UTILITIES KINGSTON

CITY OF KINGSTON WATER MASTER PLAN

ALTERNATIVES ANALYSIS AND REVIEW

JANUARY 30, 2017

WSP

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ALTERNATIVES ANALYSIS AND REVIEW

Utilities Kingston

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

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January 30, 2017

Ms. Katie Morrow
Utilities Kingston
1211 John Counter Blvd
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Subject : **City of Kingston Water Master Plan**

Dear : Ms. Morrow

We are pleased to provide our draft of the Water System Alternatives Analysis for the City of Kingston service areas. The purpose of this report is to identify the preferred alternatives to satisfy future demand during existing and future growth scenarios.

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

Yours truly,

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

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REVISION HISTORY

VERSION	DATE	DESCRIPTION
1	**OCTOBER 17, 2016**	Draft for Client Review
2	**JANUARY 30, 2017**	Final Report

SIGNATURES

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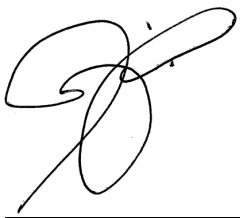

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1 INTRODUCTION

WSP was retained by Utilities Kingston to complete a Master Plan to establish servicing strategies for water infrastructure 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 presents a review of the infrastructure gaps identified in the Water Gap Analysis Report (WSP 2016) and establishes alternatives to address both existing and projected deficiencies in the water distribution system. The developed alternatives are based on the desired level of service (LOS), identified design criteria and the capacity requirements as a result of growth and development in the City.

1.1 ANALYSIS APPROACH

Alternatives have been developed based on the infrastructure deficiencies identified in the Gap Analysis Report (WSP, 2016). These deficiencies are based on the existing and projected growth scenarios being used in the Master Plan Study and assume an interconnected central pressure zone (Zone 1). The condition and LOS results from the 2036 scenario were used as the primary scenario for planned improvements and upgrades to the infrastructure, with the full build-out scenario serving as a check and balance for the recommended upgrades. The results from the 2021 and 2026 scenarios were used to identify the timing and urgency of the recommended upgrades. The ultimate scenario has been used to develop an overall strategy to help guide the servicing of these development areas with the analysis identifying high-level servicing recommendations.

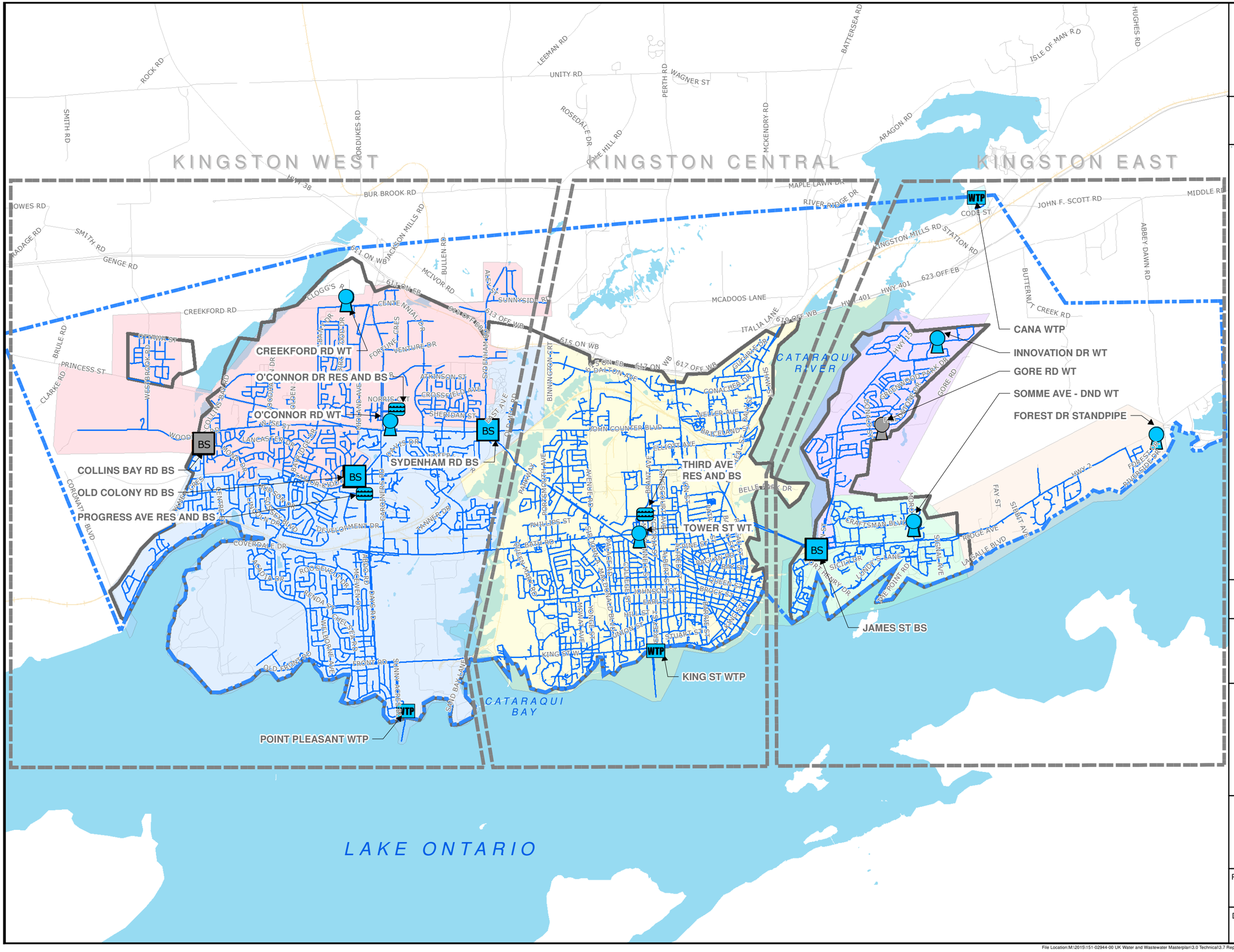
Water distribution networks are complex and intricately connected systems. Changes, operational or physical, can have an influence on system performance out to the furthest reaches of the distribution network. Infrastructure that provides a source of energy and volume to the system is used as a starting point for the evaluation; this infrastructure includes booster stations and storage tanks. Pressure, flow, headloss, leakage and available fire flow in the distribution phase are then reviewed. Discussions regarding the developed alternatives has been divided up into the various pressure zones which make up the distribution network:

1. Zone 1
2. Zone 2
3. Zone 3, 3A and 3B

Refer to Figure 1-1 below for a map of the water distribution system.

The review of alternative solutions for the system included programming of alternative scenarios into the water distribution system InfoWater model. Results from the hydraulic simulations are used to streamline the review of alternatives and to demonstrate the effectiveness of proposed recommendations

The subsequent sections further detail the development of the alternatives as well as the applied evaluation criteria. It should be noted that the evaluation of the recommended alternatives has been tailored to suit the nature and complexity of the alternative.



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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
- URBAN BOUNDARY
- AREA OF STUDY

WATER ZONE

- 1A
- 1B
- 2
- 3A
- 3B
- 3C
- CANA

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

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: CM	Checked By: MF	Code: AS	Figure No.: 1-1

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.5_Alternate Solutions\Water\Maps\151-02944-00_AS_Fig1-1_WaterSystem_Overview.mxd

2 EVALUATION AND ALTERNATIVES OF INFRASTRUCTURE

As detailed in the Gap Analysis Report (WSP, 2016) the water distribution system was evaluated using multiple scenarios to predict the effect of growth and development on the infrastructure. The approach applied to developing alternatives was to determine servicing requirements for the 20-year development projection (2036) and progressively work backward through the other analysis periods. This ensures that upgrades scheduled in 2026 or 2021 would not need to be revised to meet future requirements.

INFRASTRUCTURE	TYPE	PRESSURE ZONE	YEAR DEFICIENCY STARTS	COMMENT
East Storage	Storage	Zone 3	2021	→ Functional storage deficiency is observed starting in 2021. → By 2026 1,121m^3 of functional storage is required to be added.
Central Storage	Storage	Zone 1	2036	→ Functional storage deficiency is observed starting in 2036. → By 2036 1,212m^3 of functional storage is required to be added.
Low Pressure - Around Third Ave.	Distribution	Zone 1	2015	→ The area near the Third Ave Reservoir and Tower St Tower had some pressures between 37 and 39 psi. → These low pressures are partially due to the higher elevations in that area corresponding to pressure about 39psi during static (zero-flow) conditions with the Tower at overflow elevations.

INFRASTRUCTURE	TYPE	PRESSURE ZONE	YEAR DEFICIENCY STARTS	COMMENT
Low Pressure – Near Princess and Futures Gate	Distribution	Zone 1	2015	→ Low Pressure is observed near the intersection of Princess St. and Futures Gate.
Low Pressure - Bayridge Dr. and Taylor Kidd Blvd	Distribution	Zone 1	2015	→ Low pressure observed. → Pressure below 40psi (33 – 39psi)
High Pressure – Near James St. Booster Station	Distribution	Zone 3	2015	→ High pressures (<109psi) were seen around the James St Booster Station mainly due to the topography of the area.
High Pressure – Near Gore St.	Distribution	Zone 3 B	2021	→ During the 2021 scenario, the control parameters change due to the removal on the CFB Tower and therefore James St Booster Station is controlled by the Innovation EST.
Low Fire Flows in Westbrook Area	Distribution	Zone 2	2015	→ There is a cluster of noted where the available fire flow is less than the required LOS
Low Fire Flows - Princess between Woodhaven and Bayridge	Distribution	Zone 1	2015	→ There is a cluster of nodes where the available fire flow is less than the required LOS
Low Fire Flows - Area near Coronation Blvd.	Distribution	Zone 1	2015	→ There is a cluster of nodes where the available fire flow is less than the required LOS

INFRASTRUCTURE	TYPE	PRESSURE ZONE	YEAR DEFICIENCY STARTS	COMMENT
Low Fire Flows - Sydenham Rd. North of 401.	Distribution	Zone 1	2015	→ There is a cluster of nodes where the available fire flow is less than the required LOS
Low Fire Flows - Dalton Ave. West of Sir. John A. Blvd.	Distribution	Zone 1	2015	→ There is a cluster of nodes where the available fire flow is less than the required LOS
Low Fire Flows - Dalton Ave. West of Division St.	Distribution	Zone 1	2015	→ There is a cluster of nodes where the available fire flow is less than the required LOS
Low Fire Flows - Balsam Grove	Distribution	Zone 1	2015	→ There is a cluster of nodes where the available fire flow is less than the required LOS
Low Fire Flows - Calvin Park	Distribution	Zone 1	2015	→ There is a cluster of nodes where the available fire flow is less than the required LOS
Headloss above 3m/km – Various locations	Distribution	All Zones	2015	→ There are various pipes in the distribution system which experience high headloss
Leakage – Various Locations	Distribution	All Zones	2015	→ Leakage is experienced at various locations throughout the distribution system
Reliability – Various locations	All	All Zones	2015	→ There are various areas in the distribution system serviced by a single feed

2.1 PROCESS FOR THE EVALUATION OF ALTERNATIVES

2.1.1 APPROACH TO EVALUATION OF ALTERNATIVES

The water distribution system servicing alternatives were evaluated using the natural, social, cultural, technical and economic criteria. These criteria are applied using an evaluation matrix to assess the impacts and determine the preferred solution objectively.

This evaluation approach used to determine the preferred servicing solutions for the identified issues is explained below:

- **Step 1: Determine Evaluation Criteria** - Evaluation criteria for this project will include (1) impact on the natural environment, (2) impact on the social and cultural environments, (3) technical & operational merit, and (4) financial & economic impact. The individual impacts will typically fit into these four general categories. A breakdown of the impacts included under each criterion is defined in the section below.

- **Step 2: Create an Evaluation System -** In order to be impartial, this system was developed prior to determining the potential impacts associated with each alternative. During the evaluation, each of the alternatives was assigned a colour rating: green for “preferred,” yellow for “less preferred” and orange for “least preferred,” for each of the evaluation criterion. The colour rating reflected how the alternative performs with respect to that criterion. The four evaluation categories were assigned equal weighting as they were considered to have equal importance in the evaluation.

- **Step 3: Document Potential Impacts** - The individual impacts associated with each alternative were determined and documented. These impacts were categorized under one of the four categories of evaluation criteria described above.

- **Step 4: Evaluate the Alternatives** - Each of the alternatives was assigned a colour rating for each of the four evaluation criteria using the methodology established in Step 2. The evaluation was based on a qualitative assessment of the individual impacts documented in the table created during Step 3.

- **Step 5: Determine the Preferred Alternative** - The servicing alternative with the least overall impact was recommended for implementation.

Gaps that have been identified which have an existing servicing strategy and common or standard alterations (i.e. pipe is too small, upsize pipe; booster station doesn’t pump enough, increase pumping capacity) were determined based strictly on the technical merits to eliminate the gap.

2.1.2 EVALUATION METHODOLOGY

In order to qualitatively evaluate the servicing alternatives, each of the criteria presented in the section below were assessed in a descriptive manner rather than a quantitative manner. Rather than having a numerical or weighted ranking system, the evaluation focuses instead on the strengths and weaknesses of each servicing alternative to identify the preferred alternative. For each evaluation criterion and for each system alternative, the potential effects on the environment were identified and evaluated relative to the other alternatives as being most preferred, less preferred and least preferred. The evaluation is based on the relative advantages and disadvantages of the potential environmental effects of each alternative. A more detailed breakdown of the specific criteria for each category is listed below:

NATURAL ENVIRONMENT CONSIDERATIONS

- Natural Features
- Watercourses and Aquatic Habitat
- Natural Heritage Areas
- Areas of Natural and Scientific Interest (ANSI)
- Designated Natural Areas

SOCIAL AND CULTURAL ENVIRONMENT CONSIDERATIONS

- Proximity of Facilities to Residences, Businesses, and Institutions
- Public health
- Archaeological and Cultural Features
- Designated Heritage Features
- Wells or Wellhead Protection Areas
- Consistency with Land Use Designations, Approved Development Plans, and Proposed Land Use Changes

TECHNICAL SUITABILITY AND OPERATIONAL SUITABILITY

- Design and Constructability
- Maintaining or Enhancing Drinking Water Quality
- Security of System
- Ease of Connection to Existing Infrastructure & Ease of Modifications Required to Existing Infrastructure
- Operations and Maintenance Requirements

FINANCIAL & ECONOMIC CONSIDERATIONS

- Operations and Maintenance Costs
- Total Capital Costs

2.2 OVERVIEW OF SYSTEM ANALYSIS

The main tool used to evaluate alternative solutions is the InfoWater hydraulic model which was previously calibrated and used in the Gap Analysis. This model was updated with new scenarios to represent conditions with planned capital projects and upgraded infrastructure in order to demonstrate impacts to the water distribution system. Details regarding the programming of the alternative scenarios into the model are described in the Water Distribution System Hydraulic Modelling Report (WSP, 2016). As the water system is intricately connected some of the alternatives are modeled simultaneously; as they can have both negative and positive impacts on the results. For example increasing the hydraulic grade line (HGL) in a storage tank can increase storage and improve low pressures; it can also create high-pressure areas. Operational changes are always considered first before any capital upgrades due to their low cost to implement and the limited impact to the public and environment.

3 TREATMENT

The water treatment plants were reviewed in the gap analysis, and it was determined that the existing system has sufficient capacity to service the projected population to 2036. This is due in large part to the recent upgrade complete at the Point Pleasant water treatment plant as outlined in the previous Master Plan. Alternatives to the existing treatment facilities serving the City of Kingston have not been reviewed further. Additionally, no reliability or operational concerns have been identified by Utilities Kingston.

4 FACILITIES EAST ZONE (PRESSURE ZONE 3A, 3B AND 3C)

4.1 IDENTIFIED GAPS AND ALTERNATIVES - ZONE 3

In the east system, the primary deficiency that was observed was a functional storage deficiency developing in 2021 which occurs once the CFB Kingston EST is taken offline. By 2036, the functional storage deficiency is projected to reach 1,121 m^3 increasing from 536 m^3 and 847 m^3 in 2021 and 2026, respectively. The observed storage deficiency is partially a result of the operation of the system. Innovation EST has an elevation which does not permit its full use based on the tanks construction and the topography of the pressure zone. In order to avoid over pressuring the system to fill the tower, the maximum fill level in the tower is reduced. If the full storage capacity in Innovation EST is used, it is suspected that the functional storage deficiency can be corrected. However, increasing the HGL will likely result in a high pressure south of Gore Rd where the topography is lower and higher pressures are currently observed. In addition to the storage deficiency, Utilities Kingston Staff have also noted operational issues with Forest Dr. standpipe which includes water quality issues and freezing. Several alternatives to correct these issues have been evaluated. They have been separated into two analysis. One to resolve the storage deficiency and high pressure areas and a second to review the operational and water quality issues at Forest Dr. Standpipe.

1. Storage Deficiency and High Pressure in Zone 3

   Alternative 1 - Optimize Innovation EST and Forest Dr. Standpipe to maximize storage while not over pressurizing the system.

   Alternative 2 New pressure zone for area north of Gore Rd. with new booster station fed from Zone 1 (new feed to cross with 3rd crossing bridge) or Zone 3.

   Alternative 3 New subzone for the high-pressure area near Gore Rd. Using PRVs to reduce pressure to the local area.

2. Operational and Water Quality Concerns at Forest Dr. Standpipe

   Alternative 1 Consider elimination of Forest Dr. Standpipe with the implementation of the preferred alternative to storage deficiency and high pressure in Zone 3

   Alternative 2 – Maintain Forest Dr. Standpipe in operation with the implementation of the preferred alternative to Storage Deficiency and High Pressure in Zone 3

4.2 STORAGE DEFICIENCY AND HIGH PRESSURE IN ZONE 3

4.2.1 ALTERNATIVE 1 – OPTIMIZE INNOVATION ELEVATED STORAGE TANK AND FOREST DRIVE STANDPIPE HYDRAULIC GRADE LINE

This alternative involves adjusting the level in Innovation EST and Forest Dr. Standpipe to maximize the available storage in Zone 3 while ensuring that high pressures do not develop in the low-lying areas. Some of the service areas have elevations as low as 81.00m. It is undesirable to have pressures exceeding 100 PSI at nodes in the distribution system. Under static conditions, this would permit the elevation in the tower to have a maximum HGL of 151.28m without causing over pressure in the system. However, this does not account for the head loss that needs to be overcome in order to fill the tower. Table 4-1 below details the current operational levels of the elevated storage in the East zone.

Table 4-1 Existing Operational Levels in East Elevated Storage

	GROUND ELEV. (M)	HIGH LEVEL (M)	LOW LEVEL (M)	TYPICAL LOWER LIMIT (M)	TYPICAL UPPER LIMIT (M)	FUNCTIONAL STORAGE (M^3)
Innovation	105.7	151.3	139.2	144.8	147.4	1,502
Forest Rd	104.2	150.0	143.2	143.7	149.2	212

From the table above it can be observed that there is room in Innovation EST to make better use of the available storage. Forest Dr. Standpipe. does not have any room to increase the functional storage. The table below details the operational levels to obtain the required increase in functional storage for each analysis period. Using the hydraulic model, the fill level in Innovation EST was iteratively adjusted until storage was maximized and no pressures above 100 PSI were observed in the pressure zone. The water level that corresponded to acceptable pressures was 147.5m which is not significantly different from current operational levels and does not add significant storage.

Table 4-2 Adjusted Levels in Innovation EST

	GROUND ELEV. (M)	HIGH LEVEL (M)	LOW LEVEL (M)	TYPICAL LOWER LIMIT (M)	TYPICAL UPPER LIMIT (M)	FUNCTIONAL STORAGE (M^3)	FUNCTIONAL STORAGE INCREASE (M^3)
Innovation (2015)	105.7	151.3	139.2	144.8	147.4	1,502	0
Innovation (2021)	105.7	151.3	139.2	144.8	148.3	2,038	536
Innovation (2026)	105.7	151.3	139.2	144.8	148.9	2,349	847
Innovation (2036)	105.7	151.3	139.2	144.8	149.3	2,623	1,121
Innovation (Max)	105.7	151.3	139.2	144.8	150.4	3,235	1,733

From the results, it can be concluded that Innovation EST, when used to its full potential can address the functional storage deficiency projected for 2036 of 1,121m^3. However filling Innovation EST to this elevation does cause areas of concern due to high-pressure west of Highway 15 between Medley Ct. and Gore Rd.

4.2.2 ALTERNATIVE 2 – NEW PRESSURE ZONE AT GORE ROAD

Alternative 2 involves isolating the area north of Gore Rd. into a new pressure zone (Zone 4). A new booster station would be required to pump the water into Zone 4. Innovation EST would serve as the storage for this zone and would be isolated from Zone 3. In this configuration, Innovation EST would be significantly oversized for the population and business served in Zone 4. This isolation would also create a larger storage deficiency in Zone 3, resulting in the requirement for a new storage tank to be added to Zone 3. With the addition of storage in Zone 3, the functional storage deficiency can be addressed, and the system can be operated in a similar manner as it is today with the CFB Kingston tower which avoids high pressures. Adding a pressure zone, a booster station, and a tower would result in increased complexity to

the system, as well as significant capital and operational cost. A cursory cost/benefit analysis indicated that this solution would add additional complexity and cost to the system without a commensurate benefit. Based on the above this alternative was not reviewed further as it did not provide a reasonable solution to address the problem.

4.2.3 ALTERNATIVE 3 – NEW SUBZONE NEAR GORE ROAD

Alternative 3 builds on observations made during the analysis of Alternative 1. Alternative 3 involves increasing the HGL in Innovation EST to take full advantage of the available storage and creating a subzone to isolate the identified high-pressure area in the existing pressure zone. This area will be isolated with the use of three PRVs and isolating several local connections. In addition to the PRVs, a new 500mm watermain will be required to extend through the subzone along Highway 15 starting north of Wellington St. North to Gore Road. This main will by-pass the subzone to continue providing flow and pressure to the area north of Gore Rd.

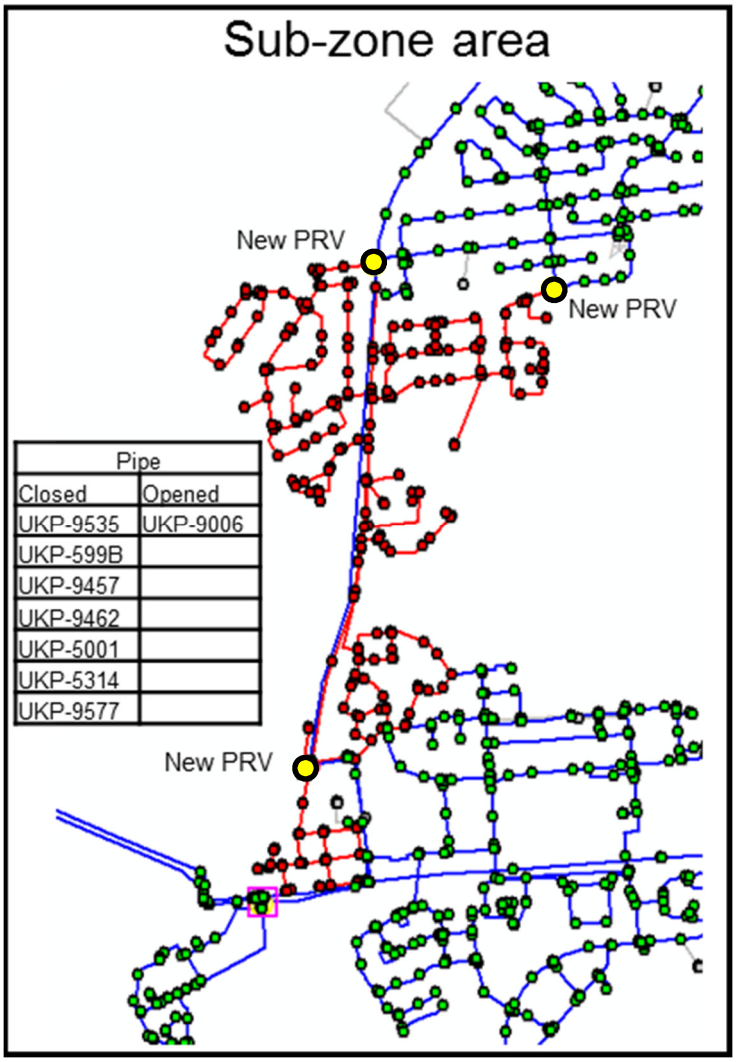


Figure 4-1 Zone 3 Alternative 3 – Proposed Subzone

Adjusting the operational levels in Innovation EST increases the functional storage to 3,177 m^3 which resolves the projected deficiency in 2036. The hydraulic model was used to evaluate the impacts of the increased HGL on the pressure zone and sub-zone. The increased HGL does increase the overall pressure in the zone, however through the implementation of the new subzone, the available pressure in the low-lying area south of Gore Rd. is restricted to levels consistent with the MOE guidelines. Flows and pressures during Average Day, Min Day, Peak Hour and Fire Flow are all within the desired level of service.

4.2.3.1 EVALUATION OF EAST STORAGE ALTERNATIVES

Table 4-3 Evaluation East Storage Alternatives

	Do nothing	Alternative 1 – Optimization of Innovation EST & Forest Standpipe	Alternative 3 – Fill Innovation, New Subzone & New Watermain
Natural Environmental Considerations			
Impacts to Animal & Vegetative Features	• None	• None	• Minor impact anticipated; work to remain within Right of Way (R.O.W.) • Some Impact on Vegetation or Green Space
Impacts to Water Course	• None	• None	• None
Natural Environment Overall Rating	No Impact to Natural Environment	• No Impact to Natural Environment	• Minor Impact to the Natural Environment
Social and Cultural Environmental Considerations			
Number of People Disrupted in Community	• Users in the East System will start experiencing storage deficiencies by 2021.	• Users in the East System will start experiencing storage deficiencies by 2021	• Upgrade would affect a moderate number of people through intermittent service disruptions during construction.
Traffic Disruption	• None	• None	• Construction of potential upgrades would have disruption to local traffic • Construction can likely be coordinated with the reconstruction of Highway 15
Social Disruption	• Insufficient volume of water	• Insufficient volume of water	• Minor disruption to EMS due to traffic / construction detour

	Do nothing	Alternative 1 – Optimization of Innovation EST & Forest Standpipe	Alternative 3 – Fill Innovation, New Subzone & New Watermain
Social/Cultural Environment Overall Rating	Insufficient water to satisfy requirements for public health and safety	Insufficient water to satisfy requirements for public health and safety	Inconvenience due to construction activities
Technical Suitability			
Level of Service	• Does not provide a solution which meets or exceeds the required level of service	• Can only satisfy required storage until decommissioning	• Ensures pressure is within required MOE limits for system users • Maximizes use of Innovation EST.
Complexity of Implementation and construction of Alternative	• None	• Modification of operational levels in Innovation EST • Monitoring of pressure in areas of lower elevation	• Construction of a new watermain extending along highway 15 • New chambers to house PRVs • New subzone and PRVs require maintenance and monitoring
Full Build-out	• Alternative cannot satisfy required storage increase of 1,303m^3 to satisfy full build-out	• Alternative cannot satisfy required storage increase of 1,303m^3 to satisfy full build-out	• Alternative can satisfy required storage increase of 1,303m^3 to satisfy full build-out
Technical/Operational Rating	Not suitable as technical criteria are not satisfied.	Not suitable as technical criteria are not satisfied.	More complex implementation. Meets long term requirements and desired level of service. Opportunity to couple with near term roadway improvement project.
Financial Considerations			
Operational/Maintenance Costs	• No operational and maintenance costs above current levels	• No operational and maintenance costs above current levels	• Minimal operational and maintenance above currently levels • Minor additional energy costs (i.e. energy wasted to reduce pressure to sub-zone)

	Do nothing	Alternative 1 – Optimization of Innovation EST & Forest Standpipe	Alternative 3 – Fill Innovation, New Subzone & New Watermain
Capital Costs (incl. Constructability Risk)	• None	• None	• Significant capital cost for new waterman and chambers for PRVs • Minor constructability risk (common type of work)
Financial Overall Rating	No change to current financials	No change to current financials	Moderate capital cost and minimal increase in operational costs
OVERALL PREFERENCE RATING	**3 – Least Preferred**	**2 – Less Preferred**	**1 - Preferred**

4.2.3.2 RECOMMENDATION

Based on the evaluation above, it recommended that Alternative 3 be implemented. The other two alternatives fail to satisfy the longer term technically requirements. Alternative 3 provides the best long-term solution to ensure a satisfactory level of service. Additionally, with the City of Kingston currently in the planning stages to complete a widening along a significant section of the proposed watermain alignment, there is potential for significant cost savings to implement this project if the two projects can be completed concurrently.

TIMING

The identified storage deficiency is observed beginning in 2021 and is a function of Development in the east, and CFB Kingston elevated storage being decommissioned. It is recommended to implement Alternative 3 before 2021.

The noted City of Kingston road widening is expected to be implemented by 2018. It is recommended that as a minimum, the watermain along Highway 15 be installed in conjunction with this project to reduce the overall capital cost.

4.3 OPERATIONAL AND WATER QUALITY CONCERNS AT FOREST DR. STANDPIPE

4.3.1 ALTERNATIVE 1 – DECOMMISSION FOREST DR. STANDPIPE

Alternative 1 considers the decommissioning of Forest Dr. standpipe with the implementation of Alternative 3. Forest Dr. standpipe is an older storage facility built in 1981 which currently has operational limitations. Forest Dr is a standpipe that experiences water quality issues and ice damage regularly due to its configuration. In 2036 a functional storage deficiency of 1,121 m^3 is projected while the east pressure zone does have a 2,301 m^3 surplus of total storage. Forest Dr. currently provides 200 m^3 of functional storage and 1,770 m^3 of total storage. It was determined that Innovation EST has the ability to add 1,733m^3 of functional storage which is sufficient to overcome the projected deficiency and replace the volume lost through decommissioning Forest Dr. There is also sufficient surplus total storage to permit its decommissioning based on required storage volumes in 2036.

The hydraulic model was used to evaluate the impact of decommissioning Forest Drive on the hydraulic performance of the distribution phase. There were very limited changes to LOS noted during Average Day, Peak Hour and Min Hour upon decommissioning of Forest Dr. However there was a notable change in the available fire flow at the far eastern extent of the distribution system as well as various other locations in Zone 3.

4.3.2 ALTERNATIVE 2 – MAINTAIN FOREST DR. STANDPIPE

The second alternative considered was to maintain Forest Dr. Standpipe. Although the facility has operational issues is does provide other benefits to the system. These benefits include providing a source of water near the eastern extend of the system to an area which is currently fed by a single feed as well as helping maintain pressure in the far reach of the system.

4.3.2.1 EVALUATION OF ALTERNATIVE

Table 4-4 Evaluation Decommission Forest Drive Standpipe

	Alternative 1 – Decommission Forest Standpipe	Alternative 2 – Maintain Forest Standpipe
Natural Environmental Considerations		
Impacts to Animal & Vegetative Features	• Minor impact anticipated; work to remain within the existing developed facility. • Some Impact on Vegetation or Green Space	• None
Impacts to Water Course	• None	• None
Natural Environment Overall Rating	Minor Impact to the Natural Environment	No Impact to Natural Environment
Social and Cultural Environmental Considerations		
Number of People Disrupted in Community	• Users near the east extent of the system would have lower fire flow rates	• None
Traffic Disruption	• None	• None
Social Disruption	• Lower fire flows for EMS	• None
Social/Cultural Environment Overall Rating	Moderate Impact to Social/Cultural Environment	None
Technical Suitability		

	Alternative 1 – Decommission Forest Standpipe	Alternative 2 – Maintain Forest Standpipe
Level of Service	• Limited impact on daily use. • Notable Impact on available fire flow to nodes further east in the distribution system • Reduced reliability due to single feed along highway 2	• Current level of service for storage is exceeded • Fire flows are in a reasonable range • Water quality issues are experienced due to low demand volumes • Provides reliability in the event of a watermain break along highway 2.
Complexity of Implementation and construction of Alternative	• Demolition of an existing storage facility.	• None
Full Build-out	• Will result in additional storage being required by full build-out	• Reduces additional storage required by full build-out
Technical/Operational Rating	Less desirable as a result of the decrease in available fire flow to users and reduced reliability	Utilities Kingston will need to continue additional operational effort to maintain water quality however overall LOS will remain unchanged. Acceptable
Financial Considerations		
Operational/Maintenance Costs	• Reduced operational and maintenance costs from current levels	• No operational and maintenance costs above current levels
Capital Costs (incl. Constructability Risk)	• Moderate capital cost to decommission standpipe • Moderate constructability risk (common type of work)	• None
Financial Overall Rating	Moderate capital cost and minimal reduction in operational costs	No change to current financials
OVERALL PREFERENCE RATING	**1 - Preferred**	**1 - Preferred**

4.3.2.2 RECOMMENDATION

From the analysis above it can be concluded that aside from storage, the facility does provide other benefits to the system. The facility is located near the eastern extent of the distribution system which is serviced by a single feed along Highway 2. Currently, in the event of a pipe break on the single feed, water can still be provided from Forest Dr. If Forest Dr. were decommissioned this redundancy and reliability would be lost, and the eastern extent of the system would be without pressure and water. Overall decommissioning this facility would result in a reduced level of service for users and is not recommended.

5 FACILITIES CENTRAL & WEST ZONE (PRESSURE ZONE 1 AND ZONE 2)

5.1 IDENTIFIED GAPS AND ALTERNATIVES - ZONE 1 AND 2

There were no gaps identified for Zone 2 in the Gap Report however, there were two observations made for Zone 1.

- → The first being that there is an excess of total storage and boosting capacity in the zone and
- → The second being that a functional storage deficiency develops by 2036.

Reducing the amount of excess storage can have benefits to the system by reducing operational and maintenance costs, however, it can also reduce the operational flexibility for the zone. Given the amount of excess total storage, it is suspected that by changing operational levels in the existing reservoirs in the zone, this deficiency can be corrected. Another approach to correct the functional storage deficiency would be to add more storage; this is not considered as it would involve significant capital investment and increase the amount of infrastructure to maintain and operate when it is not believed to be required. A list of alternatives is presented below which aim to reduce the excess total storage and increase the functional storage in the pressure zones. One or more alternatives may be selected to optimize the operation and available storage in the zone. Facilities considered for decommissioning are those which are suspected of providing limited benefit to the system based on observations by operations staff and a preliminary analysis in the hydraulic model.

1. Adjust operational levels in Third Ave. Reservoir to correct functional storage deficiency
2. Decommission Sydenham Rd. Booster Station and Old Colony Booster Station to reduce the amount of excess boosting capacity
3. Decommission O'Conner Tower to reduce the volume of excess storage
4. Decommission Progress Ave to reduce the volume of excess storage

5.1.1 ALTERNATIVE 1 – ADJUST OPERATIONAL LEVELS IN THIRD AVE. RESERVOIR

Growth and development are projected to cause a shortfall of 1,212 m^3 of functional storage in the Zone 1 by 2036. Third Ave. is a large reservoir with a capacity of 22,700 m^3 and is currently operated with a functional storage of 13,000 m^3. The reservoir has an approximate cross-sectional area of 3,900 m^2. Typical operational levels in the reservoir range from 2.2 m to 5.6 m, by increasing the range of operation by 0.5 m the functional storage deficiency can be corrected. The typical operational range would be revised to 1.7 m - 5.6 m increasing the functional storage by approximately 2,000 m^3 to a total of 15,000 m^3. This alternative is able to correct the deficiency with virtually no external impact; it is not reviewed further for this reason.

5.1.1.1 RECOMMENDATIONS

Revising the operational levels is the preferred solution to correct the functional storage deficiency.

5.1.2 ALTERNATIVE 2 - DECOMMISSION SYDENHAM RD. BOOSTER STATION AND OLD COLONY BOOSTER STATION

As a result of the excess boosting capacity that exists in Zone 2, alternatives to reduce the amount of boosting capacity were considered. Sydenham Rd. and Old Colony Booster Station were identified in the last Master Plan to be eliminated. Utilities Kingston has also indicated that they suspect these two stations are not providing much benefit to the system. Eliminating these booster stations would reduce excess boosting capacity as well as operation and maintenance costs for the system.

Booster stations and storage are interconnected. Decreasing the amount of boosting capacity reduces the surplus storage. Reducing the amount of storage reduces the amount of excess boosting capacity. The following tables detail the resulting impact on the required storage volumes and boosting capacities.

Table 5-1 Boosting Capacity Reduction Zone 1

STATION	PUMP # 1 (ML/DAY)	PUMP #2 (ML/DAY)	TOTAL CAPACITY (ML/DAY)	FIRM CAPACITY (ML/DAY)	STAND-BY CAPACITY (ML/DAY)
Total Boosting Zone 2	-	-	60.34	39.03	35.42
Old Colony Rd. BS	3.20	3.20	6.39	3.20	0
Sydenham Rd. BS	0.41	0.41	0.81	0.41	0
Total after decommissioning	**-**	**-**	**53.14**	**35.42**	**35.42**

Table 5-2 Boosting Capacity Reduction Impact to Zone 1 Level of Service

STATION	ADD (ML/D)	MDD (ML/D)	SUFFICIENT STORAGE (ML/D)	FIRM CAPACITY (ML/D)	MDD OF FIRM CAPACITY (ML/D)	STAND-BY CAPACITY (ML/D)	ADD OF STAND-BY CAPACITY (ML/D)	LOS CRITERIA MEET (ML/D)
2036 - PRIOR TO DECOMMISSIONING								
Total Boosting Zone 2	**13.29**	**19.94**	☑	**39.03**	51.1%	**35.42**	37.5%	☑
2036 – AFTER DECOMMISSIONING								
Total Boosting Zone 2	**13.29**	**19.94**	☑	**35.42**	56.3%	**35.42**	37.5%	☑

Table 5-3 Boosting Capacity Reduction Influence on Storage Requirement in Zone 1

	UNITS	ZONE 2 PRIOR TO DECOMMISSIONING	ZONE 2 AFTER DECOMMISSIONING
Max Day Demand	ML/day	20	20
Peak Hour Demand	ML/day	30	30

	UNITS	ZONE 2 PRIOR TO DECOMMISSIONING	ZONE 2 AFTER DECOMMISSIONING
Fire Flow	L/s	324	324
Peak Demand	ML/day	48	48
Peak Supply (Boosting Capacity)	ML/day	39	35
Fire Flow Duration	hr	5	5
STORAGE REQUIREMENTS			
A = Fire Storage	Cubic Meters	1,855	2,694
B = Equalization	Cubic Meters	4,984	4,984
C = Emergency	Cubic Meters	1,710	1,919
Total (with A)		8,549	9,597
AVAILABLE STORAGE			
Total	Cubic Meters	14,844	14,844
Total Functional	Cubic Meters	7,100	7,100
TOTAL			
Total Storage Surplus (with A)	Cubic Meters	**6,295**	**5,247**
Functional Surplus	Cubic Meters	**2,116**	**2,116**

From the tables above it can be concluded that decommissioning the booster stations will reduce the standby, firm and total boosting capacity in the zone to 35.42 ML/day, 35.42 ML/day and 53.14 ML/day, respectively. The reduction in capacity is still within the required level of service. However, it does increase the total required storage by 1,049 m^3. This increase in required storage is below the surplus storage projected for the zone, reducing the surplus storage to 5,247m^3 in 2036.

The next step was to confirm the impact on the available flow and pressure in the system without these facilities. The hydraulic model was used to simulate minimum day, maximum day and fire flow for the development scenarios. The modeling results confirmed that these facilities are not providing significant benefit to the system. With the facilities decommissioned there was very minimal change to the available pressure and flow in the pressure zone. Maps illustrating simulation results can be found in Appendix ‘A’.

5.1.2.1 EVALUATION OF ALTERNATIVES

Table 5-4 Evaluation to Decommission Sydenham Rd and Old Colony Booster Stations

	Do Nothing	Alternative – Decommission Sydenham Rd. and Old Colony Booster Station
Natural Environmental Considerations		
Impacts to Animal & Vegetative Features	• None	• Minor impact anticipated; work to remain within the existing developed facility sites. • Some Impact on Vegetation or Green Space
Impacts to Water Course	• None	• None
Natural Environment Overall Rating	No Impact to Natural Environment	Minor Impact to the Natural Environment
Social and Cultural Environmental Considerations		
Number of People Disrupted in Community	• None	• Users near the sites may experience inconvenience due to construction noise
Traffic Disruption	• None	• Isolated to activities near the construction site
Social Disruption	• None	• None
Social/Cultural Environment Overall Rating	None	Moderate Impact to Social/Cultural Environment
Technical Suitability		
Level of Service	• Current level of service for boosting capacity is exceeded • Does not provide significant redundancy • Operational and maintenance costs for limited benefit to the system	• Reduced operational and maintenance costs • Decommissioning does not decrease level of service to users
Complexity of Implementation and construction of Alternative	• None	• Demolition of existing facilities
Full Build-out	• Sufficient total storage in full build-out	• Sufficient total storage in full build-out
Technical/Operational Rating	Increased cost to maintain and operate with very minimal improvement to level of service	Reduced operational and maintenance costs while maintaining the existing level of service.

	Do Nothing	Alternative – Decommission Sydenham Rd. and Old Colony Booster Station
Financial Considerations		
Operational/Maintenance Costs	• No operational and maintenance costs above current levels	• Reduced operational and maintenance costs from current levels
Capital Costs (incl. Constructability Risk)	• None	Moderate capital cost to decommission storage facilities Moderate constructability risk (common type of work)
Financial Overall Rating	No change to current financials	Moderate capital cost and reduction in operational costs
OVERALL PREFERENCE RATING	**2 – Less Preferred**	**1 - Preferred**

5.1.2.2 RECOMMENDATIONS

Overall, the Old Colony and Sydenham Rd. booster stations are providing a minimal improvement to the redundancy and reliability of the system and corresponding pressure zone. There is ample storage and boosting capacity, and the overall service improvement provided to users is not significant. Eliminating these facilities will result in energy savings as well as operational and maintenance costs without negative impact to the level of service. The external impacts as a result of decommissioning these two facilities are minimal. It is recommended that this alternative be implemented.

TIMING

Based on the observed system operation during the hydraulic simulations both of these facilities can be taken offline at any point to provide operational savings. Once they are taken offline, they can be decommissioned. It is recommended that this work is completed by 2021.

5.1.3 ALTERNATIVE 3 – REDUCE EXCESS STORAGE IN ZONE 1

Similar to Alternative 2, pressure Zone 1 has excess storage and boosting capacity. O'Connor EST and Progress Ave Reservoir are two facilities which require capital improvements and present operational challenges.

5.1.3.1 ALTERNATIVE 3A - DECOMMISSION O'CONNER TOWER

O'Connor EST is a relatively small elevated storage tower; it has been reported that it does not meet current seismic standards and is in need of other upgrades. Utilities Kingston has noted that the tank fills and drains very quickly, making it difficult to operate. It is also prone to emptying during large breaks. Alternative 3 considers decommissioning this tower to reduce operational and maintenance costs as well as reduce excess storage in the pressure zone.

During preliminary analysis of the tower decommissioning, it was observed that low pressures developed around the Waterloo Village area under certain conditions. In order to resolve this issue while still removing O'Conner Tower, it was determined that a PRV/PSV could be added to the system to provide the required

additional pressure from Zone 2 to Zone 1 during these isolated conditions. Old Colony Rd booster station is being recommended to be removed; it was concluded that these would be a logical location to add a PRV/PSV as some of the infrastructure could be reused. Adding PRV/PSV at this location provides benefit to the system by resolving the low pressure in Waterloo Village area as well as providing the ability for the system to back-feed Zone 1 from Zone 2 which currently does not exist. The ability to back-feed from one pressure zone to another is a desirable operational ability improving the reliability and resiliency of the system. Maps illustrating the hydraulic simulation results can be found in Appendix 'A'.

Table 5-5 below details the impact to the required storage in Zone 1 upon decommissioning of O'Conner Tower which represents 500m^3 of functional storage and 1,100m^3 of total storage. The values presented below include the recommended increase in functional storage at Third Ave. reservoir.

Table 5-5 Decommissioning O'Connor EST - Influence on Storage Requirements in Zone 1

	UNITS	ZONE 1 PRIOR TO DECOMMISSIONING	ZONE 1 AFTER DECOMMISSIONING
Max Day Demand	ML/day	103	103
Peak Hour Demand	ML/day	155	155
Fire Flow	L/s	378	378
Peak Demand	ML/day	155	155
Peak Supply	ML/day	217	217
Fire Flow Duration	hr	6	6
Other Zone Demands (MD)	ML/day	31.22	31.22
Eligible Supply	ML/day	186.27	186.27
STORAGE REQUIREMENTS			
A = Fire Storage	Cubic Meters	0*	0*
B = Equalization	Cubic Meters	25,762	25,762
C = Emergency	Cubic Meters	6,441	6,441
Total (with A)		32,203	32,203
AVAILABLE STORAGE			
Total	Cubic Meters	47,260	46,160
Total Functional	Cubic Meters	28,550	28,050
TOTAL			
Total Storage Surplus (with A)	Cubic Meters	**15,057**	**13,957**
Functional Surplus	Cubic Meters	**2,788**	**2,288**

* Fire storage in not required in the Zone due to available firm boosting capacity.

From the tables above it can be concluded that decommissioning O'Connor EST will reduce the functional storage and total storage in the zone to 28,050 m^3 and 46,160m^3 respectively. The reduction in capacity is still within the required level of service. However, it does reduce the surplus functional to 2,288 m^3 and surplus total storage to 13,957 m^3 for the 2036 development scenario.

The next step was to confirm the impact on the available flow and pressure in the system without this facility and the implementation of the PRV/PSV at the former site of Sydenham Rd booster station. The hydraulic model was used to simulate minimum day, maximum day and fire flow for the development scenarios. The modeling results confirmed that the implementation of this alternative would maintain or improve the level of service to Zone 1 while reducing maintenance costs and improving operational flexibility.

5.1.3.2 ALTERNATIVE 3B - DECOMMISSION PROGRESS AVE

As previously identified Zone 1 has a surplus of available storage. Reducing this excess can improve operational efficiencies by reducing energy consumption and maintenance costs. Progress Ave. The reservoir has been identified by Utilities Kingston as a facility which has had structural issues; it requires roof repairs and structural crack repairs. Additionally, reservoirs are not the most efficient storage method with water being pumped up to the location of the reservoir and then all the energy is lost when it is dumped into the tank for storage.

The table below identifies the impact on the available storage with the 6,600 m^3 of total storage and 2,900 m^3 of functional storage in Progress Ave. Reservoir decommissioned. The values presented below include the recommended increase in functional storage at Third Ave. reservoir but does not include the recommendations from Alternative 3A.

Table 5-6 Decommissioning Progress Ave. Reservoir - Influence on Storage Requirements in Zone 1

	UNITS	ZONE 1 PRIOR TO DECOMMISSIONING	ZONE 1 AFTER DECOMMISSIONING
Max Day Demand	ML/day	103	103
Peak Hour Demand	ML/day	155	155
Fire Flow	L/s	378	378
Peak Demand	ML/day	155	155
Peak Supply	ML/day	217	217
Fire Flow Duration	hr	6	6
Other Zone Demands (MD)	ML/day	31.22	31.22
Eligible Supply	ML/day	186.27	186.27
STORAGE REQUIREMENTS			
A = Fire Storage	Cubic Meters	0	0
B = Equalization	Cubic Meters	25,762	25,762
C = Emergency	Cubic Meters	6,441	6,441

Total (with A)		32,203	32,203
AVAILABLE STORAGE			
Total	Cubic Meters	47,260	40,660
Total Functional	Cubic Meters	28,550	25,650
TOTAL			
Total Storage Surplus (with A)	Cubic Meters	**15,057**	**8,457**
Functional Surplus	Cubic Meters	**2,788**	**-112**

From the table above it can be concluded that decommissioning Progress Ave. reservoir significantly decreases the excess storage in 2036 and will result in a functional storage deficiency based on the assumed future operational levels in Third Ave. reservoir. The assumed operational levels in Third Ave. can be adjusted to overcome this deficiency.

5.1.3.3 EVALUATION OF ALTERNATIVE 3A AND 3B

The table below outlines the evaluation of Alternative 3A and 3B compared to doing nothing.

Table 5-7 Evaluation of Storage Alternatives in Zone 1 – Decommission O'Connor EST and Progress Ave. Reservoir

	Do Nothing	Alternative 3A– Decommission O'Connor EST & new PRV	Alternative 3B – Decommission Progress Ave. Reservoir
Natural Environmental Considerations			
Impacts to Animal & Vegetative Features	• None	• Minor impact anticipated; work to remain within the existing developed facility sites. • Some Impact on Vegetation or Green Space	• Minor impact anticipated; work to remain within the existing developed facility sites. • Some Impact on Vegetation or Green Space
Impacts to Water Course	• None	• None	• None
Natural Environment Overall Rating	No Impact to Natural Environment	Minor Impact to the Natural Environment	Minor Impact to the Natural Environment
Social and Cultural Environmental Considerations			

	Do Nothing	Alternative 3A– Decommission O'Connor EST & new PRV	Alternative 3B – Decommission Progress Ave. Reservoir
Number of People Disrupted in Community	• None	• Users near the site may experience inconvenience due to construction noise	• Users near the site may experience inconvenience due to construction noise
Traffic Disruption	• None	• Isolated to activities near the construction site	• Isolated to activities near the construction site
Social Disruption	• None	• None	• None
Social/Cultural Environment Overall Rating	None	Moderate Impact to Social/Cultural Environment	Moderate Impact to Social/Cultural Environment
Technical Suitability			
Level of Service	• The current level of service for storage is exceeded. • Increased operational and maintenance requirements	• Reduced operational and maintenance costs • Decommissioning does not decrease level of service to users • Improved level of service and operational flexibility through added ability to back feed from adjacent pressure zone. • Simplifies system operation. • Improves operation at Tower St. Tower. • Does not meet current seismic standards	• Reduced operational and maintenance costs • Reduces resiliency of the system by centralizing storage • Facility is older but well maintained • No Major capital upgrades required • Recently had an electrical and PLC upgrade
Complexity of Implementation and construction of Alternative	• None	• Demolition of an existing facility • Re-purposing two existing sites for PRV/PSV • Added maintenance of PRV/PSV infrastructure • Reduced maintenance of tank infrastructure	• Demolition of an existing facility • Reduced maintenance of tank infrastructure
Full Build-out	• Additional functional storage is required • Sufficient total storage	• Additional functional storage is required • Sufficient total storage	• Additional functional storage is required • Sufficient total storage

	Do Nothing	Alternative 3A– Decommission O'Connor EST & new PRV	Alternative 3B – Decommission Progress Ave. Reservoir
Technical/Operational Rating	Not the most efficient operation of the system. It does not reduce the reliability of the system.	Overall reduced operational and maintenance costs while maintaining the existing level of service. Improved Operational Flexibility	The infrastructure is well maintained and provides increased resiliency by decentralizing a significant volume of storage in Zone 1.
Technical Suitability			
Operational/ Maintenance Costs	• No Improvement	• Reduction in Operational/ Maintenance Costs	• Reduction in Operational/ Maintenance Costs
Capital Costs (incl. Constructability Risk)	• Significant structural upgrades are required at O'Connor EST. (Significant Risk – Unknowns with structural upgrades to older facility) • Minor Capital Improvements are required at Progress Ave. reservoir.	• Moderate capital cost to decommission storage facilities • Moderate constructability risk (common type of work)	• Moderate capital cost to decommission storage facilities • Moderate constructability risk (common type of work)
Financial Overall Rating	Moderate capital cost No improvement to current financials	Moderate capital cost and reduction in operational costs	Moderate capital cost and reduction in operational costs
OVERALL PREFERENCE RATING	**2 – Least Preferred**	**1 - Preferred**	**3 – Lest Preferred**

5.1.3.4 RECOMMENDATIONS

The preferred alternative is to decommission O'Connor EST and install new PRV/PSV at the former site of Sydenham Rd Booster Station. This alternative makes the most efficient use of existing infrastructure and provides the most operational flexibility.

TIMING

Based on the observed system operation during the hydraulic simulations is it recommended that the PRV/PSV be installed at Sydenham prior to the interconnection along Front Rd. The interconnection is anticipated to be commissioned by 2018. The PRV/PSV can be commissioned once installed and will provide benefit to the system. Once the interconnection along Front Rd is complete, O'Connor EST can be removed from service and then decommissioned. Point Pleasant should be configured to operate off of the elevation at Tower St Tower once O'Conner is removed from service.

6 DISTRIBUTION SYSTEM (ALL ZONES)

6.1 IDENTIFIED HIGH AND LOW-PRESSURE ZONES

Several locations were noted in the Gap Report as having pressures outside of the acceptable range (low and high). These included low-pressure areas around Third Ave. reservoir, the intersection of Princess St. and Futures Gate and near the intersection of Bayridge Dr. and Taylor Kidd Blvd.

6.1.1 HIGH-PRESSURE SOUTH OF GORE RD.

High pressures were noted between James St. Booster Station and south of Gore Rd. The high-pressure condition currently exists and is suspected to be primarily a result of the lower topography in the area. This high-pressure issue is corrected through the creation of a subzone which was a previously evaluated alternative.

6.1.2 THIRD AVE. RESERVOIR

The nodes in the low-pressure area around Third Ave. were found to have pressures slightly below 40 PSI under various demand scenarios. These results were supported by reviewing available hydrant tests in the area which had static results in a similar range. Although the current operating pressures in the area are lower than desired, there have not been any recorded complaints from users regarding pressure. The ground elevation in this area is higher than the surrounding area in the pressure zone which reduces the amount of available pressure based on the hydraulic grade line (HGL) of the pressure zone. Operating pressures below 40 PSI are outside of the operating range recommended by the MOE. However, the design guidelines do recognize that there are cases where operating pressures may be dictated by system size and/or topography.

During the hydraulic simulations, significant pressure changes are not observed when comparing the average day and peak hour demand scenarios. Because of this, headloss in the distribution system is not suspected to be the cause of the pressure deficiency, but rather a result of the higher ground elevation. Increasing the HGL would be one method to address the low pressure, however, the existing elevated storage facilities in the pressure zone are not suitably configured to increase the HGL. Modifications to these facilities would require significant capital investment. Another option would be to create a boosted subzone in the affected area. The area where the subzone would be required is currently extensively looped and interconnected. Creating a subzone would require isolating many loops, installing check valves and constructing a boosting facility which increases the operational complexity of the system. As there have not been complaints from systems users regarding pressure and the fire flows are currently within the desired level of service, the capital cost and the increased complexity of the system required currently outweigh the benefits of correcting the deficiency.

6.1.3 PRINCESS ST. AND FUTURES GATE – LOW PRESSURE

A low-pressure area was observed to develop near the intersection of Futures Gate and Princess St. extending south towards Uxbridge Cres. This low-pressure area is resolved through the implementation of the PRV/PSV at the former Sydenham Rd. booster station upon its decommissioning.

6.1.4 BAYRIDGE AND TAYLOR KIDD – LOW PRESSURE

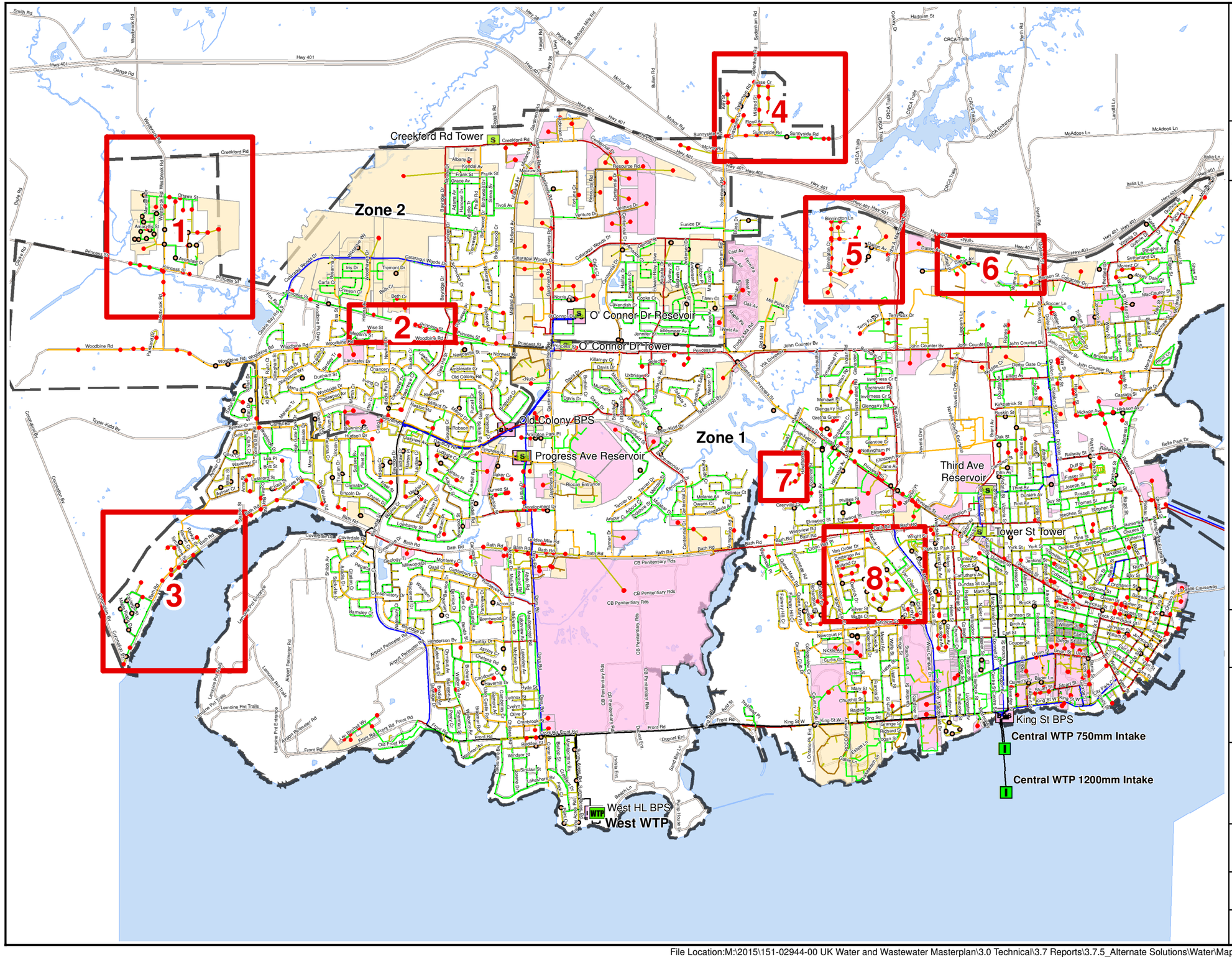
A low-pressure area was observed in the southwest corner of the intersection of Bayridge and Taylor Kid. This low-pressure area is generally above the required 40 PSI and generally only drops slightly below this

threshold during peak times in the distribution system. Due to the proximity of this area to the Zone 2 boundary, it was considered to reconfigure the pipes to service this area from Zone 2. Modifying the piping configuration would increase the pressure to this area but would reduce the reliability and resiliency. Correcting isolated pressure deficiencies that occur only during isolated periods is less preferred than maintaining the current level of redundancy to the area.

6.2 IDENTIFIED FIRE FLOW GAPS AND ALTERNATIVES

There are various locations identified throughout the distribution system where fire flow can be improved. Some nodes which experience available fire flow below the desired level of service may be restricted by their elevation or the service configuration in that area of the distribution system. As detailed by the MOECC guidelines, *water distribution systems should be designed to provide a balance between hydraulic water supply needs and water quality*. In some instances, upgrades to improve fire flow may result in a decrease in water quality as a result of increased retention time and water age. Alternatives for fire flow improvements have been selected based on the density of nodes which do not meet the desired LOS for fire flows. Eight areas of interest were identified where options for improvements will be developed. The figure on the following page illustrates their locations.

1. Westbrook Area (Area 1)
   - Alternative 1 - New feed along Princess St.
   - Alternative 2 - New feed along Creekford Rd
2. Princess between Woodhaven and Bayridge (Area 2)
   - Alternative 1 - Extend watermain on Holden to Cataraqui Woods Dr.
   - Alternative 2 - Upsize Princess
3. Area near Elmwood (Area 3)
   - Alternative 1 - New feed along Bath Rd between Rankin Cr. and Station St.
   - Alternative 2 - Loop Lower Dr. to Bath Rd.
4. Sydenham Rd. North of 401 (Area 4)
   - Alternative 1 - Twin feed
5. Dalton Ave. (Area 5)
   - Alternative 1 - Twin Feed
   - Alternative 2 - Upsize Lappans Lane to Dalton Ave.
6. Dalton Ave. (Area 6)
   - Alternative 1 - Upsize Dalton between Division St. and Don St.
7. Balsam Grove (Area 7)
   - Alternative 1 - Loop to Queen Mary along Rideau Trail
8. Calvin Park (Area 8)
   - Alternative 1 - Upsize Norman Rogers Dr. and Roden St. with loops between:
     - Herchmer Dr. and Norman Rogers Dr.;
     - Holland Cr. and Norman Rogers Dr.;
     - Michael Grass Cres. and Van Order Dr.



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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	AS	6-1

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.5_Alternate Solutions\Water\Maps\151-02944-00_AS_Fig6-1_FireFlow_Areas.mxd

Two hydraulic scenarios were evaluated for the upgrades; one scenario used all of the 'A' alternatives and the second used all the 'B' alternatives, in cases where there was no 'B' alternative 'A' was included. Maps which illustrate the results of the two analysis can be found in Appendix 'A'.

6.2.1 WESTBROOK AREA (AREA 1)

Westbrook is an area which can benefit significantly from either option 'A' or option 'B'. The hydraulic results from both scenarios are quite similar. Option 'A' would involve extending a new watermain along Princess St. from Cataraqui Woods Dr. west to Westbrook Rd. this route is along the main arterial road and crosses an environmentally protected area. Option 'B' involves extending a new watermain from Bayridge Dr. west along Creekford Rd. to Westbrook Rd. Creekford Rd. This route is significantly longer than the Princess St. route and needs to cross a smaller environmentally protected area. The evaluation of these two alternatives follows in the table below.

Table 6-1 Evaluation of Westbrook Watermain Routes

	Alternative 1 – New Watermain along Princess St.	**Alternative 2 – New Watermain along Creekford Rd.**
Natural Environmental Considerations		
Impacts to Animal & Vegetative Features	• Upgrades may impact vegetative features due to work within EPA area; work to remain mostly within Right of Way (R.O.W.) • Shortest Route	• Upgrades may impact vegetative features due to work within EPA area; work to remain mostly within Right of Way (R.O.W.) • Longest Route
Impacts to Water Course	• Potential upgrades may impact watercourse features due to potential work within EPA area; area; work to remain mostly within Right of Way (R.O.W.) • Longest Water Crossing	• Potential upgrades may impact watercourse features due to potential work within EPA area; work to remain mostly within Right of Way (R.O.W.) • Shortest Water Crossing
Natural Environment Overall Rating	Moderate Impact to Natural Environment	Minor Impact to the Natural Environment
Social and Cultural Environmental Considerations		
Number of People Disrupted in Community	• Users near the site may experience inconvenience due to construction noise	• Users near the site may experience inconvenience due to construction noise
Traffic Disruption	• Moderate (Higher AADT)	• Minor (Lower AADT)
Social Disruption	• Some residential housing along alignment	• Some residential housing along alignment
Social/Cultural Environment Overall Rating	Moderate Impact to Social/Cultural Environment	Minor Impact to Social/Cultural Environment
Technical Suitability		

	Alternative 1 – New Watermain along Princess St.	Alternative 2 – New Watermain along Creekford Rd.
Level of Service	• Improves available Fire Flow in the Westbrook area • Improves redundancy and reliability to the area	• Improves available Fire Flow in the Westbrook area • Improves redundancy and reliability to the area
Complexity of Implementation and construction of Alternative	• Long crossing of an EPA	• Crossing of EPA
Full Build-out	• Meets Full Build-out	• Meets Full Build-out • More flexibility for future servicing alternatives during full-build-out and ultimate • Extends through an area not currently part of the Urban Servicing Area
Technical/Operational Rating	Technically Suitable	Improved Flexibility to future servicing.
Operational/Maintenance Costs	Minimal Increase in Operational and Maintenance Costs.	Minimal Increase in Operational and Maintenance Costs.
Capital Costs (incl. Constructability Risk)	• Significant Risk with a Long Crossing of an EPA • Significant Cost with a Long Crossing of an EPA • Remaining work is moderate risk (common type of work)	• Moderate Risk with Crossing an EPA • Increased Cost due to longer alignment • Remaining work is moderate risk (common type of work)
Financial Overall Rating	Significant capital cost	Significant capital cost, lower risk
OVERALL PREFERENCE RATING	**2 – Less Preferred**	**1 – Preferred**

6.2.1.1 RECOMMENDATIONS

Based on the evaluation above, the preferred alternative is to provide servicing along Creekford Rd. Although the capital cost is expected to be slightly higher, this alternative provides the least construction risk, the lowest impact to the natural and social environment and is the most flexible servicing alternative for future development.

TIMING

Given the improvement in available fire flow as well as the impact to reliability and resiliency, it is recommended that this project is completed by 2026.

6.2.2 PRINCESS BETWEEN WOODHAVEN AND BAYRIDGE (AREA 2)

Two alternatives were considered to correct this area; one upsized the main along Princess while the other considered looping Holden with Cataraqui Woods Dr. Holden is a new development which is in the process of being built out. Looping though Holden St with a 300mm watermain is a technically suitable alternative which has no external impact to implement and improves looping of the system. The alternative to increasing the size along Princess is not considered further.

TIMING

This work should be completed concurrently with the development of the residential subdivision.

6.2.3 ELMWOOD (AREA 3)

Extending a new 300mm watermain along Bath Rd. was the first alternative considered to improve fire flow in this area. Based on the results of the hydraulic simulation this improvement will provide very minimal improvement to the area and would be difficult to construct. The second improvement that was considered was to loop Lower Dr. with Bath Rd. with a 150mm watermain approximately 70m long. This looping provided significant improvement to the available fire flow along Lower Dr. and is recommended to be implemented.

TIMING

Given the short length of the watermain and relatively low capital cost, it is recommended to be implemented by 2021.

6.2.4 SYDENHAM RD. NORTH OF 401 (AREA 4)

The alternative considered to improve fire flow to this area was to twin the existing 300mm watermain. Additional crossings of the 401 are cost prohibitive, technically challenging and have associated construction risk. The model results for the simulated alternative indicate the twinning this pipe will have very minimal impact to fire flows in the area. Based on the lack of performance improvement it is not recommended to be implemented. There are limited opportunities for flow improvement in this area without significantly upsizing distribution pipes, which can have an adverse impact on water age/quality as a result of the increased volume stored in the distribution mains.

6.2.5 DALTON AVE. (AREA 5)

Two alternatives were considered to improve the fire flows to this area; one involved twinning the feed and the other involved increasing the pipe size along Dalton Ave. between Sir John A. MacDonald Blvd. and Grant Timmins Dr. Both alternatives have similar technical results improving the fire flow to this area. Twinning the feed would be the preferred alternative for two reasons, it improves the redundancy and reliability to this area which is currently only serviced by one watermain, and the existing pipe is relatively new with no history of breaks.

TIMING

Given the age of the industrial park and the relative benefit, it is recommended that this is implemented by 2036.

6.2.6 DALTON AVE. (AREA 6)

The existing 200mm watermain which extends from Division to Don St. on Dalton was suspected to be the cause of the low fire flows in the area. Fire Flow was re-evaluated with this section watermain replaced with a 300mm pipe. Replacing this pipe provided a notable improvement to the fire flows in the area. Replacement of the pipe is preferred to twinning as the pipe is old and has a significant history of breaks. As a result of the poor condition of the watermain and its improvement of fire flows it is recommended that this pipe is replaced.

TIMING

Given the age of the industrial park and the relative benefit, it is recommended that this is implemented by 2026.

6.2.7 BALSAM GROVE (AREA 7)

Balsam Grove is a residential area serviced by a single watermain and experiences low fire flows. To the west, there is an unopened Right-of-Way which has a sanitary sewer extending through it. A new watermain was extended along this ROW south to Queen Mary Rd. to see if this would improve the fire flows. Extending a new pipe along the ROW is preferred to twinning or upsizing the feed into the subdivision as it improves redundancy and reliability, there is a sewer project which is required through the same corridor, and there is no history of breaks on the existing watermain. From the hydraulic simulation, it was concluded that this would improve the fire flow and is recommended to be implemented.

TIMING

Give the area of improvement and the scale of the capital project is it recommended to be implemented prior to 2036.

6.2.8 CALVIN PARK (AREA 8)

Calvin Park is another residential area with fire flows lower than the desired level of service. The improvements considered to improve the fire flow in this area included upsizing the watermain along Norman Roger's Ave. to a 300mm diameter as well as looping through three easements to Norman Rogers. The three loops are located at Herchmer Dr., Holland Cr. out to Norman Rogers Dr., Michael Grass Cres. to Van Order Dr. Norman Rogers is recommended to be upsized as it was recently lined in 2009 and is still suspected to be restricting available fire flow. The results from the hydraulic simulation indicate that these improvements will provide a notable improvement to the fire flow in the area and are recommended to be implemented.

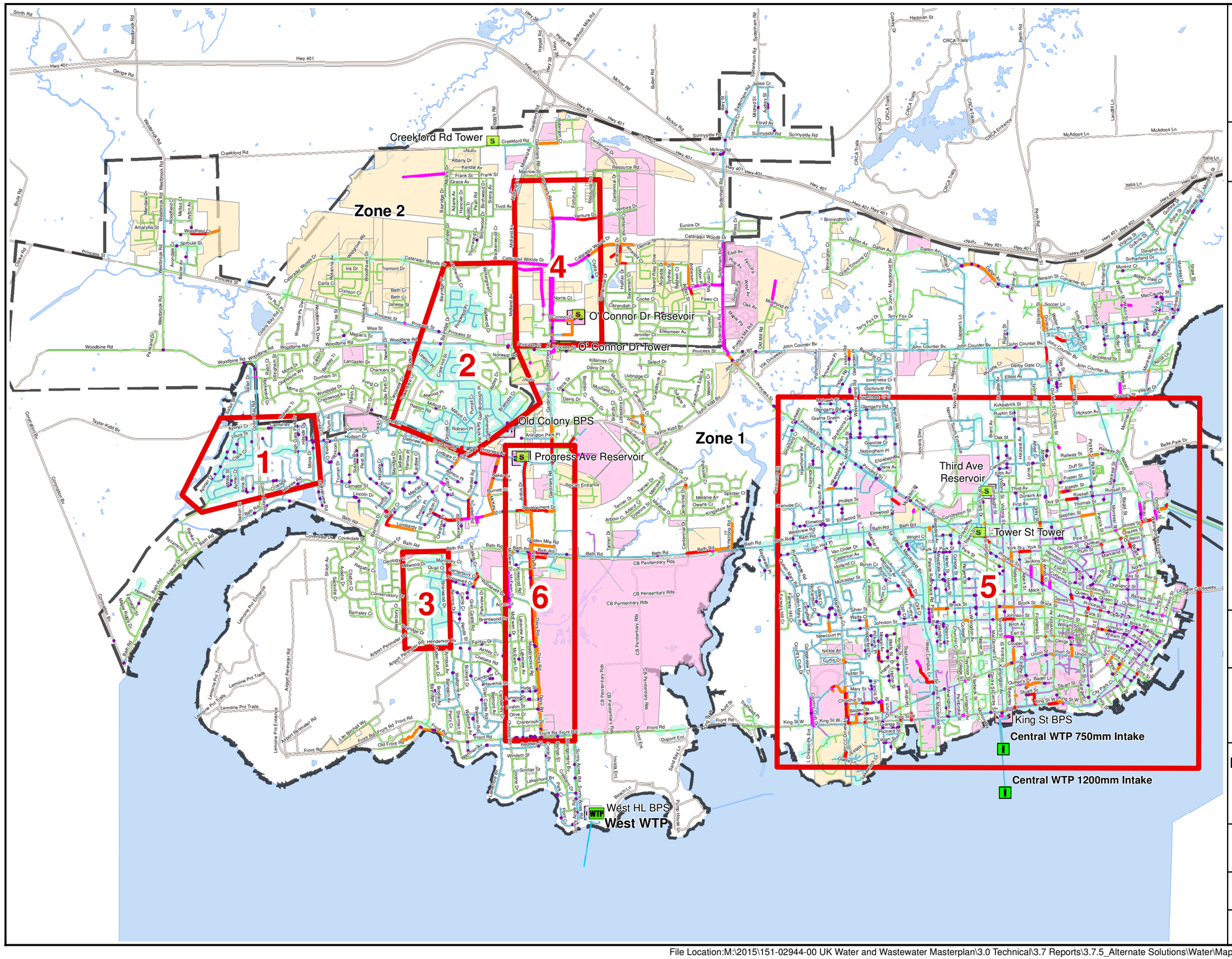
TIMING

Given the short length of the watermain and relatively low capital cost, it is recommended that the looping to be constructed by 2021. The upsize along Norman Rogers is recommended to be constructed by 2026.

6.3 LEAKAGE AND HEADLOSS IMPROVEMENTS

Pipe bursting and pipe lining are two common methods used to correct leakage, extend pipe life span and improve water quality in a distribution network. Pipe bursting or pipe replacement are generally required to address head loss deficiencies as these methods permit increases in pipe diameter. Maintaining a reasonable amount of headloss in the distribution system is a balance between managing the amount of required energy input into the system, the energy gradient across the pressure zone and ensuring the resulting volume stored in the distribution pipes does not cause water quality/age issues. The figure on the

following page illustrates pipe age, leakage and pipe head loss throughout the distribution system. The map emphasizes leakage rates above the average in the distribution network and headloss which exceeds 3m/km of pipe. In various locations in the distribution system, it can be observed that leakage is suspected to be an issue while headloss has not been flagged. These areas would be good candidates for rehabilitation methods. There are other areas which have significant leakage and various pipes flagged due to head loss. In these areas 'C' factors should be confirmed, and a pipe size increases may be warranted depending on the findings. Based on the hydraulic modeling results seven areas have been identified and are discussed further below.



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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
- Water Main Breaks

Pipe: Headloss Gradient (m/km)

- 0.000000 - 2.000000
- 2.000001 - 3.000000
- 3.000001 - 5.000000
- 5.000001 - 100.000000

Pipe Age

- 1900-1940
- 1941-1980
- 1981-2015

Leakage

- > 0.066 L/s
- > 0.044 L/s
- > 0.022 L/s
- >= 0 L/s

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

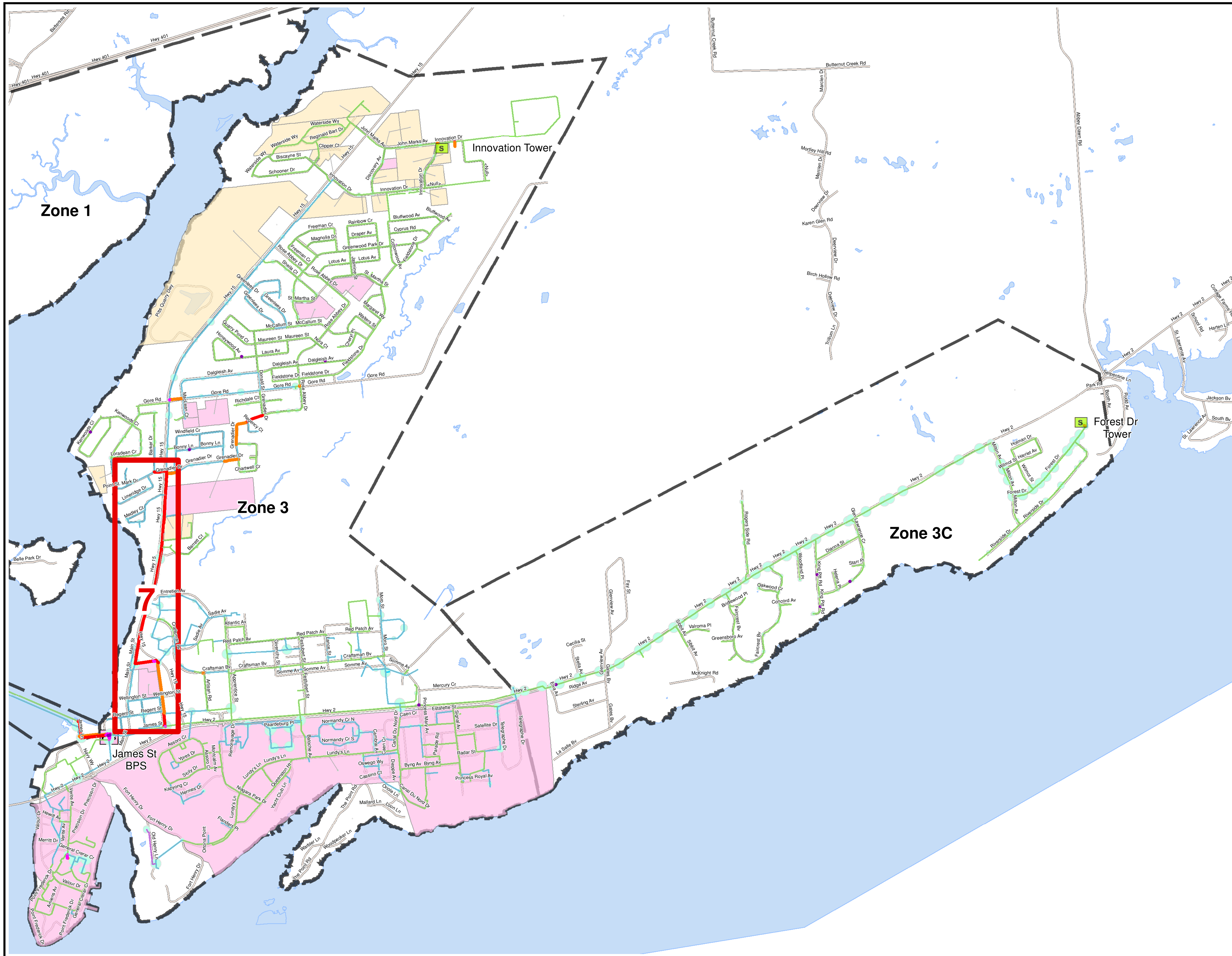
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

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

Scenario:
2036 FUTURE (PEAK HOUR)

Project No.:	Date:		
151-02944-00	DECEMBER 2016		
Drawn By:	Checked By:	Code:	Map No.:
STR	MS	WM	6-1

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.5_Alternate Solutions\Water\Maps\151-02944-00_AS_Fig6-2_Leakage_Areas.mxd



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- 2021-2026 Future Development
- 2036 Future Development
- Water Main Breaks

Pipe: Headloss Gradient (m/km)

- 0.000000 - 2.000000
- 2.000001 - 3.000000
- 3.000001 - 5.000000
- 5.000001 - 100.000000

Pipe Age

- 1900-1940
- 1941-1980
- 1981-2015

Leakage

- > 0.066 L/s
- > 0.044 L/s
- > 0.022 L/s
- >= 0 L/s

Scale: 0 175 350 700 Meters
1:25,000

N W E S

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

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

Scenario:
2036 FUTURE (PEAK HOUR)

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

Drawn By:	Checked By:	Code:	Map No.:
STR	MS	WM	6-3

File Location:M:\2015\151-02944-00 UK Water and Wastewater Masterplan\3.0 Technical\3.7 Reports\3.7.5_Alternate Solutions\Water\Maps\151-02944-00_AS_Fig6-3_LeakageAreas_East.mxd

6.3.1 LAWRENCE AND BALMORAL PARK (AREA 1)

Pipes in this area were installed in the 1970's and are suspected to be experiencing leakage above the average and has experienced a number of pipe breaks in the past. This area does not have any pipes identified with high headloss. As a result, this area would be a good candidate for rehabilitation as it is not anticipated that pipes will need to be increased. It is recommended that leakage studies be completed in this area to confirm leakage rates prior to rehabilitation.

6.3.2 OLD COLONY PARK (AREA 2)

Area 2 has pipes installed in the 1980's and has conditions similar to Area 1, high leakage, old pipes and no pipes with high headloss however historically there have been significantly fewer pipe breaks. Given the observations, this area would be a good candidate for rehabilitation in an attempt to remedy leakage. It is recommended that leakage studies be completed in this area to confirm leakage rates prior to rehabilitation.

6.3.3 HENDERSON PLACE (AREA 3)

Pipes in area 3 were installed in the 1970's and are suspected to be experiencing significant leakage. There are no pipes which are experiencing significant headloss however historically there has been a number of pipe breaks in the area. This area is not expected to require pipe size increases and would be a good candidate for rehabilitation. It is recommended that leakage studies be completed in this area to confirm leakage rates prior to rehabilitation.

6.3.4 GARDINERS RD. (AREA 4)

Two 400mm pipes extend north of O'Connor Reservoir on Gardiners Rd to Cataraqui Woods Dr. and a single feed extending north beyond Cataraqui Woods Dr. to Venture Dr. These pipes experience head loss in excess of 5m/km during periods of peak demand. The pipe on the west side of Gardiners Rd was installed in 2009, and the pipe on the east which extends up to Venture Dr. was installed in 1978. As these pipes are experiencing high head loss, it is recommended that the older pipe is replaced. Increasing the east pipe to a 600mm from a 400mm will re-distribute the flow to permit both of the pipes to experience less than 2m/km of head loss during peak periods. It is recommended that this pipe upsize extend along Gardiners Rd up to Venture Ave.

At Venture Ave. there is a pipe extending east to Fortune Cres which experiences head loss in excess of 5m/km. This is a short section of pipe which feeds an area that is relatively well looped. Increasing this pipe size would result in limited improvement. The distribution while the costs to upsize the pipe would be significant as it would require reconstruction of the road. Based on the limited impact this pipe has on the area; should the street be reconstructed it may be worthwhile to upsize the pipe. However, it is not worth reconstructing the street to upsize the pipe for the limited benefit.

The main on Cataraqui Woods Dr. between Clyde Ct. and Midland Ave. experiences significant head loss, upsizing this pipe to a 500mm through these limits would reduce the headloss experienced during periods of peak demand and permit this watermain to operate below 2m/km of headloss. It is recommended that this section of watermain be replaced.

6.3.5 DOWNTOWN (AREA 5)

In Area 5 it can be observed that there is significant leakage throughout with high headloss being observed at various locations in the area. The pipes in the area vary in age with some expected to be in excess of 100yrs. As this is the oldest part of the City and there are significant social and cultural impacts to

completing this work, at this time no specific areas have been identified. Additional investigations can be completed, and required work can be coordinated with other projects in these areas. Some of these pipes may be good candidates for rehabilitation while others should be upsized. In the area, it is recommended that testing is completed to verify pipe roughness and a pipe size increase should be considered based on the results of the testing. It is also recommended that leakage studies be completed in this area to confirm leakage rates prior to rehabilitation or replacement.

6.3.6 DAYS ROAD (AREA 6)

There are two pipes of interest in this area. One is a 600mm diameter transition main providing large volumes of water to the distribution system and 250mm pipe which provides local distribution to the adjacent subdivision. The 250mm pipe has been recently lined. Updating this pipe to have a roughness coefficient which is more consistent with a lined pipe the headloss drops below 2m/km during peak periods making this pipe no longer a concern. Reviewing the headloss experienced by the 600mm pipe over the course of the day reveals that the majority of the time the pipe is operating below the 2m/km which is within an acceptable range for a transmission main. No further recommendation are suggested for this area.

6.3.7 HIGHWAY 15 (AREA 7)

The watermain which extends through this area along Highway 15 experiences high head loss, however, based on the recommended alternative above there will be an additional 500mm pipe extending through this area which will relieve the high head loss experienced by this pipe. No further upgrade is required.

6.3.8 RECOMMENDATIONS AND TIMING

The table below summarizes the findings of the seven areas discussed above and the associated timing recommendations.

Table 6-2 Leakage Recommendations and Timing

AREA	YEAR OBSERVED	UPGRADE RECOMMENDED	OBJECTIVE
Area 1	2015	Leakage Study	Reduce Leakage
Area 2	2015	Leakage Study	Reduce Leakage
Area 3	2015	Leakage Study	Reduce Leakage
Area 4	2015	Pipe replacement. Recommended to be completed prior to 2036.	Reduce Headloss
Area 5	2015	Leakage Study/ Condition / Coefficient Testing	Reduce Headloss / Reduce Leakage
Area 6	2036	Do Nothing	-
Area 7	2021	Addressed through implementation of another Alternative	Reduce Headloss

7 RELIABILITY AND RESILIENCY

Reliability refers to the system's ability to handle routine upsets such as pipe breaks or planned maintenance to pumps or storage. Resiliency refers to the capacity to recover from major upsets such as the loss of components with long replacement lead times or the upset of complex processes. The level of redundancy becomes progressively more important as the complexity of the equipment, and the quantity water handled increases. Generally, for water distribution systems the failure of a single component must not prevent the system from satisfying design flows. The implemented amount of reliability is dependent on many factors and is ultimately up to the operating authority of the level of risk they are willing to take with the system based on unexpected events. The following items are reviewed to provide guidance with respect to resiliency and reliability improvements:

- Distribution network looping
- Distributed storage locations
- Back feeding pressure zones

7.1 DISTRIBUTION NETWORK LOOPING

In a pressurized system, one of the most important aspects to maximize reliability and resiliency is to provide looping of the distribution network. Looping provides multiple flow paths which can improve the hydraulic efficiency of the system particularly during fire flows as well as permit sections of the network to be isolated during a pipe break or other failure, minimizing service outages to users.

There are several areas of the distribution system which are currently serviced by a single pipe. Some examples include:

- Westbrook
- Southwest limit of water system along Bath Rd
- Sunnyside (north of 401 on Sydenham Road)
- East of CFB Kingston
- Highway 15 north of Gore Rd

Westbrook and Highway 15 north of Gore Rd will be corrected upon implementation of the preferred alternatives to other deficiencies noted in the system. Others were reviewed to identify improvements to fire flow. If redundancy is desired to be increased a second distribution main is generally the most cost-effective strategy compared to providing storage in the area.

7.2 STORAGE LOCATIONS & BACKFEEDING ZONES

Providing flow and pressure from multiple locations helps maintain the desired level of service in the distribution system during periods of high demand or facility failures. By not relying on one source of flow and pressure it significantly reduces the likelihood that a large pipe break or failure at a storage facility will cause a catastrophic deficiency in the system. Configuring the system to allow pressure zones to backfeed into zones of lower HGL is an effective way to accomplish this. This is commonly achieved by installing a combination pressure reducing and pressure sustaining valve at the boundary of the pressure zones. This valve is configured to maintain a constant downstream pressure and maintain a minimum upstream

pressure regardless of demand. During the normal demands, the valve would be closed, when a decrease in downstream pressure is detected the valve opens providing flow and pressure from the higher HGL to overcome the deficiency.

As indicated above a PRV/PSV is recommended to be installed to allow Zone 2 to backfeed Zone 1. This recommendation provides increased reliability to Zone 1. Completing this work between Zone 3 and Zone 1 could be completed but based on the increased reliability to Zone 1 and the configuration of Zone 1 to Zone 3 (i.e. 2 feeds) in it not recommend the install PRV/PSV from Zone 3 to Zone 1 at this time.

8 SUMMARY OF RECOMMENDATIONS

The table below provides a summary of the recommended alternatives and the gap which initially triggered the review.

Table 8-1 Infrastructure Gaps and Recommended Alternatives

INFRASTRUCTURE	OBSERVED GAP	RECOMENDED ALTERNATIVE
East Storage	By 2026 1,121 m^3 of functional storage is required to be added.	Install 3 PRV Chambers, 2km of 500mm Watermain, Isolation Valves to create a subzone in Zone 3 south of Gore Rd (No reconstruction cost included - assumed to be coordinated with HWY 15 widening). Adjust operational levels in Innovation EST once new subzone in Zone 3 is implemented.
Central Storage	By 2036 1,212 m^3 of functional storage is required to be added.	Adjust operational levels in Third Ave. Reservoir
Excess Total Storage in Central	There is an excess of total storage available in Zone 1 once interconnected.	Decommission Sydenham Rd and Old Colony booster stations. Install a PRV/PSV at former the Sydenham BS. Decommission O'Connor EST once the Front Rd interconnect is operational.
Low Pressure - Around Third Ave.	The area near the Third Ave Reservoir and Tower St Tower had some pressures between 37 and 39 psi.	Continue to Monitor
Low Pressure – Near Princess and Futures Gate	Low Pressure is observed near the intersection of Princess St. and Futures Gate.	Corrected with PRV/PSV at former Sydenham BS
Low Pressure - Bayridge Dr. and Taylor Kidd Blvd	Low pressure observed. Pressure below 40psi (33 – 39psi).	Continue to Monitor
High Pressure – Near James St. Booster Station	High pressures (<109psi) were seen around the James St Booster Station mainly due to the topography of the area.	Corrected though the creation of subzone. See East Storage above.

INFRASTRUCTURE	OBSERVED GAP	RECOMENDED ALTERNATIVE
Low Fire Flows in Westbrook Area	There is a cluster of notes where the available fire flow is less than the required LOS	Install 3.6km of 300mm watermain along Creekford Rd to Westbrook Rd.
Low Fire Flows - Princess between Woodhaven and Bayridge	There is a cluster of nodes where the available fire flow is less than the required LOS	Install 420m of 300mm Watermain to extend along Holden From Beth Cres. To Cataraqui Woods Dr.
Low Fire Flows - Area near Coronation Blvd.	There is a cluster of nodes where the available fire flow is less than the required LOS	Install 70m of 200mm dia. Watermain to loop between Lower Dr. and Bath Rd.
Low Fire Flows - Sydenham Rd. North of 401.	There is a cluster of nodes where the available fire flow is less than the required LOS	Continue to Monitor
Low Fire Flows - Dalton Ave. West of Sir. John A. Blvd.	There is a cluster of nodes where the available fire flow is less than the required LOS	Twin watermain along Dalton Ave. between Sir John A. MacDonald Blvd. and Grant Timmins Dr. 300m.
Low Fire Flows - Dalton Ave. West of Division St.	There is a cluster of nodes where the available fire flow is less than the required LOS	Replace 1km of 300mm Watermain on Dalton Ave. between Division to Don St.
Low Fire Flows - Balsam Grove	There is a cluster of nodes where the available fire flow is less than the required LOS	Install 500m of 200mm Watermain to loop Balsam Grove. Extend from Queen Mary Dr. to Sherwood Dr.
Low Fire Flows - Calvin Park	There is a cluster of nodes where the available fire flow is less than the required LOS	New 150mm watermain through easements to Norman Rogers Ave. located at Herchmer Dr.(75m), Holland Cr.(96m) out to Norman Rogers Dr., Michael Grass Cres. to Van Order Dr. (85m), Replace 1km of 300mm dia. watermain on Norman Rogers Dr. and Roden Rd. between Van Order Dr. and Johnson St.

INFRASTRUCTURE	OBSERVED GAP	RECOMENDED ALTERNATIVE
Headloss above 3m/km – Various locations	There are various pipes in the distribution system which experience high headloss	Upsize Gardiners Rd watermain (east) to 500mm - 1.2km from O'Connor Reservoir to Fortune Cres. Upsize Cataraqui Woods watermain between Clyde Ct. and Midland Ave. to 450mm (900m). Conduct studies to verify pipe roughness.
Leakage – Various Locations	Leakage is experienced in various locations throughout the distribution system	Conduct studies to verify leakage.
Reliability – Various locations	There are various areas in the distribution system serviced by a single feed	Reliability was considered as an objective when considering alternatives. There were no critical reliability issues noted.
East Storage	By 2026 1,121m^3 of functional storage is required to be added.	Install 3 PRV Chambers, 2km of 500mm Watermain, Isolation Valves to create a subzone in Zone 3 south of Gore Rd (No reconstruction cost included - assumed to be coordinated with HWY 15 widening). Adjust operational levels in Innovation EST once new subzone in Zone 3 is implemented.

9 ULTIMATE SERVICING STRATEGY

The ultimate servicing strategy is intended to provide general guidance and direction with how to best service the large development areas outside of the existing urban boundary. Given the scale of these areas, significant upgrades are required to service them when fully developed. Interim upgrades and/or phasing of the infrastructure should be evaluated when firm development plans begin to be submitted. The guidance with respect to this scenario is limited to major infrastructure; transmission, treatment, boosting and storage capacity.

9.1 TREATMENT

In the ultimate scenario, it is anticipated that the Max Day Demand will reach 188.31 ML/day which is 13.31 ML/Day above the current functional capacity of the existing treatment plants serving the City. This represents less than a 10% increase in capacity. Based on this moderate increase it is anticipated that the increased capacity would be attained through an upgrade at Point Pleasant.

9.2 ZONE 1

Mile square is a development area located just outside the south-western urban boundary. In the event, this area is developed it is anticipated that it will cause a shortfall of 4,775 m^3 of functional capacity in Zone 1. This storage should be provided near the west limit of the existing pressure zone. Transmission mains in the new development should be structured to provide a central spine through the development looping into the existing pressure zone. A new 600mm transmission main is required along Taylor Kidd Blvd. extending west from Bayridge Drive to Mile square in order to avoid low pressures in Lawrence Park and Balmoral Park subdivisions. A second feed to Elmwood should also be provided if one has not been previously constructed.

9.3 ZONE 2

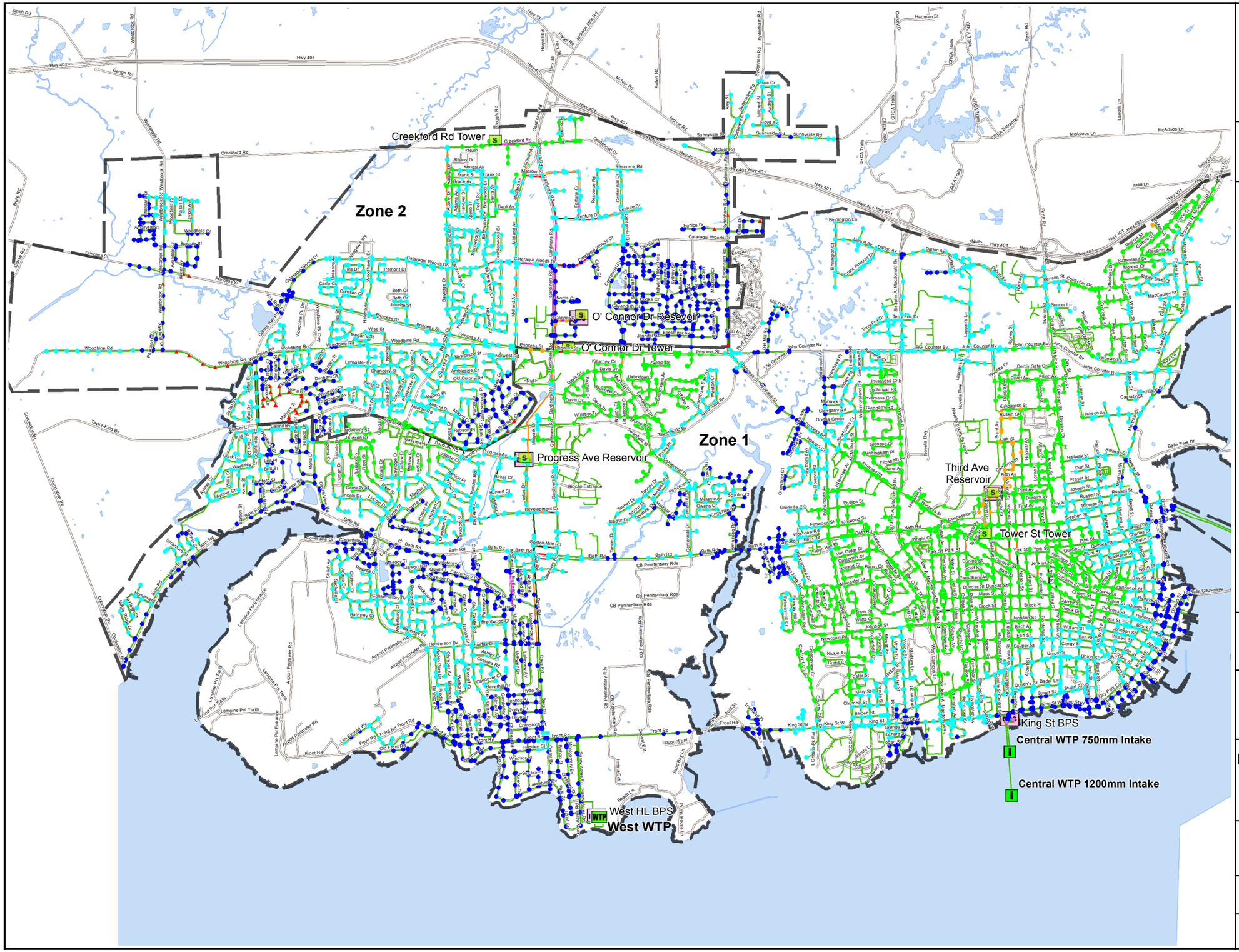
Westbrook is the primary development area influencing the water demand in Zone 2. Once this area is developed to its full potential, it is anticipated that 4 ML/day of boosting capacity will be required. This boosting capacity can be provided by upgrading the existing O'Connor Dr. Reservoir booster pumps. In addition to the boosting capacity, functional storage and total storage of 2,826 m^3 and 7,982 m^3 respectively, will be required. The total and functional storage can be provided by adding a second reservoir at O'Connor reservoir of similar size and configuration as the existing. A new 500mm transmission main is required along Creekford Rd to service the new development.

9.4 ZONE 3

There are two development areas in the ultimate scenario for the east zone. One is located to the north on Highway 15, and the other is located along Highway 2 to the east. If both of these areas are developed to their full potential, the zone will need a total storage increase of 10,954 m^3, a functional storage increase of 6,126 m^3 and a boosting capacity increase of 16.61 ML/day. The boosting capacity increase can be achieved through an upgrade at James St. The additional storage is anticipated to be provided by a new reservoir located near Rogers Side Rd. complete with booster station with a capacity of 16.61 ML/day. The transmission main along Highway 2 will need to be twinned (1x existing 300mm and 1x600mm new) to accommodate the increased flow.

Appendix A

DISTRIBUTION AND FIRE FLOW MAPS



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- 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-BASE MAP FOR OPTIMIZED CONDITION (MIN. HOUR)

Project No.:	Date:
151-02944-00	FEBRUARY 2017

Drawn By:	Checked By:	Code:	Map No.:
HC	JLD	WM	1.1.1

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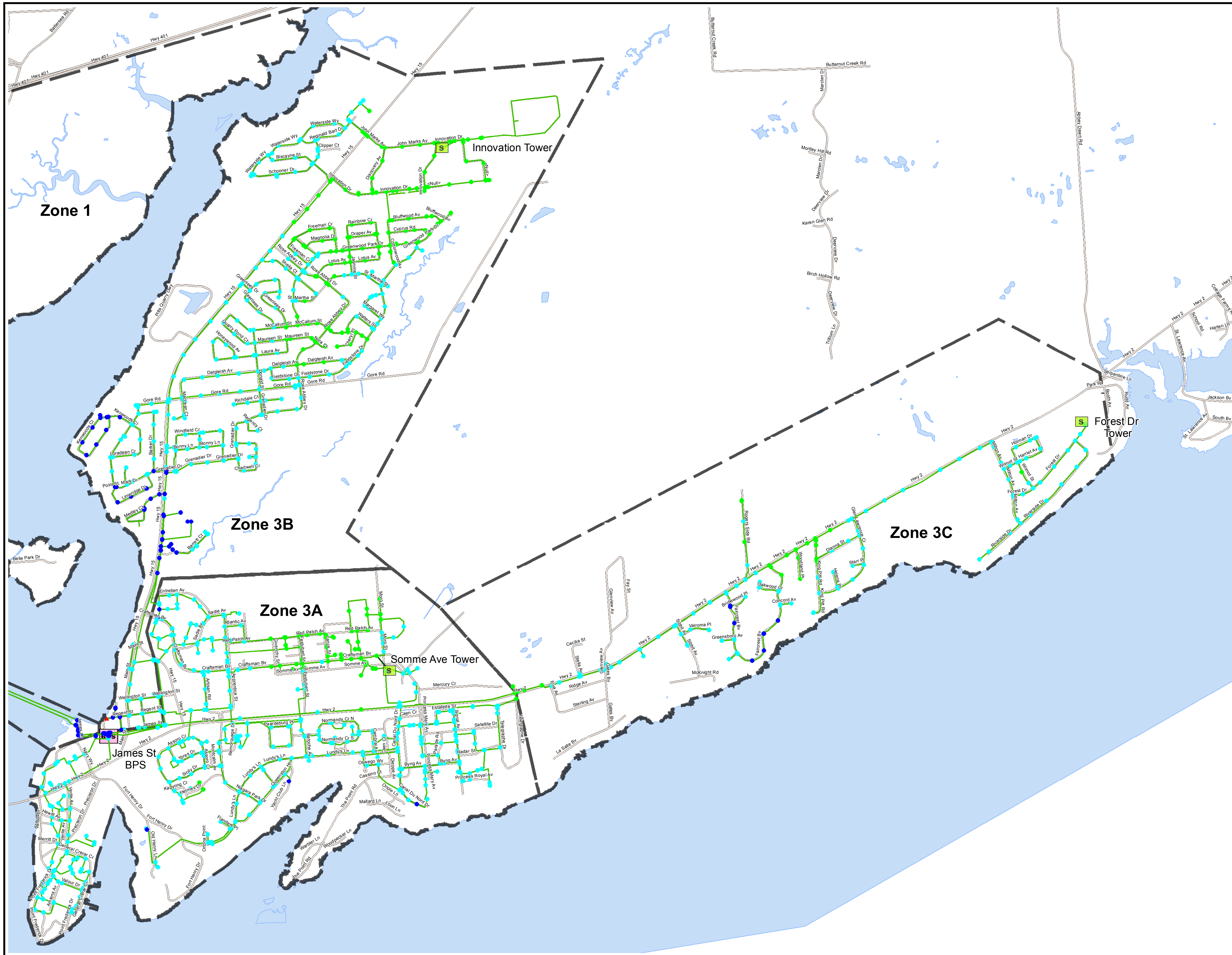

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- PressureZone
- Road
- Waterbody

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-BASE MAP FOR OPTIMIZED CONDITION (MIN. HOUR)

Project No.:	Date:
151-02944-00	FEBRUARY 2017

Drawn By:	Checked By:	Code:	Map No.:
HC	JLD	WM	1.1.2

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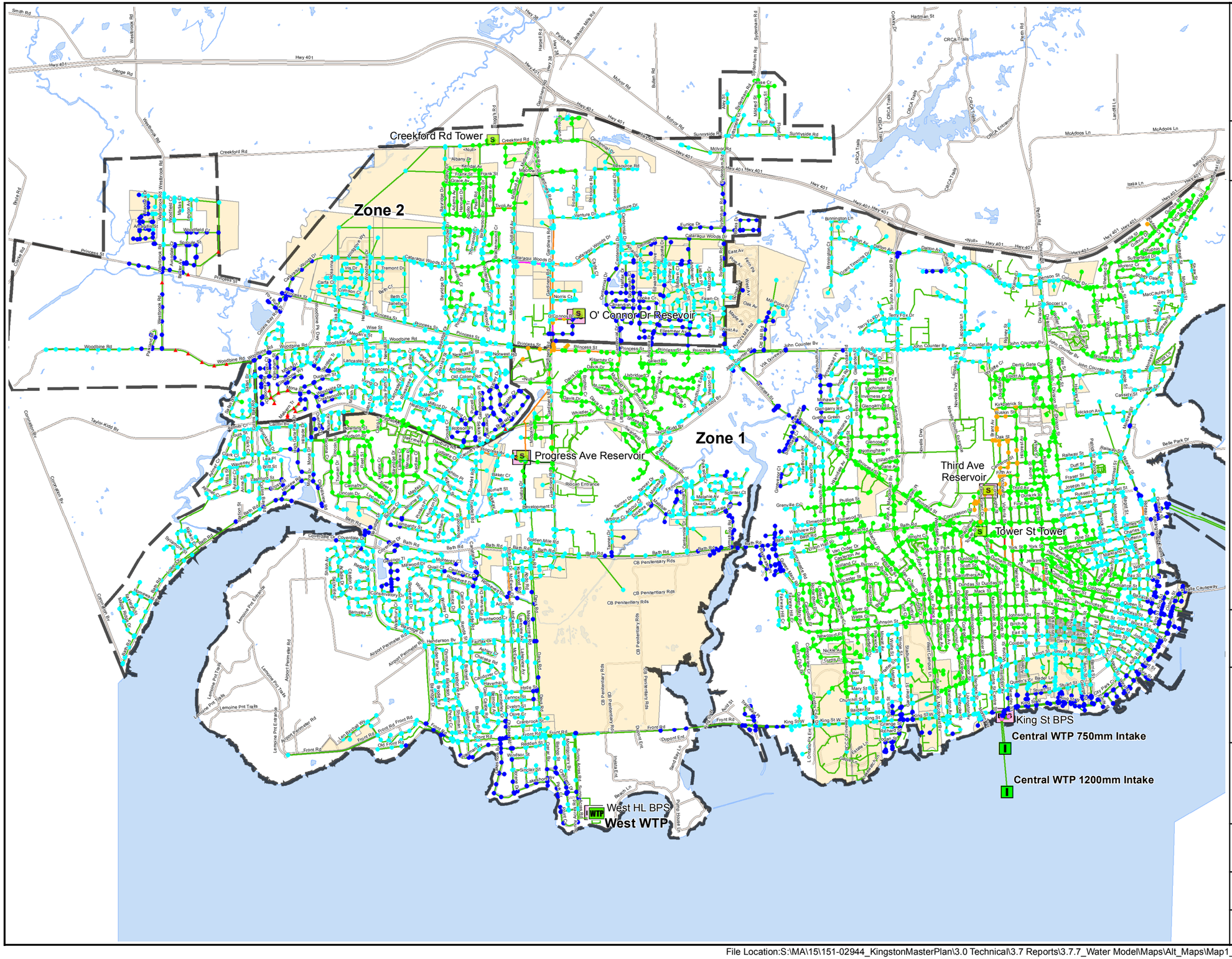

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- PressureZone
- Road
- Waterbody
- 2021 Future Development

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

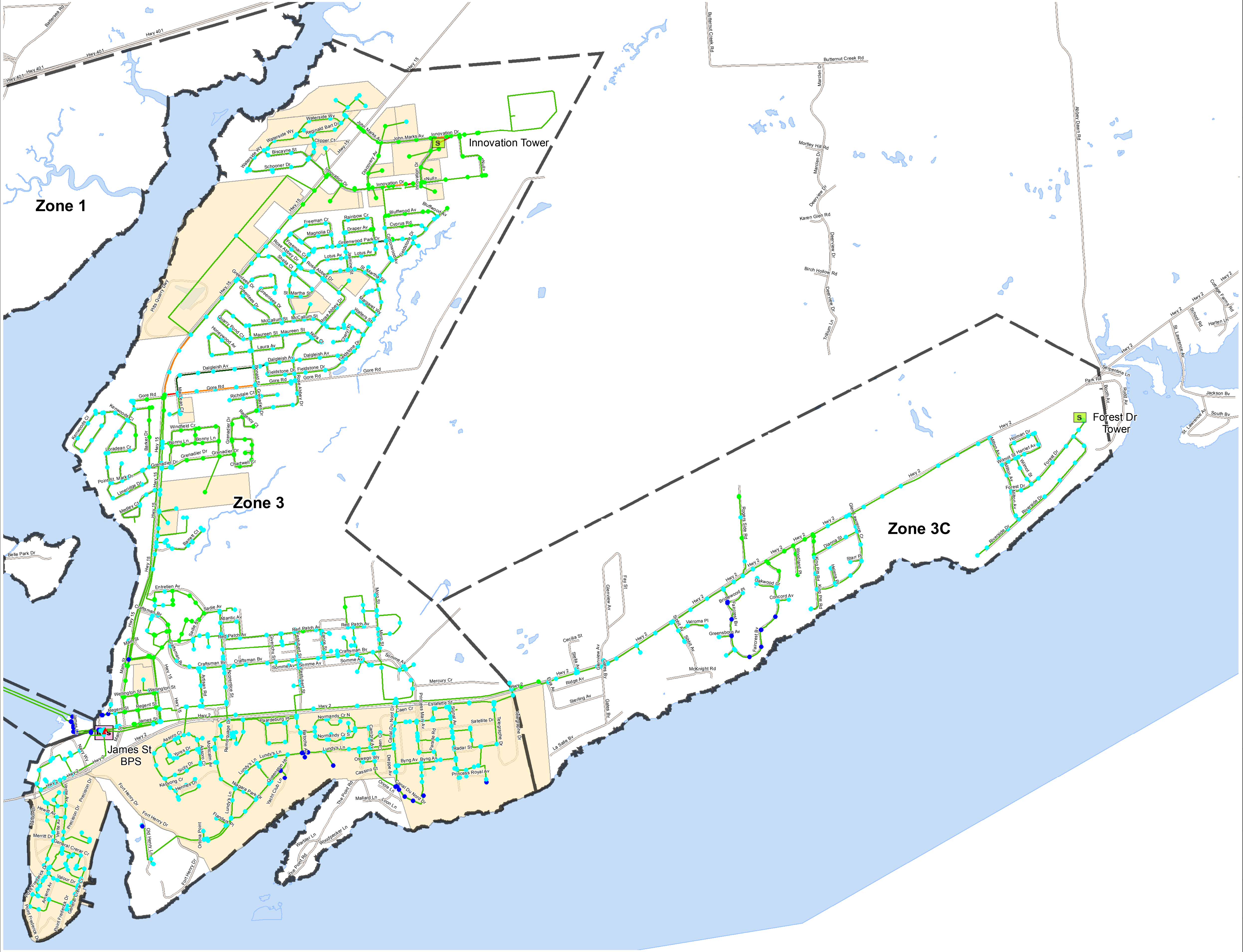
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

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

Scenario:
2021 RECOMMENDED ALTERNATIVES (MIN. HOUR)

Project No.:	Date:		
151-02944-00	FEBRUARY 2017		
Drawn By:	Checked By:	Code:	Map No.:
HC	JLD	WM	1.2.1

File Location:S:\MA\15\151-02944_KingstonMasterPlan\3.0 Technical\3.7 Reports\3.7.7_Water Model\Maps\Alt_Maps\Map1_2_1-WC_Alt2_2021_MinHr_HLoss_Pressure.mxd



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

N E S W

Project:
Water and Wastewater Master Plan

City of Kingston, Ontario

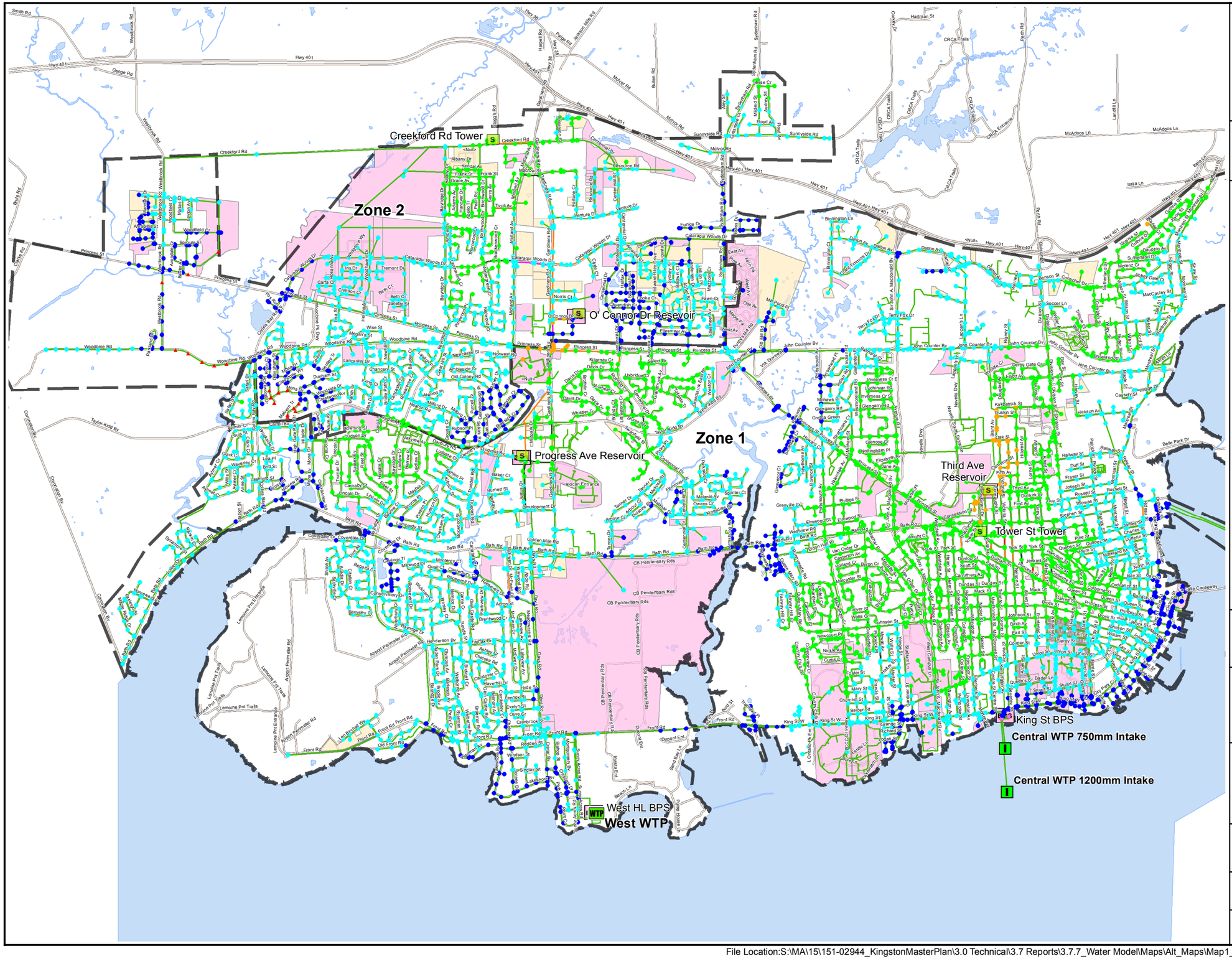
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 3, 3C)

Scenario:
2021 RECOMMENDED ALTERNATIVES (MIN. HOUR)

Project No.:	Date:
151-02944-00	FEBRUARY 2017

Drawn By:	Checked By:	Code:	Map No.:
HC	JLD	WM	1.2.2

File Location:S:\MA\15\151-02944_KingstonMasterPlan\3.0 Technical\3.7 Reports\3.7.7_Water Model\Maps\Alt_Maps\Map1_2_2-East_Alt2_2021_MinHr_HLoss_Pressure.mxd



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Utilities Kingston
UTILTIES KINGSTON
P.O. BOX 790,
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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

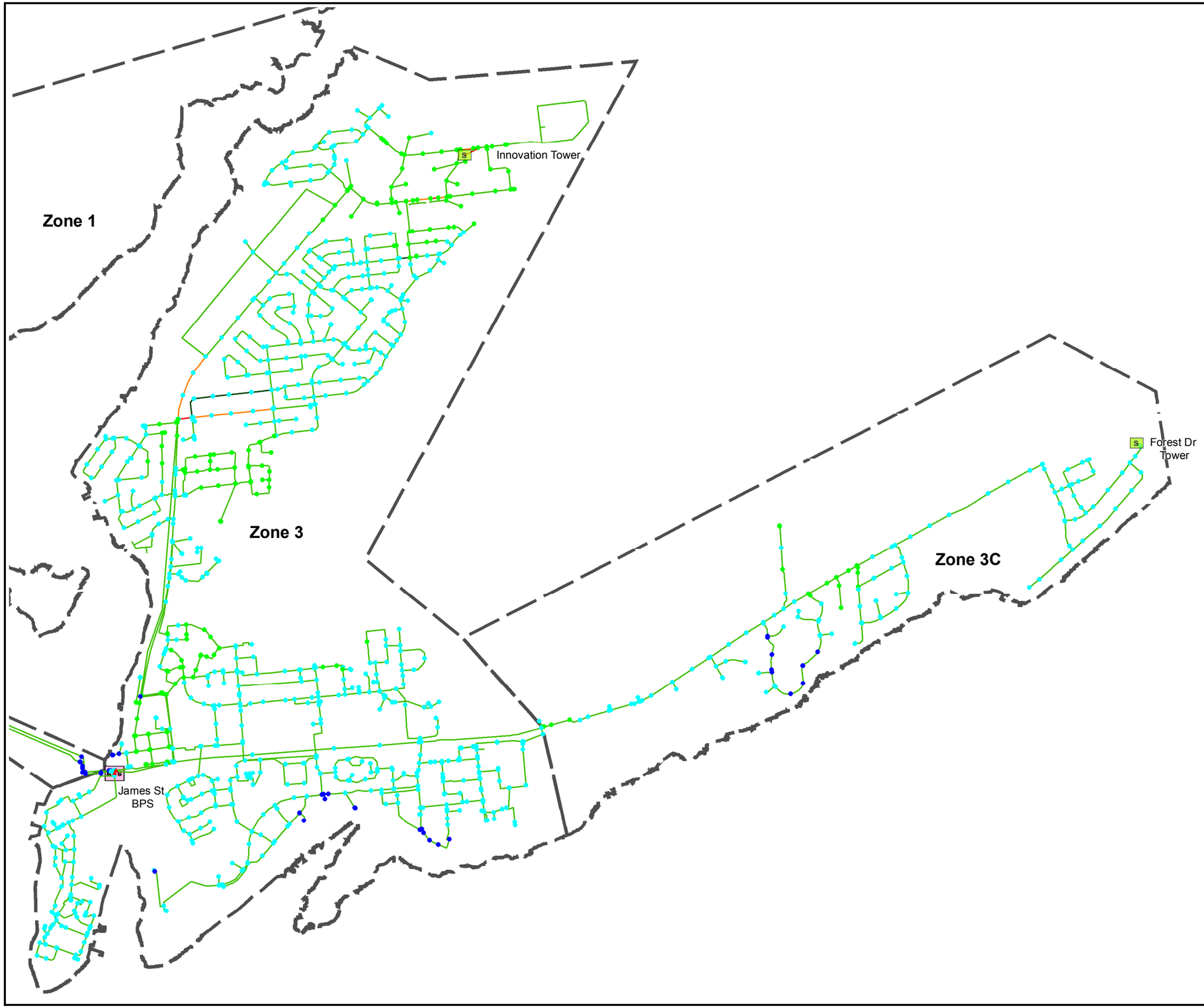
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

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

Scenario:
2026 RECOMMENDED ALTERNATIVES (MIN. HOUR)

Project No.:	Date:		
151-02944-00	FEBRUARY 2017		
Drawn By:	Checked By:	Code:	Map No.:
HC	JLD	WM	1.3.1

File Location:S:\MA\15\151-02944_KingstonMasterPlan\3.0 Technical\3.7 Reports\3.7.7_Water Model\Maps\Alt_Maps\Map1_3_1-WC_Alt2_2026_MinHr_HLoss_Pressure.mxd



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Utilities Kingston
UTILTIES KINGSTON
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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 W E S

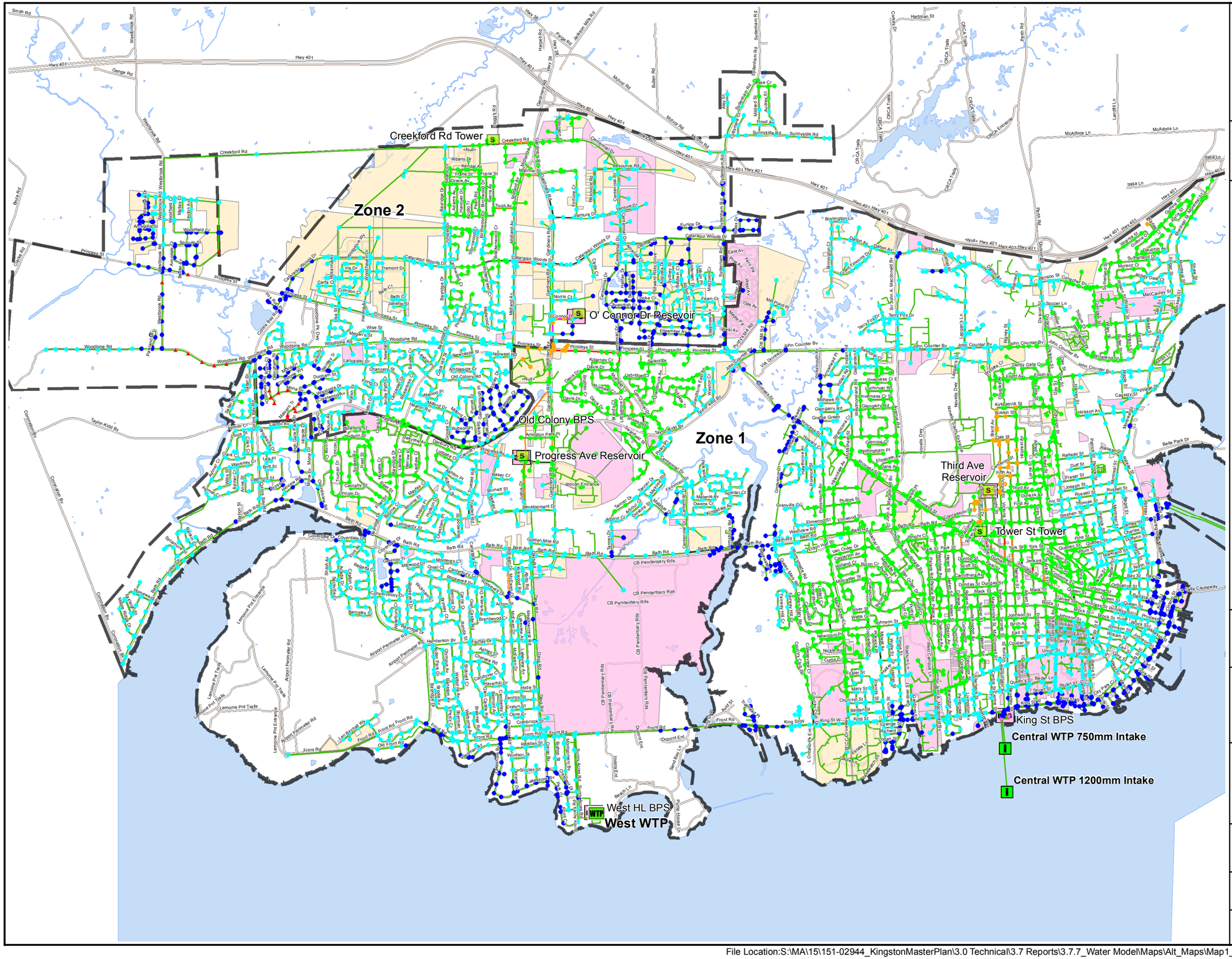
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

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

Scenario:
2026 RECOMMENDED ALTERNATIVES (MIN. HOUR)

Project No.:	Date:		
151-02944-00	FEBRUARY 2017		
Drawn By:	Checked By:	Code:	Map No.:
HC	JLD	WM	1.3.2

File Location:S:\MA\15\151-02944_KingstonMasterPlan\3.0 Technical\3.7 Reports\3.7.7_Water Model\Maps\Alt_Maps\Map1_3_2-East_Alt2_2026_MinHr_HLoss_Pressure.mxd



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Utilities Kingston
UTILTIES KINGSTON
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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

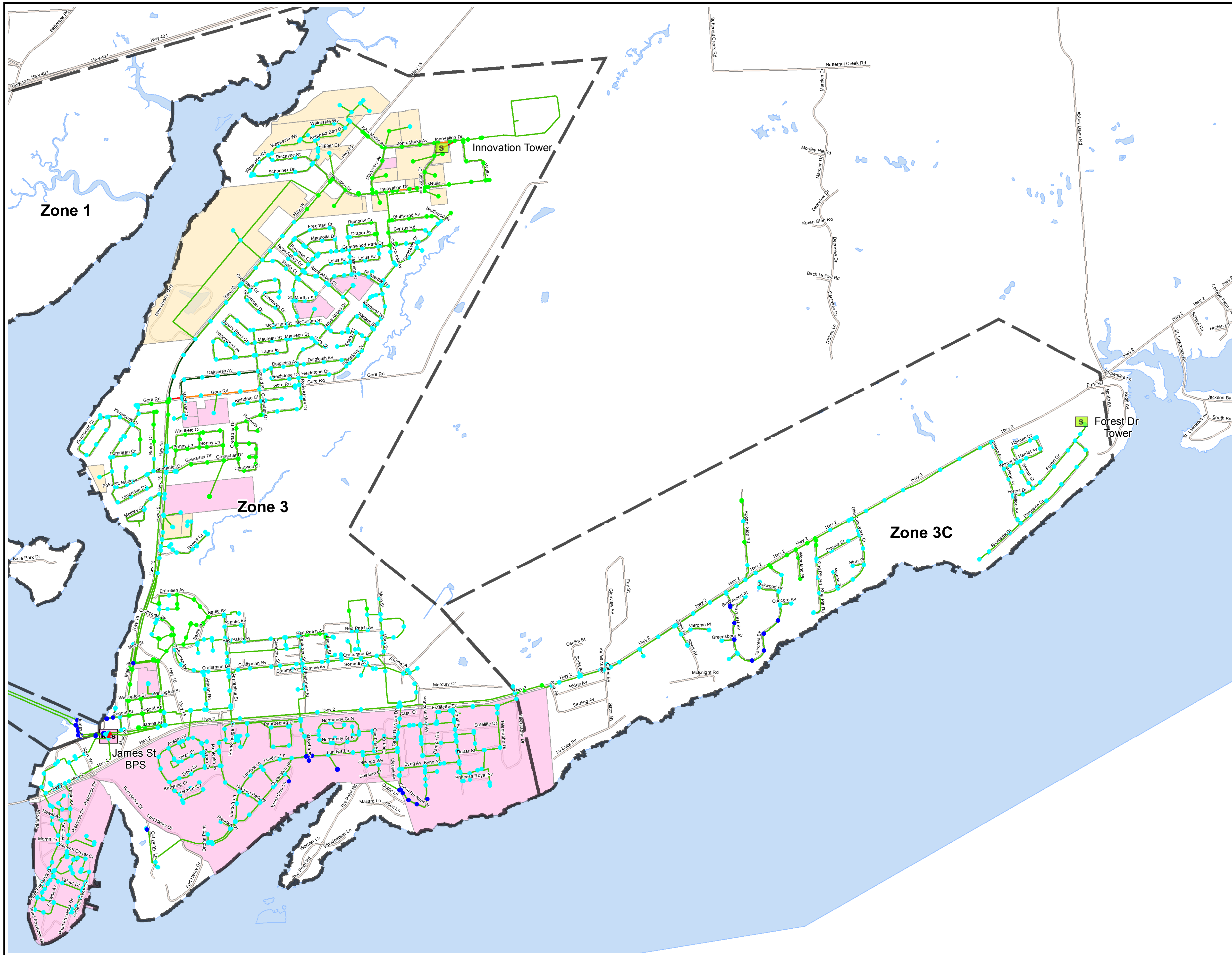
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

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

Scenario:
2036 RECOMMENDED ALTERNATIVES (MIN. HOUR)

Project No.:	Date:		
151-02944-00	FEBRUARY 2017		
Drawn By:	Checked By:	Code:	Map No.:
HC	JLD	WM	1.4.1

File Location:S:\MA\15\151-02944_KingstonMasterPlan\3.0 Technical\3.7 Reports\3.7.7_Water Model\Maps\Alt_Maps\Map1_4_1-WC_Alt2_2036_MinHr_HLoss_Pressure.mxd



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Utilities Kingston
UTILTIES KINGSTON
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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

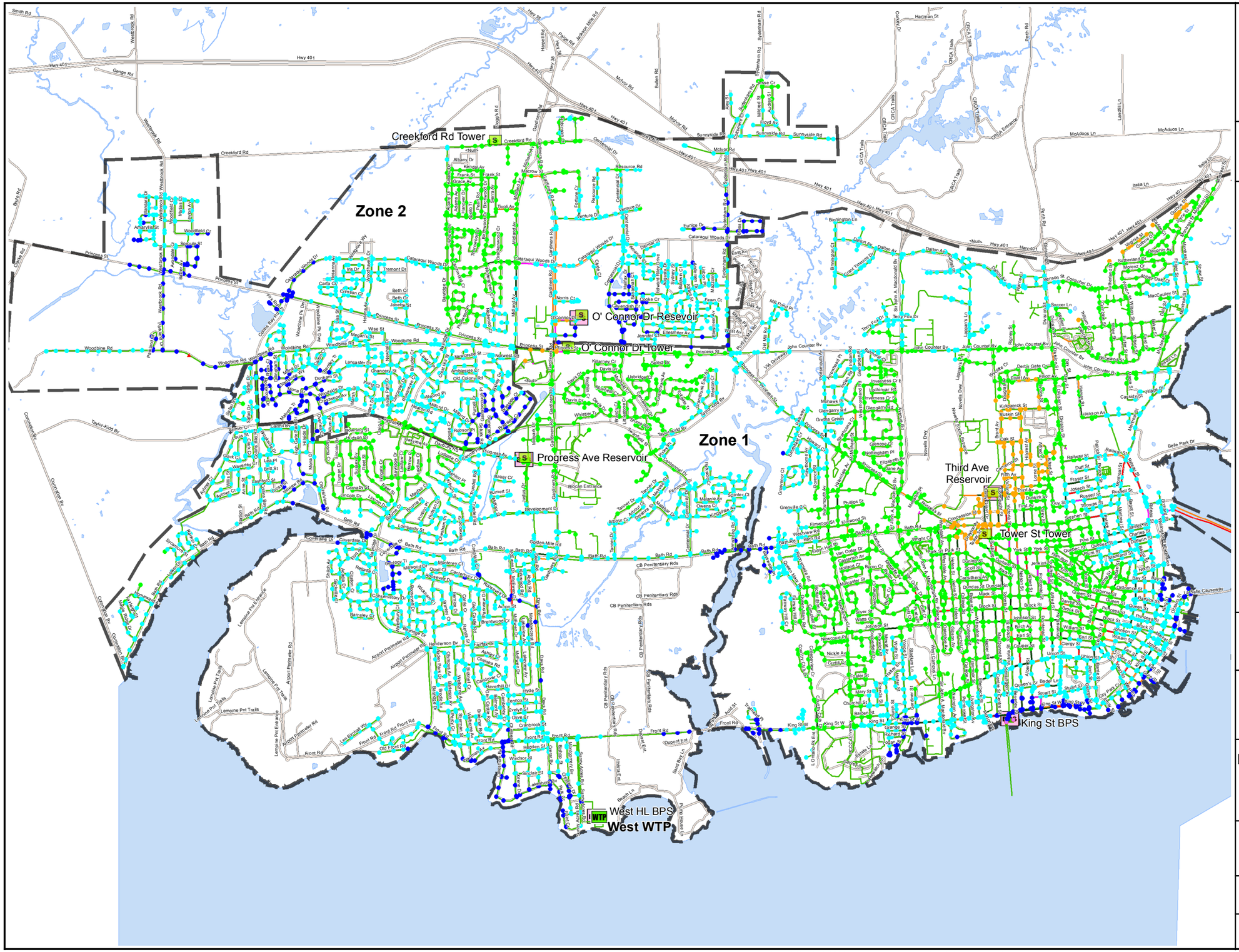
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 3, 3C)

Scenario:
2036 RECOMMENDED ALTERNATIVES (MIN. HOUR)

Project No.:	Date:
151-02944-00	FEBRUARY 2017

Drawn By:	Checked By:	Code:	Map No.:
HC	JLD	WM	1.4.2

File Location:S:\MA\15\151-02944_KingstonMasterPlan\3.0 Technical\3.7 Reports\3.7.7_Water Model\Maps\Alt_Maps\Map1_4_2-East_Alt2_2036_MinHr_HLoss_Pressure.mxd



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UTILTIES KINGSTON
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Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
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- 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

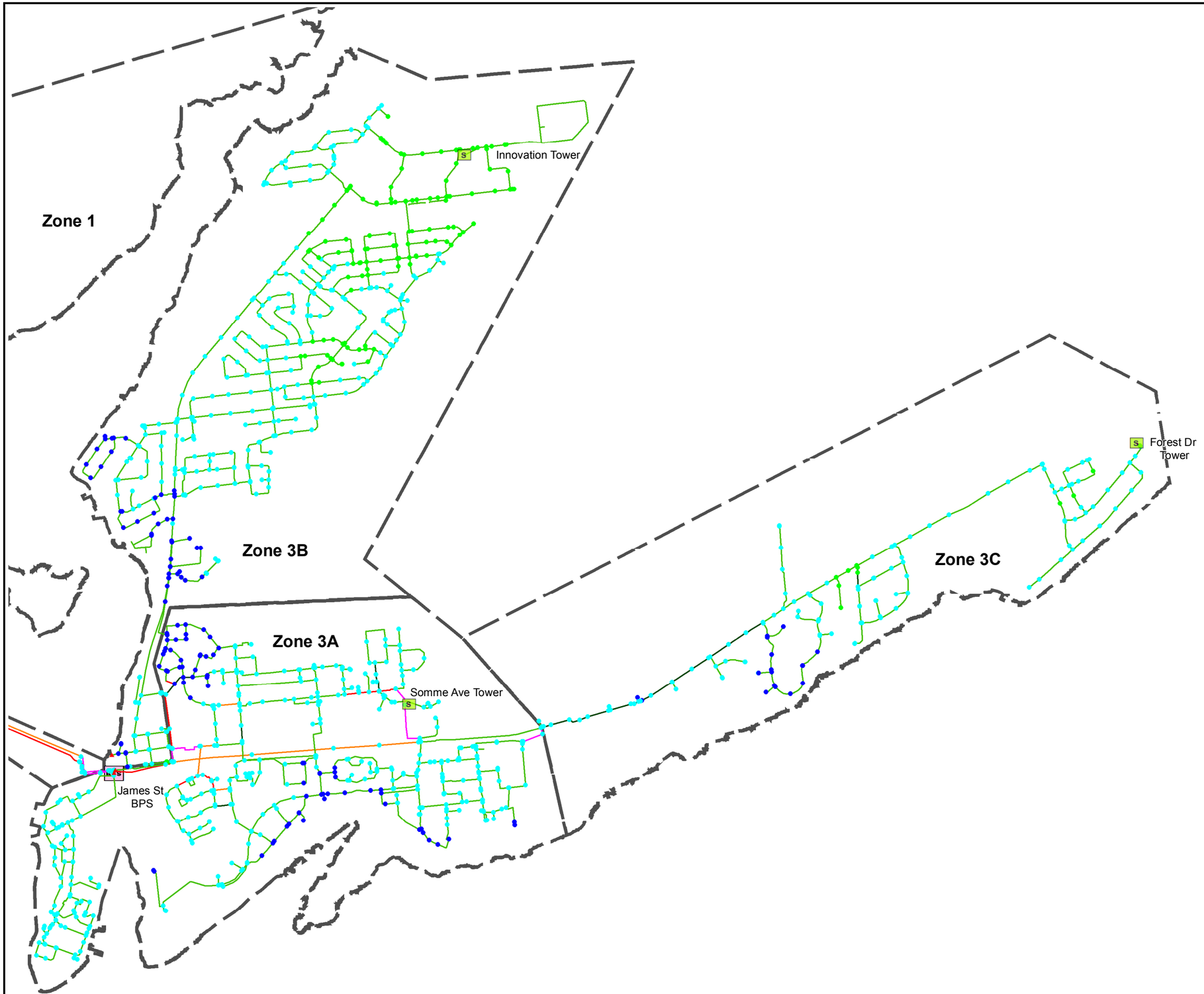
Title:
KINGSTON WATER SYSTEM - PIPE HEADLOSS AND JUNCTION PRESSURE (ZONES 1 & 2)

Scenario:
2015 INTER-CONNECTION-BASE MAP FOR OPTIMIZED CONDITION (PEAK HOUR)

Project No.:	Date:
151-02944-00	FEBRUARY 2017

Drawn By:	Checked By:	Code:	Map No.:
HC	JLD	WM	2.1.1

File Location:S:\MA\15\151-02944_KingstonMasterPlan\3.0 Technical\3.7 Reports\3.7.7_Water Model\Maps\Alt_Maps\Map2_1_1-WC_Alt1_2015Inter_PHD_HLoss_Pressure.mxd



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Legend

- WTP — Water Treatment Plant (WTP)
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- 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

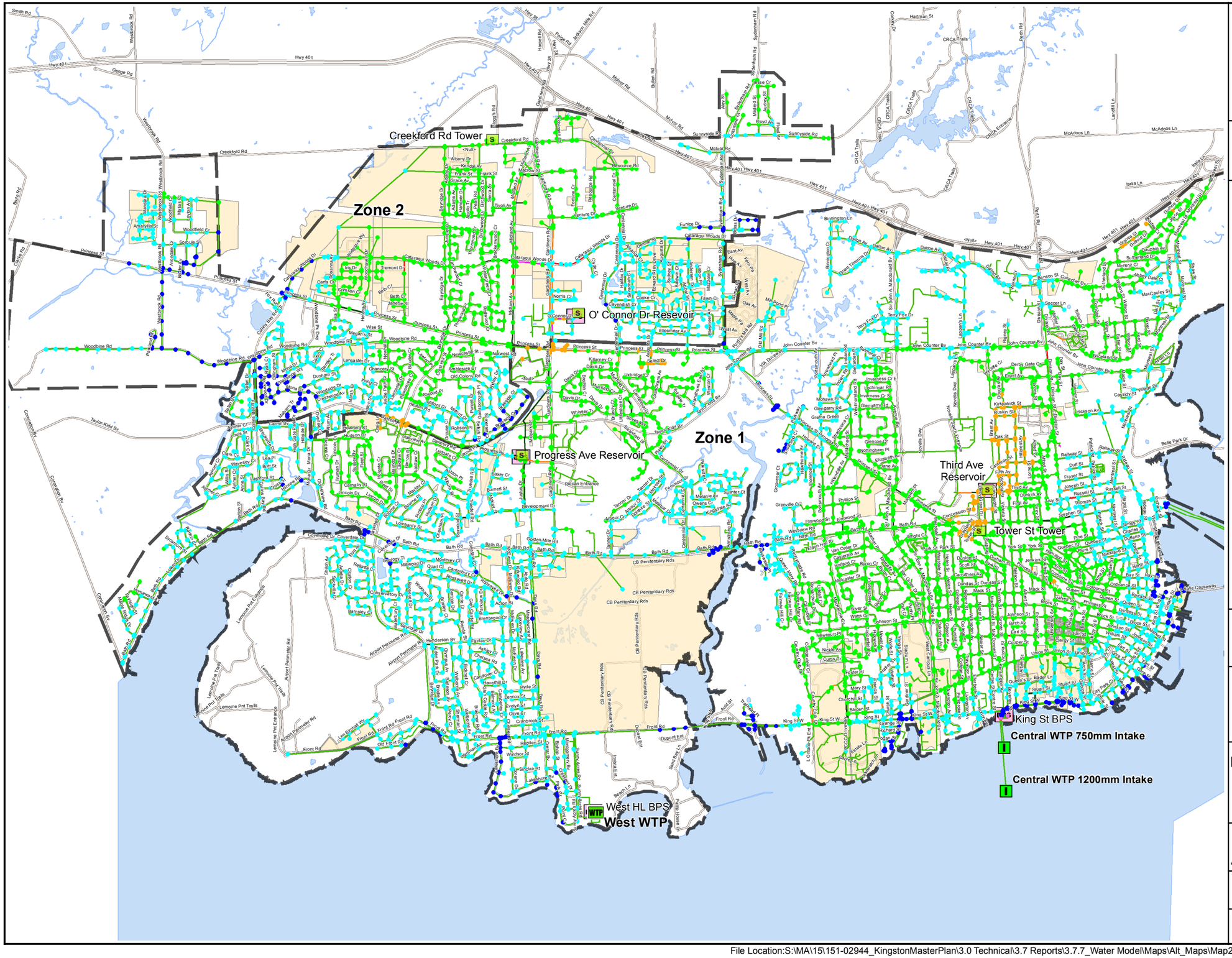
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

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

Scenario:
2015 INTER-CONNECTION-BASE MAP FOR OPTIMIZED CONDITION (PEAK HOUR)

Project No.:	Date:		
151-02944-00	FEBRUARY 2017		
Drawn By:	Checked By:	Code:	Map No.:
HC	JLD	WM	2.1.2

File Location:S:\MA\15\151-02944_KingstonMasterPlan\3.0 Technical\3.7 Reports\3.7.7_Water Model\Maps\Alt_Maps\Map2_1_2-East_Alt1_2015Inter_PHD_HLoss_Pressure.mxd



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Utilities Kingston
UTILTIES KINGSTON
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K7L 4X7

Legend

- WTP — Water Treatment Plant (WTP)
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- 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

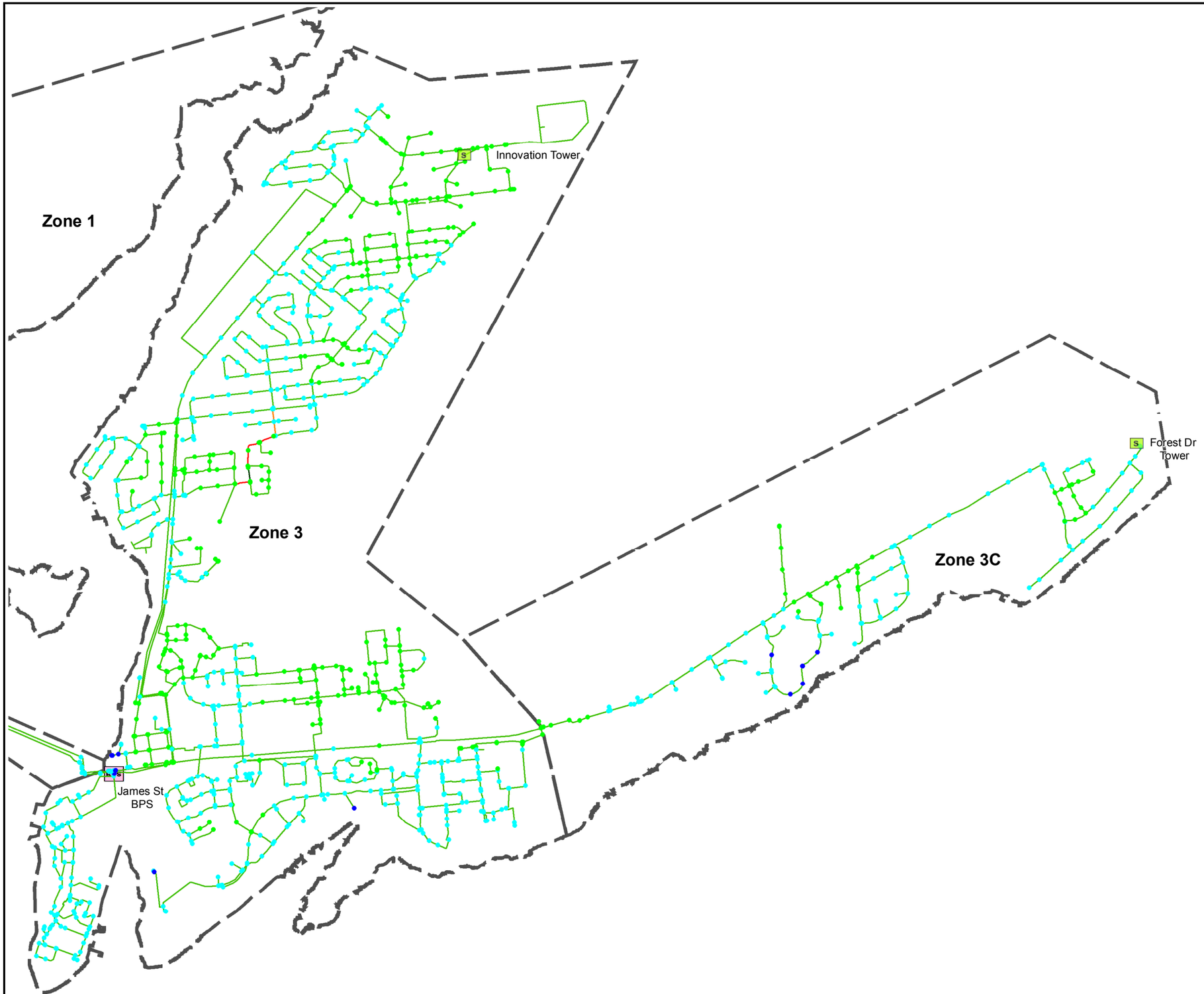
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

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

Scenario:
2021 RECOMMENDED ALTERNATIVES (PEAK HOUR)

Project No.:	Date:		
151-02944-00	FEBRUARY 2017		
Drawn By:	Checked By:	Code:	Map No.:
HC	JLD	WM	2.2.1

File Location:S:\MA\15\151-02944_KingstonMasterPlan\3.0 Technical\3.7 Reports\3.7.7_Water Model\Maps\Alt_Maps\Map2_2_1-WC_Alt2_2021_PHD_HLoss_Pressure.mxd



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

Legend

- WTP Water Treatment Plant (WTP)
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- 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

N W E S

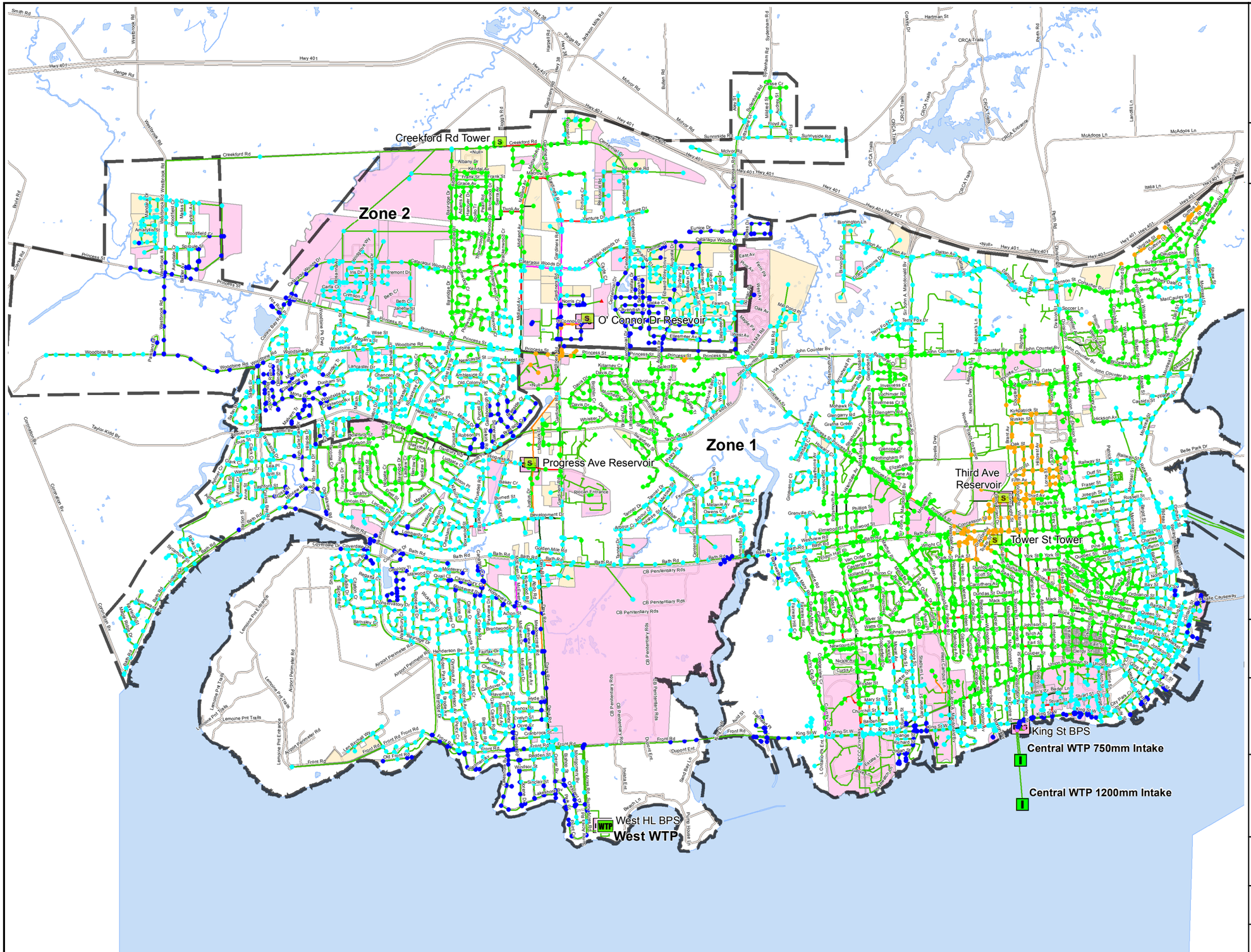
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

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

Scenario:
2021 RECOMMENDED ALTERNATIVES (PEAK HOUR)

Project No.:	Date:		
151-02944-00	FEBRUARY 2017		
Drawn By:	Checked By:	Code:	Map No.:
HC	JLD	WM	2.2.2

File Location:S:\MA\15\151-02944_KingstonMasterPlan\3.0 Technical\3.7 Reports\3.7.7_Water Model\Maps\Alt_Maps\Map2_2_2-East_Alt2_2021_PHD_HLoss_Pressure.mxd



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Utilities Kingston
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Legend

- WTP Water Treatment Plant (WTP)
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- PressureZone
- Road
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- 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

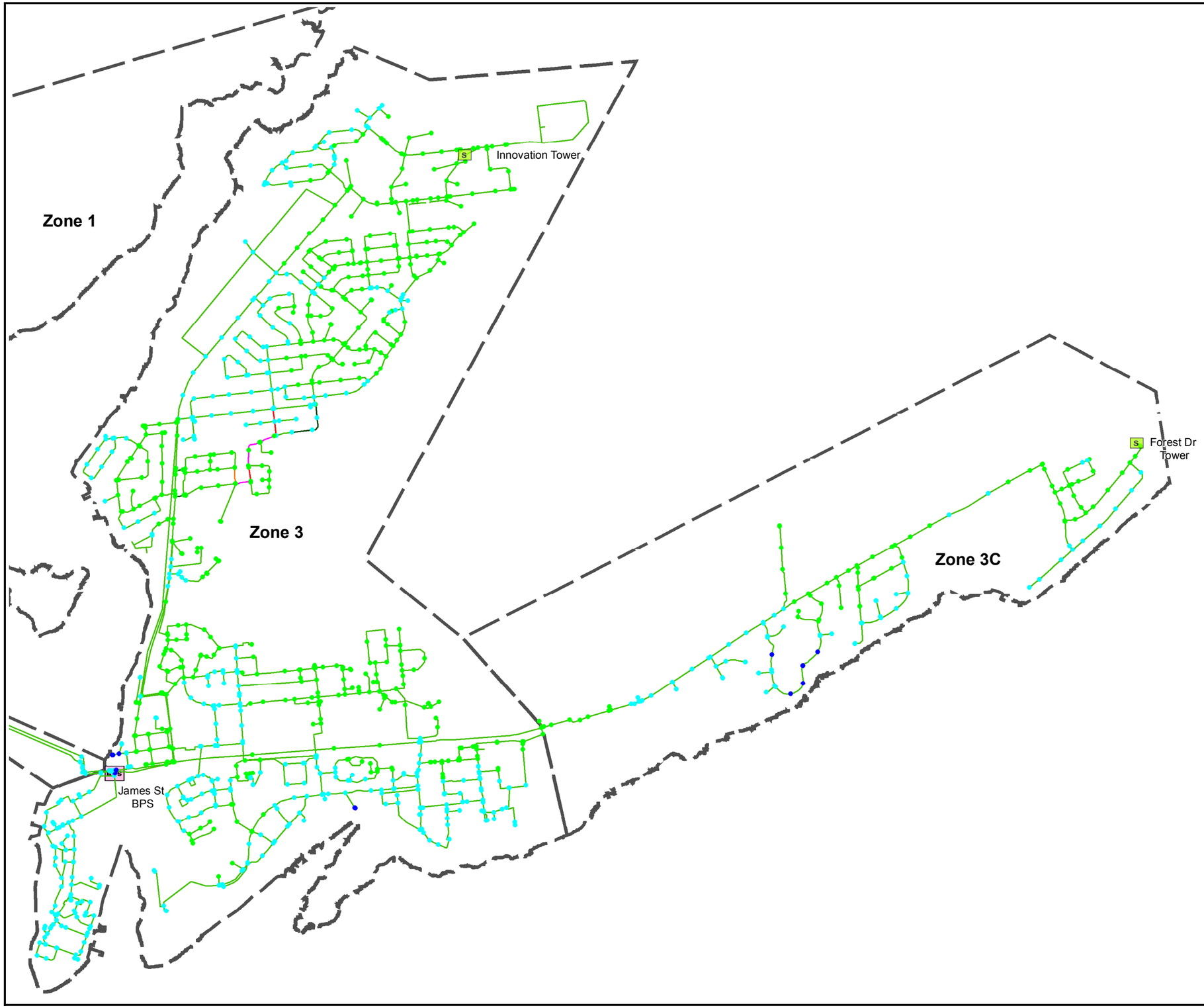
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

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

Scenario:
2026 RECOMMENDED ALTERNATIVES (PEAK HOUR)

Project No.:	Date:		
151-02944-00	FEBRUARY 2017		
Drawn By:	Checked By:	Code:	Map No.:
HC	JLD	WM	2.3.1

File Location:S:\MA\15\151-02944_KingstonMasterPlan\3.0 Technical\3.7 Reports\3.7.7_Water Model\Maps\Alt_Maps\Map2_3_1-WC_Alt2_2026_PHD_HLoss_Pressure.mxd



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Legend

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- I Raw Water Intake
- PressureZone
- Road
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- 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:
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1:25,000

N W E S

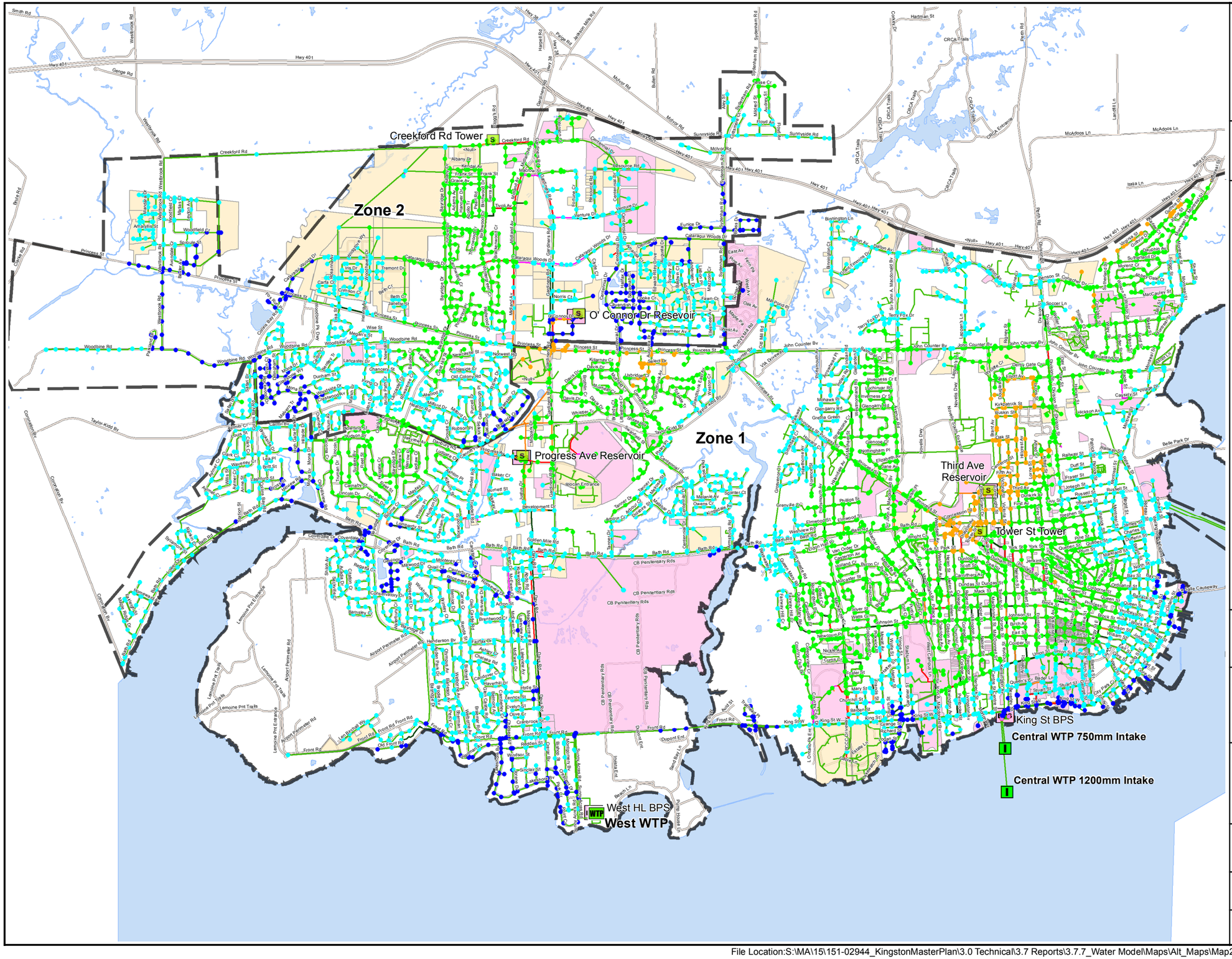
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

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

Scenario:
2026 RECOMMENDED ALTERNATIVES (PEAK HOUR)

Project No.:	Date:		
151-02944-00	FEBRUARY 2017		
Drawn By:	Checked By:	Code:	Map No.:
HC	JLD	WM	2.3.2

File Location:S:\MA\15\151-02944_KingstonMasterPlan\3.0 Technical\3.7 Reports\3.7.7_Water Model\Maps\Alt_Maps\Map2_3_2-East_Alt2_2026_PHD_HLoss_Pressure.mxd



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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

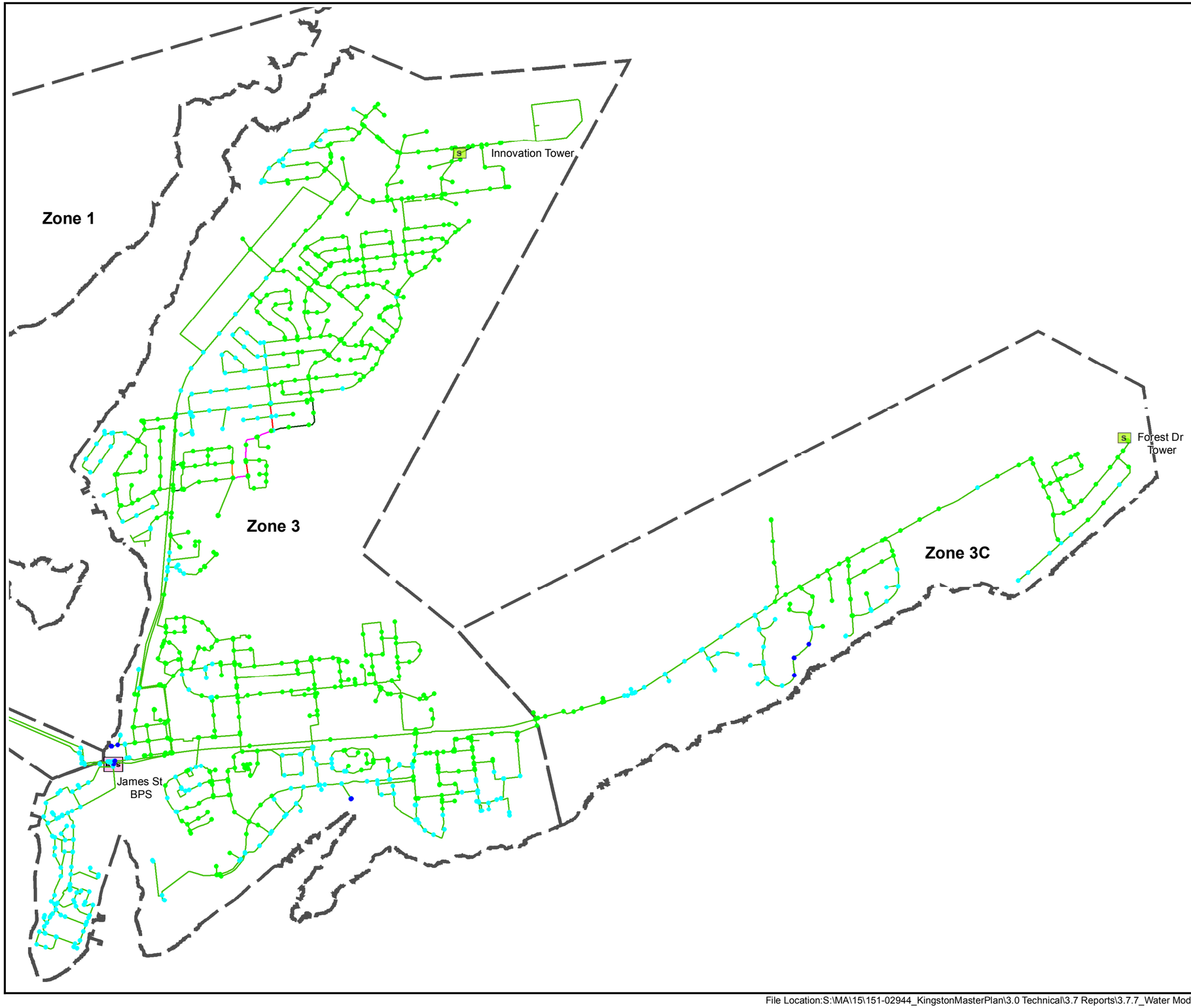
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

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

Scenario:
2036 RECOMMENDED ALTERNATIVES (PEAK HOUR)

Project No.:	Date:		
151-02944-00	FEBRUARY 2017		
Drawn By:	Checked By:	Code:	Map No.:
HC	JLD	WM	2.4.1

File Location:S:\MA\15\151-02944_KingstonMasterPlan\3.0 Technical\3.7 Reports\3.7.7_Water Model\Maps\Alt_Maps\Map2_4_1-WC_Alt2_2036_PHD_HLoss_Pressure.mxd



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Legend

- WTP Water Treatment Plant (WTP)
- S Storage Tank
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- 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 W E S

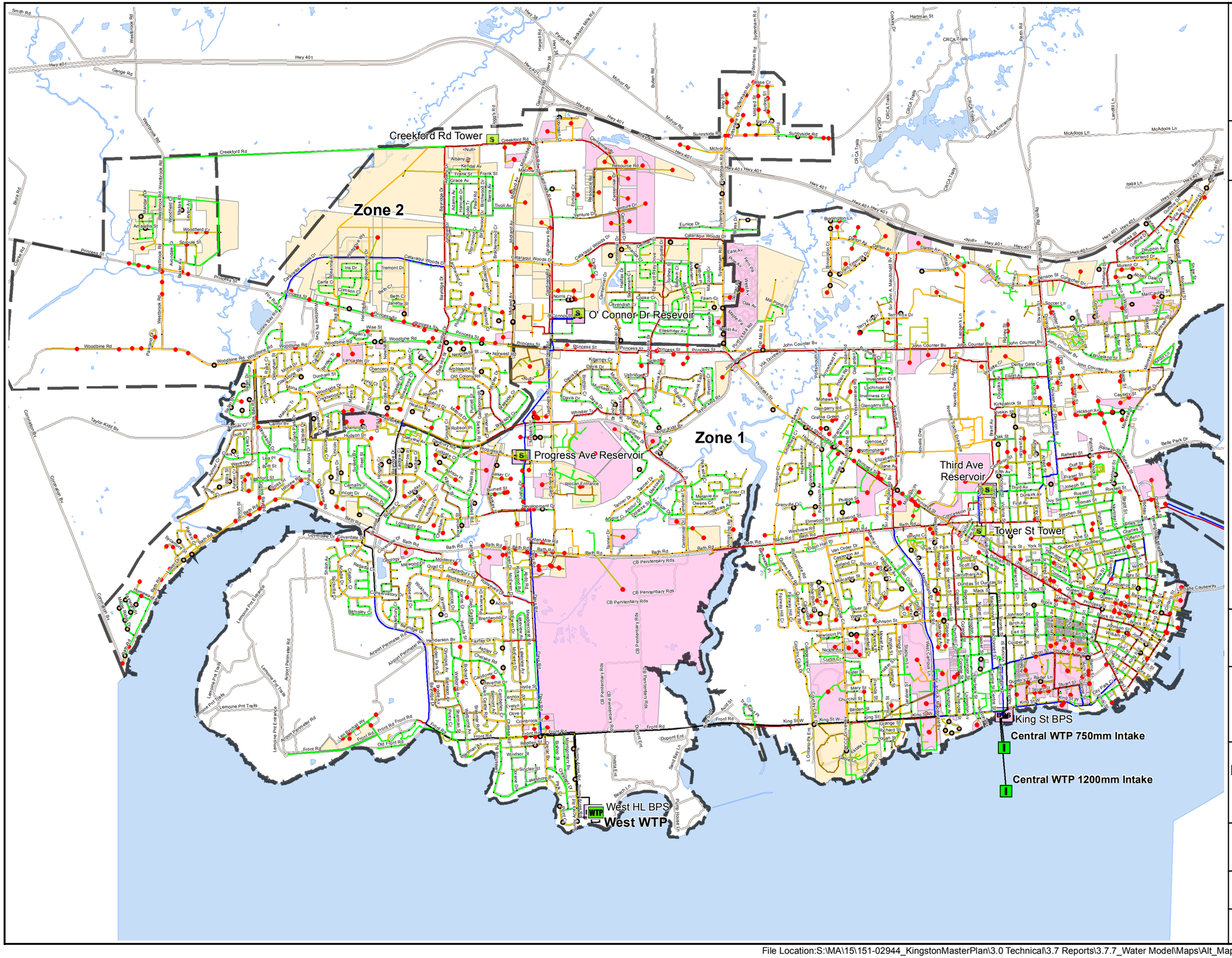
Project:
Water and Wastewater Master Plan
City of Kingston, Ontario

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

Scenario:
2036 RECOMMENDED ALTERNATIVES (PEAK HOUR)

Project No.:	Date:		
151-02944-00	FEBRUARY 2017		
Drawn By:	Checked By:	Code:	Map No.:
HC	JLD	WM	2.4.2

File Location:S:\MA\15\151-02944_KingstonMasterPlan\3.0 Technical\3.7 Reports\3.7.7_Water Model\Maps\Alt_Maps\Map2_4_2-East_Alt2_2036_PHD_HLoss_Pressure.mxd



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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

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 RECOMMENDED ALTERNATIVES (MDD+FF)

Project No.:	Date:		
151-02944-00	FEBRUARY 2017		
Drawn By:	Checked By:	Code:	Map No.:
HC	JLD	WM	3.4.1

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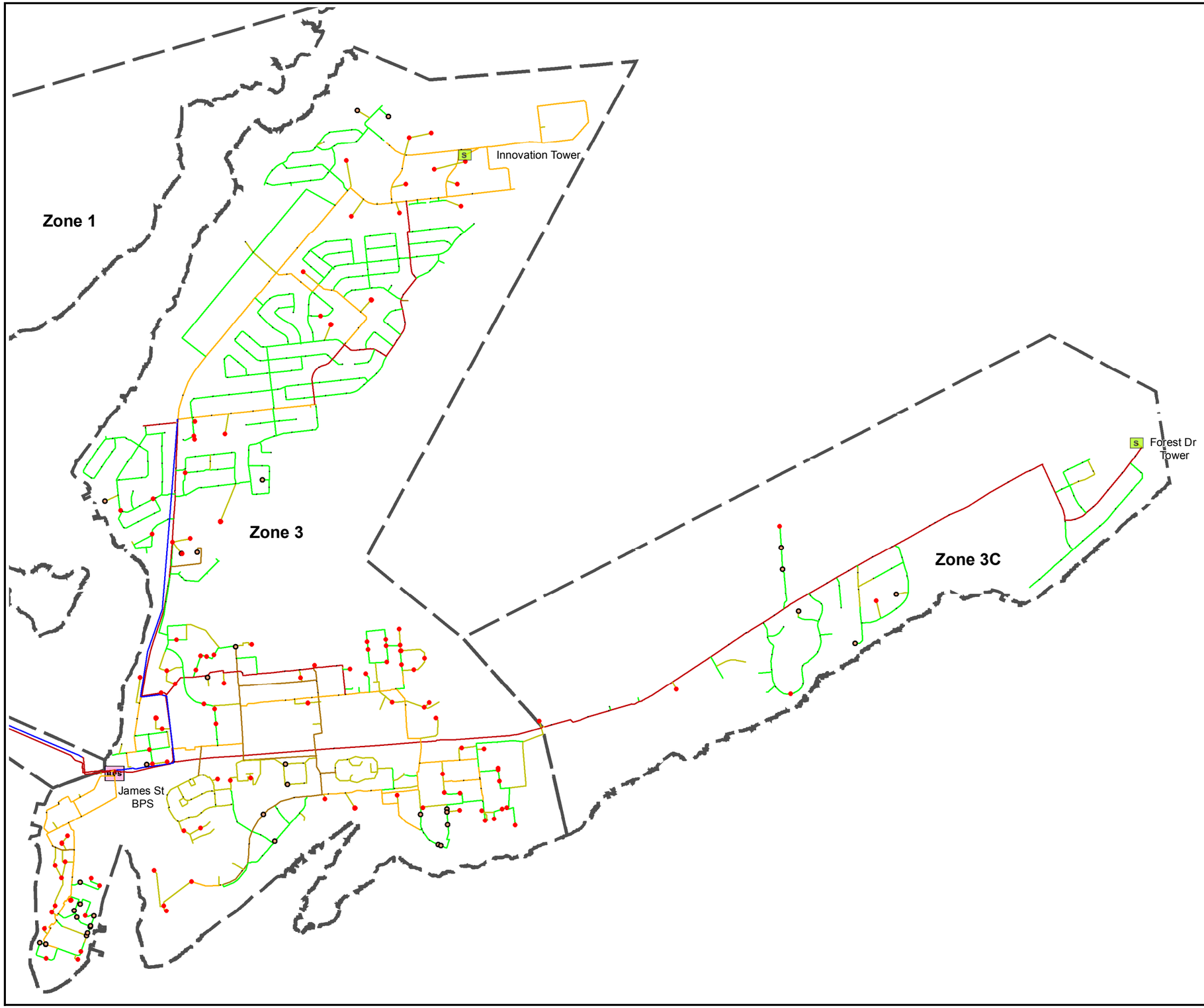

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UTILTIES KINGSTON
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KINGSTON, ONTARIO,
K7L 4X7

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

N W E S

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

Title:
KINGSTON WATER SYSTEM - FIRE FLOW AVAILABILITY (ZONES 3, 3C)

Scenario:
2036 RECOMMENDED ALTERNATIVES (MDD+FF)

Project No.:	Date:		
151-02944-00	FEBRUARY 2017		
Drawn By:	Checked By:	Code:	Map No.:
HC	JLD	WM	3.4.2

File Location:S:\MA\15\151-02944_KingstonMasterPlan\3.0 Technical\3.7 Reports\3.7.7_Water Model\Maps\Alt_Maps\Map3_4_2-East_Alt2_2036_MDD_FireFlow.mxd