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Subject: **175 John Street North Watermain Hydraulic Analysis**

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Urban Solutions

175 John Street North Watermain Hydraulic Analysis

C3 WATER INC.

November 17, 2022



VERSION	DATE	DESCRIPTION OF REVISIONS	REVISED BY	REVIEWED BY
1	August 24, 2022	Draft Report	Alec Orr	Sam Ziemann
2	November 17, 2022	Final Report	Alec Orr	Sam Ziemann

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1.0 INTRODUCTION

1.1 Background

The proposed development at 175 John Street North is located in Pressure District 2 (PD2) in the City of Hamilton (City). The development area is located on the west side of John Street North, between Cannon Street East and Robert Street. The development includes an 18-storey multiple dwelling building with 128 dwelling units and 77 parking spaces. The development area is currently supplied by a 150 mm cast iron watermain on John Street North. Figure 1-1 illustrates the proposed development area and the nearby watermains, all of which are cast iron. A figure illustrating the watermains in the development area at a wider scale is included in Appendix A.



Figure 1-1. Proposed 175 John Street North Development Area (Approximate)

PD2 is supplied by Pressure District 1 through pumping station HD002, which consists of four (4) pumps. PD2 has two (2) storage reservoirs HDR02 and HDR2A that provide balancing storage.

C3 Water Inc (C3W) has been retained by Urban Solutions to complete a watermain hydraulic analysis for the proposed development. This report provides the watermain hydraulic analysis in accordance with the City of Hamilton's Comprehensive Development Guidelines (2018) (Hamilton Guidelines) and the Ministry of Environment, Conservation and Parks (MECP) Design



Guidelines for Drinking-Water Systems (2008) (MECP Guidelines). The hydraulic assessment was completed using the City’s full pipe model, titled “Hamilton_EPS_200625_include_PD9_10” using Bentley WaterCAD Connect Edition Update 3 10.03.02.75 software.

1.2 Limitations

This technical memorandum (TM) is intended to provide servicing results for the proposed development based on the City’s hydraulic water model. This water model was built and coarsely calibrated by others. As with any modelling assignment, limitations related to the state of the model, the software capabilities, and theoretical data inputs should be considered. The model software also has inherent limitations and assumptions related to the calculation engine and inputs.

2.0 CRITERIA

2.1 Pressure Requirements

The MECP Guidelines outline maximum and minimum system pressures for standard operating conditions as well as fire flow conditions. As outlined in the City of Hamilton’s Water and Wastewater Masterplan (KMK, 2006), acceptable hydrant and service connection pressures under normal conditions range from 275 kPa to 690 kPa. Standard operating conditions were assessed for the proposed development to ensure that water services maintained acceptable pressure under various demand and fire flow conditions for existing (2021) and future (2031) scenarios. Table 2-1 provides the pressure criteria that were utilized.

Table 2-1. Pressure Requirements

Pressure Requirement	Minimum	Preferred	Maximum
Standard Operating Conditions	275 kPa (40 psi)	350 to 480 kPa (50 to 70 psi)	690 kPa (100 psi)
Maximum Day Demands + Fire Flows	140 kPa (20 psi)		

2.2 Domestic Demand

The maximum daily demand (MDD) for the proposed development was estimated by Lanhack Consultants Inc. (Lanhack). and based on a unit count of 64 one (1) bedroom and 64 two (2) bedroom units. The maximum daily demand was calculated to be 3.04 L/s. The average daily demand (ADD), and peak hour demand (PHD) were calculated using peaking factors of 1.9 and 3 based on the City of Hamilton’s WWMP. The ADD, MDD and PHD for the development are summarized in Table 2-2.

Table 2-2. Estimated Domestic Demands for the Proposed Development

Development	Demand (L/s)		
	ADD	MDD	PHD
175 John Street North	1.60	3.04	4.80

2.3 Fire Flow Requirements

The fire flow requirements for the proposed development were estimated by Lanhack based on the OBC and the Hamilton Watermain Fire Flow Requirement Design Guidelines Policy (PW19096). The City’s residential fire flow requirements are summarized in Table 2-3 below. Both methods resulted in a minimum fire flow of 150 L/s. The development is required to meet a minimum fire flow of 150 L/s at a residual pressure of 140 kPa under MDD conditions, as specified in Table 2-1.

Table 2-3. Hamilton Residential Fire Flow Requirements

Development Type	Target Fire Flow (L/s)
Residential Multi (> 3 Units)	150
Residential Medium (≤ 3 Units)	125
Residential Single	75
Residential Single (Dead End)	50

3.0 HYDRAULIC WATER MODEL

3.1 Boundary Conditions

The proposed development was modelled under the following demand scenarios under both existing (2021) and future (2031) conditions:

- Average Day Demand (ADD)
- Maximum Day Demand (MDD)
- MDD plus Fire Flow
- Peak Hour Demand (PHD)

Table 3-1 summarizes the initial boundary conditions set up in the model for PD2. The pumps at the water treatment plant (WTP) were turned off (reservoir only conditions). All pumps at pump station HD002 were turned off. The tank levels for reservoirs HDR02 and HDR2A were set to 50% full (144.33 m) and 75% full (146.08 m), respectively, as specified by the City.

Table 3-1. Model Boundary Conditions – Base Configuration

Element	Initial Status – HGL	
Tank HDR05 level	144.33 m (50%)	146.08 m (75%)
Treatment Pumps	Off	Off



Element	Initial Status – HGL	
HD002-PMP-1	Off	Off
HD002-PMP-2	Off	Off
HD002-PMP-3	Off	Off
HD002-PMP-4	Off	Off

3.2 Model Verification

The accuracy of the model in the area of the proposed development was verified using hydrant field test results, completed by SCG Flowmetrix on July 21, 2022. The hydrant field test results are summarized in Table 3-2. Figure 3-1 demonstrates the location of the residual and flow hydrants that were used for verification. Pressures were measured at the residual hydrant (HA17H051). Due to the proximity of the flow hydrant (HA17H038) to an adjacent hydro pole, SCG Flowmetrix was only able to run a one (1) port test.

Table 3-2. Hydrant Field Testing Results – July 21, 2022

Flow (L/s) at Hydrant HA17H038	Pressure (kPa) at Hydrant HA17H051
0	539
51.4	476
Theoretical Flow at 20 psi	
138.9	140

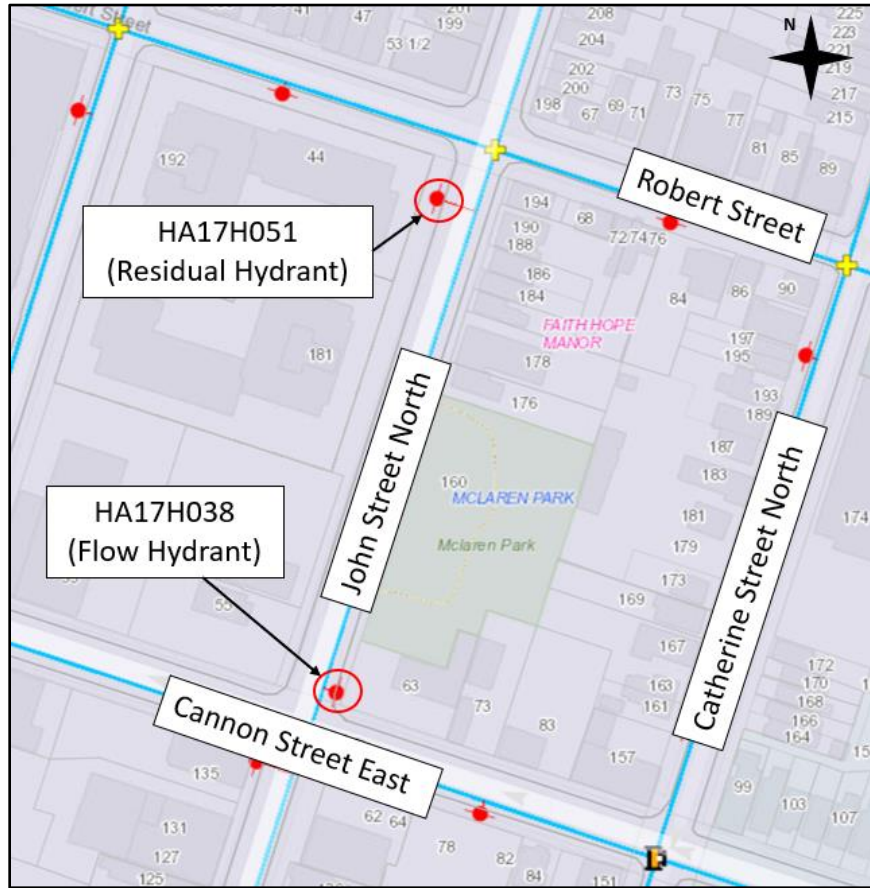


Figure 3-1. Field Testing Hydrant used for Model Verification

PD2 SCADA data was requested from the City to determine the boundary conditions during the field testing. A summary of the boundary conditions used for model verification is provided in Table 3-3. The model was compared to the hydrant test results under 2021 ADD conditions.

Table 3-3. Summary of Boundary Conditions at Time of Hydrant Testing

Element	Hydrant
	HA17H038
Time of Test	1:00 PM
Average Tank HDR02 Level	143.77 m (42%)
Average Tank HDR2A Level	144.38 m (51%)
Treatment Pump 1	Off
Treatment Pump 2	On
Treatment Pump 3	On
Treatment Pump 4	Off
Treatment Pump 5	On

Element	Hydrant
	HA17H038
Treatment Pump 6	Off
HD002-PMP-1	Off
HD002-PMP-2	Off
HD002-PMP-3	Off
HD002-PMP-4	On

Figure 3-2 illustrates the field test and model verification results for the hydrant on John St. North (HA17H038). Field results beyond the maximum testing flow are extrapolated.

The static pressure in the model was found to be higher than what was recorded in the field by 19 kPa (2.8 psi). This may be a result of elevation differences between the model node and the pressure recording instrumentation. The focus of the model verification was on the drop in pressure caused by the flow test.

When using the original C-factors in the City’s model, the pressure drop caused by the hydrant flow was found to be significantly less than what was recorded in the field. C-factors in the northeast section of PD2, near the development area, were adjusted in the model such that the model results more closely represented the field test results. A majority of the pipes in the northeast section of PD2 are cast iron (CI), ranging from 100mm to 300mm, with C-factors ranging from 80 to 131. The C-factors for the 100mm-200mm CI pipes were reduced to 27 and the C-factors for the 300mm pipes were reduced to 50. A detailed C-factor change log can be found in Appendix B.

The C-factor changes were made to the model to provide a better fit to the field tests. In C3W’s opinion the C-factors adjustments required to match the field testing data are lower than expected. There may be other factors involved in the limited hydraulic capacity of the system that could be considered such as accuracy of data such as watermain diameters, valve status, and system connectivity.

Additionally, the theoretical fire flow at 138 kPa (20 psi) was extrapolated based on only a 63 kPa (9 psi) difference between the field testing static and residual pressures. Typically, it is recommended that a 25% drop in pressure be required to adequately estimate the pressures at 20 psi, which would require a pressure drop of 131 kPa (19 psi) at hydrant HA17H05 based on the field testing static pressure.

The model was updated to best match the field results within reasonable accuracy, and the adjusted C-factors were used for the remaining analysis.

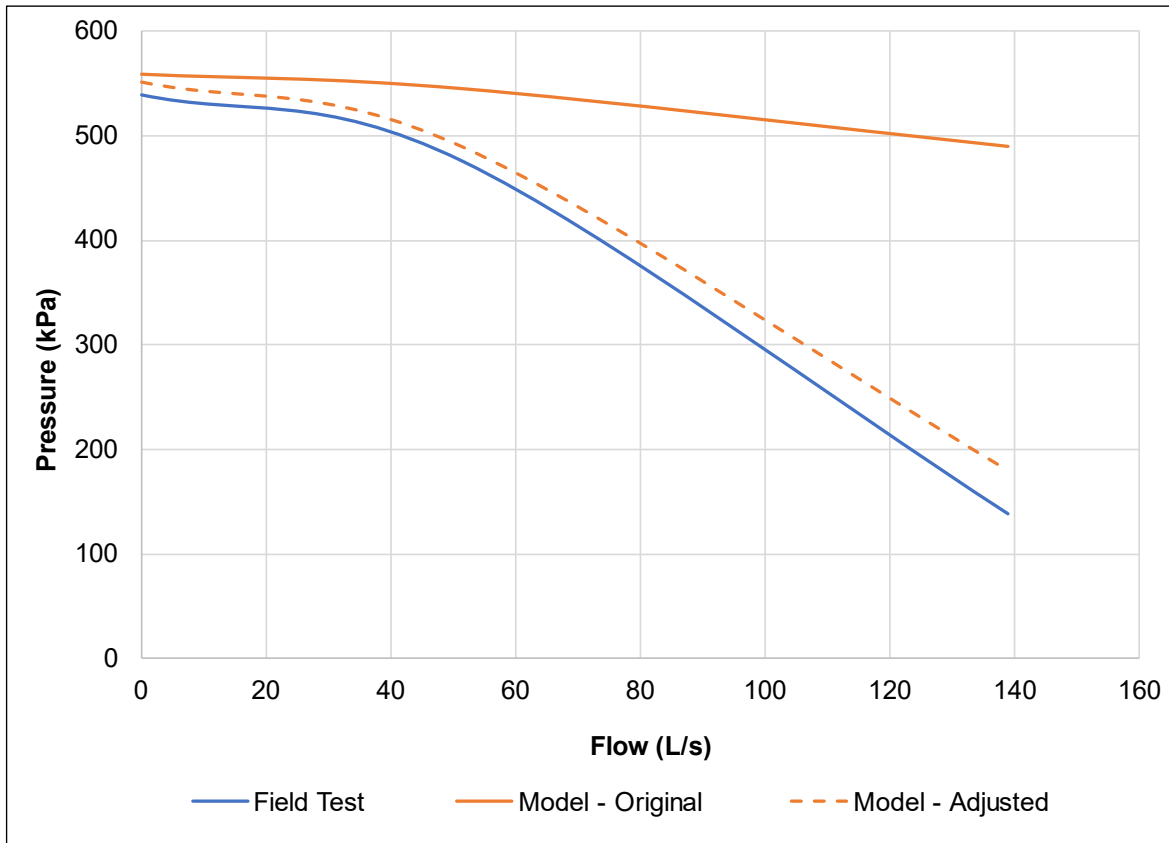


Figure 3-2. Verification Results - Hydrant HA17H038 on John St. North

3.3 Development

Figure 3-3 illustrates the location of the proposed development. The development will be serviced by a service connection on the existing 150 mm watermain on John St. North. Domestic demands for the development were applied to the development node (J-458) shown in Figure 3-3. The elevation of the demand node (89.39 m) was estimated using Hamilton’s existing water model and the elevations of the surrounding nodes.

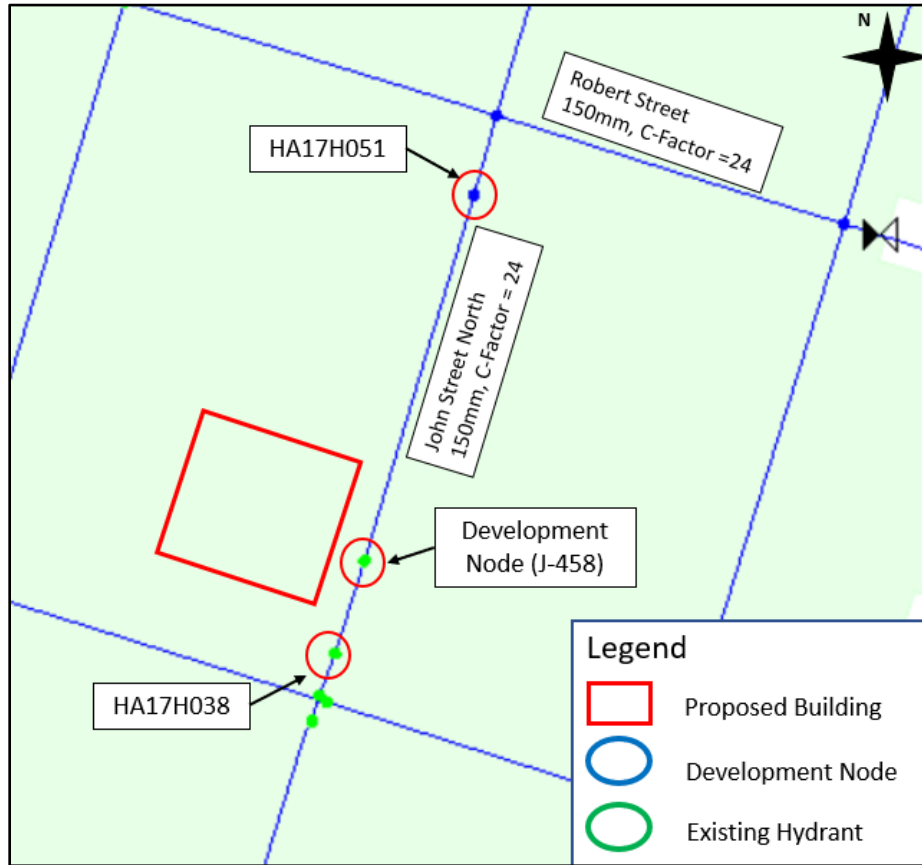


Figure 3-3. Model Layout for the 175 John St. Development

4.0 ANALYSIS

4.1 Available Fire Flow

The model was used to determine the available fire flow at the development node (J-458) and the existing hydrants shown in Figure 3-3. The model was initially run under MDD 2031 conditions at a residual pressure of 140 kPa, and HDR02 and HDR2A tank levels set at 50%, to determine the worst case available fire flow. The worst case available fire flow at the development node (J-458) and existing hydrants is summarized in Table 4-1. Under this condition, the fire flow did not meet the minimum available fire flow requirement of 150 L/s. Fire flow analysis for the existing hydrants under pre-development conditions is discussed in section 4.1.1.

The fire flow results in the model are lower than the field testing results due to pressure and flow being measured at different hydrants during the field test. The headlosses in the watermain between the two (2) hydrants is not accounted for in the field test since the pressure is not measured at the flow hydrant. In the model analysis, both the flow and pressure are measured at the same hydrant so the headlosses associated with the low C-factor in the existing 150mm watermain on John St. N are included in the calculation. Due to the low C-factor, there is a high headloss in this section of pipe which results in a low available fire flow.

Table 4-1. Worst Case Available Fire Flow Results (MDD 2031, tanks at 50%)

Node	Fire Flow (L/s)	Meets FF Criteria?
HA17H038	57.19	FALSE
HA17H051	77.17	FALSE
J-458	55.51	FALSE

The model was also run under the MDD 2031 scenario with different PD2 pump configurations and tank levels to observe the change in available fire flow at the development node and existing hydrants. Under these scenarios, the fire flow did not meet the minimum available fire flow requirement of 150 L/s at the development node or the existing hydrants. The results of this analysis are summarized in Table 4-2.

Table 4-2. Fire Flow Results - Different Pumping Scenarios and Tank Levels (MDD 2031)

Scenario	All PD2 Pumps	PD2 Tank Levels	Node	Fire Flow (L/s)	Meets FF Criteria?
1	ON	50%	HA17H038	58.8	FALSE
			HA17H051	79.44	FALSE
			J-458	57.16	FALSE
2	OFF	75%	HA17H038	58.57	FALSE
			HA17H051	79.11	FALSE
			J-458	56.91	FALSE
3	ON	75%	HA17H038	60.05	FALSE
			HA17H051	81.21	FALSE
			J-458	58.44	FALSE

By upgrading the existing 150mm watermain on John St. North, between Cannon St. East and Robert St., to a 200mm watermain (C-factor of 110), the fire flows at the development node (J-458) and the existing hydrants met the minimum available fire flow requirement of 150 L/s. Table 4-3 summarizes the fire flow results for the development node (J-458) and existing hydrants with the watermain upgrades on John. St. North. Figure 4-1 summarizes the proposed watermain upgrades required on John St. North to meet the minimum available fire flow. Fire flow results are available in Appendix C.

Table 4-3. Fire Flow Results with Watermain Upgrades on John St. North

Node	2021		2031		Meets FF Criteria?
	Tank Level				
	50%	75%	50%	75%	
HA17H038	174	178	173	178	TRUE
HA17H051	214	219	213	219	TRUE
J-458	202	208	202	207	TRUE

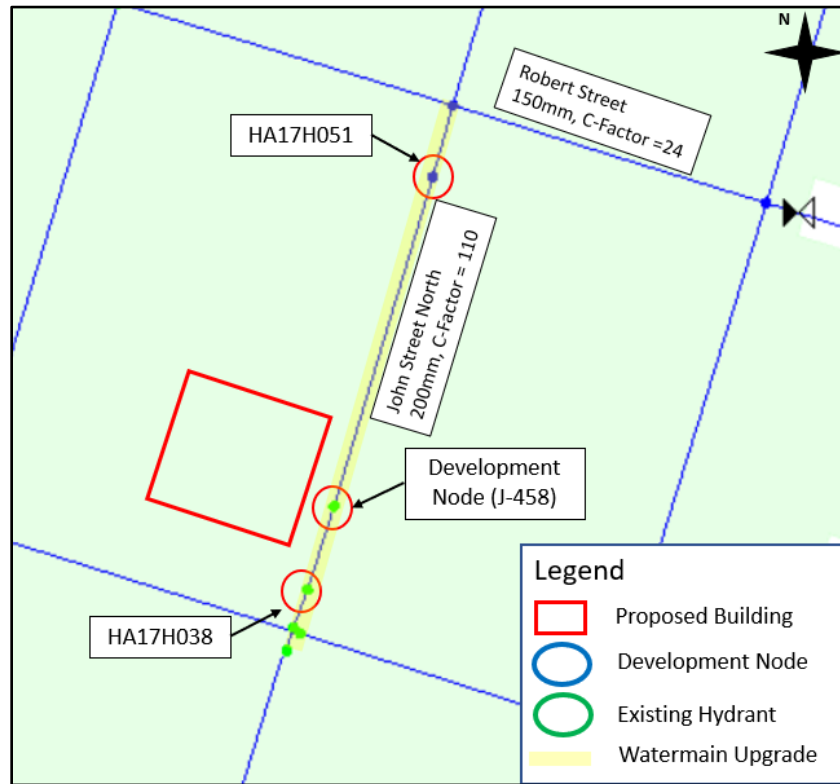


Figure 4-1. Proposed Watermain Upgrades on 175 John St. North

4.1.1 Pre-Development Conditions

Table 4-4 summarizes the fire flow results at the existing hydrants on John St. North under pre-development conditions and the MDD 2021 scenario with the PD2 tank levels set at 50% and 75%. Under pre-development conditions the fire flow did not meet the minimum available fire flow requirement of 150 L/s. The low available fire flows at the existing hydrants could be a result of the low C-factor adjustment required to match the field tests, or due to the hydrants being close to the PD2 boundary. Full fire flow results for the pre-development conditions are available in Appendix C.

Table 4-4. Fire Flow Results under Pre-Development Conditions

Node	2021		Meets FF Criteria?
	Tank Level		
	50%	75%	
HA17H038	58	60	TRUE
HA17H051	80	82	TRUE

4.2 System Pressures

The pressure results for the development node (J-458) are summarized in Table 4-5 and Table 4-6, with PD2 tank levels set to 50% and 75%, respectively, and the PD2 and WTP pumps off. This analysis was completed with the watermain upgrades on John St. North. Under each of the scenarios, the pressures ranged between 508 kPa and 551 kPa, which are within the City’s allowable operating pressure range of 275 to 690 kPa. Full system pressure results are included in Appendix D.

Table 4-5. Pressure Results (kPa) with Tanks Set to 50%

Node	ADD		MDD		PHD	
	2021	2031	2021	2031	2021	2031
J-458	534	533	525	523	512	508

Table 4-6. Pressure Results (kPa) with Tanks set to 75%

Node	ADD		MDD		PHD	
	2021	2031	2021	2031	2021	2031
J-458	551	550	542	540	529	525

4.3 Flushing

The hydraulic model was used to evaluate the flushing capacity in the proposed 200mm watermain on John St. North, with PD2 tank levels set at 50% full and the PD2 and WTP pumps offline. The 2021 ADD scenario was used to represent existing conditions for construction flushing requirements. Flushing demands were modelled to replace domestic demands while the area is under development. Results were based on a minimum velocity of 0.8 m/s as required by the MECP Guidelines. Hydrant nodes were modelled with an emitter coefficient of 11.2 L/s/m^{0.5} (150 gpm/psi). This value is recommended by the American Water Works Association (AWWA) to represent a single 60mm (2.5”) outlet and considers all lateral valve and bends within the hydrant.

Table 4-7 summarizes the flushing results for the proposed 200 mm watermain on John St. North. A flushing velocity of 0.8 m/s was achieved in the proposed 200 mm watermain when the tank levels are set to 50%. The complete flushing reports are available in Appendix E.

Table 4-7. Flushing Results with Tanks set to 50% (ADD 2021)

Pipe	Length (m)	Diameter (mm)	Flushing Velocity (m/s)	Meets Criteria
HA18W14187(1)	19	200	1.47	TRUE
HA18W14187(2)(1)(1)	119	200	1.47	TRUE
HA18W14187(2)(1)(2)	30	200	1.42	TRUE
HA18W14187(2)(2)	15	200	2.46	TRUE



5.0 CONCLUSIONS

This analysis was based on the City's existing hydraulic water model. The model was verified using field test results and the City's historical SCADA data. The C-factors of the watermains near the development area were adjusted to provide a closer representation of the hydraulic capacity of the water system based on field testing data provided. Lower than expected C-factors were required on the CI watermains near the development area to better match the model results to the field testing.

The watermain hydraulic assessment of the proposed 175 John St. North development demonstrated that:

1. The minimum available fire flow requirement of 150 L/s was not achieved at the development node (J-458) or the existing hydrants under MDD 2021 or MD 2031 conditions.
 - a. Under pre-development conditions, the fire flow requirement of 150 L/s was not met at the existing hydrants. This could be a result of the low C-factor adjustment required to match the field tests, or due to the hydrants being close to the PD2 boundary.
2. When the watermain on John St. North between Cannon St. East and Robert St. was upgraded from 150 mm to 200 mm (C-factor of 110), the minimum fire flow requirement of 150 L/s was achieved at the development node (J-458) and the existing hydrants under MDD 2021 and MDD 2031 conditions, with the PD2 tanks at 50% and 75%,
3. The service pressures under existing (MDD 2021) and ultimate build-out (currently MDD 2031*) conditions are expected to range between 508 - 551 kPa, with the watermain on John St. North upgraded to a 200 mm. The service pressures are within the City's allowable operating pressure range of 275 to 690 kPa.
4. The proposed 200 mm watermain on John St. North can achieve the minimum flushing velocity of 0.8 m/s as required by the MECF guidelines.

* As amended from time to time as per Official Plan Report Content



APPENDIX A – Existing Watermains Near Development

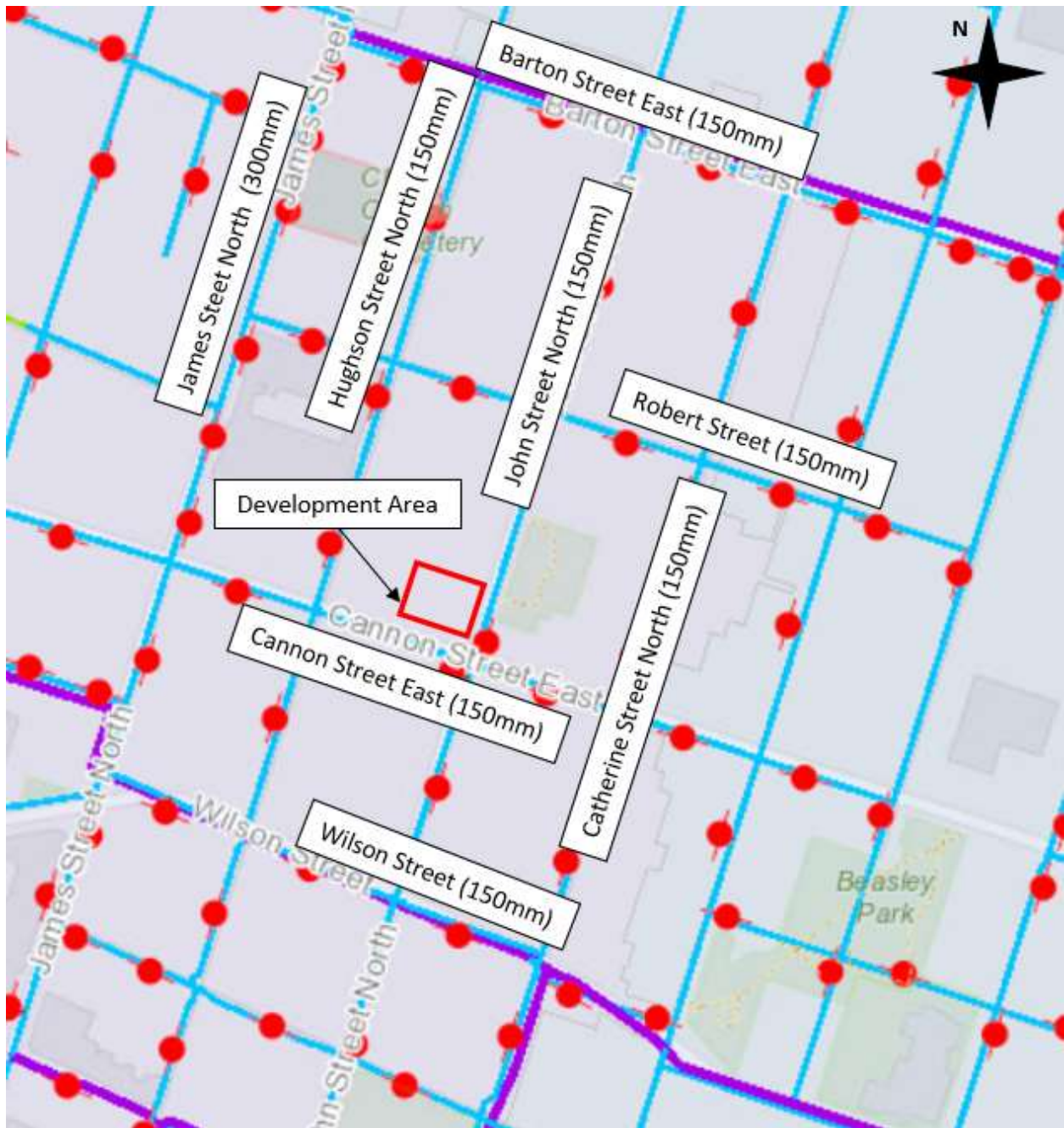


Figure A-1 Cast Iron Watermains and Diameters near Development Area



APPENDIX B – Model Verification – C-factor Change Log

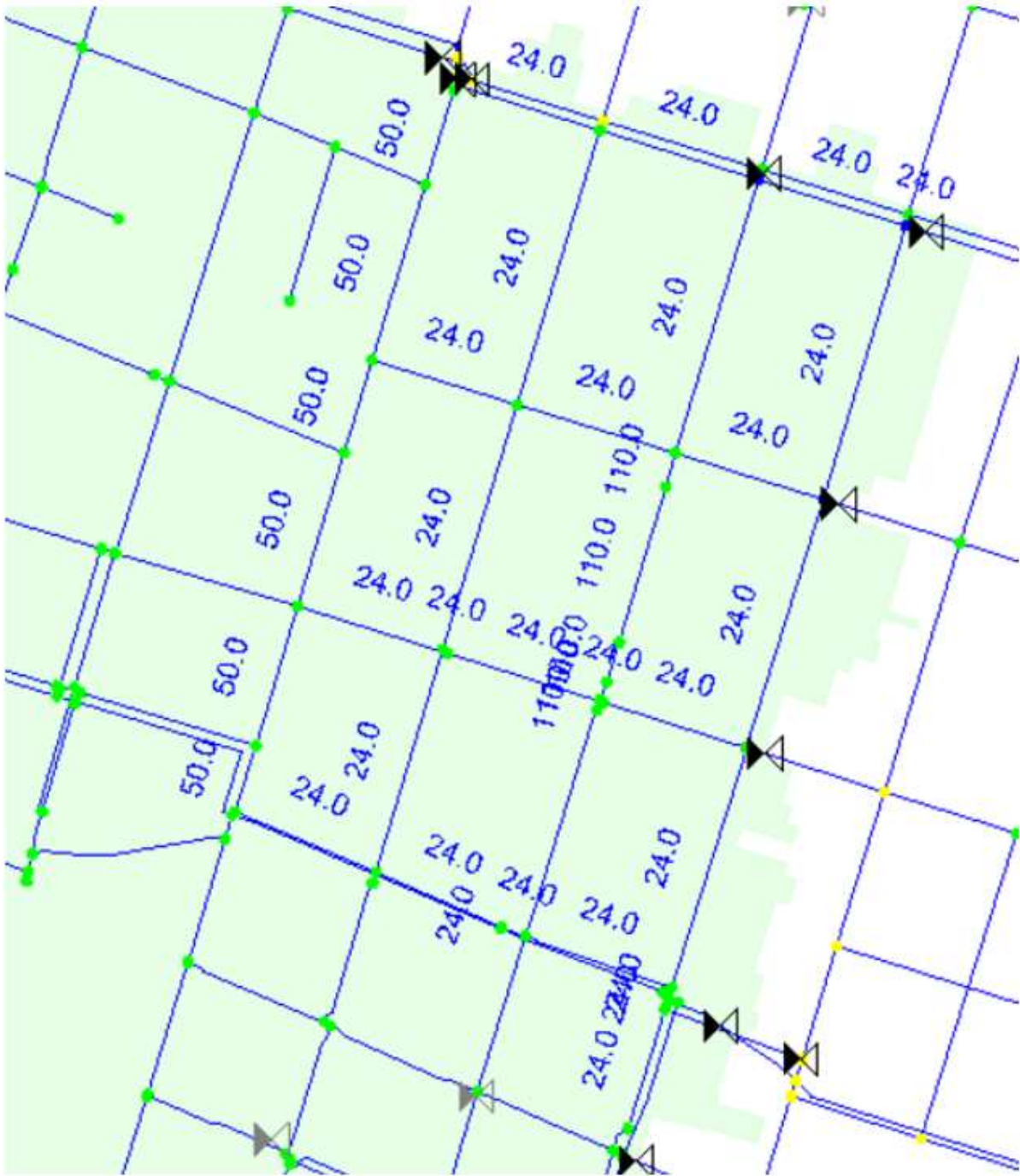


Figure B-1 Adjusted C-Factors in Pressure District 2 near Development Area

Table B-1 Model Verification C-Factor Adjustment Log

ID	Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Adjusted (verification)
23476	HA17W14168	HA17T004	HA17R009	150	Cast Iron	80	88	24
23475	HA17W14169	HA17T002	HA17T004	150	Cast Iron	80	8	24
23473	HA17W14170	HA17T001	HA17T002	150	Cast Iron	80	8	24
23393	HA17W14174	HA17T001	HA17C007	150	Cast Iron	80	110	24
23462	HA17W14178	HA17T022	HA17R003	150	Cast Iron	80	8	24
23468	HA17W14180	HA17T001	HA17T014	150	Cast Iron	80	178	24
23467	HA17W14184	HA17T014	HA18C010	150	Cast Iron	80	184	24
23428	HA17W14185	HA17T017	HA17T014	200	Cast Iron	80	106	24
23427	HA17W14186	HA17T016	HA17T017	150	Cast Iron	80	117	24
23453	HA17W14188	HA17T023	HA18C017	150	Cast Iron	80	181	24
16604	HA17W14190	HA17T023	HA17C008	150	Cast Iron	80	165	24
23392	HA17W14191	HA17C007	HA17T031	150	Cast Iron	80	19	24
26554	HA17W14192	HA17T027	HA17T031	150	Cast Iron	80	1	24
23391	HA17W14193	HA17T031	HA17C008	150	Cast Iron	80	97	24
23429	HA17W14699	HA17T022	HA17T017	150	Cast Iron	80	4	24
23424	HA17W14703	HA17T023	HA17T016	150	Cast Iron	80	5	24
23727	HA18W14018	HA18C015	HA18T030	150	Cast Iron	80	118	24
22821	HA18W14023	HA18V031	HA18T024	150	Cast Iron	80	15	24
22820	HA18W14024	HA18T024	HA18C015	150	Cast Iron	80	109	24
22885	HA18W14054	HA18C017	HA18T030	150	Cast Iron	80	203	24
22862	HA18W14055	HA18C017	HA18C011	150	Cast Iron	80	117	24
22933	HA18W14056	HA18C011	HA18C015	150	Cast Iron	80	202	24
22975	HA18W14058	HA18C010	HA18T024	150	Cast Iron	80	202	24
22867	HA18W14059	HA18C011	HA18C010	150	Cast Iron	80	110	24
33452	HA18W14187(1)	HA18C011	HA17H038	150	Cast Iron	80	19	24
33458	HA18W14187(2)(1)(1)	HA17H038	J-458	150	Cast Iron	80	119	24
33459	HA18W14187(2)(1)(2)	J-458	HA17H051	150	Cast Iron	80	30	24
33456	HA18W14187(2)(2)	HA17H051	HA17T022	150	Cast Iron	80	15	24

ID	Label	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Length (m)	Adjusted (verification)
23056	HA23W04412	HA23T002	HA23T007	300	Cast Iron	130	70	50
23057	HA23W14013	HA23T001	HA23T002	300	Cast Iron	130	130	50
23059	HA23W14014	HA23T001	HA18C017	150	Cast Iron	100	108	24
22814	HA23W14015	HA18T030	HA23T007	150	Cast Iron	80	109	24
22856	HA23W14053	HA24T017	HA23T001	300	Cast Iron	130	68	50
23340	HA24W14050	HA24T024	HA24T027	300	Cast Iron	131	49	50
23338	HA24W14051	HA24C007	HA24T024	300	Cast Iron	130	103	50
23336	HA24W14052	HA24T017	HA24C007	300	Cast Iron	130	114	50
23354	HA24W14195	HA17C008	HA24T027	150	Cast Iron	100	109	24
23426	HA24W14701	HA24C007	HA17T016	150	Cast Iron	100	112	24



APPENDIX C – Fire Flow Results

Fire Flow Analysis - Development

MDD 2021 - Tank 50%

Label	Zone	Fire Flow Iterations	Satisfies Fire Flow Constraints?	Fire Flow (Needed) (L/s)	Fire Flow (Available) (L/s)	Flow (Total Needed) (L/s)	Flow (Total Available) (L/s)	Pressure (Residual Lower Limit) (kPa)	Pressure (Calculated Residual) (kPa)	Is Fire Flow Run Balanced?
HA17H038	2	3	TRUE	150	174.29	150	174.29	20	20	TRUE
HA17H051	2	3	TRUE	150	214.03	150	214.03	20	20	TRUE
J-458	2	3	TRUE	150	202.61	153.04	205.65	20	20	TRUE

MDD 2021 - Tank 75%

Label	Zone	Fire Flow Iterations	Satisfies Fire Flow Constraints?	Fire Flow (Needed) (L/s)	Fire Flow (Available) (L/s)	Flow (Total Needed) (L/s)	Flow (Total Available) (L/s)	Pressure (Residual Lower Limit) (kPa)	Pressure (Calculated Residual) (kPa)	Is Fire Flow Run Balanced?
HA17H038	2	3	TRUE	150	178.44	150	178.44	20	20	TRUE
HA17H051	2	3	TRUE	150	219.3	150	219.3	20	20	TRUE
J-458	2	3	TRUE	150	207.56	153.04	210.6	20	20	TRUE

MDD 2031 - Tank 50%

Label	Zone	Fire Flow Iterations	Satisfies Fire Flow Constraints?	Fire Flow (Needed) (L/s)	Fire Flow (Available) (L/s)	Flow (Total Needed) (L/s)	Flow (Total Available) (L/s)	Pressure (Residual Lower Limit) (kPa)	Pressure (Calculated Residual) (kPa)	Is Fire Flow Run Balanced?
HA17H038	2	3	TRUE	150	173.72	150	173.72	20	20	TRUE
HA17H051	2	3	TRUE	150	213.30	150	213.3	20	20	TRUE
J-458	2	3	TRUE	150	201.94	153.04	204.98	20	20	TRUE

MDD 2031 - Tank 75%

Label	Zone	Fire Flow Iterations	Satisfies Fire Flow Constraints?	Fire Flow (Needed) (L/s)	Fire Flow (Available) (L/s)	Flow (Total Needed) (L/s)	Flow (Total Available) (L/s)	Pressure (Residual Lower Limit) (kPa)	Pressure (Calculated Residual) (kPa)	Is Fire Flow Run Balanced?
HA17H038	2	3	TRUE	150	177.88	150	177.88	20	20	TRUE
HA17H051	2	3	TRUE	150	218.59	150	218.59	20	20	TRUE
J-458	2	3	TRUE	150	206.89	153.04	209.93	20	20	TRUE

Fire Flow Analysis - Pre-Existing**MDD 2021 - Tank 50%**

Label	Zone	Fire Flow Iterations	Satisfies Fire Flow Constraints?	Fire Flow (Needed) (L/s)	Fire Flow (Available) (L/s)	Flow (Total Needed) (L/s)	Flow (Total Available) (L/s)	Pressure (Residual Lower Limit) (kPa)	Pressure (Calculated Residual) (kPa)	Is Fire Flow Run Balanced?
HA17H038	2	3	FALSE	150	58.45	150	58.45	20	20	TRUE
HA17H051	2	3	FALSE	150	80.11	150	80.11	20	20	TRUE
J-458	2	3	FALSE	150	58.73	150	58.73	20	20	TRUE

MDD 2021 - Tank 75%

Label	Zone	Fire Flow Iterations	Satisfies Fire Flow Constraints?	Fire Flow (Needed) (L/s)	Fire Flow (Available) (L/s)	Flow (Total Needed) (L/s)	Flow (Total Available) (L/s)	Pressure (Residual Lower Limit) (kPa)	Pressure (Calculated Residual) (kPa)	Is Fire Flow Run Balanced?
HA17H038	2	3	FALSE	150	59.82	150	59.82	20	20	TRUE
HA17H051	2	3	FALSE	150	82.04	150	82.04	20	20	TRUE
J-458	2	3	FALSE	150	60.13	150	60.13	20	20	TRUE



APPENDIX D – System Pressures

System Pressures

ADD 2021 - Tank 50%

ID	Label	Is Active?	Elevation (m)	Zone	Demand (L/s)	Demand Collection	Hydraulic Grade (m)	Pressure (kPa)
33457	J-458	TRUE	89.34	2	1.6	<Collection: 1 item>	143.89	534

ADD 2021 - Tank 75%

ID	Label	Is Active?	Elevation (m)	Zone	Demand (L/s)	Demand Collection	Hydraulic Grade (m)	Pressure (kPa)
33457	J-458	TRUE	89.34	2	1.6	<Collection: 1 item>	145.64	551

ADD 2031 - Tank 50%

ID	Label	Is Active?	Elevation (m)	Zone	Demand (L/s)	Demand Collection	Hydraulic Grade (m)	Pressure (kPa)
33457	J-458	TRUE	89.34	2	1.6	<Collection: 1 item>	143.83	533

ADD 2031 - Tank 75%

ID	Label	Is Active?	Elevation (m)	Zone	Demand (L/s)	Demand Collection	Hydraulic Grade (m)	Pressure (kPa)
33457	J-458	TRUE	89.34	2	1.6	<Collection: 1 item>	145.58	550

MDD 2021 - Tank 50%

ID	Label	Is Active?	Elevation (m)	Zone	Demand (L/s)	Demand Collection	Hydraulic Grade (m)	Pressure (kPa)
33457	J-458	TRUE	89.34	2	3.04	<Collection: 1 item>	142.97	525

MDD 2021 - Tank 75%

ID	Label	Is Active?	Elevation (m)	Zone	Demand (L/s)	Demand Collection	Hydraulic Grade (m)	Pressure (kPa)
33457	J-458	TRUE	89.34	2	3.04	<Collection: 1 item>	144.73	542

MDD 2031 - Tank 50%

ID	Label	Is Active?	Elevation (m)	Zone	Demand (L/s)	Demand Collection	Hydraulic Grade (m)	Pressure (kPa)
33457	J-458	TRUE	89.34	2	3.04	<Collection: 1 item>	142.78	523

MDD 2031 - Tank 75%

ID	Label	Is Active?	Elevation (m)	Zone	Demand (L/s)	Demand Collection	Hydraulic Grade (m)	Pressure (kPa)
33457	J-458	TRUE	89.34	2	3.04	<Collection: 1 item>	144.54	540

PHD 2021 - Tank 50%

ID	Label	Is Active?	Elevation (m)	Zone	Demand (L/s)	Demand Collection	Hydraulic Grade (m)	Pressure (kPa)
33457	J-458	TRUE	89.34	2	4.8	<Collection: 1 item>	141.61	512

PHD 2021 - Tank 75%

ID	Label	Is Active?	Elevation (m)	Zone	Demand (L/s)	Demand Collection	Hydraulic Grade (m)	Pressure (kPa)
33457	J-458	TRUE	89.34	2	4.8	<Collection: 1 item>	143.37	529

PHD 2031 - Tank 50%

ID	Label	Is Active?	Elevation (m)	Zone	Demand (L/s)	Demand Collection	Hydraulic Grade (m)	Pressure (kPa)
33457	J-458	TRUE	89.34	2	4.8	<Collection: 1 item>	141.2	508

PHD 2031 - Tank 75%

ID	Label	Is Active?	Elevation (m)	Zone	Demand (L/s)	Demand Collection	Hydraulic Grade (m)	Pressure (kPa)
33457	J-458	TRUE	89.34	2	4.8	<Collection: 1 item>	142.96	525








APPENDIX E – Flushing Results

Flushing Analysis - ADD 2021, Tanks at 50%

ID	Label	Length (m)	Diameter (mm)	Flushing Event	Velocity (Maximum Flushing) (m/s)	Satisfies Flushing Target Velocity?	Shear Stress (Maximum Flushing) (kg/m ²)	Satisfies Flushing Target Shear Stress?	Satisfies Flushing Target?
33452	HA18W14187(1)	19	200	Event - 1	1.47	TRUE	0.75	TRUE	TRUE
33458	HA18W14187(2)(1)(1)	119	200	Event - 1	1.47	TRUE	0.75	TRUE	TRUE
33459	HA18W14187(2)(1)(2)	30	200	Event - 1	1.42	TRUE	0.71	TRUE	TRUE
33456	HA18W14187(2)(2)	15	200	Event - 2	2.46	TRUE	1.95	TRUE	TRUE

Flushing Field Report

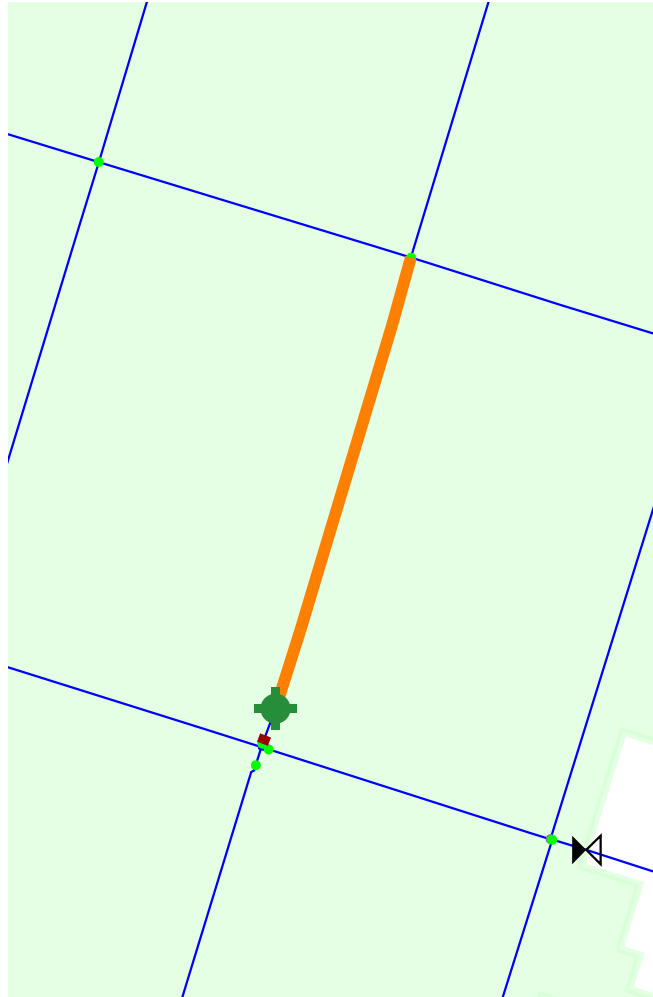
Study: Flushing Study

Legend	
	Valves to Open
	Valves to Close
	Flushing Hydrants
	Pipe Run
	Closed Pipes

Flushing Field Report

Study: Flushing Study; Area: John St Flushing; Event: Event - 1

Primary View



Flushing Field Report

Study: Flushing Study; Area: John St Flushing; Event: Event - 1

Fire Hydrant	Notes	Pressure (kPa) Static, Dynamic	Measured Flow (L/s)	Predicted Pressure (kPa)	Predicted Flow (L/s)
HA17H051				153	44.63

Valve	Operation	Notes	Flushing	Minimum	Recommended
HA18W14187(2)(2)	Close <input type="checkbox"/>		Time (min)	1.9	1.9
	<input type="checkbox"/>		Volume (ML)	0.0	0.0
	<input type="checkbox"/>		Start Time _____		
	<input type="checkbox"/>		End Time _____		
	<input type="checkbox"/>		Operator _____		
	<input type="checkbox"/>		Date _____		
	<input type="checkbox"/>		Water Quality		
	<input type="checkbox"/>			Initial	Final
	<input type="checkbox"/>		Clear	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>		Colored	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>		Chlorine Residual		
	<input type="checkbox"/>		Turbidity		
Pipe Run to be Cleaned					
HA18W14187(1), HA18W14187(2)(1)(1), HA18W14187(2)(1)(2)					

Notes _____

Flushing Field Report






Study: Flushing Study; Area: John St Flushing; Event: Event - 1

Final Actions

Valve	Operation	Notes
HA18W14187(2)(2)	Reopen <input type="checkbox"/>	
	<input type="checkbox"/>	
	<input type="checkbox"/>	
	<input type="checkbox"/>	
	<input type="checkbox"/>	
	<input type="checkbox"/>	
	<input type="checkbox"/>	
	<input type="checkbox"/>	
	<input type="checkbox"/>	
	<input type="checkbox"/>	
	<input type="checkbox"/>	
	<input type="checkbox"/>	
	<input type="checkbox"/>	
	<input type="checkbox"/>	
	<input type="checkbox"/>	
	<input type="checkbox"/>	

Flushing Field Report

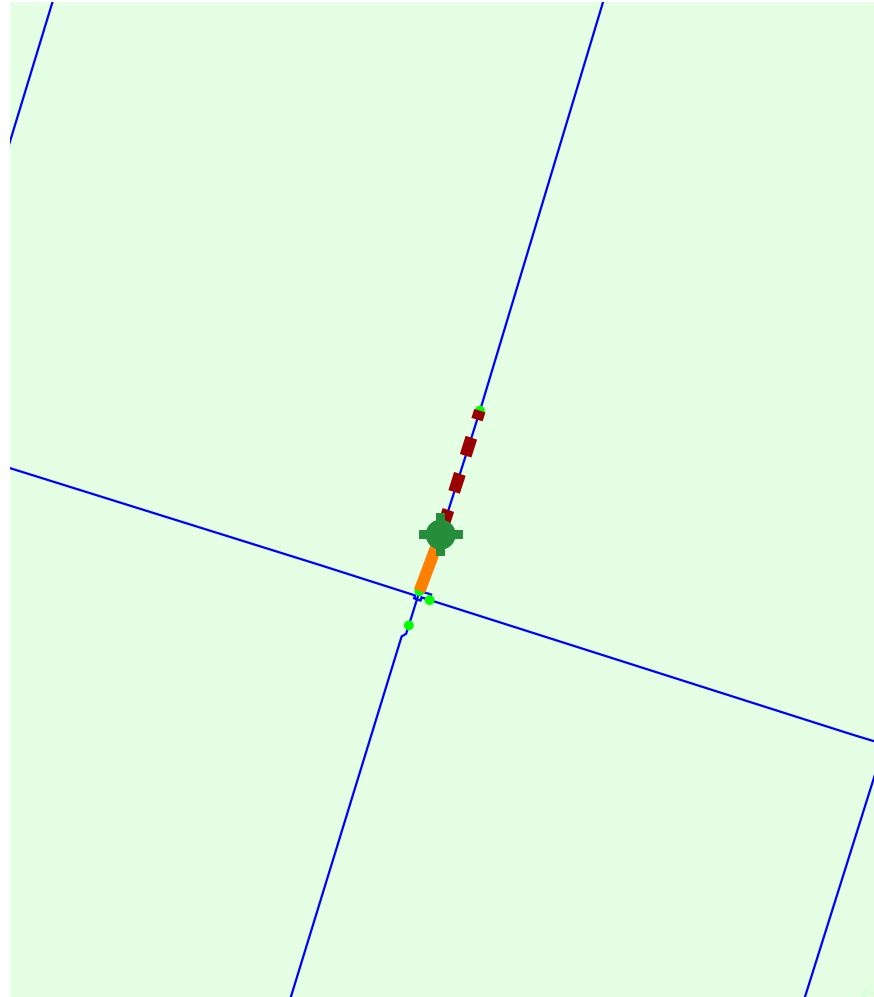
Study: Flushing Study

Legend	
	Valves to Open
	Valves to Close
	Flushing Hydrants
	Pipe Run
	Closed Pipes

Flushing Field Report

Study: Flushing Study; Area: John St Flushing; Event: Event - 2

Primary View



Flushing Field Report

Study: Flushing Study; Area: John St Flushing; Event: Event - 2

Fire Hydrant	Notes	Pressure (kPa) Static, Dynamic	Measured Flow (L/s)	Predicted Pressure (kPa)	Predicted Flow (L/s)
HA17H051				459	77.24

Valve	Operation	Notes	Flushing	Minimum	Recommended															
HA18W14187(2)(2)	Reopen <input type="checkbox"/>		Time (min)	0.1	0.1															
HA18W14187(2)(1)(2)	Close <input type="checkbox"/>		Volume (ML)	0.0	0.0															
	<input type="checkbox"/>		Start Time _____																	
	<input type="checkbox"/>		End Time _____																	
	<input type="checkbox"/>		Operator _____																	
	<input type="checkbox"/>		Date _____																	
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	<input type="checkbox"/>																			
Pipe Run to be Cleaned			Water Quality																	
HA18W14187(2)(2)			<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 60%;"> </th> <th style="width: 20%;">Initial</th> <th style="width: 20%;">Final</th> </tr> </thead> <tbody> <tr> <td>Clear</td> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> </tr> <tr> <td>Colored</td> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> </tr> <tr> <td>Chlorine Residual</td> <td> </td> <td> </td> </tr> <tr> <td>Turbidity</td> <td> </td> <td> </td> </tr> </tbody> </table>				Initial	Final	Clear	<input type="checkbox"/>	<input type="checkbox"/>	Colored	<input type="checkbox"/>	<input type="checkbox"/>	Chlorine Residual			Turbidity		
	Initial	Final																		
Clear	<input type="checkbox"/>	<input type="checkbox"/>																		
Colored	<input type="checkbox"/>	<input type="checkbox"/>																		
Chlorine Residual																				
Turbidity																				

Notes _____

Flushing Field Report

Study: Flushing Study; Area: John St Flushing; Event: Event - 2

Final Actions

Valve	Operation	Notes
HA18W14187(2)(1)(2)	Reopen <input type="checkbox"/>	
	<input type="checkbox"/>	
	<input type="checkbox"/>	
	<input type="checkbox"/>	
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