FUNCTIONAL SERVICING & STORMWATER MANAGEMENT REPORT

6888 DRUMMOND ROAD

CITY OF NIAGARA FALLS
REGIONAL MUNICIPALITY OF NIAGARA

PREPARED FOR:

SIGMA GROUP

PREPARED BY:

C.F. CROZIER & ASSOCIATES INC.
2800 HIGH POINT DRIVE, SUITE 100
MILTON, ON L9T 6P4

APRIL 2024

CFCA FILE NO. 2658-7080

CROZIER
CONSULTING ENGINEERS

Revision Number	Date	Comments
Rev. 0	April 26, 2024	Issued for First Submission (OPA/ZBA)

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1.0 Introduction

Crozier Consulting Engineers (Crozier) was retained by Sigma Group to prepare a Functional Servicing & Preliminary Stormwater Management Report in support of an Official Plan Amendment (OPA) and Zoning By-Law Amendment (ZBA) for the site located at 6888 Drummond Road, in the City of Niagara Falls.

This report demonstrates how the proposed development's functional servicing and stormwater management will integrate with the existing water, sanitary, and stormwater infrastructure.

2.0 Site Description

The subject property covers an area of 1.15 ha and is bound by and Drummond Road to the west, residential properties to the south, and a commercial restaurant to the north.

The proposed development is a 4-storey long-term care building, with 189 proposed beds. Site access will be provided via Drummond Road and the development will provide above ground parking.

3.0 Equivalent Population

The Regional Municipality of Niagara's Development Charges Background Study dated May 30, 2022, was used to determine an equivalent population estimate for the proposed residential development. The results are provided in

Table 1 Detailed calculations for Table 1 are provided in Appendix A.

Table 1: Equivalent Population Estimate

Residential	Unit Type	Unit Count	Unit Density	Population
	1 Bedroom	189	1.1	208
Institutional	**-**	**GFA (sq m)**	**Density (persons/sq m)**	**Population**
	-	15,868	63.17	251
Total Population	**459**			

The equivalent populations presented in Table 1 will be used to calculate the water demand and sanitary flow for the proposed development.

4.0 Water Servicing

The following section of the report analyses the existing and proposed domestic and fire water servicing conditions for the development. The Water Master Servicing Plan Update report dated December 5, 2023 developed by Niagara Region was referenced to calculate domestic and fire flow demands for the site.

4.1 Existing Water Servicing

A review of the as-constructed drawings and preliminary base plan received from the City of Niagara Falls shows an existing 300mm water watermain located on Drummond Road. The locations of the existing water services are shown on figure C701.

4.2 Design Water Demand

The Water Master Servicing Plan Update report dated December 5, 2023, was used to determine the maximum domestic water demand generated, by using residential and institutional water demands of 240 and 270 Lpcd respectively. Table 2 summarizes the estimated design water demand. Appendix A contains detailed calculations.

Table 2: Proposed Domestic Water Demand

	Average Daily Demand (L/s)	**Maximum Daily Demand** (L/s)	**Peak Hour Demand** (L/s)
Existing	0.00	0.00	0.00
Proposed	1.36	2.18	2.25

As shown in Table 2, the proposed peak hour demand will be 2.25 L/s, which is an increase of 2.25 L/s as compared to the existing peak hour demand.

4.3 Fire Flow Demand

The Fire Underwriters Survey (FUS) method was used to estimate the fire flow demand for the proposed development. We assumed the proposed buildings will use Type II, non-combustible construction and therefore, a coefficient of 0.8 is applied to the fire flow calculations (Water Supply for Public Fire Protection by Fire Underwriters Survey, 2020). This assumption was confirmed by the architect. This confirmation can be seen in Appendix A. An assumption was made that they proposed building will be equipped with a sprinkler system which reduces the initial fire flow demand by up to 30%. The automated sprinkler system is to be designed by the Mechanical Engineer; therefore, the detailed design of the system is not included in this report. Table 3 summarizes the required fire flow demand and duration of flow required.

Table 3: Estimated Fire Flow Demand

Standard	**Demand Flow** (L/s)	**Duration** (h)
Water Supply for Public Fire Protection by Fire Underwriters Survey (2020)	133.33	2.00

Note: Floor area was determined by the largest floor plus 25% of each of the two immediately adjoining floors.

As shown in Table 3, the proposed fire line for the proposed development is required to accommodate a fire flow demand of 133.33 L/s for a duration of 2.00 hours.

Refer to Appendix A for detailed calculations of the proposed fire flows.

4.4 Proposed Water Servicing

The proposed water servicing for the new development will include domestic and fire service. The diameter of the proposed domestic and fire service will be 150mm and 200mm respectively and will connect to the existing 300mm watermain located on Drummond Road.

Fire protection will be provided through existing municipal fire hydrants on Drummond Road and Siamese connection located near the northwest corner of the site. The proposed water servicing can be seen on figure C701.

5.0 Sanitary Servicing

The following section of the report analyses the existing and proposed sanitary servicing conditions for the development. The Water Master Servicing Plan Update report dated December 5, 2023, developed by Niagara Region was referenced to calculate sanitary demands for the site.

5.1 Existing Sanitary Servicing

A review of the as-constructed drawings and preliminary base plan received from the City of Niagara Falls shows an existing 900mm sanitary sewer located on Drummond Road. The locations of the existing sanitary services are shown on figure C701.

5.2 Sanitary Design Flow

The Water Master Servicing Plan Update report dated December 5, 2023, was used to determine the maximum sanitary demand generated, by using residential and institutional water demands of 255 and 310 Lpcd respectively. Table 4 summarizes the estimated design water demand. Appendix B contains detailed calculations.

Table 4: Proposed Sanitary Design Flow

	Average Daily Flow (L/s)	**Peak Flow** (L/s)	**Infiltration Flow** (L/s)	**Total Design Flow** (L/s)
Existing	0.00	0.00	0.46	0.46
Proposed	1.51	6.05	0.33	6.38

As shown in Table 4, the proposed design flow will be 6.38 L/s, which is an increase of 5.92 L/s as compared to the existing design flow.

5.3 Proposed Sanitary Servicing

The site will be serviced by a proposed 250mm sanitary lateral at a slope of 0.5%. The proposed sanitary lateral will include a proposed 1200mm diameter property line manhole SAN MH 1A, before tying into the existing 900mm diameter sanitary sewer along Drummond Road using a proposed Doghouse style manhole.

The sanitary servicing layout is shown on the Preliminary Servicing Plan figure C701

6.0 Stormwater Drainage Conditions

6.1 Existing Drainage Conditions

The subject property is comprised of an undeveloped green field, with a catch basin located to the south of the site. In accordance with the City of Niagara Falls design standards a pre-development runoff coefficient of 0.30 was used to model the existing condition. The site generally drains to the south where it is captured by a catch basin and drained onto Churchill street.

6.2 Proposed Drainage Condition

The proposed development as consists of a 4-storey long term care building. In addition to the construction of the new building, there is an internal roadway, surface parking, associated landscaping and a proposed bioretention cell.

The site cannot match pre-development drainage, as this would require drainage through the neighbouring property for which an easement does not exist. Due to this constraint, the minor system for the site has been designed to convey flows up to and including the 100-year storm event before discharging onto Drummond Road.

The site is divided into three catchments. Catchment 201 represents the building, which ultimately drains towards Drummond Road. Catchment 202 represents the western half of the parking lot, which is captured through 100-year pipes and drained onto Drummond Road. Overland flow during storm events greater than the 100-year storm from Catchments 201 and 202 is proposed to drain overland onto Drummond Road.

Catchment 203 represents the eastern half of the parking lot, which is captured through 100-year pipes and ultimately released onto Drummond Road. Overland flow during storm events greater than the 100-year storm from this catchment is proposed to run overland through the southeastern parking lot ultimately reaching Churchill Street. While every effort has been made to convey drainage to Drummond Road, the site naturally falling towards the southeast presents a great challenge in changing the overland flow direction, and as a result this existing condition is proposed to remain.

Catchment 201 has a corresponding runoff coefficient of 0.90, and Catchment 202 has a corresponding runoff coefficient of 0.79. Finally, catchment 203 has a corresponding runoff coefficient of 0.64.

7.0 Stormwater Management

As the site is in the City of Niagara Falls, the proposed stormwater management design must comply with the following documents:

- City of Niagara Falls Engineering Design Guidelines Manual, 2012
- Niagara Region, Wastewater Master Servicing Plan, 2017

Table 5 provides a summary of the stormwater management criteria based on the stormwater management design guidelines and consultation with Town Staff.

Table 5: Summary of Stormwater Management Controls

Control Parameter	Catchments 201, 202 and 203
Quantity	Match post-development flow to no greater than pre-development rates for all storms up to the 100-year event.
Quality	Achieve Ontario Ministry of the Environment, Conservation and Parks Enhanced Level of protection (80% total suspended solids (TSS) removal)
Erosion and Sediment	Provided during construction and until the site is stabilized. To be designed at the detailed design stage.

The following sections describe how the stormwater management criteria are adhered to on the subject property.

7.1 Stormwater Quantity Control

The Modified Rational Method was used to determine the pre-development and post-development flow rates for the site using Niagara Fall’s intensity-duration-frequency (IDF) rainfall data. The pre-development flow rates were compared to the post-development flow rates for storms up to the 100-year event to determine the on-site storage required. Table 6 summarizes the calculated release rates and subsequent on-site storage volume required to achieve the quantity control requirement.

Table 6: Summary of Peak Flow and Storage Volume

Storm Event (yr)	**Peak Flow Rate** (L/s)			**Required Storage** (m^3)	**Provided Storage** (m^3)
	Pre-Development (L/s)	**Post-Development** (L/s)			
		Uncontrolled	**Controlled**		
2	0.081	0.200	0.079	95.8	255.0
5	0.103	0.255	0.094	135.2	
10	0.131	0.323	0.108	179.7	
25	0.135	0.336	0.114	197.9	
100	0.164	0.405	0.129	255.0	

1. The entire site is controlled flow based on a 200 mm orifice tube.

Based on the results in Table 6, a 200 mm orifice tube is required downstream of the underground stormwater tank to attenuate peak flows in catchments 201-203 such that the total post-development peak flows are less than the pre-development peak flow rates. To achieve the controlled peak flow in catchment 201, approximately 255.0 m^3 of on-site stormwater storage is required upstream of the orifice tube. The on-site storage will be provided by an underground storage chamber which will design as part of detailed design.

Please refer to Appendix C for detailed stormwater management calculations.

7.2 Stormwater Quality Control

Stormwater quality controls for the site must incorporate measures to provide an Enhanced Level of Protection (Level 1) according to the Ontario Ministry of the Environment, Conservation and Parks (MECP formerly MOE) March 2003 guidelines. Enhanced water quality protection involves the removal of at least 80% of total suspended solids (TSS) from 90% of the annual runoff volume.

Water quality control will be provided though an oil and grit separator which will specified as part of detailed design.

8.0 Erosion and Sediment Controls During Construction

Erosion and sediment controls (ESC) will be installed prior to the start of any construction activities and will be maintained until the site is stabilized or as directed by the Site Engineer or the Town of Ajax. The Contractor will inspect the ESC after each significant rainfall event to ensure they are maintained in proper working condition. The ESC strategy and location of the recommended control features will be designed at detailed design and will include but not be limited to the below items:

<u>Sediment Control Fencing</u>

Sediment control fencing will be installed on the perimeter of the site to intercept sheet flow. Based on field decisions, the Site Engineer and the Owner may add additional sediment control fencing prior to, during, and following construction.

<u>Rock Mud Mat</u>

A rock mud mat will be installed at the entrance to the construction zone in order to prevent mud tracking from the site onto the surrounding lands and perimeter roadway network. All construction traffic will be restricted to this access only.

Filter Cloth in Catch Basins

Filter cloth will be installed in the existing nearby storm sewer catch basins. The filter cloth will provide sediment control to prevent silt and sediment from entering the stormwater system. Filter fabric for silt control should be Terra Fix 270R or approved equivalent.

9.0 Conclusions and Recommendations

The proposed development can be serviced for water, sanitary, and stormwater in accordance with the City and Region of Niagara Falls' requirements and standards. Our conclusions and recommendations include:

1. Water servicing for the proposed development will be provided using a 200 mm diameter fire line and a 150 mm diameter domestic line extending from the existing 300 mm diameter watermain on Drummond Road.

2. Sanitary servicing for the proposed development will be provided by 250mm diameter PVC sanitary laterals at 0.5% before ultimately tying into the existing 900mm diameter sanitary sewer along Drummond Road.

3. The Stormwater for the Site is controlled using a underground stormwater tank that has been sized to hold $255m^3$ from catchment 201. The tank will release into the storm sewers at a controlled peak flow rate through the use of a 200mm orifice tube that is less than the pre-development peak flow rate.

4. An oil/grit separator (OGS) has been proposed as a method of quality control for the flows from the proposed storm tank before they enter the storm sewer along Drummond Road.

Based on the conclusions, we recommend the approval of the development application for the site from the perspective of functional servicing and stormwater management.

Respectfully submitted,

C.F. CROZIER & ASSOCIATES INC.

C.F. CROZIER & ASSOCIATES INC.

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/LE

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APPENDIX A

Water Demand Calculations

CROZIER
CONSULTING ENGINEERS

Project: 6888 Drummond Road
Project No.: 2658-7080
Created By: LE
Checked By: JB
Date: 4/17/2024
Updated: 4/26/2024

Existing Domestic Water Demand

Site Area: 1.153 ha
One Bedroom Unit count: 0
One bedroom density: 1.1 persons/unit
Residential population: 0
Total GFA: 0.00 ha
Institutional Density: 63.17 employee/sqm
Institutional Population: 0
Total Population: 0

Design Parameters

Residential Average Demand (L/capita/d)
240

Commercial Average Demand (L/capita/d)
270

Water Demand:

Average Daily Demand = - L/day
0.00 **L/s**

Peaking Factors
Max Day = 1.60
Peak Hour = 1.65

Average Day = 0.00 L/s
Max Day = **0.00** L/s
Peak Hour = **0.00** L/s

Municipality	Average Daily Water Demand (L/s)	Max Day Demand (L/s)	Peak Hourly Demand (L/s)
Region of Peel	0.00	0.00	0.00

Notes & References

Site Statistics from Site Plan provided by Arcavia LTC

Population Densities obtained from Development Charges Background Study dated May 30, 2022

Region of Niagara 2021 Water and Wastewater Master Servicing Plan Update - Volume 3

Region of Niagara 2021 Water and Wastewater Master Servicing Plan Update - Volume 3

Max Day = Max Day * Average Day Demand
Peak Hour = Average Day Demand * Peak Hour

CROZIER
CONSULTING ENGINEERS

Project: 6888 Drummond Road
Project No.: 2658-7080
Created By: LE
Checked By: JB
Date: 4/17/2024
Updated: 4/26/2024

Domestic Water Demand

Site Area:	1.153	ha
One Bedroom Unit count:	189	
One bedroom density:	1.1	persons/unit
Residential population:	208	
Total GFA:	1.59	ha
Institutional Density:	63.17	employee/sqm
Institutional Population:	251	
Total Population:	459	

Design Parameters

Residential Average Demand (L/capita/d)
240

Commercial Average Demand (L/capita/d)
270

Water Demand:

Average Daily Demand =	117,719	L/day
	1.36	**L/s**

Peaking Factors

Max Day = 1.60
Peak Hour = 1.65

Average Day =	1.36	L/s
Max Day =	**2.18**	L/s
Peak Hour =	**2.25**	L/s

Municipality	Average Daily Water Demand (L/s)	Max Day Demand (L/s)	Peak Hourly Demand (L/s)
Region of Peel	1.36	2.18	2.25

Notes & References

Site Statistics from Site Plan provided by Arcavia LTC

Population Densities obtained from Development Charges Background Study dated May 30, 2022

Region of Niagara 2021 Water and Wastewater Master Servicing Plan Update - Volume 3

Region of Niagara 2021 Water and Wastewater Master Servicing Plan Update - Volume 3

Max Day = Max Day * Average Day Demand
Peak Hour = Average Day Demand * Peak Hour

From: Steve Mauro <SMauro@chamberlainipd.com>
Sent: Monday, April 22, 2024 11:26 AM
To: Liam Ellis; Menna Ali
Cc: James Boyd
Subject: RE: 6888 Drummond Rd - Fire Underwriters Survey Assumptions

Yes this is correct

Stephen Mauro, B. Arch Sci, MArch. OAA Architect
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From: Liam Ellis <lellis@cfcrozier.ca>
Sent: Monday, April 22, 2024 10:21 AM
To: Steve Mauro <SMauro@chamberlainipd.com>; Menna Ali <mali@chamberlainipd.com>
Cc: James Boyd <jboyd@cfcrozier.ca>
Subject: 6888 Drummond Rd - Fire Underwriters Survey Assumptions

Hi Menna and Stave,

For our upcoming submission, I was hoping you'd be able to help with confirming a few items we use for our calculations in our FSR report.

We will need to confirm the building construction type and coefficients we have assumed below:

Building Construction Type = **Noncombustible Construction** (Type II), (assuming a 0.8 coefficient in our Fire Underwriter's Survey calculation)
Occupancy Factor = **Limited Combustible Contents** (including furniture and equipment with low combustibility), (assuming a 15% reduction in our Fire Underwriter's Survey calculation)
If there are any adjustments to our assumptions that we should make, please let me know.

Thanks,

Liam Ellis
Engineering Assistant, Land Development
Office: 437.290.8998
Collingwood | Milton | Toronto | Bradford | Guelph

CROZIER & ASSOCIATES
Consulting Engineers

6888 Drummond Road
Fire Protection Volume Calculation
CFCA File: 2658-7080

Date: 4/26/2024
Design: L.E.
Check: J.B.

Water Supply for Public Fire Protection - 2020
Fire Underwriters Survey

Part II - Guide for Determination of Required Fire Flow

1. An estimate of fire flow required for a given area may be determined by the formula:

$$F = 220 * C * \text{sqrt } A$$

where

F = the required fire flow in litres per minute

C = coefficient related to the type of construction:
= 1.5 for Type V Wood Frame Construction
= 0.8 for Type IV-A Mass Timber Construction
= 0.9 for Type IV-B Mass Timer Construction
= 1.0 for Type IV-C Mass Timber Construction
= 1.5 for Type IV-D Mass Timber Construction
= 1.0 for Type III Ordinary Construction
= 0.8 for Type II Non-combustible Construction
= 0.6 for Type I Fire-Resistive construction

A = The total floor area in square metres

Proposed Buildings

GFA 3rd Floor	3601 sq.m	100%
GFA 2nd Floor	3601 sq.m	25%
GFA 4th Floor	3597 sq.m	25%
Total Area =	5400.5 sq.m	

C = 0.8 Assume fire-resistive construction (fully protected frame, floors, roof)

Therefore F = 12,934 L/min

Fire flow determined above shall not exceed:
30,000 L/min for wood frame construction
30,000 L/min for ordinary construction
25,000 L/min for non-combustible construction
25,000 L/min for fire-resistive construction

2. Values obtained in No. 1 may be reduced by as much as 25% for occupancies having low contents fire hazard or may be increased by up to 25% surcharge for occupancies having a high fire hazard.

Non-Combustible	-25%	Free Burning	15%
Limited Combustible	-15%	Rapid Burning	25%
Combustible	0% (No Change)		

Limited Combustible	-15% Reduction

-1,940 L/min reduction
10,994 L/min

Note: Flow determined shall not be less than 2,000 L/min

3. Sprinklers - The value obtained in No. 2 above maybe reduced by up to 50% for complete automatic sprinkler protection. The credit for the system will be a maximum of 30% for an adequately designed system conforming to NFPA 13 and other NFPA sprinkler standards.

As part of this analysis, building is assumed to have sprinkler protection (30% reduction),

-3,298 L/min reduction

Water Supply for Public Fire Protection - 2020
Fire Underwriters Survey

Part II - Guide for Determination of Required Fire Flow

4. Exposure - To the value obtained in No. 2, a percentage should be added for structures exposed within 30 metres by the fire area under consideration. The percentage shall depend upon the height, area, and construction of the building(s) being exposed, the separation, openings in the exposed building(s), the length and height of exposure, the provision of automatic sprinklers and/or outside sprinklers in the building(s) exposed, the occupancy of the exposed building(s) and the effect of hillside locations on the possible spread of fire.

Separation		Charge	Separation	Charge
0 to 3 m	Max.	25%	20.1 to 30 m Max.	10%
3.1 to 10 m	Max.	20%	> 30m	0%
10.1 to 20 m	Max.	15%		

Per Table 6 "Exposure Adjustment Factors for Subject Building considering Construction Type of Exposed Building Face", the above table of exposure factors is the maximum to be used. The length to height ratio for the exposed wall on each side of the building, including the construction type of the exposed building, and whether or not the exposed building has protected openings, was taken into account for each wall of the proposed buildings, in addition to the distance between the subject building and the exposed building.

	Distance (m)	Length of Exposed Building Face	Height of exposed building in stories	Length-Height Ratio	Building Type	Protected Openings?	Exposure Charge	Surcharge
North	15	30	2	60	III	Yes	2%	219.9
South	>30	-	-	-	-	-	0%	0.0
East	>30	-	-	-	-	-	0%	0.0
West	27	10	1	10	III	Yes	0%	0.0
								219.9 **L/min Surcharge**

Determine Required Fire Flow

No.1	12,934	
No. 2	-1,940	reduction
No. 3	-3,298	reduction
No. 4	220	surcharge

Required Flow: **7,916** **L/min**
Rounded to nearest 1000 L/min: **8,000** **L/min** or 133.33 L/s
2,113 USGPM

APPENDIX B

Sanitary Design Calculations

CROZIER
CONSULTING ENGINEERS

Project: 6888 Drummond Road
Project No.: 2658-7080
Created By: LE
Checked By: JB
Date: 4/17/2024
Updated: 4/26/2024

Existing Sanitary Demand

Site Area:	1.153	ha
One Bedroom Unit count:	0	
One bedroom density:	1.1	persons/unit
Residential population:	0	
Total GFA:	0.00	ha
Institutional Density:	63.17	employee/sqm
Institutional Population:	0	
Total Population:	0	

Design Parameters

Residential Average Demand (L/capita/d)
255

Commercial Average Demand (L/capita/d)
310

Sanitary Design Flow:

	Average Daily Flow =	-	L/day
	Average Daily Flow =	**0.00**	L/s
Harmon Peak Factor:	M =	**4.00**	
	Peak Flow =	**0.00**	L/s
Infiltration Flow:	Infiltration =	0.40	L/ha/s
	Total Infiltration =	**0.46**	L/s
	Total Peak Flow =	**0.46**	L/s

Summary Table

Average Daily Flow (L/s)	**Peaking Factor**	**Peak Flow** (L/s)	**Infiltration Flow** (L/s)	**Total Peak Flow** (L/s)
0.00	4.00	0.00	0.46	0.46

Notes & References

Site Statistics from Site Plan provided by Arcavia LTC

Population Densities obtained from Development Charges Background Study dated May 30, 2022

Region of Niagara 2021 Water and Wastewater Master Servicing Plan Update - Volume 4

Region of Niagara 2021 Water and Wastewater Master Servicing Plan Update - Volume 4

Max Day = Max Day * Average Day Demand

Peak Hour = Average Day Demand * Peak Hour

CROZIER
CONSULTING ENGINEERS

Project: 6888 Drummond Road
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Domestic Sanitary Demand

Site Area:	1.153	ha
One Bedroom Unit count:	189	
One bedroom density:	1.1	persons/unit
Residential population:	208	
Total GFA:	1.59	ha
Institutional Density:	63.17	employee/sqm
Institutional Population:	251	
Total Population:	459	

Design Parameters

Residential Average Demand (L/capita/d)
255

Commercial Average Demand (L/capita/d)
310

Sanitary Design Flow:

	Average Daily Flow =	130,885	L/day
	Average Daily Flow =	**1.51**	L/s
Harmon Peak Factor:	M =	**3.99**	
	Peak Flow =	**6.05**	L/s
Infiltration Flow:	Infiltration =	0.286	L/ha/s
	Total Infiltration =	**0.33**	L/s
	Total Peak Flow =	**6.38**	L/s

Summary Table

Average Daily Flow (L/s)	Peaking Factor	Peak Flow (L/s)	Infiltration Flow (L/s)	Total Peak Flow (L/s)
1.51	3.99	6.05	0.33	6.38

Notes & References

Site Statistics from Site Plan provided by Arcavia LTC

Population Densities obtained from Development Charges Background Study dated May 30, 2022

Region of Niagara 2021 Water and Wastewater Master Servicing Plan Update - Volume 4

Region of Niagara 2021 Water and Wastewater Master Servicing Plan Update - Volume 4

Max Day = Max Day * Average Day Demand

Peak Hour = Average Day Demand * Peak Hour

APPENDIX C

Stormwater Management Design Calculations

Modified Rational Calculations - Input Parameters

Storm Data: City of Niagara Falls

Time of Concentration: $T_c =$ **10** **min** (per city of Niagara Falls standards)

Return Period	A	B	C	I (mm/hr)
2 yr	522.0	5.28	0.76	65.94
5 yr	719.5	6.34	0.77	84.02
10 yr	577.9	2.48	0.67	106.77
25 yr	1020.7	7.29	0.78	110.83
100 yr	1264.6	7.72	0.78	133.78

Pre - Development Conditions

Land Use	Area (ha)	Area (m^2)	C	Weighted Average C[1]
Pervious	1.46	14553	**0.3**	**0.30**
Impervious	0.00	0	**0.9**	**0.00**
Total Site	**1.46**	**14553**	**-**	**0.30**

Post - Development Conditions

Land Use	Area (ha)	Area (m^2)	C	Weighted Average C
Pervious	0.38	3797	**0.3**	**0.08**
Impervious	1.08	10756	**0.9**	**0.67**
Total Site	**1.46**	**14553**	**-**	**0.74**

Equations:

Peak Flow

$$Q_{post} = 0.0028 \cdot C_{post} \cdot i(T_d)$$

Intensity

$$i(T_d) = A / (T + B)^C$$

Modified Rational Calculations - Peak Flows Summary

Peak Flows (m^3/s)		
Return Period	Q_{pre}	Q_{post}
2 yr	0.081	0.200
5 yr	0.103	0.255
10 yr	0.131	0.323
25 yr	0.135	0.336
100 yr	0.164	0.405

Equations:

Peak Flow

$$Q_{post} = 0.0028 \bullet C_{post} \bullet i(T_d) \bullet A$$

CROZIER
CONSULTING ENGINEERS

Project: 6888 Drummond Road
Project No.: 2658-7080
Created By: JB
Checked By: JB
Date: 2024.04.12
Updated: 2024.04.12

Modified Rational Calculations - 100-Year Storm Event

Control Criteria

100 yr: Control Post-Development Peak Flows to Pre-Development Peak Flow

100 yr: Uncontrolled Post-Development Flow:

Q_{post} = 0.405 m^3/s

100 yr: Uncontrolled Pre-Development Flow:

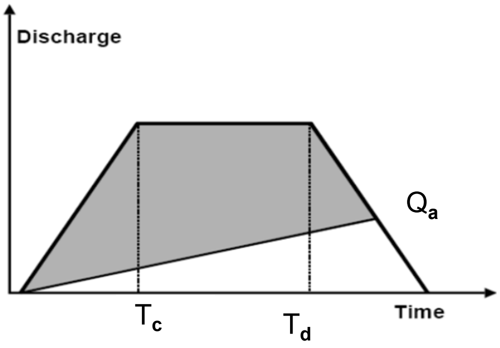
Q_{pre} = 0.164 m^3/s

100 yr: Orifice Controlled Flow Rate:

$Q_{orifice}$ = 0.1290 m^3/s

Storage Volume Determination

T_d (min)	i (mm/hr)	T_d (sec)	Q_{Uncont} (m^3/s)	S_d (m^3)
5	173.34	300	0.525	99.5
10	133.78	600	0.405	165.8
15	110.17	900	0.334	203.6
20	94.31	1200	0.286	226.7
25	82.85	1500	0.251	241.0
30	74.13	1800	0.225	249.4
35	67.26	2100	0.204	253.8
40	61.69	2400	0.187	255.0
45	57.07	2700	0.173	253.9
50	53.17	3000	0.161	251.0
55	49.83	3300	0.151	246.6
60	46.93	3600	0.142	240.9
65	44.39	3900	0.134	234.2
70	42.14	4200	0.128	226.6
75	40.13	4500	0.122	218.2
80	38.34	4800	0.116	209.2
85	36.71	5100	0.111	199.5
Required Storage Volume:				**255.0**



Peak Flow
$Q_{post} = 0.0028 \cdot C_{post} \cdot i(T_d) \cdot A$

Storage
$S_d = Q_{post} \cdot T_d - Q_{target} (T_d + T_c) / 2$

Modified Rational Calculations - 25-Year Storm Event

Control Criteria

25 yr: Control Post-Development Peak Flows to Pre-Development Peak Flow

25 yr: Uncontrolled Post-Development Flow:

Q_{post}= 0.336 m^3/s

25 yr: Uncontrolled Pre-Development Flow:

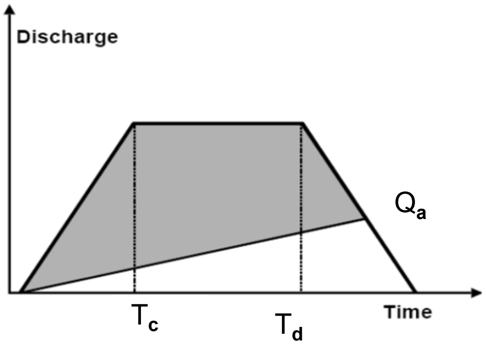
Q_{pre} = 0.135 m^3/s

25 yr: Orifice Controlled Flow Rate:

$Q_{orifice}$ = 0.114 m^3/s

Storage Volume Determination

T_d (min)	i (mm/hr)	T_d (sec)	Q_{Uncont} (m^3/s)	S_d (m^3)
5	144.59	300	0.438	80.3
10	110.83	600	0.336	133.3
15	90.93	900	0.275	162.7
20	77.67	1200	0.235	180.1
25	68.13	1500	0.206	190.3
30	60.90	1800	0.184	195.8
35	55.21	2100	0.167	197.9
40	50.61	2400	0.153	197.6
45	46.80	2700	0.142	195.4
50	43.59	3000	0.132	191.6
55	40.84	3300	0.124	186.7
60	38.45	3600	0.116	180.8
65	36.36	3900	0.110	174.0
70	34.52	4200	0.105	166.6
75	32.87	4500	0.100	158.5
80	31.40	4800	0.095	149.8
85	30.06	5100	0.091	140.7
Required Storage Volume:				**197.9**



Peak Flow

$$Q_{post} = 0.0028 \cdot C_{post} \cdot i(T_d) \cdot A$$

Storage

$$S_d = Q_{post} \cdot T_d - Q_{target} (T_d + T_c) / 2$$

Modified Rational Calculations - 10-Year Storm Event

Control Criteria

10 yr: Control Post-Development Peak Flows to Pre-Development Peak Flow

10 yr: Uncontrolled Post-Development Flow:

Q_{post} = 0.323 m^3/s

10 yr: Uncontrolled Pre-Development Flow:

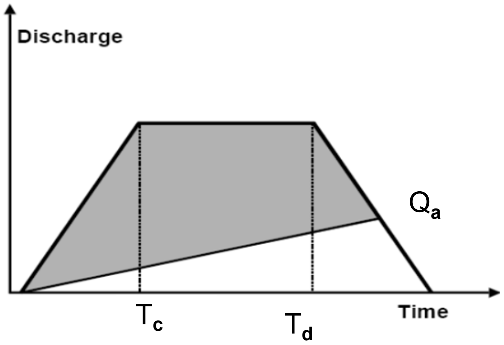
Q_{pre} = 0.131 m^3/s

10 yr: Orifice Controlled Flow Rate:

$Q_{orifice}$ = 0.108 m^3/s

Storage Volume Determination

T_d (min)	i (mm/hr)	T_d (sec)	Q_{Uncont} (m^3/s)	S_d (m^3)
5	150.36	300	0.455	87.9
10	106.77	600	0.323	129.1
15	85.22	900	0.258	151.1
20	72.03	1200	0.218	164.4
25	62.97	1500	0.191	172.4
30	56.31	1800	0.171	177.1
35	51.17	2100	0.155	179.3
40	47.05	2400	0.143	179.7
45	43.68	2700	0.132	178.6
50	40.85	3000	0.124	176.3
55	38.44	3300	0.116	173.1
60	36.35	3600	0.110	169.0
65	34.53	3900	0.105	164.2
70	32.91	4200	0.100	158.9
75	31.48	4500	0.095	153.0
80	30.19	4800	0.091	146.6
85	29.02	5100	0.088	139.7
Required Storage Volume:				**179.7**



Peak Flow

$$Q_{post} = 0.0028 \cdot C_{post} \cdot i(T_d) \cdot A$$

Storage

$$S_d = Q_{post} \cdot T_d - Q_{target} (T_d + T_c) / 2$$

Project: 6888 Drummond Road
Project No.: 2658-7080
Created By: JB
Checked By: JB
Date: 2024.04.12
Updated: 2024.04.12

Modified Rational Calculations - 5-Year Storm Event

Control Criteria

5 yr: Control Post-Development Peak Flows to Pre-Development Peak Flow

5 yr: Uncontrolled Post-Development Flow:

Q_{post} = 0.255 m^3/s

5 yr: Uncontrolled Pre-Development Flow:

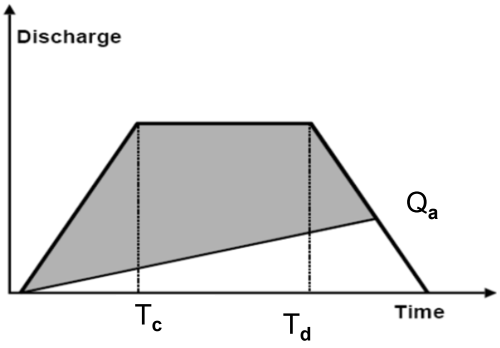
Q_{pre} = 0.103 m^3/s

5 yr: Orifice Controlled Flow Rate:

$Q_{orifice}$ = 0.094 m^3/s

Storage Volume Determination

T_d (min)	i (mm/hr)	T_d (sec)	Q_{Uncont} (m^3/s)	S_d (m^3)
5	111.26	300	0.337	58.9
10	84.02	600	0.255	96.4
15	68.44	900	0.207	116.2
20	58.21	1200	0.176	127.2
25	50.93	1500	0.154	132.9
30	45.45	1800	0.138	135.2
35	41.16	2100	0.125	135.2
40	37.71	2400	0.114	133.4
45	34.85	2700	0.106	130.2
50	32.45	3000	0.098	126.0
55	30.39	3300	0.092	120.9
60	28.62	3600	0.087	115.0
65	27.06	3900	0.082	108.6
70	25.69	4200	0.078	101.6
75	24.47	4500	0.074	94.2
80	23.37	4800	0.071	86.4
85	22.38	5100	0.068	78.3
Required Storage Volume:				**135.2**



Peak Flow
$Q_{post} = 0.0028 \cdot C_{post} \cdot i(T_d) \cdot A$

Storage
$S_d = Q_{post} \cdot T_d - Q_{target} (T_d + T_c) / 2$

Project: 6888 Drummond Road
Project No.: 2658-7080
Created By: JB
Checked By: JB
Date: 2024.04.12
Updated: 2024.04.12

Modified Rational Calculations - 2-Year Storm Event

Control Criteria

2 yr: Control Post-Development Peak Flows to Pre-Development Peak Flow

2 yr: Uncontrolled Post-Development Flow:

Q_{post}= 0.200 m^3/s

2 yr: Uncontrolled Pre-Development Flow:

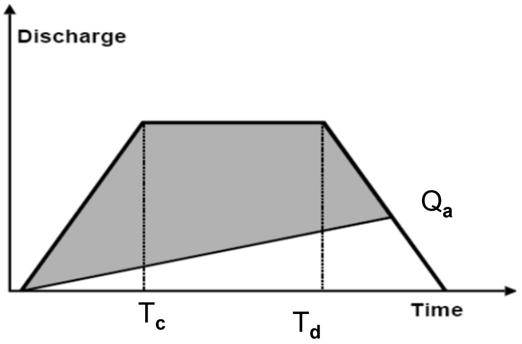
Q_{pre} = 0.081 m^3/s

2 yr: Orifice Controlled Flow Rate:

$Q_{orifice}$ = 0.079 m^3/s

Storage Volume Determination

T_d (min)	i (mm/hr)	T_d (sec)	Q_{Uncont} (m^3/s)	S_d (m^3)
5	89.07	300	0.270	45.4
10	65.94	600	0.200	72.5
15	53.19	900	0.161	85.8
20	45.00	1200	0.136	92.5
25	39.24	1500	0.119	95.4
30	34.94	1800	0.106	95.8
35	31.60	2100	0.096	94.4
40	28.92	2400	0.088	91.7
45	26.71	2700	0.081	88.1
50	24.85	3000	0.075	83.7
55	23.27	3300	0.071	78.6
60	21.91	3600	0.066	73.0
65	20.71	3900	0.063	67.0
70	19.66	4200	0.060	60.6
75	18.73	4500	0.057	53.8
80	17.89	4800	0.054	46.8
85	17.13	5100	0.052	39.5
Required Storage Volume:				**95.8**



Peak Flow
$$Q_{post} = 0.0028 \cdot C_{post} \cdot i(T_d) \cdot A$$

Storage
$$S_d = Q_{post} \cdot T_d - Q_{target} (T_d + T_c) / 2$$

CROZIER
CONSULTING ENGINEERS

PROJECT: 6888 Drummond Road
PROJECT No.: 2658-7080
DESIGN: JB
CHECK: JB
DATE: 2024.04.12
UPDATE: 2024.04.12

ORIFICE TUBE DESIGN SUMMARY

Address: 6888 Drummond Road

Outlet: 825mm diameter Storm Sewer System on Drummond Road

Orifice Type	=	Orifice Tube	
Invert Elevation	=	183.55	m
Diameter of Orifice	=	200	mm
Area of Orifice (A)	=	0.0314	sq.m
Orifice Coefficient (C_d)	=	0.82	
Calculation of Head			
Centroid Elevation	=	183.65	m
Water Elevation	=	184.93	m
Upstream Head (h)	=	1.28	

Q_a = $(C_d)(A)(2gh)^{0.5}$

Actual Controlled Discharge, Q_a = 0.1289 m^3/s

CROZIER
CONSULTING ENGINEERS

PROJECT: 6888 Drummond Road
PROJECT No.: 2658-7080
DESIGN: JB
CHECK: JB
DATE: 2024.04.12
UPDATE: 2024.04.12

ORIFICE TUBE DESIGN SUMMARY

Address: 6888 Drummond Road

Outlet: 825mm diameter Storm Sewer System on Drummond Road

Orifice Type	=	Orifice Tube	
Invert Elevation	=	183.55	m
Diameter of Orifice	=	200	mm
Area of Orifice (A)	=	0.0314	sq.m
Orifice Coefficient (C_d)	=	0.82	
Calculation of Head			
Centroid Elevation	=	183.65	m
Water Elevation	=	184.64	m
Upstream Head (h)	=	0.99	
Q_a	**=**	**$(C_d)(A)(2gh)^{0.5}$**	
Actual Controlled Discharge, Q_a	**=**	**0.1135**	**m^3/s**

CROZIER
CONSULTING ENGINEERS

PROJECT: 6888 Drummond Road
PROJECT No.: 2658-7080
DESIGN: JB
CHECK: JB
DATE: 2024.04.12
UPDATE: 2024.04.12

ORIFICE TUBE DESIGN SUMMARY

Address: 6888 Drummond Road

Outlet: 825mm diameter Storm Sewer System on Drummond Road

Orifice Type = Orifice Tube
Invert Elevation = 183.55 m
Diameter of Orifice = 200 mm
Area of Orifice (A) = 0.0314 sq.m
Orifice Coefficient (C_d) = 0.82

Calculation of Head

Centroid Elevation = 183.65 m
Water Elevation = 184.55 m
Upstream Head (h) = 0.90

Q_a = $(C_d)(A)(2gh)^{0.5}$

Actual Controlled Discharge, Q_a = 0.1082 m^3/s

CROZIER
CONSULTING ENGINEERS

PROJECT: 6888 Drummond Road
PROJECT No.: 2658-7080
DESIGN: JB
CHECK: JB
DATE: 2024.04.12
UPDATE: 2024.04.12

ORIFICE TUBE DESIGN SUMMARY

Address: 6888 Drummond Road

Outlet: 825mm diameter Storm Sewer System on Drummond Road

Orifice Type	=	Orifice Tube	
Invert Elevation	=	183.55	m
Diameter of Orifice	=	200	mm
Area of Orifice (A)	=	0.0314	sq.m
Orifice Coefficient (C_d)	=	0.82	

Calculation of Head

Centroid Elevation	=	183.65	m
Water Elevation	=	184.33	m
Upstream Head (h)	=	0.68	

Q_a = $(C_d)(A)(2gh)^{0.5}$

Actual Controlled Discharge, Q_a = 0.0938 m^3/s

CROZIER
CONSULTING ENGINEERS

PROJECT: 6888 Drummond Road
PROJECT No.: 2658-7080
DESIGN: JB
CHECK: JB
DATE: 2024.04.12
UPDATE: 2024.04.12

ORIFICE TUBE DESIGN SUMMARY

Address: 6888 Drummond Road

Outlet: 825mm diameter Storm Sewer System on Drummond Road

Orifice Type	=	Orifice Tube	
Invert Elevation	=	183.55	m
Diameter of Orifice	=	200	mm
Area of Orifice (A)	=	0.0314	sq.m
Orifice Coefficient (C_d)	=	0.82	

Calculation of Head

Centroid Elevation	=	183.65	m
Water Elevation	=	184.13	m
Upstream Head (h)	=	0.48	

Q_a = $(C_d)(A)(2gh)^{0.5}$

Actual Controlled Discharge, Q_a = 0.0790 m^3/s

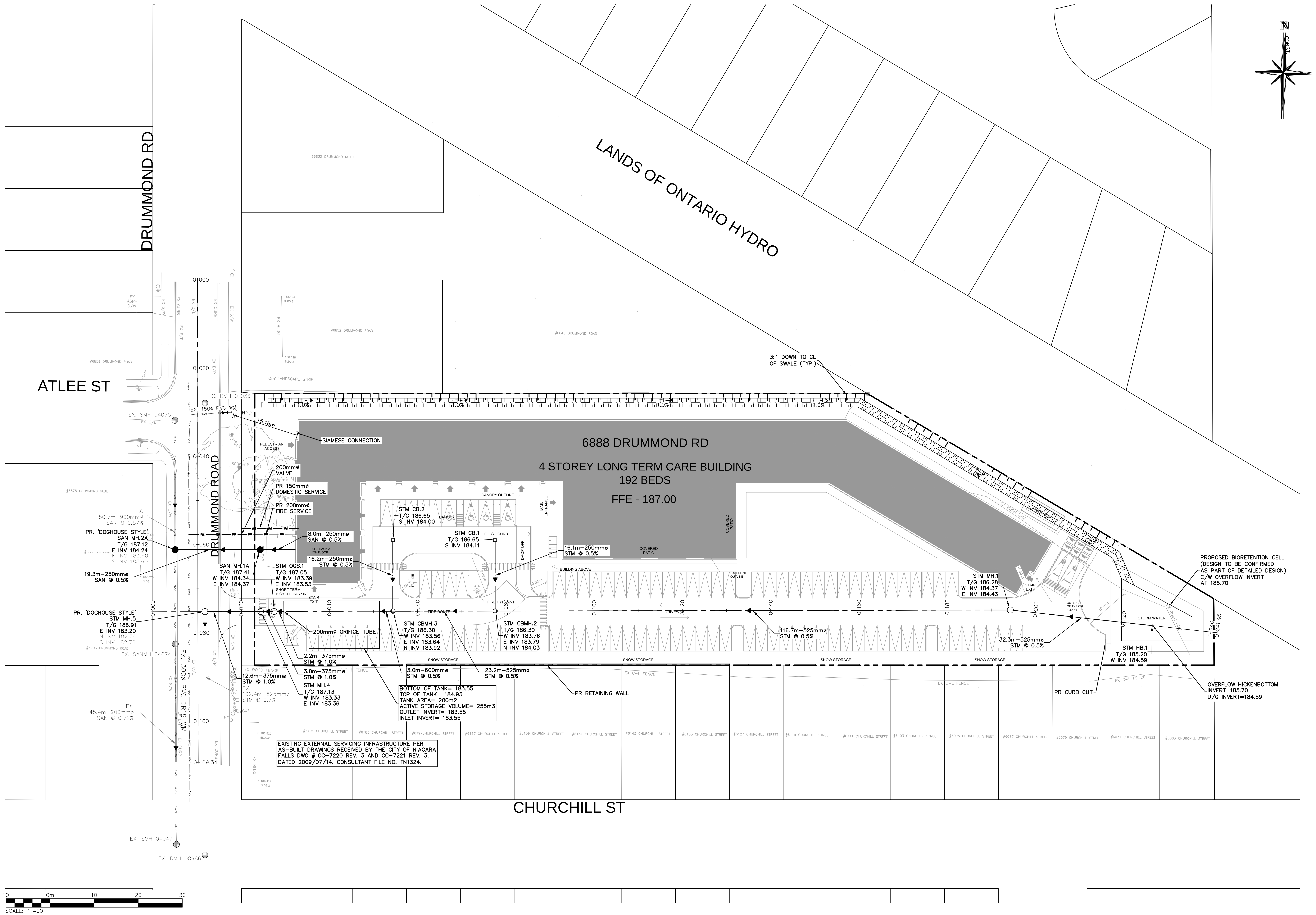
CROZIER
CONSULTING ENGINEERS

Project: 6888 Drummond Road
Project No.: 2658-7080
Created By: JB
Checked By: JB
Date: 2024.04.12
Updated: 2024.04.12

Modified Rational Calculations - Summary

Storm Event (yr)	**Peak Flow Rate**			**Required Storage** (m^3)
	Pre-Development (L/s)	**Post-Development**[1] (L/s)		
		Uncontrolled	**Controlled**	
2	0.081	0.200	0.079	95.8
5	0.103	0.255	0.094	135.2
10	0.131	0.323	0.108	179.7
25	0.135	0.336	0.114	197.9
100	0.164	0.405	0.129	255.0

FIGURES



EXISTING EXTERNAL SERVICING INFRASTRUCTURE PER AS-BUILT DRAWINGS RECEIVED BY THE CITY OF NIAGARA FALLS DWG # CC-7220 REV. 3 AND CC-7221 REV. 3, DATED 2009/07/14. CONSULTANT FILE NO. TN1324.

SCALE: N.T.S

LEGEND

- PROPERTY LINE
- PR. RETAINING WALL
- PR. SWALE & SLOPE
- PR. SLOPE (3:1 MAX.)
- CONVEYANCE SWALE
- PR. SANITARY SEWER
- PR. STORM SEWER
- PR. WATERMAIN
- PR. CATCHBASIN
- PR. CATCHBASIN MANHOLE
- PR. STORM MANHOLE
- PR. SANITARY MANHOLE
- EX. WATERMAIN
- EX. SANITARY SEWER
- EX. STORM SEWER
- EX. HYDRANT AND VALVE
- EX. MANHOLE
- PR. TRANSFORMER

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6. DO NOT SCALE DRAWINGS.

SURVEY NOTE:

SURVEY COMPLETED ON: MARCH 25, 2008. PREPARED BY MATHEWS, CAMERON, HEYWOOD–KERRY T. HOWE SURVEYING LTD.

BEARING NOTE:

COORDINATE VALUES AND DIGITAL FILE ARE IN GRID SYSTEM, UTM ZONE 17 NAD83.

Town

NiagaraFalls CANADA

No.	ISSUE	DATE: YYYY/MM/DD
0	ISSUED FOR OPA & ZBA	2024/04/26

Engineer

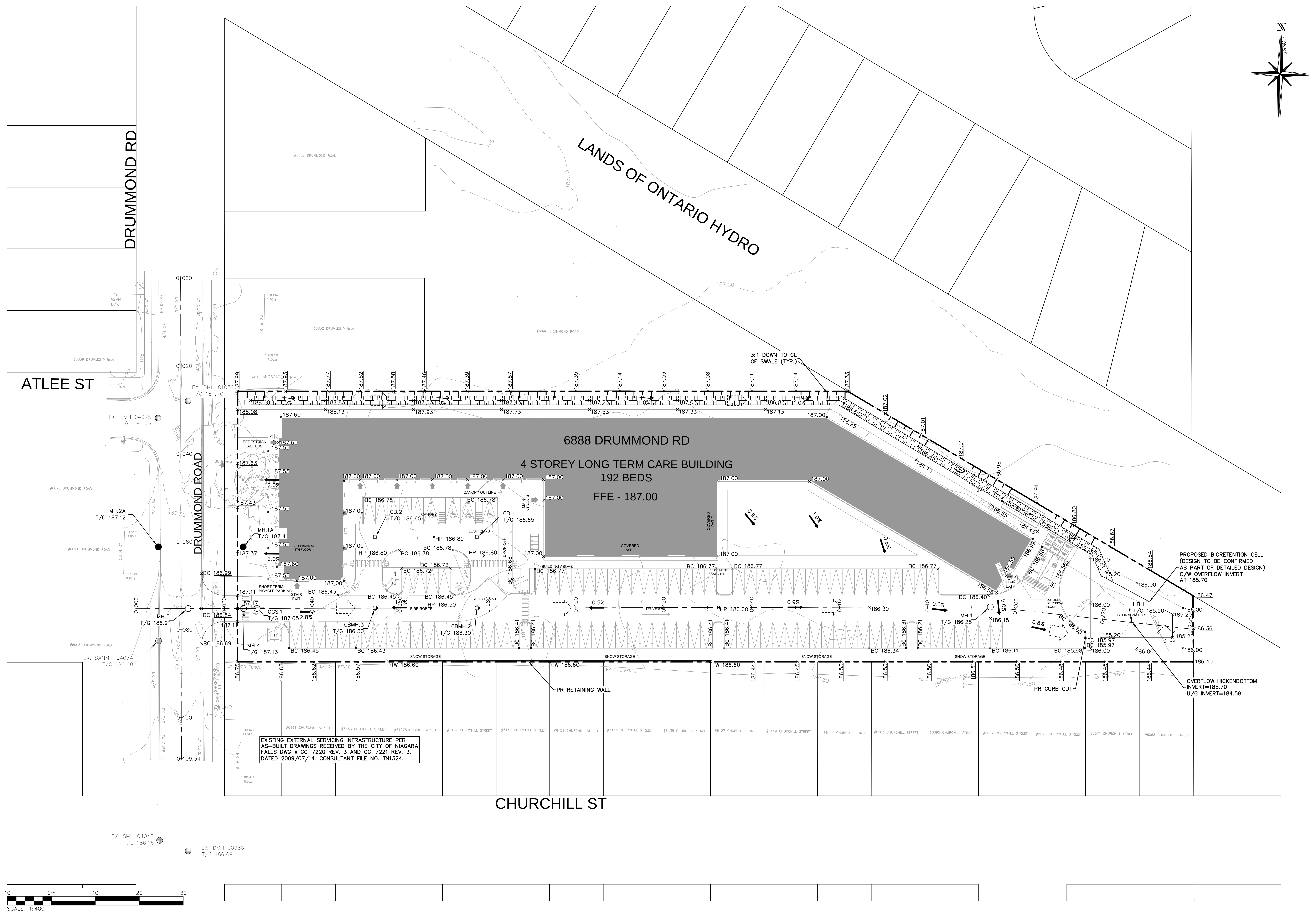
Engineer

Project
6888 DRUMMOND ROAD
CITY OF NIAGARA FALLS

Drawing
PRELIMINARY SERVICING PLAN

CROZIER
CONSULTING ENGINEERS

Drawn By S.Z./Y.K.	Design By J.B.	Project 2658–7080	
Check By J.B.	Check By J.B.	Drawing SRV–1	Sheet C701



LEGEND

+419.99	EX. GRADE
— — — —	SITE BOUNDARY
+XXX.XX	PR. ELEVATION
+XXX.XX	PR. ELEVATION (MATCH EX. ELEVATION)
+TCXXX.XX	PR. ELEVATION (TOP OF CURB)
+BCXXX.XX	PR. ELEVATION (BOTTOM OF CURB)
+TWXXX.XX	PR. ELEVATION (TOP OF WALL)
+BWXXX.XX	PR. ELEVATION (BOTTOM OF WALL)
▬	PR. RETAINING WALL
X.X% →	PR. SWALE & SLOPE
X.X% →	PR. SLOPE
┌┬┐	PR. SLOPE (3:1 MAX.)
— · —	CONVEYANCE SWALE
▣	PR. CATCHBASIN
◘	PR. CATCHBASIN MANHOLE
○	PR. STORM MANHOLE
●	PR. SANITARY MANHOLE
◉	EX. MANHOLE
T	PR. TRANSFORMER
⇨	PR. OVERLAND FLOW DIRECTION

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6. DO NOT SCALE DRAWINGS.

SURVEY NOTE:

SURVEY COMPLETED ON: MARCH 25, 2008. PREPARED BY MATHEWS, CAMERON, HEYWOOD-KERRY T. HOWE SURVEYING LTD.

BEARING NOTE:

COORDINATE VALUES AND DIGITAL FILE ARE IN GRID SYSTEM, UTM ZONE 17 NAD83.

Town

Niagara Falls
CANADA

No.	ISSUE	DATE: YYYY/MM/DD
0	ISSUED FOR OPA & ZBA	2024/04/26

Engineer

Engineer

Project
6888 DRUMMOND ROAD
CITY OF NIAGARA FALLS

Drawing
PRELIMINARY GRADING PLAN

CROZIER
CONSULTING ENGINEERS

Drawn By S.Z./Y.K.	Design By J.B.	Project 2658–7080	
Check By J.B.	Check By J.B.	Drawing GRD–1	Sheet C702

EXISTING EXTERNAL SERVICING INFRASTRUCTURE PER AS-BUILT DRAWINGS RECEIVED BY THE CITY OF NIAGARA FALLS DWG # CC-7220 REV. 3 AND CC-7221 REV. 3, DATED 2009/07/14. CONSULTANT FILE NO. TN1324.

SCALE: N.T.S

LEGEND

— - - —	PROPERTY LINE
252.00	EXISTING MAJOR CONTOUR (1.00m)
252.50	EXISTING MINOR CONTOUR (0.50m)
+419.99	EX. GRADE
➔	EMERGENCY OVERLAND FLOW ROUTE
🟥 🟥	EXISTING PRE-DEVELOPMENT DRAINAGE CATCHMENT
ID A | C	CATCHMENT I.D. AREA (ha) | RUNOFF COEFICIENT
XWM ▶ XWM	EX. WATERMAIN
XSAN ▶ XSAN	EX. SANITARY SEWER
▶	EX. STORM SEWER
○ ⧗	EX. HYDRANT AND VALVE
●	EX. MANHOLE

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5. ALL EXISTING UNDERGROUND UTILITIES TO BE VERIFIED IN THE FIELD BY THE CONTRACTOR PRIOR TO CONSTRUCTION.
6. DO NOT SCALE DRAWINGS.

SURVEY NOTE:
SURVEY COMPLETED ON: MARCH 25, 2008. PREPARED BY MATHEWS, CAMERON, HEYWOOD–KERRY T. HOWE SURVEYING LTD.

BEARING NOTE:
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Town

No.	ISSUE	DATE: YYYY/MM/DD
0	ISSUED FOR OPA & ZBA	2024/04/26

Engineer

Engineer

Project
6888 DRUMMOND ROAD
CITY OF NIAGARA FALLS

Drawing
PRE–DEVELOPMENT STORM
DRAINAGE AREA PLAN

CROZIER
CONSULTING ENGINEERS

Drawn By S.Z./Y.K.	Design By J.B.	Project 2658–7080	
Check By J.B.	Check By J.B.	Drawing STM–1	Sheet C703

EXISTING EXTERNAL SERVICING INFRASTRUCTURE PER AS-BUILT DRAWINGS RECEIVED BY THE CITY OF NIAGARA FALLS DWG # CC-7220 REV. 3 AND CC-7221 REV. 3, DATED 2009/07/14. CONSULTANT FILE NO. TN1324.

LEGEND

— - - —	PROPERTY LINE
252.00	EXISTING MAJOR CONTOUR (1.00m)
252.50	EXISTING MINOR CONTOUR (0.50m)
+419.99	EX. GRADE
➡	EXISTING OVERLAND FLOW DIRECTION
⇨	PROPOSED OVERLAND/FLOW DIRECTION
ID A | C	CATCHMENT I.D. AREA (ha) | RUNOFF COEFFICIENT
▨	CONTROLLED FLOW TO DRUMMOND RD
▨	CONTROLLED FLOW TO BIORETENTION CELL
▬ ▬	POST DEVELOPMENT DRAINAGE AREA BOUNDARY
T	PR. TRANSFORMER
▬	PR. RETAINING WALL
XWM ▶ XWM	EX. WATERMAIN
XSAN ▶ XSAN	EX. SANITARY SEWER
▶	EX. STORM SEWER
○	EX. HYDRANT AND VALVE
●	EX. MANHOLE

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SURVEY NOTE:

SURVEY COMPLETED ON: MARCH 25, 2008. PREPARED BY MATHEWS, CAMERON, HEYWOOD–KERRY T. HOWE SURVEYING LTD.

BEARING NOTE:

COORDINATE VALUES AND DIGITAL FILE ARE IN GRID SYSTEM, UTM ZONE 17 NAD83.

Town

No.	ISSUE	DATE: YYYY/MM/DD
0	ISSUED FOR OPA & ZBA	2024/04/26

Engineer

Engineer

Project

6888 DRUMMOND ROAD
CITY OF NIAGARA FALLS

Drawing

POST DEVELOPMENT STORM
DRAINAGE AREA PLAN

CROZIER
CONSULTING ENGINEERS

Drawn By S.Z./Y.K.	Design By J.B.	Project 2658–7080	
Check By J.B.	Check By J.B.	Drawing STM–2	Sheet C704