UTILITIES KINGSTON

CITY OF KINGSTON WATER MASTER PLAN

GAP ANALYSIS REPORT - WATER

JANUARY 30, 2017

CITY OF KINGSTON WATER MASTER PLAN

GAP ANALYSIS REPORT - WATER

Utilities Kingston

Final Report

Project nº : 151-02944-00
Date : January 30, 2017

–
WSP Canada Inc.
1224 Gardiners Road
Kingston, ON K7P 0G2

Phone: 613 634 7373
Fax: 613 634 3523
www.wspgroup.com

January, 2017

Ms. Katie Morrow
Utilities Kingston
85 Lappan's Lane
Kingston, ON, K7L 4X7

Subject: City of Kingston Water Master Plan

Dear Ms. Morrow:

We are pleased to provide our draft of the Water System Gap Analysis for the City of Kingston service areas. The purpose of this report is to identify capacity constraints in the Kingston Water System under the existing and future growth scenarios.

A system-wide evaluation of alternative solutions will be completed in a separate report as part of the Master Planning Process. Similarly, details pertaining to the hydraulic model construction and loading are documented separately in the Hydraulic Modeling Report.

We would be happy to discuss this report with you at your convenience.

Yours truly,

Matt Morkem, P.Eng.
Manager, Infrastructure, Kingston

WSP Canada Inc.
1224 Gardiners Road
Kingston, ON K7P 0G2
Phone: +1 613-634-7373
Fax: +1 613-634-3523
www.wspgroup.com

REVISION HISTORY

VERSION	DATE	DESCRIPTION
1	APRIL 2016	Draft Report
2	JANUARY 30, 2017	Final Report

SIGNATURES

PREPARED BY

Matt Morkem, P.Eng.
Manager, Infrastructure

SENIOR REVIEW BY

Jamie Witherspoon, P.Eng, LEED AP
Vice-President – Municipal Infrastructure - Ontario

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

1 INTRODUCTION

WSP was retained by Utilities Kingston (UK) to complete a Master Plan to establish servicing strategies for water infrastructure in the urban area for the next 20 years. The Master Plan will identify potential projects to address the servicing needs of planned growth and development within the Urban Boundary. The Master Plan is being conducted in accordance with the requirements set out in the Municipal Class Environmental Assessment (Class EA) document (Municipal Engineers Association, Amended 2011).

This report includes a capacity review of Utilities Kingston's existing water system today and into the future. The review is based on population growth projections established in the Growth Scenario Report (WSP, 2015) and projected water generation developed in this report to identify future infrastructure needs.

The outcome of these results will be the basis for the problem definition and evaluation of alternatives conducted as part of the Master Plan.

2 OVERVIEW OF EXISTING SYSTEM

2.1 WATER TREATMENT PLANTS

Raw water from Lake Ontario passes through two main water treatment plants (WTPs) that supply the majority of the Kingston water distribution system. A smaller scale water treatment plant serves the Cana subdivision north of Macdonald-Cartier Freeway (Highway 401) drawing raw water from a well.

Currently, the Kingston West water distribution system is serviced by water supplied from:

→ Point Pleasant Water Treatment Plant

The Kingston Central and East water distribution networks are currently serviced by water supplied from:

→ King Street Water Treatment Plant

The Cana subdivision is serviced by water supplied from:

→ Cana Water Treatment Plant

2.2 BOOSTER STATIONS/ RESERVOIRS

There are three booster stations (BS) and three combined reservoir/booster stations in the Kingston water distribution system.

The Kingston West water distribution system includes:

→ Sydenham Road BS

- Old Colony Road BS
- Progress Avenue Reservoir/BS
- O'Connor Drive Reservoir/BS

The Kingston Central water distribution system includes:

- Third Avenue Reservoir/BS

The Kingston East water distribution system includes:

- James Street BS

2.3 ELEVATED STORAGE TANKS

There are five elevated storage tanks (EST) and one standpipe that supply water (domestic and fire flow) and pressure to the Kingston water distribution systems.

The Kingston West water distribution system includes:

- O'Connor Drive EST
- Creekford Road EST

The Kingston Central water distribution system includes:

- Tower Street EST

The Kingston East water distribution system includes:

- Innovation Drive EST
- Somme Avenue EST (CFB Kingston)
- Forrest Drive Standpipe

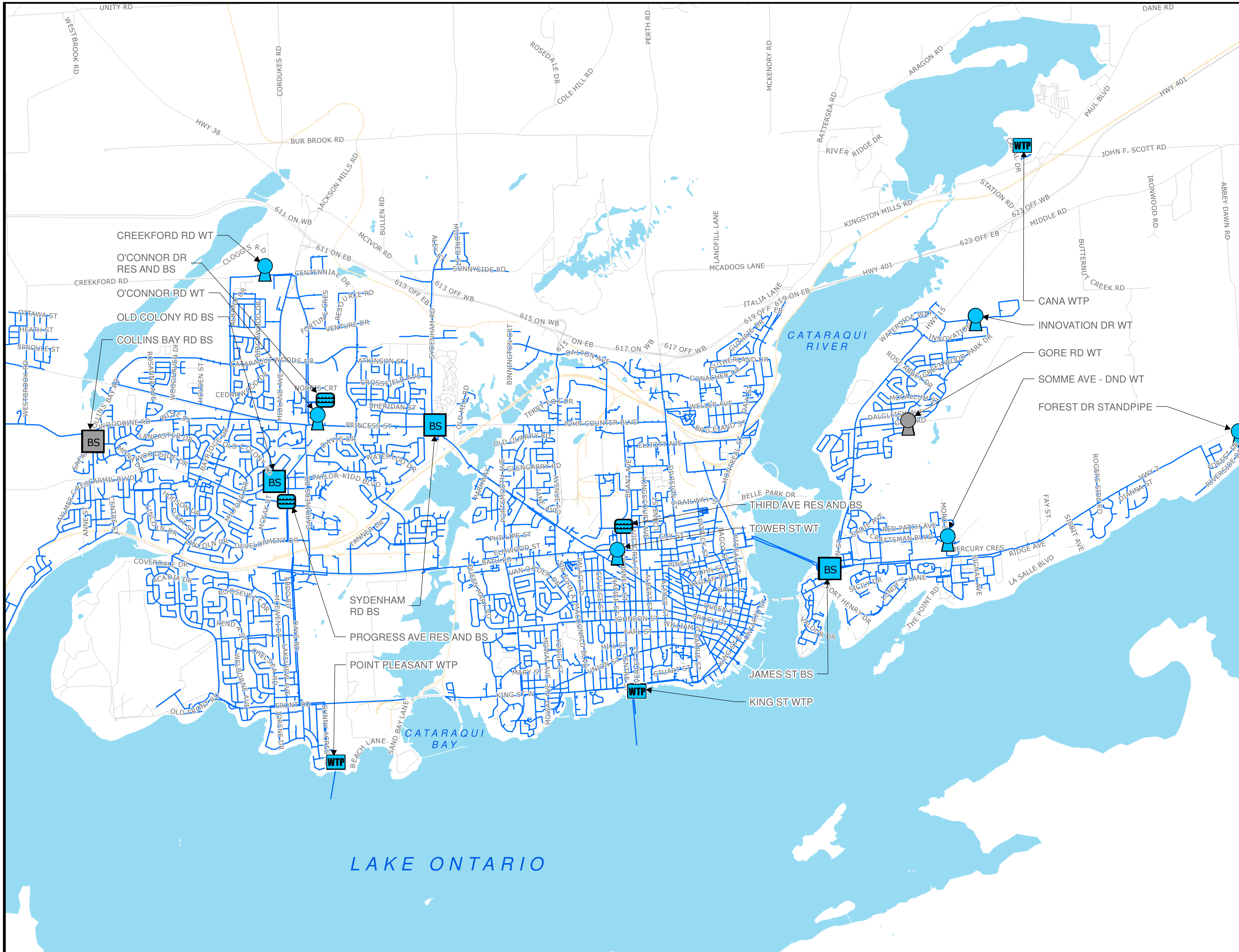
2.4 DISTRIBUTION SYSTEM

The City of Kingston's (the City's) main water distribution system comprises an area of approximately 8,258 ha. It is generally bordered by Westbrook Road to the west, Highway 401 to the north, and Abbey Dawn Road to the east. It is split into three regions:

1. Kingston West (approximately 3,953 ha)
2. Kingston Central (approximately 2,919 ha)
3. Kingston East (approximately 1,386 ha)

In addition to the above noted system, the Cana subdivision has a very small distribution system to service a small residential community.

A more detailed description of the existing system can be found in the Water Baseline Review Report (WSP, 2015). Figure 2-1 provides an overview of the main components of the system and their location.



1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP WATER TREATMENT PLANT
- BS WATER BOOSTER STATION
- BS WATER BOOSTER STATION (NOT ACTIVE)
- WATER RESERVOIR
- WATER TOWER
- WATER TOWER (NOT ACTIVE)
- WATER PIPE
- WATERBODY

Data Source: Ontario Base Mapping, Ministry of Natural Resources, August 2013. Water and Waste Water Systems, Utilities Kingston, April 2015, City of Kingston.

Scale: 0 350 700 1,400 Meters

1:55,000

Project:

Water and Wastewater Master Plan Updates

City of Kingston, Ontario

Title:

WATER DISTRIBUTION SYSTEM OVERVIEW MAP

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
CM	MF	GAP	2-1

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig2-1_WaterFacilities_Overview.mxd

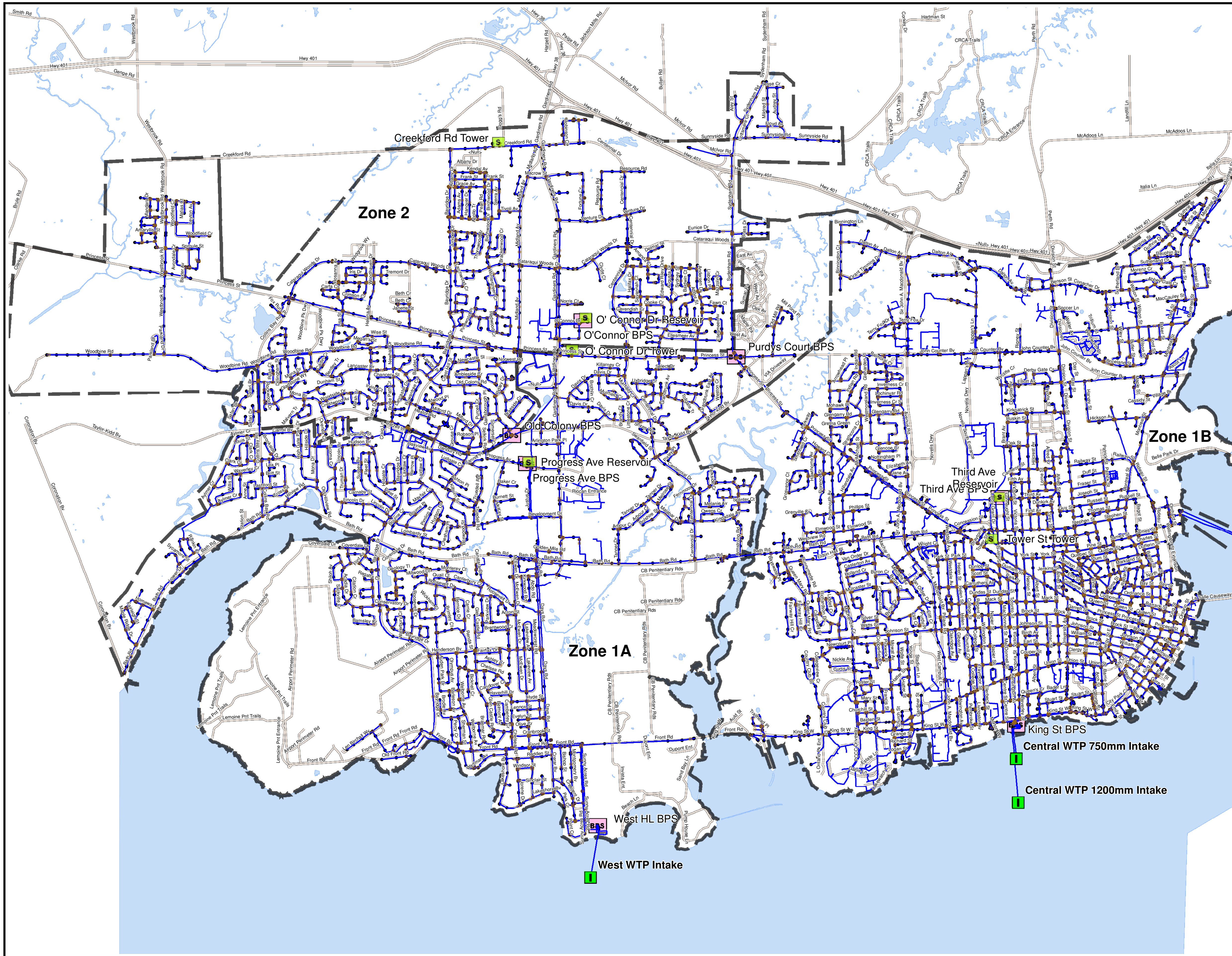
2.5 PRESSURE ZONES

Water systems are typically divided into separate hydraulic regions also known as pressure zones. This is to maintain adequate pressure in the system regardless of topography. Pressure zones are usually divided by valves (i.e. pressure sustaining valve) or pumps (i.e. booster stations). Zones containing storage where the water level varies with the hydraulic grade line are said to “float” on the system.

The existing City of Kingston water distribution system currently has six different pressure zones. Kingston West is separated from Kingston Central by the Little Cataraqui River Creek, while Kingston Central is separated by Kingston East by the Great Cataraqui River.

Water is supplied to the Point Pleasant WTP from Lake Ontario and currently supplies Kingston West. Water is supplied to the King Street WTP from Lake Ontario and pumped to service Kingston Central in addition to the James Street Booster Station which services Kingston East. Kingston West encompasses pressure zones 1A and 2. Kingston Central encompasses Zone 1B, and Kingston East encompasses Zones 3A, 3B, and 3C. Figure 2-2, and Figure 2-3, illustrate these zones.

As part of the previous Master Plan, an interconnected system was recommended between the West and Central zones. There are currently two existing interconnections, one on Bath Road, and another on Princess Street. Additional interconnections on John Counter Boulevard and Front Road/King Street West are scheduled to be completed by 2021. As some of these connections have been completed, a 2015 interconnected system has been considered in the subsequent sections. These revised zones, along with the facilities, are shown in Figure 2-4.



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- ISO Valve
- Water Treatment Plant (WTP)
- Storage Tank
- Booster Pumping Station (BPS)
- Raw Water Intake
- Pipe
- PressureZone
- Road
- Waterbody

Scale:
0 500 1,000 1,500 m
1:42,500

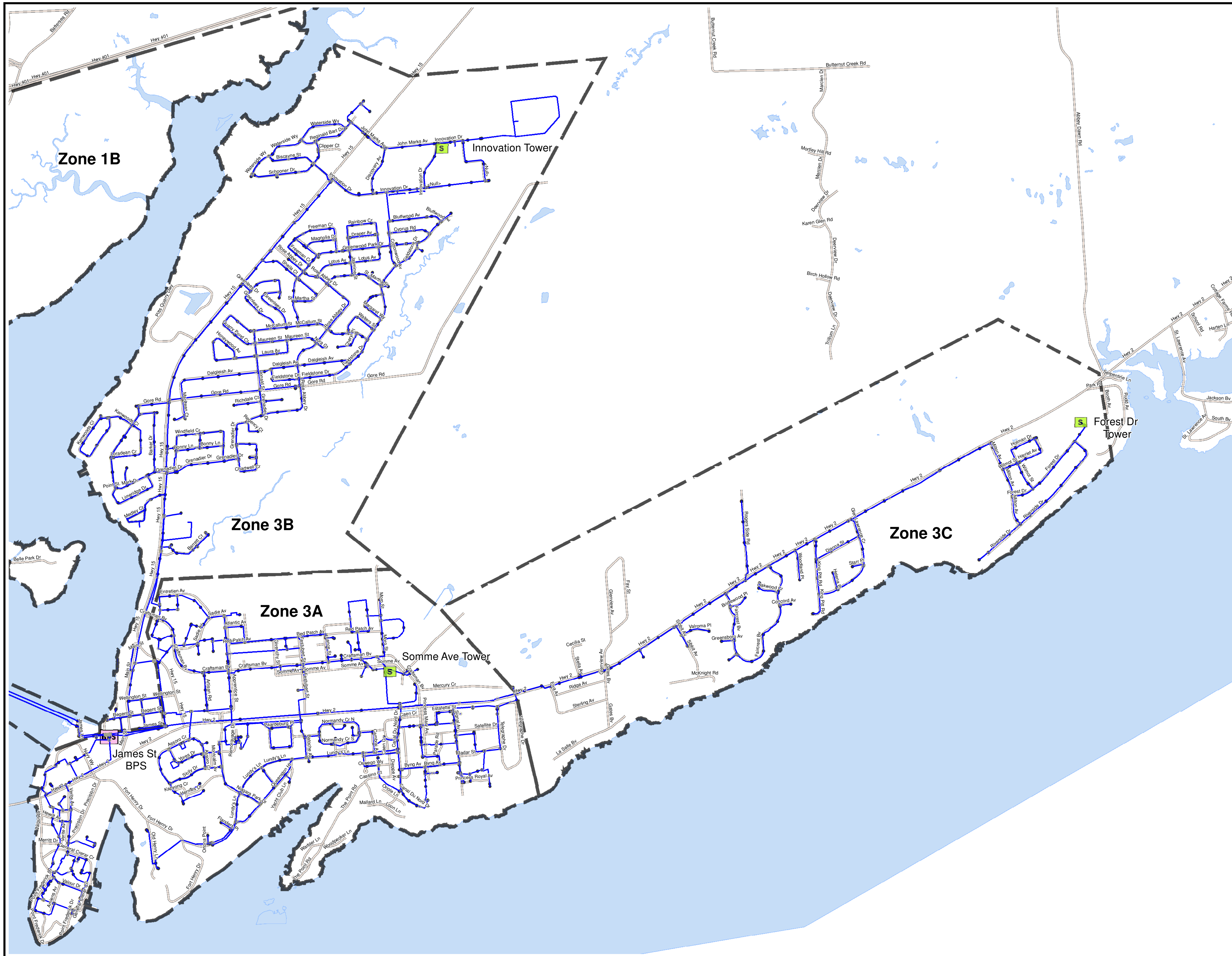
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

Title:
KINGSTON WATER SYSTEM - KEY PLAN (ZONES 1A, 1B & 2)

Scenario:
2015 EXISTING

Project No.:		Date:	
151-02944-00		DECEMBER 2016	
Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	2-2

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig2_2-WC_KeyPlan.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- ISO Valve
- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- Pipe
- PressureZone
- Road
- Waterbody

Scale:
0 200 400 600 800 m
1:25,000

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

Title:
KINGSTON WATER SYSTEM - KEY PLAN (ZONES 3A, 3B & 3C)

Scenario:
2015 EXISTING

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Map No.:
HC	JLD	GAP	2-3

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig2_3-East_KeyPlan.mxd

3 BACKGROUND

3.1 DEVELOPMENT SCENARIOS

Based on discussion with UK, the City's Planning Department, previous Master Plans and available reports, one existing condition scenario and five growth scenarios were developed. These scenarios include:

Table 3-1 Development Scenarios

SCENARIO	DESCRIPTION
2015 (Calibration)	Existing Conditions
2015 (Interconnected)	Existing Conditions with an Interconnected West and Central System
2021	Based on Committed and Pending Development Applications
2026	Based on Remaining Committed and Pending Development Applications ("Committed Condition")
2036	Based on Future Known Potential Developments
Full Build-Out	Based on Undeveloped and Underdeveloped Land as of 2036 with their Anticipated Development Density (Based on Official Plan)
Ultimate	Full Build-Out plus Specific Urban Boundary Extensions

The primary purpose of the 2021-2036 scenarios is to help evaluate the impacts on infrastructure and plan anticipated future upgrades. The full buildout and ultimate scenarios serve to provide a check and balance for the recommended upgrades in the 2021-2036 scenarios. For example, if a pipe is recommended to be upgraded to a certain size in one time step, and the size required for the same pipe in the full buildout is only incrementally larger, the cost of the two options can be evaluated. Given the relatively long life span of linear infrastructure and added flexibility for future development, the additional cost for a larger pipe may be justified.

3.2 IMMINENT PROJECTS

Utilities Kingston is currently in the process of implementing various infrastructure upgrades and capital projects which will come online during various stages of the analysis period. The table below provides a summary of the anticipated projects and identifies what scenario year they are assumed to be complete:

Table 3-2 Imminent Projects

SCENARIO	DESCRIPTION
2015 (Calibration)	→ 2015 GIS Update (provided by UK)
2015 (Interconnected)	→ Point Pleasant WTP Upgrades → Interconnection at Bath Road and Princess Street open → Cataraqui Woods Drive from Princess Street to Bayridge Drive
2021	→ Front Road Watermain Interconnection (1050 mm) → CFB Kingston EST decommissioning → James Street Booster Station Phase 1 Upgrades → Gatwick Avenue from Kendal Avenue to Creekford Road (300 mm) → Centennial Avenue to Resource Road (400 mm) → Cataraqui Woods Drive from Centennial Avenue to Sydenham Road (400 mm) → Augusta Drive from Atkinson Street to Cataraqui Woods Drive (400 mm) → John Counter Boulevard from Indian Road to Princess Street (400 mm) → Pipe/Junction Additions for New Developments
2026	→ Pipe/Junction Additions for New Developments
2036	→ Pipe/Junction Additions for New Developments
Full Build-Out	→ Pipe/Junction Additions for New Developments
Ultimate	→ Pipe/Junction Additions for New Developments

4 DESIGN CRITERIA AND LEVEL OF SERVICE

This section outlines the technical design criteria that will be used and the Level of Service (LOS) that will be applied during the analysis and planning of infrastructure in the City of Kingston for this Master Plan.

It should be noted that the LOS will support initial comparisons and further specific reviews may be done based on the results of the analysis of existing or alternative scenarios (i.e. comparing existing LOS etc.)

Where variations in parameters or guidelines are permitted, a review of applicable standards and municipalities of similar size has been completed to ensure that values used in this Master Plan are reasonable and consistent with other jurisdictions and past work in Kingston.

Water demand patterns vary between municipalities. The variations are primarily influenced by the habits and characteristics of system users. Volume as well as diurnal patterns will tend to fluctuate depending on servicing requirements, such as the size of the serviced population, type, and amount of industry present as well as condition of the infrastructure.

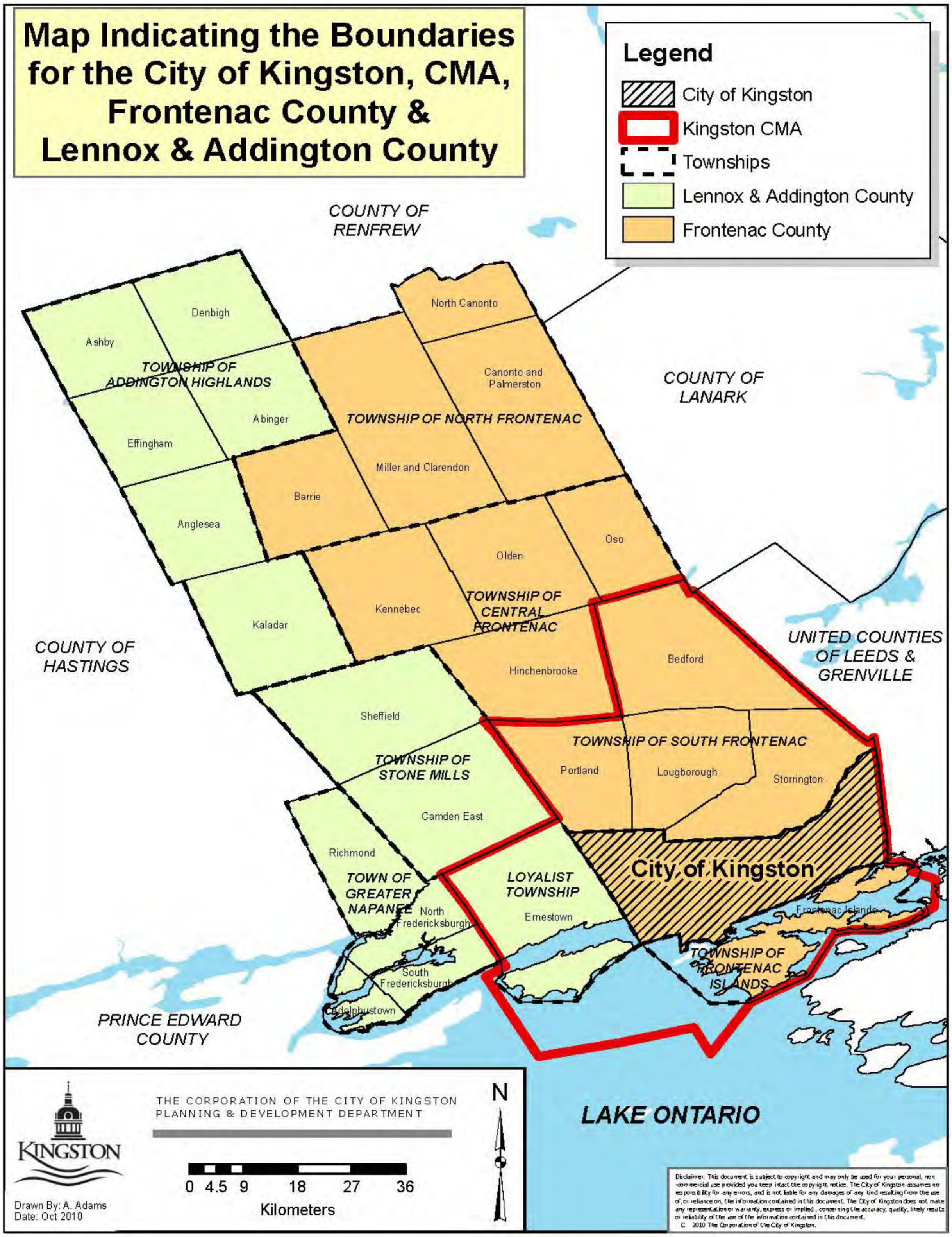
The Ministry of Environment Design Guidelines (MOECC, 2008) have attempted to account for variations in flow generation by permitting acceptable ranges for design calculations. As a result of this flexibility, many municipalities in Ontario have set standard flow generation criteria for their jurisdiction. The set design flow is typically within the MOECC's accepted range; however, it is often based on the historical flows observed by the municipality.

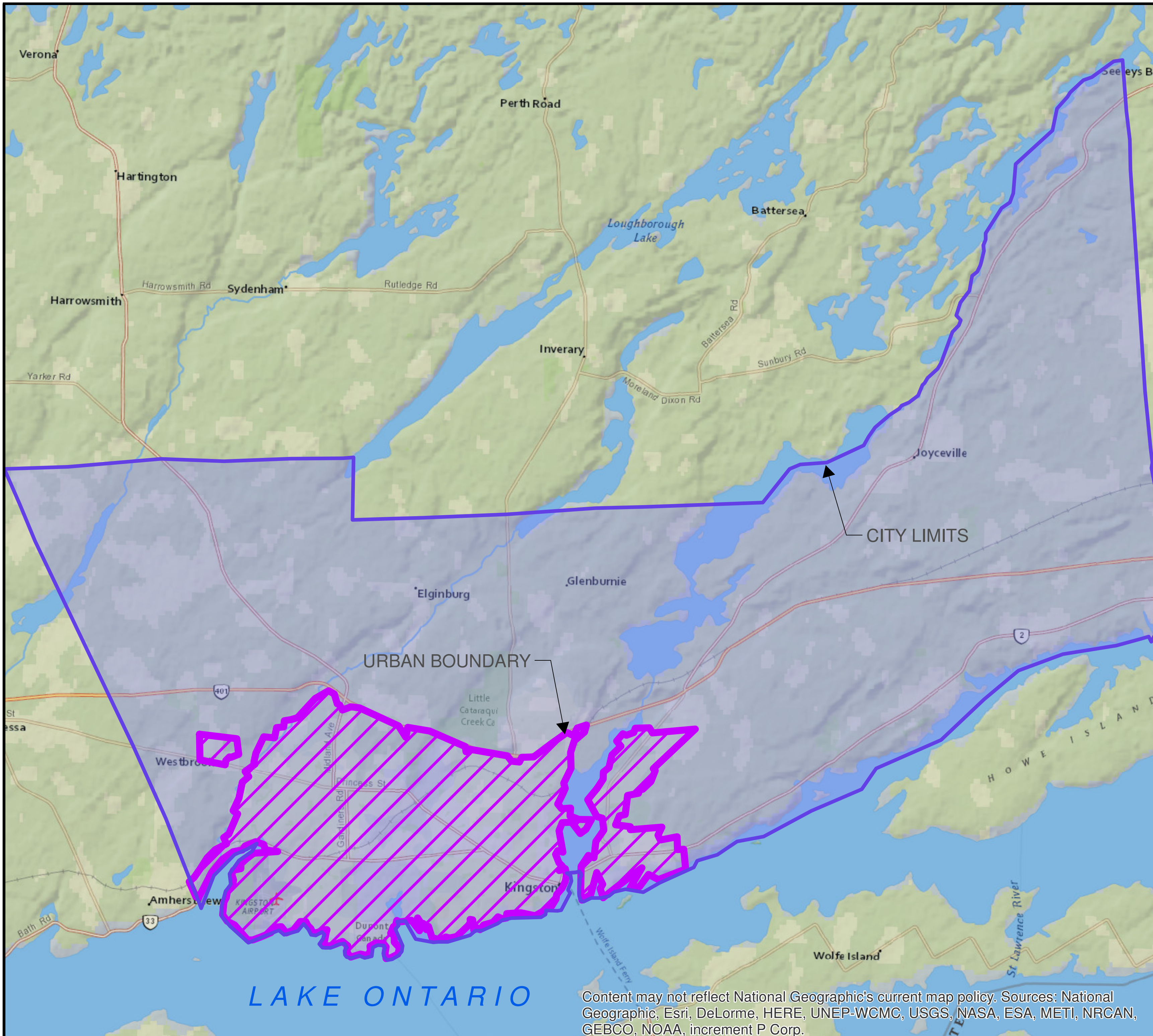
4.1 SEVICE AREA AND POPULATION

The service area for Kingston varies depending on the discussed aspects. Primarily, three separate boundaries are referenced in the different aspects of the Master Plan and the reference reports. They include:

1. Figure 4-1: Kingston Census Metropolitan Area (CMA)
2. Figure 4-2: City of Kingston Limits & Urban Boundary
3. Figure 4-3: Urban and Rural Dissemination Area (Census Areas)

Figure 4-1 Kingston CMA





WSP

1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston

UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- CITY LIMITS
- URBAN BOUNDARY

Data Source: Ontario Base Mapping, Minisitry of Natural Resources, August 2013. Water and Waste Water Systems, Utilities Kingston, April 2015, City of Kingston.

Scale: 0 1,300 2,600 Meters

1:167,500

N W E S

Project:

Water and Wastewater Master Plan Updates

City of Kingston, Ontario

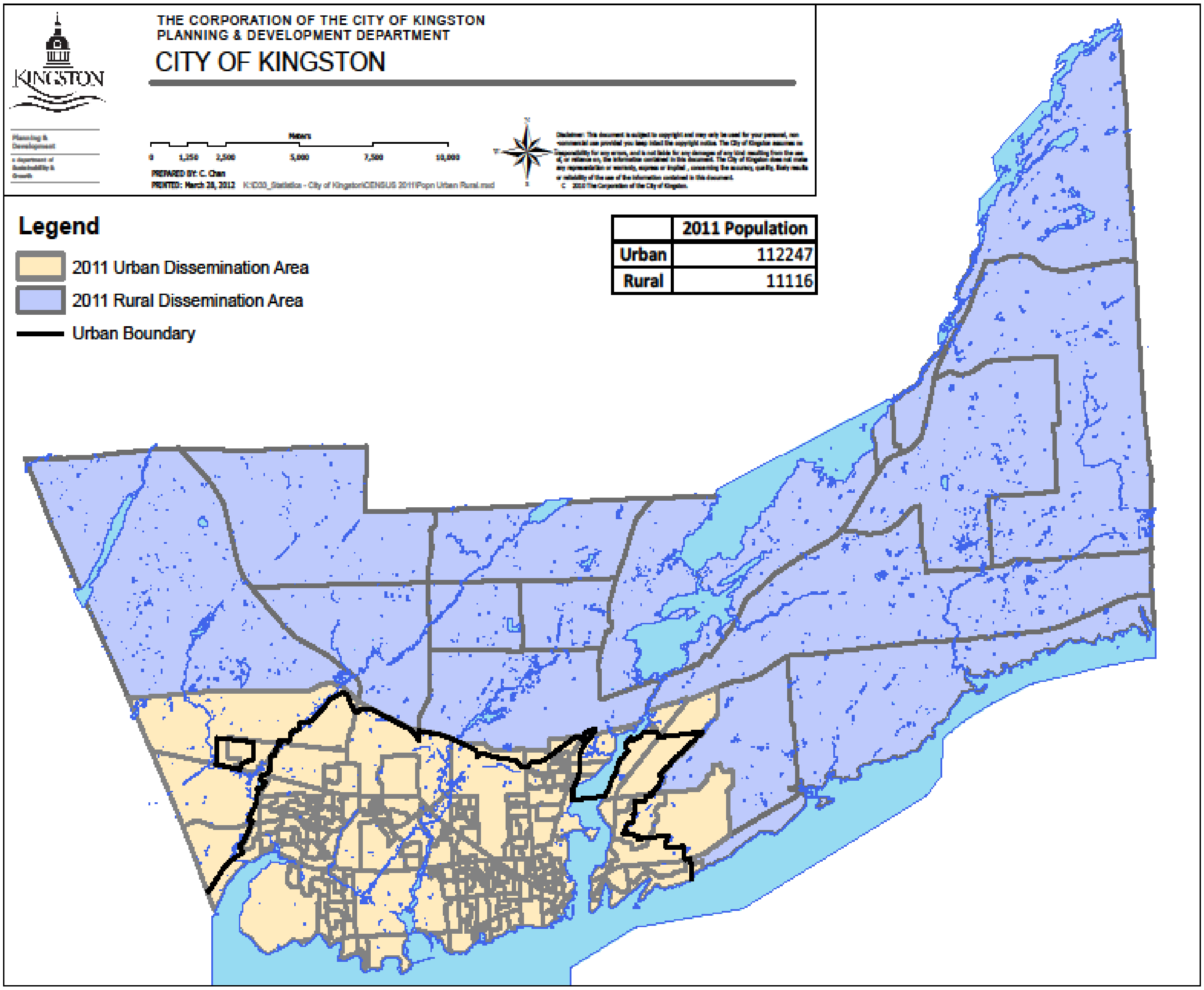
Title:

CITY OF KINGSTON BOUNDARIES

Project No.:		Date:	
151-02944-00		DECEMBER 2016	
Drawn By:	Checked By:	Code:	Figure No.:
CM	MS	GAP	4-2

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig4-2_Urban_and_City_Boundaries.mxd

Figure 4-3 Urban & Rural Dissemination Area



The municipal water service area is typically contained within the urban boundary; however, before the amalgamation of the three former municipalities and the current defined urban boundary, some water servicing was provided outside of this boundary.

As indicated in the Growth Report (WSP, 2015) the *City of Kingston and Kingston CMA population, housing and employment projections* (Meridian Planning/C4SE, 2013) or “CMA Report” was used to determine the base population for 2014 and the population growth for each scenario. The CMA report divides the urban and rural areas by the dissemination areas (Figure 4-3). In order to determine the base population for the water service areas, first, the population differences between the urban dissemination area and the urban boundary were developed. From the Census data, the dissemination areas and the GIS data provided (areas and densities), it was determined that approximately 90% of the population resides within the urban boundary in 2011. Segregating the areas into West, Central, and East, the population distribution is approximately 44%, 48% & 8% respectively. Further segregating the West area by pressure zones, 1A and 2 represent 25% and 19% respectively.

The CMA report provided populations to 2041 as well as for the high case, which was determined to be the preferred population growth case (Growth Report, WSP 2015); however, it did not provide a population projection for 2014, but for 2011 and 2016. As the relationship between the different time steps is not completely linear, an equation was developed based on the data provided to determine the 2014 population. Based on this information, the population for 2014 was determined to be 126,645 within the Kingston CMA. Using the urban-to-rural split indicated above, the base population within the urban boundary is 113,980 (126,645 * 0.9).

In addition to the above base population within the urban boundary, there are a couple of areas outside the urban boundary that have water services (north of Highway 401 near Sydenham Road, east along Highway 2, to the west along Westbrook Road). A review of the number of water meters outside the urban boundary (576) was determined, and using the 2015 population density (2.36) it was determined that approximately 1,360 additional people are service by water outside the urban boundary. Based on these additional people, the 2014 service population is approximately 115,340. The population outside the urban boundary is located within pressure Zones 2 and 3 with approximately 642 people in the Zone 2 and 718 people in Zone 3.

Based on the growth projects (Growth Report, WSP 2015) and maintaining the approximate population divide (i.e. West, Central & East), Table 4-1 below indicates the approximate population for each scenario. In addition, as the Full Buildout and Ultimate scenarios do not have a specific population, an estimated population was developed based on the number of addition residential units and the density for 2036 (2.31).

Table 4-1 Population Distribution

AREA		POPULATION					
		2014	2021	2026	2036	Full Buildout	Ultimate
Water Service Area		115,340	126,822	134,954	146,666	170,258	240,962
West (44%)	Zone 1A (25%)	28,495	31,366	33,399	36,327	42,225	59,901

AREA		POPULATION 2014	2021	2026	2036	Full Buildout	Ultimate
	Zone 2 (19%)[1]	22,298	24,480	26,025	28,250	32,733	46,166
Central (48%)		54,711	60,222	64,125	69,747	81,071	115,009
East (8%)[1]		9,836	10,754	11,405	12,342	14,229	19,886

[1]Areas outside the urban boundary added after distribution split

4.2 DEMAND CRITERIA

The specific growth within the City was developed in conjunction with UK and the City of Kingston Planning Department and is detailed in the Growth Report (WSP, 2015). In order to develop the specific growth into demand, criteria must be developed for residential, industrial, commercial and intuitional (ICI) lands.

4.2.1 STANDARDS REVIEW

A review of applicable design standards outlining a range of per capita design flows used by agencies, previous City of Kingston reports and other municipalities is summarized in Table 4-2 through Table 4-5.

Table 4-2 Residential Flow Generation Review

	ORGANIZATION	DESCRIPTION	ADF (L/CAP/D)
Residential Flow Generation	MOECC	Design Guidelines for Water, 2008	270-450
	City of Kingston	Subdivision Guidelines, 2014	350
	City of Kingston	Water Master Plan, 2007	350
	Region of Waterloo	Water Master Plan, 2009	209
	City of Guelph	Water Master Plan, 2006	300
	Region of Waterloo & City of Guelph	Design Guidelines	350
	City of Barrie	Water Master Plan, 2013	242-390
	City of Barrie	Design Standards	350

Table 4-3 Industrial Flow Generation Review

	ORGANIZATION	DESCRIPTION	ADF (M^3/HA/D)
	MOECC	Design Guidelines for Water, 2008	35 (light Industry)

	ORGANIZATION	DESCRIPTION	ADF (M^3/HA/D)
Industrial Flow Generation	City of Kingston	Subdivision Guidelines, 2014	To be considered on an individual basis
	City of Kingston	Water Master Plan, 2007	26
	Region of Waterloo	Water Master Plan, 2009	N/A (converted using equivalent population)
	City of Guelph	Water Master Plan, 2006	N/A (converted using equivalent population)
	Region of Waterloo & City of Guelph	Design Guidelines	43.2
	City of Barrie	Water Master Plan, 2013	35
	City of Barrie	Design Standards	35

Table 4-4 Commercial Flow Generation Review

	ORGANIZATION	DESCRIPTION	ADF(M^3/HA/D)
Commercial Flow Generation	MOECC	Design Guidelines for Water, 2008	2.5-5.0 L/d/m^2
	City of Kingston	Subdivision Guidelines, 2014	To be considered on an individual basis
	City of Kingston	Wastewater Master Plan, 2010	28 m^3/ha/day
	Region of Waterloo	Water Master Plan, 2009	N/A (converted using equivalent population)
	City of Guelph	Water Master Plan, 2006	N/A (converted using equivalent population)
	Region of Waterloo & City of Guelph	Design Guidelines	Core = 1.16 l/s/ha; Shopping Mall = 0.3 l/s/ha;

	ORGANIZATION	DESCRIPTION	ADF(M³/HA/D)
			General = 0.6 l/s/ha
	City of Barrie	Wastewater Master Plan, 2013	28
	City of Barrie	Design Standards	28

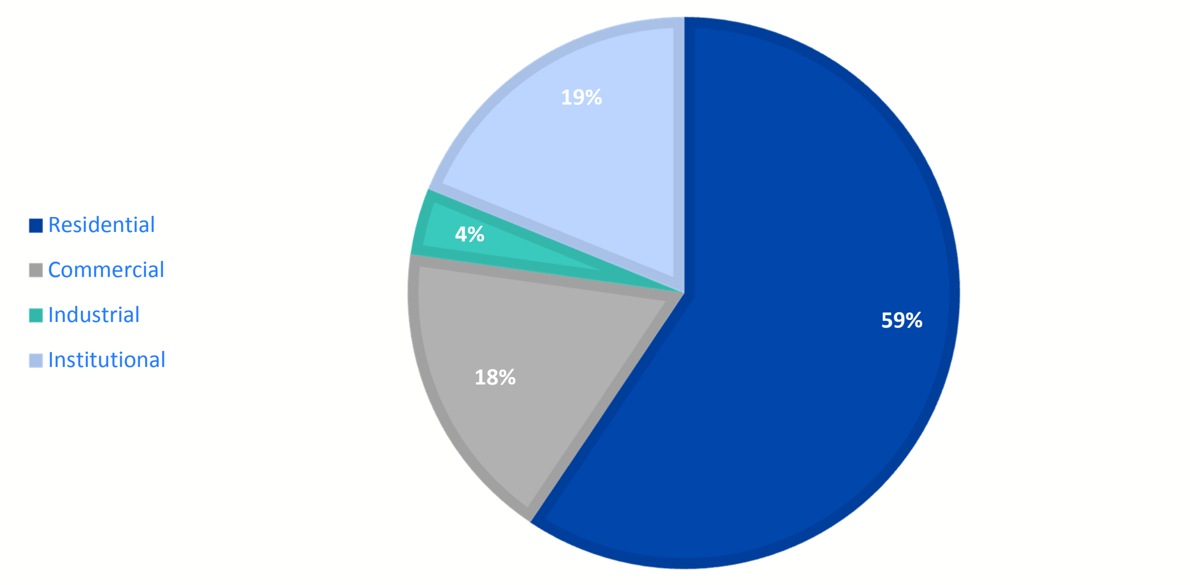
Table 4-5 Institutional Flow Generation Review

	ORGANIZATION	DESCRIPTION	ADF (M^3/HA/D)
Institutional Flow Generation	MOECC	Design Guidelines for Sewage Works 2008	Individual case based on historical records.
	City of Kingston	Subdivision Guidelines, 2014	To be considered on an individual basis.
	City of Kingston	Wastewater Master Plan, 2010	28
	Region of Waterloo	Wastewater Treatment Master Plan, 2007	N/A (converted using equivalent population)
	City of Guelph	Wastewater Master Plan, 2008	N/A (converted using equivalent population)
	Region of Waterloo & City of Guelph	Design Guidelines	In accordance with MOECC Design Guidelines
	City of Barrie	Water Master Plan, 2013	28
	City of Barrie	Design Standards	28

4.2.1.1 HISTORIC FLOW GENERATION

In order to evaluate the existing flow being generated by the City, the historic water treatment flows were reviewed. Historic potable water meter data was used to assign the proportion of flow being generated by each land use type. Figure 4-4 below illustrates the respective proportions.

Figure 4-4 2014 Water Consumption by Land Use Type



The calculated demand split was then applied to the historic demand observed at the WTPs.

Table 4-6 Water Treatment Plant Production

TREATMENT PLANT	FLOW (L/S)	FLOW (M^3/D)
Average Daily Demand from Point Pleasant WTP	233	20,135
Average Daily Demand from King Street WTP	556	48,097
Total Average Daily Dry Weather Flow (L/s)	**789**	**68,232**

Values based on 2014 plant data

The City of Kingston has been performing a comprehensive water balance study for many years. In order to account for items typically covered with other design or modeling parameters, such as leakage - as discussed further in Sections 4.9 & 9.3, they are removed from the totals indicated in Table 4-6. Items typical to water systems, such as watermain breaks, remain within the amount as these aspects are unavoidable characteristics of having a water distribution system and are not typically covered with other design or modeling parameters.

Table 4-7 Unit Water Demand by Land Use Type

LAND USE	EXISTING DEMAND (L/S)	PERCENT OF TOTAL DEMAND	AVERAGE DEMAND (L/S)	EXISTING NUMBER OF UNITS	UNIT DEMAND
Residential	789	60%	473	115,679 People*	353 L/cap/day
Commercial		18%	142	795 ha	15 m^3/ha/day
Institutional		4%	24	N/A	
Industrial		19%	115	2,666 ha	5 m^3/ha/day

**Population is based on the existing water distribution service area.*

The historic flows suggest that the residential unit flow generation is close to that being used in the design criteria; However. the calculated commercial and industrial flows are much lower. This is thought to be due to the type of industry present in the City of Kingston; the majority of the industry is ‘light’ in nature and is not a large consumer of water.

4.2.1.2 RECOMMENDATION

Table 4-8 below provides a summary of the recommended flow demand criteria based on the review of historic demands, agencies, previous City of Kingston reports and municipalities of similar size.

Table 4-8 Recommended Unit Flow Demand

LAND USE	RECOMMENDED
Residential	**350 l/cap/day** Consistent with Design Criteria, other municipalities, the MOECC guidelines and close to historic values observed.
Commercial	**28** m^3**/ha/day** Higher than historic flow; however, this will permit flexibility for varying requirements of future commercial development.
Industrial	**35** m^3**/ha/day** This is much higher than the observed historic flow. The historic flow however, is much lower than other municipalities and the MOECC guidelines. Using the historic value could limit future industrial development.
Institutional	Review of historic flows on a case by case basis is recommended.

4.3 DEMAND MULTIPLIERS

Demand multiplier parameters or guidelines typically vary based on servicing requirements. A review of historic data, applicable standards and design criteria for municipalities of similar size has been completed. This is to ensure that values used in this Master Plan are reasonable and consistent with other jurisdictions as well as past work completed in Kingston.

4.3.1 EXISTING FLOW DATA

In order to determine the demand multipliers (Maximum Day – MDD, Minimum Hour – MHD and Peak Hour – PHD), a comprehensive review of the existing flow data from King Street WTP and Point Pleasant WTP was completed. The results are summarized in Table 4-9 below.

Table 4-9 Existing Peak Factors

YEAR	KINGSTON WEST			KINGSTON CENTRAL			KINGSTON EAST			CITY OF KINGSTON		
	MDD	MHD	PHD	MDD	MHD	PHD	MDD	MHD	PHD	MDD	MHD	PHD
2010	1.36	N/A	N/A	1.20	N/A	N/A	1.92	N/A	N/A	1.19	N/A	N/A
2011	1.31	N/A	N/A	1.12	N/A	N/A	1.50	N/A	N/A	1.15	N/A	N/A
2012	1.36	N/A	N/A	1.37	N/A	N/A	1.47	N/A	N/A	1.19	N/A	N/A
2013	1.32	0.31	1.81	1.24	0.67	1.78	1.58	N/A	3.77	1.20	0.53	1.70
2014	1.29	0.29	1.84	1.43	0.68	2.04	1.60	N/A	4.09	1.33	0.51	1.90
Avg.	1.33	0.30	1.82	1.26	0.67	1.91	1.62	N/A	3.93	1.21	0.52	1.80
Max.	1.36	0.31	1.84	1.43	0.68	2.04	1.92	N/A	4.09	1.33	0.53	1.90
Min.	1.29	0.29	1.81	1.12	0.67	1.78	1.47	N/A	3.77	1.15	0.51	1.70

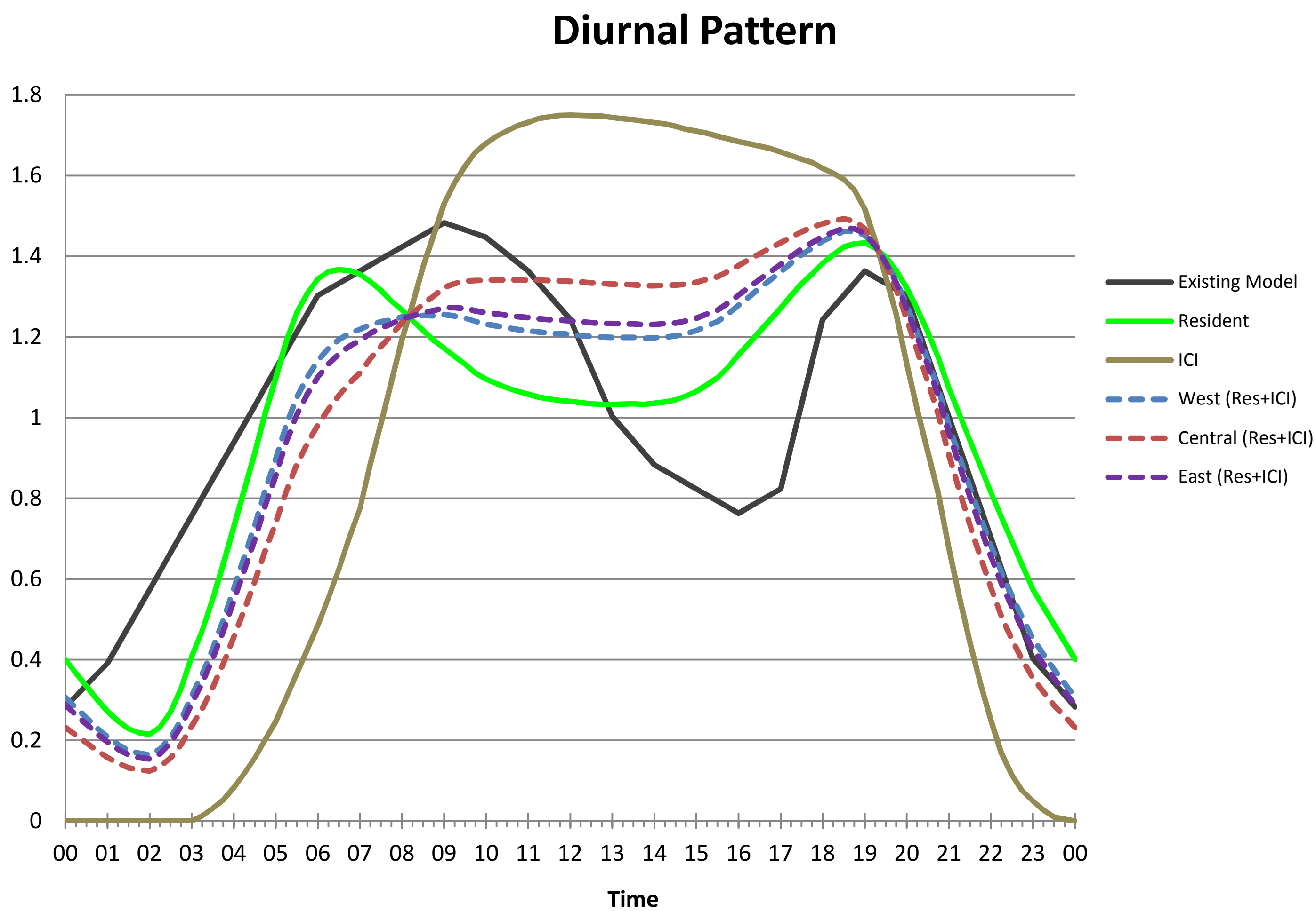
Additionally, an analysis of hourly SCADA flow data was used to identify diurnal demand patterns for the West, Central, and East areas. A residential pattern was also obtained by monitoring data collected in early 2015, and an ICI pattern was also developed. The patterns were blended in proportion to the relative land use percentage for the West, Central and East zones.

The residential pattern based on 2015 monitoring data has a morning and an evening peak, as expected, where the evening peak is slightly higher than the morning peak.

The minimum night flow, or demand, for the residential pattern based on 2015 monitoring is reasonable in comparison to other jurisdictions in North America.

The diurnal patterns can be seen in Figure 4-5 below:

Figure 4-5 Existing Diurnal Pattern



As the Cana Water Treatment System servicing area has been identified as a non–growth area, demand multipliers were not reviewed.

4.3.2 PREVIOUS REPORTS

A review of reports completed for the City of Kingston was undertaken for comparison purposes. Table 4-10 below presents the information from the review.

Table 4-10 Information from Previous Reports

Source	MHD	MDD	PHD
Subdivision Guidelines, 2014	N/A	2.75	4.25
Water Master Plan, 2007 (West)	N/A	1.77	2.72

Source	MHD	MDD	PHD
Water Master Plan, 2007 (Central & East)	N/A	1.39	1.89
Water Master Plan, 2007 (City)	N/A	1.50	2.12
East Master Plan, 2014	0.66 (95th percentile)	1.50 (95th percentile)	2.25

4.3.3 MOECC GUIDELINES

The MOECC Design Guidelines for Drinking Water Systems (MOECC, 2008) recommend that demand multipliers for the system be based on existing flow data. Additionally, they provide typical factors based on population which are presented in Table 4-11 below.

Table 4-11 MOECC Demand Multipliers

POPULATION	MHD	MDD	PHD
500 - 1 000	0.40	2.75	4.13
1 001 - 2 000	0.45	2.50	3.75
2 001 - 3 000	0.45	2.25	3.38
3 001 - 10 000	0.50	2.00	3.00
10 001 - 25 000	0.60	1.90	2.85
25 001 - 50 000	0.65	1.80	2.70
50 001 - 75 000	0.65	1.75	2.62
75 001 -150 000	0.70	1.65	2.48
greater than 150 000	0.80	1.50	2.25

Based on the above population distribution, the recommended demand multipliers are as follows:

Table 4-12 Kingston MOECC Demand Multipliers

SCENARIO	CITY			WEST			CENTRAL			EAST		
	MHD	MDD	PHD	MHD	MDD	PHD	MHD	MDD	PHD	MHD	MDD	PHD
2015	0.70	1.65	2.48	0.65	1.75	2.62	0.65	1.75	2.62	0.50	2.00	3.00
2021	0.70	1.65	2.48	0.65	1.75	2.62	0.65	1.75	2.62	0.60	1.90	2.85
2026	0.70	1.65	2.48	0.65	1.75	2.62	0.65	1.75	2.62	0.60	1.90	2.85

SCENARIO	CITY			WEST			CENTRAL			EAST		
	MHD	MDD	PHD	MHD	MDD	PHD	MHD	MDD	PHD	MHD	MDD	PHD
2036	0.70	1.65	2.48	0.65	1.75	2.62	0.65	1.75	2.62	0.60	1.90	2.85
Full Buildout	0.80	1.50	2.25	0.65	1.75	2.62	0.70	1.65	2.48	0.60	1.90	2.85
Ultimate	0.80	1.50	2.25	0.70	1.65	2.48	0.70	1.65	2.48	0.60	1.90	2.85

4.3.4 SIMILAR MUNICIPALITIES

A review of similar municipalities was completed for comparison purposes and to ensure values are within typical values of municipalities of similar size. In order to determine similar municipalities, a review of cities' size and population within Ontario was completed. Table 4-13 below presents a summary of this information.

Table 4-13 Size and Population of Comparable Ontario Cities

CITY	GEOGRAPHICAL AREA	POPULATION (2011 CENSUS)
Kingston (CMA)	**82.9**	**126,645**
Cambridge	112.8	126,748
Kitchener	136.9	219,153
Waterloo	64.0	98,780
Guelph	86.7	121,688
Barrie	77.0	135,711

The following table documents rates used in studies within the above noted similar cities.

Table 4-14 Other Cities' Demand Multipliers

	Source	MDD	PHD
Region of Waterloo	Water Master Plan, 2009	1.44	1.80 (1.44 times 1.25)
City of Guelph	Water Master Plan, 2006	1.50	N/A
Region of Waterloo & City of Guelph	Design Guidelines	As per Master Plan	
City of Barrie	Water Master Plan, 2013	1.8	N/A
	Design Standards	As per MOECC	

4.3.5 RECOMMENDATIONS

Based on the modeling that is being completed for the Master Plan, a more dynamic process is recommended for the demand multipliers. The hydraulic model is loaded with the Average Daily Demand (ADD) based on an annual volume used by each customer meter (cross-checked against production meters using a water balance). A steady-state simulation uses this value directly (ADD, average hour or 1.0 multiple).

A 24-hour or Extended-Period Simulation (EPS) will use the ADD which is multiplied by the blended diurnal pattern every hour (i.e. at 2am = ADD x 0.21) to represent the hourly demand.

Based on the review of existing data, previous City of Kingston studies, and other municipalities, a design criteria value of 1.5 is recommended for the MDD. This is slightly higher than the observed multipliers and is consistent with other City of Kingston reports, MOECC Guidelines and other municipalities. The Master Plan multiplier of 1.5 is applied to the base (ADD) in the model. The smallest pattern multiplier yields the Minimum Hour Demand (MHD) during an ADD run, and the largest multiplier yields the Peak Hour Demand (PHD) during an MDD. Therefore, based on the diurnal pattern, demand multipliers summarized in Table 4-15 below will be used.

Table 4-15 Recommended Demand Multipliers

APPLICATION	MDD	PHD
2015 Master Plan	1.5	2.25 (1.5 times diurnal peak)

4.4 FIRE FLOWS

The process to determine the fire flow (FF) demands and duration (D) on a city scale varies. Therefore, a review of applicable standards and criteria for municipalities of similar size has been completed as well as consultation with the Kingston Fire and Rescue Services (KFRS) to ensure that values used in this Master Plan are reasonable and consistent.

4.4.1 MOECC GUIDELINES

The MOECC Drinking Water Guidelines (DWG) (MOECC, 2008) is a population based approach and provides a general fire flow target for an entire area. The MOECC provides typically suggested fire flows and durations for small municipalities, but indicates that the latest edition of the FUS document should be consulted.

Based on the population split indicated above, the following fire flows and duration would apply based on the MOECC DWG (MOECC, 2008). Typically, the MOECC population based approach is more conservative.

Table 4-16 MOECC Recommended Fire Flows

SCENARIO	CITY		WEST				CENTRAL		EAST	
			ZONE 1		ZONE 2					
	FF (L/S)	D (HR)	FF (L/S)	D (HR)	FF (L/S)	D (HR)	FF (L/S)	D (HR)	FF (L/S)	D (HR)
2015	378	6	325	5	286	4.5	378	6	188	3

SCENARIO	CITY		WEST				CENTRAL		EAST	
			ZONE 1		ZONE 2					
	FF (L/S)	D (HR)	FF (L/S)	D (HR)	FF (L/S)	D (HR)	FF (L/S)	D (HR)	FF (L/S)	D (HR)
2021	378	6	340	5	301	5	378	6	197	3
2026	378	6	350	5	311	5	378	6	203	3
2036	378	6	362	5.5	324	5	378	6	213	3
Full Buildout	378	6	378	6	347	5	378	6	229	3.5
Ultimate	378	6	378	6	378	6	378	6	269	4.5

4.4.2 FIRE UNDERWRITERS SURVEY FIRE FLOW CALCULATION

The FUS method is a formula based approach to calculate the target fire flows based on the specifics of a site. Construction type, floor area, building use, exposure distance and fire suppression system (i.e. sprinklers) are considered in the calculations.

In order to calculate the FUS target fire flows on a city scale, a land use based approach was developed. This approach entailed selecting a representative sample of the different land use types to determine an average fire flow. Based on consultation with the KFRS and the *Water Study for City of Kingston Fire & Rescue* (FPSS, 2007) a representative sample of land use types throughout the City was selected to calculate the target fire flows. A desktop review of each of these locations was then completed to calculate the target fire flows based on the FUS formula assuming construction type, building use and fire suppression system. The floor area and exposure distance were determined from the GIS data provided. A detailed summary of these results can be found in Appendix A. Table 4-17 provides a summary of the results.

Table 4-17 Kingston FUS Fire Flows

LAND USE TYPE	FIRE FLOW @ 139 kPa (20 psi) L/MIN	L/S	DURATION (HR)
Industrial	16,300	270	3.5
Institutional	10,600	175	2.0
Med/High Density Residential	14,600	245	3.0
Commercial	14,400	240	3.0
Residential	6,500	110	2.0

In addition to the fire flow and duration, the FUS documents also provide recommendations for adequacy and reliability. FUS recommends that in order to provide an adequate and reliable system, cities with populations greater than 250,000 should consider the possibility of two simultaneous major fires in the area serviced by the system.

4.4.3 PREVIOUS REPORTS

A review of reports completed for the City of Kingston was carried out for comparison purposes. Table 4-18 below presents the information.

Table 4-18 Fire Flow Review - Previous Reports

SOURCE			
Subdivision Guidelines, 2014	Water Supply for Public Fire Protection, A Guide to Recommended Practices 1977, by Insurance Bureau of Canada		
Water Master Plan, 2007	Based on MOECC guidelines (July 1984), App. N		
	A fire flow target of 378 L/s for 6 hours was applied at various locations where appropriate including Sysco, Fuel Storage Area, Novelis, Princess at Montreal Street, Startek and CFB Kingston		
East Master Plan, 2014	A fire flow criteria based on zoning classification/land use was used		
	TYPE	**SEPARATION**	**FIRE FLOW @138KPa**
	Industrial	All	220L/s
	Institutional	All	220L/s
	Med Density Res & Com	All	220L/s
	Low Density Res & Com	<3	134L/s
	Low Density Res & Com	>3	94.6L/s
	Fire Flow Duration	Based on MOECC equivalent population	

4.4.4 SIMILAR MUNICIPALITIES

A review of similar municipalities was conducted for comparison purposes and to ensure values are within typical values of municipalities of similar size.

Table 4-19 below documents the criteria used in the municipalities of similar size that were reviewed.

Table 4-19 Other Cities' Demand Multipliers

LOCATION	SOURCE	MDD	PHD
Region of Waterloo	Water Master Plan, 2009	Considered two fire events. 1 critical water consumer and 1 local residential.	
		Various critical fire flows based on specific development type ranging from 150-367 L/s + minor residential fire event of 33.33 L/s	

<table>
<tr><th>LOCATION</th><th>SOURCE</th><th>MDD</th><th>PHD</th><th></th></tr>
<tr><td></td><td></td><td colspan="3">Based on FUS required duration of fire flows</td></tr>
<tr><td>City of Guelph</td><td>Water Master Plan, 2006</td><td colspan="3">Not Reviewed</td></tr>
<tr><td>Region of Waterloo & City of Guelph</td><td>Design Guidelines</td><td colspan="3">Based on the latest FUS method for specific developments</td></tr>
<tr><td rowspan="17">City of Barrie</td><td rowspan="10">Water Master Plan, 2013</td><td colspan="3">A fire flow criteria based on FUS & zoning classification/land use was used</td></tr>
<tr><td>Type</td><td colspan="2">Fire Flow</td></tr>
<tr><td>Industrial</td><td colspan="2">333 L/s</td></tr>
<tr><td>Institutional</td><td colspan="2">167 L/s</td></tr>
<tr><td>Commercial</td><td colspan="2">283 L/s</td></tr>
<tr><td>Apartments</td><td colspan="2">117 L/s</td></tr>
<tr><td>Res – Single</td><td colspan="2">50 L/s</td></tr>
<tr><td>Res – Multi</td><td colspan="2">100 L/S</td></tr>
<tr><td colspan="3">Master Plan used above criteria to review existing system & the design standard criteria (below) to review new infrastructure.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td rowspan="7">Design Standards</td><td colspan="3">A fire flow criteria based on zoning classification/land use was used</td></tr>
<tr><th>TYPE</th><th>MIN. FLOW</th><th>PREFERRED</th></tr>
<tr><td>Industrial</td><td>136L/s</td><td>152 L/s</td></tr>
<tr><td>Institutional</td><td>91 L/s</td><td>114 L/s</td></tr>
<tr><td>Commercial</td><td>91 L/s</td><td>114 L/s</td></tr>
<tr><td>Downtown</td><td>136 L/s</td><td>189 L/s</td></tr>
<tr><td>Residential – Single</td><td>57 L/s</td><td>76 L/s</td></tr>
<tr><td rowspan="2">City of Ottawa[1]</td><td rowspan="2">Water Master Plan, 2013</td><td colspan="2">Core Areas</td><td>216 L/s</td></tr>
<tr><td colspan="2">Non-Core Areas</td><td>167L/s</td></tr>
</table>

[1]While the City of Ottawa is not considered a comparably sized city, a review of their fire flow standards was completed due to its proximity to the City of Kingston

4.4.5 RECOMMENDATIONS

4.4.5.1 DISTRIBUTION FIRE FLOWS

Based on the review, a land use based fire flow approach for identifying Level of Service (LOS) is recommended. Using zoning information from the City's Official Plan and the calculated fire flows for a representative sample of buildings within each land use type, the following fire flow LOS targets are recommended:

Table 4-20 Recommended Land Use Fire Flows

LAND USE TYPE	FIRE FLOW @ 139 kPa (20 psi) L/MIN	L/S
Industrial	16,300	270
Institutional	10,600	175
Medium/High Density Residential	14,600	245
Commercial	14,400	240
Residential	6,500	110

It should be noted that the above summarized targets would be applied within the water model (most stringent target applied for multi-zoned nodes) to determine if there is a difference or gaps between the available capacity and the above noted targets. Targets may not be achieved due to limitation of the existing system.

4.4.5.2 STORAGE FIRE FLOWS

In discussion with the UK engineering and operations group, it is recommended to use the MOECC fire flow rates for storage in order to provide more operational flexibility and reliability. The following fire flow rates will be used:

Table 4-21 Recommended Storage Fire Flows and Duration

SCENARIO	CITY		WEST ZONE 1		WEST ZONE 2		CENTRAL		EAST	
	FF (L/S)	D (HR)	FF (L/S)	D (HR)	FF (L/S)	D (HR)	FF (L/S)	D (HR)	FF (L/S)	D (HR)
2015	378	6	325	5	286	4.5	378	6	188	3
2021	378	6	340	5	301	5	378	6	197	3
2026	378	6	350	5	311	5	378	6	203	3
2036	378	6	362	5.5	324	5	378	6	213	3

SCENARIO	CITY		WEST ZONE 1		WEST ZONE 2		CENTRAL		EAST	
	FF (L/S)	D (HR)	FF (L/S)	D (HR)	FF (L/S)	D (HR)	FF (L/S)	D (HR)	FF (L/S)	D (HR)
Full Buildout	378	6	378	6	347	5	378	6	229	3.5
Ultimate	378	6	378	6	378	6	378	6	269	4.5

The Cana service area has been identified as a non-growth area; the current population is less than 500 people, therefore the required fire flow duration is 2 hours for all scenarios.

4.5 WATER TREATMENT

Water treatment plants provide the treated water to the distribution system from untreated sources (lakes, wells, streams, etc.) through a variety of processes.

Water treatment facilities must be designed in accordance with the *Procedure for Disinfection of Drinking Water in Ontario* (Ontario, 2006). Drinking water treatment systems that obtain water from a surface water or GUDI well supply must achieve an overall performance providing, as a minimum, a 2-log (99%) removal or inactivation of *Cryptosporidium* oocysts, 3-log (99.9%) removal or inactivation of *Giardia* cysts, and 4-log (99.99%) removal or inactivation of viruses prior to the water being delivered to the first customer. At least 0.5-log removal or inactivation of *Giardia* cysts, and 2-log removal or inactivation of viruses must be provided through disinfection, while the remaining removal may be achieved through filtration or other equivalent treatment processes.

4.5.1 MOECC GUIDELINES

The MOECC DWG (MOECC, 2008) indicates that plant capacity should be greater or equal to the maximum day with an allowance for water need for plant use. Additionally, water treatment plants should be designed for a minimum of ten years (20 years preferred).

4.5.2 RECOMMENDATIONS

The MOECC DWG (MOECC, 2008) criterion is recommended for LOS.

4.6 WATER STORAGE

Water storage in a drinking water system is to provide continuity of supply, maintain system pressures and to meet critical water demands during fire flow and emergency conditions.

4.6.1 MOECC GUIDELINES

The MOECC DWG outlines the requirements of the required storage. The formula for calculating the required treated water storage in the distribution system is as follows:

$$Total\ Treated\ Water\ Storage\ Requirements = A + B + C$$

Where: A = Fire Storage
B = Equalization Storage (25% of Max Day Demand)

C = Emergency Storage (25% of A+B)

Fire storage is the product of the maximum fire flow required in the system and the corresponding fire duration as describe in the above section

When the system can supply more than just the maximum day demand (but less than the peak demand), the fire storage requirements can be determined using the following formula:

$$A\ = (Peak\ Demand - Pumping\ Station\ Stand - By\ Capacity) \times Fire\ Duration$$

Where: Peak demand is the greater of the peak hour demand and the maximum day plus fire demand.

Floating storage should be designed such that the elevation of the equalization volume (B) is able to maintain a minimum pressure of 275 kPa (40 psi) in the system under peak hour flow conditions. The fire (A) and emergency (C) volumes should be at elevations that sustain 275 kPa (40 psi) during peak hour demand conditions, and 140 kPa (20 psi) under the maximum day plus fire flow condition (MOECC, 2008).

4.6.2 PREVIOUS REPORTS

A review of reports completed for the City of Kingston was conducted for comparison purposes. Table 4-22 below presents the information.

Table 4-22 Water Storage Review - Previous Reports

SOURCE	
Water Master Plan, 2007	Based on the above noted MOECC Guidelines with Fire Storage based on largest fire flow for that zone
	Used maximum available fire flow in each zone up to 378L/s
East Master Plan, 2014	Based on the above note MOECC Guidelines except the Equalization Storage based on difference between daily diurnal peak hour demand and the firm pumping capacity
	Used the Large Fire demand as indicated in Fire flow section above and corresponding duration

4.6.3 RECOMMENDATIONS

The MOECC DWG (MOECC, 2008) formula is recommended for LOS with the fire flows and duration indicated in the previous section.

4.7 BOOSTER STATIONS

Water booster stations provide additional flow and pressure to the distribution system while maintaining pumped water quality.

4.7.1 MOECC GUIDELINES

Booster stations are rated based on their firm capacity. If sufficient floating storage is available in a particular pressure district, the MOECC defines firm capacity as the capacity of the station with the largest pump out of service. If there is insufficient or no floating storage, firm capacity is defined as the capacity with the two (2) largest pumps out of service (MOECC, 2008).

For pressure zones where no floating storage is available, pumping stations have to be designed to provide the greater of the peak hour demand or maximum day plus fire demand. If sufficient floating storage is available, then the pumping station only needs to be designed to provide maximum day demand.

The following approach should be adopted for stand-by power requirements:

→ In cases where no or inadequately sized floating storage is available for fire protection, it is recommended that full standby power be supplied.

→ Where adequate floating storage is available, the need for standby power is less critical. Provide sufficient standby power for the pump capacity equal to the average day demand rate. This should supply adequate quantities of water required in the event of a major power outage.

4.7.2 RECOMMENDATIONS

The MOECC DWG (MOECC, 2008) criterion is recommended for LOS.

4.8 DISTRIBUTION

Distribution systems convey treated water from the treatment plants and booster stations to the location of the demand.

4.8.1 MOECC GUIDELINES

Watermains are to be sized to carry the greater of the maximum day plus fire flow or peak hour demand. The MOECC Guidelines (MOECC, 2008) recommend the following range of acceptable pressures:

→ Under normal conditions (average to peak hour flows) 275 kPa (40 psi) to 690 kPa (100 psi),

→ During fire flow conditions pressures a minimum of 140 kPa (20 psi)

4.8.2 RECOMMENDATIONS

The MOECC DWG (MOECC, 2008) criterion is recommended for LOS.

4.9 LEAKAGE

There are no current national or provincial guidelines that provide guidance regarding the amount of water loss from a public water supply's distribution system. Neither the term "unaccounted-for-water" nor the use of percentages as measures of water loss completely describes the nature and extent of distribution system water loss. The International Water Association (IWA) and the American Water Works Association (AWWA) recommend a water balance approach to describe system losses. These associations standardized terminology and definitions as they apply to the water balance. This helps ensure consistent measurement. Figure 4-6 is a water balance table. The table is considered balanced because it accounts for all of the water in the distribution system and the sum of any of the columns should also total the System Input Volume. The City of Kingston has used this methodology in the past to evaluate the water balance in its water distribution systems.

Figure 4-6 Snapshot of High Water Loss within Distribution Systems

<table>
<tr><td rowspan="9">System Input Volume</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="7">Non-Revenue Water (NRW)</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="5">Water Losses</td><td rowspan="2">Apparent Losses (Commercial Losses)</td><td>Unauthorized Consumption</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors</td></tr>
<tr><td rowspan="3">Real Losses (Physical Losses)</td><td>Leakage in Transmission and Distribution</td></tr>
<tr><td>Storage Leaks and Overflows from Water Storage</td></tr>
<tr><td>Service Connections Leaks up to the Meter</td></tr>
</table>

Table 4-23 is the AWWA 2003 data showing water loss within select US water distribution systems (EPA 816-D-09-001, November 2009).

Table 4-23 Snapshot of high water loss within distribution systems

NAME	STATE	VOLUME INPUT (MG/YEAR)	WATER LOSSES (MG/YEAR)	% LOSS	POPULATION SERVED	PER CAPITA LOSS IN GALLONS/YEAR	VALUE OF LOSSES (2008 YR USD)
Philadelphia Water Department	PA	97,637	30,448	**31.18%**	1,670,000	58,465	$32,272,301
Cleveland Division of Water	OH	94,000	27,000	**28.72%**	1,500,000	62,667	$28,617,713
Memphis Light, Gas & Water	TN	54,798	8,330	**15.20%**	908,222	60,335	$8,829,094
Cincinnati Water Works	OH	47,047	8,303	**17.65%**	900,000	52,274	$8,800,477
Portland Water District	ME	9,293	1,678	**18.06%**	190,000	48,911	$1,778,538
Ann Arbor Utilities Department	MI	6,222	1,604	**25.78%**	163,500	38,055	$1,700,104
North Penn Water Authority	PA	3,311	538	**16.25%**	80,000	41,388	$570,234
Waterloo Water Works	IA	5,212	812	**15.58%**	75,000	69,493	$860,651
Lorain Utilities Department	OH	4,250	850	**20.00%**	74,000	57,432	$900,928
Madison County Water Department	AL	2,326	623	**26.77%**	67,200	34,613	$660,327
Elmira Water Board	NY	2,509	634	**25.27%**	65,000	38,600	$671,986

5 EXISTING FACILITY GAPS

5.1 HISTORIC DEMANDS

Water supply data from 2010 to 2014 was reviewed to determine historical water demands in the system. Average day and maximum day demand data for the past four years, and peak hour data for the past two years (2013-2014) are summarized in Table 5-1 below.

Table 5-1 Historic Water Demand

YEAR	WEST (POINT PLEASANT WTP)			CENTRAL (KING ST WTP)			EAST (JAMES ST BS)		
	ADD (M^3/d)	MDD (M^3/d)	PHD (M^3/d)	ADD (M^3/d)	MDD (M^3/d)	PHD (M^3/d)	ADD (M^3/d)	MDD (M^3/d)	PHD (M^3/d)
2010	19,708	26,802	N/A	44,785	53,742	N/A	4,541	8,718	N/A
2011	19,879	26,041	N/A	44,942	50,335	N/A	3,974	5,961	N/A
2012	20,676	28,118	N/A	43,676	59,837	N/A	4,601	6,764	N/A
2013	22,523	29,729	40,766	44,932	55,716	79,979	5,467	8,637	20,610
2014	20,135	25,973	37,048	42,663	61,007	87,032	5,434	8,694	22,225
Avg.	20,584	27,333	38,907	44,200	56,127	83,505	4,803	7,755	21,418
Max.	22,523	29,730	40,766	44,942	61,007	87,032	5,467	8,718	22,225
Min.	19,708	25,974	37,048	42,663	50,335	79,979	3,974	5,961	20,610

Central flows have been reduced by the amount consumed by the east

The combined City of Kingston historic water supply data from 2010 to 2014 is provided in Table 5-2. It can be seen that the west, central and east represent approximately 29%, 64% and 7% respectively (ADD) of the total City demand.

Table 5-2 Historic City of Kingston Water Demand

YEAR	ADD (M^3/DAY)	MDD (M^3/DAY)	PHD (M^3/DAY)
2010	69,033	82,149	N/A
2011	68,795	79,115	N/A
2012	68,953	82,054	N/A
2013	72,921	87,506	123,966
2014	68,231	90,747	129,638

YEAR	ADD (M^3/DAY)	MDD (M^3/DAY)	PHD (M^3/DAY)
Avg.	69,587	84,314	126,802
Max.	72,921	90,747	129,638
Min.	68,231	79,115	123,966

In addition to the main distribution system in the City of Kingston, data for the the small Cana service area was also reviewed (2013 – 2014) to determine historical water demands in the system. This information is presented in Table 5-3 below.

Table 5-3 Historic Cana Subdivision Demand

YEAR	ADD (M^3/DAY)	MDD (M^3/DAY)	PHD (M^3/DAY)
2013	28.6	58.7	108.5
2014	26.6	40.7	74.6
Avg.	27.6	49.7	91.5
Max.	28.6	58.7	108.5
Min.	26.6	40.7	74.6

5.2 PLANT CAPACITY

5.2.1 CAPACITY

As indicated above, the LOS for the water treatment plants should be greater or equal to the maximum day with an allowance for the required water for the treatment process.

The maximum day flows were compared to the rated capacity, and the estimated functional capacity of the water treatment plants has been indicated in Table 5-4. To be consistent with the future projections, the MDD is calculated based on the historic ADD multiplied by the recommended MDD factor.

Table 5-4 MDD vs. Plant Capacity

PLANT	PLANT RATED CAPACITY (ML/D)	PLANT "FUNCTIONAL" CAPACITY (ML/D)	MDD (ML/D)	% OF "FUNCTIONAL" CAPACITY	FUNCTIONAL CAPACITY SURPLUS (ML/D)	LOS CRITERIA MEET
Point Pleasant WTP (Existing)	45.5	41	30.20	**73.7%**	10.80	☑
King St WTP	118	95	72.14	**75.9%**	22.86	☑
City of Kingston (Existing)	163.5	136	102.35	**75.3%**	33.65	☑
City of Kingston (New)[1]	208	175	102.35	**58.5%**	72.65	☑
Cana WTS	0.11	0.10	0.04	**40.0%**	0.06	☑

1 - Includes the New Point Pleasant WTP upgrades

Based on the above noted values, both individual WTPs under existing configurations, as well as the overall city, currently meet the required LOS.

5.2.2 TREATMENT

The water treatment plants comply with the *Procedure for the Disinfection of Drinking Water in* Ontario as indicated in the table below.

Table 5-5 City of Kingston WTP CT Achievements

PLANT	SOURCE WATER	CT ACHIEVEMENT		LOS CRITERIA MEET
Kingston West WTP	Surface	Direction Filtration	2-log removal/inactivation of Giardia Cysts	☑
		Chlorine Disinfection	1-log removal/inactivation of Giardia Cysts	☑
King Street WTP	Surface	Conventional Filtration	2.5-log removal/inactivation of Giardia Cysts	☑
		Chlorine Disinfection	0.5-log removal/inactivation of Giardia Cysts	☑

PLANT	SOURCE WATER	CT ACHIEVEMENT		LOS CRITERIA MEET
Cana Subdivision WTP	GUDI[1]	Cartridge Filtration	2-log removal/inactivation of Giardia Cysts	☑
		Chlorine Disinfection	1-log removal/inactivation of Giardia Cysts	☑

[1]GUDI – Groundwater Under the Direct Influence of Surface Water

5.3 BOOSTER STATION CAPACITY

As indicated above, booster stations must be able to meet the following criteria in order to satisfy the required LOS which is based on the available floating storage. It should be noted that high lift pumps are also considered in the booster station capacity as they also provide system capacity.

→ Sufficient Floating Storage

- For each pressure, district provides maximum day demands.
- For each pressure, district provide sufficient standby power for the pump capacity equal to the average day demand rate

→ In-Sufficient Floating Storage

- For each pressure, district provides peak hour or maximum day plus fire demands (whichever are greater).
- For each pressure district provide full standby power be supplied.

The following table provides the boosting capacity of the system.

Table 5-6 Boosting Capacity

STATION	PUMP # 1	PUMP #2	PUMP #3	PUMP #4	PUMP #5	PUMP #6	PUMP #7	TOTAL CAPACITY	FIRM CAPACITY	STAND-BY CAPACITY
	UNITS: ML/DAY									
KINGSTON WEST - ZONE 1										
Point Pleasant WTP (Existing) HLPS	13.62	13.62	13.62	27.24	27.24			45.50	41.00	41.00
Point Pleasant WTP (New) HLPS[1]	30.10	30.10	30.10	27.26	27.26			90.00	80.00	80.00
Progress Ave Reservoir BS	5.44	5.44	8.12					19.01	10.89	8.12
Sub-Total (Ext)								**114.35**	**51.89**	**49.12**
Sub -Total (new)								**109.01**	**90.89**	**88.12**
KINGSTON WEST - ZONE 2										
O'Connor Dr Reservoir & BS	17.71	17.71	17.71					53.14	35.42	35.42
Old Colony Road BS[2]	3.20	3.20						6.39	3.20	0
Purdy Court BS	0.41	0.41						0.81	0.41	0
Collins Bay[3]	2.25	2.25						4.49	2.25	0
Sub-Total								**60.34**	**39.03**	**35.42**
KINGSTON CENTRAL – ZONE 1B										
King St WTP HLPS	19.53	19.53	23.59	31.80	22.72	22.72	45.62	118.00	95.00	91.07
Third Ave Reservoir & BS	15.8	15.8	31.80					63.40	31.60	31.80
Sub-Total								**181.40**	**126.60**	**122.87**
KINGSTON EAST – ZONE 3										
James St BS	16.59	16.59	16.59					49.77	33.18	33.18
Sub-Total (Ext)								**49.77**	**33.18**	**33.18**
Sub-Total (New)								**27.65**	**14.69**	**14.69**
CANA										
Cana WTS HLPS	0.13	0.13						0.26	0.13	0.00
Sub-Total (New)								**0.26**	**0.13**	**0.00**

[1]The indicated Total and Firm Capacity are based on plant capacity and not pump capacities as it is the limiting factor
[2]Capacities indicated based on VFD setpoint (i.e. capacity limited to 37L/s), pump capacity is 7.08ML/day (82L/s)
[3]Station not currently in use and therefore capacity not included in totals.

Table 5-7 below compares the firm and stand-by capacities to the MDD and ADD, respectively. Additionally, the existing and interconnected system are also compared based on the MDD and ADD.

Table 5-7 Boosting LOS

	ADD (ML/D)	MDD (ML/D)	SUFF. FLOATING STORAGE	FIRM CAPACITY (ML/D)	MDD OF FIRM CAPACITY	STAND-BY CAPACITY (ML/D)	ADD OF STAND-BY CAPACITY	LOS CRITERIA MEET
2015 (EXISTING)								
Kingston West Zone 1A	12.36	18.54	☑	51.89	**35.72%**	49.12	**25.16%**	☑
Kingston West Zone 2	7.78	11.67	☑	39.03	**29.89%**	35.42	**21.96%**	☑
Kingston Central Zone 1B	42.66	63.99	☑	126.60	**50.55%**	122.87	**34.72%**	☑
Kingston East Zone 3	5.43	8.15	☑	33.18	**24.57%**	33.18	**16.38%**	☑
2015 (INTERCONNECTED)								
Kingston West & Central Zone 1	68.23	102.35	☑	217.49	**37.95%**	210.99	**26.08%**	☑
Kingston West Zone 2	7.78	11.67	☑	39.03	**29.89%**	35.42	**21.96%**	☑
Kingston East Zone 3	5.43	8.15	☑	33.18	**24.57%**	33.18	**16.38%**	☑

Kingston West Zone 1 & 2 divide based on meter data

It can be seen from the table above that the LOS for each of the pressure districts have been meet under both scenarios.

5.4 STORAGE CAPACITY

As indicated in the previous section, the LOS for storage must satisfy the calculated storage for Fire (A), Equalization (B) and Emergency (C) requirements. Where fire storage can be reduced by the firm pumping capacity in the zone the emergency stoage is based on the greater of the PHD and the MDD plus fire flow.

The following table provides the existing available total storage and function storage. The functional storage is the calculated storage using the typical operating ranges were obtained from SCADA data and then the volumes were determined based on the as-built information that was provided.

Table 5-8 Existing Storage Capacity

STATION	TOTAL	FUNCTION	TYPICAL WATER LEVEL	
	M³	M³	m	m
KINGSTON WEST - ZONE 1				
Point Pleasant WTP (Existing)	6,560	1,750	3.25	3.75
Progress Ave Reservoir	6,600	2,900	4.5	2.5
O'Connor Dr. Water Tower	1,100	500	9.0	6.0
Sub-Total	**14,260**	**5,150**	-	-
KINGSTON WEST - ZONE 2				
O'Connor Dr. Reservoir	8,044	4000	11.75	5.25
Creekford Dr. Water Tower	6,800	3100	12.0	7.0
Sub-Total	**14,844**	**7,100**	-	-
KINGSTON CENTRAL – ZONE 1B				
King St WTP	500	0	0	0
Third Ave Reservoir	22,700	13000	5.6	2.2
Tower St. Water Tower	3,400	1600	6.5	3.0
Sub-Total	**26,600**	**14,600**	-	-
KINGSTON EAST – ZONE 3				
Innovation Dr. Water Tower	6,300	1500	9.5	6.9
CFB Kingston Water Tower	2,270	900	7.0	4.3
Forest Dr. Stand Pipe	1,770	200	6.0	0.5
Sub-Total	**10,340**	**2,600**	-	-
CANA				
Cana WTS	45	16	2.5	1.75
Sub-Total	**45**	**16**	-	-

The current required storage for each zone has been calculated in the table below based on MOECC formula and are presented in Table 5-9 below.

Table 5-9 Required Storage Capacity

		ZONE 1	ZONE 2	SUB-TOTAL	CENTRAL	EAST	SUB-TOTAL
Peak Hour Demand	ML/day	27.80	17.50	45.30	95.99	12.23	108.22
Max Day Demand	ML/day	18.54	11.67	30.20	63.99	8.15	72.14
Fire Flow	L/s	325	286	378	378	188	378

		ZONE 1	ZONE 2	SUB-TOTAL	CENTRAL	EAST	SUB-TOTAL
Fire Flow Duration	Hr	5	4.5	6	6	3	6
Peak Demand	ML/day	46.62	36.38	62.86	96.65	24.39	108.22
Firm Capacity	ML/day	51.89	39.03	90.91	126.60	33.18	159.78
Other Zone Demands (MD)	ML/day	11.67	0.00	0.00	8.15	0.00	0.00
Eligible Supply	ML/day	40.22	39.03	90.91	118.45	33.18	159.78
A = Fire Storage	m^3	1,333	-	-	-	-	-
B = Equalization	m^3	4,634	2,917	7,551	15,998	2,038	18,036
C = Emergency	m^3	1,492	729	1,888	4,000	509	4,509
Total	m^3	**7,458**	**3,646**	**9,438**	**19,998**	**2,547**	**22,545**

The total storage requirements were compared to the total assumed storage tank volumes in service and are presented in Table 5-10.

Table 5-10 Total Storage Surplus/Deficiency

		ZONE 1	ZONE 2	SUB-TOTAL	CENTRAL	EAST	SUB-TOTAL
Total Storage (Ext)	m^3	14,260	14,844	29,104	26,600	10,440	37,040
Functional Storage (Ext)	m^3	5,150	7,100	12,250	14,600	2,600	17,200
Total Required Storage	m^3	7,458	3,646	9,438	19,998	2,547	22,545
Required Equalization Storage	m^3	4,634	2,917	7,551	15,998	2,038	18,036
Total Surplus	m^3	**6,802**	**11,198**	**19,666**	**6,602**	**7,893**	**14,495**
Functional Surplus	m^3	**516**	**4,183**	**4,699**	**(1,398)**	**562**	**(836)**

Based on the current configuration, there is sufficient total storage to meet the minimum requirements in all pressure zones, but there is a deficiency in functional, or equalization, storage in the central zone.

In the 2015 interconnected scenario, Kingston West – Zone 1 and Central Zones will be interconnected, forming a single pressure zone. Additionally, the Point Pleasant WTP upgrades have also been included which provide additional storage. Based on the interconnection and upgrades to the Point Pleasant WTP, the existing storage requirements have been reviewed.

Table 5-11 2015 (Interconnected) Storage Capacity

STATION	TOTAL	FUNCTION	TYPICAL WATER LEVEL	
	M³	M³	m	m
KINGSTON WEST & CENTRAL - ZONE 1				
Point Pleasant WTP (New)	12,960	6,550	4.5	1.5
Progress Ave Reservoir	6,600	2,900	4.5	2.5
O'Connor Dr. Water Tower	1,100	500	9.0	6.0
King St WTP	500	0	0	0
Third Ave Reservoir	22,700	13,000	5.6	2.2
Tower St. Water Tower	3,400	1,600	6.5	3.0
Sub -Total	**47,260**	**24,550**	**-**	**-**

Point Pleasant functional capacity estimated based on construction drawings

Table 5-12 calculates the required minimum storage.

Table 5-12 2015 (Interconnected) Storage Requirements

		ZONE 1	ZONE 2	EAST	TOTAL
Peak Hour Demand	ML/day	123.79	17.50	12.23	153.52
Max Day Demand	ML/day	82.53	11.67	8.15	102.35
Fire Flow	L/s	378.00	286.00	188.00	378.00
Fire Flow Duration	Hr	6.00	4.50	3.00	6.00
Peak Demand	ML/day	123.79	36.38	24.39	153.52
Peak Supply	ML/day	217.49	39.03	33.18	289.69
Other Zone Demands (MD)	ML/day	19.82	0	0	0
Eligible Supply	ML/day	197.67	39.03	33.18	289.69
A = Fire Storage	m^3	0	0	0	0
B = Equalization	m^3	20,632	2,917	2,038	25,587
C = Emergency	m^3	5,158	729	509	6,397
Total	m^3	**25,791**	**3,646**	**2,547**	**31,983**

The revised storage requirements were compared to the revised storage capacities. This comparison is presented in Table 5-13 below.

Table 5-13 2015 (Interconnected) Total Storage Surplus/Deficiency

		ZONE 1	ZONE 2	EAST	TOTAL
Total Storage	m^3	47,260	14,844	10,440	72,544
Functional Storage	m^3	24,550	7,100	2,600	34,250
Total Required Storage	m^3	47,260	14,844	10,440	72,544
Required Equalization Storage	m^3	24,550	7,100	2,600	34,250
Total Surplus	m^3	**21,469**	**11,198**	**7,893**	**40,561**
Functional Surplus	m^3	**3,918**	**4,183**	**562**	**8,663**

Based on the interconnected system, there is sufficient capacity to meet the minimum LOS required for both the total and functional or equalization storage.

In addition to the main distribution system, the Cana subdivision was also reviewed. As the Cana system does not provide fire protection, the storage requires (A) are not required. Therefore the storage requirements are as indicated below:

Total Storage Requirement = Equalization (B) + Emergency (C):

Equalization Storage = 0.25 x 0.04ML/d (MDD) = 10.0 m^3

*Emergency Storage = 0.25 x 10*m^3 *litres = 2.5*m^3

*Minimum Total Water Storage = 10.0 + 2.5 = 12.5*m^3

The available storage at the Cana WTS was compared to the minimum total water storage calculated above and was found to satisfy the required LOS.

Table 5-14 Cana Storage Surplus/Deficiency

CANA WTS		
Total Storage	m^3	45.0
Functional Storage	m^3	16.0
Total Required Storage	m^3	12.5
Required Equalization Storage	m^3	10.0
Total Surplus	m^3	**32.5**
Functional Surplus	m^3	**6.0**

6 FLOW PROJECTIONS

6.1 DEVELOPMENT PROJECTIONS

The anticipated development and growth in the City was detailed in the Growth Report (WSP, 2015). This report used existing development applications along with background reports to estimate the amount and location of anticipated growth. These projections were used in conjunction with the recommended unit flow generation criteria outlined in Section 4.

6.2 PROJECTED FLOWS

The tables below detail the projected average day demands based on the anticipated development. Table 6-1 summarizes the identified development from the Growth Report.

Table 6-1 Projected Development

LAND USE	UNIT	2021	2026	2036	FULL BUILDOUT	ULTIMATE
Residential	Residential Units	4,928[1]	3,490[1]	5,070[1]	10,213[2]	30,608[3]
Off Campus Student Residential Growth	Students	1,194[4]	1,800[4]	4,341[4]	Scaled proportional to population increase.	
Industrial	Hectares	32.7[5]	49.9[5]	66.3[5]		
Industrial Business Park	Hectares	47.7[5]	76.5[5]	105.6[5]		
Commercial	Hectares	16.3[6]	18.5[6]	24.3[6]		
Institutional	Historic flow is scaled based on anticipated growth by institution[7]					

[1]Table 3-1 Growth Scenario Report
[2]Table 3-5 Growth Scenario Report
[3]Table 3-6 Growth Scenario Report
[4]Table 6-6 Growth Scenario Report
[5]Table 4-1 Growth Scenario Report
[6]Table 5-1 Growth Scenario Report (converted to ha assuming 25% lot coverage Commercial Inventory and Market Analysis City of Kingston, ON 2008)
[7]Section 6 Growth Scenario Report details the demand per unit of development.

Table 6-2 Projected Flow Generation

LAND USE	UNIT FLOW GENERATION	2021 FLOW (L/S)	2026 FLOW (L/S)	2036 FLOW (L/S)	FULL BUILDOUT FLOW (L/S)	ULTIMATE FLOW (L/S)
Residential	350 L/cap/day	46.53[1]	33.69[1]	47.45[1]	95.50	286.42
Off Campus Student Residential Growth	350 L/cap/day	7.67	6.42	13.05	0	0
Industrial	35 m^3/ha/day	13.27	6.97	7.13	5.71	0
Industrial Business Park	49 L/cap/day	0.49[2]	0.29[2]	0.30[2]		0
Commercial	28 m^3/ha/day	5.27	6.01	7.89	11.86	0
Institutional	Scaled Historical Flow	11.86	14.89	16.55	17.49	0
Total	**L/s**	**85.09**	**68.27**	**92.37**	**130.56**	**286.42**
	m^3/**day**	**7,352**	**5,899**	**7,981**	**11,280**	**24,747**

[1]Residential densities of 2.36, 2.33, 2.33, 2.31, 2.31, 2.31 people per unit were used, respectively, over the scenarios

[2]18 employees per ha of business park industrial (from Employment Land Strategy Review, Watson & Associates 2015)

Using the information presented in the table above along with the recommended demand multipliers, historic meter data and development projections, the following is a summary of the anticipated total demand in each zone:

Table 6-3 Total Flow Projections

	EXISTING	2021	2026	2036	FULL BUILD-OUT	ULTIMATE
				(M^3/D)		
KINGSTON WEST- TOTAL						
Existing ADD (previous scenario)	20,135	20,135	23,857	26,303	28,158	35,399
Future ICI+ Residential ADD	0	3,722	2,446	1,856	7,241	11,886
Total Average Day Flow	**20,135**	**23,857**	**26,303**	**28,158**	**35,399**	**47,285**

	EXISTING	2021	2026	2036	FULL BUILD-OUT	ULTIMATE
				(M^3/D)		
Total Max Day Flow	30,202	35,785	39,454	42,238	53,099	70,928
Total Peak Hour Flow	45,303	53,678	59,181	63,357	79,649	106,392
KINGSTON WEST & CENTRAL - ZONE 1						
Existing ADD (previous scenario)	55,020	55,020	59,083	62,051	68,700	78,201
Future ICI+ Residential ADD	0	4,063	2,969	6,649	9,501	0
Total Average Day Flow	**55,020**	**59,083**	**62,051**	**68,700**	**78,201**	**78,201**
Total Max Day Flow	82,530	88,624	93,077	103,050	117,301	117,301
Total Peak Hour Flow	123,795	132,93 6	139,615	154,575	175,952	175,952
KINGSTON WEST - ZONE 2						
Existing ADD (previous scenario)	7,778	7,778	10,565	12,688	13,291	14,584
Future ICI+ Residential ADD	0	2,787	2,124	602	1,294	11,886
Total Average Day Flow	**7,778**	**10,565**	**12,688**	**13,291**	**14,584**	**26,470**
Total Max Day Flow	11,667	15,847	19,033	19,936	21,876	39,705
Total Peak Hour Flow	17,500	23,771	28,549	29,904	32,814	59,557
KINGSTON EAST - ZONE 3						
Existing ADD (previous scenario)	5,434	5,434	5,962	6,792	7,522	8,009
Future ICI+ Residential ADD	0	529	830	730	487	12,861

	EXISTING	2021	2026	2036	FULL BUILD-OUT	ULTIMATE
				(M3/D)		
Total Average Day Flow	**5,434**	**5,962**	**6,792**	**7,522**	**8,009**	**20,869**
Total Max Day Flow	8,150	8,944	10,188	11,283	12,013	31,304
Total Peak Hour Flow	12,225	13,415	15,283	16,924	18,020	46,956
CITY OF KINGSTON						
Existing ADD (previous scenario)	68,231	68,231	75,609	81,531	89,512	100,793
Future ICI+ Residential ADD	0	7,379	5,922	7,981	11,281	24,746
Total Average Day Flow	**68,231**	**75,609**	**81,531**	**89,512**	**100,793**	**125,539**
Total Max Day Flow	102,346	113,414	122,297	134,268	151,190	188,309
Total Peak Hour Flow	153,519	170,121	183,446	201,402	226,784	282,464

Future ICI + Residential flow vary slightly from calculated flows due to loading and rounding procedures but are within 0.4% or less.

7 FUTURE FACILITY GAPS

7.1 WATER TREATMENT

As indicated above, the City is supplied by three water treatment plants, King Street WTP, Point Pleasant WTP and Cana WTS. It has been indicated that Cana WTS has no plans for growth and is therefore not reviewed beyond Section 5.2; however, there is significant growth planned within the main distribution system, and therefore the treatment capacity has been reviewed for the future scenarios.

The rated and estimated operating capacities for the WTPs were discussed previously in Section 2.1. Briefly, the production capacity of the King Street WTP and Point Pleasant WTP are 90 ML/d and 118 ML/d respectively, with a functional capacity of 80 ML/d and 95 ML/d, respectively. Based on an interconnected system the City’s total capacity and functional capacity are 208ML/d and 175ML/d, respectively.

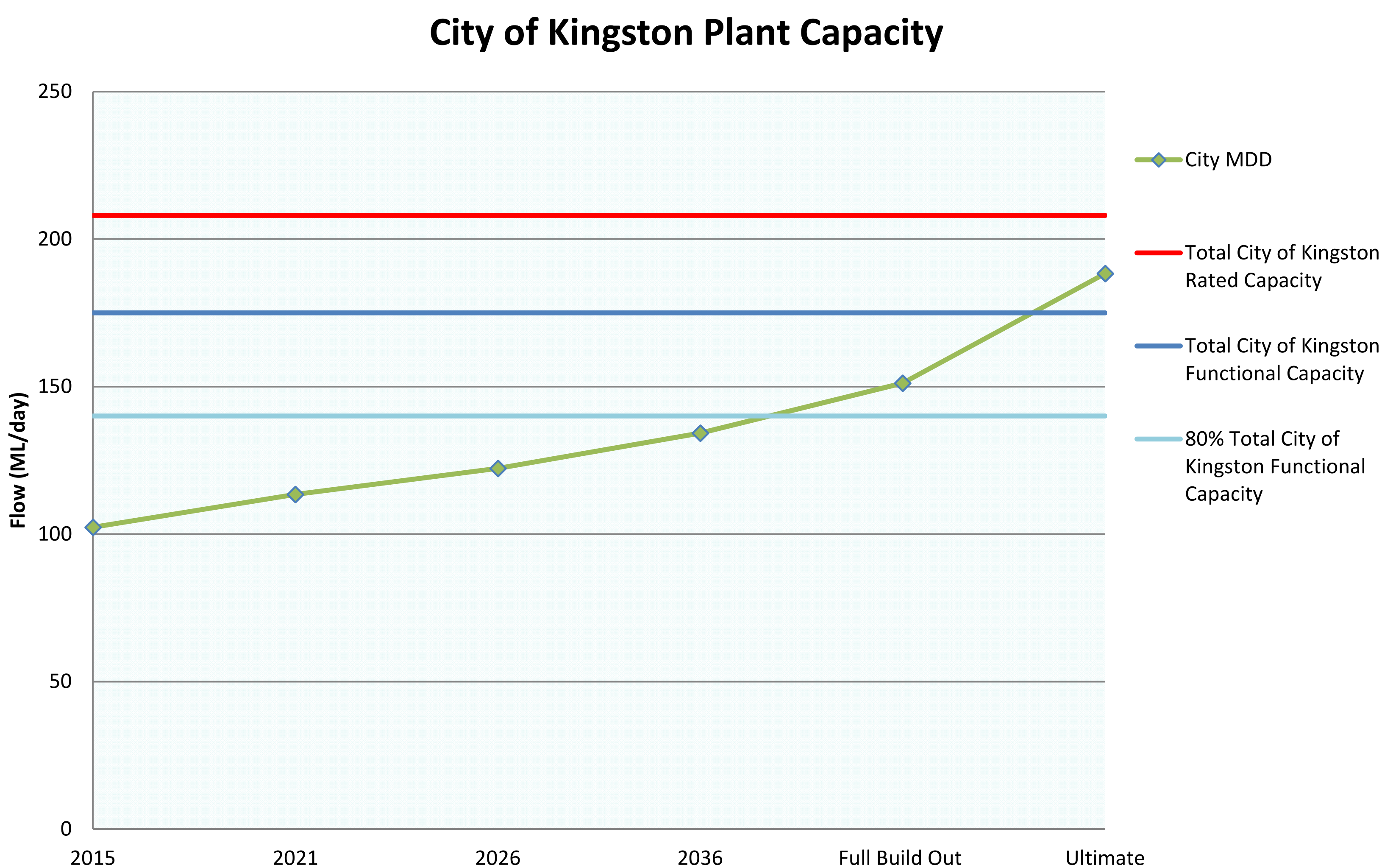
Table 7-1 below presents the MDD versus the plant capacities for the City for each of the different scenarios.

Table 7-1 Future MDD vs. Plant Capacity

	PLANT RATED CAPACITY (ML/D)	PLANT FUNCTIONAL CAPACITY (ML/D)	MDD (ML/D)	% OF FUNCTIONAL CAPACITY	FUNCTIONAL CAPACITY SURPLUS (ML/D)	LOS CRITERIA MEET
2015 (Interconnected)	208	175	102.35	**58.5%**	72.65	☑
2021	208	175	113.41	**64.8%**	61.59	☑
2026	208	175	122.30	**69.9%**	52.70	☑
2036	208	175	134.27	**76.7%**	40.73	☑
Full Build-Out	208	175	151.19	**86.4%**	23.81	☑
Ultimate	208	175	188.31	**107.6%**	-13.31	☒

The projected maximum day demands are plotted versus the total rated and firm production system capacities from the table above.

Figure 7-1 City of Kingston Plant Capacities vs. Projected MDD



The Kingston Water System has sufficient maximum day capacity to service planned population growth beyond 2036. Generally, capacity upgrades are triggered when a system reaches approximately 80% of current functional or production capacity, as there is typically a timing issue between the identification of the need and the implementation of the upgrades. Based on a system total capacity, 80% of the system's production will be reached around the 2036 timeframe that is consistent with the desired LOS indicated.

7.1.1 D-5-1

MOECC Procedure D-5-1 is used to ensure that water demand from approved development applications will not exceed the design capacity of the water treatment plant(s). In order to ensure that capacity is not exceeded, it is necessary to determine what uncommitted reserve capacity is available based on historic flows and existing development. This calculation has been completed as an interconnected system combining King Street WTP and Point Pleasant WTP, including the new upgrades.

Table 7-2 D-5-1 Calculation

COMBINED WTP

COMMITTED CAPACITY FOR GROWTH		
Current 3-Yr MDF	92,913	m^3/d
ECA Design MDF	175,000	m^3/d
RESIDENTIAL GROWTH REQUIREMENTS		
2015 Existing Serviced Population	115,340	persons
Current ADF per person	806	L/c/d
# of Committed Dwelling Units	8,528	Dwellings
Population Density	2.36	Persons/Dwelling
Committed Residential Growth	20,126	persons
Committed Residential Capacity	16,222	m^3/d
COMMERCIAL GROWTH REQUIREMENTS		
Committed Commercial Growth	34.9	ha
Committed Institutional Growth	82.0	ha
Total Committed C&I Area	116.9	ha
Unit Flow (per MOECC)	28	$m^3/ha/d$
Committed C&I Capacity	3,273	m^3/d
INDUSTRIAL GROWTH REQUIREMENTS		
Committed Industrial Growth	125.8	ha
Unit Flow (per MOECC)	35	$m^3/ha/d$
Committed I Capacity	4,403	m^3/d

COMBINED WTP

UNCOMMITTED RESERVE CAPACITY		
Hydraulic Reserve Capacity, Cr	82,087	m^3/d
Committed Residential Capacity	16,222	m^3/d
Committed I&C Capacity	3,273	m^3/d
Committed I Capacity	4,403	m^3/d
Uncommitted Reserve Capacity	**58,189**	m^3/**d**
Average Capacity Increase/Year	2173	m^3/d
Year's Capacity Available (from 2015)	37.8	yrs.

As it can be seen from the calculation above, the WTP have sufficient capacity beyond 2036. Note that the population projections indicate that the committed capacity will be reached by 2026. Therefore, the average capacity increase per year was determined based on the total committed capacity flows divided by 11 years (2015 – 2026).

7.2 BOOSTER STATIONS

As indicated in the existing conditions section, there are currently seven booster station and three water treatment plants that provide system distribution to the City of Kingston. It has been indicated that the Cana WTS has no plans for growth and is therefore not reviewed beyond section 5.2; however, there is significant growth planned within the main distribution system and therefore the pumping and boosting capacity has been reviewed for the future scenarios.

As indicated in the infrastructure additions of future projects indicated in section 3.2, the James Street Booster Station Phase 1 Upgrades will be implemented by 2021, therefore Table 7-3 below presents the revised station capacities from Table 5-6.

Table 7-3 Revised Kingston East Boosting Capacity

STATION	PUMP # 1	PUMP #2	PUMP #3	TOTAL CAPACITY	FIRM CAPACITY	STAND-BY CAPACITY
				ML/D		
KINGSTON EAST – ZONE 3						
James St BS	7.34	7.34	12.96	27.65	14.69	14.69
Sub-Total				**27.65**	**14.69**	**14.69**

New James St BS capacity based on Phase 1 upgrades only (Kingston East MP, 2013) and the provided pump curves

The table below presents the MDD versus the plant capacities for each of the different scenarios.

Table 7-4 Future MDD vs. Pumping & Boosting Capacity

	ADD (ML/D)	MDD (ML/D)	SUFF. FLOATING STORAGE	FIRM CAPACITY	MDD OF FIRM CAPACITY	STAND-BY CAPACITY	ADD OF STAND-BY CAPACITY	LOS CRITERIA MEET
2021								
Kingston West & Central Zone 1	59.08	88.62	☑	217.49	**40.75%**	210.99	**28.00%**	☑
Kingston West Zone 2	10.56	15.85	☑	39.03	**40.61%**	35.42	**29.82%**	☑
Kingston East Zone 3	5.96	8.94	☑	14.69	**60.89%**	14.69	**40.59%**	☑
2026								
Kingston West & Central Zone 1	62.05	93.08	☑	217.49	**42.80%**	210.99	**29.41%**	☑
Kingston West Zone 2	12.69	19.03	☑	39.03	**48.77%**	35.42	**35.82%**	☑
Kingston East Zone 3	6.79	10.19	☑	14.69	**69.37%**	14.69	**46.24%**	☑
2036								
Kingston West & Central Zone 1	68.70	103.05	☑	217.49	**47.38%**	210.99	**32.56%**	☑
Kingston West Zone 2	13.29	19.94	☑	39.03	**51.08%**	35.42	**37.52%**	☑
Kingston East Zone 3	7.52	11.28	☑	14.69	**76.82%**	14.69	**51.21%**	☑
FULL BUILDOUT								
Kingston West & Central Zone 1	78.20	117.30	☑	217.49	**53.93%**	210.99	**37.06%**	☑

	ADD (ML/D)	MDD (ML/D)	SUFF. FLOATING STORAGE	FIRM CAPACITY	MDD OF FIRM CAPACITY	STAND-BY CAPACITY	ADD OF STAND-BY CAPACITY	LOS CRITERIA MEET
Kingston West Zone 2	14.58	21.88	☑	39.03	**56.05%**	35.42	**41.17%**	☑
Kingston East Zone 3	8.01	12.01	☑	14.69	**81.79%**	14.69	**54.53%**	☑
ULTIMATE								
Kingston West & Central Zone 1	78.20	117.30	☑	217.49	**53.93%**	210.99	**37.06%**	☑
Kingston West Zone 2	26.47	39.70	☑	39.03	**101.74%**	35.42	**74.72%**	☒
Kingston East Zone 3	20.87	31.30	☑	14.69	**213.13%**	14.69	**142.08%**	☒

It can be seen from the table above that the LOS for each of the pressure districts has been met under all scenarios except the Ultimate scenario. The Ultimate scenario is used more for contrast to the 2015 -2036 with regards to potential upgrades, therefore as the 2015-2036 scenarios meet the pumping and boosting LOS, further upgrades are not needed at this time.

7.3 STORAGE

As indicated above, the City is supplied by a variety of reservoirs and elevated storage tanks in each zone. The Cana WTS has no plans for growth and is therefore not reviewed beyond section 5.2; however, there is significant growth planned within the main distribution system and therefore the storage capacity has been reviewed for the future scenarios.

The CFB Kingston EST is owned by the Department of National Defence (DND) and is located on their property. DND has indicated that due to life cycle age and maintenance, they would like the CFB Kingston EST decommissioned if it is no longer required. It has been indicated that the CFB Kingston EST will be decommissioned by 2021, therefore this storage has been removed from the available storage. Table 7-5 below provides the updated available storage in the east.

Table 7-5 Updated Kingston East Available Storage

STATION	TOTAL	FUNCTION	TYPICAL WATER LEVEL	
	M^3	M^3	m	m
KINGSTON EAST – ZONE 3				
Innovation Dr. Water Tower	6,400	1500	9.5	6.9
Forest Dr. Stand Pipe	1,770	200	6.0	0.5

STATION	TOTAL	FUNCTION	TYPICAL WATER LEVEL	
	M³	M³	m	m
Sub-Total (Ext)	**8,170**	**1,700**	**-**	**-**

Table 7-6 below calculates the required minimum storage.

Table 7-6 2015 (Interconnected) Storage Requirements

		ZONE 1*	ZONE 2	ZONE 3**	TOTAL
		2021			
Peak Hour Demand	ML/day	132.94	23.77	13.42	170.12
Max Day Demand	ML/day	88.62	15.85	8.94	113.42
Fire Flow	L/s	378	301	197	378
Fire Flow Duration	Hr	6.00	5.00	3.00	6.00
Peak Demand	ML/day	132.94	41.85	25.96	170.12
Firm Capacity	ML/day	217.49	39.03	14.69	271.20
Other Zone Demands (MD)	ML/day	24.79	0	0	0
Eligiable Supply	ML/day	192.70	39.03	14.69	271.20
A = Fire Storage	m^3	-	589	1,410	-
B = Equalization	m^3	22,156	3,962	2,236	28,354
C = Emergency	m^3	5,539	1,138	911	7,088
Total	m^3	**27,695**	**5,688**	**4,557**	**35,442**
		2026			
Peak Hour Demand	ML/day	139.62	28.55	15.28	183.45
Max Day Demand	ML/day	93.08	19.03	10.19	122.30
Fire Flow	L/s	378	311	203	378
Fire Flow Duration	Hr	6.00	5.00	3.00	6.00
Peak Demand	ML/day	139.62	45.90	27.73	183.45
Firm Capacity	ML/day	217.49	39.03	14.69	271.20
Other Zone Demands (MD)	ML/day	29.22	0.00	0.00	0.00
Eligiable Supply	ML/day	188.27	39.03	14.69	271.20
A = Fire Storage	m^3	8,165	5,598	2,192	8,165
B = Equalization	m^3	23,269	4,758	2,547	30,574
C = Emergency	m^3	5,817	1,548	1,044	7,644
Total	m^3	**29,087**	**7,738**	**5,221**	**38,218**
		2036			
Peak Hour Demand	ML/day	154.57	29.90	16.92	201.40

		ZONE 1*	ZONE 2	ZONE 3**	TOTAL
Max Day Demand	ML/day	103.05	19.94	11.28	134.27
Fire Flow	L/s	378	324	213	378
Fire Flow Duration	Hr	6.00	5.00	3.00	6.00
Peak Demand	ML/day	154.57	47.93	29.69	201.40
Peak Supply	ML/day	217.49	39.03	14.69	271.20
Other Zone Demands (MD)	ML/day	31.22	0	0	0
Eligiable Supply	ML/day	186.27	39.03	14.69	271.20
A = Fire Storage	m^3	-	1,855	1,875	-
B = Equalization	m^3	25,762	4,984	2,821	33,567
C = Emergency	m^3	6,441	1,710	1,174	8,392
Total	m^3	**32,203**	**8,548**	**5,869**	**41,959**
FULL BUILDOUT					
Peak Hour Demand	ML/day	175.95	32.81	18.02	226.79
Max Day Demand	ML/day	117.30	21.88	12.01	151.19
Fire Flow	L/s	378	347	229	378
Fire Flow Duration	Hr	6.00	5.00	3.50	6.00
Peak Demand	ML/day	175.95	51.86	31.80	226.79
Peak Supply	ML/day	217.49	39.03	14.69	271.20
Other Zone Demands (MD)	ML/day	33.89	0	0	0
Eligiable Supply	ML/day	183.60	39.03	14.69	271.20
A = Fire Storage	m^3	-	2,673	2,495	-
B = Equalization	m^3	29,325	5,469	3,003	37,798
C = Emergency	m^3	7,331	2,036	1,375	9,449
Total	m^3	**36,657**	**10,178**	**6,873**	**47,247**
ULTIMATE					
Peak Hour Demand	ML/day	175.95	59.56	46.96	282.47
Max Day Demand	ML/day	117.30	39.70	31.30	188.31
Fire Flow	L/s	378	378	269	378
Fire Flow Duration	Hr	6.00	6.00	4.50	6.00
Peak Demand	ML/day	175.95	72.36	54.55	282.47
Peak Supply	ML/day	217.49	39.03	14.69	271.20
Other Zone Demands (MD)	ML/day	71.01	0	0	0
Eligiable Supply	ML/day	146.48	39.03	14.69	271.20

		ZONE 1*	ZONE 2	ZONE 3**	TOTAL
A = Fire Storage	m^3	7,369	8,334	7,473	2,816
B = Equalization	m^3	29,325	9,926	7,826	47,078
C = Emergency	m^3	9,173	4,565	3,825	12,473
Total	m^3	**45,867**	**22,826**	**19,124**	**62,367**

The revised storage requirements were compared to the revised storage capacities. This comparison is presented in Table 7-7 below.

Table 7-7 2015 (Interconnected) Total Storage Surplus/Deficiency

		ZONE 1	ZONE 2	EAST	TOTAL
Total Available Storage	m^3	**47,260**	**14,844**	**8,170**	**70,274**
Functional Storage	m^3	**24,550**	**7,100**	**1,700**	**33,350**
2021					
Total	m^3	47,260	14,844	8,170	70,274
Total Functional	m^3	24,550	7,100	1,700	33,350
Total Storage Surplus	m^3	19,565	9,156	3,613	34,832
Functional Surplus	m^3	2,394	3,138	(536)	4,996
2026					
Total	m^3	47,260	14,844	8,170	70,274
Total Functional	m^3	24,550	7,100	1,700	33,350
Total Storage Surplus	m^3	18,173	7,106	2,949	32,056
Functional Surplus	m^3	1,281	2,342	(847)	2,776
2036					
Total	m^3	47,260	14,844	8,170	70,274
Total Functional	m^3	24,550	7,100	1,700	33,350
Total Storage Surplus	m^3	15,057	6,296	2,301	28,315
Functional Surplus	m^3	(1,212)	2,116	(1,121)	(217)
FULL BUILDOUT					
Total	m^3	47,260	14,844	8,170	70,274
Total Functional	m^3	24,550	7,100	1,700	33,350
Total Storage Surplus	m^3	10,603	4,666	1,297	23,027
Functional Surplus	m^3	(4,775)	1,631	(1,303)	(4,448)
ULTIMATE					
Total	m^3	47,260	14,844	8,170	70,274
Total Functional	m^3	24,550	7,100	1,700	33,350

		ZONE 1	ZONE 2	EAST	TOTAL
Total Storage Surplus	m^3	1,393	(7,982)	(10,954)	7,907
Functional Surplus	m^3	(4,775)	(2,826)	(6,126)	(13,728)

The minimum required storage is plotted versus the total available storage for each zone from the table above in Figure 7-2, Figure 7-3, Figure 7-4 and Figure 7-5 below.

Figure 7-2 Zone 1 Future Required Storage vs. Available

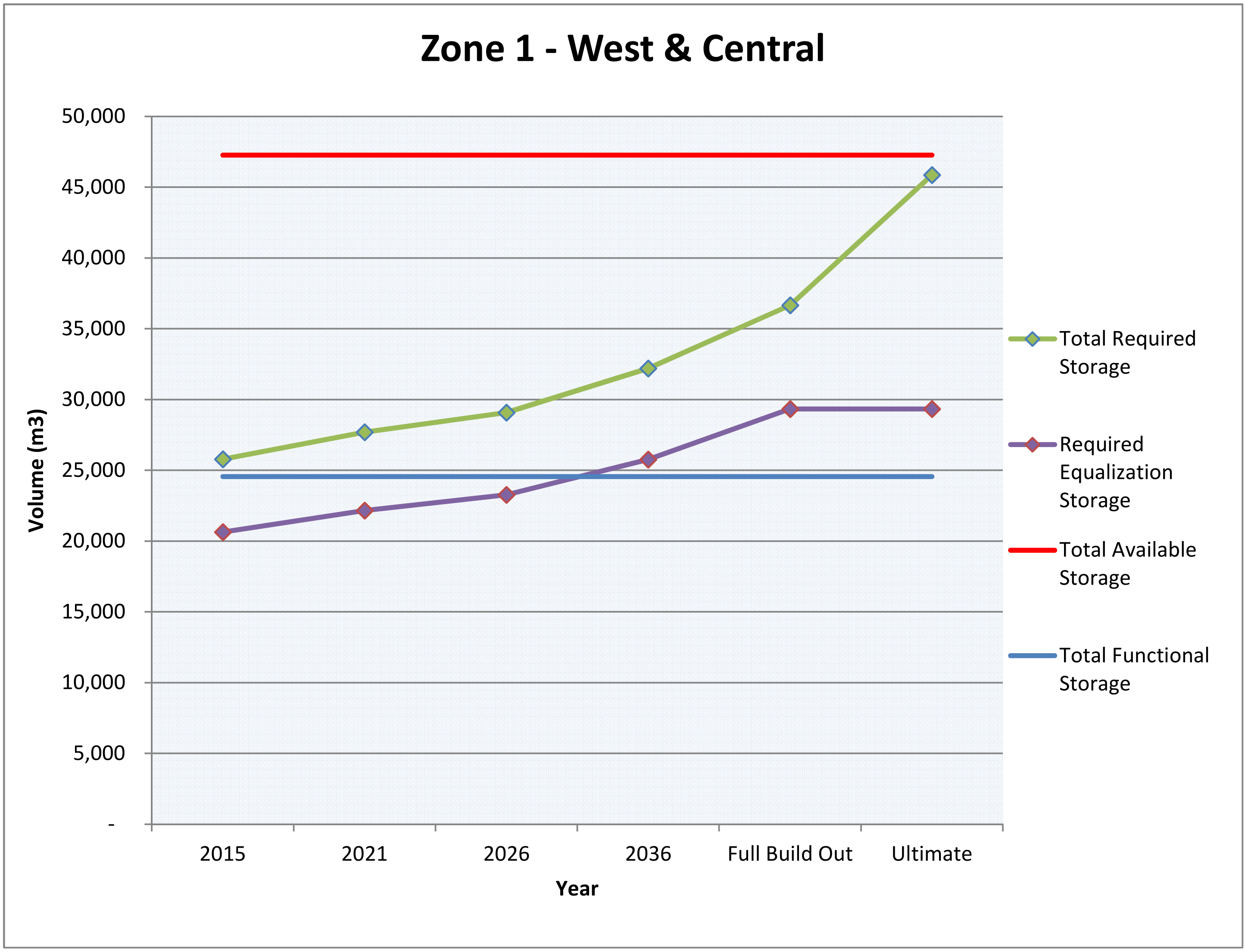


Figure 7-3 Zone 2 Future Required Storage vs. Available

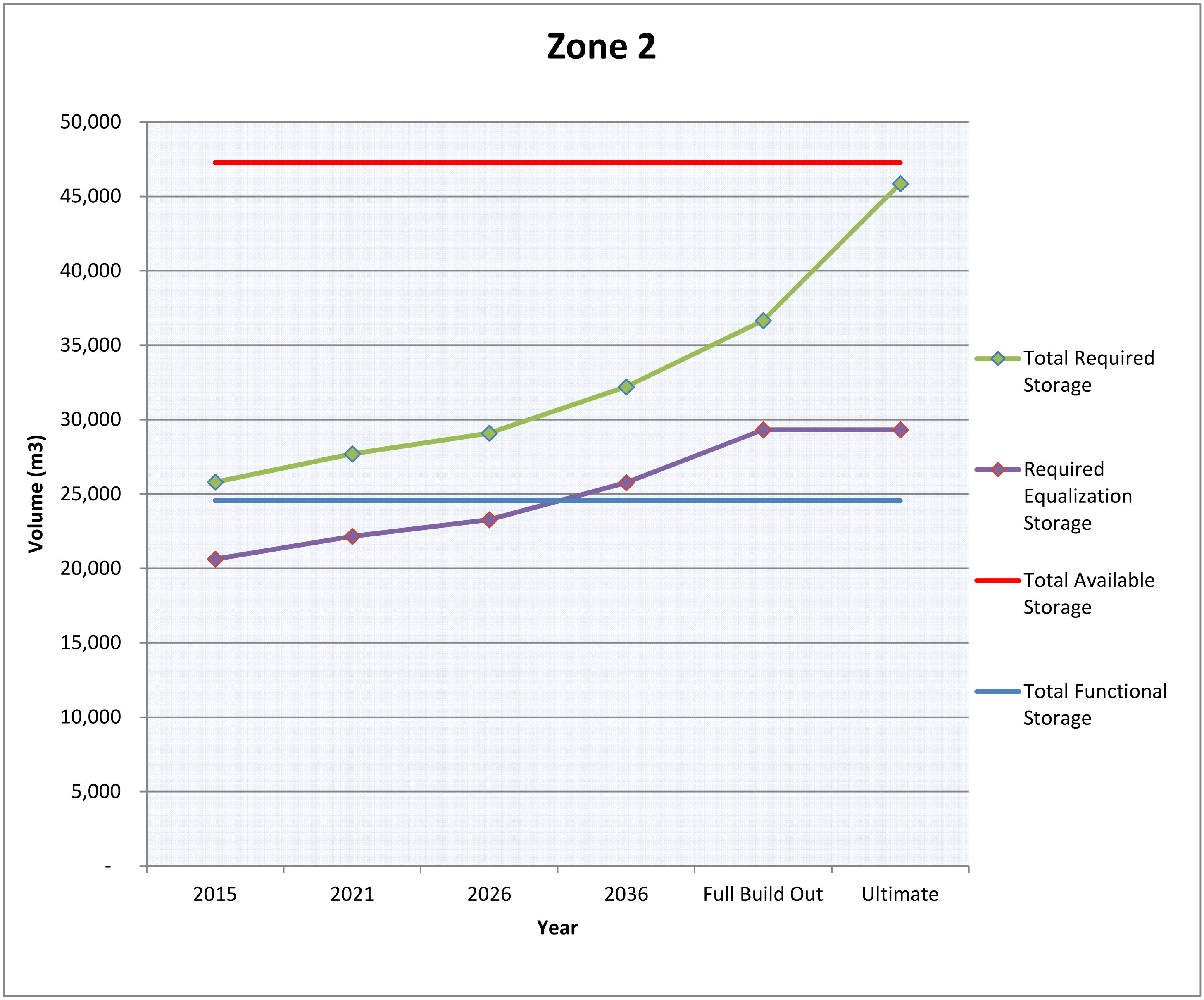


Figure 7-4 Zone 3 Future Required Storage vs. Available

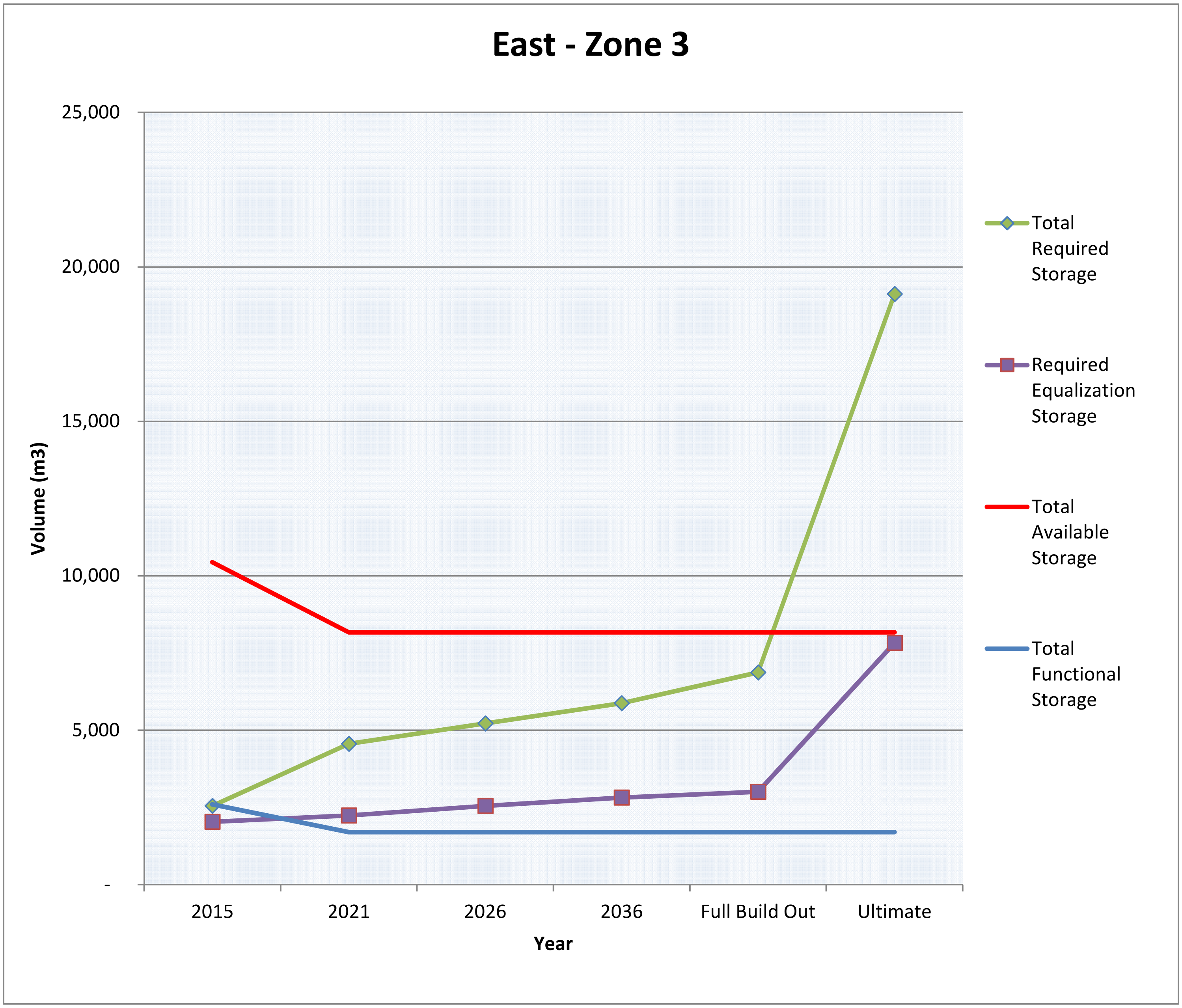
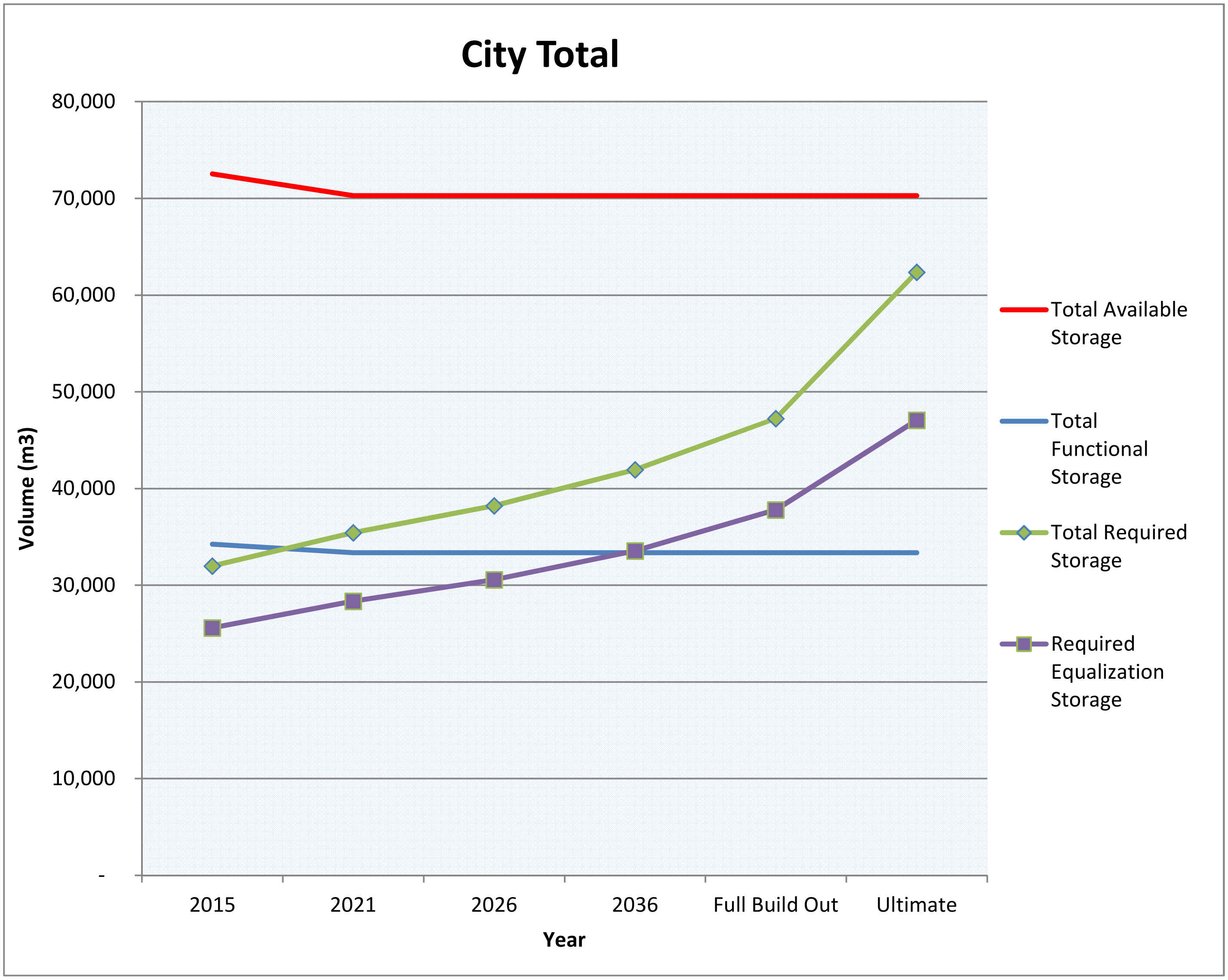


Figure 7-5 City Total Future Storage vs. Available



It can be seen from the tables and graphs above that there is some functional deficiency in the east system from 2021 continuing through 2026. There is a functional storage deficiency in Zone 1, the East and the City as a whole starting in 2036 through to the Ultimate. Some total storage deficiencies occur in Zone 2, the East and the City as a whole during the Ultimate scenario.

8 MODELLING

An all-pipe model of the system including pipes, key hydrants, storage tanks, and system water sources was developed using INFOWATER hydraulic modeling software. This model was updated based on information provided by the City to reflect current system conditions. The construction, loading and calibration of this model are documented separately in the Water Hydraulic Modelling Report (WSP, 2016).

The water model allows for simulations that can predict system responses to events under a wide range of conditions. Using the hydraulic simulations, problems can be anticipated in proposed or existing systems, and solutions can be evaluated before time, money, and materials are invested in a real-world project. Simulations can either be steady-state or extended-period.

Steady-state simulations represent a snapshot in time and are used to determine the operating behaviour of a system under static conditions. This type of analysis can be useful in determining the short-term effect of fire flows or average demand conditions on the system. Extended period simulations (EPS) are used to evaluate system performance over time. This type of analysis allows modeling the filling and emptying of storage facilities, regulating valves opening and closing, and pressures and flow rates changing throughout the system in response to varying demand conditions and automatic control strategies.

Simulations including steady-state analysis of the Average Day, Maximum Day and Maximum Day + Fire conditions were carried out using the model. Fire flow simulations were carried out throughout the system to determine whether the system could deliver fire flows under the Maximum Day demands.

8.1 WATER MODEL DEVELOPMENT

The following steps were completed to model the various scenarios:

- Total network demand on an average day basis was determined for the current scenario using 2013/2014 water production data.
- The node demand allocations assigned in the model were based on 2014 meter records, assigned to the respective property and converted from an annual volume to the Average Day Demand (ADD) in L/s. In other cases where meter records showed zero flow, the value was manually adjusted to reflect a reasonable volume (e.g.: ADD) for a respective property, depending on land use.
- Unbilled water was built into the unit rates for residential properties with meters that recorded zero water use.
- Pipes within the model were divided into 9 different pipe groups based on pipe material, age and break to account for roughness and leakage.
- The peaking factors were applied to the average day demand value to determine the maximum day demand.
- The maximum day demand plus fire flow was used to assess the system since it is typically greater than the peak hour demand. The fire flow that was simulated depended on land use

→ The model predictions were compared to real-world hydrant flow test results at fifteen locations, showing an excellent match throughout the tested ranges and with the overall agreement within 5% (steady state) and about 10% (highest hydrant flow) .

→ An interconnection framework was developed in conjunction with the existing system parameters and the data of the trial interconnect data that was provided (good agreement to measured flows and patterns) to provide an initial working system. Additionally, optimization parameters will be developed in the alternative solutions report.

9 DISTRIBUTION GAPS

9.1 PRESSURES

The minimum and maximum pressures were observed under a minimum day, average day and peak hour demand for each scenario. Based on the system modeling, maps showing pressures at nodes are presented in Appendix B.

→ Maps 5.1.1 to 5.2.7 show the average service pressures during average hour demands, ADD for the existing year 2015 and the future (inter-connected) scenarios in 2015, 2021, 2026, 2036, full-buildout and ultimate.

→ Maps 6.1.1 and 6.2.7 show the minimum service pressures during PHD, MDD for the same scenarios.

→ Maps 7.1.1 to 7.2.7 show the maximum service pressures during MHD, ADD for the same scenarios.

→ Maps 8.1.1 and 8.2.7 show the FFA for MDD (average hour) for the same scenarios

Pressures throughout the system are generally within the range prescribed (40 – 100 psi) under normal conditions. Some exceptions have been noted in the different scenarios and demand alternatives, and are reviewed below:

1. The area near the Third Avenue Reservoir and Tower Street Water Tower had some pressures between 37 and 39 psi. The situation improves between the 2015 existing condition and the 2015 interconnection and then marginally changes between 2015 interconnect and 2036 and into the Full Buildout and Ultimate. These low pressures are partially due to the higher elevations in that area corresponding to pressure about 39 psi during static (zero-flow) conditions with the Tower at overflow elevations (i.e. it is not possible to achieve 40 psi service pressure but operating schedules at the Third Avenue).
2. The area near the O'Connor Drive Reservoir and Tower had some pressures equal to 40 psi. The 2015 interconnect had some marginal effects on the area, and the remaining scenario's also had little change. Some of this area is a reservoir fill line without service connections that can be left as-is.
3. The area near the intersection of Bayridge Drive and Taylor Kidd Boulevard in Zone 1 also experienced some pressure below 40 psi (33 – 39 psi) that had little variation between the 2015 interconnect scenario and beyond.
4. The area just south west of the intersection of the Montreal Street and Highway 401 also saw some minor pressures below 40 psi in varying degrees in each scenario and demand alternative. This area is at the highest-elevation and farthest reach of Zone 1, yet the pressures are only a few psi below 40.
5. Some high pressures (<10 5psi) were seen in the Bayridge area near Mona Drive and Malvern Trail, largely in part to the topography of the area (low lying).This was relatively consistent throughout the scenarios and demand alternatives.

6. Some high pressures (<109 psi) were seen around the James St Booster Station largely due to the topography of the area (low lying).This was relatively consistent throughout the scenarios and demand alternatives.
7. During the 2021 scenario, the control parameters change due to the removal on the CFB Tower and therefore James Street Booster Station is controlled by the Innovation Drive Water Tower. Due to this change and in order to fill the tower, pressures above 100 psi are seen along the Highway 15 corridor and diminish as the demand increases between demand alternatives and scenarios.

The Full Buildout scenario is generally consistent with the other scenarios between the existing 2015 and 2036 and the observations above.

The Ultimate scenario during the Peak Hour identifies significant areas of low pressure due largely in part to the insufficient storage in the zones. Low pressure zones can be seen at both servicing areas to the west and significant lower pressures throughout the east zone to service those areas.

As indicated on the maps of the junction pressures, pipe headloss gradients have been shown to identify pipe sections or segments with higher losses that will be used to identify potential watermain cleaning, replacements or linings that may help improve system performance.

It should be noted that the computer model itself has a finite accuracy that is of the same order of magnitude as some of the pressure shortfall being investigated here: it is possible that modeling error is responsible for some of the simulated shortfall and that real-world conditions are at or above 40 psi.

9.1.1 2015 EXISTING SCENARIO

The table below presents the details on each pressure zone under the 2015 existing conditions.

Table 9-1 Pressure Zones Existing Conditions

PRESSURE ZONE	ELEVATION SERVED (M)			HGL (M)			PRESSURE (PSI)		
	MAX	MEAN	MIN	MAX	MEAN	MIN	MAX	MEAN	MIN
West-Total	124.9	97.3	76.0	173.2	149.5	132.8	107	74	41
Zone 1	108.4	88.8	76.0	166.5	140.1	134.0	107	73	43
Zone 2	124.9	107.6	85.5	173.2	161.0	138.2	106	76	43
Central 1B	110.7	92.4	76.1	135.7	134.0	127.7	83	59	33
East Total	112.5	99.6	75.8	159.8	149.7	121.8	109	71	48
Zone 3A	110.9	98.2	75.8	159.8	150.9	128.2	90	75	62
Zone 3B	112.5	100.8	76.0	156.7	148.7	146.4	109	68	48
Zone 3C	109.5	101.8	83.0	154.6	151.9	149.4	99	71	61

9.1.2 2015 (INTERCONNECTED) SCENARIO

The table below presents the details on each pressure zone under the 2015 interconnected conditions.

Table 9-2 Pressure Zones Interconnected System (2015)

PRESSURE ZONE	ELEVATION SERVED (M)			HGL (M)			PRESSURE (PSI)		
	MAX	MEAN	MIN	MAX	MEAN	MIN	MAX	MEAN	MIN
Zone 1 – Central & West)	110.7	91.2	76.0	166.5	137.0	128.8	92	65	34
Zone 2 – West	124.9	107.6	85.5	173.2	160.9	137.5	106	76	42
East Total	112.5	99.6	75.8	160.0	149.8	122.8	109	71	48
Zone 3A	110.9	98.2	75.8	160.0	151.0	128.2	90	75	62
Zone 3B	112.5	100.8	76.0	156.8	148.7	146.4	109	68	48
Zone 3C	109.5	101.8	83.0	154.7	152.0	149.4	99	71	61

9.1.3 2021 SCENARIO

The table below presents the details on each pressure zone under the 2021 conditions.

Table 9-3 Pressure Zones Interconnected System (2021)

PRESSURE ZONE	ELEVATION SERVED (M)			HGL (M)			PRESSURE (PSI)		
	MAX	MEAN	MIN	MAX	MEAN	MIN	MAX	MEAN	MIN
Zone 1 – Central & West)	110.7	91.2	76.0	162.1	136.7	132.3	105	65	34
Zone 2 – West	124.9	107.6	85.5	170.9	158.8	136.6	102	73	41
East Total	112.5	99.6	75.8	163.6	152.7	128.2	114	75	49
Zone 3A	110.9	98.2	75.8	163.6	155.6	128.2	105	82	65
Zone 3B	112.5	100.9	76.0	161.9	150.1	146.8	114	70	49
Zone 3C	109.5	101.8	83.0	159.8	154.7	149.6	104	75	63

9.1.4 2026 SCENARIO (COMMITTED)

The table below presents the details on each pressure zone under the 2026 conditions.

Table 9-4 Pressure Zones Interconnected System (2026)

PRESSURE ZONE	ELEVATION SERVED (M)			HGL (M)			PRESSURE (PSI)		
	MAX	MEAN	MIN	MAX	MEAN	MIN	MAX	MEAN	MIN
Zone 1 – Central & West)	110.7	91.2	76.0	162.0	136.6	132.3	105	65	34
Zone 2 – West	124.9	107.6	85.5	170.8	158.7	136.5	102	73	41
East Total	112.5	99.6	75.8	163.5	152.6	128.2	114	75	49
Zone 3A	110.9	98.1	75.8	163.5	155.5	128.2	106	82	65
Zone 3B	112.5	100.8	76.0	161.7	150.1	146.7	114	70	49
Zone 3C	109.5	101.8	83.0	159.7	154.6	149.6	104	75	63

9.1.5 2036 SCENARIO

The table below presents the details on each pressure zone under the 2036 conditions.

Table 9-5 Pressure Zones Interconnected System (2036)

PRESSURE ZONE	ELEVATION SERVED (M)			HGL (M)			PRESSURE (PSI)		
	MAX	MEAN	MIN	MAX	MEAN	MIN	MAX	MEAN	MIN
Zone 1 – Central & West)	110.7	91.2	76.0	161.9	136.5	132.2	104	65	34
Zone 2 – West	124.9	107.7	85.5	170.7	158.7	136.4	102	73	41
East Total	112.5	99.6	75.8	163.3	152.5	128.2	114	75	49
Zone 3A	110.9	98.1	75.8	163.3	155.4	128.2	106	81	65
Zone 3B	112.5	100.8	76.0	161.6	150.1	146.7	114	70	49
Zone 3C	109.5	101.8	83.0	159.6	154.5	149.6	104	75	63

9.1.6 FULL BUILDOUT & ULTIMATE SCENARIO

Pressure zone parameters were not provided for Full Buildout and Ultimate as these scenarios will be used to review alternatives in conjunction with the 2015 to 2036 scenarios.

9.2 FIRE FLOWS

An assessment of the available fire flows was conducted using the hydraulic model. Maps showing fire flows at each node are presented in Appendix C. The model revealed that flows generally meet current fire flow standards in most areas with the City, except along some small diameter watermains (whose capacity is limited), in poorly looped areas and certain areas throughout the system. Numerous watermains smaller than 150 mm do not have capacity to deliver fire flows to meet today's standards. These watermains were constructed in a time where design and construction standards were different from present-day. There are also small areas throughout the distribution system in each scenario that do not meet current fire flow standards, as illustrated in Appendix C.

Based on the LOS indicated above and the results from the model output, the distribution system does not meet current fire protection standards in various small areas; however, as previously noted, these areas were developed in a time where fire flow standards differed from present-day standards. A reasonable and realistic plan will be developed to improve system capacity and "close the gap" between the available capacity indicated and the target capacities.

9.3 LEAKAGE

The City has been performing a comprehensive water balance study for many years. The tables below are a summary of the water balance results for City of Kingston system as whole, and also for the three subsystems; West, Central and East, in 2014. The tables are a snapshot of the water balance details.

Figure 9-1 City of Kingston 2014 Water Balance Summary

KINGSTON DRINKING WATER SYSTEM WATER BALANCE 2014 (m^3)					Dec-2014
Net Water to System 24,904,204 100%	**Authorized Consumption** 13,808,565 55.45%	**Billed Authorized Consumption** 13,808,565 54.83%	**Billed Metered Consumption** 13,655,690	54.83%	**Revenue Water** 13,655,690 54.83%
			Billed Unmetered Consumption Unknown		
		Unbilled Authorized Consumption 152,875 0.61%	**Unbilled Metered Consumption**		**Non-Revenue Water** 11,248,514 45.17%
			Mains New & Relined (UK)	49,531	
			Watchdog Meters (Non-System)	19	
			Unbilled Unmetered Consumption		
			Water Facility Equipment	6,031	
			Fire Department	1984	
			Flow Testing	36,932	
			Flushing	52,678	
			Hydrant Maintenance	3,457	
			Mains New & Relined (UK)	0	
			New Mains (Development)	1,014	
			Private Hydrants	1,229	
			152,875	0.61%	
	Total Water Loses 11,095,639 44.55%	**Apparent Losses** 560,693.19 2.25%	Unauthorized Consumption	62,261	
			Meter Inaccuracies	464,293	
			Data Handling Errors	34,139	
			560,693.19	2.25%	
		Known Real Losses 4,706,338 18.90%	**Estimated Loss - Known Main Breaks** 3,813,416	15.31%	
			Estimated Loss - Known Service Leaks 892,921	3.59%	
		Unknown Losses 5,828,608 23.40%	5,828,608	23.40%	

Figure 9-2 2014 Kingston West System Water Balance Summary

<table>
<tr><th colspan="4">City of Kingston West Water Balance 2014 (m^3)</th><th>Dec-2014</th></tr>
<tr><td rowspan="7">Net Water to System
7,349,126
100%</td><td rowspan="3">Authorized Consumption
4,305,954
58.59%</td><td rowspan="2">Billed Authorized Consumption
4,229,983
57.56%</td><td>Billed Metered Consumption
4,229,983
57.56%</td><td rowspan="2">Revenue Water
4,229,983
57.56%</td></tr>
<tr><td>Billed Unmetered Consumption
Unknown</td></tr>
<tr><td>Unbilled Authorized Consumption
75,971
1.03%</td><td>Unbilled Metered Consumption
Mains New & Relined (UK) 15,840
Watchdog Meters (Non-System) 10
Unbilled Unmetered Consumption
Water Facility Equipment 2,761
Fire Department 208
Flow Testing 26,879
Flushing 27,330
Hydrant Maintenance 1,731
Mains New & Relined (UK) 0
New Mains (Development) 764
Private Hydrants 449
75,971 1.03%</td><td rowspan="5">Non-Revenue Water
3,119,142
42.44%</td></tr>
<tr><td rowspan="4">Total Water Loses
3,043,172
41.41%</td><td>Apparent Losses</td><td>Apparent losses are calculated on a system wide basis and may not accurately reflect area losses.</td></tr>
<tr><td rowspan="2">Known Real Losses
838,244
11.41%</td><td>Estimated Loss - Known Main Breaks
722,458 9.83%</td></tr>
<tr><td>Estimated Loss - Known Service Leaks
115,787 1.58%</td></tr>
<tr><td>Unknown Losses
2,204,927
30.00%</td><td>2,204,927 30.00%</td></tr>
</table>

Figure 9-3 2014 Kingston Central System Water Balance Summary

<table>
<tr><th colspan="4">City of Kingston Central Water Balance 2014 (m^3)</th><th>Dec-2014</th></tr>
<tr><td rowspan="7">Net Water to System
15,571,843
100%</td><td rowspan="3">Authorized Consumption
7,839,611
50.34%</td><td rowspan="2">Billed Authorized Consumption
7,774,001
49.92%</td><td>Billed Metered Consumption
7,774,001
49.92%</td><td rowspan="2">Revenue Water
7,774,001
49.92%</td></tr>
<tr><td>Billed Unmetered Consumption
Unknown</td></tr>
<tr><td>Unbilled Authorized Consumption
65,610
0.42%</td><td>Unbilled Metered Consumption
Mains New & Relined (UK) 33,692
Watchdog Meters (Non-System) 9
Unbilled Unmetered Consumption
Water Facility Equipment 1,431
Fire Department 1242
Flow Testing 9,526
Flushing 17,627
Hydrant Maintenance 1,357
Mains New & Relined (UK) 0
New Mains (Development) 1,014
Private Hydrants 727
65,610 0.42%</td><td rowspan="5">Non-Revenue Water
7,797,842
50.08%</td></tr>
<tr><td></td><td>Apparent Losses</td><td>Apparent losses are calculated on a system wide basis and may not accurately reflect area losses.</td></tr>
<tr><td rowspan="3">Total Water Loses
7,732,232
49.66%</td><td rowspan="2">Known Real Losses
3,796,305
24.38%</td><td>Estimated Loss - Known Main Breaks
3,087,318 19.83%</td></tr>
<tr><td>Estimated Loss - Known Service Leaks
708,987 4.55%</td></tr>
<tr><td>Unknown Losses
3,935,927
25.28%</td><td>3,935,927 25.28%</td></tr>
</table>

Figure 9-4 2014 Kingston East System Water Balance Summary

City of Kingston East Water Balance 2014 (m^3)					Dec-2014
Net Water to System 1,983,236 100%	Authorized Consumption 1,663,000 83.85%	Billed Authorized Consumption 1,651,706 83.28%	**Billed Metered Consumption** 1,651,706 83.28%		Revenue Water 1,651,706 83.28%
			Billed Unmetered Consumption Unknown		
		Unbilled Authorized Consumption 11,294 0.57%	**Unbilled Metered Consumption**		Non-Revenue Water 331,530 16.72%
			Mains New & Relined (UK)	0	
			Watchdog Meters (Non-System)	0	
			Unbilled Unmetered Consumption		
			Water Facility Equipment	1,839	
			Fire Department	534	
			Flow Testing	527	
			Flushing	7,722	
			Hydrant Maintenance	369	
			Mains New & Relined (UK)	0	
			New Mains (Development)	250	
			Private Hydrants	53	
			11,294	0.57%	
	Total Water Loses 320,236 16.15%	Apparent Losses	Apparent losses are calculated on a system wide basis and may not accurately reflect area losses.		
		Known Real Losses 71,788 3.62%	**Estimated Loss - Known Main Breaks** 3,640	0.18%	
			Estimated Loss - Known Service Leaks 68,148	3.44%	
		Unknown Losses 248,447 12.53%	248,447	12.53%	

While there is no specific design criteria or LOS to meet, based on other municipalities leakage rates, strategic analysis of the leakage can potentially help improve the amount of water currently lost to leakage.

9.4 ENERGY EFFICIENCY

Energy efficiency includes the pumps' electrical and hydraulic (combined) efficiency; number of pump starts per day, time-of-use electrical rates (night-time pumping); the piping system's head losses including (facility and yard piping) and what fraction of water storage is elevated or in-ground (requiring re-pumping). As long as the LOS is met, optimization of the system can be revised to maximize efficiency to lower operating costs. Specific energy efficiency measures from the simulations are discussed in the Modeling Report

(WSP, 2016), and the Alternatives Report (WSP, 2016), since the detailed energy calculations are a ‘check’ on the proposed alternative.

9.5 RELIABILITY AND RESILIENCY

Reliability refers to the system’s ability to handle routine upsets such as pipe breaks or planned maintenance to pumps or storages, for example. Resiliency refers to the ability to recover from major upsets such as the loss of components with long replacement lead times (e.g.: rail or river crossings) or the upset of complex processes such as water quality that may take days or a week to fully restore (e.g.: boil water advisory). Specific reliability and resiliency measures from the simulations will be discussed in the Alternatives Report (WSP, 2016) for the proposed alternative.

Appendix A

FIRE FLOW REVIEW

November 11, 2015

Kingston Fire and Rescue Services
500 O'Connor Dr.
Kingston, ON K7P 1N3

Re: Utilities Kingston Water Master Plans
Fire Flows

To Mr. Paul Patry:

Utilities Kingston (UK) is updating their Water Master Plans to align with current population projections and standards. The current Water Master Plan was completed in 2007, which is in need of updates given the number of infrastructure projects implemented since, as well as changes to future development plans within the urban boundary. The Updates to the Water Master Plans will identify infrastructure strategies for water servicing within the City of Kingston's urban area and within the satellite community of Cana, based on planned growth to 2036.

Utilities Kingston (UK) has retained WSP Canada Inc. to update their Water Master Plan to align with current population growth projections and standards.

During our initial consultation on October 27, 2015 a number of previous report were reviewed including the existing City of Kingston Water Master Plan (Simcoe, 2007) the Kingston East Water Supply Master Plan (CH2MHill, 2014) with regards to the approach that had been previously taken for fire flow criteria. It was decided that the proposed approach to the 2015 Water Master Plan should be provided to the Kingston Fire and Rescue Services (KFRS) for review and comment.

Based on a review of previous City of Kingston studies including the Water Study for the City of Kingston (FPSS, 2007) and various criteria from other municipalities in Ontario, a land use based fire flow approach has been developed. Based on the zoning information from the City of Kingston Official Plan, the fire flows for a representative sample of buildings within each land use type have been determined. Based on these values, the following fire flow values are proposed:

Land Use Type	Fire Flow @ 139kPa (20psi)		
	L/min	L/s	gpm
Industrial	16,300	270	4,300
Institutional	10,600	175	2,800
Med/High Density Residential	14,600	245	3,850
Commercial	14,400	240	3,800
Residential	6,500	110	1,700

WSP Canada Inc.
1224 Gardiners Road, Suite 201
Kingston, ON, CANADA, K7P 0G2
T: 613-634-7373 F: 613-634-3523
www.wspgroup.com

A detailed FUS analysis and location of the representative samples has been appended. Additionally the fire flow duration was selected based on the MOE equivalent population (2-6hrs) as it is more conservative than the FUS range (1-3hrs).

The above noted targets would be applied within our water model to determine if there is a difference or gaps between the available capacity and the above noted targets. Once this is determined, a reasonable and realistic plan will be developed to improve system capacity and “close the gap” between the available capacity and the targets capacities. It should be noted that the targets may not be achieved due to limitation of the existing system.

Yours truly,

Matt Morkem
Manager, Infrastructure, Kingston
WSP Canada Inc.

cc. Katie Morrow – Utilities Kingston

WSP Canada Inc.
1224 Gardiners Road, Suite 201
Kingston, ON, CANADA, K7P 0G2
T: 613-634-7373 F: 613-634-3523
www.wspgroup.com

CITY OF KINGSTON WATER MASTERPLAN LAND USE FIRE FLOW REVIEW

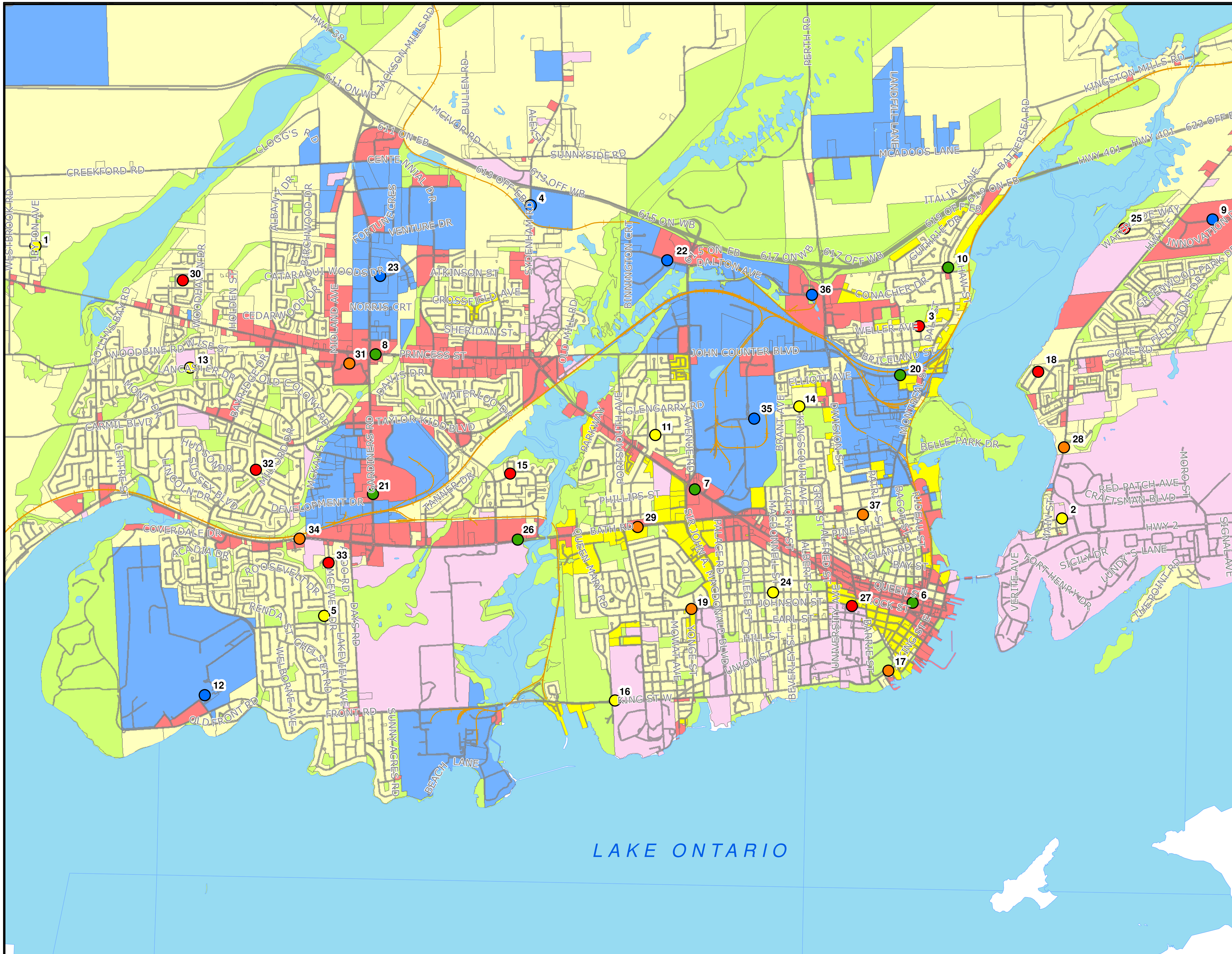
Location	Type	Building Description	Map Label	Floor Area (m2)	No. of Floors	Total Area (m^2) A	Construction Type Factor C	Fire Flow (L/min) 220CvA a	Occupancy Hazard b	Fire Flow Reduction (L/min) a*b c	Fire Flow (L/min) a-c d	Sprinkler e	Exposure Side 1 f1	Side 2 f2	Side 3 f3	Side 4 f4	Total Exposure f1+f2+f3+f4 ≠<75% f	Fire Flow Reduction (L/min) d*(e+f) g	Required Fire Flow (L/min) d+g	Average Fire Flow (L/min)
Cataraqui Woods Dr., east of Gardiners Rd.	Industrial	Cataraqui Industrial Estates	23	18858	1	18858	0.8	24,200	15%	3630.00	27,830	-40%	5%	0%	0%	0%	5%	-9700.00	18,100	
Dalton Ave. at Grant Timmins Dr.	Industrial	Two story industrial	22	1178	1	1178	0.8	6,000	25%	1500.00	7,500	0%	10%	10%	0%	0%	20%	1500.00	9,000	
Innovation Dr. (north)	Industrial	Lyreco	9	18427	1.25	23034	1	33,400	0%	0.00	33,400	-50%	0%	0%	0%	0%	0%	-16700.00	16,700	**16,300**
Novellis	Industrial	Two story	35	38601	2	77202	0.8	48,900	25%	12225.00	61,125	-50%	0%	0%	0%	0%	0%	-30600.00	30,500	
Sydendam Road, south of Eunice Drive	Industrial	Shell	4	425	1	425	1	4,500	25%	1125.00	5,625	0%	10%	10%	5%	5%	30%	1700.00	7,300	
Brock St. at MacDonnell St.	Institutional	Kingston Chinese Alliance Church	24	453	1	453	1	4,700	-15%	-705.00	3,995	0%	20%	15%	15%	15%	65%	2600.00	6,600	
King St., west of Portsmouth Ave.	Institutional	St. Lawrence College	16	6082	2.25	13685	1	25,700	-15%	-3855.00	21,845	-50%	5%	0%	5%	0%	10%	-8700.00	13,100	
Kirkpatrick St. at Kingscourt Ave.	Institutional	Queen Elizabeth Collegiate & Vocational Institute	14	7296	2	14592	1	26,600	-15%	-3990.00	22,610	-50%	10%	15%	5%	0%	30%	-4500.00	18,100	
Lancaster Dr. at Limestone Dr.	Institutional	Lancaster Drive PS	13	3860	1	3860	1	13,700	-15%	-2055.00	11,645	-50%	25%	25%	0%	0%	50%	0.00	11,600	
Len Birchall Way	Institutional	Kingston Flying Club	12	4027	1	4027	1	14,000	-15%	-2100.00	11,900	0%	5%	0%	0%	0%	0%	0.00	11,900	**10,600**
McMahon Ave. at Westmorland Rd.	Institutional	St. Paul CS	11	1228	1	1228	1	7,700	-15%	-1155.00	6,545	-50%	25%	25%	5%	0%	55%	300.00	6,800	
Roosevelt Dr. at Henderson Blvd.	Institutional	J.R. Henderson PS	5	4689	1	4689	1	15,100	-15%	-2265.00	12,835	-30%	10%	10%	10%	0%	30%	0.00	12,800	
Wellington St. at Drummond St.	Institutional	J.E. Horton PS (Two story)	2	1427	2	2853	1	11,800	-15%	-1770.00	10,030	-30%	10%	0%	0%	0%	10%	-2000.00	8,000	
Woodfield Cres. at Leyton Ave.	Institutional	W.J. Holsgrove PS	1	1468	1	1468	1	8,400	-15%	-1260.00	7,140	-30%	10%	0%	5%	10%	25%	-400.00	6,700	
Cataraqui Town Centre	Med/High Density Residential	2 story	31	38627	2	77255	0.8	48,900	0%	0.00	48,900	-50%	5%	0%	0%	0%	5%	-22000.00	26,900	
Princess St., near Bagot St.	Med/High Density Residential	Shoppers Drug Mart (with apartments above)	6	1602	3	4805	1	15,200	-15%	-2280.00	12,920	-30%	25%	25%	20%	20%	75%	5800.00	18,700	
Bath Road at Canatara Court	Med/High Density Residential	8 story apartment	34	959	8	7675	1	19,300	-15%	-2895.00	16,405	-50%	10%	10%	0%	0%	20%	-4900.00	11,500	
Bath Road east of Portsmouth	Med/High Density Residential	11 story aparment	29	1119	11	12313	0.8	19,500	-15%	-2925.00	16,575	-50%	15%	0%	15%	0%	30%	-3300.00	13,300	
Cowdy St. at Adelaide St.	Med/High Density Residential	Three story apartments	37	295	3	884	1	6,500	-15%	-975.00	5,525	0%	25%	25%	0%	5%	55%	3000.00	8,500	**14,600**
Highway 15 and Barrett Court	Med/High Density Residential	9 story apartment	28	1248	9	11228	1	23,300	-15%	-3495.00	19,805	-50%	0%		0%	0%	0%	-9900.00	9,900	
John Counter Blvd. at Maple St.	Med/High Density Residential	11 story apartment building	20	1328	11	14613	0.8	21,300	-15%	-3195.00	18,105	-50%	0%	10%	0%	20%	30%	-3600.00	14,500	
Johnson St. at Yonge St.	Med/High Density Residential	3 story apartments	19	809	3	2426	1	10,800	-15%	-1620.00	9,180	0%	15%	0%	10%	20%	45%	4100.00	13,300	
Bath Rd., east of Centennial Dr.	Commercial	Frontenac Mall	26	26578	1	26578	1	35,900	-15%	-5385.00	30,515	-50%	0%	0%	10%	0%	10%	-12200.00	18,300	
Dalton Ave. at Warne Cr.	Commercial	Tackaberry Heating and Refrigeration Supplies	36	2154	1	2154	1	10,200	15%	1530.00	11,730	0%	0%	0%	5%	5%	10%	1200.00	12,900	
Gardiners Rd., between Development Dr. and Progress Ave.	Commercial	Home Depot	21	12020	1	12020	0.8	19,300	0%	0.00	19,300	-50%	0%	0%	20%	0%	20%	-5800.00	13,500	**14,400**
Montreal St. at Sutherland Dr.	Commercial	Greenridge Plaza	10	1849	1	1849	1	9,500	0%	0.00	9,500	0%	5%	5%	20%	20%	50%	4800.00	14,300	
Princess St., east of Gardiners Rd.	Commercial	Crossbury Square	8	989	1	989	1	6,900	0%	0.00	6,900	0%	10%	10%	20%	20%	60%	4100.00	11,000	
Princess St., east of Sir John A. MacDonald Blvd.	Commercial	Loblaws	7	7794	2	11691	1	19,000	0%	0.00	19,000	-50%	20%	5%	5%	5%	35%	-2900.00	16,100	
Biscayne St. at Waterside Way	Residential	Bungalow	25	232	1	232	1	3,300	-15%	-495.00	2,805	0%	25%	25%	15%	10%	75%	2100.00	4,900	
Iris Dr.	Residential	Two story house	30	237	2	474	1	4,800	-15%	-720.00	4,080	0%	25%	25%	15%	10%	75%	3100.00	7,200	
Johnson and Division	Residential	Two story housing	27	440	2	880	1	6,500	-15%	-975.00	5,525	0%	25%	25%	15%	15%	75%	4100.00	9,600	
Kenwoods Cir.	Residential	Bungalow	18	265	1	265	1	3,600	-15%	-540.00	3,060	0%	25%	25%	20%	10%	75%	2300.00	5,400	
King St. at Simcoe St.	Residential	Three story house	17	367	3	1102	1	7,300	-15%	-1095.00	6,205	0%	5%	25%	10%	0%	40%	2500.00	8,700	**6,500**
Kingsdale Ave. at Parkside Cr.	Residential	Two story house	15	237	2	473	1	4,800	-15%	-720.00	4,080	0%	25%	25%	20%	10%	75%	3100.00	7,200	
McEwen Dr.	Residential	Bungalow	33	110	1	110	1	2,300	-15%	-345.00	1,955	0%	25%	25%	10%	10%	70%	1400.00	3,400	
Pembridge Cres. west of Milford Dr.	Residential	Two story	32	170	2	340	1	4,100	-15%	-615.00	3,485	0%	25%	25%	25%	5%	75%	2600.00	6,100	
Weller Ave. at Baker St.	Residential	Two story house	3	154	2	309	1	3,900	-15%	-585.00	3,315	0%	25%	25%	10%	10%	70%	2300.00	5,600	

Construction Type	
1.5	Wood Frame
1	Ordinary Construction
0.8	Non-Combustible Construction
0.6	Fire Resistive Construction

Occupancy Hazard	
-25%	Non Combustible
-15%	Limited Combustible
0%	Combustible
15%	Free Burning
25%	Rapid Burning

Sprinklers	
0%	No Sprinkler System
-30%	Sprinkler System
-40%	Standard Water Supply Water & Fire
-50%	Full Supervised &Standard Water Supply

Exposure	(per side)
25%	0 to 3m
20%	3.1 to 10m
15%	10.1 to 20m
10%	20.1 to 30m
5%	30.1 to 45m
0%	>45m



1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- COMMERCIAL
- INDUSTRIAL
- INSTITUTIONAL
- MEDIUM DENSITY RESIDENTIAL
- RESIDENTIAL
- OPEN SPACE
- COMMERCIAL
- INDUSTRIAL/BUSINESS PARK
- INSTITUTIONAL
- LOW DENSITY RESIDENTIAL
- MEDIUM/HIGH DENSITY RESIDENTIAL

Data Source: Ontario Base Mapping, Ministry of Natural Resources, August 2013. Water and Waste Water Systems, Utilities Kingston, April 2015, City of Kingston.

Scale:
0 300 600 1,200 Meters
1:43,000

N W E S

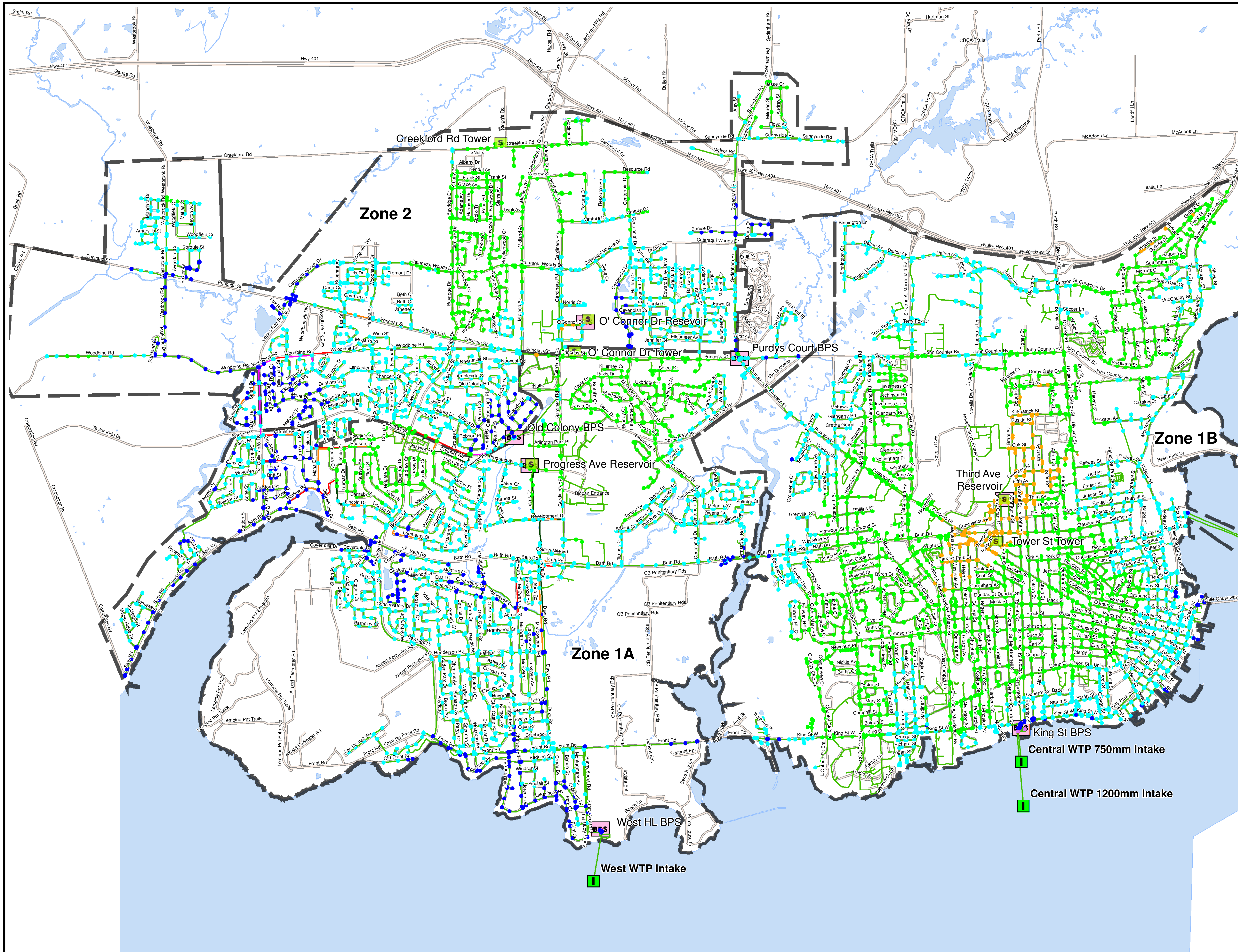
Title:

LAND USE FIRE FLOW LOCATIONS

Project No.:	Date:		
--	NOVEMBER, 2015		
Drawn By:	Checked By:	Code:	Figure No.:
CM	MM	--	--

Appendix B

DISTRIBUTION MAPS



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- \> 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- \> 5.0

Scale:
0 500 1,000 1,500 m
1:42,500

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

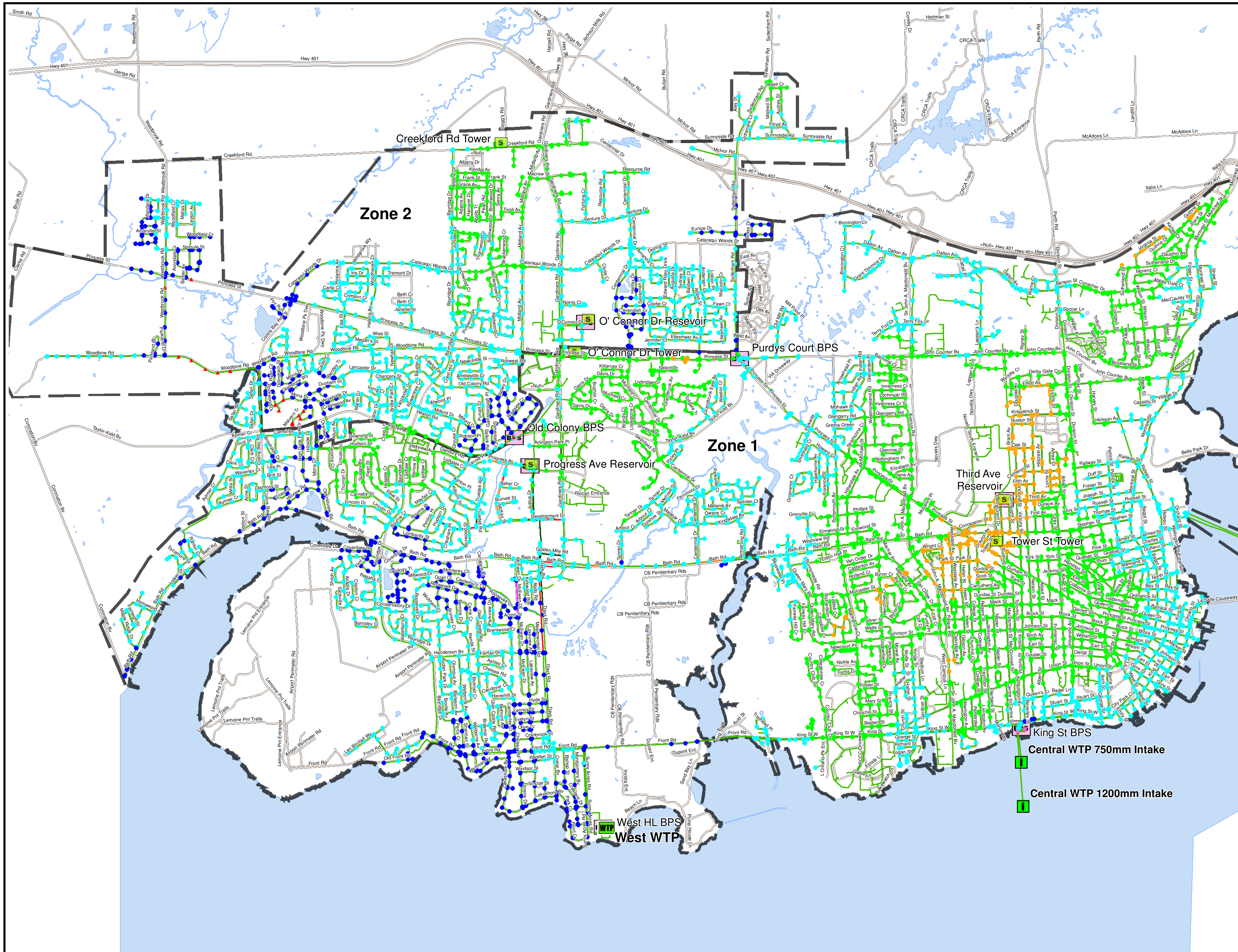
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 1A, 1B & 2)

Scenario:
2015 EXISTING (AVERAGE HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	5-1-1

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig5_1_1_WC_2015_AvgHr_HLoss_Pressure.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 500 1,000 1,500 m
1:42,500

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

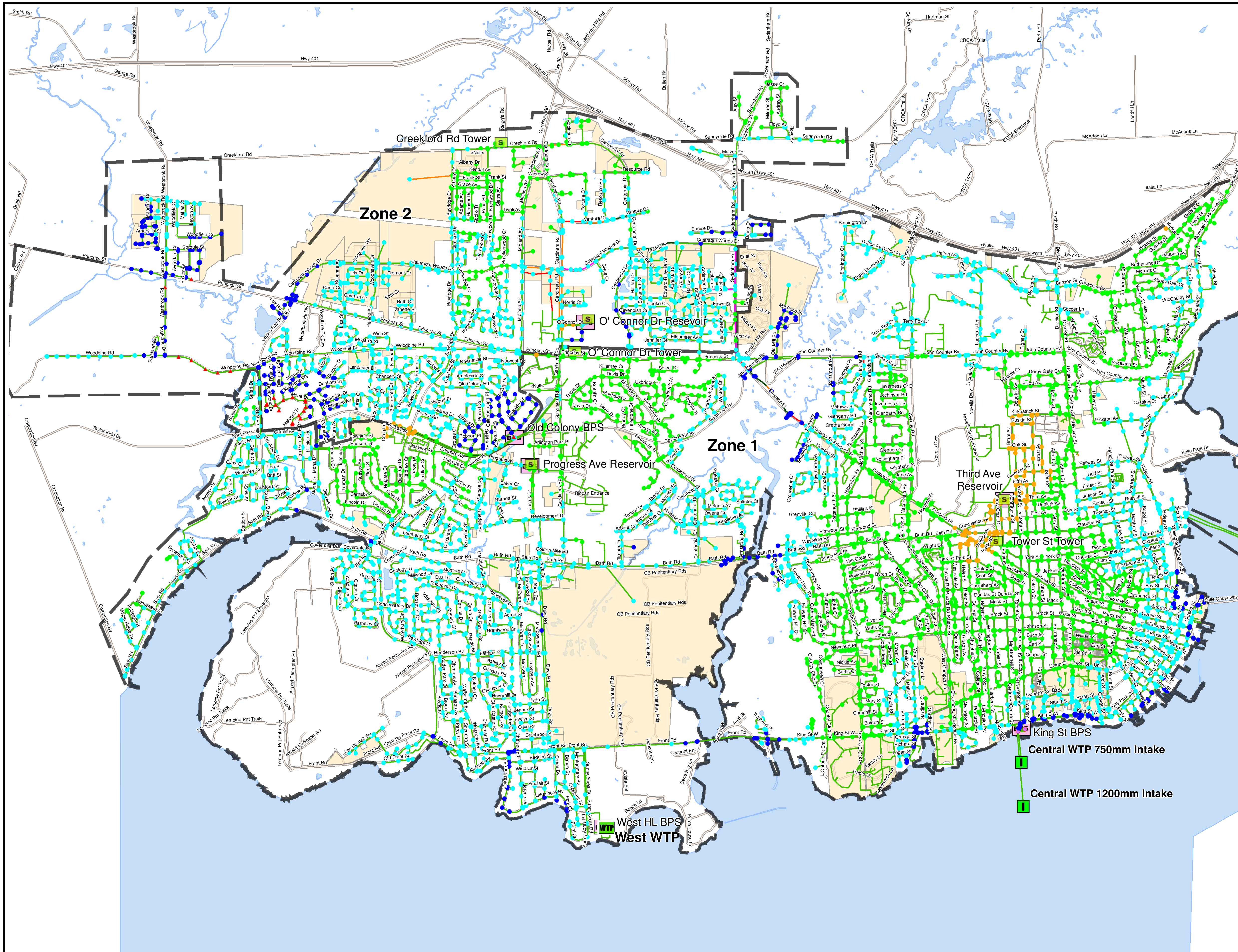
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 1 & 2)

Scenario:
2015 INTER-CONNECTION (AVERAGE HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	5-1-2

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig5_1_2-WC_2015Inter_AvgHr_HLoss_Pressure.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021 Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 500 1,000 1,500 m
1:42,500

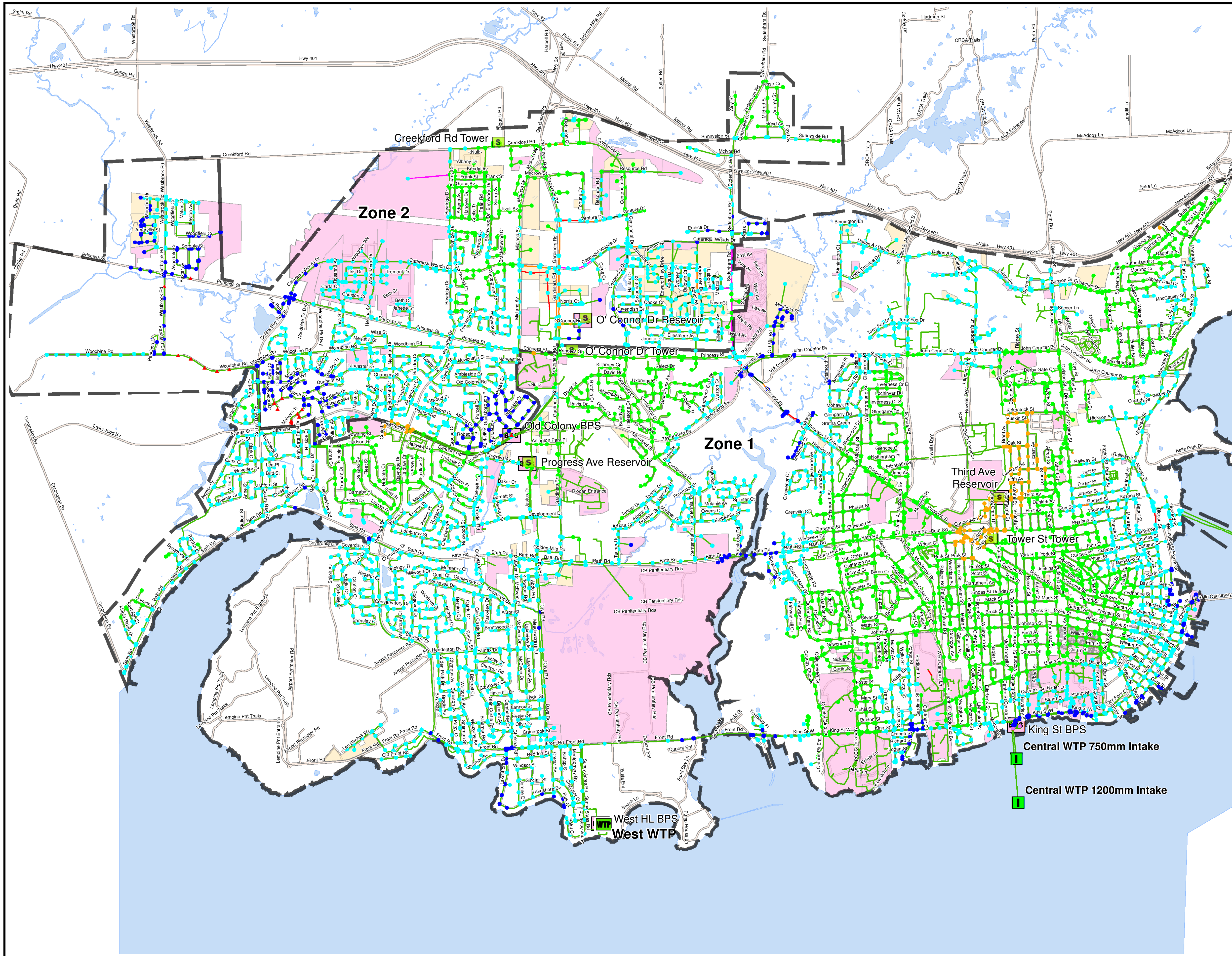
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 1 & 2)

Scenario:
2021 FUTURE (AVERAGE HOUR)

Project No.:		Date:	
151-02944-00		DECEMBER 2016	
Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	5-1-3

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig5_1_3-WC_2021_AvgHr_HLoss_Pressure.mxd



WSP

1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston

UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-Future Development
- 2026-Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 500 1,000 1,500 m
1:42,500

N E S W

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

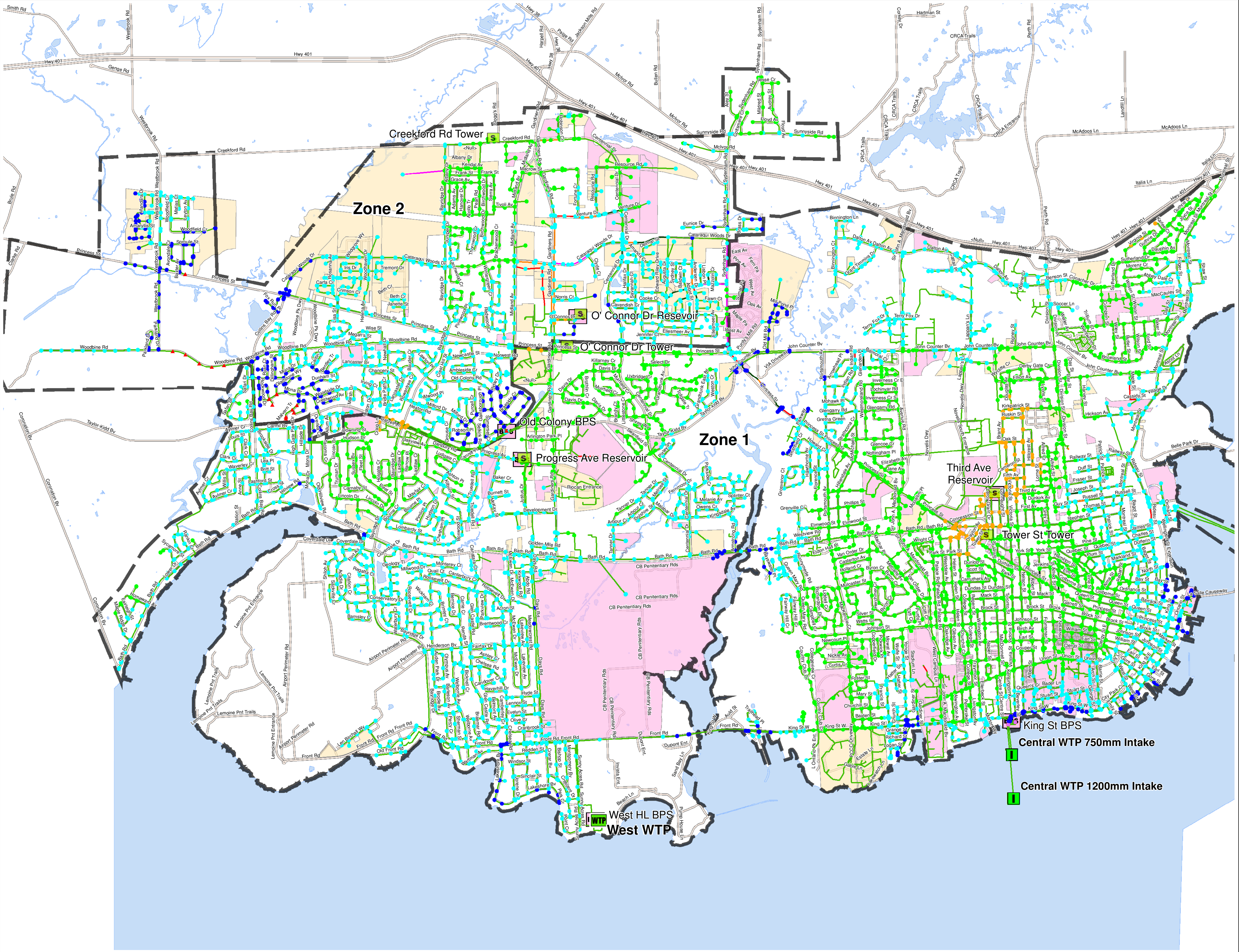
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 1 & 2)

Scenario:
2026 FUTURE (AVERAGE HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	5-1-4

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig5_1_4-WC_2026_AvgHrHLoss_Pressure.mxd



1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-2026 Future Development
- 2036 Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 500 1,000 1,500 m
1:42,500

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

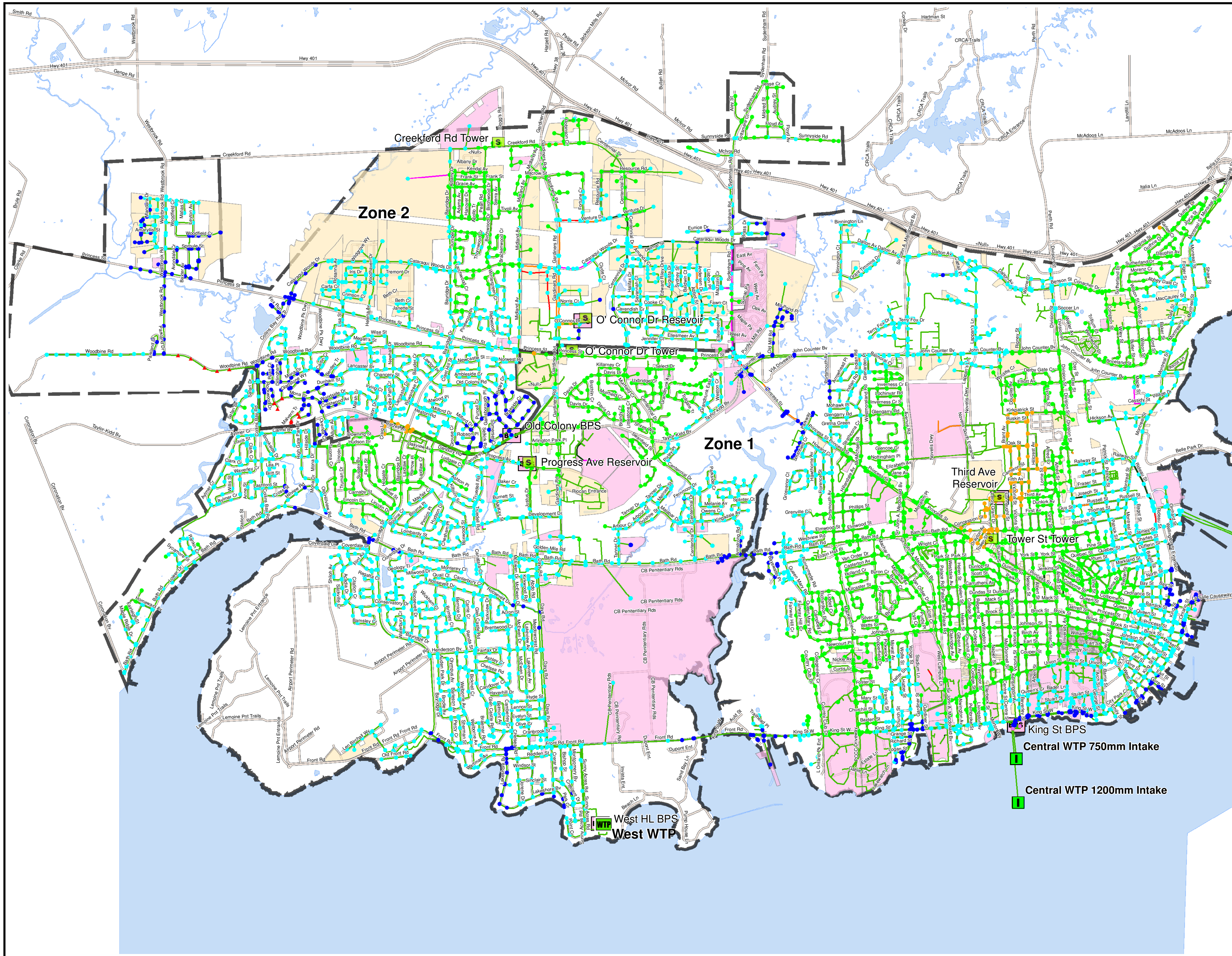
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 1 & 2)

Scenario:
2036 FUTURE (AVERAGE HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	5-1-5

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig5_1_5-WC_2036_AvgHr_HLoss_Pressure.mxd



1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-2026 Future Development
- Buildout Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 500 1,000 1,500 m
1:42,500

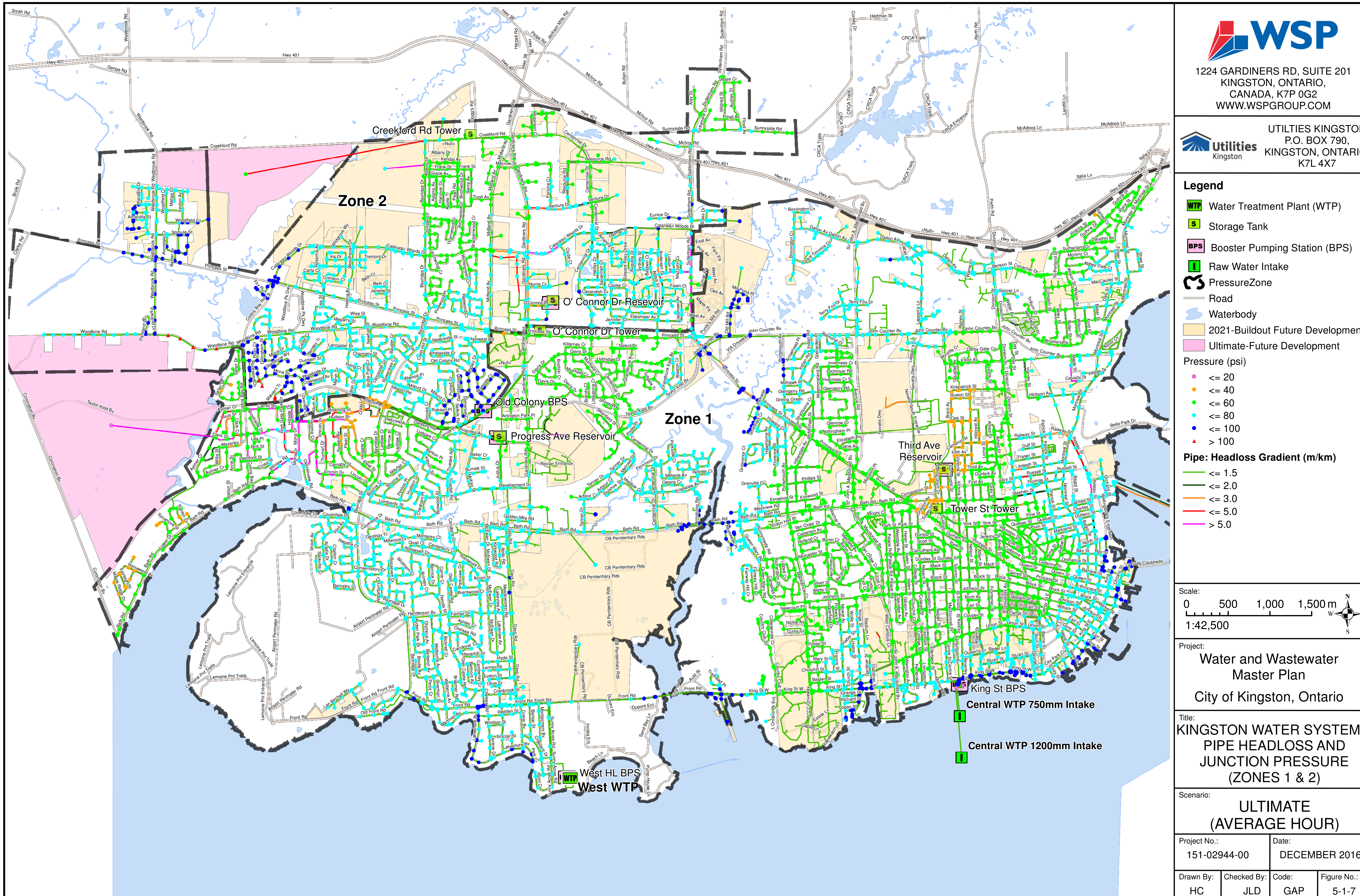
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 1 & 2)

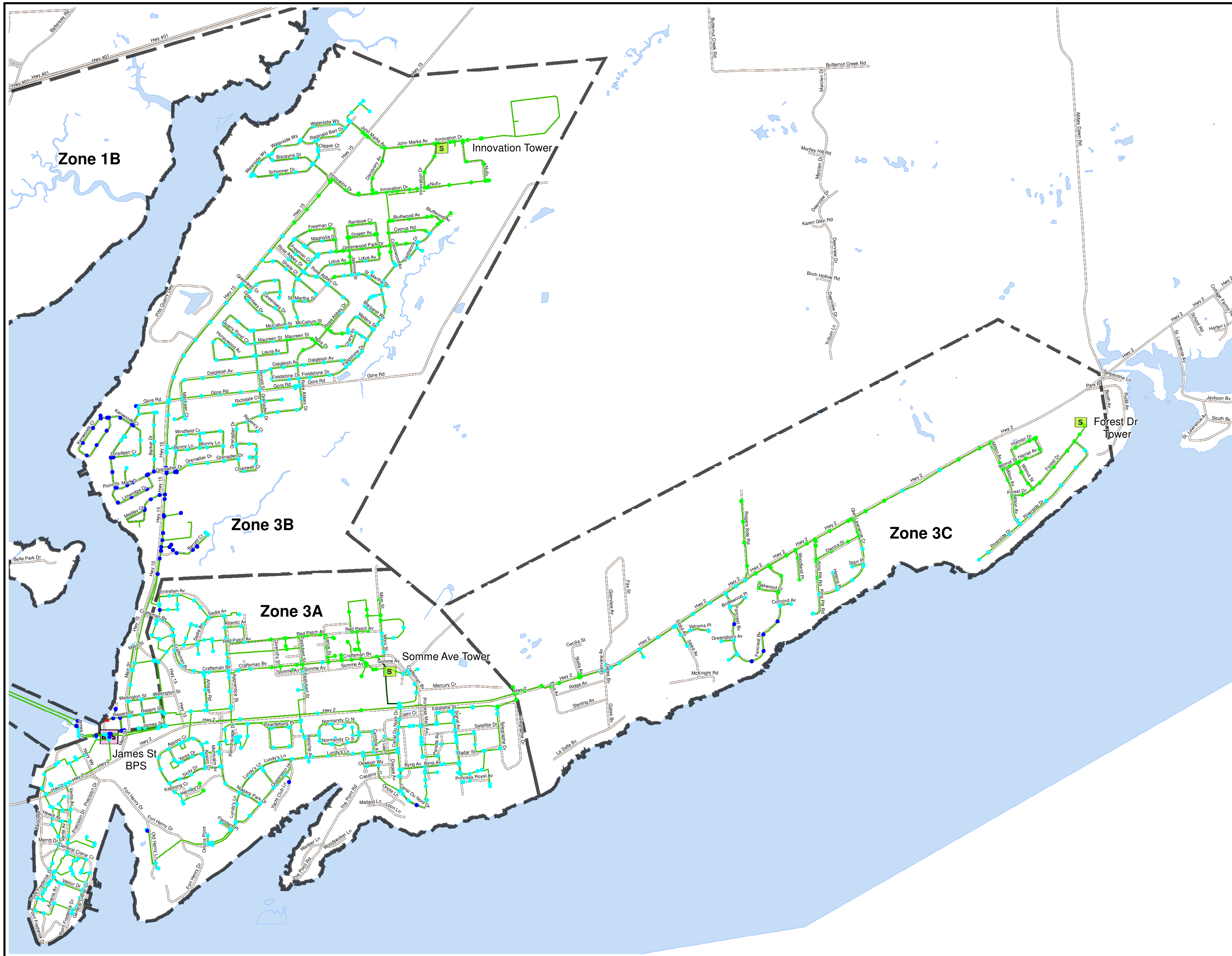
Scenario:
FULL BUILDOUT (AVERAGE HOUR)

Project No.:		Date:	
151-02944-00		DECEMBER 2016	
Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	5-1-6

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig5_1_6-WC_BO_AvgHr_HLoss_Pressure.mxd



File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig5_1_7-WC_ULT_AvgHr_HLoss_Pressure.mxd



WSP

1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston

UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale: 0 200 400 600 800 m
1:25,000

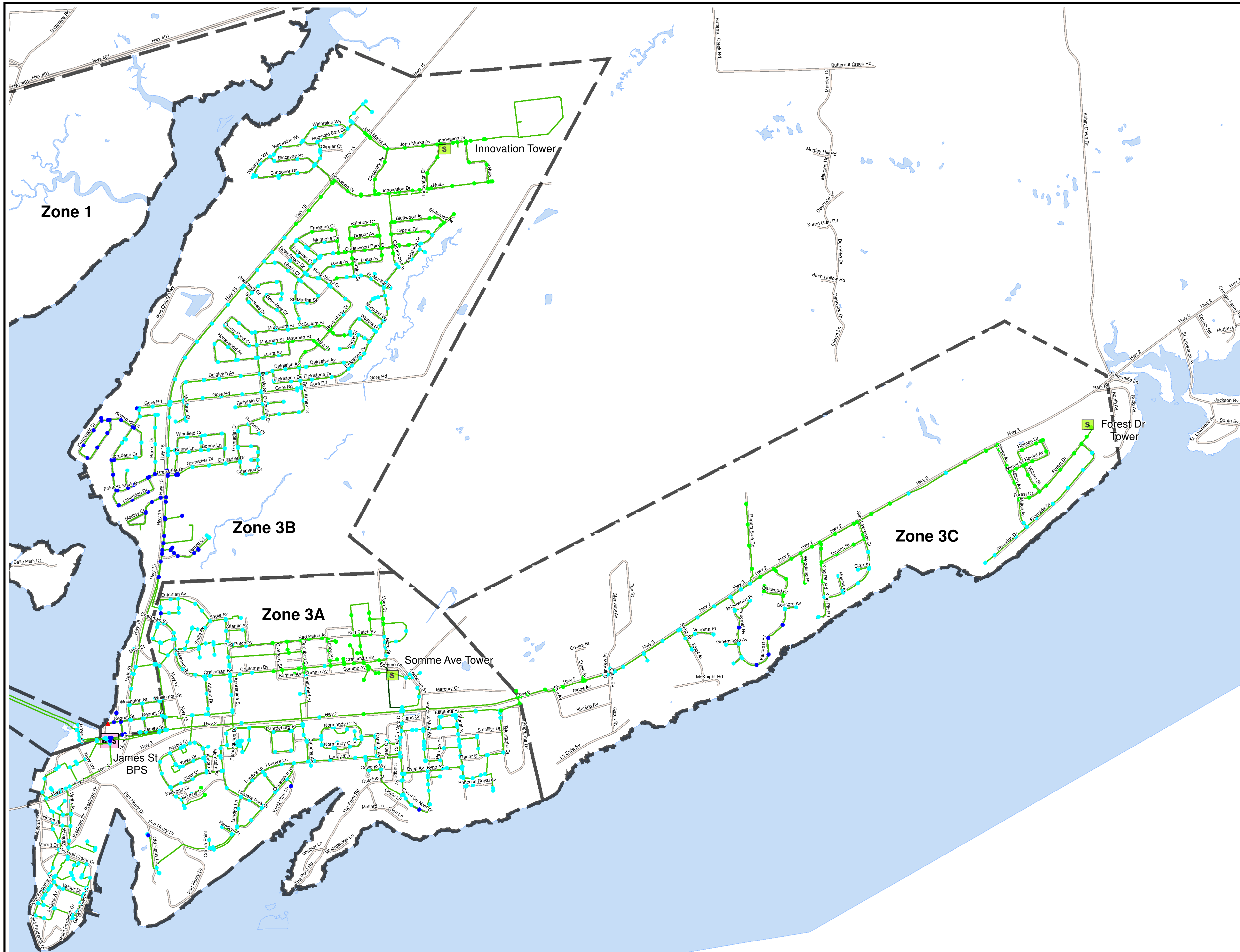
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 3A, 3B & 3C)

Scenario:
2015 EXISTING (AVERAGE HOUR)

Project No.:	Date:		
151-02944-00	DECEMBER 2016		
Drawn By: HC	Checked By: JLD	Code: GAP	Figure No.: 5-2-1

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig5_2_1-East_2015_AvgHr_HLoss_Pressure.mxd



WSP

1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston

UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- Raw Water Intake
- PressureZone
- Road
- Waterbody

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 200 400 600 800 m
1:25,000

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

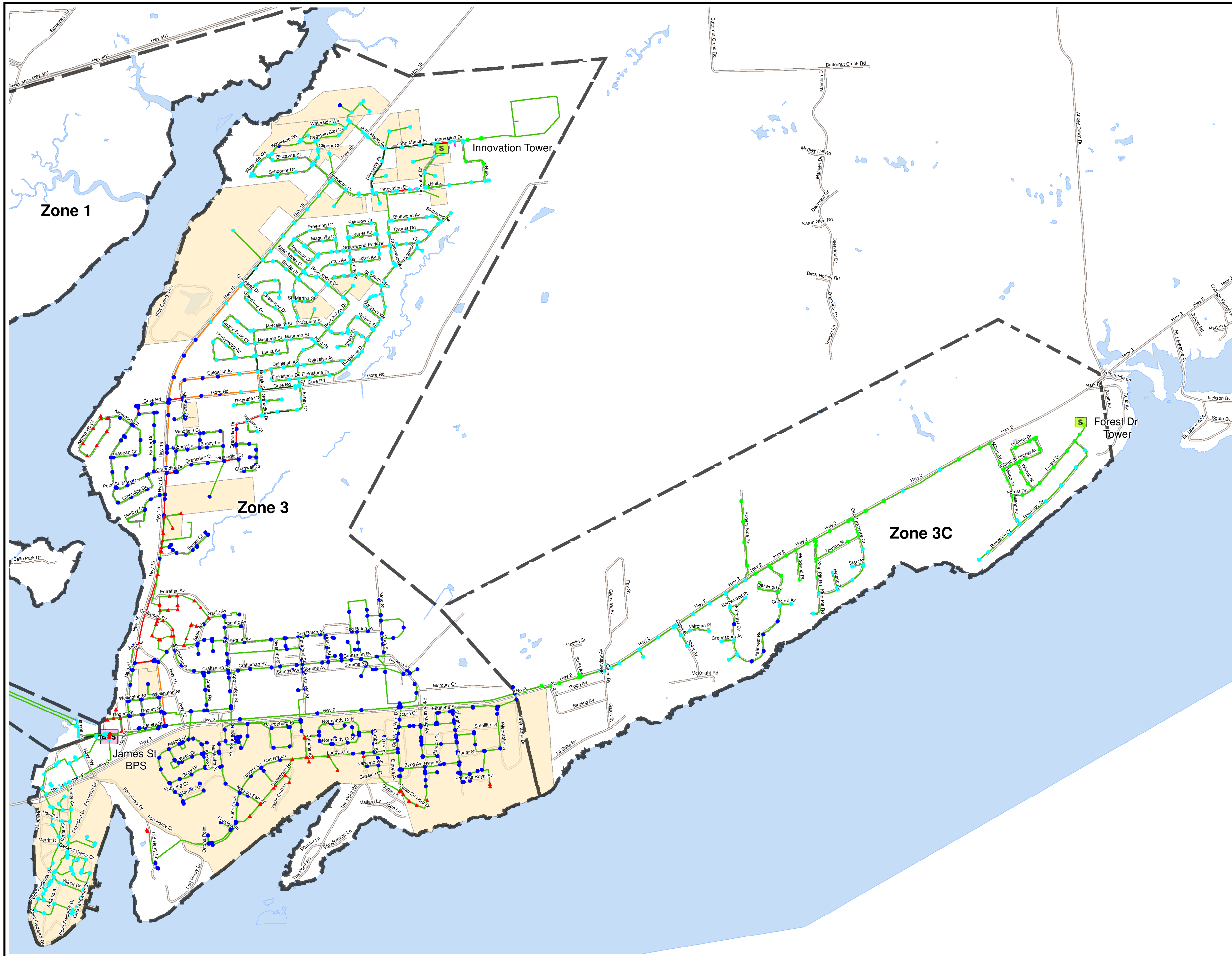
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 3A, 3B & 3C)

Scenario:
2015 INTER-CONNECTION (AVERAGE HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	5-2-2

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig5_2_2-East_2015Inter_AvgHr_HLoss_Pressure.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021 Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 200 400 600 800 m
1:25,000

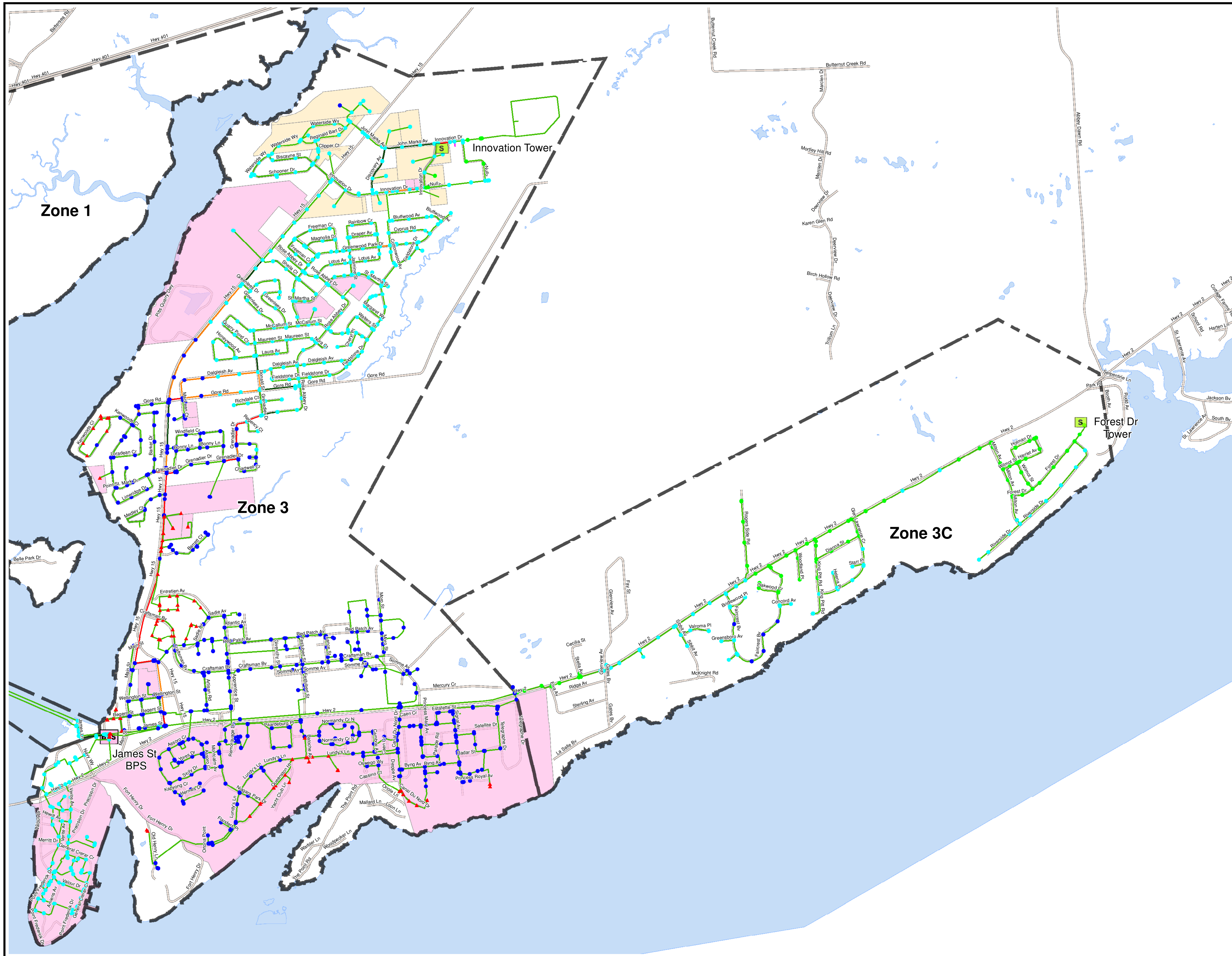
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 3 & 3C)

Scenario:
2021 FUTURE (AVERAGE HOUR)

Project No.:	Date:		
151-02944-00	DECEMBER 2016		
Drawn By: HC	Checked By: JLD	Code: GAP	Figure No.: 5-2-3

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig5_2_3-East_2021_AvgHr_HLoss_Pressure.mxd



WSP

1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston

UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-Future Development
- 2026-Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 200 400 600 800 m
1:25,000

N E S W

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

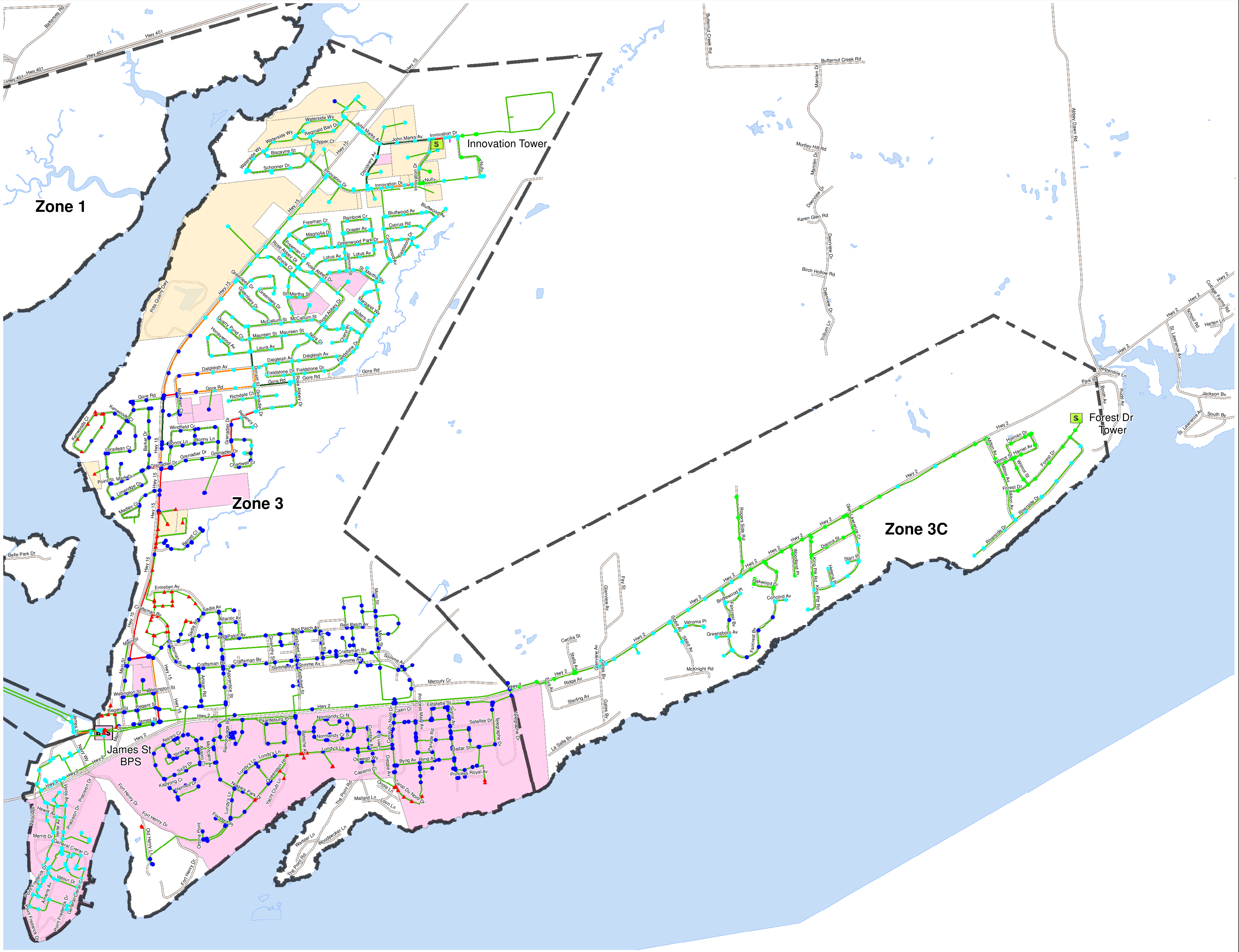
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 3 & 3C)

Scenario:
2026 FUTURE (AVERAGE HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	5-2-4

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig5_2_4-East_2026_AvgHrHLoss_Pressure.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-2026 Future Development
- 2036 Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 200 400 600 800 m
1:25,000

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

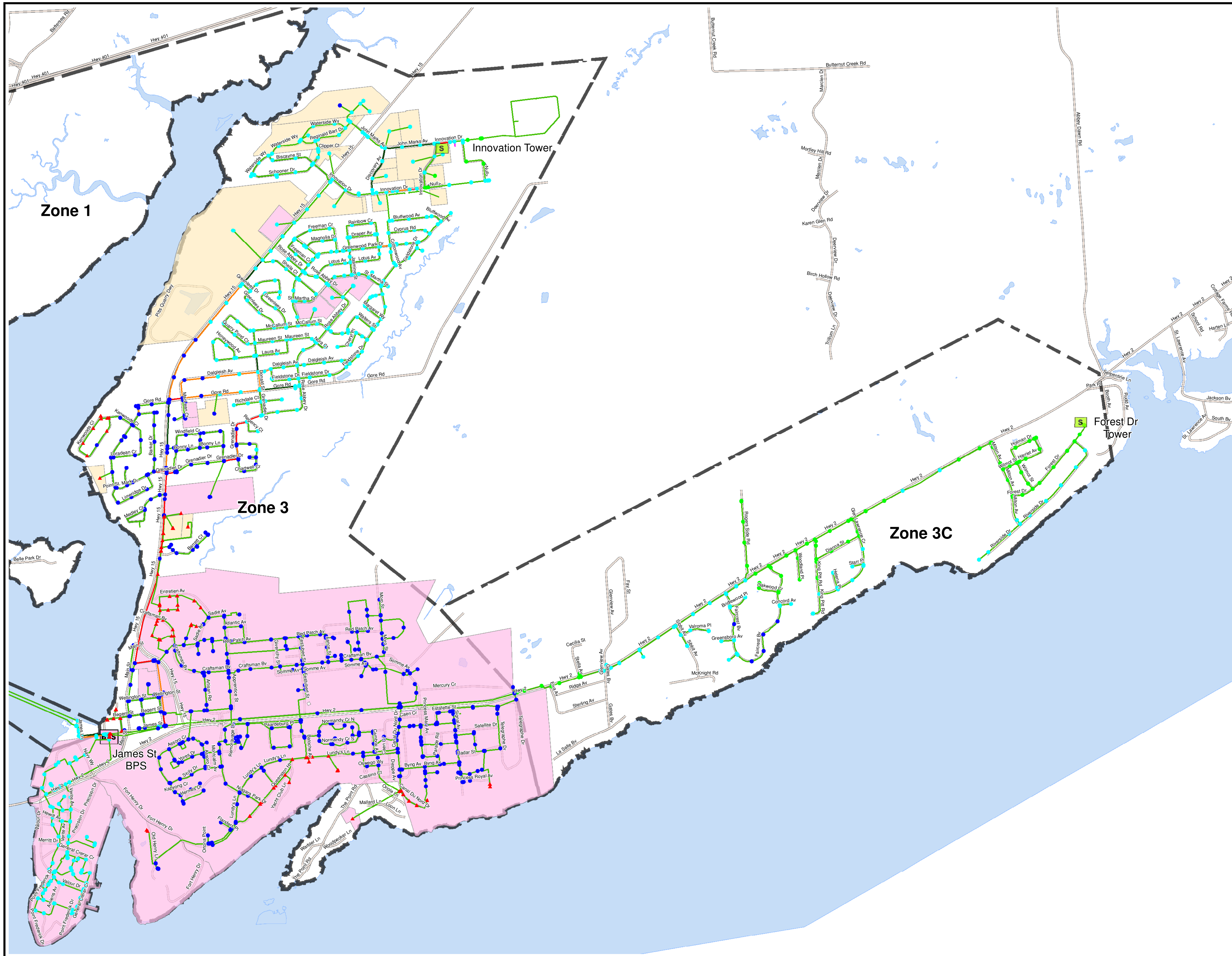
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 3 & 3C)

Scenario:
2036 FUTURE (AVERAGE HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	5-2-5

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig5_2_5-East_2036_AvgHr_HLoss_Pressure.mxd



1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-2026 Future Development
- Buildout Future Development

Pressure (psi)
- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)
- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 200 400 600 800 m
1:25,000

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

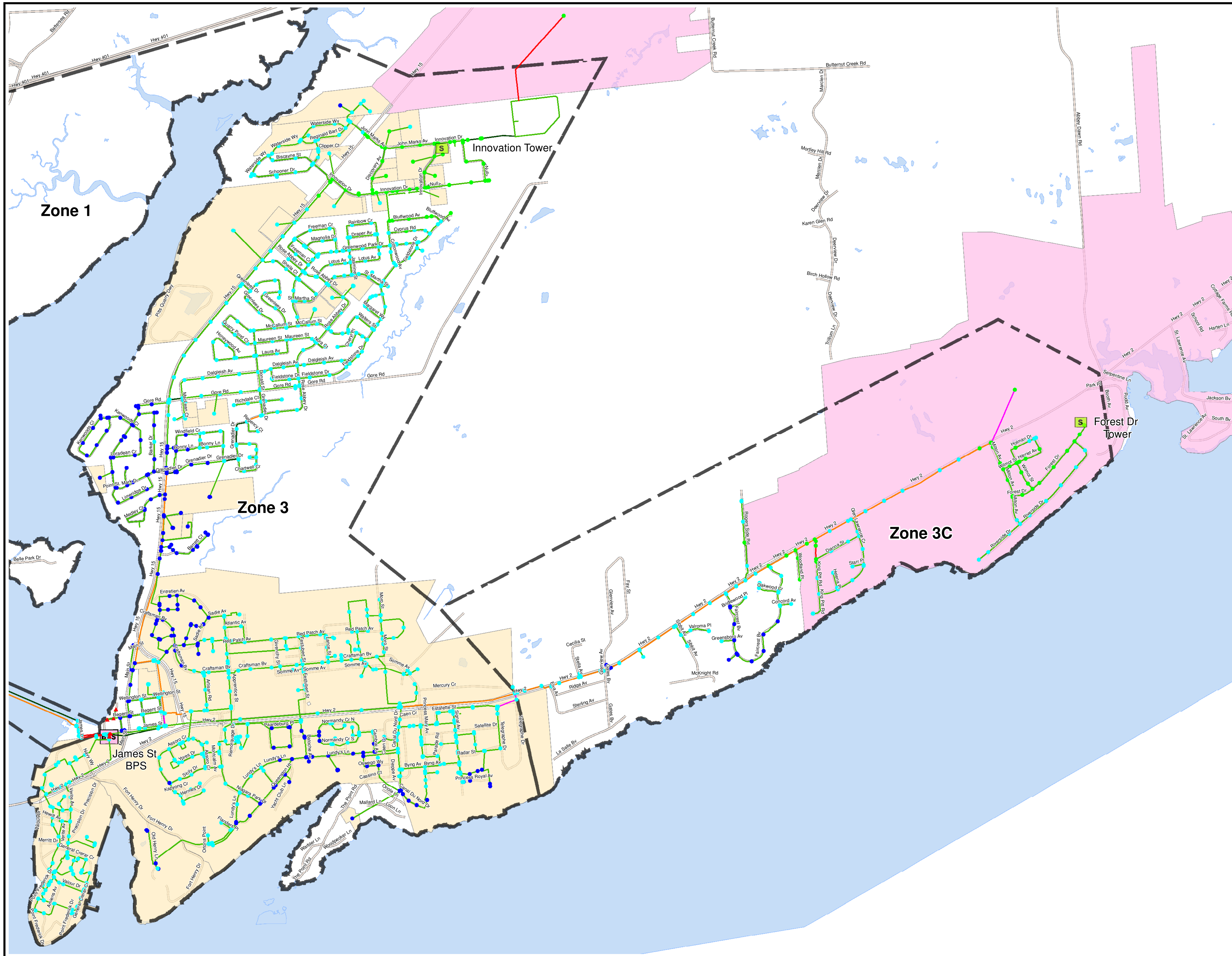
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 3 & 3C)

Scenario:
FULL BUILDOUT (AVERAGE HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	5-2-6

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00-GAP_Fig5_2_6-East_BO_AvgHr_HLoss_Pressure.mxd



WSP

1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston

UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-Buildout Future Development
- Ultimate-Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 200 400 600 800 m
1:25,000

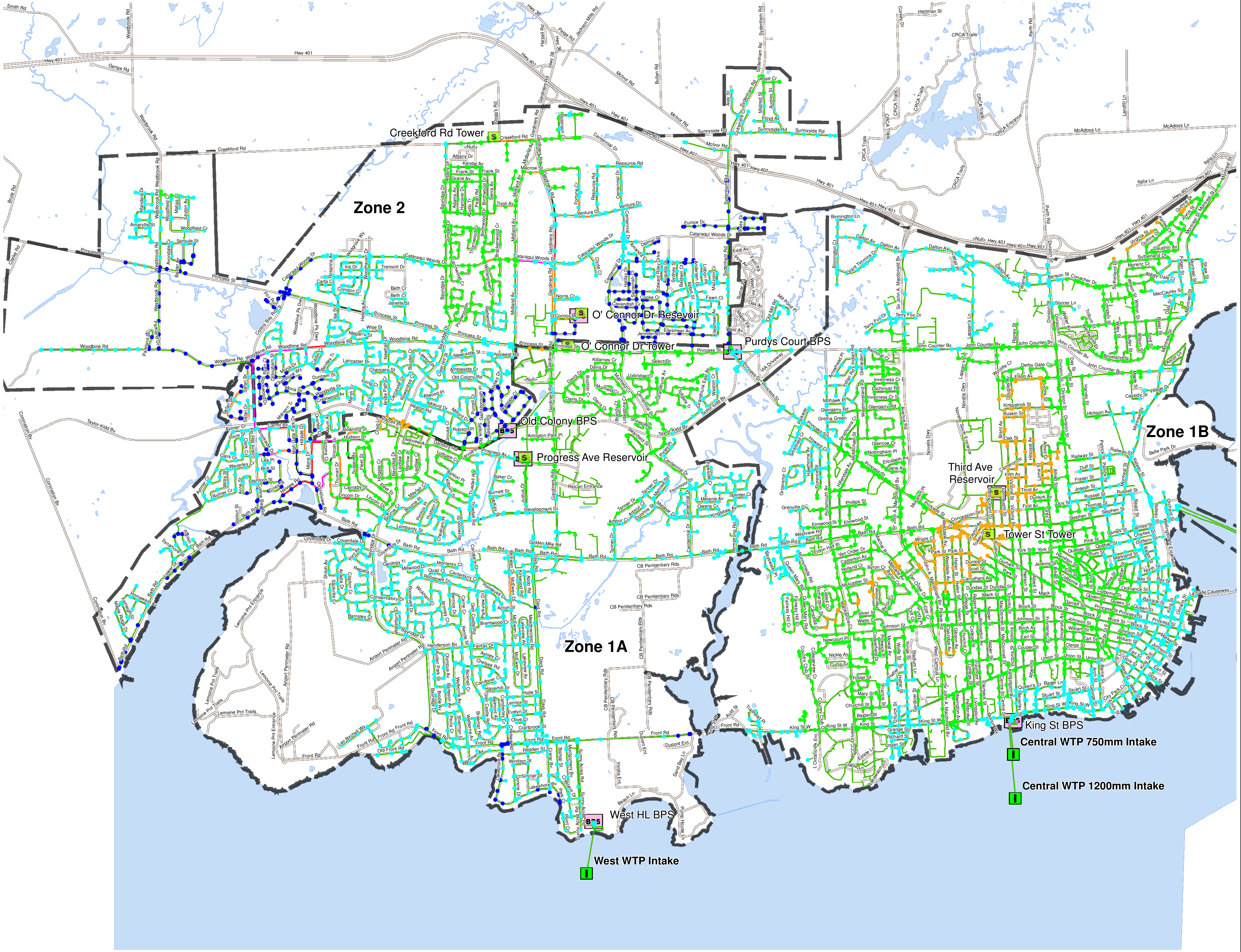
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 3 & 3C)

Scenario:
ULTIMATE (AVERAGE HOUR)

Project No.:	Date:		
151-02944-00	DECEMBER 2016		
Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	5-2-7

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig5_2_7-East_ULT_AvgHr_HLoss_Pressure.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 500 1,000 1,500 m
1:42,500

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

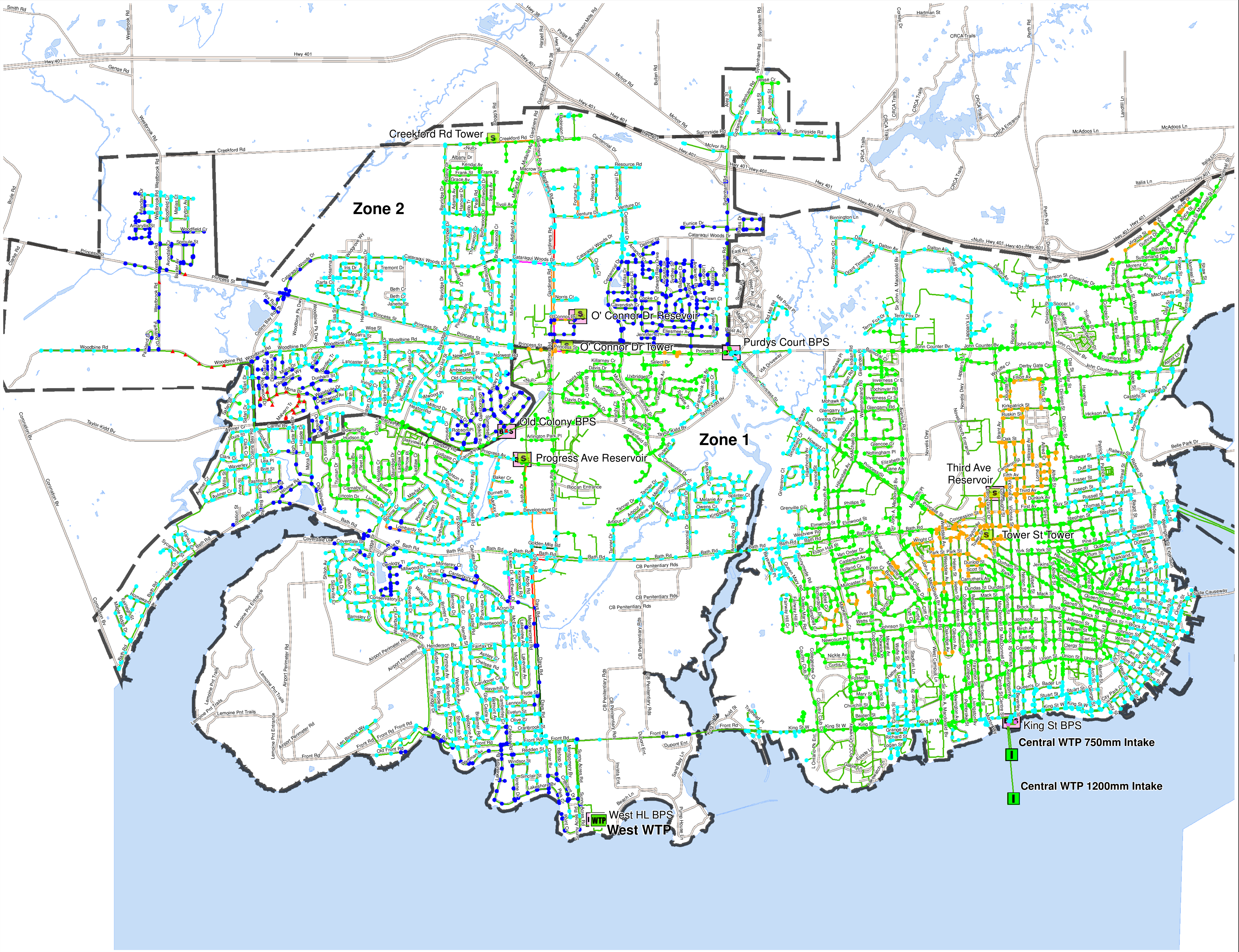
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 1A, 1B & 2)

Scenario:
2015 EXISTING (MINIMUM HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	6-1-1

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig6_1_1-WC_2015_MinHr_HLoss_Pressure.mxd



WSP

1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston

UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale: 0 500 1,000 1,500 m
1:42,500

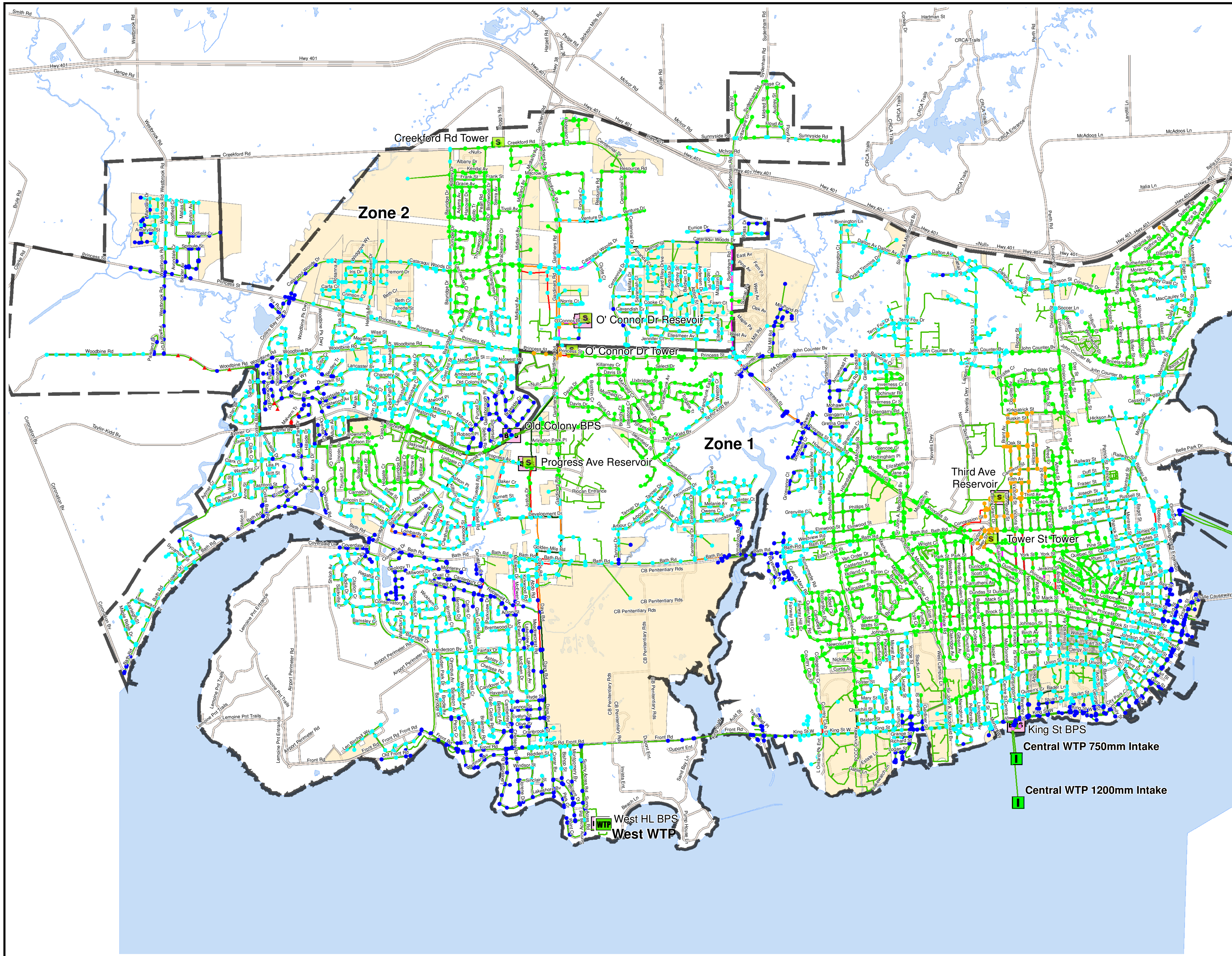
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 1 & 2)

Scenario:
2015 INTER-CONNECTION (MINIMUM HOUR)

Project No.:		Date:	
151-02944-00		DECEMBER 2016	
Drawn By: HC	Checked By: JLD	Code: GAP	Figure No.: 6-1-2

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig6_1_2-WC_2015Inter_MinHr_HLoss_Pressure.mxd



WSP

1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston

UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021 Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 500 1,000 1,500 m
1:42,500

N W E S

Project:
Water and Wastewater
Master Plan

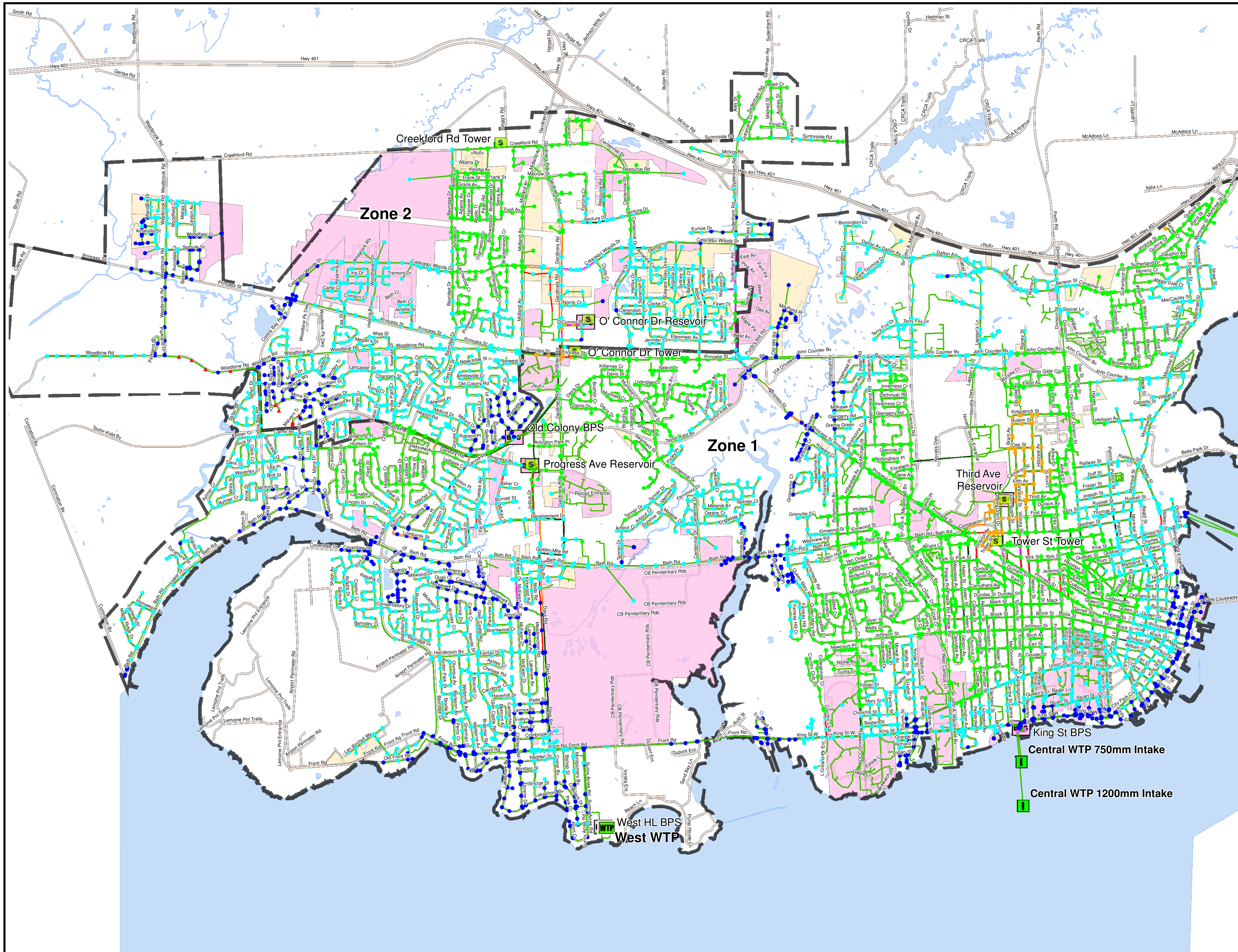
City of Kingston, Ontario

Title:
KINGSTON WATER SYSTEM -
PIPE HEADLOSS AND
JUNCTION PRESSURE
(ZONES 1 & 2)

Scenario:
2021 FUTURE
(MINIMUM HOUR)

Project No.:		Date:	
151-02944-00		DECEMBER 2016	
Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	6-1-3

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig6_1_3-WC_2021_MinHr_HLoss_Pressure.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-Future Development
- 2026-Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 500 1,000 1,500 m
1:42,500

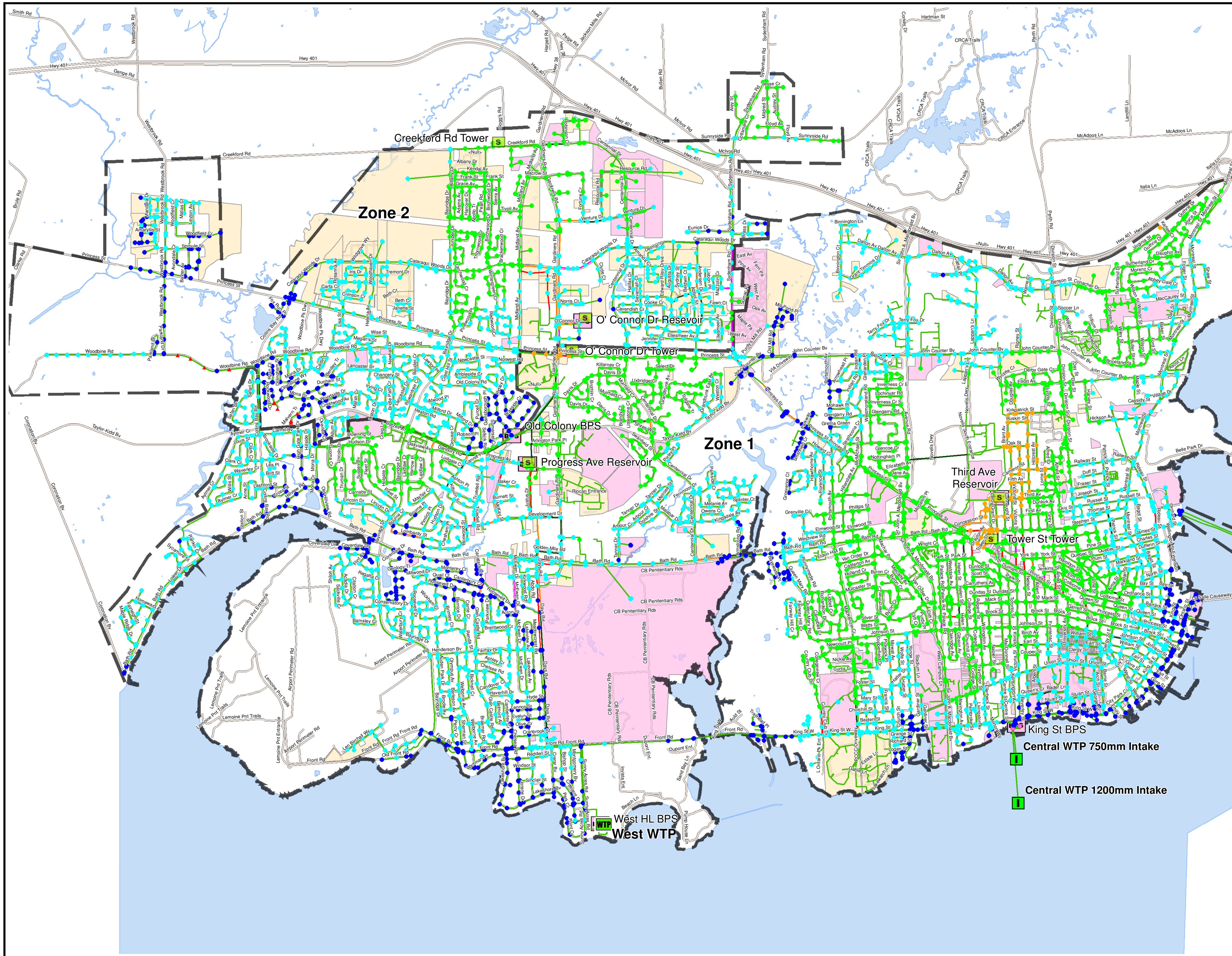
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 1 & 2)

Scenario:
2026 FUTURE (MINIMUM HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	6-1-4



WSP

1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston

UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-2026 Future Development
- 2036 Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 500 1,000 1,500 m
1:42,500

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

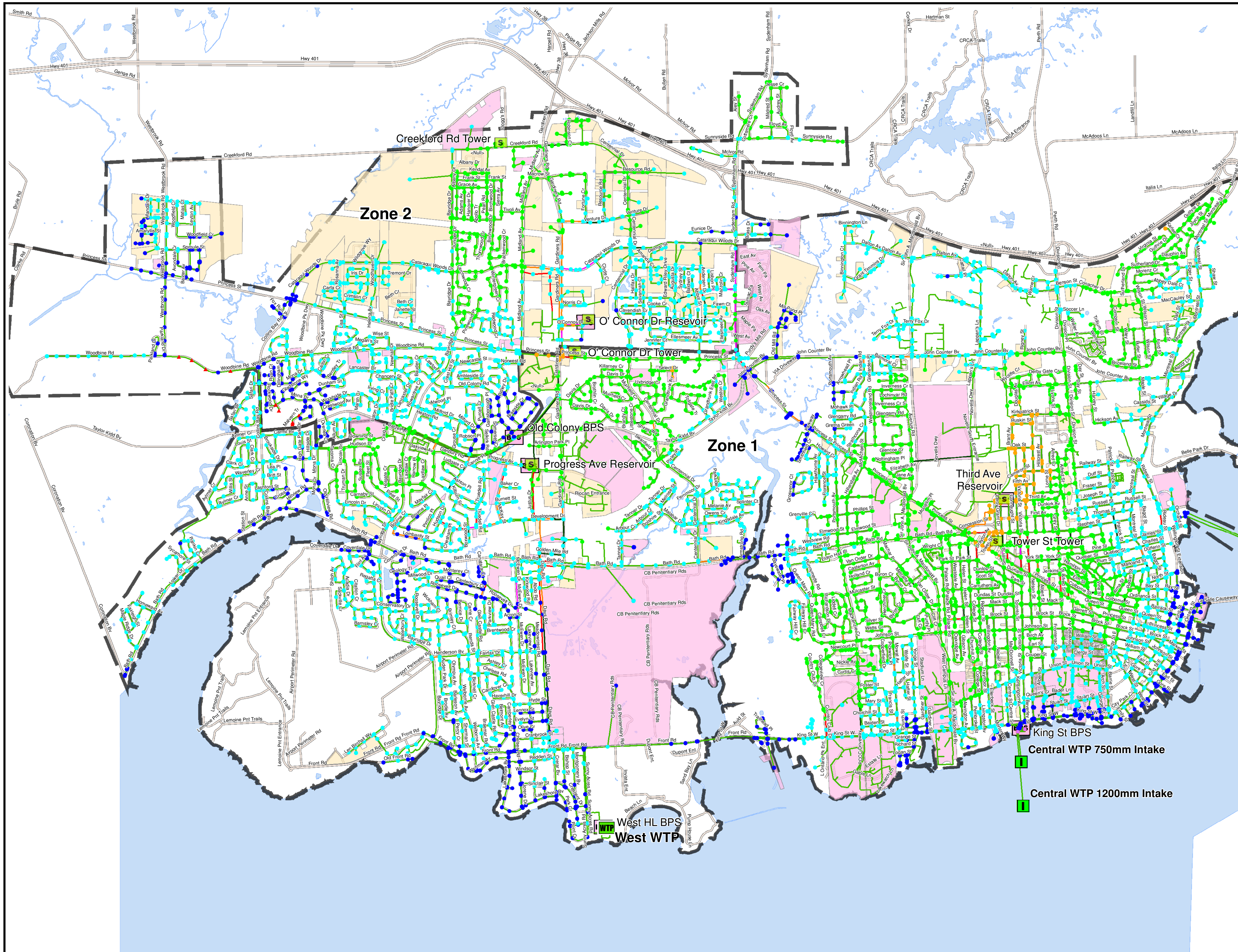
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 1 & 2)

Scenario:
2036 FUTURE (MINIMUM HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	6-1-5

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig6_1_5-WC_2036_MinHr_HLoss_Pressure.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-2026 Future Development
- Buildout Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 500 1,000 1,500 m
1:42,500

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

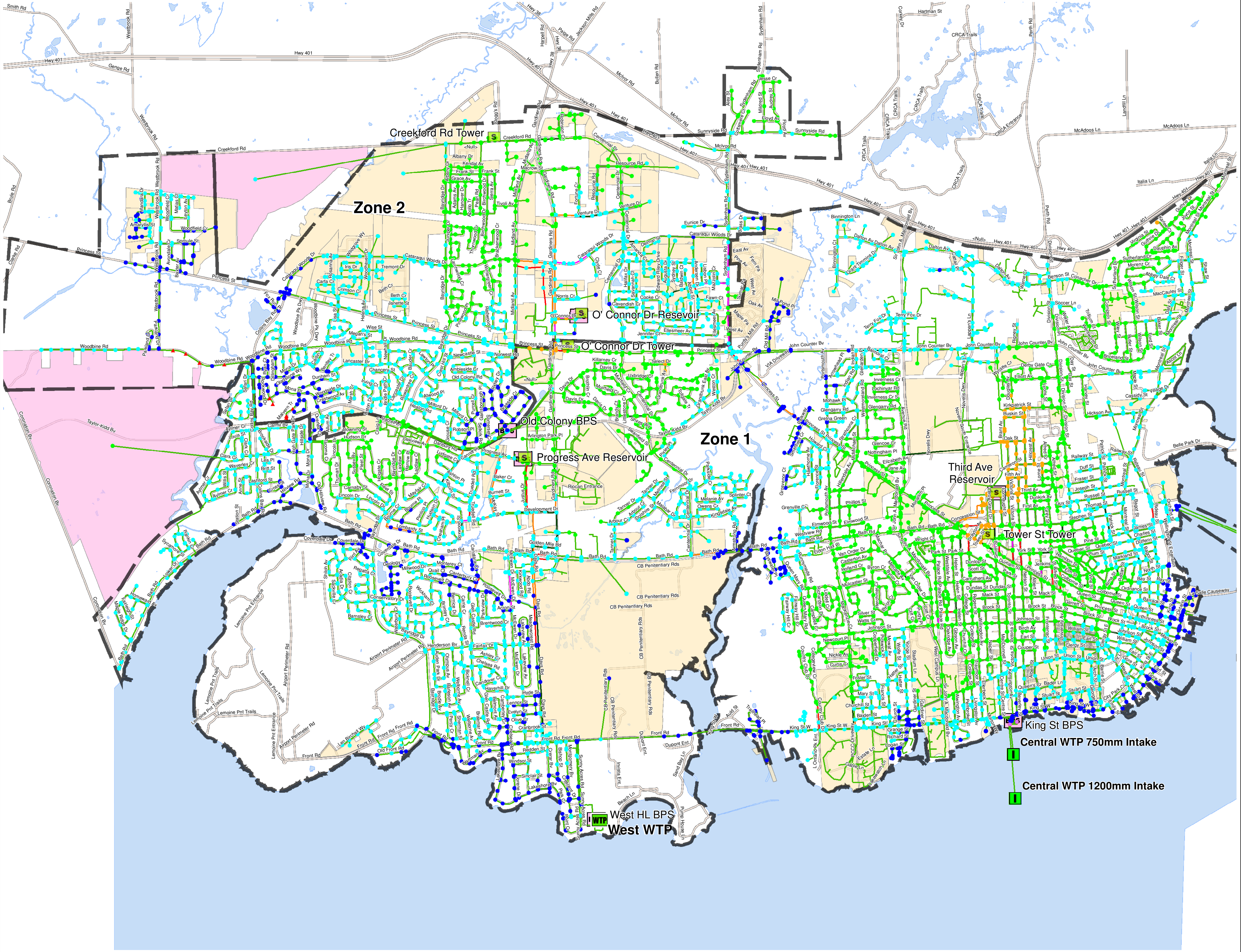
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 1 & 2)

Scenario:
FULL BUILDOUT (MINIMUM HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	6-1-6

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig6_1_6-WC_BO_MinHr_HLoss_Pressure.mxd



1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-Buildout Future Development
- Ultimate-Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale: 0 500 1,000 1,500 m
1:42,500

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

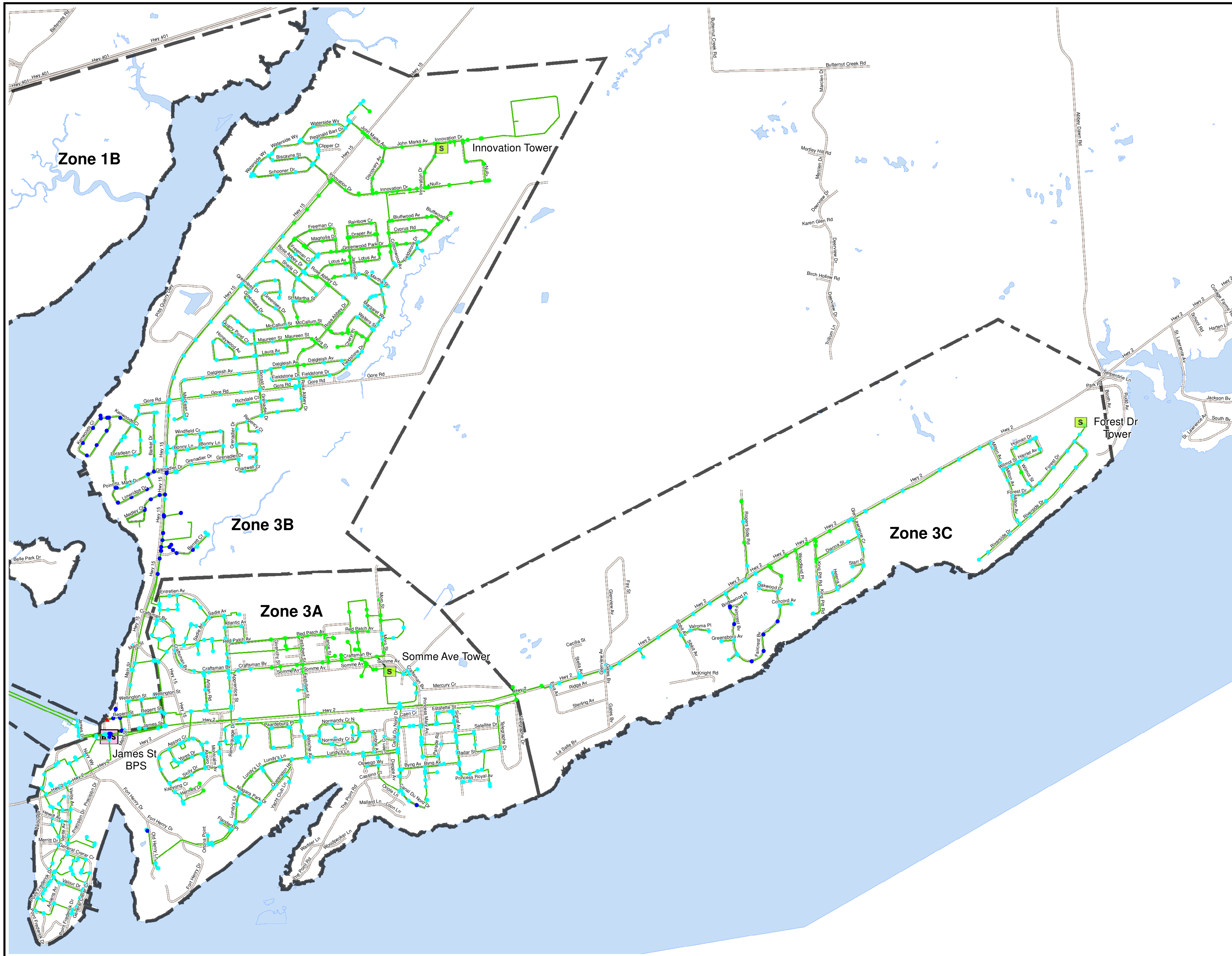
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 1 & 2)

Scenario:
ULTIMATE (MINIMUM HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	6-1-7

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig6_1_7-WC_ULT_MinHr_HLoss_Pressure.mxd



WSP

1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston

UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 200 400 600 800 m
1:25,000

N W E S

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

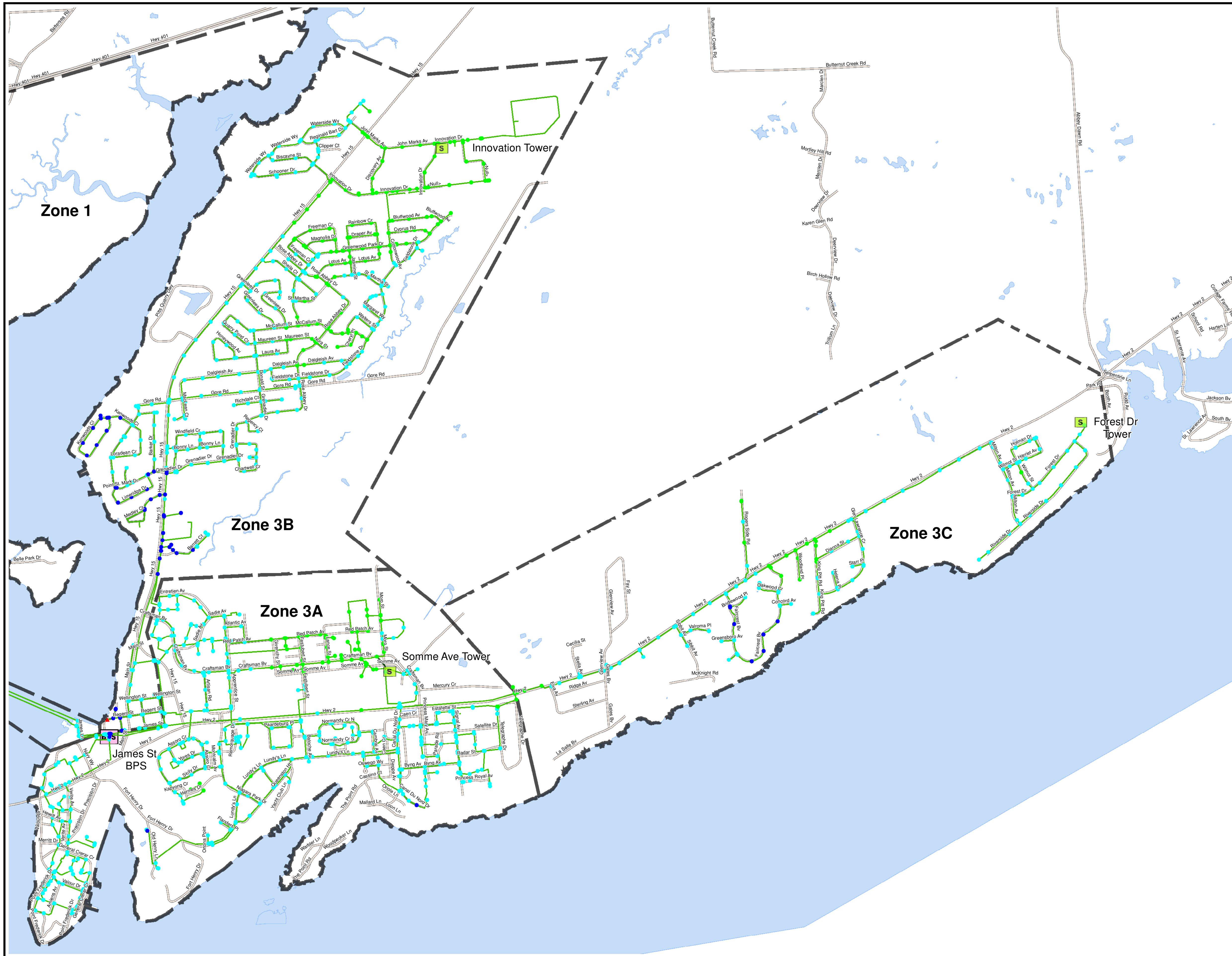
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 3A, 3B & 3C)

Scenario:
2015 EXISTING (MINIMUM HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	6-2-1

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig6_2_1-East_2015_MinHr_HLoss_Pressure.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 200 400 600 800 m
1:25,000

Project:
Water and Wastewater Master Plan

City of Kingston, Ontario

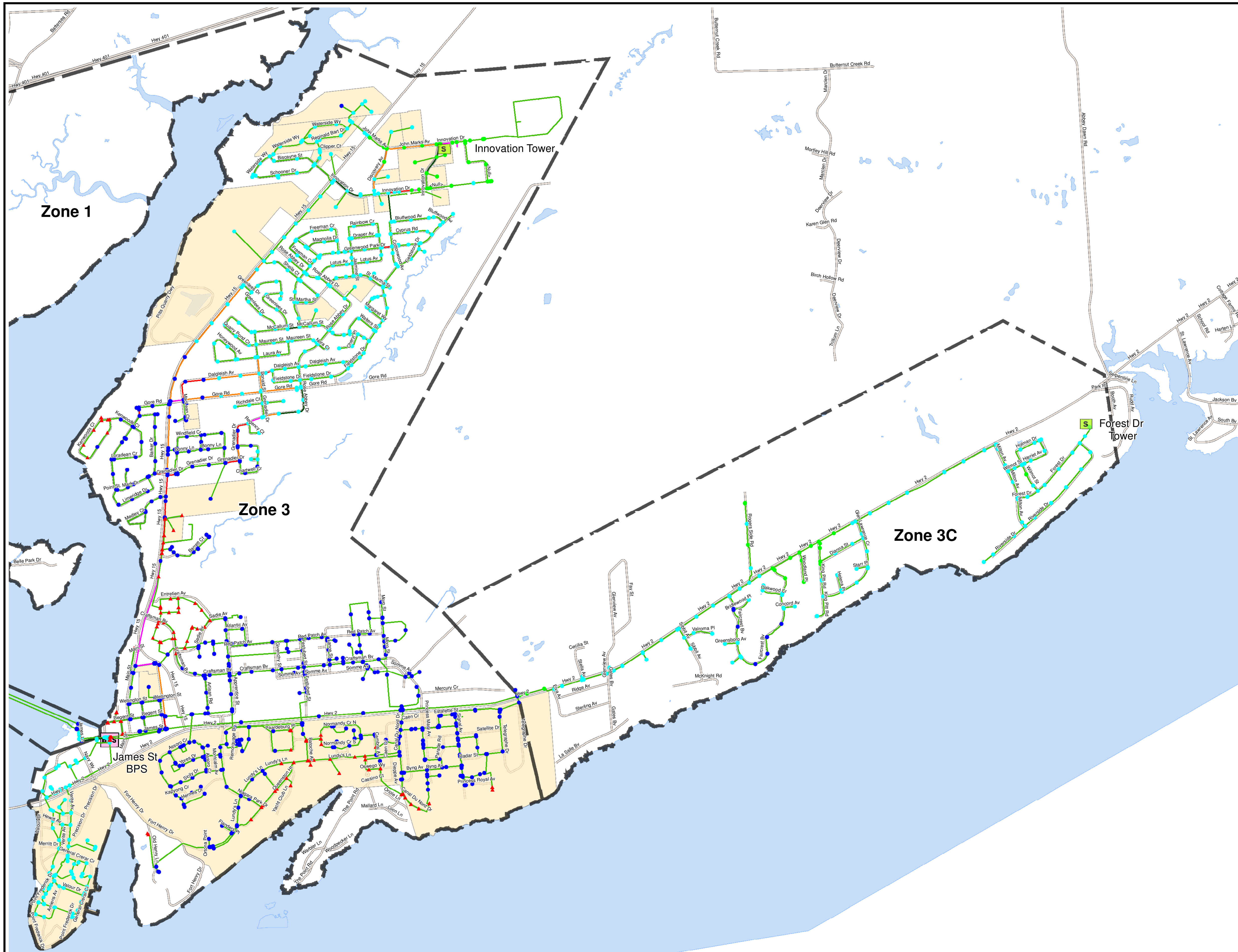
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 3A, 3B & 3C)

Scenario:
2015 INTER-CONNECTION (MINIMUM HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	6-2-2

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig6_2_2-East_2015Inter_MinHr_HLoss_Pressure.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021 Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale: 0 200 400 600 800 m
1:25,000

N E S W

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

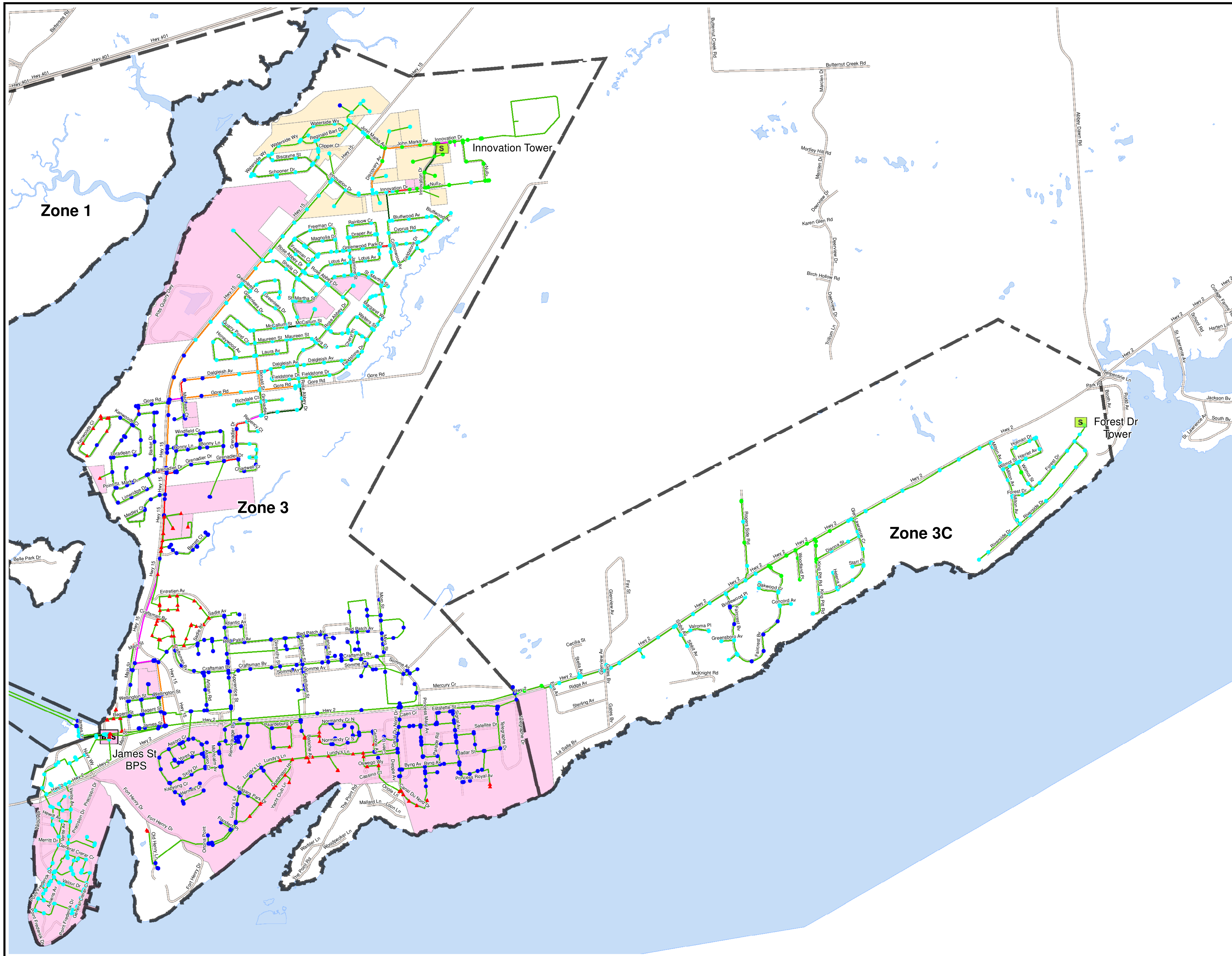
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 3 & 3C)

Scenario:
2021 FUTURE (MINIMUM HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	6-2-3

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig6_2_3-East_2021_MinHr_HLoss_Pressure.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-Future Development
- 2026-Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 200 400 600 800 m
1:25,000

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

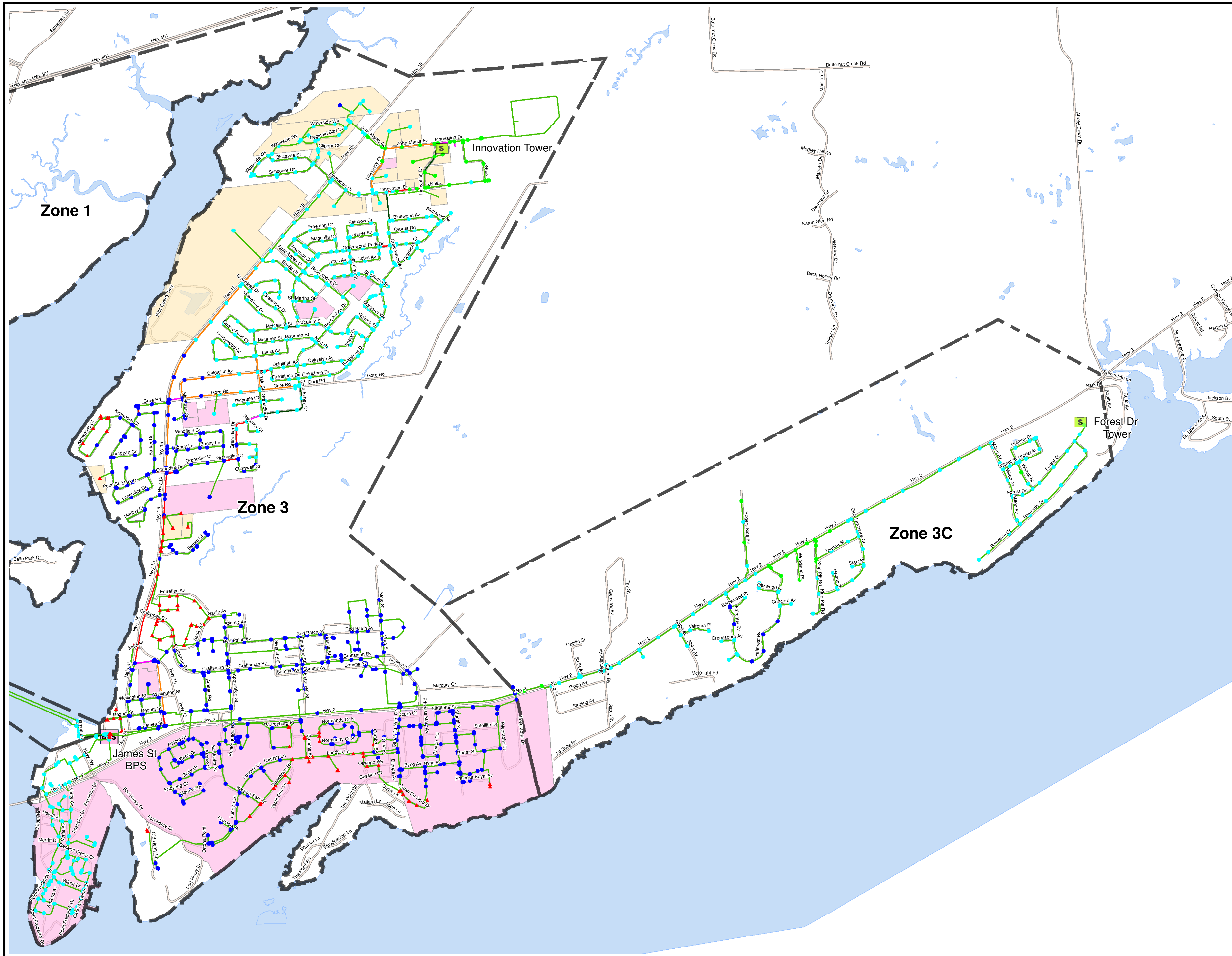
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 1 & 2)

Scenario:
2026 FUTURE (MINIMUM HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	6-2-4

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig6_2_4-East_2026_MinHr_HLoss_Pressure.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-2026 Future Development
- 2036 Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 200 400 600 800 m
1:25,000

N E S W

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

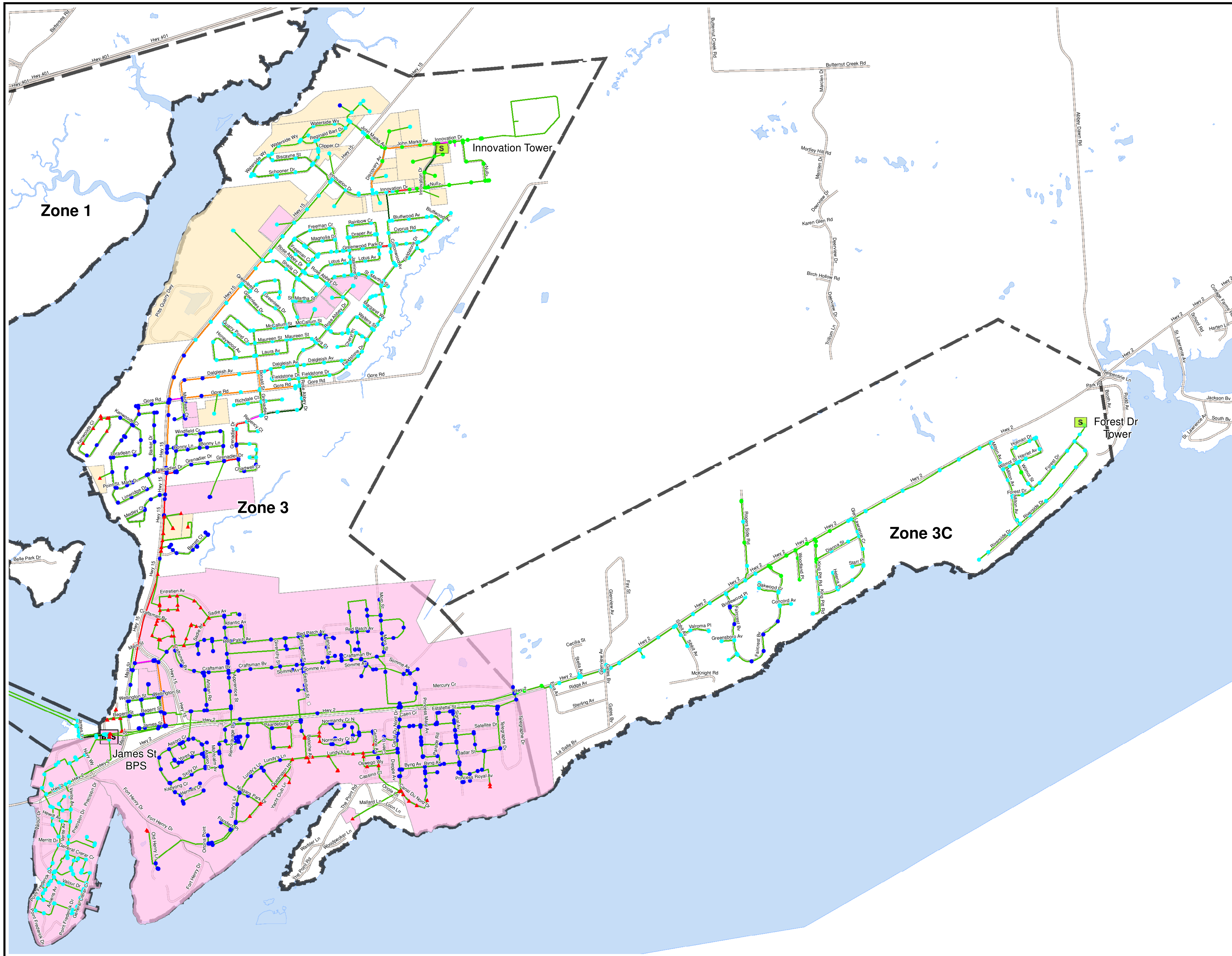
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 3 & 3C)

Scenario:
2036 FUTURE (MINIMUM HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	6-2-5

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig6_2_5-East_2036_MinHr_HLoss_Pressure.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-2026 Future Development
- Buildout Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 200 400 600 800 m
1:25,000

N E S W

Project:
Water and Wastewater Master Plan

City of Kingston, Ontario

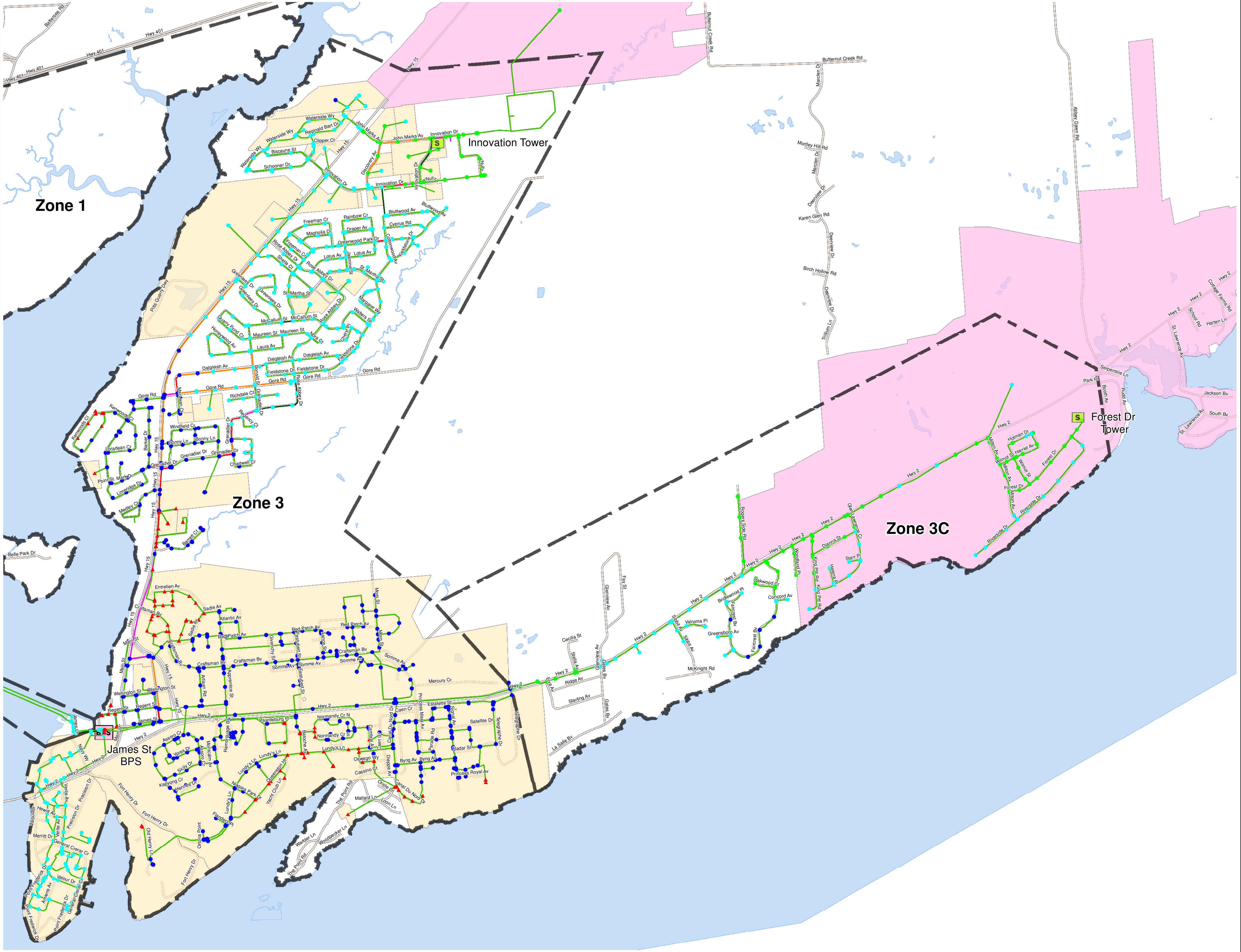
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 3 & 3C)

Scenario:
FULL BUILDOUT (MINIMUM HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	6-2-6

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig6_2_6-East_BO_MinHr_HLoss_Pressure.mxd



WSP

1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston

UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-Buildout Future Development
- Ultimate-Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 200 400 600 800 m
1:25,000

N E S W

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

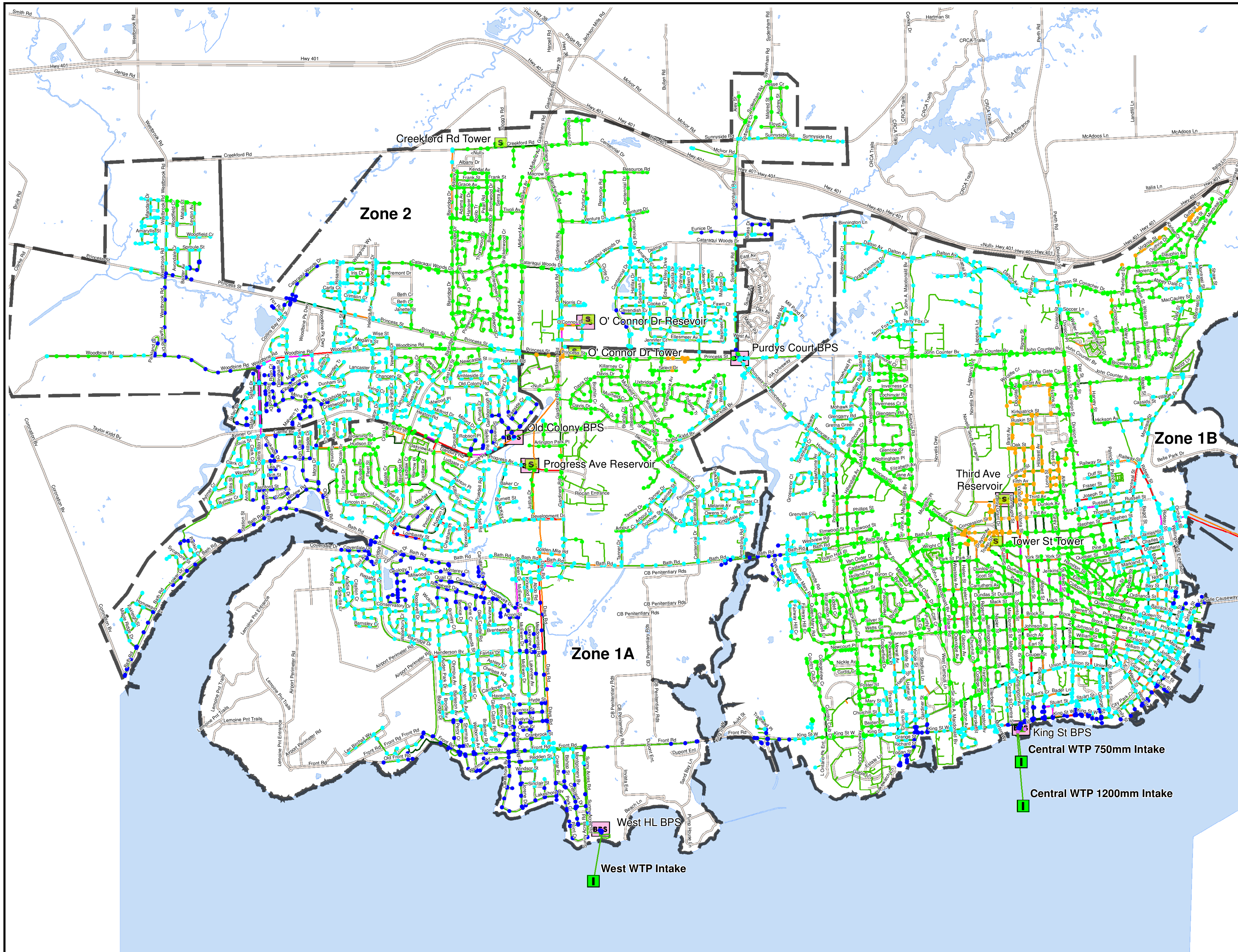
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 3 & 3C)

Scenario:
ULTIMATE (MINIMUM HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	6-2-7

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig6_2_7-East_ULT_MinHr_HLoss_Pressure.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 500 1,000 1,500 m
1:42,500

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

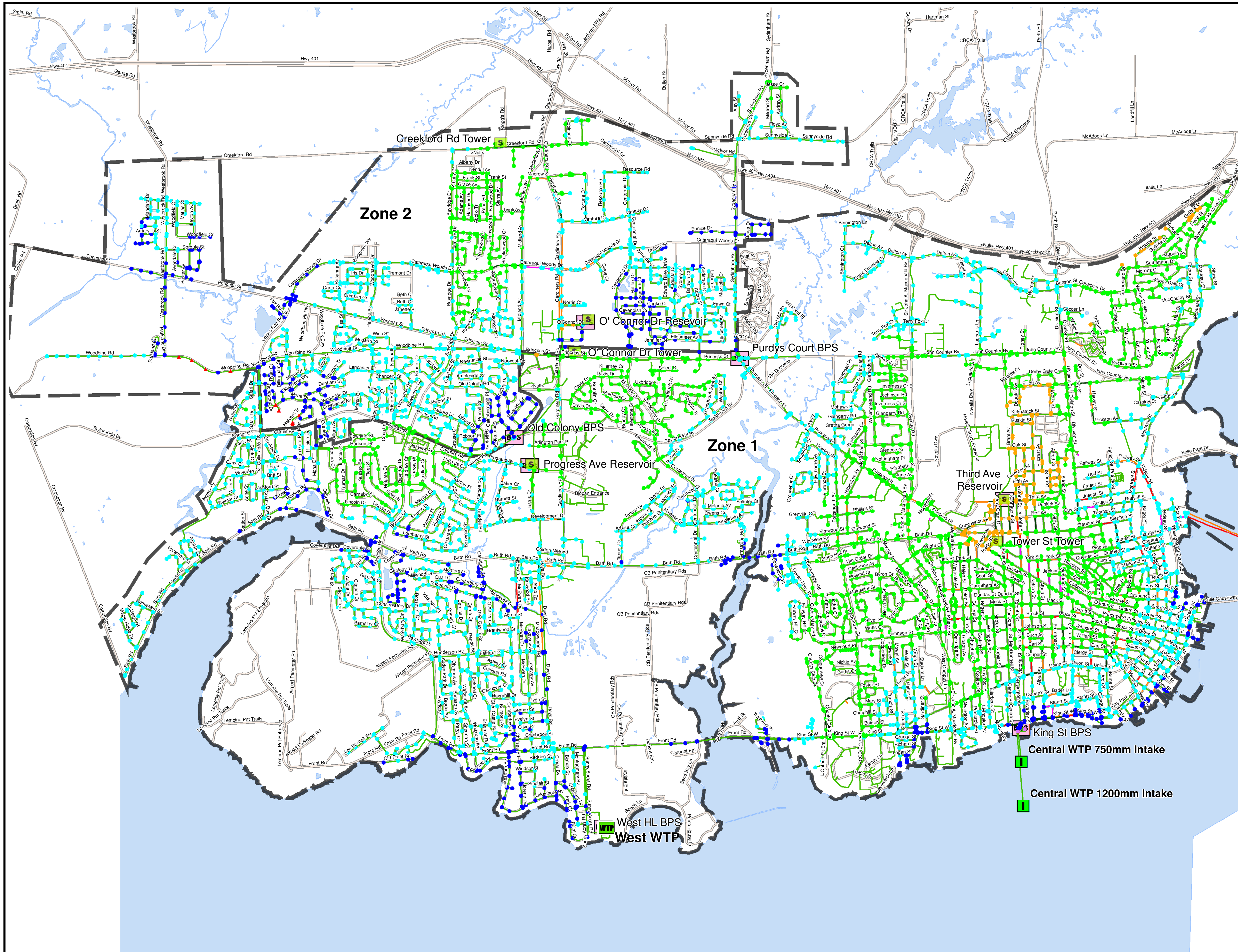
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 1A, 1B & 2)

Scenario:
2015 EXISTING (PEAK HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	7-1-1

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig7_1_1-WC_2015_PHD_HLoss_Pressure.mxd



1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 500 1,000 1,500 m
1:42,500

Project:
Water and Wastewater
Master Plan

City of Kingston, Ontario

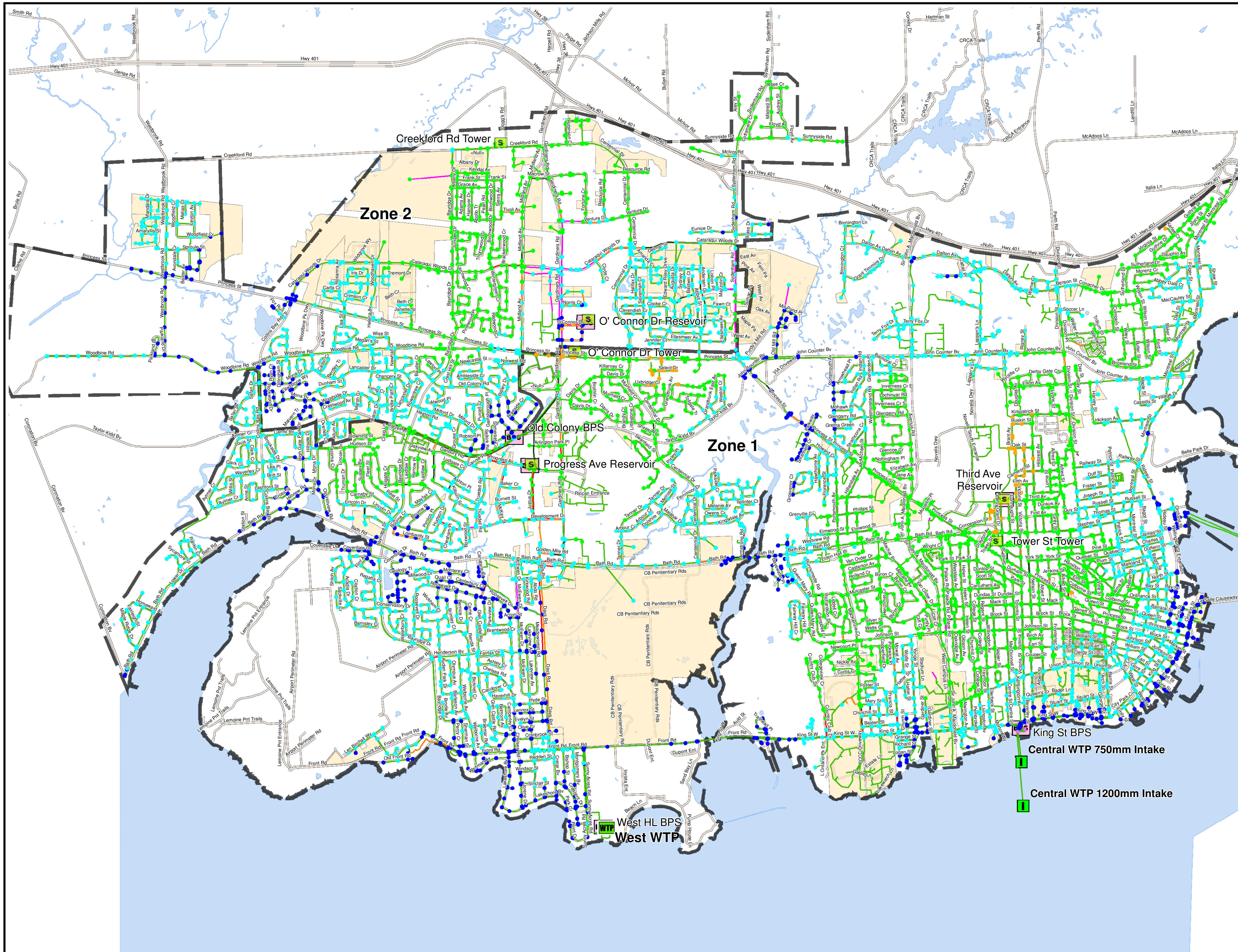
Title:
KINGSTON WATER SYSTEM -
PIPE HEADLOSS AND
JUNCTION PRESSURE
(ZONES 1 & 2)

Scenario:
2015 INTER-CONNECTION
(PEAK HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	7-1-2

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig7_1_2-WC_2015Inter_PHD_HLoss_Pressure.mxd



WSP

1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston

UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021 Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 500 1,000 1,500 m
1:42,500

Project:
Water and Wastewater
Master Plan

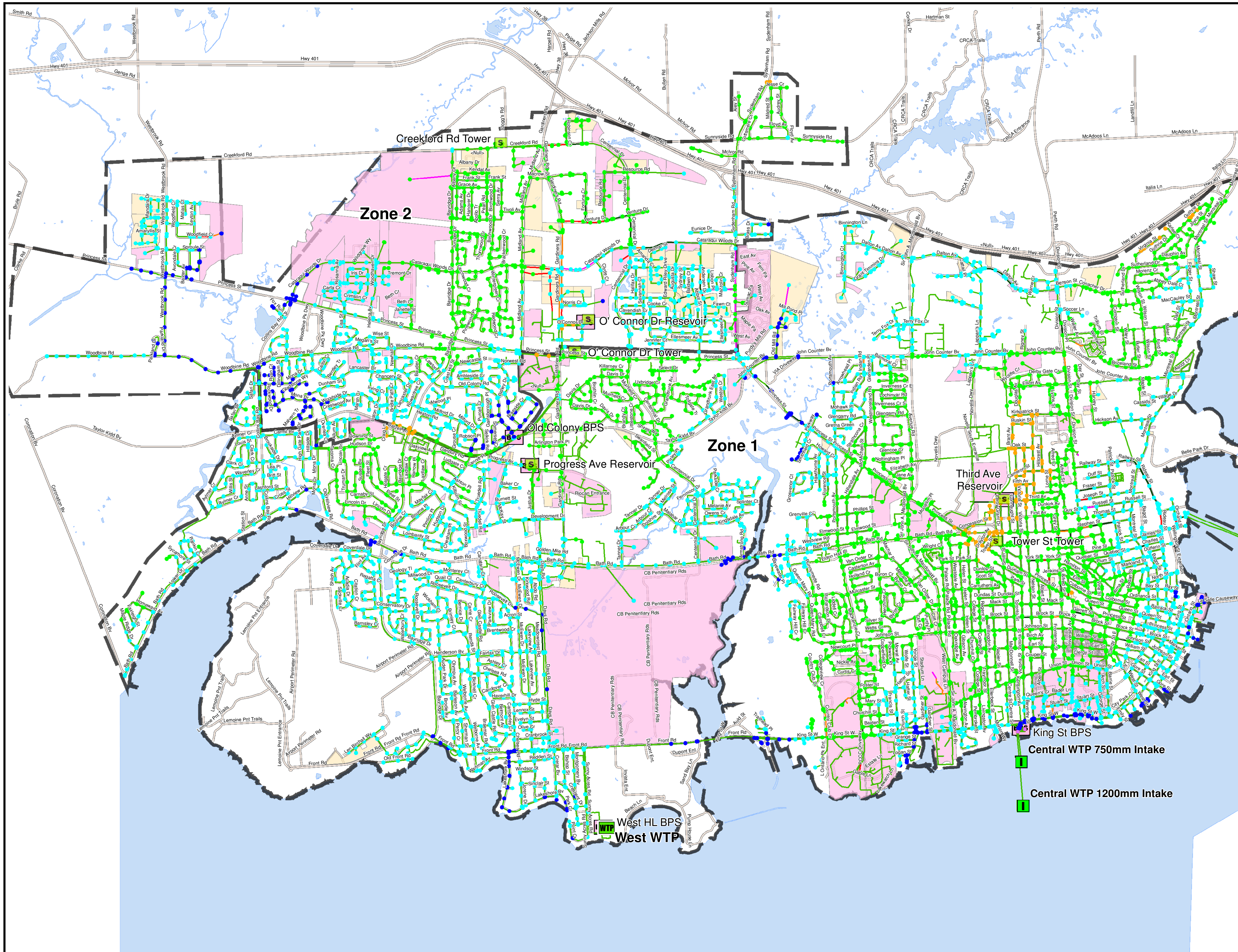
City of Kingston, Ontario

Title:
KINGSTON WATER SYSTEM -
PIPE HEADLOSS AND
JUNCTION PRESSURE
(ZONES 1 & 2)

Scenario:
2021 FUTURE
(PEAK HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	7-1-3



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021 Future Development
- 2026 Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale: 0 500 1,000 1,500 m
1:42,500

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

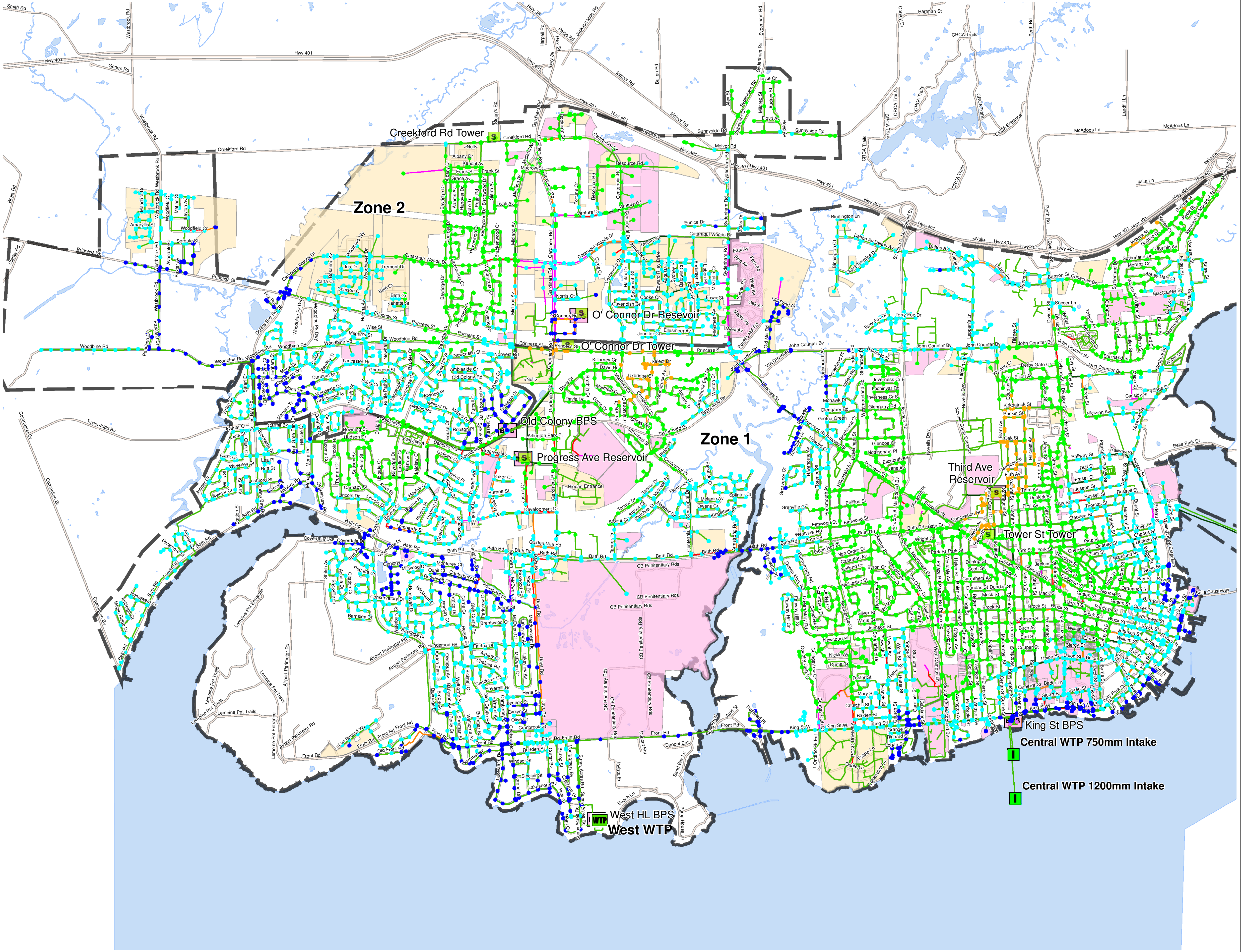
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 1 & 2)

Scenario:
2026 FUTURE (PEAK HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	7-1-4

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig7_1_4-WC_2026_PHD_HLoss_Pressure.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-2026 Future Development
- 2036 Future Development

Pressure (psi)
- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)
- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 500 1,000 1,500 m
1:42,500

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

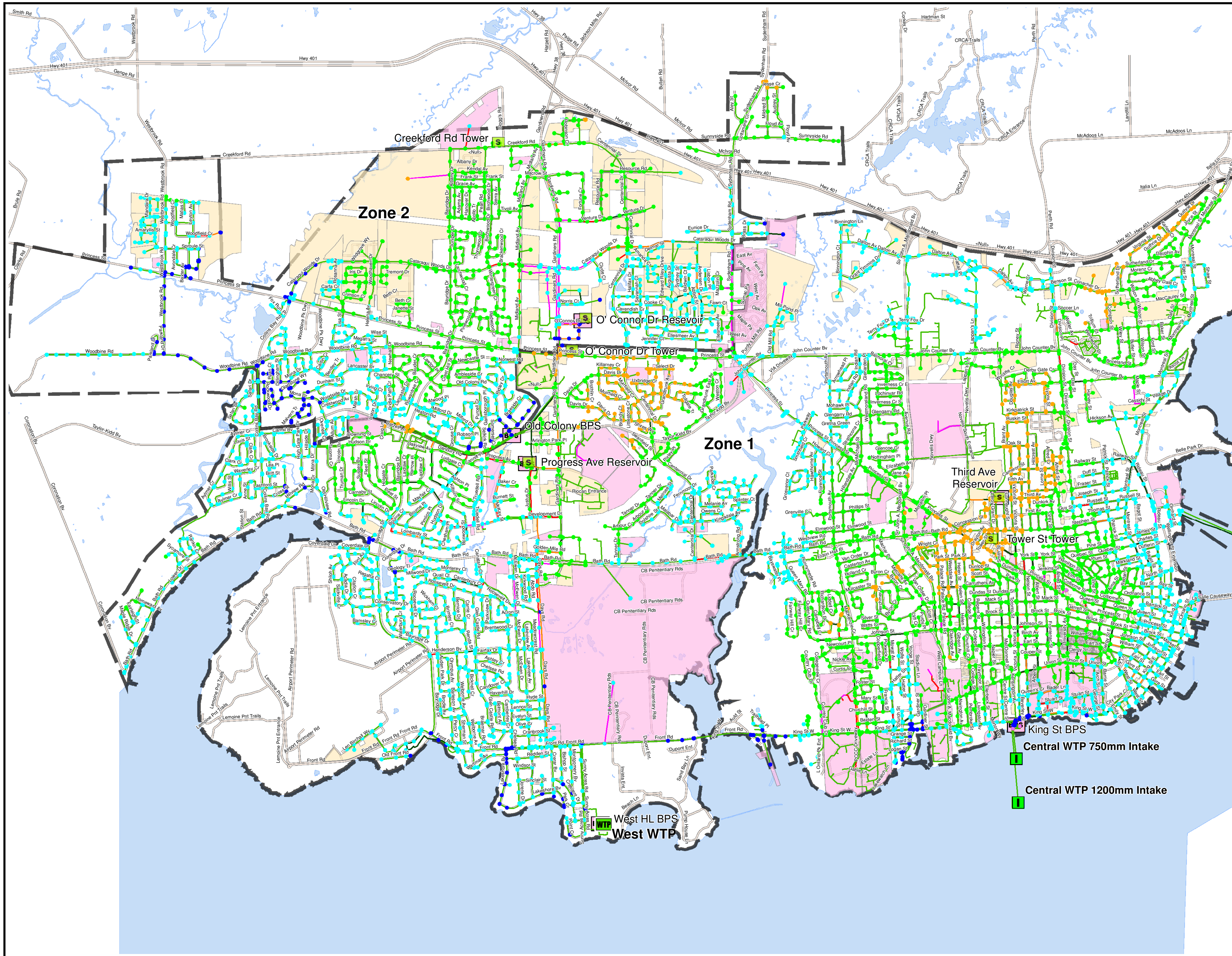
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 1 & 2)

Scenario:
2036 FUTURE (PEAK HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	7-1-5

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig7_1_5-WC_2036_PHD_HLoss_Pressure.mxd



WSP

1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston

UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-2026 Future Development
- Buildout Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 500 1,000 1,500 m
1:42,500

Project:
Water and Wastewater Master Plan

City of Kingston, Ontario

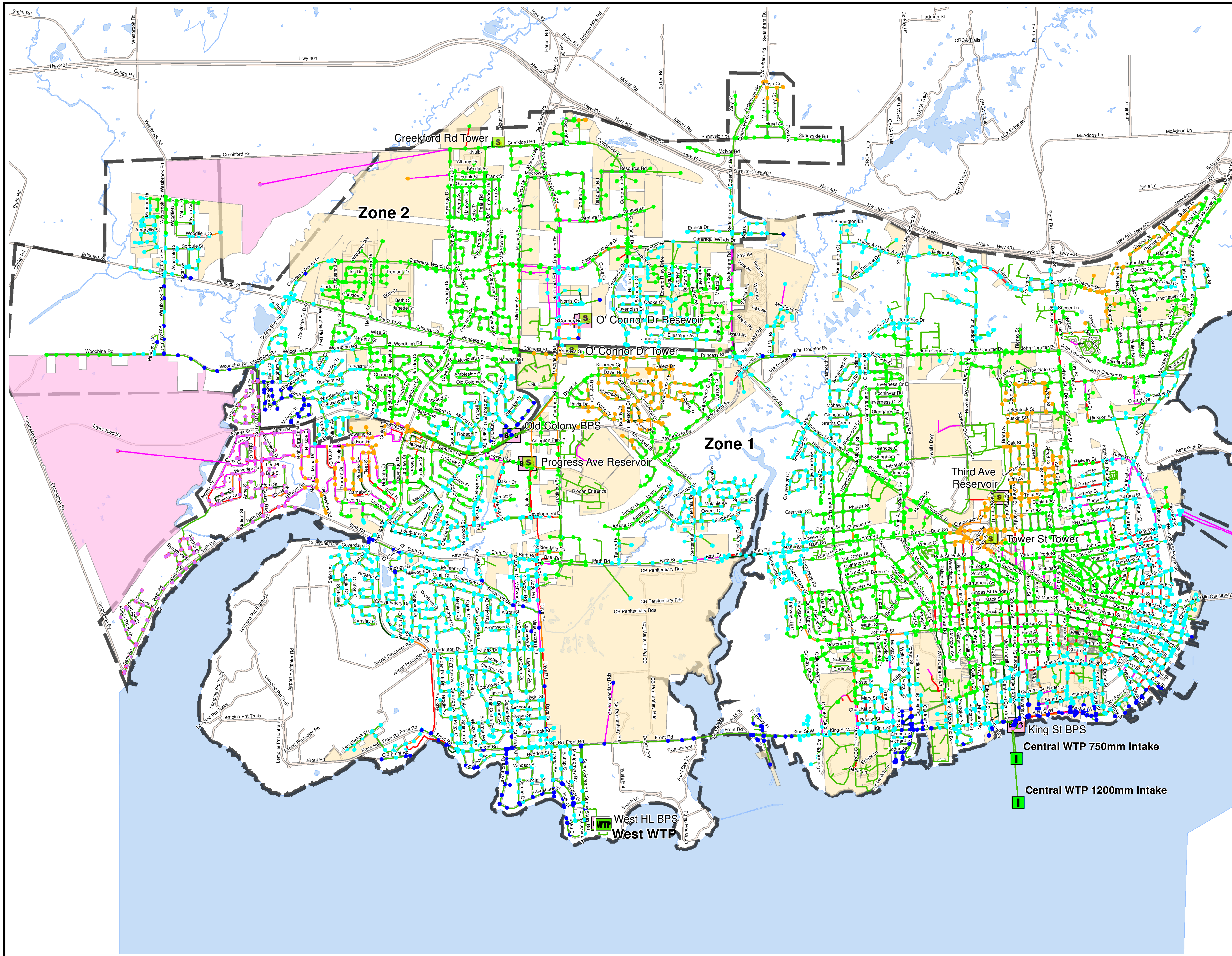
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 1 & 2)

Scenario:
FULL BUILDOUT (PEAK HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	7-1-6

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig7_1_6-WC_BO_PHD_HLoss_Pressure.mxd



1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-Buildout Future Development
- Ultimate-Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale: 0 500 1,000 1,500 m
1:42,500

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

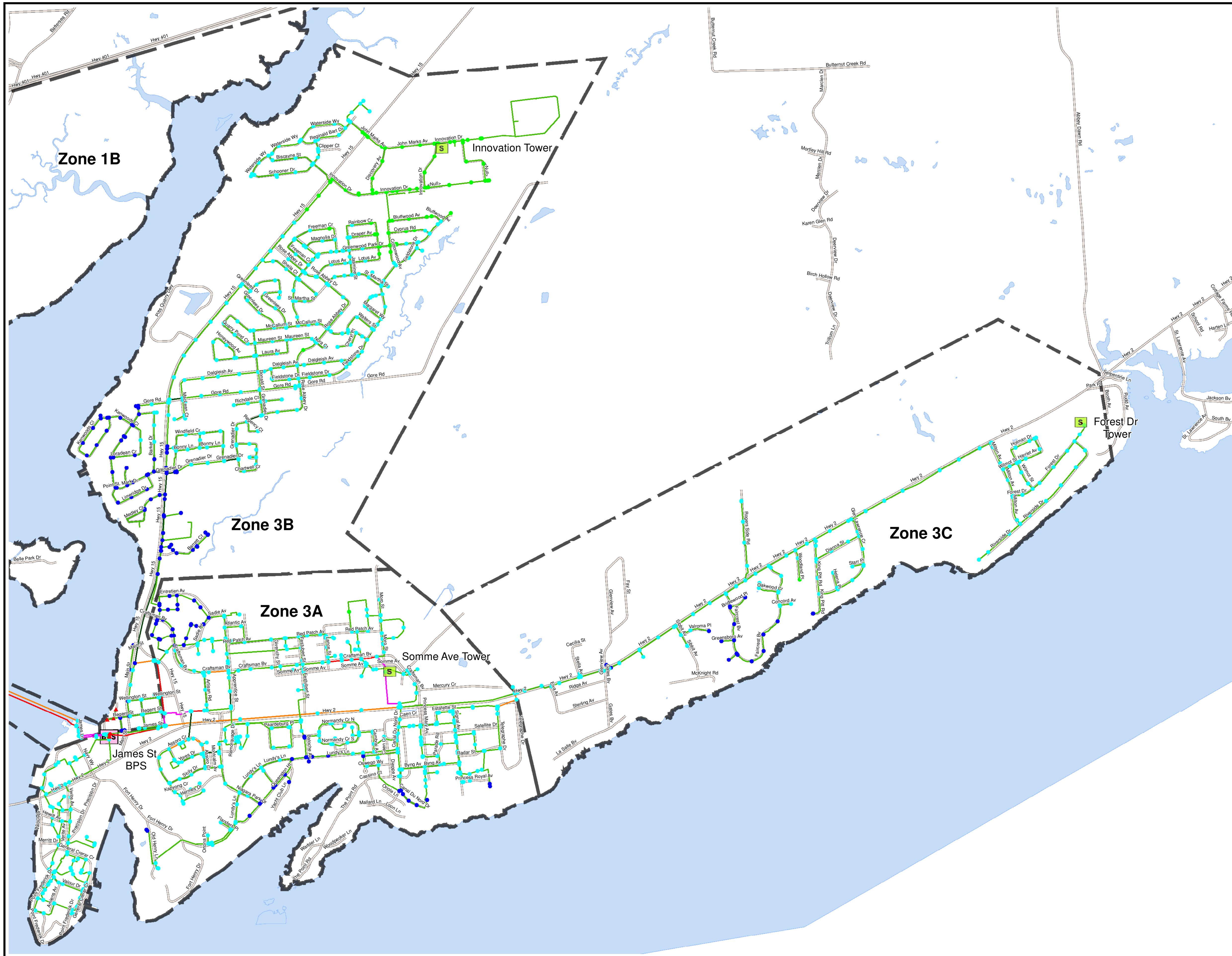
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 1 & 2)

Scenario:
ULTIMATE (PEAK HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	7-1-7

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig7_1_7-WC_ULT_PHD_HLoss_Pressure.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- \> 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- \> 5.0

Scale: 0 200 400 600 800 m

1:25,000

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

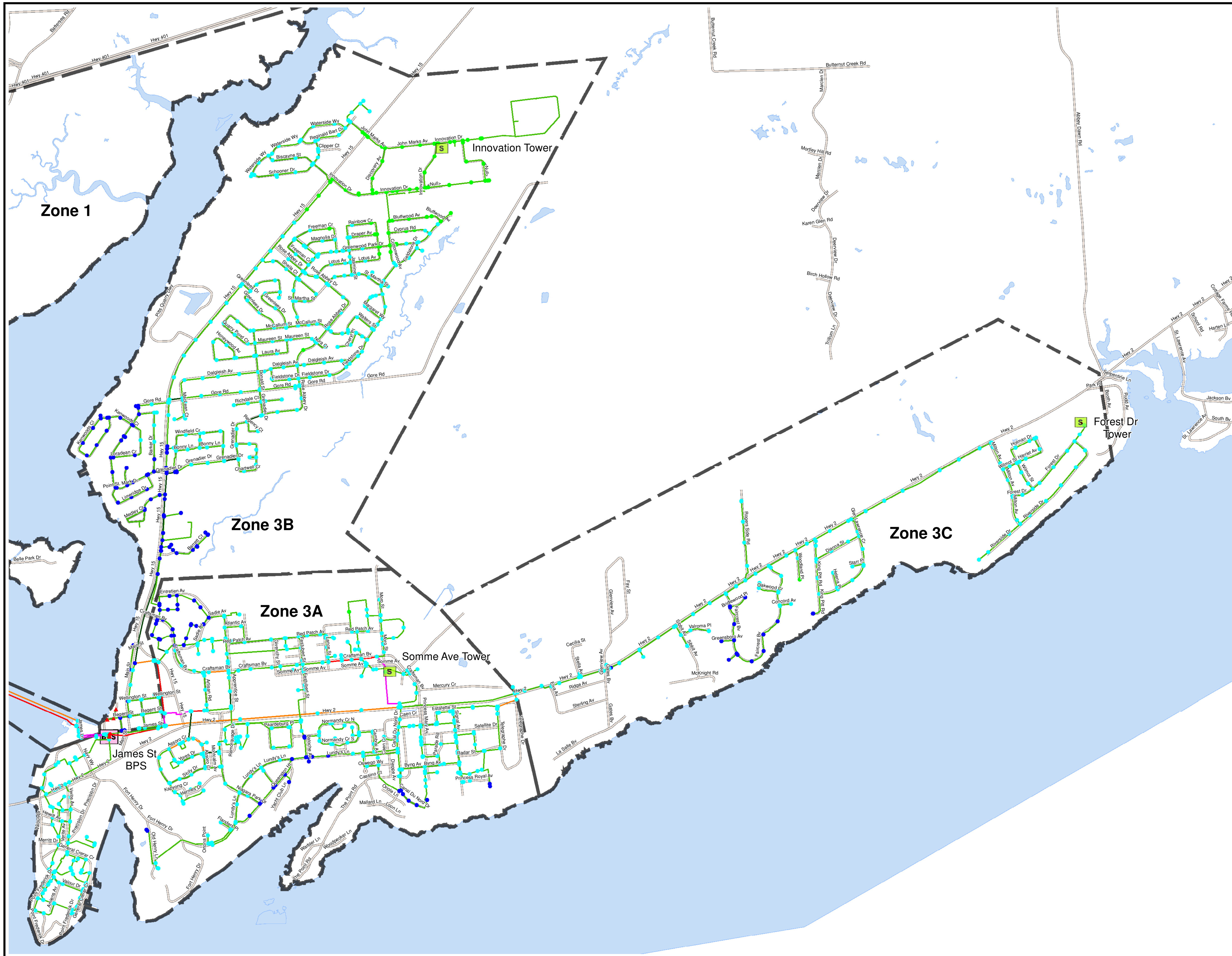
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 3A, 3B & 3C)

Scenario:
2015 EXISTING (PEAK HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	7-2-1

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.1_Baseline\Maps\151-02944-00_GAP_Fig7_2_1-East_2015_PHD_HLoss_Pressure.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- Raw Water Intake
- PressureZone
- Road
- Waterbody

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 200 400 600 800 m
1:25,000

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

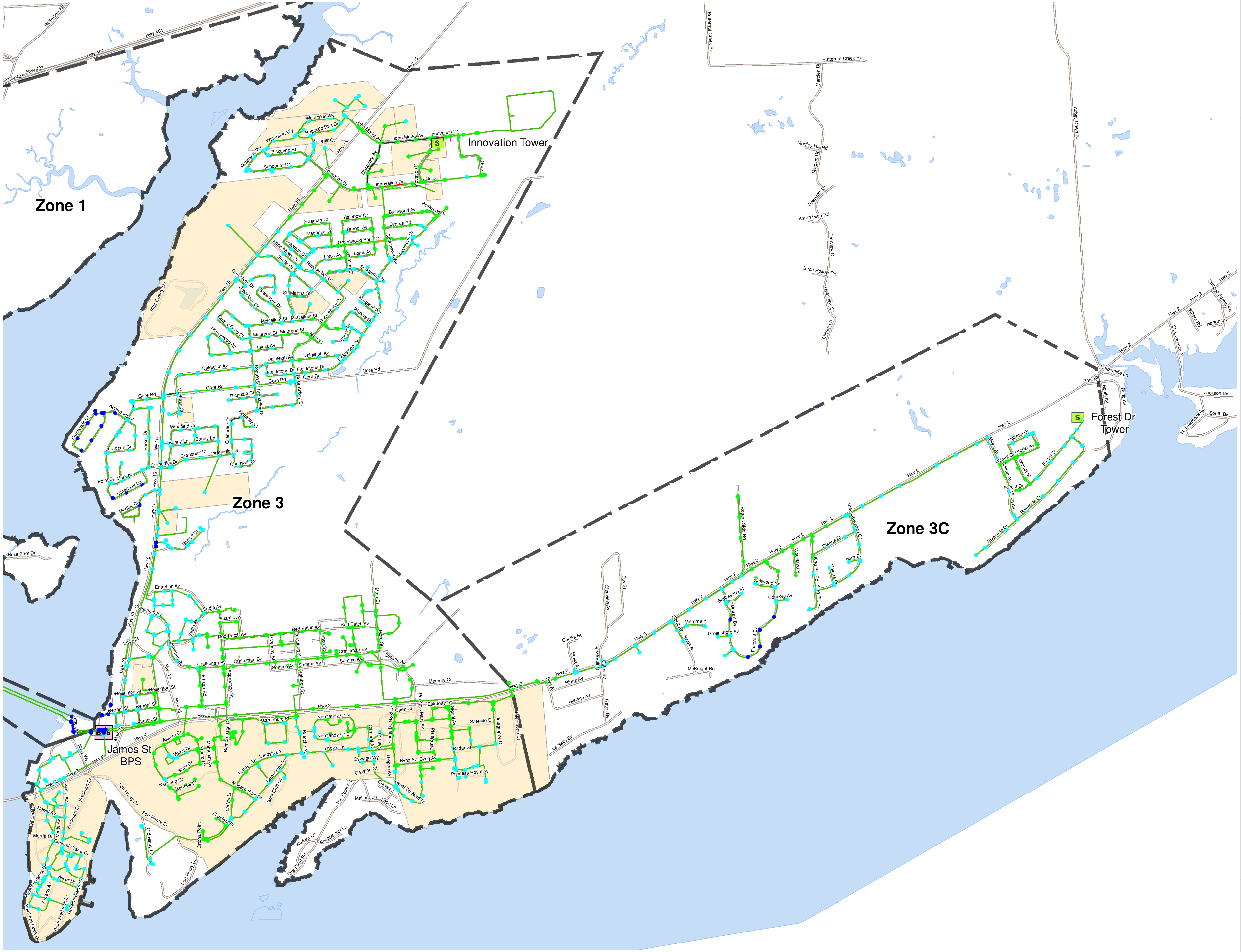
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 3A, 3B & 3C)

Scenario:
2015 INTER-CONNECTION (PEAK HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	7-2-2

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig7_2_2-East_2015Inter_PHD_HLoss_Pressure.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021 Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 200 400 600 800 m
1:25,000

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

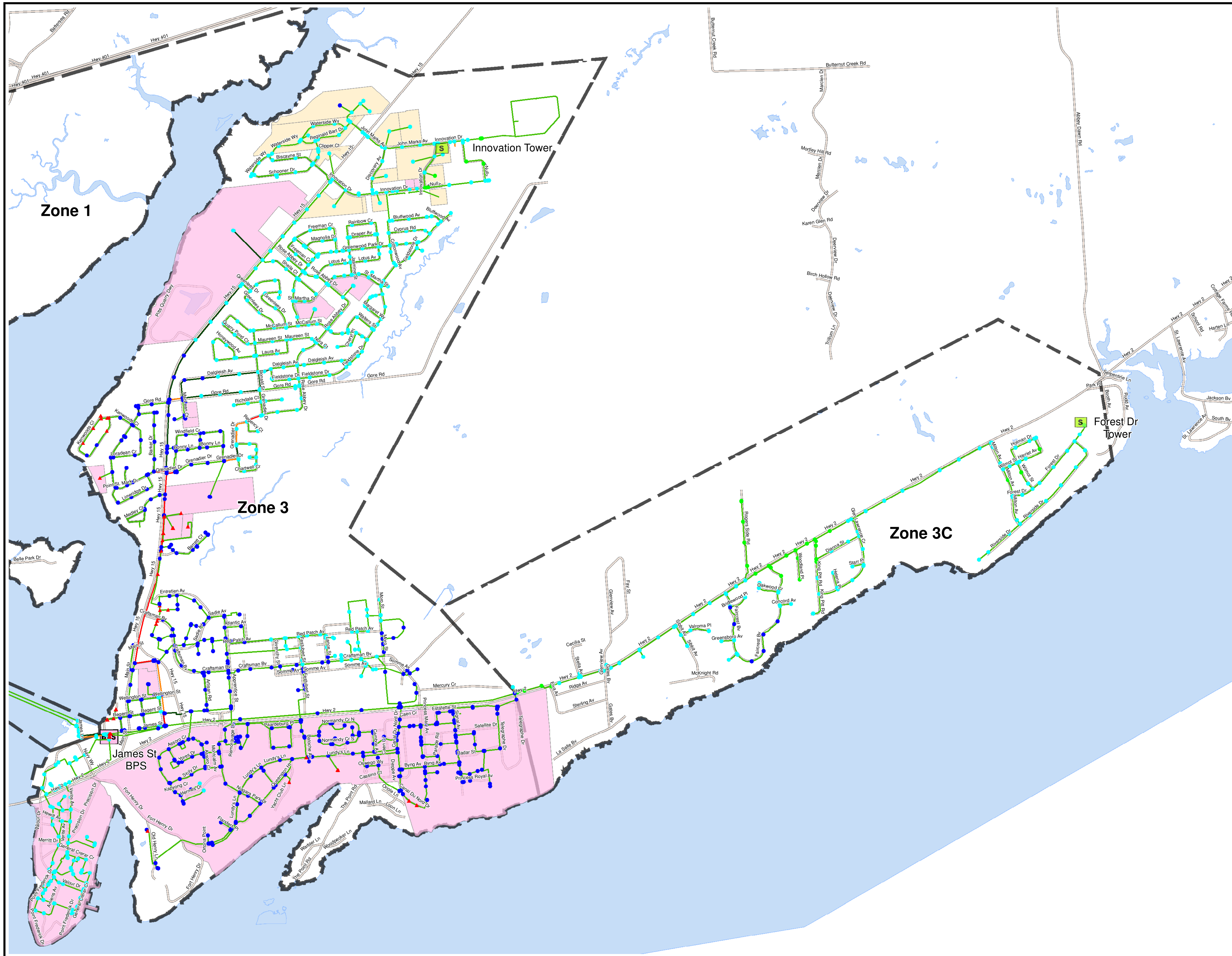
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 3 & 3C)

Scenario:
2021 FUTURE (PEAK HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	7-2-3

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig7_2_3-East_2021_PHD_HLoss_Pressure.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021 Future Development
- 2026 Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 200 400 600 800 m
1:25,000

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

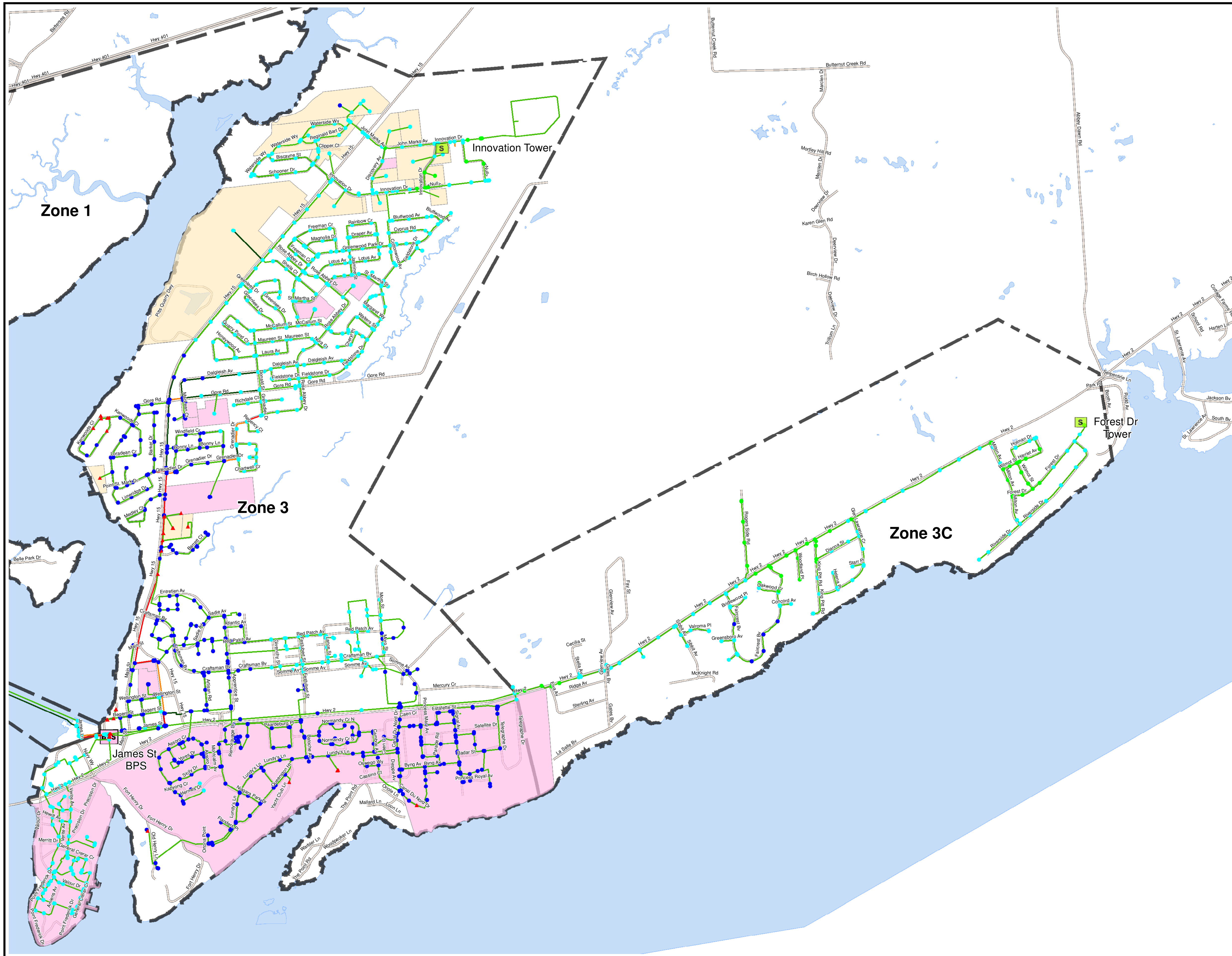
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 3 & 3C)

Scenario:
2026 FUTURE (PEAK HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	7-2-4

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig7_2_4-East_2026_PHD_HLoss_Pressure.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-2026 Future Development
- 2036 Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 200 400 600 800 m
1:25,000

Project:
Water and Wastewater Master Plan

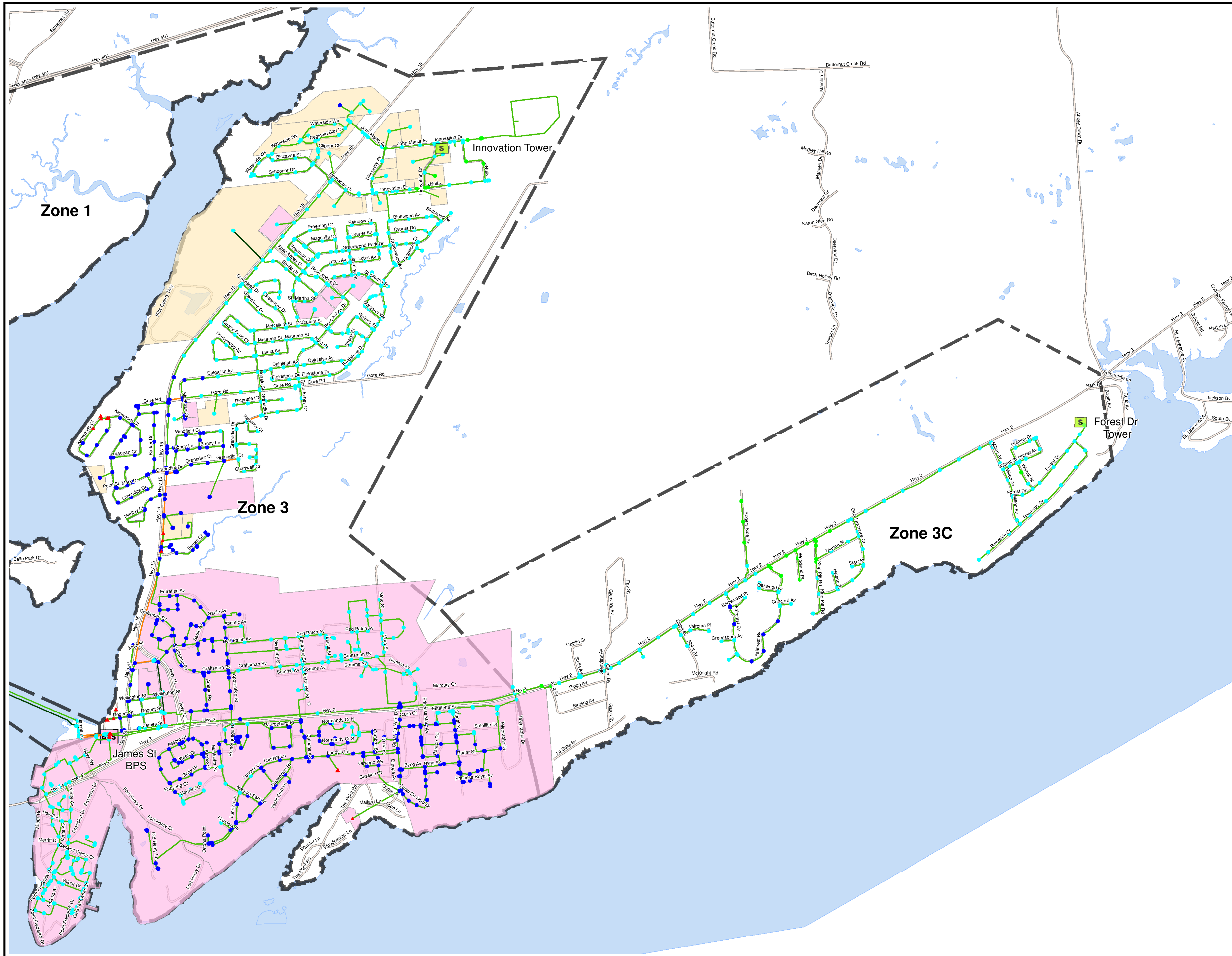
City of Kingston, Ontario

Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 3 & 3C)

Scenario:
2036 FUTURE (PEAK HOUR)

Project No.:	Date:		
151-02944-00	DECEMBER 2016		
Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	7-2-5

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig7_2_5-East_2036_PHD_HLoss_Pressure.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-2026 Future Development
- Buildout Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 200 400 600 800 m
1:25,000

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

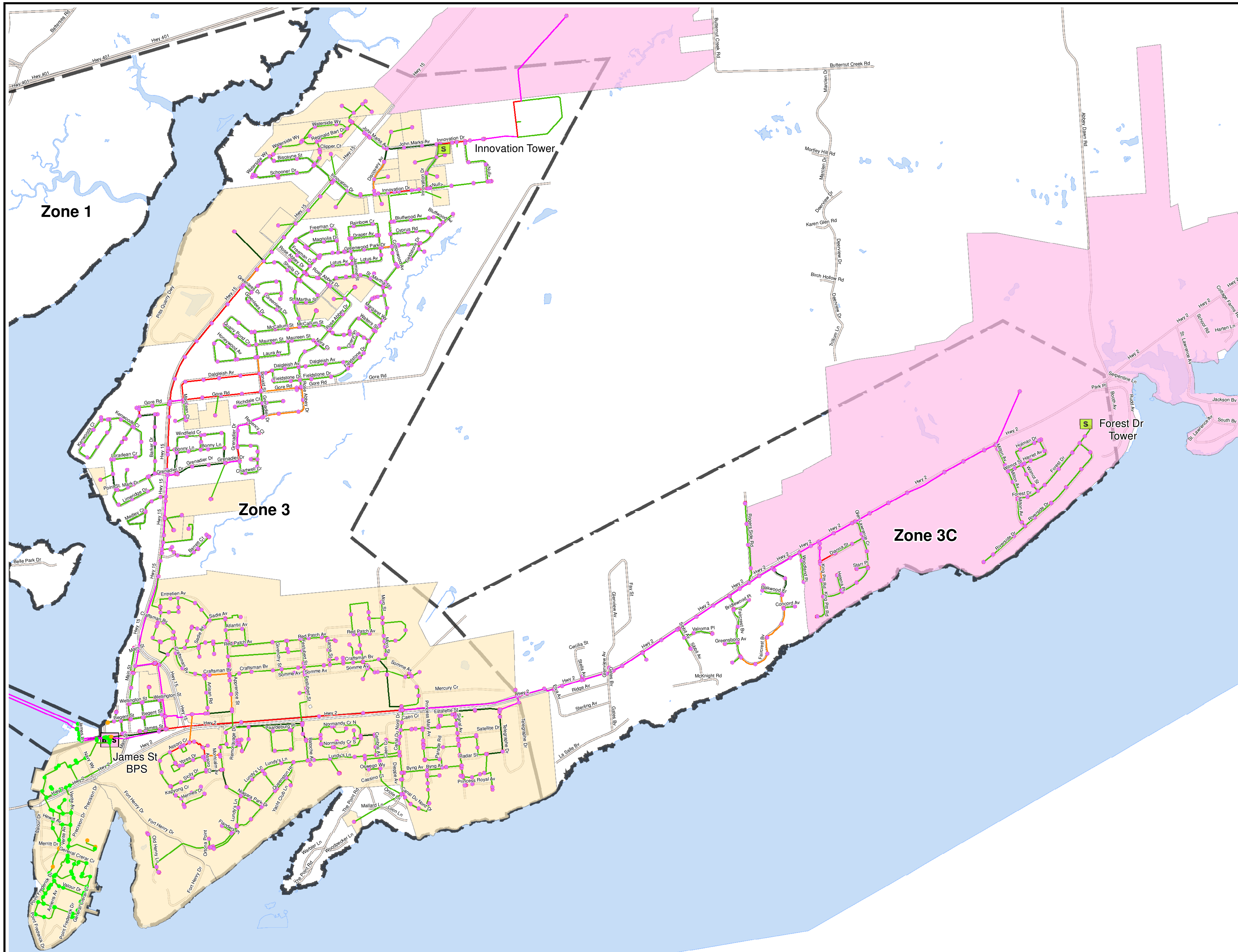
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 3 & 3C)

Scenario:
FULL BUILDOUT (PEAK HOUR)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	7-2-6

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig7_2_6-East_BO_PHD_HLoss_Pressure.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-Buildout Future Development
- Ultimate-Future Development

Pressure (psi)

- <= 20
- <= 40
- <= 60
- <= 80
- <= 100
- > 100

Pipe: Headloss Gradient (m/km)

- <= 1.5
- <= 2.0
- <= 3.0
- <= 5.0
- > 5.0

Scale:
0 200 400 600 800 m
1:25,000

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 3 & 3C)

Scenario:
ULTIMATE (PEAK HOUR)

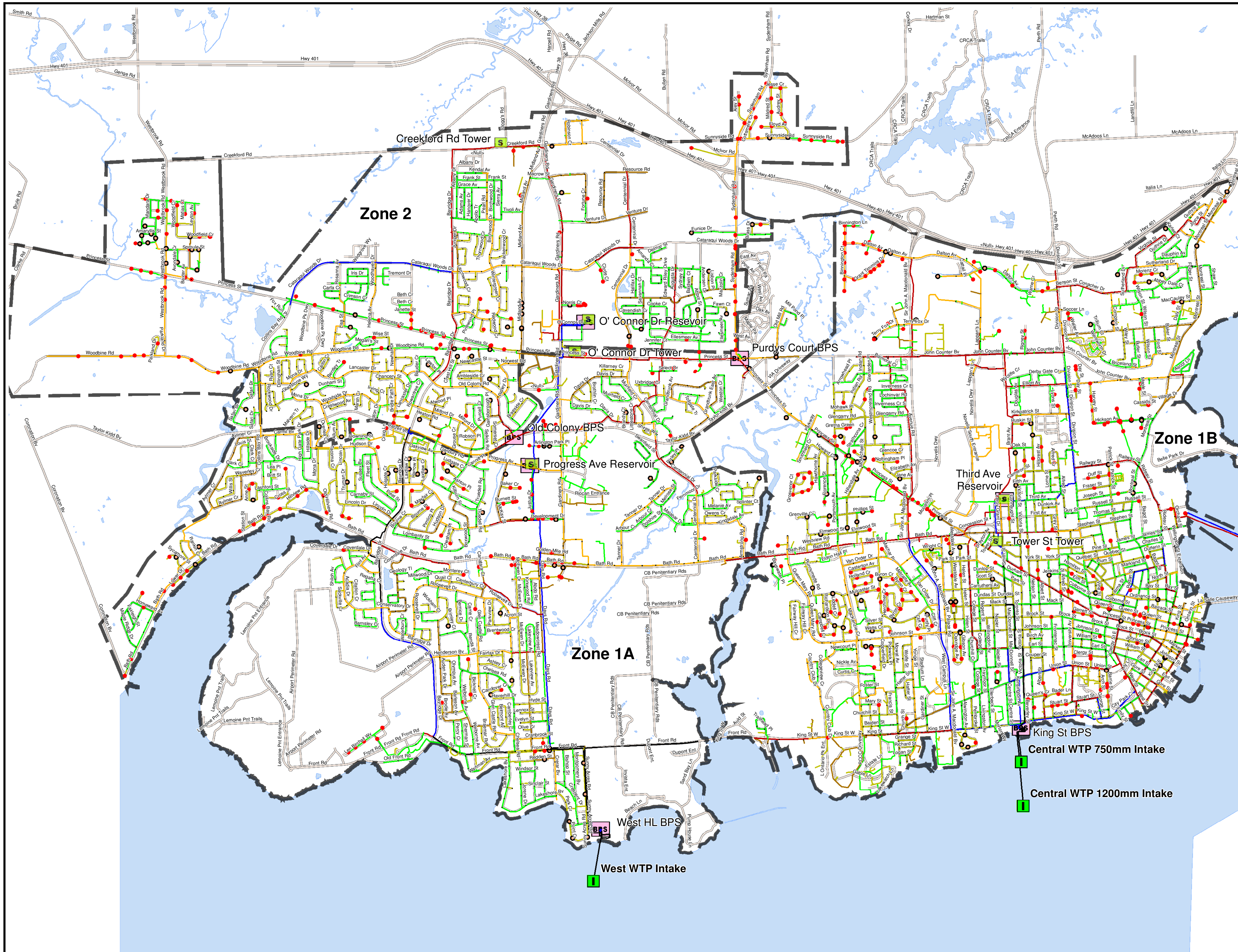
Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	7-2-7

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig7_2_7-East_ULT_PHD_HLoss_Pressure.mxd

Appendix C

FIRE FLOW MAPS



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody

Fire Flow (Available) (L/s)

- <= 80 (Res) or 230 (ICI)
- < 100 (Res) or 270 (ICI)
- >= 100 (Res) or 270 (ICI)

Pipe: Diameter (mm)

- <= 150
- <= 200
- <= 250
- <= 300
- <= 450
- <= 600
- > 600

Scale:
0 500 1,000 1,500 m
1:42,500

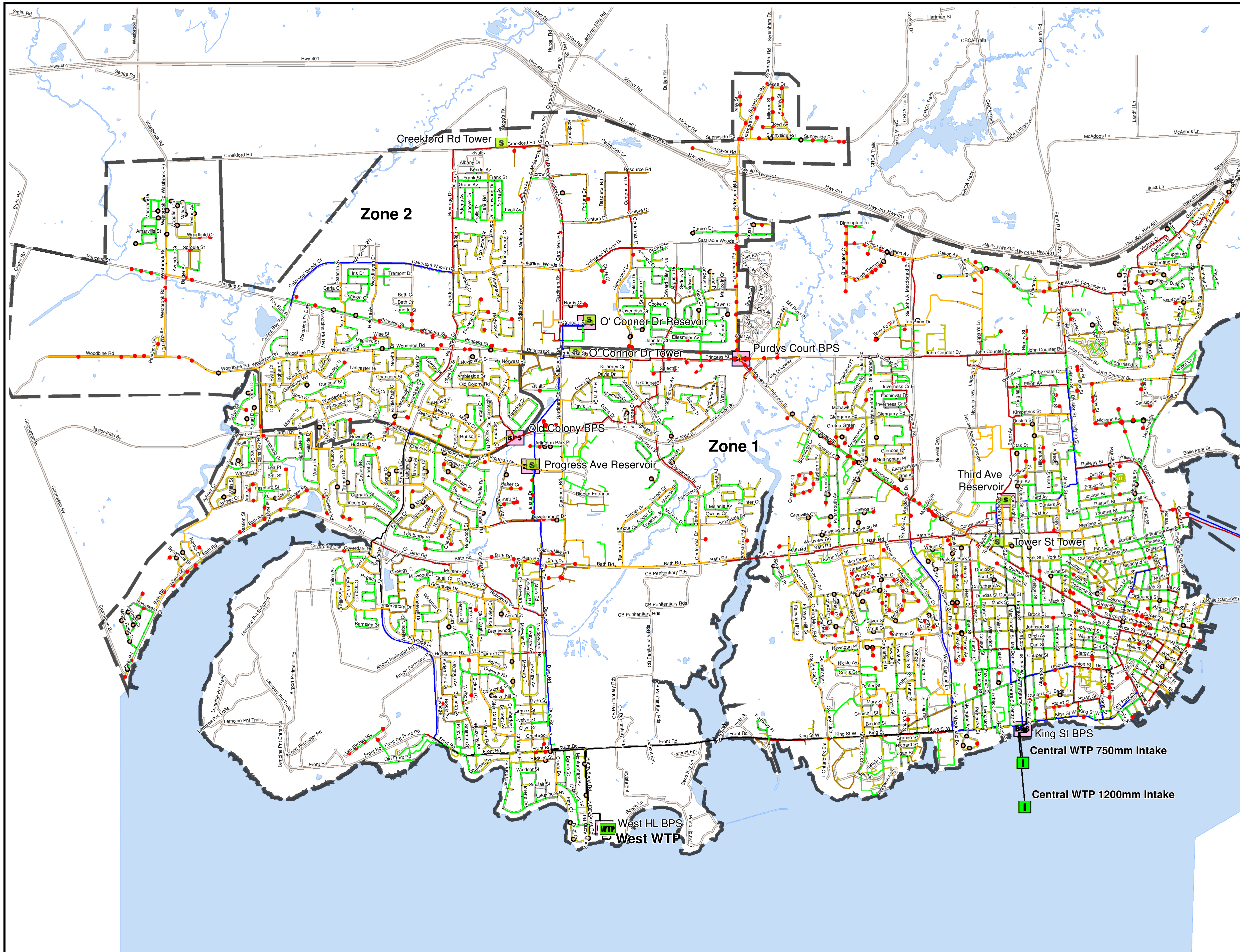
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

Title:
KINGSTON WATER SYSTEM - FIRE FLOW AVAILABILITY (ZONES 1A, 1B & 2)

Scenario:
2015 EXISTING (MDD+FF)

Project No.:	Date:		
151-02944-00	DECEMBER 2016		
Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	8-1-1

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig8_1_1-WC_2015_MDD_FireFlow.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody

Fire Flow (Available) (L/s)

- <= 80 (Res) or 230 (ICI)
- < 100 (Res) or 270 (ICI)
- >= 100 (Res) or 270 (ICI)

Pipe: Diameter (mm)

- <= 150
- <= 200
- <= 250
- <= 300
- <= 450
- <= 600
- > 600

Scale:
0 500 1,000 1,500 m
1:42,500

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

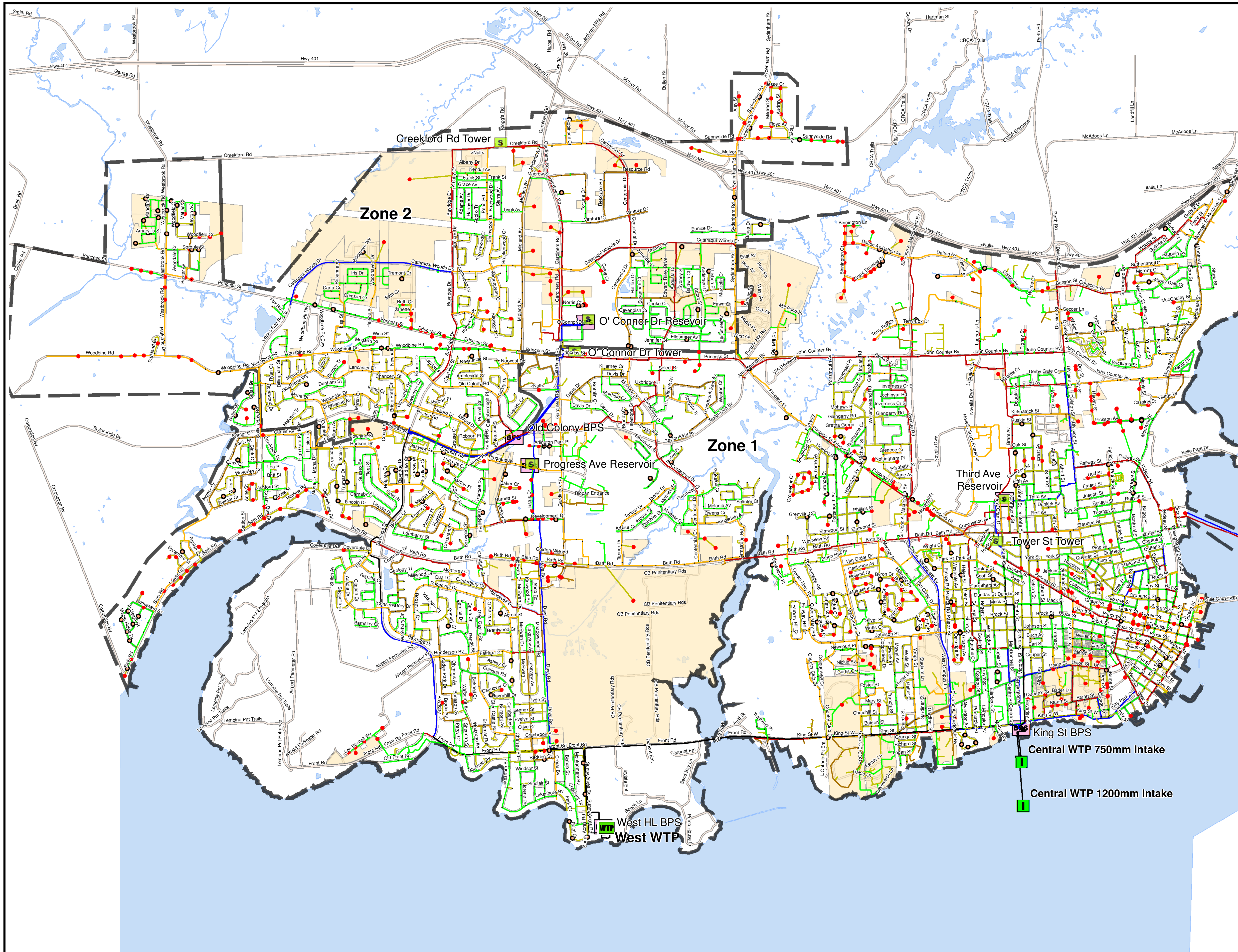
Title:
KINGSTON WATER SYSTEM - FIRE FLOW AVAILABILITY (ZONES 1 & 2)

Scenario:
2015 INTER-CONNECTION (MDD+FF)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	8-1-2

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig8_1_2-WC_2015Inter_MDD_FireFlow.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021 Future Development

Fire Flow (Available) (L/s)

- <= 80 (Res) or 230 (ICI)
- < 100 (Res) or 270 (ICI)
- >= 100 (Res) or 270 (ICI)

Pipe: Diameter (mm)

- <= 150
- <= 200
- <= 250
- <= 300
- <= 450
- <= 600
- > 600

Scale:
0 500 1,000 1,500 m
1:42,500

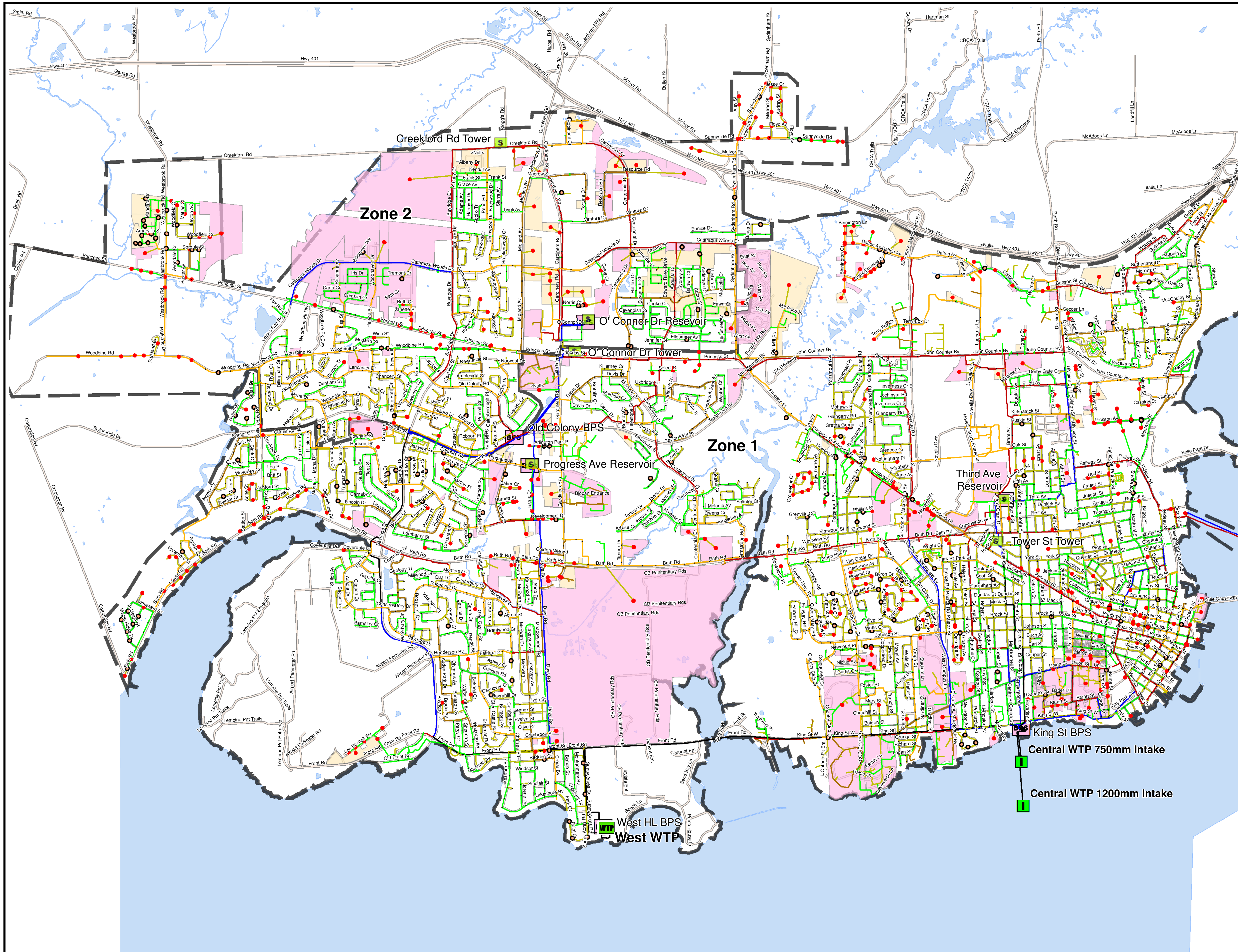
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

Title:
KINGSTON WATER SYSTEM - FIRE FLOW AVAILABILITY (ZONES 1 & 2)

Scenario:
2021 FUTURE (MDD+FF)

Project No.:		Date:	
151-02944-00		DECEMBER 2016	
Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	8-1-3

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig8_1_3-WC_2021_MDD_FireFlow.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021 Future Development
- 2026 Future Development

Fire Flow (Available) (L/s)

- <= 80 (Res) or 230 (ICI)
- < 100 (Res) or 270 (ICI)
- >= 100 (Res) or 270 (ICI)

Pipe: Diameter (mm)

- <= 150
- <= 200
- <= 250
- <= 300
- <= 450
- <= 600
- > 600

Scale:
0 500 1,000 1,500 m
1:42,500

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

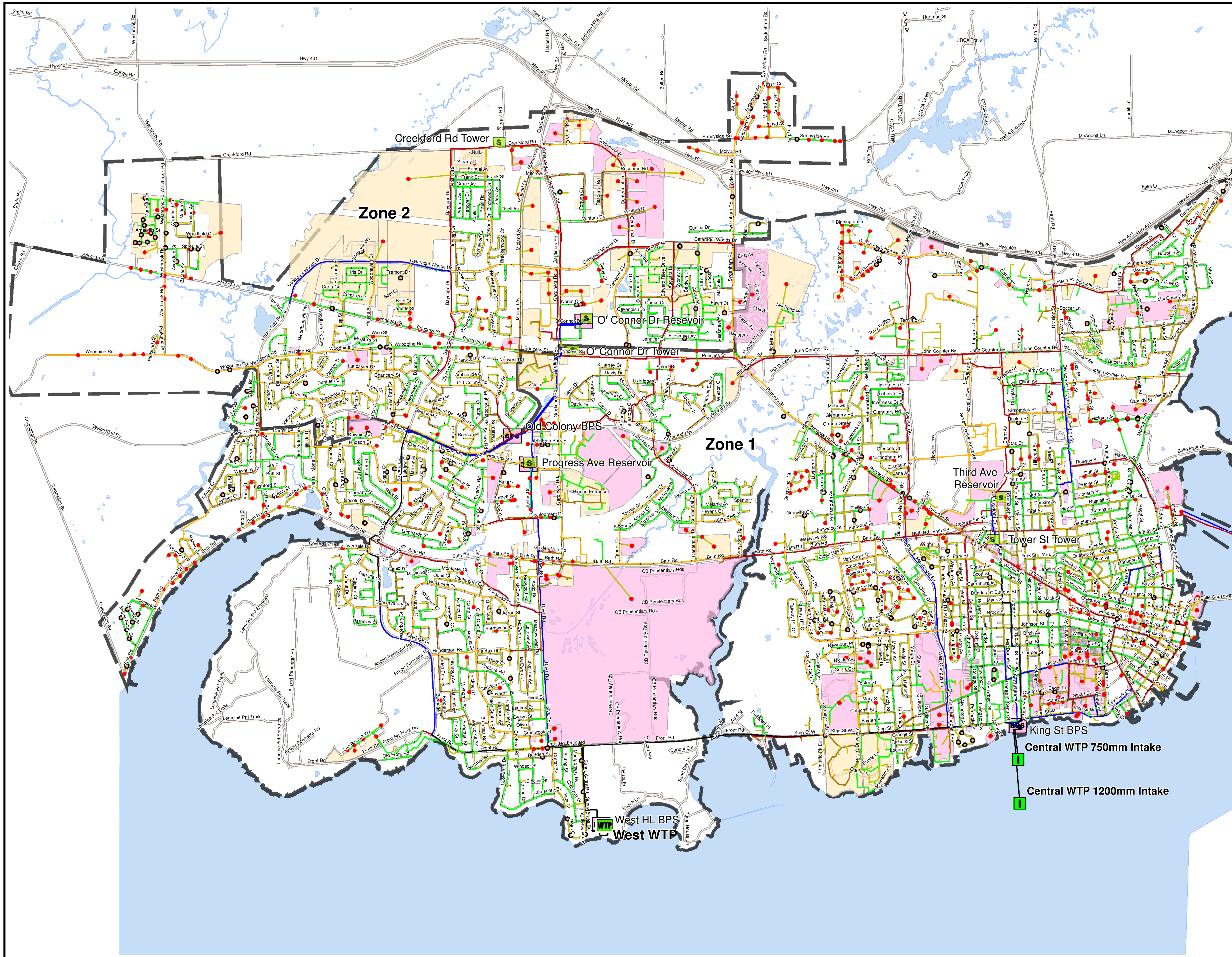
Title:
KINGSTON WATER SYSTEM - FIRE FLOW AVAILABILITY (ZONES 1 & 2)

Scenario:
2026 FUTURE (MDD+FF)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	8-1-4

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig8_1_4-WC_2026_MDD_FireFlow.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-2026 Future Development
- 2036 Future Development

Fire Flow (Available) (L/s)

- <= 80 (Res) or 230 (ICI)
- < 100 (Res) or 270 (ICI)
- >= 100 (Res) or 270 (ICI)

Pipe: Diameter (mm)

- <= 150
- <= 200
- <= 250
- <= 300
- <= 450
- <= 600
- > 600

Scale:
0 500 1,000 1,500 m
1:42,500

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

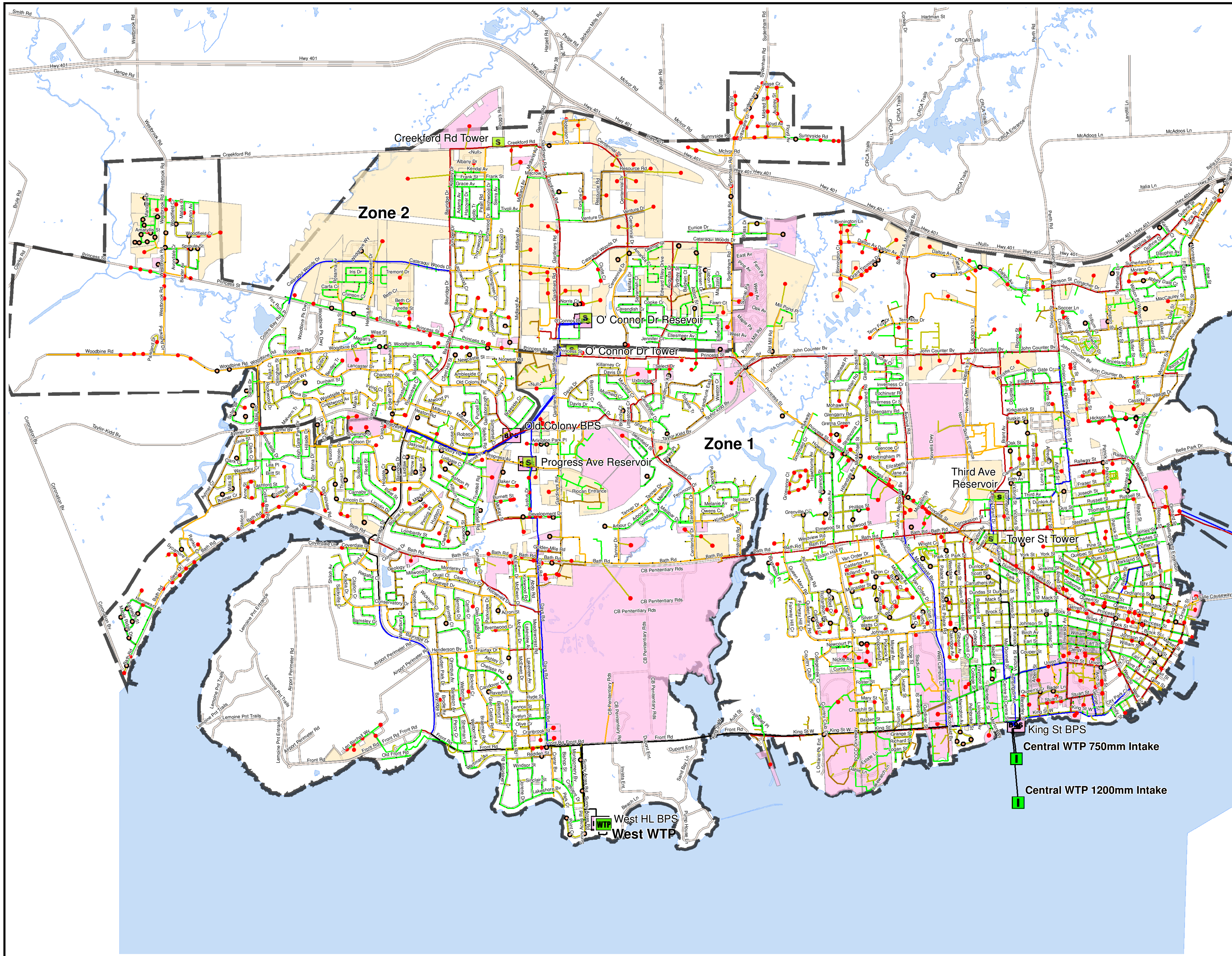
Title:
KINGSTON WATER SYSTEM - FIRE FLOW AVAILABILITY (ZONES 1 & 2)

Scenario:
2036 FUTURE (MDD+FF)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	8-1-5

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig8_1_5-WC_2036_MDD_FireFlow.mxd



WSP

1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston

UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-2026 Future Development
- Buildout Future Development

Fire Flow (Available) (L/s)

- <= 80 (Res) or 230 (ICI)
- < 100 (Res) or 270 (ICI)
- >= 100 (Res) or 270 (ICI)

Pipe: Diameter (mm)

- <= 150
- <= 200
- <= 250
- <= 300
- <= 450
- <= 600
- > 600

Scale:
0 500 1,000 1,500 m
1:42,500

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

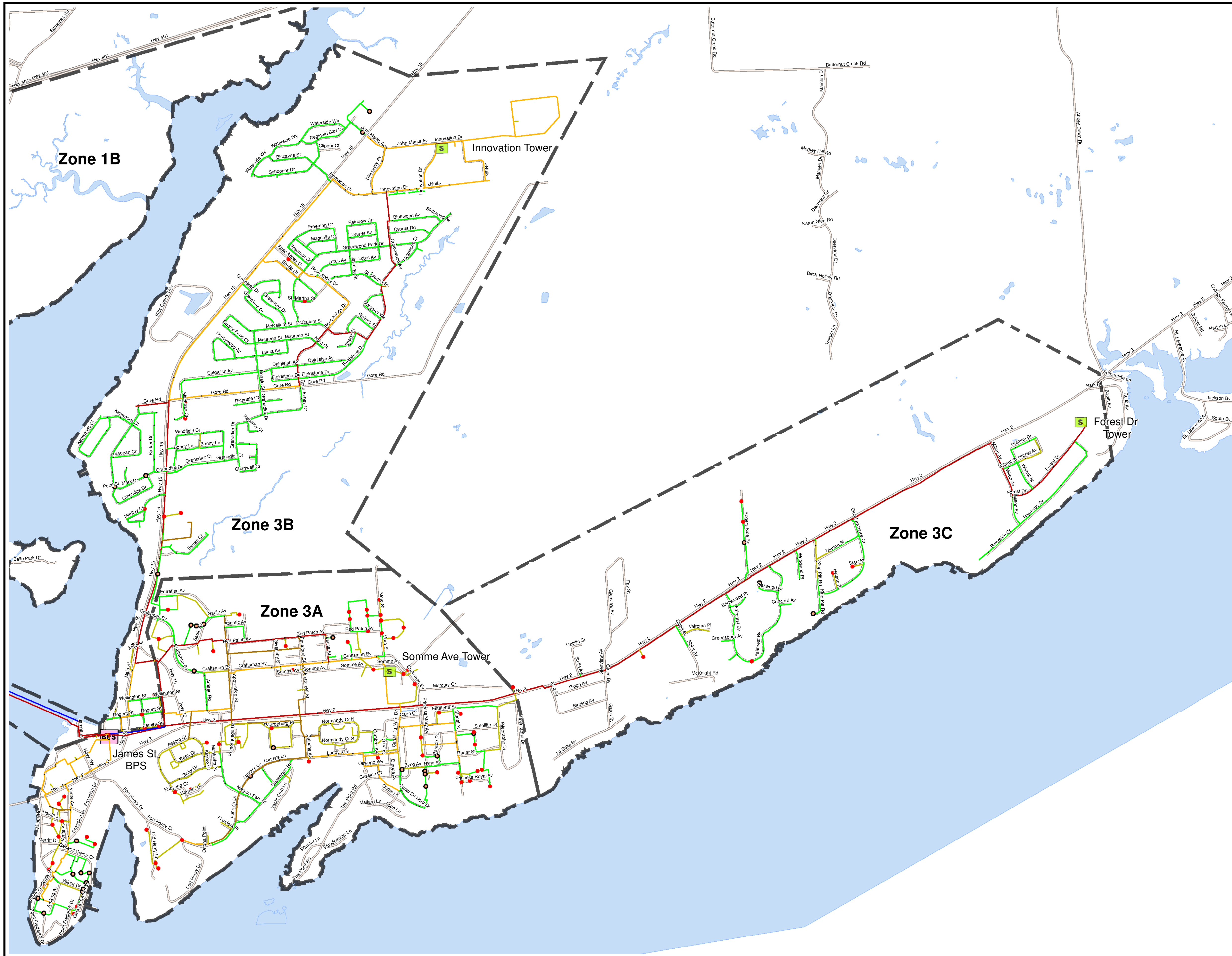
Title:
KINGSTON WATER SYSTEM - FIRE FLOW AVAILABILITY (ZONES 1 & 2)

Scenario:
FULL BUILDOUT (MDD+FF)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	8-1-6

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig8_1_6-WC_BO_MDD_FireFlow.mxd



WSP

1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston

UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- Raw Water Intake
- PressureZone
- Road
- Waterbody

Fire Flow (Available) (L/s)

- <= 80 (Res) or 230 (ICI)
- < 100 (Res) or 270 (ICI)
- >= 100 (Res) or 270 (ICI)

Pipe: Diameter (mm)

- <= 150
- <= 200
- <= 250
- <= 300
- <= 450
- <= 600
- > 600

Scale:
0 200 400 600 800 m
1:25,000

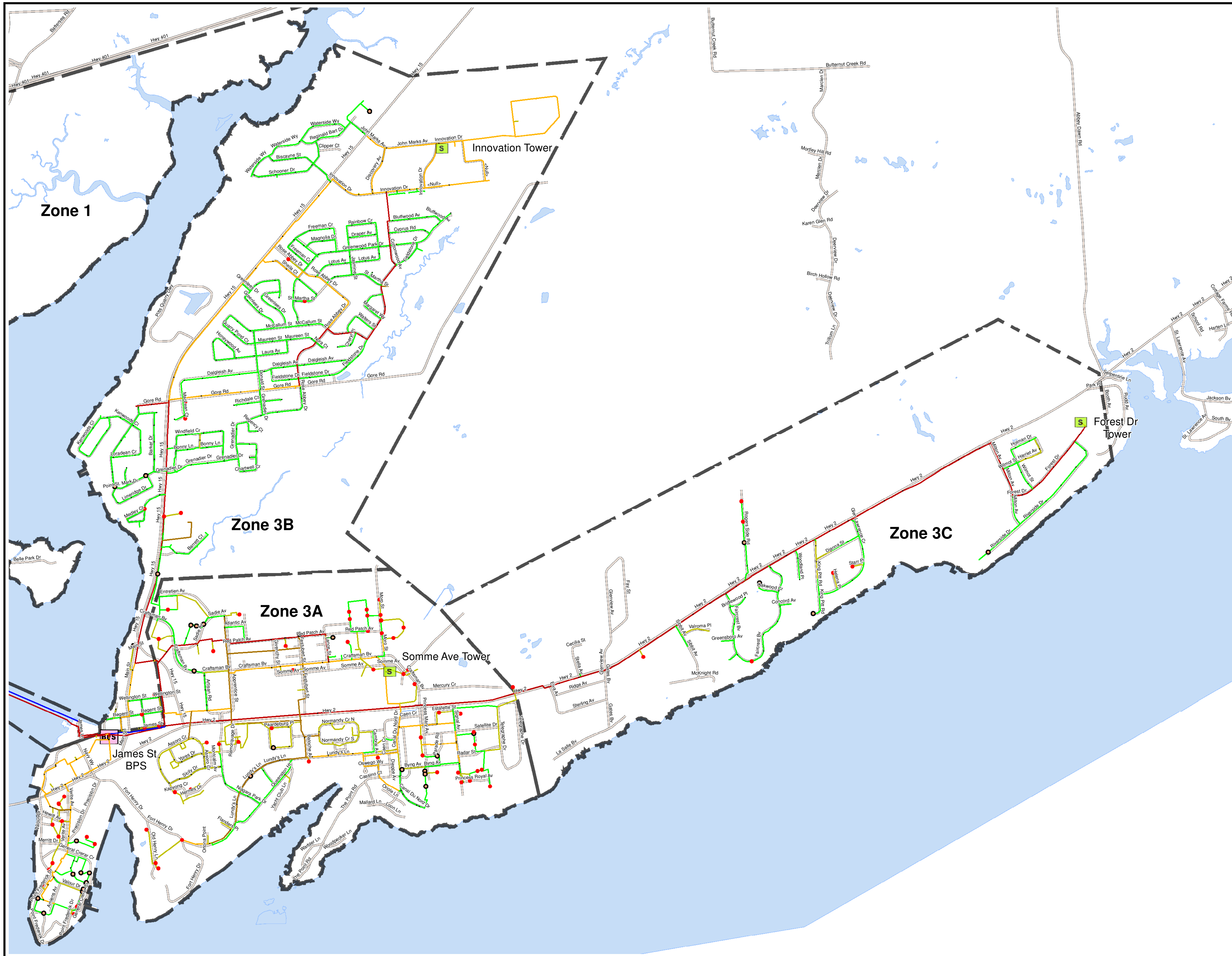
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

Title:
KINGSTON WATER SYSTEM - FIRE FLOW AVAILABILITY (ZONES 3A, 3B & 3C)

Scenario:
2015 EXISTING (MDD+FF)

Project No.:	Date:		
151-02944-00	DECEMBER 2016		
Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	8-2-1

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig8_2_1-East_2015_MDD_FireFlow.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody

Fire Flow (Available) (L/s)

- <= 80 (Res) or 230 (ICI)
- < 100 (Res) or 270 (ICI)
- >= 100 (Res) or 270 (ICI)

Pipe: Diameter (mm)

- <= 150
- <= 200
- <= 250
- <= 300
- <= 450
- <= 600
- > 600

Scale:
0 200 400 600 800 m
1:25,000

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

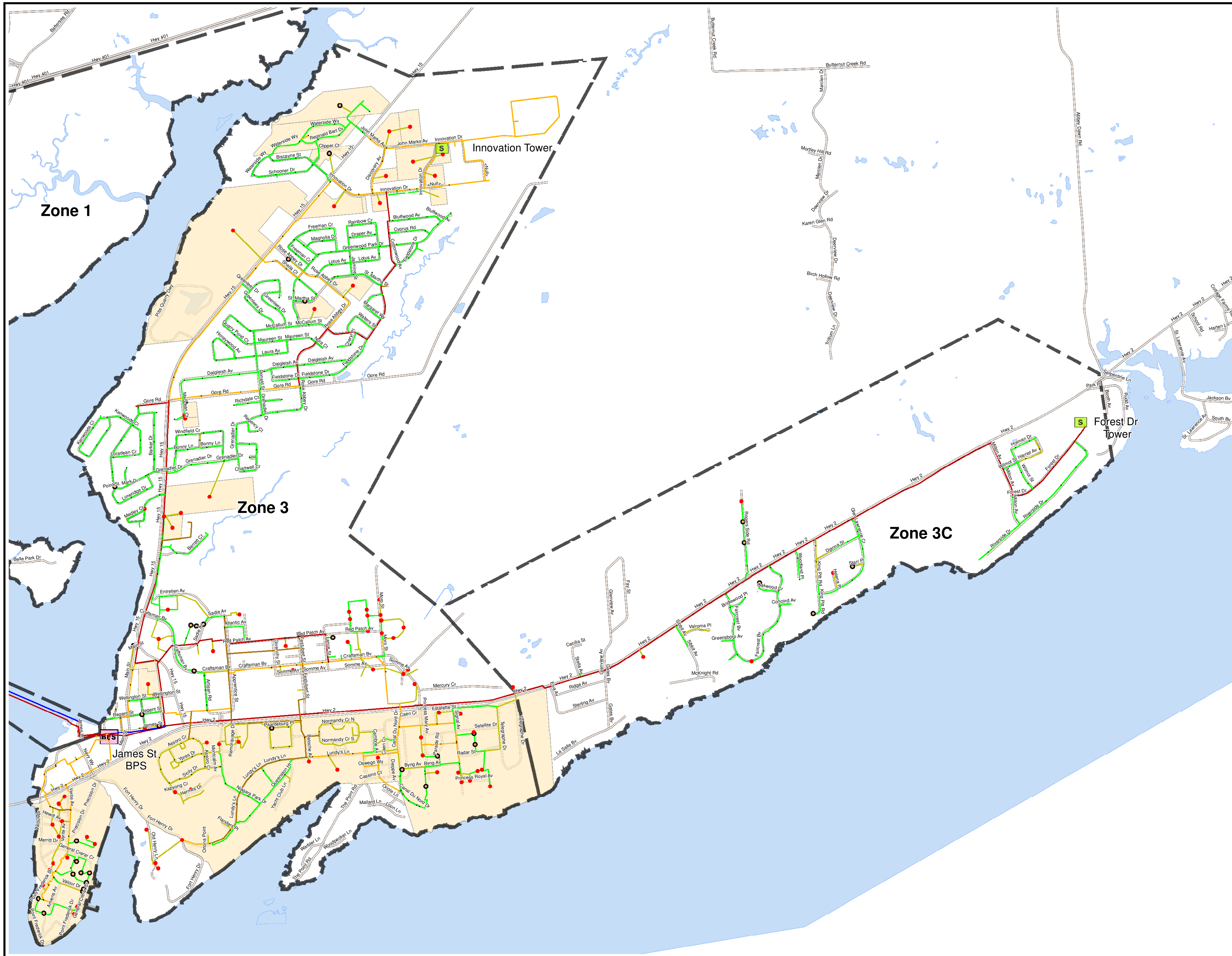
Title:
KINGSTON WATER SYSTEM - FIRE FLOW AVAILABILITY (ZONES 3A, 3B & 3C)

Scenario:
2015 INTER-CONNECTION (MDD+FF)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	8-2-2

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig8_2_2-East_2015Inter_MDD_FireFlow.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021 Future Development

Fire Flow (Available) (L/s)

- <= 80 (Res) or 230 (ICI)
- < 100 (Res) or 270 (ICI)
- >= 100 (Res) or 270 (ICI)

Pipe: Diameter (mm)

- <= 150
- <= 200
- <= 250
- <= 300
- <= 450
- <= 600
- > 600

Scale:
0 200 400 600 800 m
1:25,000

Project:
Water and Wastewater
Master Plan

City of Kingston, Ontario

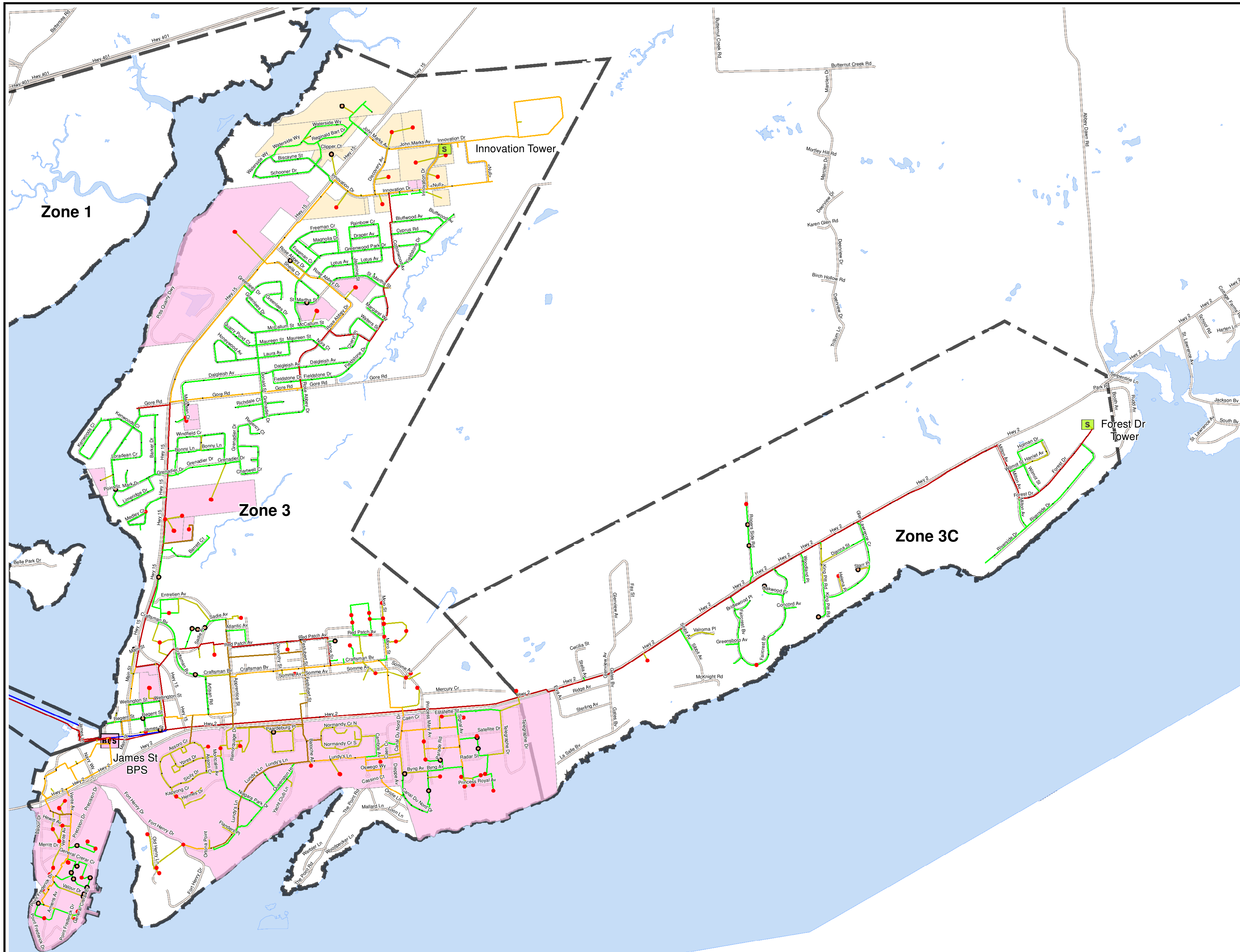
Title:
KINGSTON WATER SYSTEM -
FIRE FLOW AVAILABILITY
(ZONES 3 & 3C)

Scenario:
2021 FUTURE
(MDD+FF)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	8-2-3

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig8_2_3-East_2021_MDD_FireFlow.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021 Future Development
- 2026 Future Development

Fire Flow (Available) (L/s)

- <= 80 (Res) or 230 (ICI)
- < 100 (Res) or 270 (ICI)
- >= 100 (Res) or 270 (ICI)

Pipe: Diameter (mm)

- <= 150
- <= 200
- <= 250
- <= 300
- <= 450
- <= 600
- > 600

Scale:
0 200 400 600 800 m
1:25,000

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

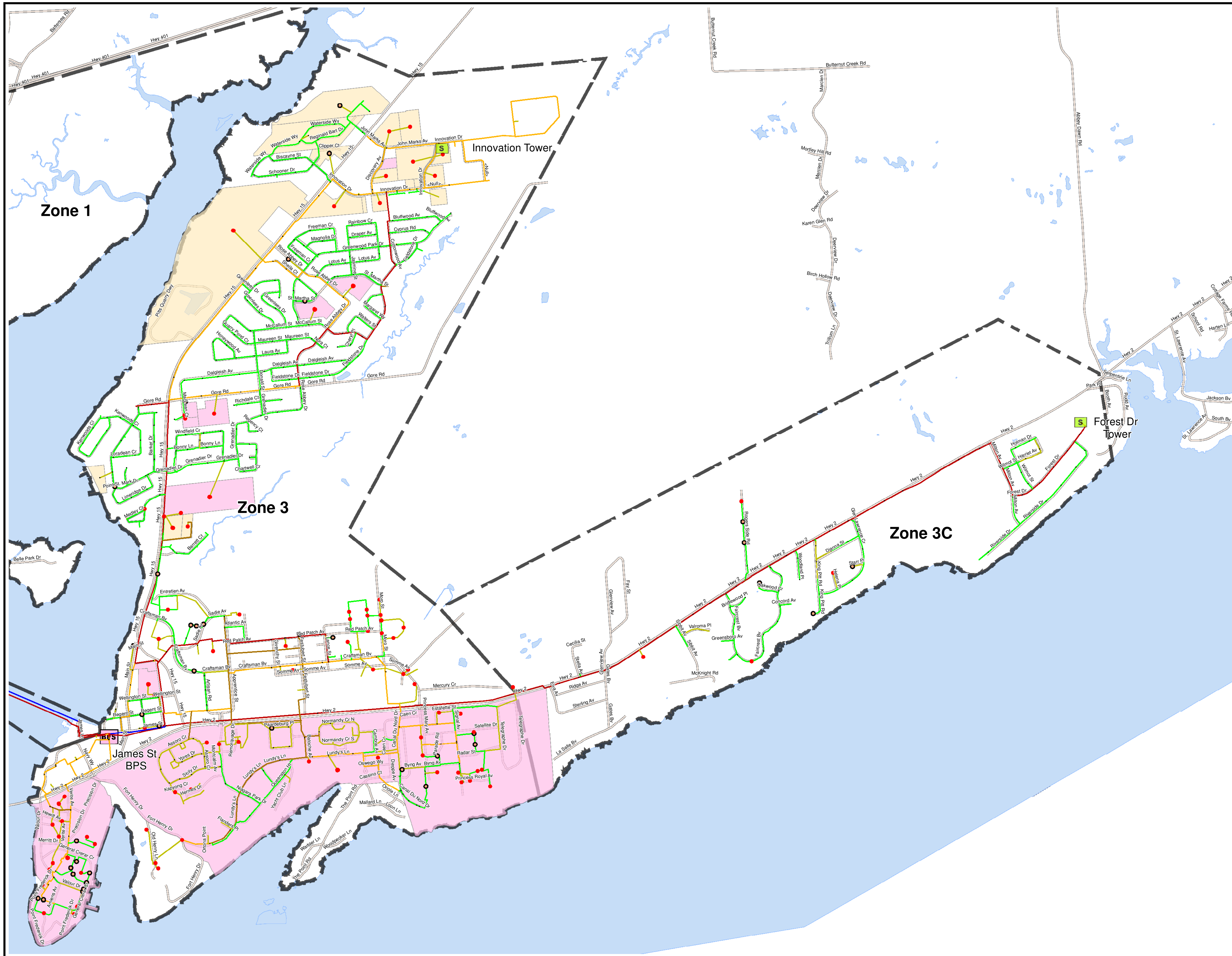
Title:
KINGSTON WATER SYSTEM - FIRE FLOW AVAILABILITY (ZONES 3 & 3C)

Scenario:
2026 FUTURE (MDD+FF)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	8-2-4

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig8_2_4-East_2026_MDD_FireFlow.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-2026 Future Development
- 2036 Future Development

Fire Flow (Available) (L/s)

- <= 80 (Res) or 230 (ICI)
- < 100 (Res) or 270 (ICI)
- >= 100 (Res) or 270 (ICI)

Pipe: Diameter (mm)

- <= 150
- <= 200
- <= 250
- <= 300
- <= 450
- <= 600
- > 600

Scale:
0 200 400 600 800 m
1:25,000

Project:
Water and Wastewater Master Plan

City of Kingston, Ontario

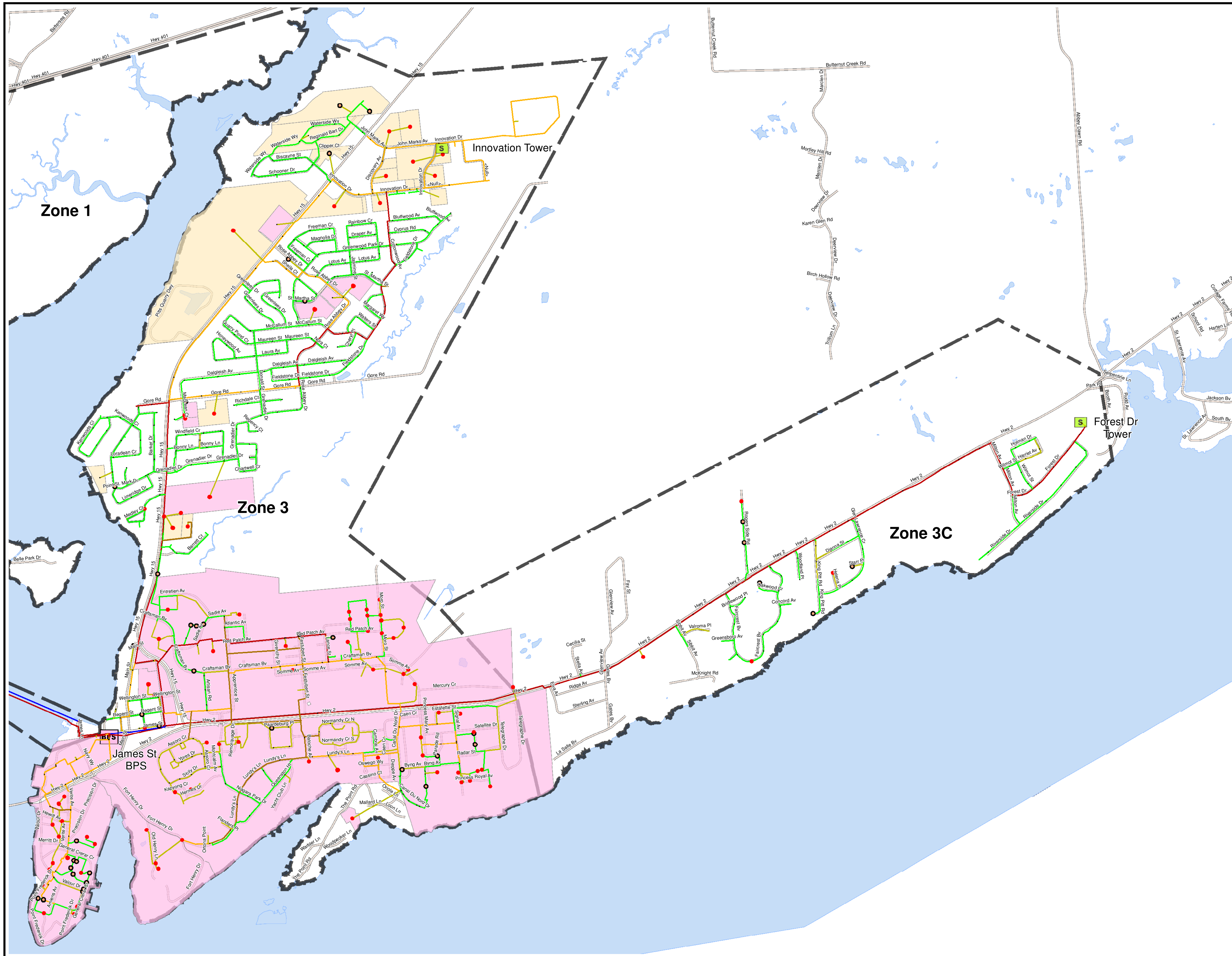
Title:
KINGSTON WATER SYSTEM - FIRE FLOW AVAILABILITY (ZONES 3 & 3C)

Scenario:
2036 FUTURE (MDD+FF)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	8-2-5

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig8_2_5-East_2036_MDD_FireFlow.mxd



WSP
1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston
UTILITIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-2026 Future Development
- Buildout Future Development

Fire Flow (Available) (L/s)

- <= 80 (Res) or 230 (ICI)
- < 100 (Res) or 270 (ICI)
- >= 100 (Res) or 270 (ICI)

Pipe: Diameter (mm)

- <= 150
- <= 200
- <= 250
- <= 300
- <= 450
- <= 600
- > 600

Scale: 0 200 400 600 800 m
1:25,000

Project: Water and Wastewater Master Plan
City of Kingston, Ontario

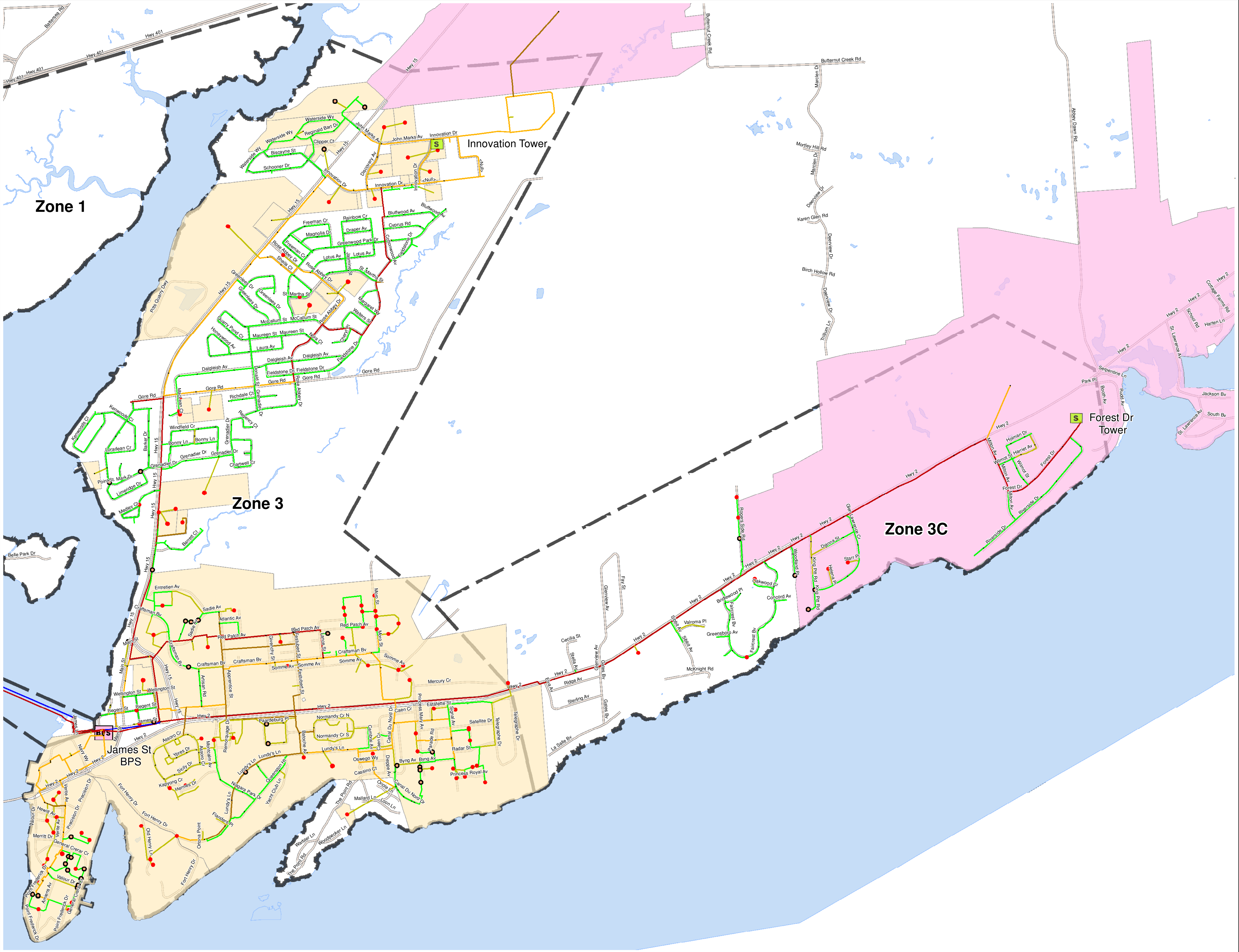
Title: KINGSTON WATER SYSTEM - FIRE FLOW AVAILABILITY (ZONES 3 & 3C)

Scenario: FULL BUILDOUT (MDD+FF)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	8-2-6

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig8_2_6-East_BO_MDD_FireFlow.mxd



WSP

1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Utilities Kingston

UTILTIES KINGSTON
P.O. BOX 790,
KINGSTON, ONTARIO,
K7L 4X7

Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
- BPS Booster Pumping Station (BPS)
- I Raw Water Intake
- PressureZone
- Road
- Waterbody
- 2021-Buildout Future Development
- Ultimate-Future Development

Fire Flow (Available) (L/s)

- <= 80 (Res) or 230 (ICI)
- < 100 (Res) or 270 (ICI)
- >= 100 (Res) or 270 (ICI)

Pipe: Diameter (mm)

- <= 150
- <= 200
- <= 250
- <= 300
- <= 450
- <= 600
- > 600

Scale:
0 200 400 600 800 m
1:25,000

Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

Title:
KINGSTON WATER SYSTEM - FIRE FLOW AVAILABILITY (ZONES 3 & 3C)

Scenario:
ULTIMATE (MDD+FF)

Project No.:	Date:
151-02944-00	DECEMBER 2016

Drawn By:	Checked By:	Code:	Figure No.:
HC	JLD	GAP	8-2-7

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.4_Gap Analysis\Water\Maps\151-02944-00_GAP_Fig8_2_7-East_ULT_MDD_FireFlow.mxd