FUNCTIONAL SERVICING AND STORMWATER MANAGEMENT REPORT

REGIONAL MUNICIPALITY OF WATERLOO

41 WESTHILL DRIVE

Project No.: 2024-0744-10

April 29, 2026

WALTERFEDY

REGIONAL MUNICIPALITY OF WATERLOO

FUNCTIONAL SERVICING AND STORMWATER MANAGEMENT REPORT

41 Westhill Drive

Table of Contents

Page

1.0 INTRODUCTION 1
- 1.1 Background 1
- 1.2 Reference Report and Drawings 1

2.0 REVIEW AGENCIES 1
- 2.1 Region of Waterloo 1
- 2.2 City of Waterloo 1
- 2.3 Other Utilities 1

3.0 EXISTING CONDITIONS 1
- 3.1 Topography and Land Use 1
- 3.2 Water, Sanitary, and Storm Servicing 2

4.0 PROPOSED SANITARY SERVICING DESIGN 2

5.0 PROPOSED Water Servicing Design 2
- 5.1 Design Criteria 2
- 5.2 Fire Flow Demand 3
- 5.3 Domestic Demand 3
- 5.4 Service Design 4

6.0 STORMWATER MANAGEMENT SYSTEM 4
- 6.1 Stormwater Management Design 4
- 6.2 Water Quality Control 5
- 6.3 Water Quantity (Peak Flow) Control 5

7.0 EROSION AND SEDIMENT CONTROL 5

8.0 CONCLUSIONS 6

Tables
Drawings
Appendices

1.0 INTRODUCTION

The following Functional Servicing and Stormwater Management Report was prepared in support of the Zoning By-law amendment (ZBA) application for the proposed residential development at 41 Westhill Drive in Waterloo. The site is currently an unoccupied greenspace, northwest of the intersection of Westhill Drive and Ira Needels Boulevard. The proposed residential development will be six storeys high, containing 56 residential units and the corresponding parking.

1.1 Background

The site is bound by the Westhill Retirement Residence, Ira Needles Boulevard to the southwest, and Westhill Drive to the east/northeast. The site is currently undeveloped greenspace, with no municipal service connections from Westhill Drive or Ira Needles Boulevard.

1.2 Reference Report and Drawings

The Guidelines and Standards referenced in this report include:

1. *Design Guidelines and Supplemental Specifications for Municipal Services* (DGSSMS), Corporation of the Region of Waterloo and Area Municipalities, February 2024
2. *The City of Waterloo, Engineering and Landscape Manual*, May 2024
3. *Design Guidelines for Sewage Works*, Ministry of the Environment, Conservation and Parks (MECP), March 2019
4. *Water Supply for Public Fire Protection – A Guide to Recommended Practice in Canada*, Fire Underwriters Survey, 2020

2.0 REVIEW AGENCIES

2.1 Region of Waterloo

The Region of Waterloo will be responsible for the review of the Zoning By-Law Amendment and Official Plan Amendment Applications.

2.2 City of Waterloo

The City of Waterloo will be responsible for reviewing and approving the Zoning By-Law Amendment and Site Plan Applications, along with the designs for site servicing, grading, and stormwater management for the proposed development.

2.3 Other Utilities

Coordination with gas, hydro and telecommunications providers will be required to ensure they have appropriate adjacent infrastructure to support the development.

3.0 EXISTING CONDITIONS

3.1 Topography and Land Use

. A topographic survey of the site was completed by KRCMAR in June 2022. The site generally drains from north-to-south. The site elevations range from 386.98 at the northern corner of the disturbance limits to 383.70 at the western corner of the property line. The elevation at the southern corner of the lot is 384.34, and 385.36 at the eastern limit of the site.

3.2 Water, Sanitary, and Storm Servicing

The storm sewer infrastructure runs along both Ira Needles Boulevard and Westhill Drive. The storm sewer main along the far side of the Ira Needles Boulevard right-of-way drains from east-to-west, upsizing from 375-mm-diameter to 450-mm-diameter across the frontage of the site. There are two catchbasins with 300-mm-diameter leads along the near curbline of Ira Needles Boulevard in front of the site connected to the mainline. A catchbasin on the northeastern side of the site, within the Westhill Drive right-of-way, drains a roadside ditch and ultimately connects to the same Ira Needles mainline system.

The nearest sanitary sewer network to the site is a maintenance hole located within the Ira Needles Boulevard right-of-way, approximately 50 m away from the site.

4.0 PROPOSED SANITARY SERVICING DESIGN

The sanitary design standards for the proposed development at 41 Westhill Dr. are outlined in the Regional DGSSMS, MECP guidelines, and the City of Waterloo Engineering and Landscape Manual. The proposed sanitary service design includes an extension of the municipal sewer along the Ira Needles Boulevard right-of-way approximately 95 m to the property frontage, and a 200-mm-diameter site service.

The proposed development is a residential building, and the average flow for this classification as specified by the DGSSMS is 275L/c/d. T Table I provides a summary breakdown of the total sanitary flow based on the factors discussed above.

Table I: Proposed Sanitary Flow

Total Site Area	0.283 ha
Total Number of Units	56 units
Total Population Per Unit	2.07 ppu
Average Sewage Flow	275 L/c/d
Harmon Peaking Factor	4.23
Infiltration/Inflow Allowance	0.25 L/ha/s
Total Sanitary Flow	1.631 L/s

Refer to Appendix A for detailed calculations on the total sanitary flow and overall sanitary design for the proposed development, demonstrating that the proposed design will adequately convey the design flow.

5.0 PROPOSED WATER SERVICING DESIGN

5.1 Design Criteria

The MECP Guidelines indicate that the required design water demand should be the higher of the total maximum daily demand plus fire flow, or the peak hourly demand. The MECP also specifies the following:

- The minimum pressure that must be maintained in the water service network is 140 kPa (20 psi) under maximum day demand combined with fire flow.

The DGSSMS requires that watermain distribution systems be able to convey the larger of maximum daily demand and fire flow or the peak hourly demand. Additionally, it is recommended that the average daily flow from any development be conveyed with a resulting pressure within the range of 350 kPa (50 psi) to 550 kPa (80 psi).

The Region also stipulates that the minimum resultant pressure under any non-fire demand scenario shall not be less than 275 kPa (40 psi). With the inclusion of fire flows, the minimum residual pressure in the distribution system shall not be less than 140 kPa (20 psi) or shall not cause velocities in the system, at any point, to be greater than 5 m/s. If static pressure in the system exceeds 550 kPa (80 psi), the Region requires the use of individual pressure-reducing valves for new developments.

5.2 Fire Flow Demand

The proposed water servicing deign must satisfy the fire flow demands using the methods outlined in the Water Supply for Public Fire Protection in Canada by the Fire Underwriters Survey (FUS). The effective area was taken as the total floor area of all floors, assuming each floor is uniform with the building footprint. The Occupancy and Contents Adjustment Factor is taken as -15%, because most of the contents and occupancy of the proposed residential building is classified as Limited Combustible Contents. The construction coefficient, which is based on the type of material used to construct the structure, is assumed to be Type III - Ordinary Construction with a construction coefficient of 1.0. The surrounding buildings are all greater then 30 m away from the structure and so exposure charges will not need to be considered. The following Table II summarizes the Fire Flow Calculations; the associated design sheet can be found in Appendix B.

Table II: Proposed Fire Flow Demand

Total Site Area	0.283 ha
Effective Area	1220 m^2
Construction Coefficient	C = 1.0, Ordinary Construction
Occupancy and Contents Adjustment Factor	-15%, Limited Combustible Contents
Exposure Charges	0%, Greater than 30 m
Total Required Fire Flow	100 L/s (1585 usgpm)

5.3 Domestic Demand

The domestic water demand calculations for the proposed development have been performed based on the methods outlined in the MECP Drinking Water Systems Guidelines and the Region of Waterloo DGSSMS.

The average water demand was estimated using the historical usage rate of 225 L/cap/day, as per the DGSSMS and MECP guidelines. Peaking factors were applied to estimate maximum daily and peak hourly flows. The proposed development is expected to accommodate a population of 116 people, as per the City of Waterloo's People-Per-Unit design criteria. For the peaking factors, values from the MECP for municipalities with populations greater than 150,000 were used. A maximum daily peaking factor of 1.5 and a peak hourly factor of 2.25 over a 12-hour operational period were applied to calculate demand across the entire 0.28 ha site. Table 2 provides a summary of the anticipated water demand for the proposed development.

Table III: Proposed Domestic Water Demand

Total Site Area	0.283 ha
Total Number of Units	56
Equivalent Population Density	2.07 Persons/unit
Design Population	116 Persons
Average Daily Demand	225 L/cap/day
Maximum Daily Peaking Factor	1.5
Maximum Hourly Peaking Factor	2.25
Maximum Daily Demand	0.5 L/s
Maximum Hourly Demand	0.75 L/s

Refer to Appendix B for the domestic water demand, fire flow demand design sheet.

Sufficient capacity is available to serve the site from the existing 400-mm-diameter watermain in Westhill Drive.

5.4 Service Design

The design will utilize the existing water lines to adequately service the proposed building; the service will connect to the proposed building along northeastern face of the building. A 200-mm-diameter service will tee off the existing watermain running along Westhill Drive. There is a fire hydrant along the property line of 38 Westhill Drive to provide the required hydrant coverage for fire department connection.

6.0 STORMWATER MANAGEMENT SYSTEM

The preliminary design for the storm water management system was performed using the modified rational method along with the City of Waterloo Engineering and Landscape Manual. The proposed stormwater management design was attenuates the peak discharge of the post-development, 100-year storm to the 100-year, pre-development discharge rate.

The overall stormwater management design for the western portion of the site will consist of repurposing the existing storm network surrounding the site where feasible, and adding in new structures and leads. Some of the existing structures around the site will need be replaced with catchbasin manholes.

6.1 Stormwater Management Design

The development area was divided into catchments based on the runoff classification as presented in the Table IV, below.

Table IV: Proposed & Existing Percent Impervious Areas

Existing	***Percent Impervious***	***Runoff Coefficient***
0.000 ha	100%	C = 0.9
0.283 ha	0%	C = 0.2
Proposed	***Percent Impervious***	***Runoff Coefficient***
0.190 ha	100%	C = 0.9
0.093 ha	0%	C = 0.2

The values presented in the table above were used to determine the existing and proposed runoff coefficients for the total site area of 0.283 ha. Composite runoff coefficients of 0.20 and 0.67, respectively, are calculated using these values and parameters outlined in the City of Waterloo Engineering and Landscape Manual to determine the design flow and the required storage volume. The parameters and the values discussed above are summarized in Table V, below.

Table V: Required Storage Volume

Site Area	0.283 ha
Rainfall Intensity Equation Coefficients for 5-year Storm	A = 1755 b = 12.347 c = 0.895
Rainfall Intensity Equation Coefficients for 100-year Storm	A = 4692 b = 17.437 c = 0.956
Inlet Time (minutes)	10
Design Flow (100-year, pre-development release rate)	31 L/s (0.031 m^3/s)
Required Storage Volume	56.35 m^3

The storm design for the site will include connections to existing infrastructure withing the surrounding rights-of-way. Upgrades to the existing catchbasins within the rights-of-way will be required to facilitate the connection(s). On site storage will be required to achieve peak flow targets.

6.2 Water Quality Control

The water quality will be maintained through the use of green infrastructure practises such as bioswales and infiltration galleries, or a manufactured treatment unit device.

6.3 Water Quantity (Peak Flow) Control

The proposed design will provide the required storage volume of 56.35 m^3 to meet the required peak flow targets. Quantity control can be provided through the use of underground detention storage, or surface detention storage to be determined during detailed design.

7.0 EROSION AND SEDIMENT CONTROL

Any sediment that is tracked onto the roadway during construction will be promptly cleaned by the Contractor. To minimize the amount of mud being carried onto the roadway, a mud mat will be installed at the primary construction exit. Furthermore, a silt fence will be placed around the entire site to prevent sediment from leaving the area and will remain in place and maintained until landscaping is completed and the soil is fully vegetated. Catchbasin silt sacks, and coir logs / Silt Soxx check dams will also be implemented as required to protect the storm sewer infrastructure and surrounding swales etc. Silt fences will also be installed around any on-site stockpiles, with the stockpiles kept at least 2.5 meters from the property boundary.

Additionally, the existing ditches and culverts will be inspected periodically to ensure sediment does not accumulate during construction. Any inlet structures that could be affected by sediment will also be protected and maintained according to the erosion and sediment control (ESC) details.

8.0 CONCLUSIONS

Based on the analysis and design outlined in this report it can be concluded that:

- A 200 mm sanitary service will have adequate capacity to support the requirements of the proposed development.
- The existing 200 mm water service will be able to service the proposed building under both domestic and fire flow conditions.
- Stormwater management quantity control can be provided through on site storage and flow restriction.
- All erosion and sediment control measures should be followed as per City of Waterloo Standard details and notes, including but not limited to silt fence, mud mats, and catch basin protection.

All of which is respectfully submitted,

WALTERFEDY



Tyler Keller, P.Eng.
Project Manager
Associate

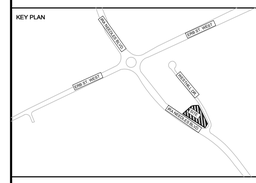
tkeller@walterfedy.com
519.576.2150, Ext. 237

DRAWINGS

LEGEND

- PROPERTY LINE
- LOT LINE
- LEGAL EASEMENT
- IB — IRON BAR
- IP — IRON PIPE
- SIB — STANDARD IRON BAR
- CC — CUT CROSS
- EX LS — EXISTING LAMP STANDARD
- EX UP — EXISTING UTILITY POLE
- EXISTING GUY WIRE
- EX SIGN — EXISTING SIGN
- EX CB — EXISTING CATCHBASIN
- EX DCB — EXISTING DOUBLE CATCHBASIN
- EX MH — EXISTING STORM MANHOLE
- EX CBMH — EXISTING CATCHBASIN MANHOLE
- EX SAN MH — EXISTING SANITARY MANHOLE
- EX HYD — EXISTING FIRE HYDRANT
- EX WV — EXISTING WATERMAIN VALVE
- EXISTING SANITARY SERVICE
- EXISTING STORM SERVICE
- EXISTING WATERMAIN
- EXISTING ASPHALT
- EXISTING CONCRETE
- EXISTING CURB
- CB — PROPOSED CATCHBASIN
- DCB — PROPOSED DOUBLE CATCHBASIN
- DICB — PROPOSED DITCH INLET CATCHBASIN
- CBMH — PROPOSED CATCHBASIN MANHOLE
- MH — PROPOSED STORM MANHOLE
- MH — PROPOSED SANITARY MANHOLE
- HYD — PROPOSED FIRE HYDRANT
- WV — PROPOSED WATERMAIN VALVE
- PROPOSED FIRE DEPARTMENT CONNECTION
- [123.45] — PROPOSED GRADE
- 2.0% 2.0% — PROPOSED DRAINAGE ARROW/SLOPE
- PROPOSED SANITARY SEWER/SERVICE
- PROPOSED STORM SEWER/SERVICE
- PROPOSED WATERMAIN/SERVICE
- PROPOSED CURB
- PROPOSED BUILDING
- PROPOSED LIGHT DUTY ASPHALT SURFACE
- PROPOSED CONCRETE SURFACE
- PROPOSED STORMWATER MANAGEMENT AREA

KEY PLAN



DATE	ISSUANCE	NO.
2025.04.08	ISSUED WITH FUNCTIONAL SERVICING REPORT	1
2026.04.29	REISSUED FOR ZBA	2

CLIENT
REGION OF WATERLOO

PROJECT
41 WESTHILL DR.

WATERLOO, ON

TITLE
FUNCTIONAL GRADING PLAN

WALTERFEDY

TORONTO | CALGARY | **KITCHENER** | HAMILTON

800.685.1378 **walterfedy.com**

LICENSED PROFESSIONAL ENGINEER
T. B. KELLER
100529026
2026-04-29
PROVINCE OF ONTARIO

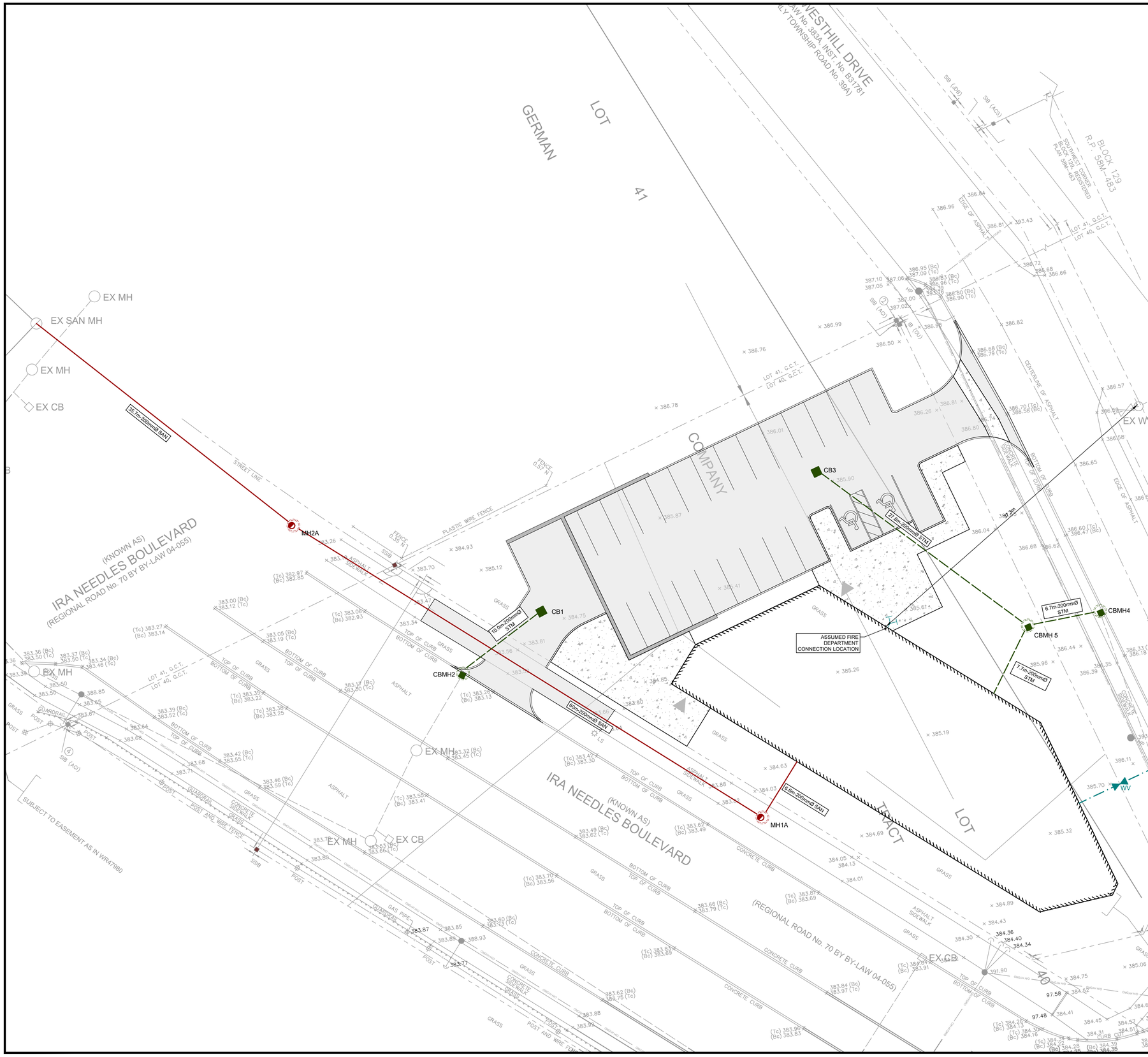
REPRODUCTION OR DISTRIBUTION FOR PURPOSES OTHER THAN AUTHORIZED BY WALTERFEDY, A PART OF WF GROUP, IS FORBIDDEN. CONTRACTORS SHALL VERIFY AND BE RESPONSIBLE FOR ALL DIMENSIONS AND CONDITIONS ON THE JOB AND REPORT ANY VARIATIONS FROM THE DIMENSIONS AND CONDITIONS SHOWN ON DRAWINGS TO WALTERFEDY, A PART OF WF GROUP. - DO NOT SCALE THIS DRAWING -

COPYRIGHT © 2026 WalterFedy, A Part of WF Group Inc.

SCALE:	1:200
DATE:	2026-04-29
PROJECT NO.:	2024-0744-10
DRAWN BY:	TG/EHN
CHECKED BY:	JZ

SHEET NO.:
C2-1

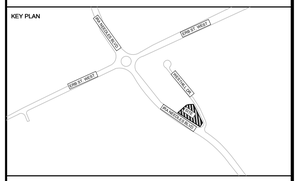
P:\2024\07441(10)\06-DWGS\CWL\2024-0744-10_GRD; C2-1; DWG To PDF no layers.pc3; Tyler Keller; 2026-04-29 11:26:43 AM



LEGEND

	PROPERTY LINE
	LOT LINE
	LEGAL EASEMENT
IB	IRON BAR
IP	IRON PIPE
SIB	STANDARD IRON BAR
CC	CUT CROSS
EX LS	EXISTING LAMP STANDARD
EX UP	EXISTING UTILITY POLE
	EXISTING GUY WIRE
EX SIGN	EXISTING SIGN
EX CB	EXISTING CATCHBASIN
EX DCB	EXISTING DOUBLE CATCHBASIN
EX MH	EXISTING STORM MANHOLE
EX CBMH	EXISTING CATCHBASIN MANHOLE
EX SAN MH	EXISTING SANITARY MANHOLE
EX HYD	EXISTING FIRE HYDRANT
EX WV	EXISTING WATERMAIN VALVE
	EXISTING SANITARY SERVICE
	EXISTING STORM SERVICE
	EXISTING WATERMAIN
	EXISTING ASPHALT
	EXISTING CONCRETE
	EXISTING CURB
CB	PROPOSED CATCHBASIN
DCB	PROPOSED DOUBLE CATCHBASIN
DICB	PROPOSED DITCH INLET CATCHBASIN
CBMH	PROPOSED CATCHBASIN MANHOLE
MH	PROPOSED STORM MANHOLE
MH	PROPOSED SANITARY MANHOLE
HYD	PROPOSED FIRE HYDRANT
WV	PROPOSED WATERMAIN VALVE
	PROPOSED FIRE DEPARTMENT CONNECTION
[123.45]	PROPOSED GRADE
2.0% 2.0%	PROPOSED DRAINAGE ARROW/SLOPE
	PROPOSED SANITARY SEWER/SERVICE
	PROPOSED STORM SEWER/SERVICE
	PROPOSED WATERMAIN/SERVICE
	PROPOSED CURB
	PROPOSED BUILDING
	PROPOSED LIGHT DUTY ASPHALT SURFACE
	PROPOSED CONCRETE SURFACE
	PROPOSED STORMWATER MANAGEMENT AREA

KEY PLAN



DATE	ISSUANCE	NO.
2025.04.08	ISSUED WITH FUNCTIONAL SERVICING REPORT	1
2026.04.29	REISSUED FOR ZBA	2

CLIENT
REGION OF WATERLOO

PROJECT
41 WESTHILL DR.

WATERLOO, ON

TITLE
FUNCTIONAL SERVICING PLAN

WALTERFEDY
TORONTO | CALGARY | KITCHENER | HAMILTON
800.685.1378 walterfedy.com

LICENSED PROFESSIONAL ENGINEER
T. B. KELLER
100529026
2026-04-29
PROVINCE OF ONTARIO

REPRODUCTION OR DISTRIBUTION FOR PURPOSES OTHER THAN AUTHORIZED BY WALTERFEDY, A PART OF WF GROUP, IS FORBIDDEN. CONTRACTORS SHALL VERIFY AND BE RESPONSIBLE FOR ALL DIMENSIONS AND CONDITIONS ON THE JOB AND REPORT ANY VARIATIONS FROM THE DIMENSIONS AND CONDITIONS SHOWN ON DRAWINGS TO WALTERFEDY, A PART OF WF GROUP. - DO NOT SCALE THIS DRAWING -

COPYRIGHT © 2026 WalterFedy, A Part of WF Group Inc.

SCALE:	1:200
DATE:	2026-04-29
PROJECT NO.:	2024-0744-10
DRAWN BY:	TG/EHN
CHECKED BY:	JZ

SHEET NO.: C3-1

P:\2024\0744\10\06-DWGS\CIVIL\2024-0744-10_SVC; C3-1; DWG To PDF no layers.pc3; Tyler Keller; 2026-04-29 11:24:14 AM

APPENDIX A

Sanitary Design Calculations

Project:	41 Westhill Dr			Design Data		
Project No:	2024-0744-10			Min. Velocity	0.6	m/s
Date:	2025-03-31			Max. Velocity	3.0	m/s
Designed By:	TG	Checked By:	JJZ	Manning's 'n'	0.013	
				Infiltration	0.25	l/s/ha

SANITARY SEWER DESIGN CALCULATIONS

Residential			Commercial			Industrial			Institutional		
Peaking Factor	Harmon		Peaking Factor	2.5		Peaking Factor	2		Peaking Factor	2	
Avg. Daily Flow	275	L/c/d	Avg. Daily Flow	0.5	L/s/ha	Avg. Daily Flow	0.4	L/s/ha	Avg. Daily Flow	0.25	L/s/ha

Pipe Data				Residential				Cumulative			Commercial		Industrial		Institutional		Infiltration		Total Flow	Design Data			
From	To	Length	Area	Units	Density	Population	Area	Population	Peak Factor	Area	Total Area	Area	Total Area	Area	Total Area	Area	Total Area		Diameter	Slope	Q_{FULL}	V_{FULL}
		(m)	*(ha)*		*(ppu)*	*(people)*	*(ha)*	*(people)*		*(ha)*	*(ha)*	*(ha)*	*(ha)*	*(ha)*	*(ha)*	*(ha)*	*(ha)*	**(L/s)**	*(mm)*	*(%)*	*(L/s)*	*(m/s)*
BLG PROP	M1A	5.3	0.283	56	2.07	**116**	0.283	116	**4.23**	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.28	**1.631**	200	2.00	**46.38**	**1.48**
MH1A	MH2A	36.6	0	0	0	**0**	0	0	**4.50**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.631**	200	2.00	**46.38**	**1.48**
MH2A	EXMH	5.4	0	0	0	**0**	0	0	**4.50**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.631**	200	2.00	**46.38**	**1.48**

APPENDIX B

Water Service Design Calculations

REQUIRED DOMESTIC FLOW

OBC / MECP

WALTERFEDY

Project	41 Westhill Dr
Project #	2024-0744-10
Designer	TG
Address	41 Westhill Dr, Waterloo
Description	Domestic Water Demand

Building Description (Proposed Conditions)	Area (ha)	Units	Persons/Unit	Population	Demand	Max Daily Peak Factor	Max Hourly Peak Factor	Max Daily Demand (L/s)	Max Hourly Demand (L/s)
41 Westhill PR Residence	0.28	56	2.07	116	225 L/person/day	1.65	2.5	0.50	0.75
						TOTAL		**0.50**	**0.75**

REQUIRED FIRE FLOW

Water Supply for Public Fire Protection (FUS 2020)

WALTERFEDY

Project	41 Westhill Dr.
Project #	2024-0744-10
Designer	TG
Address	41 Westhill Dr, Waterloo
Description	Existing Fire Demand

$$F = 220 \times C \times \sqrt{A}$$

F = Required fire flow (LPM)
C = Coefficient related to type of construction
A = Total floor area (including all storeys but excluding any basement levels at least 50% below grade)

Type of Construction	Ordinary Construction	**C =**	1.0
Description	Brick and Masonry Walls, Combustible Interiors		

Total Floor Area	813	m^2
# Storeys	6	
Fire Resistant Building?	NO	
Vertical Openings and Exterior Vertical Communications protected with minimum one (1) hr rating?	NO	
Area	4878	m^2
Description		
Required Fire Flow	15000	L/min

Occupancy Charge	Limited-Combustible Contents			
Fire Flow Reduction	-15%	**OR**	-2250	L/min
Required Fire Flow	12750	L/min		

Automated Sprinker Protection	YES		
Designed to NFPA 13 Standard	YES	-30%	
Standard Water Supply to Sprinklers and Standpipes	YES	-10%	
Fully Supervised System	YES	-10%	
Fire Flow Adjustment		-6375	L/min

Exposure 1 (North)	**Distance**	0	m	**Charge**	0%
Description	Existing Dwelling				
Exposure 2 (South)	**Distance**	-	m	**Charge**	0%
Description	Existing Golf Course				
Exposure 3 (East)	**Distance**	56	m	**Charge**	0%
Description	Existing Building				
Exposure 4 (West)	**Distance**	35	m	**Charge**	0%
Description	The Westhill Retirement Residence				

Total Exposure Charge	0%	
Fire Flow Adjustment	0	L/min

Total Required Fire Flow	6000	L/min
Total Required Fire Flow	1585	U.S. GPM
Total Required Fire Flow	100	L/s

Hazen-Williams Equations

$$S = \frac{h_f}{L} = \frac{10.67Q^{1.852}}{C^{1.852}d^{4.8704}}$$ SI Units

$$S = \frac{h_f}{L} = \frac{4.52Q^{1.852}}{C^{1.852}d^{4.8704}}$$ US Customary

Q_d *(domestic flow rate)*	0.75	*L/s*
Q_f *(fire flow rate)*	100	*L/s*
Q *(total flow rate)*	100.750	*L/s*
C *(pipe roughness coefficient)*	150	
d *(inside diameter)*	200	*mm*
k *(conversion factor for units)*	10.67	*SI*
L *(length)*	22	*m*

Unit Conversion

100.750	*L/s*	=	1596.920	*USgpm*
1	*USgpm*	=	0.063	*L/s*
1	*psi*	=	0.70307	*mH_2O*
1	*mH_2O*	=	1.422333	*psi*
1	*kPa*	=	0.101972	*mH_2O*
1	*mH_2O*	=	9.806614	*kPa*
1	*kPa*	=	0.145	*psi*
1	*psi*	=	6.895	*kPa*

Water Turnover - Domestic	15.359	min
Water Turnover - Combined	0.114	min

Domestic + Fire Flow

S *(hydraulic slope/head loss)*	0.0360	*mH_2O/m*	Elevation at Source	383.8 *m*
h_f *(total head loss)*	0.792	*mH_2O*	Head at Source	68 *psi *assumed for calculations*
V *(velocity)*	3.207	*m/s*	Elevation at Building	386.8 *m*
			Head at Building	62.606 *psi*

Domestic Only

S *(hydraulic slope/head loss)*	0.0000	*mH_2O/m*	Elevation at Source	383.8 *m*
h_f *(total head loss)*	0.000	*mH_2O*	Head at Source	68 *psi *assumed for calculations*
V *(velocity)*	0.024	*m/s*	Elevation at Building	386.8 *m*
			Head at Building	63.733 *psi*

APPENDIX C

Storm Design Calculations

41 Westhill Drive - Waterloo

Modified Rational Method Worksheet

Project: 2024-0744-10

100-year City of Waterloo Storm Parameters

$I = A/(B+T)^{\wedge C}$ (mm/hr)

A= 4692.0

B= 17.44

C= 0.956

		C
Pervious Area	0.283 ha	0.2
Impervious Area	0 ha	0.9

Area of site being investigated (ha) =	**0.283**
Composite Runoff Coeff. (C) =	**0.20**
Rainfall Intensity (mm/hr)	**239.79**
Release Rate (m^3/s) =	**0.031**

Duration (T)		Intensity (I)		Q
(min)	(sec)	(mm/hr)	(m/s)	(m^3/s)
10	**600**	**197.837**	**0.0000550**	**0.031**
15	900	168.579	0.0000468	0.027
20	1200	146.988	0.0000408	0.023
25	1500	130.387	0.0000362	0.020
30	1800	117.217	0.0000326	0.018
35	2100	106.508	0.0000296	0.017
40	2400	97.627	0.0000271	0.015
45	2700	90.140	0.0000250	0.014
50	3000	83.740	0.0000233	0.013
55	3300	78.205	0.0000217	0.012
60	3600	73.371	0.0000204	0.012
65	3900	69.111	0.0000192	0.011
70	4200	65.328	0.0000181	0.010
75	4500	61.945	0.0000172	0.010
80	4800	58.903	0.0000164	0.009
85	5100	56.151	0.0000156	0.009
90	5400	53.651	0.0000149	0.008
95	5700	51.368	0.0000143	0.008
100	6000	49.275	0.0000137	0.008

41 Westhill Drive - Waterloo

Modified Rational Method Worksheet

Project: 2024-0744-10

100-year City of Waterloo Storm Parameters

$I = A/(B+T)^{\wedge C}$ (mm/hr)

A= 4692.0

B= 17.44

C= 0.956

		C
Pervious Area	0.093 ha	0.2
Impervious Area	0.19 ha	0.9

Area of site being investigated (ha) =	**0.283**
Composite Runoff Coeff. (C) =	**0.67**
Rainfall Intensity (mm/hr)	**239.79**
Release Rate (m^3/s) =	**0.031**

Duration (T)		Intensity (I)		Q_{POST}	Storm Volume	Release Volume	Storage Volume
(min)	(sec)	(mm/hr)	(m/s)	(m^3/s)	(m^3)	(m^3)	(m^3)
5	300	239.793	0.0000666	0.126	37.88722	9.331	28.556
10	600	197.837	0.0000550	0.104	62.51659	18.663	43.854
15	900	168.579	0.0000468	0.089	79.90638	27.994	51.912
20	1200	146.988	0.0000408	0.077	92.89649	37.325	55.571
25	**1500**	**130.387**	**0.0000362**	**0.069**	**103.0057**	**46.657**	**56.349**
30	1800	117.217	0.0000326	0.062	111.1215	55.988	55.134
35	2100	106.508	0.0000296	0.056	117.7984	65.319	52.479
40	2400	97.627	0.0000271	0.051	123.4007	74.651	48.750
45	2700	90.140	0.0000250	0.047	128.1785	83.982	44.197
50	3000	83.740	0.0000233	0.044	132.3087	93.313	38.995
55	3300	78.205	0.0000217	0.041	135.9207	102.645	33.276
60	3600	73.371	0.0000204	0.039	139.111	111.976	27.135
65	3900	69.111	0.0000192	0.036	141.9533	121.307	20.646
70	4200	65.328	0.0000181	0.034	144.5049	130.639	13.866
75	4500	61.945	0.0000172	0.033	146.8107	139.970	6.841
80	4800	58.903	0.0000164	0.031	148.907	149.301	-0.394
85	5100	56.151	0.0000156	0.030	150.8229	158.633	-7.810
90	5400	53.651	0.0000149	0.028	152.5824	167.964	-15.381
95	5700	51.368	0.0000143	0.027	154.2054	177.295	-23.090
100	6000	49.275	0.0000137	0.026	155.7082	186.627	-30.918

Max. required storage volume = 56.35 m^3

Q_{POST} = (C i A) x 10000 m^2/ha

Storage Volume = Q_{POST} x T

Release Volume = Release Rate x T

Storage Volume = Storm Volume - Release Rate