niagara Region
1815 Sir Isaac Brock Way, P.O. Box 1042
Thorold, ON L2V 4T7
Phone: **905-980-6000 ext. 3770** Toll-free: 1-800-263-7215
Adam.Boudens@niagararegion.ca

From: jcampbell@terra-dynamics.com <jcampbell@terra-dynamics.com>
Sent: Wednesday, April 6, 2022 1:23 PM
To: 'Jessica Abrahamse' <jabrahamse@npca.ca>; Lampman, Cara <Cara.Lampman@niagararegion.ca>; Boudens, Adam <Adam.Boudens@niagararegion.ca>
Cc: 'Michael Auduong' <michael@armstrongplan.ca>; 'John Castro' <JCastro@empirecommunities.com>; JSwartz@empirecommunities.com; 'Mochrie, Adele' <amochrie@dillon.ca>
Subject: Grand Niagara Hydrogeological Water Balance Terms of Reference

Good afternoon Jessica, Cara and Adam,

Please find attached as requested during pre-consultation, a proposed hydrogeology water balance terms of reference regarding the Grand Niagara site for your review and comment.

If you have any questions regarding the attached please feel free to contact me directly.

Jayme D. Campbell, P.Eng.
Senior Water Resource Engineer
Terra-Dynamics Consulting Inc.
432 Niagara Street, Unit 2, St. Catharines, Ontario L2M 4W3
Phone: 289-407-0915
https://terra-dynamics.com/

Common sense solutions to environmental challenges

Due to the COVID-19 pandemic, the NPCA has taken measures to protect staff and public while providing continuity of services. The NPCA main office is open by appointment only with limited staff, please refer to the Staff Directory and reach out to the staff member you wish to speak or meet with directly. Our Conservation Areas are currently open, but may have modified amenities and/or regulations.

Updates regarding NPCA operations and activities can be found at Get Involved NPCA Portal, or on social media at

NPCA's Facebook Page & NPCA's Twitter page.

jcampbell@terra-dynamics.com

From:	jcampbell@terra-dynamics.com
Sent:	May 10, 2022 1:16 PM
To:	'ngodfrey@npca.ca'
Cc:	'Sarah Mastroianni'; Adam.Boudens@niagararegion.ca; 'Michael Auduong'; 'John Castro'; JSwartz@empirecommunities.com; 'Mochrie, Adele'
Subject:	RE: Grand Niagara Hydrogeological Water Balance Terms of Reference
Attachments:	Figure 2 Monitoring Base Map.pdf; Figure 1 Location of Subject Lands.pdf

Good afternoon Nicolas,

Thank you for your email, please find attached a figure showing the location of the monitoring stations as requested.

Monitoring is proposed to be completed for a year.

Pre- and post development catchments will be determined, mapped, documented and used for the water balance analyses.

Jayme D. Campbell, P.Eng.
Senior Water Resource Engineer
Terra-Dynamics Consulting Inc.
432 Niagara Street, Unit 2, St. Catharines, Ontario L2M 4W3
Phone: 289-407-0915
https://terra-dynamics.com/

Common sense solutions to environmental challenges

From: Nicholas Godfrey <ngodfrey@npca.ca>
Sent: May 4, 2022 3:03 PM
To: jcampbell@terra-dynamics.com
Cc: Sarah Mastroianni <smastroianni@npca.ca>; Boudens, Adam <Adam.Boudens@niagararegion.ca>
Subject: RE: Grand Niagara Hydrogeological Water Balance Terms of Reference

Good afternoon Jayme,

Our office has reviewed the Hydrogeologic and Water Balance Assessment Proposed Terms of Reference, Grand Niagara Residential Subdivision prepared by Terra-Dynamics Consulting Inc., dated April 6, 2022. NPCA staff are generally supportive of the proposed scope of work. We note the following comments to incorporate into a revised ToR:

1. The Terms of Reference has identified that 9 wetland monitoring stations, 5 shallow groundwater monitoring wells and 2 surface water monitoring stations will be established and/or instrumented with datalogging pressure transducers within the study area. Please provide a figure which identifies the proposed monitoring locations.
2. The Terms of Reference does not specify the intended duration of monitoring. Please identify the duration of monitoring.

3. The Terms of Reference does not discuss catchments of the wetlands and watercourses present within the study area. Pre and post development catchments must be clearly identified and documented in the report and within a figure.

Please let me know if you require further information or clarification.

Best,

Nicholas Godfrey, M.A.
Watershed Planner
Niagara Peninsula Conservation Authority (NPCA)
250 Thorold Road West, 3rd Floor, Welland, ON, L3C 3W2
905-788-3135, ext. 278
ngodfrey@npca.ca
www.npca.ca

From: jcampbell@terra-dynamics.com <jcampbell@terra-dynamics.com>
Sent: Wednesday, May 4, 2022 1:36 PM
To: 'Boudens, Adam' <Adam.Boudens@niagararegion.ca>; 'Lampman, Cara' <Cara.Lampman@niagararegion.ca>
Cc: 'Michael Auduong' <michael@armstrongplan.ca>; 'John Castro' <JCastro@empirecommunities.com>; JSwartz@empirecommunities.com; 'Mochrie, Adele' <amochrie@dillon.ca>; David Deluce <ddeluce@npca.ca>; Sarah Mastroianni <smastroianni@npca.ca>; 'Loiacono, Johnpaul' <Johnpaul.Loiacono@niagararegion.ca>
Subject: RE: Grand Niagara Hydrogeological Water Balance Terms of Reference

Good afternoon Adam,

Thank you for your reply.

Do you know if NPCA will be providing their own review? I understand you are separate agencies but perhaps you know?

Thank you.

Jayme D. Campbell, P.Eng.
Senior Water Resource Engineer
Terra-Dynamics Consulting Inc.
432 Niagara Street, Unit 2, St. Catharines, Ontario L2M 4W3
Phone: 289-407-0915
https://terra-dynamics.com/

Common sense solutions to environmental challenges

From: Boudens, Adam <Adam.Boudens@niagararegion.ca>
Sent: May 4, 2022 1:34 PM
To: jcampbell@terra-dynamics.com; Lampman, Cara <Cara.Lampman@niagararegion.ca>
Cc: 'Michael Auduong' <michael@armstrongplan.ca>; 'John Castro' <JCastro@empirecommunities.com>; JSwartz@empirecommunities.com; 'Mochrie, Adele' <amochrie@dillon.ca>; D Deluce <ddeluce@npca.ca>; Sarah Mastroianni <smastroianni@npca.ca>; Loiacono, Johnpaul <Johnpaul.Loiacono@niagararegion.ca>
Subject: RE: Grand Niagara Hydrogeological Water Balance Terms of Reference

Hi Jayme,

Thanks for your patience. Regional Environmental Planning staff have reviewed the Hydrogeological Water Balance Terms of Reference and offer no objection to the work plan proposed.

Please do not hesitate to reach out with any questions.

Best regards,
Adam

Adam Boudens
Senior Environmental Planner/Ecologist

Planning and Development Services, Niagara Region
1815 Sir Isaac Brock Way, P.O. Box 1042
Thorold, ON L2V 4T7
Phone: **905-980-6000 ext. 3770** Toll-free: 1-800-263-7215
Adam.Boudens@niagararegion.ca

From: jcampbell@terra-dynamics.com <jcampbell@terra-dynamics.com>
Sent: Wednesday, April 6, 2022 1:23 PM
To: 'Jessica Abrahamse' <jabrahamse@npca.ca>; Lampman, Cara <Cara.Lampman@niagararegion.ca>; Boudens, Adam <Adam.Boudens@niagararegion.ca>
Cc: 'Michael Auduong' <michael@armstrongplan.ca>; 'John Castro' <JCastro@empirecommunities.com>; JSwartz@empirecommunities.com; 'Mochrie, Adele' <amochrie@dillon.ca>
Subject: Grand Niagara Hydrogeological Water Balance Terms of Reference

Good afternoon Jessica, Cara and Adam,

Please find attached as requested during pre-consultation, a proposed hydrogeology water balance terms of reference regarding the Grand Niagara site for your review and comment.

If you have any questions regarding the attached please feel free to contact me directly.

Jayme D. Campbell, P.Eng.

Senior Water Resource Engineer
Terra-Dynamics Consulting Inc.
432 Niagara Street, Unit 2, St. Catharines, Ontario L2M 4W3
Phone: 289-407-0915
https://terra-dynamics.com/

Common sense solutions to environmental challenges

Due to the COVID-19 pandemic, the NPCA has taken measures to protect staff and public while providing continuity of services. The NPCA main office is open by appointment only with limited staff, please refer to the Staff Directory and reach out to the staff member you wish to speak or meet with directly. Our Conservation Areas are currently open, but may have modified amenities and/or regulations.

Updates regarding NPCA operations and activities can be found at Get Involved NPCA Portal, or on social media at NPCA's Facebook Page & NPCA's Twitter page.

jcampbell@terra-dynamics.com

From: Nicholas Godfrey <ngodfrey@npca.ca>
Sent: June 2, 2022 2:37 PM
To: jcampbell@terra-dynamics.com
Subject: RE: Grand Niagara Hydrogeological Water Balance Terms of Reference

Good afternoon Jayme,

The proposed changes satisfy our earlier comments.

Best,

Nicholas Godfrey, M.A.
Watershed Planner
Niagara Peninsula Conservation Authority (NPCA)
250 Thorold Road West, 3rd Floor, Welland, ON, L3C 3W2
905-788-3135, ext. 278
ngodfrey@npca.ca
www.npca.ca

> Due to the COVID-19 pandemic, the NPCA has taken measures to protect staff and public while providing continuity of services. The NPCA main office is currently closed with limited staff, please refer to the Staff Directory and reach out to the staff member you wish to speak or meet with directly. Our Conservation Areas are currently open, but may have modified amenities and/or regulations.
>
> Updates regarding NPCA operations and activities can be found at Get Involved NPCA Portal, or on social media at NPCA's Facebook Page & NPCA's Twitter page.

From: jcampbell@terra-dynamics.com <jcampbell@terra-dynamics.com>
Sent: May 11, 2022 1:01 PM
To: Nicholas Godfrey <ngodfrey@npca.ca>
Cc: Sarah Mastroianni <smastroianni@npca.ca>
Subject: RE: Grand Niagara Hydrogeological Water Balance Terms of Reference

Thank you

Jayme D. Campbell, P.Eng.
Senior Water Resource Engineer
Terra-Dynamics Consulting Inc.
432 Niagara Street, Unit 2, St. Catharines, Ontario L2M 4W3
Phone: 289-407-0915
https://terra-dynamics.com/

Common sense solutions to environmental challenges

From: Nicholas Godfrey <ngodfrey@npca.ca>
Sent: May 11, 2022 1:00 PM

To: jcampbell@terra-dynamics.com
Cc: Sarah Mastroianni <smastroianni@npca.ca>
Subject: RE: Grand Niagara Hydrogeological Water Balance Terms of Reference

Hi Jayme,

No – this is the first time I'm receiving this email. I'll circulate to tech staff for review and be in touch shortly.

Thanks Jayme.

Best,

Nicholas Godfrey, M.A.
Watershed Planner
Niagara Peninsula Conservation Authority (NPCA)
250 Thorold Road West, 3rd Floor, Welland, ON, L3C 3W2
905-788-3135, ext. 278
ngodfrey@npca.ca
www.npca.ca

From: jcampbell@terra-dynamics.com <jcampbell@terra-dynamics.com>
Sent: May 11, 2022 12:49 PM
To: Nicholas Godfrey <ngodfrey@npca.ca>
Cc: Sarah Mastroianni <smastroianni@npca.ca>
Subject: FW: Grand Niagara Hydrogeological Water Balance Terms of Reference

Good afternoon Nicholas,

Did my email of yesterday reach you?
I ask because I got a message it bounced back, but perhaps on my end as I have been having some email trouble.

Jayme D. Campbell, P.Eng.
Senior Water Resource Engineer
Terra-Dynamics Consulting Inc.
432 Niagara Street, Unit 2, St. Catharines, Ontario L2M 4W3
Phone: 289-407-0915
https://terra-dynamics.com/

Common sense solutions to environmental challenges

From: jcampbell@terra-dynamics.com <jcampbell@terra-dynamics.com>
Sent: May 10, 2022 1:16 PM

To: 'ngodfrey@npca.ca' <ngodfrey@npca.ca>
Cc: 'Sarah Mastroianni' <smastroianni@npca.ca>; Adam.Boudens@niagararegion.ca; 'Michael Auduong' <michael@armstrongplan.ca>; 'John Castro' <JCastro@empirecommunities.com>; JSwartz@empirecommunities.com; 'Mochrie, Adele' <amochrie@dillon.ca>
Subject: RE: Grand Niagara Hydrogeological Water Balance Terms of Reference

Good afternoon Nicolas,

Thank you for your email, please find attached a figure showing the location of the monitoring stations as requested.

Monitoring is proposed to be completed for a year.

Pre- and post development catchments will be determined, mapped, documented and used for the water balance analyses.

Jayme D. Campbell, P.Eng.
Senior Water Resource Engineer
Terra-Dynamics Consulting Inc.
432 Niagara Street, Unit 2, St. Catharines, Ontario L2M 4W3
Phone: 289-407-0915
https://terra-dynamics.com/

Common sense solutions to environmental challenges

From: Nicholas Godfrey <ngodfrey@npca.ca>
Sent: May 4, 2022 3:03 PM
To: jcampbell@terra-dynamics.com
Cc: Sarah Mastroianni <smastroianni@npca.ca>; Boudens, Adam <Adam.Boudens@niagararegion.ca>
Subject: RE: Grand Niagara Hydrogeological Water Balance Terms of Reference

Good afternoon Jayme,

Our office has reviewed the Hydrogeologic and Water Balance Assessment Proposed Terms of Reference, Grand Niagara Residential Subdivision prepared by Terra-Dynamics Consulting Inc., dated April 6, 2022. NPCA staff are generally supportive of the proposed scope of work. We note the following comments to incorporate into a revised ToR:

1. The Terms of Reference has identified that 9 wetland monitoring stations, 5 shallow groundwater monitoring wells and 2 surface water monitoring stations will be established and/or instrumented with datalogging pressure transducers within the study area. Please provide a figure which identifies the proposed monitoring locations.
2. The Terms of Reference does not specify the intended duration of monitoring. Please identify the duration of monitoring.
3. The Terms of Reference does not discuss catchments of the wetlands and watercourses present within the study area. Pre and post development catchments must be clearly identified and documented in the report and within a figure.

Please let me know if you require further information or clarification.

Best,

Nicholas Godfrey, M.A.
Watershed Planner
Niagara Peninsula Conservation Authority (NPCA)
250 Thorold Road West, 3rd Floor, Welland, ON, L3C 3W2
905-788-3135, ext. 278
ngodfrey@npca.ca
www.npca.ca

Due to the COVID-19 pandemic, the NPCA has taken measures to protect staff and public while providing continuity of services. The NPCA main office is currently closed with limited staff, please refer to the Staff Directory and reach out to the staff member you wish to speak or meet with directly. Our Conservation Areas are currently open, but may have modified amenities and/or regulations.

Updates regarding NPCA operations and activities can be found at Get Involved NPCA Portal, or on social media at NPCA's Facebook Page & NPCA's Twitter page.

From: jcampbell@terra-dynamics.com <jcampbell@terra-dynamics.com>
Sent: Wednesday, May 4, 2022 1:36 PM
To: 'Boudens, Adam' <Adam.Boudens@niagararegion.ca>; 'Lampman, Cara' <Cara.Lampman@niagararegion.ca>
Cc: 'Michael Auduong' <michael@armstrongplan.ca>; 'John Castro' <JCastro@empirecommunities.com>; JSwartz@empirecommunities.com; 'Mochrie, Adele' <amochrie@dillon.ca>; David Deluce <ddeluce@npca.ca>; Sarah Mastroianni <smastroianni@npca.ca>; 'Loiacono, Johnpaul' <Johnpaul.Loiacono@niagararegion.ca>
Subject: RE: Grand Niagara Hydrogeological Water Balance Terms of Reference

Good afternoon Adam,

Thank you for your reply.

Do you know if NPCA will be providing their own review? I understand you are separate agencies but perhaps you know?

Thank you.

Jayme D. Campbell, P.Eng.
Senior Water Resource Engineer
Terra-Dynamics Consulting Inc.
432 Niagara Street, Unit 2, St. Catharines, Ontario L2M 4W3
Phone: 289-407-0915
https://terra-dynamics.com/

Common sense solutions to environmental challenges

From: Boudens, Adam <Adam.Boudens@niagararegion.ca>
Sent: May 4, 2022 1:34 PM
To: jcampbell@terra-dynamics.com; Lampman, Cara <Cara.Lampman@niagararegion.ca>
Cc: 'Michael Auduong' <michael@armstrongplan.ca>; 'John Castro' <JCastro@empirecommunities.com>; JSwartz@empirecommunities.com; 'Mochrie, Adele' <amochrie@dillon.ca>; D Deluce <ddeluce@npca.ca>; Sarah

Mastroianni <smastroianni@npca.ca>; Loiacono, Johnpaul <Johnpaul.Loiacono@niagararegion.ca>
Subject: RE: Grand Niagara Hydrogeological Water Balance Terms of Reference

Hi Jayme,

Thanks for your patience. Regional Environmental Planning staff have reviewed the Hydrogeological Water Balance Terms of Reference and offer no objection to the work plan proposed.

Please do not hesitate to reach out with any questions.

Best regards,
Adam

Adam Boudens
Senior Environmental Planner/Ecologist

Planning and Development Services, Niagara Region
1815 Sir Isaac Brock Way, P.O. Box 1042
Thorold, ON L2V 4T7
Phone: **905-980-6000 ext. 3770** Toll-free: 1-800-263-7215
Adam.Boudens@niagararegion.ca

From: jcampbell@terra-dynamics.com <jcampbell@terra-dynamics.com>
Sent: Wednesday, April 6, 2022 1:23 PM
To: 'Jessica Abrahamse' <jabrahamse@npca.ca>; Lampman, Cara <Cara.Lampman@niagararegion.ca>; Boudens, Adam <Adam.Boudens@niagararegion.ca>
Cc: 'Michael Auduong' <michael@armstrongplan.ca>; 'John Castro' <JCastro@empirecommunities.com>; JSwartz@empirecommunities.com; 'Mochrie, Adele' <amochrie@dillon.ca>
Subject: Grand Niagara Hydrogeological Water Balance Terms of Reference

CAUTION EXTERNAL EMAIL: This email originated from outside of the Niagara Region email system. Use caution when clicking links or opening attachments unless you recognize the sender and know the content is safe.

Good afternoon Jessica, Cara and Adam,

Please find attached as requested during pre-consultation, a proposed hydrogeology water balance terms of reference regarding the Grand Niagara site for your review and comment.

If you have any questions regarding the attached please feel free to contact me directly.

Jayme D. Campbell, P.Eng.
Senior Water Resource Engineer
Terra-Dynamics Consulting Inc.
432 Niagara Street, Unit 2, St. Catharines, Ontario L2M 4W3
Phone: 289-407-0915
https://terra-dynamics.com/

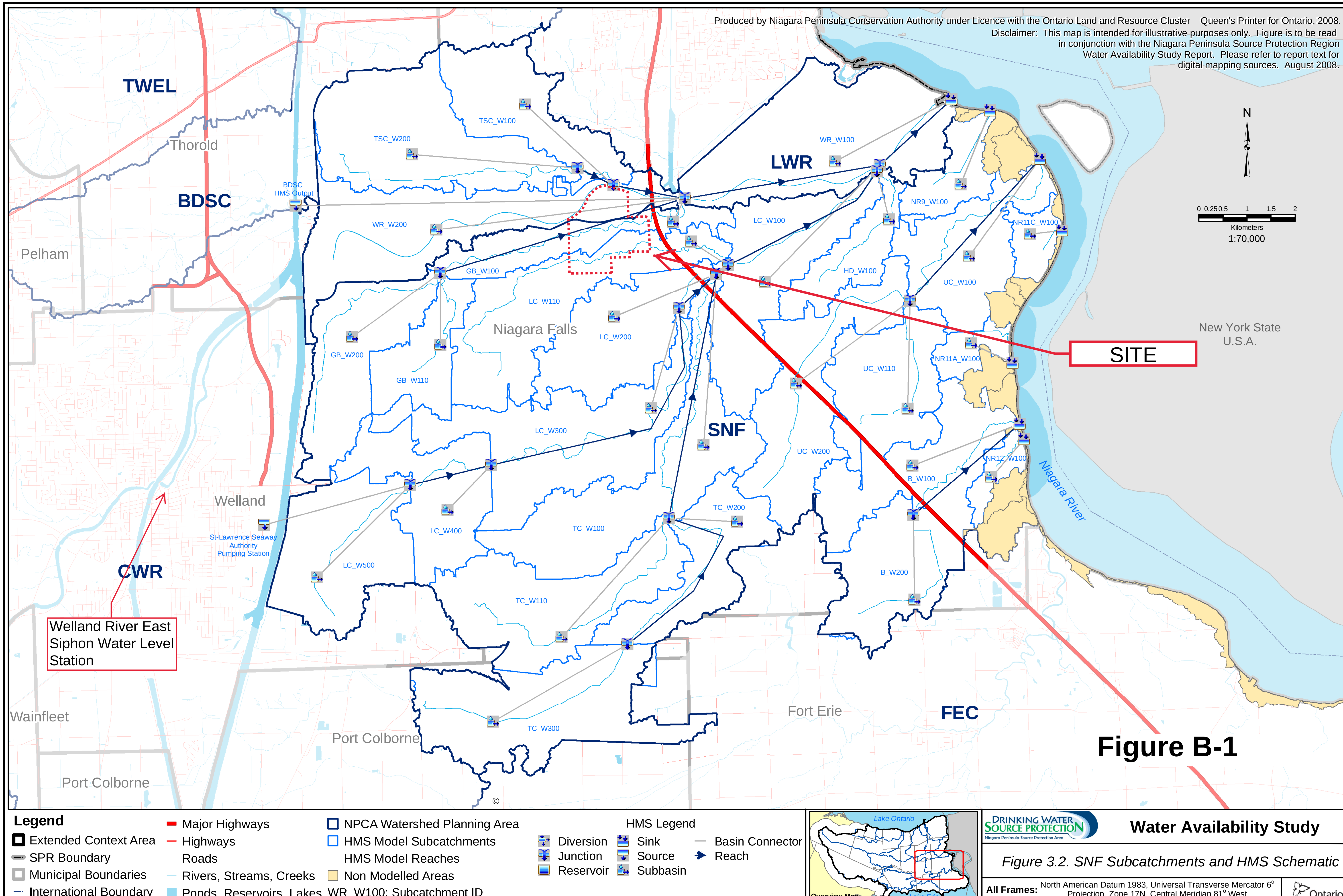
Common sense solutions to environmental challenges

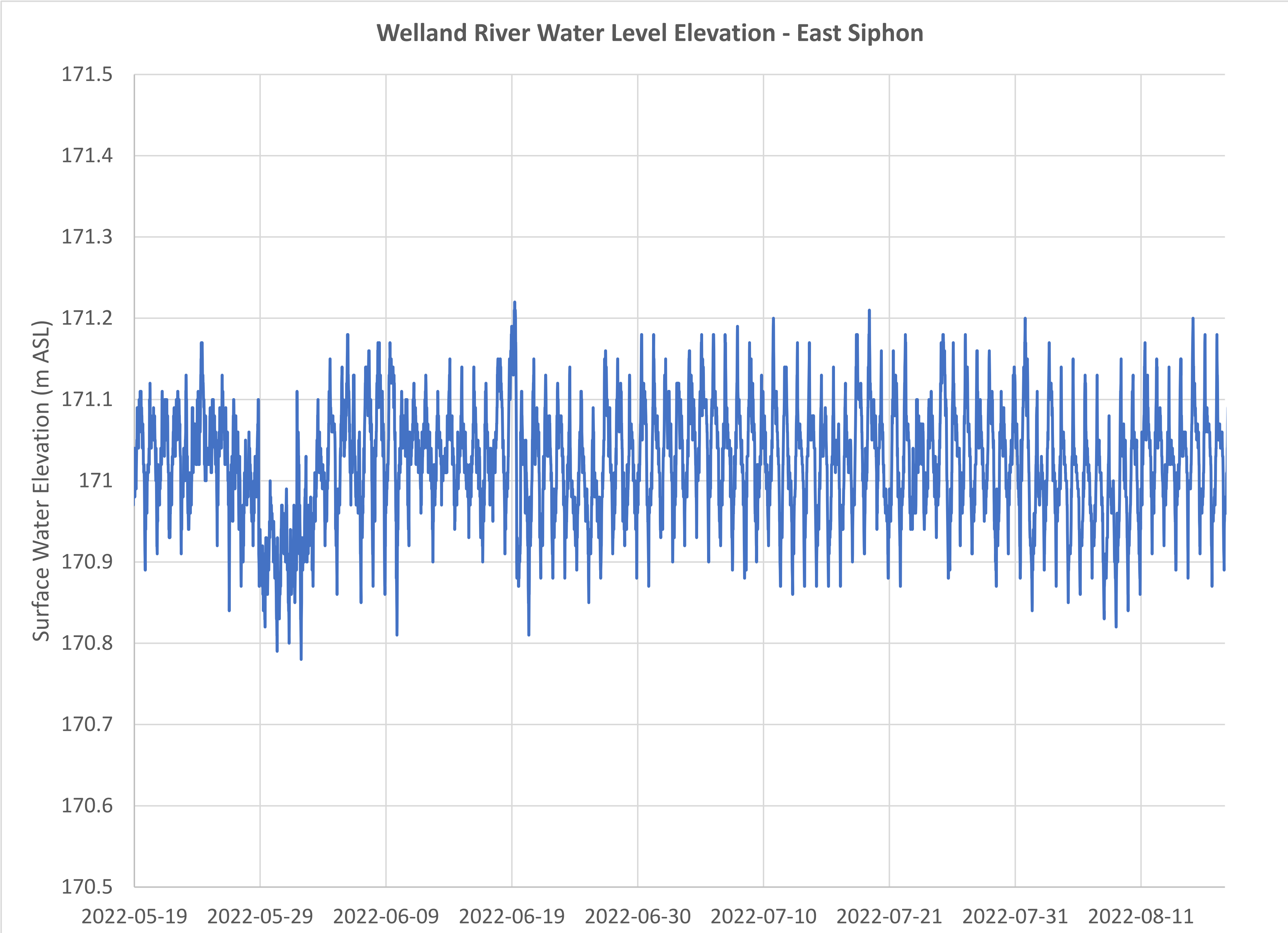
Due to the COVID-19 pandemic, the NPCA has taken measures to protect staff and public while providing continuity of services. The NPCA main office is open by appointment only with limited staff, please refer to the Staff Directory and reach out to the staff member you wish to speak or meet with directly. Our Conservation Areas are currently open, but may have modified amenities and/or regulations.

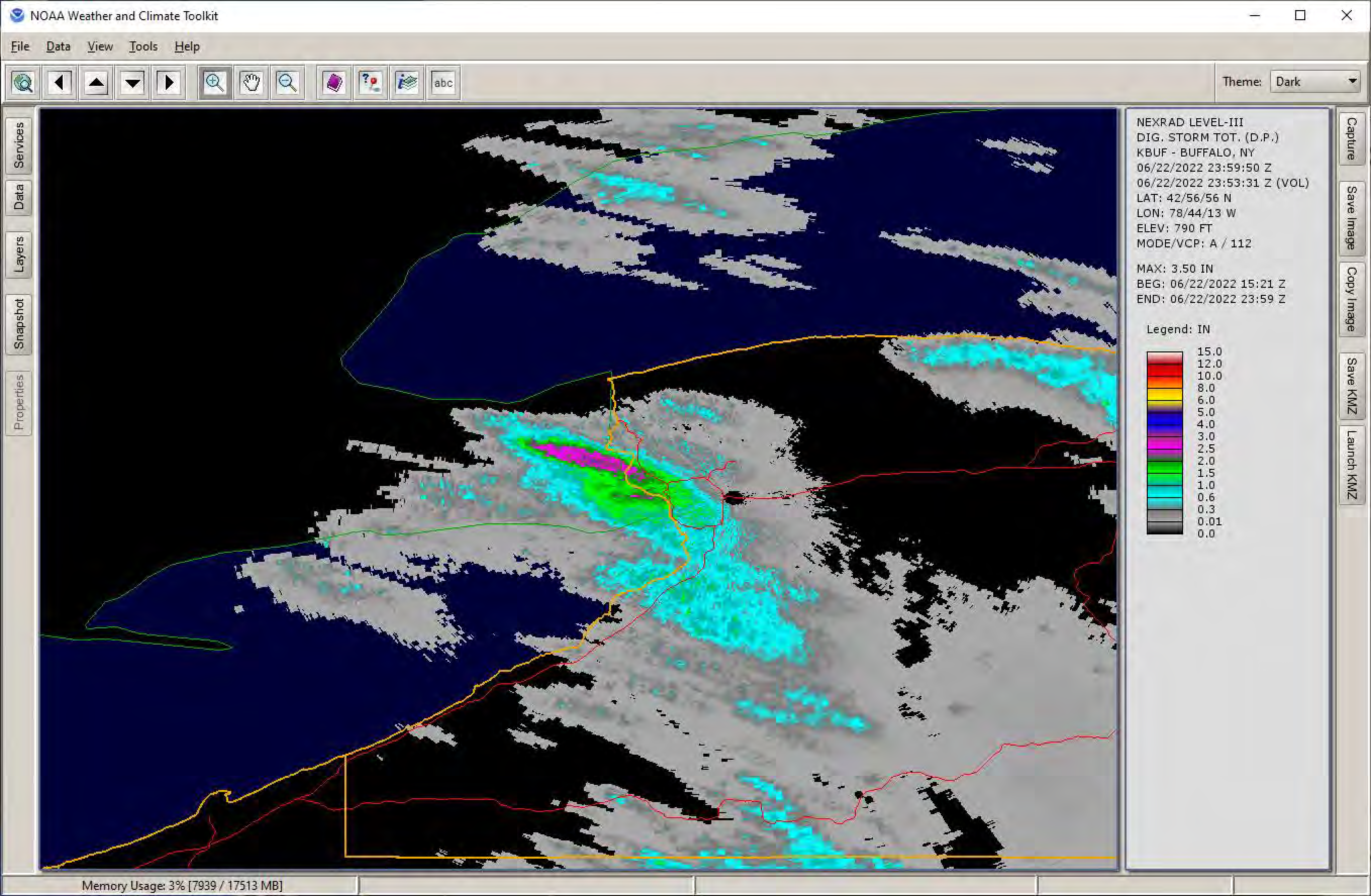
Updates regarding NPCA operations and activities can be found at Get Involved NPCA Portal, or on social media at NPCA's Facebook Page & NPCA's Twitter page.

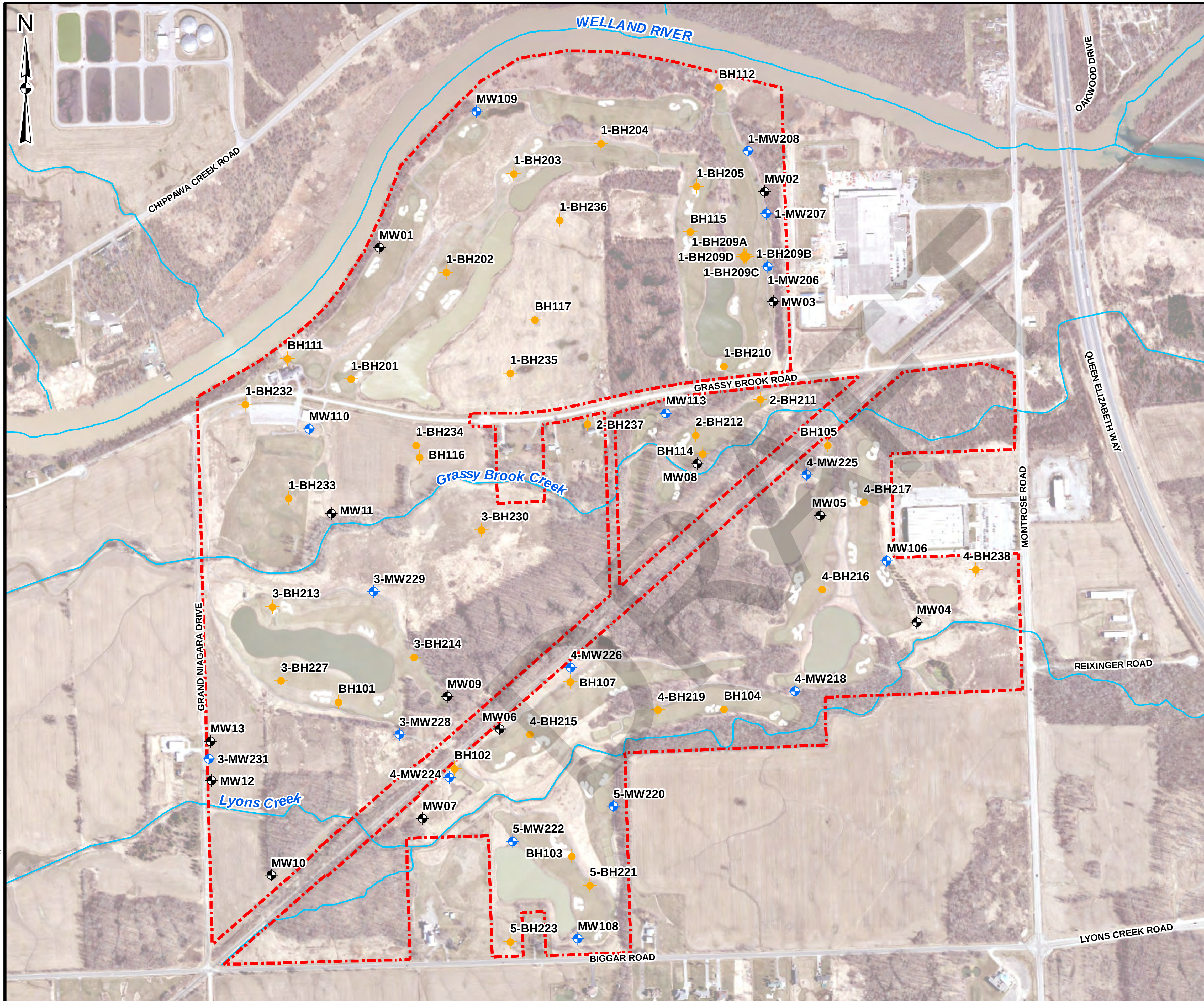
Appendix B

Supporting Information


Produced by Niagara Peninsula Conservation Authority under Licence with the Ontario Land and Resource Cluster Queen's Printer for Ontario, 2008.
Disclaimer: This map is intended for illustrative purposes only. Figure is to be read in conjunction with the Niagara Peninsula Source Protection Region Water Availability Study Report. Please refer to report text for digital mapping sources. August 2008.
TWEL
Thorold
BDSC
BDSC HMS Output
Pelham
LWR
SNF
CWR
FEC
Welland
Niagara Falls
Fort Erie
Port Colborne
Wainfleet
New York State U.S.A.
Niagara River
SITE
Welland River East Siphon Water Level Station
St-Lawrence Seaway Authority Pumping Station
TSC_W100
TSC_W200
WR_W100
WR_W200
NR9_W100
NR11C_W100
NR11A_W100
NR12_W100
LC_W100
LC_W110
LC_W200
LC_W300
LC_W400
LC_W500
GB_W100
GB_W110
GB_W200
HD_W100
UC_W100
UC_W110
UC_W200
B_W100
B_W200
TC_W100
TC_W110
TC_W200
TC_W300
N
0 0.25 0.5 1 1.5 2
Kilometers
1:70,000
Figure B-1
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
Non Modelled Areas
WR_W100: Subcatchment ID
HMS Legend
Diversion
Junction
Reservoir
Sink
Source
Subbasin
Basin Connector
Reach
Lake Ontario
Lake Erie
Overview Map
DRINKING WATER SOURCE PROTECTION
Niagara Peninsula Source Protection Area
Water Availability Study
Figure 3.2. SNF Subcatchments and HMS Schematic
All Frames: North American Datum 1983, Universal Transverse Mercator 6° Projection, Zone 17N, Central Meridian 81° West.
Ontario


Welland River Water Level Elevation - East Siphon
Surface Water Elevation (m ASL)
171.5
171.4
171.3
171.2
171.1
171
170.9
170.8
170.7
170.6
170.5
2022-05-19
2022-05-29
2022-06-09
2022-06-19
2022-06-30
2022-07-10
2022-07-21
2022-07-31
2022-08-11


NOAA Weather and Climate Toolkit
File Data View Tools Help
abc
Theme: Dark
Services
Data
Layers
Snapshot
Properties
NEXRAD LEVEL-III
DIG. STORM TOT. (D.P.)
KBUF - BUFFALO, NY
06/22/2022 23:59:50 Z
06/22/2022 23:53:31 Z (VOL)
LAT: 42/56/56 N
LON: 78/44/13 W
ELEV: 790 FT
MODE/VCP: A / 112
MAX: 3.50 IN
BEG: 06/22/2022 15:21 Z
END: 06/22/2022 23:59 Z
Legend: IN
15.0
12.0
10.0
8.0
6.0
5.0
4.0
3.0
2.5
2.0
1.5
1.0
0.6
0.3
0.01
0.0
Capture
Save Image
Copy Image
Save KMZ
Launch KMZ
Memory Usage: 3% [7939 / 17513 MB]



W:\PROJECTS\Toronto\CT3243.01 Grand Niagara RSCs\MXD\CT3243.01 FIG 1 SAMPLE LOCATION PLAN_PHASE TWO LETTER.mxd

LEGEND

SITE BOUNDARY

WATERCOURSES

SAMPLE LOCATIONS

BOREHOLE (TERRAPEX)

MONITORING WELL (TERRAPEX)

MONITORING WELL (WSP)

DATA SOURCE: NIAGARA REGION
MAP PROJECTION: NAD 1983 UTM ZONE 17N

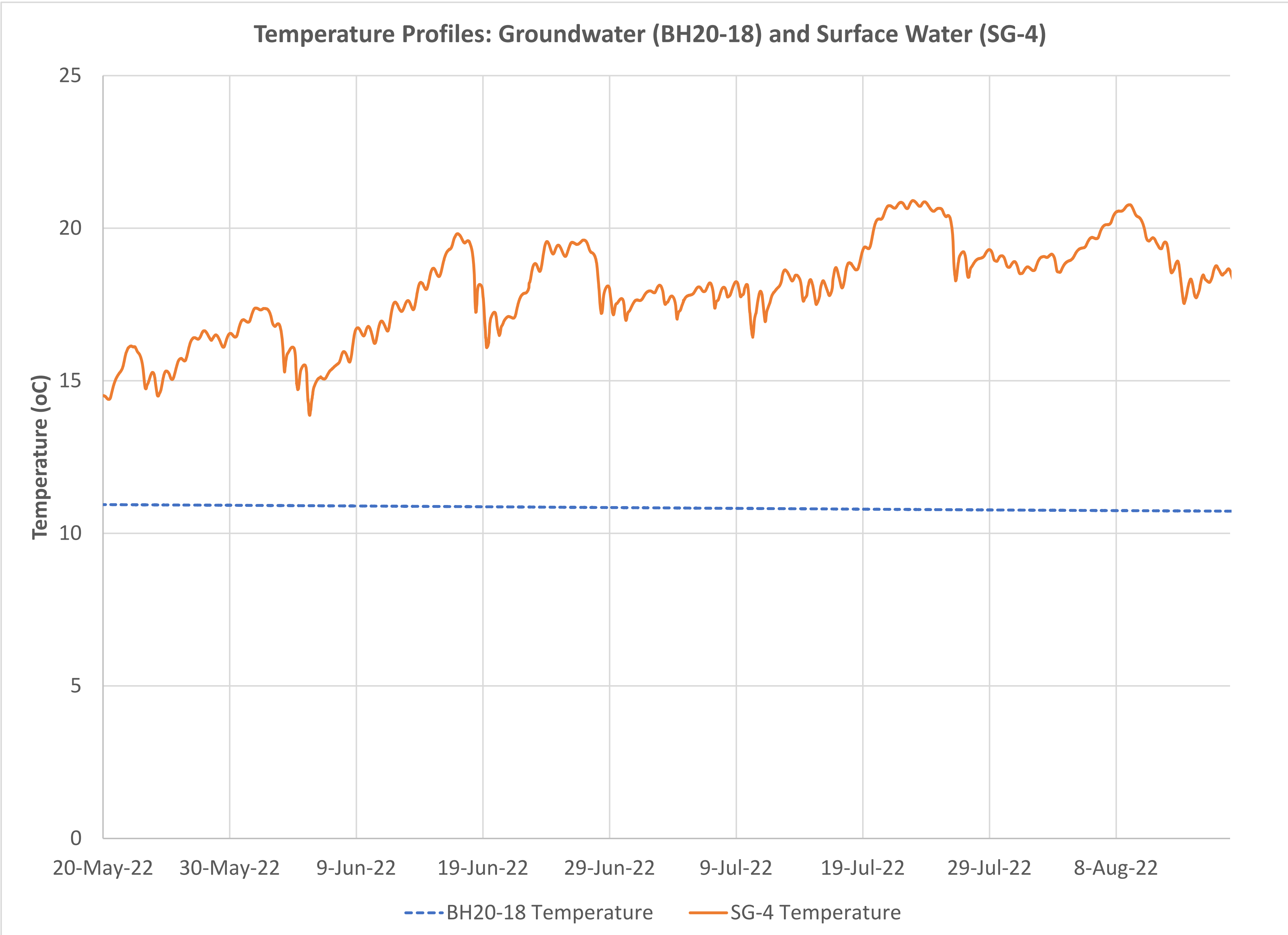
CLIENT: EMPIRE COMMUNITIES

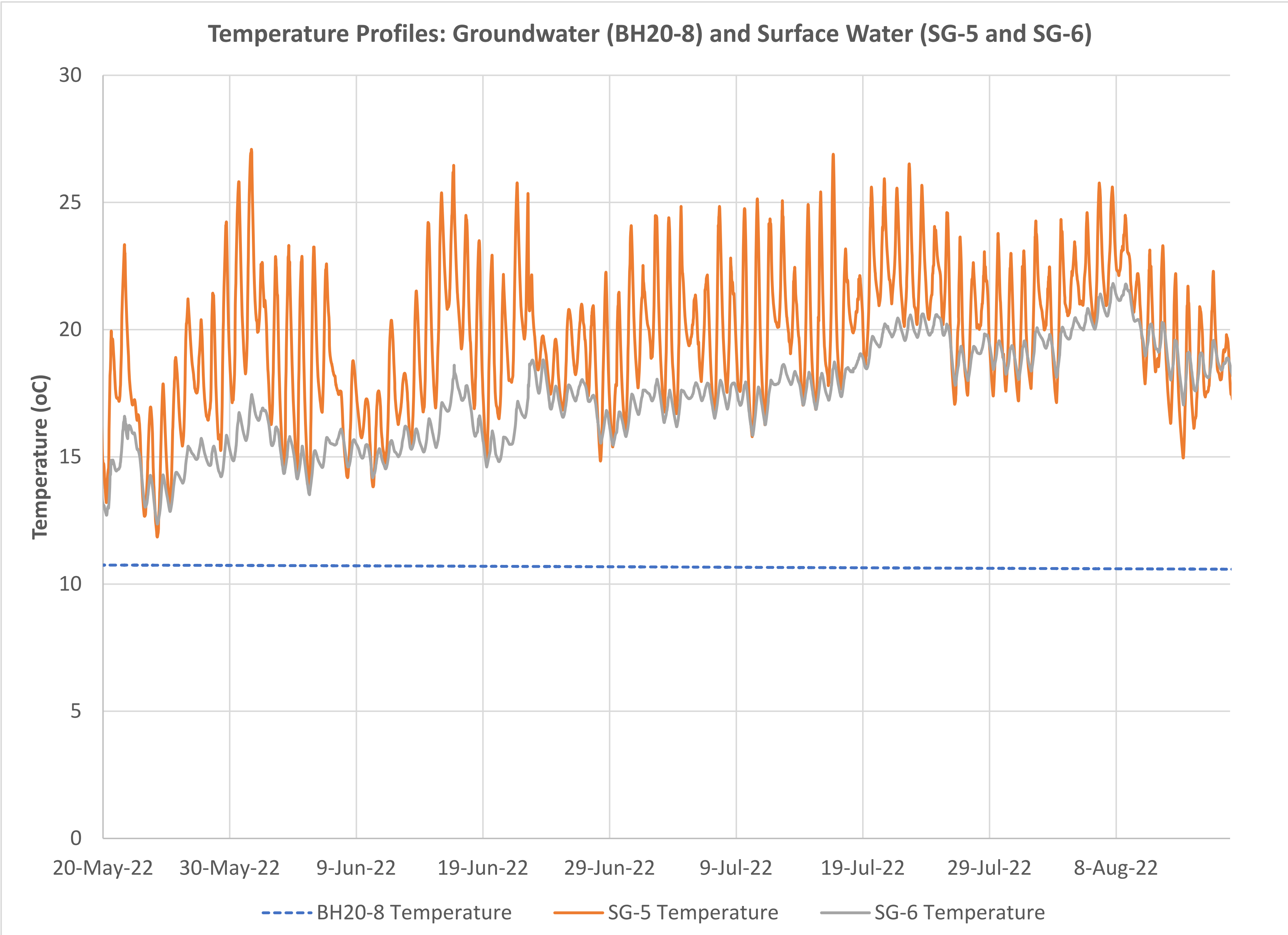
SITE LOCATION: 8547 GRASSY BROOK ROAD NIAGARA FALLS, ONTARIO

TERRAPEX

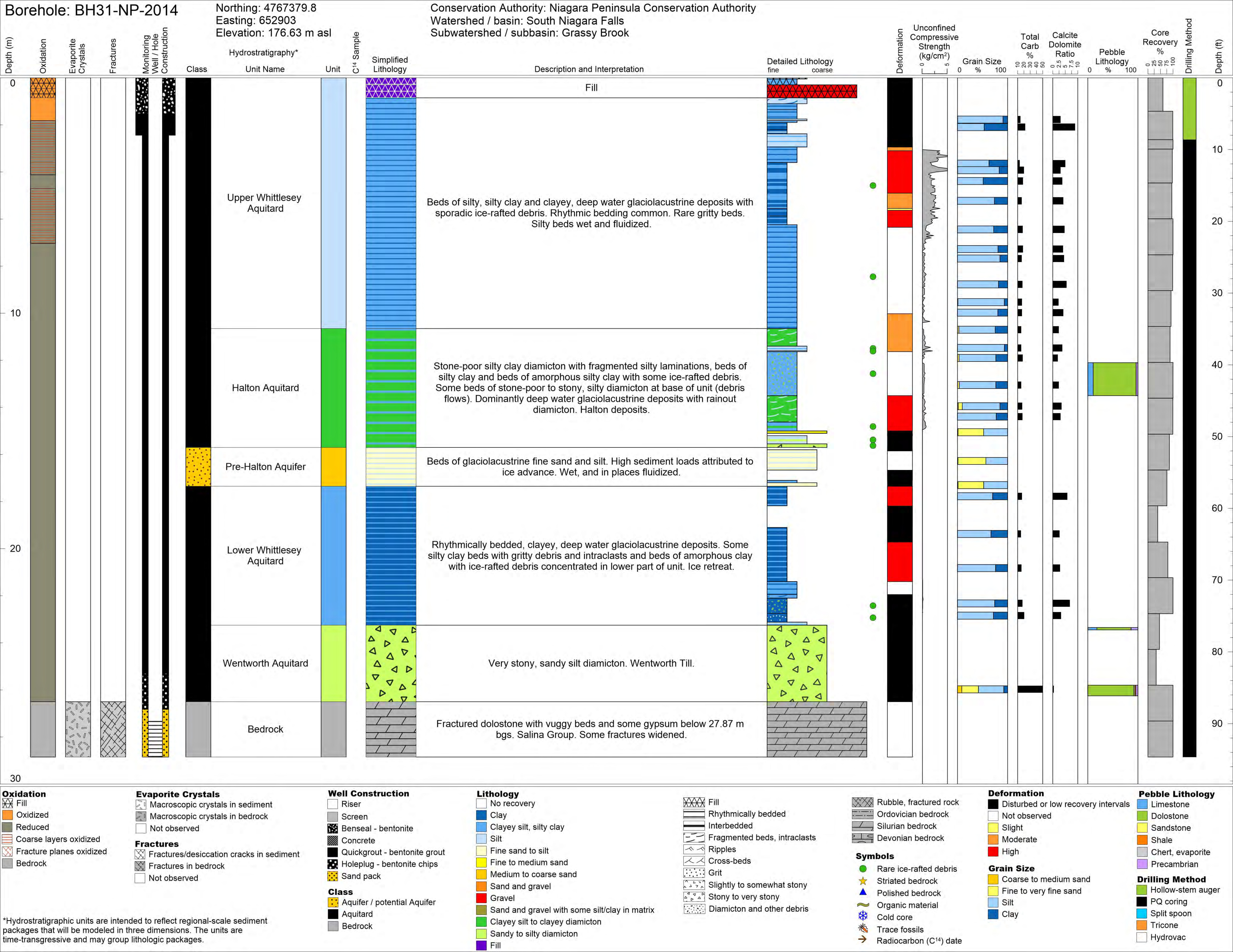
TITLE: **SAMPLE LOCATION PLAN**

DRAWN BY:	PROJECT NO.:	CHECKED BY:
JS	CT3243.01	CR
REVISION:	DATE:	FIGURE:
00	SEPTEMBER 2022	2

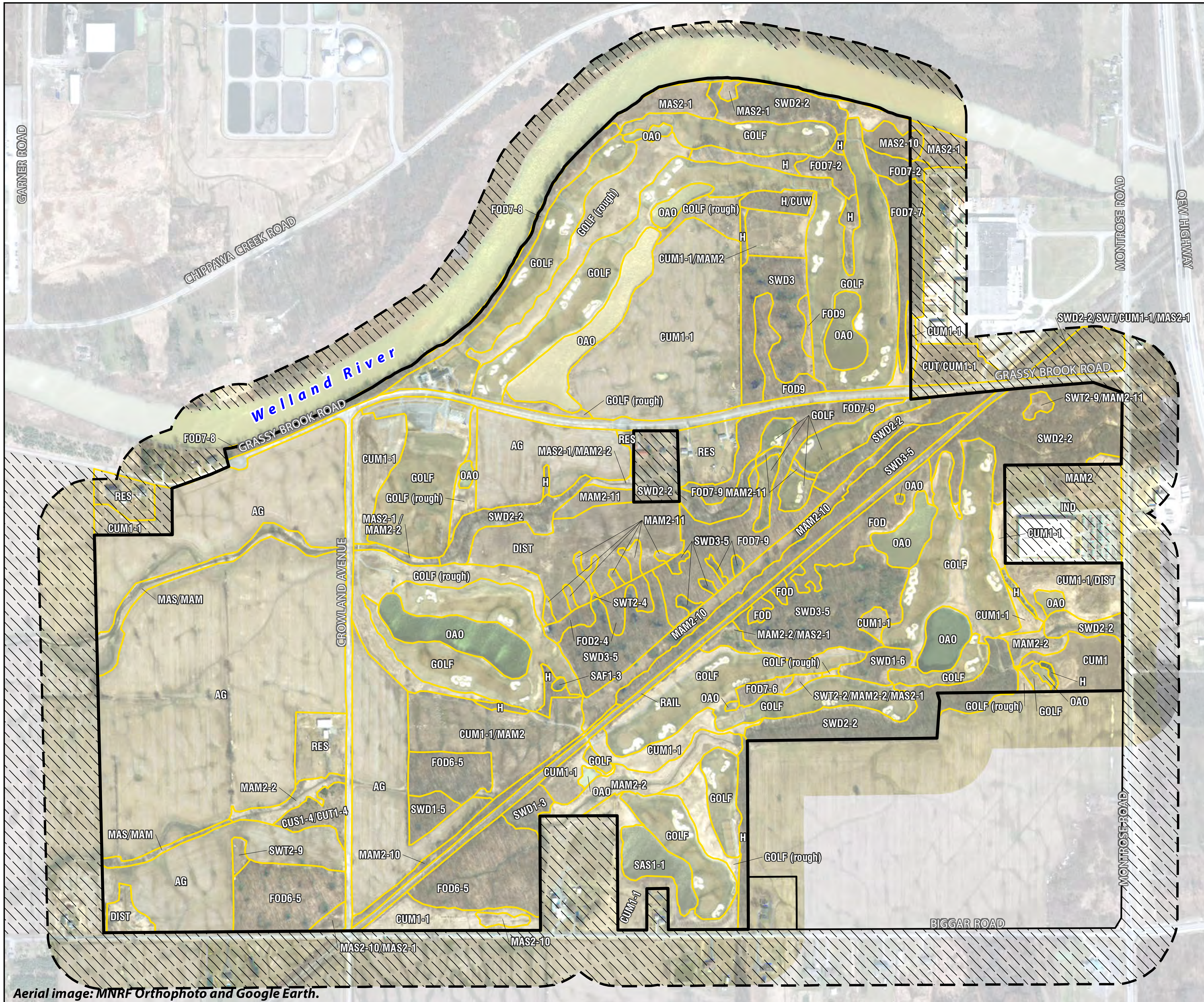

Temperature Profiles: Groundwater (BH20-18) and Surface Water (SG-4)
25
20
15
10
5
0
Temperature (oC)
20-May-22
30-May-22
9-Jun-22
19-Jun-22
29-Jun-22
9-Jul-22
19-Jul-22
29-Jul-22
8-Aug-22
BH20-18 Temperature
SG-4 Temperature



Temperature Profiles: Groundwater (BH20-8) and Surface Water (SG-5 and SG-6)
Temperature (oC)
30
25
20
15
10
5
0
20-May-22
30-May-22
9-Jun-22
19-Jun-22
29-Jun-22
9-Jul-22
19-Jul-22
29-Jul-22
8-Aug-22
BH20-8 Temperature
SG-5 Temperature
SG-6 Temperature



Borehole: BH31-NP-2014
Northing: 4767379.8
Easting: 652903
Elevation: 176.63 m asl
Conservation Authority: Niagara Peninsula Conservation Authority
Watershed / basin: South Niagara Falls
Subwatershed / subbasin: Grassy Brook
Depth (m)
Oxidation
Evaporite Crystals
Fractures
Monitoring Well / Hole Construction
Class
Hydrostratigraphy*
Unit Name
Unit
C14 Sample
Simplified Lithology
Description and Interpretation
Detailed Lithology
fine
coarse
Deformation
Unconfined Compressive Strength (kg/cm2)
Grain Size
0 % 100
Total Carb %
Calcite Dolomite Ratio
Pebble Lithology
0 % 100
Core Recovery %
Drilling Method
Depth (ft)
Fill
Upper Whittlesey Aquitard
Beds of silty, silty clay and clayey, deep water glaciolacustrine deposits with sporadic ice-rafted debris. Rhythmic bedding common. Rare gritty beds. Silty beds wet and fluidized.
Halton Aquitard
Stone-poor silty clay diamicton with fragmented silty laminations, beds of silty clay and beds of amorphous silty clay with some ice-rafted debris. Some beds of stone-poor to stony, silty diamicton at base of unit (debris flows). Dominantly deep water glaciolacustrine deposits with rainout diamicton. Halton deposits.
Pre-Halton Aquifer
Beds of glaciolacustrine fine sand and silt. High sediment loads attributed to ice advance. Wet, and in places fluidized.
Lower Whittlesey Aquitard
Rhythmically bedded, clayey, deep water glaciolacustrine deposits. Some silty clay beds with gritty debris and intraclasts and beds of amorphous silty clay with ice-rafted debris concentrated in lower part of unit. Ice retreat.
Wentworth Aquitard
Very stony, sandy silt diamicton. Wentworth Till.
Bedrock
Fractured dolostone with vuggy beds and some gypsum below 27.87 m bgs. Salina Group. Some fractures widened.
0
10
20
30
0
10
20
30
40
50
60
70
80
90
Oxidation
Fill
Oxidized
Reduced
Coarse layers oxidized
Fracture planes oxidized
Bedrock
Evaporite Crystals
Macroscopic crystals in sediment
Macroscopic crystals in bedrock
Not observed
Fractures
Fractures/desiccation cracks in sediment
Fractures in bedrock
Not observed
Well Construction
Riser
Screen
Benseal - bentonite
Concrete
Quickgrout - bentonite grout
Holeplug - bentonite chips
Sand pack
Class
Aquifer / potential Aquifer
Aquitard
Bedrock
Lithology
No recovery
Clay
Clayey silt, silty clay
Silt
Fine sand to silt
Fine to medium sand
Medium to coarse sand
Sand and gravel
Gravel
Sand and gravel with some silt/clay in matrix
Clayey silt to clayey diamicton
Sandy to silty diamicton
Fill
Fill
Rhythmically bedded
Interbedded
Fragmented beds, intraclasts
Ripples
Cross-beds
Grit
Slightly to somewhat stony
Stony to very stony
Diamicton and other debris
Rubble, fractured rock
Ordovician bedrock
Silurian bedrock
Devonian bedrock
Symbols
Rare ice-rafted debris
Striated bedrock
Polished bedrock
Organic material
Cold core
Trace fossils
Radiocarbon (C14) date
Deformation
Disturbed or low recovery intervals
Not observed
Slight
Moderate
High
Grain Size
Coarse to medium sand
Fine to very fine sand
Silt
Clay
Pebble Lithology
Limestone
Dolostone
Sandstone
Shale
Chert, evaporite
Precambrian
Drilling Method
Hollow-stem auger
PQ coring
Split spoon
Tricone
Hydrovac
*Hydrostratigraphic units are intended to reflect regional-scale sediment packages that will be modeled in three dimensions. The units are time-transgressive and may group lithologic packages.



0 200 Meters

N

SAVANTA

Grand Niagara Holdings

Non-participating land

120m adjacent lands

Ecological Land Classification

ELC Legend

FOREST

FOD	Deciduous Forest
FOD2-4	Dry-Fresh Oak-Hardwood Deciduous Forest
FOD6-5	Fresh-Moist Sugar Maple-Hardwood Deciduous Forest
FOD7-2	Fresh-Moist Ash Lowland Deciduous Forest
FOD7-6*	Fresh-Moist Red Maple Lowland Deciduous Forest
FOD7-7*	Fresh-Moist Ash-Elm Lowland Deciduous Forest
FOD7-8*	Fresh-Moist Walnut-Ash-Willow Lowland Deciduous Forest
FOD7-9*	Fresh-Moist Pin Oak-Green Ash Lowland Deciduous Forest
FOD9	Fresh-Moist Oak-Maple-Hickory Deciduous Forest

SWAMP

SWD1-3	Pin Oak Mineral Deciduous Swamp
SWD1-5*	Green Ash-Pin Oak Mineral Deciduous Swamp
SWD1-6*	Pin Oak-Ash-Maple Mineral Deciduous Swamp
SWD2-2	Green Ash Mineral Deciduous Swamp
SWD3	Maple Mineral Deciduous Swamp
SWD3-5*	Maple Mineral Deciduous Swamp
SWT	Thicket Swamp
SWT2-2	Willow Mineral Thicket Swamp
SWT2-4	Buttonbush Mineral Thicket Swamp
SWT2-9	Grey Dogwood Mineral Thicket Swamp

MARSH

MAM	Meadow Marsh
MAM2	Mineral Meadow Marsh
MAM2-2	Reed-canary Grass Mineral Meadow Marsh
MAM2-10	Forb Mineral Meadow Marsh
MAM2-11*	Mixed Mineral Meadow Marsh
MAS	Shallow Marsh
MAS2-1	Cattail Mineral Shallow Marsh
MAS2-10*	Common Reed Mineral Shallow Marsh

OPEN WATER

OAO	Open Aquatic

SHALLOW WATER

SAS1-1	Pondweed Submerged Shallow Aquatic
SAF1-3	Duckweed Floating-leaved Shallow Aquatic

CULTURAL

CUW	Cultural Woodland
CUS1-4*	White Pine Cultural Savanna
CUT	Cultural Thicket
CUT1-4	Grey Dogwood Cultural Thicket
CUM1-1	Fresh-Moist Old Field Meadow

**not listed in Southern Ontario ELC Guide*

RES	Residence
H	Hedgerow

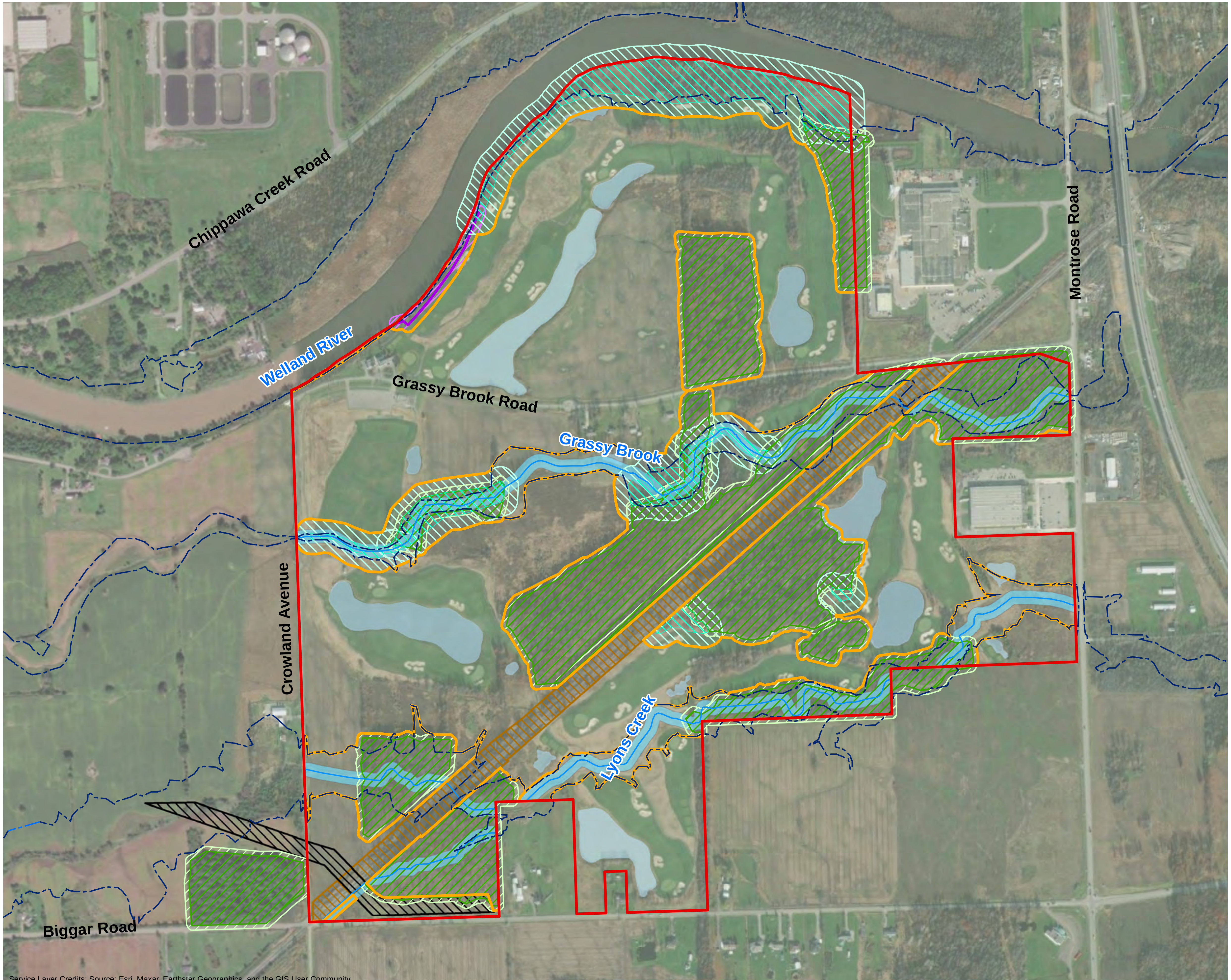
Grand Niagara

Figure 3
Vegetation Communitiies

Document Path: S:\8520 - SAV 7201 Grand Niagara\gis\mxd\2015 11 21 report figures\Figure 3 Vegetation Communities.mxd Date Saved: Wednesday, May 18, 2016

EMPIRE GRAND NIAGARA
EIS ADDENDUM

PROPOSED DEVELOPMENT LIMITS
FIGURE 3



Legend
- Study Area (Development Lands)
- Proposed Development Limit
- Top of Bank (staked June 17, 2022)
- Top of Bank 15m
- Wetland (staked with NPCA June 21, 2022)
- Wetlands 30m
- Dripline (staked with Region of Niagara June 17, 2022)
- Woodlands 10m
- 100 Year Flood
- 100 Year Flood Line - Potential Shallow
- Watercourse
- Watercourse 15m Buffer
- Waterbody
- Pipeline Easement
- Rail Line

0 50 100 200 Metres
SCALE 1:8000
N W E S

MAP DRAWING INFORMATION:
DATA PROVIDED BY MNDMNRF, NPCA

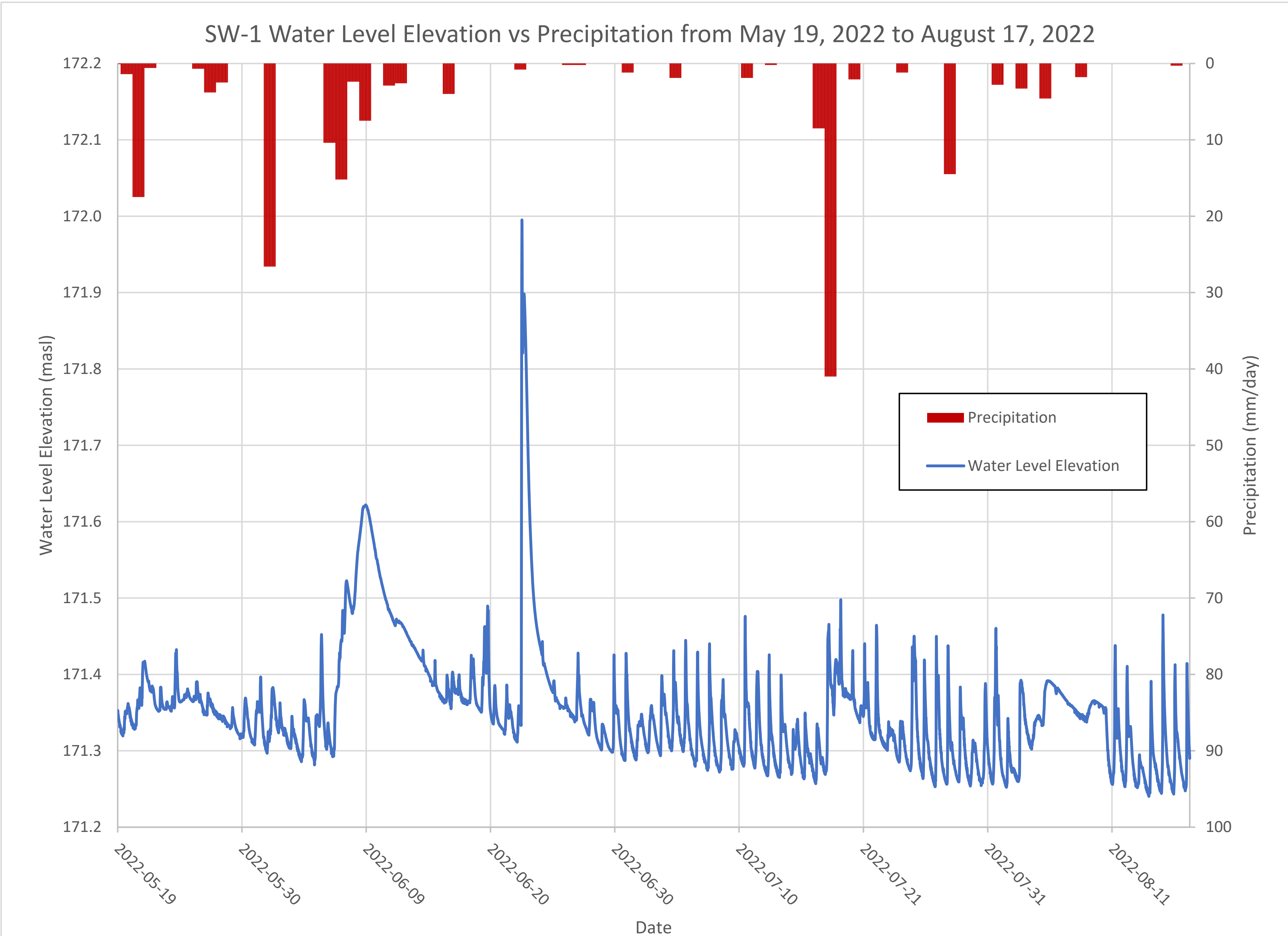
MAP CREATED BY: ZJB / LK
MAP CHECKED BY: KM / AM
MAP PROJECTION: NAD 1983 UTM Zone 17N

DILLON CONSULTING

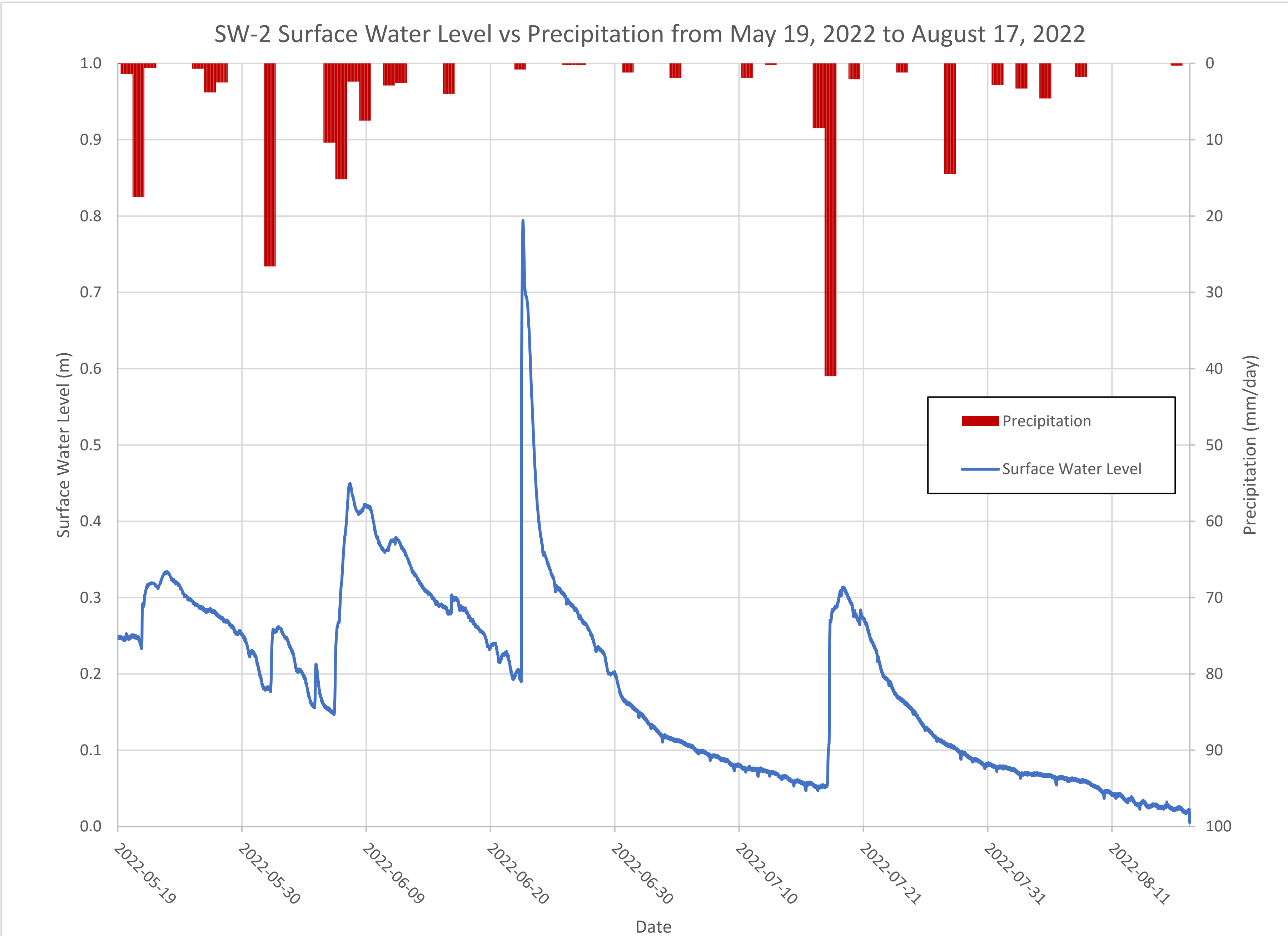
PROJECT: 21-2364
STATUS: DRAFT
DATE: 2022-07-11

Appendix C

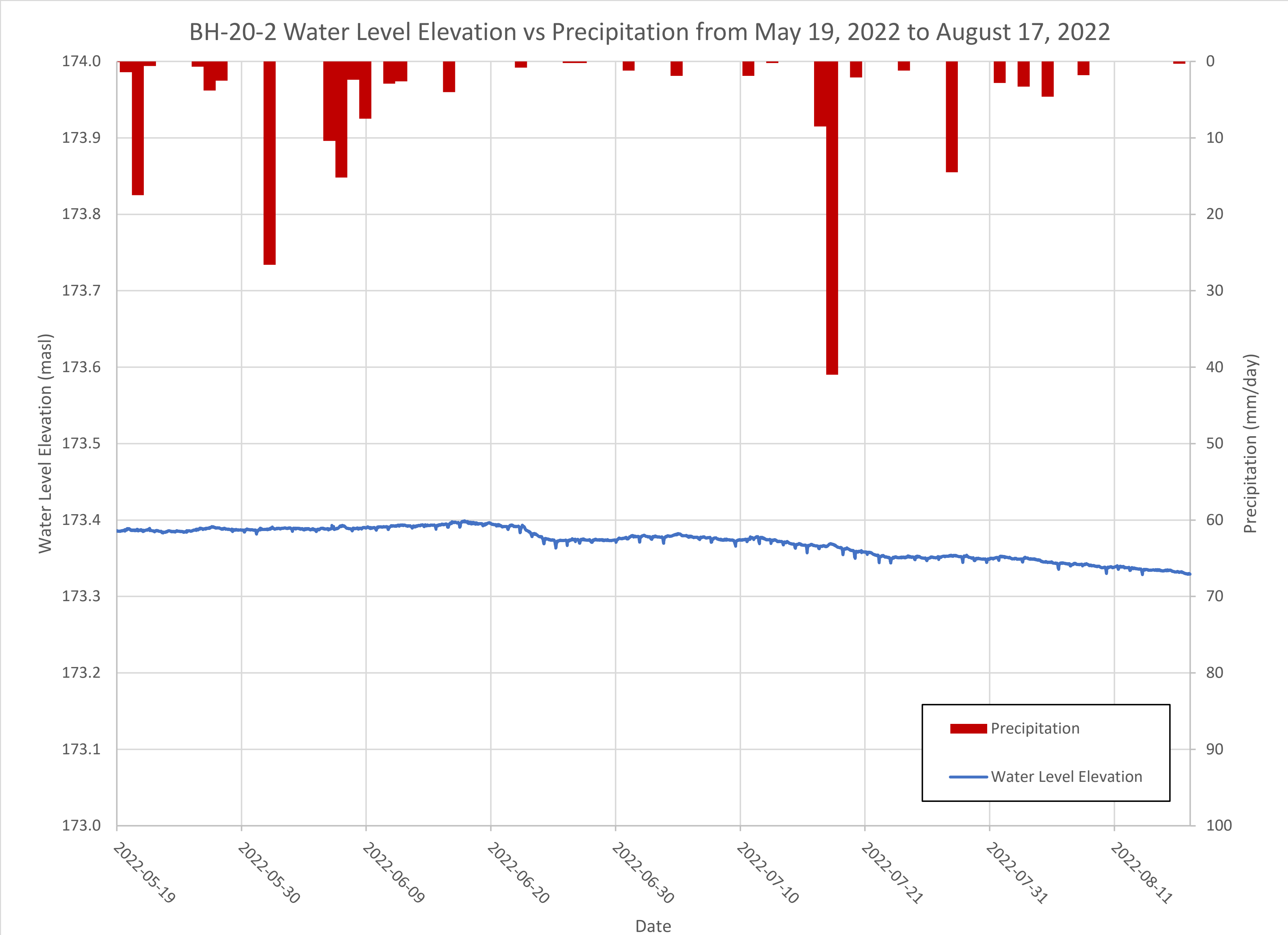
Hydrographs



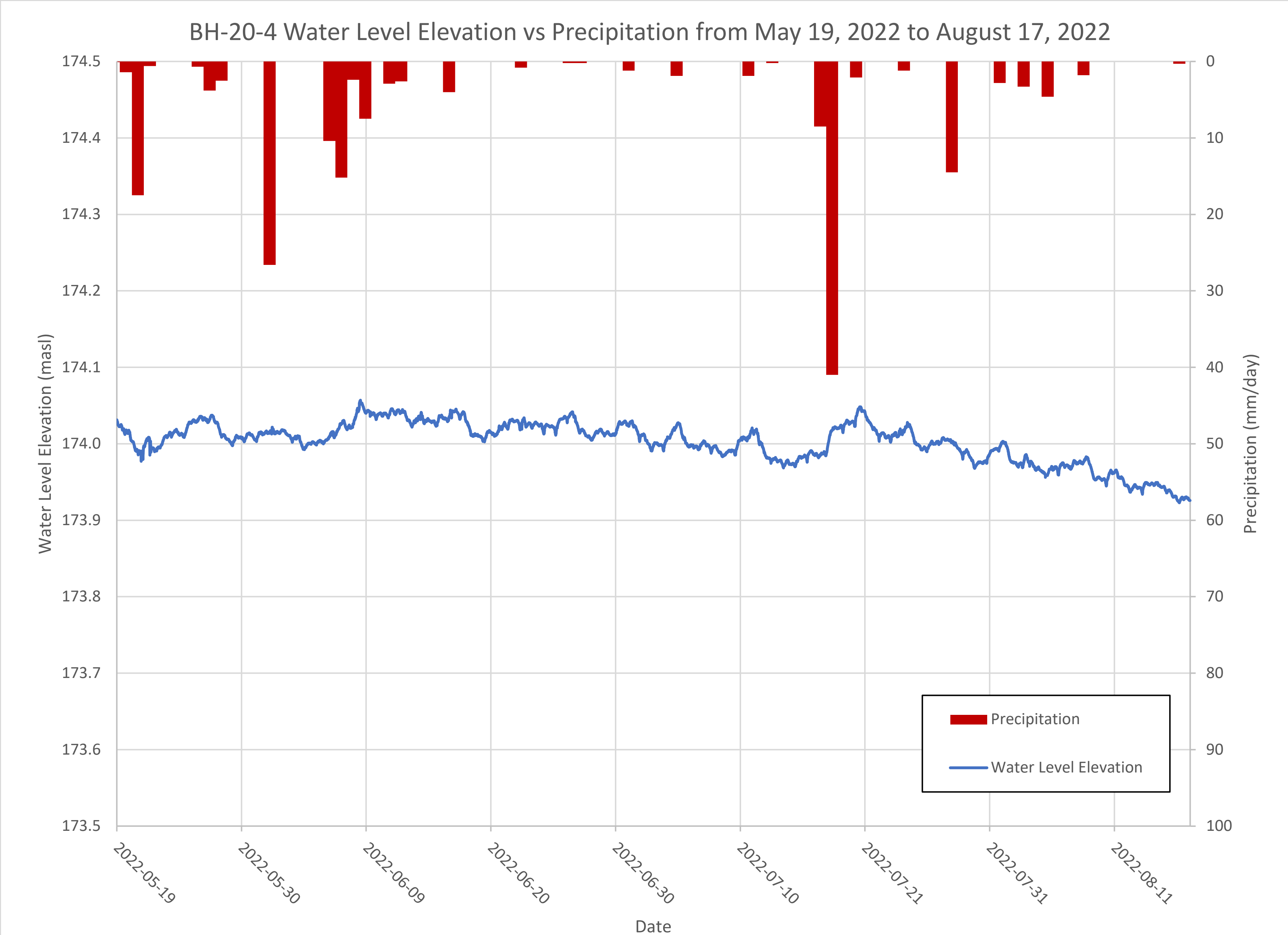
SW-1 Water Level Elevation vs Precipitation from May 19, 2022 to August 17, 2022
Water Level Elevation (masl)
172.2
172.1
172.0
171.9
171.8
171.7
171.6
171.5
171.4
171.3
171.2
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
Precipitation
Water Level Elevation
2022-05-19
2022-05-30
2022-06-09
2022-06-20
2022-06-30
2022-07-10
2022-07-21
2022-07-31
2022-08-11
Date



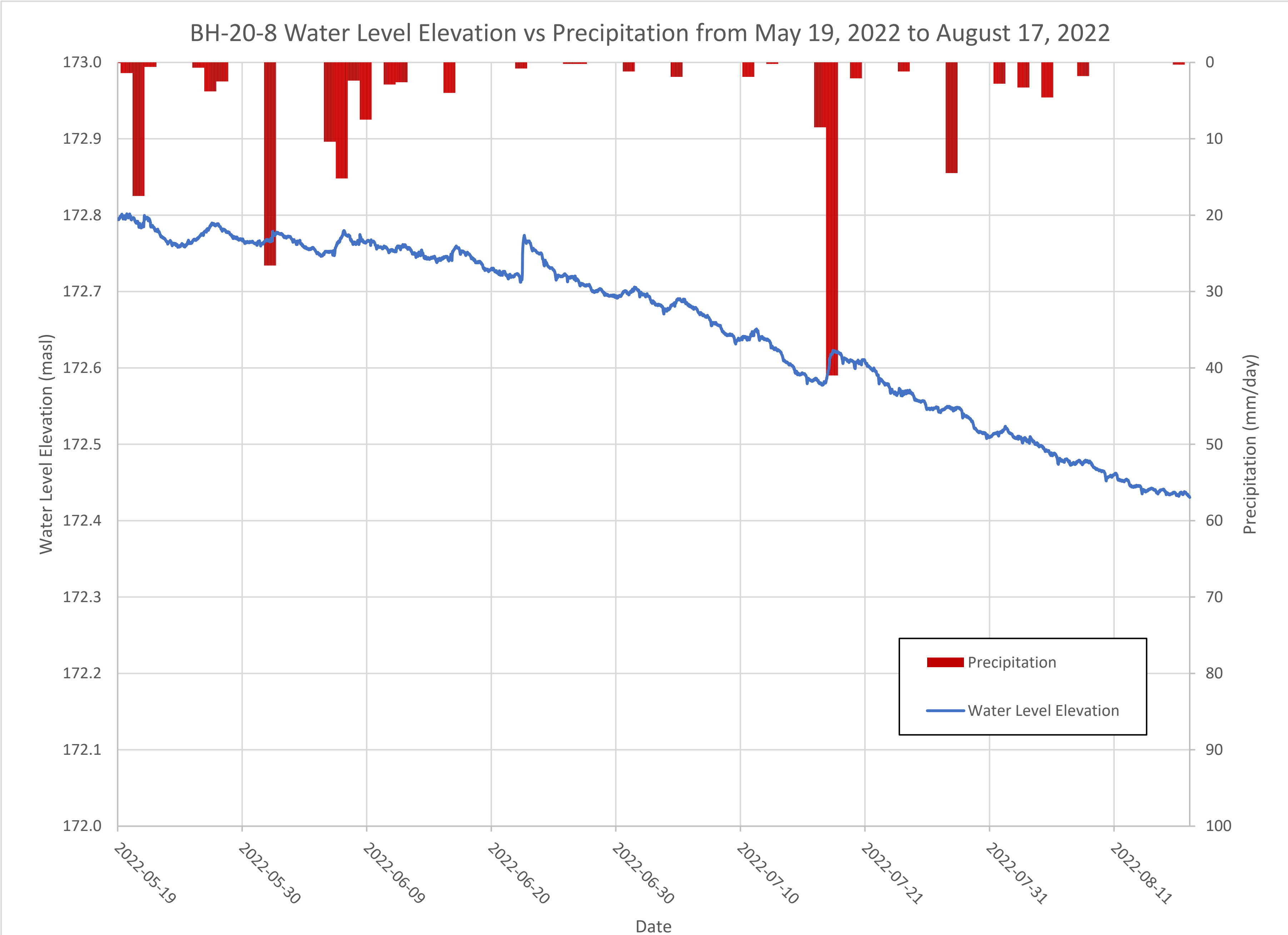
SW-2 Surface Water Level vs Precipitation from May 19, 2022 to August 17, 2022
Surface Water Level (m)
Precipitation (mm/day)
Date
Precipitation
Surface Water Level
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
50
60
70
80
90
100
2022-05-19
2022-05-30
2022-06-09
2022-06-20
2022-06-30
2022-07-10
2022-07-21
2022-07-31
2022-08-11



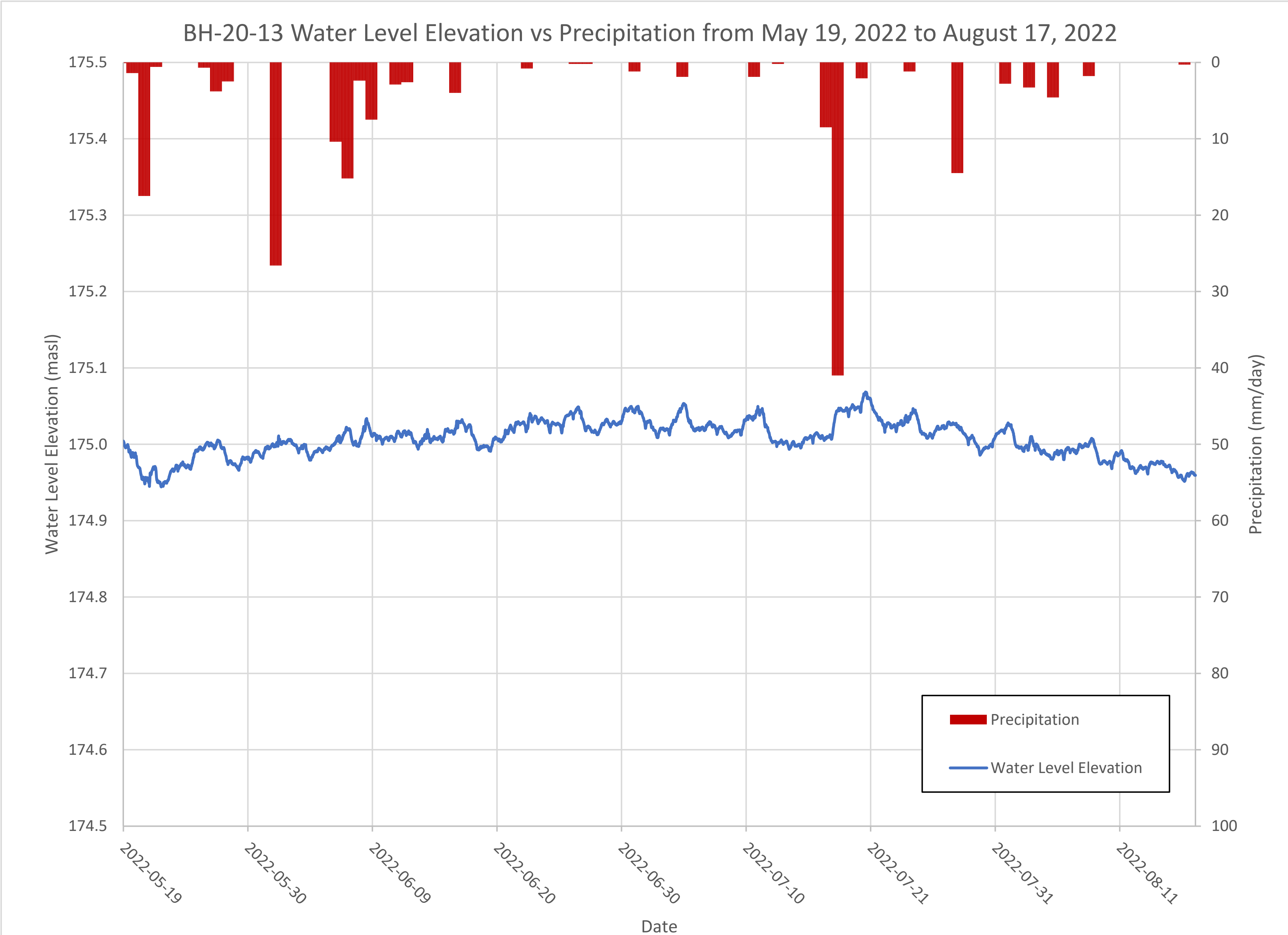
BH-20-2 Water Level Elevation vs Precipitation from May 19, 2022 to August 17, 2022
Water Level Elevation (masl)
174.0
173.9
173.8
173.7
173.6
173.5
173.4
173.3
173.2
173.1
173.0
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
2022-05-19
2022-05-30
2022-06-09
2022-06-20
2022-06-30
2022-07-10
2022-07-21
2022-07-31
2022-08-11
Date
Precipitation
Water Level Elevation



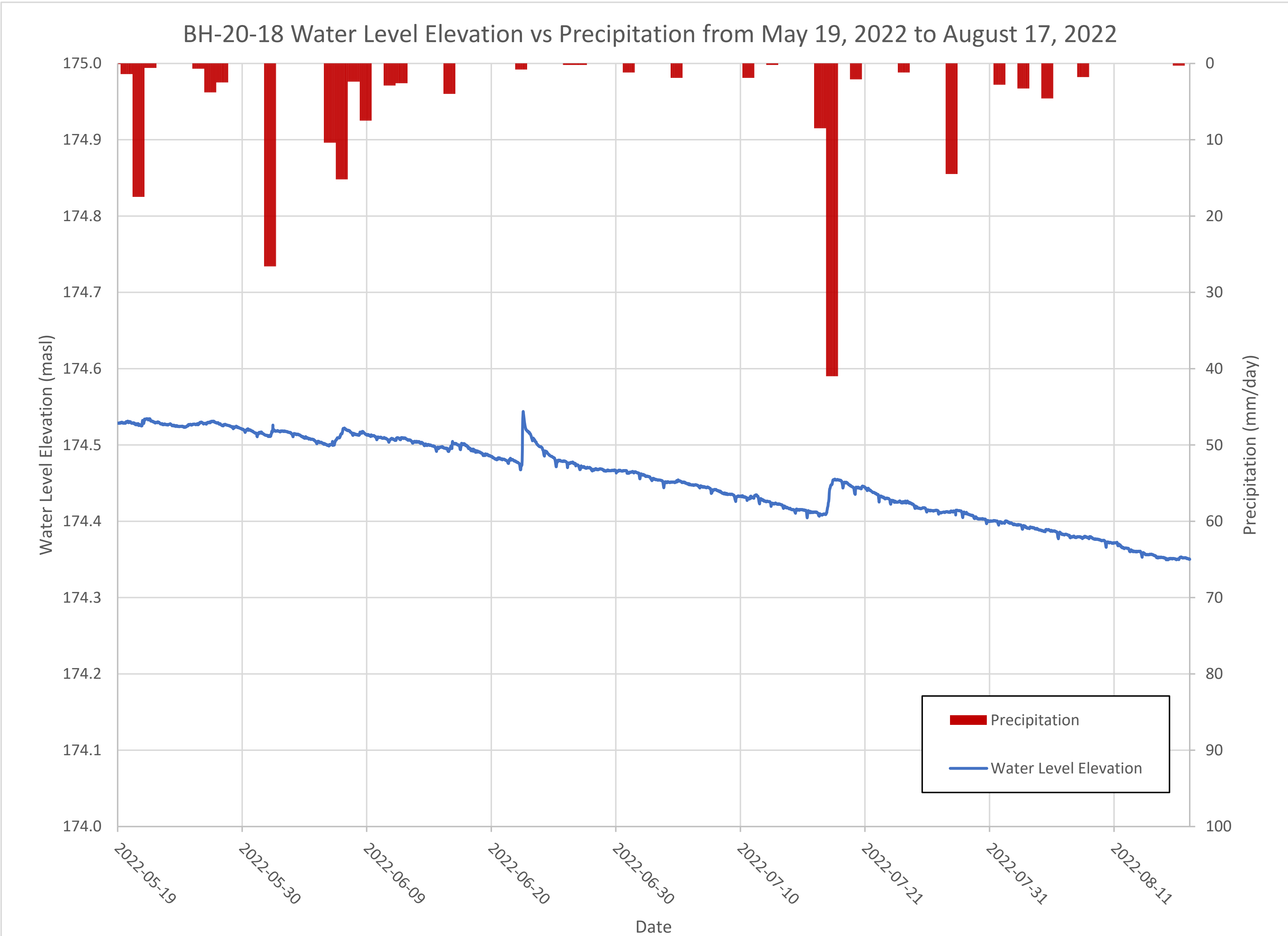
BH-20-4 Water Level Elevation vs Precipitation from May 19, 2022 to August 17, 2022
Water Level Elevation (masl)
Precipitation (mm/day)
Date
174.5
174.4
174.3
174.2
174.1
174.0
173.9
173.8
173.7
173.6
173.5
0
10
20
30
40
50
60
70
80
90
100
2022-05-19
2022-05-30
2022-06-09
2022-06-20
2022-06-30
2022-07-10
2022-07-21
2022-07-31
2022-08-11
Precipitation
Water Level Elevation



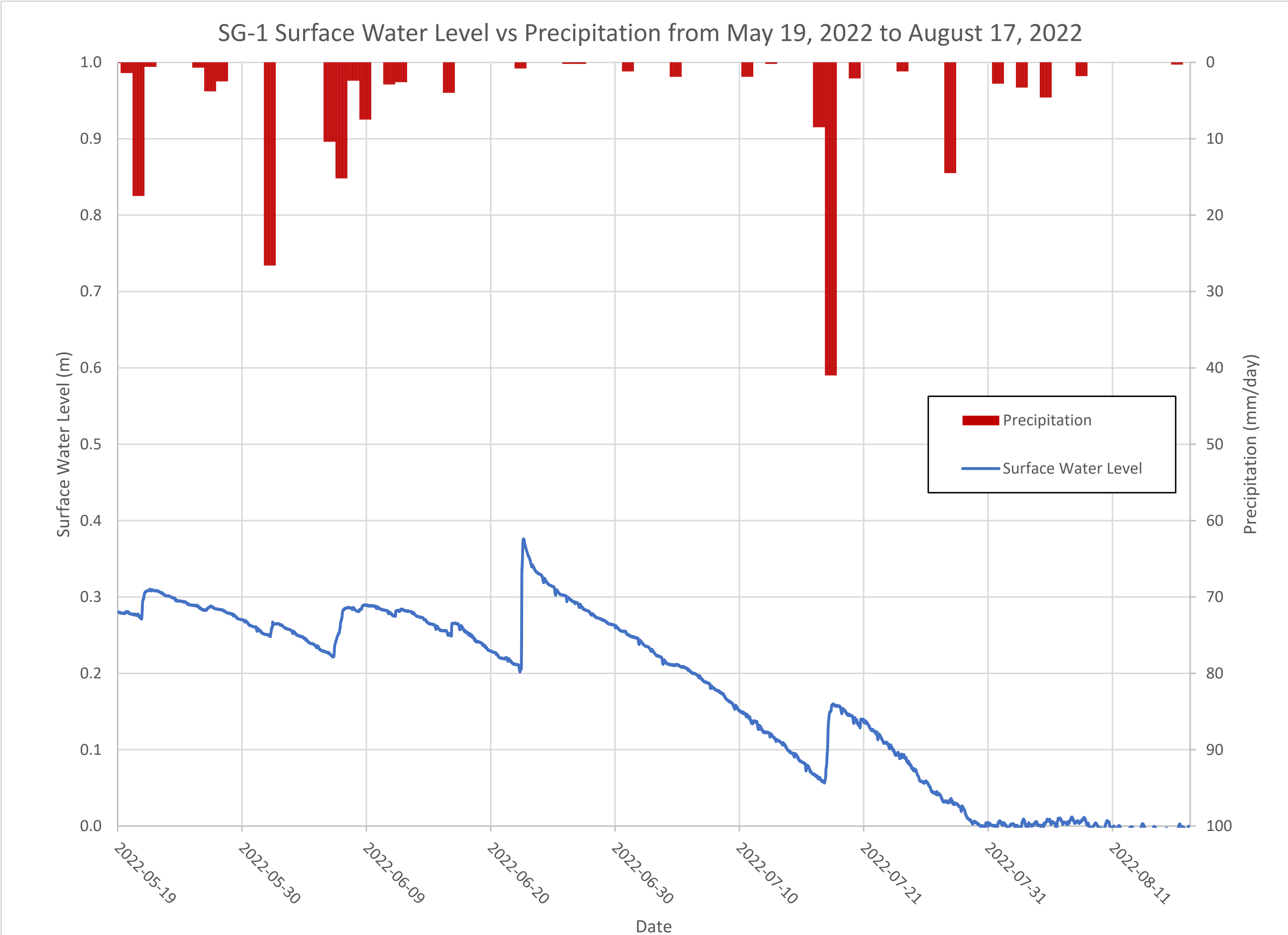
BH-20-8 Water Level Elevation vs Precipitation from May 19, 2022 to August 17, 2022
Water Level Elevation (masl)
173.0
172.9
172.8
172.7
172.6
172.5
172.4
172.3
172.2
172.1
172.0
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
2022-05-19
2022-05-30
2022-06-09
2022-06-20
2022-06-30
2022-07-10
2022-07-21
2022-07-31
2022-08-11
Date
Precipitation
Water Level Elevation



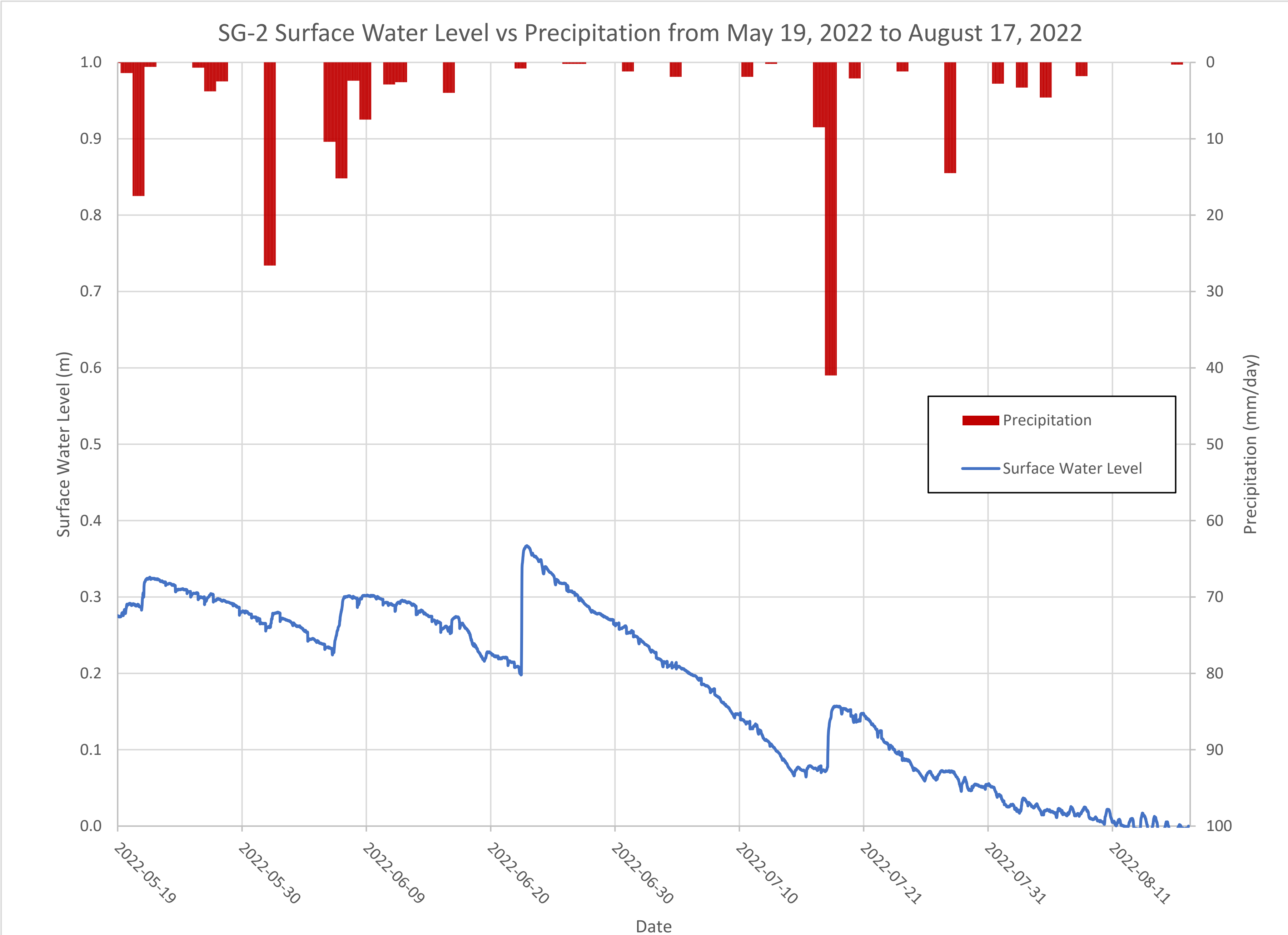
BH-20-13 Water Level Elevation vs Precipitation from May 19, 2022 to August 17, 2022
Water Level Elevation (masl)
175.5
175.4
175.3
175.2
175.1
175.0
174.9
174.8
174.7
174.6
174.5
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
2022-05-19
2022-05-30
2022-06-09
2022-06-20
2022-06-30
2022-07-10
2022-07-21
2022-07-31
2022-08-11
Date
Precipitation
Water Level Elevation

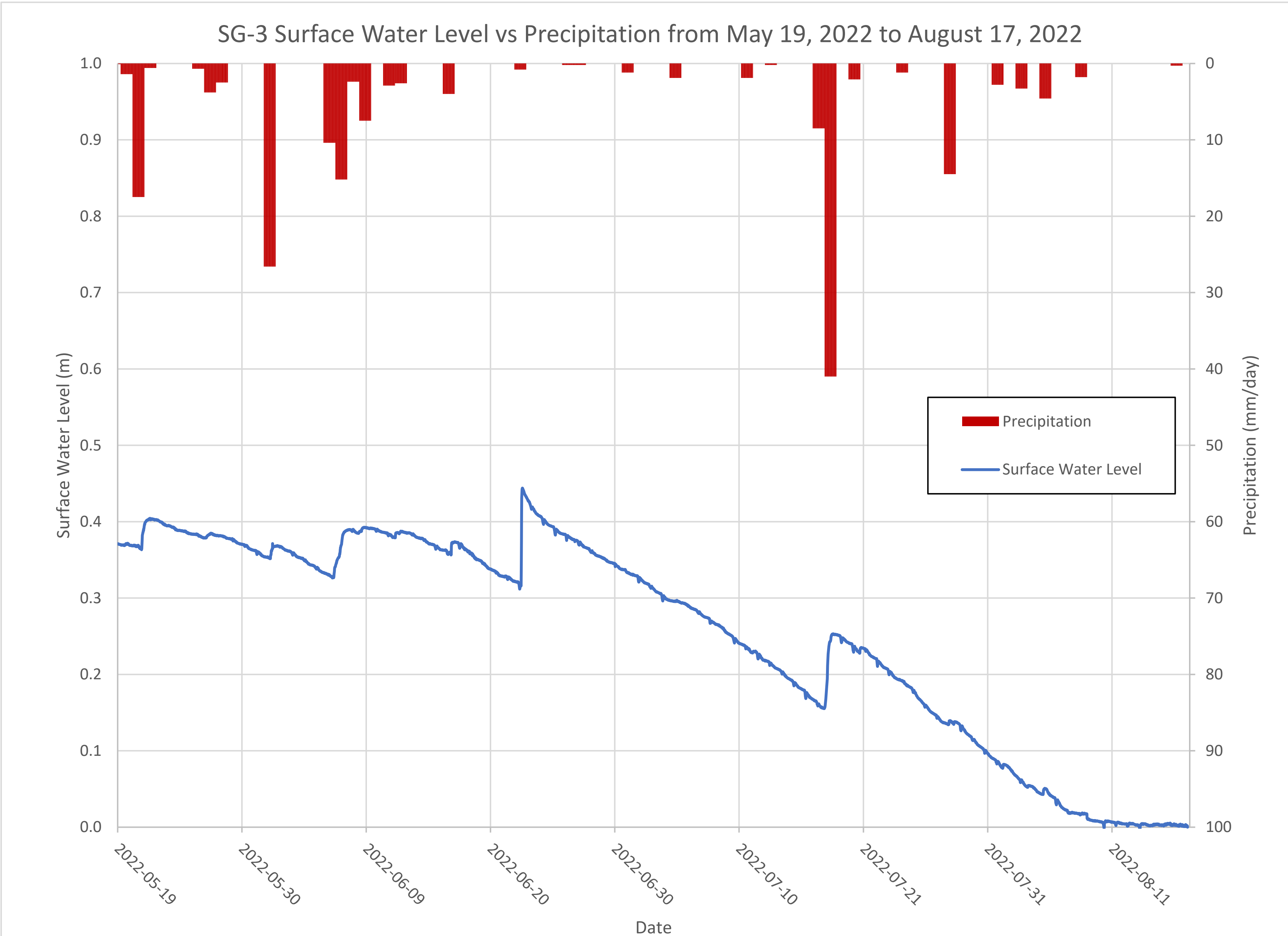


BH-20-18 Water Level Elevation vs Precipitation from May 19, 2022 to August 17, 2022
Water Level Elevation (masl)
Precipitation (mm/day)
175.0
174.9
174.8
174.7
174.6
174.5
174.4
174.3
174.2
174.1
174.0
0
10
20
30
40
50
60
70
80
90
100
2022-05-19
2022-05-30
2022-06-09
2022-06-20
2022-06-30
2022-07-10
2022-07-21
2022-07-31
2022-08-11
Date
Precipitation
Water Level Elevation

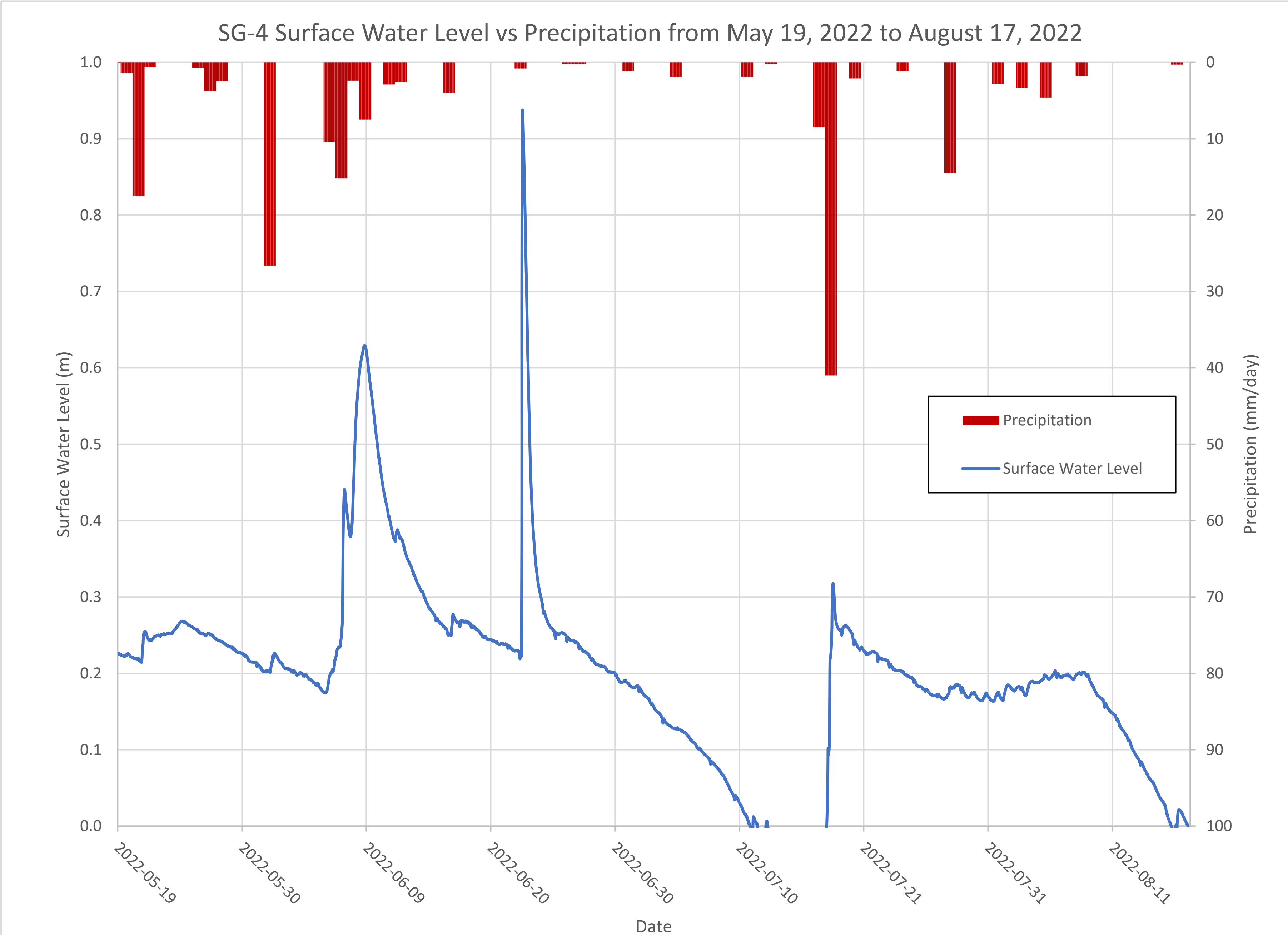


SG-1 Surface Water Level vs Precipitation from May 19, 2022 to August 17, 2022
Surface Water Level (m)
Precipitation (mm/day)
Date
Precipitation
Surface Water Level
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
50
60
70
80
90
100
2022-05-19
2022-05-30
2022-06-09
2022-06-20
2022-06-30
2022-07-10
2022-07-21
2022-07-31
2022-08-11

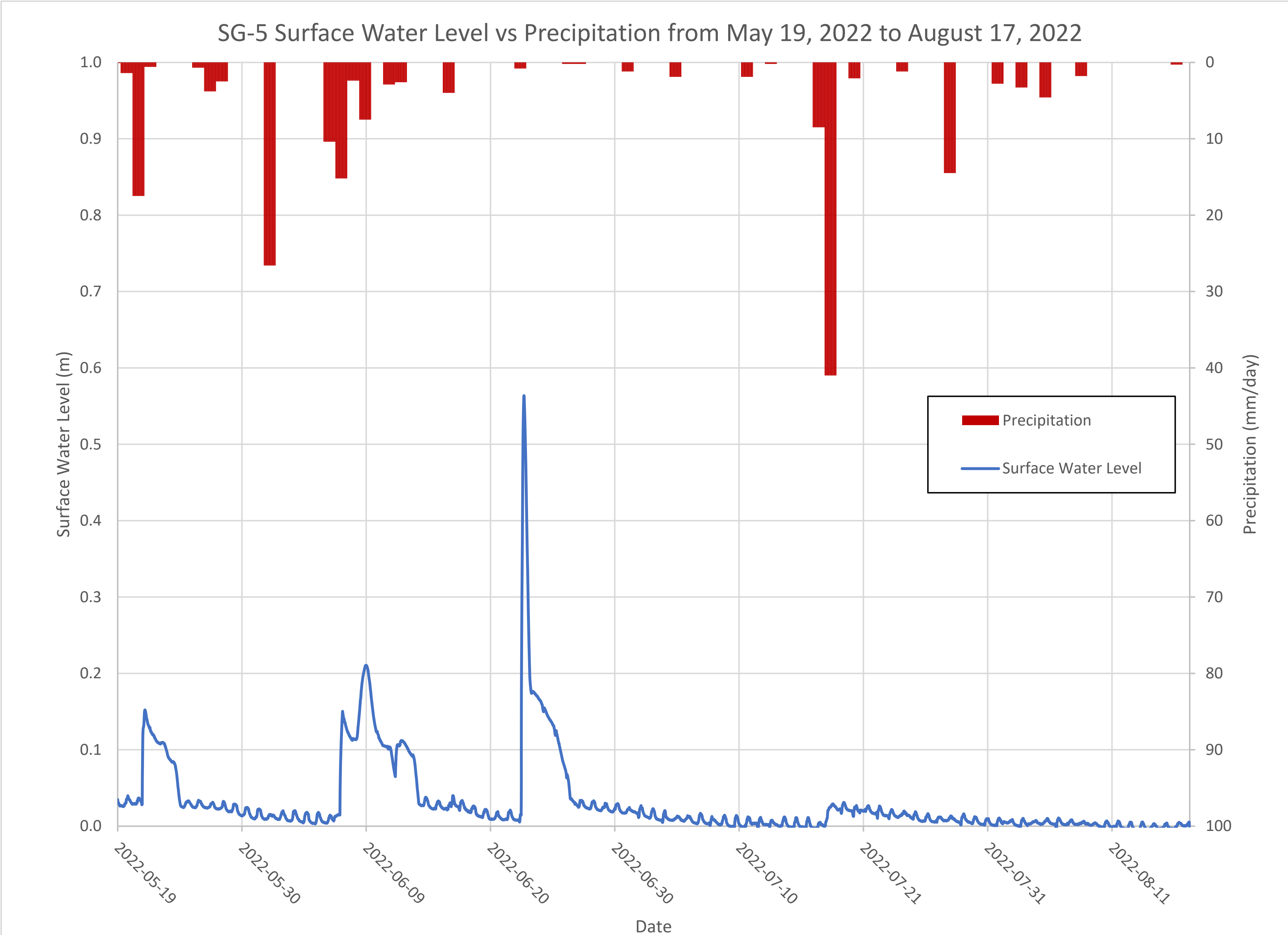

SG-2 Surface Water Level vs Precipitation from May 19, 2022 to August 17, 2022
Surface Water Level (m)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
Precipitation
Surface Water Level
2022-05-19
2022-05-30
2022-06-09
2022-06-20
2022-06-30
2022-07-10
2022-07-21
2022-07-31
2022-08-11
Date



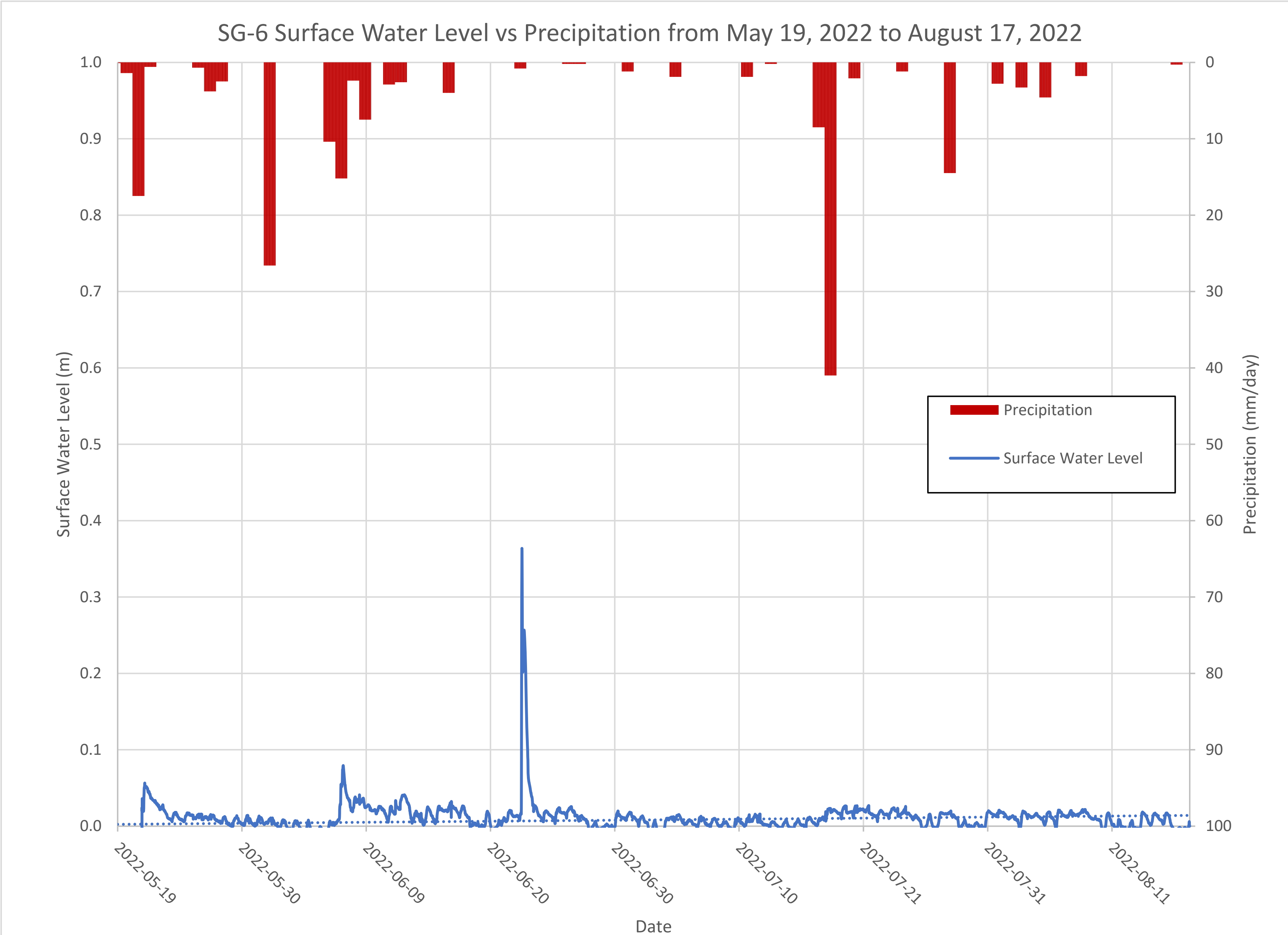
SG-3 Surface Water Level vs Precipitation from May 19, 2022 to August 17, 2022
Surface Water Level (m)
Precipitation (mm/day)
Date
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
50
60
70
80
90
100
2022-05-19
2022-05-30
2022-06-09
2022-06-20
2022-06-30
2022-07-10
2022-07-21
2022-07-31
2022-08-11
Precipitation
Surface Water Level



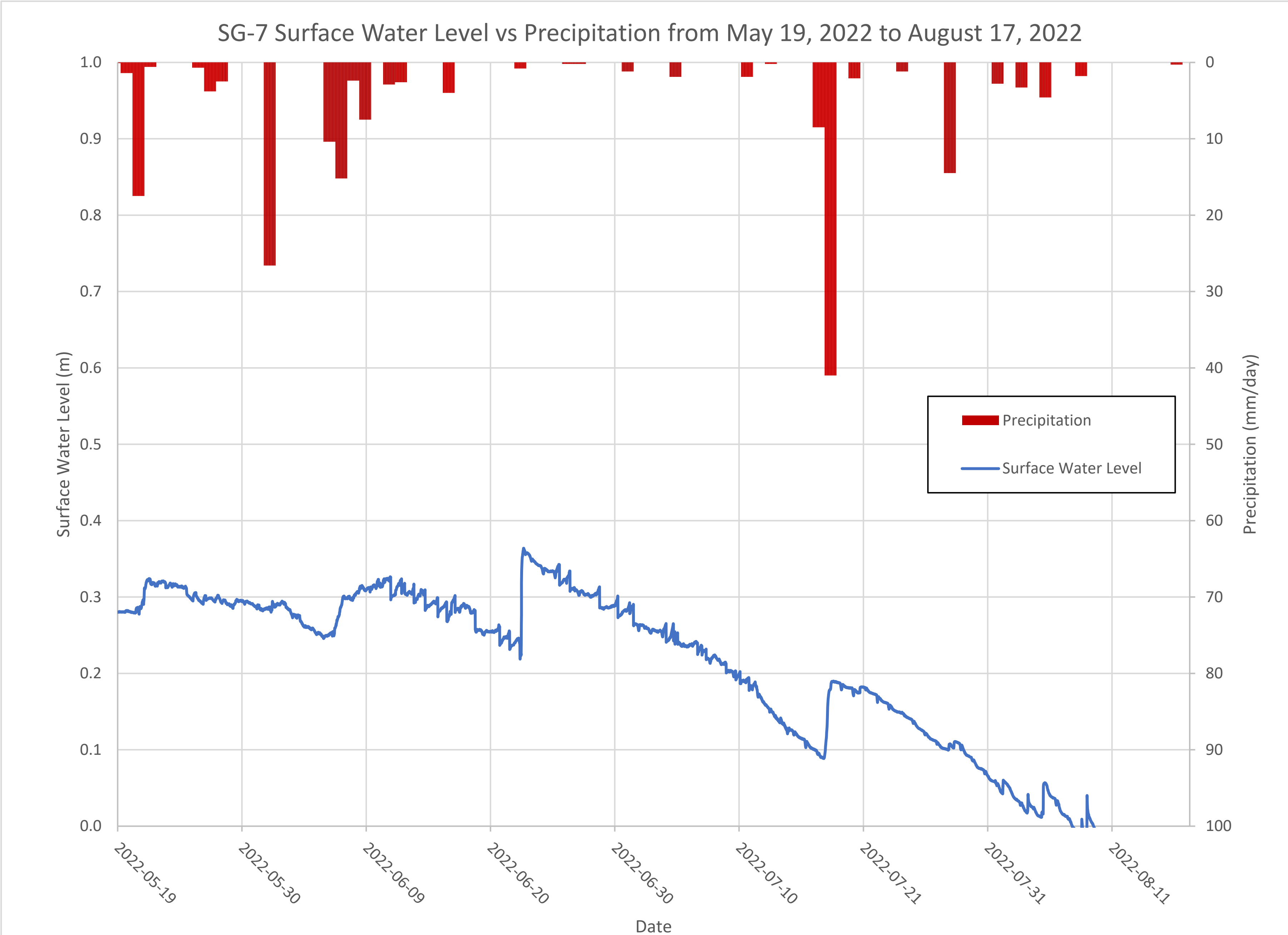
SG-4 Surface Water Level vs Precipitation from May 19, 2022 to August 17, 2022
Surface Water Level (m)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
Precipitation
Surface Water Level
2022-05-19
2022-05-30
2022-06-09
2022-06-20
2022-06-30
2022-07-10
2022-07-21
2022-07-31
2022-08-11
Date



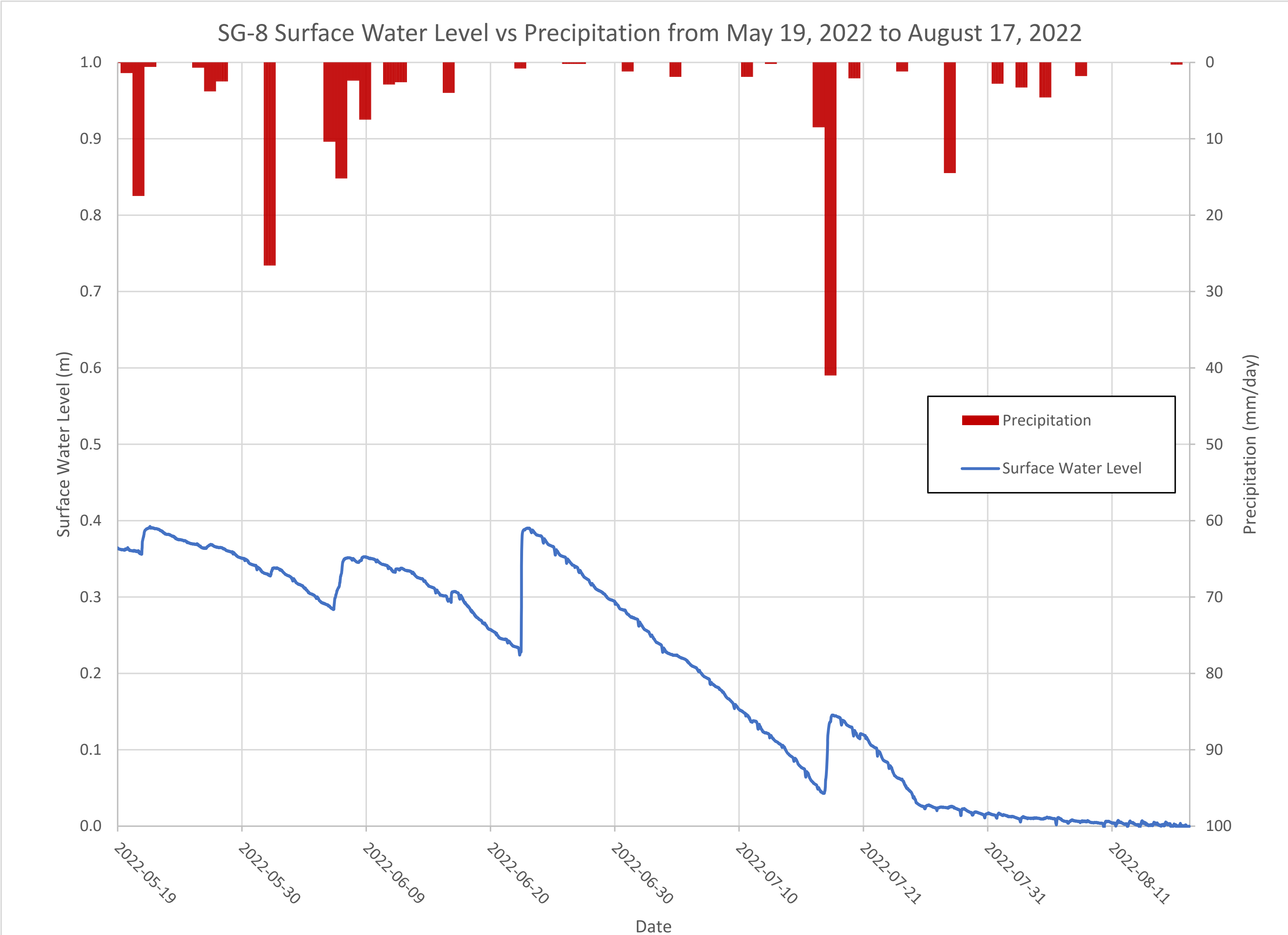
SG-5 Surface Water Level vs Precipitation from May 19, 2022 to August 17, 2022
Surface Water Level (m)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
Precipitation
Surface Water Level
2022-05-19
2022-05-30
2022-06-09
2022-06-20
2022-06-30
2022-07-10
2022-07-21
2022-07-31
2022-08-11
Date



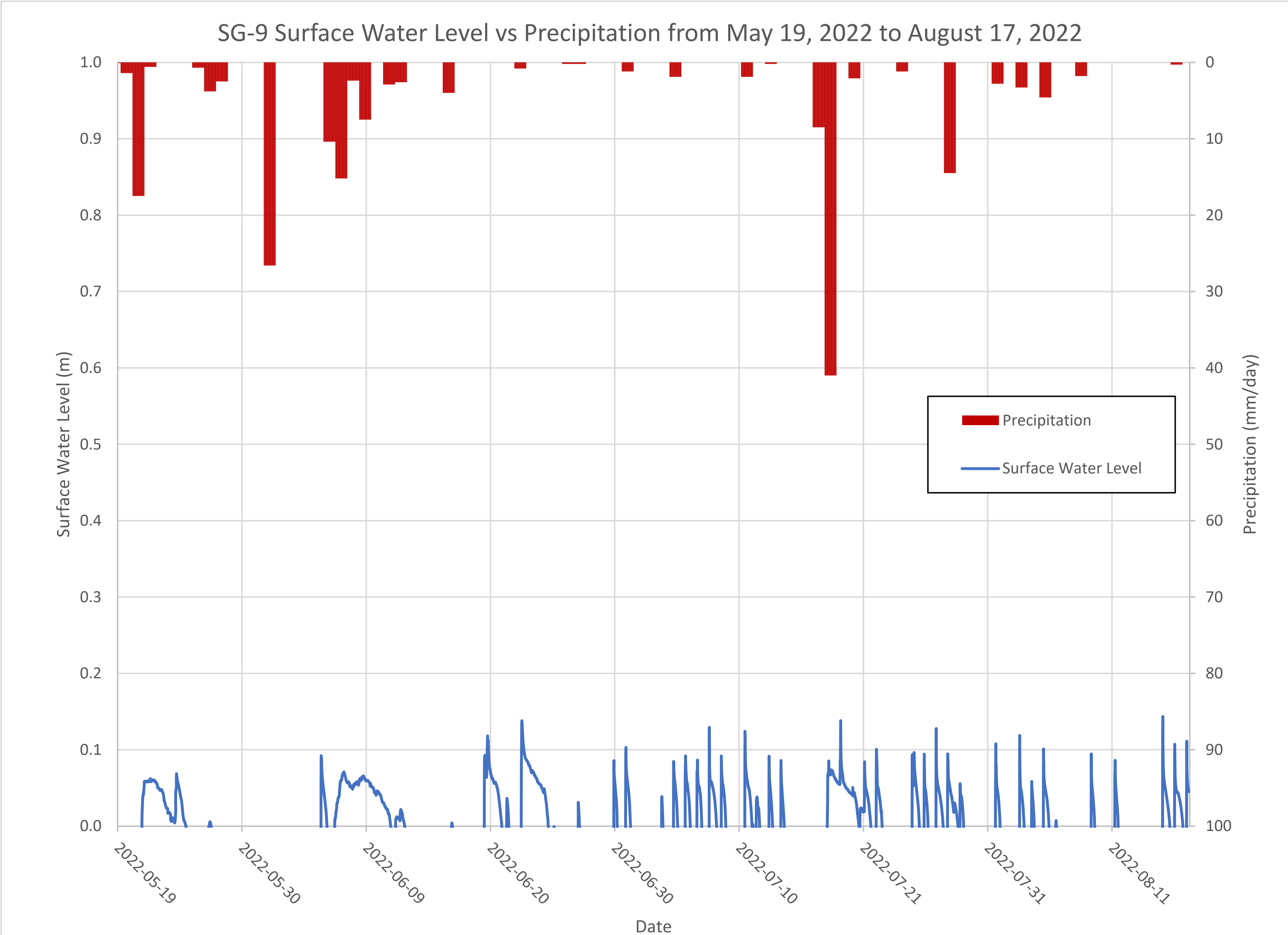
SG-6 Surface Water Level vs Precipitation from May 19, 2022 to August 17, 2022
Surface Water Level (m)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
Precipitation
Surface Water Level
2022-05-19
2022-05-30
2022-06-09
2022-06-20
2022-06-30
2022-07-10
2022-07-21
2022-07-31
2022-08-11
Date



SG-7 Surface Water Level vs Precipitation from May 19, 2022 to August 17, 2022
Surface Water Level (m)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
Precipitation
Surface Water Level
2022-05-19
2022-05-30
2022-06-09
2022-06-20
2022-06-30
2022-07-10
2022-07-21
2022-07-31
2022-08-11
Date



SG-8 Surface Water Level vs Precipitation from May 19, 2022 to August 17, 2022
Surface Water Level (m)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
Precipitation
Surface Water Level
2022-05-19
2022-05-30
2022-06-09
2022-06-20
2022-06-30
2022-07-10
2022-07-21
2022-07-31
2022-08-11
Date



SG-9 Surface Water Level vs Precipitation from May 19, 2022 to August 17, 2022
Surface Water Level (m)
Precipitation (mm/day)
Date
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
50
60
70
80
90
100
2022-05-19
2022-05-30
2022-06-09
2022-06-20
2022-06-30
2022-07-10
2022-07-21
2022-07-31
2022-08-11
Precipitation
Surface Water Level

Appendix D

Photographs

Niagara Empire Site Visit May 19, 2022

SG-1

GPS 17T 652146 4766638

Top DP-> Sediment=61.6cm

Top DP-> Water= 34cm

Depth at DP= 27.4cm

SG-2

GPS 17T 652386 4766776

Top DP-> Sediment=68.2cm

Top DP-> Water= 39.4cm

Depth at DP= 28.6cm

SG-3

GPS 17T 651784 4766630

Top DP-> Sediment=61.4 cm

Top DP-> Water= 25.9cm

Depth at DP= 35.5cm

SG-4

GPS 17T 651488 4766883

Top DP-> Sediment=60 cm

Top DP-> Water= 33.2cm

Depth at DP= 26.5cm

SG-5

GPS 17T 652358 4767051

Top DP-> Sediment=69.5cm

Top DP-> Water= 64.9cm

Depth at DP= 4.2cm

SG6

GPS 17T 652857 4767142

Top DP-> Sediment=60.8cm

Top DP-> Water= Dry

Depth at DP= Dry

SG-7

GPS 17T 652153 4767390

Top DP-> Sediment=49.2cm

Top DP-> Water= 21.5cm

Depth at DP= 27.6cm

SG-8

GPS 17T 652098 4767201

Top DP-> Sediment=62.8cm

Top DP-> Water= 28.5cm

Depth at DP= 34.6cm

SG-9

GPS 17T 652079 4767837

Top DP-> Sediment=51.2cm

Top DP-> Water= Dry

Depth at DP= Dry

SW1

GPS 17T 652881 4767130

Top DP-> Sediment=61.2cm

Top DP-> Water= 27.2cm

Depth at DP= 34.5cm

SW2

GPS 17T 652898 4766683

Top DP-> Sediment=66.5cm

Top DP-> Water= 39cm

Depth at DP= 26.6cm

Niagara Empire Site Visit August 18, 2022

SG-1

GPS 17T 652146 4766638

Top DP-> Sediment=Dry

Top DP-> Water= Dry

SG-2

GPS 17T 652386 4766776

Top DP-> Water= Dry

Depth at DP= Dry

SG-3

GPS 17T 651784 4766630

Top DP-> Water= Dry

Depth at DP= Dry

SG-4

GPS 17T 651488 4766883

Top DP-> Water= Dry

Depth at DP= Dry

SG-5

GPS 17T 652358 4767051

Top DP-> Water= Dry

Depth at DP= Dry

SG6

GPS 17T 652857 4767142

Top DP-> Water= Dry

Depth at DP= Dry

SG-7

GPS 17T 652153 4767390

Top DP-> Water= Dry

Depth at DP= Dry

SG-8

GPS 17T 652098 4767201

Top DP-> Water= Dry

Depth at DP= Dry

SG-9

GPS 17T 652079 4767837

Top DP-> Water= 48cm

Depth at DP= 4.5cm

SW-1

GPS 17T 652881 4767130

Top DP-> Water= 32.5cm

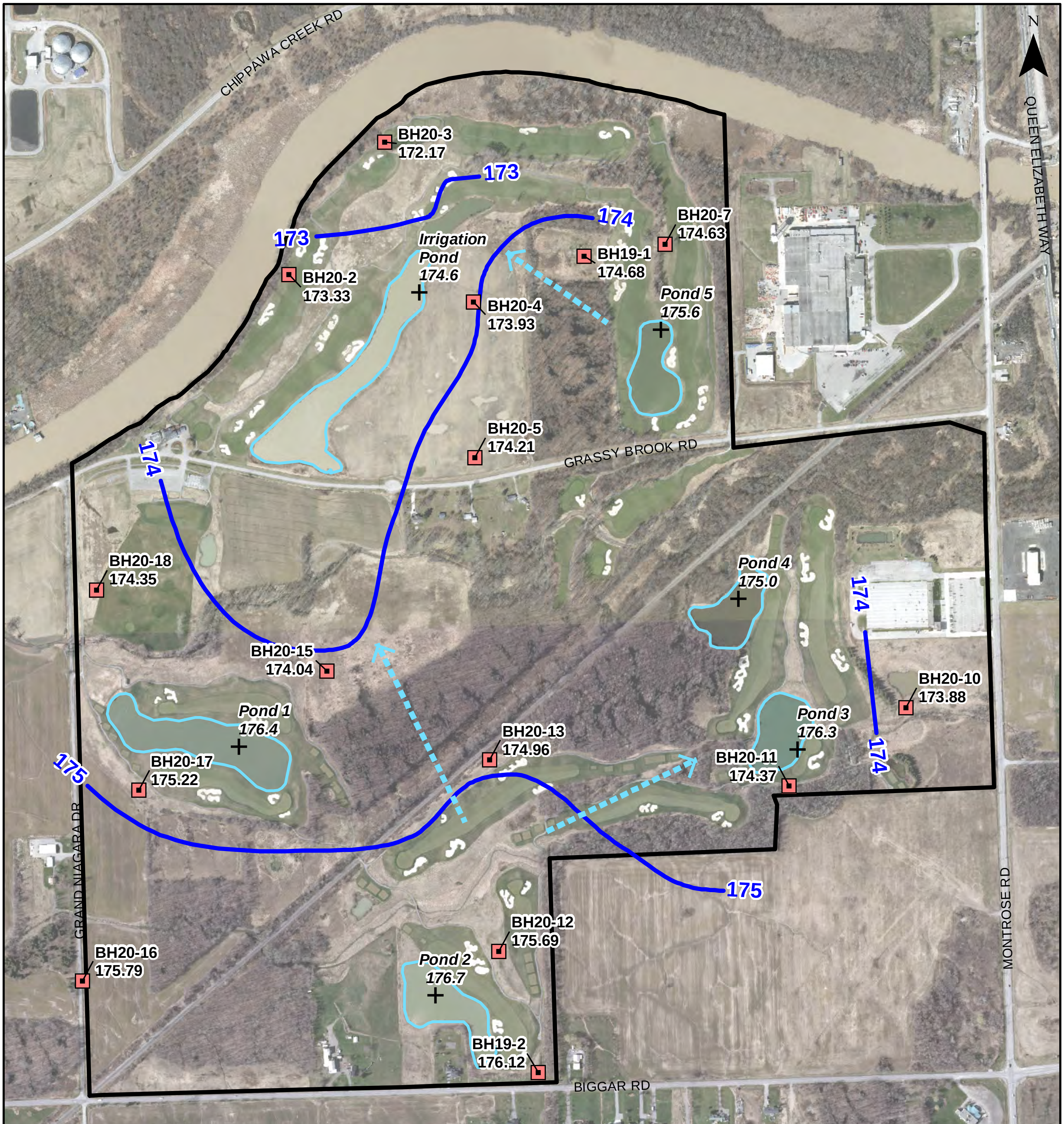
Depth at DP= 27.5cm

<u>SW-2</u>

GPS 17T 652898 4766683

Top DP-> Water= 63.5cm

Depth at DP= <1cm



Subject Lands

Groundwater Monitoring Well

Groundwater Elevation August 2022 (m ASL)

Groundwater Flow Direction

Pond

Pond Surface Elevation (m ASL)

Potentiometric Surface

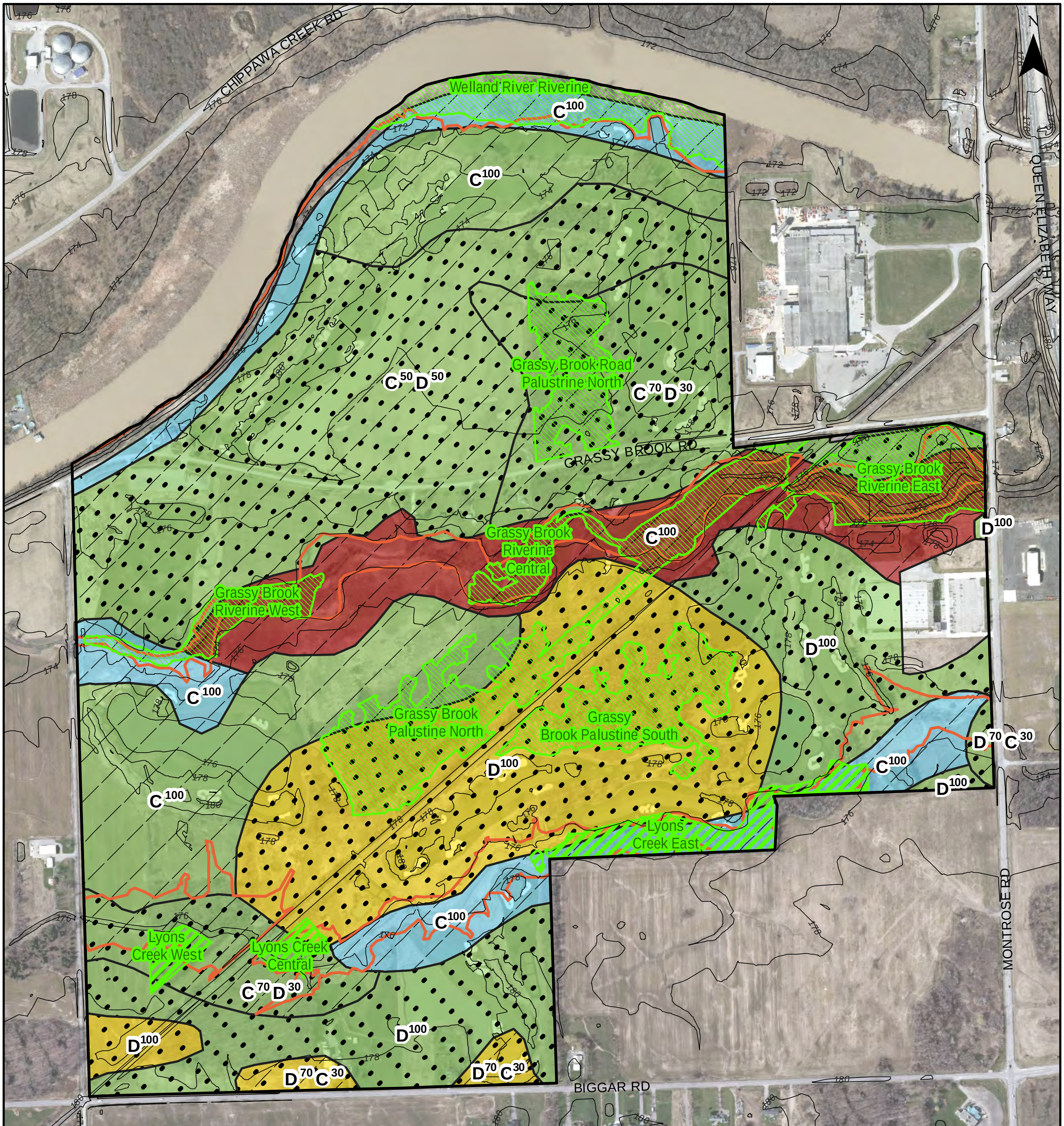
Grand Niagara, Empire (Grand Niagara) GP Inc.
8547 Grassy Brook Road, Niagara Falls, ON.

TDC Terra-Dynamics Consulting Inc.

0 200 M

1:10,000

Figure 6



Subject Lands

Floodplain Extent

Surface Contour 2m (NPCA)

Wetlands

Non-provincially Significant Wetland

Provincially Significant Wetland

Soils (OMAFRA)

Soil Name

Alluvium

Cashel - Heavy Red

Niagara

Welland

Hydrologic Soil Group (%)

Group C

Group C/D

Group D

Soils

Grand Niagara, Empire (Grand Niagara) GP Inc.
8547 Grassy Brook Road, Niagara Falls, ON.

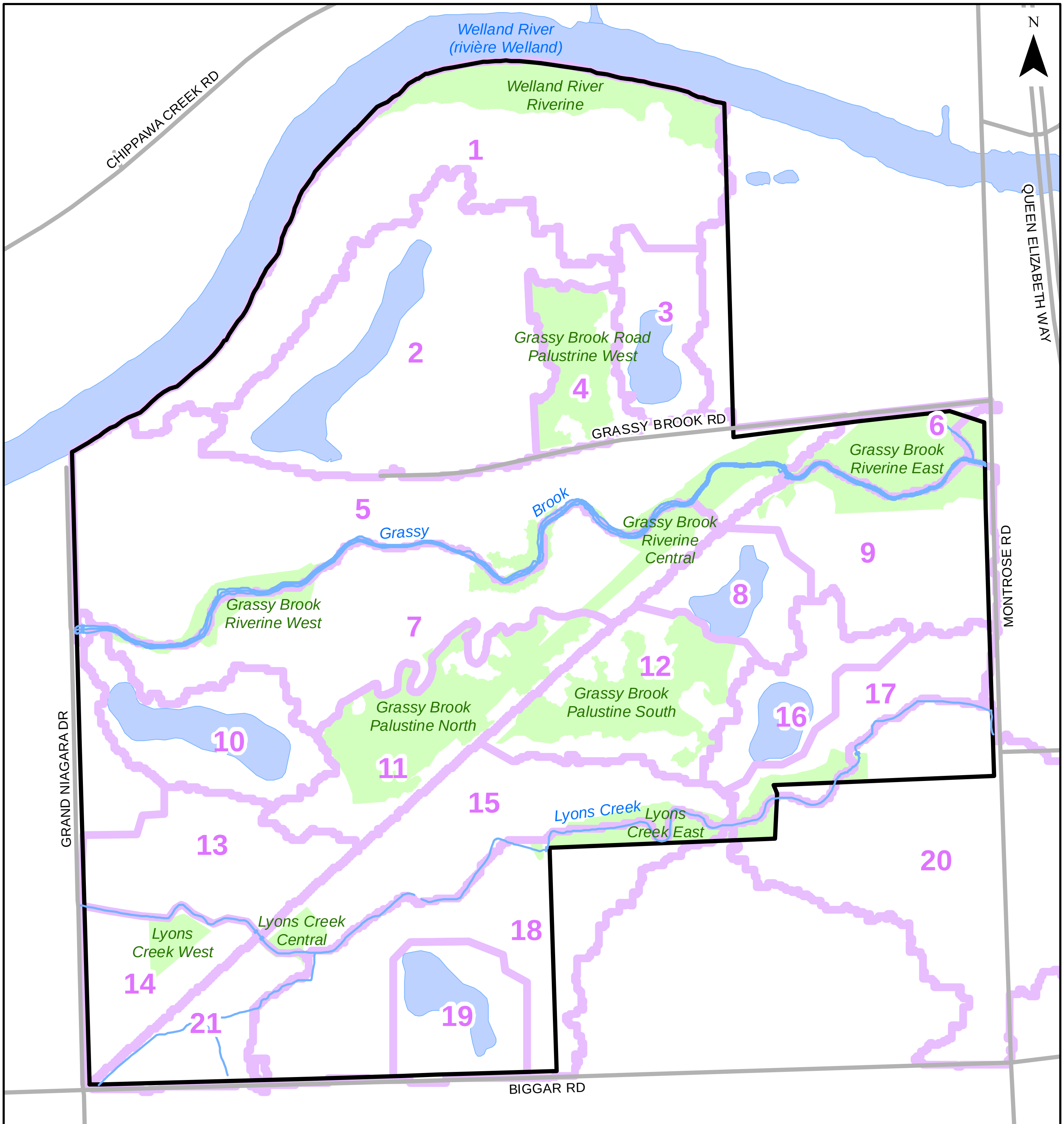
TDC Terra-Dynamics Consulting Inc.

0 200 M

1:10,000

Figure 7

Path: H:\TERRA_DYNAMICS\9559 - TD 8547 Grassy Brook Rd\gis\mxd\Figure 7 Soils.mxd Revised: October 11, 2022



Subject Lands

Catchment

Watercourse (NPCA)

Wetlands

Catchment ID

1 Welland River Riverine Wetland
2 Main Irrigation Pond
3 Pond
4 Palustrine Wetland Grassy Brook North
5 Lower Grassy Brook North
6 Lower Grassy Brook Northeast
7 Lower Grassy Brook South
8 Pond
9 Lower Grassy Brook Southwest
10 Pond
11 Palustrine Wetland Railway North
12 Palustrine Wetland Railway South
13 West Lyons Creek North
14 West Lyons Creek South
15 Central Lyons Creek North
16 Pond
17 East Lyons Creek North
18 Central Lyons Creek South
19 Pond
20 East Lyons Creek South
21 Lyons Creek South

Surface Water and Wetland Catchments

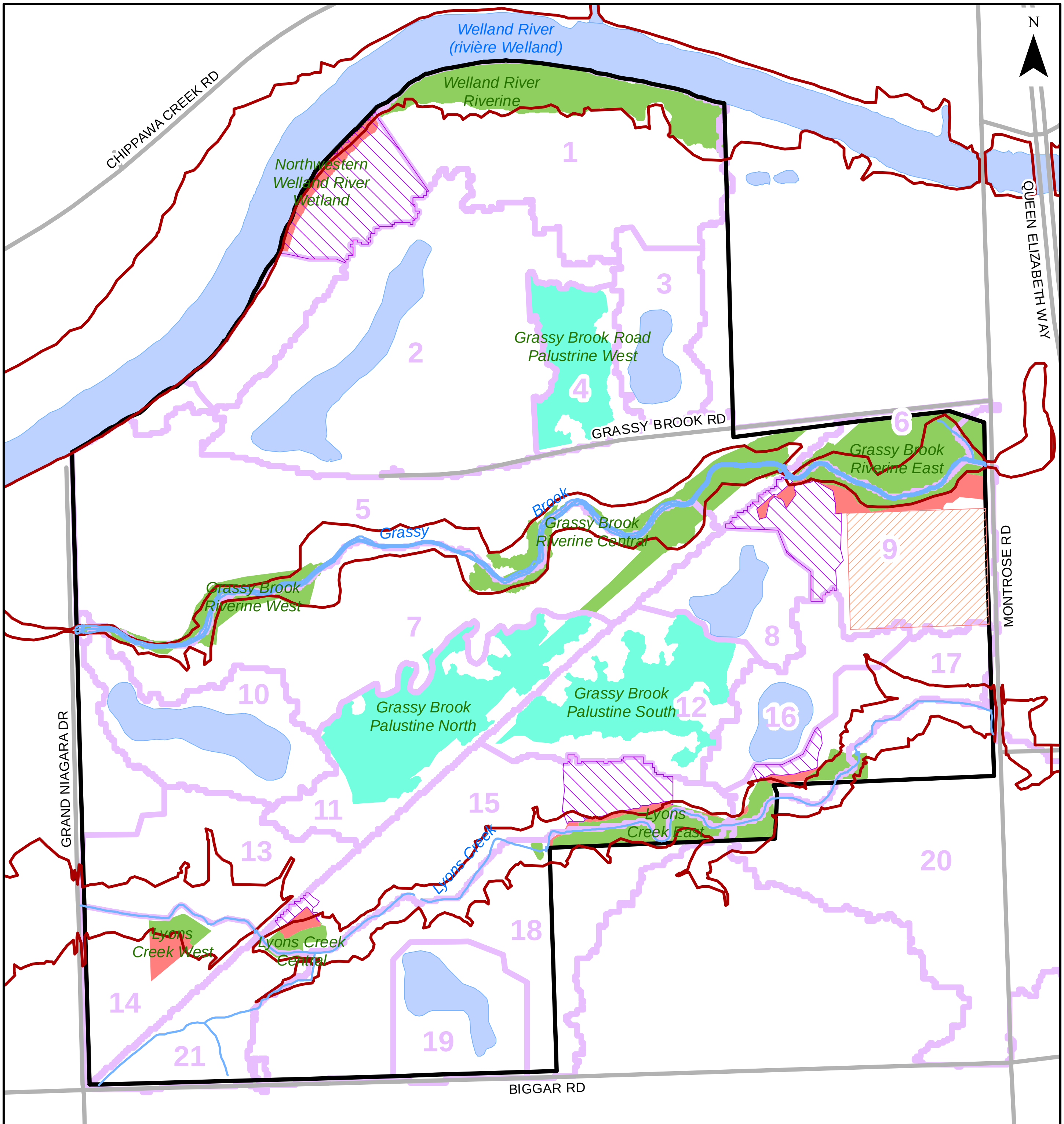
Grand Niagara, Empire (Grand Niagara) GP Inc.
8547 Grassy Brook Road, Niagara Falls, ON.

TDC Terra-Dynamics Consulting Inc.

0 200 M
1:10,000

Figure 10

Path: H:\TERRA_DYNAMICS\9559 - TD 8547 Grassy Brook Rd\gis\mxd\Figure 10 Surface Water and Wetland Catchments.mxd Revised: October 11, 2022



Subject Lands
Industrial Area
Regulated Floodplain (NPCA)
Watercourse (NPCA)
Waterbody
Catchment
Subcatchment

Wetland Hydrologic Class

Precipitation
Riverine
Runoff

See Figure 10 for Catchment ID explanations.

Wetland Hydrologic Classifications

Grand Niagara, Empire (Grand Niagara) GP Inc.
8547 Grassy Brook Road, Niagara Falls, ON.

TDC Terra-Dynamics Consulting Inc.

0 200 M

1:10,000

Figure 11

Path: H:\TERRA_DYNAMICS\9559 - TD 8547 Grassy Brook Rd\gis\mxd\Figure 11 Wetland Hydrologic Classifications.mxd Revised: November 4, 2022

Table 4a
Monitoring Well Details and Water Levels

Well I.D.	Ground Elevation (m ASL)	Stick-Up (m)	TOC Elevation (m ASL)	Well Depth Below TOC (m)	Well Depth below ground (m)	Date	Water level (m below TOC)	Water Level below ground (m)	Depth at Staff Gauge (m)	Water Level Elevation (m ASL)
BH20-2	174.54	0.80	175.34	18.30	17.50	20-Dec-20	3.50	2.70	-	171.84
						10-Mar-21	2.45	1.65	-	172.89
						19-May-22	1.94	1.14	-	173.40
						18-Aug-22	2.01	1.21	-	173.33
BH20-4	175.51	0.75	176.26	10.68	9.93	20-Dec-20	2.99	2.24	-	173.27
						10-Mar-21	2.67	1.92	-	173.59
						19-May-22	1.94	1.18	-	174.33
						18-Aug-22	2.33	1.58	-	173.93
BH20-8	177.18	0.78	177.96	10.68	9.91	20-Dec-20	5.97	5.19	-	171.99
						10-Mar-21	5.85	5.07	-	172.11
						19-May-22	5.16	4.38	-	172.80
						18-Aug-22	5.52	4.75	-	172.43
BH20-13	177.42	0.87	178.29	10.70	9.84	20-Dec-20	4.43	3.56	-	173.86
						10-Mar-21	3.90	3.03	-	174.39
						19-May-22	3.27	2.40	-	175.02
						18-Aug-22	3.33	2.46	-	174.96
BH20-18	175.25	0.77	176.02	10.68	9.91	20-Dec-20	2.07	1.30	-	173.95
						10-Mar-21	2.02	1.25	-	174.00
						19-May-22	1.49	0.72	-	174.53
						18-Aug-22	1.67	0.90	-	174.35
SG1	177.50	0.62	178.12	0.78	0.16	19-May-22	0.34	-	0.27	177.78
						18-Aug-22	Dry	Dry	Dry	Dry
SG2	176.50	0.68	177.18	0.78	0.10	19-May-22	0.39	-	0.29	176.79
						18-Aug-22	Dry	Dry	Dry	Dry
SG3	177.50	0.61	178.11	0.78	0.17	19-May-22	0.26	-	0.36	177.86
						18-Aug-22	Dry	-	Dry	Dry

Table 4a
Monitoring Well Details and Water Levels

Well I.D.	Ground Elevation (m ASL)	Stick-Up (m)	TOC Elevation (m ASL)	Well Depth Below TOC (m)	Well Depth below ground (m)	Date	Water level (m below TOC)	Water Level below ground (m)	Depth at Staff Gauge (m)	Water Level Elevation (m ASL)
SG4	173.50	0.60	174.10	0.78	0.18	19-May-22	0.33	-	0.27	173.77
						18-Aug-22	Dry	-	Dry	Dry
SG5	172.60	0.70	173.30	0.78	0.09	19-May-22	0.65	-	0.04	172.65
						18-Aug-22	Dry	-	Dry	Dry
SG6	172.50	0.61	173.11	0.78	0.17	19-May-22	Dry	-	Dry	Dry
						18-Aug-22	Dry	-	Dry	Dry
SG7	176.50	0.49	176.99	0.78	0.29	19-May-22	0.22	-	0.28	176.78
						18-Aug-22	Dry	-	Dry	Dry
SG8	176.50	0.63	177.13	0.78	0.15	19-May-22	0.29	-	0.35	176.84
						18-Aug-22	Dry	-	Dry	Dry
SG9	170.50	0.51	171.01	0.78	0.27	19-May-22	Dry	-	Dry	Dry
						18-Aug-22	0.48	-	0.05	170.53
SW-1	171.00	0.61	171.61	0.78	0.17	19-May-22	0.27	-	0.35	171.34
						18-Aug-22	0.33	-	0.28	171.29
SW-2	175.00	0.67	175.67	0.78	0.12	19-May-22	0.39	-	0.27	175.28
						18-Aug-22	0.64	-	0.01	175.03

Note:
MW=Monitoring well; SG=Staff gauge; TOC= Top of Casing; m ASL=metres above sea level; * - Depth at staff gauge

Table 4b
Additional Monitoring Well Details and Water Levels

Well I.D.	Ground Elevation (m ASL)	Stick-Up (m)	TOC Elevation (m ASL)	Well Depth Below TOC (m)	Well Depth below ground (m)	Date	Water level (m below TOC)	Water Level below ground (m)	Water Level Elevation (m ASL)
BH20-3	172.37	1.00	173.37	12.20	11.20	20-Dec-20	1.45	0.45	171.92
						10-Mar-21	1.53	0.53	171.84
						18-Aug-22	1.20	0.20	172.17
BH20-5	176.60	1.00	177.60	15.25	14.25	20-Dec-20	13.46	12.46	164.14
						10-Mar-21	4.40	3.40	173.20
						18-Aug-22	3.39	2.39	174.21
BH20-7	176.90	1.00	177.90	10.68	9.68	20-Dec-20	6.00	5.00	171.90
						10-Mar-21	4.35	3.35	173.55
						18-Aug-22	3.27	2.27	174.63
BH20-10	174.68	1.00	175.68	12.20	11.20	20-Dec-20	7.85	6.85	167.83
						10-Mar-21	1.80	0.80	173.88
						18-Aug-22	1.80	0.80	173.88
BH20-11	176.45	1.00	177.45	18.30	17.30	20-Dec-20	9.64	8.64	167.81
						10-Mar-21	4.00	3.00	173.45
						18-Aug-22	3.08	2.08	174.37
BH20-12	178.33	1.00	179.33	15.20	14.20	20-Dec-20	14.52	13.52	164.81
						10-Mar-21	4.31	3.31	175.02
						18-Aug-22	3.64	2.64	175.69
BH20-15	176.79	1.00	177.79	10.68	9.68	20-Dec-20	4.99	3.99	172.80
						10-Mar-21	5.10	4.10	172.69
						18-Aug-22	3.75	2.75	174.04
BH20-16	177.69	1.00	178.69	10.68	9.68	20-Dec-20	3.62	2.62	175.07
						10-Mar-21	3.40	2.40	175.29
						18-Aug-22	2.90	1.90	175.79
BH20-17	177.84	1.00	178.84	15.23	14.23	20-Dec-20	6.98	5.98	171.86
						10-Mar-21	3.98	2.98	174.86
						18-Aug-22	3.62	2.62	175.22
BH19-1	176.12	1.00	177.12	8.80	7.80	20-Dec-20	NA	NA	NA
						10-Mar-21	3.48	2.48	173.64
						18-Aug-22	2.44	1.44	174.68
BH19-2	179.94	1.00	180.94	8.50	7.50	20-Dec-20	NA	NA	NA
						10-Mar-21	6.70	5.70	174.24
						18-Aug-22	4.82	3.82	176.12

TABLE 11a - Soil Water Holding Capacity 400 mm
USGS Wetland Monthly Water Balance

Date	P	PET	P-PET	Soil Moisture	AET	PET-AET	Snow Storage	Surplus	ROtotal	Comments
========	========	========	========	========	========	========	========	========	========	
January	76.9	9.7	44.8	400	9.7	0	29.3	44.8	47.2	Surplus
February	61.6	11.8	49.1	400	11.8	0	28.4	49.1	48.9	Surplus
March	65.7	21.7	62.8	400	21.7	0	6.9	62.8	57.8	Surplus
April	73.7	39.8	37	400	39.8	0	0	37	49.7	Surplus
May	86	72	9.7	400	72	0	0	9.7	32.2	Surplus
June	81.9	107.2	-29.4	370.6	107.2	0	0	0	18	Soil Water Utilization
July	82.4	127.1	-48.9	325.4	123.6	3.6	0	0	11.1	Soil Water Utilization
August	80.8	102.1	-25.4	304.7	97.4	4.7	0	0	7.5	Soil Water Utilization
September	97.5	61.4	31.2	336	61.4	0	0	0	6.6	Soil Water Recharge
October	84.5	32.8	47.5	383.5	32.8	0	0	0	5.1	Soil Water Recharge
November	95.2	17.4	73	400	17.4	0	0	56.5	33.4	Surplus
December	86.6	11.1	63.9	400	11.1	0	8.6	63.9	49.3	Surplus
Sum	972.8				605.9				366.8	

TABLE 11b - Soil Water Holding Capacity 385 mm
USGS Wetland Monthly Water Balance

Date	P	PET	P-PET	Soil Moisture	AET	PET-AET	Snow Storage	Surplus	ROtotal	Comments
========	========	========	========	========	========	========	========	========	========	
January	76.9	9.7	44.8	385	9.7	0	29.3	44.8	47.3	Surplus
February	61.6	11.8	49.1	385	11.8	0	28.4	49.1	49	Surplus
March	65.7	21.7	62.8	385	21.7	0	6.9	62.8	57.8	Surplus
April	73.7	39.8	37	385	39.8	0	0	37	49.7	Surplus
May	86	72	9.7	385	72	0	0	9.7	32.2	Surplus
June	81.9	107.2	-29.4	355.6	107.2	0	0	0	18	Soil Water Utilization
July	82.4	127.1	-48.9	310.5	123.4	3.7	0	0	11.1	Soil Water Utilization
August	80.8	102.1	-25.4	290.1	97.2	4.9	0	0	7.5	Soil Water Utilization
September	97.5	61.4	31.2	321.3	61.4	0	0	0	6.6	Soil Water Recharge
October	84.5	32.8	47.5	368.8	32.8	0	0	0	5.1	Soil Water Recharge
November	95.2	17.4	73	385	17.4	0	0	56.8	33.6	Surplus
December	86.6	11.1	63.9	385	11.1	0	8.6	63.9	49.4	Surplus
Sum	972.8				605.5				367.3	

TABLE 11c 0 Soil Water Holding Capacity 360 mm
USGS Wetland Monthly Water Balance

Date	P	PET	P-PET	Soil Moisture	AET	PET-AET	Snow Storage	Surplus	ROtotal	Comments
========	========	========	========	========	========	========	========	========	========	
January	76.9	9.7	44.8	360	9.7	0	29.3	44.8	47.3	Surplus
February	61.6	11.8	49.1	360	11.8	0	28.4	49.1	49	Surplus
March	65.7	21.7	62.8	360	21.7	0	6.9	62.8	57.8	Surplus
April	73.7	39.8	37	360	39.8	0	0	37	49.8	Surplus
May	86	72	9.7	360	72	0	0	9.7	32.2	Surplus
June	81.9	107.2	-29.4	330.6	107.2	0	0	0	18	Soil Water Utilization
July	82.4	127.1	-48.9	285.8	123.2	4	0	0	11.1	Soil Water Utilization
August	80.8	102.1	-25.4	265.6	96.9	5.2	0	0	7.5	Soil Water Utilization
September	97.5	61.4	31.2	296.9	61.4	0	0	0	6.6	Soil Water Recharge
October	84.5	32.8	47.5	344.4	32.8	0	0	0	5.1	Soil Water Recharge
November	95.2	17.4	73	360	17.4	0	0	57.4	33.9	Surplus
December	86.6	11.1	63.9	360	11.1	0	8.6	63.9	49.5	Surplus
Sum	972.8				605				367.8	

TABLE 11d - Soil Water Holding Capacity 350 mm
USGS Wetland Monthly Water Balance

Date	P	PET	P-PET	Soil Moisture	AET	PET-AET	Snow Storage	Surplus	ROtotal	Comments
========	========	========	========	========	========	========	========	========	========	
January	76.9	9.7	44.8	350	9.7	0	29.3	44.8	47.4	Surplus
February	61.6	11.8	49.1	350	11.8	0	28.4	49.1	49	Surplus
March	65.7	21.7	62.8	350	21.7	0	6.9	62.8	57.8	Surplus
April	73.7	39.8	37	350	39.8	0	0	37	49.8	Surplus
May	86	72	9.7	350	72	0	0	9.7	32.2	Surplus
June	81.9	107.2	-29.4	320.6	107.2	0	0	0	18	Soil Water Utilization
July	82.4	127.1	-48.9	275.9	123	4.1	0	0	11.1	Soil Water Utilization
August	80.8	102.1	-25.4	255.9	96.7	5.4	0	0	7.5	Soil Water Utilization
September	97.5	61.4	31.2	287.1	61.4	0	0	0	6.6	Soil Water Recharge
October	84.5	32.8	47.5	334.6	32.8	0	0	0	5.1	Soil Water Recharge
November	95.2	17.4	73	350	17.4	0	0	57.6	34	Surplus
December	86.6	11.1	63.9	350	11.1	0	8.6	63.9	49.6	Surplus
Sum	972.8				604.6				368.1	

Table 13a - Wetland Runoff Water Balance, Welland River Riverine Wetland FOD

	Jun	Jul	Aug	Sep	Oct	Area (ha)	
Average Monthly Precipitation (mm)	82	82	81	98	85		
Upgradient Runoff (mm)	11.8	3	3.1	4.3	6		
Wetland Deficit (mm)	29	75	95	64	17		
Pre-development							
Wetland Deficit (m^3)	249	645	817	550	146	0.86	Wetland
Pre-development Upgradient Runoff (m^3)	453	115	119	165	230	3.84	Upland
Saturated Soils	Yes	No	No	No	Yes		
Post-development							
30 m Buffer Upgradient Runoff (m^3)	103	26	27	37	52	0.87	30 m buffer
Saturated Soils	No	No	No	No	No		
Deficit after considering Buffer (m^3)	147				94		
Impervious Runoff Area Needed (m^2)	1,790				1,106		

Table 13b - Wetland Runoff Water Balance, Grassy Brook Riverine East Catchment 9

	Jun	Jul	Aug	Sep	Oct
Average Monthly Precipitation (mm)	82	82	81	98	85
Upgradient Runoff (mm)	11.8	3	3.1	4.3	6
Wetland Deficit (mm)	29	75	95	64	17
Pre-development					
Wetland Deficit (m^3)	151	390	494	333	88
Pre-development Upgradient Runoff (m^3)	247	63	65	90	125
Saturated Soils	Yes	No	No	No	Yes
Post-development					
Buffer/Open Space Upgradient Runoff (m^3)	74	19	20	27	38
Saturated Soils	No	No	No	No	No
Deficit (m^3)	76				51
Area (m^2)	932				595

Area (ha)	
0.52	Wetland
2.09	Upland
0.63	Constraints Buffer/Open Space

Table 13c - Wetland Runoff Water Balance, Lyons Creek Riverine Central Catchment 15

	Jun	Jul	Aug	Sep	Oct	Area (ha)	
Average Monthly Precipitation (mm)	82	82	81	98	85		
Upgradient Runoff (mm)	11.8	3	3.1	4.3	6		
Wetland Deficit (mm)	29	75	95	64	17		
Pre-development							
Wetland Deficit (m^3)	55	143	181	122	32	0.19	Wetland
Pre-development Upgradient Runoff (m^3)	21	5	6	8	11	0.18	Upland
Saturated Soils	No	No	No	No	No		
Post-development							
Buffer/Open Space Upgradient Runoff (m^3)	72	18	19	26	37	0.61	Constraints Buffer/Open Space
Saturated Soils	Yes	No	No	No	Yes		
Deficit (m^3)	-17				-4		
Area (m^2)	-206				-51		

Table 13d - Wetland Runoff Water Balance, Lyons Creek Riverine East Catchment 15

	Jun	Jul	Aug	Sep	Oct
Average Monthly Precipitation (mm)	82	82	81	98	85
Upgradient Runoff (mm)	11.8	3	3.1	4.3	6
Wetland Deficit (mm)	29	75	95	64	17
Pre-development					
Wetland Deficit (m^3)	58	150	190	128	34
Pre-development Upgradient Runoff (m^3)	207	53	54	75	105
Saturated Soils	Yes	No	No	No	Yes
Post-development					
Buffer/Open Space Upgradient Runoff (m^3)	30	8	8	11	15
Saturated Soils	No	No	No	No	No
Deficit (m^3)	29				19
Area (m^2)	348				224

Area (ha)	
0.20	Wetland
1.75	Upland
0.25	Constraints Buffer/Open Space

Table 13e - Wetland Runoff Water Balance, Lyons Creek Riverine East Catchment 17

	Jun	Jul	Aug	Sep	Oct	Area (ha)	
Average Monthly Precipitation (mm)	82	82	81	98	85		
Upgradient Runoff (mm)	11.8	3	3.1	4.3	6		
Wetland Deficit (mm)	29	75	95	64	17		
Pre-development							
Wetland Deficit (m^3)	38	98	124	83	22	0.13	Wetland
Pre-development Upgradient Runoff (m^3)	44	11	11	16	22	0.37	Upland
Saturated Soils	Yes	No	No	No	Yes		
Post-development							
Buffer/Open Space Upgradient Runoff (m^3)	17	4	4	6	8	0.14	Constraints Buffer/Open Space
Saturated Soils	No	No	No	No	No		
Deficit (m^3)	21				14		
Area (m^2)	258				161		