NIAGARA FALLS THUNDERING WATERS DEVELOPMENT

FUNCTIONAL SERVICING STUDY

GR (CAN) INVESTMENT CO. LIMITED

CITY OF NIAGARA FALLS

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1.0 INTRODUCTION

GR (CAN) Investment Co. Ltd. has acquired approximately 486 acres [195.8 ha (+/-)] of land adjacent to the Thundering Waters Golf Course (the "Thundering Waters" Lands). It is currently proposed to develop the lands with a mix of commercial (retail shops, nursing homes, sports complexes and fields, a school and hotels), residential (single family homes, townhouses, and apartment building/condo minimum units both low and high rise), park lands (green space) and other employment uses.

In order to develop the lands, a Secondary Plan for the development is required. As part of the Secondary Plan, among other requirements, a Functional Servicing Study is required to determine the preferred approach to servicing the Thundering Waters Lands based on existing infrastructure capacity and related upgrades, to support development. Terms of Reference for the preparation of a Functional Servicing Study were prepared consultatively with the City of Niagara Falls, Region of Niagara and Niagara Peninsula Conservation Authority (NPCA) (ref. Appendix E). This report has followed the approved Terms of Reference (TOR) with the objective of detailing how the subject site would be serviced.

The study area is located in the City of Niagara Falls, bounded by Oldfield Road to the north, Dorchester Road to the west and south, and by the existing industrial developments to the east. Figure 1.1 shows the subject area in its current state.

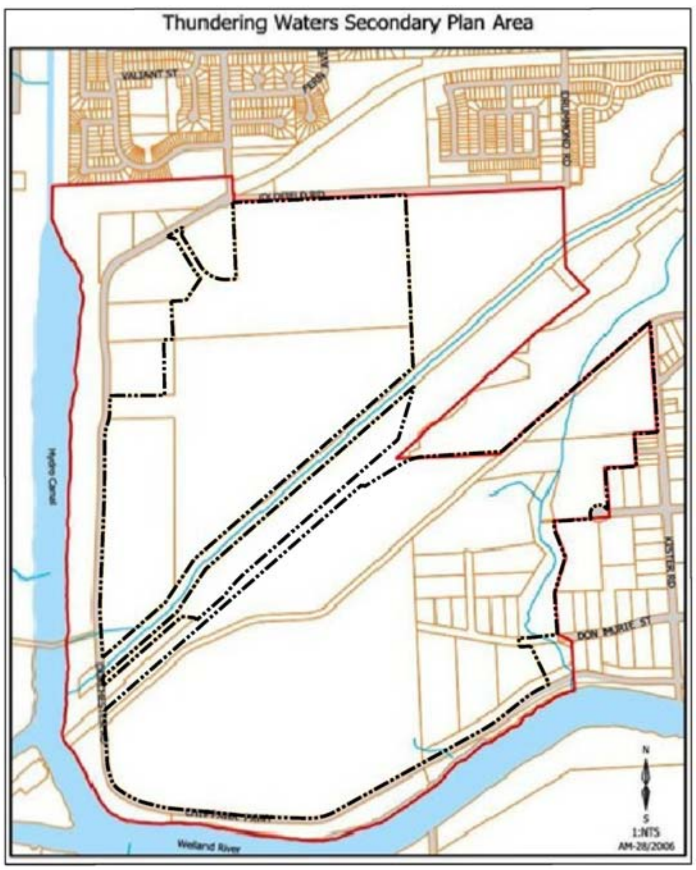

Figure 1.1 Study Area

The purpose and objectives of the Functional Servicing Study, in support of the Niagara Falls Thundering Waters Development Secondary Plan area, is to document existing service conditions and capacities, and prepare a conceptual servicing master plan for the proposed development with order of magnitude costs to address the ultimate build out of the area as per the proposed area land use. The Functional Servicing Plan is intended to satisfy the joint and integrated requirements of the Environmental Assessment and Planning Acts.

The specific objectives for this study include:

i. Assess the existing servicing capacities of the water, wastewater and stormwater systems.

ii. Analyze the impact of the proposed development on the existing systems using current MOECC, Region of Niagara, and City of Niagara Falls standards for development.

iii. Determine site servicing feasibility and requirements for new infrastructure and any necessary upgrades to the existing infrastructure systems (linear and treatment).

iv. Consider the potential opportunities and needs of other utility servicing such as gas, hydro, and communications.

v. Establish management and servicing strategies consistent with the recommendations of the Environmental Impact Study (under separate cover).

vi. Address the requirements of the MEA Class Environmental Assessment process (2011).

Per the approved TOR, this report provides a summary of existing information serving as background to establishing an understanding of the area’s services specific to water, wastewater and storm, as well as other utilities. This information provided by the City, Region and Conservation Authority, and has served as the basis for evaluating proposed future development scenarios and determining required servicing for the Thundering Waters Lands.

2.0 BACKGROUND INFORMATION

As part of the process involved in establishing the Terms or Reference for preparation of the Functional Servicing Plan, Amec Foster Wheeler staff met with City of Niagara Falls, Niagara Region, and NPCA staff on a number of occasions to pre-consult on municipal servicing requirements and develop an improved understanding of available background information. In terms of the Functional Servicing Plan, the available information is specific to water, wastewater, stormwater, and related utilities. The City of Niagara Falls provided information related to the following:

- Con Rail Drain
  - 12 tif images and geotechnical report
- Master Drainage Plan Update Study
- Culvert plans depicting locations
- Various other Reports and Plans including:
  - Review of Municipal Servicing Requirements Thundering Waters, Warren Woods, NCLG, R.V. Anderson,
  - Thundering Waters Estates Stormwater Management Plan
  - related OLS surveys
  - Plan and Profile images of various infrastructure
  - Storm District maps, excerpts from Storm Drainage Report Volume 1 December 1981, Storm Drainage Report Volume 2 December 1981
  - Storm drainage maps
  - Plans of watermains
  - Area Geotechnical investigations
  - GIS Shape files for:
    - contours
    - parcels
    - road centre lines
    - sanitary mains
    - sanitary maintenance holes
    - storm inlet structures
    - storm maintenance holes
    - watermains
  - Thundering Waters UEM Site Servicing Feasibility Study
  - 2011 Municipal Bridge Appraisals
- Thundering Waters Draft Master Plan dated May 19th 2016 from RTKL and MSH;
- City of Niagara Falls Engineering Standards – Sewer Design Criteria;
- Niagara Region Water and Wastewater Master Plan (2011 update);
- As constructed drawings for the 825 mm sewer on Dorchester Road, the 1375 mm sewer on Oldfield Road, and the overflow at the South Side HLPS;
- City of Niagara Falls – Review of Municipal Servicing requirements for Thundering Waters, June 27, 2007, R.V. Anderson Associated Limited;

- Site Servicing Feasibility Study, Thundering Waters Development, Niagara Falls, July 11, 2006, Urban Environmental Management Inc.

Further information was also requested and received from the Region of Niagara, including the water and wastewater models and as-builts for Regional trunk systems, specifically existing water and wastewater infrastructure.

In addition, NPCA provided base mapping (2010) and other mapping depicting its Regulatory Limit on the Welland River and Power Canal. The Niagara Peninsula Conservation Authority also provided information related to the following:

- NPCA Stormwater Management Guidelines
- Aerial Mapping
- Natural environment information screening maps
- GIS Shape files for:
    - watershed planning areas
    - conservations areas
    - regulated floodplains
    - regulation lands
    - regulated wetlands and allowance
    - top of slope and allowance
    - intake protection zones, vulnerable aquifers, groundwater recharge areas

3.0 STORMWATER SERVICING

3.1 Introduction

As part of the preparation of the Functional Servicing Plan, it has been necessary to establish an understanding of the existing storm drainage systems comprised of local catchment areas, open water features, municipal drains, municipal storm systems, and receiving watercourses. By defining these existing features and establishing the design capacity through contemporary hydrologic and hydraulic assessments, the existing system has been characterized so that the impact of future planned urbanization can be assessed and appropriate management plans developed accordingly. The sections which follow outline existing information specific to the storm drainage assessment and the related analyses to develop this understanding.

3.2 Background Information Review

As noted in Section 2, various parties have provided data/information related to the stormwater systems including the City of Niagara Falls, Region of Niagara, and the NPCA, including:

Mapping:

- Storm Servicing Map (Regional Municipality of Niagara, 2015).
- Thundering Waters – Flood Plain (Niagara Peninsula Conservation Authority, 2015)
- LiDAR information of Thundering Waters and surrounding area. (Leading Edge Geomatics, 2015).
- GIS Mapping from Natural Areas Inventory Report. (Niagara Peninsula Conservation Authority, 2011).
- Niagara Natural Environment Information Screening Maps. (Niagara Peninsula Conservation Authority, 2011).
- Thundering Waters Aerial Mapping (Niagara Peninsula Conservation Authority, 2011).
- Shapefiles (from the City of Niagara Falls): Storm maintenance holes and inlets, parcels, road centerlines, and 1 m contours.
- Shapefiles (from the Niagara Peninsula Conservation Authority): Watershed Planning Areas, Hunting Areas Conservation Areas, Trails, HydroNet-related shapefiles, NNEI Screening Layer, Riverine Floodplain Mapping, NNEI Screening Layer, Wetland Allowance, Top of Slope Allowance, Top of Slope, Regulated Wetlands, Regulated Shoreline Area, Regulated Floodplains, Regulation Lands, Shoreline Mapping, Surface Water Intake Protection zones, highly vulnerable aquifers, significant groundwater recharge areas.

Drawings:

- Conrail Drainage Channel. (City of Niagara Falls, 1979).
- Plan and Profile Drawings, Storm Drainage Maps. (from the City of Niagara Falls).
  - Drummond Road Watermain (2003)
  - Dorchester Road (1999)
  - 1982 Operating Budget Watermain Drummond Road (1982)
  - Kister Road (1981)
  - Drummond Park Village Subdivision (1979)

  - Falls Industrial Subdivision Extension (1978)
  - Reg. Plan M-67 (1976)
  - Dorchester Road Plan & Profile (1974)
  - Drummond Road Sanitary Sewer
  - Local Improvement Program Dorchester Road (1973)
  - Proposed Watermain Construction Drummond Road (1971)
  - Reg. Plan 243 (1969)
  - Langendoem Subdivision (1968)
  - Existing Conditions (1960)
  - Future Services on Oldfield Road (undated)
- Digital Elevation Model 1 m contours (Niagara Peninsula Conservation Authority, 2010).

Documents:

- *Preliminary Stormwater Management Plan for Thundering Waters Estates.* (Upper Canada Consultants, 2012).

This report provides a preliminary stormwater management plan for a proposed site (immediately north of Oldfield Road and west of Drummond Road) and associated external lands. The report provides relevant soil information. It also indicates that existing drainage is towards the Conrail Drainage Channel, and that proposed stormwater management will address quality control but not quantity or erosion control.

- *2011 Municipal Bridge Appraisal.* (City of Niagara Falls, 2011).

Five (5) inspection/maintenance reports of culverts within the Thundering Waters Study Area.

- *Stormwater Management Guidelines.* (Niagara Peninsula Conservation Authority, 2010).

This document provides guidance for the assessment of urban impacts on water resources specific to water quality, flooding and erosion, related to the Niagara Peninsula. The document is not intended to replace any local criteria and policies (i.e. of the City of Niagara Falls), but rather it is considered a complement to other guidelines.

- *Review of Municipal Servicing Requirements.* (R.V. Anderson Associates Ltd., 2007).

This report provides a review of municipal servicing requirements for Thundering Waters and Warren Woods. It also references the Site Servicing Feasibility Study by Urban & Environmental Management Inc., for site drainage patterns and stormwater management requirements.

- *Site Servicing Feasibility Study.* (Urban & Environmental Management Inc., 2006).

The report specifies existing drainage patterns for the Thundering Waters site. Quality control is required for outlet into the Power Canal or the Welland River, at a Normal (Level 2) treatment level, based upon fish habitat requirements. The report makes recommendations for proposed stormwater management. This report estimates approximately 46.2 ha contribute to the Conrail

Drain, however this estimate is noted to preclude the contribution of runoff from approximately 220 ha (+/-) of developed land upstream of the site (ref. Appendix A).

- *Storm Drainage Report Volumes 1 and 2*. (R.V. Anderson Associates Ltd., 1981).

This report is an update to the “1968 Report on Flood Control and Pollution Abatement” indicating storm sewers and channels constructed between 1968 and 1980 and recommends proposed storm sewers and channels for the City of Niagara Falls.

Other:

- Master Drainage Plan Update Study PIC #1 Slides (Aquafor Beech, Undated)

3.3 Field Reconnaissance

A field reconnaissance was undertaken by Amec Foster Wheeler staff on October 1, 2015 (ref. Appendix A for photographic inventory), with a focus on reviewing existing drainage patterns and hydraulic structures. The following have been noted from the field reconnaissance:

- Between Stanley Avenue and Oldfield Road, Dorchester Road and Chippawa Parkway are two-lane roads with a rural cross-section, running generally parallel to the Power Canal and Welland River, respectively. The roads bound the subject property to the west and south.
- Dense vegetation was observed along the full extent of Dorchester Road and Chippawa Parkway surrounding the site (ref. Photo 11).
- The northwest corner of the Dorchester Road - Oldfield Road intersection is supported by gabion baskets. (ref. Photo 29).
- A 1200 mm diam. concrete culvert, located approximately 300 m west of Stanley Avenue, has been identified in the field (ref. Culvert #1 on Drawing 3.1). The inlet invert of the culvert is sunk beneath the invert of the channel by approximately 0.3 m (ref. Photo 1). The culvert was partially submerged at the time of the field reconnaissance as it was under the influence of backwater from the Welland River; the depth of water at the downstream end of the culvert is approximately 0.4 m (ref. Photo 7). A separation has been noted at the inlet of the culvert, where the most upstream length of pipe is disconnected from the remainder of the culvert (ref. Photo 6). The outlet of this pipe is damaged. (ref. Photo 8).
- Immediately upstream of the 1200 mm diam. concrete culvert, the creek has a bankfull depth and width of approximately 0.2 m and 2.3 m, respectively. The creek has a rocky bottom with little vegetation growing out of the water, while the overbanks have thick vegetation consisting of trees and brush. (ref. Photos 2, 3, 4, and 5).
- A 900 mm diam. corrugated steel culvert, located approximately 700 m west of Stanley Avenue, was identified in the field (ref. Culvert # 3 on Drawing 3.1). The culvert was partially submerged at the time of the field reconnaissance as it was under the influence of backwater from the Welland River; the depth of water at the upstream end of the culvert was approximately 0.3 m (ref. Photo 9). The portions of the pipe which are visible are rusted. (ref. Photo 9 and 10).

- Near the southwest corner of the subject property, a 450 mm diam. Corrugated steel culvert was identified (ref. Culvert # 4). The pipe appears to be in good condition with no visible deficiencies (ref. Photo 12 and 13).
- Located approximately 100 m north of the CNR tracks at Dorchester Road, the Conrail Drain has an accumulation of vegetation and debris (ref. Culvert # 5). The inlet of the culvert crossing at Dorchester Road has a build-up of debris against the safety grate. (ref. Photo 14). The invert of the Conrail Drain corridor, immediately east of Dorchester Road, is lined with tall grass and the entire drain is covered with light brush and young tree growth. (ref. Photo 15). The culvert crossing at Dorchester Road was not measured during the field reconnaissance. The outlet is inaccessible, secured by a chain link fence and barbed wire. (ref. Photo 16).
- A road crossing culvert located approximately 100 m north of the Con Rail Drain, within a defined valley, was identified. (ref. Culvert # 9 on Drawing 3.1). The 1200 mm diam. smooth steel pipe, is heavily corroded, with holes located in the pipe wall (ref. Photo 18). At the outlet, the bottom half (approximate) of the pipe is filled with rocks and debris (ref. Photo 17).
- A road crossing culvert located approximately 1050 m north of the Con Rail Drain, was identified. (ref. Culvert # 10 on Drawing 3.1). The 850 mm diam. corrugated steel pipe appears to be in good condition with no visible defects at the inlet (ref. Photo 19). The outlet was located in a stand of thick brush and was difficult to view (ref. Photo 20).
- At the intersection of Dorchester Road and Oldfield Road as well as along Dorchester Road immediately west of Oldfield Road, flow is directed west through roadside ditches and various driveway culverts. (ref. Photos 21, 22, 23, 24, 30, and 32). Road crossing culverts (ref. Culverts 12, 13, 14, 15, and 16 on Drawing 3.1) direct flow from south of Dorchester Road to north of Dorchester Road where the roadside ditch is deeper, with greater flow capacity (ref. Photos 21, 23, 28, and 31). The ditch along the north side of Dorchester Road outlets through a 900 mm by 650 mm elliptical corrugated steel driveway culvert (ref. Culvert 11 on Drawing 3.1) flowing west towards the Power Canal. (ref. Photos 25, 26, and 27).

3.4 Baseline Assessment

The study area is located near the confluence of the Welland River and the Power Canal within the City of Niagara Falls in the Welland River Watershed. The site is bounded by Dorchester Road toward the west, Chippawa Parkway to the south hydro corridor to the north, and an open unnamed watercourse to the east.

The site measures approximately 195.8 ha (+/-) (ref. Figure 1.1) and is densely vegetated with forests and wetlands. Soils information from the Canadian Soil Information Service (CANSIS) indicates that the majority of soils within the site are of SCS Hydrologic Soil Class C, and D indicating an *imperfect* to *poor* soil infiltration characterization for the site. Available topographic information indicates that the site generally drains from north to south, although grades across the site are quite low (i.e. approximately 0.1 %) and is relatively flat, with low points and pools throughout, reflective of wetland drainage.

The following provides the key findings of the Baseline Assessment based upon a review of available background information and the field reconnaissance.

Drainage boundaries of the Thundering Waters site (ref. Drawing 3.2):

- The western limit of the site is bounded by Dorchester Road, which runs adjacent to the Power Canal.
- The southern limit of the site is bounded by Chippawa Parkway, which runs adjacent to the Welland River.
- The eastern limit is west of Kister Road. Drainage from Don Murie Street, Progress Street, Kister Road, Ramsey Road is predominantly directed south or east, away from the Thundering Waters site based on plan and profile drawings provided (City of Niagara Falls).
- The north / northwest limit is represented by subdivisions north of the hydro corridor. Storm sewers within these subdivisions direct flow north and away from the Thundering Waters Site based on plan and profile drawings provided (City of Niagara Falls). Major flows, from portions of this area are directed south and intercepted by roadside ditches along Dorchester Road, west of Oldfield Road and ultimately outletting to the Power Canal.
- The north / northeast portion of the site is adjacent to the Thundering Waters Golf Course, as well as the headwaters of the Conrail Drain Channel (ref. Drawing 3.14), which drains through the Thundering Waters site.

In summary:

i. The Thundering Waters site drains to two notable watercourses and numerous on-site culverts (ref. Drawings 3.1, 3.2, and 3.5): the southern portion of the site drains to the Welland River through culverts crossing Chippawa Parkway, with the most pronounced drainage feature being a creek which runs along the eastern edge of the Thundering Waters property (Eastern Watercourse).

ii. The northern portion of the site drains to the Power Canal via culverts crossing Dorchester Road, with the most pronounced water feature being the Conrail Drain Channel.

iii. The Conrail Drain Channel drainage feature splits the site, running northeast to southwest alongside the C.N.R. tracks which also span the Thundering Waters site. The City of Niagara Falls has confirmed that the Conrail Drain Channel is not a Municipal Drain and the NPCA has indicated that it is not a fish habitat feature [ref. Thundering Waters Secondary Plan Characterization and Environmental Impact Study, June 2016, Dougan & Associates].

The Conrail Drain, which traverses the site, represents the most significant drainage feature on the property. The Conrail Drain receives and conveys runoff from 67 ha (+/-) within the Thundering Waters holdings, as well as runoff from some 298 ha (+/-) of predominantly urbanized lands upstream of the development (ref. Drawing 3.2 and Drawing 80-CA-1 in Appendix A).

The unnamed watercourse (notionally referred to as the 'Eastern Watercourse' for this report) along the east limit of the subject property receives runoff from 40.2 ha (+/-) of the site, as well as runoff from 75.2 ha (+/-) of industrial lands and the Thundering Waters Golf Club to the east (ref. Drawing 3.2).

A hydraulic structure inventory has been prepared based upon a desktop review of information provided, as well as findings from the field reconnaissance conducted as part of this study. The hydraulic structure location plan is provided in Drawing 3.1, and the size and type of structures is presented in Table 3.1.

Table 3.1. Hydraulic Structure Inventory

Culvert #	Configuration (Size, Shape, Material)	Comments / Source
1	1200 mm diam. Circ. Conc.	Measured during field reconnaissance
2	CSPPA (Approximate rise of 1000 mm)	2011 Municipal Bridge Appraisal ID Number: S053C (City of Niagara Falls, 2011).
3	900 mm diam. CSP	Measured during field reconnaissance
4	450 mm diam. CSP	Measured during field reconnaissance
5	5500 mm X 3500 mm CSPPA	Culvert is located within the Conrail Drain Channel and crosses Dorchester Road. 2011 Municipal Bridge Appraisal ID Number: S049C (City of Niagara Falls, 2011). Observed during field reconnaissance
6	5500 mm X 3500 mm CSPPA	Culvert is located within the Conrail Drain Channel. 2011 Municipal Bridge Appraisal ID Number: S050C (City of Niagara Falls, 2011).
7	5500 mm X 3500 mm CSPPA	Culvert is located within the Conrail Drain Channel. 2011 Municipal Bridge Appraisal ID Number: S148C (City of Niagara Falls, 2011).
8	5100 mm X 3300 mm CSPPA	Culvert is located within the Conrail Drain Channel. 2011 Municipal Bridge Appraisal ID Number: S149C (City of Niagara Falls, 2011). This document indicates a slightly larger culvert with a rise of approximately 3700 mm.
9	1200 mm diam. SSP	Measured during field reconnaissance
10	850 mm diam. CSP	Measured during field reconnaissance
11	900 mm X 650 mm diam. Elliptical CSP	Driveway culvert (does not cross Dorchester Road) acts as outlet for a roadside ditch ultimately draining to the power canal. Measured during field reconnaissance
12	650 mm diam. CSP	Measured during field reconnaissance

Table 3.1. Hydraulic Structure Inventory		
Culvert #	**Configuration (Size, Shape, Material)**	**Comments / Source**
13	350 mm diam. CSP	Dorchester Road (Proposed Watermain). Municipal Reference Number: CC-4240 (City of Niagara Falls, 2000).
14	650 mm diam. CSP	Measured during field reconnaissance
15	525 mm diam. CSP	Measured during field reconnaissance
16	450 mm diam. CSP	Measured during field reconnaissance
17	1200 mm diam. Circ. Conc.	Measured during field reconnaissance

3.4.1 Hydrology

Hydrologic analyses have been completed for the study area in order to establish return period peak flow rates for the 2 year through 100 year events at the outlets of the site to the Power Canal, Eastern Watercourse and the Welland River, under existing land use conditions. The hydrologic analyses have been completed using the Visual OTTHYMO hydrologic model, Version 2.4.

Subcatchment boundaries within the site have been established based upon the topographic mapping provided for use in this study as well as the LiDAR mapping prepared by Leading Edge Geomatics, and used to obtain peak flows at key points of interest and the drainage outlets from the site to the Power Canal and the Welland River, as well as at hydraulic structures along the Conrail Drain and confluences along the respective watercourses at the east boundary of the site. The subcatchment boundary plan is provided in Drawing 3.2. The Visual OTTHYMO model has been developed to include the contributing drainage areas to the Conrail Drain upstream of the site based upon the information provided by the City of Niagara Falls (ref. Drawing 80-CA-1 in Appendix A), as well as the external drainage areas contributing to the watercourse along the east limit of the site. The existing conditions hydrologic model schematic is provided on Drawing 3.4.

Subcatchment areas have been measured from the base mapping and topography provided by the City and the NPCA. As noted, the areas for the external subcatchments discharging to the Conrail Drain have been determined based upon the information provided on Drawing 80-CA-1 of Appendix A.

Impervious coverages for the urban subcatchments have been determined based upon a review of available aerial photographs and Drawing 80-CA-1 to determine land use composition. A 50 % (+/-) impervious coverage has been adopted for residential areas based on a review of mapping and an 85 % (+/-) impervious coverage for commercial and industrial lands based upon a similar review.

The SCS Soil Class and the Curve Number (CN) for the pervious areas have been estimated based on the mapping from the Canadian Soil Information Service (CANSIS) database. The surficial soils within the study area are presented in Drawing 3.3. As noted earlier, the information in the CANSIS database indicates that majority of soils within the study area are of Hydrologic Soil Class C or D, or a mixture of C-D, indicating an imperfect to poor drainage characterization for the site.

For the rural catchments, time-to-peak has been determined using the Airport Equation due to the largely undeveloped nature of these subcatchments, and applying runoff coefficients calculated in accordance with the approach outlined in the 1998 MTO Drainage Manual. Length and slope of the catchments have been measured from the base mapping provided for use in this study.

All remaining parameters for the hydrologic model have applied the default parameters in accordance with the Visual OTTHYMO methodology. The resulting subcatchment parameters which have been established for the hydrologic model are summarized in Tables 3.2 and 3.3 for the rural (non-urban) and urban subcatchments respectively.

Conveyance elements have been incorporated into in the model to represent the hydrologic influence of routing through the Conrail Drain and the watercourse along the east limit of the site. The cross-section and slope of the routing elements representing the Conrail Drain have been established based upon the information provided in the available design drawings for that system and verified by a field review, as well as a review of the base mapping and contour data. The cross-section and slope for the routing elements representing the watercourse at the east limit of the site have been established based upon the contour data and base mapping provided for use in this study.

Table 3.2. Hydrologic Model Parameterization (Rural / Non-Urban Catchments)

VO2 Subcatchment Name (NASHYD)	Contributing Drainage Area (ha)	CN (AMC II)	TP (hr)
101	36.6	89	2.35
102	31.4	77	1.60
103	74.0	77	2.71
105	17.8	77	1.18
106	3.9	70	0.60
107	58.1	80	1.87
108	12.8	77	1.24
109	11.7	77	0.93
110	14.9	70	1.08
111	12.5	73.5	0.95
112	5.4	70	0.88
113	60.7	73.5	1.12
114	15.8	70	0.92
207	22.0	84	1.71

Table 3.3. Hydrologic Model Parameterization (Urban Catchments)

VO2 Subcatchment Name (STANDHYD)	Contributing Drainage Area (ha)	CN (AMC II)	Impervious Coverage (%)
104	6.0	80	85
201	28.5	80	57
202	14.5	80	53
203	56.1	80	58
204	11.5	80	77
205	36.5	80	71
206	50.4	80	50

Synthetic design storms have been developed for the hydrologic analyses. The 12 hour SCS distribution has been selected due to the size of the study area, as well as the current rural (non-urban) land use throughout the site. Intensity-duration-frequency (IDF) equations have been furnished by NPCA for use in determining the 2 year through 100 year synthetic design storms. Upon closer review and inspection of the relationships, it has been noted that the depth of rainfall for the 10 year storm, as calculated using the IDF relationships provided by NPCA, is less than the depth of rainfall for the 5 year storm, which is contrary to anticipated trends. Consequently, rainfall depths for the 2 through 100 year storm events have been established based upon the IDF relationships applied by the Ministry of Transportation within the local region. Recognizing that the 100 year storm event represents the Regulatory storm for the NPCA, the IDF relationship, as provided by NPCA, has been used to develop the 12 hour SCS storm for the 100 year event; this is in addition to the 100 year storm as determined based upon the IDF relationships applied by MTO. The resulting synthetic design storms are provided in Appendix A.

Peak flows for the various return periods at key points in the study area (ref. Drawing 3.2 and 3.4) have been determined using the hydrologic model and associated synthetic design storms. The resulting peak flows are presented in Table 3.4.

Table 3.4. VO2 Existing Conditions Simulated Peak Frequency Flows (m^3/s)							
Flow Node	Frequency Storm Events						
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year (MTO)	100 Year (NPCA)
501	9.30	14.16	17.55	22.03	25.49	28.91	23.31
502	9.25	14.07	17.44	21.89	25.34	28.73	23.16
503	12.89	19.32	23.79	29.48	33.92	38.46	31.14
504	16.61	24.66	30.08	37.74	43.19	49.27	39.83
505	16.58	24.60	29.99	37.62	43.03	49.08	39.69
506	0.98	1.69	2.23	2.94	3.5	4.09	3.14
507	0.95	1.62	2.14	2.83	3.35	3.91	3.01
508	0.85	1.46	1.92	2.53	2.99	3.48	2.69
509	0.76	1.29	1.69	2.22	2.62	3.05	2.37
510	0.65	1.10	1.44	1.88	2.22	2.57	2.00
104	0.83	1.16	1.39	1.66	1.86	2.07	1.74
105	0.20	0.35	0.46	0.61	0.72	0.84	0.65
107	0.52	0.89	1.16	1.51	1.78	2.06	1.61
113	0.63	1.10	1.46	1.95	2.32	2.71	2.08
114	0.16	0.29	0.39	0.52	0.62	0.73	0.55

The results in Table 3.4 indicate that the routing influence of the Conrail Drain decreases the peak flows from upstream to downstream for all events between the 2 year and 100 year return period storms. This is considered attributable to the low gradient and large hydraulic cross-section within the Conrail Drain, which provides an attenuative effect, as flows are routed through the system, as well as the comparatively small local drainage area contributions in the lower portion of the Conrail Drain. For all other nodes of interest, the peak flows are consistent with anticipated trends based upon drainage area size and land use.

Validation of simulated flow response has been conducted by comparing unitary flow rates from various other studies and watercourse systems in similar physiographic regions, with calibrated runoff models (ref. Table 3.5).

Table 3.5. Unitary Peak Flow Comparison ($m^3/s/ha$)								
Flow Node / Subcatchment Number/ Location	Frequency Storm Events							
	Area (ha)	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year (MTO)	100 Year (NPCA)
501	365.3	0.025	0.039	0.048	0.060	0.070	0.079	0.064
506	115.4	0.008	0.015	0.019	0.025	0.030	0.035	0.027
104	6.0	0.139	0.194	0.232	0.277	0.311	0.346	0.290
105	17.8	0.011	0.020	0.026	0.034	0.041	0.047	0.037
113	60.7	0.010	0.018	0.024	0.032	0.038	0.045	0.034
114	15.4	0.010	0.019	0.025	0.034	0.040	0.047	0.036
Battlefield Creek at escarpment	487.1	0.004	0.008	0.011	0.015	0.019	0.022	0.022
North Waterdown Borers Creek	466.9	0.006	0.011	0.014	0.018	0.021	0.023	0.023
Unnamed Grand River Tributary	57.8	0.025	0.040	0.052	0.067	0.089	0.109	0.109
Sixteen Mile Creek	444.4	0.003	0.006	0.009	0.012	0.016	0.019	0.019
Huttonville Creek Headwater Tributary	74	0.007	0.014	0.021	0.030	0.045	0.061	0.061

As evident from Table 3.5, unitary flows for standalone subcatchments 105, 113, and 114 compare well with one another and subcatchment 104 produces higher unitary flows, characteristic of a highly urbanized drainage area. The results indicate that the flow rates at watercourse outlets 501 and 506 are generally above the range of most watercourse systems for all design storms. It had been noted previously that rainfall volume data provided by the MTO is higher than the NPCA rainfall data, producing more conservative peak flows for all storm events. The hydrologic assessment for Thundering Waters also uses the design storm methodology, however some of the comparison flows are based upon continuous simulation (i.e. Battlefield Creek, North Waterdown, and Sixteen Mile Creek) which can potentially provide for lower peak flows, when compared to the design storm methodology. This comparison also does not differentiate between factors such as soil permeability and routing attenuation. Based on the consistency of unitary peak flows from individual subcatchments, the hydrologic modelling results are considered to be reasonable for the purposes of this study and generally conservative.

3.4.2 Hydraulics

As noted previously, the Conrail Drain and the unnamed watercourse along the east limit of the property receive flows from external properties and convey the external and internal flows through the site. As such, hydraulic analyses have been completed for these systems, in order to characterize the hydraulic function of these features with respect to conveyance capacity.

The hydraulic analyses have applied the HEC-RAS methodology to determine the water surface elevations along the Conrail Drain and the unnamed watercourse along the east limit of the site (Eastern Watercourse).

The cross-section geometry and elevations for the sections along the Conrail Drain have been established based upon the information in the design drawings provided by the City of Niagara Falls, and verified based upon a review of the base mapping provided for this study. Manning's roughness coefficients of 0.05 and 0.06 have been applied for the base and side slopes of the Conrail Drain respectively, based upon the conditions observed during field reconnaissance (ref. Appendix A). The culverts along the Conrail Drain have been simulated based upon the structure sizes and dimensions noted in Table 3.1, and as verified during the field reconnaissance.

Similarly, the cross-section geometry and elevations of the Eastern Watercourse have been established based upon the base mapping provided for use in this study. The low flow channel width and depth of the Eastern Watercourse has been represented in the model based upon field measurements taken upstream of Culvert #1 during field reconnaissance, and has been applied throughout the balance of the reach. Manning's roughness coefficients of 0.045 and 0.10 have been applied for the low flow channel and the overbanks respectively, based upon the observed condition of the channel and overbanks during field reconnaissance. At the upstream-most limit of the model, the roughness coefficient has been set to 0.03 for the channel and overbank to represent the manicured grass conditions within the golf course. The hydraulic structure at the watercourse outlet at Chippawa Parkway has been incorporated into the model based upon the size and type of structure measured during field reconnaissance; the structure invert has been simulated based upon measured cover at the structure during field reconnaissance, and top of road elevations provided in the base mapping.

Normal depth has been utilized as the downstream boundary condition within the model, based upon the slope of the Conrail Drain, in the absence of floodplain data for the Power Canal. Delineation of the regulated flood plain of the Welland River has been provided by the NPCA (ref. Drawing 3.5), and the corresponding water surface elevation has been approximated from the contours (i.e. 173 m +/- at the Eastern Watercourse). A sensitivity analysis between this known water surface elevation and normal depth during the 100 year event resulted in marginal water surface elevation differences (i.e. ~ 0.02 m). Based on the comparable water surface elevations and the absence of known water surface elevations for the remaining design events, normal depth has been utilized as the downstream boundary condition within the model, based upon the slope of the Eastern Watercourse just upstream of the confluence with the Welland River.

The simulated peak flows from the hydrologic analyses (ref. Table 3.4) have been incorporated into the HEC-RAS hydraulic models, and the model has been executed conservatively under the subcritical flow regime to determine the flood characteristics of the Conrail Drain and the Eastern Watercourse related to conveyance of runoff for all events up to and including the 100 year design storm. The simulated water surface elevations are presented in Tables 3.6 and 3.7. As discussed in the previous section, *Hydrology,* two (2) alternative 100 year storm events have been assessed: the NPCA 100 year storm event representing the area's Regulatory storm, and the MTO 100 year storm event with the greatest rainfall volume of all storms assessed in this report. Floodlines for the two (2) alternative 100 year storm events for the Conrail Drain and the Eastern Watercourse are provided in Drawing 3.5.

Table 3.6. Conrail Drain Channel HEC-RAS Existing Conditions Simulated Water Surface Elevations (m)							
HEC-RAS Cross Section Number	Frequency Storm Events						
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	100 Year (NPCA)
Culvert #8							
2099.77	178.32	178.76	179.01	179.31	179.51	179.72	179.39
2029	178.19	178.64	178.90	179.22	179.44	179.67	179.30
1765	177.66	178.09	178.35	178.67	178.91	179.17	178.76
1484	176.76	177.25	177.55	177.93	178.25	178.59	178.04
1437.13	176.59	177.06	177.35	177.70	178.01	178.34	177.81
Culvert #7							
1373.13	176.54	176.96	177.20	177.47	177.65	177.83	177.54
1308	176.43	176.85	177.10	177.37	177.57	177.76	177.45
1001	175.90	176.32	176.56	176.84	177.03	177.22	176.91
659	175.28	175.68	175.92	176.20	176.41	176.61	176.28
429	174.64	175.05	175.31	175.63	175.87	176.11	175.72
381	174.53	174.93	175.18	175.48	175.71	175.94	175.57
Culvert #6							
332.24	174.49	174.86	175.08	175.35	175.54	175.72	175.42
286	174.40	174.78	175.01	175.28	175.48	175.67	175.36
212	174.25	174.63	174.86	175.15	175.35	175.55	175.23
97.53	173.79	174.15	174.37	174.64	174.83	175.01	174.71
Culvert #5							
35.06	173.75	174.06	174.25	174.45	174.60	174.72	174.51
0.00	173.61	173.93	174.12	174.34	174.49	174.63	174.39

Table 3.7. Eastern Watercourse HEC-RAS Existing Conditions Simulated Water Surface Elevations (m)							
HEC-RAS Cross Section Number	Frequency Storm Events						
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	100 Year (NPCA)
9	178.09	178.19	178.24	178.32	178.36	178.40	178.33
Culvert #17							
8	177.32	177.41	177.46	177.48	177.52	177.55	177.50
7	177.09	177.14	177.16	177.24	177.27	177.30	177.26
6	176.07	176.10	176.13	176.09	176.10	176.11	176.10
5	175.08	175.12	175.15	175.24	175.29	175.32	175.28
4	174.13	174.19	174.22	174.17	174.13	174.14	174.12
3	173.07	173.10	173.12	173.28	173.59	173.94	173.37
2	172.32	172.64	172.86	173.16	173.54	173.91	173.29
Culvert #1							
1	171.90	172.01	172.07	172.14	172.19	172.23	172.16

The results of the analyses indicate that the reach of the Conrail Drain through the subject property, as well as the Eastern Watercourse, generally convey all events up to and including the 100 year storm event (based upon both the MTO and the NPCA IDF relationships) below the top of bank for each system. As such, the 100 year floodplain associated with each system is virtually entirely contained within the feature, and does not appreciably extend onto the adjacent property.

3.4.3 Regulatory Mapping

The location of the Regulatory floodplain of the Welland River has been provided by the NPCA (ref. Drawing 3.5, Floodline Mapping Limits). No Regulatory mapping has been provided regarding the Power Canal.

3.4.4 Summary

The Thundering Waters lands are currently undeveloped, with dense vegetation and some wetlands. Soils exhibit a low permeability, and grades across the site are low. The Conrail Drain and an unnamed watercourse at the east limit of the property (Eastern Watercourse) receive and convey runoff from external properties through, or along, the site. All runoff from events up to and including the 100 year design storm is contained within the features, and does not breach the top of bank and extend onto the site.

The baseline information presented herein has been used to evaluate stormwater management alternatives and to establish a preferred stormwater management plan for the site (ref. Section 3.5, 3.6 and 3.7). The extent and form of the proposed development, has been used to establish criteria for the sizing of stormwater management infrastructure to mitigate impacts.

3.5 Future Land Use and Grading Plan

The proposed development of the Thundering Waters lands consists primarily of low density residential land uses, with some medium and higher density residential land uses and condominium development, recreational land uses, and commercial land uses. The land use concept for the future development is provided on Drawing 3.6 (ref. RTKL, May 19, 2016).

A conceptual grading plan has been developed for the future land use plan, in order to support the servicing concepts and thereby assess the potential for balancing cut and fill within the proposed development area. The conceptual grades have been established based upon current drainage standards and requirements as per the City Standards for Site Planning (City of Niagara Falls, 1992); the following principles have been applied:

- Grades adjacent to proposed stormwater management facilities have been established at 2.4 m (+/-) above the 2 year water surface elevation within the receiving watercourse, in order to account for a 1.1 m (+/-) depth of extended detention storage and storm sewer outlet, and 1.3 m (+/-) cover to centreline of road.
- Road grades established at 0.5 % minimum as per City of Niagara Falls standards.
- Storm drainage plan to maintain existing drainage boundaries to the extent possible, adjusted as required to establish drainage boundaries along future roads within the development area.
- Future elevations along the railway to match existing.

- Future grades along Dorchester Road and Chippawa Parkway surrounding the development may be raised if required to accommodate future grading within the development area.
- Roadway crossings required to match existing road grades within surrounding area, where future roads are proposed to connect with existing roads.

The preliminary conceptual grading plan for the future development area is presented in Drawing 3.7.

A cut and fill assessment has been completed for the preliminary conceptual grading plan, in order to verify the extent to which balancing cut and fill requirements for the future development is possible. These results indicate that the preliminary conceptual grading plan would result in a surplus of earth from the site. Notwithstanding, at the next stages of planning and design further optimization will be conducted in order to reduce and / or eliminate any significant surplus. Furthermore, preliminary borehole investigations completed by Amec Foster Wheeler (ref. Geotechnical Investigation Proposed Paradise Niagara Falls Development (Draft), June 2016) to date indicate the presence of fill across the site as much as 5.2 m (+/-) deep below the topsoil. If the existing fill material is deemed unsuited for re-use as engineered fill on-site, the removal of fill from the site and replacement with engineered material may be necessary in order to provide final grades which would comply with Municipal standards. A further geotechnical assessment of the material is required in order to confirm whether the existing material is suitable for re-use as engineered fill.

3.6 Stormwater Management Criteria

3.6.1 Erosion Control

The Thundering Waters development area is located near the terminus of the Welland River at the Niagara River. Recognizing the size of the development area relative to the size of the upstream drainage area along the Welland River (i.e. 195 ha (+/-) for the site, versus 800 km^2 for the watershed), it is anticipated that the future development of the Thundering Waters lands will not have any appreciable impact to the erosion potential along the Welland River. Consequently, erosion controls are not considered warranted for the Thundering Waters development area (Note: this premise was supported by NPCA during the pre-consultation phase; ref. Appendix E). This approach is also consistent with that which was advanced for the *Preliminary Stormwater Management Plan for Thundering Waters Estates.* (Upper Canada Consultants, 2012).

3.6.2 Flood Control

Similarly, recognizing the size of the development area relative to the size of the upstream drainage area along the Welland River, it is considered that the future development of the Thundering Waters lands will not have an appreciable impact to the flood potential along the Welland River. Consequently, quantity controls for flood protection are also not considered warranted for the Thundering Waters development area to mitigate flood impacts along the Welland River. This approach, supported by NPCA during the pre-consultation phase, is also noted to be consistent with that which was advanced for the *Preliminary Stormwater Management Plan for Thundering Waters Estates.* (Upper Canada Consultants, 2012).

3.6.3 Stormwater Quality Control

The future development within the Thundering Waters lands is required to provide stormwater quality control to a *Normal* standard of treatment, as a minimum (ref. Appendix E). The future land use plan and conceptual grading plan have been reviewed in order to identify opportunities to provide stormwater quality control for the future development area to this standard.

Wet Pond Facilities

The future development within the southern portion of the site is proposed to drain toward the Welland River at existing watercourse outlets in the area. Due to the size of the contributing drainage areas (i.e. all greater than 5 ha in size), end-of-pipe facilities in the form of wet ponds have been proposed to provide the requisite stormwater quality control.

The end-of-pipe facilities have been sized in accordance with the criteria provided in the Stormwater Management Planning and Design Guidelines (Ministry of the Environment, 2003) for wet pond facilities designed to a “normal” standard of treatment. Additional analyses have been completed to provide preliminary estimates of the facility footprints required, based upon the following criteria:

- 7:1 side slopes required within 3 m of the permanent pool.
- 5:1 side slopes required above and below the 7:1 shelf.
- Extended detention storage to be provided at a maximum depth of 1.5 m.
- Permanent pool volume to be provided at an average depth of 2 m.
- Requirements for maintenance access and decanting zones represent 20% of the facility footprint.

The locations of the proposed wet pond facilities are provided on Drawing 3.8, and the corresponding storage volumes and facility footprints are summarized in Table 3.8.

Table 3.8. Preliminary Sizing of Wet Pond Facilities

Facility ID	Contributing Drainage Area		Stormwater Quality Volumes[1] (m^3)		Estimated Footprint (ha)
	Size (ha)	Imperviousness (%)	Permanent Pool	Extended Detention Storage	
S1	33.7	53	2300	1400	0.5
S2	15.6	71	1500	700	0.9

1. Assuming “Normal” treatment standards

Oil/Grit Separators

The development within the northern portion of the Thundering Waters site generally drains toward the Conrail Drain in multiple locations. The proposed drainage outlets to the Conrail Drain coincide with the proposed watercourse crossings, in order to provide a more distributed discharge system and minimize the concentration of flow. While this more distributed approach minimizes the size of the local conveyance system (i.e. storm sewers), it also effectively precludes the direct feasibility of implementing a centralized stormwater quality management system with wet end-of-pipe facilities, as the local contributing drainage areas would be considered too small to support a wet facility (i.e. < 5 ha.). As such, a distributed stormwater quality management system, consisting of oil/grit separators located at the multiple storm sewer outlets to the Conrail Drain, has been proposed for the development area discharging toward the Conrail Drain.

The oil/grit separators have been sized assuming Stormceptor™ units would be implemented to achieve the requisite *Normal* standard of stormwater quality control. The locations of the oil/grit separators are presented on Drawing 3.8, and the preliminary sizes of Stormceptor™ units are summarized in Table 3.9.

Table 3.9. Preliminary Sizing of Oil/Grit Separators

Unit ID	Contributing Drainage Area		Stormceptor Unit Required
	Size (ha)	Imperviousness (%)	
OG1	3.4	55	STC 2000
OG2	5.1	60	STC 4000
OG3	1.8	60	STC 750
OG4	3.5	85	STC 4000
OG5	3.0	85	STC 4000
OG6	4.7	80	STC 6000
OG7	4.9	83	STC 6000
OG8	1.2	85	STC 750
OG9	2.1	60	STC 1500
OG10	2.8	60	STC 2000
OG11	2.6	60	STC 2000
OG12	6.7	85	STC 9000

Low Impact Development Best Management Practices (LID BMPs)

As indicated in the conceptual grading plan, the development areas surrounding and adjacent to the existing wetlands to be maintained post-development on the site are proposed to drain directly toward the wetlands. Due to the size of the contributing drainage areas, as well as the natural features to which these lands drain, stormwater quality controls are recommended in the form of Low Impact Development Best management Practices (LID BMPs) to provide the requisite stormwater quality control at source and prior to discharging into the wetlands. The LID BMPs would most appropriately be comprised of vegetated technologies (i.e. grassed swales, buffer strips) and other more robust practices (i.e. bioswales, rain gardens) and could be naturally integrated into the proposed buffers surrounding the protected wetlands.

The locations of the proposed LID BMPs are provided on Drawing 3.8, and the equivalent storage volumes [when compared to criteria for wet pond facilities in the Stormwater Management Planning and Design Guidelines (Ministry of the Environment, 2003)] are summarized in Table 3.10.

Table 3.10. Equivalent Preliminary Sizing of LID BMPs

Conceptual LID BMP ID	Contributing Drainage Area		Equivalent Stormwater Quality Volumes based on a Wet Pond Facility[1] (m^3)	
	Size (ha)	Imperviousness (%)	Permanent Pool	Extended Detention Storage
A, B	2.83	85	320	120
C, D, E	2.09	70	190	90
F, G, H	8.19	53	560	330
I, J, K, L, M	7.45	55	530	300
N	6.70	85	740	270

1. Assuming “Normal” treatment standards

In addition to the proposed end-of-pipe water quality treatment, it is also recommended that source controls and LID BMP’s be implemented within the development area, in order to provide additional stormwater quality control at-source and to provide a treatment train approach toward integrated stormwater management. The source controls are proposed to be comprised of vegetated technologies (i.e. grassed swales, buffer strips), as well as storage infiltration practices (i.e. bioswales, rain gardens) and other infiltration practices (i.e. permeable pavement, infiltration trenches), as opportunities may exist. The selection of source controls for stormwater quality management should be further investigated as part of the detailed design process at Draft Plan including consultation with City and NPCA staff. The actual quantum of LID BMPs and the amount in either the public or private realm will dictate the amount of potential reduction in the end-of-pipe systems and associated credit which the City and NPCA would be willing to support. As noted, this will need to be addressed at the detailed design stage in consultation with the City and NPCA; as it is currently proposed, the stormwater management plan conservatively depicts the extent of facilities with no reduction due to the application of LID BMPs.

3.6.4 Stormwater Conveyance Systems

The stormwater conveyance system within the future development of the Thundering Waters lands is proposed to consist of open watercourses, and urban major and minor drainage systems (i.e. storm sewers and overland conveyance within the road right-of-way). The following summarizes the various components of the stormwater conveyance systems.

Open Watercourses

Hydrology

The Conrail Drain and Eastern Watercourse are proposed to convey runoff from portions of the future development area in the Thundering Waters lands, as well as runoff from external drainage areas. Hydraulic structures are proposed along each system to accommodate the future transportation network.

Hydrologic analyses have been completed to determine the change in return period peak flows along each open watercourse system under the future land use condition within the Thundering Waters lands. The Visual OTTHYMO hydrologic model for existing land use conditions has been revised to reflect the drainage areas as per the conceptual grading plan, and the impervious coverage for the subcatchments has been determined based upon the land use plan and corresponding coverage information provided for reference in this assessment (ref. Drawing 3.6). The subcatchment boundary plan for the future land use conditions within the Thundering Waters lands is presented in Drawing 3.9, and the subcatchment parameters are summarized in Tables 3.11 and 3.12.

Table 3.11. Hydrologic Model Parameterization for Rural Subcatchments Under Future Land Use Conditions for Thundering Waters Lands

VO2 Subcatchment Name (NASHYD)	Contributing Drainage Area (ha)	CN (AMC II)	TP (hr)
101	36.6	89	2.35
102	31.4	77	1.60
103	50.1	77	1.91
107	58.1	80	1.87
108a	7.2	77	0.91
108c	1.6	77	0.45
109a	5.3	79	0.55
110a	3.2	72	0.61
110b	8.2	75	0.53
111a	5.4	74	0.57
113a	14.8	75	0.94
113c	3.3	76	0.50
113e	5.6	74	0.30
207	22.0	84	1.71
312	5.5	77	0.73

Table 3.12. Hydrologic Model Parameterization for Urban Subcatchments Under Future Land Use Conditions for Thundering Waters Lands

VO2 Subcatchment Name (STANDHYD)	Contributing Drainage Area (ha)	CN (AMC II)	Impervious Coverage (%)
104	6.0	80	85
105	2.8	77	85
108b	6.7	80	85
109b	1.5	80	85
111b	4.1	70	37
112	4.2	70	37
113b	8.2	77	53
113d	7.4	77	55
201	28.5	80	57
202	14.5	80	53
203	56.1	80	58
204	11.5	80	77
205	36.5	80	71
206	50.4	80	50
301	3.4	77	55
302	5.1	80	60
303	1.8	80	60
304	3.5	80	85
305	3.0	74	85
306	4.7	80	80
307	4.9	77	83
308	1.2	77	85
309	2.1	77	60
310	2.8	80	60
311	2.6	80	60
401	33.7	74	53
601	15.6	77	71

Consistent with the methodology applied for the existing land use conditions, simulated return period peak flows have been developed for the study area, using the 12 hour SCS distribution. The intensity-duration-frequency (IDF) equations established by the Ministry of Transportation have been applied for the 2 year through 100 year storm events, as well as the IDF relationships provided by NPCA for the 100 year storm event. Peak flows for the various return periods at key points in the study area (ref. Drawing 3.9) have been extracted from the model results. The simulated peak return period flows are summarized in Table 3.13, and the percent difference compared to existing conditions are presented in Table 3.14.

Table 3.13. Simulated Peak Flows for Future Land Use Conditions (m^3/s)							
Flow Node	Return Period (Years)						
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year (MTO)	100 Year (NPCA)
501	10.72	16.21	20.06	25.36	29.31	33.25	26.75
502	11.22	17.1	21.23	26.77	30.95	35.02	28.34
503	12.89	19.32	23.79	29.48	33.92	38.46	31.14
504	16.61	24.66	30.08	37.74	43.19	49.27	39.83
505	16.58	24.6	29.99	37.62	43.03	49.08	39.69
506	1.14	1.75	2.18	2.76	3.2	3.68	2.92
507	1.05	1.62	2.03	2.6	3.02	3.48	2.75
508	0.93	1.4	1.74	2.19	2.55	2.94	2.31
509	1.28	1.85	2.26	2.77	3.15	3.55	2.91
510	0.59	0.99	1.3	1.7	2	2.32	1.81
511	10.83	16.46	20.45	25.76	29.78	33.62	27.25
512	11.12	16.92	21.02	26.49	30.65	34.6	28.06
104	0.83	1.16	1.39	1.66	1.86	2.07	1.74
107	0.52	0.89	1.16	1.51	1.78	2.06	1.61
113	1.66	2.45	3.1	3.86	4.43	5.02	4.06
114	2.54	3.75	4.6	5.68	6.86	8.03	5.96
601	1.6	2.45	2.94	3.68	4.16	4.78	3.85

Table 3.14. Percent Change in Simulated Peak Flows for Future Land Use Conditions Compared to Existing Land Use Conditions (%)							
Flow Node	Return Period (Years)						
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year (MTO)	100 Year (NPCA)
501	15	14	14	15	15	15	15
503	0	0	0	0	0	0	0
505	0	0	0	0	0	0	0
506	16	4	-2	-6	-9	-10	-7
508	9	-4	-9	-13	-15	-16	-14
114	1488	1193	1079	992	1006	1000	984
113	163	123	112	98	91	85	95
104	0	0	0	0	0	0	0
107	0	0	0	0	0	0	0

The results in Tables 3.13 and 3.14 indicate that the peak flows along the Conrail Drain would be maintained at existing conditions at the upstream limit of the site (i.e. at Nodes 503 and 505), however the peak flows along the reach through the Thundering Waters development would increase as a result of the proposed development (i.e. at Node 501), generally 15% above existing levels. The results also indicate that peak flows along the Eastern Watercourse (i.e. at Nodes

506 and 508) for major storm events would be slightlyreduced compared to existing levels, as a result of the implementation of the urban drainage and stormwater management system which would effectively reduce the contributing drainage area to the watercourse, diverting a minor amount of runoff directly toward the Welland River and away from the unnamed eastern watercourse. For minor storm events, peak flows along the Eastern Watercourse (i.e. at Nodes 506 and 508) would slightly increase as a result of the proposed development (i.e. subcatchment 108b) contributing to the Eastern Watercourse.

The results further indicate that runoff from areas directly discharging to the Welland River (i.e. Nodes 113 and 114) would increase significantly compared to existing conditions. As noted previously, the increased flows are anticipated to have a negligible impact to the total peak flows along the Welland River due to the size of the development area relative to the total drainage area along the Welland River.

Hydraulics

Hydraulic analyses have been completed to assess the flood potential along the open watercourses resulting from the proposed development of the Thundering Waters lands, as well as to size the proposed hydraulic structures to satisfy current hydraulic design criteria related to freeboard and clearance. The HEC-RAS hydraulic model which was developed to assess the existing conditions along the Conrail Drain and the Eastern Watercourse has been revised to incorporate the hydraulic structures under the proposed condition for the Thundering Waters lands. The governing design event has been determined in accordance with the Highway Drainage Design Standards (MTO, January 2008), which establishes the design event based upon the span of the structure proposed, as well as the classification of the roadway. The design standards are summarized in Table 3.15.

Table 3.15. Design Flow Return Period for Bridges and Culverts (ref. MTO, 2008)

Functional Road Classification	Return Period Design Flows (Years)	
	Total Span ≤ 6.0 m	Total Span > 6.0 m
Freeway, Urban Arterial	50	100
Rural Arterial, Collector Road	25	50
Local Road	10	25

For arterial roadways, a minimum 1.0 m freeboard is applicable for high vulnerability bridges (i.e. bridges that can be washed away or significantly damaged during flooding). For low vulnerability bridges (i.e. bridges that will not experience significant damage during flooding), a 0.3 m freeboard criteria may be applied for the applicable design event. In addition, the Canadian Bridge Code recommends a 1.0 m clearance between the soffit and the design event for high vulnerability bridges and 0.3 m clearance for low vulnerability bridges.

In addition to the open watercourses, hydraulic structures are required at various locations in order to provide a hydrologic and ecological connection between the wetlands and the receivers. Hydraulic analyses for these structures have been completed using the nomographs provided in the MTO Drainage Manual, and assuming inlet control conditions. The structures have been sized to convey the 100 year peak flow, and to provide the requisite freeboard and clearance as per Table 3.15.

The rise of the hydraulic structures at each crossing has been established assuming a minimum 1 m deep road deck (i.e. top of road to soffit) at the crossing, and applying the general grades established in the conceptual grading plan. For this assessment, all roadways within the limits of the Thundering Waters lands have been classified as urban collector roads, and the roads surrounding the development have been classified as urban arterial roads. The location of the proposed hydraulic structures assessed as part of this study is provided on Drawing 3.10, and the recommended size of hydraulic structures are provided in Table 3.16, along with the freeboard and clearance for the applicable design event.

Table 3.16. Hydraulic Analysis Summary for Proposed Crossings

Crossing ID	Recommended Opening (Span x Height)	Clearance Event		Freeboard Event	
		Water Surface Elevation (m)	Clearance (m)	Water Surface Elevation (m)	Freeboard (m)
C1	8.0 m x 3.7 m	175.37 (100 year)	0.63	175.37 (100 year)	1.63
C2	8.0 m x 4.4 m	176.33 (50 year)	1.07	176.33 (50 year)	2.07
C3	7.5 m x 4.1 m	176.53 (50 year)	0.87	176.53 (50 year)	1.87
C4	7.5 m x 3.9 m	176.72 (50 year)	0.68	176.72 (50 year)	1.68
C5	3.5 m x 1.1 m	172.25 (100 year)	0.65	172.25 (100 year)	1.65
C6	1.5 m x 1.0 m	176.70 (100 Year)	0.30	176.70 (100 Year)	1.30
C7	1.5 m x 1.0 m	178.66 (100 Year)	0.34	178.66 (100 Year)	1.34
C8	3.0 m x 1.0 m	177.66 (50 Year)	0.34	177.66 (50 Year)	1.34
C9	6.0 m x 1.0 m	171.72 (100 Year)	0.28	171.72 (100 Year)	0.78

The results in Table 3.16 indicate that the proposed crossings would satisfy current requirements for freeboard and clearance for low vulnerability structures.

Additional hydraulic analyses have been completed for the Conrail Drain to confirm that a minimum 0.3 m freeboard would be provided between the top-of-bank and the 100 year water surface elevation, to provide the required flood protection for the future development of the Thundering Waters lands adjacent to the drain. The 100 year storm generated from the MTO IDF relationships has been applied for this assessment, as this has been determined to represent the more conservative condition. The minimum top-of-bank elevation has been estimated from the conceptual grading plan for the reach of the Conrail Drain bounded by the Thundering Waters development area, and from the topographic mapping where the existing grades would be retained under the future land use condition. This assessment has also assumed that the bottom-width of the Conrail Drain would be generally retained as per the existing condition, and that the top-width would be increased as required in order to provide a 3:1 side slope and match the proposed grade as per the conceptual grading plan (ref. Appendix A for conceptual cross-section). The results of this assessment are presented in Table 3.17.

Table 3.17. Freeboard Assessment for Conrail Drain

HEC-RAS Section ID	Estimated Minimum Future Conditions Top of Bank (m)	100 Year Event (MTO)		100 Year Event (NPCA)	
		Water Surface Elevation (m)	Freeboard (m)	Water Surface Elevation (m)	Freeboard (m)
1373.13	181.0	177.83	3.17	177.53	3.47
1308	180.7	177.75	2.95	177.43	3.27
1001	179.6	177.21	2.39	176.87	2.73
793.6	178.4	176.98	1.42	176.65	1.75
768	178.4	176.93	1.47	176.6	1.8
692.15	178.4	176.64	1.76	176.32	2.08
666.55	178.4	176.58	1.82	176.27	2.13
659	178.4	176.58	1.82	176.27	2.13
590.7	178.4	176.43	1.97	176.12	2.28
492.5	178.4	176.2	2.2	175.91	2.49
429	178.1	176.08	2.02	175.79	2.31
381	177.9	175.98	1.92	175.69	2.21
332.24	177.7	175.88	1.82	175.59	2.11
286	177.6	175.77	1.83	175.49	2.11
212	177.4	175.61	1.79	175.32	2.08
97.53	177.0	175.23	1.77	174.97	2.03
35.06	177.0	174.92	2.08	174.68	2.32
0.00	177.7	174.79	2.89	174.54	3.14

The results in Table 3.17 indicate that the minimum 0.3 m freeboard criteria would be satisfied by the conceptual grades, with extension of the side slopes to match future grades as required. This assessment also assumes that the type and density of vegetation under future conditions would be comparable to that under existing conditions and would thus yield a roughness coefficient comparable to existing conditions. The results of these hydraulic analyses should be verified at the detailed design stage, and should be updated as required based upon the landscape plan and the proposed grading plan for the development area.

The future configuration of the Conrail Drain Channel is anticipated to be restored and enhanced using natural channel design principles. The inclusion of a meandering low flow channel (thalweg) and defined overbanks within the thalweg, characterize a typical, natural channel, as demonstrated in a cross-section graphic included in Appendix 'A.' The specific attributes of the proposed Conrail Drain is to be determined during detailed design and should satisfy the following principles:

- Flood protection must be provided to proposed properties adjacent to the Conrail Drain Channel, satisfying the necessary freeboard criteria along the proposed top of bank.
- Flood elevations are not to increase within the Conrail Drain Channel upstream of the Thundering Waters site.
- The riparian storage provided by the existing configuration of the Conrail Drain Channel is to be replicated in the proposed condition.
- Proposed hydraulic structures within the Conrail Drain Channel are to satisfy the necessary clearance and freeboard criteria.
- As part of incorporating a naturalized design, the Conrail Drain channel is to be enhanced with riparian vegetation to provide dynamic stability in addition to aesthetics. Vegetation specified within the proposed low flow channel and overbanks is to be of a type and density which provides comparable roughness coefficients for the positive hydraulics of the channel.

Closed Conduits

The proposed development of the Thundering Waters lands would potentially eliminate a portion of the open watercourse at the upstream limit of the unnamed eastern watercourse, which receives and conveys flows from the adjacent golf course. In order to capture and convey the flows from the golf course under future conditions, a storm pipe enclosure could be designed to capture and convey the external 100 year peak flow or alternatively a localized watercourse realignment could be considered.

Hydraulic analyses have been completed to determine the size of potential storm pipes required to capture and convey the 100 year flow from the golf course and local flows west of Kister Road. The HEC-RAS hydraulic model for the existing conditions has been applied for this assessment. The peak flows within the model have been updated to incorporate the flows for future land use conditions, and the storm pipe has been sized assuming that existing upstream and downstream inverts would be maintained and a minimum 1.2 m cover would be required. The storm pipe conveying flows from the golf course has been sized such that the upstream water surface elevation at the golf course would not increase compared to existing conditions. The storm pipe conveying local flows west of Kister Road has been sized such that future water surface elevations immediately upstream of the proposed storm pipe would not be greater than existing water surface elevations and would be contained within the overbanks of the Eastern Watercourse. The results of this assessment have indicated that a 1.5 x 0.96 m elliptical pipe would be required to capture and convey runoff from the golf course and from local drainage west of Kister Road under future land use conditions (ref. Drawing 3.11). Further discussions will be required with City staff and

NPCA on the acceptability of this local piped enclosure or the potential for localized creek realignments to accommodate the development plan.

Urban Major and Minor System

The drainage system within the limits of the Thundering Waters lands is proposed to consist of an urban major and minor drainage system. Storm sewers designed to a 5 year standard are proposed along the road network to capture and convey runoff during the more frequent events; during less frequent events (i.e. above the 5 year condition), peak flows would be conveyed within the road right-of-way, without encroaching onto adjacent private properties. The layout of the minor system is provided on Drawing 3.11.

In addition to conveying runoff from the development area, the storm sewers within the southern portion of the site would be required to capture and convey runoff from the existing wetlands, located within future land use subcatchments: 109a, 110a, and 111a (ref. Drawing 3.9). Under existing conditions, runoff from the wetlands is conveyed toward the Eastern Watercourse [located within future land use subcatchments: 108c, 110b, and 111b (ref. Drawing 3.9)] via various headwater drainage features. This distributed supply of runoff from the wetland to the Eastern Watercourse may be maintained under future conditions via the implementation of a third pipe system or through the implementation of additional outlets from the storm sewer to the Eastern Watercourse. As an alternative, the runoff may be captured and conveyed to the future stormwater management facilities, thereby bypassing the watercourse system. Further discussion is required with NPCA regarding the preferred approach for conveying runoff from the wetlands through the future development area.

3.7 Water Balance

The conceptual grading plan for the Thundering Waters site has been developed to provide a features-based water balance to the retained wetlands within the site. Hydrologic analyses have been completed using Rational Method, in order to verify that the grading plan would not decrease the volume of surface water to the respective features compared to existing conditions. The results of this assessment are presented in Table 3.18 and Drawing 3.12 and Drawing 3.13.

Table 3.18. Water Balance Assessment

Wetland ID	A x C		Runoff Volume (m^3)[1]		
	Existing	Proposed	Existing	Proposed	% Difference
W1	3.46	3.85	32,736	36,487	11%
W2	3.49	4.26	33,020	40,317	22%
W3	8.79	10.19	83,262	96,564	16%
W4	15.17	16.12	143,759	152,783	6%
W5	40.22	41.86	381,098	396,614	4%
W6	3.71	3.66	35,162	34,641	-1%

[1] Precipitation and runoff volumes have been determined using the average annual precipitation data (i.e. 947.5 mm) from Environment Canada collected at the "Niagara Falls NPCSH" climate station between the years 1981 and 2010.

The results of the water balance assessment indicate that the conceptual grading plan would provide a supply of surface water to the features as much as 22 % more than existing conditions. At the detailed design stage, the grading plan may need to be refined in order to more closely match the existing surface water budget to the features; note that the calculations herein have not accounted for the influence of LID BMPs.

The results in Table 3.18 also indicate that the contributing drainage area to the wetlands would be anticipated to slightly decrease under future conditions as a result of the proposed development and associated site grading. However, the increased impervious coverage would serve to maintain the water supply, thereby minimizing potential impacts to surface water to the feature.

3.8 Stormwater Management Plan

The components of the preferred stormwater management plan are provided on Drawings 3.8, 3.11, and 3.12. The preferred stormwater management plan consists of the following components:

i. Two wet ponds designed to provide stormwater quality control to a “Normal” standard of treatment as a minimum, for the future development within the portion of the Thundering Waters lands located south of the railway.
ii. Oil/grit separators designed to provide stormwater quality control to a “Normal” standard of treatment as a minimum, for the future development within the portion of the Thundering Waters lands north of the railway and east of the Eastern Watercourse.
iii. LID BMPs designed to provide stormwater quality control to a “Normal” standard of treatment as a minimum, for the future development within the portion of the Thundering Waters lands contributing to the preserved wetlands and as a method to enhance water quality and promote on-site infiltration and achieve water balance.
iv. Retention and enhancement of the Conrail Drain and portions of the Eastern Watercourse to serve as conveyance systems.
v. Hydraulic structures crossing the Conrail Drain and the Eastern Watercourse, designed in accordance to current standards for freeboard and clearance.
vi. Hydraulic structures conveying localized drainage directly to the Power Canal, Welland River, or between preserved wetlands designed to convey the 100 year storm event at or below full flow conditions.
vii. A closed conduit or local creek realignment at the north limit of the Eastern Watercourse, designed to a 100 year design standard, in order to capture runoff from the golf course and convey it to the Eastern Watercourse east of the site.
viii. Urban major and minor system within the development area (5 year and 100 year standard).
ix. A third pipe dedicated system to capture runoff from the central wetland (i.e. future land use subcatchments: 109a, 110a, and 111a (ref. Drawing 3.9) and convey it to the Eastern Watercourse (i.e. future land use subcatchments: 108c, 110b, and 111b (ref. Drawing 3.9), or catchbasins along the central wetland connected to the storm sewer system with lateral outlets from the storm sewers adjacent to the Eastern Watercourse in order to maintain the supply of water.

3.9 Cleanwater Pumping System – Conrail Drain

Thundering Waters intends to use a restored Conrail Drain as a feature in the new community. Currently the watercourse is quite linear and devoid of much in the way of environmental or aesthetic elements. As part of the restoration, the watercourse would be proposed to be reconfigured using natural channel design principles, as well as suitable planting in accordance with NPCA planting guidelines. Further, since the Conrail Drain tends to have a very low baseflow, particularly during the drier summer months, it has been proposed to construct a cleanwater pumping station to draw water from the Welland River and pump it to the internal headwater of the Conrail Drain within the Thundering Waters lands. Given the potential for local environmental impacts, the siting and configuration of the intake will need to be consultatively established with MNRF and possibly the Department of Fisheries and Oceans (DFO). Further, it is noted that the Welland River surface water would essentially go to the same location (Power Canal) as it would under current conditions, while contributing flow and possible local habitat enhancement to the Conrail Drain.

At the detailed design stage, the following will need to be addressed:

- Location of intake
- Type of intake
- Location of pump including appurtenances such as back-up pumps and power
- Rated capacity of pump
- Forcemain alignment
- Operations criteria (seasonal variations in rates)
- Maintenance (short and long term)
- Ownership

Drawing 3.10 depicts a notional configuration for the concept of a cleanwater pumping station.

4.0 WASTEWATER SERVICING

This section provides information on the existing available wastewater sewers in the area, presents an assessment of their hydraulic capacity, evaluates the alternative servicing methods, and identifies the preferred wastewater servicing scheme for the Thundering Waters Development. The analysis includes the assessment of the conveyance capacity of proposed municipal sewers as well as a review of the total capacity of the receiving sewer system. The existing demand in the receiving system has not been reviewed.

The overall wastewater servicing concept is given in Drawing 4.1 at the end of this report. It provides an overview of the elements described in this section.

4.1 Purpose

The purpose of the wastewater servicing assessment is to assess the feasibility of connecting the proposed development to the existing Niagara Region wastewater collection and treatment system, as well as to provide a conceptual servicing plan for wastewater collection and conveyance to Niagara Region's System.

The analysis indicates the estimated demand on the receiving Niagara Region system and is intended to facilitate the planning of trunk infrastructure growth. As new developments are introduced to the system, they can consume available capacity of the existing infrastructure downstream to the wastewater treatment plant, reducing the capability of future development to be serviced. By establishing the wastewater flows that will be generated by the Thundering Waters development, the City of Niagara Falls and Region of Niagara can assess the influence in the collection system model and determine the short term and long term effects from the development. Working with the Region and the City of Niagara Falls, the wastewater flows generated by the Thundering Waters development can be coordinated with the local and regional master servicing planning.

4.2 Background Information

The following background information was reviewed for the preparation of the conceptual sanitary servicing plan:

- Thundering Waters Draft Master Plan dated May 19th 2016 from RTKL and MSH;
- City of Niagara Falls Engineering Standards – Sewer Design Criteria;
- Niagara Region Water and Wastewater Master Plan (2011 update);
- As constructed drawings for the 825 mm sewer on Dorchester Road, the 1375 mm sewer on Oldfield Road, and the overflow at the South Side HLPS;
- City of Niagara Falls – Review of Municipal Servicing requirements for Thundering Waters, June 27, 2007, R.V. Anderson Associated Limited;
- Site Servicing Feasibility Study, Thundering Waters Development, Niagara Falls, July 11, 2006, Urban Environmental Management Inc.

4.3 Methodology

The following methodology was undertaken to develop a conceptual wastewater servicing plan for the Thundering Waters development.

i. Evaluation of the future sanitary sewershed characteristics from the development in terms of sewershed area, estimated residential population, and estimated employment population;
ii. Development of a framework for generating sanitary flows based on the City of Niagara Falls criteria and the expected ultimate land use for the development;
iii. Evaluation of topography constraints through the review of a conceptual grading plan, and assessment of potential for construction of gravity sewer systems;
iv. Review of the Niagara Region's Master Plan to identify the nearest receiving point and to evaluate the available capacity envisaged in the Master Plan;
v. Development of a conceptual gravity sewer system plan that meets City of Niagara Falls standards, and that connects to the Region of Niagara System;
vi. Review pumping requirements associated with the servicing plan and identify potential locations / location for pumping stations;
vii. Evaluate the demand on the wastewater treatment system associated with the Thundering Waters development.

4.4 Design Criteria

The following criteria was applied to the conceptual design.

Table 4.1. Design Criteria for the Wastewater Collection System

Dry Weather Flow			
Residential Population	380 l/person-day	From City of Niagara Falls Best Practice Estimate	These unit flow generation rates are applied to the populations expected in the development – as the plans are preliminary. The final population may vary from those used in this report.
Employment Population	150l/person-day		
Diurnal Variation / Daily Peaks	Harmon Peaking factor	From City of Niagara Falls	The Harmon Peaking Factor is applied to instantaneous flow for the design of pipes with no storage – with respect to pump stations the peak factor can be reduced depending on the wet well characteristics and routing.
Wet Weather Flow			
Design Inflow Infiltration Allowance	0.18l/s-ha	Niagara Falls Standard for New Sewers	

4.5 Existing Collection System

The Niagara Region Collection system is accessible via the South Side High Lift Pumping Station (HLPS). According to the 2011 Master Plan Update the South Side HLPS has a firm capacity of 760 l/s.

Existing Sewers

The Thundering Waters development can connect into the South Side HLPS via an existing 825 mm sewer located on Dorchester Road at an invert of approximately 175.49 m.

This sewer drains into a 1375 mm diameter sewer that crosses the Power Canal and enters the South Side HLPS.

The existing sewer capacities are evaluated in two reaches below:

Table 4.2. Existing Sewer Region of Niagara Sewer Capacities Downstream of the Thundering Waters Source – As constructed drawings & GIS information received)	
Sewer Reach	**Full Flow Capacity**
Dorchester Road 825 mm Sewer @ 0.15%	556 l/s
Oldfield Road 1375 mm Sewer @ 0.16%	2135 l/s

As discussed in Section 4.7, the demand in these sewers from the Thundering Waters development is approximately 160 l/s (Instantaneous Flow based on daily peak / Harmon Peak factor). This represents 25% of the capacity of the Dorchester Road sewer and 7.5% of the Capacity in the Oldfield Road sewer.

South Side High Lift Sewage Pumping Station

The following demand projections are extracted from the 2011 Master Plan Update for the South Side HLPS:

Table 4.3. Capacity and Demand Projections in the South Side HLPS (2011 Niagara Region W WW Master Plan Update AECOM 2011)		
South Side High Lift SPS		
	PDWF (l/s)	**PWWF (l/s)**
Capacity	760	
2011	158	2117
2016	204	2210
2021	253	2311
2026	298	2403
2031	321	2450
Ultimate Build-Out	535	2888

The Thundering Waters lands were included as potential future development contributions to the South Side SPS in the 2011 Master Plan Update. Niagara Region is currently updating its Master Plan. The development of Thundering Waters may accelerate the growth in demand expected in the South Side HLPS.

As discussed in Section 4.7, the demand on the South Side HLPS from the Thundering Waters development is approximately 93 l/s (Based on attenuated Peaking Factor associated with attenuation within the wet well). This represents approximately 12% of the capacity of the South Side HLPS.

4.6 Wastewater Treatment Capacity

The South Side HLPS service area is pumped to the Niagara Falls WWTP. The capacity of the WWTP is 68.2 MLD (Dry weather flow capacity – Source 2011 Niagara Region W WW Master Plan Update AECOM 2011).

The 2011 Master Plan also has projected flows to the facility, and as per the projections in the MP, by 2016 we should be at 76.6% of capacity, and the Thundering Waters lands are identified as having development or intensification potential in the Master Plan Update. The Master Plan is currently being updated to reflect the existing conditions.

As discussed in Section 4.7, the demand on the Niagara Falls WWTP from the Thundering Waters development is approximately 4.3 MLD (Based full day dry-weather flow). This represents approximately 6.3% of the capacity of the wastewater treatment plant.

4.7 System Design Flows

The population estimate utilized for the wastewater collection system is given below. It is noted that this may differ slightly from the planning estimates. The estimate is based on the buildings and proposed land uses and provides a factor of safety to ensure that the system is designed to meet extreme conditions. The population estimates are as follows:

Table 4.4. System Design Population

	Units	Population factor	Population
Total Bungalows	480	3	1,440
Total Single Family Detached	92	3	276
Total Condo/Apartments	2,296	2.5	5,740
Total Town Houses	214	3	642
Hotels	400	2.4	960
Retirement Facility / Long Term Care	150	2.4	360
Subtotal			**9,418**
10% Uncertainty			**942**
Total Residential			**10,360**
Employment			
High Tech Centre	100		**1,000**
Theater			1,000
Commercial Centre			1,000
Total Employment			**3,000**

Wastewater system design flows are evaluated differently for the various system components. Flows through gravity sewers are evaluated based on an instantaneous flow (typically in l/s) representing the peak flow that would occur at a given time during the day. Pump Stations typically have some wet well storage and send the flow to the system in batches. The pump station / wet well configuration allows for some attenuation in the system, and a lesser peaking factor can be applied to the flow in order to determine the pump station demand.

Treatment Facilities are evaluated using two different flow criteria. The first criteria applied is the dry-weather flow capacity which establishes the amount of waste that the plant needs to remove from the stream. The second criteria applied is the wet weather flow capacity. In wet weather events, the waste is diluted in higher flows. The wet weather flow capacity plant's hydraulic capacity to treat the stream without overflowing. The treatment plant flows discussed in this report represent the dry weather capacity. As plants typically have large volume attenuation, their capacity is expressed in terms of the daily total flow. For example the Niagara Falls WWTP capacity is rated at 68.2 MLD (Millions of litres per day). The 68.2 million litres can be treated whether it arrives in a one hour period in 24 hours, or whether it arrives as a steady stream spread over 24 hours.

<u>Gravity Sewer Flow From Thundering Waters Development into the Niagara Region System</u>

For the trunk sewer gravity pipe shown at the end of the system the demand is evaluated at 160 l/s as follows:

Table 4.5. Gravity Sewer Pipe Flow Estimate Downstream of Development

Res	Emp	Average	Harmon Peak Factor	Peak Flow (l/s)	Extraneous Flow (l/s)	Design Flow (l/s)
10160	3000	49.9	2.84	141.5	18.36	160

<u>Demand on the South Side HLPS From Thundering Waters Development</u>

The load on the Region's South Side Sewage Pumping Station is evaluated at 93 l/s as follows:

Table 4.6. Conceptual Flow Estimate for Thundering Waters Contribution to South Side HLPS

Res	Emp	Average	Attenuated Peak Factor	Peak Flow (l/s)	Extraneous Flow (l/s)	Design Flow (l/s)
10160	3000	49.9	1.50	74.8	18.4	93

Demand on the Niagara Falls WWTP from Thundering Waters Development

The load on the Niagara Falls WWTP is evaluated at 4.3 MLD as follows:

Table 4.7. Design Flow Estimate for Thundering Waters Contribution to Niagara Falls WWTP			
Res	**Emp**	**Average (l/s)**	**Daily Dry Weather Flow (MLD)**
10160	3000	49.9	4.3

Demand for the New Sewage Pumping Station

Most of the Thundering Waters development will be graded via gravity sewers to a new sewage pumping station. The estimated demand for the pumping station is 88 l/s as follows:

Table 4.8. Conceptual Flow Estimate for New Pump Station / Forcemain Design						
Res	**Emp**	**Average (l/s)**	**Attenuated Peak Factor**	**Peak Flow (l/s)**	**Extraneous Flow (l/s)**	**Design Flow (l/s)**
9360	3000	46	1.50	69.6	18.36	88

4.8 Topographic Constraints

The site topography ranges in elevation from 174 to 180 and it is bounded by the Welland River to the south and the Power Canal to the west. The lower lands are situated in the southern portion of the development.

A preliminary grading plan was prepared by Amec Foster Wheeler through the development of the stormwater management (SWM) servicing concept (ref. Drawing 3.7). There are two proposed SWM facilities included in the southern portion of the development.

4.9 Proposed Concept

The proposed concept is shown on Drawing 4.1. The concept integrates with the SWM concept plan and the proposed pumping station is included in a conceptual location near the SWM facility in the south west portion of the development. It is recommended that a separate block be identified for the wastewater pumping station adjacent to the stormwater management block.

Collection System

The concept is based on connecting to Niagara Region's collection system via the existing 825 mm sewer on Dorchester Road at an invert of 175.49 m.

The small portion of the development in the northwest corner will be able to drain via gravity directly to this point. Topographic constraints require that the rest of the property be serviced by a pumping station in order to get to the connection point. An internal gravity collection system will be implemented to bring the wastewater from these areas to the new sewage pumping station.

New Sewage Pumping Station Concept

The dimensions of this block should be approximately 20 m x 40 m to allow for the design of the wastewater pumping station, wet well, and diesel generator. The pumping station should be designed in consultation with Niagara Region in a wet well – dry well arrangement likely with 3 pumps of equal capacity.

The electrical panel and diesel generator will be above grade and should be integrated with the architectural character of the development.

Noise mitigation should be integrated in the design. This will be an important consideration for the configuration of the generator.

The pumping station will require 3 phase power.

The following table provides the conceptual details for the pumping station and forcemain.

Table 4.9. Conceptual Design Calculations for New Sewage Pumping Station

	Input	Calc'd	
Bottom of Wet Well	163.00 m		
Top Of Wet Well	165.00 m		
Receiving Sewer Level	177.00 m		
Static Head		14.00 m	
Forcemain Diameter	250 mm		
Design Flow	88 l/s		
C Factor	120		
Velocity		1.79 m/s	
Frictional Slope (Hazen Williams)	1.43%		
Pipe Length	1025 m		
Friction Head		12.88 m	
Total Head		26.88 m	
Raw Power		23.2 kW	
Pump Efficiency	80%		
Motor Efficiency	80%		
Power Requirements		36.3 kW	48.6 HP

4.10 External Servicing Opportunity for properties to the South of the Welland River

Niagara Region has provided some information on external developable properties to the South of the Welland River. The Vedic development proposal may also be proceeding along a similar timeline as the Thundering Waters development.

The Vedic property is the main development area located on the South Side of the Welland River. As per information provided by Niagara Region (see Appendix B), the Region has envisaged a pump station solution that discharges to the same location as the proposed Thundering Waters development.

The total potential developable area to the South of the Welland River is approximately 165 ha. The details of the development proposal for this area in terms of employment /residential populations, and total sewershed area have not been provided. It is reasonable to expect that the developable land to the South of could ultimately support a total population of 10,000 people and could double the flow directed to the system.

The joint solution would involve the following:

- Upsizing the Pump Station and Forcemain System to meet the additional demand from the lands to the South of the Welland River;
- Providing an external sewer to connect to at the boundary as shown in the proposed plan;

Under the current preferred strategy the new pumping station is sized for the Thundering Waters development only.

A joint solution would likely be cost-shared among the benefitting land owners based on the share of the flow in the system. Cost shareable items in the joint solution would include:

- Forcemain (Cost Share based on percentage of capacity assigned to the benefitting land owners);
- Pump Station (Cost Share based on percentage of capacity assigned to the benefitting land owners);
- External Sewer Connection (100 % of capacity dedicated to external lands – funded entirely by external lands)

5.0 WATER SERVICING

5.1 Purpose

The purpose of the wastewater servicing assessment is to assess the feasibility of connecting the proposed development to the existing Niagara Region water supply system, as well as to provide a conceptual servicing plan for providing water supply through a connection to Niagara Region's System.

The analysis indicates the estimated water demands, identifies the connection points to the system and confirms that the internal network is adequate to convey and supply water to the required standard (MOECC, City of Niagara Falls, and Region of Niagara).

As new developments are introduced to the system, they can consume available capacity of the Region's water supply infrastructure, particularly the storage, pumping and treatment requirements. Pumping, storage and transmission requirements are shared services that are planned at the Regional level. By establishing the water demands that will be generated by the Thundering Waters development, the City of Niagara Falls and Region of Niagara can assess the influence on the pumping, storage and transmission infrastructure and determine the short term and long term effects from the development. Working with the Region and the City of Niagara Falls, the water demands generated by the Thundering Waters development can be coordinated with the local and regional master servicing planning.

The overall water servicing concept is given in Drawing 5.1 at the end of this report. It provides an overview of the elements described in this section.

5.2 Methodology

Background information relating to the existing municipal water distribution system in the vicinity of the site was obtained from the City of Niagara Falls. That information was used to identify existing watermains in proximity to the site.

Boundary conditions are input in the model at the connection points based on the expected hydraulic grade line available in the system during operation. This approach confirms that the proposed pipes can deliver the flow requirements within a pressurized system that meets the overall demand of the zone. In order to verify system pressures, the boundary condition is taken at the nearest trunk watermain (1050 mm watermain on Oldfield Road) where it is assumed that the Region's system can maintain a steady hydraulic grade under all conditions in the distribution system.

The Region's Master Plan was reviewed to evaluate and integrate this development with the projected growth and to confirm that the development proposal can be accommodated. The Region's model was not provided to verify the existing pumping, storage and transmission in the system.

Water demand calculations for the proposed site were based on proposed land use and relevant criteria. Certain assumptions were made with regards to the existing water distribution infrastructure.

MOECC guidelines were used in conjunction with City of Niagara Falls design standards, as well as information gathered from the Region of Niagara Master Servicing Plan.

The source documents are listed below in Section 5.2.1 and design criteria are presented in Section 5.4.

5.2.1 Background Documents

The following background studies and information regarding the Site and surrounding area were referenced during the water supply analysis:

- City of Niagara Falls Standard Drawings and Design Criteria, January 2012
- Regional Municipality of Niagara Water and Wastewater Master Servicing Plan, 2011, AECOM
- Guidelines for the Design of Water Distribution Systems, 2008, Ministry of the Environment (MOE);
- Water Supply for Public Fire Protection, 1999, Fire Underwriters Survey;
- City of Niagara Falls – Review of Municipal Servicing requirements for Thundering Waters, June 27, 2007, R.V. Anderson Associated Limited;
- Site Servicing Feasibility Study, Thundering Waters Development, Niagara Falls, July 11, 2006, Urban Environmental Management Inc.

5.3 Background Information

The subject lands are part of the Niagara Falls Water Distribution System. The Niagara Falls Water Distribution System is a single pressure zone with a top operating water level of 245 m[1].

The Niagara Falls W.T.P is located approximately 5 km to the east of the Thundering Waters site along the Niagara River, and would be the main source of water for the development. The water production capacity of the WTP is 145.5 MLD.

The Niagara Falls pressure zone has a total storage capacity of 37.4 ML distributed throughout the pressure zone. The 2011 Master Plan update indicates that this storage volume will be sufficient until 2026.

The 2016 projected water demands according to the current Region of Niagara Master Servicing Plan is 79.6 MLD, which means that 55% of the overall production of the WTP is being used. As discussed in section 5.6 below is 6.5 MLD, representing 4.5 % of the capacity of the distribution system.

---

[1] Top water level of 245 estimated based on ADD pressures provided by the Region 69.8 m at Don Murie Street Connection Point.

The proposed Thundering Waters development site currently does not have any water service. The Niagara Falls pressure zone is accessible to the proposed development site at the following points:

- 300 mm PVC watermain on Dorchester Road
- 300 mm Ductile Iron watermain at Progress Avenue
- 300 mm Ductile Iron watermain at Don Murie Street

Each of these points is connected to an existing 1050 mm transmission main along Old Field road that is connected to the Niagara Falls WTP.

However, access to a municipal water supply is available to the northwest and to the east of the

5.4 Design Guidelines

Based on the review of background information, Amec Foster Wheeler identified the design criteria for the potable water servicing (Table 5.1) as follows:

Table 5.1. Design Criteria – Water Distribution

	Criteria	Source
Flow Demands		
Average Day Demand	300 l/cap/day	Region
Maximum Day Factor (equivalent population 100,000 – applied to the pressure zone)	1.65	MOECC
Peak Hour Demand Factor (equivalent population 10,000)	2.85	MOECC
Fire Flow Requirements		
For Development area (Equivalent population 10,000) – 189 l/s for 3 hours		
Storage Requirements (S = A + B + C)		MOECC
(A) Storage for Fire Flow (189 l/s for 3 hours)		
(B) Equalization Storage = 25% of Max day demand		
(C) Emergency storage at 25% of equalization storage plus fire flow storage		
Pipe Design		
Residential Area Minimum Size Industrial/Commercial Area Minimum Size High Density Residential	150 mm for mainline 200 mm for mainline 300 mm for mainline	City
Minimum Cover	No less than 1.50 m	City
Operating Pressure		
Pressure Range (Min-Max)	275-700 kPa (40-100 psi)	City
Normal Operating	350-480 kPa (50-70 psi)	MOECC
Minimum pressure during Peak Hour Demand	275 (40 psi)	

5.5 Proposed Water Distribution System Concept

A proposed water distribution system is shown in drawing 5.1 to service the development.

The design approach in developing the proposed network is as follows:

- Establish a 300 mm PVC connection through the development to improve the redundancy and reliability of the Region's water supply system;
- Establish a redundant 300 mm PVC connection through the system to improve the redundancy of the system;
- Service every road with 150 mm to 200 mm PVC watermains – sizing will be finalized when they hydrants are laid out;
- Minimize any new dead ends in the system for water quality and operational efficiency;

Note that the minimum pressure requirements in the development can be met with watermains smaller than 300 mm and the oversizing is provided to improve service within the pressure zone to existing and potential future development (such as the lands to the South of the Welland River)

5.6 Water Demands

The population estimates for the water demands are provided in Table 4.4.

Water demands are evaluated for various scenarios and system components. Bulk Water Supply requirements consider the max day system demand. The max-day peak factor within the Niagara Falls pressure zone considers the total population in the pressure zone as it is a shared system.

The Max-day + Fire Scenario used to evaluate the minimum pressure requirement (149 KPa) considers a local max day factor based on the local population.

Thundering Waters Demand from Niagara Falls Water Supply System (Pressure Zone)

The increase in demand in the Niagara Falls Pressure Zone is evaluated at 6.5 MLD as follows:

Table 5.2. Water Demand from Thundering Waters Development on Niagara Falls Distribution System

Res	Emp	Average Day Demand (MLD)	Max Day Factor (MOECC)	Max Day
10160	3000	3.9	1.65	6.5

Peak Hourly Demand in Thundering Waters Development

The following table estimates the peak hourly demand in the Thundering Waters development.

Table 5.3. Peak Hour Demand in Thundering Waters Distribution System				
Res	**Emp**	**Average Day Demand (l/s)**	**Peak Hourly Factor (MOECC)**	**Peak Hourly demand (l/s)**
10160	3000	45.7	2.85	130.2

Fire demands

Based on the MOECC design guidelines, a flow requirement of 189 l/s is added to the local max day demand in the Thundering Waters development. As this flow rate is not likely to be retrieved from a single hydrant, it is modelled at two points (95 l/s and 94 l/s) to confirm that the system can accommodate the flow and maintain the proposed pressures.

For the purposes of this FSR, the fireflow has been taken from points along the 300 mm transmission system, this process will be refined at the detailed design stage when hydrants are applied in order to size the local mains.

5.7 Water Distribution Analysis

A steady state model run was completed with the following scenarios and is included in Appendix C:

- Average Day Demand
- Peak Hourly Demand
- Max Day + Fire Demand (with fire flows taken at high points within the system at two nodes i.e. 94 l/s + 95 l/s = 189 l/s)

The model runs indicate that the minimum pressures can be easily maintained within the system based on a boundary condition HGL of 245 m available in the 1050 mm Oldfield Road transmission main.

The model runs also indicate that the normal operating pressures within the system may be at or slightly above the 700 KPa guideline. This issue can be addressed by mitigating measures such as:

- Individual pressure reducing valves at some service connections in the lower areas;
- Pressure reducing valves within the Niagara Falls distribution system to create a lower pressure sub-zone;
- When selecting watermains and appurtenances confirm that they have a high enough pressure rating to sustain pressures up to a higher than normal threshold (eg. 800 KPa rather than 700 Pa);

5.8 External Servicing Opportunity for properties to the South of the Welland River

Niagara Region has provided some information on external developable properties to the South of the Welland River. The Vedic development proposal may also be proceeding along a similar timeline as the Thundering Waters development.

The Vedic property is the main development area located on the South Side of the Welland River. As per information provided by Niagara Region (see Appendix B), the Region has envisaged a pump station solution that discharges to the same location as the proposed Thundering Waters development.

The total potential developable area to the South of the Welland River is approximately 165 ha. The details of the development proposal for this area in terms of employment /residential populations have not been provided. It is reasonable to expect that the developable land to the South of could ultimately support a total population of 10,000.

This area, if it is connected to the Niagara Falls distribution system will require a looped connection. The concept shown in drawing 5.1 provides a potential connection at the South end that would need to cross the Welland River.

6.0 OTHER UTILITIES

Over the course of this first phase investigations, various utility providers have been contacted and requested to provide maps and drawings of their existing utility services. The drawings from each of the utility providers is included in Appendix C and details are discussed in the following.

6.1 Bell (Telecommunications)

Bell currently provides minimal servicing to the proposed development site. Existing development to the southeast is serviced with buried cable along Progress Street, Don Murie Street, and Kister Road. Overhead service is provided along Dorchester Road, extending as far as the current industrial development limit. A service extension would have to be provided in order to service the site. Further consultation over the course of the Secondary Plan process will be required to define the nature of the upgrades.

6.2 Cogeco

Cogeco's existing services extend south from Dorchester Road, and terminate at the limit of the current development boundary on Dorchester Road. The current Oldfield development, which lies to the north of the proposed development site, is being serviced from the east along Drummond Road. These upgrades are ongoing. Cogeco also has service along Kister which ends just north of Progress Street, and a service extension would have to be provided in order to service the site.

6.3 Enbridge (Natural Gas)

Local servicing exists along Progress Street, Don Murie Street, and Kister Road. Dorchester Road is serviced as far south as the existing industrial development boundary. To the west of the Power Canal, Enbridge provides services along the Queen Elizabeth Way (east and west side), and show plans for a future crossing of the canal which could service the southwest portion of the development.

6.4 Hydro Electricity

Niagara Peninsula Energy Inc. (NPEI) currently provides services to the north, and to the east of the proposed development. Along Dorchester Road, a 3-phase / 13,800 volt hydro line extends to the existing industrial development. At this point a 1-phase / 8,000 volt, primary overhead distribution pole line continues south along Dorchester Road, terminating at the railway crossing. Along Don Murie Street and Progress Street, 3-phase / 13,800 volt, primary overhead distribution lines are provided and terminate at the development limits.

7.0 SUMMARY

In summary, the proposed development site has been in its existing condition since before the previous Region of Niagara Master Plan (2011), hence the information from that master plan are still considered valid. The site is densely vegetated with some wetland areas that have to be considered during future servicing. The soils on the subject property generally exhibit low infiltration, have a high generation of runoff can be expected. The property is relatively flat, with a mild grade (ie. Less than 0.1%) sloping towards the Welland River, or towards the Power Canal. The Conrail Drain runs north east to southwest through the subject property, creating a separation in grade, and acts as a significant drainage feature for the property. The Conrail Drain is capable of containing the flows generated during the 100 year storm, preventing any potential floodplain limitations in developing final land uses. The level terrain in combination with the Conrail Drain will have design implications for sanitary servicing, and with the water servicing design to a lesser extent.

The proposed development site has a well serviced perimeter providing good access to existing services. Oldfield Road acts a major artery for all of the required services for development. The proximity to Oldfield Road will provide the Thundering Waters development with:

- Sufficient water pressure and supply (>100 psi, 218 L/s)
  - Water services may require pressure reducing valves.
- South Side High Lift SPS and trunk sewer connection has sufficient capacity to receive wastewater flows
- Conrail Drain and water feature at eastern boundary can convey the equivalent of the 100 year storm in their existing state.
- Cogeco, Bell, and NPEI utility services can be extended to provide required service for development. The proposed site is not currently serviced.

The Oldfield Estates development which is located to the north of Oldfield Road will have no direct impact on the Thundering Waters development, as it shares major servicing from the trunk water main, and trunk sanitary sewer along Oldfield Road.

Report prepared by,

Amec Foster Wheeler Environment & Infrastructure
a division of Amec Foster Wheeler Americas Limited

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Principal Consultant

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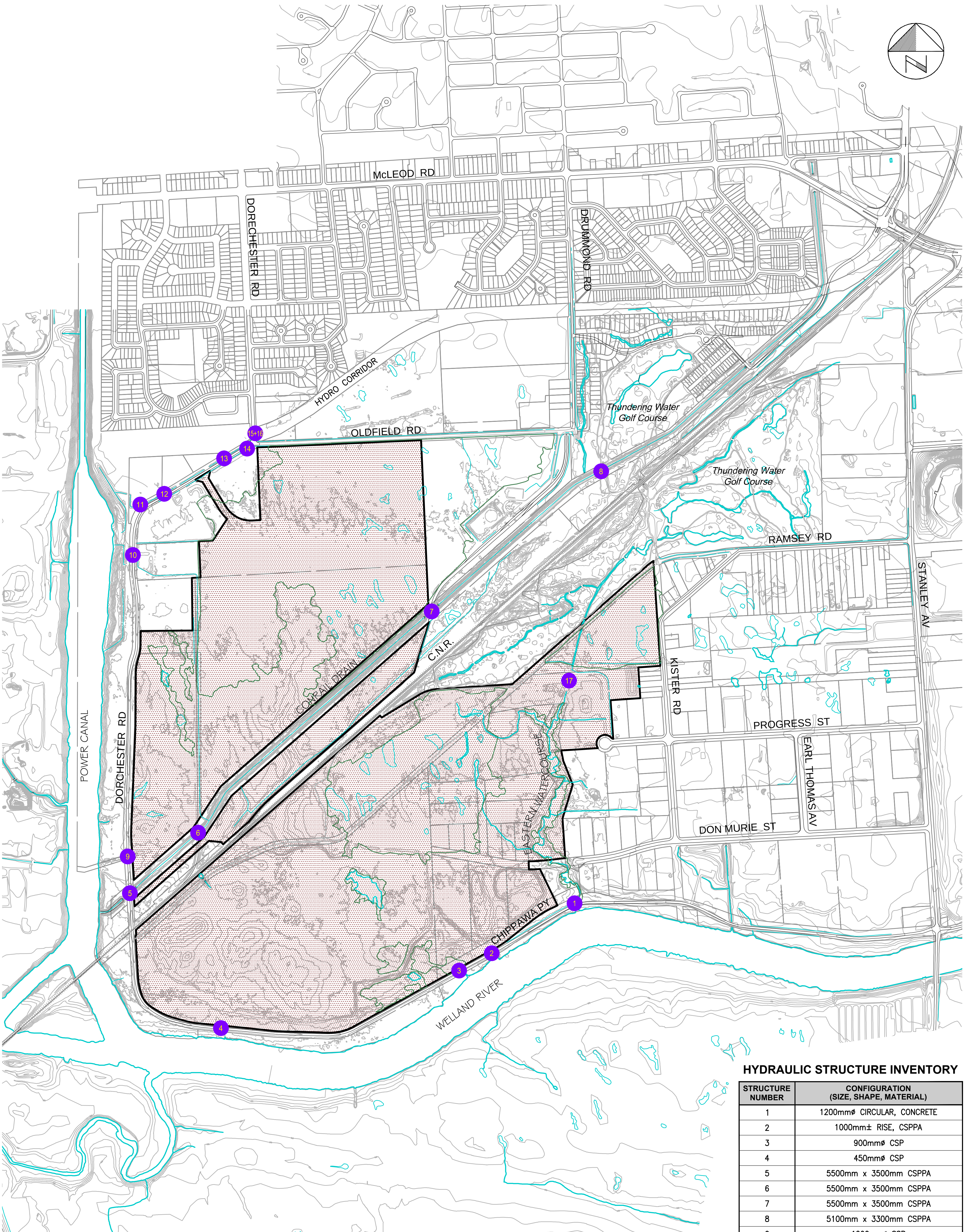
Associate

Per: Andre Poirer, P.Eng.
Senior Municipal Engineer

Per: Alan Winter, P. Eng.
Senior Associate



HYDRAULIC STRUCTURE INVENTORY

STRUCTURE NUMBER	CONFIGURATION (SIZE, SHAPE, MATERIAL)
1	1200mmø CIRCULAR, CONCRETE
2	1000mm± RISE, CSPPA
3	900mmø CSP
4	450mmø CSP
5	5500mm x 3500mm CSPPA
6	5500mm x 3500mm CSPPA
7	5500mm x 3500mm CSPPA
8	5100mm x 3300mm CSPPA
9	1200mmø SSP
10	850mmø CSP
11	900mm x 650mm ELLIPTICAL CSP
12	650mmø CSP
13	350mmø CSP
14	650mmø CSP
15	525mmø CSP
16	450mmø CSP
17	1200mmø CIRCULAR, CONCRETE

LEGEND

PROPERTY FABRIC
WATERCOURSE
WETLAND BOUNDARY
CONTOUR (1m)
LANDS OWNED BY GR(CAN) INVESTMENTS
6 HYDRAULIC STRUCTURE LOCATION AND REFERENCE ID#

SCALE VALID ONLY FOR 24"x36" VERSION

THUNDERING WATERS SECONDARY PLAN
CITY OF NIAGARA FALLS

HYDRAULIC STRUCTURE INVENTORY

amec foster wheeler

Scale 1:6000
0 75 150 300

Consultant File No. TP115026

Drawing No. 3.1

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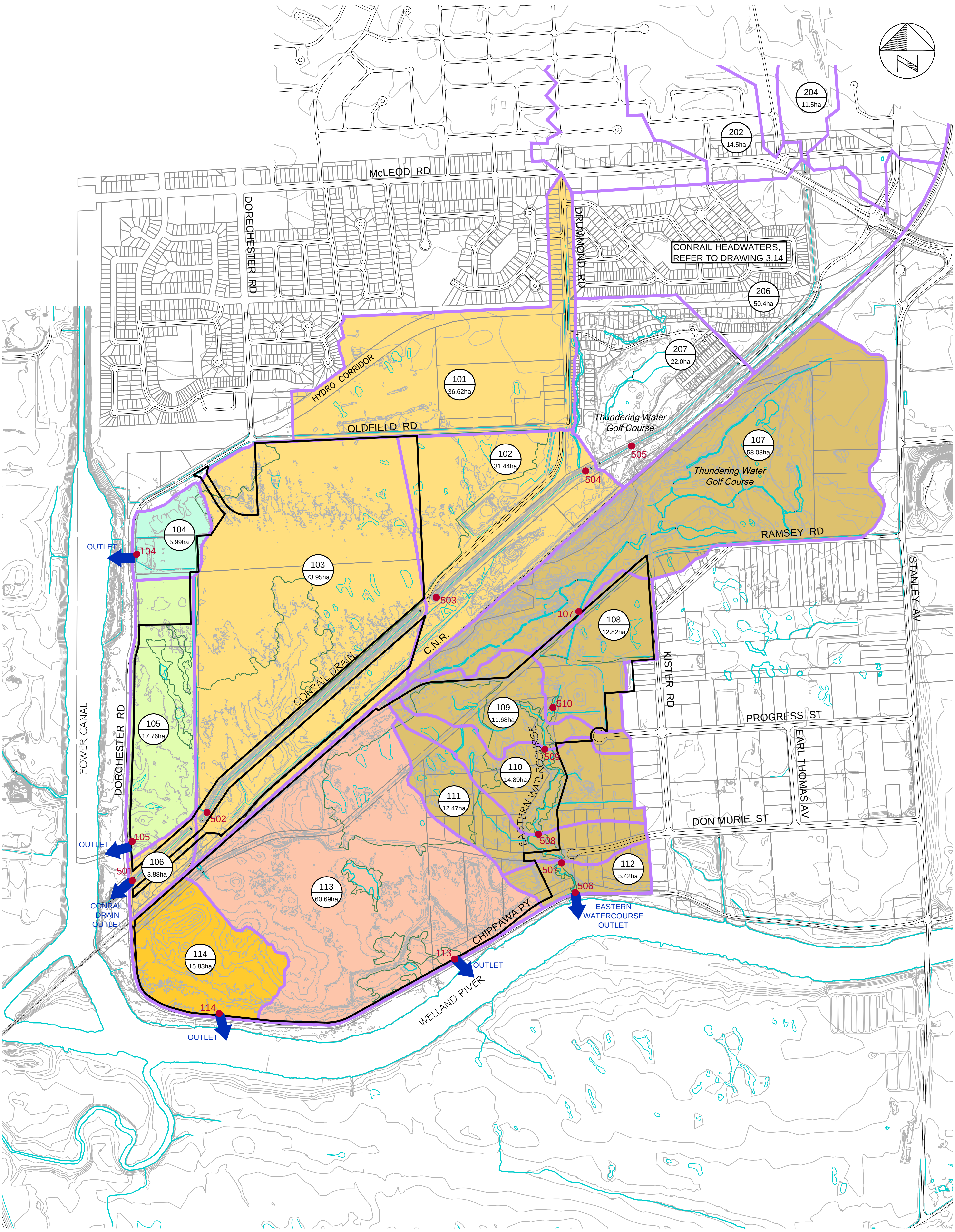

LEGEND

PROPERTY FABRIC
WATERCOURSE
WETLAND BOUNDARY
CONTOUR (1m)
LANDS OWNED BY GR(CAN) INVESTMENTS
SUBCATCHMENT BOUNDARY
100 / 25.0ha — SUBCATCHMENT ID# / SUBCATCHMENT AREA
● 501 — FLOW NODE AND REFERENCE ID#

SCALE VALID ONLY FOR 24"x36" VERSION

THUNDERING WATERS SECONDARY PLAN CITY OF NIAGARA FALLS	SUBCATCHMENT BOUNDARY PLAN (EXISTING LAND USE CONDITIONS)	amec foster wheeler	Scale 1:6000 (0 75 150 300) Consultant File No. TP115026 Drawing No. 3.2

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Last Saved: 2016-06-21 Last Saved By: richard.bartolo

LEGEND

- PROPERTY FABRIC
- WATERCOURSE
- WETLAND BOUNDARY
- CONTOUR (1m)
- LANDS OWNED BY GR(CAN) INVESTMENTS
- LINCOLN CLAY
- WELLAND SILT–CLAY
- HALDIMAND SILT–CLAY + LINCOLN CLAY
- NIAGARA SILT–CLAY–LOAM
- ONTARIO SILT–CLAY + ALLUVIUM SILT–CLAY–LOAM
- ONTARIO SILT–CLAY
- NIAGARA SILT–CLAY–LOAM + ALLUVIUM SILT–CLAY–LOAM
- ALLUVIUM SILT–CLAY–LOAM
- UNCLASSIFIED

SOILS INFORMATION SOURCE:
CANADIAN SOIL INFORMATION SERVICE (CANSIS), AGRICULTURE AND AGRI–FOOD CANADA, GOVERNMENT OF CANADA

SCALE VALID ONLY FOR 24"x36" VERSION

THUNDERING WATERS SECONDARY PLAN CITY OF NIAGARA FALLS	SOILS MAPPING	amec foster wheeler	Scale 1:6000 (0 75 150 300) Consultant File No. TP115026 Drawing No. 3.3

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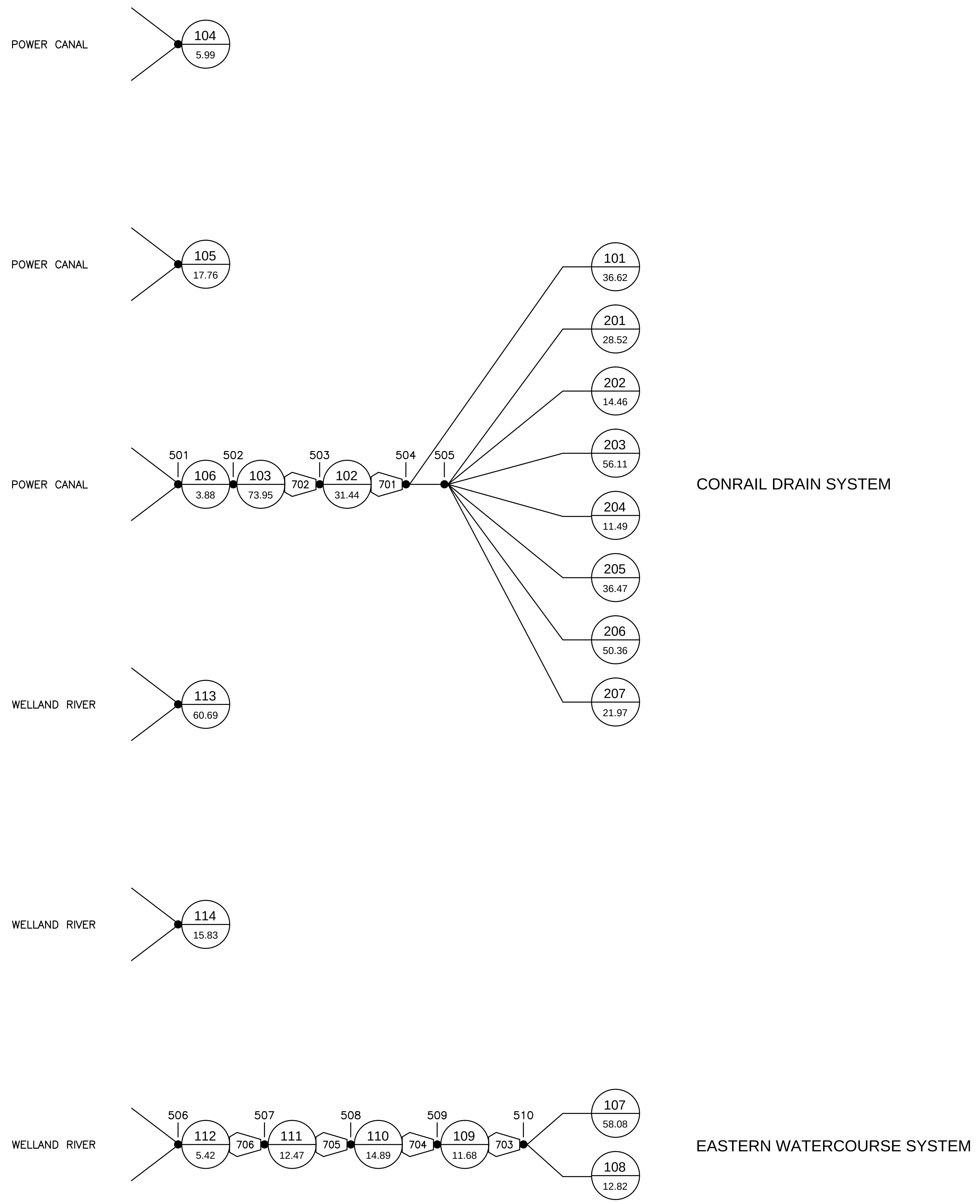

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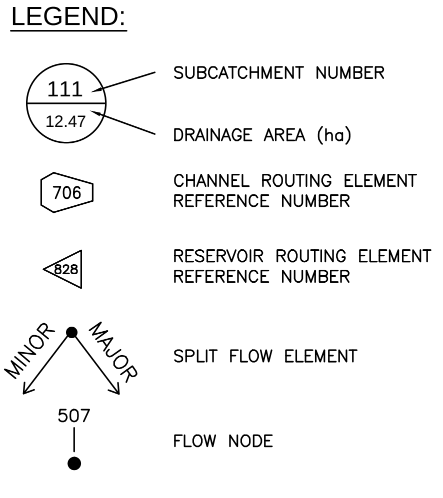
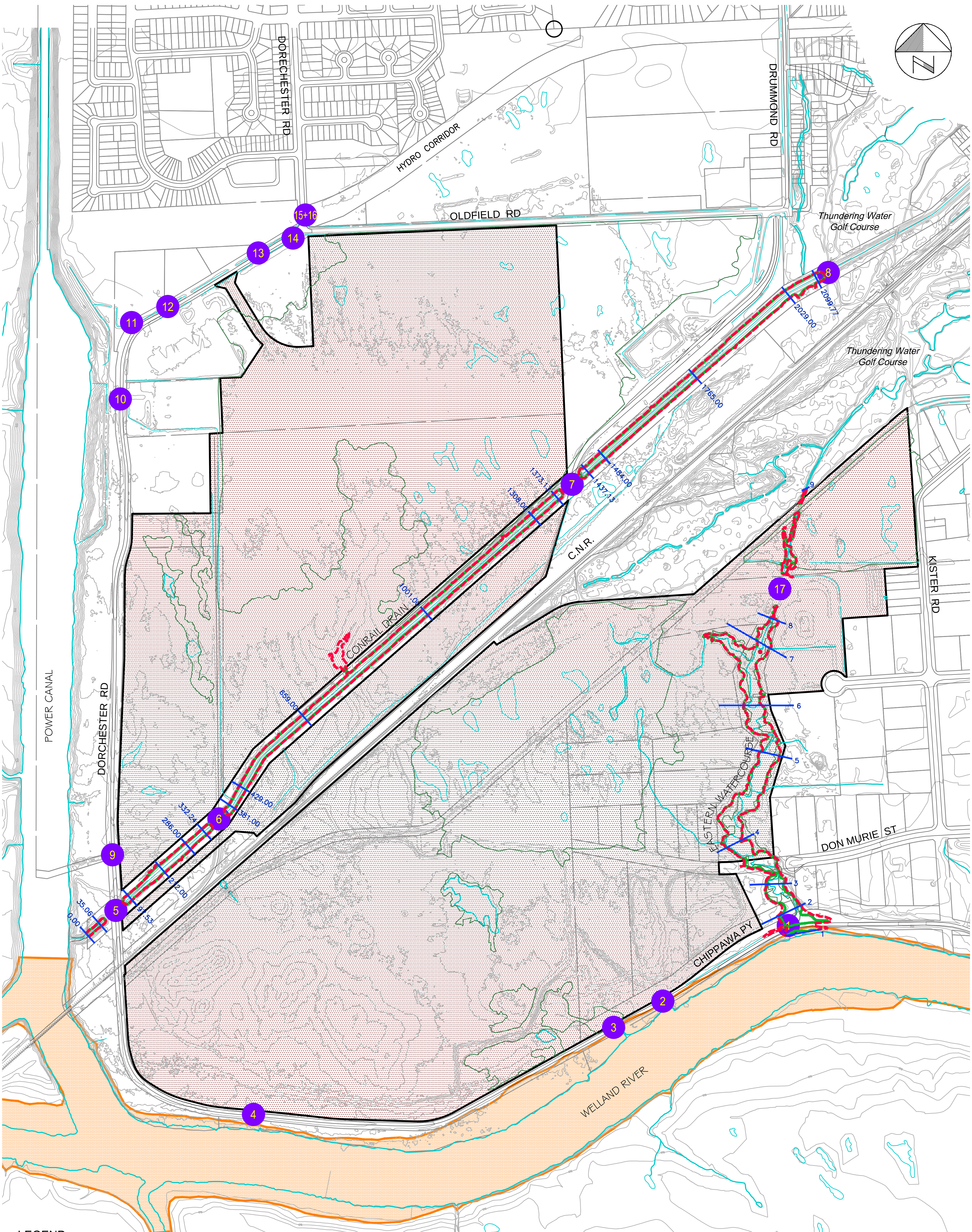


THUNDERING WATERS SECONDARY PLAN CITY OF NIAGARA FALLS	HYDROLOGIC MODEL SCHEMATIC (EXISTING LAND USE CONDITIONS)	amec foster wheeler	Scale: NOT TO SCALE Consultant File No.: TP115026 Drawing No.: 3.4



LEGEND

PROPERTY FABRIC

WATERCOURSE

WETLAND BOUNDARY

CONTOUR (1m)

LANDS OWNED BY GR(CAN) INVESTMENTS

6 HYDRAULIC STRUCTURE LOCATION AND REFERENCE ID#

8212.49 HEC–RAS CROSS–SECTION LOCATION

100 YEAR FLOOD LINE

100 YEAR FLOOD LINE (REGULATORY–NPCA)

WELLAND RIVER REGULATED FLOOD PLAIN (NPCA)

SCALE VALID ONLY FOR 24"x36" VERSION

THUNDERING WATERS SECONDARY PLAN CITY OF NIAGARA FALLS	FLOODLINE MAPPING LIMITS (EXISTING LAND USE CONDITIONS)	amec foster wheeler	Scale 1:4000 (0 50 100 200) Consultant File No. TP115026 Drawing No. 3.5

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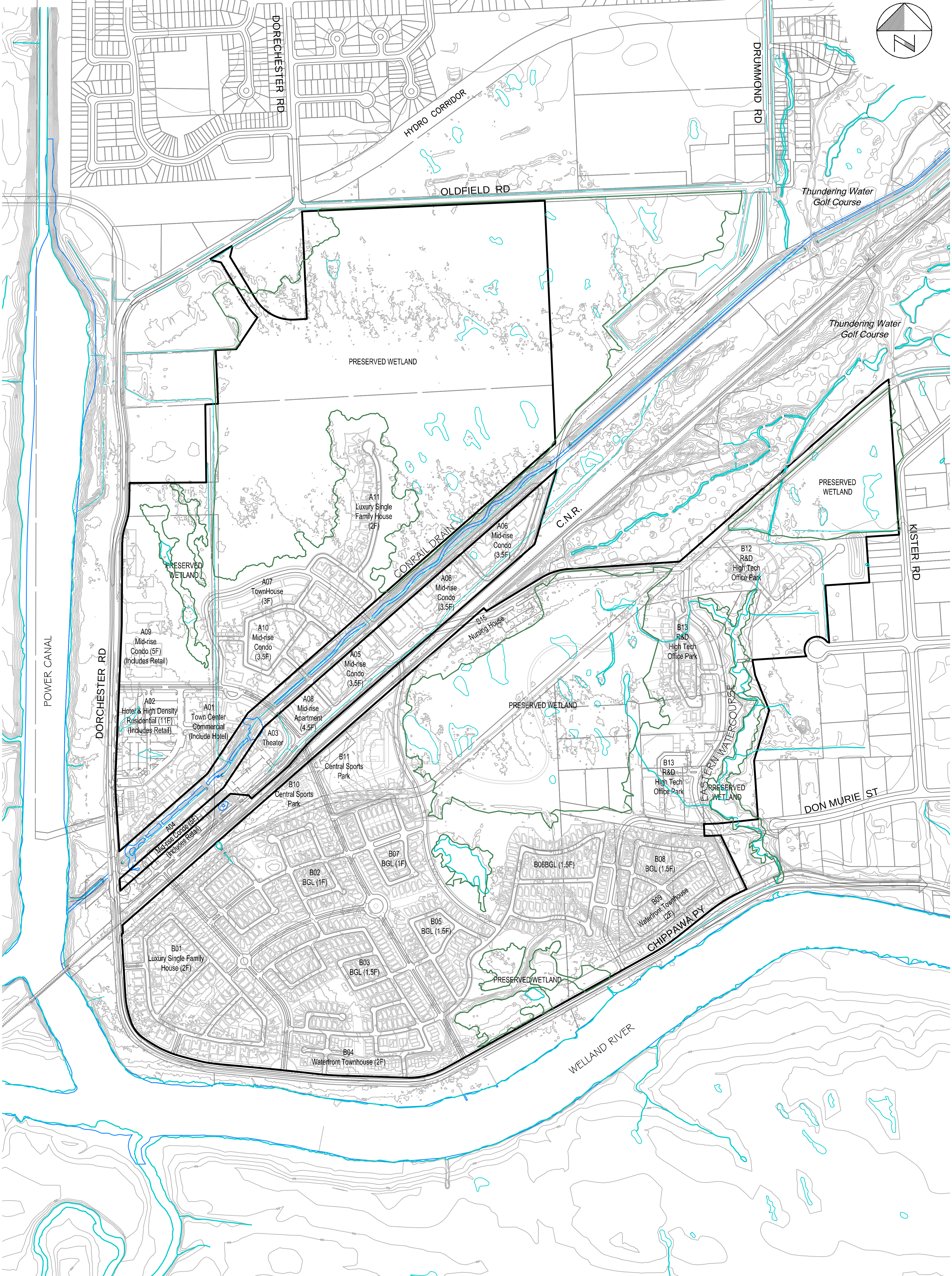
Last Saved: 2016-06-13



LEGEND

- PROPERTY FABRIC
- WATERCOURSE
- WETLAND BOUNDARY
- CONTOUR (1m)
- LANDS OWNED BY GR(CAN) INVESTMENTS

LAND USE INFORMATION SOURCE:
RTKL, MAY 19 2016

SCALE VALID ONLY FOR 24"x36" VERSION

THUNDERING WATERS SECONDARY PLAN

CITY OF NIAGARA FALLS

FUTURE LAND USE PLAN

amec foster wheeler

Scale 1:4000
0 50 100 200

Consultant File No.
TP115026

Drawing No.
3.6

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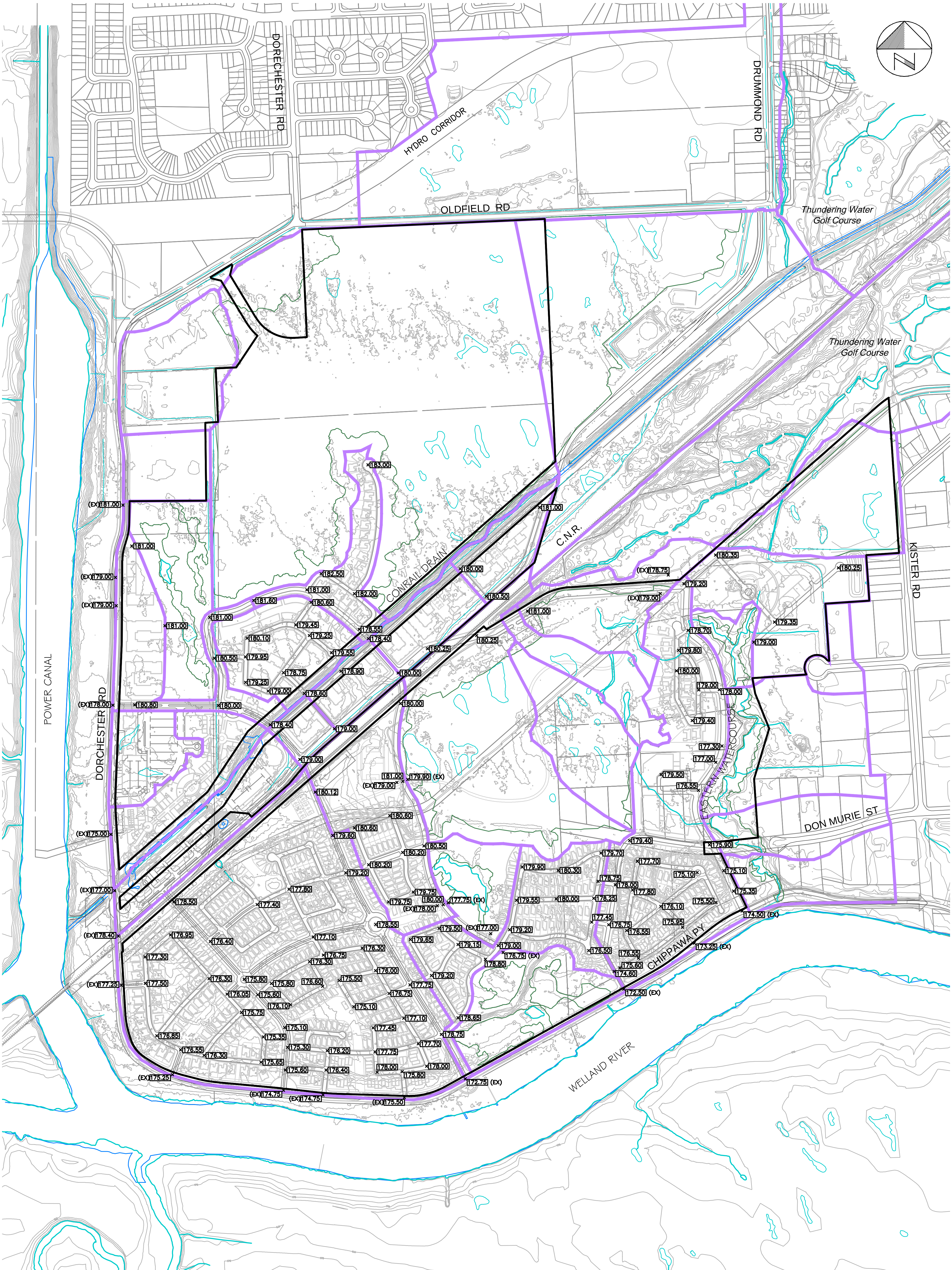

LEGEND

- PROPERTY FABRIC
- WATERCOURSE
- WETLAND BOUNDARY
- CONTOUR (1m)
- LANDS OWNED BY GR(CAN) INVESTMENTS
- SUBCATCHMENT BOUNDARY
- ×178.00 PROPOSED GRADE

THUNDERING WATERS SECONDARY PLAN

CITY OF NIAGARA FALLS

CONCEPTUAL GRADING PLAN

amec foster wheeler

SCALE VALID ONLY FOR 24"x36" VERSION

Scale 1:4000 (0 50 100 200)

Consultant File No. TP115026

Drawing No. 3.7

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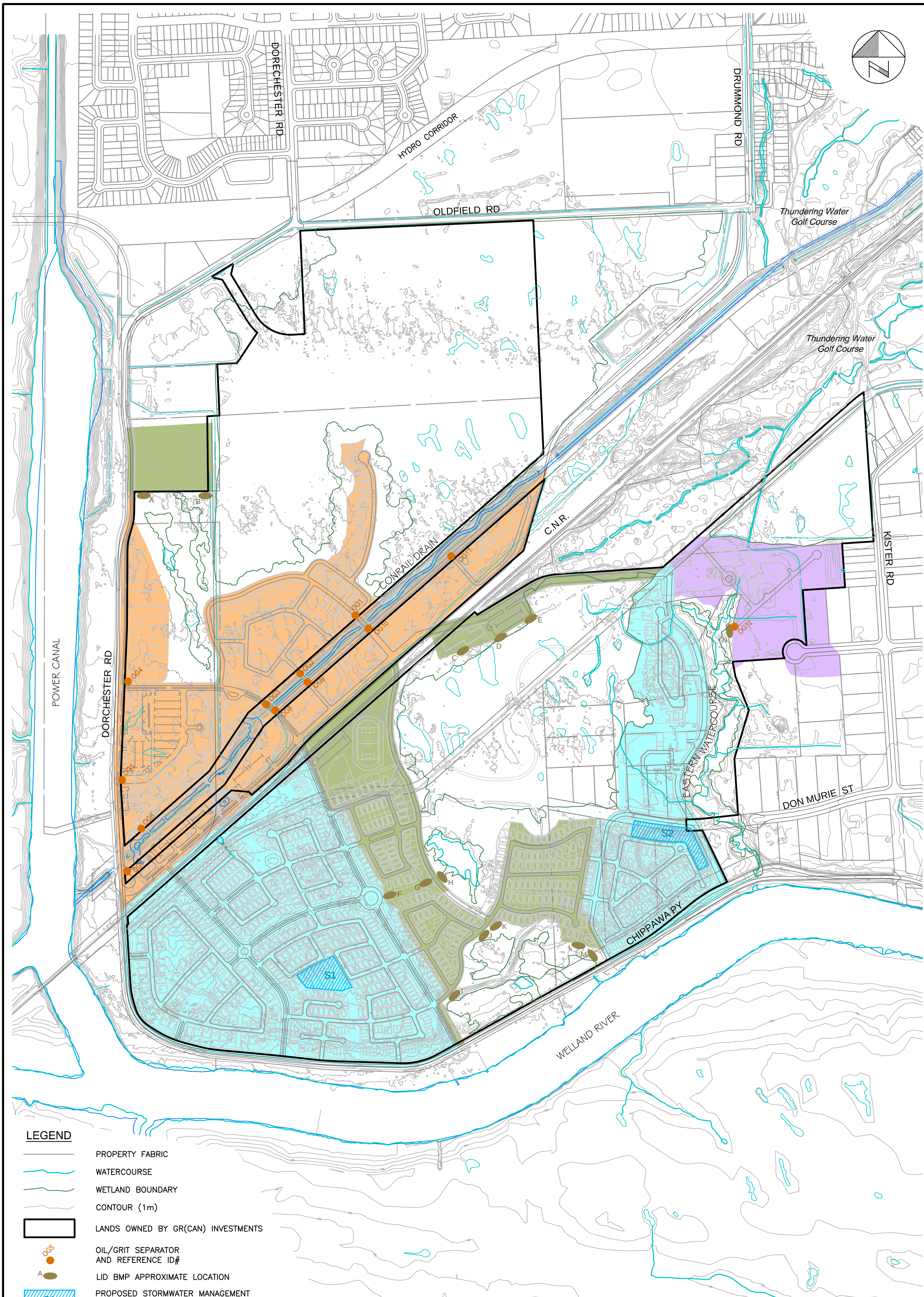

THUNDERING WATERS SECONDARY PLAN

CITY OF NIAGARA FALLS

STORMWATER QUALITY MANAGEMENT PLAN

amec foster wheeler

SCALE VALID ONLY FOR 24"x36" VERSION

Scale 1:4000

Consultant File No. TP115026

Drawing No. 3.8

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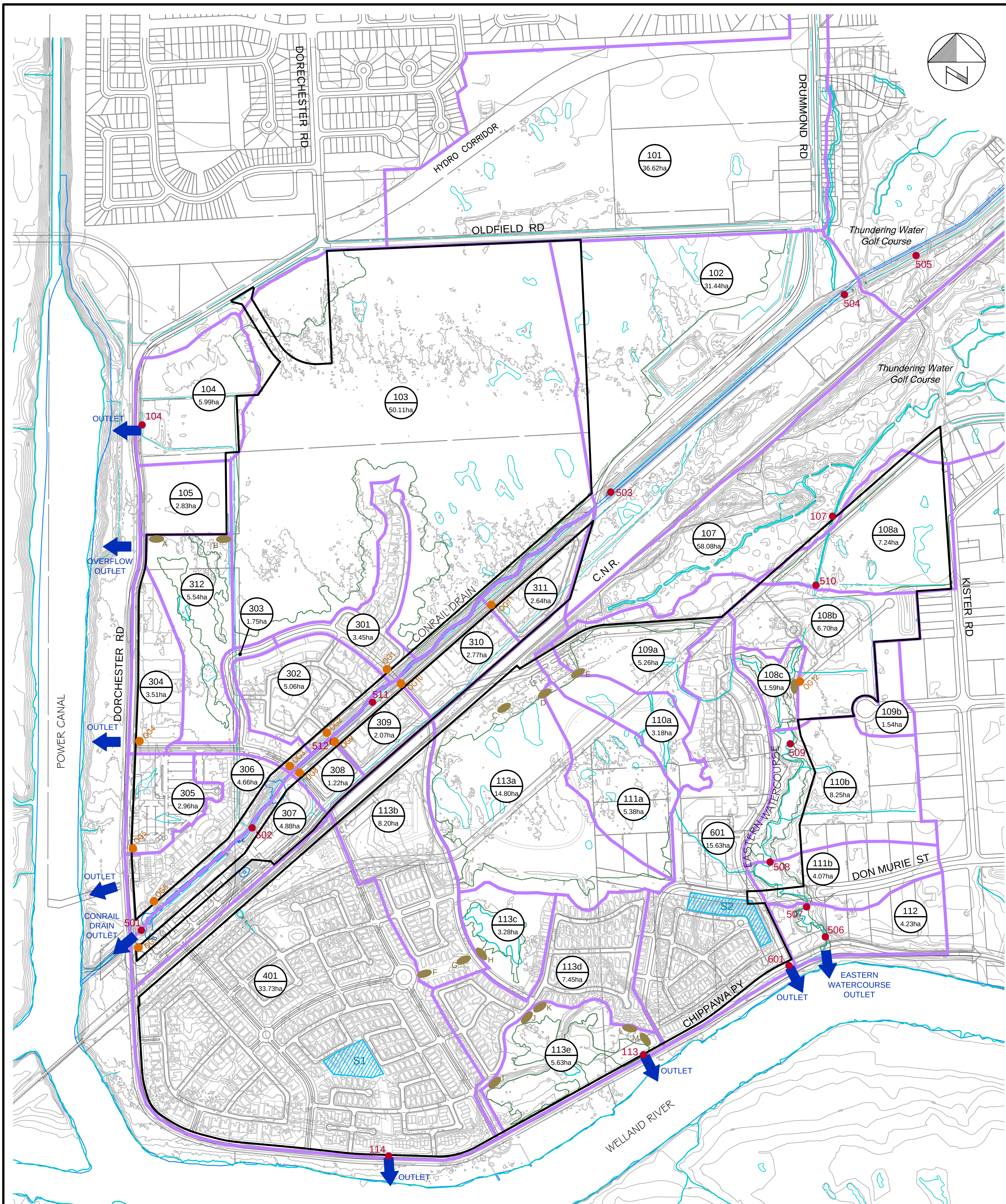

LEGEND

- PROPERTY FABRIC
- WATERCOURSE
- WETLAND BOUNDARY
- CONTOUR (1m)
- LANDS OWNED BY GR(CAN) INVESTMENTS
- SUBCATCHMENT BOUNDARY
- 100 / 25.0ha — SUBCATCHMENT ID# / SUBCATCHMENT AREA
- 501 — FLOW NODE AND REFERENCE ID#
- OG5 — OIL/GRIT SEPARATOR AND REFERENCE ID#
- A — LID BMP APPROXIMATE LOCATION
- S1 — PROPOSED STORMWATER MANAGEMENT FACILITY AND REFERENCE ID#

THUNDERING WATERS SECONDARY PLAN CITY OF NIAGARA FALLS	SUBCATCHMENT BOUNDARY PLAN (FUTURE LAND USE CONDITIONS)	amec foster wheeler	SCALE VALID ONLY FOR 24"x36" VERSION Scale 1:4000 Consultant File No. TP115026 Drawing No. 3.9

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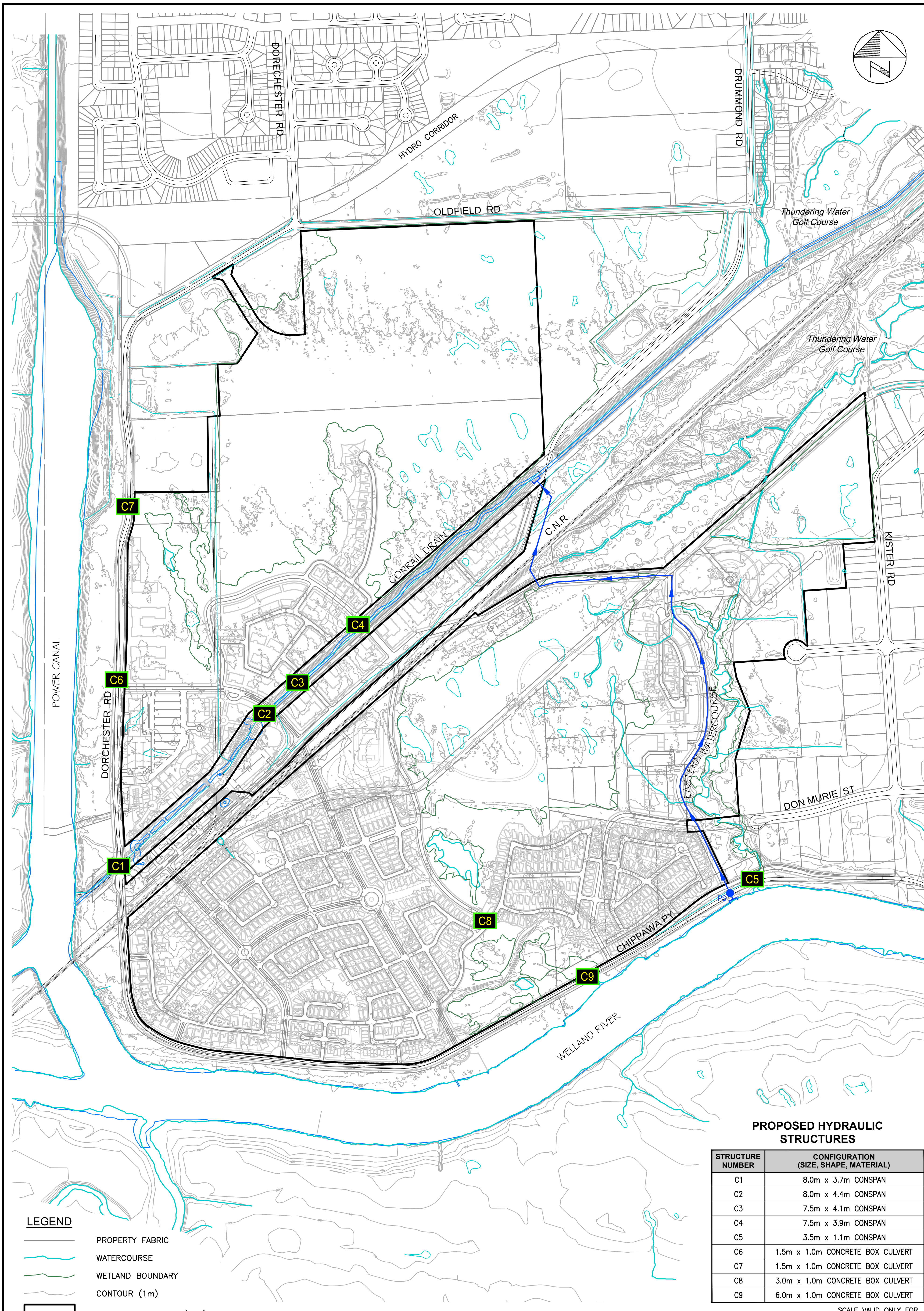


PROPOSED HYDRAULIC STRUCTURES

STRUCTURE NUMBER	CONFIGURATION (SIZE, SHAPE, MATERIAL)
C1	8.0m x 3.7m CONSPAN
C2	8.0m x 4.4m CONSPAN
C3	7.5m x 4.1m CONSPAN
C4	7.5m x 3.9m CONSPAN
C5	3.5m x 1.1m CONSPAN
C6	1.5m x 1.0m CONCRETE BOX CULVERT
C7	1.5m x 1.0m CONCRETE BOX CULVERT
C8	3.0m x 1.0m CONCRETE BOX CULVERT
C9	6.0m x 1.0m CONCRETE BOX CULVERT

SCALE VALID ONLY FOR 24"x36" VERSION

THUNDERING WATERS SECONDARY PLAN

CITY OF NIAGARA FALLS

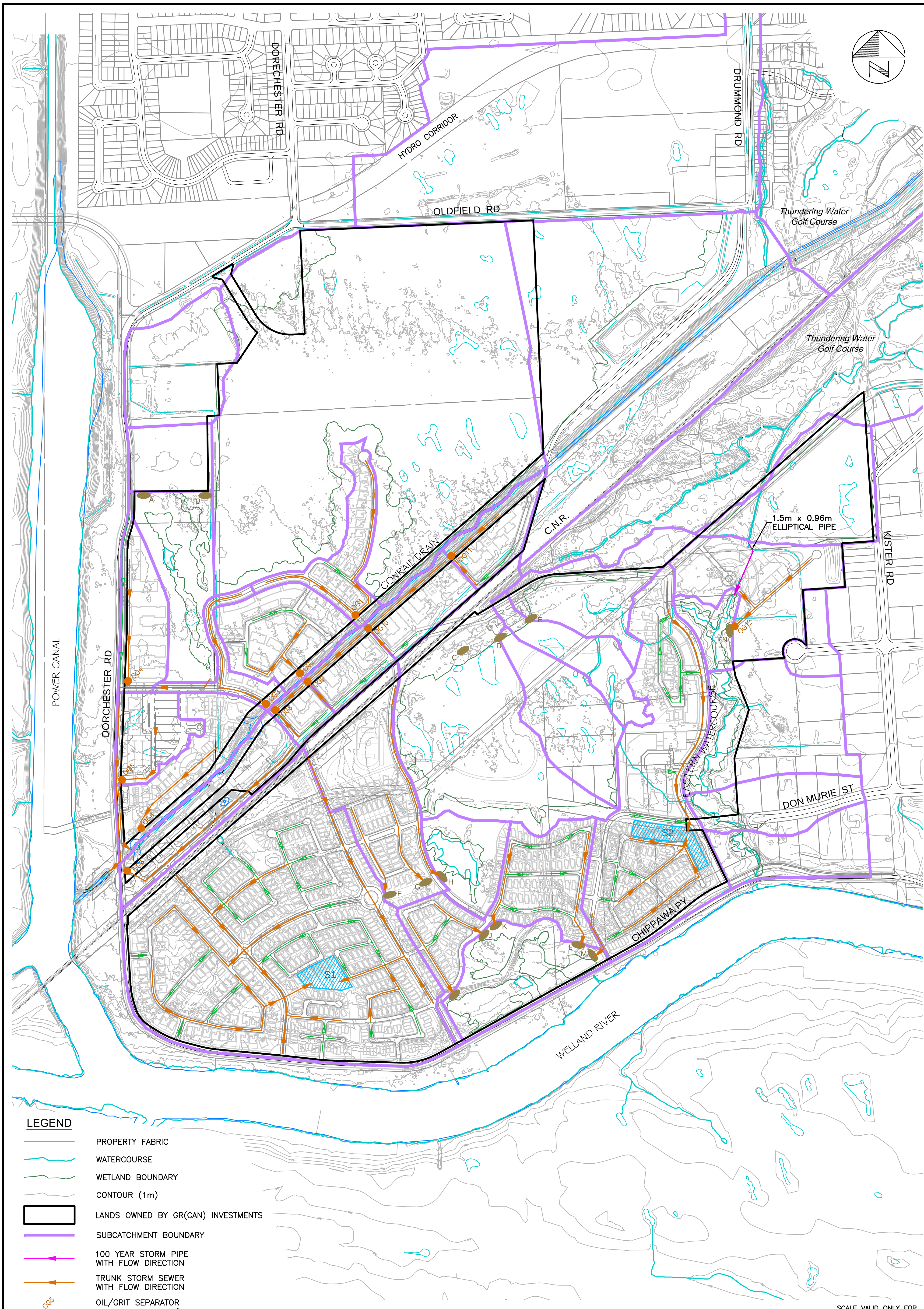
PROPOSED HYDRAULIC STRUCTURE AND CLEANWATER PUMPING SYSTEM LOCATION PLAN

amec foster wheeler

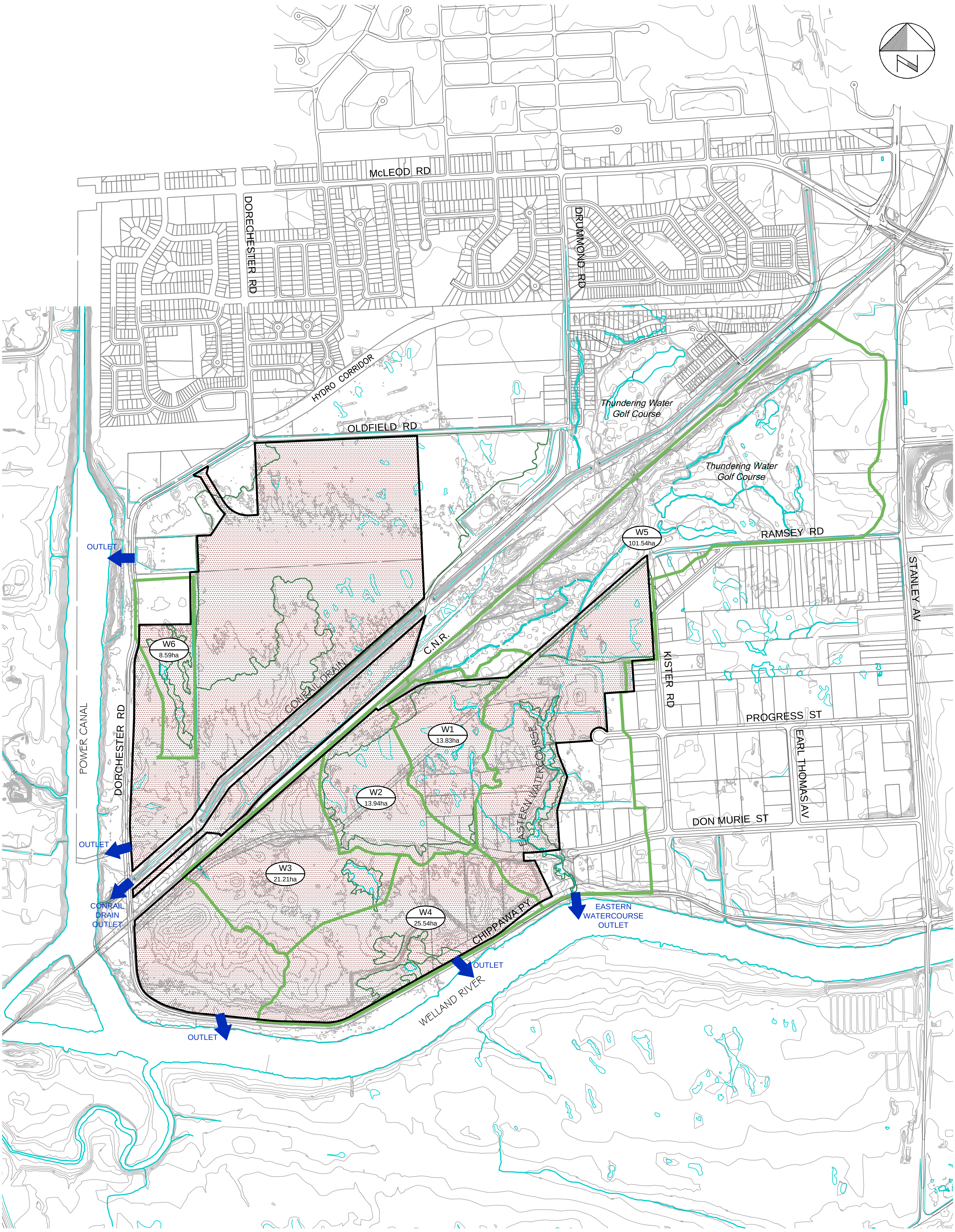
Scale 1:4000 (0 50 100 200)

Consultant File No. TP115026

Drawing No. 3.10



THUNDERING WATERS SECONDARY PLAN CITY OF NIAGARA FALLS	FUNCTIONAL STORM SEWER LAYOUT (MINOR SYSTEM)	amec foster wheeler	Scale 1:4000 Consultant File No. TP115026 Drawing No. 3.11



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Plotted By: richard.bartolo

Plotted: 2016-06-21

Last Saved By: richard.bartolo

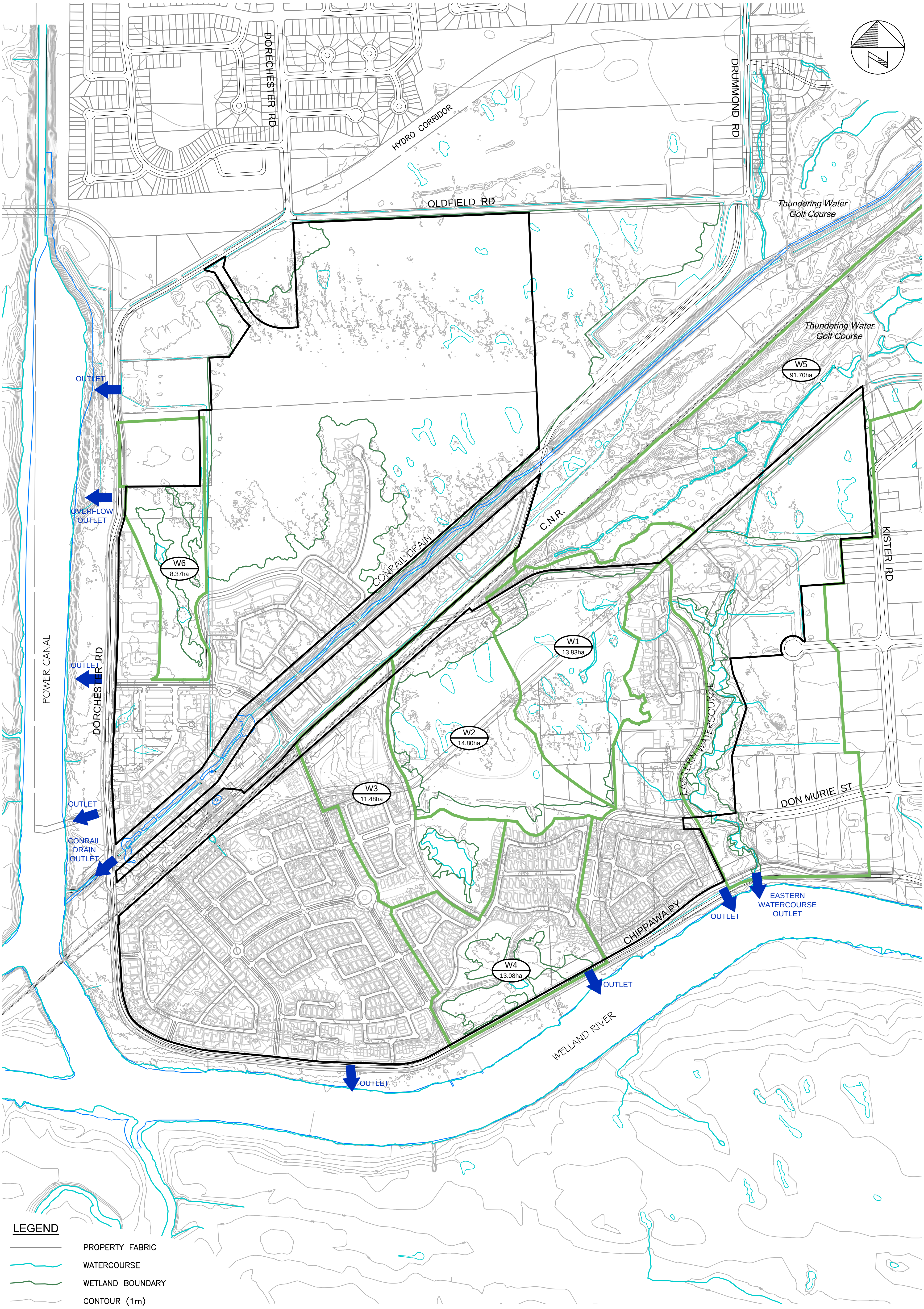
Last Saved: 2016-06-21

LEGEND

- PROPERTY FABRIC
- WATERCOURSE
- WETLAND BOUNDARY
- CONTOUR (1m)
- LANDS OWNED BY GR(CAN) INVESTMENTS
- DRAINAGE BOUNDARY
- W3 — DRAINAGE TO WETLAND ID#
- 21.21ha — DRAINAGE AREA

SCALE VALID ONLY FOR 24"x36" VERSION

THUNDERING WATERS SECONDARY PLAN CITY OF NIAGARA FALLS	DRAINAGE AREAS TO WETLANDS (EXISTING LAND USE CONDITIONS)	amec foster wheeler	Scale 1:6000 (0 75 150 300) Consultant File No. TP115026 Drawing No. 3.12



LEGEND

- PROPERTY FABRIC
- WATERCOURSE
- WETLAND BOUNDARY
- CONTOUR (1m)
- LANDS OWNED BY GR(CAN) INVESTMENTS
- DRAINAGE BOUNDARY
- W3 / 21.21ha — DRAINAGE TO WETLAND ID# / DRAINAGE AREA

THUNDERING WATERS SECONDARY PLAN CITY OF NIAGARA FALLS	DRAINAGE AREAS TO WETLANDS (FUTURE LAND USE CONDITIONS)	amec foster wheeler	SCALE VALID ONLY FOR 24"x36" VERSION Scale 1:4000 (0 50 100 200) Consultant File No. TP115026 Drawing No. 3.13

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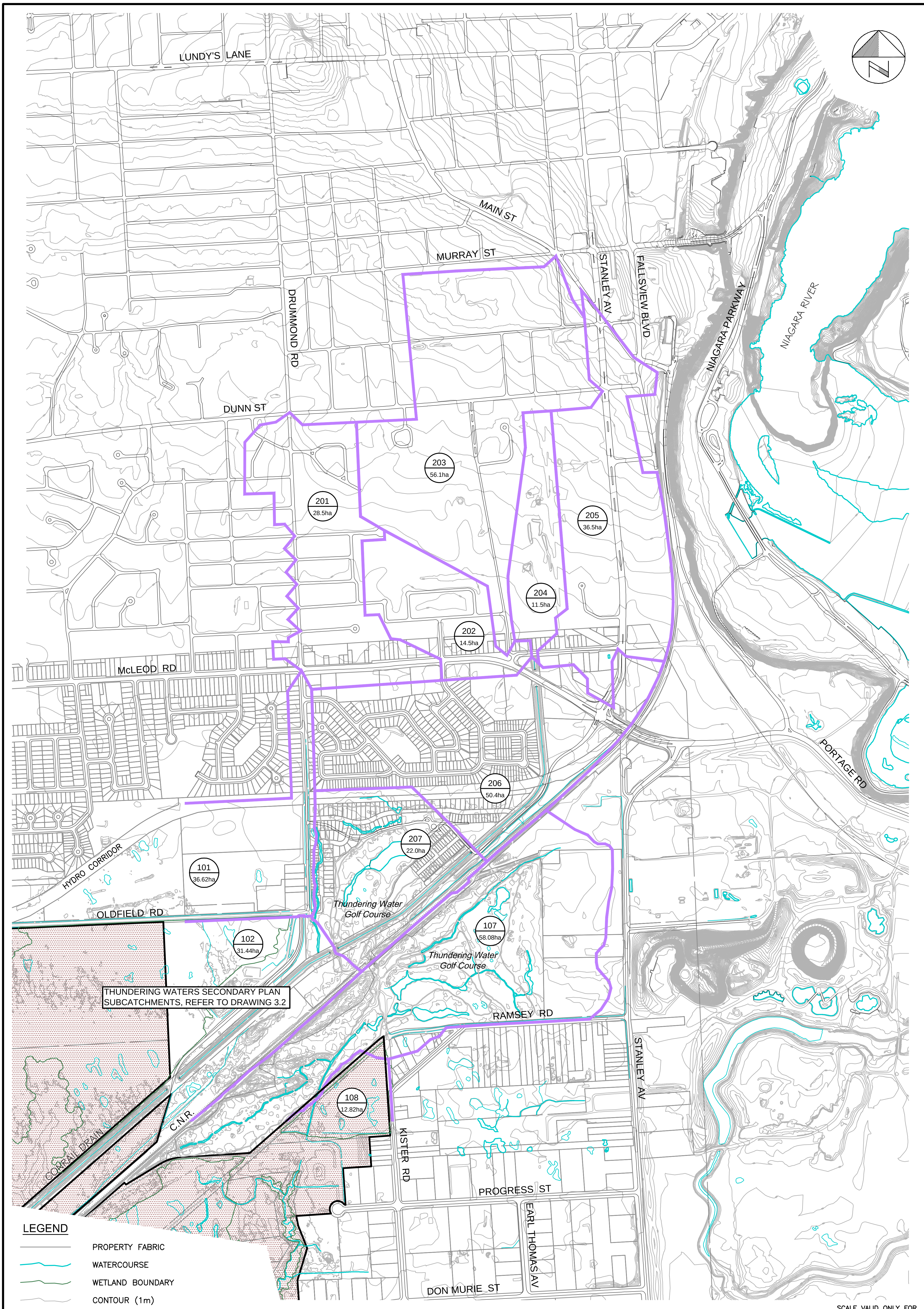

SCALE VALID ONLY FOR 24"x36" VERSION

THUNDERING WATERS SECONDARY PLAN

CITY OF NIAGARA FALLS

SUBCATCHMENT BOUNDARY PLAN

(CONRAIL DRAIN HEADWATERS)

amec foster wheeler

Scale 1:6000 (0 75 150 300)

Consultant File No. TP115026

Drawing No. 3.14

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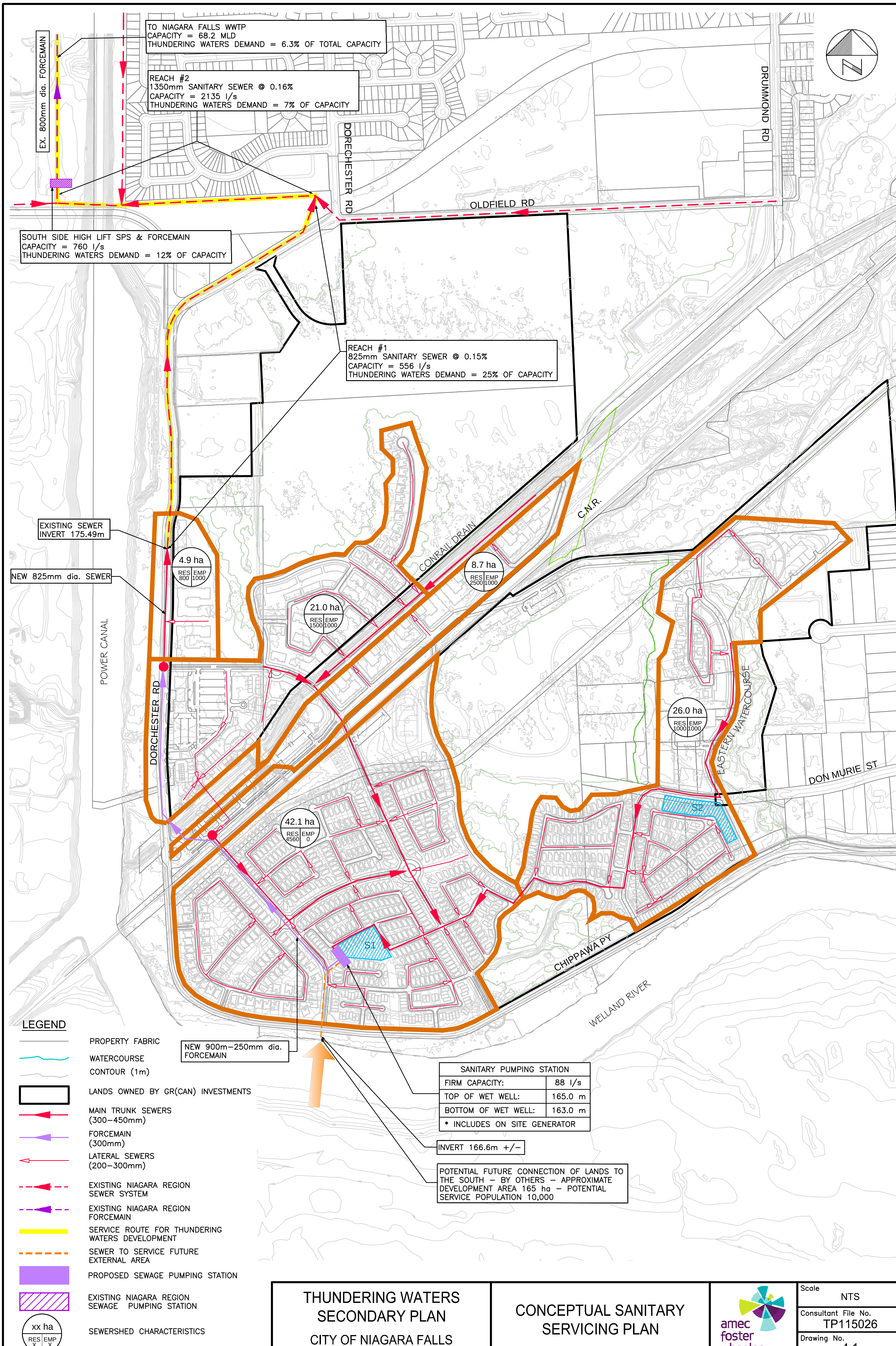

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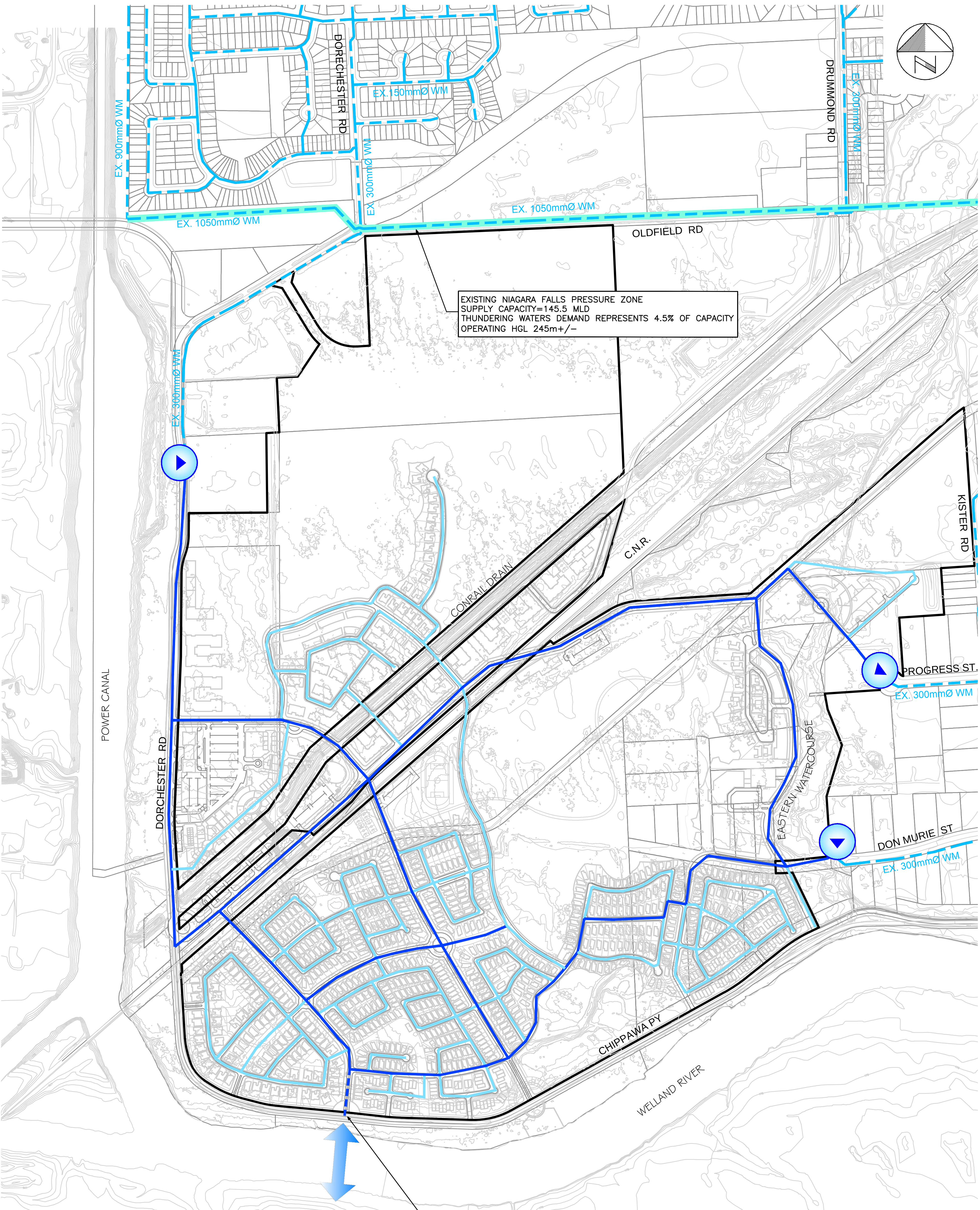


LEGEND

- LANDS OWNED BY GR(CAN) INVESTMENTS
- EXISTING WATERMAIN
- PROPOSED WATERMAIN (300mm)
- PROPOSED WATERMAIN (150–200mm)
- WATERMAIN TO SERVICE FUTURE EXTERNAL AREA
- EXISTING 1050mmØ WATERMAIN
- PROPOSED CONNECTION POINTS TO NIAGARA REGION DISTRIBUTION SYSTEM.

THUNDERING WATERS SECONDARY PLAN

CITY OF NIAGARA FALLS

CONCEPTUAL WATER SERVICING PLAN

amec foster wheeler

Scale: NTS

Consultant File No.: TP115026

Drawing No.: 5.1

APPENDIX A

HYDROLOGY AND HYDRAULICS

Thundering Waters

Photo 1: Culvert inlet under the influence of backwater from the Welland River.

Photo 2: Creek banks upstream of culvert.

Photo 3: Main channel of creek - looking upstream.

Photo 4: West overbank of creek - looking upstream. Dense vegetation present.

Photo 5: East overbank of creek - looking upstream. Dense vegetation present.

Photo 6: Upstream length of pipe, separated from remainder of culvert.

Photo 7: Culvert outlet under the influence of backwater from the Welland River.

Photo 8: Culvert outlet in state of disrepair.

Photo 9: Culvert inlet under the influence of backwater from the Welland River. Culvert rusted.

Photo 10: Culvert outlet under the influence of backwater from the Welland River. Culvert rusted.

Photo 11: Dense vegetation present along Dorchester Road and Chippawa Parkway.

Photo 12: Culvert outlet in good condition.

Photo 13: Culvert inlet in good condition.

Photo 14: Conrail Drain inlet with safety grate and debris blockage.

Photo 15: Conrail Drain Channel - looking upstream. Vegetation growth within channel.

Photo 16: Conrail Drain outlet inaccessible due to chain link fence.


Photo 17: Culvert outlet partially blocked by large rocks.


Photo 18: Culvert outlet heavily corroded with holes in the pipe wall.


Photo 19: Culvert inlet in good condition.


Photo 20: Culvert outlet in stand of thick brush.

Thundering Waters

Photo 21: South ditch - with CSP culvert in good condition.

Photo 22: South ditch - shallow and regularly maintained.

Photo 23: North ditch - with CSP culvert in good condition.

Photo 24: North ditch - deep with vegetation growth.

Photo 25: Driveway culvert inlet.

Photo 26: Driveway culvert outlet.

Photo 27: Drainage outlet to power canal.

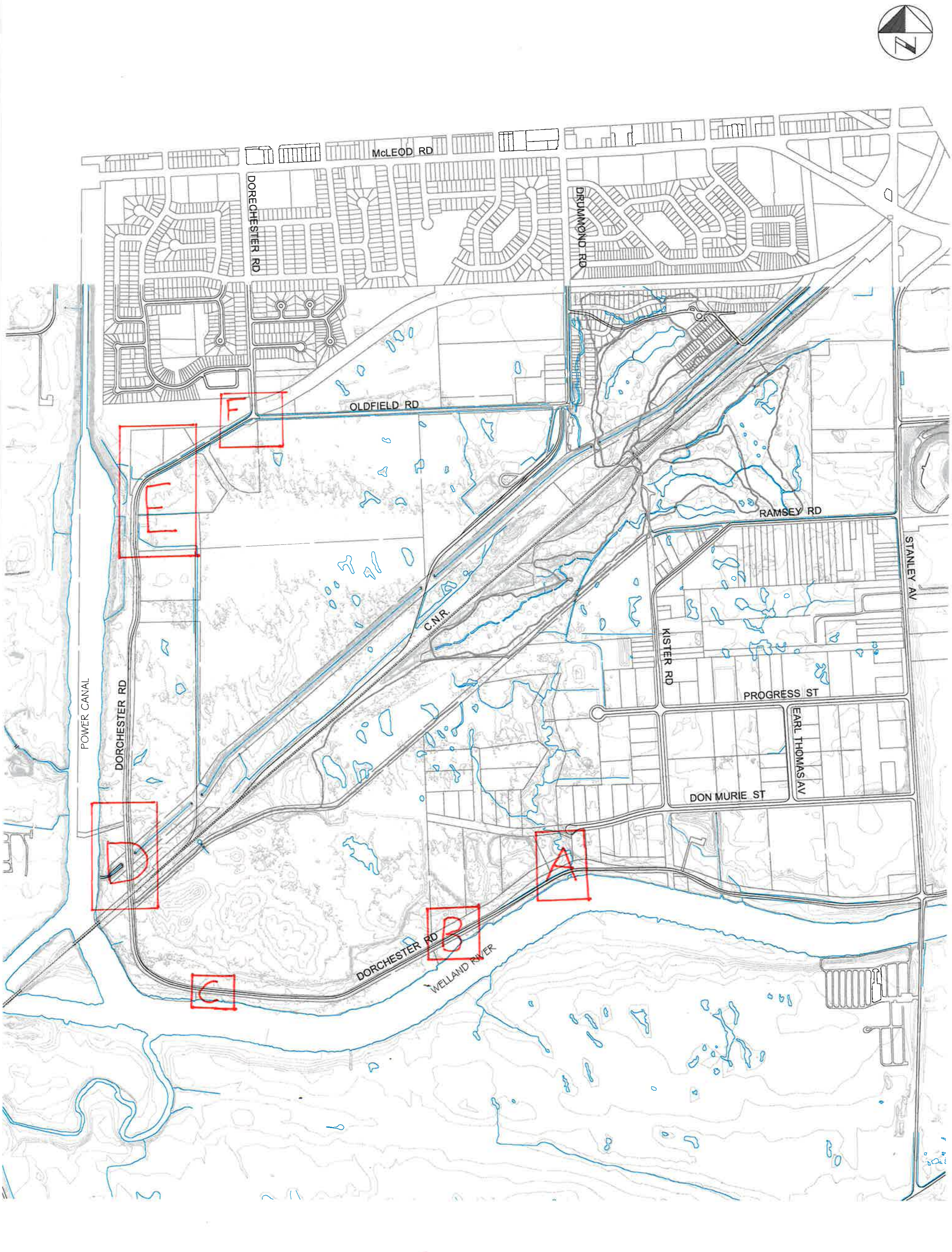
Photo 28: Culvert outlet to north ditch with thick vegetation.

Photo 29: Gabion baskets supporting road surface.

Photo 30: Oldfield Road north ditch.

Photo 31: Twin culvert inlets.

Photo 32: Oldfield Road south ditch.



LEGEND

PROPERTY FABRIC
WATERCOURSE
CONTOUR (1m)
Z Sheet Identifier

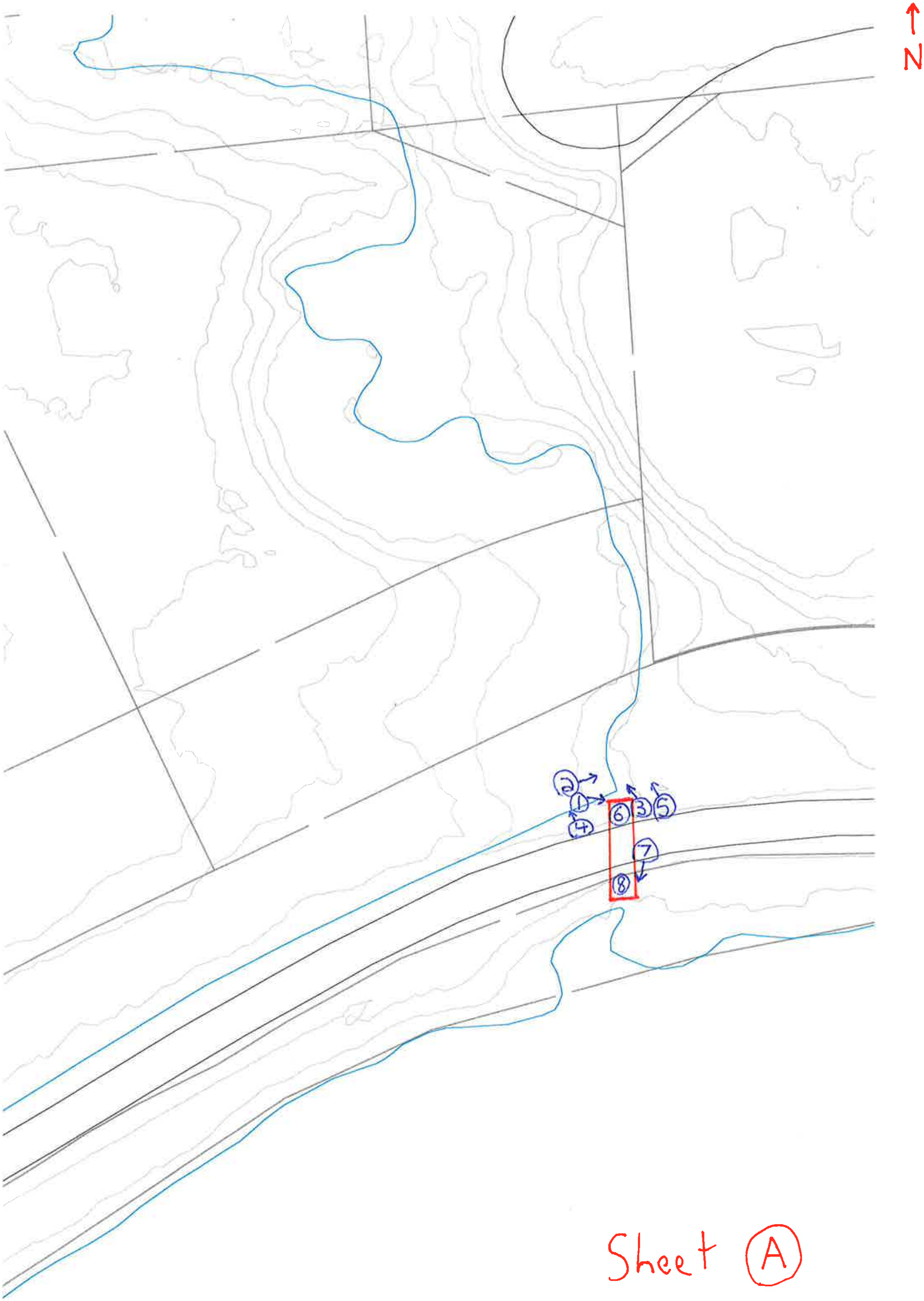
THUNDERING WATERS SECONDARY PLAN
CITY OF NIAGARA FALLS

PHOTOGRAPHIC INVENTORY

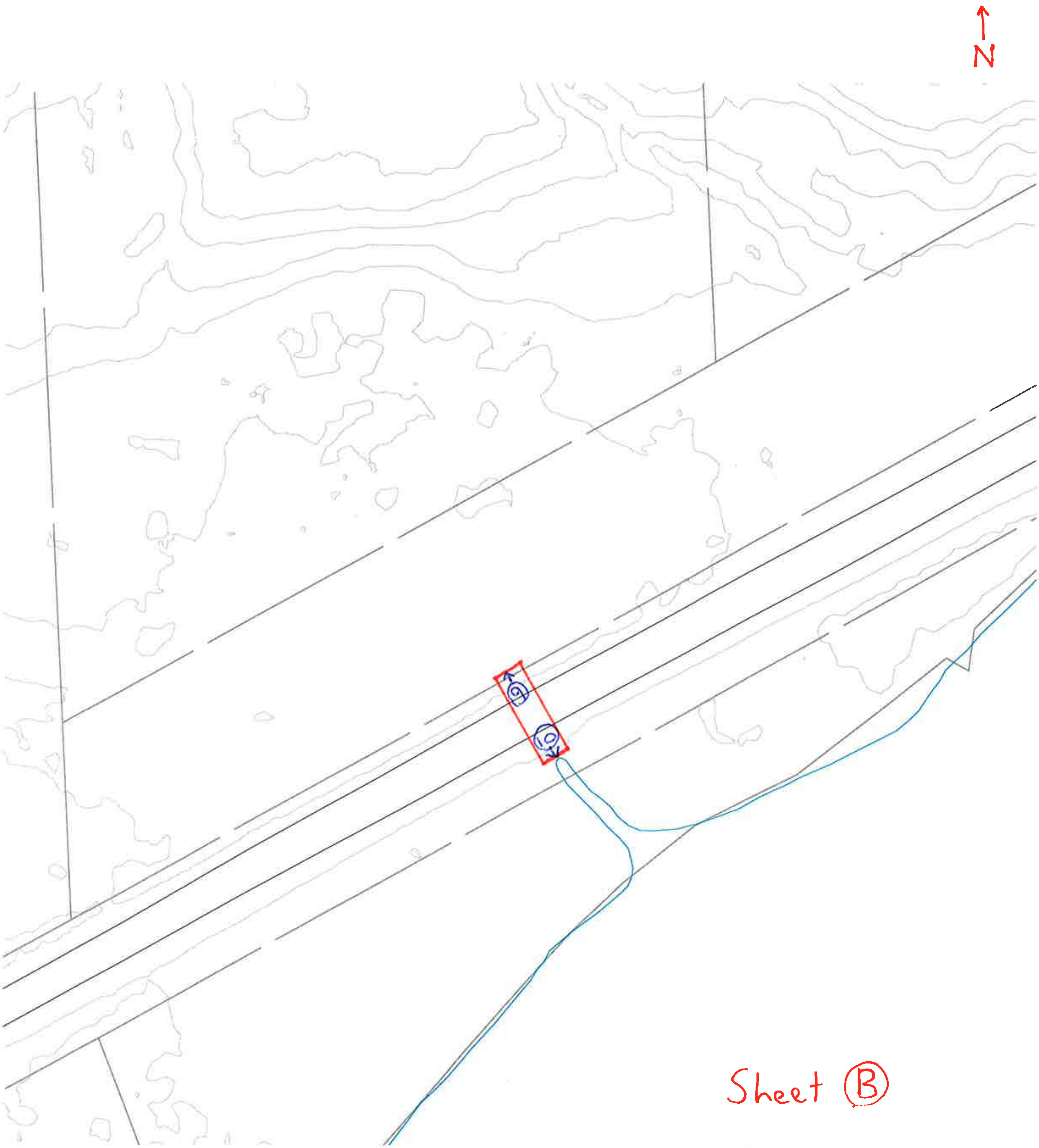
amec foster wheeler

SCALE VALID ONLY FOR 24"x36" VERSION
Scale 1:6000
0 75 150 300
Consultant File No. TP115026
Drawing No.

Last Saved: 2015-10-16 Last Saved By: richard.bartolo Plotted: 2015-10-16 Plotted By: richard.bartolo Path: P:\Work\TP115026\water\dwg\2015-10(Report)\PhotoInventory.dwg



Sheet A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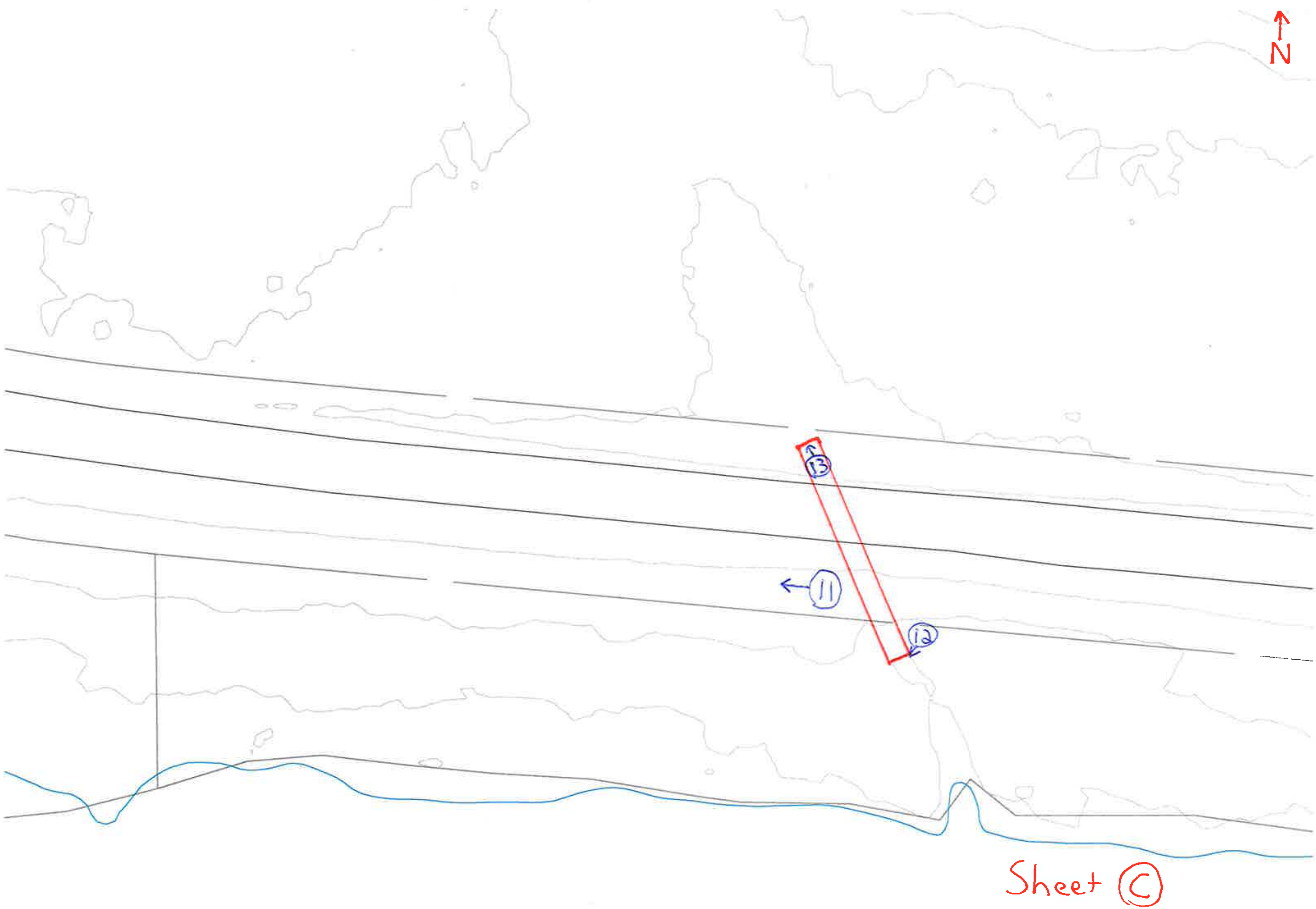
Sheet B



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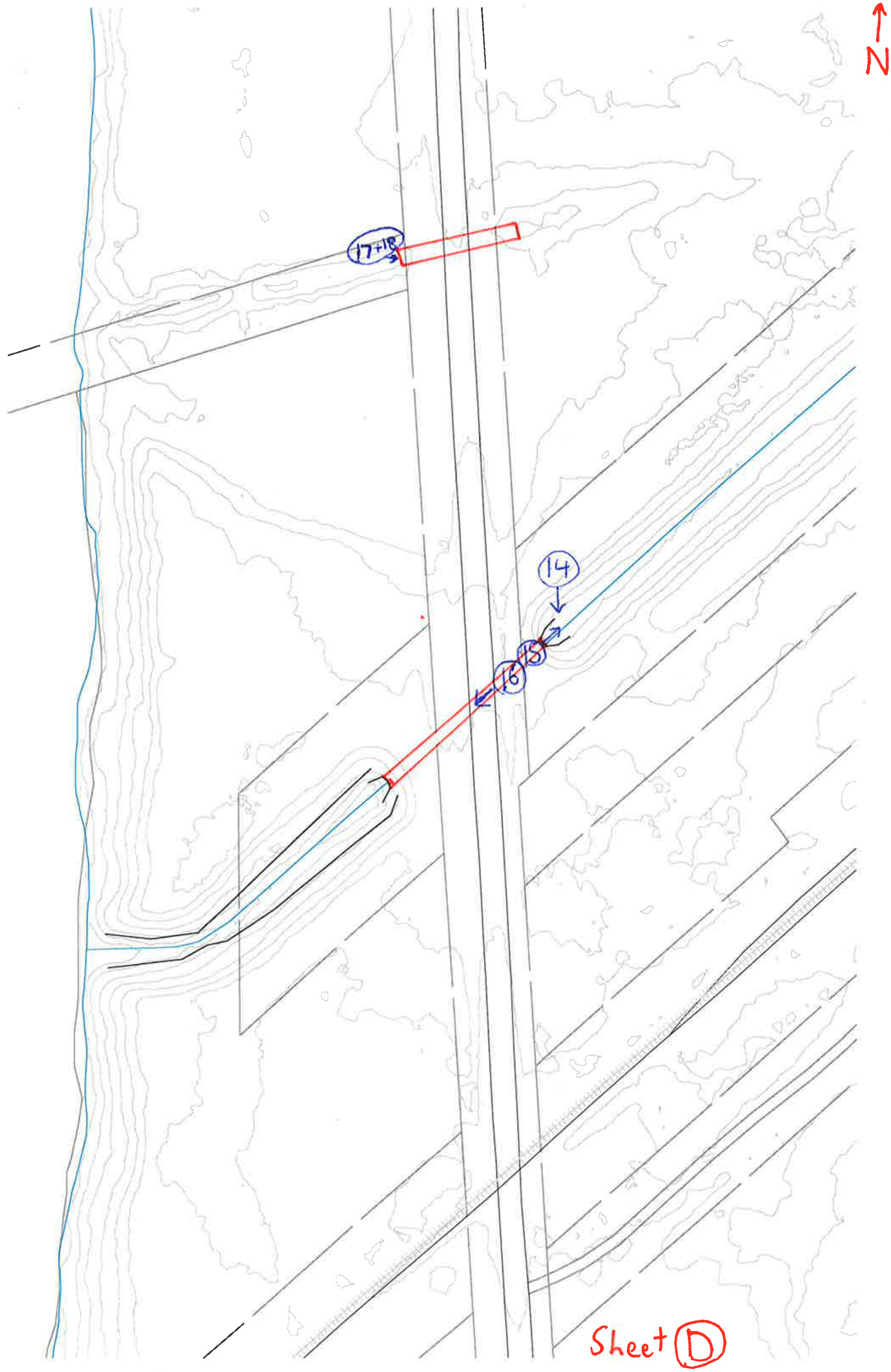
11
12
Sheet C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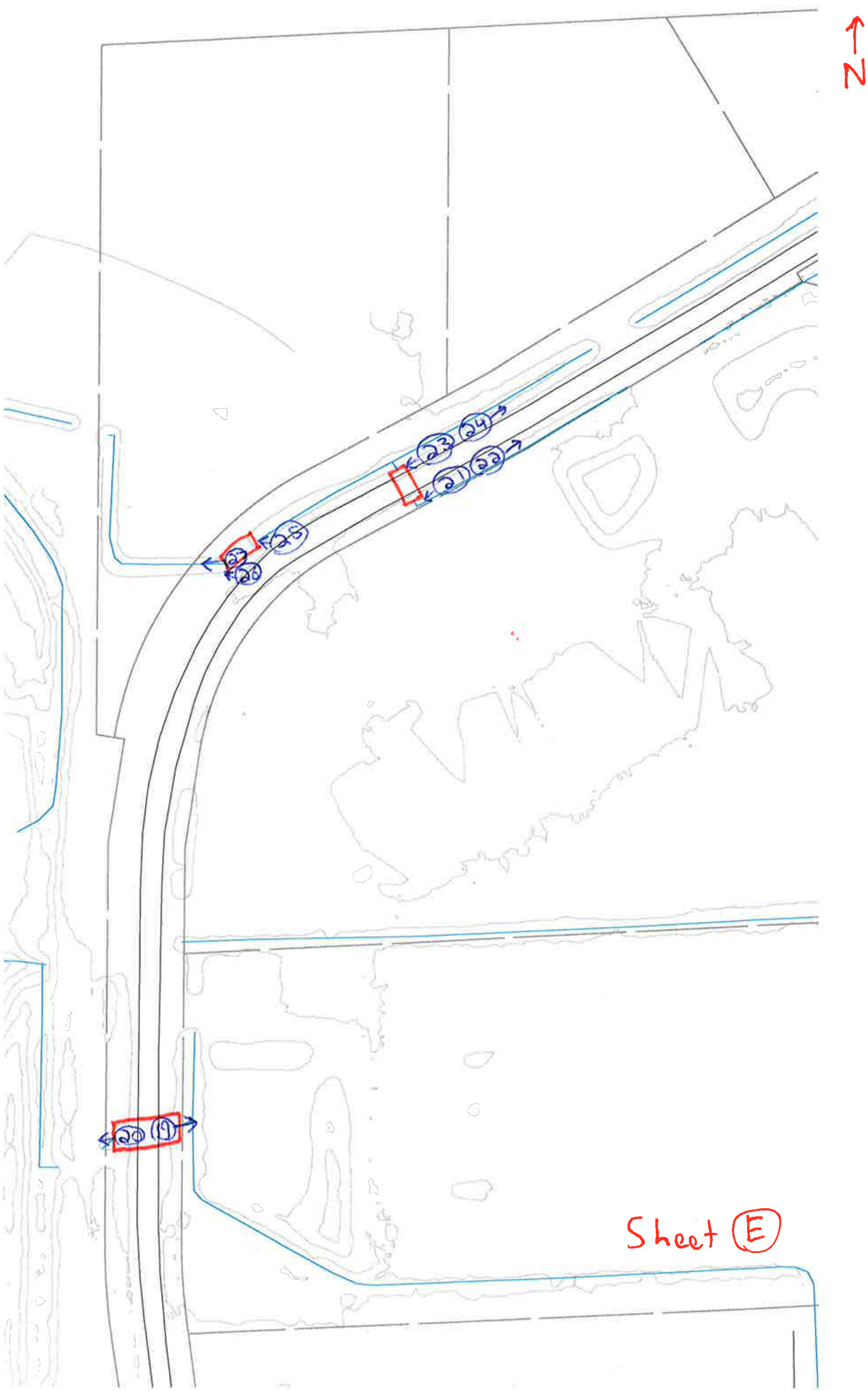
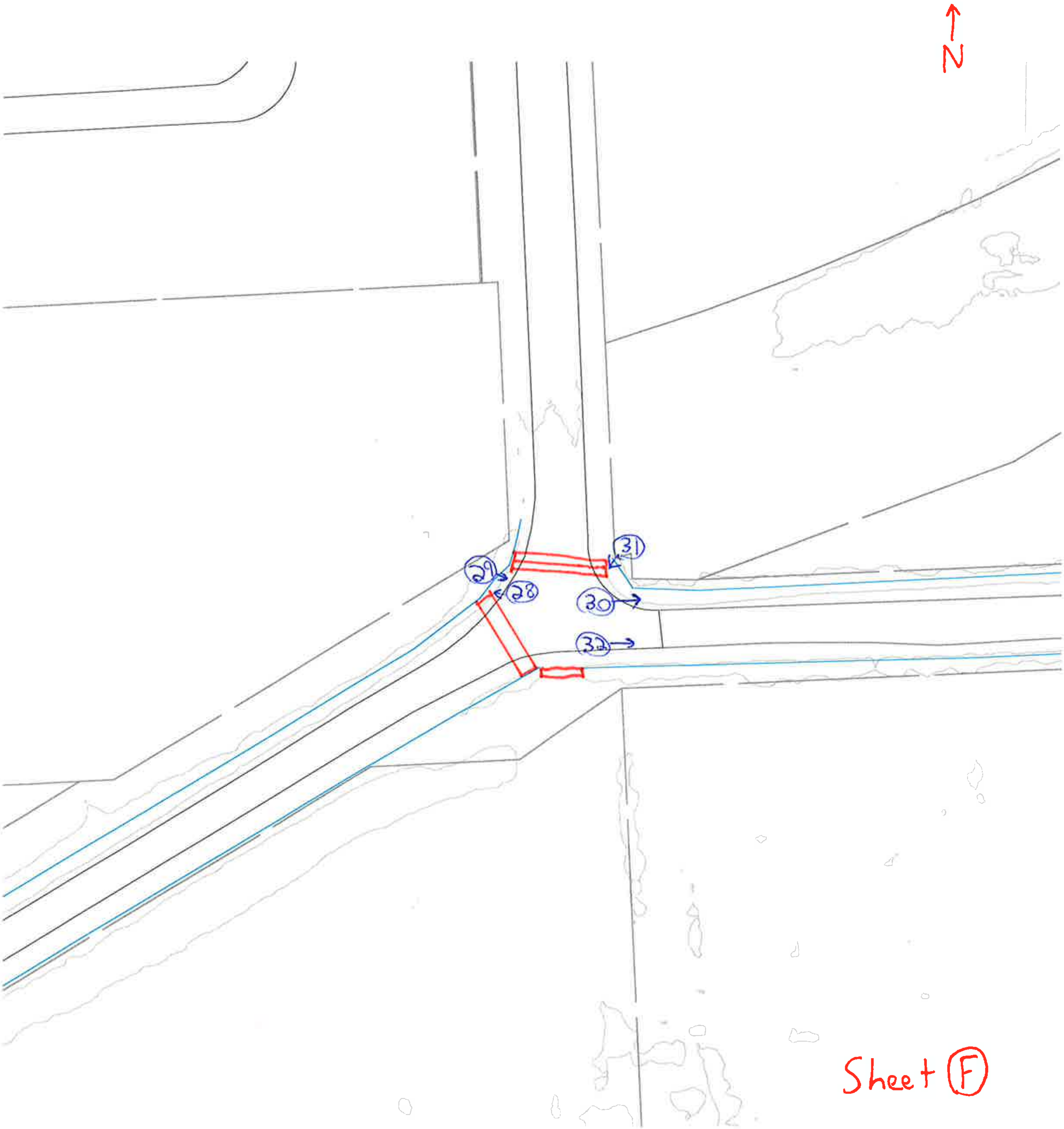
17+18
14
15
16
Sheet D



Sheet (E)



N
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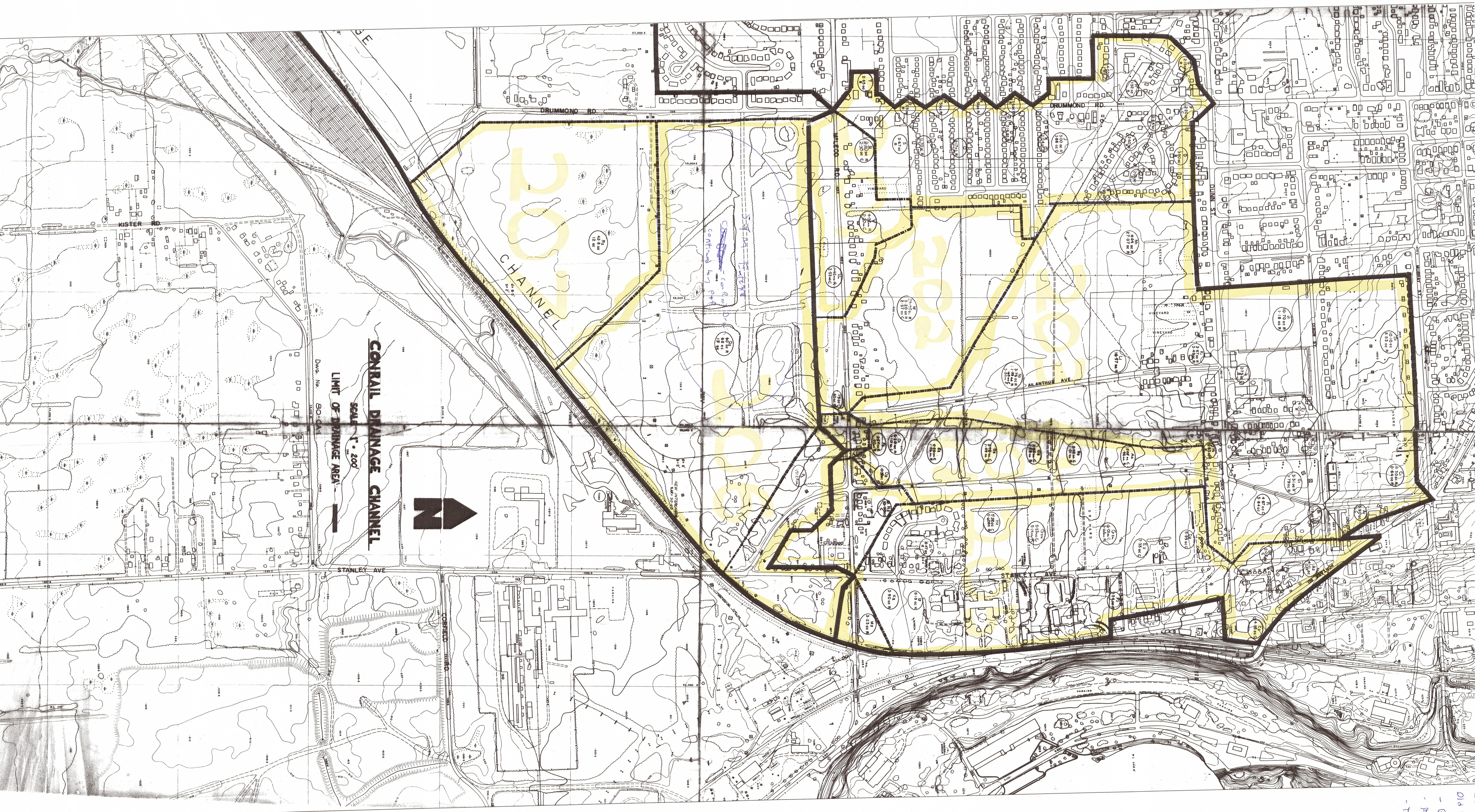
29
28
30
32
Sheet F



Old Field Road and Mcleod Road.
- Google Earth: ~828m
- Figure 1 (1:8000): ~828m
- This drawing (using 1:6000 scale): ~900m
↳ 1:6000 measurement × 828m/900m = Actual length
↳ Estimated scale of drawing ≅ 1:4583

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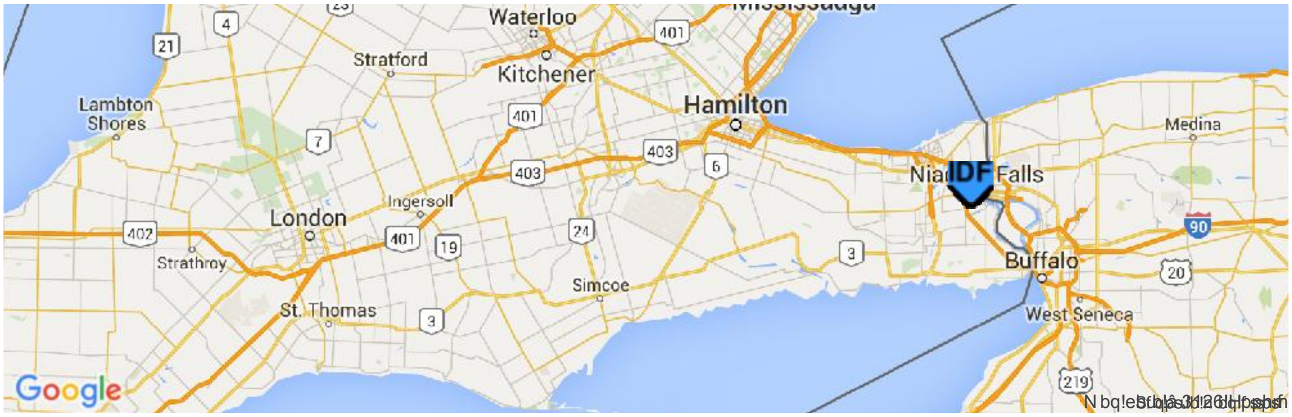
IDF CURVE LOOKUP

Coordinate Selection | Terms of Use | About

Active coordinate

43° 3' 15" N, 79° 6' 14" W (43.054167,-79.104167)Modify selection

Retrieved: Fri, 9 Oct 2015 18:49:59 UTC



Map options: Modify selection | Show/hide gauging stations | Re-center selection

Coordinate summary

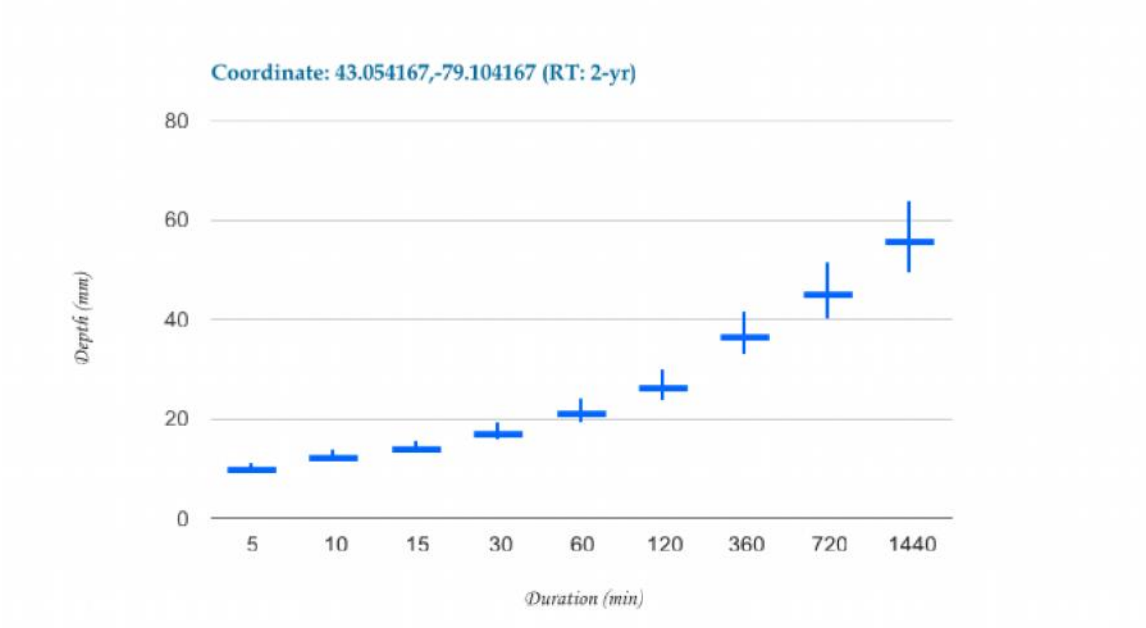
These are the coordinates in the selection.

IDF Curve: 43° 3' 15" N, 79° 6' 14" W (43.054167,-79.104167)

Results

An IDF curve was found for this set of coordinates.

Return period: 2-yr Choose another return period



MTO Switch variable: Intensity or Depth

Coefficient summary

Notes

A: 21.6 (+2.6, -2.3)

B: -0.7 (+0.006, -0.006)

Statistics

Rainfall intensity (mm hr^{-1})

Duration	5-min		10-min		15-min		30-min		1-hr		2-hr		6-hr		12-hr		24-hr	
Intensity (mm hr^{-1})	123.0	+12.8	75.7	+8.2	57.0	+6.3	35.1	+4.1	21.6	+2.6	13.3	+1.7	6.2	+0.8	3.8	+0.5	2.3	+0.3
		-11.4		-7.3		-5.6		-3.6		-2.3		-1.5		-0.7		-0.5		-0.3

Rainfall depth (mm)

Duration	5-min		10-min		15-min		30-min		1-hr		2-hr		6-hr		12-hr		24-hr	
Depth (mm)	10.2	+1.1	12.6	+1.4	14.3	+1.6	17.5	+2.0	21.6	+2.6	26.6	+3.3	37.0	+4.9	45.5	+6.2	56.0	+8.0
		-1.0		-1.2		-1.4		-1.8		-2.3		-2.9		-4.3		-5.4		-6.9

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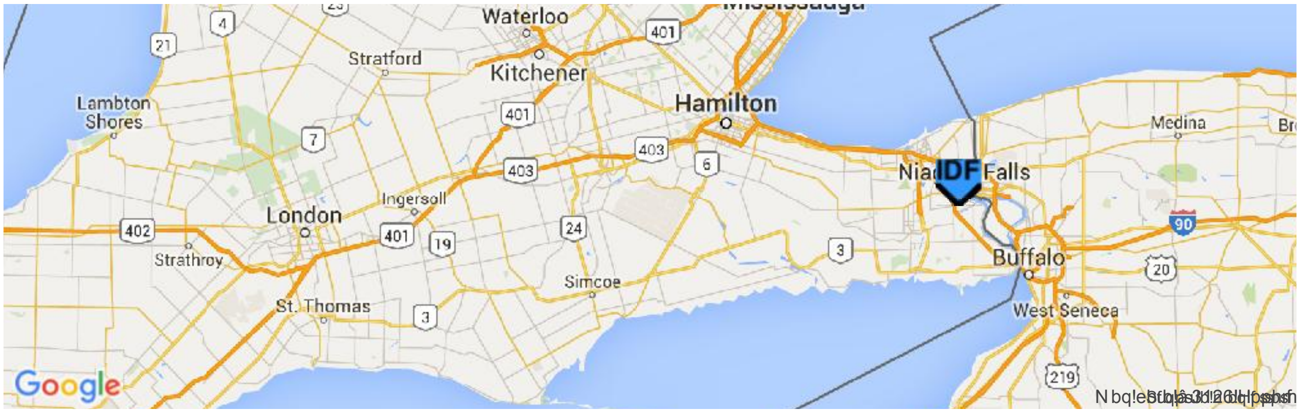
Active coordinate

43° 3' 15" N, 79° 6' 14" W (43.054167,-79.104167)Modify selection

Retrieved: Fri, 9 Oct 2015 18:51:03 UTC



Map options: Modify selection | Show/hide gauging stations | Re-center selection

Coordinate summary

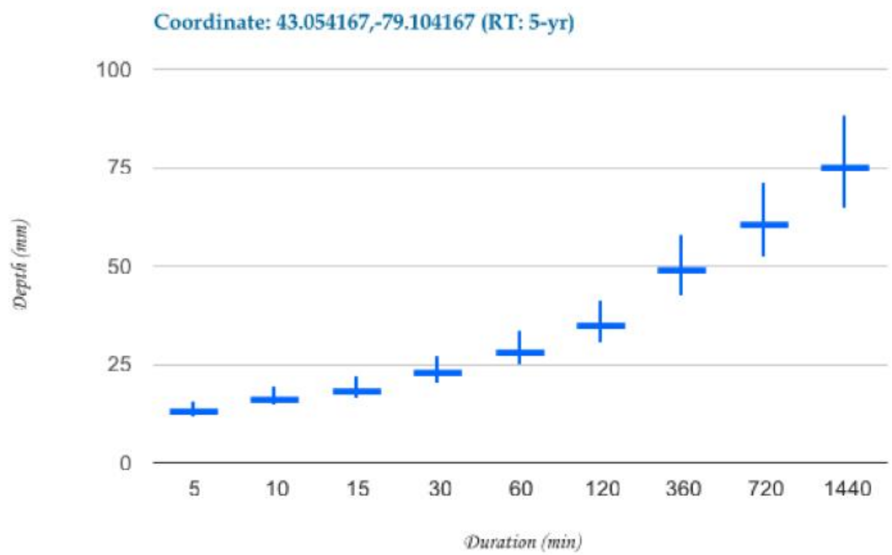
These are the coordinates in the selection.

IDF Curve: 43° 3' 15" N, 79° 6' 14" W (43.054167,-79.104167)

Results

An IDF curve was found for this set of coordinates.

Return period: 5-yr Choose another return period



MTO Switch variable: Intensity or Depth

Coefficient summary

Notes

A: 28.8 (+4.8, -4.1)

B: -0.697 (+0.001, -0.001)

Statistics

Rainfall intensity (mm hr^{-1})

Duration	5-min		10-min		15-min		30-min		1-hr		2-hr		6-hr		12-hr		24-hr	
Intensity (mm hr-1)	162.8	+26.7 / -22.8	100.4	+16.5 / -14.1	75.7	+12.5 / -10.7	46.7	+7.7 / -6.6	28.8	+4.8 / -4.1	17.8	+3.0 / -2.5	8.3	+1.4 / -1.2	5.1	+0.9 / -0.7	3.1	+0.5 / -0.5

Rainfall depth (mm)

Duration	5-min		10-min		15-min		30-min		1-hr		2-hr		6-hr		12-hr		24-hr	
Depth (mm)	13.6	+2.2 / -1.9	16.7	+2.8 / -2.4	18.9	+3.1 / -2.7	23.3	+3.9 / -3.3	28.8	+4.8 / -4.1	35.5	+6.0 / -5.1	49.6	+8.4 / -7.1	61.1	+10.4 / -8.8	75.4	+12.9 / -10.9

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Active coordinate

43° 3' 15" N, 79° 6' 14" W (43.054167,-79.104167)Modify selection

Retrieved: Fri, 9 Oct 2015 18:51:52 UTC

Map options: Modify selection | Show/hide gauging stations | Re-center selection

Coordinate summary

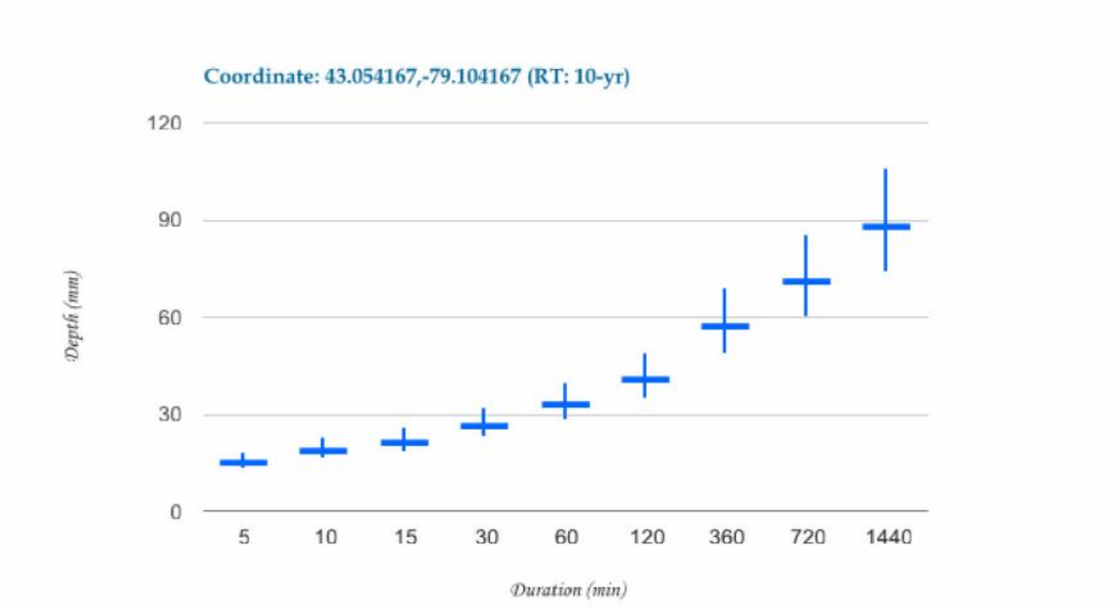
These are the coordinates in the selection.

IDF Curve: 43° 3' 15" N, 79° 6' 14" W (43.054167,-79.104167)

Results

An IDF curve was found for this set of coordinates.

Return period: 10-yr Choose another return period



MTO Switch variable: Intensity or Depth

Coefficient summary

Notes

A: 33.6 (+6.4, -5.4)

B: -0.695 (+0.002, -0.002)

Statistics

Rainfall intensity (mm hr^{-1})

Duration	5-min	10-min	15-min	30-min	1-hr	2-hr	6-hr	12-hr	24-hr

Intensity (mm hr^{-1})	189.0	+34.9	116.7	+21.7	88.1	+16.5	54.4	+10.3	33.6	+6.4	20.8	+4.0	9.7	+1.9	6.0	+1.2	3.7	+0.7
		-29.6		-18.4		-13.9		-8.7		-5.4		-3.4		-1.6		-1.0		-0.6

Rainfall depth (mm)

Duration	**5-min**		**10-min**		**15-min**		**30-min**		**1-hr**		**2-hr**		**6-hr**		**12-hr**		**24-hr**	
Depth (mm)	15.7	+2.9	19.5	+3.6	22.0	+4.1	27.2	+5.1	33.6	+6.4	41.5	+8.0	58.0	+11.3	71.7	+14.1	88.6	+17.5
		-2.5		-3.1		-3.5		-4.3		-5.4		-6.7		-9.5		-11.8		-14.7

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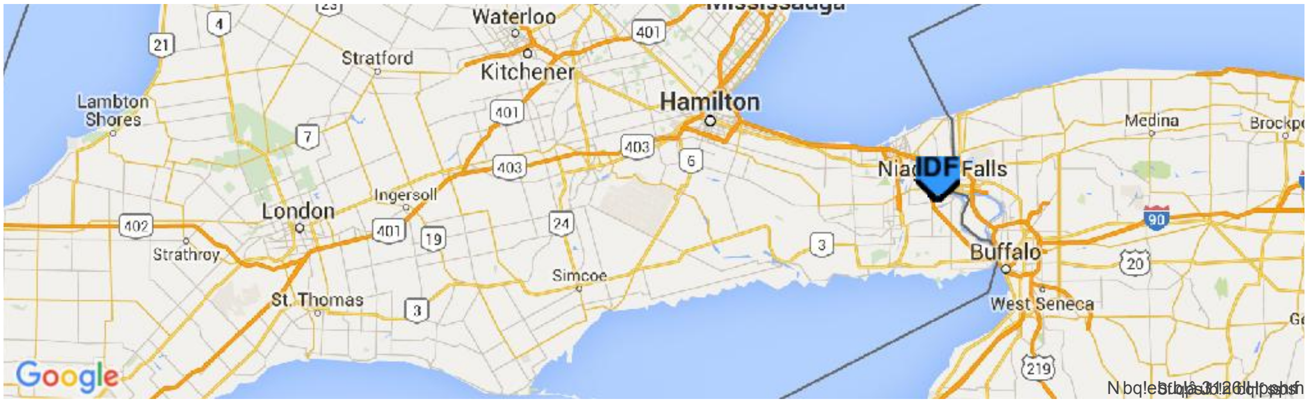
Active coordinate

43° 3' 15" N, 79° 6' 14" W (43.054167,-79.104167)Modify selection

Retrieved: Fri, 9 Oct 2015 18:52:26 UTC



Map options: Modify selection | Show/hide gauging stations | Re-center selection

Coordinate summary

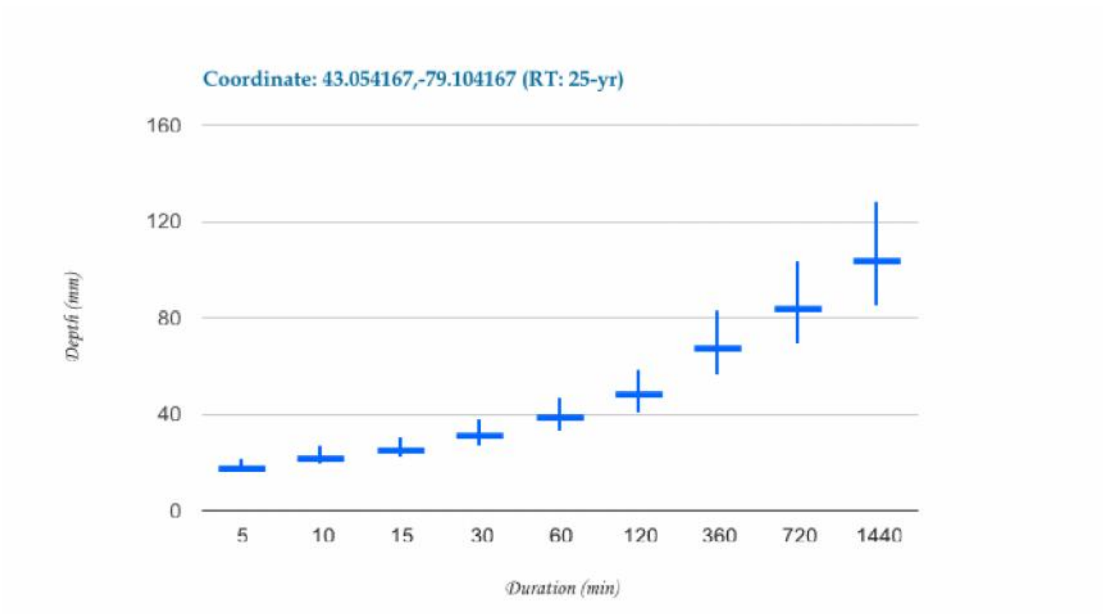
These are the coordinates in the selection.

IDF Curve: 43° 3' 15" N, 79° 6' 14" W (43.054167,-79.104167)

Results

An IDF curve was found for this set of coordinates.

Return period: 25-yr Choose another return period



MTO Switch variable: Intensity or Depth

Coefficient summary

Notes

A: 39.6 (+7.9, -6.6)

B: -0.694 (+0.008, -0.008)

Statistics

Rainfall intensity (mm hr^{-1})

Duration	5-min	10-min	15-min	30-min	1-hr	2-hr	6-hr	12-hr	24-hr

Intensity (mm hr⁻¹)	222.2	+39.1	137.3	+25.1	103.6	+19.3	64.1	+12.4	39.6	+7.9	24.5	+5.0	11.4	+2.5	7.1	+1.6	4.4	+1.0
		-33.3		-21.2		-16.3		-10.4		-6.6		-4.2		-2.0		-1.3		-0.8

Rainfall depth (mm)

Duration	**5-min**		**10-min**		**15-min**		**30-min**		**1-hr**		**2-hr**		**6-hr**		**12-hr**		**24-hr**	
Depth (mm)	18.5	+3.3	22.9	+4.2	25.9	+4.8	32.0	+6.2	39.6	+7.9	49.0	+10.1	68.5	+14.9	84.7	+18.9	104.7	+24.1
		-2.8		-3.5		-4.1		-5.2		-6.6		-8.4		-12.2		-15.5		-19.6

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IDF CURVE LOOKUP

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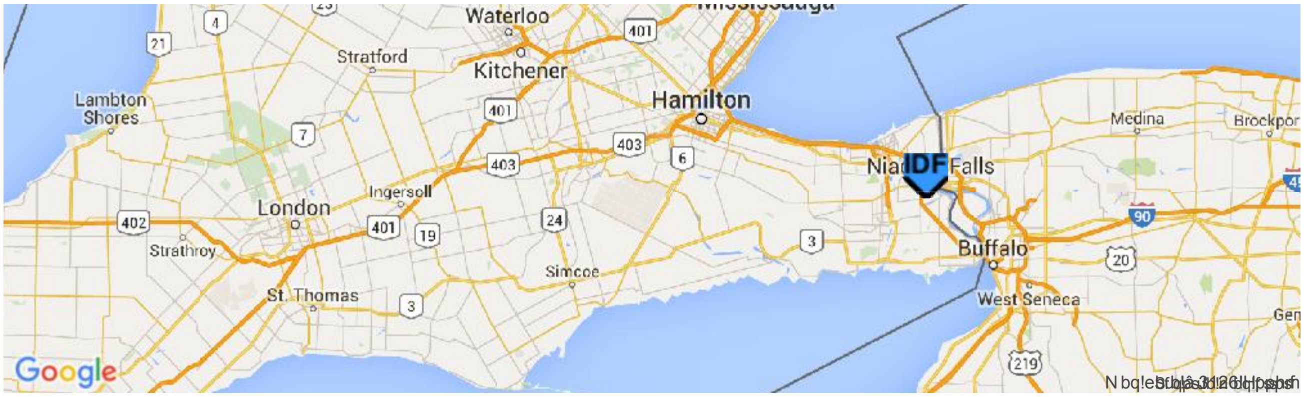
Active coordinate

43° 3' 15" N, 79° 6' 14" W (43.054167,-79.104167)Modify selection

Retrieved: Fri, 9 Oct 2015 18:53:04 UTC



Map options: Modify selection | Show/hide gauging stations | Re-center selection

Coordinate summary

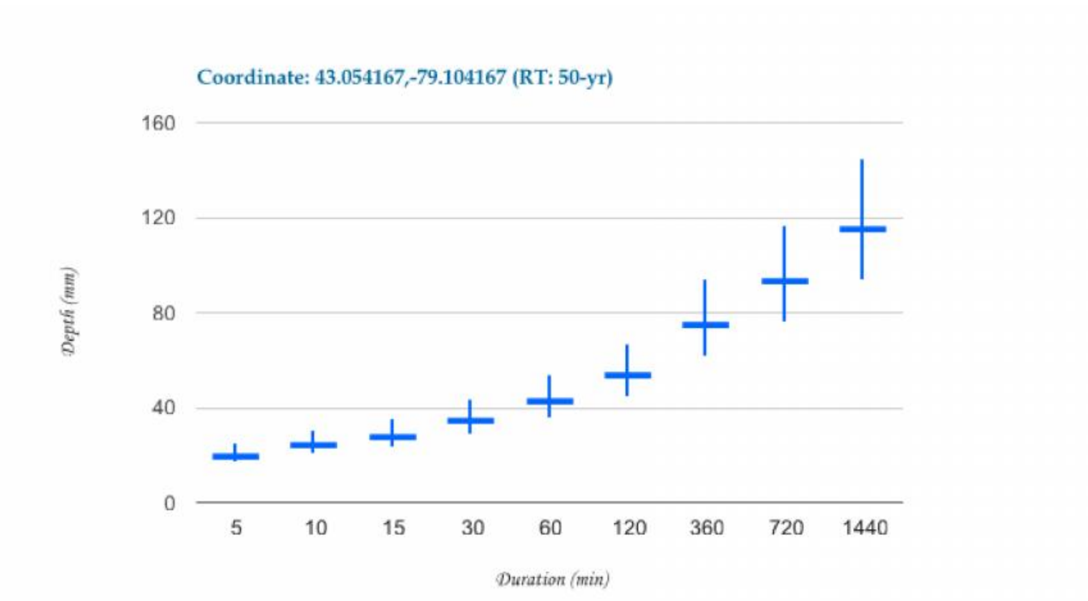
These are the coordinates in the selection.

IDF Curve: 43° 3' 15" N, 79° 6' 14" W (43.054167,-79.104167)

Results

An IDF curve was found for this set of coordinates.

Return period: 50-yr Choose another return period



MTO Switch variable: Intensity or Depth

Coefficient summary

Notes

A: 44 (+10.2, -8.2)

B: -0.694 (+0.004, -0.003)

Statistics

Rainfall intensity (mm hr^{-1})

Duration	5-min	10-min	15-min	30-min	1-hr	2-hr	6-hr	12-hr	24-hr
Intensity									

(mm hr^{-1})	246.8	+54.2 / -44.5	152.6	+34.0 / -27.8	115.2	+25.9 / -21.1	71.2	+16.3 / -13.1	44.0	+10.2 / -8.2	27.2	+6.4 / -5.1	12.7	+3.1 / -2.4	7.8	+1.9 / -1.5	4.8	+1.2 / -0.9

Rainfall depth (mm)

Duration	5-min		10-min		15-min		30-min		1-hr		2-hr		6-hr		12-hr		24-hr	
Depth (mm)	20.6	+4.5 / -3.7	25.4	+5.7 / -4.6	28.8	+6.5 / -5.3	35.6	+8.1 / -6.6	44.0	+10.2 / -8.2	54.4	+12.8 / -10.2	76.1	+18.3 / -14.5	94.1	+23.0 / -18.1	116.4	+28.8 / -22.6

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Coordinate Selection | Terms of Use | About

Active coordinate

43° 3' 15" N, 79° 6' 14" W (43.054167,-79.104167)Modify selection

Retrieved: Fri, 9 Oct 2015 18:53:40 UTC

Map options: Modify selection | Show/hide gauging stations | Re-center selection

Coordinate summary

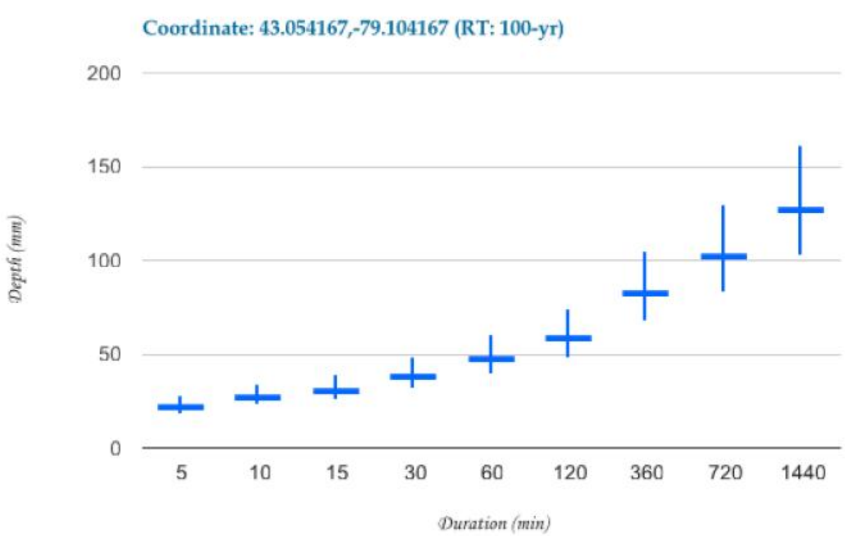
These are the coordinates in the selection.

IDF Curve: 43° 3' 15" N, 79° 6' 14" W (43.054167,-79.104167)

Results

An IDF curve was found for this set of coordinates.

Return period: 100-yr Choose another return period



MTO Switch variable: Intensity or Depth

Coefficient summary

Notes

A: 48.5 (+11.8, -9.5)

B: -0.694 (+0.004, -0.003)

Statistics

Rainfall intensity (mm hr^{-1})

Duration	5-min		10-min		15-min		30-min		1-hr		2-hr		6-hr		12-hr		24-hr	
Intensity	272.1	+62.9	168.2	+39.4	126.9	+30.0	78.5	+18.8	48.5	+11.8	30.0	+7.4	14.0	+3.5	8.6	+2.2	5.3	+1.4

(mm hr^{-1})		-51.7		-32.2		-24.4		-15.2		-9.5		-5.9		-2.8		-1.7		-1.1

Rainfall depth (mm)

Duration	**5-min**		**10-min**		**15-min**		**30-min**		**1-hr**		**2-hr**		**6-hr**		**12-hr**		**24-hr**	
Depth (mm)	22.7	+5.2	28.0	+6.6	31.7	+7.5	39.2	+9.4	48.5	+11.8	60.0	+14.8	83.9	+21.2	103.7	+26.5	128.3	+33.2
		-4.3		-5.4		-6.1		-7.6		-9.5		-11.8		-16.8		-20.9		-26.1

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IDF CURVE LOOKUP
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Active coordinate

43° 3’ 15" N, 79° 6’ 14" W (43.054167,-79.104167)Modify selection

Retrieved: Fri, 9 Oct 2015 18:45:33 UTC

Map options: Modify selection | Show/hide gauging stations | Re-center selection

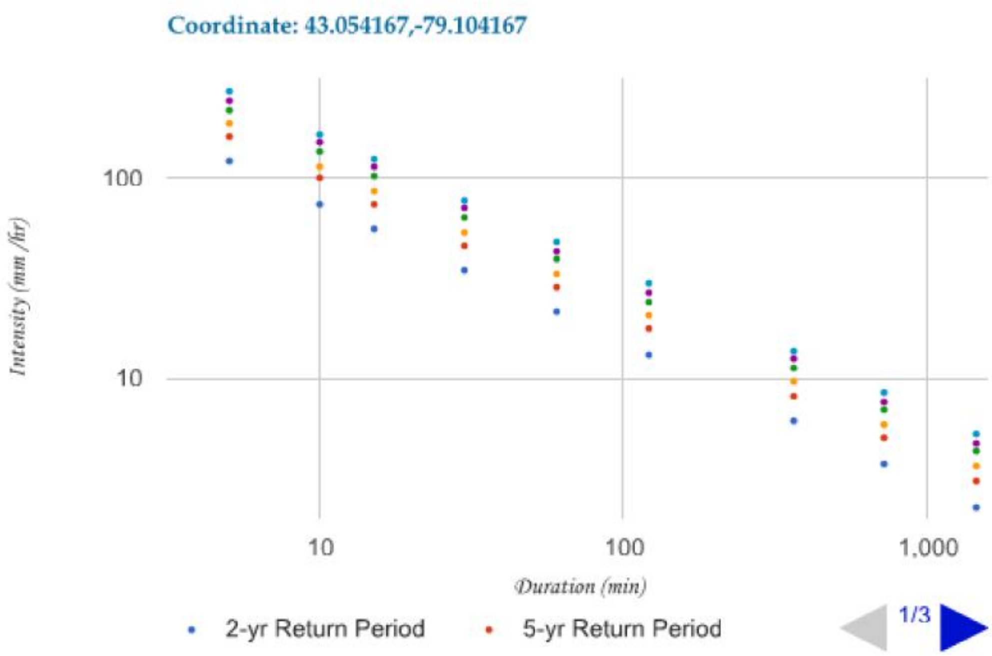
Coordinate summary

These are the coordinates in the selection.

IDF Curve: 43° 3’ 15" N, 79° 6’ 14" W (43.054167,-79.104167)

Results

An IDF curve was found for this set of coordinates.



Coefficient summary

Notes

Click a return period in the table header for more detail.

Return period	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
A	21.6	28.8	33.6	39.6	44.0	48.5
B	-0.700	-0.697	-0.695	-0.694	-0.694	-0.694

Statistics

Rainfall intensity (mm hr^{-1})

Duration	5-min	10-min	15-min	30-min	1-hr	2-hr	6-hr	12-hr	24-hr
2-yr	123.0	75.7	57.0	35.1	21.6	13.3	6.2	3.8	2.3
5-yr	162.8	100.4	75.7	46.7	28.8	17.8	8.3	5.1	3.1
10-yr	189.0	116.7	88.1	54.4	33.6	20.8	9.7	6.0	3.7
25-yr	222.2	137.3	103.6	64.1	39.6	24.5	11.4	7.1	4.4
50-yr	246.8	152.6	115.2	71.2	44.0	27.2	12.7	7.8	4.8
100-yr	272.1	168.2	126.9	78.5	48.5	30.0	14.0	8.6	5.3

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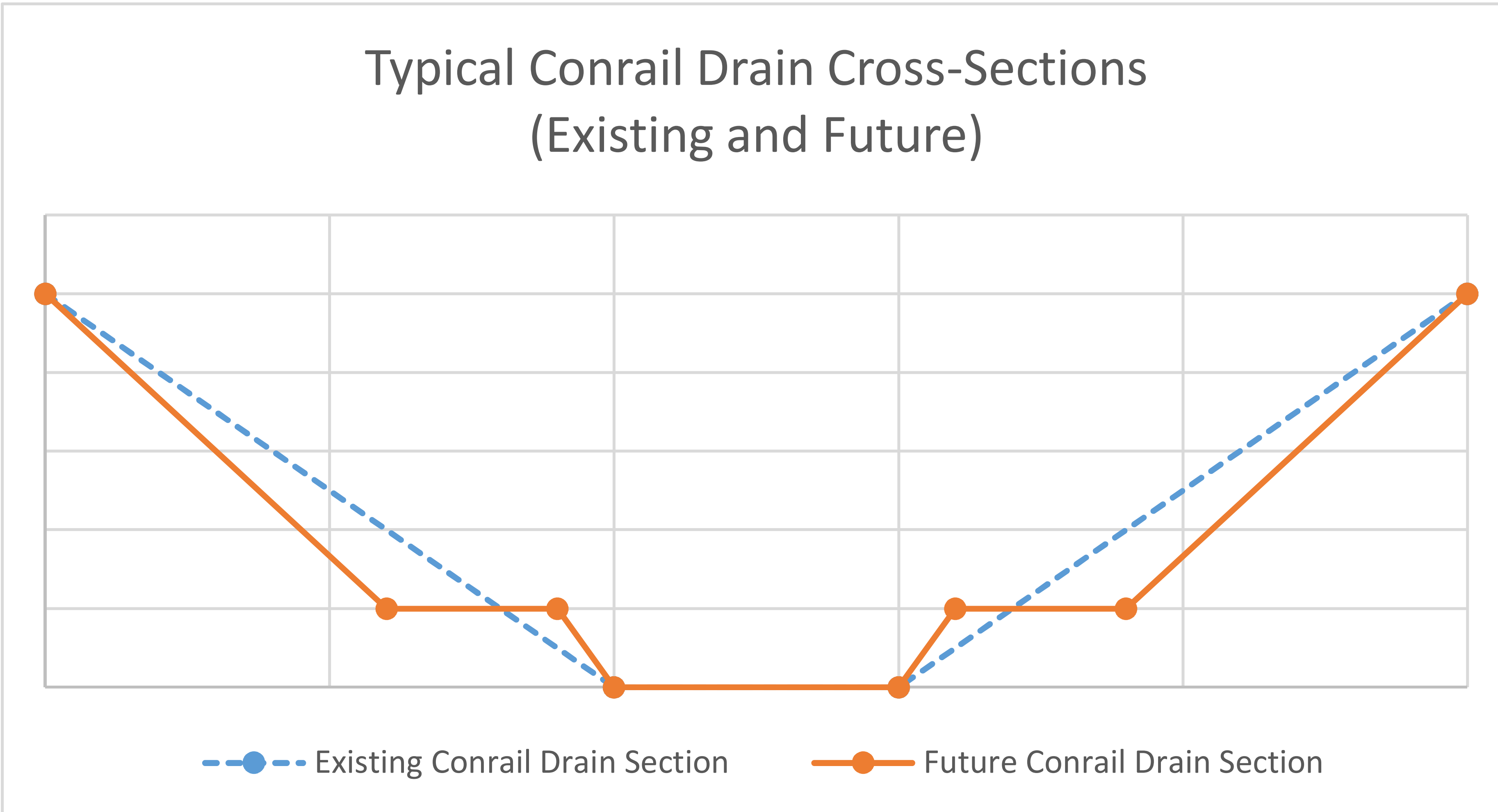
12 HOUR SCS II DESIGN STORM

Total Depth			45.5	61.1	71.7	84.7	94.1	103.7	88.1

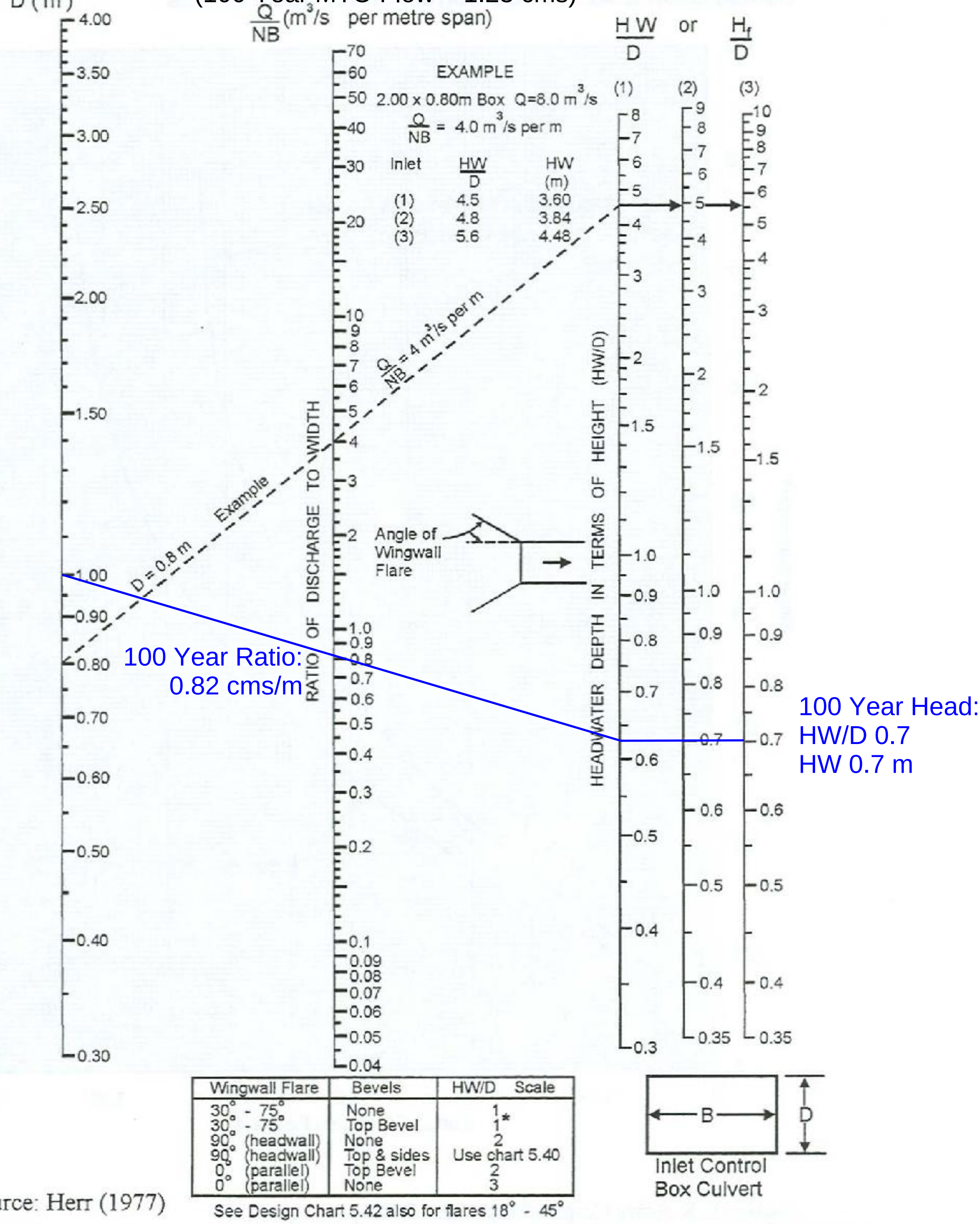
	*Time Ending	*% Inc	Depth/Increment						
			2	5	10	25	50	100	100 - NPCA
	0	0	0						
120	2	0.05	2.275	3.055	3.585	4.235	4.705	5.185	4.405
180	3	0.03	1.365	1.833	2.151	2.541	2.823	3.111	2.643
210	3.5	0.02	0.91	1.222	1.434	1.694	1.882	2.074	1.762
240	4	0.02	0.91	1.222	1.434	1.694	1.882	2.074	1.762
270	4.5	0.03	1.365	1.833	2.151	2.541	2.823	3.111	2.643
300	5	0.04	1.82	2.444	2.868	3.388	3.764	4.148	3.524
330	5.5	0.06	2.73	3.666	4.302	5.082	5.646	6.222	5.286
345	5.75	0.12	5.46	7.332	8.604	10.164	11.292	12.444	10.572
360	6	0.33	15.015	20.163	23.661	27.951	31.053	34.221	29.073
390	6.5	0.09	4.095	5.499	6.453	7.623	8.469	9.333	7.929
420	7	0.04	1.82	2.444	2.868	3.388	3.764	4.148	3.524
450	7.5	0.03	1.365	1.833	2.151	2.541	2.823	3.111	2.643
480	8	0.03	1.365	1.833	2.151	2.541	2.823	3.111	2.643
600	10	0.07	3.185	4.277	5.019	5.929	6.587	7.259	6.167
720	12	0.04	1.82	2.444	2.868	3.388	3.764	4.148	3.524

* ref Design Chart 1.05 MTO Drainage Manutal


Typical Conrail Drain Cross-Sections
(Existing and Future)
Existing Conrail Drain Section
Future Conrail Drain Section

Design Chart 5.39: Inlet Control: Box Culvert

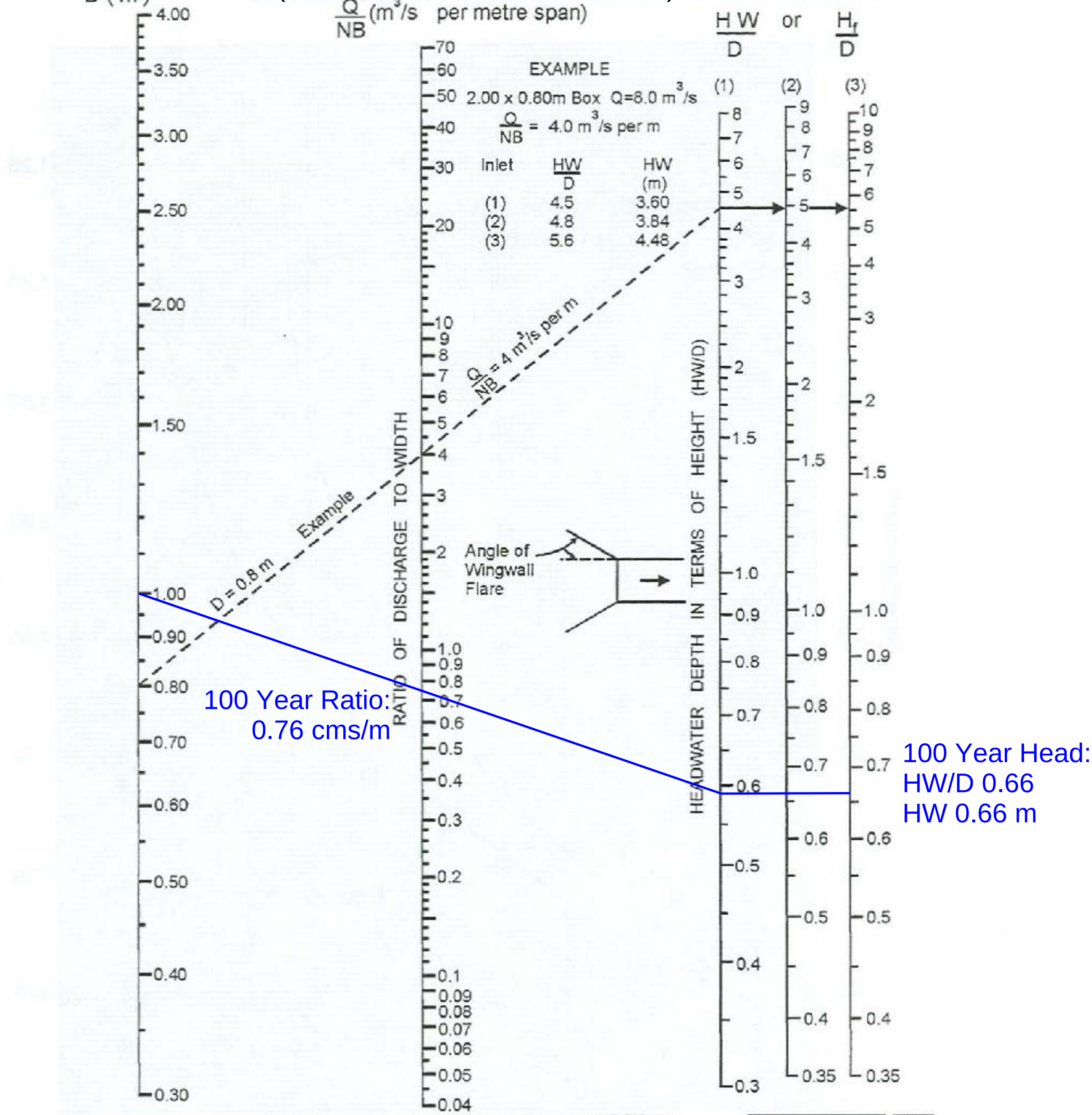
C6 - Proposed Box Culvert Conveying Subcatchment 304
(100 Year MTO Flow = 1.23 cms)



Source: Herr (1977)

Design Chart 5.39: Inlet Control: Box Culvert

C7 - Proposed Overflow Box Culvert Conveying Subcatchments 105 and 312
(100 Year MTO Flow = 1.14 cms)



Wingwall Flare	Bevels	HW/D Scale
30° - 75°	None	1
30° - 75°	Top Bevel	1*
90° (headwall)	None	2
90° (headwall)	Top & sides	Use chart 5.40
0° (parallel)	Top Bevel	2
0° (parallel)	None	3

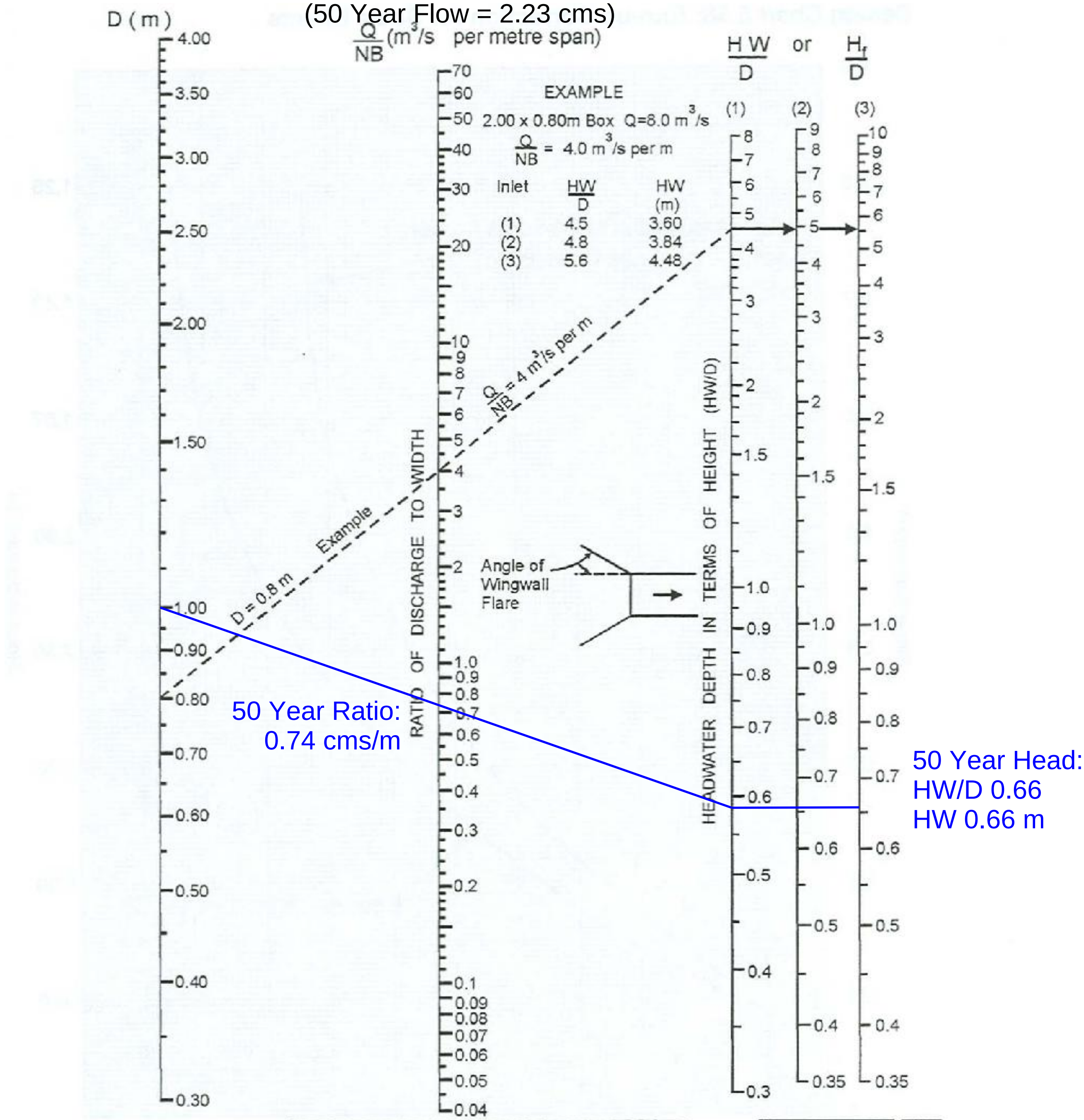
Source: Herr (1977)

See Design Chart 5.42 also for flares 18° - 45°

Design Chart 5.39: Inlet Control: Box Culvert

C8 - Proposed Box Culvert Connecting Subcatchments 113c and 113e

(50 Year Flow = 2.23 cms)



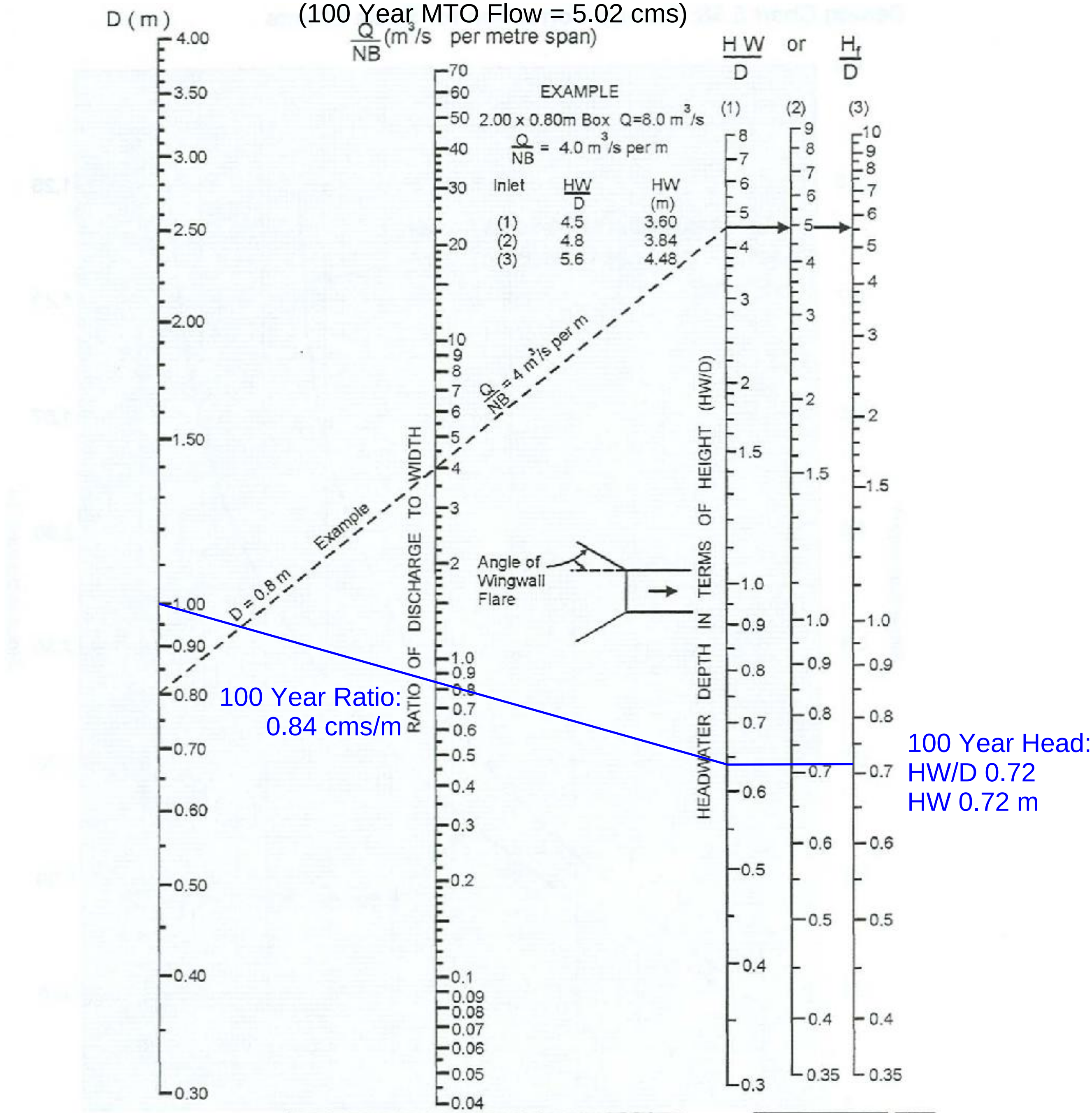
Wingwall Flare	Bevels	HW/D Scale
30° - 75°	None	1
30° - 75°	Top Bevel	1*
90° (headwall)	None	2
90° (headwall)	Top & sides	Use chart 5.40
0° (parallel)	Top Bevel	2
0° (parallel)	None	3

See Design Chart 5.42 also for flares 18° - 45°

Source: Herr (1977)

Design Chart 5.39: Inlet Control: Box Culvert

C9 - Proposed Box Culvert Connecting Subcatchment 113e to the Welland River
(100 Year MTO Flow = 5.02 cms)



Wingwall Flare	Bevels	HW/D Scale
30° - 75°	None	1
30° - 75°	Top Bevel	1*
90° (headwall)	None	2
90° (headwall)	Top & sides	Use chart 5.40
0° (parallel)	Top Bevel	2
0° (parallel)	None	3

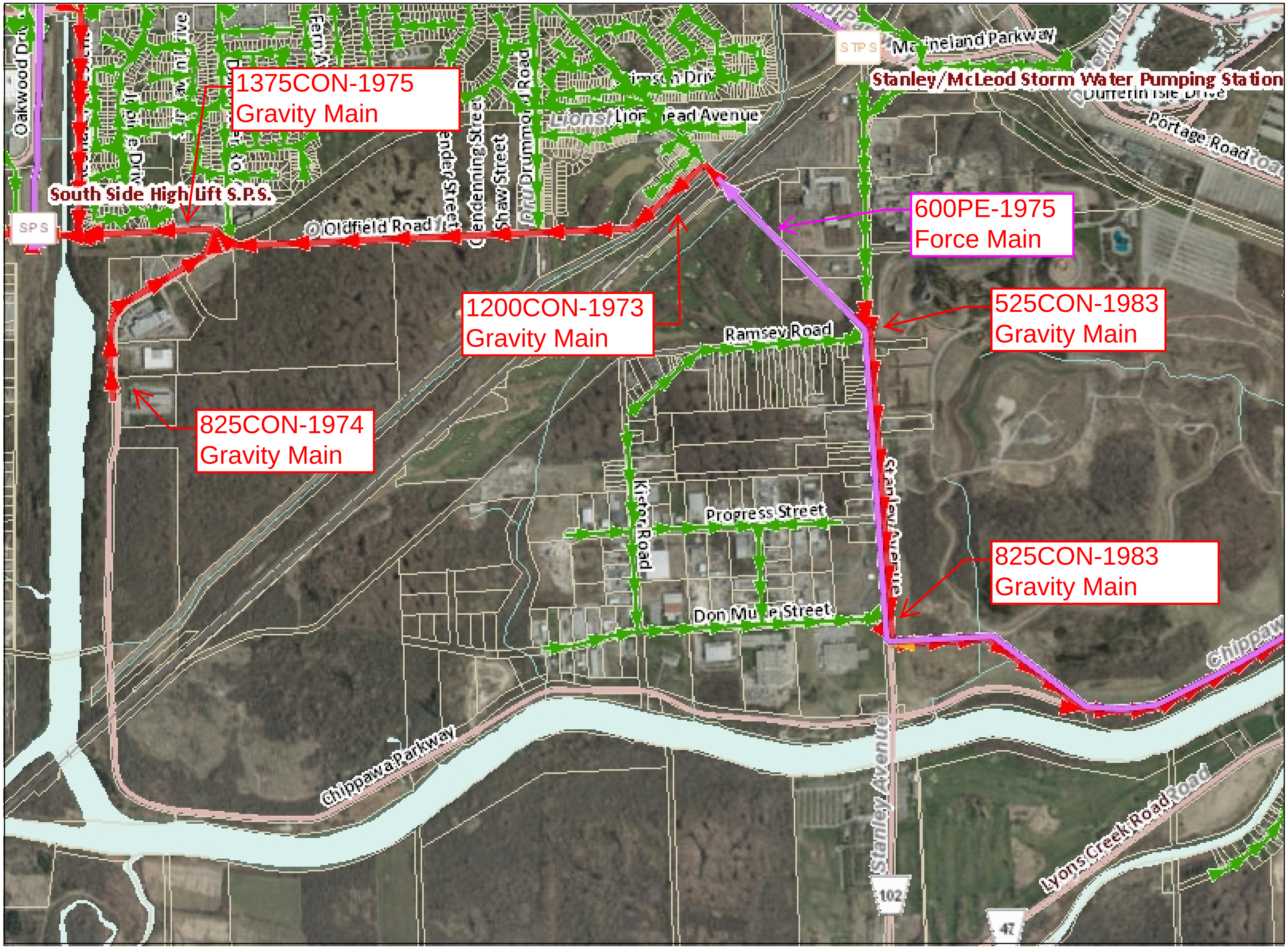
Source: Herr (1977)

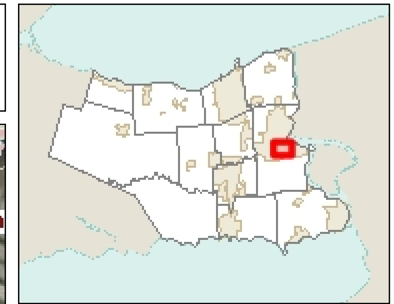
See Design Chart 5.42 also for flares 18° - 45°

APPENDIX B

EXISTING AND FUTURE SANITARY COLLECTION

Thundering Waters- Sanitary Servicing





Legend

RMoN Sanitary Facility Point
- Wastewater Treatment Plant
- Sewage Pumping Station
- Odour Control Facility
- Flume
- Lagoon
- Biosolids Storage Facility
- Combined Sewage Detention Facili
- Sewage Detention Facility
- Diversion Chamber
- Storm Water Pumping Station

RMoN Sanitary Force Main
- Force Main
- Force Main Under Construction

RMoN Sanitary Gravity Main
- Sanitary Gravity Pipe
- Sanitary Gravity Pipe Under Constr
- Combined Sewer Overflow
- Combined Sewer Overflow Under C
- Sanitary Siphon
- Sanitary Siphon Under Constructio
- Wastewater Effluent
- Wastewater Effluent Under Constru
- Sanitary Inline Storage
- Sanitary Inline Storage Under Cons

RMoN WMT Sanitary Facility F

1,016.0 0 508.00 1,016.0 Meters

N

Notes

Vedic Resort Infrastructure

External Servicing

N

Niagara Region

gis@niagararegion.ca

Printed: Apr 16, 2012

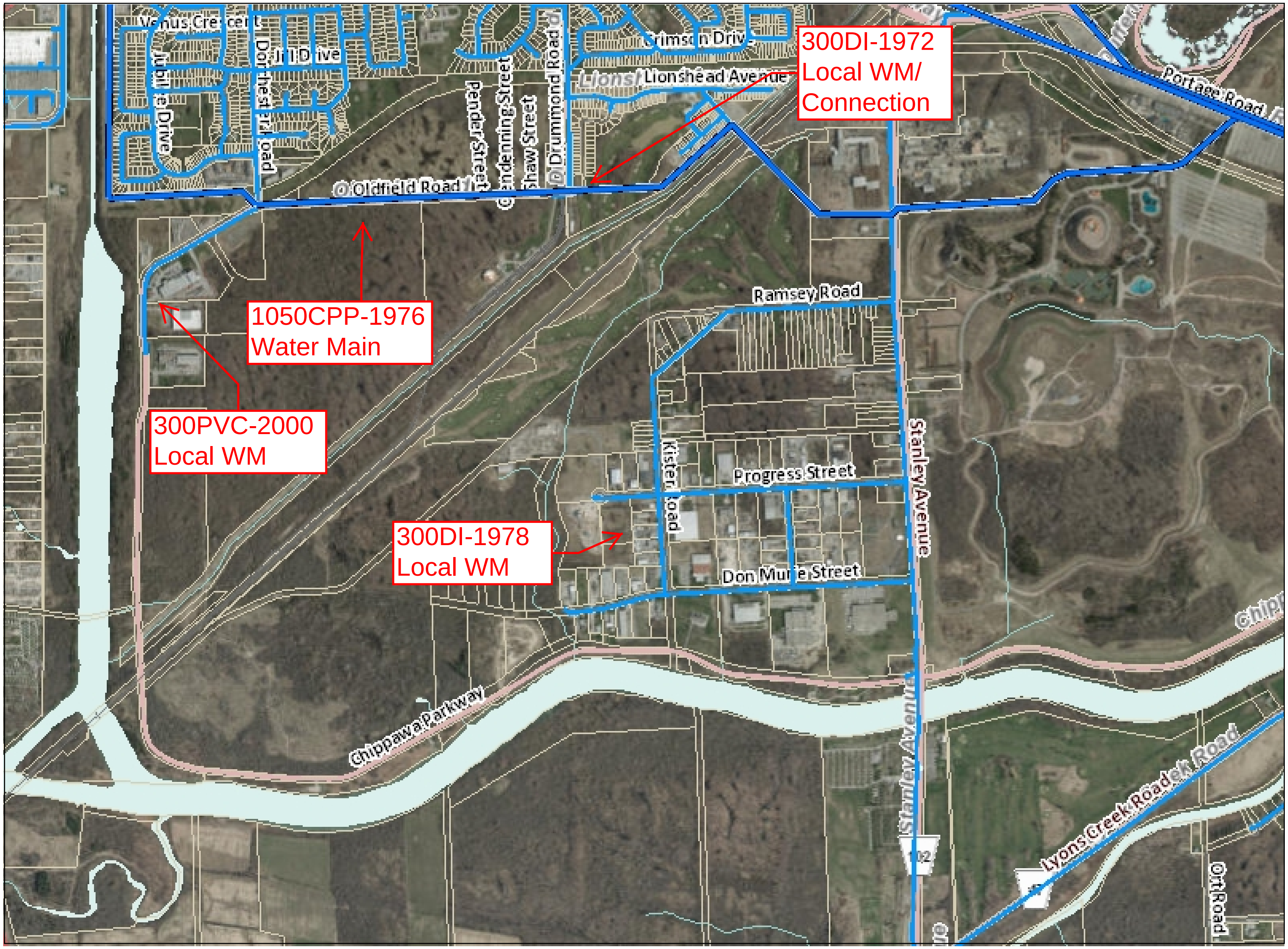
Approximate Developable Area on south side of Welland River

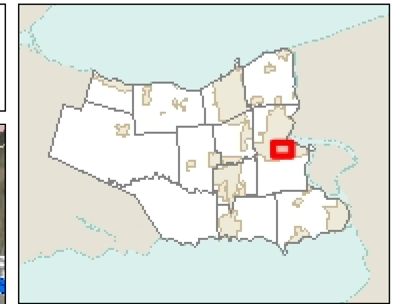
APPENDIX C

WATER DISTRIBUTION SYSTEM MODEL OUTPUT

Thundering Waters- Water Servicing

Niagara Region





Legend

RMoN Water Facility Point

- Water Treatment Plant
- Pumping Station
- Chlorine Facility
- Elevated Tank
- Reservoir
- Standpipe

RMoN Water Main

- Transmission
- Transmission Under Construction
- Intake

LAM Water Facility Point

LAM Water Main

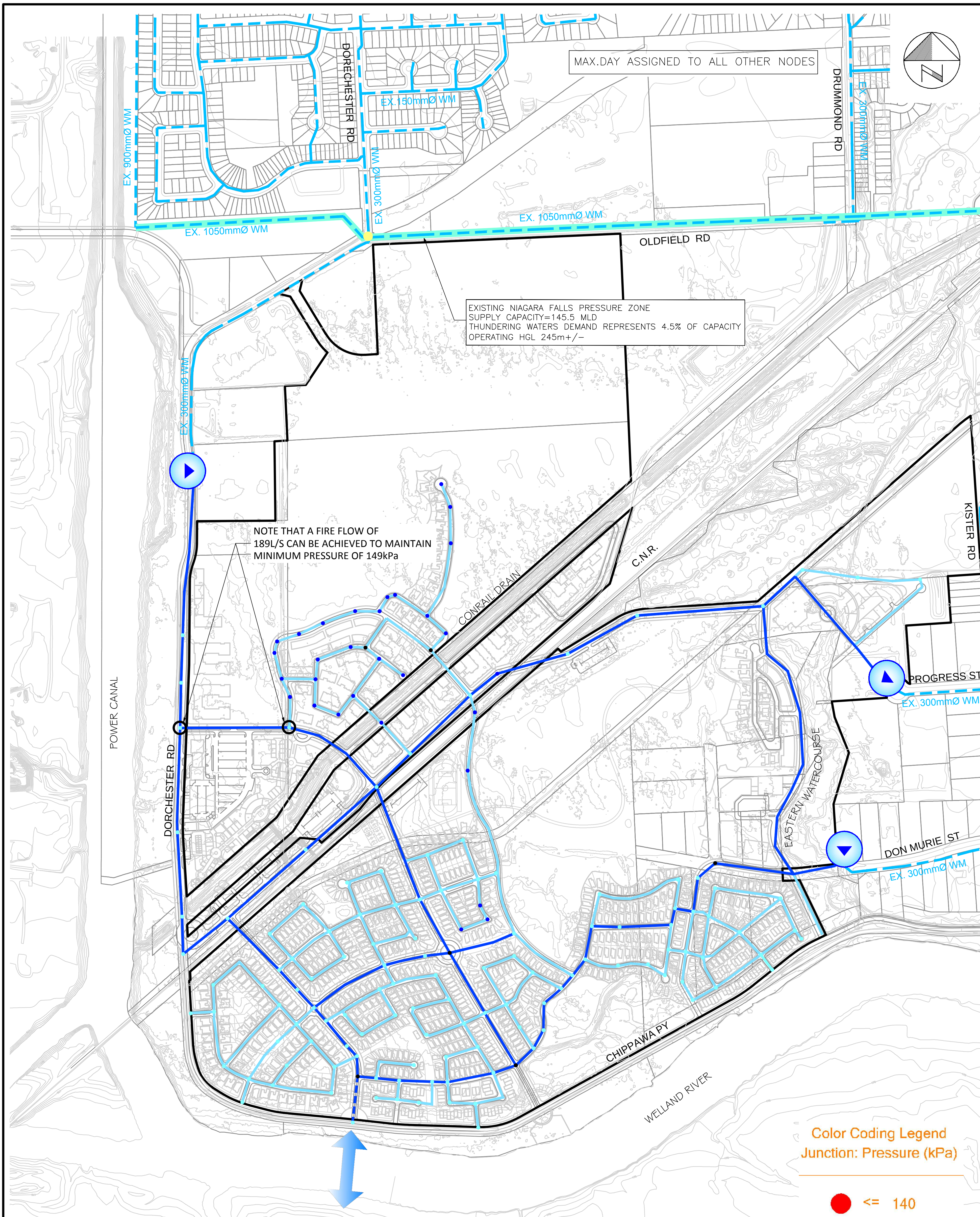
Streets Labels

1,016.0 | 0 | 508.00 | 1,016.0 | Meters

N

This map is a user generated static output from an Internet mapping site and is for reference only. Data layers that appear on this map may or may not be accurate, current, or otherwise reliable. This map is not to be used for navigation.

Notes

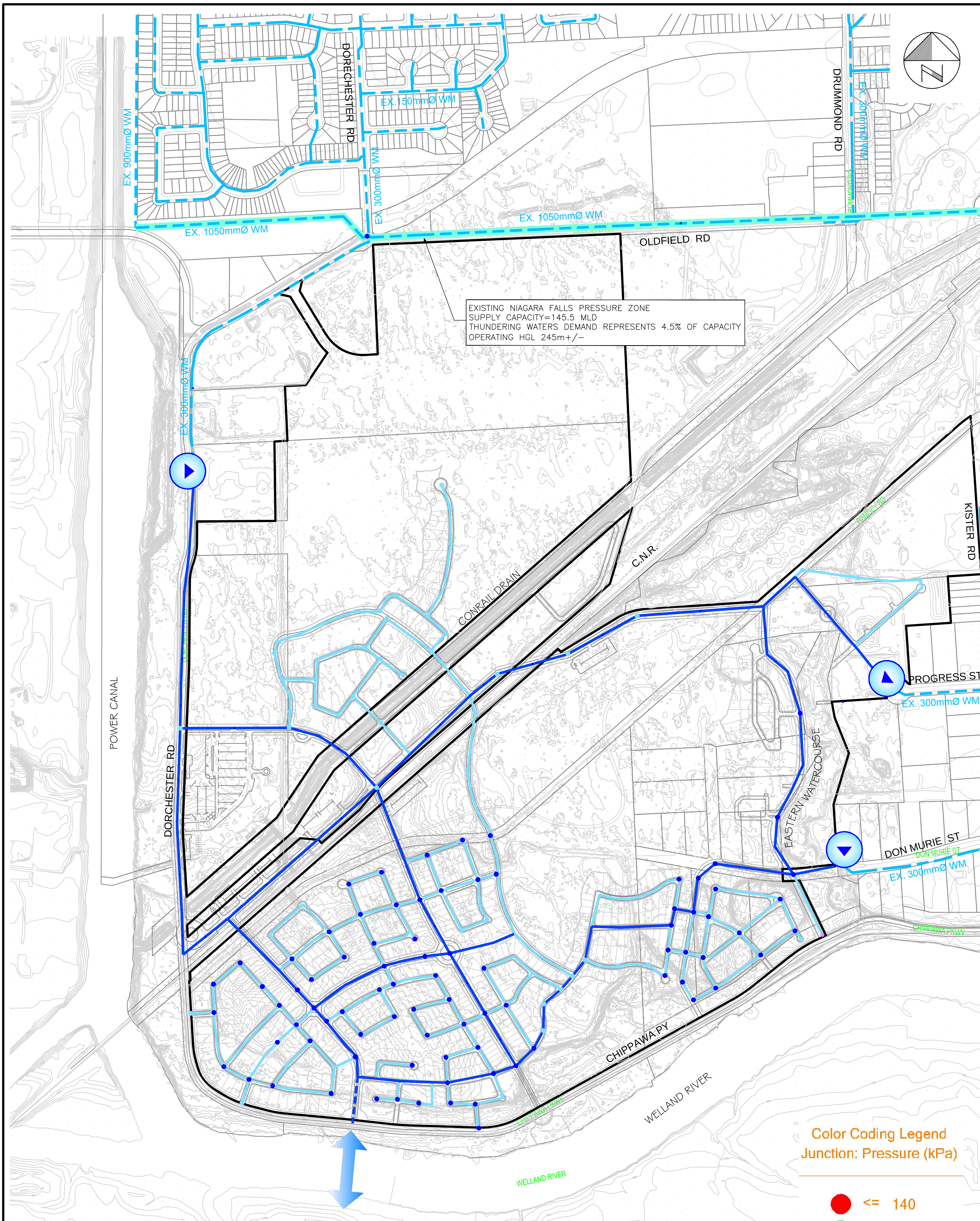


LEGEND

- LANDS OWNED BY GR(CAN) INVESTMENTS
- EXISTING WATERMAIN
- PROPOSED WATERMAIN (300mm)
- PROPOSED WATERMAIN (150–200mm)
- WATERMAIN TO SERVICE FUTURE EXTERNAL AREA
- EXISTING 1050mmØ WATERMAIN
- PROPOSED CONNECTION POINTS TO NIAGARA REGION DISTRIBUTION SYSTEM.

THUNDERING WATERS SECONDARY PLAN CITY OF NIAGARA FALLS	FIRE FLOW ANALYSIS SERVICING PLAN	amec foster wheeler	Scale: NTS Consultant File No.: TP115026 Drawing No.: 5.1

Path: P:\Work\TP115026\Municipal\water\Exhibits 2016-06-14\Max Day+FF.dwg
Plotted By: murad.khan
Plotted: 2016-06-21
Last Saved By: murad.khan
Last Saved: 2016-06-21



LEGEND

- LANDS OWNED BY GR(CAN) INVESTMENTS
- EXISTING WATERMAIN
- PROPOSED WATERMAIN (300mm)
- PROPOSED WATERMAIN (150–200mm)
- WATERMAIN TO SERVICE FUTURE EXTERNAL AREA
- EXISTING 1050mmØ WATERMAIN
- PROPOSED CONNECTION POINTS TO NIAGARA REGION DISTRIBUTION SYSTEM.

THUNDERING WATERS SECONDARY PLAN CITY OF NIAGARA FALLS	PEAK HOUR ANALYSIS SERVICING PLAN	amec foster wheeler	Scale: NTS Consultant File No.: TP115026 Drawing No.: 5.1

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Plotted: 2016-06-21
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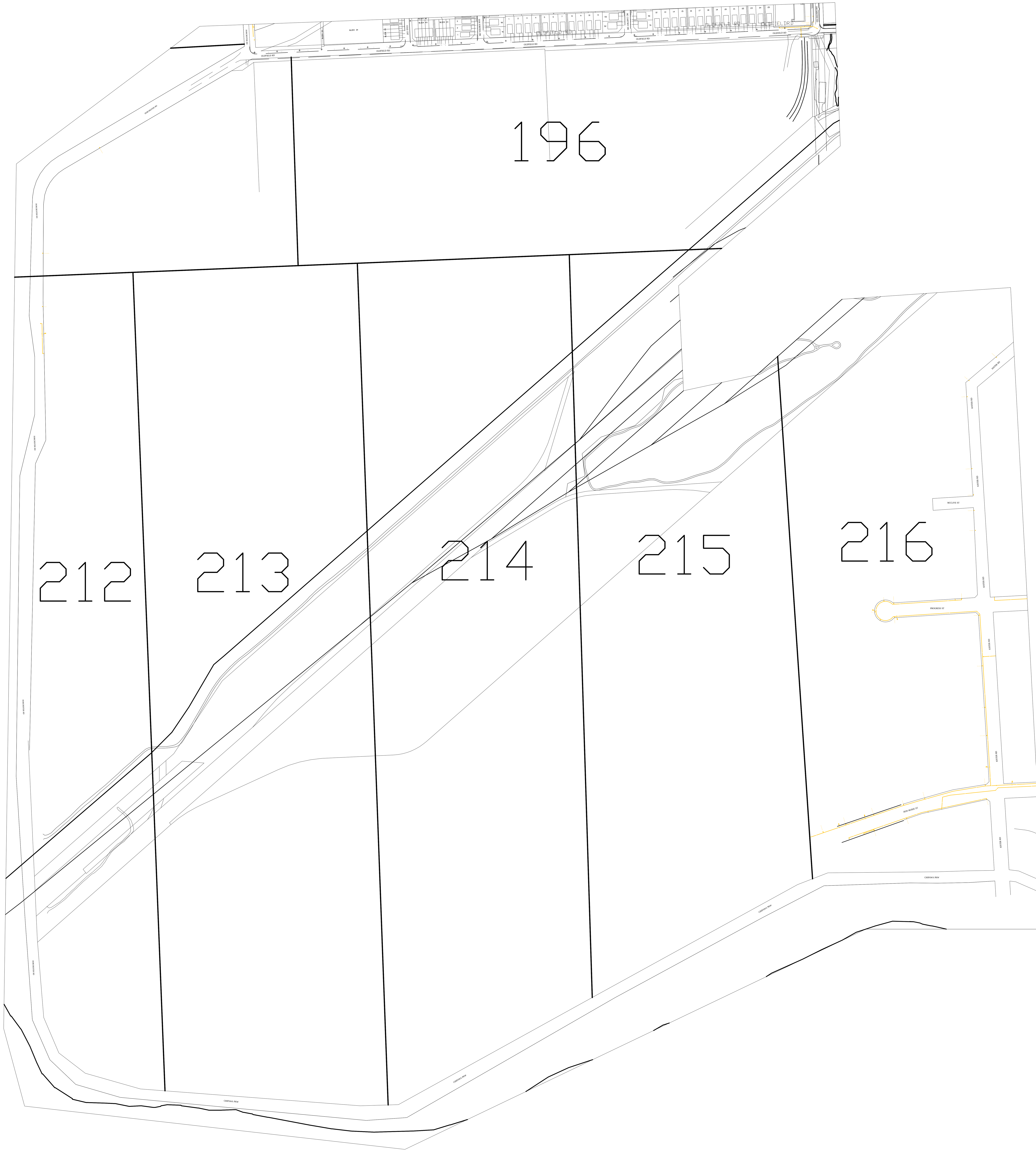
Last Saved: 2016-06-21

APPENDIX D

EXISTING UTILITY PROVIDER MAPS



PLEASE NOTE:

THIS DRAWING IS FOR MARKUP ONLY - NOT FOR PERMIT TO PROCEED CONSTRUCTION. BELL CANADA PLANT LOCATION IS APPROXIMATE.

BELL CANADA

Municipal Operations Department
Floor 5 Blue, 100 Borough Drive
Scarborough, Ontario, M1P 4W2
Ph. 416-296-6929

Bell Canada Legend Info

C	Existing Conduit
B	Existing Buried Cable
BP	Existing Bell Pole
	Existing Pedestal

CALL FOR LOCATES
1-800-400-2255

HAND DIG
if within 1m of Bell plant

HAND DIG
when crossing Bell plant

Maintain clearance of 0.6m

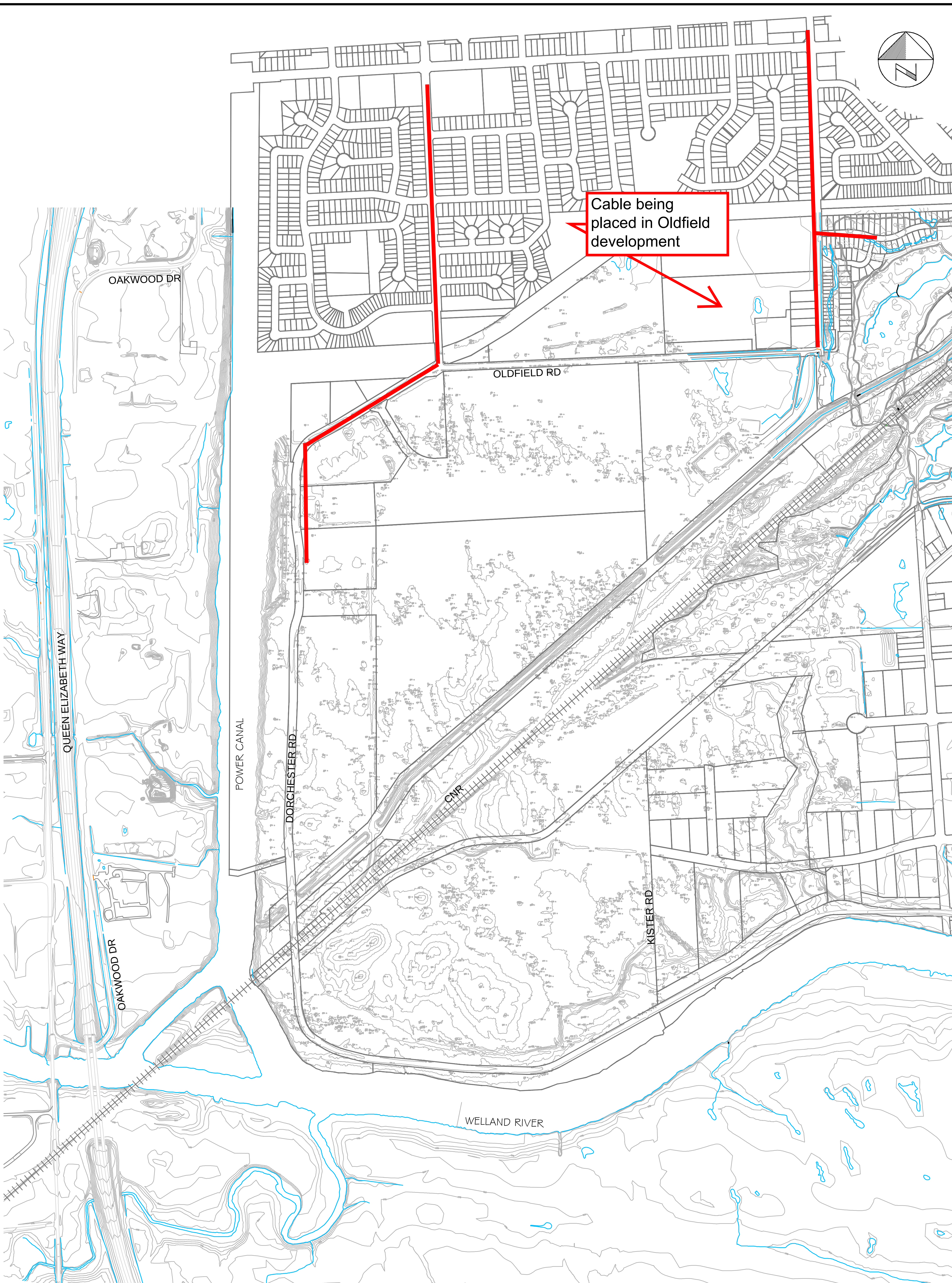
If further details required
You must acquire Locates or Test Pits

telecon design MEMBER OF TELECON GROUP
200 TOWN CENTRE BLVD, SUITE 300
MARKHAM, ONT, CANADA L3R 8G5
TEL: (905) 470-2112
FAX: (905) 470-8956

Dwg # - 1

Mark Up # - 51911

Designer - ROSANNA SANCHEZ



LEGEND

- WATER MAIN
- SANITARY SEWER
- PROPERTY LINE
- STORM MANHOLE
- SANITARY MANHOLE
- STORM CATCHBASIN

SCALE VALID ONLY FOR 24"x36" VERSION

THUNDERING WATERS SECONDARY PLAN CITY OF NIAGARA FALLS	STUDY AREA	amec foster wheeler	Scale 1:5000 (0 50 100 200) Consultant File No. TP115026 Figure No. 1

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Plotted: 2015-09-02
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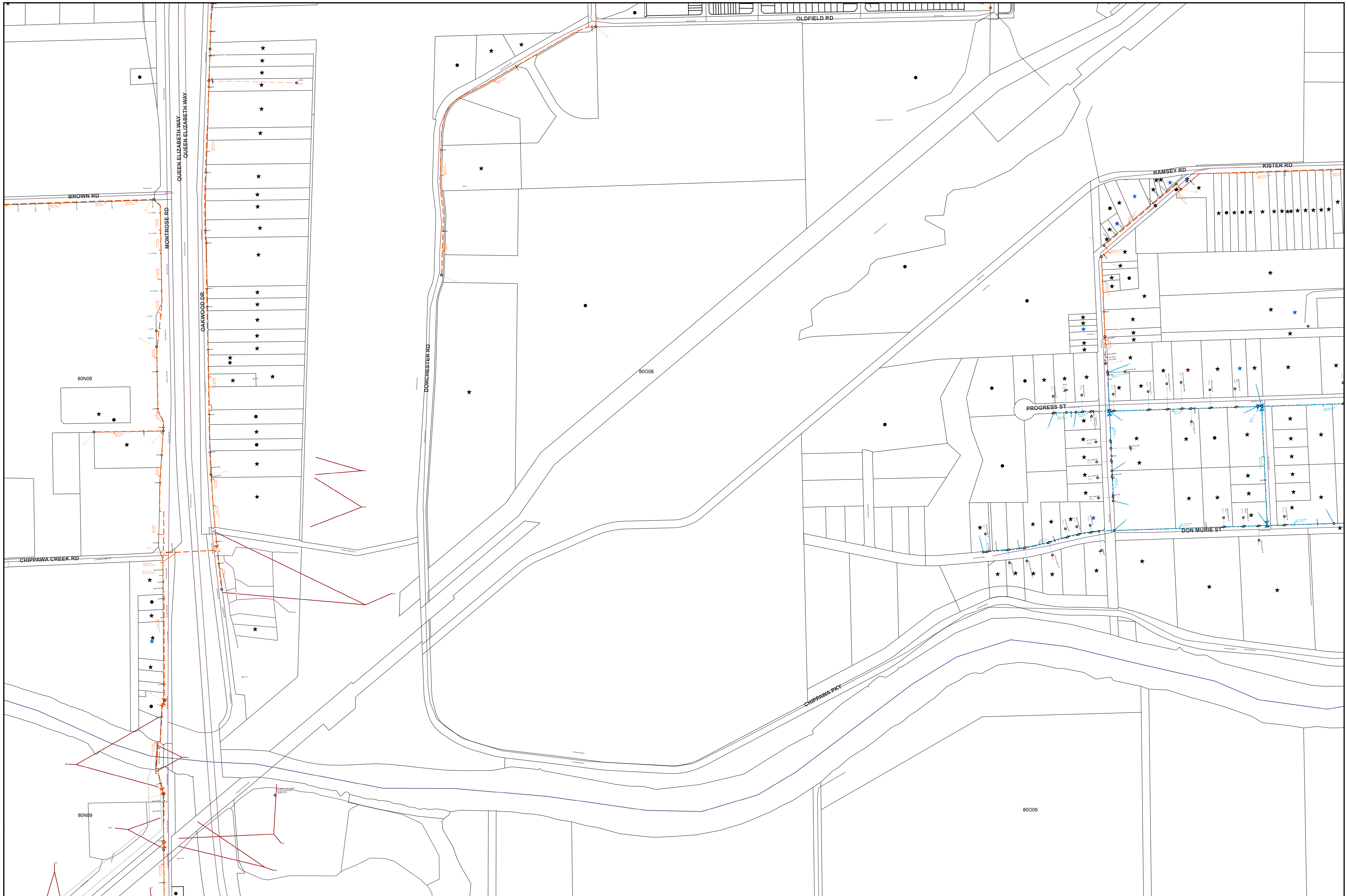
Last Saved: 2015-09-02



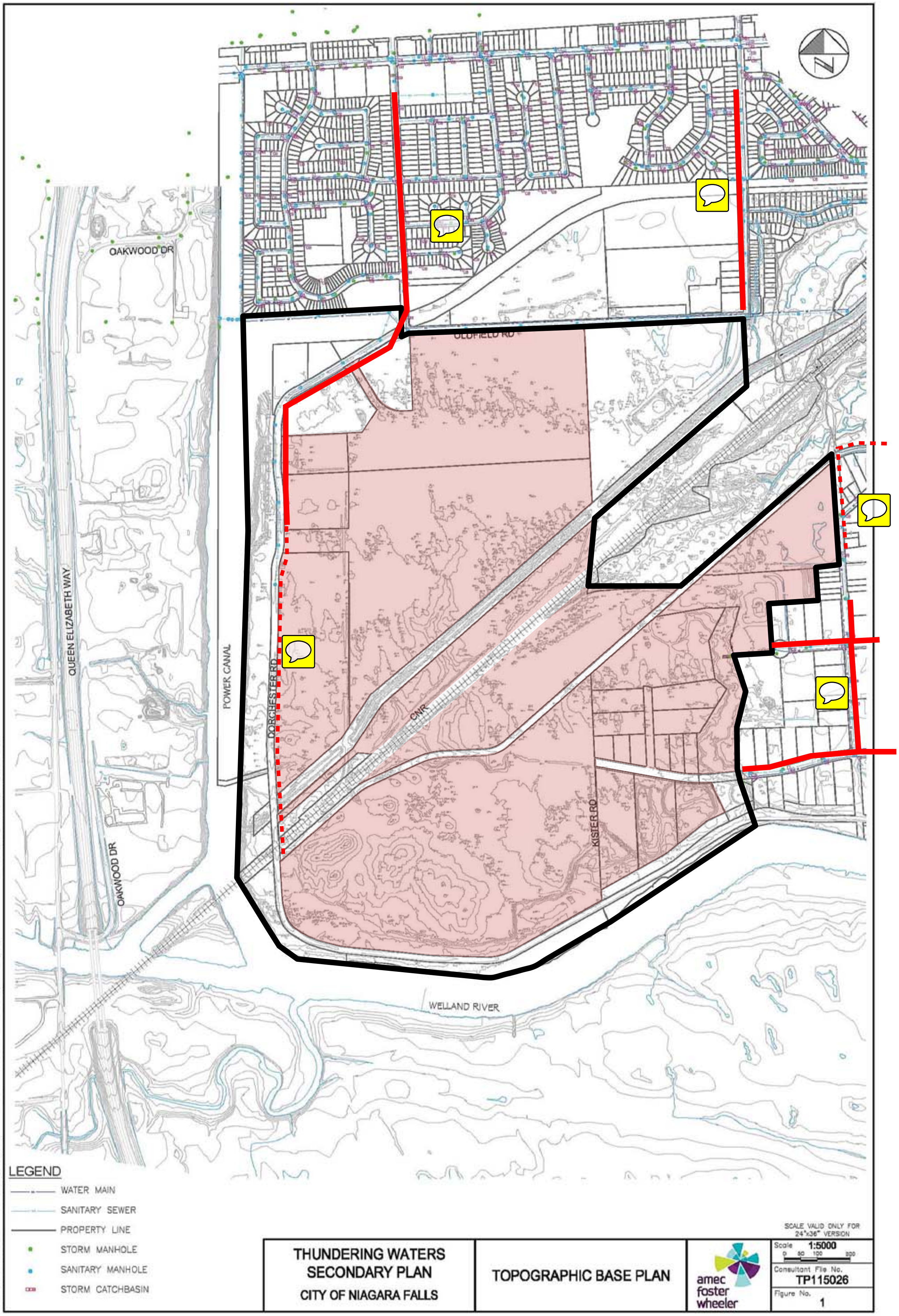
N

ENBRIDGE

Plotted By: Robert D'Onofrio

Date Plotted: 9/17/2015 7:52:51 AM

Note : Map is not to scale.



Proposed Secondary Plan Study Area

Lands Owned by GR(CAN) Investments

APPENDIX E

TERMS OF REFERENCE FOR FUNCTIONAL SERVICING PLAN

Niagara Falls Paradise Development

Terms of Reference for Functional Servicing Plan

Niagara Falls, Ontario

Prepared for:

GR (CAN) Investment Co., LTD

Prepared by:

Amec Foster Wheeler
3215 North Service Road
Burlington, ON L7N 3G2
(905) 335-2353

July 2015 (Updated August 26, 2015)

Project No. TP115026

NIAGARA FALLS PARADISE DEVELOPMENT

“Draft” Terms of Reference Functional Servicing Plan

Submitted to:

GR (CAN) Investment Co., LTD

Submitted by:

Amec Foster Wheeler Environment & Infrastructure
3215 North Service Road
Burlington, ON L7N 3G2
(905) 335-2353

July 2015
(Updated August 26, 2015)

TP115026

TABLE OF CONTENTS

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LIST OF APPENDICES

1.0 PURPOSE AND OBJECTIVES

To prepare a Functional Servicing Plan in support of the Niagara Falls Paradise Development Secondary Plan area, to document existing service conditions and capacities, prepare a conceptual servicing master plan for the proposed development with order of magnitude costs to address the ultimate build out of the area as per the proposed area land use. To satisfy the joint requirements of the Environmental Assessment and Planning Acts.

Objectives:

1. Assess the existing servicing capacities of the water, wastewater and stormwater systems.
2. Analyze the impact of the proposed development on the existing systems using current MOECC, Region of Niagara, and City of Niagara Falls standards for development.
3. Determine site servicing feasibility and requirements for new infrastructure and any necessary upgrades to the existing infrastructure systems (linear and treatment).
4. Consider the potential opportunities and needs of other utility servicing such as gas, hydro, and communications.
5. Establish management and servicing strategies consistent with the recommendations of the EIS.
6. Address the requirements of the MEA Class Environmental Assessment process (2011).

2.0 BACKGROUND INFORMATION

Amec Foster Wheeler staff met with City of Niagara Falls, Niagara Region, and NPCA staff April 17, 2015 (ref. Appendix A for Meeting Minutes) to pre-consult on municipal servicing requirements and develop an improved understanding of available background information. In terms of the Functional Servicing Plan, the available information is specific to water, wastewater, stormwater, and related utilities. The City of Niagara Falls subsequently provided information related to the following:

- Con Rail Drain
    - 12 tif images and geotechnical report
- Master Drainage Plan Update Study
- Culvert plan depicting locations
    - Review of Municipal Servicing Requirements Thundering Waters, Warren Woods, NCLG, R.V. Anderson,
    - Thundering Waters Estates Stormwater Management Plan
    - related OLS surveys
    - Plan and Profile images of various infrastructure
    - Storm District maps, excerpts from Storm Drainage Report Volume 1 December 1981, Storm Drainage Report Volume 2 December 1981
    - storm drainage maps
    - plans of watermains
    - Area Geotechnical investigations Don Murray Street wall
    - GIS Shape files for:
        - contours
        - parcels
        - road centre lines
        - sanitary mains
        - sanitary maintenance holes
        - storm inlet structures
        - storm maintenance holes
        - watermains
    - Thundering Waters UEM Site Servicing Feasibility Study

Further information has been requested from the Region of Niagara, including the water and wastewater models and as-builts for Regional trunk systems, specifically existing water and wastewater infrastructure.

3.0 CONSULTATION

As noted, a focussed consultation meeting was held in April 2015 to review specific requirements related to the preparation of the FSP; these include, as follows (ref. Appendix A for full documentation of meeting):

i) Need to contact private utilities including hydro, gas, and telecommunications to determine the approach to servicing the subject developments, including any potential barriers.
ii) City recommended OPG be contacted, particularly with respect to any restrictions associated with its adjacent land use. [Note: Appendix A provides documentation of the meeting with OPG and the associated outcomes.]
iii) Need to contact MTO, given the potential for interest in the property and related transportation concerns. [Note: Separate Terms of Reference have been prepared for the Transportation Master Plan.]
iv) City staff expressed the need to include meetings with the Stanley Avenue Business Park Group and OPG throughout the consultation process.
v) As part of the Class EA procedures, the City recommended a minimum of two (2) Public Information Centres (PIC) to solicit public participation.
vi) Land development south of the Welland River, referred to as Veda Lands, will require separate consultation as this is within the servicing catchment for sanitary drainage.
vii) For the Class Environmental Assessment, it will be necessary to include factors such as the natural, social, economic, and functional environments.
viii) City will maintain contact with the PUCC regarding local utility companies.
ix) City advised that area servicing work would be Development Charge eligible.
x) City advised that Con Rail Drain is not a Municipal Drain.
xi) NPCA advised that lands will require *Normal* (Level 2) water quality treatment.
xii) It is recognized that Low Impact Development measures are appropriate and encouraged.

4.0 WORK PLAN TASKS

A. Background Information Collection and Review and Consultation

		Deliverable
Task 1:	Gather background data, information and mapping from City, Region, MTO, MNRF, NPCA and OPG. Conduct a data gap analysis and determine need and approach to any supplemental information collection. Summarize relevance to current study of functional servicing.	*Report Section summarizing background information*
Task 2:	Meet with development proponent south of Welland River (Veda Lands) to determine intent and status of development plans.	*Meeting Minutes*
Task 3:	Contact private utility providers [gas, hydro (OPG and NPEI) and communications] to determine the existing services/utilities and general approach to servicing the proposed development area. Analysis of loads and requirements will not be completed, rather the opportunities and barriers will be identified with input from the utilities.	*Plans of area plant from utilities*
Task 4:	Prepare a summary of available background data/information and circulate for review to ensure completeness.	*Summary per task*

B. Class Environmental Assessment – Public Consultation

Task 1:	A Notice of Study will be prepared in accordance with the provisions of the Environmental Assessment (EA) Act. The objective would be to ensure that the Functional Master Plans (Storm, Sanitary, and Water) for servicing this Secondary Plan area suitably address the needs of the EA Act as formal Master Plans to address Phases 1 and 2, while concurrently supporting the Planning Act provisions. It is assumed that a fully integrated Notice of Study, including the planning and transportation components will be prepared, for clarity before the regulators and the Public.	*Notice (Note: Newspaper charges not included)*
Task 2:	Public Information Centre (PIC) #1 will be held shortly after gathering and summarizing all background data and information. The purpose will be to present to the public and stakeholders the objectives of the overall study (including land use and transportation) focussed on the background studies and related schedule.	*PIC Panels, PowerPoint, Handouts, & Summary of PIC*
Task 3:	Public Information Centre (PIC) #2 will be held following the generation of a land use plan and servicing alternatives and assessment of same for stormwater, water, and sanitary. The objective of this Public meeting will be to provide the attending public with a clear understanding of the Study Objectives, associated Problem Statement, alternatives, related screening and assessment, leading to a preferred servicing solution.	*PIC Panels, PowerPoint, Handouts, & Summary of PIC*

		Deliverable
Task 4:	Public Information Centre (PIC) #3 will be held following the refinement of the land use and servicing plans based on input from the City, Agencies and Public. The preferred Master Plan Solutions for the land use plan for Thundering Waters will be presented.	*PIC Panels, PowerPoint, Handouts, & Summary of PIC*

C. Existing System Assessment

Task 1:	Review existing services (water, wastewater and storm) and related facilities within, and adjacent to, the Niagara Falls Paradise Development Secondary Plan area and determine current capacities and what additional inputs can be supported. This will need to be done through review and execution of existing models and associated analyses of the existing systems pipe sizes, and assumed input. In addition, acquire flood risk mapping for Power Canal and Welland River from Niagara Peninsula Conservation Authority (NPCA) and review / update accordingly.	*Updated existing system models for water, waste water and stormwater*
Task 2:	Prepare a Draft Preliminary Report detailing the existing assessment and associated constraints and meet with the City of Niagara Falls, Region of Niagara, and NPCA to provide an overview of the associated findings.	*Draft Preliminary Report; Meeting Minutes*
Task 3:	Update the Preliminary Report on the basis of any input received from the meeting with the City of Niagara Falls, Region of Niagara, and NPCA.	*Updated Preliminary Report*

D. Future Land Use Impact Assessment and Management Plan

Task 1:	Review the initial Niagara Falls Paradise Development Secondary Plan area and identify service connection locations from the lands to the existing systems adjacent to the proposed lands and recommend any internal measures that may be required such as pumping stations, booster stations etc.	*Conceptual Servicing Layout*
Task 2:	Prepare a functional servicing layout detailing possible upgrades/improvements to current services and capacities. This will need to be completed by modelling the proposed development within the framework of the existing system models and determining required upgrades to system geometry (to address capacity issues in the existing system) and any potential upgrades to existing water supply and treatment facilities, as a result of the proposed development.	*Future system models (stormwater/ Wastewater/ Water)*
Task 3:	Review existing fire flow capacities and identify future requirements.	*Future Requirements for Fireflow*

Task 4:	Determine locations for service extensions for sanitary sewer, watermain and storm sewers as necessary. Consideration will also need to be given to on-site stormwater, Low Impact Development (LID) Best Management Practices (BMPs) to reduce the impacts of storm water on the existing sewer systems and any proposed new outfalls to the river.	*Refined Servicing Layout and related BMPs*
Task 5:	Establish stormwater management criteria and determine appropriate strategy to manage surface runoff for future build out conditions.	*Stormwater Management Criteria and Strategy*
Task 6:	Review existing topographic information for the proposed development area and the elevations of existing servicing at the proposed connection points. Prepare a functional grading plan. If grading alone is not considered practical for servicing, recommend locations for additional measures such as pumping stations.	*Functional Grading Plan*
Task 7:	Determine preliminary costs for expansion of existing services and/or bringing in new services with higher capacities. Investigate any potential alternative funding sources.	*Preliminary costs for expansion of existing services*
Task 8:	Prepare draft Functional Servicing Study report addressing the study goals, objectives and tasks, and submit to the City, Region and NPCA for review and comments.	*Functional Servicing Plan Report*
Task 9:	Revise draft report based on comments received, and prepare and submit a final report addressing the requirements of the Class EA servicing as a functional master plan for the Secondary Plan area.	*Revised Report*

5.0 SCHEDULE

The schedule will need to recognize the concurrent streams of support work related to the Environmental Impact Study, Transportation Plan and Land Use Plan, which will all contribute to the generation of both land use and servicing for this development. Generally, the schedule will be as follows:

Pre-consultation:	Spring 2015
Background Information Collection and Review :	Spring/Summer 2015
Existing System Assessment:	Summer/Fall 2015
Impact Assessment/Management Plan:	Winter 2016

Appendix A

Consultation