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OPUS DAYTONKNIGHT

City of Prince George

Water Service Network Plan 2014

Final



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City of Prince George

Water Service Network Plan 2014

Final

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Executive Summary

Introduction

The City of Prince George provides water to a population of over 76,000 persons, including the supply, pumping, storage and distribution of approximately 91 Megalitres (20 million gallons) of water daily. The City desires an update to its Water Service Network Plan for continued upgrades of the water system that will accommodate future growth and replacement of aging infrastructure. The capacity of the City's water system to provide service to accommodate future growth varies, depends on a number of factors such as the level of service required, location of future growth, age of infrastructure, etc. This study will assist the City in understanding the capacity of its current water system and will identify servicing opportunities and constraints in order that future upgrades may be planned in an economic and efficient manner. It will also identify upgrade requirements along with a proposed schedule and costs.

Community Growth Plans

Notwithstanding that the City's population growth has been relatively flat in the past decade, the City recognizes that prospects for growth exist as a result of strong economic indicators in the Northern B.C. region. The OCP (Official Community Plan) notes that the City has adequate zoned areas, underutilized land or land planned for potential development that is required to support community growth in horizons typical of infrastructure planning efforts (20-50 years). The OCP suggests preferred locations for growth of up to 17,600 persons in the foreseeable future (short term growth), and identifies land areas (residential neighborhood plans, commercial and light industrial) for additional population growth of over 70,400 persons (long term growth). This Water Service Network Plan Update has reviewed the required infrastructure upgrades required to meet both these short term and long term growth projections.

Water Supply

The City's water system is provided with raw water that is pumped from wells that are located along the Nechako and Fraser Rivers. In most cases that water is of high quality, is potable, and is not provided with treatment other than disinfection. Water system improvements constructed in the past decade have allowed for the abandonment of three smaller / older wells. Improvements to water system interconnectivity in the network are planned to provide for the abandonment of another small well, the Willow Cale Well (PW-627) in the foreseeable future. Of the remaining active wells, most of the water is provided by three large diameter collector wells, the Wilson Park West (PW-605), Wilson Park East (PW-601) and Fishtrap Collector (PW-660) Wells located adjacent to the Nechako River.

There are no concerns with the supply capacity of the City's three primary water wells. The City's existing Maximum Day Demand (MDD) is approximately 1,000 L/s (20 MGD) but could increase to 1,400 L/s (26.5 MGD) under short term growth projections and 2,000L/s (40 MGD) under the long term growth projections. By comparison, the City's three main collector wells have supply capacity of over 3,150 L/s (60 MGD).

These three primary wells have sufficient capacity to supply the entire City if upgrades to water transmission main capacity and pressure zone interconnectivity were implemented. The City could, for example, abandon the Willow Cale Well (PW-627) in the Danson / BCR Industrial Park that is considered to be at risk, and would be less dependent on operation of the College Heights wells (PW-621 and PW-624). Recommended improvements for water supply interconnectivity include:

- Construction of a trunk watermain between PW-605 and PW-660
- Update of the PRV settings and controls between Pressure Zone 1 and 2
- Construction of a trunk watermain extension from the end of Boundary Road to the Danson Reservoir

The Corral Well (PW-650) which services the Western Acres area, near the City's western boundary, does not have sufficient capacity of Maximum Day Demand for that area, and should be replaced or supplemented with a new well. Further, for economic reasons it does not make sense to provide any interconnectivity mains for the Western Acres area.

Water Supply Pump Stations

The capacity of the three primary pump stations located above the primary supply wells is less than the ultimate capacity of the wells in the ground. The total pumping capacity of the three wells is approximately 1,720 L/s which is still adequate to provide service to the entire City well into the future (short term growth demand is 1,400 L/s), provided inter-zone connectivity is improved.

Specifically, the Fishtrap Island collector well and pump station (PW-660) has capacity beyond the servicing requirements of the Hart and Nechako areas, so that connection of this pump station to Pressure Zone 2 will provide significant supply redundancy and reliability to the South water system in the short term and meet supply requirements in the long term. The original design of PW-660 provided for this future connection. Similarly, the design of the pump stations at the Wilson Park East Well (PW-601 and PW-602) provided allowances for the installation of additional pumps that will increase network capacity. While the existing capacity of these pump stations (over 500 L/s) is sufficient for growth in the short term, installation of additional pumps will increase capacity to over 700 L/s which is required to meet long term growth requirements. This includes the downtown core (Pressure Zone 1), Blackburn, Airport Industrial Lands and BCR / Danson light industrial areas.

Water Booster Pumping Stations

Most of the City's water booster pump stations have capacity to pump water to water storage reservoirs to meet existing maximum day demands and short term growth requirements. Exceptions include PW-623 and PW-628 which pump water from lower pressure zones to higher elevations at the Blackburn / Airport, and Lalonde growth areas, respectively. Timing for the upgrade of PW 623 will depend largely on the rate of growth of the Airport Light Industrial Lands to provide water supply to the Danson / BCR areas from Pressure Zone 1 and on the ability through recommended PRV network improvements.

In the long term, construction of a water trunk main and booster pump stations connecting the Danson / BCR lands to Pressure Zone 1 via a crossing of the Simon Fraser Bridge is preferred to

relying solely on PW-623 to provide water service to lands east of the Fraser River. In the long term, PW-630, which pumps water from Pressure Zone 2 to the University Heights and College Heights areas, will require significant improvements to increase capacity. Upgrades to PW-630 were planned for in its original design and can be implemented in the future, depending on the rate of growth of the University Heights development. Any upgrades which have been found necessary for PW-628 and PW-636 have been transferred to PW-630.

Fire pumps have also been recommended for Pressure Zones in the City which do not have a reservoir supply. Sizing and preliminary cost estimates for fire pumps have been included in the improvement recommendations.

PRV Stations

As described above, performance of the City's water system is highly dependent on the function of pressure reducing valves which interconnect and allow the transfer of water from zones of higher elevation / pressure to lower zones. This is particularly true of Pressure Zone 01. A Zone 01 and Zone 02 interconnectivity analysis was carried out to determine the benefit of applying additional PRVs to the system. The results found that fire flow deficiencies within Pressure Zone 01 were subject to local street-by-street watermain upgrades rather than any supply upgrades through additional PRVs. The Griffiths and Zone 15 PRVs should be constructed to increase reliability/redundancy of the system, however, local watermain upgrades should be considered to increase fire flows to deficient areas.

The City would benefit from a program to field check all downstream pressure settings of each PRV in its system and to check the lead/lag valve operational characteristics within each PRV station. This would provide more confidence in the modelled results.

Water Storage

Water storage reservoirs store water for balancing peak water demands, for fire protection, and for emergency conditions in the water system. Analyses of the City's reservoirs suggests that many of the reservoirs have less than ideal capacity, but that, in many cases, the storage short comings may be managed by transferring of water from Pressure Zones of higher elevation to lower elevations through PRV stations that interconnect various areas of the City. In some areas, the service areas are either too remote or are too sparsely populated to justify the cost of providing increased water storage for fire protection.

Pressure Zone 02, however, cannot "borrow" water from the upper pressure zones that it is connected to due to the significant magnitude of demands in the system, and relies heavily on the water stored in PW-805, on Cranbrook Hill. The need to increase the size of this reservoir was also identified in the original Water Service Infrastructure Master Plan (Opus DaytonKnight 2000).

Several other reservoir improvements are recommended to address existing volume shortages (Pressure Zone 25), short term volume shortages (Pressure Zone 22), and long term volume shortages (Pressure Zone 07 and 02)

Transmission Network

Opus DaytonKnight further reviewed the reliability of the transmission network in the City and assessed their contribution to the City's ability to refill each of its system reservoirs during the maximum day demand scenario.

For the North water system, our analysis indicated that there were generally no concerns with refilling of system reservoirs. However, based on discussions with City staff, the primary transmission main connecting the Fishtrap Collector Well supply (PW-660) to the Vellencher Reservoir (PW-817) and, in turn, the entire North water network, was susceptible to failure due to a shallow bury depth. Opus DaytonKnight reviewed several options to strengthen the transmission supply and has recommended, as the preferred route along Foothills Boulevard, the construction of a new transmission main.

While the transmission main network for the South water system was found well constructed, the transmission mains also pass through residential neighbourhoods and contain many connections along the mains before reaching system reservoirs. This is especially true for the transmission main leading from the Wilson Park West (PW-605) Well to the Cranbrook Hill Reservoir (PW-805). Due to the headloss from the direct connections off the transmission main and increasing demands, the City is currently having difficulty refilling PW-805 during maximum day demands even with three pumps running at PW-605. A transmission main to connect the Fishtrap Collector Wells (PW-660) is recommended to aid in the refill of PW-805.

Distribution Network

Opus DaytonKnight has updated the City's existing hydraulic model to determine the existing level of service the City is currently providing to its residents, as well as how the system would look like under the short term and long term development scenarios. System pressures and available fire flows coincident to maximum day demand were carefully reviewed under all three scenarios, and the selection of water system improvements was carried out in order to first meet the requirements of existing deficiencies while also being sized for future growth.

From the numerous transmission main and watermain upgrades reviewed, only those deemed to address a significantly larger amount of fire flow deficiencies with a lower amount of effort were identified and have been included in the City's Capital Projects List.

There are six categories considered for watermain upgrades:

- Short Term High Priority Upgrades – these are projects which would resolve existing deficiencies in the Prince George water system and are chosen mainly due to the large impact of fire flow deficiencies they resolve at a relatively lower budget. Several reservoir upgrades are also included to provide for adequate volumes of water during a fire coincident to maximum day demand. **The total estimated cost of these upgrades is $45,640,000.**

- Short Term Low Priority Upgrades – these are projects which would also resolve existing deficiencies but are less significant than the high priority upgrades. These upgrades also improve

the system reliability through additional supply routes to different pressure zones in the Prince George water system. **The total estimated cost of these upgrades is $26,842,000.**

- Long Term Upgrades – these are projects which are identified as less critical, but should be carried out to improve system reliability and fire flows to small areas in the City. These upgrades include recommendations to transfer properties from one pressure zone to another and the decommissioning of existing trunk mains under the highway network passing through the City. **The total estimated cost of these upgrades is $21,979,000.**

- Critical Watermain Replacements – Watermain replacements have been identified through a Risk & Criticality Assessment carried out for the entire watermain network in the City. The assessment has identified around 5% (in length) of the City's watermains to be categorized as "Very High Risk" watermain assets. The complete replacement of these watermains have been included in the Capital Projects List. **The total estimated cost of these upgrades is $35,856,000.**

- 100 mm Watermain Upgrades – Undersized (100 mm diameter) watermains were identified in the City of Prince George. These watermains need to at least 150 mm across the City to ensure that any hydrants connected off of them are able to provide an adequate fire flows coincident to maximum day demand. Further, those 100 mm watermains identified in the Downtown Core should be upsized to at least 200 mm. **The total estimated cost of these upgrades is $39,215,000.**

- Additional Projects Identified at Workshop with Operations Staff – A workshop held with operations staff provided suggestions for additional water infrastructure related projects for the Capital Projects List. Additional projects include conceptual, pre-design, and detailed design investigations to address all discussions and concerns arising from the workshop. **The total estimated cost of these upgrades is $733,000.**

In summary, the estimated total cost of upgrades recommended for the Water Service Network Plan is $170,265,000. This includes allowances of 30% for Contingency and 12% for Engineering. The projects selected in this Water Service Network Plan will eliminate the majority of the supply, pumping, transmission and distribution (pressure and fire flow) concerns in the foreseeable future.

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1 Introduction

The City of Prince George (City) retained Opus DaytonKnight Consultants Ltd. (Opus DaytonKnight) to update the City's Water Service Network Plan.

A technical assessment of the hydraulic infrastructure was undertaken to determine the condition of the existing supply network and recommend improvements to address current deficiencies in the system and address future challenges brought about by projected system growth. A major component of the technical assessment included the update, calibration, and subsequent analysis of the City's hydraulic water model, which was critical in developing the specific distribution network improvement projects and servicing strategies identified in this report. The updated hydraulic model provides a tool for the analysis in order to:

- Assess the existing hydraulic performance and current operational settings. Thus, determining the necessary short and/or medium term improvements required in the system;
- Assess the existing system's ability in coping with the City's future projected water demands through population growth. Thus, determining the necessary long term improvements and upgrade works necessary to serve the projected growth.

A Capital Projects List has been prepared at the end of this report which provides recommendations to the City for water infrastructure improvements to service both the existing population and growth envisaged by the City's Official Community Plan (OCP). This report provides a complete analysis of the City of Prince George's existing water supply sources, storage reservoirs, pump stations, pressure reducing stations and transmission and distribution network.

1.1 Scope of Work

The terms of reference prepared by the City of Prince George identified the key study issues to be addressed. The following summarizes the scope of work undertaken for the Water Service Network Plan:

- Gather and review all existing information related to the water supply, such as studies, reports, drawings, water quality data, operational data, etc. from the City;
- Meet with the City operations staff to obtain and compile all relevant operational data;
- Obtain historical data on average day, maximum day and peak hour demands;
- Assess the influence of the existing population and future growth in the water model;
- Review field data and results from the hydrant flow testing program completed for the City;
- Model Calibration;
- Assess distribution system and reservoir capacity design criteria requirements;
- Analyse existing and future water system deficiencies and propose recommendations for system improvements to address each deficiency;
- Carry out a Risk & Criticality Assessment of the City's watermains to develop a prioritization methodology for their replacement; and,
- Prepare cost estimates and a Capital Projects List for the proposed upgrades.

1.2 Data Collection and Information Review

Historical data, water system information and previous studies that have been reviewed during development of this report include:

- 2012 City of Prince George water meter records
- 2011 City of Prince George Official Community Plan (including all Schedules)
- 2008-2012 City of Prince George pumping records
- 2000 City of Prince George Water Service Infrastructure Master Plan
- All available Neighbourhood Plans from the City website
- GIS shape files from City of Prince George Open Data Catalogue
- Operational information on the City's Reservoirs, Pump stations and PRVs

1.3 Acknowledgements

Opus DaytonKnight acknowledges the support and cooperation of the City of Prince George and extends its appreciation to Dave Dyer, P.Eng., Manager, Utilities, Kristy Brown, CTech, Supervisor Utilities, Kim Hattle, AScT, Engineering Assistant, and Tiina Watt, Supervisor, Long Range Planning, for their assistance to the project team at Opus DaytonKnight in preparing the report.

The model development, analysis and report was prepared by Clive Leung, EIT, for Opus DaytonKnight with supervision and direction from Scott Bilbrough, P.Eng., and Gurjit Sangha, P.Eng.

1.4 Abbreviations

ADD	Average Day Demand
BC	British Columbia
FUS	Fire Underwriters Survey
GIS	Geographic Information System
HGL	Hydraulic Grade Line
ICI	Industrial/Commercial/Institutional
kPa	kilopascal
L/c/d	Litres per capita per day
L/s	Litres per second
MDD	Maximum Day Demand
ML	Million Litres
ML/d	Million Litres per Day
OCP	Official Community Plan
PHD	Peak Hour Demand
PRV	Pressure Reducing Valve
psi	pounds per square inch
WTP	Water Treatment Plant

2 Existing Water System

This section provides an overview and general description of the existing water system in the City of Prince George.

2.1 System Overview

The City of Prince George water system consists of 19 pressure zones, 15 storage reservoirs, and includes over 550 km of watermain. The City is supplied through six groundwater wells, one north of the Nechako River and five south of the river. Groundwater wells which have been taken out of normal operation in recent years are able to provide emergency and backup water supply to the City of Prince George if needed.

The City currently serves over 76,000 people on its water system and provides over 16 million cubic metres of potable water for consumption per year. As of 2013, the system is comprised of supply wells, storage reservoirs, pump and PRV stations, transmission and distribution mains, service connections and fire hydrants as summarized in Table 2-1 and shown in Figure 2-1 and Figure 2-2.

Table 2-1 Water System Summary

Water System Component	Quantity
Pressure Zones	19
Supply Wells	6
Storage reservoirs	15
Pump Stations	17
Pressure Reducing Valves	18
Length of watermains (km)	553.6
Service connections	25,268
Fire Hydrants (Owned by City)	2,057

Hydraulic schematics of the south and north water systems were also produced and are illustrated in Figure 2-3 and Figure 2-4.

2.2 Water Supply and Treatment

The City of Prince George receives raw groundwater from six underground wells adjacent to the Nechako and Fraser Rivers. The raw water is treated with a disinfectant (sodium hypochlorite) and fluoridated.

New modern and standardized chlorine analysers were added to the water system in 2011 to monitor and ensure appropriate levels of disinfection were being introduced at wells and re-chlorination booster stations.

There are six active wells in the City of Prince George. The north system is supplied solely by the newly constructed (2006) Fishtrap Collector Well and pumping system. Table 2-2 summarizes the well capacities for both the south and north water systems.

Table 2-2 Existing Supply Wells

System	Well	Serviced by	Available Capacity (Mgpd)	Available Capacity (L/s)
South	Wilson Park East	601, 602	24.0	1,052
	Wilson Park West	605	18.0	789
	College	621, 624	5.01	220*
	Corral	625	0.042	1.8*
	Willow Cale	627	2.08	90.9*
North	Fishtrap	660	24.6	1,078

*indicates pump capacity

PW605 Wilson Park West Well
PW601 Wilson Park East Well
PW602 Cameron PS
PW633 Freeman PRV
PW805 Cranbrook Hill Reservoir
PW630 UNBC PS
PW622 Crest PRV
PW623 Patricia PS
PW637 Hwy 16 PRV
PW823 Gunn Rd Reservoir
PW803 Carney Hill Reservoir
PW830 UNBC Reservoir
UNBC PRV
PW641 Recreation PRV
PW635 Ferry PRV
PW636 Andres PS
PW643 Upper Tyner PRV
PW806 BCR Reservoir
PW644 Lower Tyner PRV
PW836 Tyner Reservoir
PW624 College North Well
PW613 O'Grady PRV
PW621 College South Well
PW828 Vanway Reservoir
PW628 Lalonde PS
PW824 Lalonde Reservoir
PW634 Bernard PRV
PW639 St. Patrick PRV
PW642 FRBL PRV
PW638 Domano PRV (Closed)
PW627 Willow Cale Well
PW629 Sintich PS
PW827 Danson Reservoir
PW625 Corral Well
PZ 09
PZ 08
PZ 02
PZ 01
PZ 7A
PZ 7B
PZ 07
PZ 06
PZ 04
PZ 03
PZ 3A
PZ 15
PZ 16
PZ 21
PZ 22
PZ 23
PZ 25
PW823 Gunn Rd Reservoir
PW614 Somerville PS
PW814 Tabor Lake Reservoir
Planned 2015

Legend

- City Parcel
- Ground Well
- Storage Reservoir
- Well/Booster Pump Station
- PRV
- Hart/Nechako Watermain
- SouthWest/Core Watermain

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Client: CITY OF PRINCE GEORGE

City of Prince George
SouthWest/Core Water Distribution System

Project No:	D-17460.00
Designed:	CL
Drawn:	CL
Approved:	
Note:	Figure 2-1
Scale:	0 250 500 Meters; 1:40,000 @ Tabloid
Map No	1
Date	DEC 2014
Revision	
Revision Date	

Path: G:\opus_dk\municipal\174 Prince George\gis\D-174.60 Water Service Network Plan Update\Figure 2-1 - South Water System.mxd

Legend

- Ground Well
- Storage Reservoir
- Well/Booster Pump Station
- PRV
- Hart/Nechako Watermain
- SouthWest/Core Watermain

N W E S

PW817 Vellencher Reservoir
PW615 Vellencher PS
PW612 Cook PRV
PW617 Croft PRV
PW611 Randle PRV
PW640 Knell PRV
PW650 Foothills PS
PW860 Foothills Reservoir
PW607 Meadowbrook PRV
PW660 Fishtrap Well
PW832 Edgewood Reservoir
PW810 Lower Hart Reservoir
PW609 Ongman PRV
PW619 Inverness PS

PZ 12
PZ 11
PZ 10
PZ 09
PZ 13
PZ 08
PZ 02
PZ 01

LINDSTROM RD
ARROW RD
FOX DR
ZRAL RD
KELLY RD
HOLDNER RD
NIELSON RD
HART HWY
VIKING RD
TWINBERRY DR
WAPITI RD
GREENWOOD ST
KILLY RD
KNIGHT CRES
GLENDALE DR
FOOTHILLS BLVD
SPARROW RD
DOMAGALA RD
CHIEF LAKE RD
PETER RD
ESTAVILLA DR
ARABIAN RD
CHESTNUT DR
FLAMINGO RD
SABYAM RD
HART HIGHWAY FRNTG
DIAMOND DR
JADE DR
OPAL DR
NORDIC DR
MARTIN RD
RUBY CRES
KINCHEN DR
CARR RD
PEARL DR
GREENFOREST CRES
THEE CRT
WEISBROD RD
TAFT DR
ADAM DR
RUNDSTROM RD
DAWSON RD
VALLEYVIEW DR
GRAY DR
TURNER RD
HEATHER RD
DAGG RD
GLENVIEW DR
HELM DR
EDEN DR
MESA ST
RICHET ST
EDELWEISS RD
KELLY RD
MADILL RD
BUTTE PL
MONTEREY RD
AUSTIN RD
OLYMPIA PL
SETON CRES
DRIFTWOOD RD
BERGER CRES
BALSUM RD
HAZEL DR
BIRCHWOOD DR
VELLENCHER RD
WINSLOW DR
WINSLOW PL
KIM PL
STAUBLE RD
ENNS RD
HIGHLAND DR
OAKRIDGE CRES
INGALA DR
CROFT RD
LEHMAN ST
MONTEREY RD
HARTWAY DR
ERICKSON ST
LANGLEY CRES
KILLARNEY DR
BERWICK DR
DUNDEE DR
NIXON CRES
SUSSEX LANE
WILDWOOD CRES
CARLISLE WAY
RIDGE VIEW DR
PANORAMA CRES
SADLER DR
MINOTTI DR
RANDLE RD
LANE
BANZER DR
OLD SUMMIT LAKE RD
IONA RD
SHAMROCK RD
SLOAN RD
WAGON TRAIL RD
FEHR RD
NORANDA RD
KENWORTH RD
PERRIN HTS
PERRIN RD
CLEARWOOD CRES
BELLAMY RD
NORTHWOOD PULPMILL RD
MCLARTY CRES
HILLSIDE DR
BENCH DR
RIVERDALE CRES
ROSIA RD
RIVERVIEW RD
OTWAY RD
SANDBERG RD
NORTH MEADOW RD
STURGEON RD
DEVER RD
WINSTON RD
MICHAEL RD
CRAIG DR
CHURCHILL RD
STEVENS DR
NORTH NECHAKO RD
FOOTHILLS BLVD
BEDARD RD
MCMILLAN DR
MCTAVISH RD
CLUBHOUSE DR
HOUGHTALING RD
ABERDEEN RD
GAGNE PL
AINTREE DR
PERTH RD
BLUEBERRY RD
HOFERKAMP RD
CUTBANK RD
WOLCZUK RD
PG PULPMILL RD
MCGOWAN DR
STIRLING DR
HERITAGE CRES
REBELO DR
CLARE CRES
KING DR
MCDERMID DR
ZIMMARO AVE
1ST AVE
SENKPIEL AVE
FREIMULLER AVE
CLAXTON CRES
LANE
GATEWAY
CORLESS CRES
MCQUEEN CRES
MCLEAN DR
GORDON CRES
MCINTYRE CRES
OSPIKA BLVD
DEZELL DR
RILEY DR
QUINN ST
LANE
OGILVIE ST
BOYD ST
OLIVER AVE
MORAN CRES
HAMMOND AVE
SUTHERLAND RD
PRESTON RD
RICHARD RD
TOMLIN RD
ONGMAN RD
CAMERON ST
RIVER RD

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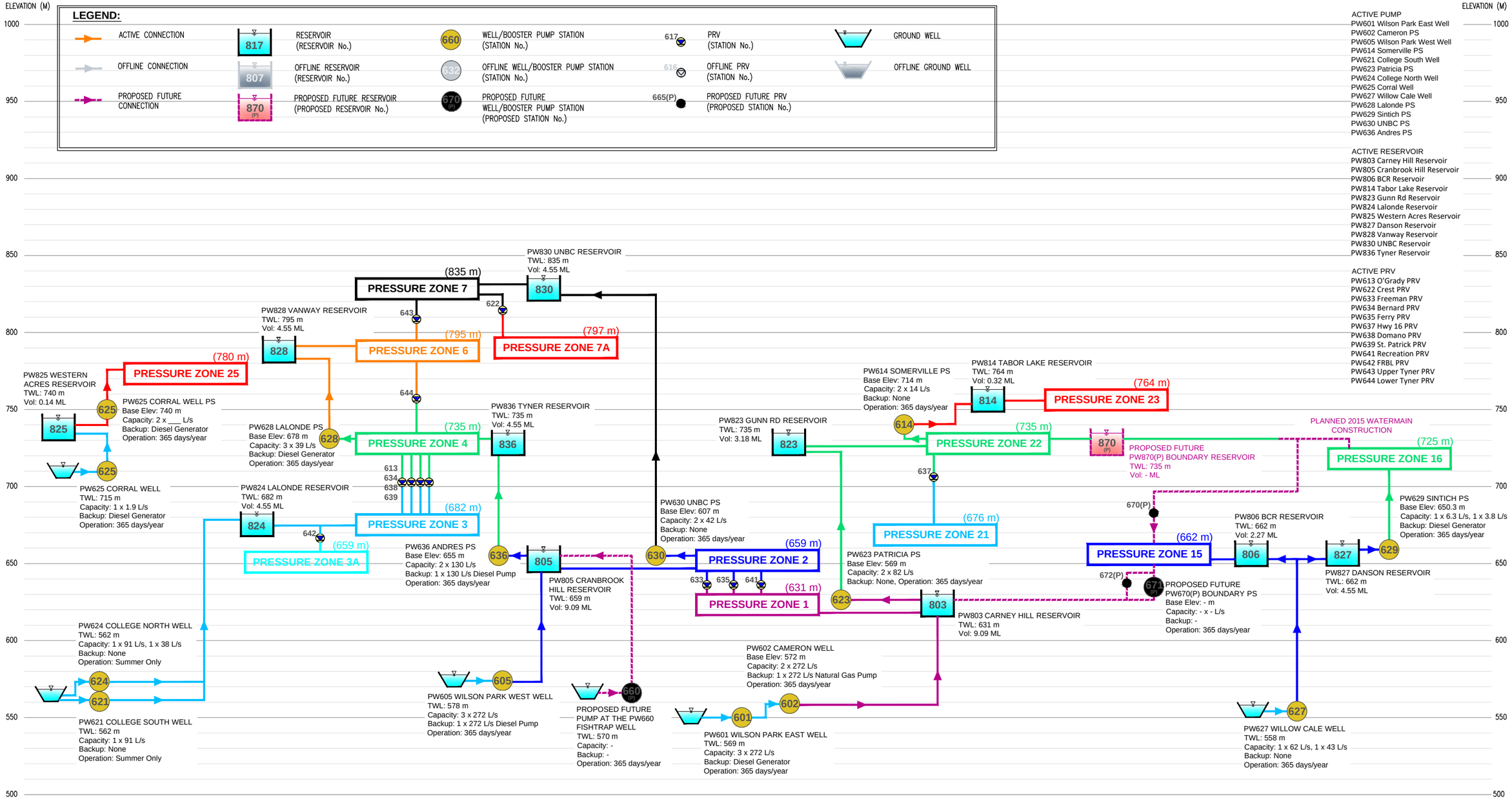
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Client: CITY OF PRINCE GEORGE

City of Prince George
Hart/Nechako Water Distribution System

Project No:	D-17460.00
Designed:	CL
Drawn:	CL
Approved:	
Note:	Figure 2-2
Scale:	0 125 250 Meters; 1:40,000 @ Tabloid
Map No	1
Date	DEC 2014
Revision	
Revision Date	

Path: G:\opus_dk\municipal\174 Prince George\gis\D-174.60 Water Service Network Plan Update\Figure 2-2 - North Water System.mxd



CITY OF PRINCE GEORGE
WATER SERVICE NETWORK UPDATE
HYDRAULIC SCHEMATIC - SOUTHWEST/CORE

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DWG. D-17460.00

FIGURE 2-3

FILE: \\vcsv01\groups\Projects\Municipal\174 Prince George\pro\D-17460.00 Water Service Network Plan Update\400 Technical\420 Design\HyD-17460.00 Southwest and Core Schematic.dwg Tab FIGURE 2-1 14-12-11 vcsvw0

LEGEND:

- ACTIVE CONNECTION
- OFFLINE CONNECTION
- PROPOSED FUTURE CONNECTION
- 817 — RESERVOIR (RESERVOIR No.)
- 807 — OFFLINE RESERVOIR (RESERVOIR No.)
- 870 (P) — PROPOSED FUTURE RESERVOIR (PROPOSED RESERVOIR No.)
- 660 — WELL/BOOSTER PUMP STATION (STATION No.)
- 632 — OFFLINE WELL/BOOSTER PUMP STATION (STATION No.)
- 670 (P) — PROPOSED FUTURE WELL/BOOSTER PUMP STATION (PROPOSED STATION No.)
- 617 — PRV (STATION No.)
- 616 — OFFLINE PRV (STATION No.)
- 665(P) — PROPOSED FUTURE PRV (PROPOSED STATION No.)
- GROUND WELL
- OFFLINE GROUND WELL

ELEVATION (M): 1000, 950, 900, 850, 800, 750, 700, 650, 600, 550, 500

ACTIVE PUMP
PW615 Vellencher PS
PW619 Inverness PS
PW650 Foothills PS
PW660 Fishtrap Well

ACTIVE RESERVOIR
PW810 Lower Hart Reservoir
PW817 Vellencher Reservoir
PW832 Edgewood Reservoir
PW860 Foothills Reservoir

ACTIVE PRV
PW607 Meadowbrook PRV
PW609 Ongman PRV
PW611 Randle PRV
PW612 Cook PRV
PW617 Croft PRV
PW640 Knell PRV

(850 m) **PRESSURE ZONE 12**

615 — PW615 VELLENCHER PS
Base Elev: 793.7 m
Capacity: 2 x 10.7 L/s, 1 x 9.3 L/s
Backup: None
Operation: 365 days/year

817 — PW817 VELLENCHER RESERVOIR
TWL: 803 m
Vol: 4.55 ML

(803 m) **PRESSURE ZONE 11**

617, 612

(751 m) **PRESSURE ZONE 10**

611, 640

(705 m) **PRESSURE ZONE 9**

609

(650 m) **PRESSURE ZONE 8**

(769 m) **PRESSURE ZONE 13**

619 — PW619 INVERNESS PS
Base Elev: 662 m
Capacity: 2 x 2.0 L/s
Backup: Diesel Generator
Operation: 365 days/year

810 — PW810 LOWER HART RESERVOIR
TWL: 705 m
Vol: 4.55 ML

650 — PW650 FOOTHILLS PS
Base Elev: 654 m
Capacity: 3 x 135 L/s
Backup: Diesel Generator
Operation: 365 days/year

860 — PW860 FOOTHILLS RESERVOIR
TWL: 659 m
Vol: 4.55 ML

607

832 — PW832 EDGEWOOD RESERVOIR
TWL: 650 m
Vol: 2.73 ML

660 — PW660 FISHTRAP WELL
TWL: 570 m
Capacity: 2 x 360 L/s
Backup: Diesel Generator
Operation: 365 days/year

607 — PW607 NORTH NECHAKO WELL
TWL: 554 m
Capacity: 1 x 90 L/s
Backup: None
Operation: Offline

632 — PW632 RUSTAD WELL
TWL: 592 m
Capacity: Unknown
Operation: Offline

608, 610 — PW608/610 CAMERON WELL
TWL: 567 m
Capacity: Unknown
Operation: Offline

CITY OF PRINCE GEORGE
WATER SERVICE NETWORK UPDATE
HYDRAULIC SCHEMATIC - HART/NECHAKO SYSTEM

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FIGURE 2-4

FILE: \\vcsvr01\groupdlb\opus_dk\municipal\174 Prince George\proj\D-17460.00 Water Service Network Plan Update\400 Technical\420 Design\HyD-17460.00 Hart Nechako Schematic.dwg Tab FIGURE 2-1 14-12-11 vccww0

2.3 Pump Stations

There are 17 pump stations in the City of Prince George. The stations and the number of pumps in each station are listed in Table 2-3.

Table 2-3 Existing Pump Stations

System	ID	Pump Station	Type	# of Pumps	Standby Pumps	Elev (m)	Zones Supplied
South	601	Wilson Park East	Well	3	Diesel Generator	569.0	PZ 01, 21, 22, 23
	602	Cameron	PS	2	+1 Natural Gas pump	572.0	PZ 01, 21, 22, 23
	605	Wilson Park West	Well	3	+1 Diesel pump	578.0	PZ 02, 04, 06, 07, 07A
	614	Somerville	PS	2		714.0	PZ 23
	621	College South	Well	1		562.0	PZ 03
	623	Patricia	PS	2		569.0	PZ 21, 22, 23
	624	College North	Well	2		562.0	PZ 03
	625	Corral	Well	1	Diesel Generator + 2 system pumps	740.0	PZ 25
	627	Willow Cale	Well	2		558.0	PZ 15, 16
	628	Lalonde	PS	3	Diesel Generator	678.0	PZ 06
	629	Sintich	PS	2	Diesel Generator	650.3	PZ 16
	630	UNBC	PS	2		607.0	PZ 07, 07A
	636	Andres	PS	2	+1 Diesel pump	655.0	PZ 04, 06
North	615	Vellencher	PS	3		793.7	PZ 12
	619	Inverness	PS	2	Diesel Generator	662.0	PZ 13
	650	Foothills	PS	3	Diesel Generator	654.0	PZ 08, 09, 10, 11, 12, 13
	660	Fishtrap	Well	2	Diesel Generator	570.0	PZ 08, 09, 10, 11, 12, 13

*the pump elevation is approximate and based on available 1m contour data from the City's GIS database

2.4 Pressure Reducing Valve Stations

There are 18 pressure reducing (PRV) stations in the City of Prince George. Elevations of the pressure reducing stations and their valve settings are summarized in Table 2-4. Where two valves are present, the lead valve is shown first.

Table 2-4 PRV Parameters

System	ID	PRV Station	Elev (m)	Valve Dia. (in.)	D/S Pressure Setting (psi)	D/S HGL Setting (m)	Zone Supplied
South	613	O'Grady	653.3	6"	41	682	PZ 03
	622	Crest	733.2	2" and 6"	91 and 87	797 and 794	PZ 07A
	633	Freeman	593.0	3" and 10"	53 and 49	630 and 627	PZ 01
	634	Bernard	650.0	6"	37	676	PZ 03
	635	Ferry	588.0	6"	60	630	PZ 01
	637	Hwy 16	627.0	8"	70	676	PZ 21
	638	Domano (closed)	624.0	6"	60	666	PZ 03
	639	St. Patrick	642.0	6"	58	683	PZ 03
	641	Recreation	589.0	8"	35	614	PZ 01
	642	FRBL	613.0	8"	65	659	PZ 03A
	643	Upper Tyner	757.6	10"	60	800	PZ 06
	644	Lower Tyner	707.0	10"	37	733	PZ 04
North	607	Meadowbrook	614.0	8"	50	649	PZ 08
	609	Ongman	571.6	8" and 8"	110 and 106	649 and 646	PZ 08
	611	Randle	661.2	6" and 3"	61 and 57	704 and 701	PZ 09
	612	Cook	701.2	3" and 6"	59 and 55	743 and 740	PZ 10
	617	Croft	712.1	2" and 4"	55 and 51	751 and 748	PZ 10
	640	Knell	658.7	6" and 2"	50 and 46	694 and 691	PZ 09

Opus DaytonKnight staff have currently estimated downstream settings based on information from the City's updated Pump Station Manual, the City's PRV Summary Sheet, the City's existing water model, and various e-mail communications with City staff.

The settings provided in the Pump Station Manual and the City's PRV Summary Sheet provide system pressures downstream of each PRV. This, however, does not indicate if the PRV is open or closed. If the PRV is open, the setting is likely/possibly higher than the measured downstream pressure, and if the PRV is closed, the PRV setting is likely lower. While not critical in most cases as we are confident in most of our estimations, the true PRV settings would enable Opus DaytonKnight to verify that operations staff have the correct settings to; 1) ensure reservoirs are filling during maximum day demand; 2) better understand the interaction of the PRVs between Pressure Zone 01 and 02; and 3) ensure that the settings for the lead/lag operation at certain PRV stations are correct.

One such example where we find a large discrepancy is at the boundary of Pressure Zone 01 and 02. The Freeman PRV (PW-633) has a downstream setting of 65 psi as listed in the PRV Summary Sheet. However, it is unknown if the valve is opened or closed during this measurement. With the elevation of the PRV at 593 m, the corresponding HGL setting of the PRV is modelled at 639 m HGL. This

compares to the TWL of 630.3 m of the Carney Hill reservoir (PW-803). Under normal circumstances, Opus DaytonKnight expects that the HGL at this location is 639m only when the Cameron pump station (PW-602) is in operation and refilling the Zone 1 reservoir. The Freeman PRV, which is supposed to act as a secondary PRV rather than a primary PRV, would likely be set at an HGL around 5-10 metres below the TWL of the reservoir and therefore is likely closed when the downstream pressure is 65 psi. As a result, Opus DaytonKnight believes the setting of the PRV is likely much lower than 65 psi, but cannot estimate what it could be based on the data available.

Opus DaytonKnight suggests that downstream settings for all stations be field checked to improve the accuracy of the model.

Also, as indicated in the City's documents, the larger PRVs in both the Randle (PW-611) and Knell (PW-640) PRV stations are set as the lead valves. The typical operation of a PRV station would be to have the smaller valve as the lead PRV and the larger valve as the lag PRV. These stations should be checked for correct operation.

2.5 Storage Reservoirs

There are 15 storage reservoirs in the City of Prince George. Table 2-5 summarizes the storage reservoirs for both the south and north water systems.

Table 2-5 Existing Reservoir Capacities

System	ID	Reservoir	Top Water Level (m)	Storage Volume (ML)	Zone Supplied
South	803	Carney Hill	631.0	9.09	PZ 01
	805	Cranbrook Hill	659.0	9.09	PZ 02
	806	BCR	662.0	2.73	PZ 15, 16
	814	Tabor Lake	764.0	0.32	PZ 23
	823	Gunn Rd	735.0	3.15	PZ 21, 22
	824	Lalonde	682.0	4.55	PZ 03
	825	Western Acres	740.0*	0.14	PZ 25
	827	Danson	662.0	4.55	PZ 15, 16
	828	Vanway	795.0	4.55	PZ 06
	830	UNBC	835.0	4.55	PZ 07, 07A
	836	Tyner	735.0	4.55	PZ 04
North	810	Lower Hart	705.0	4.55	PZ 09
	817	Vellencher	803.0	4.55	PZ 08, 09, 10, 11, 12, 13
	832	Edgewood	650.0	2.73	PZ 08
	860	Foothills	659.0	4.55	PZ 08, 09, 10, 11, 12, 13

*the top water level is approximate and based on available information from City records

2.6 Distribution System

The distribution system for the City consists of over 550 kilometres of watermain supplying over 76,000 residents, in addition to industrial, commercial, and institutional uses. The distribution pipes range in diameter from 100 mm to 1200 mm and were installed between 1955 and 2011. A summary of the existing pipe diameters and approximate total lengths are listed in Table 2-6, which is based on the GIS database information provided by the City.

Table 2-6 Existing Watermains

Diameter (mm)	Length in North System (m)	Length in South System (m)	Total Length (m)
100	17,456	20,196	37,652
150	62,576	193,592	256,168
200	29,274	84,050	113,324
250	7,486	31,426	38,912
300	4,108	34,433	38,541
350	415	15,802	16,217
400	6,144	11,457	17,601
450	-	1,057	1,057
500	-	9,214	9,214
600	1,376	18,545	19,921
750	2,325	1,932	4,257
900	-	301	301
1200	-	465	465
TOTAL	**131,162**	**422,469**	**553,631**

3 Water Demand

This section primarily focuses on the methodology of deriving the existing water demand and the anticipated short term and long term demands associated with population growth and future ICI development in the City of Prince George. Demand was summarized for three distinct water systems for the City; namely the north, south and western acres water systems. The south and western acres water systems are both included in the City's "South" model.

3.1 Population

3.1.1 Serviced Population

Population data was available from various sources, which included:

- a 2009 City reported estimate to Environment Canada for benchmarking purposes;
- a 2011 estimate from Census Canada; and,
- a 2013 estimate from BC Stats.

The 2009 City reported estimate of serviced population to Environment Canada was 83,225 persons. According to Initiatives Prince George, this population uses Census population data amalgamated with population from Fraser-Fort George Electoral Areas 'D', 'C', 'A', 'F' and the Shelley area. Meanwhile, the 2011 Census Canada population for the City of Prince George was 71,974, while the BC Stats estimated population for the same year (2011) was 73,423. BC Stats estimates are based on 2011 Census counts and adjusted for census net under-coverage and incompletely enumerated Indian reserves. Under the recommendation of Opus DaytonKnight, the City agreed that the serviced population would be based on BC Stats estimates.

At a conservative growth rate of 2.0%, a 2013 population of 76,482 was modelled under the existing scenario.

3.1.2 Serviced Population Allocation

Figure 3-1 illustrates the dissemination block information obtained from Census Canada which was used as a basis to allocate the population (and demand) in the City's updated hydraulic water models. While dissemination block information is less accurate for large dissemination block parcels, Opus DaytonKnight amended these parcels to more accurately allocate populations in the City.

3.1.3 Projected Population

A forecast of future serviced population was made based on input from the planning department, figures from the Official Community Plan, various neighbourhood plans, and Opus DaytonKnight's understanding of the growth priority areas as discussed with the City's planning department.

During discussions with the planning department, two population scenarios were developed. One for short term growth projections and one for long term growth. Working together with the City, Opus

DaytonKnight produced short term and long term population growth estimates based on 18 colour coded areas represented in Table 3-1 and illustrated in Figure 3-2.

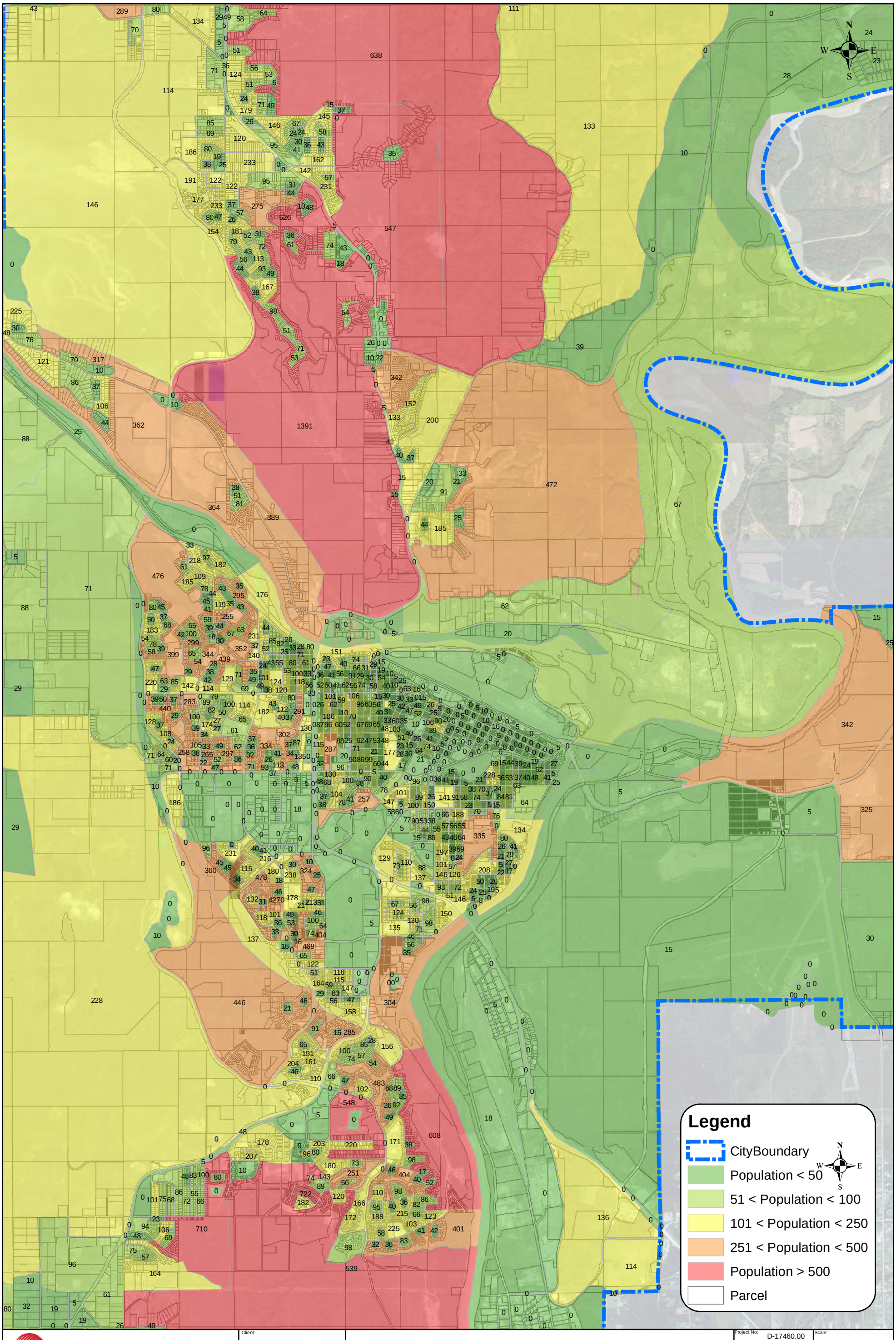
Table 3-1 Future Population Estimates

Object ID	Neighbourhood Name	Short Term Population Total	Sub-Neighbourhood Short Term Split	Sub-Neighbourhood Short Term Population	Long Term Population Total
1	Blackburn	352	100%	352	1,408
2	College Heights GP	5,280	10%	528	2,112
3	College Heights Infill		10%	528	2,112
4	College Heights Phase 1 & 2		75%	3,960	15,840
5	College Heights Future		5%	264	1,056
6	Hart GP	2,640	10%	264	1,056
7	Hart Infill		10%	264	1,056
8	Hart Phase 1 & 2		75%	1,980	7,920
9	Hart Future		5%	132	528
10	Downtown GP	2,640	25%	660	2,640
11	Downtown Infill		75%	1,980	7,920
12	Inner Bowl GP	3,520	25%	880	3,520
13	Inner Bowl Infill		75%	2,640	10,560
14	West Bowl GP	2,640	25%	660	2,640
15	West Bowl Infill		75%	1,980	7,920
16	Rural Infill	528	20%	106	422
17	Rural Phase 1 & 2		75%	396	1,584
18	Rural Future		5%	26	106
Total New Growth		**17,600**		**17,600**	**70,400**

The long term population growth increases the short term population growth by a factor of four. The short term population estimate for the City of Prince George is 94,082 while the long term population estimate is 146,882.

3.1.4 Projected Population Allocation

These population figures were loaded into the existing model to develop the future short term and long term demands.



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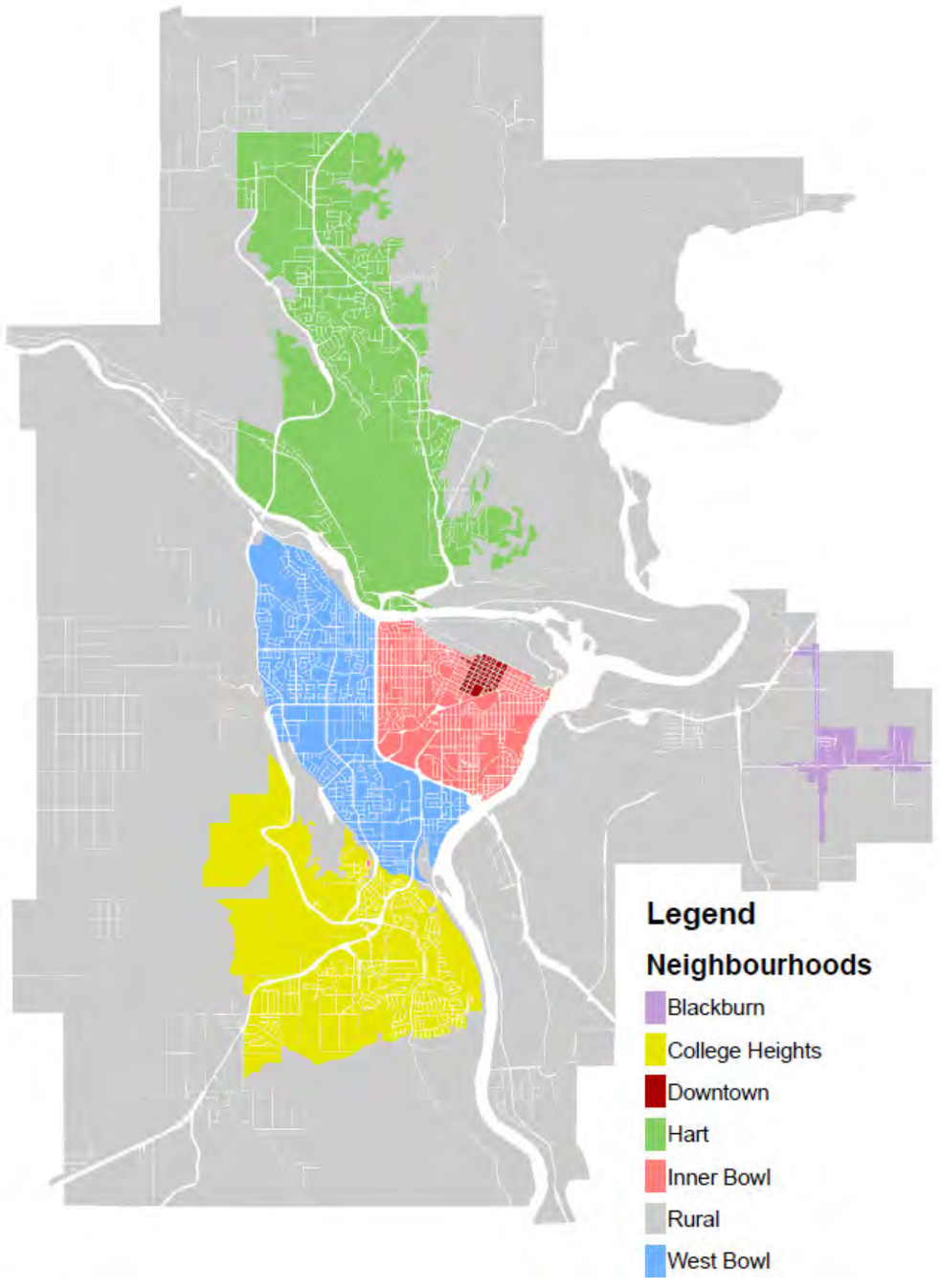
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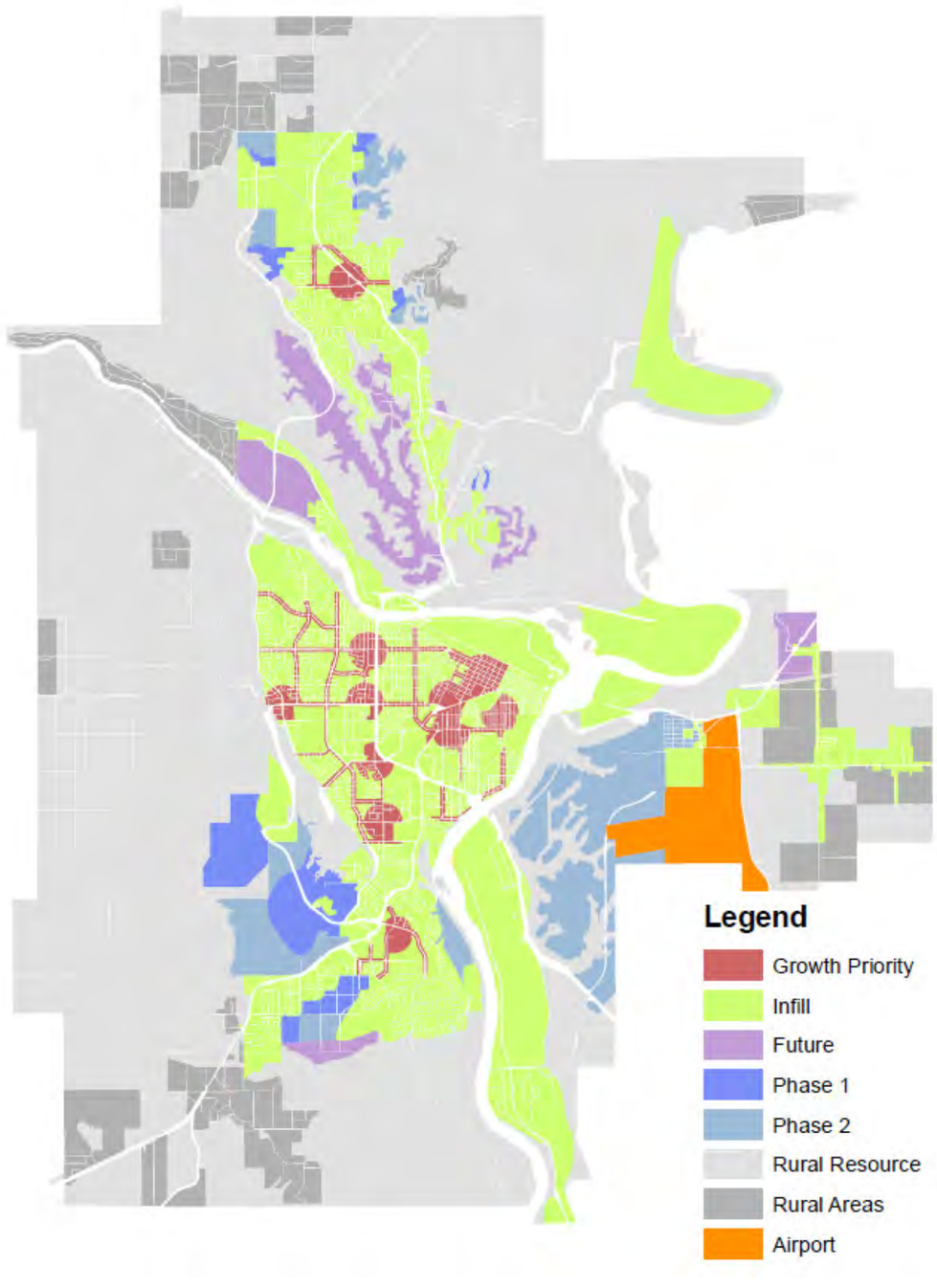
Client: CITY OF PRINCE GEORGE

2011 Census Population Dissemination Blocks

Project No:	D-17460.00
Designed:	CL
Drawn:	CL
Approved:	
Note:	Figure 3-1
Scale:	0 375 750 Meters; 1:40,000 @ Tabloid
Map No	1
Date	DEC 2014
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Client:
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Anticipated Population Growth Areas

Project No:	D-17460.00
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Drawn:	CL
Approved:	
Note:	
Figure 3-2	
Scale:	0 875 1,750 Meters 1:120,000 @ Tabloid
Map No	1
Date	DEC 2014
Revision	
Revision Date	

Path: G:\opus_dk\municipal\174 Prince George\gis\D-174.60 Water Service Network Plan Update\Figure 3-2 - Projected Populations.mxd

3.2 Existing Demands

Flow meter data from the City's pump stations was collected and analyzed from 2007 to 2012. Pump records from 2012 were used to calculate the average day, maximum day and peak hour demands for the City. These calculated values were used to update the existing demands in City's hydraulic water model.

3.2.1 Average Day Demand

The Average Day Demand (ADD) is the average demand in the water system over an entire year. The value is useful in analyzing historic demands and general usage patterns in the City and in estimating future demands. Determining the future ADD is important in determining the future supply requirements for the water system.

An ADD of 533.0 L/s is calculated from the 2012 pump records. This equates to an ADD per capita rate of 604 L/c/d. Table 3-2 summarizes the split of this average day demand between the three water systems.

Table 3-2 Average Day Demands

	ADD (L/s)
North	70.1
South	462.1
Western Acres	0.8
Total	**533.0**

3.2.1.1 ICI Demands

A spreadsheet was provided by the City of Prince George which included all the individual meter data available in the City of Prince George. The meter data included records from six single family homes, 227 apartments/multi-family/strata units and 9 trailer courts, which were removed when calculating the total ICI demand for the City.

The average day demand recorded from the ICI meters was calculated at 68.5 L/s for 2012 and is shown in Table 3-3. This was compiled for 1,300 metered ICI properties covering a total area of 1,816 hectares.

Table 3-3 ICI Demands

	Connections	Total Flow (L/s)	Average Flow (L/s/conn)
Institutional	145	11.5	0.08
Commercial & Industrial	1,155	57.0	0.05
Total	**1,300**	**68.5**	

3.2.1.2 ICI Demand Allocation

ICI demands were allocated to the model by linking the meter records in a spreadsheet format to a parcel shapefile in GIS via the Folio ID number to determine the spatial location of each demand. The meter data was identified as either "Institutional" or "Commercial and Industrial" when input into the parcel shapefile.

After all the metered demands and demand types had been assigned to their parcels, the parcels were converted into nodes and imported into the hydraulic model by assigning them to the closest watermain and then proportionally distributing them to the nearest two nodes along the watermain.

3.2.1.3 Residential Demands

Since the residential properties are not individually metered, residential ADD was approximated by subtracting the metered ICI demands from the total recorded average day demand. This equates to a 2012 residential ADD of 533 L/s – 68.5 L/s = 464.5 L/s.

At a population of 76,482, this equates to a residential ADD per capita demand of 525 L/c/d. This residential ADD value includes leakage.

3.2.1.4 Residential Demand Allocation

Residential demands were allocated according to the population allocation as detailed in Section 4.1.2.

3.2.2 Maximum Day Demand

The Maximum Day Demand (MDD) gives an estimation of the maximum water usage for one day (often the hottest summer day) in a year. It is used for sizing the City's reservoir storage capacities, pumping capacities and transmission mains.

An MDD of 1,041.7 L/s is calculated for the City of Prince George from the 2012 pump records. This equates to an MDD per capita rate of 1,178 L/c/d. Table 3-4 summarizes the maximum day demands in each of the water systems.

Table 3-4 Maximum Day Demands

	MDD (L/s)	Date
North	156.7	July 18, 2012
South	883.4	July 18, 2012
Western Acres	1.56	July 13, 2012
Total	**1,041.7**	

3.2.3 Peak Hour Demand

The Peak Hour Demand (PHD) is an estimation of the maximum water usage of the system in an hour during a day in a certain year. The peak hour demand usually occurs on or around the day when MDD

occurs. The PHD is recorded through water usage from the source as well as balancing storage in the system reservoirs. In the absence of reservoirs, the supply must meet this demand.

The recorded well pumping records as well as hourly reservoir levels across the system across three days surrounding July 18th, 2013 were used to calculate the peak hour demand. The analysis carried out to determine the peak hour demand in the City is attached in Appendix A. Table 3-5 summarizes the peak hour demands recorded in each of the water systems.

Table 3-5 Peak Hour Demands

	PHD (L/s)	Date & Time
North	256.0	July 17, 2012 @ 8pm
South	1453.0	July 17, 2012 @ 7pm
Western Acres	2.24	July 18, 2012 @ 5pm
Total	**1,711.2**	

3.3 Short Term and Long Term Future Demands

In addition to developing the future population projections for the short term and long term scenarios as detailed in Section 3.1.3, Opus DaytonKnight worked with the City's planning department to review schedules from the Official Community Plan, various neighbourhood plans, and Opus DaytonKnight's understanding of the growth priority areas to determine the future institutional, commercial and industrial development areas in the City of Prince George. City planning staff met with Opus DaytonKnight staff to finalize population and ICI projections for the short term and long term scenarios.

The following neighbourhood plans were reviewed in detail.

- Crescents Neighbourhood Plan (November 2003: UMA Engineering)
- Wessner Heights Neighbourhood Plan (June 2004: L&M Engineering)
- Fraser River Bench Lands Neighbourhood Plan (October 2006: L&M Engineering)
- Ospika South Neighbourhood Plan (November 2006: Eric Vance & Associates)
- University Heights Neighbourhood Plan (July 2007: L&M Engineering)
- Airport Light Industrial Plan (September 2008: L&M Engineering)
- Golf Course – Pine Centre Neighbourhood Plan (October 2010: Site360 Consulting)
- Glenview Crescents Neighbourhood Plan (April 2011: L&M Engineering)

Other documentation also reviewed included a memorandum detailing retail and service commercial projections for the City under the OCP and a drawing marked up by the City's planning department illustrating five areas of commercial growth and two areas on industrial growth in the near future, which are included in Appendix B. Appendix B also contains additional figures which illustrate the Institutional, Commercial and Industrial areas and demands which are have been added by Opus DaytonKnight to the City's hydraulic water models.

Table 3-6 provides a summary of the additional population and ICI demands developed in conjunction with City planning staff. The resulting average day demand developed form the basis for demand loading under the short term and long term scenarios in the City's hydraulic water models.

Table 3-6 Existing, Short Term and Long Term Average Day Demand

	Additional Residential Population	Total Population	Additional Residential ADD (L/s)	Additional ICI ADD (L/s)	Total ADD (L/s)
Existing	-	76,482	-	-	533.0
Short Term	+17600	94,082	+107.2	+109.7	749.9
Long Term	+70400	164,482	+321.6	+22.7	1,094.2

Appendix C provides a detailed summary of how average day demands are distributed within each water model for the existing, short term and long term conditions.

3.4 Peaking Factors and Demands

Since most future population growth will be concentrated as single family residential demand, it is important to develop an understanding of the residential peaking factors for each of the water systems modeled in this assignment. The total average day, maximum day and peak hour demands in each of the three water systems modeled was broken down into their residential, industrial and commercial and institutional components for the purposes of populating the City's hydraulic water models.

Opus DaytonKnight has summarized the existing average day, maximum day and peak hour demands for each of the water systems in the City of Prince George in Appendix C. Based on typical peaking factors of 1.1 for MDD and 1.5 for PHD for the ICI demands, Opus DaytonKnight has back-calculated the peaking factors ranging from 2.0 to 2.3 for maximum day demand and from 3.1 to 3.8 for peak hour demand.

Table 3-7 provides a summary of the maximum day demands under the existing, short term and long term scenarios.

Table 3-7 Existing, Short Term and Long Term Maximum Day Demand

Model	Existing MDD (L/s)	Short Term MDD (L/s)	Long Term MDD (L/s)
South	883.4	1,186.2	1,766.5
Western Acres	1.56	1.64	1.68
North	156.7	197.5	312.4

Appendix C provides a detailed summary of how maximum day and peak hour demands are distributed within each water model for the existing, short term and long term conditions through the use of peaking factors.

3.5 Demand by Zone

Table 3-8 and Table 3-9 summarizes the estimated maximum day demand within each pressure zone for the existing, short term and long term demands. It should be noted that the estimates are approximate and based on the population allocation methodology detailed in Section 3.1.2.

Table 3-8 South Model Maximum Day Demand by Zone

Zone	Existing	Short Term	Long Term
PZ 01	236.4	308.1	533.4
PZ 02	379.3	428.1	531.0
PZ 03	101.4	111.3	134.3
PZ 04	48.0	58.0	88.0
PZ 06	51.4	94.5	214.4
PZ 07	7.3	13.0	43.5
PZ 07A	1.0	1.1	1.3
PZ 15	18.6	49.2	51.4
PZ 16	1.3	1.3	1.4
PZ 21	0.2	0.2	0.2
PZ 22	21.8	105.4	128.8
PZ 23	5.7	6.5	12.0
PZ 25	1.6	1.6	1.7
Total	**874.0**	**1,177.84**	**1,741.3**

Table 3-9 North Model Maximum Day Demand by Zone

Zone	Existing	Short Term	Long Term
PZ 08	19.9	20.6	21.9
PZ 09	26.2	29.8	37.7
PZ 10	6.5	8.1	10.3
PZ 11	90.8	123.9	223.9
PZ 12	13.5	13.9	17.0
PZ 13	0.6	0.6	0.7
Total	**157.4**	**196.9**	**311.4**

3.6 Demand Summary

Demands developed through this chapter will be used to assess each of the City's water system's abilities to adequately meet level of service requirements for existing residents and projected growth in the City of Prince George. These demands form an integral part of the model update process and form the basis on which recommendations for short term and long range infrastructure improvements for the water utility are made.

4 Model Updates

Copies of the Southwest, Core, Hart/Nechako, and Western Acres models were received from the City of Prince George at the beginning of this assignment. Opus DaytonKnight was tasked to update these models with current field information and also to combine the Southwest, Core and Western Acres models into one model for the City of Prince George.

4.1 Infrastructure Updates

Newly constructed watermains were identified and added to the water distribution models through GIS information provided by the City. Watermains added are mainly those replaced and newly constructed with the most recent data provided.

4.1.1 South Model Updates

The following tasks have been carried out to update the City's water models to match the configuration of the current water system south of the Nechako River:

- The City's Southwest, Core and Western Acres models were combined together to form the largest water model for the City called the South Model;
- The merging exercise resulted in duplicates of 21 nodes, 33 pipes and 2 pumps, the model was carefully processed so that all duplicates were removed and the best information was used in the new combined water model;
- There were two overlapping areas which required more attention to detail. The pressurized system from the UNBC Pump Station (PW-630) to the UNBC Reservoir (PW-830) and the system from the Andres Pump Station (PW-636) to the Tyner Reservoir (PW-836) was reviewed in detail to ensure the correct pumping arrangement, pump curves, controls and levels were transferred to the new combined water model;
- Future watermains and corresponding demands were added from the recently completed East Prince George and Airport Light Industrial Lands study; and,
- Future watermains and corresponding demands were added from the recently completed University Heights study.

4.1.2 North Model Updates

The following tasks have been carried out to update the City's water model to match the configuration of the current water system north of the Nechako River:

- The City's Hart/Nechako water model was updated to reflect the 2006 construction of the Fishtrap Wells and pumping station;
- The Foothills Reservoir and pump station were also added to the model;
- The decommissioning of PW-607 and its downstream PRV was also updated in the model

4.2 Demand Updates

Table 4-1 summarizes the demands added to the three different modeled water systems in the City of Prince George. Maximum day and peak hour demand calculations were carried out for each of the water systems to ensure that current water demands would be represented in each of the water system models.

Table 4-1 Modeled Demands

Model	ADD (L/s)	MDD (L/s)	PHD (L/s)
North	70.1	156.7	256.0
South	462.1	883.4	1,453.0
Western Acres	0.8	1.56	2.24

5 Model Calibration

Calibration of the water model took into consideration the 19 existing pressure zones in the City's water system. For the purposes of this study, it was determined that a hydrant flow testing program would be carried out in six (6) pressure zones to ensure a relatively confident calibration of the model.

5.1 Calibration Methodology

Six sets of hydrant flow tests were conducted over two days within the City of Prince George. Test sets #3-6 were completed for the South model on September 16th, 2013 and Test sets #1 and #2 for the North model on September 17th, 2013.

The procedure used to collect data for model calibration was multi-pressure monitoring, and is outlined as follows:

- Four high-resolution pressure loggers (± 0.2% of full scale) were installed on predetermined hydrants within the test zone and one was installed on the hydrant adjacent to the flow hydrant;
- One 2.5-inch turbine flow meter (accuracy 0.5%) was installed on a predetermined flow hydrant port to achieve full hydrant flow, this was repeated two more times within each test set;
- City crew monitored flow and supervised drainage and dechlorination;
- Flow rates were recorded from an analog readout meter. This flow is later used to simulate flow in the water model to calibrate the modelled system pressure changes to those recorded by the pressure loggers; and,
- Pressure loggers were removed, stopped, and downloaded into a computer program. From this recorded data, static and residual pressures were later retrieved.

5.2 Calibration Parameters

Recorded system demands were provided from the City's SCADA system to determine the actual water usage during the days the hydrant flow tests were carried out. Table 5-1 summarizes the recorded demands and compares the values to the average day demand for the calibration scenario.

Table 5-1 Recorded Daily Demands

Flow Test Date	Demand (L/s)	Ratio To ADD
September 16, 2013	627.1	1.36
September 17, 2013	55.2	0.79

Records of reservoir levels were obtained from the City's SCADA system in order to estimate background levels during the testing. Pump settings and PRV settings were verified by the City prior to model calibration.

5.3 Field Calibration

Six sets of hydrant flow tests were conducted as follows:

- Set 1 – Pressure Zone 11
- Set 2 – Pressure Zone 9
- Set 3 – Pressure Zone 1
- Set 4 – Pressure Zone 2
- Set 5 – Pressure Zone 3
- Set 6 – Pressure Zone 6

The hydrant testing configurations are included in Appendix D.

Through the model calibration exercise, Opus DaytonKnight identified areas where possible valve closures and incorrect model elevations were occurring, and details of these were submitted to the City for review. The City provided an updated list of closed valves which was used to further verify the model. The iterative process was used to fine tune and calibrate the model to ensure results from the model represented actual field results.

5.4 Results and Discussion

The acceptable tolerance between field and computer predicted results are within 10%.

All the test areas were found to have correlation during static and fire hydrant testing conditions. Only 3% (5/144) of the recorded pressures in the field during the hydrant testing program differed by more than 10% from the model predicted values. This calibration provides us with confidence that the model is sufficiently calibrated for the purposes of system modelling and analysis.

Results of the hydrant testing and the calibrated values of the water model are summarized in Appendix E.

6 Design Criteria

The design criteria used to review the system's minimum and maximum service pressures, maximum velocities, available fire flows, storage volumes and fire hydrant spacing is described under this section.

6.1 Service Pressures

Minimum service pressures are required to ensure an adequate flow and pressure of water at all serviced properties in the City of Prince George. There are, in most cases, two conditions in which systems should be designed for minimum service pressures. They are 1) the maximum day demand plus fire flow condition, and 2) the peak hour condition. Furthermore, maximum service pressures in the system also need to be regulated to prevent over-pressurizing of the system.

Table 6-1 summarizes the range of service pressures under various demand conditions.

Table 6-1 Service Pressure Requirements

During Average Day	Maximum	150 psi (1035 kPa)
During Maximum Day Plus Fire Flow	Minimum	20 psi (140 kPa)
During Peak Hour	Minimum	40 psi (275 kPa)

The City of Prince George's current design guidelines agree with the above except for a minimum residual requirement during maximum day plus fire flows. The current guideline is less stringent requiring only a 30 psi residual in the system within 400 metres of the fire flow location. Opus DaytonKnight recommends that a more stringent standard be followed as summarized in the table above.

6.2 Maximum Velocity

The recommended maximum acceptable velocity for flows in the water distribution system is 3.5 m/s during fire flow demand and 6.0 m/s across PRVs during peak hour demand. These high velocities can identify constrictions in the water system and introduce high head losses into the system. Headloss is a large concern when attempting to supply adequate system pressures and fire flows to the extents of a distribution system.

6.3 Fire Protection and Storage

Water distribution systems must be able to deliver large volumes of water for fire protection in addition to normal water demands. Fire protection considerations are:

a. Only one fire will be fought at any one time;
b. To ensure pumper trucks obtain adequate water supplies from hydrants, a minimum residual pressure (20 psi) on the street main is required during fires; and,
c. Fire flow is coincident with peak day demand.

Table 6-2 shows the recommended minimum fire flow requirements for various land use areas and required fire flow durations for the City of Prince George. Values for the minimum required fire flows and required durations are based on the several studies, reports, and guidelines, including:

- 2011 East Prince George and Airport Light Industrial Lands Water Servicing Study;
- 2010 HB Lanarc Residential Wood Frame Innovation Comprehensive District Study;
- 2008 City of Prince George University Heights Water Modelling Study;
- 2005 MMCD Design Guideline Manual;
- 2001 City of Prince George Design Guidelines; and,
- 2000 City of Prince George Water Service Infrastructure Master Plan.

Table 6-2 Proposed Fire Flow Requirements

Land Use	Min. Required Fire Flow		Req. Duration of Fire Flow
	(L/s)	(USgpm)	(Hours)
Single Family Residential	60	950	1.5
Multi-Family Residential	150	2,400	2.0
Small Institutional	150	2,400	2.0
Small Commercial	150	2,400	2.0
Complex Commercial	225	3,600	3.0
Major Institutional	250	3,600	3.5
Light Industrial	250	4,000	3.5
Heavy Industrial	250	4,000	3.5

Additional fire flow requirements may be added for semi-rural properties, especially in the northern and southern extents of the City's water distribution system. These semi-rural properties were assigned a fire flow requirement of 30 L/s in the 2000 Prince George water master plan. This fire flow requirement is supported by a recommendation from the City's recent FUS study detailing a reduced fire flow requirement of 10 L/s for rural/semi-rural properties.

The City's current land use zoning map was used to assign fire flow requirements to each model node. Required fire flows were chosen based on the land-use surrounding the nodes. For nodes that neighboured two different land uses, the land use with the higher fire flow requirement was assigned to the node.

6.4 Supply Storage

Water storage reservoirs are located at specific elevations to establish pressure zones within the distribution system. Typical design pressures within a zone vary from a minimum of 30 to 40 psi to a maximum of 120 to 150 psi. During a fire event, minimum pressures are allowed to drop to 20 psi.

Water storage is used to balance and optimize supply and delivery of water. If properly sized, reservoirs will store water during low demand periods and supplement the source supply during peak hour demand. Typically, reservoirs are designed to refill every day and to have adequate storage capacity to provide for balancing storage, which is estimated as 25% of maximum day demand, and fire storage based on the FUS recommended flow and duration listed in Table 5-2. Emergency storage is also required. Storage volumes requirements are estimated based on the following formula:

$$Volume = A + B + C$$

Where:

- A = Fire Storage (required extent and duration of fire flow as noted in the guidelines above)
- B = Equalization Storage (25% of maximum day demand serviced by the Reservoir)
- C = Emergency Storage (25% of A + B)

6.5 Fire Hydrant Coverage

A hydrant coverage analysis is also carried out to ensure there is adequate fire hydrant coverage throughout the City of Prince George. The City of Prince George design guidelines sets out the hydrant spacing requirements as follows:

- Single Family Residential = 200m diameter coverage; and,
- Commercial, Industrial, Institutional and Multi-Family= 100m diameter coverage.

6.6 Other Criteria

Other criteria from the City's design guidelines which were used for this report include:

- *Criteria 3.2.2.3* – c=110 for all mains 250 mm and smaller; c=125 for all mains 300mm and larger;
- *Criteria 3.2.2.8* – The hydraulic grade in mains larger than 250 mm diameter shall not exceed 0.5%; The velocity of flows shall not exceed 2.0 m/s for ultimate design flows; and,
- *Criteria 3.3.2.1* – The minimum size of new watermains shall be 200 mm diameter; except 150 mm watermains may be used for short dead ends less than 100 m in length where no future extension is planned.

7 South Water System Analysis

This section of the report covers the hydraulic analysis of the existing South water system under the existing, short term and long term demand conditions. The objective of the analysis is to assess the system's performance with respect to compliance with the level of service outlined in Section 6 and to highlight existing deficiencies in the system and appropriate upgrading options to address existing, short and long term deficiencies.

Analysis covered in this section includes a review of the capacity of the source supplies, an assessment of the available storage and pumping capacities, a review of the operation of the existing PRVs, and the available system pressures and fire flows in the distribution system.

7.1 Source Supply Capacity

In the South water systems, water is supplied primarily from five underground wells. Raw water is pumped from these wells and treated with a disinfectant (sodium hypochlorite) and fluoridated prior to entering the distribution system. Table 7-1 summarizes the source capacities of the existing wells.

Table 7-1 Existing South Supply Wells

Well	Available Capacity (Mgpd)	Available Capacity (L/s)
Wilson Park East (PW-601, PW-602)	24.0	1,052
Wilson Park West (PW-605)	18.0	789
College (PW-621, PW-624)	5.01	220*
Corral (PW-625)	0.042	1.8*
Willow Cale (PW-627)	2.08	90.9*
Total	49.132	2,153.7

*indicates pump capacity

The long term maximum day demand in the South water system was calculated at 1,766.5 L/s in Section 3. Opus DaytonKnight notes that the Wilson Park East and Wilson Park West wells alone will be able to supply this demand. Therefore, there are no concerns with the supply capacities or the treatment of the source waters even for long term buildout of the South water system.

However, Opus DaytonKnight notes that if efforts were made to increase the reliability of the pumping supply at these wells and upsizing of transmission mains were to occur across the City to deliver water from the Wilson Park East and West Wells across the South water system, the City would be able to decommission the existing College Heights and Willow Cale wells in its future servicing strategy. The decommissioning of the Willow Cale wells is considered in the pump station review in Section 7.3. The College Heights wells are kept for system reliability.

The Corral well (PW-625) currently services the Western Acres water system. However, the pumping capacity at the Corral well source is currently just meeting the maximum day demand of the

community. McElhanney and Golder reports completed in 2004 and 2005 identified a second aquifer for the area, and suggested two well sites for groundwater investigation. The first well site is located adjacent to the existing PW-625 well, while the second well site is located in a more northerly direction towards the Chief Memorial Park. The recommended safe yield of the existing well (PW-625) is 3.0 L/s, so pumping capacities can be increased in the short term. The well adjacent to PW-625 has a possible long-term flow rate of 19.0 L/s, while the second well site has a possible rate of 1.7 L/s. Alternatively, other domestic wells which have already been constructed may be used if agreements can be secured by the City with the existing well owners.

7.1.1 Recommendations

The existing well site adjacent to the existing Western Acres well (PW-625) has a capacity which meets the current needs of the Western Acres system and beyond. As the site is currently privately owned, Opus DaytonKnight recommends that the City set aside some finances to develop a procurement strategy and finance the detailed design investigation to incorporate the existing well into the current water system.

7.2 Storage Reservoirs

This section provides an assessment into the existing storage capacities of the City's reservoirs to determine if they meet existing, short term, and long term storage requirements. The minimum fire storage required is governed by the highest fire demand required within the zone. The balancing, fire, and emergency storage volumes have been calculated based on the design criteria noted in Sections 6.3 and 6.4. Only the City owned reservoirs were analyzed, privately owned storage tanks were excluded from the analysis.

7.2.1 Existing Pressure Zone Supplies

Table 7-2 summarizes the each of the storage reservoirs and their associated volumes in the South water system.

Table 7-2 Existing Reservoir Contributions

Pressure Zone	Reservoir	Volume (ML)
PZ 01	803	9.09
PZ 02	805	9.09
PZ 03	824	4.55
PZ 04	836	4.55
PZ 06	828	4.55
PZ 07	830	4.55
PZ 07A	-	-
PZ 15	806 & 827	6.82
PZ 16	-	-

Pressure Zone	Reservoir	Volume (ML)
PZ 21	-	-
PZ 22	823	3.18
PZ 23	814	0.32
PZ 25	825	0.14

While reservoirs are designed to meet the demands of the pressure zone it serves, reservoir volumes may cascade into lower pressure zones or be pumped into higher pressure zones to meet storage volume deficiencies during fire flow demand. Those pressure zones without storage reservoirs require supply from adjacent zones to meet the fire flow demand. Those pressure zones are:

- Storage to service fire flow volumes and peak hour demand in Pressure Zone 07A is supplied from cascading water from the reservoir in Pressure Zone 07;
- Pressure Zone 16 may be serviced through pumping of storage volumes from Pressure Zone 15; and,
- Pressure Zone 21 may be serviced from cascading water from the reservoir in Pressure Zone 22.

7.2.2 Existing Storage Capacity Assessment

Table 7-3 illustrates the components that contribute to the storage capacity requirements and compares that value to the existing available storage in each pressure zone under the existing demand conditions.

Table 7-3 Existing Storage Capacity Analysis

Zone	A - Fire Storage (ML)	B - Equalization Storage (ML)	C- Emergency Storage (ML)	Required Storage A+B+C (ML)	Available Storage (ML)	Excess (ML)	Deficient?
PZ 01	3.15	5.11	2.06	10.32	9.09	**-1.23**	Yes
PZ 02	3.15	8.19	2.84	14.18	9.09	**-5.09**	Yes
PZ 03	3.15	2.19	1.34	6.68	4.55	**-2.13**	Yes
PZ 04	3.15	1.04	1.05	5.23	4.55	**-0.69**	Yes
PZ 06	3.15	1.11	1.07	5.33	4.55	**-0.78**	Yes
PZ 07	3.15	0.16	0.83	4.13	4.55	**0.41**	No
PZ 07A	0.32	0.02	0.09	0.43	-	**-0.43**	Yes
PZ 15	3.15	0.40	0.89	4.44	6.82	**2.38**	No
PZ 16	0.32	0.03	0.09	0.44	-	**-0.44**	Yes
PZ 21	1.08	0.003	0.27	1.35	-	**-1.35**	Yes
PZ 22	3.15	0.47	0.91	4.53	3.18	**-1.35**	Yes
PZ 23	3.15	0.12	0.82	4.09	0.32	**-3.77**	Yes
PZ 25	1.08	0.04	0.28	1.39	0.14	**-1.26**	Yes

The above analysis shows that there are storage volume deficiencies in all pressure zones except for Pressure Zones 07 and 15. However, most deficiencies in pressure zones can be addressed by cascading/pumping remaining water (Available Storage minus Equalization Storage) from neighbouring zones.

A summary of the remaining storage deficiencies (after consideration of cascading/pumping from adjacent zones) and corresponding storage volume improvements as recommended by Opus DaytonKnight are listed below:

- There is a deficiency of 1.23 ML in Pressure Zone 01. The City is currently able to address deficient fire flow volumes by cascading water through PRVs to utilize the excess storage volumes from Pressure Zone 02, PW-805 (9.09 – 8.19 = 0.90 ML). However, this volume does not fully address the volume required in Pressure Zone 01.
    - » Construction of a new reservoir servicing Pressure Zone 01 (0.33 ML) is suggested.
    - » With the potential future connection of the Foothills Reservoir (PW-860) to Pressure Zone 02, there may be an additional volume (4.55 ML) which could be used address storage volume deficiencies.
- There is a deficiency of 5.09 ML in Pressure Zone 02. Water cannot be cascaded from higher pressure zones or pumped from lower pressure zones to address this deficiency.
    - » Construction of a new reservoir servicing Pressure Zone 02 (5.09 ML) is suggested.
    - » With the potential future connection of the Foothills Reservoir (PW-860) to Pressure Zone 02, there may be an additional volume (4.55 ML) which could be used address storage volume deficiencies.
- There is a deficiency of 1.26 ML in Pressure Zone 25.
    - » Construction of a new reservoir servicing Pressure Zone 25 (1.26 ML) is suggested.

7.2.3 Short Term Storage Capacity Assessment

Table 7-4 illustrates the components that contribute to the storage capacity requirements and compares that value to the existing available storage in each pressure zone under the short term demand conditions.

Table 7-4 Short Term Storage Capacity Analysis

Zone	A - Fire Storage (ML)	B - Equalization Storage (ML)	C- Emergency Storage (ML)	Required Storage A+B+C (ML)	Available Storage (ML)	Excess (ML)	Deficient?
PZ 01	3.15	6.66	2.45	12.26	9.09	**-3.16**	Yes
PZ 02	3.15	9.25	3.10	15.50	9.09	**-6.41**	Yes
PZ 03	3.15	2.40	1.39	6.94	4.55	**-2.40**	Yes
PZ 04	3.15	1.25	1.10	5.50	4.55	**-0.96**	Yes

Zone	A - Fire Storage (ML)	B - Equalization Storage (ML)	C- Emergency Storage (ML)	Required Storage A+B+C (ML)	Available Storage (ML)	Excess (ML)	Deficient?
PZ 06	3.15	2.04	1.30	6.49	4.55	**-1.94**	Yes
PZ 07	3.15	0.28	0.86	4.29	4.55	**0.26**	No
PZ 07A	0.32	0.02	0.09	0.43	-	**-0.43**	Yes
PZ 15	3.15	1.06	1.05	5.27	6.82	**1.55**	No
PZ 16	0.32	0.02	0.09	0.43	-	**-0.43**	Yes
PZ 21	1.08	0.003	0.27	1.35	-	**-1.35**	Yes
PZ 22	3.15	2.28	1.36	6.78	3.18	**-3.60**	Yes
PZ 23	3.15	0.14	0.82	4.11	0.32	**-3.80**	Yes
PZ 25	1.08	0.04	0.28	1.39	0.14	**-1.26**	Yes

Under the short term future condition, there remains storage volume deficiencies in all pressure zones except for Pressure Zones 07 and 15. Again, most deficiencies in pressure zones can be addressed by cascading/pumping remaining water (Available Storage minus Equalization Storage) from neighbouring zones.

A summary of the remaining storage deficiencies (after consideration of cascading/pumping from adjacent zones) and corresponding storage volume improvements as recommended by Opus DaytonKnight are listed below:

- There is a deficiency of 3.16 ML in Pressure Zone 01. There are insufficient storage volumes to address these deficient fire flow volumes. Water cannot be cascaded from higher pressure zones or pumped from lower pressure zones to address this deficiency.
    - » Construction of a new reservoir servicing Pressure Zone 01 (3.16 ML) is suggested.
    - » With the potential future connection of the Foothills Reservoir (PW-860) to Pressure Zone 02, there may be an additional volume (4.55 ML) which could be used address storage volume deficiencies.
- There is a deficiency of 6.41 ML in Pressure Zone 02. There are insufficient storage volumes to address these deficient fire flow volumes. Water cannot be cascaded from higher pressure zones or pumped from lower pressure zones to address this deficiency.
    - » Construction of a new reservoir servicing Pressure Zone 02 (6.41 ML) is suggested.
    - » With the potential future connection of the Foothills Reservoir (PW-860) to Pressure Zone 02, there may be an additional volume (4.55 ML) which could be used address storage volume deficiencies.
- There is a deficiency of 3.60 ML in Pressure Zone 22. The City would be able to address deficient fire flow volumes by pumping water to utilize the excess storage volumes from Pressure Zone 01, PW-803 (9.09 – 6.66 = 2.43 ML). However, this volume does not fully address the volume required in Pressure Zone 22.

  - » Construction of a new reservoir servicing Pressure Zone 22 (1.17 ML) is suggested.

- There is a deficiency of 3.80 ML in Pressure Zone 23. The City would be unable to address deficient fire flow volumes by pumping water to utilize the excess storage volumes from Pressure Zone 22, PW-823 (3.18 – 2.28 = 0.90 ML) and Pressure Zone 01, PW-803 (9.09 – 6.66 = 2.43 ML). However, this volume does not fully address the volume required in Pressure Zone 23.
  - » Construction of a new reservoir servicing Pressure Zone 23 (0.47 ML) is suggested.
- There is a deficiency of 1.26 ML in Pressure Zone 25.
  - » Construction of a new reservoir servicing Pressure Zone 25 (1.26 ML) is suggested.

7.2.4 Long Term Storage Capacity Assessment

Table 7-5 illustrates the components that contribute to the storage capacity requirements and compares that value to the existing available storage in each pressure zone under the long term demand conditions.

Table 7-5 Long Term Storage Capacity Analysis

Zone	A - Fire Storage (ML)	B - Equalization Storage (ML)	C- Emergency Storage (ML)	Required Storage A+B+C (ML)	Available Storage (ML)	Excess (ML)	Deficient?
PZ 01	3.15	11.52	3.67	18.34	9.09	**-9.25**	Yes
PZ 02	3.15	11.47	3.66	18.27	9.09	**-9.18**	Yes
PZ 03	3.15	2.90	1.51	7.56	4.55	**-3.02**	Yes
PZ 04	3.15	1.90	1.26	6.31	4.55	**-1.77**	Yes
PZ 06	3.15	4.63	1.95	9.73	4.55	**-5.18**	Yes
PZ 07	3.15	0.94	1.02	5.11	4.55	**-0.57**	Yes
PZ 07A	0.32	0.03	0.09	0.44	-	**-0.44**	Yes
PZ 15	3.15	1.11	1.07	5.33	6.82	**1.49**	No
PZ 16	0.32	0.03	0.09	0.44	-	**-0.44**	Yes
PZ 21	1.08	0.004	0.27	1.36	-	**-1.36**	Yes
PZ 22	3.15	2.78	1.48	7.42	3.18	**-4.23**	Yes
PZ 23	3.15	0.26	0.85	4.26	0.32	**-3.94**	Yes
PZ 25	1.08	0.04	0.28	1.40	0.14	**-1.26**	Yes

Under the long term condition, there are storage volume deficiencies in all pressure zones except for Pressure Zone 15. For the long term condition, only a few deficiencies can be addressed by cascading/pumping remaining water (Available Storage minus Equalization Storage) from neighbouring zones.

There are eight remaining pressure zones which maintain their storage deficiencies. Table 7-6 summarizes the storage sizing deficiencies and Table 7-7 provides the recommended storage capacity

increases for the South water system to address shortages under the existing, short term and long term demand conditions.

7.2.5 Summary and Recommendations

Upon review of the storage capacity analysis above, it was found that current reservoirs volumes are insufficient to address shortages in fire flow volumes for the South part of the City as summarized below.

Table 7-6 Storage Capacity Deficiencies

Zone	Existing Deficiency	Sizing	Short Term Deficiency	Sizing	Long Term Deficiency	Sizing
PZ 01	✓	0.33	✓	3.16	✓	9.25
PZ 02	✓	5.09	✓	6.41	✓	9.18
PZ 06					✓	1.57
PZ 07					✓	0.57
PZ 21					✓	0.96
PZ 22			✓	1.17	✓	4.23
PZ 23			✓	0.47	✓	3.94
PZ 25	✓	1.26	✓	1.26	✓	1.26

Five reservoir improvements are recommended for the South water system to address storage deficiencies up to the long term scenario. Table 7-7 details the size of the reservoir and the maximum day demand trigger at the pressure zone that it supplies.

Table 7-7 Storage Capacity Recommendations

Rec #	Zone	Size (ML)	Deficiency Addressed	MDD Trigger	Notes
R-1	PZ 25	2.27	Existing	-	
R-2	PZ 02	6.82	Existing	-	4.55 ML can be added through connecting the Foothills Reservoir across the Nechako River.
R-3	PZ 22	4.55	Short Term	92 L/s in PZ22	Also addresses deficiencies in PZ 21 & 23; should be constructed earlier to provide fire flows to PZ 22.
R-4	PZ 07	2.27	Long Term	28 L/s in PZ07	Also addresses deficiency in PZ 06.
R-5	PZ 02	4.55	Long Term	445 L/s in PZ02	

Substantial reservoir upgrades have been identified to address existing storage volume deficiencies and support the anticipated long term growth (65,575 to 125,347 persons) in the South water system.

7.3 Pump Stations

This section provides an assessment on the existing capacities of the City's pump stations to determine if they are able to service the maximum day demands within each of the City's pressure zones under the existing, short term and long term scenarios. Only the City owned pump stations were analyzed, privately owned pump stations were excluded from the analysis.

7.3.1 Existing Pumping Capacity

Design flows for all pumps were estimated based on the modeled pump curves. The design capacity of a pump station is the combined design flow of all the pumps minus the largest pump. Table 7-8 summarizes the design capacity at each of the City's pump stations.

Table 7-8 Existing Pump Capacity

Pump Station	Pump ID	Rated Capacity (L/s)	Design Capacity (L/s)
601	601-1	272	544
	601-2	272	
	601-3	272	
602	602-1	272	544
	602-2	272	
	602-3, Standby Natural Gas	272	
605	605-1	272	816
	605-2	272	
	605-3	272	
	605-4, Standby Diesel	272	
614	614-1	14	14
	614-2	14	
621 & 624	621-1	91	129
	624-1	91	
	624-2	38	
623	623-1	82	82
	623-2	82	
625	625-1, Well pump	1.9	1.9
	625-2, Distribution pump	1.9	1.9
	625-3, Distribution pump	1.9	
627	627-1	62	43
	627-2	43	
628	628-1	39	78

Pump Station	Pump ID	Rated Capacity (L/s)	Design Capacity (L/s)
	628-2	39	
	628-3	39	
629	629-1	6.3	3.8
	629-2	3.8	
630	630-1	42	42
	630-2	42	
636	636-1	130	260
	636-2	130	
	636-3, Standby Diesel	130	

For pump stations that supply water to pressure zones with storage reservoirs, the pump stations are assessed based on their capability in meeting the maximum day demand of the pressure zone. For those that pumped to dead end systems, such as PW-629, the pumps are assessed based on their capability to meet peak hour demand.

7.3.2 Existing Pump Capacity Assessment

We note that the City intends to connect Pressure Zone 22 to Pressure Zones 16 and 15 later this year with the intention of providing water from Pressure Zone 22 to the Danson Reservoir in Pressure Zone 15 via an altitude valve. With this connection, the current Patricia (PW-623) pump station would be able to service all of Pressure Zones 15, 16, 21, 22, and 23. This requirement is reflected in the capacity analysis for PW-623.

Pressure Zones 04, 06, 07, 07A are currently serviced by the UNBC (PW-630) pump station from the north, and the Andres (PW-636) and Lalonde (PW-628) pump stations from the east. The current servicing strategy for these zones is to maximize supply from the UNBC pump station as much as possible. Therefore, the current capacities of PW-636 and PW-628 will be kept unchanged while pump capacity increases as required for the area will be concentrated at PW-630.

Table 7-9 summarizes the service areas associated with each of the pump stations and compares the required pump capacity to the existing available pump capacity under existing demand conditions.

Table 7-9 Existing Pump Capacity Analysis

Pump Station	Service Area	Capacity Required (L/s)	Design Capacity (L/s)	Excess (L/s)	Deficient?
601	PZ 01, 21, 22, 23	264.1	544.0	**279.9**	No
602	PZ 01, 21, 22, 23	264.1	544.0	**279.9**	No
605	PZ 02, 04, 06, 07, 07A	487.0	816.0	**329.0**	No
614	PZ 23	5.7	14.0	**8.3**	No

Pump Station	Service Area	Capacity Required (L/s)	Design Capacity (L/s)	Excess (L/s)	Deficient?
621 & 624	PZ 03	101.4	129.0	**27.6**	No
623	PZ 15, 16, 21, 22, 23	47.6	82.0	**34.4**	No
625	PZ 25	1.6	1.9	**0.3**	No
627	PZ 15, 16	2.3	43.0	**40.7**	No
628[1]	PZ 06	51.4	78.0	**26.6**	No
629[2]	PZ 16[1]	2.2	3.8	**1.6**	No
630	PZ 07, 07A	8.3	42.0	**33.7**	No
636[1]	PZ 04, 06	99.4	260.0	**160.6**	No

1 all pumping upgrades required at PW-628 and PW-636 will be transferred to PW-630
2 peak hour capacity assessed for PW-629

The above analysis shows that there are currently no pumping capacity deficiencies in the South water system.

7.3.3 Short Term Pump Capacity Assessment

Table 7-10 summarizes the service areas associated with each of the pump stations and compares the required pump capacity to the existing available pump capacity under the short term demand conditions.

Table 7-10 Short Term Pump Capacity Analysis

Pump Station	Service Area	Capacity Required[1] (L/s)	Design Capacity (L/s)	Excess (L/s)	Deficient?
601	PZ 01, 21, 22, 23	420.2	544.0	**123.9**	No
602	PZ 01, 21, 22, 23	420.2	544.0	**123.9**	No
605	PZ 02, 04, 06, 07, 07A	594.7	816.0	**221.3**	No
614	PZ 23	6.5	14.0	**7.5**	No
621 & 624	PZ 03	111.3	129.0	**17.7**	No
623	PZ 15, 16, 21, 22, 23	162.7	82.0	**-80.7**	Yes
625	PZ 25	1.6	1.9	**0.3**	No
627	PZ 15, 16	50.7	43.0	**-7.7**	Yes
628[1]	PZ 06	94.5	78.0	**-16.5**	Yes
629[2]	PZ 16	1.5	3.8	**2.3**	No
630	PZ 07, 07A	14.1	42.0	**27.9**	No
636[1]	PZ 04, 06	152.5	260.0	**107.5**	No

1 all pumping upgrades required at PW-628 and PW-636 will be transferred to PW-630
2 peak hour capacity assessed for PW-629

Under the short term condition, there are pumping capacity deficiencies at the Patricia Pump Station (PW-623), the Willow Cale Wells (PW-627) and the Lalonde Pump Station (PW-628). A summary of each deficiency and how they can be addressed is listed below:

- There is a pumping deficiency of 80.7 L/s at the Patricia Pump Station (PW-623).
    - » Pumping upgrades are required at PW-623 to increase the design capacity from 82.0 L/s to 162.7 L/s.
- There is a pumping deficiency of 7.7 L/s at the Willow Cale Wells (PW-627). Pumping upgrades are required at PW-627 to increase the design capacity from 43.0 L/s to 50.7 L/s. However, pump station upgrades at Patricia Pump Station (PW-623) may allow the City to decommission PW-627. As upgrades to the Patricia Pump Station are already recommended, no pumping upgrades are required at PW-627.
- There is a pumping deficiency of 16.5 L/s at the Lalonde Pump Station (PW-628). This deficiency would be met by cascading the excess capacity of Pressure Zone 07, PW-630 (27.9 L/s) into Pressure Zone 06.

7.3.4 Long Term Pump Capacity Assessment

Table 7-11 summarizes the service areas associated with each of the pump stations and compares the required pump capacity to the existing available pump capacity under the long term demand conditions.

Table 7-11 Long Term Pump Capacity Analysis

Pump Station	Service Area	Capacity Required[1] (L/s)	Design Capacity (L/s)	Excess (L/s)	Deficient?
601	PZ 01, 21, 22, 23	674.4	544.0	**-130.4**	Yes
602	PZ 01, 21, 22, 23	674.4	544.0	**-130.4**	Yes
605	PZ 02, 04, 06, 07, 07A	878.1	816.0	**-62.1**	Yes
614	PZ 23	12.0	14.0	**2.0**	No
621 & 624	PZ 03	134.3	129.0	**-5.3**	Yes
623	PZ 15, 16, 21, 22, 23	183.0	82.0	**-101.0**	Yes
625	PZ 25	1.7	1.9	**0.2**	No
627	PZ 15, 16	53.7	43.0	**-10.7**	Yes
628[1]	PZ 06	214.4	78.0	**-136.4**	Yes
629[2]	PZ 16	2.3	3.8	**1.5**	No
630	PZ 07, 07A	44.8	42.0	**-2.8**	Yes
636[1]	PZ 04, 06	302.4	260.0	**-42.4**	Yes

1 all pumping upgrades required at PW-628 and PW-636 will be transferred to PW-630
2 peak hour capacity assessed for PW-629

Under the long term condition, there are pumping capacity deficiencies at PW-601, PW-602, PW-605, PW-623, PW-627, PW-628, PW-630 and PW-636. A summary of each deficiency and how they can be addressed is listed below:

- There is a pumping deficiency of 130.4 L/s at the Wilson Park East Wells (PW-601).
    - » Pumping upgrades are required at PW-601 to increase the design capacity from 544.0 L/s to 674.4 L/s.
- There is a pumping deficiency of 130.4L/s at the Cameron Pump Station (PW-602).
    - » Pumping upgrades are required at PW-602 to increase the design capacity from 544.0 L/s to 674.4 L/s.
- There is a pumping deficiency of 62.1 L/s at the Wilson Park West Wells (PW-605).
    - » Pumping upgrades are required at PW-605 to increase the design capacity from 816.0 L/s to 878.1 L/s.
- There is a pumping deficiency of 5.3 L/s in the College North and South Wells (PW-621 and PW-624).
    - » Pumping upgrades are required at PW-621 and PW-624 to increase the design capacity from 129.0 L/s to 134.3 L/s.
- There is a pumping deficiency of 101.0 L/s at the Patricia Pump Station (PW-623).
    - » Pumping upgrades are required at PW-623 to increase the design capacity from 82.0 L/s to 183.0 L/s.
- There is a pumping deficiency of 10.7 L/s at the Lalonde Pump Station (PW-627). Pumping upgrades are required at PW-627 to increase the design capacity from 43.0 L/s to 53.7 L/s. However, pump station upgrades at Patricia Pump Station (PW-623) may allow the City to decommission PW-627. As upgrades to the Patricia Pump Station are already recommended, no pumping upgrades are required at PW-627.
- There is a pumping deficiency of 136.4 L/s in PW-628. As the current servicing strategy for the South water system is to maximize supply from the UNBC pump station as much as possible, the pumping capacity upgrade will be added to the increase required at PW-630.
- There is a pumping deficiency of 2.8 L/s in PW-630.
    - » Pumping increases at PW-628 and PW-636 are also applied at this station. Pumping upgrades are required at PW-630 to increase the design capacity from 42.0 L/s to 223.6 L/s.
- There is a pumping deficiency of 42.4 L/s in PW-636. As the current servicing strategy for the South water system is to maximize supply from the UNBC pump station as much as possible, the pumping capacity upgrade will be added to the increase required at PW-630.

7.3.5 Summary and Recommendations

Upon review of the pumping capacity analysis for the existing, short term and long term conditions, it was found that current pump capacities are insufficient to supply maximum day demand flows and refill system reservoirs for the South water system as summarized in Table 7-12 below.

Table 7-12 Pump Capacity Deficiencies

Pump Station	Existing Deficiency	Capacity Required (L/s)	Short Term Deficiency	Capacity Required (L/s)	Long Term Deficiency	Capacity Required (L/s)
601					✓	130.4
602					✓	130.4
605					✓	62.1
623			✓	80.7	✓	101.0
630					✓	223.6

The Sintich pump station (PW-629) currently pumps into a dead end system and is designed to supply the peak hour demand of the system it is servicing. However, the City intends to connect the existing Pressure Zone 22 with Pressure Zone 16 with a watermain construction later this year (2015) and this connection would extend Pressure Zone 22 such that Pressure Zone 16 would no longer exist. Opus DaytonKnight envisions that the Sintich pump station would no longer be required at its current capacity as well. Therefore, no fire pump improvement is proposed for Pressure Zone 16.

Pressure Zone 23 also has insufficient fire flow servicing from sizing and location of the Tabor Lake Reservoir. The Somerville pump station (PW-614) was identified for upgrades to improve fire flows to the zone. The following table illustrates the fire pump sizing required for PW-614 under existing, short term and long term conditions.

Table 7-13 Fire Pump Sizing

Pump ID	FF Required (L/s)	Existing MDD (L/s)	Short Term MDD (L/s)	Long Term MDD (L/s)	Design Capacity (L/s)
614-Fire	60.0	5.7	6.5	12.0	72.0

Seven pump station improvements are recommended for the South water system as follows:

Table 7-14 Pump Capacity Recommendations

Rec #	Pump ID	Total Capacity Required (Additional Capacity)	Approx. Head Required	Deficiency Addressed	MDD Trigger	Notes
P-1	614-Fire	72 L/s	30 m	Existing	-	Supplies FF to PZ 23 (40HP)

Rec #	Pump ID	Total Capacity Required (Additional Capacity)	Approx. Head Required	Deficiency Addressed	MDD Trigger	Notes
P-2	Fraser	54 L/s	35 m	Short Term	43 L/s in PZ 15, 16	A new booster station across the Fraser River to connect PZ 01 to PZ 15 will enable the City to decommission PW-627. (30HP)
P-3	623	183 L/s (101 L/s)	110 m	Short Term	82 L/s in PZ 21, 22, 23	(200HP)
P-4	601	729 L/s (185 L/s)	10 m	Long Term	544 L/s in PZ 01, 21, 22, 23	(40HP)
P-5	602	729 L/s (185 L/s)	70 m	Long Term	544 L/s in PZ 01, 21, 22, 23	(250HP)
P-6	605	878 L/s (62 L/s)	85 m	Long Term	816 L/s in PZ 02, 04, 06, 07, 07A	(100HP)
P-7	630	224 L/s (182 L/s)	176 m	Long Term	105 L/s in PZ 06, 260 L/s in PZ 04, 06, & 42 L/s in PZ 07, 07A	(550HP)

A new pump station across the Fraser River would increase demand on the supply well at PW-601 and PW-602 but would eliminate the pump upgrade at PW-627. This would enable the City to decommission the Willow Cale wells (PW-627) and utilize these wells as an emergency/back-up supply to the City. The new pump station would increase the pumping capacity requirements to 729 L/s at PW-601 and PW-602 under the long term demand condition.

In addition, a new connection of the South water system across the Nechako River to the Fishtrap Collector Wells (PW-660) may eliminate the need for pumping recommendations P-4, P-5 and P-6. This transmission main upgrade (T-1) is detailed further in Section 7.6.2.

It is further noted that a detailed operational review of each of the pump stations was not carried out, but it is understood from a workshop with operational staff that there are current operational struggles to maintain water levels at the Cranbrook Hill Reservoir (PW-805) via pumping from three pumps operating at the Wilson Park West Wells (PW-605). Opus DaytonKnight suggests conceptual design investigations to review any operational issues found in the system's pumping supply.

7.4 PRV Station Review

PRV stations were reviewed based on the highest velocities predicted by the water model. Predicted flows and velocities were determined during peak hour demands. As a general guideline, the recommended peak velocity through a PRV is 6.0 m/s during peak hour demand.

Table 7-15 summarizes the predicted peak velocities under each condition.

Table 7-15 PRV Station Analysis

ID	PRV Station	Diameter (in.)	Existing PHD		Short Term PHD		Long Term PHD	
			Flow (L/s)	Velocity (m/s)	Flow (L/s)	Velocity (m/s)	Flow (L/s)	Velocity (m/s)
613	O'Grady	6"	23.7	1.3	28.6	1.6	41.7	2.4
622	Crest	2"	1.7	0.9	1.8	0.9	2.2	1.1
		6"	0	0	0	0	0	0
633	Freeman	3"	0.2	0.05	41.1	9.3	18.1	4.1
		10"	0	0	0	0	210.5	4.3
634	Bernard	6"	0	0	0	0	0	0
635	Ferry	6"	10.0	0.6	12.6	0.7	20.5	1.2
637	Hwy 16	8"	0.2	0.01	0.2	0.01	0.3	0.01
638	Domano	6"	Inactive		Inactive		Inactive	
639	St. Patrick	6"	71.8	4.1	74.0	4.2	79.2	4.5
641	Recreation	8"	0	0	0	0	0	0
642	FRBL	8"	0	0	0	0	0	0
643	Upper Tyner	10"	3.6	0.07	60.5	1.2	226.3	4.6
644	Lower Tyner	10"	0	0	0	0	0	0

The Freeman lead PRV is currently identified as having velocities exceeding 6.0 m/s during the peak hour demand under the short term demand scenario.

Further, the Bernard (PW-634), Recreation (PW-641), FRBL (PW-642), and Lower Tyner (PW-644) PRVs are modelled as closed during peak hour demand. This operation should be confirmed by the City's operations department.

7.4.1 Recommendations

There is a concern with high velocities through the Freeman (PW-633) PRV station. To address this issue, the Freeman lag PRV should be set at a higher setting to ensure it turns on to assist the lead PRV during peak hour demand under the short term demand scenario.

7.5 Zone 1 & 2 Interconnectivity

Opus DaytonKnight carried out an assessment into the interconnectivity of Pressure Zones 01 and 02 and the current operation of the PRV stations between the zones. In particular, the operation of the three (3) existing PRV stations providing water from Pressure Zone 02 to Pressure Zone 01 were reviewed. Figure 7-1A illustrates the existing available fire flows in Pressure Zone 01 with the current PRV settings. There are currently 109 fire flow deficiencies in Pressure Zone 01.

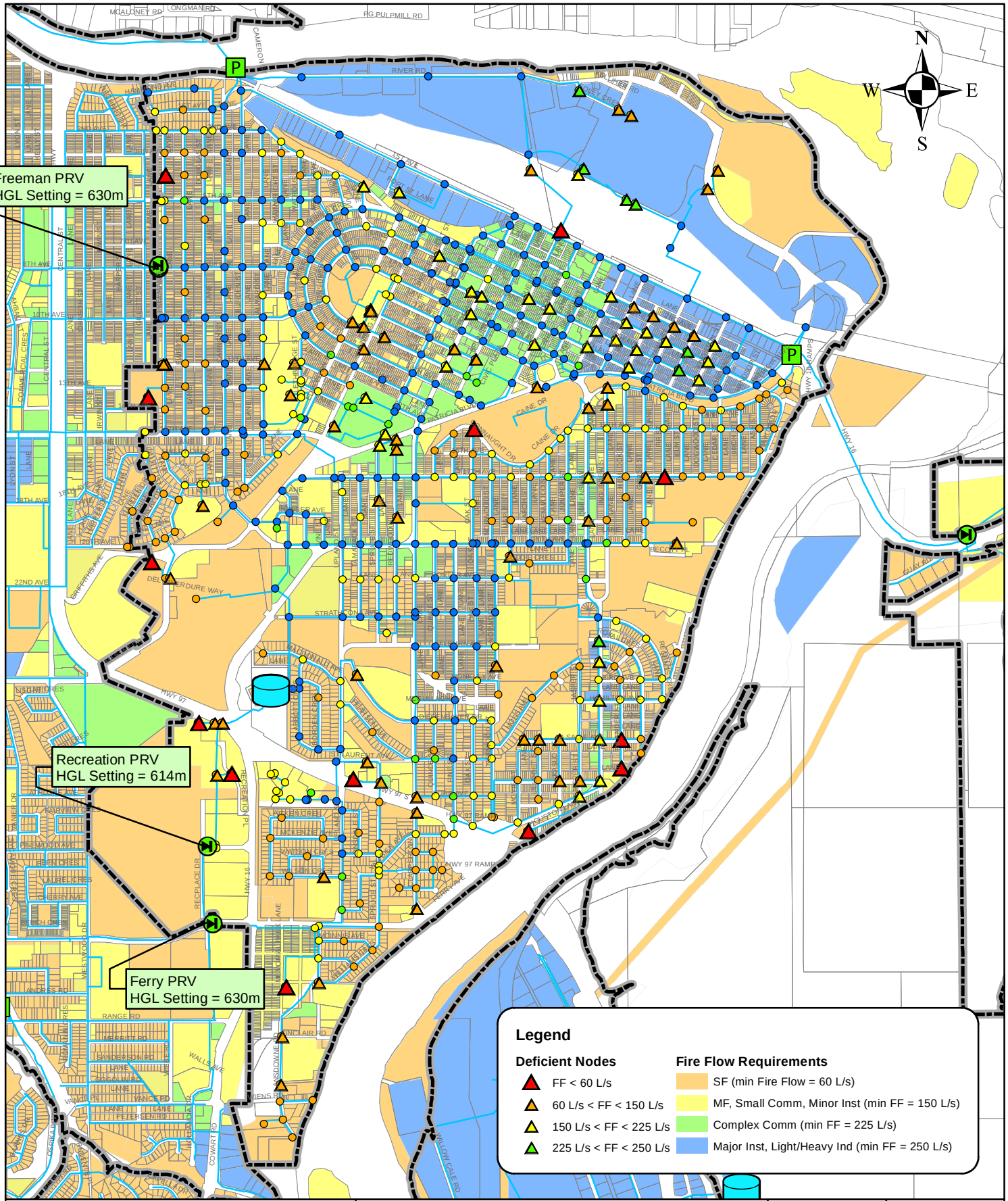
The City has noted that a valve at the intersection of 20th Ave and Griffiths Ave has historically been opened to provide additional fire flow servicing for the system. Opus DaytonKnight has modelled an additional PRV at this location. The construction of this additional PRV generally increases fire flows to the entire zone but only reduces the number of fire flow deficiencies from 109 to 102. Figure 7-1B illustrates these results.

Opus DaytonKnight recommends that the PRV settings for all four (4) PRVs be set at 627m to ensure that the PRVs are in operation during maximum day plus fire flow demand and peak hour demands. This, however, increases the fire flow deficiencies back to 110. This is due to the fact that the PRVs are currently set close to 630m, which is theoretically too high under normal operation. The drawback of setting the PRVs at 630m is that since it is very close to the top water level of the Carney Hill Reservoir in Pressure Zone 01, the Carney Hill Reservoir would experience minimal drawdown. Figure 7-1C illustrates the 110 fire flow deficiencies.

Finally, an additional PRV station from Pressure Zone 15 is also considered to back feed water into Pressure Zone 01 only during fire flow conditions. This reduces fire flow deficiencies to 100 and is shown in Figure 7-1D. In addition to improving fire flows in Pressure Zone 01, this connection also improves the reliability and redundancy of the water system.

7.5.1 Recommendations

These analyses illustrate that additional PRVs would benefit Pressure Zone 01 in terms of increased reliability/redundancy of water supply to the City's water system. However, it also illustrates that fire flow deficiencies within Pressure Zone 01 are subject to local street-by-street watermain upgrades rather than any supply point upgrades through additional PRVs. The Griffiths and Pressure Zone 15 PRVs should be constructed to increase reliability/redundancy of the system, but more importantly local watermain upgrades should be considered to increase fire flows to deficient areas.



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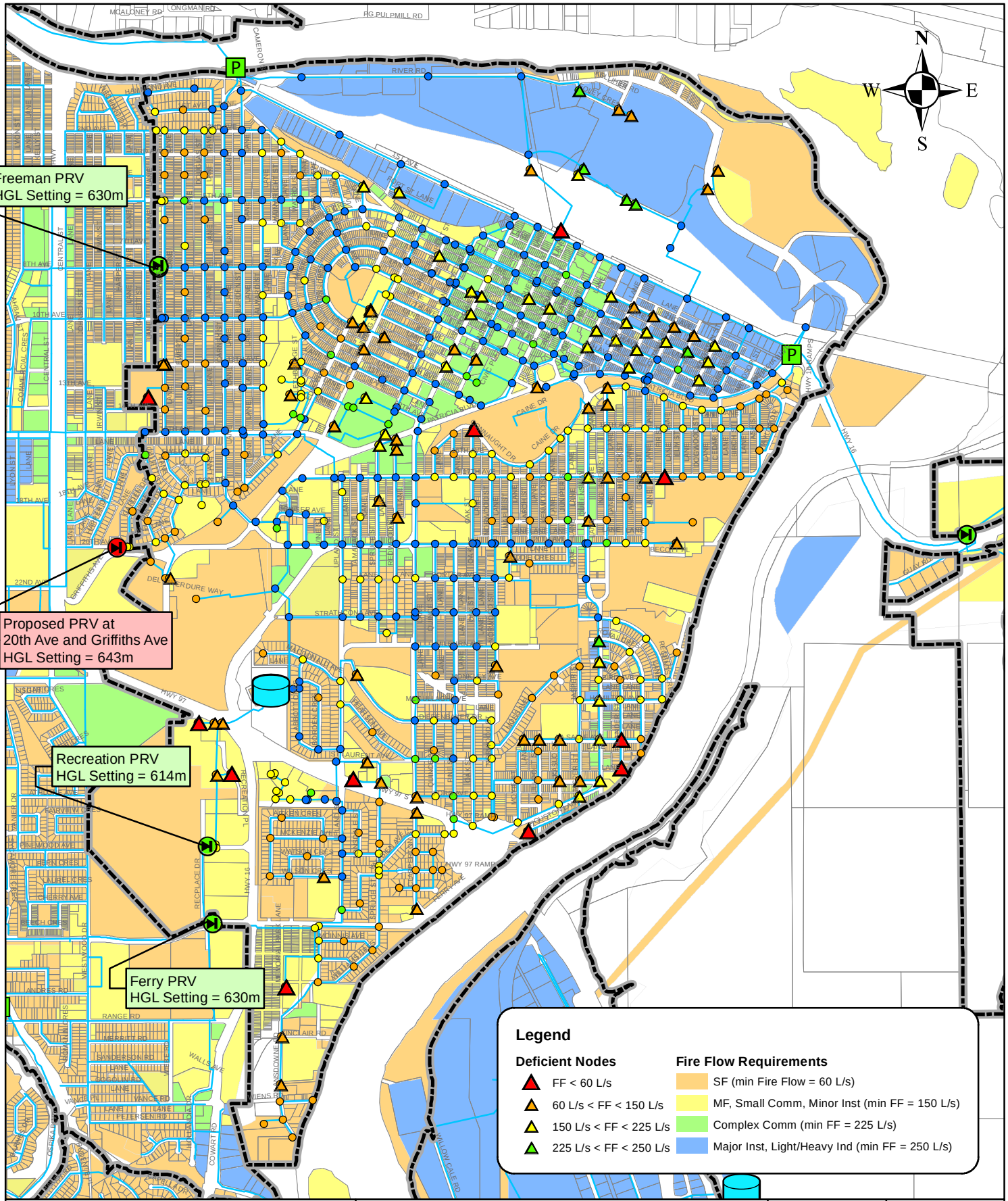
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Client: CITY OF PRINCE GEORGE

Pressure Zone 01 Existing Fire Flows

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Drawn:	CL
Approved:	
Scale:	0 125 250 Meters
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Note:	
Figure 7-1A	
Map No	1
Date	DEC 2014
Revision	
Revision Date	

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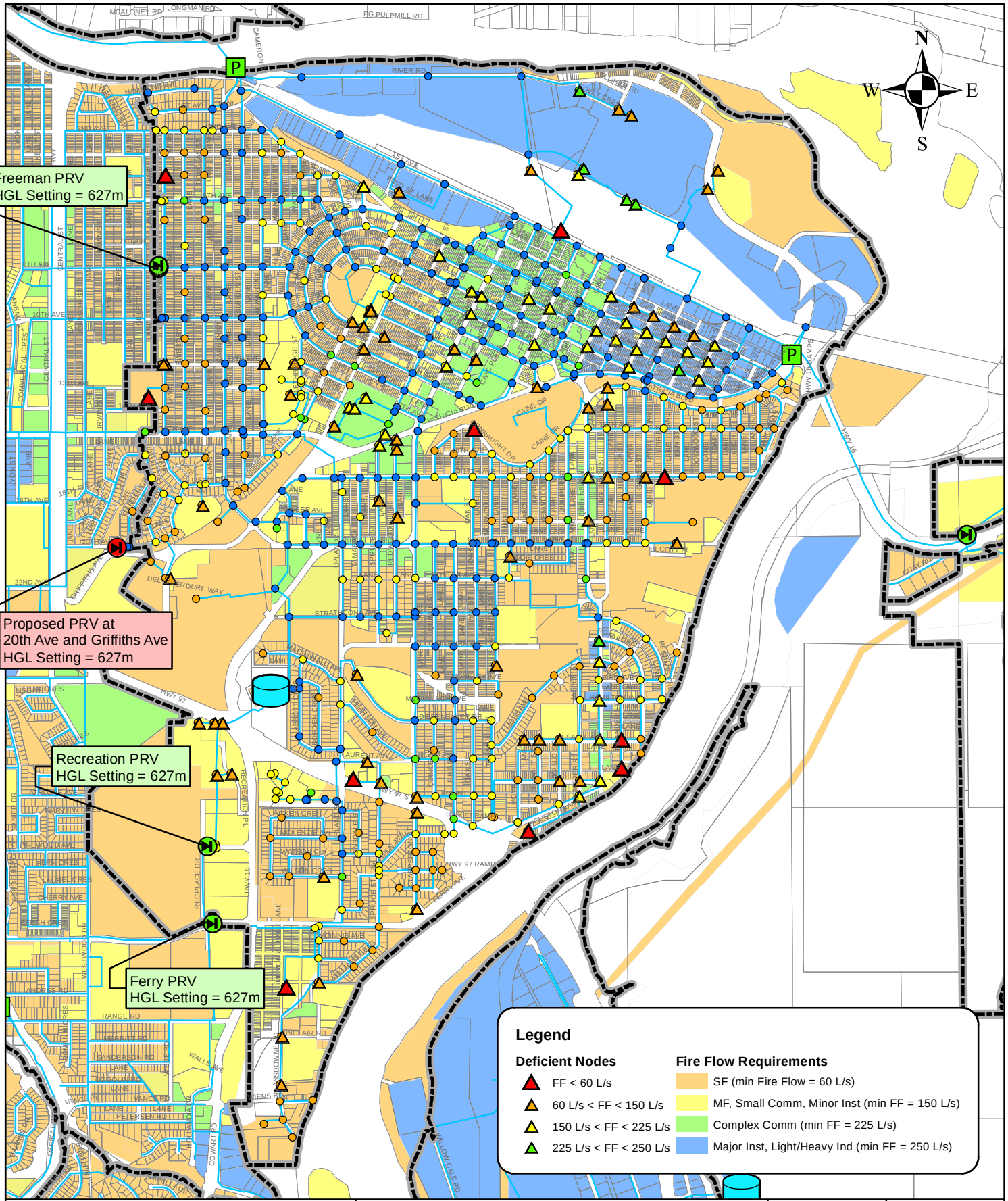
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Pressure Zone 01 Fire Flows with Griffiths PRV

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Map No	1
Date	DEC 2014
Revision	
Revision Date	

Figure 7-1B

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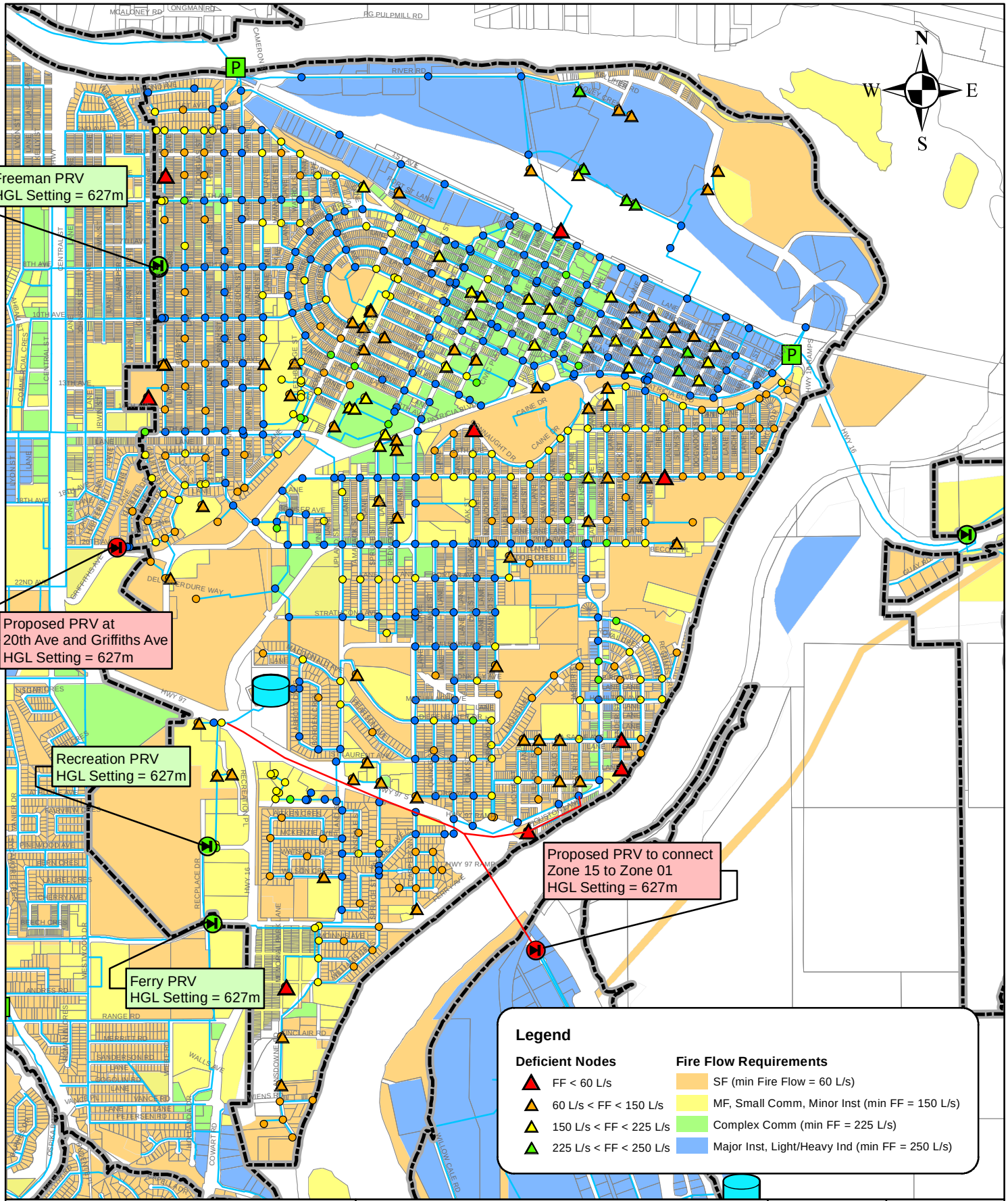
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Pressure Zone 01 Fire Flows with Ideal PRV Settings

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Drawn:	CL
Approved:	
Note:	
Scale:	0 125 250 Meters; 1:25,000 @ Tabloid
Map No	1
Date	DEC 2014
Revision	
Revision Date	

Figure 7-1C

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Pressure Zone 01 Fire Flows with Griffiths and Zone 15 PRV

Project No:	D-17460.00
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Drawn:	CL
Approved:	
Note:	
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Map No	1
Date	DEC 2014
Revision	
Revision Date	

Figure 7-1D

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7.6 Transmission and Distribution

A hydraulic analysis of the watermains was carried out using the updated InfoWater model.

7.6.1 Transmission Mains Analysis

A supply analysis reviewing the transmission mains in the system determines the system's ability to fill its reservoirs in 24 hours during conditions of maximum day demand. This analysis aims to simulate the delivery of treated water from the water source over to system reservoirs and simulate the refilling the reservoirs during maximum day demand. This will determine if there is sufficient hydraulic capacity in the system to transport the source water to the system reservoirs.

There are no dedicated transmission mains in the south water systems. Rather, the transmission mains form part of the distribution system, with distribution mains extending throughout the network. Recommendations to improve the reliability of the water supply have been identified and reviewed for constructability.

7.6.2 Transmission Main Recommendations

Our analysis shows that the City is currently struggling to refill its Cranbrook Hill (PW-805) and Carney Hill (PW-803) reservoirs during maximum day demand.

To increase the reliability of the supply and ensure refilling of the system's reservoirs, a transmission main should be constructed from the Fishtrap Collector Well (PW-660) to connect across the Nechako River to the South water system and would extend all the way to the Cranbrook Hill Reservoir (PW-605). Opus DaytonKnight has previously started on the detailed design of this transmission main and an associated new reservoir adjacent to the existing Cranbrook Hill Reservoir for increased volume capacity.

Transmission main recommendations include:

- T-1: The construction of 3,810mm of 350mm watermain to connect the Fishtrap Collector Wells (PW-660) to the Cranbrook Hill Reservoir (PW-605)
- T-2: Construct a pump station crossing the Fraser River. Included is the construction of 1,990m of 350mm watermain from the Carney Hill Reservoir (PW-803) to the new pump station.
- T-3: Increase the pump capacity at the Patricia (PW-623) pump station to 183 L/s
- T-4: Increase the pump capacity at the UNBC (PW-630) pump station to 224 L/s.

The proposed transmission main improvements are illustrated in Figure 7-2. Recommendations provided through T-2, T-3 and T-4 are each already noted in the pumping recommendations P-2, P-3 and P-7, respectively.

Transmission Upgrade T-1:
- 3,810m of 350mm watermain
- provides increased water supply from the Fishtrap Collector Wells

Transmission Upgrade T-3:
- Pumping capacity of PW-623 should be increased from 82 L/s to 183 L/s
- Due to antipated growth in East PG

Transmission Upgrade T-4:
- Pumping capacity of PW-630 should be increased from 42 L/s to 224 L/s
- Improves Fishtrap supply to PZ 04, 06 and 07

Transmission Upgrade T-2:
- Construction of a Pump/PRV station to allow water flow between PZ01 and PZ15
- This improves redundancy in the system

Transmission Upgrade T-2:
- 1,990m of 350mm watermain
- provides increased water supply to the BCR/Danson Lands

Legend
- Pump Stations
- PRV Stations
- Reservoirs
- Source
- Proposed Transmission Upgrade
- SouthWest/Core Watermains
- Hart/Nechako Watermains

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South Model Transmission Upgrades

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7.6.3 Distribution System Analysis

Existing ADD, MDD, and PHD scenarios were simulated to review node pressures, available fire flows and pipe velocities throughout the system.

7.6.3.1 Average Day Demand

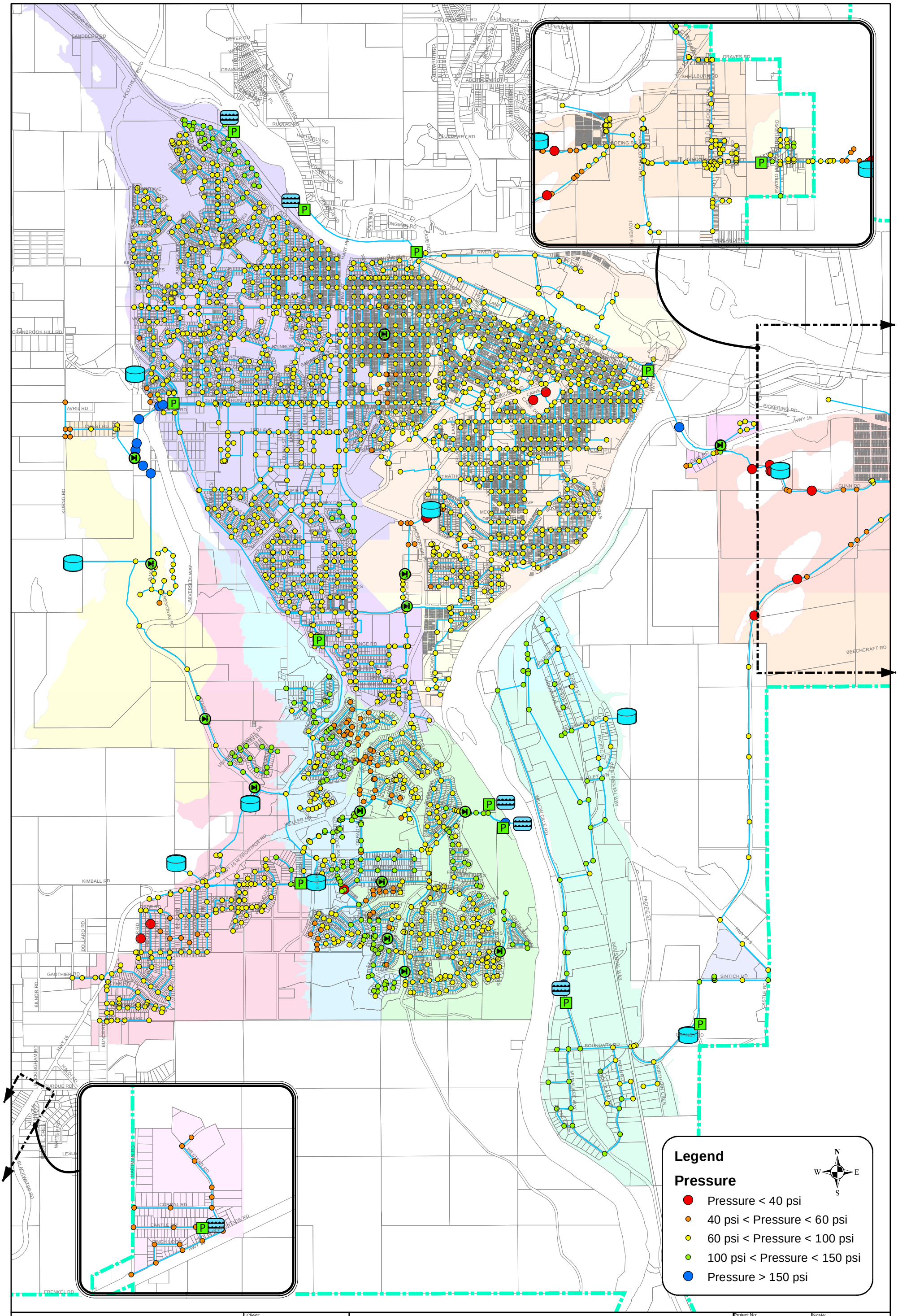
The maximum pressure within each zone occurs at the property at the lowest elevation compared to the HGL of the zone set either by a Reservoir, PRV or Pump. Table 7-16 summarizes the number of nodes which currently have pressures exceeding 150 psi.

Table 7-16 South Model Average Day Pressures

Zone	# Nodes above the Maximum Allowable Pressure		
	Existing	Short Term	Long Term
All Zones	8	8	8

There are 8 nodes with pressures above 150 psi in the model. However, all these high pressures occur in immediately downstream of pump stations and are within watermains where there are no properties connected off them.

In terms of high pressure at properties, the maximum allowable pressure is not exceeded under the existing, short term and long term scenarios. As illustrated in Figure 7-3, Figure 7-4, and Figure 7-5, there are no property locations within the City of Prince George where pressures are more than 150 psi.



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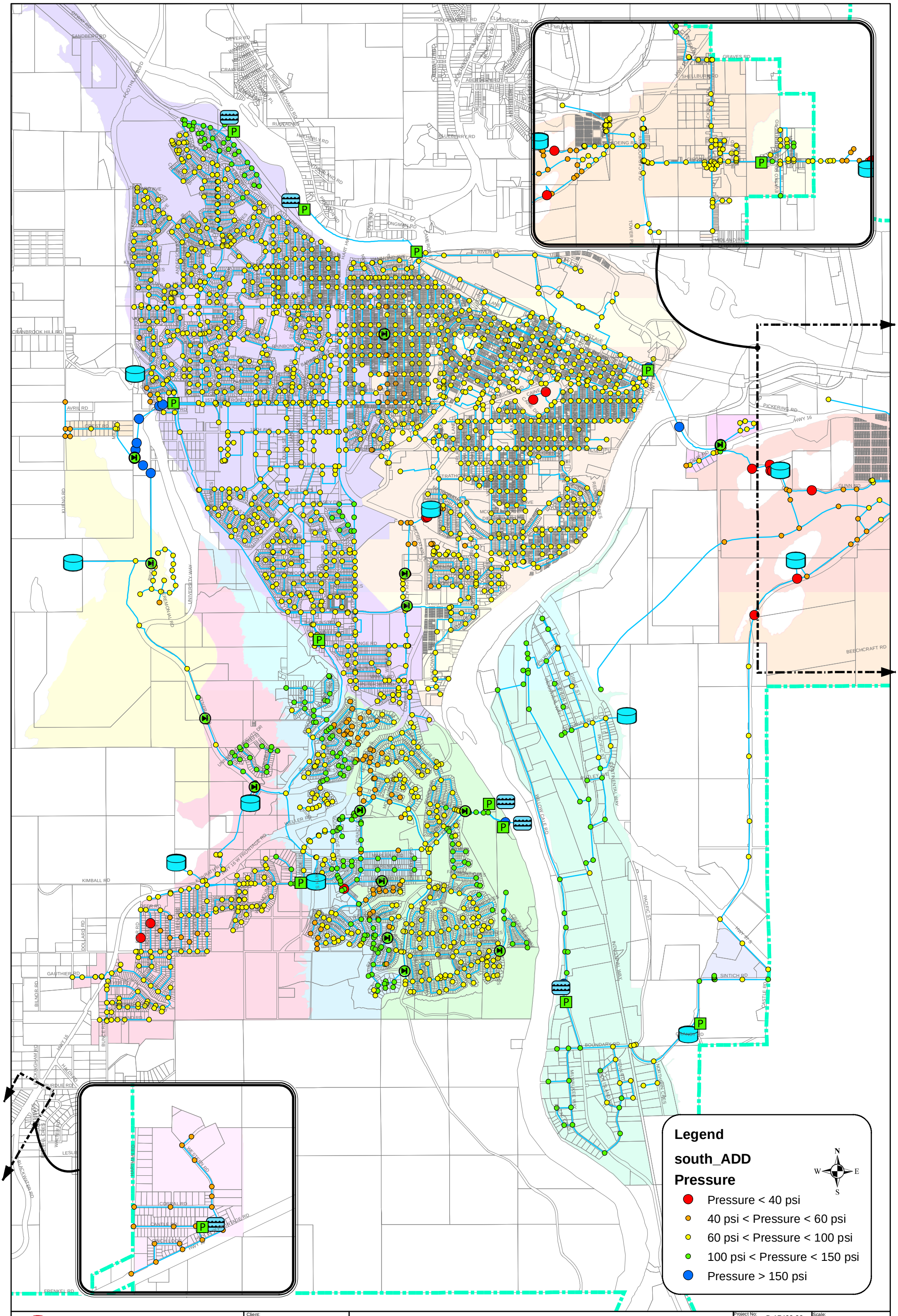
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South Model
Average Day Pressures under Existing Condition

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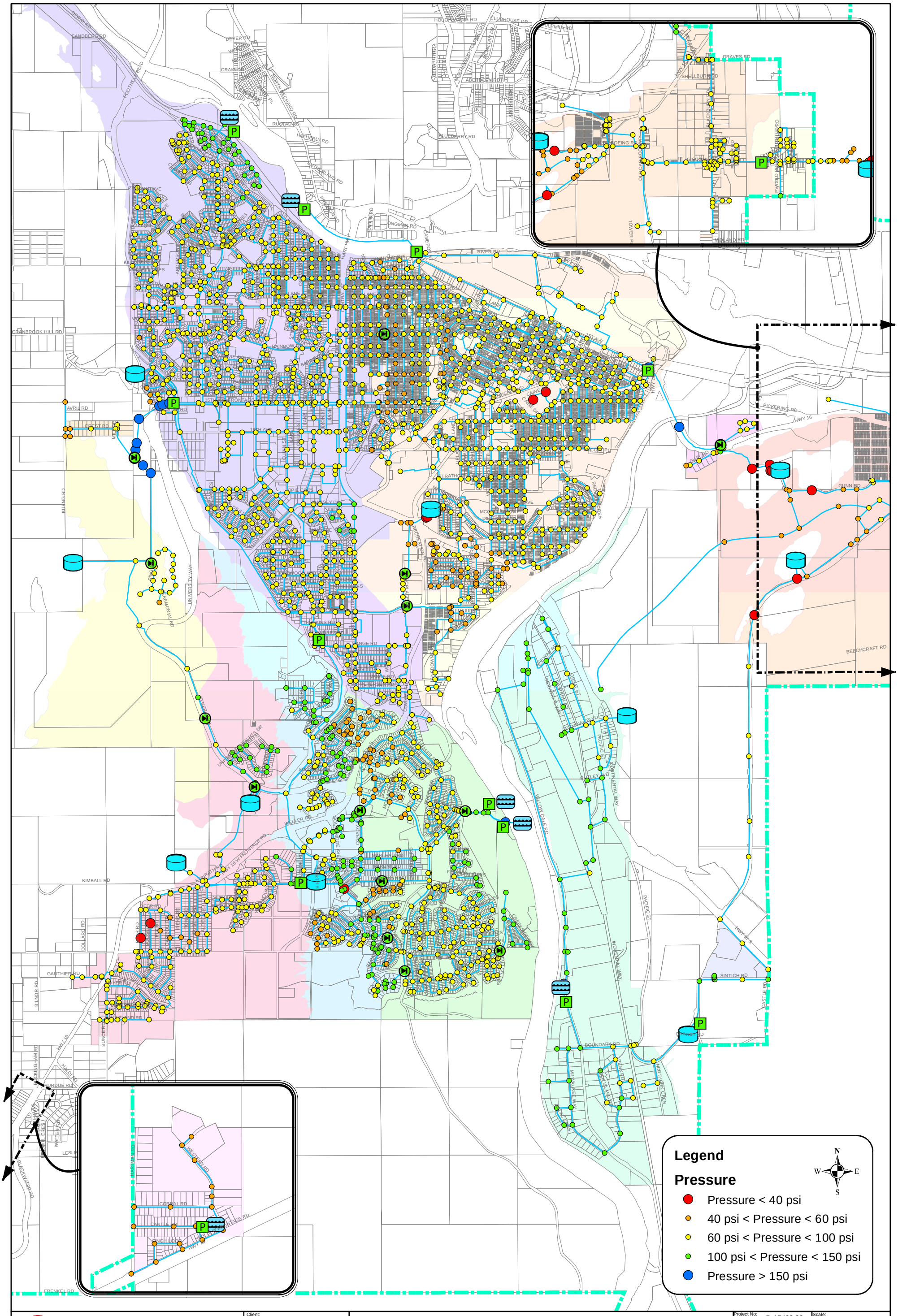
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South Model
Average Day Pressures - Short Term Condition

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South Model
Average Day Pressures - Long Term Condition

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7.6.3.2 Peak Hour Demand

The minimum pressures within each zone occur at the property at the highest elevation compared to the HGL of the zone set either by a Reservoir, PRV or Pump. Table 7-17 summarizes the number of nodes which currently have pressures below 40 psi.

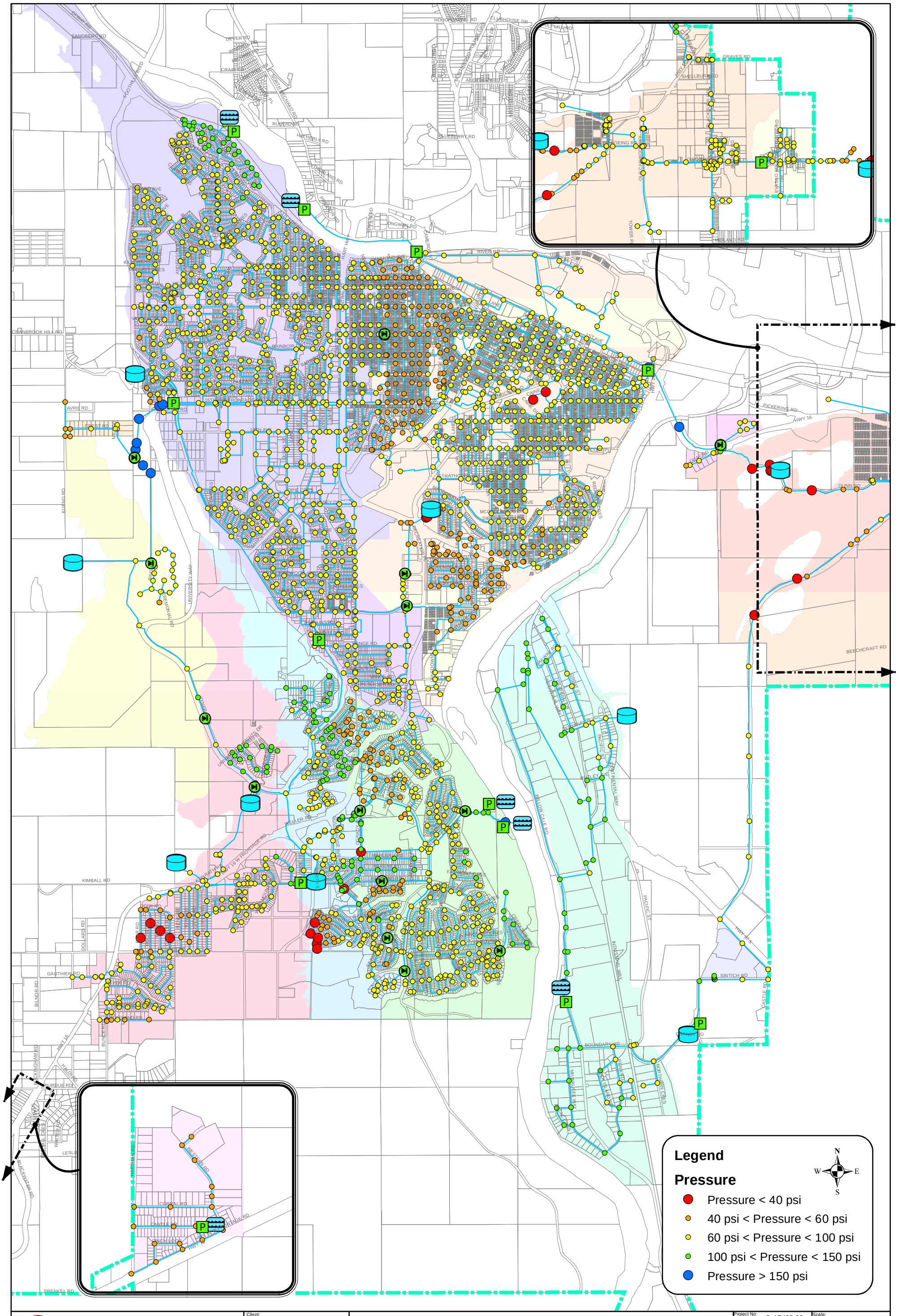
Table 7-17 South Model Peak Hour Pressures

Zone	# Nodes below the Minimum Allowable Pressure		
	Existing	Short Term	Long Term
01	4	4	24
03	2	2	2
04	5	7	12
06	4	4	5
22	7	7	7
TOTAL	**22**	**24**	**50**

Pressures do not meet minimum requirements in Pressure Zones 01, 03, 04, 06 and 22. Figure 7-6, Figure 7-7, and Figure 7-8 illustrate the locations within the City of Prince George where pressures are less than 40 psi under existing, short term and long term conditions.

Existing conditions are acceptable, as only 22 out of 2417 nodes (0.9 %) have pressures lower than 40 psi. This carries forward to the short term and long term scenarios where only 24 (1.0%) and 50 (2.0%) nodes are deficient.

Under the long term scenario, deficiencies in Pressure Zone 01 occur along Freeman Street near the boundary with Pressure Zone 02 and just west of the Simon Fraser Bridge. Deficiencies in Pressure Zone 03 occur at O'Grady Rd, in Pressure Zone 04 along Grayshell Road and Eastview Street, and the deficiencies in Pressure Zone 06 occur in the higher portions of Bear Road, Moose Road, Elk Road, Cariboo Road and Irene Road. Meanwhile, low pressures also occur adjacent to the zone reservoirs in Pressure Zone 22.



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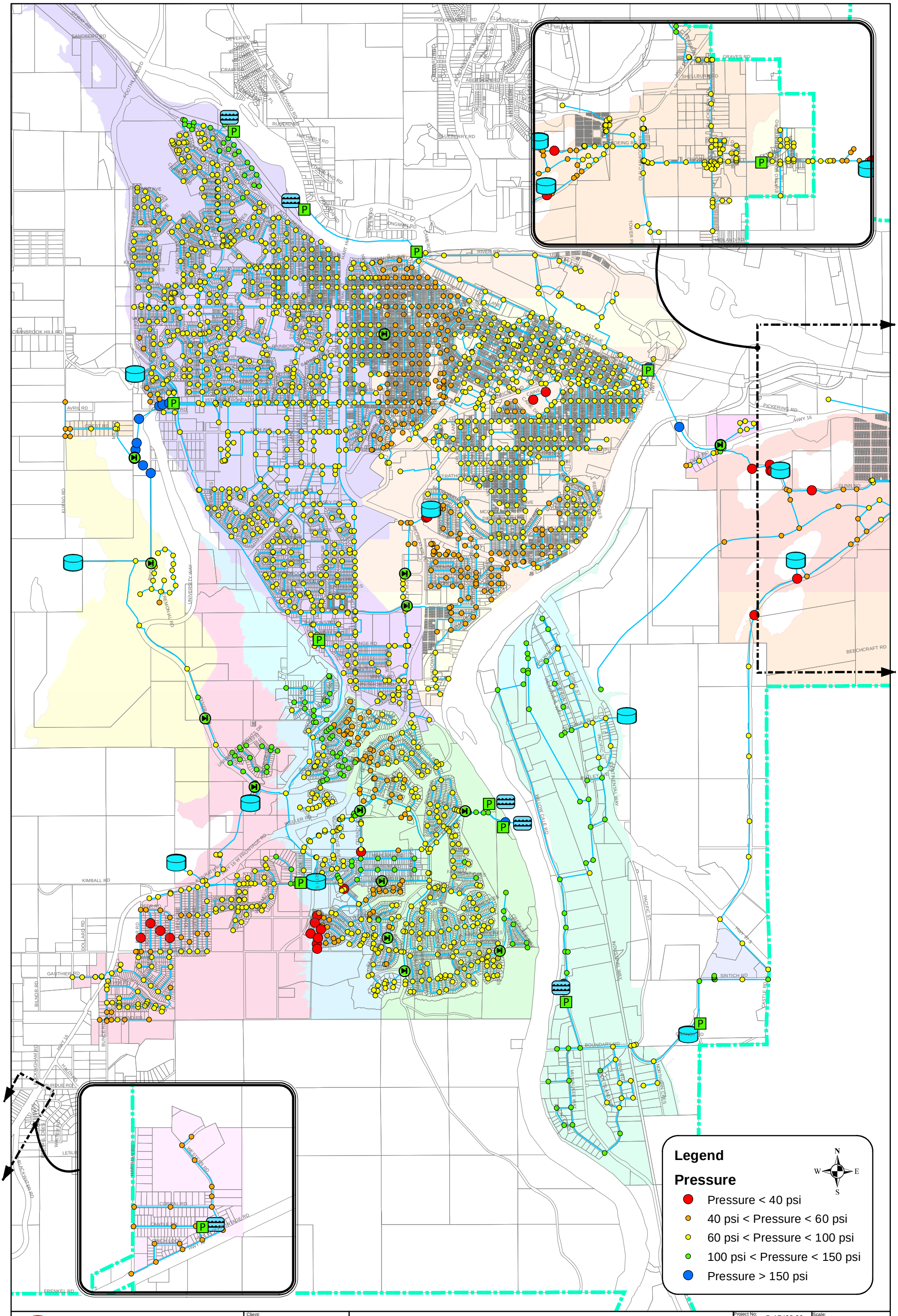
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South Model
Peak Hour Pressures under Existing Condition

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Figure 7-6	
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South Model
Peak Hour Pressures - Short Term Condition

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Legend

Pressure

- Pressure < 40 psi
- 40 psi < Pressure < 60 psi
- 60 psi < Pressure < 100 psi
- 100 psi < Pressure < 150 psi
- Pressure > 150 psi

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South Model
Peak Hour Pressures - Long Term Condition

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7.6.3.3 Maximum Day Demand plus Fire Flow

The results from the fire flow analysis are as summarized in Figure 7-9, Figure 7-10, and Figure 7-11 which illustrate the various ranges of fire flow requirements and availabilities throughout the system and identifies where deficiencies are occurring. Out of a total of 2300 nodes modeled, a substantial amount of fire flow deficiencies are currently occurring in the south model. While some of these deficiencies may be ignored as no fire hydrants exist at those locations, the City should still construct the water system to be able to provide the fire flows should fire hydrants be installed at locations where none are currently present.

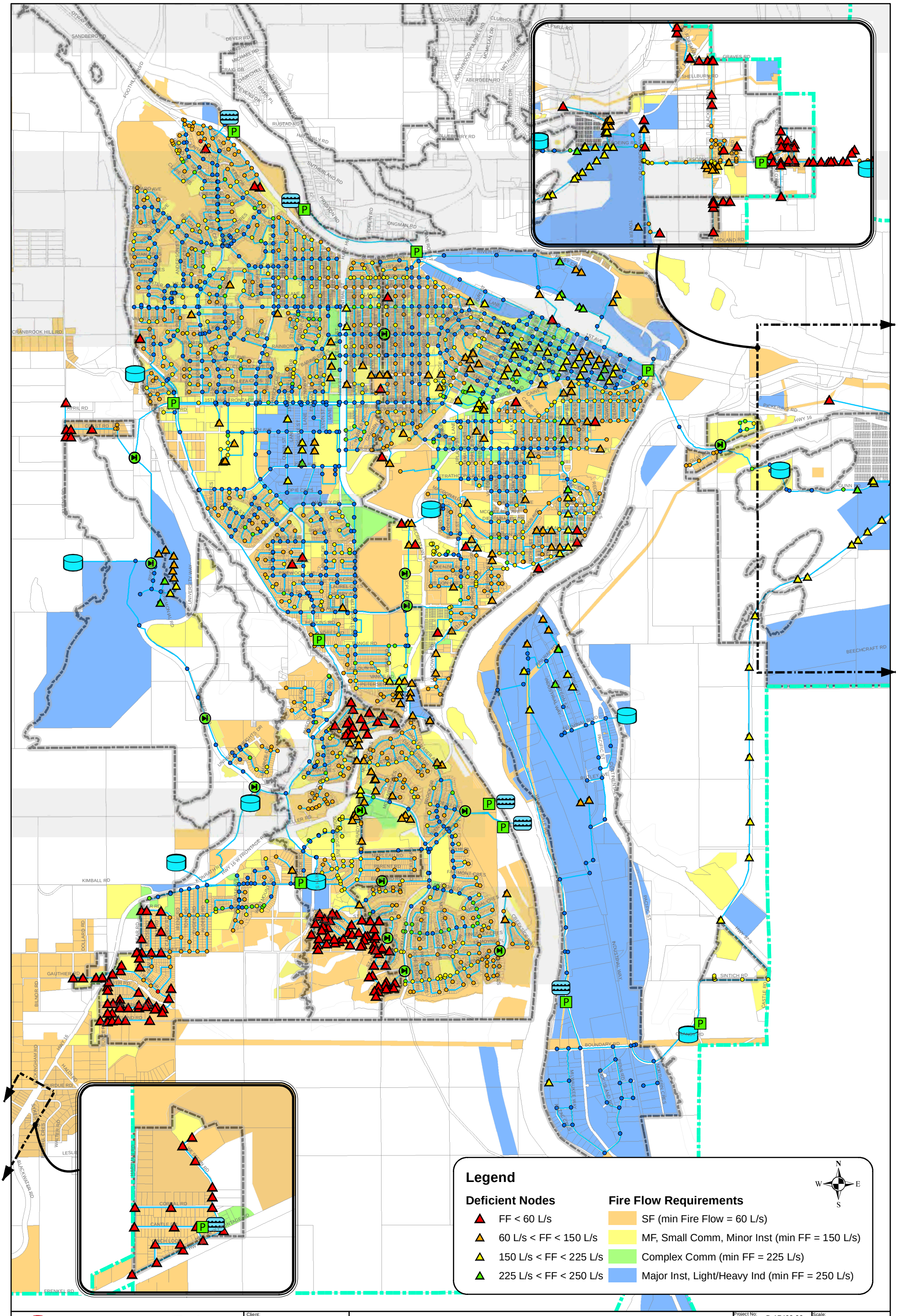
Results from the flow flow analysis coincident to maximum are broken down by land use as listed in Table 7-18.

Table 7-18 South Model Available Fire Flows

Land Use	Desired Fire Flow (L/s)	# Nodes with less than the Desired Fire Flow		
		Existing	Short Term	Long Term
Single Family Residential	60	203	215	244
Multi-Family Residential, Small Institutional, Small Commercial	150	100	113	146
Complex Commercial	225	48	56	65
Major Institutional, Light Industrial, Heavy Industrial	250	111	86	89
TOTAL		**462**	**470**	**544**

The number of nodes unable to achieve the required residual pressures at the desired fire flows totals 462-544 (20-24 % of the system nodes). Many areas where the desired fire flow levels cannot be achieved are at either dead ends in the system, or along undersized watermains within the water network.

Recommendations made at the end of this report are able to reduce fire flow deficiencies from a total of 462 under the existing condition to less than 244.



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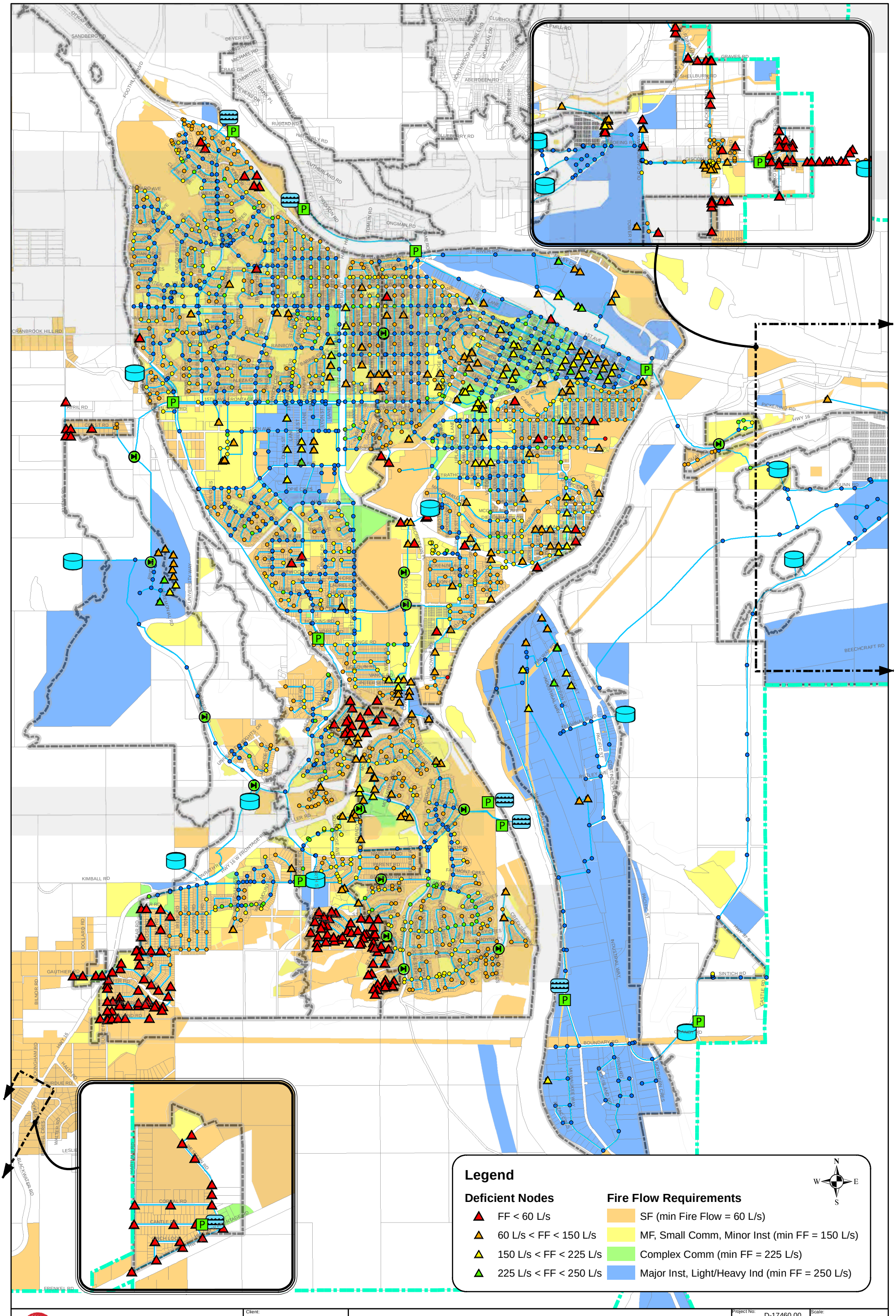
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South Model
Available Fire Flows under Existing Condition

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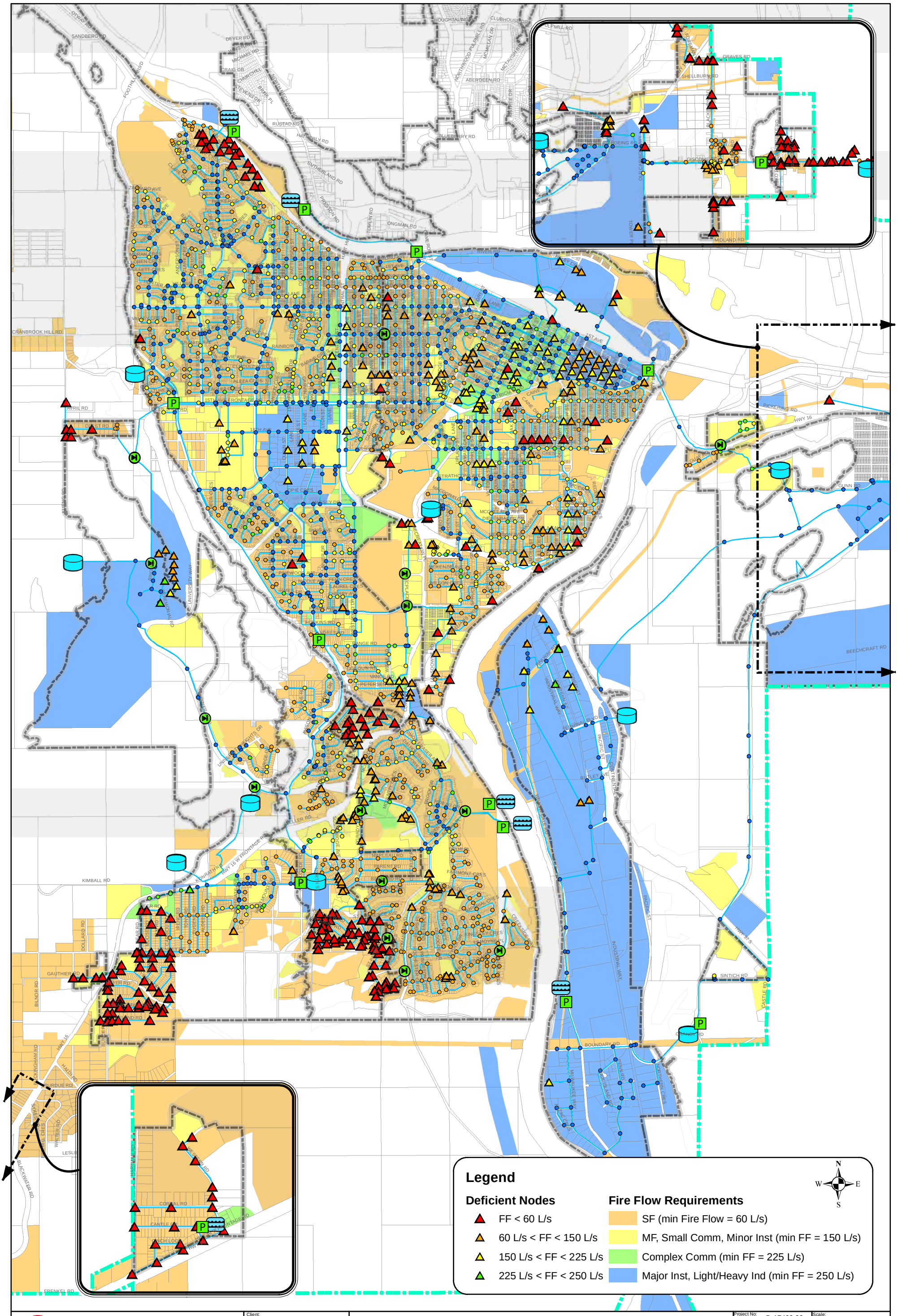
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South Model
Available Fire Flows - Short Term Condition

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South Model
Available Fire Flows - Long Term Condition

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Figure	7-11
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Path: G:\opus_dk\municipal\174 Prince George\gis\D-174.60 Water Service Network Plan Update\Figure 7-11 - South Model Long Term FF.mxd

7.6.4 Distribution System Recommendations

The recommendations presented in this section are limited to the main distribution system and generally do not directly address dead ends in the system. Improvements for fire flow servicing to dead ends should be addressed on a case-by-case basis, especially as there are opportunities in the future to have required watermain upgrades borne by developers wanting to connect to the existing water system.

Table 7-19 summarizes the recommended upgrade works to overcome the existing deficiencies. These recommendations are chosen to reduce the most fire flow deficiencies with as little construction as possible.

Table 7-19 Distribution System Upgrade Recommendations

Item	Proposed Work	Deficiency Resolved	Scenario
W-01-1	Construct 300m of 250mm watermain from Ospika Blvd N to King Dr	Fire Flows	Existing
W-01-2	Construct 80m of 250mm watermain to connect Petersen Road to Hollandia Place	Fire Flows	Existing
W-02-1	Construct a new PRV station at intersection of 20th Ave and Griffiths Ave	Fire Flows	Existing
W-02-2	Increase the downstream setting of PRV PW-641 from 35 psi (25 m) to 54 psi (38 m)	Fire Flows	Existing
W-02-3	Construct 430m of 300mm watermain along Ontario Street from 1st Ave to 5th Ave	Fire Flows	Existing
W-02-4	Construct 350m of 300mm watermain along Ottawa Street from 1st Ave to 4th Ave	Fire Flows	Existing
W-02-5	Construct 150m of 250mm watermain along Patricia Blvd from Queensway to Ingledew Street	Fire Flows	Existing
W-02-6	Construct 1,990m of 350mm watermain on Hwy 97 from Hwy 16 to existing stub	Fire Flows	Existing
W-02-7	Construct 700m of 250mm watermain from Hwy 97 to Jasper Street	Fire Flows	Existing
W-02-8	Construct Pump/PRV station to connect Zone 1 to Zone 15	Fire Flows	Existing
W-03-1A	Construct 400m of 300mm watermain from McGill Crescent to Cowart Road	Fire Flows	Existing
W-03-1B	Construct 675m of 300mm watermain along Cowart Road north from Simon Fraser Ave	Fire Flows	Existing
W-03-1C	Close watermain crossing Hwy16	Fire Flows	Existing
W-04-1	Construct 500m of 300mm watermain to connect Vista View Road to the Zone 4 Reservoir	Fire Flows & PH Pressures	Existing
W-04-2	Construct 120m of 250mm watermain to connect Marleau Road to O'Grady Road	Fire Flows	Existing

Item	Proposed Work	Deficiency Resolved	Scenario
W-04-3A	Construct PRV station at intersection of Baker Rd and Davis Dr	Fire Flows	Existing
W-04-3B	Construct PRV station at intersection of Wheeler Road and Hwy 16	Fire Flows	Existing
W-04-3C	Close watermain crossing Hwy16 at Eton Avenue	Fire Flows	Existing
W-06-1	Construct 140m of 200mm watermain to connect Westmount Drive to Hillcrest Road	Fire Flows	Existing
W-06-2	Construct 220m of 300mm watermain on Bear Rd	Fire Flows	Existing
W-06-3	Construct 500m of 200mm watermain on Henry Rd	Fire Flows	Existing
W-07-1	Construct 160 metres of 250mm watermain	Fire Flows	Existing
W-07-2	Increase D/S pressure setting at the Crest PRV (PW-622) from 91 psi (64 m) to 121 psi (85 m)	Fire Flows	Existing
W-22-1	Construct a new PRV station at the intersection of Sintich Road to connect Pressure Zone 22 with Pressure Zone 15	Fire Flows	Existing

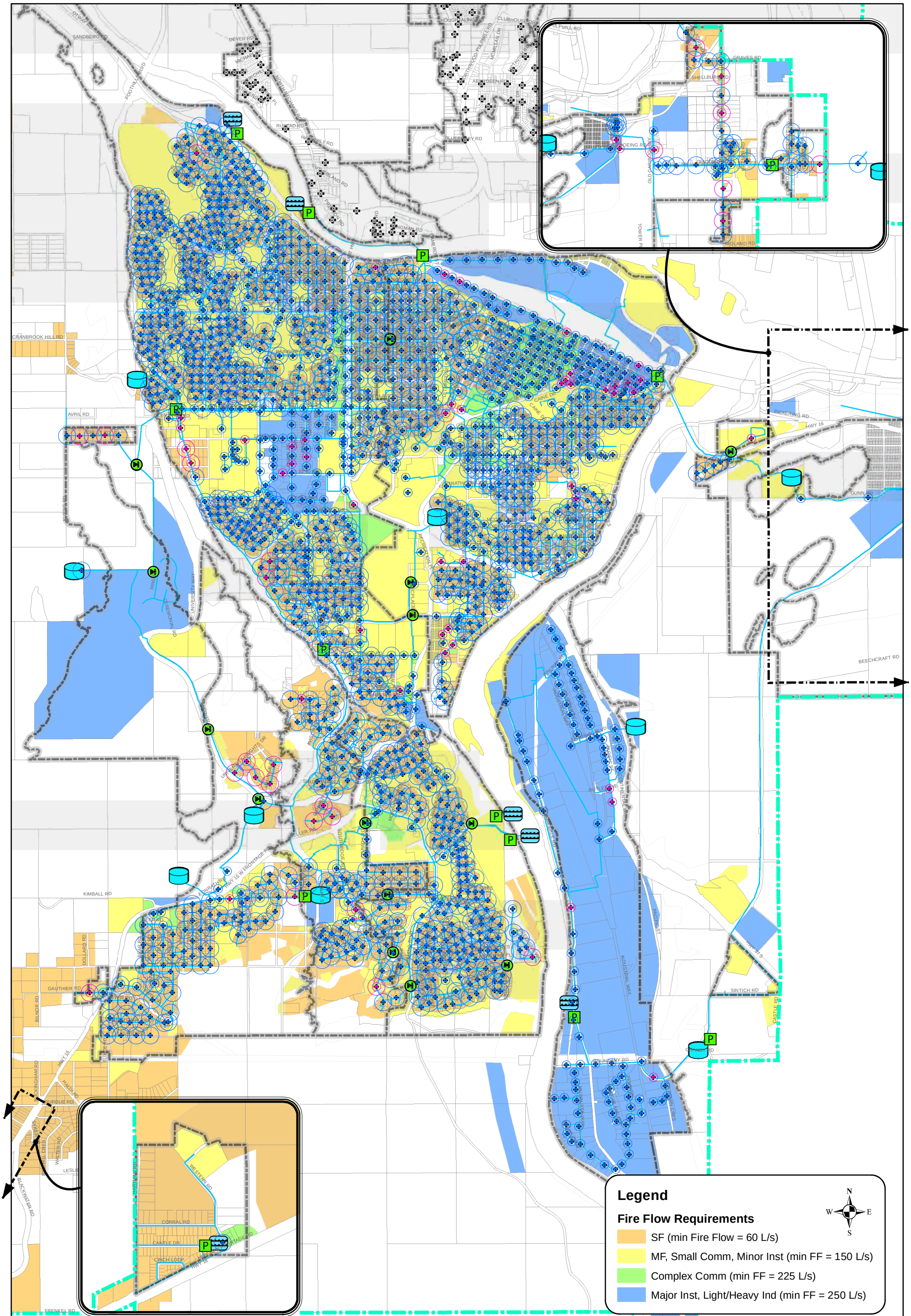
7.7 Hydrant Coverage Analysis

A mapping of the City's existing fire hydrants was carried out to determine the area of influence and coverage of existing hydrants. The City currently operates 1,643 fire hydrants in the South water system. Figure 7-12 illustrates the existing hydrant coverage mapping and identifies areas where coverage is deficient through recommended locations of new hydrants. Coverage for hydrants is illustrated in two circles as required for every hydrant, a smaller circle representing a 100m diameter coverage (which indicates the ICI servicing distance), and a larger circle representing a 200m diameter coverage (which indicates the residential servicing distance).

An analysis for future hydrant coverage requirements under the short term and long term scenarios was not carried out for the purposes of this report. Future hydrant servicing requirements should be made on a case-by-case basis in the course of the watermain construction approval processes for new developments as they occur in the City of Prince George.

7.7.1 Recommendations

73 additional hydrants are recommended for the City's South water system as illustrated in Figure 7-12. A further study with the local fire department should be conducted to prioritize the need for these hydrants.



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South Model
Hydrant Coverage Analysis

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8 North Water System Analysis

This section of the report covers the hydraulic analysis of the existing North water system under the existing, short term and long term demand conditions. The objective of the analysis is to assess the system's performance with respect to compliance with the level of service outlined in Section 6 and to highlight existing deficiencies in the system and appropriate upgrading options to address existing, short and long term deficiencies.

Analysis covered in this section includes a review of the capacity of the source supplies, an assessment of the available storage and pumping capacities, a review of the operation of the existing PRVs, and the available system pressures and fire flows in the distribution system.

8.1 Source Supply Capacity

In the North water system, water is supplied primarily from the Fishtrap Collector Well (PW-660). Raw water is pumped from the Fishtrap Well and treated with a disinfectant (sodium hypochlorite) and fluoridated prior to entering the distribution system. Raw water may also be supplied from the North Nechako well (PW-607), which is currently operating offline but acts as a backup/emergency supply for the system. Table 8-1 summarizes the source capacity of the existing Fishtrap Collector Well.

Table 8-1 Existing Supply Wells

Well	Available Capacity (Mgpd)	Available Capacity (L/s)
Fishtrap (PW-660)	24.6	1,078

The long term maximum day demand in the North water system was calculated at 312.4 L/s in Section 3. There are currently no concerns with the supply capacities or the treatment of the source waters even for long term buildout of the North water system. No source capacity improvements are recommended.

8.2 Storage Reservoirs

This section provides an assessment on the existing storage capacities of the City's reservoirs to determine if they meet existing, short term and long term storage requirements. The minimum fire storage required is governed by the highest fire demand required within the zone. The balancing, fire, and emergency storage volumes have been calculated based on the design criteria noted in Sections 6.3 and 6.4. Only the City owned reservoirs were analyzed, privately owned storage tanks were excluded from the analysis.

8.2.1 Existing Reservoir Capacity

Table 8-2 summarizes the each of the storage reservoirs and their associated volumes in the North water system.

Table 8-2 Existing Reservoir Contributions

Pressure Zone	Reservoir	Volume (ML)
PZ 08	832	2.73
PZ 09	810	4.55
PZ 10	-	-
PZ 11	817 & 860	9.09
PZ 12	-	-
PZ 13	-	-

While reservoirs are designed to meet the demands of the pressure zone it serves, reservoir volumes may cascade into lower pressure zones or be pumped into higher pressure zones to meet storage volume deficiencies during fire flow demand. Those pressure zones without storage reservoirs require supply from adjacent zones to meet the fire flow demand. Those pressure zones are:

- Storage to service fire flow volumes in Pressure Zone 10 is supplied from cascading water from the reservoir in Pressure Zone 11;
- Pressure Zone 12 may be serviced through pumping of storage volumes from Pressure Zone 11; and,
- Pressure Zone 13 may be serviced through pumping of storage volumes from Pressure Zone 09.

8.2.2 Existing Storage Capacity Assessment

Table 8-3 illustrates the components that contribute to the storage capacity requirements and compares that value to the existing available storage in each pressure zone under the existing demand conditions.

Table 8-3 Existing Storage Capacity Analysis

Zone	A - Fire Storage (ML)	B - Equalization Storage (ML)	C- Emergency Storage (ML)	Required Storage A+B+C (ML)	Available Storage (ML)	Excess (ML)	Deficient?
PZ 08	3.15	0.43	0.90	4.48	2.73	**-1.75**	Yes
PZ 09	3.15	0.57	0.93	4.64	4.55	**-0.10**	Yes
PZ 10	0.32	0.14	0.12	0.58	-	**-0.58**	Yes
PZ 11	1.08	1.96	0.76	3.80	9.09	**5.29**	No
PZ 12	0.32	0.29	0.15	0.77	-	**-0.77**	Yes
PZ 13	0.32	0.01	0.08	0.42	-	**-0.42**	Yes

The above analysis shows that there is a storage volume deficiency currently in the pressure zones supplied by all reservoirs except for Pressure Zone 11. The City is currently able to address fire flow deficient volumes in Pressure Zones 08, 09 and 10 by cascading water through PRVs to utilize the excess storage volumes from Pressure Zone 11, PW-817 & PW-860 (9.09 – 1.96 = 7.13 ML). Fire flow

volume deficiencies in Pressure Zones 12 and 13 can be addressed by pumping water to utilize the excess storage volumes from Pressure Zone 11 as well. Therefore, no new reservoirs are required at this time.

8.2.3 Short Term Storage Capacity Assessment

Table 8-4 illustrates the components that contribute to the storage capacity requirements and compares that value to the existing available storage in each pressure zone under the short term demand conditions.

Table 8-4 Short Term Storage Capacity Analysis

Zone	A - Fire Storage (ML)	B - Equalization Storage (ML)	C- Emergency Storage (ML)	Required Storage A+B+C (ML)	Available Storage (ML)	Excess (ML)	Deficient?
PZ 08	3.15	0.45	0.90	4.50	2.73	**-1.77**	Yes
PZ 09	3.15	0.64	0.95	4.74	4.55	**-0.20**	Yes
PZ 10	0.32	0.18	0.13	0.62	-	**-0.62**	Yes
PZ 11	1.08	2.68	0.94	4.69	9.09	**4.40**	No
PZ 12	0.32	0.30	0.16	0.78	-	**-0.78**	Yes
PZ 13	0.32	0.01	0.08	0.42	-	**-0.42**	Yes

Under the short term condition, there remains a storage volume deficiency in the pressure zones supplied by all reservoirs except for Pressure Zone 11. Again, the City would be able to address fire flow deficient volumes in Pressure Zones 08, 09 and 10 by cascading water through PRVs to utilize the excess storage volumes from Pressure Zone 11, PW-817 & PW-860 (9.09 – 2.68 = 6.41 ML). Fire flow volume deficiencies in Pressure Zones 12 and 13 can be addressed by pumping water to utilize the excess storage volumes from Pressure Zone 11 as well. No new reservoirs are required.

8.2.4 Long Term Storage Capacity Assessment

Table 8-5 illustrates the components that contribute to the storage capacity requirements and compares that value to the existing available storage in each pressure zone under the long term demand conditions.

Table 8-5 Long Term Storage Capacity Analysis

Zone	A - Fire Storage (ML)	B - Equalization Storage (ML)	C- Emergency Storage (ML)	Required Storage A+B+C (ML)	Available Storage (ML)	Excess (ML)	Deficient?
PZ 08	3.15	0.47	0.91	4.53	2.73	**-1.80**	Yes
PZ 09	3.15	0.82	0.99	4.96	4.55	**-0.41**	Yes
PZ 10	0.32	0.22	0.14	0.68	-	**-0.68**	Yes
PZ 11	1.08	4.84	1.48	7.39	9.09	**1.70**	No
PZ 12	0.32	0.37	0.17	0.86	-	**-0.86**	Yes

Zone	A - Fire Storage (ML)	B - Equalization Storage (ML)	C- Emergency Storage (ML)	Required Storage A+B+C (ML)	Available Storage (ML)	Excess (ML)	Deficient?
PZ 13	0.32	0.02	0.09	0.43	-	**-0.43**	Yes

Under the long term condition, there still remains the storage volume deficiency in the pressure zones supplied by all reservoirs except for Pressure Zone 11. Again, the City would be able to address fire flow deficient volumes in Pressure Zones 08, 09 and 10 by cascading water through PRVs to utilize the excess storage volumes from Pressure Zone 11, PW-817 & PW-860 (9.09 – 4.84 = 4.25 ML). Fire flow volume deficiencies in Pressure Zones 12 and 13 can be addressed by pumping water to utilize the excess storage volumes from Pressure Zone 11 as well. No new reservoirs are required.

8.2.5 Summary and Recommendations

Upon review of the storage capacity analysis for the existing, short term and long term conditions, it was found that current reservoirs volumes would be sufficient to address shortages in fire flow volumes for the North part of the City under all scenarios reviewed.

The recently constructed Foothills Reservoir enables the City to address the anticipated growth (10,559 to 21,183 persons) in the North water system and carry forward to the long term scenario with no reservoir upgrades.

8.3 Pump Stations

This section provides an assessment on the existing capacities of the City's pump stations to determine if they are able to service the maximum day demands within each of the City's pressure zones under the existing, short term and long term scenarios. Only the City owned pump stations were analyzed, privately owned pump stations were excluded from the analysis.

8.3.1 Existing Pumping Capacity

Design flows for all pumps were estimated based on the modeled pump curves. The design capacity of a pump station is the combined design flow of all the pumps minus the largest pump. Table 8-6 summarizes the capacity at each of the City's pump stations.

Table 8-6 Existing Pump Capacities

Pump Station	Pump ID	Rated Capacity (L/s)	Design Capacity (L/s)
615	615-1	10.7	20
	615-2	10.7	
	615-3	9.3	
619	619-1	2.0	2
	619-2	2.0	

Pump Station	Pump ID	Rated Capacity (L/s)	Design Capacity (L/s)
650	650-1	135	270
	650-2	135	
	650-3	135	
660	660-1	360	360
	660-2	360	

For pump stations that supply water to pressure zones with storage reservoirs, the pump stations are assessed based on their capability in meeting the maximum day demand of the pressure zone. For those that pumped to dead end systems, such as PW-615 and PW-619, the pumps are assessed based on their capability to meet peak hour demand.

8.3.2 Existing Pump Capacity Assessment

Table 8-7 summarizes the service areas associated with each of the pump stations and compares the required pump capacity to the existing available pump capacity under the existing demand conditions.

Table 8-7 Existing Pump Capacity Analysis

Pump Station	Service Area	Capacity Required[1] (L/s)	Design Capacity (L/s)	Excess (L/s)	Deficient?
615	PZ 12	21.6	20.0	**-1.6**	Yes
619	PZ 13	0.9	2.0	**1.1**	No
650	PZ 08, 09, 10, 11, 12, 13	157.4	270	**112.6**	No
660	PZ 08, 09, 10, 11, 12, 13	157.4	360	**202.6**	No

1 peak hour capacity assessed for PW-615 and PW-619

The above analysis shows that there is currently one pumping capacity deficiency in the North water system. The current pumps at the Vellencher Pump Station (PW-615) are unable to meet the peak hour demand requirements of Pressure Zone 12. Pumping improvements are required at PW-615.

8.3.3 Short Term Pump Capacity Assessment

Table 8-8 summarizes the service areas associated with each of the pump stations and compares the required pump capacity to the existing available pump capacity under the short term demand conditions.

Table 8-8 Short Term Pump Capacity Analysis

Pump Station	Service Area	Capacity Required[1] (L/s)	Design Capacity (L/s)	Excess (L/s)	Deficient?
615	PZ 12	22.9	20.0	**-2.9**	Yes
619	PZ 13	1.0	2.0	**1.0**	No

Pump Station	Service Area	Capacity Required[1] (L/s)	Design Capacity (L/s)	Excess (L/s)	Deficient?
650	PZ 08, 09, 10, 11, 12, 13	196.9	270	**73.1**	No
660	PZ 08, 09, 10, 11, 12, 13	196.9	360	**163.1**	No

1 peak hour capacity assessed for PW-615 and PW-619

Under the short term condition, there is still only one pumping capacity deficiency in the North water system. The pumps at the Vellencher Pump Station (PW-615) would be unable to meet the peak hour demand requirements of Pressure Zone 12. Again, pumping improvements are required at PW-615.

8.3.4 Long Term Pump Capacity Assessment

Table 8-9 summarizes the service areas associated with each of the pump stations and compares the required pump capacity to the existing available pump capacity under the long term demand conditions.

Table 8-9 Long Term Pump Capacity Analysis

Pump Station	Service Area	Capacity Required[1] (L/s)	Design Capacity (L/s)	Excess (L/s)	Deficient?
615	PZ 12	27.9	20.0	**-7.9**	Yes
619	PZ 13	1.2	2.0	**0.8**	No
650	PZ 08, 09, 10, 11, 12, 13	311.4	270	**-41.4**	Yes
660	PZ 08, 09, 10, 11, 12, 13	311.4	360	**48.6**	No

1 peak hour capacity assessed for PW-615 and PW-619

Under the long term condition, there is a pumping capacity deficiency at the Vellencher Pump Station (PW-615) and the Foothills Pump Station (PW-650). PW-615 would have to be improved from 20 L/s to 28 L/s and PW-650 would have to be improved from 270 L/s to 312 L/s.

8.3.5 Summary and Recommendations

Upon review of the pumping capacity analysis for the existing, short term and long term conditions, it was found that current pump capacities are insufficient to supply maximum day demand flows and refill system reservoirs for the North water system as summarized below.

Table 8-10 Pump Capacity Deficiencies

Pump Station	Existing Deficiency	Capacity Required (L/s)	Short Term Deficiency	Capacity Required (L/s)	Long Term Deficiency	Capacity Required (L/s)
615	✓	1.6	✓	2.9	✓	7.9
650					✓	41.4

The Vellencher (PW-615) and Inverness (PW-619) Pump Stations currently pump into dead end systems and are designed to supply the peak hour demand of the system they are servicing. Upgrades are required at the PW-615 to meet the peak hour demand.

Also, Pressure Zones 12 and 13 have insufficient fire flow servicing from the existing pump stations and an additional fire pump would be required at both stations. The following table illustrates the fire pump sizing required under existing, short term and long term conditions.

Table 8-11 Fire Pump Sizing

Pump ID	FF Required (L/s)	Existing MDD (L/s)	Short Term MDD (L/s)	Long Term MDD (L/s)	Design Capacity (L/s)
615-Fire	150.0	13.5	13.9	17.0	167.0
619-Fire	150.0	0.6	0.6	0.7	151.0

Four pump station improvements are recommended for the North water system as follows:

Table 8-12 Pump Capacity Recommendations

Rec #	Pump ID	Total Capacity Required (Additional Capacity)	Approx. Head Required	Deficiency Addressed	MDD Trigger	Notes
P-8	615	28 L/s (8 L/s)	50 m	Existing	-	Meets PHD of PZ 12 (10HP)
P-9	615-Fire	167 L/s	50 m	Existing	-	Supplies FF to PZ 12 (150HP)
P-10	619-Fire	151 L/s	70 m	Existing	-	Supplies FF to PZ 13 (200HP)
P-11	650	312 L/s (42 L/s)	150 m	Long Term	270 L/s in system	(100HP)

8.4 PRV Station Review

PRV stations were reviewed based on the highest velocities predicted by the water model. Predicted flows and velocities were determined during peak hour demands. As a general guideline, the recommended peak velocity through the PRVs is 6.0 m/s during peak hour demand. Table 8-13 summarizes the predicted peak velocities under each condition.

Table 8-13 PRV Station Analysis

ID	PRV Station	Diameter (in.)	Existing PHD		Short Term PHD		Long Term PHD	
			Flow (L/s)	Velocity (m/s)	Flow (L/s)	Velocity (m/s)	Flow (L/s)	Velocity (m/s)
607	Meadowbrook	8”	10.9	0.6	11.2	0.6	12.4	0.7
609	Ongman	8”	0.7	0.02	0.7	0.02	1.0	0.03
		8”	0	0	0	0	0	0

ID	PRV Station	Diameter (in.)	Existing PHD		Short Term PHD		Long Term PHD	
			Flow (L/s)	Velocity (m/s)	Flow (L/s)	Velocity (m/s)	Flow (L/s)	Velocity (m/s)
611	Randle	6”	23.8	1.4	25.7	1.5	30.0	1.7
		3”	0	0	0	0	0	0
612	Cook	3”	0	0	0	0	9.2	2.1
		6”	0	0	0	0	0	0
617	Croft	2”	34.3	17.5	38.7	19.7	37.2	19.0
		4”	0	0	0	0	0	0
640	Knell	6”	0	0	0	0	0	0
		2”	0	0	0	0	0	0

The Croft lead PRV is currently identified as having velocities exceeding 6.0 m/s during the peak hour demand under the existing, short term and long term demand scenarios. Also, the Ongman lag (PW-609), Randle lag (PW-611), Cook lead and lag (PW-612), Croft lag (PW-617), and Knell lead and lag (PW-640) PRVs are modelled as closed during peak hour demand. This operation should be confirmed by the City’s operations department.

8.4.1 Recommendations

There is a concern with high velocities through the Croft (PW-617) PRV station. To address this issue, the City should either install a larger lead PRV at the Croft PRV station or the Croft lag PRV should be set at a higher setting to ensure it turns on to assist the lead PRV during peak hour demand.

8.5 Transmission and Distribution

A hydraulic analysis of the watermains was carried out using the updated InfoWater model.

8.5.1 Transmission Mains Analysis

A supply analysis reviewing the transmission mains in the system determines the system’s ability to fill its reservoirs in 24 hours during conditions of maximum day demand. This analysis aims to simulate the delivery of treated water from the water source over to system reservoirs and simulate the refilling the reservoirs during maximum day demand. This will determine if there is sufficient hydraulic capacity in the system to transport the source water to the system reservoirs.

The transmission main for the North water system runs along the western portion of the system and extends approximately 950 metres from the Fishtrap Collector Wells (PW-660) to the Foothills Reservoir (PW-860) and a further 1,700 metres to the Vellencher Reservoir (PW-817). The current transmission main is sized at 300 mm, has a shallow depth of bury along trucking roads and gravel trails in the North water system. The City has raised concerns of this pipe bursting due to site conditions and its overall criticality to the operation of the North water system.

Recommendations for improvements include replacement of the transmission main or the provision of a second transmission main to the North water system. To increase the reliability of the supply, the following three options were considered:

a. A transmission main could be constructed from the Cameron Pump Station (PW-602) to connect the South water system across the Nechako River to the North water system;
b. Twinning of the existing transmission main along the current alignment; and,
c. Twinning of the existing transmission main via Foothills Blvd and entering Pressure Zone 11 along Highland Drive.

Option 1 is not considered as the transmission main to bring water from the Cameron Pump Station (PW-602) to the Vellencher Reservoir (PW-817) would have to be 10 kilometres in length. The potential transmission main alignments for Options 2 and 3 are illustrated in Figure 8-1.

8.5.2 Transmission Main Recommendations

The potential alignment for a second transmission main (T-5) from the Foothills pump station (PW-650) to the Vellencher Reservoir (PW-817) is shown in Figure 8-1. This alignment has an added benefit of the addition of a PRV at Highland Drive which can be connected to areas of Pressure Zone 11 where there are currently low fire flows.

City staff have also noted that there is no check valve on the current transmission main installed. Construction of a check valve (T-6) at the Vellencher Reservoir to prevent backflow of water in case of a pump failure is also identified as an upgrade required.

Legend

- Source
- Reservoirs
- Pump Stations
- PRV Stations
- Hart/Nechako Watermains
- Southwest/Core Watermains
- Potential Alignment
- Alternate Alignment
- Other Future Potential Servicing Opportunities

N W E S

Transmission Upgrade T-6:
- install check valve on existing transmission main upstream of Vellencher Reservoir
- prevents backflow of water in PW-650

Alternate Alignment (T-5)
- 2,765m of 350mm watermain
- Twinning with existing watermain

Transmission Upgrade T-5:
- 3,450m of 400mm watermain
- potential for a new PRV station mid-way to Pressure Zone 11 at Highland Drive to provide improved fire flows

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North Model Transmission Upgrades

Project No:	D-17460.00
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Note:	
Figure	8-1
Scale:	0 125 250 Meters; 1:40,000 @ Tabloid
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Path: G:\opus_dk\municipal\174 Prince George\gis\D-174.60 Water Service Network Plan Update\Figure 8-1 - North Model Transmission Upgrades.mxd

8.5.3 Distribution System Analysis

Existing ADD, MDD, and PHD scenarios were simulated to review node pressures, available fire flows and pipe velocities throughout the system.

8.5.3.1 Average Day Demand

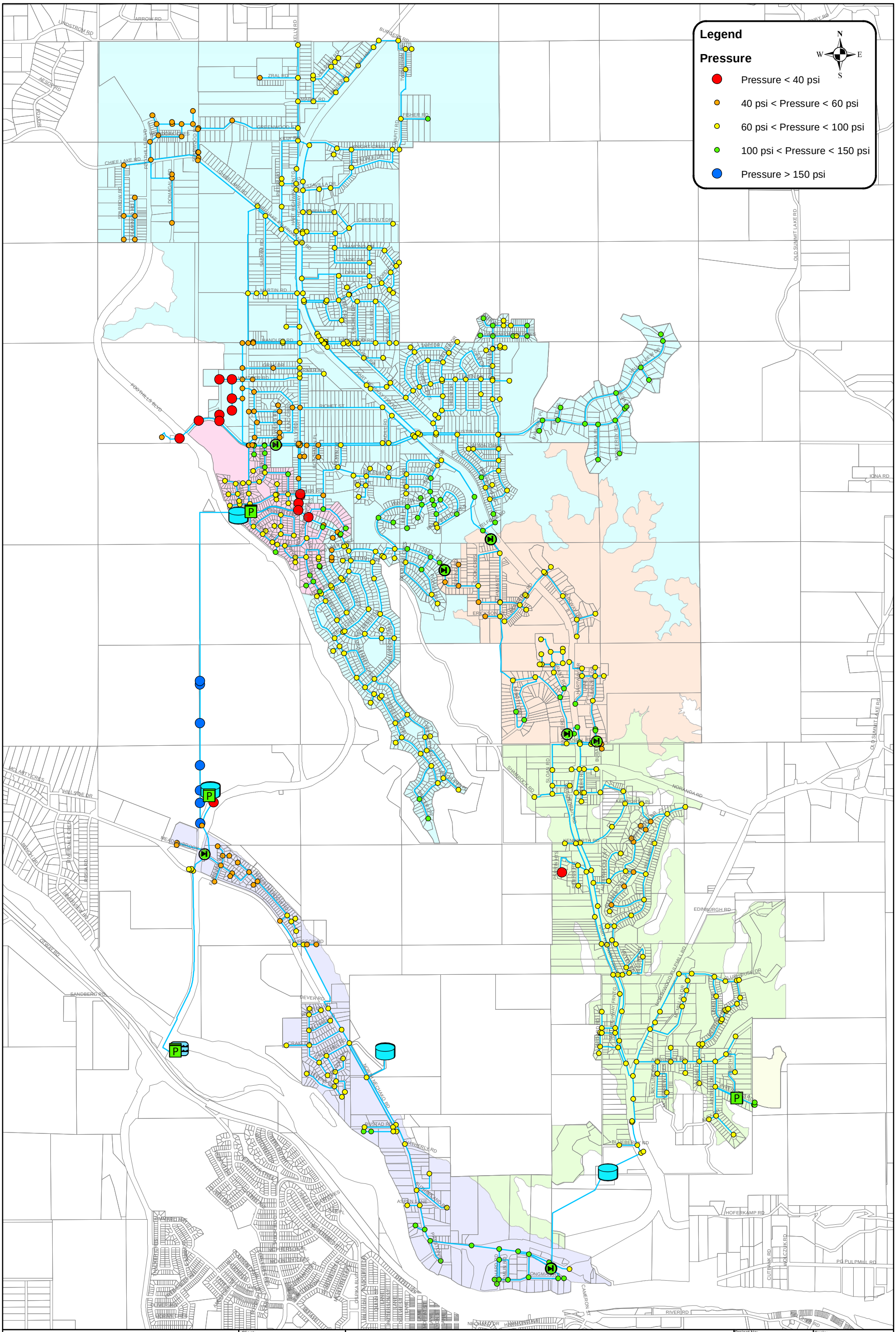
The maximum pressure within each zone occurs at the property at the lowest elevation compared to the HGL of the zone set either by a Reservoir, PRV or Pump. Table 8-14 summarizes the number of nodes which currently have pressures exceeding 150 psi.

Table 8-14 North Model Average Day Pressures

Zone	# Nodes above the Maximum Allowable Pressure		
	Existing	Short Term	Long Term
All Zones	7	7	7

There are 7 nodes with pressures above 150 psi in the model. However, all these high pressures occur in immediately downstream of pump stations and are within watermains where there are no properties connected off them.

In terms of high pressure at properties, the maximum allowable pressure is not exceeded under the existing, short term and long term scenarios. As illustrated in Figure 8-2, Figure 8-3, and Figure 8-4, there are no locations within the City of Prince George where pressures are more than 150 psi.



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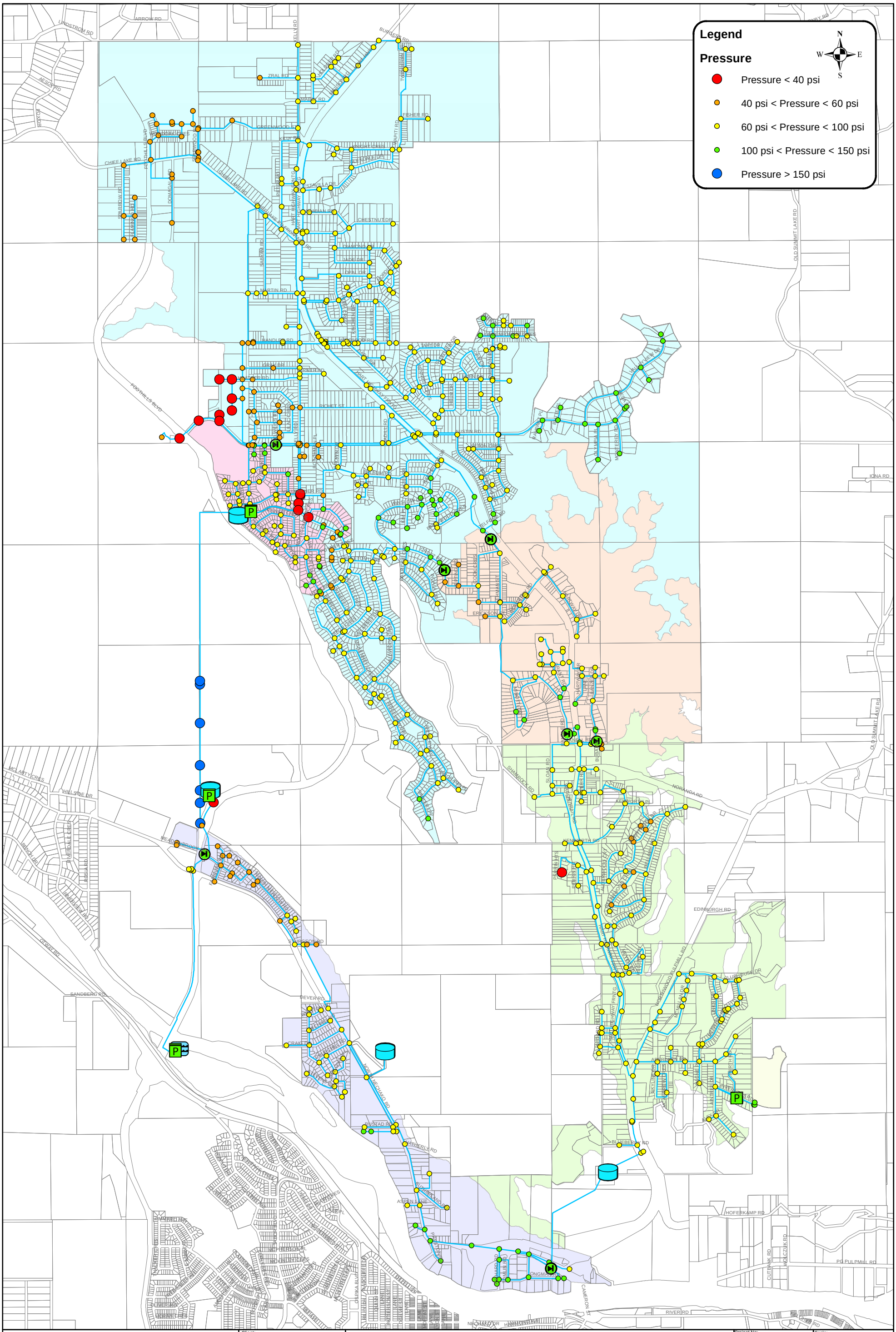
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North Model
Average Day Pressures under Existing Condition

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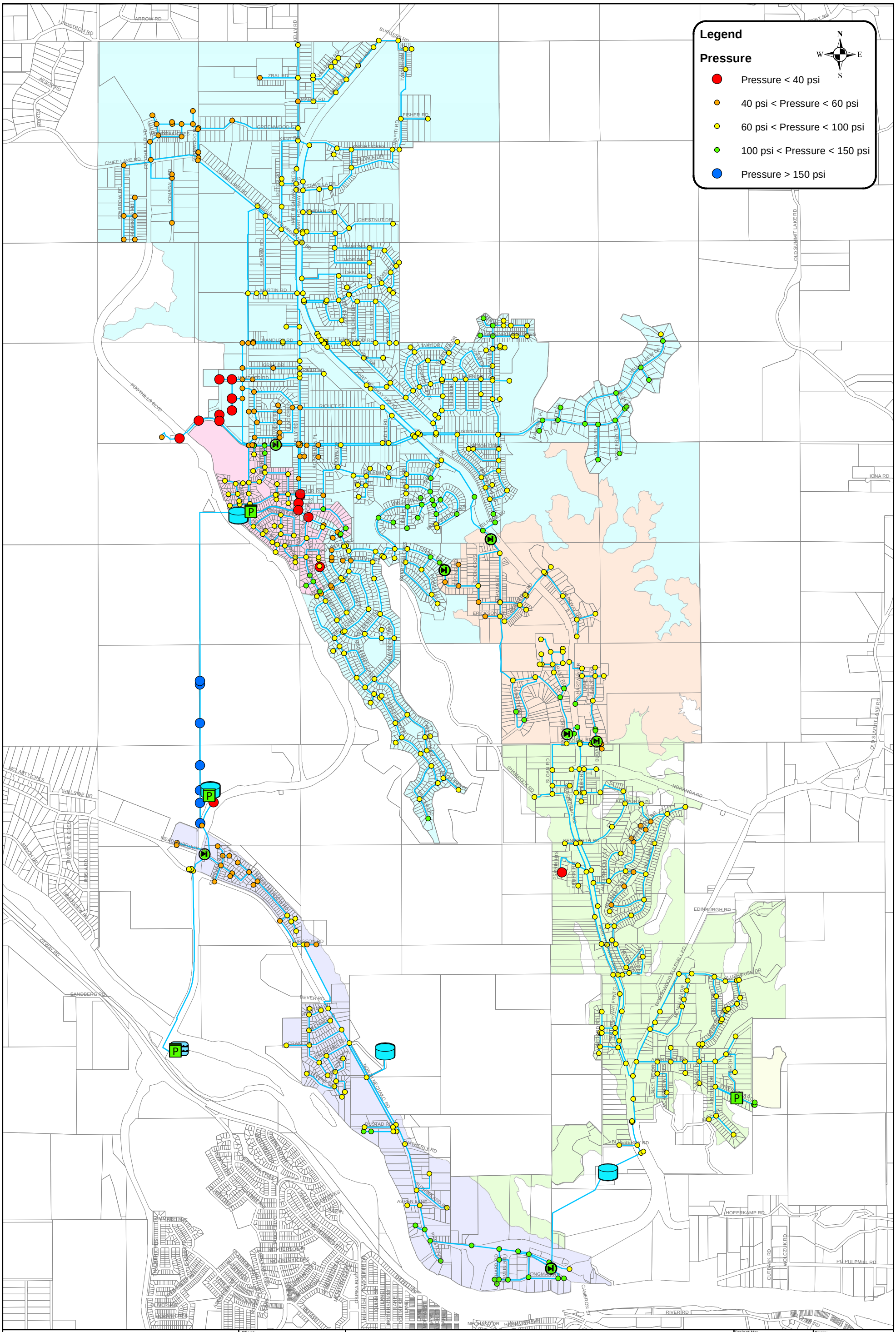
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North Model
Average Day Pressures - Short Term Condition

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North Model
Average Day Pressures - Long Term Condition

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8.5.3.2 Peak Hour Demand

The minimum pressures within each zone occur at the property at the highest elevation compared to the HGL of the zone set either by a Reservoir, PRV or Pump. Table 8-15 summarizes the number of nodes which currently have pressures below 40 psi.

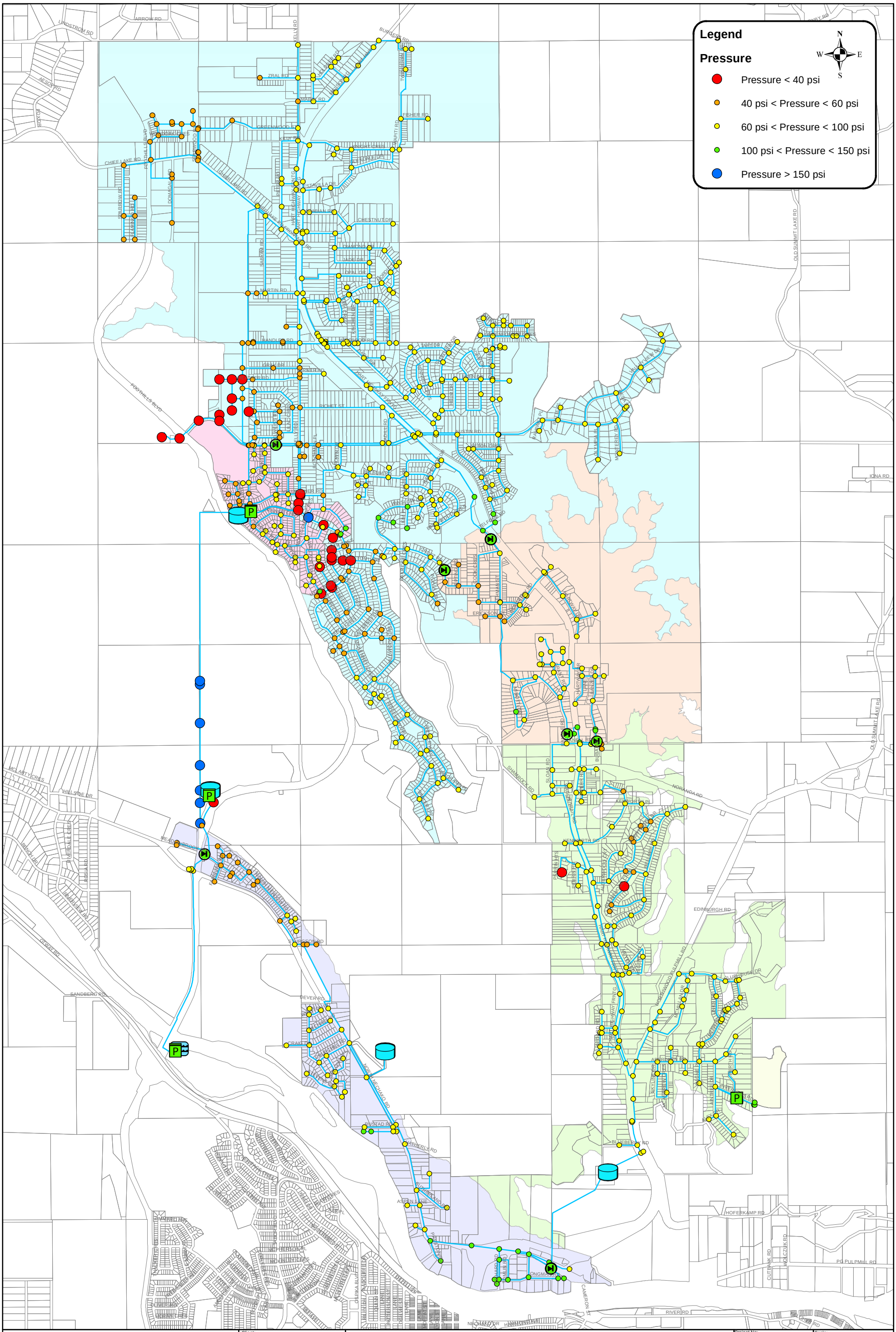
Table 8-15 North Model Peak Hour Pressures

Zone	# Nodes below the Minimum Allowable Pressure		
	Existing	Short Term	Long Term
09	2	2	3
11	24	38	123
TOTAL	**26**	**40**	**126**

Pressures do not meet minimum requirements in Pressure Zones 09 and 11. Figure 8-5, Figure 8-6, and Figure 8-7 illustrate the locations within the City of Prince George where pressures are less than 40 psi under existing, short term and long term conditions.

Existing conditions are acceptable, as only 26 out of 755 nodes (3.4 %) have pressures lower than 40 psi. However, when the short term and long term scenarios are reached, there are more deficiencies in the system, increasing to 40 (5.3%) and 126 (31.7%) nodes.

There are substantially more low pressure deficiencies in Pressure Zone 11. The deficiencies occur near the maximum servicing elevation of the zone. In this case the zone is serviced by a Reservoir, so the hydraulic grade cannot be increased to address the low pressures. Rather, substantial watermain upgrades are recommended to reduce headlosses in the distribution system as the water travels from the reservoir to the rest of the pressure zone.



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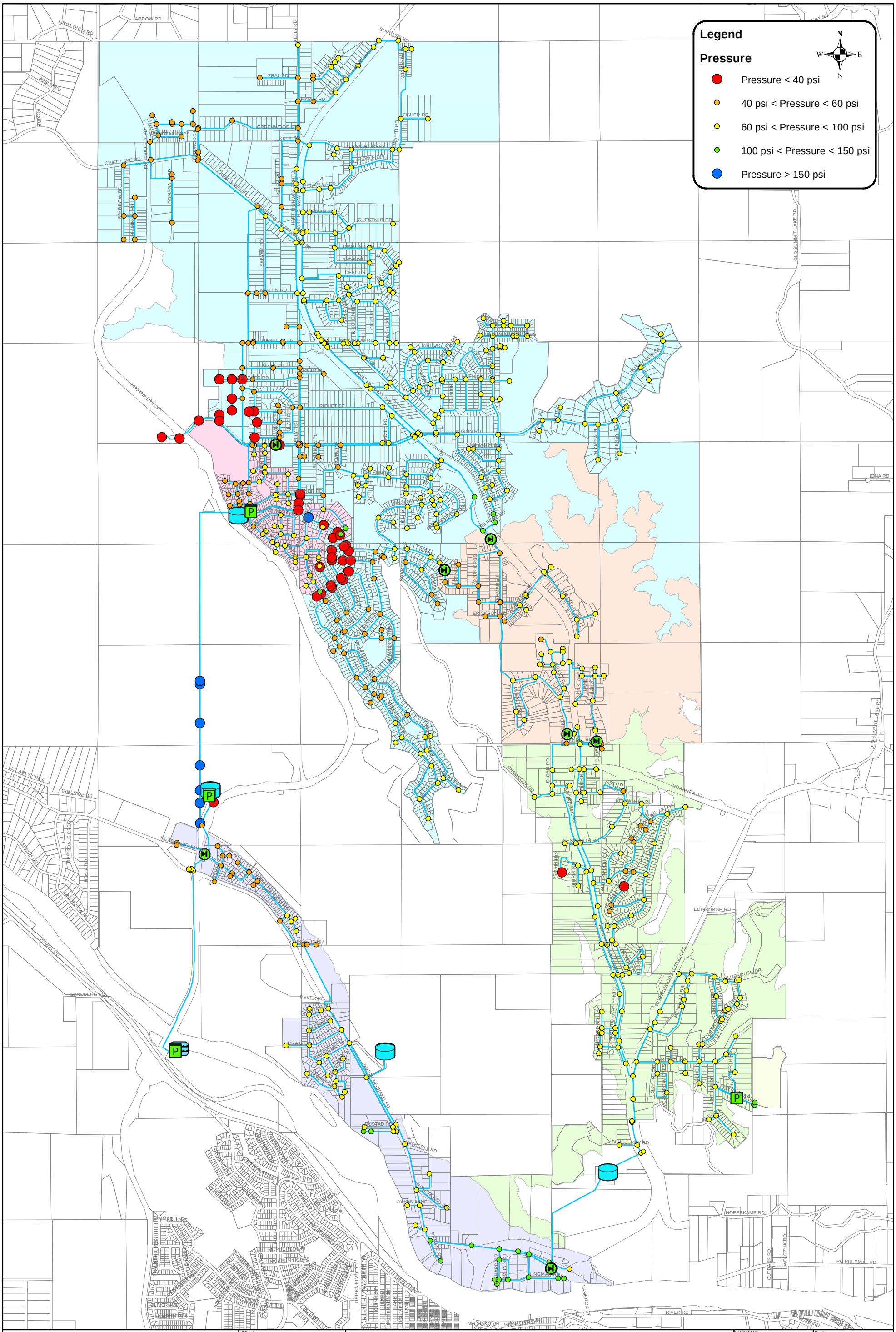
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North Model
Peak Hour Pressures under Existing Condition

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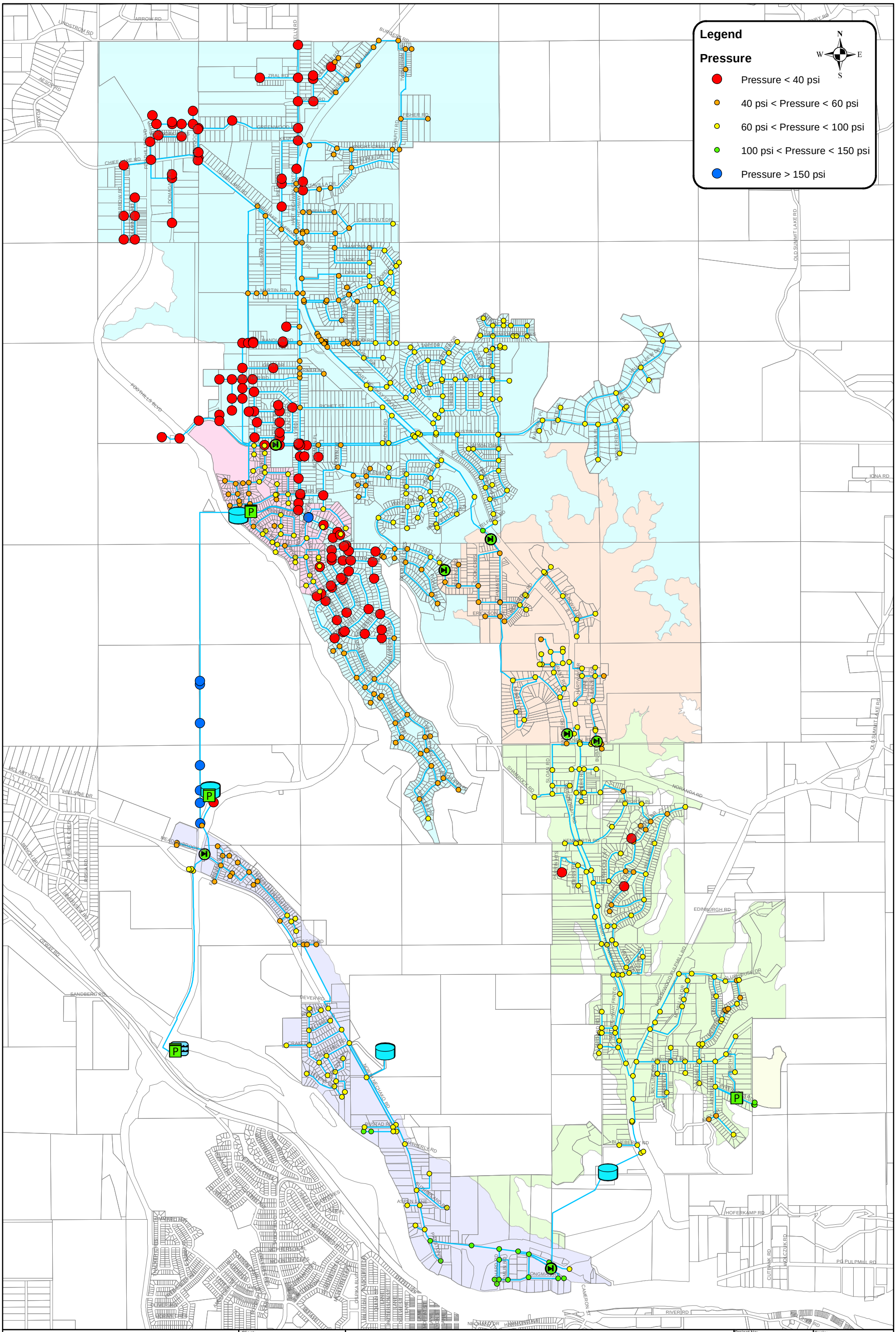
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North Model
Peak Hour Pressures - Short Term Condition

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North Model
Peak Hour Pressures - Long Term Condition

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Figure 8-7

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8.5.3.3 Maximum Day Demand plus Fire Flow

The results from the fire flow analysis are as summarized in Figure 8-8, Figure 8-9, and Figure 8-10 which illustrate the various ranges of fire flow requirements and availabilities throughout the system and identifies where deficiencies are occurring. Out of a total of 694 nodes modeled, a substantial amount of fire flow deficiencies are currently occurring in the North model. While some of these deficiencies may be ignored as no fire hydrants exist at those locations, the City should still construct the water system to be able to provide the fire flows should fire hydrants be installed at locations where none are currently present.

Results from the flow analysis coincident to maximum are broken down by land use as listed in Table 8-16.

Table 8-16 North Model Available Fire Flows

Land Use	Desired Fire Flow (L/s)	# Nodes with less than the Desired Fire Flow		
		Existing	Short Term	Long Term
Single Family Residential	60	254	268	319
Multi-Family Residential, Small Institutional, Small Commercial	150	51	53	72
Complex Commercial	225	14	15	20
Major Institutional, Light Industrial, Heavy Industrial	250	50	50	50
	TOTAL	**369**	**386**	**461**

The number of nodes unable to achieve the required residual pressures at the desired fire flows totals 369-461 (53-66 % of the fire flow nodes). Many areas where the desired fire flow levels cannot be achieved are at either dead ends in the system, or along undersized watermains within the water network.

Recommendations made at the end of this report is able to reduce fire flow deficiencies from a total of 369 under the existing condition to less than 125.

Legend

Deficient Nodes

- FF < 60 L/s
- 60 L/s < FF < 150 L/s
- 150 L/s < FF < 225 L/s
- 225 L/s < FF < 250 L/s

Fire Flow Requirements

- SF (min Fire Flow = 60 L/s)
- MF, Small Comm, Minor Inst (min FF = 150 L/s)
- Complex Comm (min FF = 225 L/s)
- Major Inst, Light/Heavy Ind (min FF = 250 L/s)

N W E S

North Model
Available Fire Flows under Existing Condition

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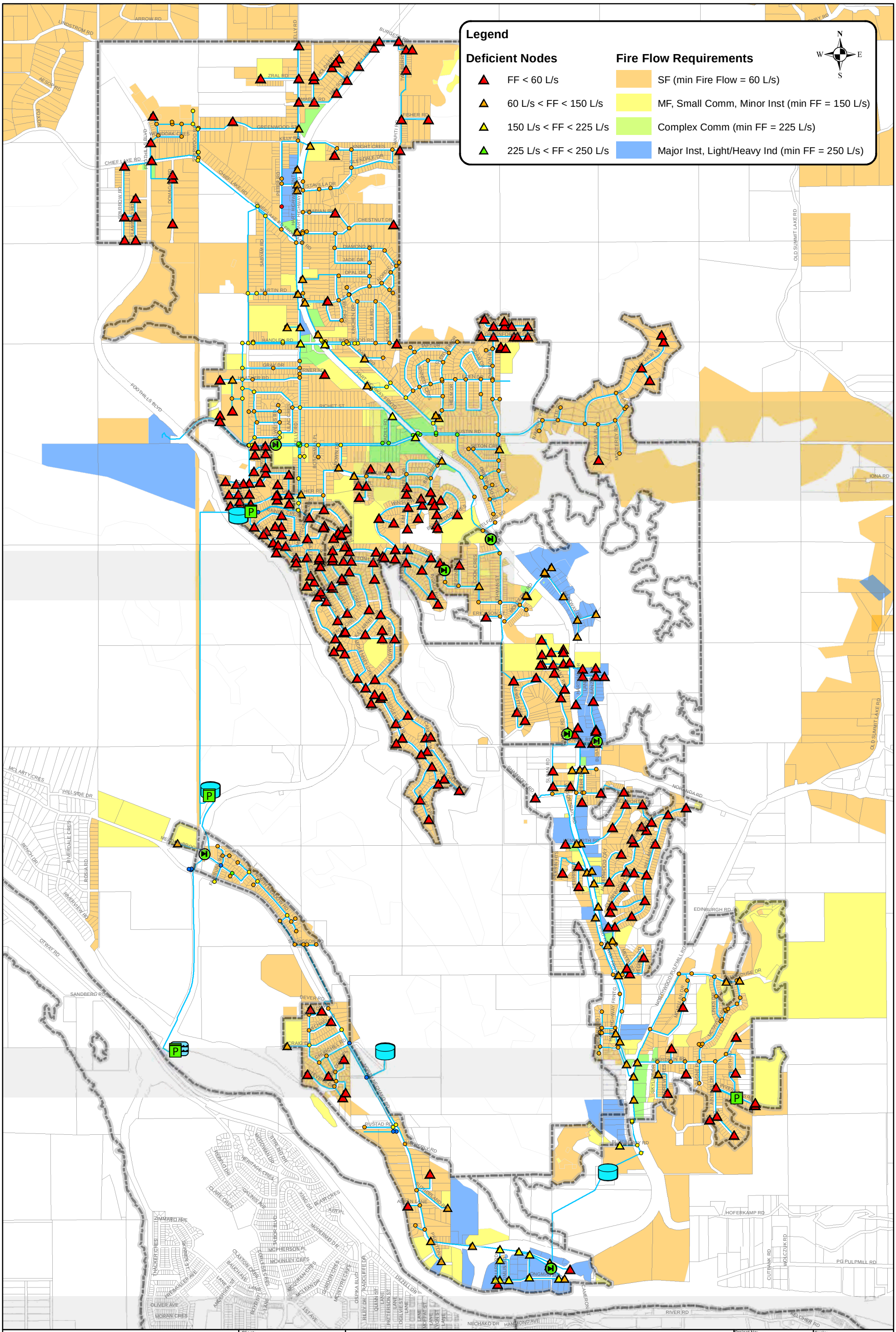
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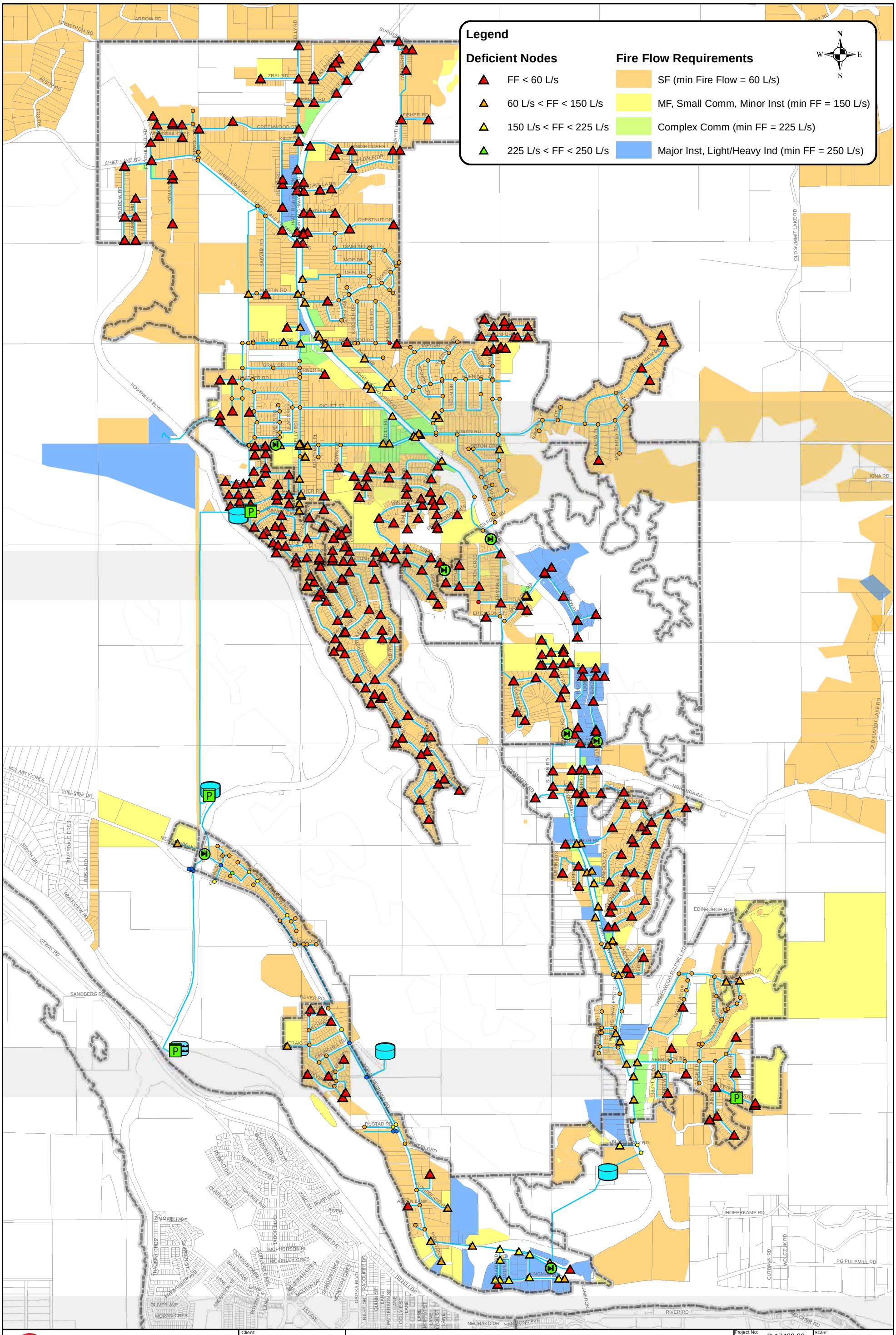
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Client: CITY OF PRINCE GEORGE

North Model
Available Fire Flows - Short Term Condition

Project No:	D-17460.00
Designed:	CL
Drawn:	CL
Approved:	
Note:	Figure 8-9
Scale:	0 125 250 Meters; 1:40,000 @ Tabloid
Map No	1
Date	DEC 2014
Revision	
Revision Date	

Path: G:\opus_dk\municipal\174 Prince George\gis\D-174.60 Water Service Network Plan Update\Figure 8-9 - North Model Short Term FF.mxd



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Client: CITY OF PRINCE GEORGE

North Model
Available Fire Flows - Long Term Condition

Project No:	D-17460.00
Designed:	CL
Drawn:	CL
Approved:	
Note:	Figure 8-10
Scale:	0 125 250 Meters; 1:40,000 @ Tabloid
Map No	1
Date	MAY 2014
Revision	
Revision Date	

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8.5.4 Distribution System Recommendations

The recommendations presented in this section are limited to the main distribution system and generally do not directly address dead ends in the system. Improvements for fire flow servicing to dead ends should be addressed on a case-by-case basis, especially as there are opportunities in the future to have required watermain upgrades borne by developers wanting to connect to the existing water system.

Table 8-17 summarizes the recommended upgrade works to overcome the existing deficiencies. These recommendations are chosen to reduce the most fire flow deficiencies with as little construction as possible.

Table 8-17 Distribution System Upgrade Recommendations

Rec #	Proposed Work	Deficiency Resolved	Scenario
W-08-1	Construct 75m of 350mm watermain to connect Winston Road to North Nechako Road	Fire Flows	Existing
W-08-2	Construct 120m of 200mm watermain to connect Winston Road and Michael Road	Fire Flows	Existing
W-08-3	Construct 1560m of 300mm watermain along North Nechako Road from Rustad Road to Richard Road	Fire Flows	Existing
W-09-1	Construct 155m of 200mm watermain along Noranda Rd W from Sloan Road to Hwy 97	Fire Flows	Existing
W-09-2	Construct 850m of 250mm watermain on Noranda Rd E	Fire Flows	Existing
W-09-3	Construct 120m of 350mm watermain along Northwood Pulp Road south of McMillan Drive	Fire Flows	Existing
W-09-4	Construct 1011m of 400mm watermain from the Lower Hart Reservoir (PW-810) to the intersection of Hart Hwy and Northwood Pulp Mill Rd	Fire Flows	Existing
W-10-1	Construct 400m of 300mm watermain from Lehman Street to Grant Road	Fire Flows	Existing
W-10-2	Construct 260m of 300mm watermain across Hart Hwy	Fire Flows	Existing
W-10-3	Construct 450m of 300mm watermain along Banzer Drive	Fire Flows	Existing
W-10-4	Construct 190m of 250mm watermain along Hartway Drive	Fire Flows	Existing
W-11-1	Construct 860m of 350mm watermain from Highland Drive and Wallace Crescent to Sussex Lane and Wildwood Crescent	Fire Flows	Existing
W-11-2	Construct 500m of 200mm watermain on Clown Dr from Vellencher Rd to Austin Rd W	Fire Flows	Existing
W-11-3	Construct 740m of 200mm watermain east of Dawson Rd from Austin Rd to Cluff Rd	Fire Flows	Existing
W-11-4	Construct 1,724m of 450mm watermain along Kelly Road S from Austin Road W to Chief Lake Road, and 605m of 300mm watermain along Hwy 97 from Chief Lake Road to Karin Road	Fire Flows	Existing

Rec #	Proposed Work	Deficiency Resolved	Scenario
W-11-5	Construct 350m of 300mm watermain on Chief Lake Rd from Sabyam Road to Hart Hwy	Fire Flows	Existing
W-11-6	Construct 800m of 200mm watermain from Zral Rd to Sparwood Rd	Fire Flows	Existing
W-11-7	Various Valve Closures and Openings to increase the areas serviced in Pressure Zone 11	Fire Flows	Existing
W-11-7A	Construct 105m of 200mm watermain to connect Poyner Crescent to Wallace Crescent	Fire Flows	Existing
W-11-7B	Construct 125m of 200mm watermain along Wallace Crescent north of Highland Drive	Fire Flows	Existing
W-11-8	Construct 225m of 200mm watermain on Balsum Rd from Hazel Dr to Birchwood Dr	Fire Flows	Existing
W-11-9	Construct 1310m of 200mm watermain on from intersection of Austin Road and Hart Hwy to the Cook PRV (PW-612)	Fire Flows	Existing
W-11-10	Construct 575m of 200mm watermain to connect Turner Rd to Richet St (New Watermain Loop)	Fire Flows	Existing

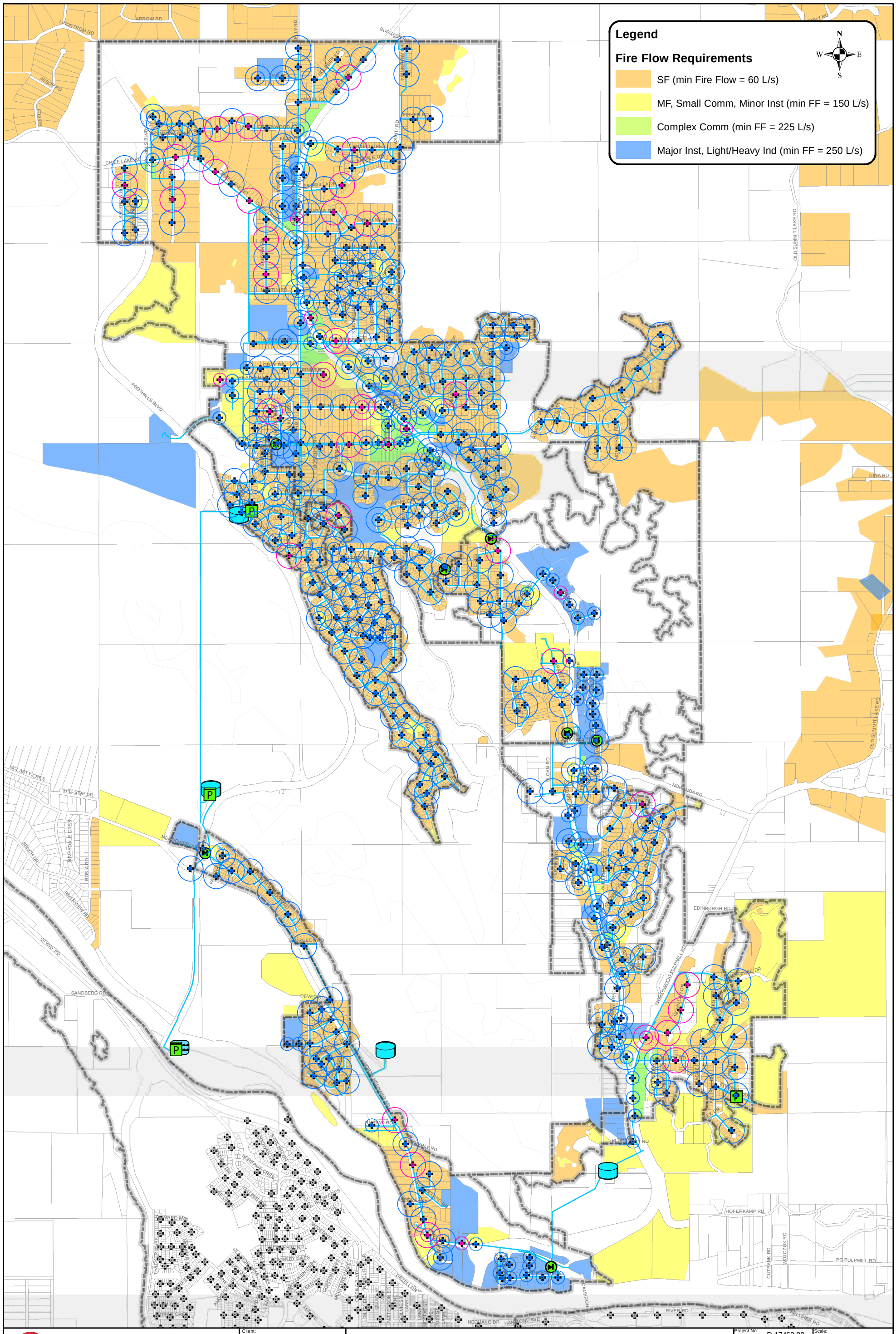
8.6 Hydrant Coverage Analysis

The City currently operates 414 fire hydrants in the North water system. Figure 8-11 illustrates the coverage of the existing hydrants and identifies locations for new hydrants where the coverage is deficient. The existing coverage is illustrated by two circles. The smaller circle represents a 100m diameter coverage (the ICI servicing distance) and the larger circle represents a 200m diameter coverage (the residential servicing distance).

An analysis for future hydrant coverage requirements under the short term and long term scenarios was not carried out for the purposes of this report. Future hydrant construction should be made on a case-by-case basis in the course of the watermain construction approval process for new developments as they occur in the City of Prince George.

8.6.1 Recommendations

40 additional hydrants are recommended for the City's North water system as illustrated in Figure 8-11. A further study with the local fire department should be conducted to prioritize the need for these hydrants.



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Client: CITY OF PRINCE GEORGE

North Model
Hydrant Coverage Analysis

Project No:	D-17460.00
Designed:	CL
Drawn:	CL
Approved:	
Note:	Figure 8-11
Scale:	0 125 250 Meters; 1:40,000 @ Tabloid
Map No	1
Date	DEC 2014
Revision	
Revision Date	

Path: G:\opus_dk\municipal\174 Prince George\gis\D-174.60 Water Service Network Plan Update\Figure 8-11 - Hydrant Coverage.mxd

9 Watermain Risk & Criticality

Opus DaytonKnight has carried out an assignment to assess the criticality of each of the watermains in the City of Prince George water network. The risk assessment approach taken will allow the City to adequately prioritize and budget for its watermain renewals to best meet the needs of its water system. This section summarizes the findings of the watermain risk & criticality assignment.

The complete Watermain Risk and Criticality Assessment report is provided in Appendix F.

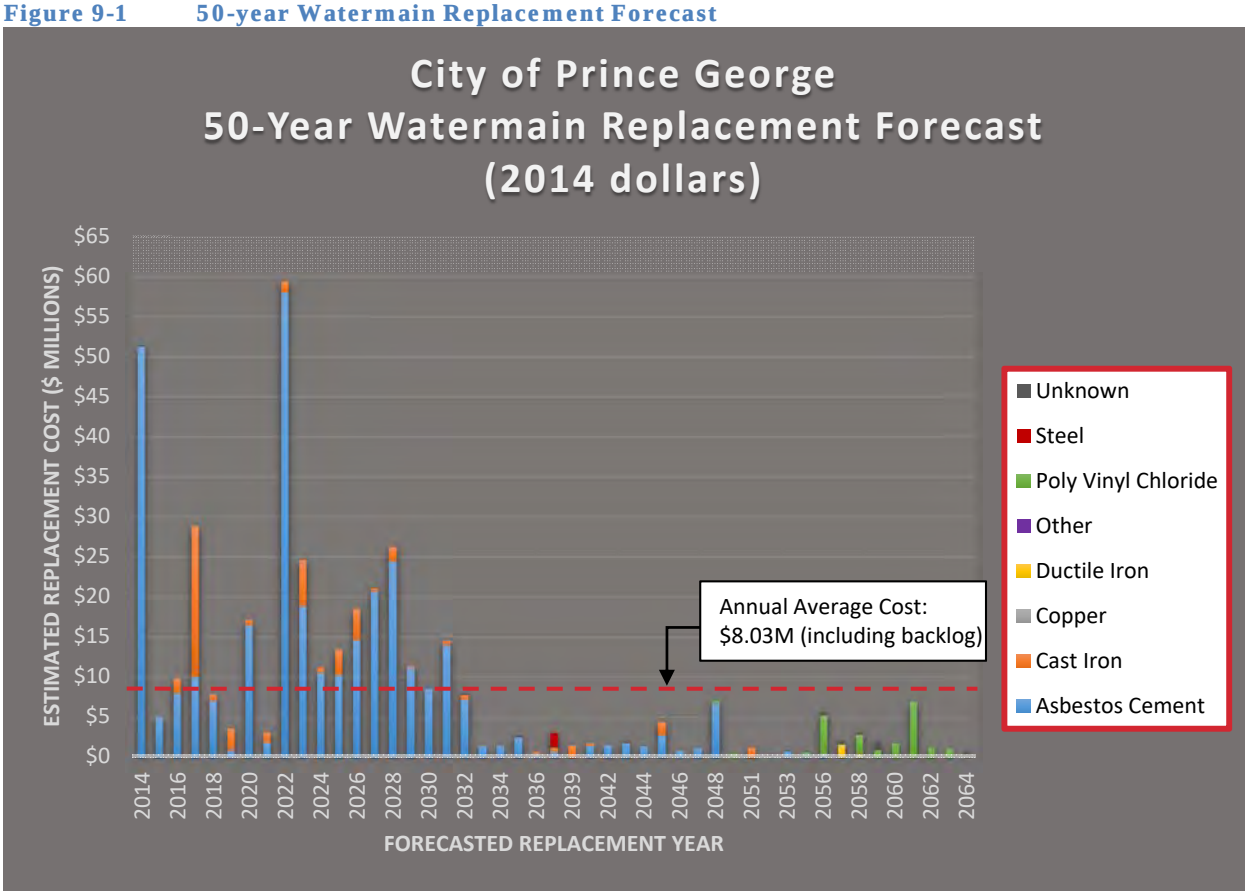
9.1 Objective

The objective of the risk & criticality assessment of the City's watermains is not only to provide an illustration of the current state of the watermains, but a risk-based approach to renewal planning and prioritization for all renewals for the City's entire watermain network.

9.2 The City's Current Infrastructure Funding Gap

A 50-year watermain replacement forecast carried out by Opus DaytonKnight indicates that the total replacement value for the watermains totals $401 million over the next 50 years, which equates to an annual replacement rate of approximately $8.0 million. Figure 9-1 illustrates the replacement forecast.

Figure 9-1 50-year Watermain Replacement Forecast



The City's 30-year forecast of a $4.99 million funding re-investment requirement for the linear water assets (City of Prince George Finance and Audit Committee, Council Presentation, June 25, 2014) is lower than Opus DaytonKnight's 50-year forecast of a $8.0 million funding requirement as illustrated above. Opus DaytonKnight notes that the difference can be accounted for in the higher unit rates used for replacement of the watermains.

The City of Prince George is noted to have been spending about $0.27 million annually on watermain replacements (2009 – 2013 average), indicating a large funding liability for its linear water assets. The City is currently facing a significant infrastructure gap.

9.3 Risk & Criticality Approach

Opus DaytonKnight has developed a watermain risk framework unique to the City of Prince George to identify and prioritize the City's watermain renewals. Our team has leveraged the skills of our expert asset management staff in British Columbia and New Zealand to develop a standardized risk framework through which the likelihood and consequence of failure of the City's watermain assets were assessed.

The watermain risk framework is a tool that standardizes assessments and decisions made about watermains by categorizing each asset according to specific scenarios and decision drivers. The framework is used to assess each watermain with regards to various types of impacts and consequences a break or loss of service might have, specifically any resulting social, economic, environmental, or operational concerns.

To establish the watermain risk framework, seven (7) key business and community drivers were identified to shape the framework as follows:

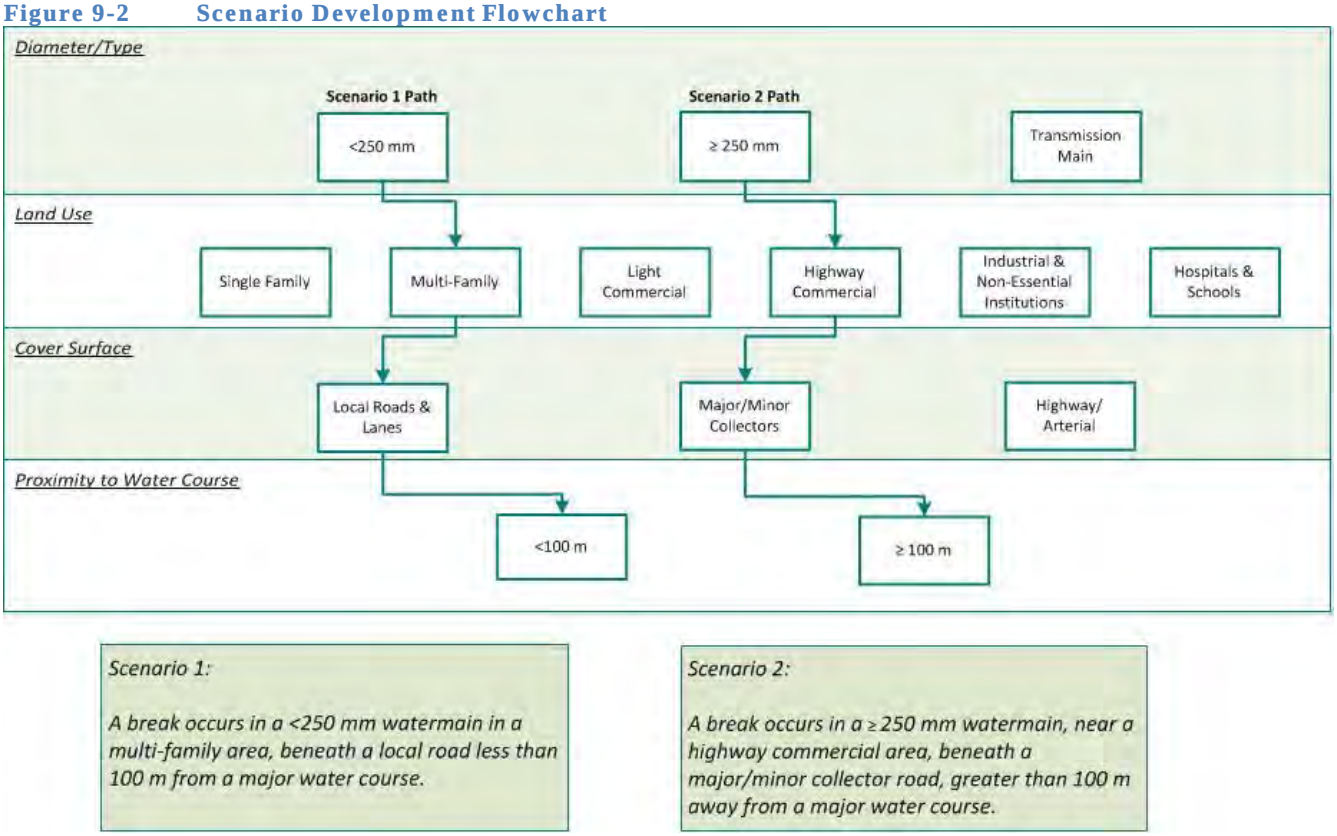
- Business Continuity
- People
- Financial
- Reputation / Image
- Environmental
- Political & Strategic
- Technical

The framework includes questions under each driver which guides the City in determining the level of service it deems appropriate for certain watermains. The complete framework is found in Appendix F.

After development of the framework, the consequence of failure of each watermain asset was generated through the assessment of 108 separate consequence scenarios. The scenarios were made up of 6 different adjacent land use considerations, 3 different watermain diameter ranges, 3 difference road cover surfaces and 2 different considerations for proximity to water courses.

Figure 9-2 illustrates the scenario development carried out for the City of Prince George.

Figure 9-2 Scenario Development Flowchart



Concurrently, likelihood of failure rankings were developed based on an assessment of watermain age, construction material and typical static pressure levels experienced in the watermains.

The final likelihood and consequence of failure scores were processed through a Risk Matrix to determine the final Risk Rating of each watermain. The Risk Matrix is provided in Table 9-1 and categorizes risk into L (Low), M (Medium), H (High) and VH (Very High) risk ratings.

Table 9-1 Risk Matrix

Risk Matrix					
Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
Rare	L	L	M	M	H
Unlikely	L	L	M	M	H
Possible	L	M	H	H	H
Likely	M	M	H	H	VH
Almost Certain	M	H	H	VH	VH

For each risk level, an 'Action Required' was identified. The appropriate response for each risk level follows inTable 9-2.

Table 9-2 Risk Rating & Action Priority

Level of Risk	Action required timing
Very High Risk	Immediate corrective action (i.e. action is required now)
High Risk	Prioritized action required (i.e. make safe and program in current/next program)
Medium Risk	Planned action required (i.e. make safe and include in forward programs)
Low Risk	Manage by routine procedures

9.4 Findings

The Watermain Risk & Criticality Assessment has found that 5% (in length) of the City's watermains were categorized as "Very High Risk" and would require replacement as soon as possible. The capital construction cost estimated to replace all the "Very High Risk" watermains is approximately $25 million. At a watermain replacement funding rate of $5 million/year, the "Very High Risk" watermains will likely be completely replaced in the next 5 years.

This confirms that the City of Prince George should increase its spending for watermain replacements, and a line item representing renewal/replacement of these watermains has been included in the City's Capital Projects List in Section 10.

A detailed replacement schedule by pipe is included for "Very High Risk" watermains in the full report provided for the Risk & Criticality Assessment in Appendix F.

10 Improvement Projects Summary

Sections 7 and 8 set out the required water system upgrades to address water demand requirements in the existing and future (short term and long term) conditions. The projects identified through our system analysis are prioritized in terms of short term improvements (which focus on easy to address system deficiencies and critical system conveyance issues) and long term improvements (which focus on distribution and system improvements to improve the level of service to residents up to the long term buildout condition).

Also included in the list of capital works are the following:

- Watermain replacements as a result of the risk and criticality assessment as identified in Section 9;
- Replacement of 100mm watermains in the system; and,
- Other water infrastructure related projects (e.g. small watermain projects, conceptual, pre-design, and detailed design investigations) as identified through the Workshop held with Operations staff on October 27, 2014 as summarized in Appendix G.

10.1 Cost Estimate Basis

Cost estimates provided in the Capital Projects List have been prepared based on unit cost rates from relevant past projects within the City of Prince George and Opus DaytonKnight's cost database, adjusted to 2014 constant dollars. Where appropriate, allowances are also included for river crossings and road restoration.

Table 10-1 summarizes the unit costs used to estimate the capital improvement works.

Table 10-1 Unit Rates For Budgeting

Asset	Size	Unit Cost ($)	Unit
Watermains	200	800	lin.m
	250	940	lin.m
	300	1,090	lin.m
	350	1,230	lin.m
	450	1,600	lin.m
Reservoirs	All	650	m3
Pump Stations	New Station	10,000	HP
	Additional Pump	5,000	HP
PRV Stations	150mm lead PRV	150,000	ea.
Fire Hydrants	All	5,000	ea.

Cost estimates will also include allowances of 12% for engineering fees and 30% for contingency and GST would be additional.

For future adjustment, an Engineering News Record Construction Cost Index of 9,846 (September 2014) is recommended to account for inflation and increased labour and construction costs over time.

The ENR indexes measure how much it costs to purchase a package of goods compared to what it was in the base year. For the City of Prince George, Opus DaytonKnight recommends using the ENR's Construction Cost Index (CCI) as this index is typically used to estimate costs for jobs where labour costs are a high proportion of total costs. Comparatively, ENR's Building Cost Index (BCI) provides estimates which are more applicable for structures (i.e. commercial buildings and private dwellings). The City should note that the ENR costs merely offer a snapshot of general cost trends but are applicable for the purposes of helping City staff estimate project costs as they occur in the future.

10.2 Capital Plan

The proposed Capital Projects List is organized into the following projects:

- Short Term High Priority Improvement Projects
- Short Term Low Priority Improvement Projects
- Long Term Improvement Projects
- "Very High Risk" Watermain Renewals
- Watermain upgrades for 100mm diameter watermains
- Water infrastructure related projects identified through a workshop held with operations staff

Short term improvement projects were selected to address easy to address system deficiencies and critical system conveyance issues with high and low priority rankings. High priority projects indicate those recommended for completion within the next 5 years. Low priority projects indicate those recommended for completion within the next 5 – 10 years.

Long term improvement projects are those identified which address a smaller amount of deficiencies when compared to short term projects. These long term improvements improve the water system's conveyance and distribution system reliability in terms of meeting increasing demands as a result of growth. Long term projects are recommended for completion within the next 10 – 25 years.

Watermains categorized as "Very High Risk" are also included. As the list of these watermains is extensive, one representative entry for these watermains is included in the Capital Projects List. The "Very High Risk" watermains have their own priority replacement schedule as found in Appendix F.

Watermain upgrades are identified for all existing watermains which are sized 100 mm. These watermains need to at least 150 mm across the City to ensure that any hydrants connected off of them are able to provide an adequate fire flows coincident to maximum day demand. Further, those 100 mm watermains identified in the Downtown Core should be upsized to at least 200 mm.

A workshop held with operations staff provided suggestions for additional water infrastructure related projects for the Capital Projects List. These projects include:

- Condition and redundancy related projects at the reservoirs and pump stations;
- System reliability related projects regarding watermain upgrades for those pipes which are shallow or currently exposed; and,
- Projects to identify and resolve current operational issues in the water utility.

Opus DaytonKnight has recommended additional projects for the Capital Projects List including conceptual, pre-design, and detailed design investigations to address all discussions and concerns arising from the workshop.

The Capital Projects List is summarized in Table 10-2. City staff should note that when utilizing costs from the Capital Projects List that these cost estimates are based on an ENR Construction Cost Index (CCI) of 9,846 for September 2014 and should be adjusted to account for increased costs through review of the updated CCI at the time of tender and construction.

These projects are also illustrated in Figure 10-1 and Figure 10-2.

Table 10-2 Capital Projects List

City of Prince George - 2014 Water Service Master Plan Update

Criticality Ranking indicating Project Priority	
9 - 10	Very High
7 - 8	High
5 - 6	Medium
1 - 4	Low

Engineering and Contingency (%) 42%

ID	Description	Addresses Low Pressures	Addresses Low Fire Flows	Supports Development	Increases System Reliability	Criticality Level	Length (m)	Size (m3, HP, mm or #)	Unit Cost ($)	Unit	Cost ($)	Cost + E&C ($)
Short Term High Priority Upgrades												
R-1	Construct a 2.27 ML Reservoir for Pressure Zone 25				✗	8		2,270	$ 650	/m3	$ 1,475,500	$ 2,095,210
R-2	Construct a 6.82 ML Reservoir for Pressure Zone 02				✗	7		6,820	$ 650	/m3	$ 4,433,000	$ 6,294,860
R-3	Construct a 4.55 ML Reservoir for Pressure Zone 22			✗	✗	10		4,550	$ 650	/m3	$ 2,957,500	$ 4,199,650
P-1	Install a pump for fire flow servicing at the Somerville Pump Station (PW-614) ; capacity = 72 L/s (40HP)		✗	✗		10		40	$ 5,000	/HP	$ 200,000	$ 284,000
P-8	Increase pumping capacity of the Vellencher Pump Station (PW-615) from 20 L/s to 28 L/s (10HP)	✗				8		10	$ 5,000	/HP	$ 50,000	$ 71,000
P-9	Install a pump for fire flow servicing at the Vellencher Pump Station (PW-615); capacity = 167 L/s (150HP)		✗			10		150	$ 5,000	/HP	$ 750,000	$ 1,065,000
P-10	Install a pump for fire flow servicing at the Inverness Pump Station (PW-619); capacity = 151 L/s (200HP)		✗			9		200	$ 5,000	/HP	$ 1,000,000	$ 1,420,000
P-12	Increase pumping capacity of the Fishtrap Collector Wells (PW-660) to supply Pressure Zone 2 as a backup for PW-605				✗	8			n/a	ea	n/a	n/a
T-6	Install check valve on transmission main leading up to the Vellencher Reservoir (PW-817)			✗	✗	10			$ 25,000	ea	$ 25,000	$ 35,500
W-01-1	Construct 300m of 250mm watermain from Ospika Blvd N to King Dr		✗		✗	9	300	250	$ 940	/lin.m.	$ 282,000	$ 400,440
W-01-2	Construct 80m of 250mm watermain to connect Petersen Road to Hollandia Place		✗		✗	7	80	250	$ 940	/lin.m.	$ 75,200	$ 106,784
W-01-3	Construct 1050m of 900mm watermain to connect the Fishtrap Collector Wells (PW-660) to the Wilson Park West Wells (PW-605) **(study to confirm sizing currently underway)**				✗	8	1,050	900	$ 3,050	/lin.m.	$ 3,202,500	$ 4,547,550
W-01-4	Recreation Place Improvements **(study currently underway)**		✗		✗	8	1,200	300	$ 1,090	/lin.m.	$ 1,308,000	$ 1,857,360
W-02-3	Construct 430m of 300mm watermain along Ontario Street from 1st Ave to 5th Ave		✗		✗	7	430	300	$ 1,090	/lin.m.	$ 468,700	$ 665,554
W-02-4	Construct 350m of 300mm watermain along Ottawa Street from 1st Ave to 4th Ave		✗		✗	7	350	300	$ 1,090	/lin.m.	$ 381,500	$ 541,730
W-02-5	Construct 150m of 250mm watermain along Patricia Blvd from Queensway to Ingledew Street		✗		✗	7	150	250	$ 940	/lin.m.	$ 141,000	$ 200,220
W-02-7	Construct 700m of 250mm watermain from Hwy 97 to Jasper Street		✗		✗	7	700	250	$ 940	/lin.m.	$ 658,000	$ 934,360
W-02-9	Construct 100m of 200mm watermain along 7th Ave from Wainwright St to Alward St		✗	✗	✗	6	100	200	$ 800	/lin.m.	$ 80,000	$ 113,600
W-02-10	Contruct 15m of 200mm watermain to connect parallel watermains running on Norwood St				✗	5	15	200	$ 800	/lin.m.	$ 12,000	$ 17,040
W-02-11	Abandon section of watermain west of intersection of Queensway and Regent Cres				✗	4			$ 5,000	ea	$ 5,000	$ 7,100
W-04-1	Construct 500m of 300mm watermain to connect Vista View Road to the Zone 4 watermain on North Street and Cathedral Avenue	✗	✗	✗	✗	9	500	300	$ 1,090	/lin.m.	$ 545,000	$ 773,900
W-04-2	Construct 120m of 250mm watermain to connect Marleau Road to O'Grady Road		✗		✗	7	120	250	$ 940	/lin.m.	$ 112,800	$ 160,176
W-06-1	Construct 140m of 200mm watermain to connect Westmount Drive to Hillcrest Road		✗		✗	7	140	200	$ 800	/lin.m.	$ 112,000	$ 159,040

Table 10-2 Capital Projects List

City of Prince George - 2014 Water Service Master Plan Update

Criticality Ranking indicating Project Priority	
9 - 10	Very High
7 - 8	High
5 - 6	Medium
1 - 4	Low

Engineering and Contingency (%) 42%

ID	Description	Addresses Low Pressures	Addresses Low Fire Flows	Supports Development	Increases System Reliability	Criticality Level	Length (m)	Size (m3, HP, mm or #)	Unit Cost ($)	Unit	Cost ($)	Cost + E&C ($)
W-06-2	Construct 220m of 300mm watermain on Bear Rd		x	x	x	9	220	300	$ 1,090	/lin.m.	$ 239,800	$ 340,516
W-06-3	Construct 500m of 200mm watermain on Henry Rd		x	x	x	9	500	200	$ 800	/lin.m.	$ 400,000	$ 568,000
W-07-1	Construct 160 metres of 250mm watermain to connect watermains on Ring Road		x		x	8	160	250	$ 940	/lin.m.	$ 150,400	$ 213,568
W-07-2	Increase D/S pressure setting at the Crest PRV (PW-622) from 91 psi (64 m) to 121 psi (85 m)		x			8			$ 5,000	ea	$ 5,000	$ 7,100
W-08-1	Construct 75m of 350mm watermain to connect Winston Road to North Nechako Road		x		x	7	75	350	$ 1,230	/lin.m.	$ 92,250	$ 130,995
W-08-2	Construct 120m of 200mm watermain to connect Winston Road and Michael Road		x		x	7	120	200	$ 800	/lin.m.	$ 96,000	$ 136,320
W-08-3	Construct 1,560m of 300mm watermain along North Nechako Road from Rustad Road to Richard Road		x			9	1,560	300	$ 1,090	/lin.m.	$ 1,700,400	$ 2,414,568
W-09-1	Construct 155m of 200mm watermain along Noranda Rd W from Sloan Road to Hwy 97		x		x	8	155	200	$ 800	/lin.m.	$ 124,000	$ 176,080
W-09-2	Construct 850m of 250mm watermain on Noranda Rd E		x		x	8	850	250	$ 940	/lin.m.	$ 799,000	$ 1,134,580
W-09-3	Construct 120m of 350mm watermain on Northwood Pulp Mill Rd from Hart Hwy to Aberdeen Rd		x	x		9	120	350	$ 1,230	/lin.m.	$ 147,600	$ 209,592
W-09-4	Construct 1,011m of 400mm watermain from the Lower Hart Reservoir (PW-810) to the intersection of Hart Hwy and Northwood Pulp Mill Rd		x	x		9	1,011	400	$ 1,380	/lin.m.	$ 1,395,180	$ 1,981,156
W-10-1	Construct 400m of 300mm watermain from Lehman Street to Grant Road		x		x	9	400	300	$ 1,090	/lin.m.	$ 436,000	$ 619,120
W-10-2	Construct 260m of 300mm watermain across Hart Hwy north of Collins Road		x		x	9	260	300	$ 1,090	/lin.m.	$ 283,400	$ 402,428
W-11-1	Construct 860m of 350mm watermain from Highland Drive and Wallace Crescent to Sussex Lane and Wildwood Crescent		x			9	860	350	$ 1,230	/lin.m.	$ 1,057,800	$ 1,502,076
W-11-2	Construct 500m of 200mm watermain on Clown Dr from Vellencher Rd to Austin Rd W		x			8	500	200	$ 800	/lin.m.	$ 400,000	$ 568,000
W-11-3	Construct 740m of 200mm watermain east of Dawson Rd from Austin Rd to Cluff Rd		x			8	740	200	$ 800	/lin.m.	$ 592,000	$ 840,640
W-11-4	Construct 1,724m of 450mm watermain along Kelly Road S from Austin Road W to Chief Lake Road, and 605m of 300mm watermain along Hwy 97 from Chief Lake Road to Karin Road		x	x		8	1,724	450	$ 1,600	/lin.m.	$ 2,758,400	$ 3,916,928
	see above		x	x		8	605	300	$ 1,090	/lin.m.	$ 659,450	$ 936,419
W-11-5	Construct 350m of 300mm watermain on Chief Lake Rd from Sabyam Road to Hart Hwy		x			7	350	300	$ 1,090	/lin.m.	$ 381,500	$ 541,730
W-11-6	Construct 800m of 200mm watermain from Zral Rd to Sparwood Rd		x		x	7	800	200	$ 800	/lin.m.	$ 640,000	$ 908,800
W-11-9	Construct 1310m of 200mm watermain on from intersection of Austin Road and Hart Hwy to the Cook PRV (PW-612)		x	x		8	1,310	200	$ 800	/lin.m.	$ 1,048,000	$ 1,488,160
W-11-10	Construct 575m of 200mm watermain to connect Turner Rd to Richet St (New Watermain Loop)		x	x	x	8	575	200	$ 800	/lin.m.	$ 460,000	$ 653,200
Subtotal												$ 45,640,050
Short Term Low Priority Upgrades												
P-2 / W-02-8	Construct a pump/PRV station across the Fraser River with capacity of 54 L/s (30HP) to connect Pressure Zone 1 to Pressure Zone 15			x	x	7		30	$ 10,000	/HP	$ 300,000	$ 426,000

Table 10-2 Capital Projects List

City of Prince George - 2014 Water Service Master Plan Update

Criticality Ranking indicating Project Priority	
9 - 10	Very High
7 - 8	High
5 - 6	Medium
1 - 4	Low

Engineering and Contingency (%) 42%

ID	Description	Addresses Low Pressures	Addresses Low Fire Flows	Supports Development	Increases System Reliability	Criticality Level	Length (m)	Size (m3, HP, mm or #)	Unit Cost ($)	Unit	Cost ($)	Cost + E&C ($)
P-3 / T-3	Increase pumping capacity of the Patricia Pump Station (PW-623) from 82 L/s to 183 L/s (200HP)		✗	✗		9		200	$ 5,000	/HP	$ 1,000,000	$ 1,420,000
T-1	Construct 3,810m of 750mm watermain from the Fishtrap Collector Well (PW-660) to Cranbrook Hill Reservoir (PW-805)				✗	6	3,810	750	$ 2,610	/lin.m.	$ 9,944,100	$ 14,120,622
T-5	Construct 3,450m of 400mm watermain from Foothills Pump Station (PW-650) to Vellencher Reservoir (PW-817). A new PRV Station should be added to provide water mid-way to Pressure Zone 11 at Highland Drive to service fire flows.	✗	✗	✗	✗	10	3,450	400	$ 1,380	/lin.m.	$ 4,761,000	$ 6,760,620
	see above	✗	✗	✗	✗	10			$ 150,000	ea	$ 150,000	$ 213,000
W-02-1	Construct a new PRV station at intersection of 20th Ave and Griffiths Ave		✗		✗	8			$ 150,000	ea	$ 150,000	$ 213,000
W-02-6 / T-2	Construct 1,990m of 350mm watermain on Hwy 97 from Hwy 16 to existing stub			✗	✗	7	1,990	350	$ 1,230	/lin.m.	$ 2,447,700	$ 3,475,734
W-22-1	Construct a new PRV station at the intersection of Sintich Road to connect Pressure Zone 22 with Pressure Zone 15			✗	✗	7			$ 150,000	ea	$ 150,000	$ 213,000
Subtotal												$ 26,841,976
Long Term Upgrades												
R-4	Construct a 2.27 ML Reservoir for Pressure Zone 07				✗	6		2,270	$ 650	/m3	$ 1,475,500	$ 2,095,210
R-5	Construct a 4.55 ML Reservoir for Pressure Zone 02				✗	5		4,550	$ 650	/m3	$ 2,957,500	$ 4,199,650
P-4	Increase pumping capacity of the Wilson Park East Well (PW-601) from 544 L/s to 728 L/s (40HP)	✗		✗		7		40	$ 5,000	/HP	$ 200,000	$ 284,000
P-5	Increase pumping capacity of the Cameron Pump Station (PW-602) from 544 L/s to 728 L/s (250HP)	✗		✗		7		250	$ 5,000	/HP	$ 1,250,000	$ 1,775,000
P-6	Increase pumping capacity of the Wilson Park West Well (PW-605) from 816 L/s to 878 L/s (100HP)			✗		7		100	$ 5,000	/HP	$ 500,000	$ 710,000
P-7 / T-4	Increase pumping capacity of the UNBC Pump Station (PW-630) from 42 L/s to 224 L/s (550HP)			✗		7		550	$ 10,000	/HP	$ 5,500,000	$ 7,810,000
P-11	Increase pumping capacity of the Foothills Pump Station (PW-650) from 270 L/s to 312 L/s (100HP)	✗	✗	✗		6		100	$ 5,000	/HP	$ 500,000	$ 710,000
W-03-1A	Construct 400m of 300mm watermain from McGill Crescent to Cowart Road		✗		✗	5	400	300	$ 1,090	/lin.m.	$ 436,000	$ 619,120
W-03-1B	Construct 675m of 300mm watermain along Cowart Road north from Simon Fraser Ave		✗		✗	5	675	300	$ 1,090	/lin.m.	$ 735,750	$ 1,044,765
W-03-1C	Close watermain crossing Hwy16		✗		✗	5			$ 5,000	ea	$ 5,000	$ 7,100
W-04-3A	Construct PRV station at intersection of Baker Rd and Davis Dr	✗	✗		✗	7			$ 150,000	ea	$ 150,000	$ 213,000
W-04-3B	Construct PRV station at intersection of Wheeler Road and Hwy 16	✗	✗		✗	7			$ 150,000	ea	$ 150,000	$ 213,000
W-04-3C	Close watermain crossing Hwy16 at Eton Avenue		✗		✗	7			$ 5,000	ea	$ 5,000	$ 7,100
W-10-3	Construct 450m of 300mm watermain along Banzer Drive		✗		✗	5	450	300	$ 1,090	/lin.m.	$ 490,500	$ 696,510
W-10-4	Construct 190m of 250mm watermain along Hartway Drive		✗		✗	5	190	250	$ 940	/lin.m.	$ 178,600	$ 253,612

Table 10-2 Capital Projects List

City of Prince George - 2014 Water Service Master Plan Update

Criticality Ranking indicating Project Priority	
9 - 10	Very High
7 - 8	High
5 - 6	Medium
1 - 4	Low

Engineering and Contingency (%) 42%

ID	Description	Addresses Low Pressures	Addresses Low Fire Flows	Supports Development	Increases System Reliability	Criticality Level	Length (m)	Size (m3, HP, mm or #)	Unit Cost ($)	Unit	Cost ($)	Cost + E&C ($)
W-11-7	Various valve closures and openings to expand the area serviced by Pressure Zone 11	✗				5			$ 15,000	ea	$ 15,000	$ 21,300
W-11-7A	Construct 105m of 200mm watermain to connect Poyner Crescent to Wallace Crescent	✗				5	105	200	$ 800	/lin.m.	$ 84,000	$ 119,280
W-11-7B	Construct 125m of 200mm watermain along Wallace Crescent north of Highland Drive	✗				5	125	200	$ 800	/lin.m.	$ 100,000	$ 142,000
W-11-8	Construct 225m of 200mm watermain on Balsum Rd from Hazel Dr to Birchwood Dr		✗			5	225	200	$ 800	/lin.m.	$ 180,000	$ 255,600
	Install Fire Hydrants, South Water System, 73 Nos.					Medium		73	$ 5,000	ea	$ 365,000	$ 518,300
	Install Fire Hydrants, North Water System, 40 Nos.					Medium		40	$ 5,000	ea	$ 200,000	$ 284,000
Subtotal												$ 21,978,547
Critical Watermain Replacements												
	Replacement of "Very High Risk" Watermains				✗	Very High			$ 25,250,847	L.S.	$ 25,250,847	$ 35,856,203
Subtotal												$ 35,856,203
100mm Watermain Upgrades												
	North Water System		✗	✗	✗	Medium	17,478	150	$ 730	/lin.m.	$ 12,758,896	$ 18,117,633
	South Water System - Outside Downtown		✗		✗	Medium	18,560	150	$ 730	/lin.m.	$ 13,548,749	$ 19,239,223
	South Water System - Inside Downtown Core		✗	✗	✗	High	1,636	200	$ 800	/lin.m.	$ 1,308,800	$ 1,858,496
Subtotal												$ 39,215,352
Additional Projects Identified at Workshop with Operations Staff												
A-1	Develop a program to field check all downstream settings for every PRV in the City's water system, and to check the lead/lag valve operational characteristics in each PRV station				✗	High			$ 150,000	ea	$ 150,000	$ 213,000
A-2	Hydrant Infill Risk Evaluation and Prioritisation Study					Medium			$ 15,000	ea	$ 15,000	$ 21,300
A-3	A Pre-Design Investigation for re-routing of the watermain through Carrie Jane Gray Park.				✗	High			$ 8,000	ea	$ 8,000	$ 11,360
A-4	Adjust the Freeman PRV (PW-633) such that the PRV is not altitude controlled via the Carney Hill Reservoir (PW-803) but pressure controlled to drops in downstream pressure		✗		✗	High			$ 5,000	ea	$ 5,000	$ 7,100
A-5	A Pre-Design Investigation to improve pressures to the upper floors of the University Hospital of Northern BC and the Ramada Hotel	✗			✗	Very High			$ 8,000	ea	$ 8,000	$ 11,360
A-6	A Conceptual Design for the interconnection of the Wilson Park West Well (PW-605) and the Fishtrap Collector Well (PW-660) to identify the size of the river crossing and pumping requirements **(currently underway)**				✗	High			$ 15,000	ea	$ 15,000	$ 21,300
A-7	A Conceptual Design to improve operational capacity at the Wilson Park East Well (PW-601) and the Cameron Pump Station (PW-602), including a review of the hydraulic and electrical upgrades needed to allow 2 pumps in each station to run			✗	✗	Very High			$ 25,000	ea	$ 25,000	$ 35,500
A-8	A Condition Assessment Investigation to carry out a review of leakage at the Cranbrook Hill Reservoir (PW-805) and possible remediation strategies				✗	High			$ 25,000	ea	$ 25,000	$ 35,500
A-9	A Conceptual Design to add an isolation valve at the Ongman PRV (PW-609) and a check valve at the Lower Hart Reservoir (PW-810).				✗	High			$ 10,000	ea	$ 10,000	$ 14,200

Table 10-2 Capital Projects List

City of Prince George - 2014 Water Service Master Plan Update

Criticality Ranking indicating Project Priority	
9 - 10	Very High
7 - 8	High
5 - 6	Medium
1 - 4	Low

Engineering and Contingency (%) 42%

ID	Description	Addresses Low Pressures	Addresses Low Fire Flows	Supports Development	Increases System Reliability	Criticality Level	Length (m)	Size (m3, HP, mm or #)	Unit Cost ($)	Unit	Cost ($)	Cost + E&C ($)
A-10	A Conceptual Design to assess the possible decommissioning of the College North (PW-621) and College South (PW-624) wells					Medium			$ 25,000	ea	$ 25,000	$ 35,500
A-11	A Conceptual Design to assess the possible decommissioning of Danson (PW-827) and BCR (PW-806) reservoirs after a new reservoir is constructed in Pressure Zone 22					Medium			$ 25,000	ea	$ 25,000	$ 35,500
A-12	A Pre-Design Investigation to construct a chlorination station at the new reservoir constructed in Pressure Zone 22				x	Medium			$ 15,000	ea	$ 15,000	$ 21,300
A-13	A Procurement Strategy and subsequent Detailed Design Investigation to incorporate the existing private well into the current Western Acres system				x	High			$ 40,000	ea	$ 40,000	$ 56,800
A-14	Large Backup Generator for the UNBC Pump Station (PW-630)				x	High			$ 75,000	ea	$ 75,000	$ 106,500
A-15	A Pre-Design Investigation to review and provide estimates to install generators or diesel pumps at each of the City's pump stations				x	High			$ 35,000	ea	$ 35,000	$ 49,700
A-16	Water Meter for the Upper Tyner PRV station (PW-643)					Low			$ 40,000	ea	$ 40,000	$ 56,800
Subtotal												$ 732,720
TOTAL												**$ 170,264,848**

ID	Description	Addresses Low Pressures	Addresses Low Fire Flows	Supports Development	Increases System Reliability	Criticality Level
Short Term High Priority Upgrades						
R-1	Construct a 2.27 ML Reservoir for Pressure Zone 25				×	8
R-2	Construct a 6.82 ML Reservoir for Pressure Zone 02				×	7
R-3	Construct a 4.55 ML Reservoir for Pressure Zone 22			×	×	10
P-1	Install a pump for fire flow servicing at the Somerville Pump Station (PW-614) ; capacity = 72 L/s (40HP)		×	×		10
P-12	Increase pumping capacity of the Fishtrap Collector Wells (PW-660) to supply Pressure Zone 2 as a backup for PW-605				×	8
W-01-1	Construct 300m of 250mm watermain from Ospika Blvd N to King Dr		×		×	9
W-01-2	Construct 80m of 250mm watermain to connect Petersen Road to Hollandia Place		×		×	7
W-01-3	Construct 1050m of 900mm watermain to connect the Fishtrap Collector Wells (PW-660) to the Wilson Park West Wells (PW-605) **(study to confirm sizing currently underway)**				×	8
W-01-4	Recreation Place Improvements **(study currently underway)**		×		×	8
W-02-3	Construct 430m of 300mm watermain along Ontario Street from 1st Ave to 5th Ave		×		×	7
W-02-4	Construct 350m of 300mm watermain along Ottawa Street from 1st Ave to 4th Ave		×		×	7
W-02-5	Construct 150m of 250mm watermain along Patricia Blvd from Queensway to Ingledew Street		×		×	7
W-02-7	Construct 700m of 250mm watermain from Hwy 97 to Jasper Street		×		×	7
W-02-9	Construct 100m of 200mm watermain along 7th Ave from Wainwright St to Alward St		×	×	×	6
W-02-10	Contruct 15m of 200mm watermain to connect parallel watermains running on Norwood St				×	5
W-02-11	Abandon section of watermain west of intersection of Queensway and Regent Cres				×	4
W-04-1	Construct 500m of 300mm watermain to connect Vista View Road to the Zone 4 watermain on North Street and Cathedral Avenue	×	×	×	×	9
W-04-2	Construct 120m of 250mm watermain to connect Marleau Road to O'Grady Road		×		×	7
W-06-1	Construct 140m of 200mm watermain to connect Westmount Drive to Hillcrest Road		×		×	7
W-06-2	Construct 220m of 300mm watermain on Bear Rd		×	×	×	9
W-06-3	Construct 500m of 200mm watermain on Henry Rd		×	×	×	9
W-07-1	Construct 160 metres of 250mm watermain to connect watermains on Ring Road		×		×	8
W-07-2	Increase D/S pressure setting at the Crest PRV (PW-622) from 91 psi (64 m) to 121 psi (85 m)		×			8
Short Term Low Priority Upgrades						
P-2 / W-02-8	Construct a pump/PRV station across the Fraser River with capacity of 54 L/s (30HP) to connect Pressure Zone 1 to Pressure Zone 15			×	×	7
P-3 / T-3	Increase pumping capacity of the Patricia Pump Station (PW-623) from 82 L/s to 183 L/s (200HP)		×	×		9
T-1	Construct 3,810m of 750mm watermain from the Fishtrap Collector Well (PW-660) to Cranbrook Hill Reservoir (PW-805)				×	6
W-02-1	Construct a new PRV station at intersection of 20th Ave and Griffiths Ave		×		×	8
W-02-6 / T-2	Construct 1,990m of 350mm watermain on Hwy 97 from Hwy 16 to existing stub			×	×	7
W-22-1	Construct a new PRV station at the intersection of Sintich Road to connect Pressure Zone 22 with Pressure Zone 15			×	×	7

ID	Description	Addresses Low Pressures	Addresses Low Fire Flows	Supports Development	Increases System Reliability	Criticality Level
Long Term Upgrades						
R-4	Construct a 2.27 ML Reservoir for Pressure Zone 07				×	6
R-5	Construct a 4.55 ML Reservoir for Pressure Zone 02				×	5
P-4	Increase pumping capacity of the Wilson Park East Well (PW-601) from 544 L/s to 728 L/s (40HP)	×		×		7
P-5	Increase pumping capacity of the Cameron Pump Station (PW-602) from 544 L/s to 728 L/s (250HP)	×		×		7
P-6	Increase pumping capacity of the Wilson Park West Well (PW-605) from 816 L/s to 878 L/s (100HP)			×		7
P-7/T-4	Increase pumping capacity of the UNBC Pump Station (PW-630) from 42 L/s to 224 L/s (550HP)			×		7
W-03-1A	Construct 400m of 300mm watermain from McGill Crescent to Cowart Road		×		×	5
W-03-1B	Construct 675m of 300mm watermain along Cowart Road north from Simon Fraser Ave		×		×	5
W-03-1C	Close watermain crossing Hwy16		×		×	5
W-04-3A	Construct PRV station at intersection of Baker Rd and Davis Dr	×	×		×	7
W-04-3B	Construct PRV station at intersection of Wheeler Road and Hwy 16	×	×		×	7
W-04-3C	Close watermain crossing Hwy16 at Eton Avenue		×		×	7
	Install Fire Hydrants, South Water System, 73 Nos.					Medium
Critical Watermain Replacements						
	Replacement of "Very High Risk" Watermains				×	Very High
100mm Watermain Upgrades						
	South Water System - Outside Downtown		×		×	Medium
	South Water System - Inside Downtown Core		×	×	×	High
Additional Projects Identified at Workshop with Operations Staff						
A-1	Develop a program to field check all downstream settings for every PRV in the City's water system, and to check the lead/lag valve operational characteristics in each PRV station				×	High
A-2	Hydrant Infill Risk Evaluation and Prioritisation Study					Medium
A-3	A Pre-Design Investigation for re-routing of the watermain through Carrie Jane Gray Park.				×	High
A-4	Adjust the Freeman PRV (PW-633) such that the PRV is not altitude controlled via the Carney Hill Reservoir (PW-803) but pressure controlled to drops in downstream pressure		×		×	High
A-5	A Pre-Design Investigation to improve pressures to the upper floors of the University Hospital of Northern BC and the Ramada Hotel	×			×	Very High
A-6	A Conceptual Design for the interconnection of the Wilson Park West Well (PW-605) and the Fishtrap Collector Well (PW-660) to identify the size of the river crossing and pumping requirements **(currently underway)**				×	High
A-7	A Conceptual Design to improve operational capacity at the Wilson Park East Well (PW-601) and the Cameron Pump Station (PW-602), including a review of the hydraulic and electrical upgrades needed to allow 2 pumps in each station to run			×	×	Very High
A-8	A Condition Assessment Investigation to carry out a review of leakage at the Cranbrook Hill Reservoir (PW-805) and possible remediation strategies				×	High
A-10	A Conceptual Design to assess the possible decommissioning of the College North (PW-621) and College South (PW-624) wells					Medium
A-11	A Conceptual Design to assess the possible decommissioning of Danson (PW-827) and BCR (PW-806) reservoirs after a new reservoir is constructed in Pressure Zone 22					Medium
A-12	A Pre-Design Investigation to construct a chlorination station at the new reservoir constructed in Pressure Zone 22				×	Medium
A-13	A Procurement Strategy and subsequent Detailed Design Investigation to incorporate the existing private well into the current Western Acres system				×	High
A-14	Large Backup Generator for the UNBC Pump Station (PW-630)				×	High
A-15	A Pre-Design Investigation to review and provide estimates to install generators or diesel pumps at each of the City's pump stations				×	High
A-16	Water Meter for the Upper Tyner PRV station (PW-643)					Low

Legend

- Ground Well
- Storage Reservoir
- Well/Booster Pump Station
- PRV
- Existing Watermains
- Watermain Upgrades
- 100mm Watermains
- Very High Risk Assets

- Pressure Zone 01
- Pressure Zone 02
- Pressure Zone 03
- Pressure Zone 04
- Pressure Zone 06
- Pressure Zone 07
- Pressure Zone 15
- Pressure Zone 16
- Pressure Zone 21
- Pressure Zone 22
- Pressure Zone 23
- Pressure Zone 25
- Pressure Zone 07A

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CITY OF PRINCE GEORGE

City of Prince George
Water System Improvement Projects - South of Nechako River

Figure 10-1

1:17,500 @ ANSI-D

Scale: 0 170 340 680 Meters

Path: G:\opus_dk\municipal\174 Prince George\gis\D-174.60 Water Service Network Plan Update\Figure 10-1 - South System Improvements D-size-V10.mxd

ID	Description	Addresses Low Pressures	Addresses Low Fire Flows	Supports Development	Increases System Reliability	Criticality Level
Short Term High Priority Upgrades						
P-8	Increase pumping capacity of the Vellencher Pump Station (PW-615) from 20 L/s to 28 L/s (10HP)	×				8
P-9	Install a pump for fire flow servicing at the Vellencher Pump Station (PW-615); capacity = 167 L/s (150HP)		×			10
P-10	Install a pump for fire flow servicing at the Inverness Pump Station (PW-619); capacity = 151 L/s (200HP)		×			9
T-6	Install check valve on transmission main leading up to the Vellencher Reservoir (PW-817)			×	×	10
W-08-1	Construct 75m of 350mm watermain to connect Winston Road to North Nechako Road		×		×	7
W-08-2	Construct 120m of 200mm watermain to connect Winston Road and Michael Road		×		×	7
W-08-3	Construct 1,560m of 300mm watermain along North Nechako Road from Rustad Road to Richard Road		×			9
W-09-1	Construct 155m of 200mm watermain along Noranda Rd W from Sloan Road to Hwy 97		×		×	8
W-09-2	Construct 850m of 250mm watermain on Noranda Rd E		×		×	8
W-09-3	Construct 120m of 350mm watermain on Northwood Pulp Mill Rd from Hart Hwy to Aberdeen Rd		×	×		9
W-09-4	Construct 1,011m of 400mm watermain from the Lower Hart Reservoir (PW-810) to the intersection of Hart Hwy and Northwood Pulp Mill Rd		×	×		9
W-10-1	Construct 400m of 300mm watermain from Lehman Street to Grant Road		×		×	9
W-10-2	Construct 260m of 300mm watermain across Hart Hwy north of Collins Road		×		×	9
W-11-1	Construct 860m of 350mm watermain from Highland Drive and Wallace Crescent to Sussex Lane and Wildwood Crescent		×			9
W-11-2	Construct 500m of 200mm watermain on Clown Dr from Vellencher Rd to Austin Rd W		×			8
W-11-3	Construct 740m of 200mm watermain east of Dawson Rd from Austin Rd to Cluff Rd		×			8
W-11-4	Construct 1,724m of 450mm watermain along Kelly Road S from Austin Road W to Chief Lake Road, and 605m of 300mm watermain along Hwy 97 from Chief Lake Road to Karin Road		×	×		8
W-11-5	Construct 350m of 300mm watermain on Chief Lake Rd from Sabyam Road to Hart Hwy		×			7
W-11-6	Construct 800m of 200mm watermain from Zral Rd to Sparwood Rd		×		×	7
W-11-9	Construct 1310m of 200mm watermain on from intersection of Austin Road and Hart Hwy to the Cook PRV (PW-612)		×	×		8
W-11-10	Construct 575m of 200mm watermain to connect Turner Rd to Richet St (New Watermain Loop)		×	×	×	8

ID	Description	Addresses Low Pressures	Addresses Low Fire Flows	Supports Development	Increases System Reliability	Criticality Level
Short Term Low Priority Upgrades						
T-5	Construct 3,450m of 400mm watermain from Foothills Pump Station (PW-650) to Vellencher Reservoir (PW-817). A new PRV Station should be added to provide water mid-way to Pressure Zone 11 at Highland Drive to service fire flows.	×	×	×	×	10
Long Term Upgrades						
P-11	Increase pumping capacity of the Foothills Pump Station (PW-650) from 270 L/s to 312 L/s (100HP)	×	×	×		6
W-10-3	Construct 450m of 300mm watermain along Banzer Drive		×		×	5
W-10-4	Construct 190m of 250mm watermain along Hartway Drive		×		×	5
W-11-7	Various valve closures and openings to expand the area serviced by Pressure Zone 11	×				5
W-11-7A	Construct 105m of 200mm watermain to connect Poyner Crescent to Wallace Crescent	×				5
W-11-7B	Construct 125m of 200mm watermain along Wallace Crescent north of Highland Drive	×				5
W-11-8	Construct 225m of 200mm watermain on Balsum Rd from Hazel Dr to Birchwood Dr		×			5
W-11-9	Install Fire Hydrants, North Water System, 40 Nos.					Medium
Critical Watermain Replacements						
	Replacement of "Very High Risk" Watermains				×	Very High
100mm Watermain Upgrades						
	North Water System		×	×	×	Medium
Additional Projects Identified at Workshop with Operations Staff						
A-1	Develop a program to field check all downstream settings for every PRV in the City's water system, and to check the lead/lag valve operational characteristics in each PRV station				×	High
A-2	Hydrant Infill Risk Evaluation and Prioritisation Study					Medium
A-9	A Conceptual Design to add an isolation valve at the Ongman PRV (PW-609) and a check valve at the Lower Hart Reservoir (PW-810).				×	High
A-15	A Pre-Design Investigation to review and provide estimates to install generators or diesel pumps at each of the City's pump stations				×	High

Legend

- Ground Well
- Storage Reservoir
- Well/Booster Pump Station
- PRV
- Existing Watermains
- Watermain Upgrades
- 100mm Watermains
- Very High Risk Assets

- Pressure Zone 08
- Pressure Zone 09
- Pressure Zone 10
- Pressure Zone 11
- Pressure Zone 12
- Pressure Zone 13

W-11-6 W-11-5 W-11-4 W-11-3 W-11-10 W-11-2 W-11-8 W-11-9 W-11-7 W-11-7A W-11-7B W-11-1 T-5 T-6 P-8, P-9 P-11 W-10-1 W-10-2 W-10-3 W-10-4 W-9-1 W-9-2 W-09-3 W-09-4 P-10 W-08-1 W-08-2 W-08-3

PW817 Vellencher Reservoir; PW615 Vellencher PS; PW612 Cook PRV; PW617 Croft PRV; PW611 Randle PRV; PW640 Knell PRV; PW860 Foothills Reservoir; PW650 Foothills PS; PW607 Meadowbrook PRV; PW660 Fishtrap Well; PW832 Edgewood Reservoir; PW619 Inverness PS; PW810 Lower Hart Reservoir; PW609 Ongman PRV

PZ 10; PZ 11; PZ 12; PZ 09; PZ 13; PZ 08; PZ 02

ZRAL RD; KELLY RD; VIKING RD; HOLDNER RD; NIELSON RD; TIMBERRY DR; VENTA DR; HART HWY; FISHER RD; WAPITI RD; GREENWOOD ST; KILLY RD; WELSH RD; KNIGHT CRES; ESTAVILLA DR; GLENDALE DR; FOOTHILLS BLVD; CHIEF LAKE RD; WREN RD; SPARROW RD; DOMASELA RD; FLAMINGO PL; PEFFER RD; HART HIGHWAY FRNTG; ARABIAN RD; CHESTNUT DR; SABYAM RD; DIAMOND DR; JADE DR; EMERALD DR; BRONS RD; OPAL DR; NORDIC DR; MARTIN RD; RUBY CRES; KINCHEN DR; CARR RD; PEARL DR; GRAY DR; HEATHER RD; LILAC CRES; RICHET ST; TULIP RD; EDELWEISS RD; BURKITT PL; BOSCHUMA PL; MADILL RD; TAFT DR; HOOVER DR; GLENVIEW DR; HELM DR; LANGER CRES; RACE RD; AUSTIN RD; ADAM DR; DAWSON RD; EVA DR; BUTTE PL; VALLEYVIEW DR; VERA ST; OLYMPIA PL; MONTEREY RY RD; SETON CRES; DRIFTWOOD RD; BIRCHWOOD CRES; BALSUM RD; HAZEL DR; COTTONWOOD PL; KIM PL; WINSLOW DR; CROFT RD; GAMBRIDGE CRES; INGALA DR; LEPPINGTON PL; COOK CRES; LEHMAN ST; HARTWAY DR; BANZER PL; LANE; RANDLE RD; KNELL RD; SILVERCREST RD; SLOAN RD; SUMMERHILL RD; BUBA RD; WAGON TRAIL RD; NORANDA RD; PERRIN HTS; PERRIN RD; ALDERWOOD CRT; BRENTWOOD; BELLAMY RD; CLEARWOOD CRES; NORTHWOOD PULPMILL RD; EDINBURGH RD; MEYER RD; GUBBINS DR; LEGGATT RD; CLUBHOUSE DR; LINKS DR; MCKINLAY DR; BELLARD RD; HART HIGHWAY FRNTG; PERTH RD; GLADSTONE RD; SKYLINE DR; NORTHWOOD RD; CLAIRMONT RD; GLENEAGLE PL; MACKENZIE PL; MACINTYRE DR; HARDY RD; IONA RD; WILLOWBROOK RD; SHADY VALLEY RD; WILM RD; FRASER FLATS RD; HOFERKAMP RD; PG PULPMILL RD; CUTBANK RD; WOLCZUK RD; NORTH NECHAKO RD; RAMP; RIVERVIEW RD; OTWAY RD; NORTH MEADOW RD; DEVER RD; CHURCHILL RD; MICHAEL RD; CRAIG DR; STEVENS DR; RUSTAD RD; HAVERLY RD; SUTHERLAND RD; PRESTON RD; POZER RD; TOMLIN RD; ONGMAN RD; LEONARD PL; RYSER AVE; REBELO DR; CLAIRE CRES; STROM PL; HERITAGE CRES; MCGOWAN DR; STIRLING DR; ELSIN PL; DUNCAN PL; CRIEFF PL; OSPIKA BLVD; BLAIR CRES; AYR PL; KING DR; GALINIS AVE; FLYNN AVE; EWEN AVE; TABOR BLVD; DORNBIERER CRES; ZIMMARO AVE; WADE ST; WOOD PL; 1ST AVE; VAN SOMER ST; THACKER CRES; SKINNER ST; FREIMILLER AVE; NEFF CRES; CLAXTON CRES; BAUCH AVE; LANE; GORLESS CRES; BAXTER AVE; MCKINLEY CRES; ALLEN AVE; MCQUEEN CRES; MCPHERSON PL; PARKER DR; MCDERMID DR; MCIVOR ST; MCLEAN DR; GORDON CRES; MCINTYRE CRES; RADCLIFFE DR; QUINN ST; DEZELL DR; CARLISLE WAY; PANORAMA CRES; SKOLDER DR; REDBERN DR; WILDWOOD CRES; MOREENEN CRES; NIXON CRES; KILLARNEY DR; JOSEPH PL; CALVIN LANE; DIANDER DR; REBENACK RD; HIGHLAND DR; LANGLEY CRES; SANDERSON CRES; BERGER CRES; CANNON DR; BURKITT PL; EEDELWEISS RD; TULIP RD; LILAC CRES; HEATHER RD; GRAY DR; RICHET ST; MADILL RD; RACE RD; HART HIGHWAY FRNTG; DRIFTWOOD RD; BIRCHWOOD CRES; BALSUM RD; HAZEL DR; COTTONWOOD PL; KIM PL; WINSLOW DR; CROFT RD; GAMBRIDGE CRES; INGALA DR; LEPPINGTON PL; COOK CRES; LEHMAN ST; HARTWAY DR; BANZER PL; LANE; RANDLE RD; KNELL RD; SILVERCREST RD; SLOAN RD; SUMMERHILL RD; BUBA RD; WAGON TRAIL RD; NORANDA RD; PERRIN HTS; PERRIN RD; ALDERWOOD CRT; BRENTWOOD; BELLAMY RD; CLEARWOOD CRES; NORTHWOOD PULPMILL RD; EDINBURGH RD; MEYER RD; GUBBINS DR; LEGGATT RD; CLUBHOUSE DR; LINKS DR; MCKINLAY DR; BELLARD RD; HART HIGHWAY FRNTG; PERTH RD; GLADSTONE RD; SKYLINE DR; NORTHWOOD RD; CLAIRMONT RD; GLENEAGLE PL; MACKENZIE PL; MACINTYRE DR; HARDY RD; IONA RD; WILLOWBROOK RD; SHADY VALLEY RD; WILM RD; FRASER FLATS RD; HOFERKAMP RD; PG PULPMILL RD; CUTBANK RD; WOLCZUK RD; NORTH NECHAKO RD; RAMP; RIVERVIEW RD; OTWAY RD; NORTH MEADOW RD; DEVER RD; CHURCHILL RD; MICHAEL RD; CRAIG DR; STEVENS DR; RUSTAD RD; HAVERLY RD; SUTHERLAND RD; PRESTON RD; POZER RD; TOMLIN RD; ONGMAN RD; LEONARD PL; RYSER AVE; REBELO DR; CLAIRE CRES; STROM PL; HERITAGE CRES; MCGOWAN DR; STIRLING DR; ELSIN PL; DUNCAN PL; CRIEFF PL; OSPIKA BLVD; BLAIR CRES; AYR PL; KING DR; GALINIS AVE; FLYNN AVE; EWEN AVE; TABOR BLVD; DORNBIERER CRES; ZIMMARO AVE; WADE ST; WOOD PL; 1ST AVE; VAN SOMER ST; THACKER CRES; SKINNER ST; FREIMILLER AVE; NEFF CRES; CLAXTON CRES; BAUCH AVE; LANE; GORLESS CRES; BAXTER AVE; MCKINLEY CRES; ALLEN AVE; MCQUEEN CRES; MCPHERSON PL; PARKER DR; MCDERMID DR; MCIVOR ST; MCLEAN DR; GORDON CRES; MCINTYRE CRES; RADCLIFFE DR; QUINN ST; DEZELL DR; CARLISLE WAY; PANORAMA CRES; SKOLDER DR; REDBERN DR; WILDWOOD CRES; MOREENEN CRES; NIXON CRES; KILLARNEY DR; JOSEPH PL; CALVIN LANE; DIANDER DR; REBENACK RD; HIGHLAND DR; LANGLEY CRES; SANDERSON CRES; BERGER CRES; CANNON DR; BURKITT PL; EEDELWEISS RD; TULIP RD; LILAC CRES; HEATHER RD; GRAY DR; RICHET ST; MADILL RD; RACE RD; HART HIGHWAY FRNTG; DRIFTWOOD RD; BIRCHWOOD CRES; BALSUM RD; HAZEL DR; COTTONWOOD PL; KIM PL; WINSLOW DR; CROFT RD; GAMBRIDGE CRES; INGALA DR; LEPPINGTON PL; COOK CRES; LEHMAN ST; HARTWAY DR; BANZER PL; LANE; RANDLE RD; KNELL RD; SILVERCREST RD; SLOAN RD; SUMMERHILL RD; BUBA RD; WAGON TRAIL RD; NORANDA RD; PERRIN HTS; PERRIN RD; ALDERWOOD CRT; BRENTWOOD; BELLAMY RD; CLEARWOOD CRES; NORTHWOOD PULPMILL RD; EDINBURGH RD; MEYER RD; GUBBINS DR; LEGGATT RD; CLUBHOUSE DR; LINKS DR; MCKINLAY DR; BELLARD RD; HART HIGHWAY FRNTG; PERTH RD; GLADSTONE RD; SKYLINE DR; NORTHWOOD RD; CLAIRMONT RD; GLENEAGLE PL; MACKENZIE PL; MACINTYRE DR

N W E S

OPUS DAYTONKNIGHT

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CITY OF PRINCE GEORGE

City of Prince George
Water System Improvement Projects - North of Nechako River

Figure 10-2

1:12,500 @ ANSI-D

Scale: 0 120 240 480 Meters

Path: G:\opus_dk\municipal\174 Prince George\gis\D-174.60 Water Service Network Plan Update\Figure 10-2 - North System Improvements D-size V.10.0.mxd



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Appendix A
Peak Hour Demand Calculation

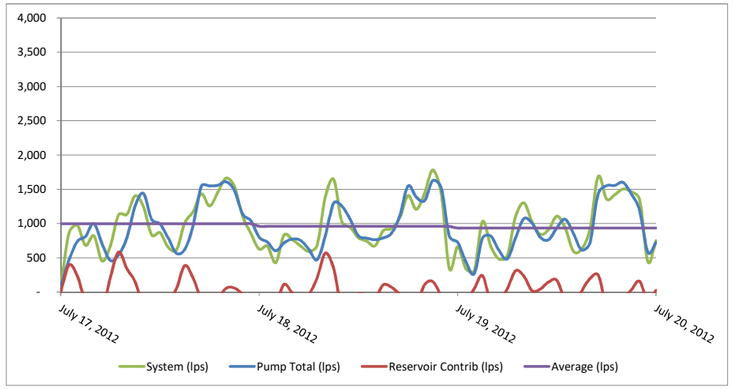
PEAK HOUR DEMAND = 1,782 lps

South 1,453

Total flow

	Pump Total (lps)	Reservoir Contrib (lps)	System (lps)	Average (lps)
17-07-2012 0:00	95	-	95	998
17-07-2012 1:00	468	394	862	998
17-07-2012 2:00	739	238	977	998
17-07-2012 3:00	813	-131	682	998
17-07-2012 4:00	1,001	-178	822	998
17-07-2012 5:00	704	-250	454	998
17-07-2012 6:00	461	214	675	998
17-07-2012 7:00	543	585	1,128	998
17-07-2012 8:00	790	342	1,133	998
17-07-2012 9:00	1,258	148	1,406	998
17-07-2012 10:00	1,440	-192	1,248	998
17-07-2012 11:00	1,061	-227	834	998
17-07-2012 12:00	995	-128	868	998
17-07-2012 13:00	790	-135	654	998
17-07-2012 14:00	565	51	616	998
17-07-2012 15:00	623	387	1,009	998
17-07-2012 16:00	966	206	1,172	998
17-07-2012 17:00	1,544	-110	1,434	998
17-07-2012 18:00	1,549	-293	1,257	998
17-07-2012 19:00	1,558	-102	1,457	998
17-07-2012 20:00	1,610	55	1,665	998
17-07-2012 21:00	1,483	60	1,543	998
17-07-2012 22:00	1,140	-35	1,106	998
17-07-2012 23:00	1,042	-188	854	998
18-07-2012 0:00	801	-173	628	960
18-07-2012 1:00	730	-60	670	960
18-07-2012 2:00	602	-172	430	960
18-07-2012 3:00	717	114	831	960
18-07-2012 4:00	774	-10	764	960
18-07-2012 5:00	754	-80	675	960
18-07-2012 6:00	625	-30	594	960
18-07-2012 7:00	473	208	681	960
18-07-2012 8:00	821	569	1,391	960
18-07-2012 9:00	1,298	348	1,646	960
18-07-2012 10:00	1,254	-226	1,028	960
18-07-2012 11:00	1,063	-119	944	960
18-07-2012 12:00	822	-28	793	960
18-07-2012 13:00	788	-44	744	960
18-07-2012 14:00	765	-90	675	960
18-07-2012 15:00	791	106	896	960
18-07-2012 16:00	859	71	930	960
18-07-2012 17:00	1,113	-31	1,082	960
18-07-2012 18:00	1,548	-139	1,409	960
18-07-2012 19:00	1,386	-178	1,208	960
18-07-2012 20:00	1,335	107	1,442	960
18-07-2012 21:00	1,629	153	1,782	960
18-07-2012 22:00	1,526	-75	1,451	960
18-07-2012 23:00	817	-472	344	960
19-07-2012 0:00	728	-67	660	935
19-07-2012 1:00	445	-104	340	935
19-07-2012 2:00	268	48	316	935
19-07-2012 3:00	787	242	1,028	935
19-07-2012 4:00	818	-149	670	935
19-07-2012 5:00	608	-126	482	935
19-07-2012 6:00	485	47	532	935
19-07-2012 7:00	790	311	1,101	935
19-07-2012 8:00	1,070	235	1,304	935
19-07-2012 9:00	1,006	20	1,026	935
19-07-2012 10:00	799	44	843	935
19-07-2012 11:00	765	148	913	935
19-07-2012 12:00	937	171	1,108	935
19-07-2012 13:00	1,063	-125	938	935
19-07-2012 14:00	855	-260	595	935
19-07-2012 15:00	613	15	628	935
19-07-2012 16:00	719	196	915	935
19-07-2012 17:00	1,438	248	1,686	935
19-07-2012 18:00	1,553	-194	1,359	935
19-07-2012 19:00	1,556	-135	1,420	935
19-07-2012 20:00	1,601	-96	1,505	935
19-07-2012 21:00	1,433	32	1,465	935
19-07-2012 22:00	1,195	158	1,353	935
19-07-2012 23:00	583	-136	447	935
20-07-2012 0:00	726	26	752	935

DATE	602	605	624	625	627	660	DAILY TOTALS	daily (m3)	daily (lps)	
17-Jul-12	13826	46150	5840	114	1914	12693	80537	80537	932.1	998
18-Jul-12	15534	54090	4724	100	1982	13467	89897	89897	1040.5	960
19-Jul-12	14829	48310	6636	116	1981	11865	83737	83737	969.2	935
20-Jul-12	14447	48770	4873	112	2069	13543	83814	83814	970.1	



Total flow

	Pump Total (lps)	Reservoir Contrib (lps)	System (lps)	Average (lps)
17-07-2012 0:00	93	309	402	849
17-07-2012 1:00	466	156	622	849
17-07-2012 2:00	737	-202	536	849
17-07-2012 3:00	784	-235	549	849
17-07-2012 4:00	747	-160	588	849
17-07-2012 5:00	512	236	748	849
17-07-2012 6:00	460	446	906	849
17-07-2012 7:00	542	212	754	849
17-07-2012 8:00	789	8	797	849
17-07-2012 9:00	1,006	-130	875	849
17-07-2012 10:00	1,186	-142	1,045	849
17-07-2012 11:00	801	-31	770	849
17-07-2012 12:00	759	-47	712	849
17-07-2012 13:00	788	-48	741	849
17-07-2012 14:00	563	318	882	849
17-07-2012 15:00	608	147	754	849
17-07-2012 16:00	711	19	731	849
17-07-2012 17:00	1,286	-213	1,072	849
17-07-2012 18:00	1,294	-74	1,220	849
17-07-2012 19:00	1,302	54	1,356	849
17-07-2012 20:00	1,563	-110	1,453	849
17-07-2012 21:00	1,482	-189	1,292	849
17-07-2012 22:00	908	-87	821	849
17-07-2012 23:00	785	-26	758	849
18-07-2012 0:00	540	75	615	823
18-07-2012 1:00	537	-90	447	823
18-07-2012 2:00	601	54	655	823
18-07-2012 3:00	716	-88	628	823
18-07-2012 4:00	524	40	564	823
18-07-2012 5:00	491	44	535	823
18-07-2012 6:00	539	125	664	823
18-07-2012 7:00	472	420	892	823
18-07-2012 8:00	820	199	1,019	823
18-07-2012 9:00	1,215	-305	910	823
18-07-2012 10:00	998	-41	957	823
18-07-2012 11:00	804	42	846	823
18-07-2012 12:00	799	-131	667	823
18-07-2012 13:00	787	-165	622	823
18-07-2012 14:00	707	86	793	823
18-07-2012 15:00	537	213	750	823
18-07-2012 16:00	602	97	699	823
18-07-2012 17:00	851	-49	802	823
18-07-2012 18:00	1,292	-141	1,151	823
18-07-2012 19:00	1,300	3	1,303	823
18-07-2012 20:00	1,333	-44	1,290	823
18-07-2012 21:00	1,610	-233	1,377	823
18-07-2012 22:00	1,272	-357	916	823
18-07-2012 23:00	556	87	643	823
19-07-2012 0:00	464	49	513	794
19-07-2012 1:00	228	154	382	794
19-07-2012 2:00	267	142	409	794
19-07-2012 3:00	785	-224	562	794
19-07-2012 4:00	757	-166	591	794
19-07-2012 5:00	351	171	522	794
19-07-2012 6:00	235	397	633	794
19-07-2012 7:00	536	321	857	794
19-07-2012 8:00	984	-78	905	794
19-07-2012 9:00	1,005	-121	884	794
19-07-2012 10:00	797	11	809	794
19-07-2012 11:00	764	41	805	794
19-07-2012 12:00	729	-32	697	794
19-07-2012 13:00	809	-155	655	794
19-07-2012 14:00	789	-28	761	794
19-07-2012 15:00	612	117	729	794
19-07-2012 16:00	718	159	876	794
19-07-2012 17:00	1,230	-131	1,100	794
19-07-2012 18:00	1,293	-76	1,217	794
19-07-2012 19:00	1,297	-79	1,217	794
19-07-2012 20:00	1,344	43	1,388	794
19-07-2012 21:00	1,345	55	1,400	794
19-07-2012 22:00	1,193	-260	933	794
19-07-2012 23:00	502	32	534	794
20-07-2012 0:00	469	-	469	794

North 256

Total flow

	Pump Total (lps)	Reservoir Contrib (lps)	System (lps)	Average (lps)
17-07-2012 0:00	-	85	85	140
17-07-2012 1:00	-	82	82	140
17-07-2012 2:00	-	71	71	140
17-07-2012 3:00	27	58	85	140
17-07-2012 4:00	252	-90	162	140
17-07-2012 5:00	191	-21	170	140
17-07-2012 6:00	-	140	140	140
17-07-2012 7:00	-	131	131	140
17-07-2012 8:00	-	139	139	140
17-07-2012 9:00	251	-63	188	140
17-07-2012 10:00	253	-86	167	140
17-07-2012 11:00	259	-98	161	140
17-07-2012 12:00	235	-89	146	140
17-07-2012 13:00	-	98	98	140
17-07-2012 14:00	-	68	68	140
17-07-2012 15:00	14	60	74	140
17-07-2012 16:00	253	-129	125	140
17-07-2012 17:00	257	-79	178	140
17-07-2012 18:00	254	-28	226	140
17-07-2012 19:00	255	1	256	140
17-07-2012 20:00	45	170	215	140
17-07-2012 21:00	-	155	155	140
17-07-2012 22:00	231	-101	130	140
17-07-2012 23:00	256	-146	110	140
18-07-2012 0:00	260	-134	126	140
18-07-2012 1:00	191	-82	110	140
18-07-2012 2:00	-	60	60	140
18-07-2012 3:00	-	78	78	140
18-07-2012 4:00	249	-120	129	140
18-07-2012 5:00	262	-75	188	140
18-07-2012 6:00	84	84	168	140
18-07-2012 7:00	-	149	149	140
18-07-2012 8:00	-	148	148	140
18-07-2012 9:00	82	78	160	140
18-07-2012 10:00	255	-78	177	140
18-07-2012 11:00	258	-69	188	140
18-07-2012 12:00	22	87	109	140
18-07-2012 13:00	-	75	75	140
18-07-2012 14:00	57	20	77	140
18-07-2012 15:00	253	-141	111	140
18-07-2012 16:00	256	-128	128	140
18-07-2012 17:00	261	-91	170	140
18-07-2012 18:00	255	-38	217	140
18-07-2012 19:00	85	103	188	140
18-07-2012 20:00	-	196	196	140
18-07-2012 21:00	17	158	175	140
18-07-2012 22:00	253	-115	138	140
18-07-2012 23:00	260	-154	106	140
19-07-2012 0:00	263	-153	110	143
19-07-2012 1:00	215	-106	109	143
19-07-2012 2:00	-	100	100	143
19-07-2012 3:00	-	75	75	143
19-07-2012 4:00	60	40	100	143
19-07-2012 5:00	256	-125	131	143
19-07-2012 6:00	249	-87	162	143
19-07-2012 7:00	253	-87	167	143
19-07-2012 8:00	85	98	183	143
19-07-2012 9:00	-	165	165	143
19-07-2012 10:00	-	136	136	143
19-07-2012 11:00	-	129	129	143
19-07-2012 12:00	207	-92	115	143
19-07-2012 13:00	252	-105	147	143
19-07-2012 14:00	65	43	108	143
19-07-2012 15:00	-	80	80	143
19-07-2012 16:00	-	90	90	143
19-07-2012 17:00	206	-63	143	143
19-07-2012 18:00	259	-59	199	143
19-07-2012 19:00	258	-17	241	143
19-07-2012 20:00	256	-11	245	143
19-07-2012 21:00	86	103	190	143
19-07-2012 22:00	-	125	125	143
19-07-2012 23:00	79	-6	74	143
20-07-2012 0:00	256	-	256	143

Western Acres 2.24

Total flow

	Pump Total (lps)	Reservoir Contrib (lps)	System (lps)	Average (lps)
17-07-2012 0:00	1.32	0.19	1.51	1.22
17-07-2012 1:00	1.32	0.22	1.53	1.22
17-07-2012 2:00	1.32	0.21	1.53	1.22
17-07-2012 3:00	1.32	-0.87	0.45	1.22
17-07-2012 4:00	1.32	-0.86	0.46	1.22
17-07-2012 5:00	1.32	-0.90	0.42	1.22
17-07-2012 6:00	1.32	-0.85	0.47	1.22
17-07-2012 7:00	1.32	-0.57	0.75	1.22
17-07-2012 8:00	1.32	0.60	1.92	1.22
17-07-2012 9:00	1.32	0.46	1.78	1.22
17-07-2012 10:00	1.32	0.57	1.89	1.22
17-07-2012 11:00	1.32	0.79	2.11	1.22
17-07-2012 12:00	1.32	0.63	1.95	1.22
17-07-2012 13:00	1.32	0.60	1.92	1.22
17-07-2012 14:00	1.32	0.29	1.61	1.22
17-07-2012 15:00	1.32	-0.49	0.83	1.22
17-07-2012 16:00	1.32	-0.45	0.87	1.22
17-07-2012 17:00	1.32	-0.24	1.08	1.22
17-07-2012 18:00	1.32	-0.07	1.25	1.22
17-07-2012 19:00	1.32	-0.19	1.13	1.22
17-07-2012 20:00	1.32	-0.23	1.09	1.22
17-07-2012 21:00	1.32	-0.25	1.07	1.22
17-07-2012 22:00	1.32	-0.44	0.88	1.22
17-07-2012 23:00	1.32	-0.60	0.72	1.22
18-07-2012 0:00	1.16	-0.82	0.33	1.23
18-07-2012 1:00	1.16	0.00	1.16	1.23
18-07-2012 2:00	1.16	0.39	1.54	1.23
18-07-2012 3:00	1.16	0.43	1.59	1.23
18-07-2012 4:00	1.16	0.46	1.62	1.23
18-07-2012 5:00	1.16	0.49	1.65	1.23
18-07-2012 6:00	1.16	0.31	1.47	1.23
18-07-2012 7:00	1.16	0.50	1.66	1.23
18-07-2012 8:00	1.16	0.57	1.73	1.23
18-07-2012 9:00	1.16	0.58	1.74	1.23
18-07-2012 10:00	1.16	-0.21	0.95	1.23
18-07-2012 11:00	1.16	-0.54	0.62	1.23
18-07-2012 12:00	1.16	-0.46	0.70	1.23
18-07-2012 13:00	1.16	-0.68	0.48	1.23
18-07-2012 14:00	1.16	-0.79	0.37	1.23
18-07-2012 15:00	1.16	-0.75	0.41	1.23
18-07-2012 16:00	1.16	-0.51	0.65	1.23
18-07-2012 17:00	1.16	1.08	2.24	1.23
18-07-2012 18:00	1.16	1.00	2.16	1.23
18-07-2012 19:00	1.16	0.90	2.06	1.23
18-07-2012 20:00	1.16	0.83	1.99	1.23
18-07-2012 21:00	1.16	-0.05	1.10	1.23
18-07-2012 22:00	1.16	-0.45	0.70	1.23
18-07-2012 23:00	1.16	-0.48	0.68	1.23
19-07-2012 0:00	1.34	-0.79	0.55	1.23
19-07-2012 1:00	1.34	-0.89	0.45	1.23
19-07-2012 2:00	1.34	-0.89	0.46	1.23
19-07-2012 3:00	1.34	-0.13	1.21	1.23
19-07-2012 4:00	1.34	0.31	1.65	1.23
19-07-2012 5:00	1.34	0.43	1.77	1.23
19-07-2012 6:00	1.34	0.39	1.73	1.23
19-07-2012 7:00	1.34	0.55	1.90	1.23
19-07-2012 8:00	1.34	0.48	1.82	1.23
19-07-2012 9:00	1.34	0.59	1.94	1.23
19-07-2012 10:00	1.34	0.73	2.07	1.23
19-07-2012 11:00	1.34	0.49	1.83	1.23
19-07-2012 12:00	1.34	-0.61	0.73	1.23
19-07-2012 13:00	1.34	-0.66	0.68	1.23
19-07-2012 14:00	1.34	-0.60	0.74	1.23
19-07-2012 15:00	1.34	-0.45	0.89	1.23
19-07-2012 16:00	1.34	-0.33	1.01	1.23
19-07-2012 17:00	1.34	-0.15	1.19	1.23
19-07-2012 18:00	1.34	-0.10	1.24	1.23
19-07-2012 19:00	1.34	0.09	1.43	1.23
19-07-2012 20:00	1.34	-0.04	1.30	1.23
19-07-2012 21:00	1.34	-0.10	1.25	1.23
19-07-2012 22:00	1.34	-0.39	0.95	1.23
19-07-2012 23:00	1.34	-0.77	0.57	1.23
20-07-2012 0:00	1.34	-	1.34	1.23

Appendix B
OCP Land Use

ICI BP's Sq M to Aug. 2010

G P ROLLO & ASSOCIATES
Land Economists

Memorandum

To: Peter Whitelaw, HB Lanarc; City of Prince George Long Range Planning

From: Justin Barer, G.P. Rollo & Associates Ltd.

Subject: **Prince George Retail and Service Commercial Projections**

Date: February 19th 2010

This is a preliminary memorandum outlining our findings with regards to the following questions:

- Is the commercial market in Prince George currently underserved, over-served, or in relative equilibrium?
- What is the potential growth in demand for commercial space (sq.ft. leasable area) in Prince George over the next 25 years?
- How many acres of land are required to accommodate projected commercial demand?
- How many additional acres, if any, of zoned commercial land does Prince George require?

The Prince George retail and service commercial inventory indicates that, as of 2008, the City contains approximately 3,329,000 square feet of retail and 4,280,000 square feet of service commercial space, for a total retail and service commercial space inventory of 7.61 million square feet. Using population projections provided by Urban Futures, we find that, on a per-capita basis, Prince George contains 45 square feet of retail and 58 square feet of service commercial in 2008.

A brief commercial demand projection was undertaken to test the level of commercial saturation in the Prince George market. Using an approach that relates the population's retail and service commercial expenditure potential to square feet supportable, and which includes a significant inflow factor that accounts for the City's long-standing role as a major regional service centre, it was found that in 2008 the City of Prince George could support approximately 7.60 million square feet of combined retail and service commercial space. The commercial floor space inventory indicates that Prince George contains 7.61 million square feet of combined retail and service commercial space. It is therefore reasonable to conclude that the commercial market is in a state of relative equilibrium at present.

The ratios of retail and service commercial square feet per capita – 45 and 58 respectively – reflect the City's significant ongoing role as a regional service centre. Given the combined factors of relative market equilibrium at present, Prince George's expected continuing role as a regional centre in the coming decades, and an assumption that spending patterns will remain relatively consistent across the region, it is reasonable to conclude that the per-capita square feet figures for retail and service commercial can be held constant at 45 and 58 for the purposes of retail and service commercial space projections.

Between 2010 and 2030, the City of Prince George is expected to add 4,340 residents to its population base.[1] This population growth will necessitate the construction of an additional 446,000 square feet of new retail and service commercial space over that time period. From 2030 to 2035,

[1] Population forecasts for the City of Prince George were prepared by Urban Futures in December 2009.

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the City's population is projected to decrease by nearly 200 residents.[2] This population loss will translate into a net decrease in demand for commercial space during that period. Taking into account both population increase between 2010 and 2030 and population decline from 2030 to 2035, the 25 year net additional demand for retail and commercial floor area is approximately 426,000 square feet. See Table 1 below.

Table 1 – Projected Retail and Service Commercial Space Requirements, 2010-2035

Gross Warranted Retail and Service Commercial Space, Prince George Sq.Ft. Gross Leasable Area					
	Gross Retail Space	Gross Service Commercial Space	Net Change, Retail	Net Change, Service Commercial	Net Change, Total Commercial Space
2010	3,358,787	4,318,173			
2015	3,436,753	4,418,409	77,966	100,236	178,202
2020	3,495,773	4,494,288	59,020	75,878	134,899
2025	3,534,396	4,543,943	38,623	49,655	88,278
2030	3,553,935	4,569,063	19,539	25,120	44,659
2035	3,545,059	4,557,652	-8,876	-11,411	-20,287
Net Change, 2010 - 2035			186,272	239,478	425,750

Using conservative Floor Space Ratios (FSRs) of 0.30 for both retail and service commercial, we find that approximately 47 acres of zoned commercial land is required to accommodate all new commercial space requirements over the next 25 years.

The City of Prince George has a large oversupply of zoned commercial land. It is estimated that under-utilized and vacant commercial land in the City accounted for 737 acres in 2008.[3] This is compared to a 25 year demand estimate of only 47 acres. For instance, approximately 38 acres of under-utilized and vacant commercial space is located at the City's 11 designated shopping centre sites. This space alone would be enough to accommodate all of the City's commercial land needs through the year 2021. Similarly, downtown Prince George contains approximately 92 acres of under-utilized and vacant zoned commercial land. By way of illustration, if all commercial land demand for the next 25 years were clustered in the downtown core, 49% of this under-utilized and vacant land base would still remain in 2035.

If the FSR for retail and service commercial is adjusted downward to a very conservative 0.12 for all future retail and service commercial uses, only 116 acres of zoned commercial land would be required to accommodate demand for the next 25 years. In other words, even under a scenario with very conservative FSR assumptions, under-utilized and vacant commercial land across Prince George would still amount to over 620 acres by 2035. Again by way of illustration, all land needs in this low density scenario could be met within Downtown Prince George alone for the next 10 years.

[2] Urban Futures, December 2009.

[3] Under-utilized commercial lands are defined as lands with assessed value of improvements at less than 10% of total assessed land value. Vacant commercial land has no assessed value of improvements.

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Table 2 – Land Required to Accommodate Current and Future Commercial Space, and supply of Under-utilized and Vacant Commercial Lands

Year	Population Projections	Gross Retail and Service Commercial Floor Area Needed (SF)	Additional Acres Required (5-year intervals)*	Underutilized and Vacant Zoned Commercial Acres**
2010	74,674	7,676,960		737
2015	76,408	7,855,162	19	717
2020	77,720	7,990,061	15	703
2025	78,579	8,078,339	10	693
2030	79,013	8,122,998	5	688
2035	78,816	8,102,710	-2	690

Population Projections conducted by Urban Futures, 2009. Analysis by G.P. Rollo & Associates
*Assumes 0.3 FSR for retail and service commercial
** Underutilized land has assessed value of improvements at <10% of assessed land value. Vacant land has no improvements value.

Figure 1 – Commercial Land Demand 2010-2035 vs. Available and Developed Area

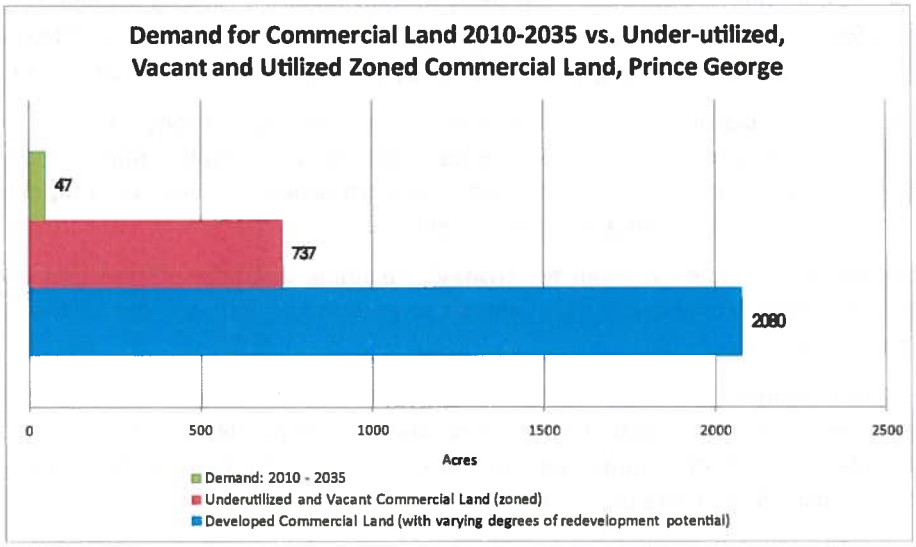
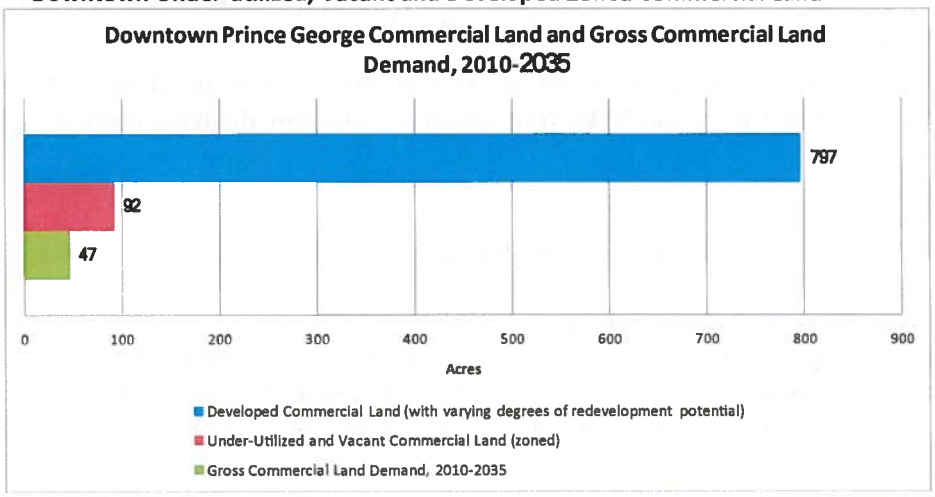


Figure 2 – Gross Commercial Land Demand 2010-2035 vs. Downtown Under-utilized, Vacant and Developed Zoned Commercial Land



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While significant space does exist for commercial growth on vacant commercial land across the City, careful consideration should be given to the City's growth strategy and the type of commercial precincts it wishes to develop. The demand for new retail and service space generated by population growth in the coming decades provides a unique opportunity to re-imagine and revitalize existing neighbourhoods in the City.

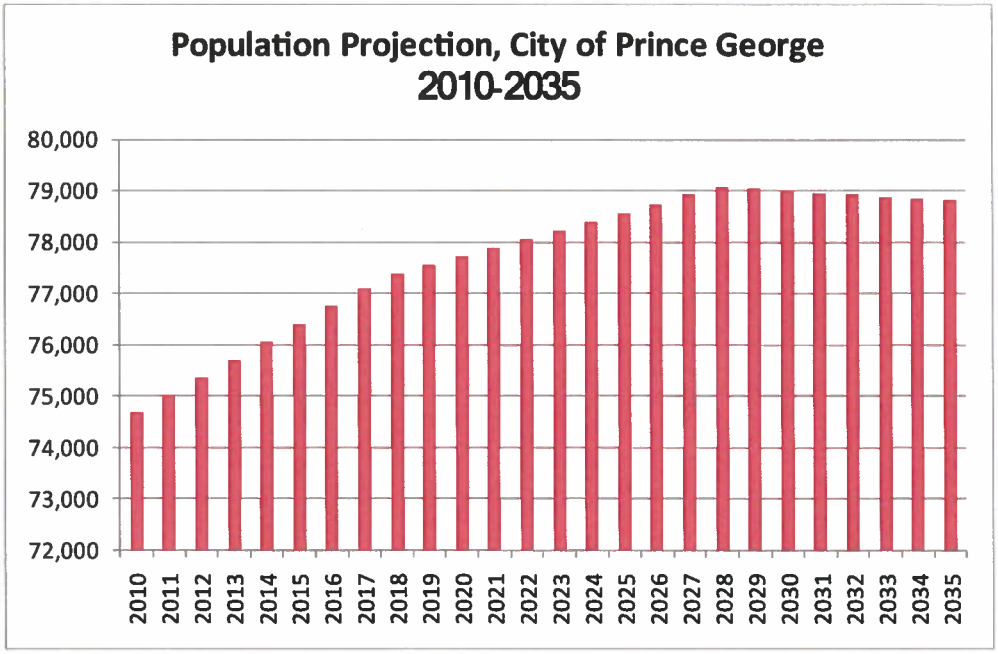
Some key issues to consider:

- While 426,000 square feet of commercial space over 25 years could easily be accommodated through traditional expansion of existing shopping centre sites or through suburban shopping centres or highway-oriented pad development on vacant zoned commercial land, we recommend that the City not permit such development. Rather, the demand for new commercial space should be used as an opportunity to strengthen, intensify and revitalize existing urban and inner suburban neighbourhoods around neighbourhood-oriented commercial precincts.
- The commercial floor area opportunities will likely be split between existing shopping centre sites and new/existing neighbourhood centres designated for future growth. The City should address in the OCP how commercial growth is to be apportioned to different types of sites.
- On existing shopping centre sites, there is likely significant opportunity in the coming decades to redevelop traditional interior-oriented centres as multiple family residential (townhouse and apartment) developments with outward-facing commercial components. This is consistent with a trend seen across North America.
- Further consideration should be given for strategic rezoning of under-utilized and vacant commercial sites where commercial development is undesirable and counter to the City's preferred growth strategy.
- The City of Prince George market has been tending toward suburban residential growth, with far-flung auto-oriented commercial centres being built and expanded to serve these new neighbourhoods. Consideration should be given to strategies for reorienting the market and making higher density living more desirable.
- Given that retail is generally one of the final 'pieces' in the urban puzzle – retailers' location choices are driven more by the presence of customers than by the availability of cheap land – the creation of higher density well-designed and well-marketed walkable neighbourhoods is a necessary precondition for successful neighbourhood commercial development.
- Due to significant oversupply of vacant commercial land at existing shopping centres, development of new highway-oriented commercial or suburban shopping malls should be avoided.

Next Steps:

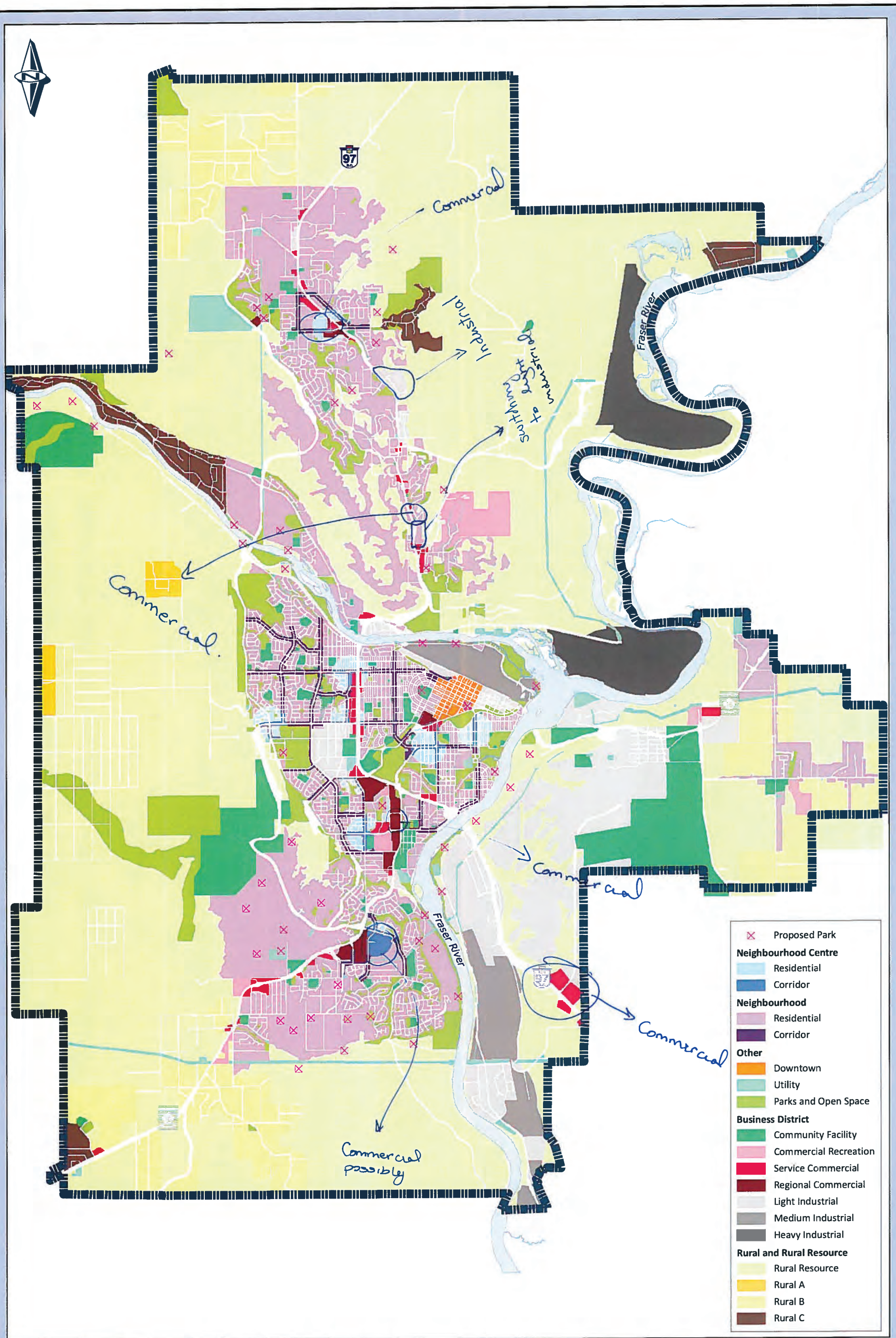
- Proceed with a growth vision for the City, focusing on revitalization and intensification of existing neighbourhoods.
- Identify areas for potential neighbourhood commercial precincts.
- Proceed with neighbourhood level market and commercial positioning studies to identify the appropriate size, mix and orientation of future neighbourhood commercial precincts.
- Identify economic feasibility of proposed neighbourhood FSRs and proposed commercial programmes.

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Source: Urban Futures, December 2009

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0 500 1,000 1,500 2,000 Meters

Future Land Use

OCP Schedule B-6, Bylaw No. 8383

HB LANARC

CITY OF PRINCE GEORGE
Geographic Information Systems Group

Path: \\Pc631\gisdev\Projects\OCP2011\B-6_FutureLandUse.mxd - 13/03/2012 - 4:33:34 PM

ICI Loading in InfoWater Model

Legend

2012 C&I Water Meters Loaded
2012 INST Water Meters Loaded

Zoning

<all other values>

ZONECODE

C1
C1l
C2
C3
C4
C4l
C5
C6
C6l
C7
C8
C9
C9r
M1
M2
M3
M4
M5
M6
M7
P1
P2
P3
P4
P5
P6
U1
U2
W
Z1
Z10
Z11
Z15
Z2
Z3
Z4
Z5
Z6
Z7
Z8
Z9

Wessner Heights
Neighbourhood Plan
Area = 10.0 ha

Glenview Crescents Neighbourhood Plan
Area = 7.7 ha

Crescents Neighbourhood Plan
Area = 20.9 ha

LEGEND

New MF as noted by Neighbourhood Plans

Existing Multifamily

- <all other values>
- RM1
- RM2
- RM3
- RM4
- RM5
- RM6
- RM7
- RS5
- RS5c
- Z12

Multifamily Zoning

Not considered for water model

Institutional Zoning

LEGEND

New Instiutional as noted in Neighbourhood Plans

Institution Type

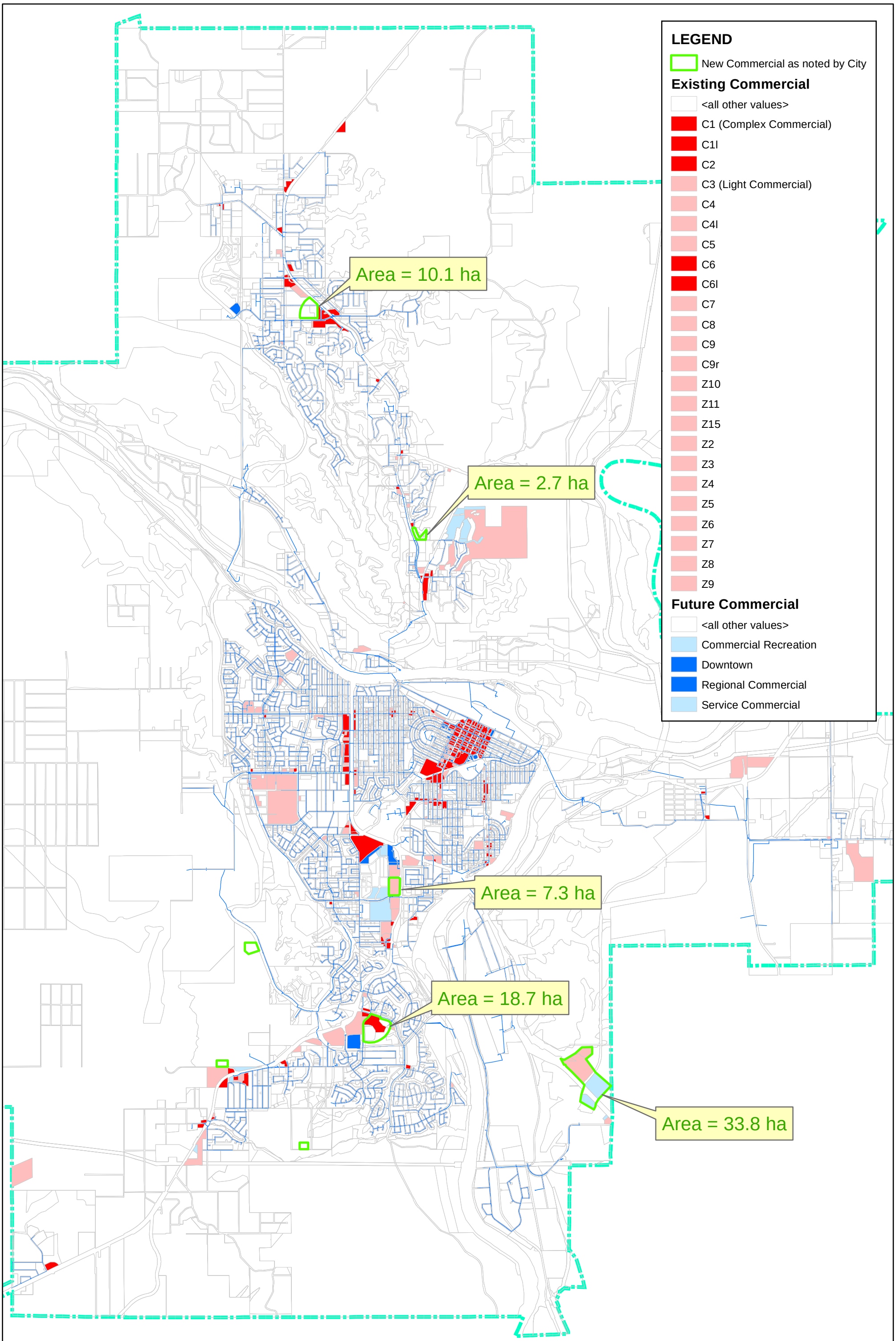
- <all other values>
- Community Centre or Club
- Education
- Education Religious Assembly
- Emergency Service
- Health
- Other
- Religious Assembly
- Transfer Station

Existing Institutional

- <all other values>
- P1 (Parks and Recreation)
- P2 (Minor Institutional)
- P3 (Major Instiutional)
- P4
- P5
- P6
- W

Future Institutional

- <all other values>
- Community Facility
- Corridor
- Parks & Open Space
- Rural Resource
- Utility



Commercial Zoning

Not considered for water model

Area = 26.1 ha

Area = 5.5 ha

LEGEND

New Industrial Area as noted City

Existing Zoning

<all other values>

M1 (Light Industrial)

M2

M3

M4

M5 (Heavy Industrial)

M6

M7

Future Zoning

<all other values>

Light Industrial

Medium Industrial

Heavy Industrial

Industrial Zoning

OPUS DAYTONKNIGHT

Appendix C
Detailed Demand Distribution

C.1 South Model Average Day Demand

Table C-1 shows the additional demands calculated for the South water system.

Table C-1
Additional South System Demands

Condition	Type	Additional ADD (L/s)	Details
OCP	Residential	91.5	Population increase from 65,501 to 80,518
OCP	Institutional	1.4	Five proposed schools in College Heights and Ospika South area
OCP	Commercial	13.2	12 ha in commercial centres and demand from East PG Study
OCP	Industrial	91.0	demand from East PG Study
Phase 1	Residential	273.1	Population increase from 80,518 to 125,347
Phase 1	Commercial	21.0	59.8 ha remaining in commercial centres
		491.2	

C.2 Western Acres Model Average Day Demand

Table C-2 shows the additional demands calculated for the Western Acres system.

Table C-2
Additional Western Acres System Demands

Condition	Type	Additional ADD (L/s)	Details
OCP	Residential	0.04	Population increase from 103 to 109
Phase 1	Residential	0.02	Population increase from 109 to 112
		0.06	

C.3 North Model Average Day Demand

Table C-3 shows the additional demands calculated for the North water system.

Table C-3
Additional North System Demands

Condition	Type	Additional ADD (L/s)	Details
OCP	Residential	15.6	Population increase from 10,652 to 13,215
OCP	Commercial	2.8	8 ha in commercial centres
OCP	Industrial	1.3	31.6 ha in industrial centres
Phase 1	Residential	48.5	Population increase from 13,215 to 21,183
Phase 1	Commercial	1.7	4.8 ha remaining in commercial centres
		69.9	

C.4 South Model Peaking Demands

Existing Demands

Table C-4 shows the existing demands contained in the South water system.

Table C-4
South Model Existing Demands

Category	Demands (L/s)			Peaking Factors		
	ADD	MDD	PHD	ADD	MDD	PHD
Single Family	399.1	814.1	1358.5	1.0	2.0	3.4
Institutional	10.4	11.4	15.6	1.0	1.1	1.5
Comm & Ind	52.6	57.9	78.9	1.0	1.1	1.5
Total	**462.1**	**883.4**	**1453.0**	**1.0**	**1.9**	**3.1**

Future Demands

Table C-5 shows the OCP demands contained in the South water system.

Table C-5
South Model OCP Demands

Category	Demands (L/s)			Peaking Factors		
	ADD	MDD	PHD	ADD	MDD	PHD
Single Family	490.6	1000.7	1670.0	1.0	2.0	3.4
Institutional	11.8	13.0	17.7	1.0	1.1	1.5
Comm & Ind	156.8	172.5	235.2	1.0	1.1	1.5
Total	**659.1**	**1186.2**	**1922.8**	**1.0**	**1.8**	**2.9**

Table C-6 shows the Phase 1 demands contained in the South water system.

Table C-6
South Model Phase 1 Demands

Category	Demands (L/s)			Peaking Factors		
	ADD	MDD	PHD	ADD	MDD	PHD
Single Family	763.7	1557.9	2599.7	1.0	2.0	3.4
Institutional	11.8	13.0	17.7	1.0	1.1	1.5
Comm & Ind	177.8	195.6	266.7	1.0	1.1	1.5
Total	**953.2**	**1766.5**	**2884.1**	**1.0**	**1.9**	**3.0**

C.5 Western Acres Model Peaking Demands

Existing Demands

Table C-7 shows the existing demands contained in the Western Acres system.

Table C-7
Western Acres Model Existing Demands

Category	Demands (L/s)			Peaking Factors		
	ADD	MDD	PHD	ADD	MDD	PHD
Single Family	0.62	1.32	1.91	1.0	2.1	3.1
Institutional	0.22	0.24	0.33	1.0	1.1	1.5
Comm & Ind	0.0	0.0	0.0	1.0	1.1	1.5
Total	**0.84**	**1.56**	**2.24**	**1.0**	**1.9**	**2.7**

Future Demands

Table C-8 shows the OCP demands contained in the Western Acres system.

Table C-8
Western Acres Model OCP Demands

Category	Demands (L/s)			Peaking Factors		
	ADD	MDD	PHD	ADD	MDD	PHD
Single Family	0.66	1.40	2.03	1.0	2.1	3.1
Institutional	0.22	0.24	0.33	1.0	1.1	1.5
Comm & Ind	0.0	0.0	0.0	1.0	1.1	1.5
Total	**0.88**	**1.64**	**2.36**	**1.0**	**1.9**	**2.7**

Table C-9 shows the Phase 1 demands contained in the Western Acres system.

Table C-9
Western Acres Model Phase 1 Demands

Category	Demands (L/s)			Peaking Factors		
	ADD	MDD	PHD	ADD	MDD	PHD
Single Family	0.68	1.44	2.09	1.0	2.1	3.1
Institutional	0.22	0.24	0.33	1.0	1.1	1.5
Comm & Ind	0.0	0.0	0.0	1.0	1.1	1.5
Total	**0.90**	**1.68**	**2.42**	**1.0**	**1.9**	**2.7**

C.6 North Model Peaking Demands

Existing Demands

Table C-10 shows the existing demands contained in the North water system.

Table C-10
North Model Existing Demands

Category	Demands (L/s)			Peaking Factors		
	ADD	MDD	PHD	ADD	MDD	PHD
Single Family	64.9	151.0	248.2	1.0	2.3	3.8
Institutional	0.8	0.9	1.2	1.0	1.1	1.5
Comm & Ind	4.4	4.8	6.6	1.0	1.1	1.5
Total	**70.1**	**156.7**	**256.0**	**1.0**	**2.2**	**3.7**

Future Demands

Table C-11 shows the OCP demands contained in the North water system.

Table C-11
North Model OCP Demands

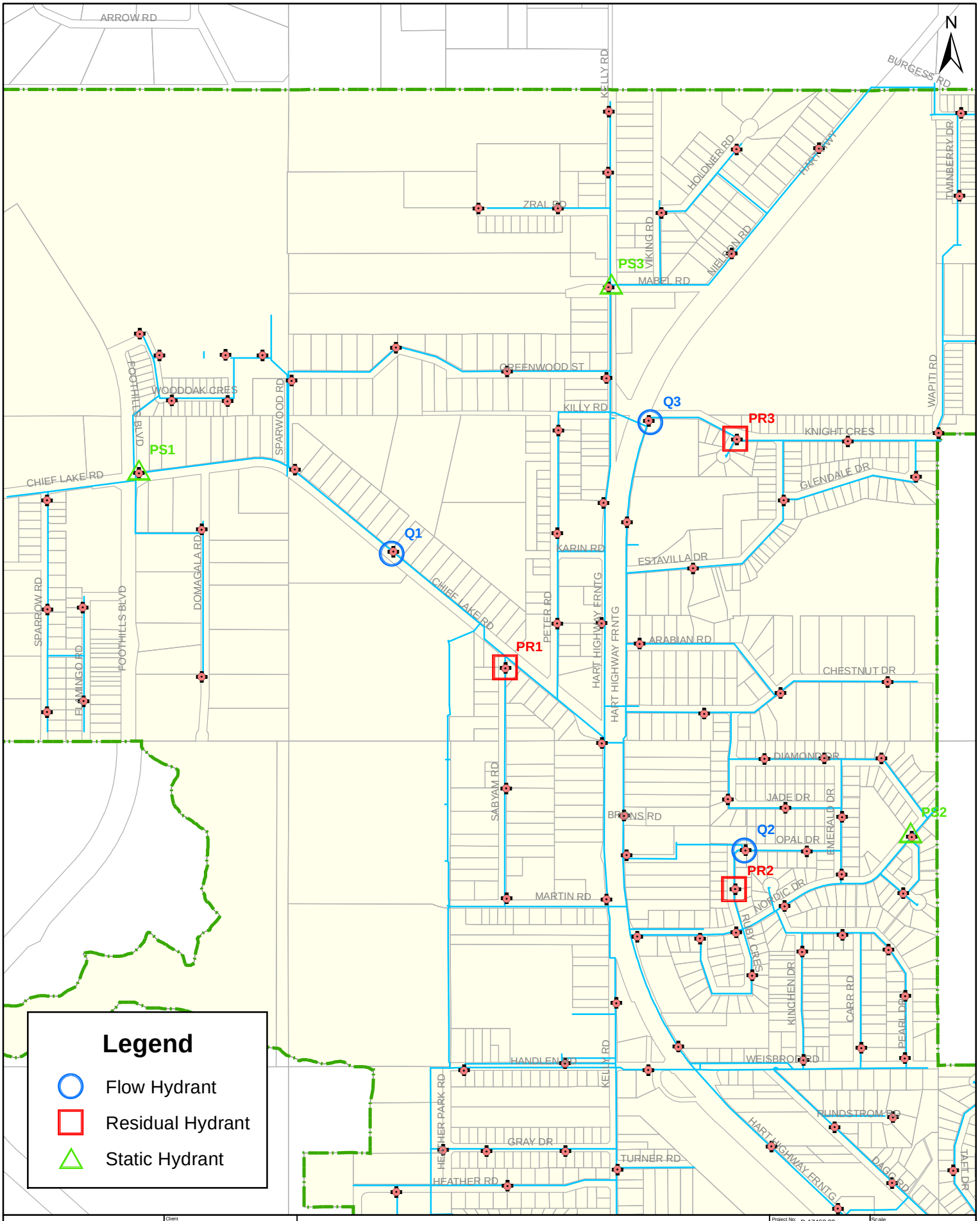
Category	Demands (L/s)			Peaking Factors		
	ADD	MDD	PHD	ADD	MDD	PHD
Single Family	80.5	187.3	307.9	1.0	2.3	3.8
Institutional	0.8	0.9	1.2	1.0	1.1	1.5
Comm & Ind	8.5	9.4	12.8	1.0	1.1	1.5
Total	**89.8**	**197.5**	**321.9**	**1.0**	**2.2**	**3.6**

Table C-12 shows the Phase 1 demands contained in the North water system.

Table C-12
North Model Phase 1 Demands

Category	Demands (L/s)			Peaking Factors		
	ADD	MDD	PHD	ADD	MDD	PHD
Single Family	129.1	300.3	493.6	1.0	2.3	3.8
Institutional	0.8	0.9	1.2	1.0	1.1	1.5
Comm & Ind	10.2	11.2	15.3	1.0	1.1	1.5
Total	**140.1**	**312.4**	**510.1**	**1.0**	**2.2**	**3.6**

Appendix D
Hydrant Flow Test Sets



Legend

- Flow Hydrant
- Residual Hydrant
- Static Hydrant

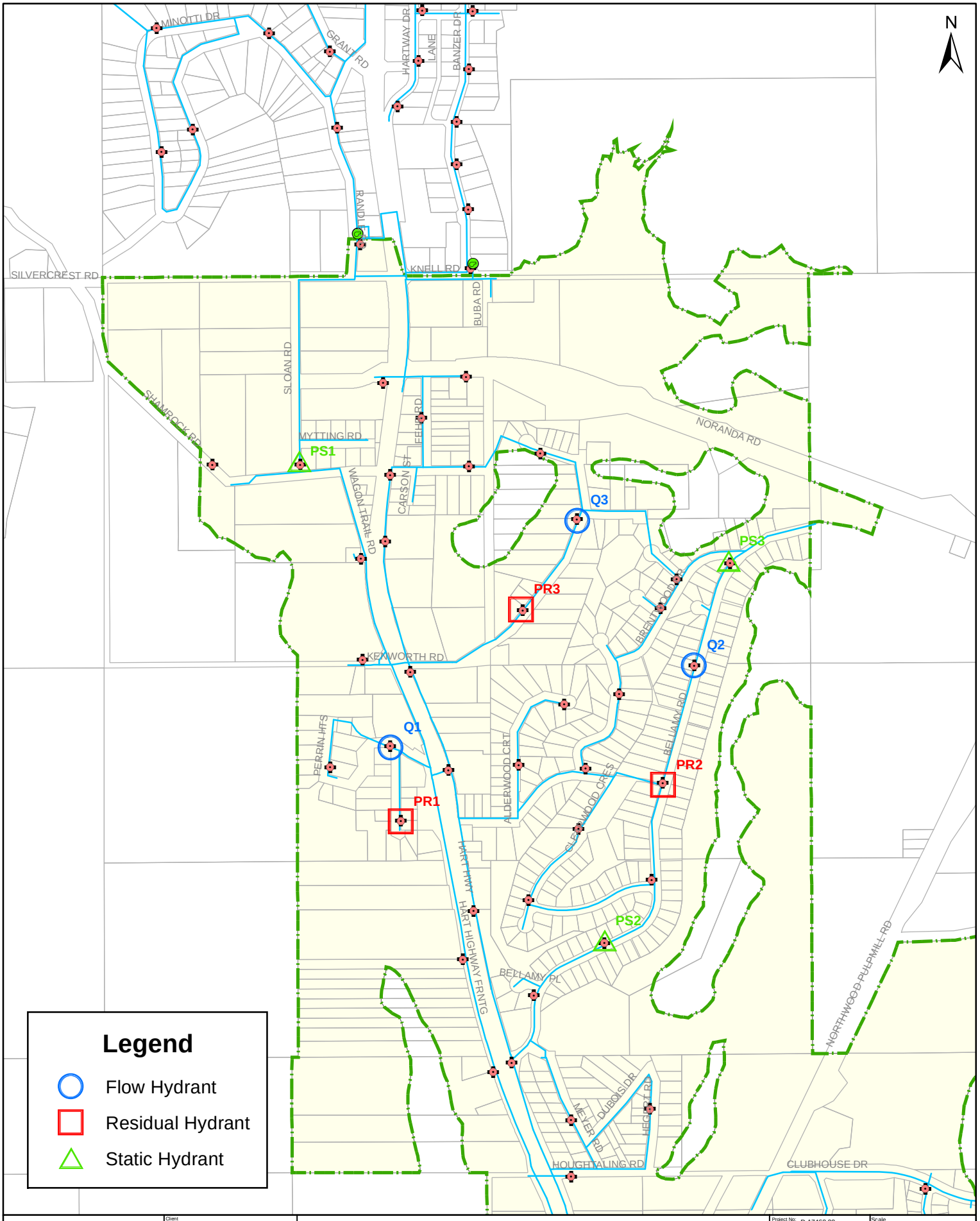
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North Vancouver Office , #210 - 889 Harbourside Drive
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Client: CITY OF PRINCE GEORGE

2013 HYDRANT TESTING PROGRAM
FLOW SET #1 - PRESSURE ZONE 11

Project No: D-17460.00
Designed: CL
Drawn: CL
Approved:
Note:
Figure 4-1
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1:12,000 @ Tabloid
Map No 1
Date 12/08/2013
Revision
Revision Date

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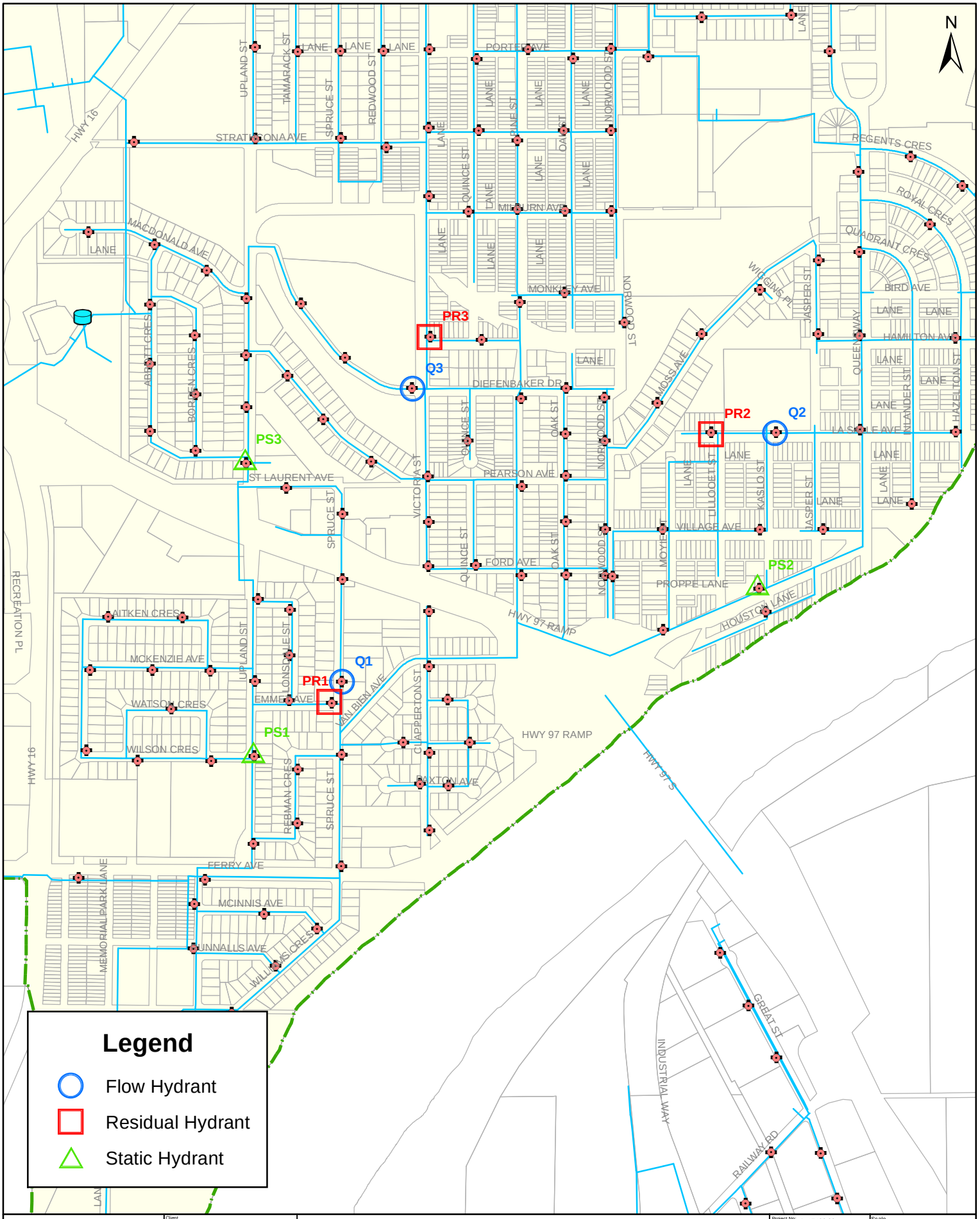
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2013 HYDRANT TESTING PROGRAM
FLOW SET #2 - PRESSURE ZONE 9

Project No:	D-17460.00
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Note:	Figure 4-2
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Map No	1
Revision	
Date	12/08/2013
Revision Date	

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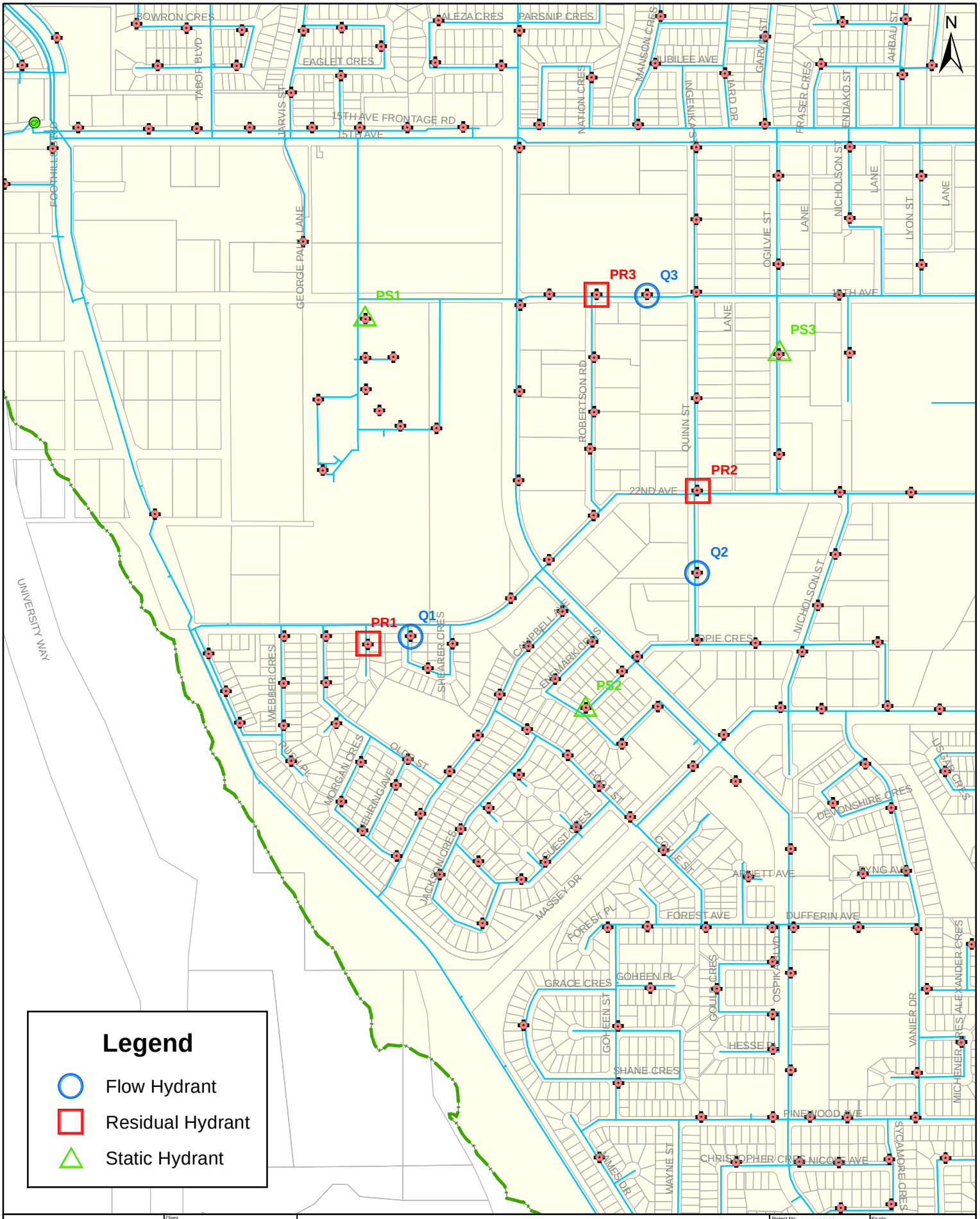
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2013 HYDRANT TESTING PROGRAM
FLOW SET #3 - PRESSURE ZONE 1

Project No: D-17460.00
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Note:
Figure 4-3
Scale: 0 85 170 Metres
1:10,000 @ Tabloid
Map No 1
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Revision Date

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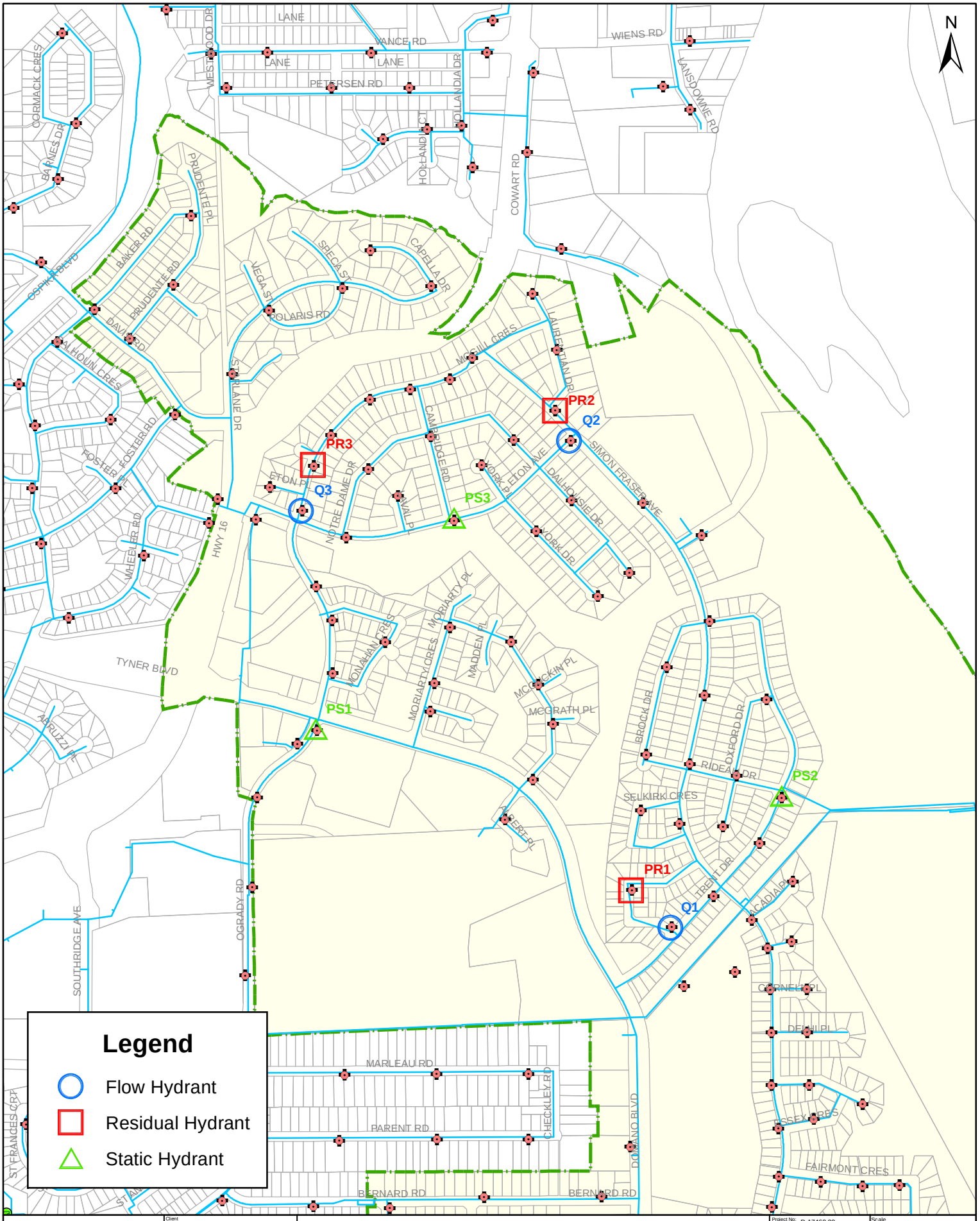
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2013 HYDRANT TESTING PROGRAM
FLOW SET #4 - PRESSURE ZONE 2

Project No:	D-17460.00
Designed:	CL
Drawn:	CL
Approved:	
Note:	Figure 4-4
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Map No	1
Revision	
Date	12/08/2013
Revision Date	

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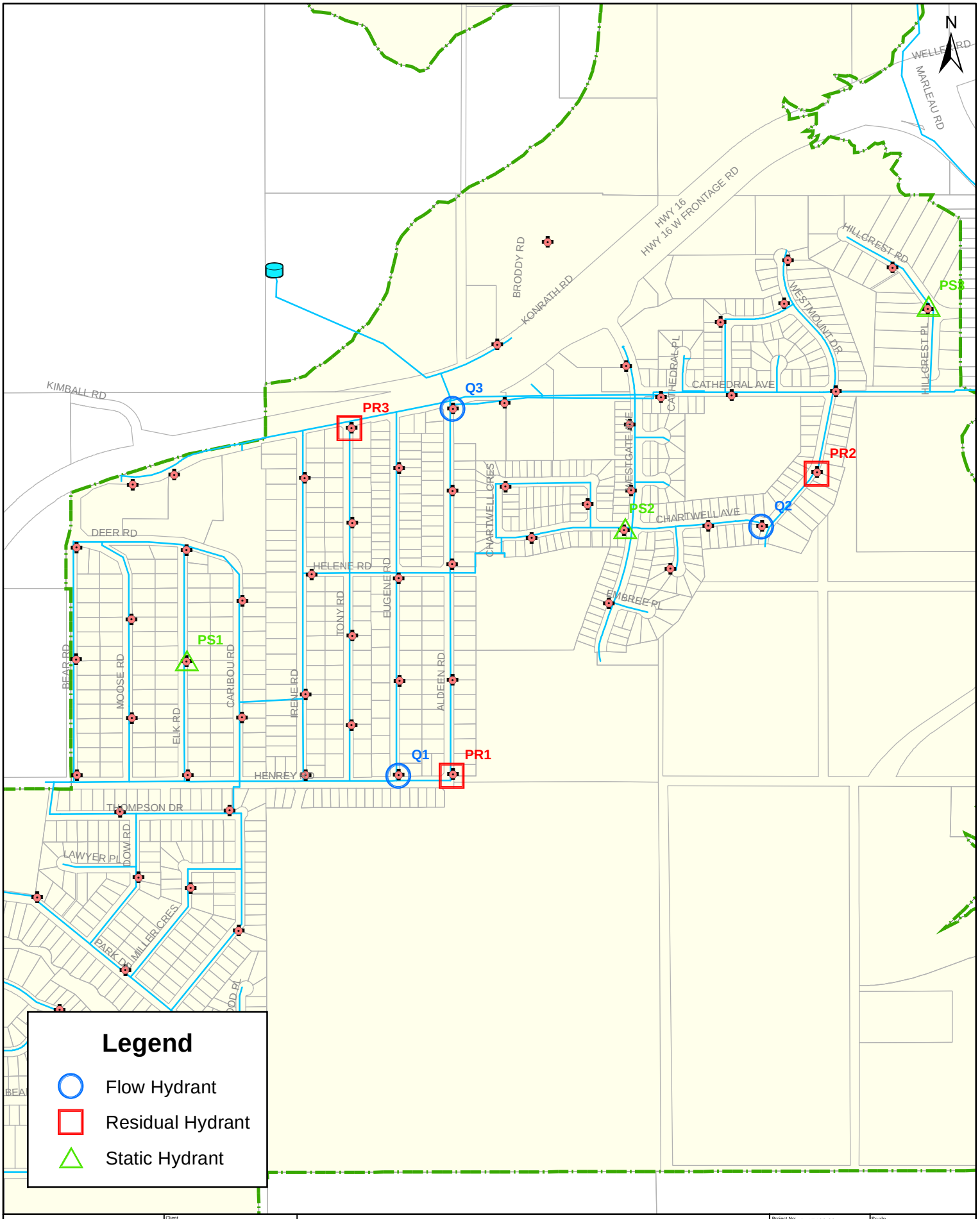
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2013 HYDRANT TESTING PROGRAM
FLOW SET #5 - PRESSURE ZONE 3

Project No: D-17460.00
Designed: CL
Drawn: CL
Approved:
Note:
Figure 4-5

Scale: 0 80 160 Meters
1:10,000 @ Tabloid
Map No 1
Date 12/08/2013
Revision
Revision Date

Path: H:\Projects\100174 Prince George\D-17460 Water Service Network Plan Update\Hydrant Flow Testing\Figure 4-5.mxd



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2013 HYDRANT TESTING PROGRAM
FLOW SET #6 - PRESSURE ZONE 6

Project No:	D-17460.00
Designed:	CL
Drawn	CL
Approved	
Note:	Figure 4-6
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Map No	1
Date	12/08/2013
Revision	
Revision Date	

Path: H:\Projects\100174 Prince George\D-17460 Water Service Network Plan Update\Hydrant Flow Testing\Figure 4-6.mxd

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Appendix E
Calibration Results

TABLE E-1
FIELD RESULTS VS. COMPUTER PREDICTED RESULTS

Date	Flow set no.	Location	Hydrant Test No. & Time	Flow (L/s)	InfoWater ID	Hydrant No.	Elev. (m)	Field Result				Computer Result				Static Pressure Diff (psi)	% diff Static Pressure	Residual Pressure Diff (psi)	% diff Residual Pressure	Demand Boundary Conditions
								Static (psi)	Residual (psi)	Static HGL (m)	Residual HGL (m)	Static (psi)	Residual (psi)	Static HGL (m)	Residual HGL (m)					
17-Sep-13	1	Pressure Zone 11	Q1	53.0	S1-Q1	FW71A														
			9:40 AM		S1-PR1	GV15A	755.2	64.9	52.2	800.8	791.9	63.2	62.9	799.6	799.5	-1.7	-2.7%	10.7	20.6%	
					S1-PS1	FW42A	766.6	49.3	25.2	801.3	784.3	49.2	23.9	801.2	783.4	-0.1	-0.3%	-1.3	-5.0%	
					S1-PS2	GV63A	737.2	92.7	86.7	802.4	798.2	91.1	87.6	801.3	798.8	-1.6	-1.7%	0.9	1.0%	
					S1-PS3	GW25A	759.6	60.0	46.7	801.8	792.4	59.1	51.3	801.1	795.7	-0.9	-1.6%	4.6	9.9%	
			Q2	78.2	S1-Q2	GV43A														
			10:00		S1-PR2	GV42A	747.4	74.9	52.1	800.1	784.0	76.7	51.6	801.3	783.7	1.8	2.4%	-0.5	-1.0%	
					S1-PS1	FW42A	766.6	49.0	37.7	801.1	793.1	49.2	40.4	801.2	795.0	0.2	0.3%	2.7	7.1%	1.01*ADD
					S1-PS2	GV63A	737.2	92.0	72.4	801.9	788.1	91.1	72.4	801.3	788.1	-0.9	-1.0%	0.0	0.0%	
					S1-PS3	GW25A	759.6	60.3	45.7	802.0	791.7	59.1	44.5	801.1	790.9	-1.2	-2.1%	-1.2	-2.6%	
			Q3	71.0	S1-Q3	GW23B														
			10:20		S1-PR3	GW33A	745.0	76.8	47.9	799.0	778.7	79.8	44.8	801.1	776.5	3.0	4.0%	-3.1	-6.4%	
					S1-PS1	FW42A	766.6	48.7	29.7	800.8	787.5	49.2	32.4	801.2	789.4	0.5	0.9%	2.7	9.0%	
					S1-PS2	GV63A	737.2	91.5	77.3	801.5	791.5	91.1	80.0	801.3	793.4	-0.4	-0.4%	2.7	3.4%	
					S1-PS3	GW25A	759.6	59.2	27.3	801.2	778.8	59.1	24.7	801.1	776.9	-0.1	-0.2%	-2.6	-9.6%	
17-Sep-13	2	Pressure Zone 9	Q1	41.0	S2-Q1	HQ53A														
			11:14		S2-PR1	HQ54B	655.1	64.6	46.6	700.5	687.9	67.1	49.8	702.3	690.1	2.5	3.8%	3.2	6.8%	
					S2-PS1	HR42A	652.3	77.5	69.4	706.8	701.1	71.0	67.8	702.3	700.0	-6.5	-8.3%	-1.6	-2.4%	
					S2-PS2	HQ72B	644.9	83.7	71.2	703.7	695.0	81.6	77.4	702.2	699.3	-2.2	-2.6%	6.2	8.7%	
					S2-PS3	JR11A	658.2	65.8	54.4	704.5	696.4	62.6	58.3	702.2	699.2	-3.2	-4.9%	3.9	7.1%	
			Q2	63.7	S2-Q2	HQ84A														
			11:31		S2-PR2	HQ85B	650.9	73.5	23.9	702.6	667.7	73.0	22.0	702.2	666.4	-0.5	-0.7%	-1.9	-7.8%	
					S2-PS1	HR42A	652.3	77.4	63.1	706.7	696.7	71.0	65.9	702.3	698.6	-6.4	-8.2%	2.8	4.4%	1.01*ADD
					S2-PS2	HQ72B	644.9	82.7	49.2	703.0	679.5	81.6	51.3	702.2	681.0	-1.2	-1.4%	2.1	4.2%	
					S2-PS3	JR11A	658.2	66.3	17.5	704.8	670.5	62.6	18.5	702.2	671.2	-3.7	-5.6%	1.0	5.6%	
			Q3	62.8	S2-Q3	GW23B														
			11:47		S2-PR3	GW33A	645.5	82.1	48.1	703.2	679.3	80.7	47.8	702.2	679.1	-1.4	-1.8%	-0.3	-0.6%	
					S2-PS1	FW42A	652.3	77.3	62.8	706.6	696.5	71.0	65.9	702.3	698.6	-6.3	-8.1%	3.1	4.9%	
					S2-PS2	GV63A	644.9	83.4	60.9	703.5	687.7	81.6	64.4	702.2	690.2	-1.9	-2.2%	3.5	5.7%	
					S2-PS3	GW25A	658.2	65.4	31.4	704.2	680.3	62.6	30.4	702.2	679.6	-2.8	-4.3%	-1.0	-3.3%	
16-Sep-13	3	Pressure Zone 1	Q1	62.8	S3-Q1	JJ12A														
			13:53		S3-PR1	HJ82C	588.0	54.8	50.4	626.5	623.4	59.1	55.2	629.6	626.8	4.3	7.8%	4.8	9.6%	
					S3-PS1	HJ81A	587.0	58.0	56.5	627.8	626.7	60.5	58.8	629.5	628.3	2.5	4.3%	2.3	4.0%	
					S3-PS2	JJ53A	572.0	79.4	76.6	627.8	625.9	82.1	80.9	629.7	628.9	2.7	3.4%	4.3	5.5%	
					S3-PS3	HJ85C	587.0	58.5	56.8	628.1	626.9	60.4	59.2	629.4	628.7	1.9	3.2%	2.4	4.3%	
			Q2	66.9	S3-Q2	JJ55A														
			14:28		S3-PR2	JJ45A	585.0	79.9	74.9	641.2	637.7	63.6	45.7	629.7	617.2	-16.3	-20.4%	-29.2	-38.9%	
					S3-PS1	HJ81A	587.0	58.0	56.5	627.8	626.7	60.5	59.7	629.5	629.0	2.5	4.3%	3.2	5.6%	1.02*ADD
					S3-PS2	JJ53A	572.0	79.3	75.0	627.8	624.7	82.1	75.0	629.7	624.8	2.8	3.5%	0.0	0.1%	
					S3-PS3	HJ85C	587.0	58.9	57.1	628.4	627.1	60.4	59.7	629.4	629.0	1.5	2.5%	2.6	4.6%	
			Q3	85.2	S3-Q3	JJ15A														
			14:09		S3-PR3	JK21C	569.0	79.2	74.1	624.7	621.1	86.5	81.1	629.8	626.0	7.3	9.2%	7.0	9.4%	
					S3-PS1	HJ81A	587.0	58.0	56.2	627.8	626.5	60.5	59.4	629.5	628.8	2.5	4.3%	3.2	5.8%	
					S3-PS2	JJ53A	572.0	79.5	74.1	627.9	624.1	82.1	78.9	629.7	627.5	2.6	3.2%	4.8	6.5%	
					S3-PS3	HJ85C	587.0	58.6	56.8	628.2	626.9	60.4	59.5	629.4	628.8	1.8	3.0%	2.7	4.8%	
16-Sep-13	4	Pressure Zone 2	Q1	82.6	S4-Q1	GK32A														
			13:05		S4-PR1	GK22B	605.0	75.8	73.9	658.3	657.0	75.1	73.5	657.8	656.7	-0.7	-0.9%	-0.4	-0.5%	
					S4-PS1	GK25A	604.8	75.2	74.3	657.7	657.0	76.8	76.1	658.8	658.3	1.6	2.1%	1.8	2.4%	
					S4-PS2	GK41A	603.0	80.7	77.0	659.7	657.1	77.8	76.7	657.7	656.9	-2.9	-3.5%	-0.3	-0.4%	
					S4-PS3	GK75A	604.8	78.7	77.5	660.1	659.3	76.3	75.4	658.4	657.8	-2.5	-3.1%	-2.1	-2.7%	
			Q2	83.9	S4-Q2	GK53A														
			12:45		S4-PR2	GK54A	603.0	74.7	71.5	655.5	653.3	78.2	76.3	658.0	656.7	3.5	4.7%	4.8	6.7%	
					S4-PS1	GK25A	604.8	72.2	68.8	655.6	653.2	76.8	75.9	658.8	658.2	4.6	6.4%	7.1	10.3%	1.02*ADD
					S4-PS2	GK41A	603.0	75.4	72.9	656.0	654.3	77.8	76.3	657.7	656.7	2.4	3.2%	3.4	4.7%	
					S4-PS3	GK75A	604.8	73.3	70.3	656.3	654.2	76.3	74.9	658.4	657.5	3.0	4.0%	4.6	6.6%	
			Q3	83.3	S4-Q3	?														
			12:28		S4-PR3	GL41B	603.0	75.6	72.6	656.2	654.0	79.1	77.1	658.6	657.2	3.5	4.6%	4.5	6.2%	
					S4-PS1	GK25A	604.8	72.4	70.0	655.7	654.0	76.8	75.6	658.8	657.9	4.4	6.1%	5.6	8.0%	
					S4-PS2	GK41A	603.0	75.0	73.7	655.7	654.8	77.8	76.8	657.7	657.0	2.8	3.8%	3.1	4.2%	
					S4-PS3	GK75A	604.8	72.5	70.8	655.8	654.6	76.3	75.5	658.4	657.9	3.8	5.2%	4.7	6.7%	
16-Sep-13	5	Pressure Zone 3	Q1	91.8	S5-Q1															
			10:47		S5-PR1	HF62A	614.2	92.9	86.4	679.5	674.9	95.2	88.3	681.1	676.3	2.3	2.4%	1.9	2.2%	
					S5-PS1	HF24B	647.0	46.1	44.0	679.4	677.9	48.6	47.7	681.2	680.6	2.5	5.4%	3.7	8.5%	
					S5-PS2	HF73B	613.0	95.8	92.7	680.4	678.2	96.9	93.6	681.1	678.8	1.1	1.1%	0.9	1.0%	
					S5-PS3	HG41A	638.6	58.6	55.7	679.8	677.8	60.4	58.3	681.1	679.6	1.8	3.1%	2.6	4.7%	
			Q2	68.8	S5-Q2															
			11:09		S5-PR2	HG52A	634.0	64.1	56.7	679.1	673.9	66.9	57.5	681.1	674.4	2.8	4.4%	0.8	1.4%	
					S5-PS1	HF24B	647.0	45.7	43.5	679.1	677.6	48.6	47.4	681.2	680.3	2.9	6.3%	3.9	9.0%	1.02*ADD
					S5-PS2	HF73B	613.0	95.4	93.4	680.1	678.7	96.9	93.8	681.1	678.9	1.4	1.5%	0.4	0.4%	
					S5-PS3	HG41A	638.6	58.4	51.4	679.7	674.7	60.4	52.5	681.1	675.5	2.0	3.4%	1.1	2.1%	
			Q3	62.8	S5-Q3															
			11:30		S5-PR3	HG22A	643.0	51.0	43.9	678.9	673.9	54.1	47.8	681.1	676.6	3.1	6.2%	3.9	9.0%	
					S5-PS1	HF24B	647.0	45.5	43.3	679.0	677.4	48.6	47.4	681.2	680.3	3.1	6.7%	4.1	9.4%	
					S5-PS2	HF73B	613.0	95.2	93.9	679.9	679.0	96.9	94.9	681.1	679.7	1.6	1.7%	1.0	1.0%	
					S5-PS3	HG41A	638.6	58.4	53.3	679.7	676.1	60.4	54.4	681.1	676.9	2.0	3.4%	1.1	2.1%	
16-Sep-13	6	Pressure Zone 6	Q1	76.3	S6-Q1															
			9:22		S6-PR1	FD85A	744.0	69.1	55.4	792.6	783.0	67.6	55.8	791.6	783.2	-1.5	-2.1%	0.4	0.7%	
					S6-PS1	FE61A	765.0	41.1	27.1	793.9	784.1	37.5	27.6	791.4	784.4	-3.6	-8.8%	0.5	1.8%	
					S6-PS2	?	745.9	67.8	60.4	793.5	788.3	66.9	64.3	792.9	791.1	-0.9	-1.3%	3.9	6.5%	
					S6-PS3	GE65A	704.0	126.5	121.5	792.9	789.4	128.1	126.1	794.1	792.6	1.6	1.2%	4.6	3.7%	
			Q2	76.3	S6-Q2															
			10:05		S6-PR2	?	742.3	76.1	73.0	795.8	793.6	72.9	67.0	793.6	789.4	-3.2	-4.2%	-6.0	-8.2%	
					S6-PS1	FE61A	765.0	39.8	35.7	793.0	790.1	37.5	35.1	791.4	789.7	-2.3	-5.8%	-0.6	-1.7%	1.02*ADD
					S6-PS2	?	745.9	67.3	63.2	793.2	790.3	66.9	62.3	792.9	789.7	-0.4	-0.6%	-0.9	-1.5%	
					S6-PS3	GE65A	704.0	127.1	123.2	793.4	790.6	128.1	124.8	794.1	791.8	1.0	0.8%	1.6	1.3%	
			Q3	87.4	S6-Q3															
			9:44		S6-PR3	FE83A	740.0	70.0	59.7	789.2	782.0	73.5	70.9	791.7	789.9	3.5	5.0%	11.2	18.8%	
					S6-PS1	FE61A	765.0	38.9	32.7	792.4	788.0	37.5	34.8	791.4	789.5	-1.4	-3.7%	2.1	6.5%	
					S6-PS2	?	745.9	67.3	57.8	793.2	786.5	66.9	62.9	792.9	790.1	-0.4	-0.6%	5.1	8.9%	
					S6-PS3	GE65A	704.0	126.7	119.1	793.1	787.7	128.1	122.8	794.1	790.3	1.4	1.1%	3.7	3.1%	

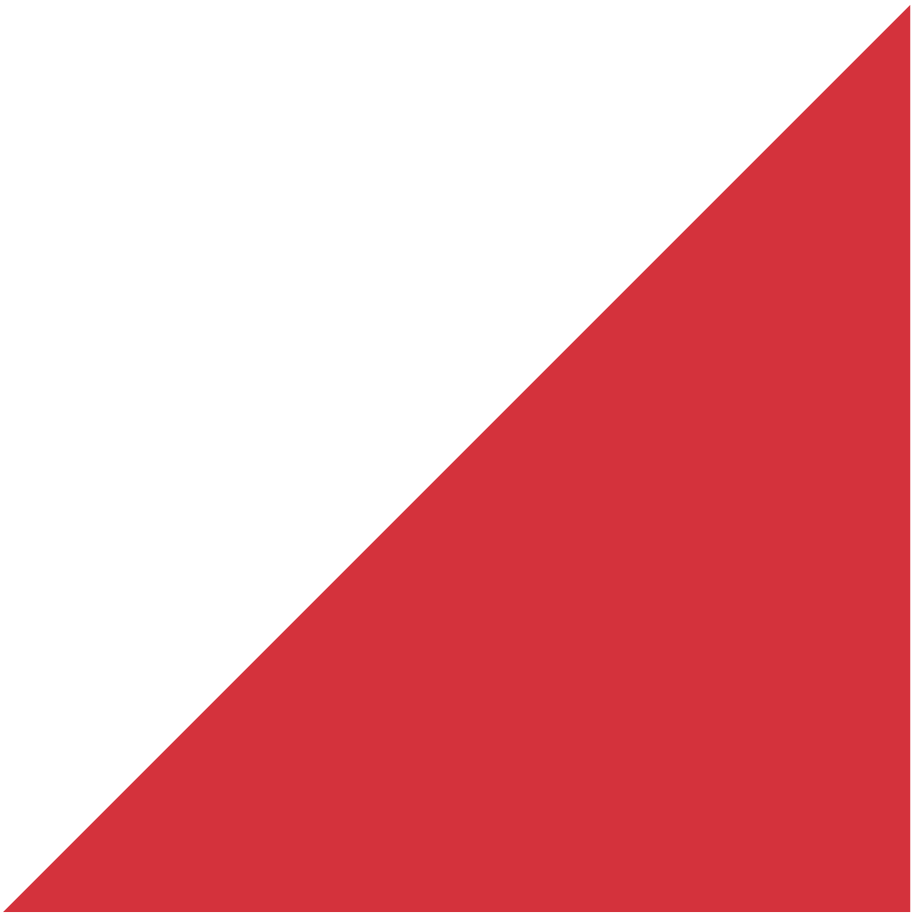
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Appendix F
Condition Assessment Report

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City of Prince George - Watermain Risk & Criticality Assessment

Watermain Risk & Criticality Assessment



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City of Prince George - Watermain Risk & Criticality Assessment

Watermain Risk & Criticality Assessment

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1 Introduction

There has been an increasing need by municipalities in Canada and other countries to adopt an effective means of asset management to evaluate service delivery models. The water utility is one such service which demands an in-depth look into its management, as distribution systems can be difficult infrastructures to manage, by virtue of having an inherently unreliable measure of physical condition. As watermains age, a challenge is presented to municipalities when assigning limited capital expenditures to their replacement or rehabilitation. The effective management of watermains requires a reasonable condition assessment framework.

This report presents Opus DaytonKnight Consultants Ltd. (Opus DK)'s comprehensive study into developing a risk assessment for the watermain distribution system of the City of Prince George (City), based on the City's existing Water Main Risk Framework. The report will outline the current state of the watermain distribution system in the City, including current infrastructure conditions and long term reinvestment projections, and the motivation for a comprehensive risk assessment. The risk assessment approach and the development of the watermain inventory required has been detailed and documented in this report. The report encompasses key findings, including a priority list for the replacement of high risk watermains.

Risk Assessment Model

The risk assessment model is a risk management tool designed to classify watermains based on the social, economic, environmental and operational consequences of a break or loss of service, and the probability of failure, informed by parameters such as age, material, and static pressure. These parameters have been developed from the City's current Water Main Risk Framework in RIVA DS.

The intent of the risk assessment is to empower the City to make informed management decisions, in order to focus resources and efforts on critical watermains. The risk assessment process is subjective, and should be regularly reviewed and refined with up-to-date information, in conjunction with other related issues, such as:

- Risk Management
- Levels of Service
- Renewals Planning
- Operations and Maintenance Practices

The strategy included in this document should be seen as a "first cut", and may be used to determine a similar approach for condition assessment of the City's wastewater and stormwater linear assets.

2 Current Situation

The City of Prince George, located at the confluence of the Fraser and Nechako Rivers, services a population of approximately 75,000 residents. Although there has been close to no population growth over the last decade, the economic climate in the City, and more generally in Northern BC, shows strong indications of growth over the next 20 years, and will likely require the City to expand and

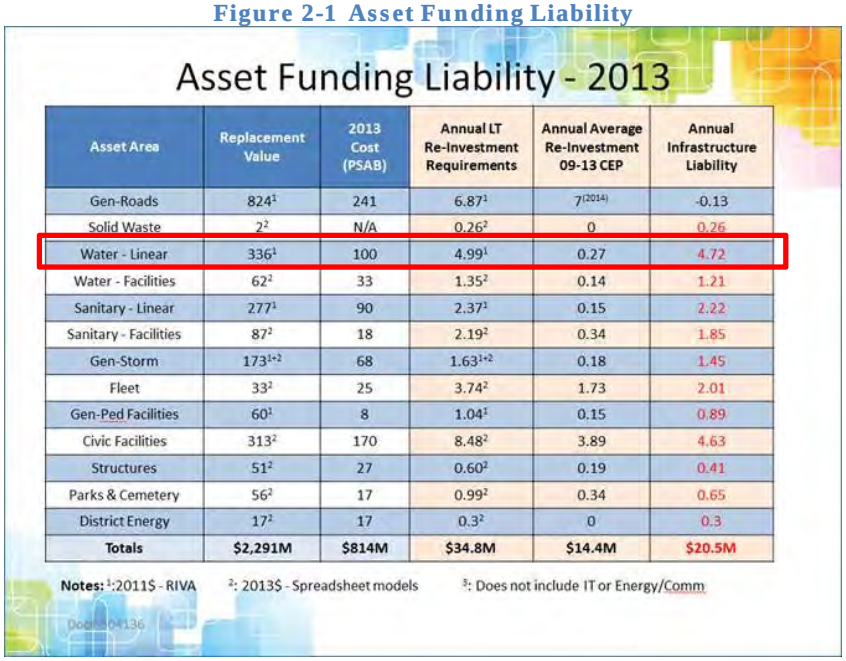
develop its water infrastructure. Concurrently, the City's current watermain network will require replacement and rehabilitation as the assets near their expected end of service life.

The City's water distribution system contains a variety of watermains of varying ages, materials, and sizes. These assets will deteriorate differently and will need to be replaced at different times depending on factors such as pipe age, material, static pressure, size, criticality, surrounding conditions and operating factors. The city is currently renewing its assets on an as-needed basis at an average annual replacement cost of $0.27 million per year, but will need to effectively prioritize replacements and its water & wastewater infrastructure, and implement asset management best practices to achieve this.

2.1 City's Calculated Funding Gap

The City provided Opus DK with information on the City's current asset funding liability, and three funding scenarios for water infrastructure (including linear and point assets) over the next 30 years. The following figures are part of a presentation made to the City Finance and Audit Committee, and the Whole Council on June 25, 2014.

Figure 2-1 Asset Funding Liability



Asset Funding Liability - 2013

Asset Area	Replacement Value	2013 Cost (PSAB)	Annual LT Re-Investment Requirements	Annual Average Re-Investment 09-13 CEP	Annual Infrastructure Liability
Gen-Roads	824[1]	241	6.87[1]	7[(2014)]	-0.13
Solid Waste	2[2]	N/A	0.26[2]	0	0.26
Water - Linear	336[1]	100	4.99[1]	0.27	4.72
Water - Facilities	62[2]	33	1.35[2]	0.14	1.21
Sanitary - Linear	277[1]	90	2.37[1]	0.15	2.22
Sanitary - Facilities	87[2]	18	2.19[2]	0.34	1.85
Gen-Storm	173[1+2]	68	1.63[1+2]	0.18	1.45
Fleet	33[2]	25	3.74[2]	1.73	2.01
Gen-Ped Facilities	60[1]	8	1.04[1]	0.15	0.89
Civic Facilities	313[2]	170	8.48[2]	3.89	4.63
Structures	51[2]	27	0.60[2]	0.19	0.41
Parks & Cemetery	56[2]	17	0.99[2]	0.34	0.65
District Energy	17[2]	17	0.3[2]	0	0.3
Totals	**$2,291M**	**$814M**	**$34.8M**	**$14.4M**	**$20.5M**

Notes: [1]:2011$ - RIVA [2]: 2013$ - Spreadsheet models [3]: Does not include IT or Energy/Comm

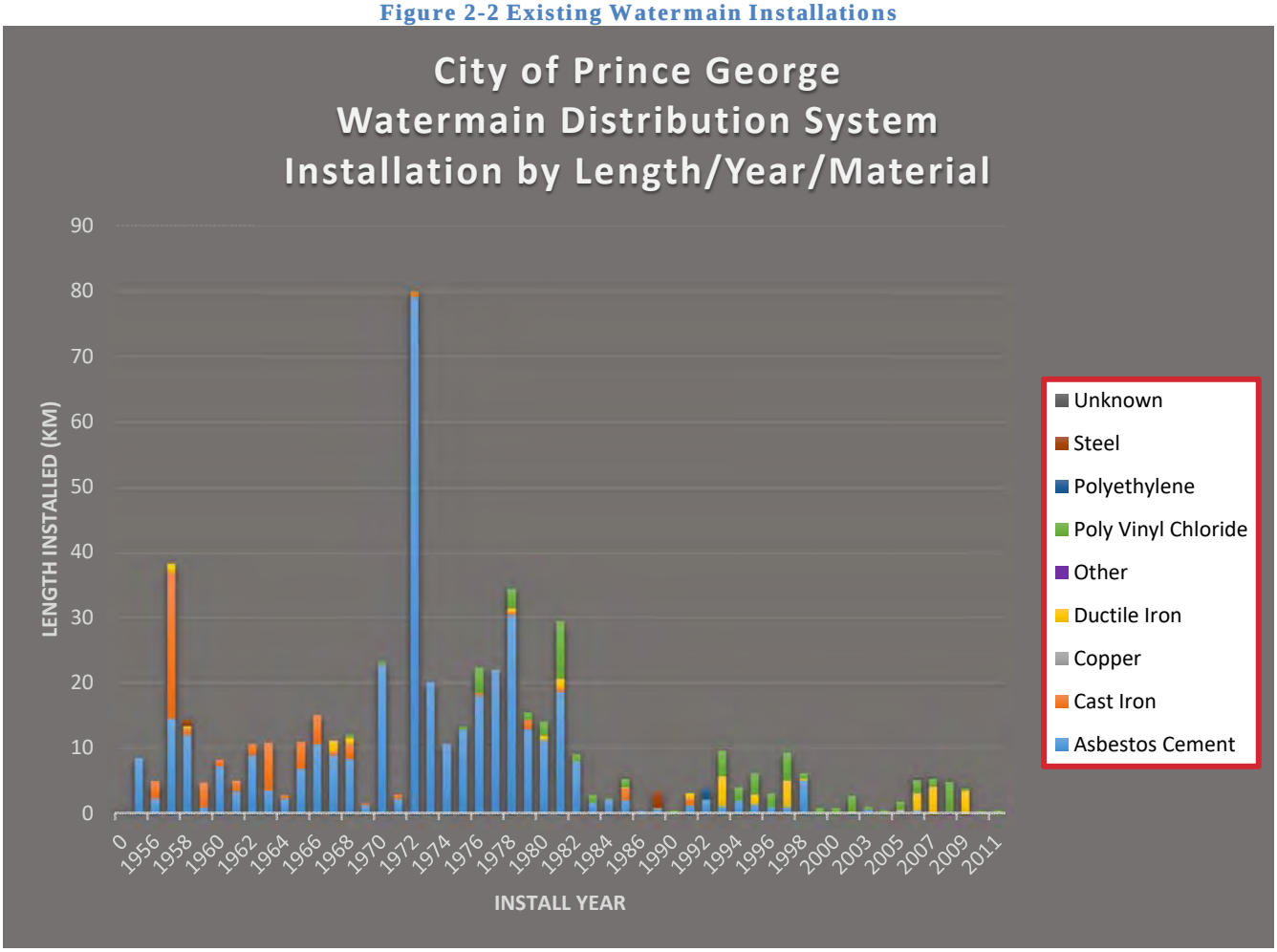
Source: City of Prince George Finance & Audit Committee, Council Presentation (June 25, 2014)

The findings from the asset funding liability (Figure 2-1) show an annual infrastructure liability to linear water assets of $4.72 million. Over 30 years, the unadjusted total capital replacement cost would be $141.6 million.

2.2 Opus DK Calculated Funding Gap

An inventory of the existing watermains has been produced as part of this exercise to develop an understanding of the existing watermain infrastructure in the City of Prince George. Figure 2-2 illustrates the watermain inventory in Prince George by length of watermains installed over the last 60 years, classified by material.

Figure 2-2 Existing Watermain Installations



To determine a replacement forecast for the existing watermains in the system, typical service life estimates and units costs for watermain replacements were compiled.

Based on typical service lives from the BC Local Government Infrastructure and Finance Division's May 2008 Guide to the Amortization of Tangible Capital Assets (included in Appendix E), and Opus DK's previous experience with watermain infrastructure in British Columbia, the following service life estimates have been developed:

Table 2-1 Typical Watermain Service Lives

Asset Life	
Pipe Material	Life (Years)
Steel	80
Polyethylene	80
Poly Vinyl Chloride	80
Ductile Iron	100
Copper	80
Cast Iron	60
Asbestos Cement	50
Unknown/Other	50

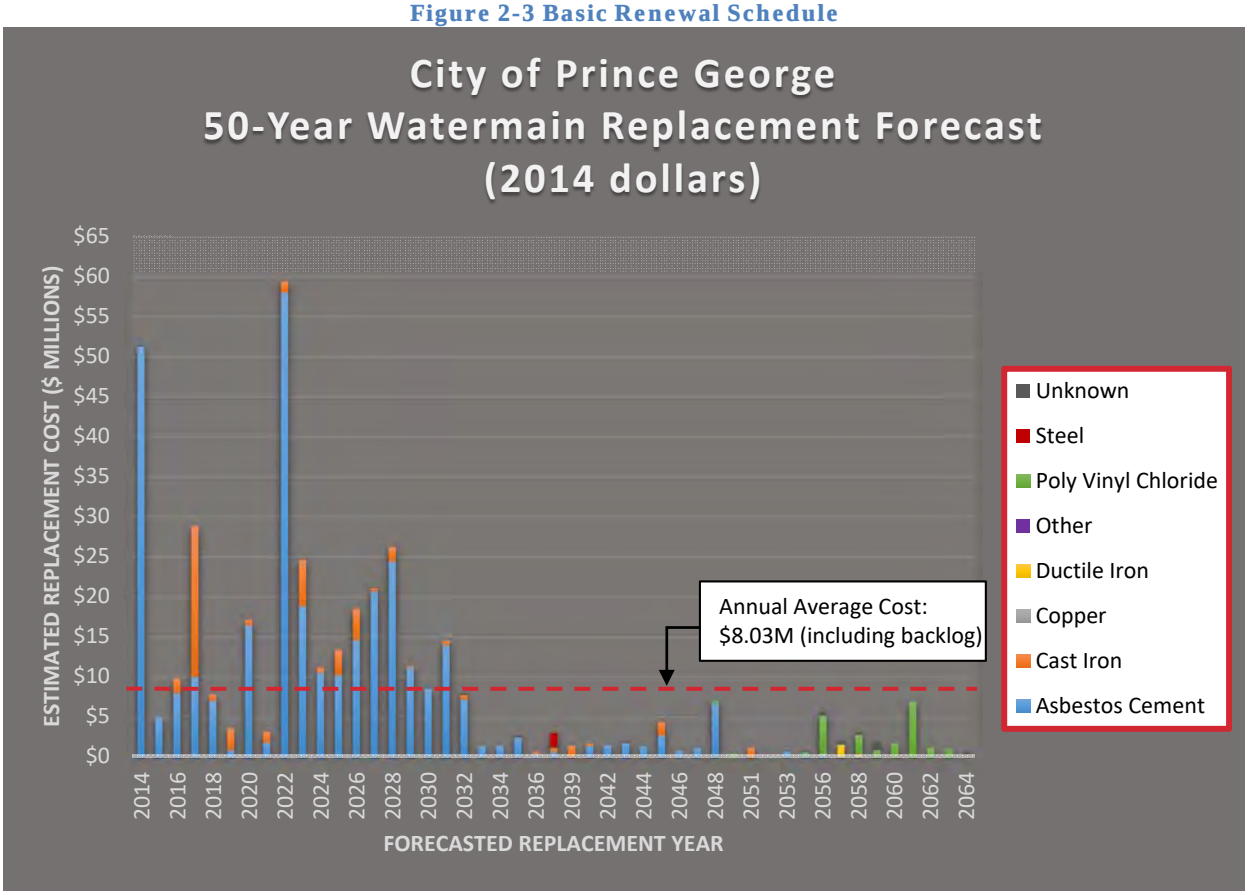
Recent revised unit costs for pipe replacement were determined in discussion with City staff on the basis of pipe material cost, and then adjusted using previous project experience for additional expenditures such as labour, tie-ins and service connections, valves and air valves.

Table 2-2 Pipe Unit Cost

Pipe Unit Cost			
Diameteter (mm)	Unit Cost ($/m)	Diameteter (mm)	Unit Cost ($/m)
≤100	$580	500	$1,810
150	$730	600	$2,180
200	$800	750	$2,610
250	$940	900	$3,050
300	$1,090	1000	$3,480
350	$1,230	1200	$4,060
400	$1,380	1500	$5,080
450	$1,600	-	-

Tables 2-1 and 2-2 were used to create the following basic watermain renewal schedule for the City's watermain network.

Figure 2-3 Basic Renewal Schedule



Forecasting existing watermains to the end of service life provides a 50 year view. From Figure 2-3, it is shown that the average capital replacement cost is estimated to be $8.03 million (2014 dollars). At this average cost, the total unadjusted replacement value is $401.4 million for 2014-2064. These estimates are higher than the City's June 25, 2014 forecasted funding liability due to conservative estimates for recently revised unit costs for watermain replacement. The major spike in end of service life forecasted for 2022 is based on the replacement of asbestos cement watermains installed in 1972 (there was over 79 km of AC watermains installed in that year).

Given the current reinvestment budget and both the City's and Opus DK's forecasts, the City will be faced with a significant long-term infrastructure gap. There are several mitigative strategies and programs that can reduce the forecasted infrastructure gap if implemented. These range from annual increases in capital renewal budgets, proactive operations, maintenance, and inspections programs, and comprehensive asset management programs.

The risk assessment is such an asset management tool, which by identifying critical watermains, will allow the City to achieve cost savings through preventive maintenance and effective watermain renewal. A proactive maintenance program can reduce the impacts of major breaks on operational costs. The City will also likely be able to extend the service life of some critical watermains.

The remainder of the Report will serve to define the risk assessment approach, and deliver the risk assessment results and tools for future use.

3 Risk Assessment Approach

The City currently runs the Decision Support (DS) module of the RIVA modelling software for Strategic Long Range, Asset, Risk and Budget Management. Opus DK further developed the City's RIVA Water Main Risk Framework to identify and prioritize City watermain conditions. Risk in the context of asset management is a measure of the consequence of the asset's failure combined with its probability of failure. Our team leveraged the skills of our expert asset management staff in BC and New Zealand to develop a standardized risk framework through which the consequence and probability of failure of assets were assessed. Sections 3.2 and 3.3 demonstrate the process of adapting the existing Water Main Risk Framework into the risk assessment of the City watermain network.

The ultimate goal is to provide to the City a comprehensive summary list of prioritized watermain assets, so that the City may be able to accurately plan their capital expenditure strategy for the long term. In addition, the remainder of this section of the report will serve to explain the methodology behind the risk assessment, as well as serve as a guideline on using the risk framework for future use.

Throughout the approach to defining risk and criticality, several figures showing a variety of pipework information have been prepared for analysis. Details on how these classifications were determined are detailed in subsequent sections. Key figures are included in Appendix A.

3.1 Risk Framework

The watermain risk framework is a tool that establishes the risk management context. It attempts to standardize assessments, and decisions made about watermains by categorizing each asset according to specific scenarios and decision drivers. The framework is used to assess the various types of impacts and consequences a break or loss of service in a watermain might have on the City, specifically any resulting social, economic, environmental, or operational concerns.

To establish the watermain risk framework, key business and community drivers were identified to shape the framework, which is split into six (6) risk consequence categories, as follows:

- Business Continuity
- People
- Financial
- Environmental
- Political & Strategic
- Technical

The framework includes questions under each driver which will guide the City in determining the level of service it deems appropriate to service certain watermains. The consequence of failure for a break or loss of service is assessed through key questions and given an individual score, of which the maximum is then taken. The severity of consequences for each category is scored from 1 to 10, ranking from 'catastrophic' to 'insignificant'. The probability of failure is likewise scored out of 10, ranging from 'Frequent' to 'Rare.' The complete framework is found in Appendix C.

3.2 Consequence of Failure

The City's watermains will deteriorate differently and will need to be replaced at different times depending on a variety of factors. Opus DK has reviewed the material considerations and the social,

environmental, and economic factors identified as consequence of failure parameters in the City's Water Main Risk Framework in RIVA. We have taken into account the following parameters to classify the City watermains according to different failure scenarios:

- Land Use
- Diameter/Type (including transmission mains)
- Cover Surface
- Riparian Protection Development Permit Area

Watermain size and pipe flow considerations have been amalgamated into the Diameter/Type parameter, which evaluates the size of a watermain and whether or not a given watermain is a transmission main. Classifying watermains by their proximity to water courses has been refined to whether or not watermains are within the Riparian Protection Area, as defined in the Official Community Plan (OCP) Schedule D-2 from Bylaw #8383. Failure severity, a parameter based on pipe material, has been excluded as pipe material has been used in determining probability of failure.

Table 3-1 illustrates the breakdown of classifications for each parameter.

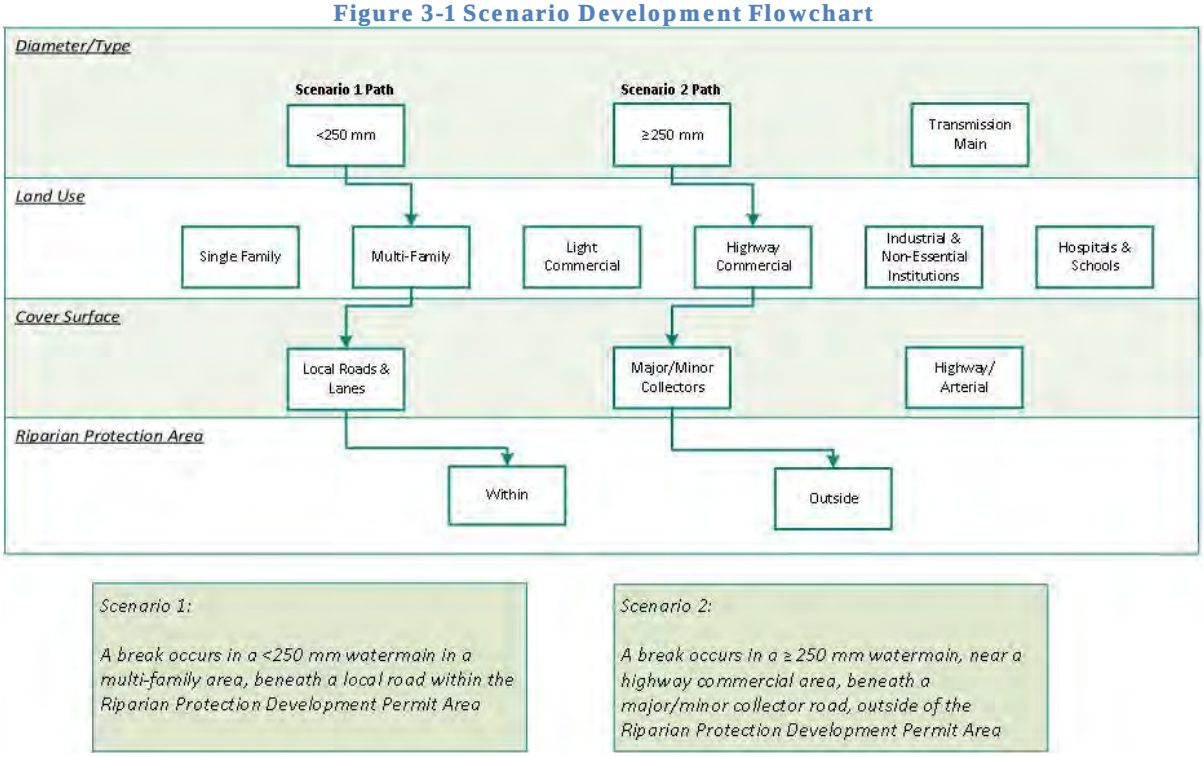
Table 3-1 Parameters for Scenario Development

Parameters for Scenario Development			
Land Use	Diameter/Type	Cover Surface	Riparian Protection Area
Single Family	<250 mm	Local Roads & Lanes	Within
Multi-Family	≥250 mm	Major/Minor Collectors	Outside
Light Commercial	Transmission Main	Highway/Arterial	-
Highway Commercial	-	-	-
Industrial & Non-Essential Institutional	-	-	-
Community Facilities	-	-	-

Figure 3-2 illustrates the process of how each parameter builds upon other parameters to generate different scenarios, in order to capture a wide variety of watermain conditions. In total, 108 different scenarios were generated and then input into the risk framework to be assigned consequence of failure rankings for each key driver, as specified above. The final consequence of failure scores were ranked out of 1 to 10; 1-2 Insignificant, 3-4 Minor, 5-6 Moderate, 7-8 Major, and 9-10 Catastrophic.

The complete framework illustrating all assessed scenarios is included in Appendix D.

Figure 3-1 Scenario Development Flowchart



The classification of each watermain into a distinct scenario allows for a rigorous ranking through the risk framework, minimizing any uncertainty or subjective evaluation of watermains on a case-by-case basis.

3.3 Probability of Failure

The probability of failure for a given watermain was determined through an assessment of the physical attributes and operating conditions of the watermain, taking into account age, material, and static pressure. Other factors considered in the Water Main Risk Framework in RIVA but not included due to unavailable data are flow deficiency, repair history, and other factors such as soil corrosivity, groundwater, and frost susceptibility at pipe zone. Opus DK believes the current method of evaluating the probability of failure based on age, material and static pressure should prove sufficient, though as information becomes available, it would be useful to refine the ranking. The assigned ranks for each category are shown in Table 3-2 below.

Table 3-2 Probability of Failure Ranking

	Rank				
	1-2	3-4	5-6	7-8	9-10
Age	<10 years	-	10-50 years	-	50-70 years
Material	HDPE, Polyethylene, Ductile Iron and Steel	-	PVC and Copper	Asbestos Cement	Cast Iron
Static Pressure	-	-	<40 psi 40-60 psi 60-80 psi	80-100 psi	>100 psi

Each watermain is assigned a score based on the above matrix and an average ranking was assigned to each watermain. The score was rounded to the nearest integer and a final rank of 1 to 10 was assigned, to represent the Probability of failure; 1-2 Rare, 3-4 Unlikely, 5-6 Possible, 7-8 Likely, and 9-10 Almost Certain.

3.4 Risk Matrix

The risk rating of each watermain was evaluated following the identification of risk scenarios through the risk framework, and the measurement of consequences and probabilities of failure. The risk ratings range from "Low Risk" to "Very High Risk" through four levels, with each level triggering a unique response action.

The risk rating was generated according to Table 3-3 below.

Table 3-3 Risk Matrix

Risk Matrix					
Probability	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
Rare	L	L	M	M	H
Unlikely	L	L	M	M	H
Possible	L	M	H	H	H
Likely	M	M	H	H	VH
Almost Certain	M	H	H	VH	VH

For each risk level, an 'Action Required' was identified. The appropriate response for each risk level was crafted in collaboration with expert asset management staff in BC and New Zealand, and follows Table 3-4 below.

Table 3-4 Risk Rating & Action Priority

Level of Risk	Rank	Action required timing
Very High Risk	9-10	Immediate corrective action (i.e. action is required now)
High Risk	7-8	Prioritized action required (i.e. make safe and program in current/next program)
Medium Risk	5-6	Planned action required (i.e. make safe and include in forward programs)
Low Risk	1-4	Manage by routine procedures

Results in Section 5 provide a breakdown of ratings for each category in the risk matrix, as well as maps of the City watermains coded to their individual risk ratings, and assigned consequence and probability of failure.

4 Watermain Inventory Development

In order to properly classify each watermain asset with an appropriate consequence of failure and probability of failure, work was required in GIS to develop a watermain inventory with key attributes ascribed to each asset. Opus DK made use of shapefiles available from the City to analyse each watermain. Section 4 of the report summarizes how each watermain was ascribed the following values:

- Pipe Diameter/Type
- Pipe Age
- Pipe Material
- Transmission Mains
- Land Use Classification
- Cover Surface
- Pressure Classification
- Riparian Protection Area Classification

Several of the above parameters were already prescribed to the watermains in the available shapefiles. These include pipe diameter, pipe age, and pipe material. These attributes were directly plotted for analysis and are included in Appendix A. Items 4.1–4.5 are also shown in Appendix A.

4.1 Diameter/Type

Watermain diameters were already given. Transmission mains were identified using engineering judgement and our familiarity with the system. Each watermain was then classified as either <250 mm, ≥ 250 mm, or as a Transmission Main.

4.2 Land Use Classification

Land use parcels were created in ArcMAP 10 using City GIS, and zoning bylaws from the City website. By this method, single family, multi-family, light commercial, highway commercial, industrial and institutional zones were identified. Community facilities such as hospitals, care facilities, education centres, and places of religious assembly were identified through OCP Schedule B-8 from Bylaw #8383 (included in Appendix E). Figure 4-1 demonstrates the parcel breakdown for the City. Each zone category was given a rank of 0-6, as follows:

Table 4-1 Land Use Ranking

Land Use	Rank
Unassigned	0
Single Family	1
Multi-Family	2
Light Commercial	3
Highway Commercial	4
Industrial & Institutional	5
Community Facilities	6

Western Acres

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LAND USE RANKING

- Single Family
- Multi-Family
- Light Commercial
- Highway Commercial
- Industrial & Institutional
- Community Facilities

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City of Prince George
Watermain Risk & Criticality Assessment
Land Use Ranking

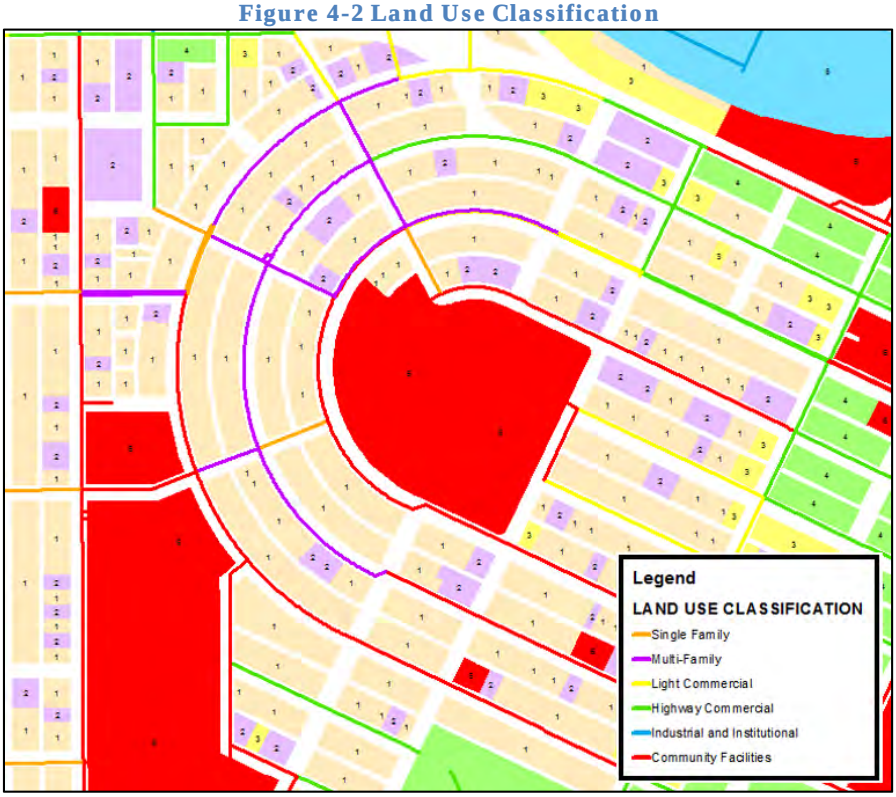
Project No: D-17460.00
Designed: CL
Drawn: CL
Approved:
Note:
Figure 4-1

Scale: 0 245 490 Meters
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Map No
Date: OCT 2014
Revision
Revision Date

Path: G:\opus_dk\municipal\174 Prince George\gis\D-17460 Water Service Network Plan Update\Michael Test\Figure 4-1 Land Use Ranking V2.mxd

Watermains were then assigned the nearest, high-value zoning rank. Figure 4-3 shows a close-up of Downtown Prince George bordered in the south-east by the Yellowhead Highway, in the north by 5 Ave, in the north-east by 3rd Ave, and in the west by Alward St. The figure shows zones with assigned ranks, and the corresponding colour coding for the watermains.

Figure 4-2 Land Use Classification



4.3 Cover Surface Classification

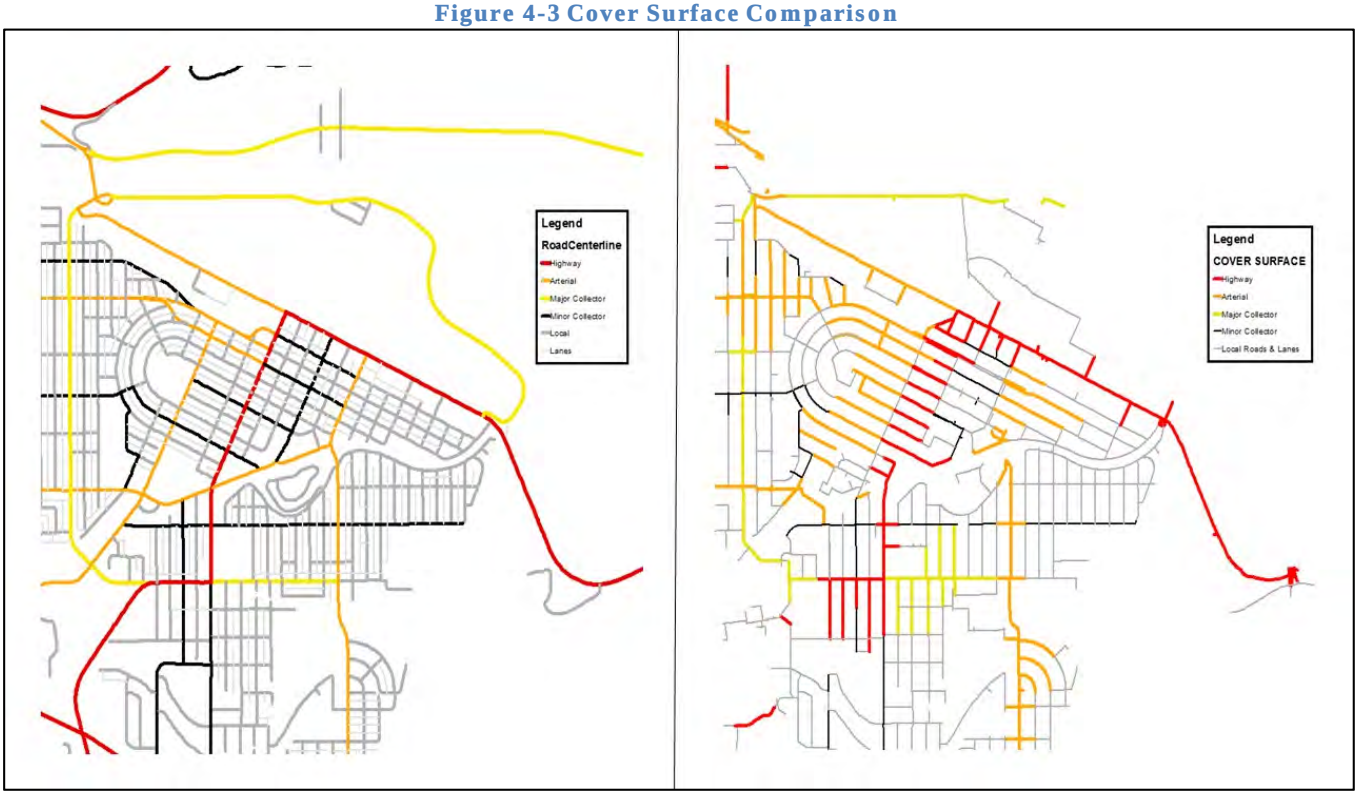
Cover surface was approximated from the road designations in the City GIS. Originally, a buffer was used to automatically assign each watermain the closest high-ranking road type, but this proved to be overly conservative, therefore some adjustments were made manually. The roads were classified in the City GIS as follows:

Table 4-2 Road Use Classification

Road class	Road type
0	Hwy Connector
1	N/A
2	Highways
3	Arterial
4	Major Connector
5	Minor Connector
6	Local
7	Lanes
8	Unassigned
9	Highway Ramps

The road designations used for classifying cover surface were grouped into Highway/Arterial, Major/Minor Collectors, and Local Roads & Lanes. A side-by-side comparison of central Prince George in Figure 4-3 demonstrates the approximate fit between the actual roads and the watermains beneath. Note that short lengths of watermains crossing high-ranking roads were given high ranks.

Figure 4-3 Cover Surface Comparison



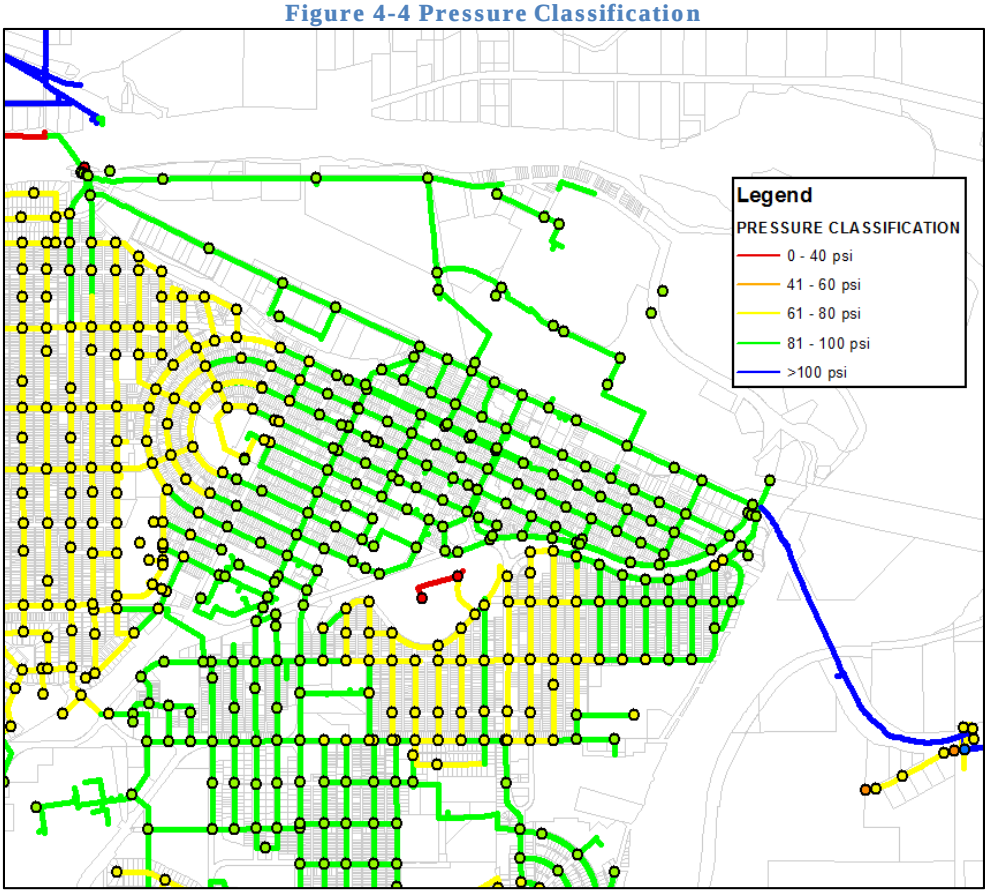
4.4 Riparian Protection Area

Watermains were classified whether they did or did not fall within the Riparian Protection Area, as defined in OCP Schedule D-2 from Bylaw #8383 (included in Appendix E). Watermains found fully or partially within the Riparian Protection Area were weighed heavier towards their consequence of failure due to environmental considerations.

4.5 Pressure Classification

Watermains were given pressure classifications according to the closest, largest pressure value at model nodes. Figure 4-4 demonstrates how watermains took on maximum characteristics of nearby pressure nodes in downtown Prince George.

Figure 4-4 Pressure Classification



5 Results & Conclusions

5.1 Consequence and Probability of Failure Results

Maps of the watermains by consequence and probability of failure ratings are shown on subsequent pages in Figures 5-1 and 5-2, respectively.

Western Acres

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CONSEQUENCE OF FAILURE

- Very High
- High
- Medium
- Low
- Very Low

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City of Prince George
Watermain Risk & Criticality Assessment
Consequence of Failure Rating

Project No: D-17460.00
Designed: CL
Drawn: CL
Approved:
Note:
Figure 5-1

Scale: 0 255 510 Meters
1:65,000 @ Tabloid
Map No
Date: OCT 2014
Revision
Revision Date

Path: G:\opus_dk\municipal\174 Prince George\gis\D-174.60 Water Service Network Plan Update\Michael Test\Figure 5-1 Consequence of Failure.mxd

Western Acres

Legend

PROBABILITY OF FAILURE

- Almost Certain
- Likely
- Possible
- Unlikely
- Rare

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City of Prince George
Watermain Risk & Criticality Assessment
Probability of Failure Rating

Project No: D-17460.00	Scale: 0 235 470 Meters
Designed: CL	1:65,000 @ Tabloid
Drawn: CL / Approved:	Map No / Date: OCT 2014
Note: Figure 5-2	Revision / Revision Date

Path: G:\opus_dk\municipal\174 Prince George\gis\D-174.60 Water Service Network Plan Update\Michael Test\Figure 5-2 Likelihood of Failure.mxd

5.2 Risk Rating Assessment

The results from the condition assessment combined the consequence and probability of failure ratings, taken from the watermain inventory, into the risk matrix. The result of the risk assessment was the categorization of the City's watermains into four categories:

- VH – Very High Risk watermains. The failure of these watermains cannot be tolerated as they are critical assets in danger of proximate failure. Immediate corrective action should be taken.
- H – High Risk watermains. The replacement or rehabilitation of these watermains should be prioritized. Operational, maintenance, and inspection programs and plans should be modified to include these assets.
- M – Medium Risk watermains. These watermains are of intermediate risk, and require a balanced approach to management. They should be included in future improvement plans.
- L – Low Risk watermains. The failure of these watermains can be tolerated, and a 'run to failure' option is viable following review. Improvement strategies can be set by balancing cost and level of service to minimize life cycle cost, while providing a minimum acceptable level of service to residents.

The results from the risk matrix are presented in a map of the City watermains in Figure 5-3 below. The risk assessment categorized the watermain network as approximately:

- 5% Very High Risk.
- 35% High Risk.
- 41% Medium Risk.
- 19% Low Risk.

Note that these percentages are representative of the total length of the watermain network analyzed, which totals just over 548 km. Table 5-1 further breaks down these ratings, following Figure 5-3.

Western Acres

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RISK CLASSIFICATION

- VERY HIGH
- HIGH
- MEDIUM
- LOW

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City of Prince George
Watermain Risk & Criticality Assessment
Risk Rating

Project No: D-17460.00
Designed: CL
Drawn: CL Approved:
Note:

Figure 5-3

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Map No
Date: OCT 2014
Revision
Revision Date

Path: G:\opus_dk\municipal\174 Prince George\gis\D-17460 Water Service Network Plan Update\Michael Test\Figure 5-3 Risk Rating Assessment.mxd

Table 5-1 illustrates the rating breakdown of watermains into the risk matrix, shown as a percentage of the total length of all watermains in the network.

Table 5-1 Risk Rating - Breakdown by Percentage

Risk Rating - Breakdown by Percentage					
Probability	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
Rare	0.0%	0.0%	0.0%	0.0%	0.0%
Unlikely	0.9%	0.0%	0.5%	1.3%	0.1%
Possible	19.0%	0.1%	2.4%	9.5%	1.1%
Likely	37.2%	0.1%	4.6%	17.6%	1.0%
Almost Certain	2.8%	0.0%	0.0%	1.7%	0.1%

Table 5-2 summarizes the percent breakdown of watermains into different risk ratings, along with the actions required. The amount of watermains designated 'Very High Risk' are below 10% of all watermains in the distribution system. This provides the City a reasonable and manageable number of watermains to replace.

Table 5-2 Actionable Risk Results

Level of Risk	Risk Distribution	Action Required
Very High Risk (VH)	5%	Immediate corrective action (i.e. action is required now)
High Risk (H)	35%	Prioritized action required (i.e. make safe and program in current/next program)
Medium Risk (M)	41%	Planned action required (i.e. make safe and include in forward programs)
Low Risk (L)	19%	Manage by routine procedures

5.3 Conclusion

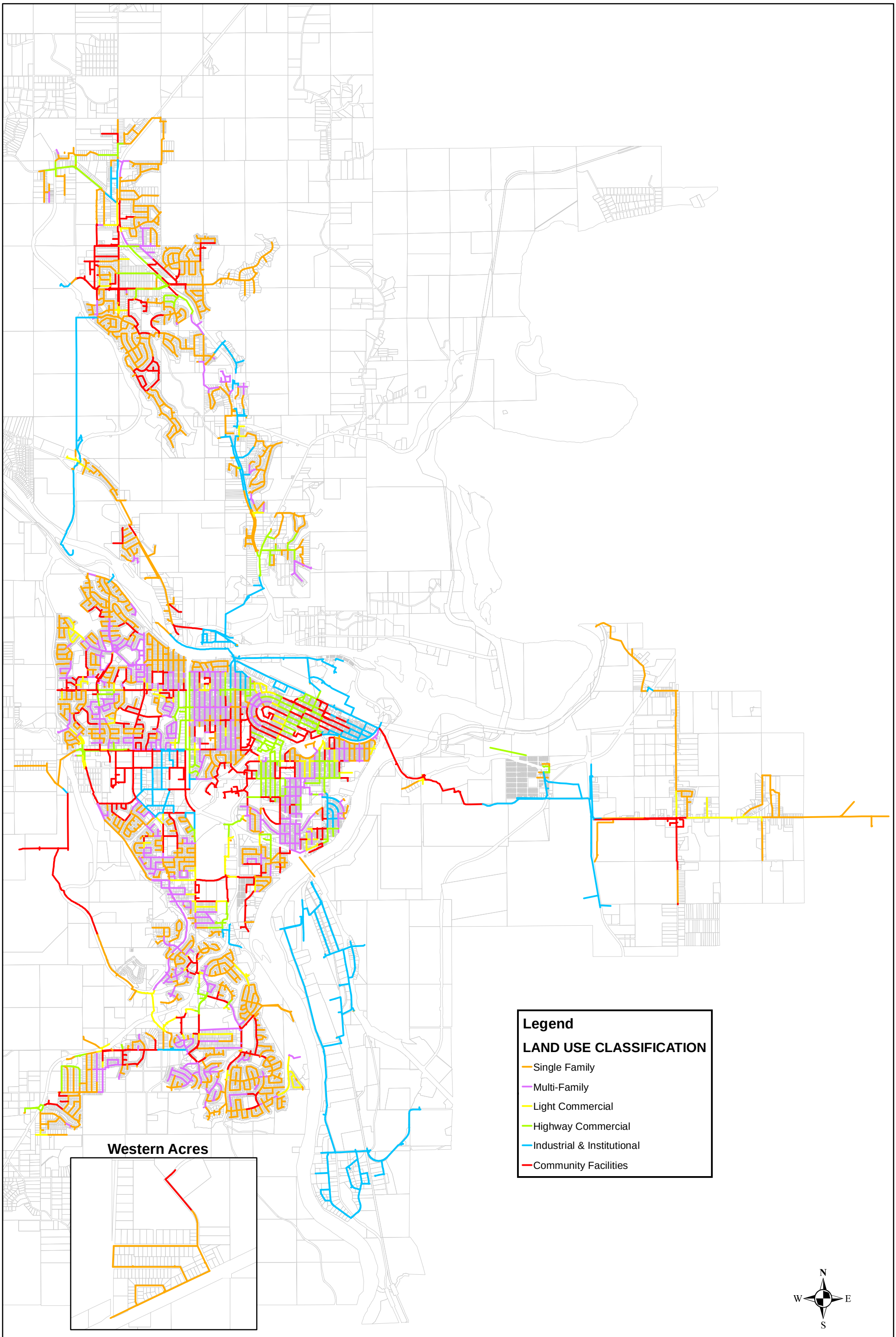
Through the risk assessment process, an unadjusted annual infrastructure liability of $8.03 million, averaged over 50 years (2014-2064) has been identified.

It would be beneficial for the City to focus on the replacement and management of those watermains identified as 'Very High Risk', which have been prioritized in a summary table included in Appendix B. As the risk assessment model provides a snapshot of the current state of the water distribution system, it is recommended that the risk assessment be updated periodically to ensure up-to-date results.

With the risk assessment model and the tools provided through the risk framework and matrix, the City has a foundation for the effective risk management of its watermain network. The optimal use of these tools is to integrate them into the daily practices and decision-making of the City Council and Staff. Refinement and improvement upon these tools will allow for a better understanding of the network to make informed decisions concerning reinvestments, particularly towards critical infrastructure.

Appendix A

Key Figures



OPUS DAYTONKNIGHT
North Vancouver Office , #210 - 889 Harbourside Drive
Tel (604) 990 4800 Fax (604) 990 4805

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Client: CITY OF PRINCE GEORGE

City of Prince George
Watermain Risk & Criticality Assessment
Land Use Classification

Project No: D-17460.00
Designed: CL
Drawn: CL
Approved:
Scale: 0 250 500 Meters
1:65,000 @ Tabloid
Map No
Date: OCT 2014
Revision
Revision Date

Figure A-1

Path: G:\opus_dk\municipal\174 Prince George\gis\D-174.60 Water Service Network Plan Update\Michael Test\Figure A-1 Land Use Classification.mxd

Western Acres

Legend

DIAMETER CLASSIFICATION

- <250 mm
- >=250 mm
- Transmission Main

N

W E

S

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Client: CITY OF PRINCE GEORGE

City of Prince George
Watermain Risk & Criticality Assessment
Diameter/Type Classification

Project No:	D-17460.00
Designed:	CL
Drawn:	CL
Approved:	
Note:	Figure A-2
Scale:	0 250 500 Meters; 1:65,000 @ Tabloid
Map No	
Date	OCT 2014
Revision	
Revision Date	

Path: G:\opus_dk\municipal\174 Prince George\gis\D-17460 Water Service Network Plan Update\Michael Test\Figure A-2 Diameter Type Classification.mxd

Legend

COVER SURFACE

- Highway
- Arterial
- Major Collector
- Minor Collector
- Local Roads & Lanes

Western Acres

N

W E

S

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Client: CITY OF PRINCE GEORGE

City of Prince George
Watermain Risk & Criticality Assessment
Cover Surface Classification

Project No: D-17460.00
Designed: CL
Drawn: CL
Approved:
Scale: 0 245 490 Meters
1:65,000 @ Tabloid
Note:
Figure A-3
Map No
Date: OCT 2014
Revision
Revision Date

Path: G:\opus_dk\municipal\174 Prince George\gis\D-174.60 Water Service Network Plan Update\Michael Test\Figure A-3 Cover Surface Classification.mxd

Western Acres

Legend

AGE CLASSIFICATION

- 0 - 10 years
- 11 - 30 years
- 31 - 50 years
- >50 years

N

W E

S

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Client: CITY OF PRINCE GEORGE

City of Prince George
Watermain Risk & Criticality Assessment
Age Classification

Project No: D-17460.00
Designed: CL
Drawn: CL Approved:
Note:
Figure A-4

Scale: 0 237.5 475 Meters
1:65,000 @ Tabloid
Map No
Date: OCT 2014
Revision
Revision Date

Path: G:\opus_dk\municipal\174 Prince George\gis\D-174.60 Water Service Network Plan Update\Michael Test\Figure A-4 Age Classification.mxd

Legend

MATERIAL DESCRIPTION

- PVC; Steel; Polyethylene
- Ductile Iron; Copper
- Asbestos Cement
- Cast Iron
- Other; Unknown

Western Acres

N

W E

S

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Client: CITY OF PRINCE GEORGE

City of Prince George
Watermain Risk & Criticality Assessment
Material Classification

Project No: D-17460.00
Designed: CL
Drawn: CL
Approved:
Note:
Figure A-5

Scale: 0 255 510 Meters
1:65,000 @ Tabloid
Map No
Date: OCT 2014
Revision
Revision Date

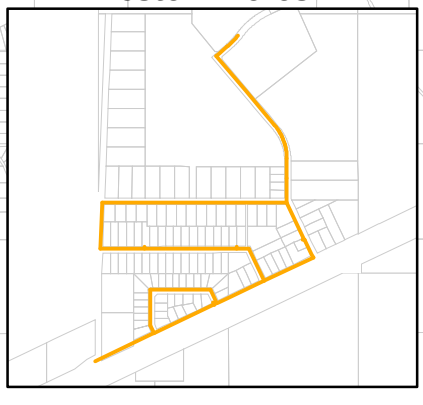
Path: G:\opus_dk\municipal\174 Prince George\gis\D-17460 Water Service Network Plan Update\Michael Test\Figure A-5 Material Classification.mxd

Legend

PRESSURE CLASSIFICATION

- 0 - 40 psi
- 41 - 60 psi
- 61 - 80 psi
- 81 - 100 psi
- >100 psi

Western Acres



N

W E

S

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Client: CITY OF PRINCE GEORGE

City of Prince George
Watermain Risk & Criticality Assessment
Pressure Classification

Project No: D-17460.00
Designed: CL
Drawn: CL
Approved:
Note:
Scale: 0 2.5 5.0 Meters
1:65,000 @ Tabloid
Map No
Date: OCT 2014
Revision
Revision Date

Figure A-6

Path: G:\opus_dk\municipal\174 Prince George\gis\D-17460 Water Service Network Plan Update\Michael Test\Figure A-6 Pressure Classification.mxd

Western Acres

Legend
PROXIMITY TO WATER COURSE
RPA
0
1

N
W E
S

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Tel (604) 990 4800 Fax (604) 990 4805

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Client:
CITY OF PRINCE GEORGE

City of Prince George
Watermain Risk & Criticality Assessment
Proximity to Water Course Classification

Project No: D-17460.00
Designed: CL
Drawn: CL
Approved:
Note:
Figure A-7

Scale: 0 255 510 Meters
1:65,000 @ Tabloid
Map No
Date: OCT 2014
Revision
Revision Date

Path: G:\opus_dk\municipal\174 Prince George\gis\D-17460 Water Service Network Plan Update\Michael Test\Figure A-7 V2 Riparian Protection Area.mxd

Appendix B

Summary of Priority Watermain Replacements

City of Prince George - Watermain Risk & Criticality Assessment
Summary Table - "Very High Risk" Watermains Replacement Projects

FID	Consequence of Failure Parameters						Probability of Failure Parameters					Risk Rating	Risk	Diameter (mm)	Length (m)	Replacement Cost	Replacement Year
	Land Usage	Diameter Type (mm)	Cover Surface	Riparian Protection Development Permit Area	Consequence of Failure rating	Consequence of Failure	Age (years)	Material	Static Pressure (psi)	Probability of Failure Rating	Probability of Failure						
3540	Highway Commercial	Transmission	Highway/Arterial	Outside	10	Very High	56	AC	69	8	Likely	8	VERY HIGH	300	20	$ 21,755	2014
3577	Multi-Family	Transmission	Highway/Arterial	Outside	10	Very High	56	AC	69	8	Likely	8	VERY HIGH	300	8	$ 8,368	2014
3659	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	56	AC	94	8	Likely	8	VERY HIGH	400	441	$ 608,147	2014
3662	Highway Commercial	Transmission	Highway/Arterial	Outside	10	Very High	56	AC	69	8	Likely	8	VERY HIGH	300	6	$ 6,042	2014
3663	Highway Commercial	Transmission	Highway/Arterial	Outside	10	Very High	56	AC	69	8	Likely	8	VERY HIGH	300	73	$ 79,745	2014
4670	Multi-Family	Transmission	Highway/Arterial	Outside	10	Very High	57	AC	68	8	Likely	8	VERY HIGH	300	8	$ 8,582	2014
4844	Multi-Family	Transmission	Highway/Arterial	Outside	10	Very High	57	AC	68	8	Likely	8	VERY HIGH	300	10	$ 11,186	2014
4877	Highway Commercial	Transmission	Highway/Arterial	Outside	10	Very High	56	AC	69	8	Likely	8	VERY HIGH	300	216	$ 235,430	2014
4878	Highway Commercial	Transmission	Highway/Arterial	Outside	10	Very High	56	AC	69	8	Likely	8	VERY HIGH	300	6	$ 6,135	2014
4879	Highway Commercial	Transmission	Highway/Arterial	Outside	10	Very High	56	AC	69	8	Likely	8	VERY HIGH	300	9	$ 10,240	2014
4946	Multi-Family	Transmission	Highway/Arterial	Outside	10	Very High	57	AC	69	8	Likely	8	VERY HIGH	300	79	$ 86,393	2014
4956	Community Facilities	Transmission	Highway/Arterial	Outside	10	Very High	57	AC	90	8	Likely	8	VERY HIGH	300	37	$ 40,093	2014
4987	Industrial & Institutional	>=250	Highway/Arterial	Outside	8	High	58	CI	91	10	Almost Certain	8	VERY HIGH	300	116	$ 126,819	2016
4988	Multi-Family	<250	Highway/Arterial	Outside	8	High	58	CI	91	10	Almost Certain	8	VERY HIGH	100	43	$ 25,054	2016
303	Light Commercial	<250	Highway/Arterial	Outside	8	High	57	CI	87	10	Almost Certain	8	VERY HIGH	100	260	$ 150,770	2017
315	Highway Commercial	>=250	Highway/Arterial	Outside	8	High	57	CI	88	10	Almost Certain	8	VERY HIGH	300	88	$ 95,833	2017
316	Highway Commercial	Transmission	Highway/Arterial	Outside	10	Very High	57	CI	88	10	Almost Certain	8	VERY HIGH	300	89	$ 96,600	2017
324	Highway Commercial	<250	Highway/Arterial	Outside	8	High	57	CI	91	10	Almost Certain	8	VERY HIGH	200	98	$ 78,096	2017
340	Highway Commercial	<250	Highway/Arterial	Outside	8	High	57	CI	83	10	Almost Certain	8	VERY HIGH	150	264	$ 193,066	2017
342	Community Facilities	<250	Highway/Arterial	Outside	8	High	57	CI	92	10	Almost Certain	8	VERY HIGH	150	390	$ 284,561	2017
344	Community Facilities	<250	Major/Minor Collectors	Outside	8	High	57	CI	84	10	Almost Certain	8	VERY HIGH	150	92	$ 67,190	2017
345	Highway Commercial	<250	Highway/Arterial	Outside	8	High	57	CI	84	10	Almost Certain	8	VERY HIGH	150	129	$ 94,020	2017
346	Community Facilities	<250	Major/Minor Collectors	Outside	8	High	57	CI	84	10	Almost Certain	8	VERY HIGH	150	154	$ 112,671	2017
1598	Community Facilities	>=250	Local Roads & Lanes	Outside	8	High	57	CI	93	10	Almost Certain	8	VERY HIGH	300	31	$ 33,482	2017
1600	Highway Commercial	<250	Highway/Arterial	Outside	8	High	57	CI	92	10	Almost Certain	8	VERY HIGH	150	244	$ 178,133	2017
1601	Community Facilities	>=250	Local Roads & Lanes	Outside	8	High	57	CI	92	10	Almost Certain	8	VERY HIGH	300	18	$ 19,399	2017
1602	Community Facilities	<250	Highway/Arterial	Outside	8	High	57	CI	86	10	Almost Certain	8	VERY HIGH	150	374	$ 273,293	2017
4282	Community Facilities	>=250	Highway/Arterial	Outside	8	High	57	CI	89	10	Almost Certain	8	VERY HIGH	300	238	$ 259,428	2017
4283	Community Facilities	>=250	Local Roads & Lanes	Outside	8	High	57	CI	90	10	Almost Certain	8	VERY HIGH	300	112	$ 122,564	2017
4296	Community Facilities	<250	Highway/Arterial	Outside	8	High	57	CI	94	10	Almost Certain	8	VERY HIGH	200	145	$ 116,296	2017
4297	Industrial & Institutional	<250	Highway/Arterial	Outside	8	High	57	CI	94	10	Almost Certain	8	VERY HIGH	200	8	$ 6,557	2017
4298	Industrial & Institutional	<250	Highway/Arterial	Outside	8	High	57	CI	94	10	Almost Certain	8	VERY HIGH	200	4	$ 2,878	2017
4299	Community Facilities	<250	Highway/Arterial	Outside	8	High	57	CI	95	10	Almost Certain	8	VERY HIGH	150	426	$ 311,284	2017
4312	Community Facilities	Transmission	Major/Minor Collectors	Outside	8	High	57	CI	90	10	Almost Certain	8	VERY HIGH	300	88	$ 96,141	2017
4314	Community Facilities	<250	Local Roads & Lanes	Outside	8	High	57	CI	80	10	Almost Certain	8	VERY HIGH	150	24	$ 17,484	2017
4491	Highway Commercial	>=250	Highway/Arterial	Outside	8	High	57	CI	88	10	Almost Certain	8	VERY HIGH	300	6	$ 6,572	2017
4511	Community Facilities	<250	Highway/Arterial	Outside	8	High	57	CI	83	10	Almost Certain	8	VERY HIGH	100	99	$ 57,646	2017
4513	Community Facilities	<250	Local Roads & Lanes	Outside	8	High	57	CI	83	10	Almost Certain	8	VERY HIGH	150	21	$ 15,091	2017
4516	Community Facilities	<250	Local Roads & Lanes	Outside	8	High	57	CI	80	10	Almost Certain	8	VERY HIGH	150	88	$ 64,263	2017
4578	Community Facilities	<250	Local Roads & Lanes	Outside	8	High	57	CI	82	10	Almost Certain	8	VERY HIGH	100	130	$ 75,249	2017
4579	Highway Commercial	<250	Highway/Arterial	Outside	8	High	57	CI	91	10	Almost Certain	8	VERY HIGH	200	127	$ 101,861	2017
4585	Community Facilities	<250	Local Roads & Lanes	Outside	8	High	57	CI	92	10	Almost Certain	8	VERY HIGH	150	1	$ 1,025	2017
4592	Highway Commercial	<250	Highway/Arterial	Outside	8	High	57	CI	82	10	Almost Certain	8	VERY HIGH	150	404	$ 294,630	2017
4593	Light Commercial	>=250	Highway/Arterial	Outside	8	High	57	CI	81	10	Almost Certain	8	VERY HIGH	350	315	$ 387,969	2017
4635	Community Facilities	<250	Major/Minor Collectors	Outside	8	High	57	CI	95	10	Almost Certain	8	VERY HIGH	150	17	$ 12,505	2017
4636	Community Facilities	>=250	Major/Minor Collectors	Outside	8	High	57	CI	95	10	Almost Certain	8	VERY HIGH	300	65	$ 70,970	2017
4637	Community Facilities	>=250	Local Roads & Lanes	Outside	8	High	57	CI	95	10	Almost Certain	8	VERY HIGH	300	14	$ 15,425	2017
4638	Community Facilities	>=250	Local Roads & Lanes	Outside	8	High	57	CI	95	10	Almost Certain	8	VERY HIGH	300	46	$ 49,666	2017
4639	Highway Commercial	<250	Highway/Arterial	Outside	8	High	57	CI	93	10	Almost Certain	8	VERY HIGH	150	244	$ 178,320	2017
4657	Community Facilities	Transmission	Highway/Arterial	Outside	10	Very High	57	CI	90	10	Almost Certain	8	VERY HIGH	350	171	$ 209,762	2017
4658	Light Commercial	Transmission	Highway/Arterial	Outside	10	Very High	57	CI	91	10	Almost Certain	8	VERY HIGH	350	98	$ 120,286	2017
4659	Community Facilities	Transmission	Highway/Arterial	Outside	10	Very High	57	CI	90	10	Almost Certain	8	VERY HIGH	350	26	$ 32,031	2017
4660	Community Facilities	<250	Highway/Arterial	Outside	8	High	57	CI	90	10	Almost Certain	8	VERY HIGH	150	80	$ 58,715	2017
4690	Community Facilities	<250	Local Roads & Lanes	Outside	8	High	57	CI	81	10	Almost Certain	8	VERY HIGH	150	17	$ 12,326	2017
4954	Community Facilities	Transmission	Highway/Arterial	Outside	10	Very High	57	CI	90	10	Almost Certain	8	VERY HIGH	300	159	$ 173,658	2017
4955	Community Facilities	Transmission	Highway/Arterial	Outside	10	Very High	57	CI	71	8	Likely	8	VERY HIGH	300	6	$ 6,358	2017
4957	Community Facilities	<250	Highway/Arterial	Outside	8	High	57	CI	89	10	Almost Certain	8	VERY HIGH	150	381	$ 277,773	2017
4960	Highway Commercial	<250	Highway/Arterial	Outside	8	High	57	CI	82	10	Almost Certain	8	VERY HIGH	200	93	$ 74,069	2017
4961	Highway Commercial	<250	Highway/Arterial	Outside	8	High	57	CI	82	10	Almost Certain	8	VERY HIGH	200	84	$ 67,124	2017
4962	Community Facilities	>=250	Highway/Arterial	Outside	8	High	57	CI	81	10	Almost Certain	8	VERY HIGH	300	136	$ 148,042	2017
4963	Community Facilities	>=250	Highway/Arterial	Outside	8	High	57	CI	84	10	Almost Certain	8	VERY HIGH	300	36	$ 39,224	2017
4964	Community Facilities	>=250	Highway/Arterial	Outside	8	High	57	CI	88	10	Almost Certain	8	VERY HIGH	300	83	$ 90,655	2017
4965	Community Facilities	<250	Highway/Arterial	Outside	8	High	57	CI	84	10	Almost Certain	8	VERY HIGH	200	10	$ 8,251	2017
4969	Community Facilities	>=250	Local Roads & Lanes	Outside	8	High	57	CI	92	10	Almost Certain	8	VERY HIGH	300	92	$ 99,813	2017
4970	Community Facilities	>=250	Local Roads & Lanes	Outside	8	High	57	CI	92	10	Almost Certain	8	VERY HIGH	300	2	$ 1,661	2017
5007	Light Commercial	<250	Highway/Arterial	Outside	8	High	57	CI	85	10	Almost Certain	8	VERY HIGH	150	260	$ 189,987	2017
5008	Community Facilities	<250	Local Roads & Lanes	Outside	8	High	57	CI	80	10	Almost Certain	8	VERY HIGH	150	73	$ 53,370	2017
5038	Highway Commercial	>=250	Highway/Arterial	Outside	8	High	57	CI	88	10	Almost Certain	8	VERY HIGH	300	1	$ 1,345	2017
5039	Highway Commercial	>=250	Highway/Arterial	Outside	8	High	57	CI	89	10	Almost Certain	8	VERY HIGH	300	88	$ 96,399	2017
5040	Highway Commercial	>=250	Highway/Arterial	Outside	8	High	57	CI	89	10	Almost Certain	8	VERY HIGH	300	88	$ 95,726	2017
5041	Highway Commercial	<250	Highway/Arterial	Outside	8	High	57	CI	91	10	Almost Certain	8	VERY HIGH	200	57	$ 45,760	2017
5042	Highway Commercial	<250	Highway/Arterial	Outside	8	High	57	CI	91	10	Almost Certain	8	VERY HIGH	200	2	$ 1,222	2017
5073	Light Commercial	Transmission	Major/Minor Collectors	Outside	8	High	57	CI	91	10	Almost Certain	8	VERY HIGH	350	35	$ 43,535	2017
5074	Community Facilities	<250	Major/Minor Collectors	Outside	8	High	57	CI	92	10	Almost Certain	8	VERY HIGH	200	276	$ 220,602	2017
5088	Community Facilities	Transmission	Major/Minor Collectors	Outside	8	High	57	CI	91	10	Almost Certain	8	VERY HIGH	300	90	$ 97,997	2017
5092	Community Facilities	<250	Highway/Arterial	Outside	8	High	57	CI	87	10	Almost Certain	8	VERY HIGH	200	195	$ 155,876	2017
5093	Community Facilities	<250	Major/Minor Collectors	Outside	8	High	57	CI	82	10	Almost Certain	8	VERY HIGH	100	195	$ 112,956	2017
5095	Light Commercial	<250	Highway/Arterial	Outside	8	High	57	CI	91	10	Almost Certain	8	VERY HIGH	150	94	$ 68,255	2017
5096	Community Facilities	<250	Major/Minor Collectors	Outside	8	High	57	CI	84	10	Almost Certain	8	VERY HIGH	150	93	$ 68,227	2017
5108	Light Commercial	<250	Highway/Arterial	Outside	8	High	57	CI	81	10	Almost Certain	8	VERY HIGH	200	4	$ 3,459	2017
5110	Community Facilities	<250	Local Roads & Lanes	Outside	8	High	57	CI	82	10	Almost Certain	8	VERY HIGH	200	47	$ 37,513	2017
5111	Community Facilities	<250	Local Roads & Lanes	Outside	8	High	57	CI	82	10	Almost Certain	8	VERY HIGH	200	95	$ 75,985	2017
5112	Community Facilities	<250	Highway/Arterial	Outside	8	High	57	CI	84	10	Almost Certain	8	VERY HIGH	200	102	$ 81,931	2017
5129	Community Facilities	<250	Highway/Arterial	Outside	8	High	57	CI	94	10	Almost Certain	8	VERY HIGH	150	455	$ 332,042	2017
5486	Community Facilities	>=250	Highway/Arterial	Outside	8	High	57	CI	87	10	Almost Certain	8	VERY HIGH	300	95	$ 103,112	2017
5489	Community Facilities	<250	Local Roads & Lanes	Outside	8	High	57	CI	82	10	Almost Certain	8	VERY HIGH	200	36	$ 28,851	2017
5588	Community Facilities	<250	Major/Minor Collectors	Outside	8	High	57	CI	92	10	Almost Certain	8	VERY HIGH	150	340	$ 248,044	2017
5642	Community Facilities	<250	Highway/Arterial	Outside	8	High	57	CI	83	10	Almost Certain	8	VERY HIGH	150	92	$ 67,099	2017
5643	Community Facilities	<250	Highway/Arterial	Outside	8	High	57	CI	89	10	Almost Certain	8	VERY HIGH	200	62	$ 49,577	2017
5652	Highway Commercial	>=250	Highway/Arterial	Outside	8	High	57	CI	85	10	Almost Certain	8	VERY HIGH	350	261	$ 320,466	2017
5653	Community Facilities	>=250	Highway/Arterial	Outside	8	High	57	CI	92	10	Almost Certain	8	VERY HIGH	350	244	$ 300,150	2017
5655	Highway Commercial	<250	Highway/Arterial	Outside	8	High	57	CI	82	10	Almost Certain	8	VERY HIGH	150	261	$ 190,194	2017
5656	Highway Commercial	<250	Highway/Arterial	Outside	8	High	57	CI	85	10	Almost Certain	8	VERY HIGH	150	114	$ 83,180	2017
5657	Highway Commercial	<250	Highway/Arterial	Outside	8	High	57	CI	90	10	Almost Certain	8	VERY HIGH	150	130	$ 94,962	2017
5662	Community Facilities	<250	Highway/Arterial	Outside	8	High	57	CI	90	10	Almost Certain	8	VERY HIGH	200	366	$ 292,834	2017
5825	Community Facilities	>=250	Highway/Arterial	Outside	8	High	57	CI	92	10	Almost Certain	8	VERY HIGH	300	123	$ 134,168	2017
5826	Community Facilities	<250	Highway/Arterial	Outside	8	High	57	CI	94	10	Almost Certain	8	VERY HIGH	150	12	$ 8,767	2017
5827	Community Facilities	>=250	Highway/Arterial	Outside	8	High	57	CI	92	10	Almost Certain	8	VERY HIGH	300	21	$ 22,890	2017
6719	Community Facilities	>=250	Local Roads & Lanes	Outside	8	High	57	CI	95	10	Almost Certain	8	VERY HIGH	300	89	$ 97,020	2017
6838	Community Facilities	>=250	Major/Minor Collectors	Outside	8	High	57	CI	95	10	Almost Certain	8	VERY HIGH	300	35	$ 38,554	2017
6875	Highway Commercial	<250	Highway/Arterial	Outside	8	High	57	CI	84	10	Almost Certain	8	VERY HIGH	150	5	$ 3,650	2017
6876	Highway Commercial	<250	Highway/Arterial	Outside	8	High	57	CI	92	10	Almost Certain	8	VERY HIGH	150	36	$ 26,280	2017
6982	Community Facilities	<250	Local Roads & Lanes	Outside	8	High	57	CI	82	10	Almost Certain	8	VERY HIGH	200	14	$ 10,987	2017
6983	Community Facilities	<250	Local Roads & Lanes	Outside	8	High	57	CI	82	10	Almost Certain	8	VERY HIGH	200	11	$ 8,476	2017

City of Prince George - Watermain Risk & Criticality Assessment
Summary Table - "Very High Risk" Watermains Replacement Projects

FID	Consequence of Failure Parameters						Probability of Failure Parameters					Risk Rating	Risk	Diameter (mm)	Length (m)	Replacement Cost	Replacement Year
	Land Usage	Diameter Type (mm)	Cover Surface	Riparian Protection Development Permit Area	Consequence of Failure rating	Consequence of Failure	Age (years)	Material	Static Pressure (psi)	Probability of Failure Rating	Probability of Failure						
6984	Community Facilities	<250	Local Roads & Lanes	Outside	8	High	57	CI	82	10	Almost Certain	8	VERY HIGH	200	14	$ 10,981	2017
6988	Highway Commercial	>=250	Highway/Arterial	Outside	8	High	57	CI	81	10	Almost Certain	8	VERY HIGH	300	107	$ 116,205	2017
6989	Community Facilities	<250	Highway/Arterial	Outside	8	High	57	CI	84	10	Almost Certain	8	VERY HIGH	200	6	$ 4,937	2017
6992	Light Commercial	<250	Highway/Arterial	Outside	8	High	57	CI	81	10	Almost Certain	8	VERY HIGH	200	2	$ 1,219	2017
1091	Community Facilities	Transmission	Highway/Arterial	Outside	10	Very High	46	AC	91	8	Likely	8	VERY HIGH	400	83	$ 115,027	2018
4951	Community Facilities	<250	Highway/Arterial	Outside	8	High	56	CI	90	10	Almost Certain	8	VERY HIGH	150	137	$ 99,915	2018
211	Highway Commercial	<250	Highway/Arterial	Outside	8	High	55	CI	92	10	Almost Certain	8	VERY HIGH	200	79	$ 63,439	2019
305	Highway Commercial	<250	Highway/Arterial	Outside	8	High	55	CI	92	10	Almost Certain	8	VERY HIGH	150	87	$ 63,869	2019
308	Highway Commercial	<250	Highway/Arterial	Outside	8	High	55	CI	91	10	Almost Certain	8	VERY HIGH	200	116	$ 92,767	2019
339	Community Facilities	<250	Highway/Arterial	Outside	8	High	55	CI	92	10	Almost Certain	8	VERY HIGH	200	558	$ 446,246	2019
4487	Community Facilities	<250	Local Roads & Lanes	Outside	8	High	55	CI	95	10	Almost Certain	8	VERY HIGH	100	93	$ 53,853	2019
4582	Highway Commercial	<250	Highway/Arterial	Outside	8	High	55	CI	92	10	Almost Certain	8	VERY HIGH	150	134	$ 98,104	2019
4587	Highway Commercial	<250	Highway/Arterial	Outside	8	High	55	CI	92	10	Almost Certain	8	VERY HIGH	200	92	$ 73,349	2019
4588	Community Facilities	<250	Highway/Arterial	Outside	8	High	55	CI	95	10	Almost Certain	8	VERY HIGH	200	497	$ 397,896	2019
4590	Highway Commercial	<250	Highway/Arterial	Outside	8	High	55	CI	92	10	Almost Certain	8	VERY HIGH	100	246	$ 142,735	2019
4591	Highway Commercial	<250	Highway/Arterial	Outside	8	High	55	CI	95	10	Almost Certain	8	VERY HIGH	150	246	$ 179,668	2019
4942	Highway Commercial	<250	Highway/Arterial	Outside	8	High	55	CI	91	10	Almost Certain	8	VERY HIGH	200	96	$ 76,614	2019
4943	Highway Commercial	<250	Highway/Arterial	Outside	8	High	55	CI	92	10	Almost Certain	8	VERY HIGH	200	77	$ 61,752	2019
5491	Community Facilities	<250	Major/Minor Collectors	Outside	8	High	55	CI	95	10	Almost Certain	8	VERY HIGH	200	143	$ 114,486	2019
6727	Community Facilities	<250	Major/Minor Collectors	Outside	8	High	55	CI	95	10	Almost Certain	8	VERY HIGH	200	53	$ 42,044	2019
6994	Community Facilities	<250	Major/Minor Collectors	Outside	8	High	55	CI	95	10	Almost Certain	8	VERY HIGH	200	17	$ 13,888	2019
4828	Community Facilities	<250	Local Roads & Lanes	Outside	8	High	54	CI	89	10	Almost Certain	8	VERY HIGH	150	14	$ 10,227	2020
4830	Community Facilities	<250	Local Roads & Lanes	Outside	8	High	54	CI	89	10	Almost Certain	8	VERY HIGH	150	83	$ 60,884	2020
4993	Industrial & Institutional	<250	Highway/Arterial	Outside	8	High	54	CI	95	10	Almost Certain	8	VERY HIGH	150	151	$ 110,074	2020
314	Community Facilities	<250	Local Roads & Lanes	Outside	8	High	53	CI	90	10	Almost Certain	8	VERY HIGH	100	323	$ 187,279	2021
4526	Highway Commercial	<250	Highway/Arterial	Outside	8	High	53	CI	89	10	Almost Certain	8	VERY HIGH	150	5	$ 3,957	2021
159	Community Facilities	<250	Highway/Arterial	Outside	8	High	52	CI	93	10	Almost Certain	8	VERY HIGH	150	236	$ 172,379	2022
858	Community Facilities	Transmission	Highway/Arterial	Outside	10	Very High	42	AC	106	8	Likely	8	VERY HIGH	150	27	$ 19,474	2022
859	Community Facilities	Transmission	Highway/Arterial	Outside	10	Very High	42	AC	106	8	Likely	8	VERY HIGH	150	10	$ 7,087	2022
1863	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	42	AC	122	8	Likely	8	VERY HIGH	200	126	$ 101,001	2022
1864	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	42	AC	119	8	Likely	8	VERY HIGH	200	34	$ 26,858	2022
3178	Community Facilities	Transmission	Highway/Arterial	Outside	10	Very High	42	AC	110	8	Likely	8	VERY HIGH	150	554	$ 404,685	2022
4959	Light Commercial	<250	Highway/Arterial	Outside	8	High	52	CI	81	10	Almost Certain	8	VERY HIGH	150	115	$ 84,135	2022
4966	Highway Commercial	>=250	Highway/Arterial	Outside	8	High	52	CI	85	10	Almost Certain	8	VERY HIGH	300	261	$ 283,990	2022
5654	Community Facilities	<250	Highway/Arterial	Outside	8	High	52	CI	92	10	Almost Certain	8	VERY HIGH	150	244	$ 178,139	2022
6060	Community Facilities	Transmission	Highway/Arterial	Outside	10	Very High	42	AC	108	8	Likely	8	VERY HIGH	150	14	$ 10,056	2022
6785	Multi-Family	Transmission	Highway/Arterial	Within	10	Very High	42	AC	143	8	Likely	8	VERY HIGH	200	177	$ 141,305	2022
960	Multi-Family	<250	Highway/Arterial	Outside	8	High	51	CI	81	10	Almost Certain	8	VERY HIGH	150	117	$ 85,398	2023
961	Community Facilities	<250	Local Roads & Lanes	Outside	8	High	51	CI	80	10	Almost Certain	8	VERY HIGH	150	13	$ 9,831	2023
4692	Community Facilities	<250	Local Roads & Lanes	Outside	8	High	51	CI	91	10	Almost Certain	8	VERY HIGH	250	81	$ 76,409	2023
5411	Community Facilities	<250	Local Roads & Lanes	Outside	8	High	51	CI	91	10	Almost Certain	8	VERY HIGH	150	91	$ 66,751	2023
5412	Community Facilities	<250	Highway/Arterial	Outside	8	High	51	CI	91	10	Almost Certain	8	VERY HIGH	150	125	$ 91,485	2023
6922	Community Facilities	<250	Local Roads & Lanes	Outside	8	High	51	CI	91	10	Almost Certain	8	VERY HIGH	150	32	$ 23,481	2023
1071	Community Facilities	<250	Local Roads & Lanes	Outside	8	High	50	CI	83	10	Almost Certain	8	VERY HIGH	150	100	$ 72,975	2024
2426	Industrial & Institutional	<250	Highway/Arterial	Outside	8	High	50	CI	83	10	Almost Certain	8	VERY HIGH	150	29	$ 21,062	2024
2427	Industrial & Institutional	>=250	Local Roads & Lanes	Outside	8	High	50	CI	84	10	Almost Certain	8	VERY HIGH	300	383	$ 417,764	2024
5271	Community Facilities	<250	Major/Minor Collectors	Outside	8	High	50	CI	84	10	Almost Certain	8	VERY HIGH	150	118	$ 85,985	2024
282	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	37	AC	112	8	Likely	8	VERY HIGH	350	92	$ 112,690	2027
284	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	37	AC	105	8	Likely	8	VERY HIGH	350	277	$ 340,402	2027
287	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	37	AC	112	8	Likely	8	VERY HIGH	350	7	$ 9,148	2027
3273	Community Facilities	Transmission	Highway/Arterial	Outside	10	Very High	37	AC	100	8	Likely	8	VERY HIGH	500	33	$ 59,727	2027
4333	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	37	AC	92	8	Likely	8	VERY HIGH	350	346	$ 425,218	2027
4334	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	37	AC	102	8	Likely	8	VERY HIGH	350	143	$ 176,223	2027
5537	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	37	AC	110	8	Likely	8	VERY HIGH	350	515	$ 633,331	2027
1490	Highway Commercial	Transmission	Highway/Arterial	Outside	10	Very High	36	AC	97	8	Likely	8	VERY HIGH	300	218	$ 237,380	2028
2553	Highway Commercial	Transmission	Highway/Arterial	Outside	10	Very High	36	AC	94	8	Likely	8	VERY HIGH	300	35	$ 38,196	2028
2554	Highway Commercial	Transmission	Highway/Arterial	Outside	10	Very High	36	AC	94	8	Likely	8	VERY HIGH	300	76	$ 83,265	2028
2557	Community Facilities	Transmission	Highway/Arterial	Outside	10	Very High	36	AC	89	8	Likely	8	VERY HIGH	300	20	$ 21,724	2028
2559	Community Facilities	Transmission	Highway/Arterial	Outside	10	Very High	36	AC	89	8	Likely	8	VERY HIGH	300	304	$ 331,520	2028
6064	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	36	AC	110	8	Likely	8	VERY HIGH	150	19	$ 14,123	2028
6066	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	36	AC	110	8	Likely	8	VERY HIGH	150	134	$ 97,886	2028
6067	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	36	AC	110	8	Likely	8	VERY HIGH	200	72	$ 57,731	2028
6079	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	36	AC	187	8	Likely	8	VERY HIGH	200	234	$ 187,028	2028
283	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	35	AC	105	8	Likely	8	VERY HIGH	350	9	$ 11,228	2029
285	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	35	AC	105	8	Likely	8	VERY HIGH	350	10	$ 12,692	2029
286	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	35	AC	105	8	Likely	8	VERY HIGH	350	71	$ 87,784	2029
419	Industrial & Institutional	Transmission	Highway/Arterial	Within	10	Very High	35	AC	95	8	Likely	8	VERY HIGH	250	317	$ 298,127	2029
1335	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	35	AC	92	8	Likely	8	VERY HIGH	250	25	$ 23,835	2029
1336	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	35	AC	92	8	Likely	8	VERY HIGH	250	7	$ 6,115	2029
1337	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	35	AC	102	8	Likely	8	VERY HIGH	250	7	$ 6,820	2029
1338	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	35	AC	102	8	Likely	8	VERY HIGH	350	22	$ 27,072	2029
2014	Highway Commercial	Transmission	Highway/Arterial	Within	10	Very High	35	AC	97	8	Likely	8	VERY HIGH	200	39	$ 31,563	2029
4329	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	35	AC	92	8	Likely	8	VERY HIGH	250	27	$ 25,109	2029
4330	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	35	AC	92	8	Likely	8	VERY HIGH	250	11	$ 10,491	2029
4331	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	35	AC	92	8	Likely	8	VERY HIGH	250	7	$ 6,503	2029
4332	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	35	AC	102	8	Likely	8	VERY HIGH	350	23	$ 27,734	2029
4335	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	35	AC	102	8	Likely	8	VERY HIGH	350	16	$ 20,111	2029
5755	Industrial & Institutional	Transmission	Highway/Arterial	Within	10	Very High	35	AC	97	8	Likely	8	VERY HIGH	300	194	$ 211,817	2029
6080	Industrial & Institutional	Transmission	Highway/Arterial	Within	10	Very High	35	AC	95	8	Likely	8	VERY HIGH	250	21	$ 19,665	2029
6082	Highway Commercial	Transmission	Highway/Arterial	Within	10	Very High	35	AC	97	8	Likely	8	VERY HIGH	300	22	$ 23,803	2029
6083	Highway Commercial	Transmission	Highway/Arterial	Within	10	Very High	35	AC	97	8	Likely	8	VERY HIGH	200	313	$ 250,512	2029
6085	Highway Commercial	Transmission	Highway/Arterial	Within	10	Very High	35	AC	97	8	Likely	8	VERY HIGH	200	16	$ 13,087	2029
7159	Industrial & Institutional	Transmission	Highway/Arterial	Within	10	Very High	35	AC	95	8	Likely	8	VERY HIGH	250	70	$ 65,790	2029
1938	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	32	AC	95	8	Likely	8	VERY HIGH	350	135	$ 165,599	2032
424	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	35	CI	187	8	Likely	8	VERY HIGH	250	563	$ 528,882	2039
856	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	35	CI	187	8	Likely	8	VERY HIGH	250	77	$ 72,328	2039
2827	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	35	CI	187	8	Likely	8	VERY HIGH	250	293	$ 275,049	2039
6078	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	35	CI	187	8	Likely	8	VERY HIGH	250	15	$ 13,989	2039
6625	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	35	CI	187	8	Likely	8	VERY HIGH	250	53	$ 49,561	2039
6906	Light Commercial	Transmission	Highway/Arterial	Outside	10	Very High	23	AC	88	8	Likely	8	VERY HIGH	300	60	$ 65,870	2041
561	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	29	CI	79	8	Likely	8	VERY HIGH	250	508	$ 477,070	2045
5714	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	16	AC	81	8	Likely	8	VERY HIGH	400	51	$ 69,856	2048
1773	Light Commercial	Transmission	Highway/Arterial	Outside	10	Very High	38	PVC	200	8	Likely	8	VERY HIGH	400	19	$ 26,143	2056
1906	Light Commercial	Transmission	Highway/Arterial	Outside	10	Very High	38	PVC	200	8	Likely	8	VERY HIGH	400	7	$ 9,635	2056
1907	Light Commercial	Transmission	Highway/Arterial	Outside	10	Very High	38	PVC	200	8	Likely	8	VERY HIGH	400	4	$ 4,896	2056
6481	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	38	PVC	200	8	Likely	8	VERY HIGH	400	2497	$ 3,446,304	2056
6578	Industrial & Institutional	Transmission	Highway/Arterial	Outside	10	Very High	38	PVC	200	8	Likely	8	VERY HIGH	400	342	$ 472,428	2056

Appendix C

Risk Framework

Risk Consequence Categories

		Business Continuity		People		Finanical		Environmental		Political & Strategic		Technical	
Questions		What is the risk to day-to-day community businesses, activities and systems? What effect on stakeholders and community? What will be the impact on the level of service provided by the City?		Are there risks related to health and safety, capacity and capability? Internally, are there behavioral or performance effects on the City Staff?		What is the risk that there is inadequate funding provided for replacement costs (due to contractors, material, traffic,etc), and/or that the final project cost is >10% of the budget?		What is the risk to the environment (ecology, soil contamination, water quality, noise levels, odour, dust, etc) due to the effects of chlorinated water?		What is the risk at the Political and or Corporate level due to possible impact to City's core business objectives?		Are there risks due to specific critical technologies and or the overall technical complexity of these watermain replacements (has it been done successfully before?, design and or implementation complexity?, specialised technical skill required?, speed of technology change, etc)	

Likelihood

Likelihood		Probability		Frequency		Description	Rating
Almost Certain		>50%		Continuous or will happen frequently		The threat will most certainly occur in the foreseeable future	**5**
Likely		20%-50%		5 - 12 times per year		The threat will probably occur in the foreseeable future	**4**
Possible		10%-20%		1 -5 times per year		The threat has a good possibility of occurrence	**3**
Unlikely		1%-10%		Once every 2 -5 years		The threat has little chance of occurring in the foreseeable future	**2**
Rare		<1%		Less than once every 5 years		The Threat is unlikely to occur in the foreseeable future	**1**

Consequence

Descriptor		Business Continuity		People		Finanical		Environmental		Political & Strategic		Technical	Rating
Catastrophic	5	Significant effects to day to day business function with prolonged and significant impact on levels of service	5	Life threatening injuries or fatalities/ Significant and prolonged lack of internal staff capacity requiring significant and prolonged additional external resources.	5	Financial shortfall or loss > $1M in any 12 month period	5	Significant and wide spread adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	5	Significant and prolonged political attention with considerable impact on the City's ability to meet business objectives across multiple years.	5	Excessive project delays, significant cost overrun, complete technology or technical process failure.	5
Major	4	Major effects to day to day business function with significant about short term impact on levels of service	4	Single life-threatening injury or fatality/ Significant but short term lack of internal staff capacity requiring short term external resources.	4	Financial shortfall or loss $150k - $1M in any 12 month period	4	Major but localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	4	Significant but short term political attention with impact on the City ahieving core business objectives within one given year.	4	Major project delays, major cost blowout, technology or technical process requires re-work to fit purpose.	**4**
Moderate	3	Moderate effects to day to day business function with moderate short term impact on levels of service	3	An injury requiring moderate medical care/ Moderate but short term lack of internal staff capacity, possible short term use of external resource.	3	Financial shortfall or loss $50k - 150k in any 12 month period	3	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	3	Short term political attention with minor impact on the City achieving business objectives.	3	Moderate - Moderate project delays, small cost overun, some minor technical errors to resolve.	**3**
Minor	2	Minor effects to day to day business function with minor impact on levels of service	2	Injury no more than first aid/ Internal staff capable but require monitoring and management.	2	Financial shortfall or loss $10k - 50k in any 12 month period	2	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	2	Short term political interest with negligable impact on business objectives.	2	Minor project delays and or minor cost overun.	**2**
Insignificant	1	Negligible effects to day to day business function with insignificant impact on levels of service	1	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss <$10k in any 12 month period	1	Negligible or no localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	1	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	**1**

Appendix D

Scenario Development Framework

Business Continuity	People	Finanical	Environmental	Political & Strategic	Technical	
What is the risk to day-to-day community businesses, activities and systems? What effect on stakeholders and community? What will be the impact on the level of service provided by the City?	Are there risks related to health and safety, capacity and capability? Internally, are there behavioral or performance effects on the City Staff?	What is the risk that there is inadequate funding provided for replacement costs (due to contractors, material, traffic,etc), and/or that the final project cost is >10% of the budget?	What is the risk to the environment (ecology, soil contamination, water quality, noise levels, odour, dust, etc) due to the effects of chlorinated water?	What is the risk at the Political and or Corporate level due to possible impact to City's core business objectives?	Are there risks due to specific critical technologies and or the overall technical complexity of these watermain replacements (has it been done successfully before?, design and or implementation complexity?, specialised technical skill required?, speed of technology change, etc)	

Primary Category	Secondary Item	Item	Item	Event	Business Continuity		People		Financial		Environmental		Political & Strategic		Technical		Rating
Land Usage	Diameter/type	Cover Surface	Riparian Protection Area		Consequence	Ranking	Consequence	Ranking	Consequence	Ranking	Consequence	Ranking	Consequence	Ranking	Consequence	Ranking	
Single Family	<250	Local Roads & Lanes	Within		Negligible effects to day to day business function with insignificant impact on levels of service	1	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss <$10k in any 12 month period	1	Negligible or no localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	1	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	1
			Outside		Negligible effects to day to day business function with insignificant impact on levels of service	1	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss <$10k in any 12 month period	1	Negligible or no localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	1	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	1
		Major/Minor Collectors	Within		Negligible effects to day to day business function with insignificant impact on levels of service	1	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss <$10k in any 12 month period	1	Negligible or no localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	1	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	1
			Outside		Negligible effects to day to day business function with insignificant impact on levels of service	1	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss <$10k in any 12 month period	1	Negligible or no localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	1	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	1
		Highway/Arterial	Within		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $50k - 150k in any 12 month period	3	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	3	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	3
			Outside		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $50k - 150k in any 12 month period	3	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	2	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	3
	>=250	Local Roads & Lanes	Within		Negligible effects to day to day business function with insignificant impact on levels of service	1	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $10k - 50k in any 12 month period	2	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**3**	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	3
			Outside		Negligible effects to day to day business function with insignificant impact on levels of service	**1**	Health and safety monitoring required/ Staff fully capable.	**1**	Financial shortfall or loss $10k - 50k in any 12 month period	**2**	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**2**	No political or core business objective impact	**1**	Minor technical issue, negligible adverse effect to project.	**1**	2
		Major/Minor Collectors	Within		Minor effects to day to day business function with minor impact on levels of service	2	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $10k - 50k in any 12 month period	2	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**3**	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	3
			Outside		Minor effects to day to day business function with minor impact on levels of service	**2**	Health and safety monitoring required/ Staff fully capable.	**1**	Financial shortfall or loss $10k - 50k in any 12 month period	**2**	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**2**	No political or core business objective impact	**1**	Minor technical issue, negligible adverse effect to project.	**1**	2
		Highway/Arterial	Within		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $50k - 150k in any 12 month period	3	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**3**	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	3
			Outside		Moderate effects to day to day business function with moderate short term impact on levels of service	**3**	Health and safety monitoring required/ Staff fully capable.	**1**	Financial shortfall or loss $50k - 150k in any 12 month period	**3**	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**2**	No political or core business objective impact	**1**	Minor technical issue, negligible adverse effect to project.	**1**	3
		Local Roads & Lanes	Within		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $50k - 150k in any 12 month period	3	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	3	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	3

Business Continuity	People	Finanical	Environmental	Political & Strategic	Technical	
What is the risk to day-to-day community businesses, activities and systems? What effect on stakeholders and community? What will be the impact on the level of service provided by the City?	Are there risks related to health and safety, capacity and capability? Internally, are there behavioral or performance effects on the City Staff?	What is the risk that there is inadequate funding provided for replacement costs (due to contractors, material, traffic,etc), and/or that the final project cost is >10% of the budget?	What is the risk to the environment (ecology, soil contamination, water quality, noise levels, odour, dust, etc) due to the effects of chlorinated water?	What is the risk at the Political and or Corporate level due to possible impact to City's core business objectives?	Are there risks due to specific critical technologies and or the overall technical complexity of these watermain replacements (has it been done successfully before?, design and or implementation complexity?, specialised technical skill required?, speed of technology change, etc)	

Primary Category	Secondary Item	Item	Item	Event	Business Continuity		People		Financial		Environmental		Political & Strategic		Technical		Rating
		Local Roads & Lanes	Outside		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $50k - 150k in any 12 month period	3	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	2	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	3
	Transmission	Major/Minor Collectors	Within		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $50k - 150k in any 12 month period	3	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	3	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	3
			Outside		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $50k - 150k in any 12 month period	3	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	2	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	3
		Highway/Arterial	Within		Major effects to day to day business function with significant about short term impact on levels of service	4	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $150k - $1M in any 12 month period	4	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	3	Short term political interest with negligable impact on business objectives.	2	Minor technical issue, negligible adverse effect to project.	1	4
			Outside		Major effects to day to day business function with significant about short term impact on levels of service	4	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $150k - $1M in any 12 month period	4	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	2	Short term political interest with negligable impact on business objectives.	2	Minor technical issue, negligible adverse effect to project.	1	4
		Local Roads & Lanes	Within		Negligible effects to day to day business function with insignificant impact on levels of service	1	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss <$10k in any 12 month period	1	Negligible or no localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	1	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	1
			Outside		Negligible effects to day to day business function with insignificant impact on levels of service	1	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss <$10k in any 12 month period	1	Negligible or no localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	1	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	1
	<250	Major/Minor Collectors	Within		Negligible effects to day to day business function with insignificant impact on levels of service	1	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss <$10k in any 12 month period	1	Negligible or no localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	1	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	1
			Outside		Negligible effects to day to day business function with insignificant impact on levels of service	1	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss <$10k in any 12 month period	1	Negligible or no localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	1	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	1
		Highway/Arterial	Within		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $150k - $1M in any 12 month period	4	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	3	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	4
			Outside		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $150k - $1M in any 12 month period	4	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	2	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	4
		Local Roads & Lanes	Within		Negligible effects to day to day business function with insignificant impact on levels of service	1	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $50k - 150k in any 12 month period	3	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**3**	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	3
			Outside		Negligible effects to day to day business function with insignificant impact on levels of service	**1**	Health and safety monitoring required/ Staff fully capable.	**1**	Financial shortfall or loss $50k - 150k in any 12 month period	**3**	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**2**	No political or core business objective impact	**1**	Minor technical issue, negligible adverse effect to project.	**1**	3

Business Continuity	People	Finanical	Environmental	Political & Strategic	Technical	
What is the risk to day-to-day community businesses, activities and systems? What effect on stakeholders and community? What will be the impact on the level of service provided by the City?	Are there risks related to health and safety, capacity and capability? Internally, are there behavioral or performance effects on the City Staff?	What is the risk that there is inadequate funding provided for replacement costs (due to contractors, material, traffic,etc), and/or that the final project cost is >10% of the budget?	What is the risk to the environment (ecology, soil contamination, water quality, noise levels, odour, dust, etc) due to the effects of chlorinated water?	What is the risk at the Political and or Corporate level due to possible impact to City's core business objectives?	Are there risks due to specific critical technologies and or the overall technical complexity of these watermain replacements (has it been done successfully before?, design and or implementation complexity?, specialised technical skill required?, speed of technology change, etc)	

Primary Category	Secondary Item	Item	Item	Event	Business Continuity		People		Financial		Environmental		Political & Strategic		Technical		Rating
Mult-Family	>=250	Major/Minor Collectors	Within		Minor effects to day to day business function with minor impact on levels of service	2	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $50k - 150k in any 12 month period	3	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**3**	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	3
			Outside		Minor effects to day to day business function with minor impact on levels of service	**2**	Health and safety monitoring required/ Staff fully capable.	**1**	Financial shortfall or loss $50k - 150k in any 12 month period	**3**	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**2**	No political or core business objective impact	**1**	Minor technical issue, negligible adverse effect to project.	**1**	3
		Highway/Arterial	Within		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $150k - $1M in any 12 month period	4	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**3**	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	4
			Outside		Moderate effects to day to day business function with moderate short term impact on levels of service	**3**	Health and safety monitoring required/ Staff fully capable.	**1**	Financial shortfall or loss $150k - $1M in any 12 month period	**4**	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**2**	No political or core business objective impact	**1**	Minor technical issue, negligible adverse effect to project.	**1**	4
	Transmission	Local Roads & Lanes	Within		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $150k - $1M in any 12 month period	4	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	3	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	4
			Outside		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $150k - $1M in any 12 month period	4	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	2	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	4
		Major/Minor Collectors	Within		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $150k - $1M in any 12 month period	4	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	3	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	4
			Outside		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $150k - $1M in any 12 month period	4	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	2	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	4
		Highway/Arterial	Within		Major effects to day to day business function with significant about short term impact on levels of service	4	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss > $1M in any 12 month period	5	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	3	Short term political interest with negligable impact on business objectives.	2	Minor technical issue, negligible adverse effect to project.	1	5
			Outside		Major effects to day to day business function with significant about short term impact on levels of service	4	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss > $1M in any 12 month period	5	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	2	Short term political interest with negligable impact on business objectives.	2	Minor technical issue, negligible adverse effect to project.	1	5
	<250	Local Roads & Lanes	Within		Negligible effects to day to day business function with insignificant impact on levels of service	1	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss <$10k in any 12 month period	1	Negligible or no localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	1	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	1
			Outside		Negligible effects to day to day business function with insignificant impact on levels of service	1	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss <$10k in any 12 month period	1	Negligible or no localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	1	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	1
		Major/Minor	Within		Negligible effects to day to day business function with insignificant impact on levels of service	1	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss <$10k in any 12 month period	1	Negligible or no localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	1	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	1

Business Continuity	People	Finanical	Environmental	Political & Strategic	Technical	
What is the risk to day-to-day community businesses, activities and systems? What effect on stakeholders and community? What will be the impact on the level of service provided by the City?	Are there risks related to health and safety, capacity and capability? Internally, are there behavioral or performance effects on the City Staff?	What is the risk that there is inadequate funding provided for replacement costs (due to contractors, material, traffic,etc), and/or that the final project cost is >10% of the budget?	What is the risk to the environment (ecology, soil contamination, water quality, noise levels, odour, dust, etc) due to the effects of chlorinated water?	What is the risk at the Political and or Corporate level due to possible impact to City's core business objectives?	Are there risks due to specific critical technologies and or the overall technical complexity of these watermain replacements (has it been done successfully before?, design and or implementation complexity?, specialised technical skill required?, speed of technology change, etc)	

Primary Category	Secondary Item	Item	Item	Event	Business Continuity		People		Financial		Environmental		Political & Strategic		Technical		Rating
Light Commercial	>=250	Collectors	Outside		Negligible effects to day to day business function with insignificant impact on levels of service	1	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss <$10k in any 12 month period	1	Negligible or no localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	1	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	1
		Highway/Arterial	Within		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $150k - $1M in any 12 month period	4	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	3	Short term political interest with negligable impact on business objectives.	2	Minor technical issue, negligible adverse effect to project.	1	4
			Outside		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $150k - $1M in any 12 month period	4	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	2	Short term political interest with negligable impact on business objectives.	2	Minor technical issue, negligible adverse effect to project.	1	4
		Local Roads & Lanes	Within		Minor effects to day to day business function with minor impact on levels of service	2	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $50k - 150k in any 12 month period	3	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**3**	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	3
			Outside		Minor effects to day to day business function with minor impact on levels of service	**2**	Health and safety monitoring required/ Staff fully capable.	**1**	Financial shortfall or loss $50k - 150k in any 12 month period	**3**	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**2**	No political or core business objective impact	**1**	Minor technical issue, negligible adverse effect to project.	**1**	3
		Major/Minor Collectors	Within		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $50k - 150k in any 12 month period	3	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**3**	Short term political interest with negligable impact on business objectives.	2	Minor technical issue, negligible adverse effect to project.	1	3
			Outside		Moderate effects to day to day business function with moderate short term impact on levels of service	**3**	Health and safety monitoring required/ Staff fully capable.	**1**	Financial shortfall or loss $50k - 150k in any 12 month period	**3**	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**2**	Short term political interest with negligable impact on business objectives.	**2**	Minor technical issue, negligible adverse effect to project.	**1**	3
		Highway/Arterial	Within		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $150k - $1M in any 12 month period	4	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**3**	Short term political interest with negligable impact on business objectives.	2	Minor technical issue, negligible adverse effect to project.	1	4
			Outside		Moderate effects to day to day business function with moderate short term impact on levels of service	**3**	Health and safety monitoring required/ Staff fully capable.	**1**	Financial shortfall or loss $150k - $1M in any 12 month period	**4**	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**2**	Short term political interest with negligable impact on business objectives.	**2**	Minor technical issue, negligible adverse effect to project.	**1**	4
	Transmission	Local Roads & Lanes	Within		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $150k - $1M in any 12 month period	4	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	3	Short term political interest with negligable impact on business objectives.	2	Minor technical issue, negligible adverse effect to project.	1	4
			Outside		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $150k - $1M in any 12 month period	4	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	2	Short term political interest with negligable impact on business objectives.	2	Minor technical issue, negligible adverse effect to project.	1	4
		Major/Minor Collectors	Within		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $150k - $1M in any 12 month period	4	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	3	Short term political interest with negligable impact on business objectives.	2	Minor technical issue, negligible adverse effect to project.	1	4
			Outside		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $150k - $1M in any 12 month period	4	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	2	Short term political interest with negligable impact on business objectives.	2	Minor technical issue, negligible adverse effect to project.	1	4

Business Continuity	People	Finanical	Environmental	Political & Strategic	Technical	
What is the risk to day-to-day community businesses, activities and systems? What effect on stakeholders and community? What will be the impact on the level of service provided by the City?	Are there risks related to health and safety, capacity and capability? Internally, are there behavioral or performance effects on the City Staff?	What is the risk that there is inadequate funding provided for replacement costs (due to contractors, material, traffic,etc), and/or that the final project cost is >10% of the budget?	What is the risk to the environment (ecology, soil contamination, water quality, noise levels, odour, dust, etc) due to the effects of chlorinated water?	What is the risk at the Political and or Corporate level due to possible impact to City's core business objectives?	Are there risks due to specific critical technologies and or the overall technical complexity of these watermain replacements (has it been done successfully before?, design and or implementation complexity?, specialised technical skill required?, speed of technology change, etc)	

Primary Category	Secondary Item	Item	Item	Event	Business Continuity		People		Financial		Environmental		Political & Strategic		Technical		Rating
		Highway/Arterial	Within		Major effects to day to day business function with significant about short term impact on levels of service	4	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss > $1M in any 12 month period	5	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	3	Short term political attention with minor impact on the City achieving business objectives.	3	Minor technical issue, negligible adverse effect to project.	1	5
			Outside		Major effects to day to day business function with significant about short term impact on levels of service	4	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss > $1M in any 12 month period	5	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	2	Short term political attention with minor impact on the City achieving business objectives.	3	Minor technical issue, negligible adverse effect to project.	1	5
	<250	~~Local Roads & Lanes~~	Within		#N/A		#N/A		#N/A		#N/A		#N/A		#N/A		0
			Outside		#N/A		#N/A		#N/A		#N/A		#N/A		#N/A		0
		~~Major/Minor Collectors~~	Within		#N/A		#N/A		#N/A		#N/A		#N/A		#N/A		0
			Outside		#N/A		#N/A		#N/A		#N/A		#N/A		#N/A		0
		Highway/Arterial	Within		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $150k - $1M in any 12 month period	4	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	3	Short term political interest with negligable impact on business objectives.	2	Minor technical issue, negligible adverse effect to project.	1	4
			Outside		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $150k - $1M in any 12 month period	4	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	2	Short term political interest with negligable impact on business objectives.	2	Minor technical issue, negligible adverse effect to project.	1	4
Hwy Commerical	>=250	~~Local Roads & Lanes~~	Within		#N/A		#N/A		#N/A		#N/A		#N/A		#N/A		0
			Outside		#N/A		#N/A		#N/A		#N/A		#N/A		#N/A		0
		~~Major/Minor Collectors~~	Within		#N/A		#N/A		#N/A		#N/A		#N/A		#N/A		0
			Outside		#N/A		#N/A		#N/A		#N/A		#N/A		#N/A		0
		Highway/Arterial	Within		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $150k - $1M in any 12 month period	4	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**3**	Short term political interest with negligable impact on business objectives.	2	Minor technical issue, negligible adverse effect to project.	1	4

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		~~Highway/Arterial~~	Outside		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss $150k - $1M in any 12 month period	4	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	2	Short term political interest with negligable impact on business objectives.	2	Minor technical issue, negligible adverse effect to project.	1	4
	Transmission	~~Local Roads & Lanes~~	Within		#N/A		#N/A		#N/A		#N/A		#N/A		#N/A		0
			Outside		#N/A		#N/A		#N/A		#N/A		#N/A		#N/A		0
		~~Major/Minor Collectors~~	Within		#N/A		#N/A		#N/A		#N/A		#N/A		#N/A		0
			Outside		#N/A		#N/A		#N/A		#N/A		#N/A		#N/A		0
		Highway/Arterial	Within		Major effects to day to day business function with significant about short term impact on levels of service	4	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss > $1M in any 12 month period	5	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	3	Short term political attention with minor impact on the City achieving business objectives.	3	Minor technical issue, negligible adverse effect to project.	1	5
			Outside		Major effects to day to day business function with significant about short term impact on levels of service	4	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss > $1M in any 12 month period	5	Minimal localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	2	Short term political attention with minor impact on the City achieving business objectives.	3	Minor technical issue, negligible adverse effect to project.	1	5
	<250	Local Roads & Lanes	Within		Negligible effects to day to day business function with insignificant impact on levels of service	1	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss <$10k in any 12 month period	1	Negligible or no localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	1	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	1
			Outside		Negligible effects to day to day business function with insignificant impact on levels of service	1	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss <$10k in any 12 month period	1	Negligible or no localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	1	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	1
		Major/Minor Collectors	Within		Negligible effects to day to day business function with insignificant impact on levels of service	1	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss <$10k in any 12 month period	1	Negligible or no localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	1	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	1
			Outside		Negligible effects to day to day business function with insignificant impact on levels of service	1	Health and safety monitoring required/ Staff fully capable.	1	Financial shortfall or loss <$10k in any 12 month period	1	Negligible or no localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	1	No political or core business objective impact	1	Minor technical issue, negligible adverse effect to project.	1	1
		Highway/Arterial	Within		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Injury no more than first aid/ Internal staff capable but require monitoring and management.	2	Financial shortfall or loss $150k - $1M in any 12 month period	4	Major but localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	4	Short term political interest with negligable impact on business objectives.	2	Minor technical issue, negligible adverse effect to project.	1	4
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Primary Category	Secondary Item	Item	Item	Event	Business Continuity		People		Financial		Environmental		Political & Strategic		Technical		Rating
Industrial & Non-Essential Institutional	>=250	Local Roads & Lanes	Within		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Injury no more than first aid/ Internal staff capable but require monitoring and management.	2	Financial shortfall or loss $50k - 150k in any 12 month period	3	Major but localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**4**	Short term political interest with negligable impact on business objectives.	2	Minor technical issue, negligible adverse effect to project.	1	4
			Outside		Moderate effects to day to day business function with moderate short term impact on levels of service	**3**	Injury no more than first aid/ Internal staff capable but require monitoring and management.	**2**	Financial shortfall or loss $50k - 150k in any 12 month period	**3**	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**3**	Short term political interest with negligable impact on business objectives.	**2**	Minor technical issue, negligible adverse effect to project.	**1**	3
		Major/Minor Collectors	Within		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Injury no more than first aid/ Internal staff capable but require monitoring and management.	2	Financial shortfall or loss $50k - 150k in any 12 month period	3	Major but localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**4**	Short term political interest with negligable impact on business objectives.	2	Minor technical issue, negligible adverse effect to project.	1	4
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		Highway/Arterial	Within		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Injury no more than first aid/ Internal staff capable but require monitoring and management.	2	Financial shortfall or loss $150k - $1M in any 12 month period	4	Major but localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**4**	Short term political interest with negligable impact on business objectives.	2	Minor technical issue, negligible adverse effect to project.	1	4
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	Transmission	Local Roads & Lanes	Within		Moderate effects to day to day business function with moderate short term impact on levels of service	3	Injury no more than first aid/ Internal staff capable but require monitoring and management.	2	Financial shortfall or loss $150k - $1M in any 12 month period	4	Major but localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	4	Short term political interest with negligable impact on business objectives.	2	Minor technical issue, negligible adverse effect to project.	1	4
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		Local Roads & Lanes	Within		Major effects to day to day business function with significant about short term impact on levels of service	4	Single life-threatening injury or fatality/ Significant but short term lack of internal staff capacity requiring short term external resources.	4	Financial shortfall or loss $150k - $1M in any 12 month period	4	Major but localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	4	Significant but short term political attention with impact on the City ahieving core business objectives within one given year.	4	Minor technical issue, negligible adverse effect to project.	1	4

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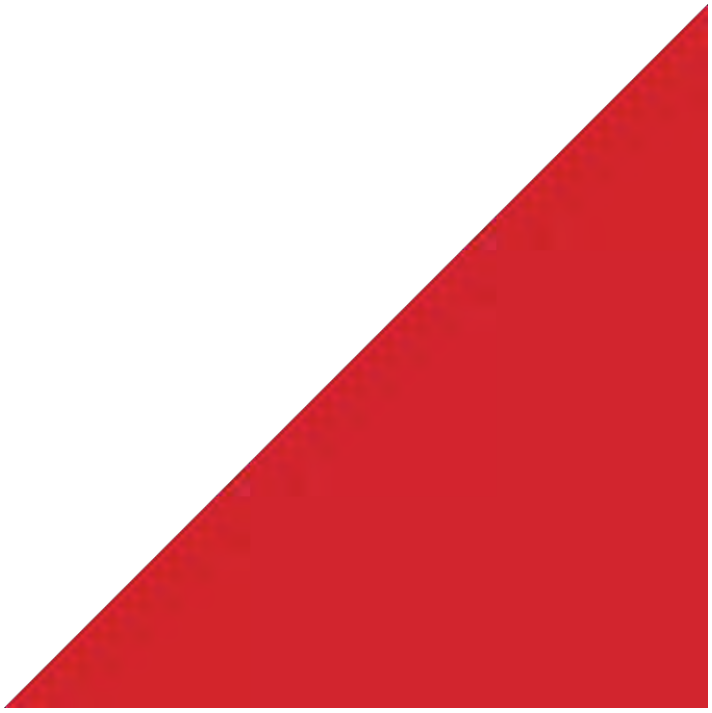
Primary Category	Secondary Item	Item	Item	Event	Business Continuity		People		Financial		Environmental		Political & Strategic		Technical		Rating
Hospitals & Schools	<250	Local Roads & Lanes	Outside		Major effects to day to day business function with significant about short term impact on levels of service	4	Single life-threatening injury or fatality/ Significant but short term lack of internal staff capacity requiring short term external resources.	4	Financial shortfall or loss $150k - $1M in any 12 month period	4	Major but localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	4	Significant but short term political attention with impact on the City ahieving core business objectives within one given year.	4	Minor technical issue, negligible adverse effect to project.	1	4
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		Highway/Arterial	Within		Major effects to day to day business function with significant about short term impact on levels of service	4	Single life-threatening injury or fatality/ Significant but short term lack of internal staff capacity requiring short term external resources.	4	Financial shortfall or loss $150k - $1M in any 12 month period	4	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	3	Short term political attention with minor impact on the City achieving business objectives.	3	Minor technical issue, negligible adverse effect to project.	1	4
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	>=250	Local Roads & Lanes	Within		Major effects to day to day business function with significant about short term impact on levels of service	4	Single life-threatening injury or fatality/ Significant but short term lack of internal staff capacity requiring short term external resources.	4	Financial shortfall or loss $50k - 150k in any 12 month period	3	Moderate localised adverse effects on living organisims and environment by effluents, emissions, wastes, resource depletion, etc	**3**	Short term political attention with minor impact on the City achieving business objectives.	3	Minor technical issue, negligible adverse effect to project.	1	4
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Appendix E

Reference Material



Guide to the Amortization of Tangible Capital Assets

Local Government Infrastructure and Finance Division

May 2008

BRITISH COLUMBIA
The Best Place on Earth

5) Water Infrastructure

Particularly for asset category #5 (Water Infrastructure), #6 (Sewage Infrastructure) and #7 (Drainage Infrastructure), the following two options are relevant. Local governments can either:

- Aggregated Approach: Elements of the asset category are pooled together under one heading, i.e. a sewage treatment plant; or
- Separated Approach: Treat elements of the asset class as multiple components, i.e. amortize the components of a sewage treatment plant separately.

Based on the engineering management of water infrastructure assets, these assets have been grouped along the lines of:

- Water Supply Infrastructures;
- Treatment Infrastructures; and
- Distribution Infrastructures.

As the aggregated approach is particularly relevant for treatment and distribution infrastructure, aggregated useful lives for major system components in these categories have been provided.

Building Infrastructures

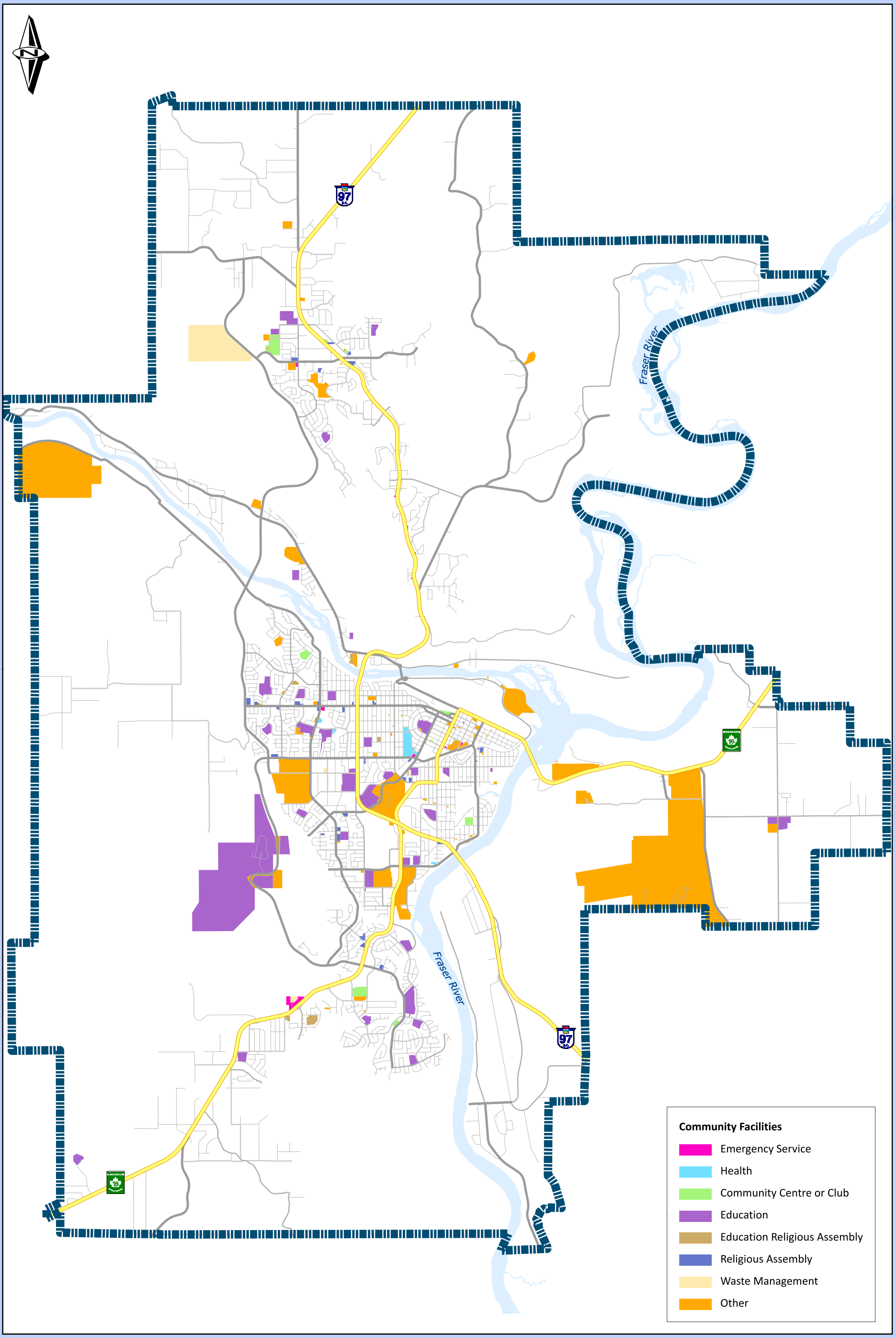
This section deals only with direct components of water infrastructures, such as water pumps, wells and water pipes. Therefore, the useful lives of buildings that may house water treatment should use the rates for the corresponding structure found in Section #2 (buildings).

Key Factor for Pipes: Type of Material

The key factor in estimating the useful life of many components, such as pipes, is the material used. The depth of pipe and the Ph level of the soil are also considerations; however the type of material used is the key variable in determining useful life. Since soil characteristics vary across the Province, this document is limited to providing general guidance based on research.

5) Useful Lives of Water Infrastructures		
Asset	***Useful Life in Years***	***Comments***
Supply Infrastructures		
Dams-Earthen	40	Still under review, may need to use engineering estimate
Dams-Concrete	60	Still under review, may need to use engineering estimate
Manmade Lakes/Waterways	100	
Reservoirs-Concrete	50	Includes both above ground and in-ground reservoirs
Reservoirs-Other	35	Includes lined earth, wood stave and steel reservoirs
Water Towers and Tanks	35	
Wells	60	This includes the well casing
Wells-Screen for wells	25	
Treatment Infrastructure		
Aggregated Approach		
Aggregated Approach-Treatment Plant	25	This may include all components of the plant (listed in detail below) excluding the building itself
Separated Approach		
Treatment Infrastructure—Disinfection		
Chlorinating Systems	25	
UV Disinfection Systems	25	
Ozonation Disinfection	25	
Treatment Infrastructure—Water Treatment		
Aerator	15	This includes the components of an aerator (tank, compressor hose, etc.), with the exception of a blower
Blower	10	This is a component of an aerator
Clarifier	20	This component removes solids from water
Filters-Sand	25	
Filters-Membrane	15	Includes ceramic and polyurethane filters
Flocculator	20	
SCADA Software	5	
Screens-Bar and Rotary	10	
Screens-Stainless Steel	10	
Thickener	20	

Distribution Infrastructure		
Aggregated Approach		
Aggregated Approach-Waterworks distribution	50	Use this, should you wish to amortize on a system wide basis
Separated Approach		
Fire Hydrants-Steel and Ductile Iron	40	
Fittings for Pipes-Ceramic, Concrete, Plastic and Steel	20	These are for fittings for pipes
Generator	20	Typically for pumping station
Manholes	50	
Meters	5	If material and including flow meters
Pipes-Brick	60	
Pipes-Cast Iron (British Standard)	100	Pipes are considered lined, where relevant
Pipes-Cast Iron (Other Classes)	60	
Pipes-Concrete	50	Includes reinforced and non-reinforced concrete and asbestos cement
Pipes-Copper	80	
Pipes-Ductile Iron	100	
Pipes-Galvanized Steel	60	
Pipes-PVC	80	
Pipes-Steel	80	
Pipes-Vitrified Clay	50	
Pumps	20	Includes pumps for wells
Valves	40	



0 500 1,000 1,500 2,000 Meters

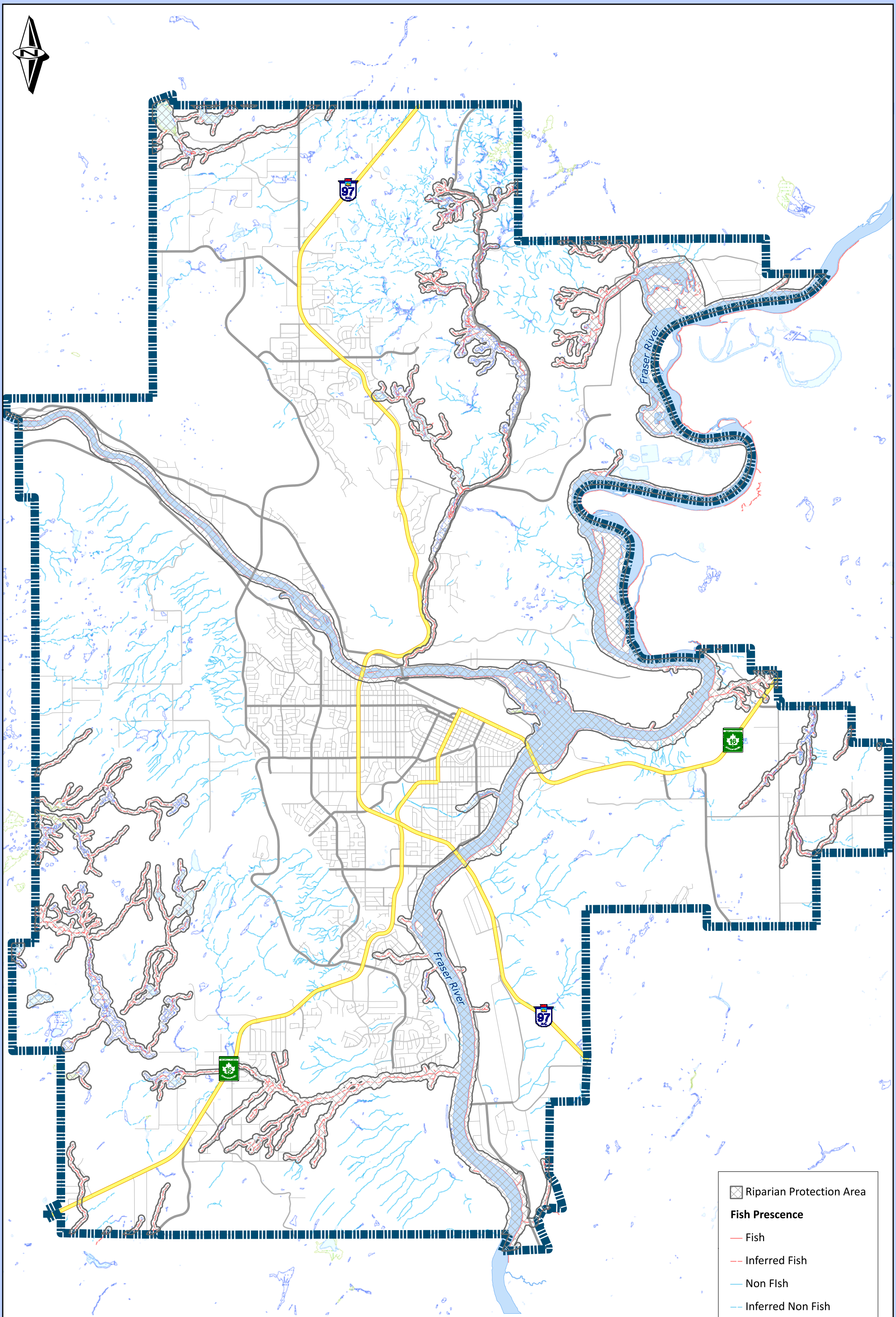
Community Facilities

OCP Schedule B-8, Bylaw No. 8383

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Geographic Information Systems Group

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Riparian Protection Development Permit Areas

OCP Schedule D-2, Bylaw No. 8383

0 500 1,000 1,500 2,000 Meters

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Geographic Information Systems Group

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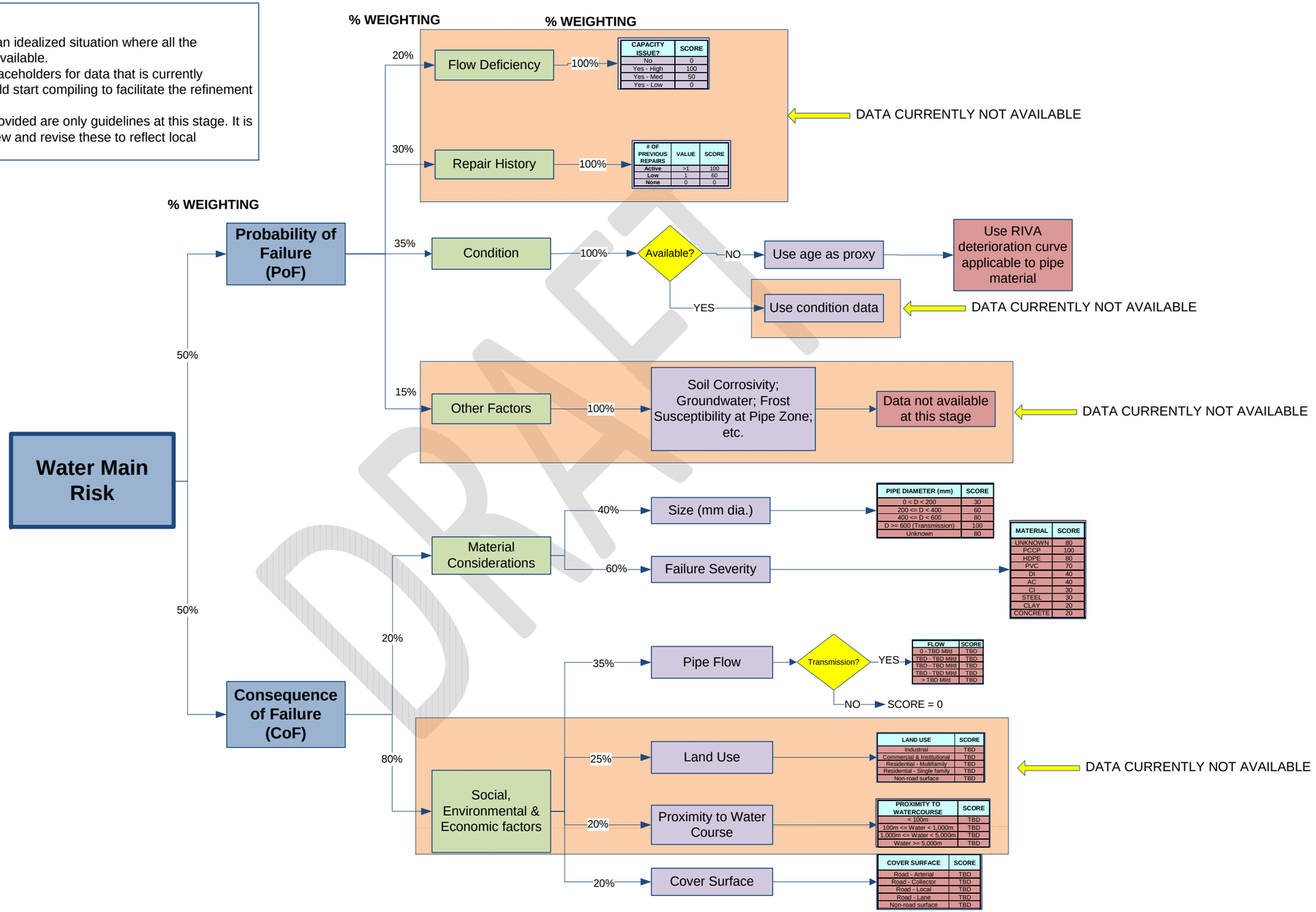
APPENDIX 'D'

CITY OF PRINCE GEORGE RIVA ASSESSMENT MANAGEMENT SYSTEM:
WATER MAIN RISK FRAMEWORK CHART

City of Prince George RIVA Asset Management System: Water Main Risk Framework

Notes:

1. The risk framework presents an idealized situation where all the necessary input data would be available.
2. The process map indicates placeholders for data that is currently unavailable, which the City should start compiling to facilitate the refinement of the RIVA analysis.
3. The weightings and scores provided are only guidelines at this stage. It is recommended that the City review and revise these to reflect local conditions and experience.



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Appendix G
Notes from Workshop with Operations Staff

A workshop was held on October 27, 2014 with the City's Operations staff at the City of Prince George Works Yard. Preliminary findings of the Water Master Plan were presented by Opus DK and an open floor discussion was held between members of the project team, other engineering staff in the City and operations staff to identify other water infrastructure related projects to be included in the Water Master Plan.

The following notes are compiled from the meeting, along with how Opus DK has addressed them in the Water Master Plan.

Discussions on Pressure Zones 1 and 2	Addressed by
Low fire flows are present near PW-605	Improvement Project D-01-1.
There is a pipe that is exposed where it crosses the water course at the Carrie Jane Grey Park (see image below) it has to be drained each fall to prevent freezing 	The City would like to re-route the watermains so they are on City-owned property and not under the dealerships. A Pre-Design Investigation for re-routing of the watermain through Carrie Jane Gray Park has been added to the Capital Plan.
The PRV at 8th and Freeman is currently altitude-controlled to water levels at the PW-803 reservoir. The reservoir must be low before PRV will open. However, this setting causes the hospital to lose pressures during maximum day demand and operations staff have historically had to open a valve at 20th Avenue and Garden Drive to maintain pressures at the hospital. Operations staff note that one drawback would be if a main were to break in the area, the PRV would open and flood the area at the break.	The issue of flooding at a break immediately downstream of a PRV station is common to any PRV and should not be used as a reason to limit the operation of the PRV to control via water level at PW-803. Opus DK recommends to adjust PW-633 (Freeman PRV) such that the PRV is not altitude controlled but pressure controlled to drops in downstream pressures. This project has been added to the Capital Plan.
Low pressures were noted at the upper floors of the University Hospital of Northern BC and the Ramada Hotel. A question was presented if the Hospital and Ramada should be equipped with a booster pump.	A Pre-Design Investigation to improve pressures to the upper floors of the Hospital and Ramada is a proposed project in the Capital Plan.
There is a current project to review the interconnection of PW-605 and PW-660 connection. The question is if the pumps should be run together or one at a time. It is noted that the PW-660 (Fishtrap Wells) needs 2 more pumps in order to provide full redundancy to the South water system.	A Conceptual Design for the interconnection of PW605 and PW660 to identify the size of the river crossing and pumping requirements has been added to the Capital Plan.

PW-605 (Wilson Park West Well) is at currently running at its design capacity with 3 pumps running, and if 1 motor or pump quits, the station would not be able to keep up with the system demand. The back up diesel pump is not sufficient for redundancy purposes. It was noted that PW-601 (Wilson Park East Well) and PW-602 (Cameron pump station) only have one pump running at each station. Reasons include: 1) an electronics upgrade is required to run both pumps at each station at the same time, and 2) the pipe is not full from PW-601 to PW-602, thus introducing potential negative pressures in the pipe which will in turn suck in river water into the system. Opus DK believes PW-605 is supplying parts of Pressure Zone 1 during maximum day demand through the Pressure Zone 2 to Pressure Zone 1 PRVs, and is the reason why operations staff note that the station is running over capacity while the model shows it to be okay (The model assumes PW-605 does not supply Pressure Zone 1). Opus DK notes that resolving this issue, having two pumps operating a each station may help the current supply issues at PW-605.	A Conceptual Design to improve operational capacity at PW-601 and PW-602, including a review of the electrical upgrades needed to allow 2 pumps to run in each station has been added to the Capital Plan. The design should also include a field review the actual setpoints of the PRVs to ensure PW-605 is not servicing Pressure Zone 1 during maximum day demand.
Operations staff have noted that PW-805 (Cranbrook Hill Reservoir) has cracks which are too large to plug, and a large amount of leakage is occuring at the reservoir as a result.	A Condition Assessment Investigation to carry out a review of leakage at PW-805 (Cranbrook Hill Reservoir) and possible remediation strategies is proposed in the Capital Plan.
It was discussed that PW-805 (Cranbrook Hill Reservoir) needs more storage capacity.	Improvement Projects R-2 and R-5.
There is an old pump station building at the intersection of 8th Avenue and Central Street. This building could be reinstated to further supply water from Pressure Zone 2 to Pressure Zone 1.	This location is within Pressure Zone 2 and not close to Pressure Zone 1. Opus DK suggests that this should not be re-instated.
Fire Flow deficiencies in the Downtown Core of the City are due to undersized 4" (100 mm) and 6" (150 mm) watermains.	The minimum sizing for watermains in the Downtown area should be 8" (200 mm). Upgrades to watermains will be identified through the replacement of these watermains highlighted in the condition assessment report and added to the Capital Plan.
Operations staff have identified a project to construct a watermain loop to connect Alward Street and Wainwright Street west of 7th Avenue. Services along this stretch would be changed to ¾".	Improvement Project D-02-8.
Operations staff have identified a project to construct a watermain loop at the intersection of Norwood Street and Ford Avenue.	Improvement Project D-02-9.
It was identified by Operations staff that PW-630 (UNBC pump station) needs a large backup generator.	Project added to Capital Plan.
It was identified by Operations staff that the backup generator at PW-614 was too small.	A Pre-Design Investigation to review and provide estimates to install generators or diesel pumps at each of the City's pump stations has been added to the Capital Plan.

Discussions on Pressure Zones 3, 4 and 6	Addressed by
There is a potential option to abandon wells PW-624 and PW-621 (College North and South Wells) in the long term, as the wells are currently downstream of WWTC discharge.	A Conceptual Design to assess the possible decommissioning of PW-621 and PW-624 has been added to the Capital Plan.
Low fire flow are identified in northern portions of Pressure Zone 3 on the west side of Highway 16. This is a small area of Pressure Zone 3 which is serviced by a single watermain crossing Highway 16 along Eton Avenue. As the City would also like to limit the number of watermain crossings along the Highway, a proposed 2 PRV system from Pressure Zone 4 to service this area is recommended.	Improvement Projects D-04-3A, D-04-3B and D-04-3C.
It was identified by Operations staff that PW-643 (Upper Tyner PRV) needs a water meter.	Project added to Capital Plan.

Discussions on Pressure Zones 8, 9, 10, 11, 12 and 13	Addressed by
The existing transmission watermain from PW-650 (Foothills pump station) to PW-817 (Vellencher reservoir) is a high risk asset which needs redundancy. The City would like to provide a second transmission main to the area. Opus DK has reviewed a transmission main alignment up along Foothills Boulevard. Operations staff agree to this alignment as it provides better access for maintenance compared to the transmission main along the existing alignment.	Improvement Project T-5.
There are still some properties experiencing low pressures during peak demand in Pressure Zone 11. The area acts similar to a dead end with no loop. Opus DK suggests that a PRV can be constructed to draw water off the proposed transmission main along Foothills Boulevard as it travels up to PW-817.	Improvement Project T-5 includes the addition of a PRV station.
The is a recommended project to twin the existing watermain along Kelly Road and the Hary Highway from Vellencher to Karin Road (i.e. the Chief Lake area)	Improvement Project D-11-4.
Watermains along Madill Road, Richet Street, and Turner Road are all currently 100mm diameter watermains. Upgrades are required to improve fire flow mid-block.	All watermains with diameter 100mm and below are identified and included for upgrade in the Capital Plan.
There are currently fire flow deficiencies in Pressure Zones 12 and 132. These deficiencies can be addressed through the installation of fire pumps at PW-615 and PW-619 (Vellencher and Inverness pump stations)	Improvement Projects P-9 and P-10.
An upgrade to PW-609 is required as there is currently no way to isolate the main if there is a main break at PW810.	A Conceptual Design to add an isolation valve at PW-609 and a check valve at PW-810 has been added to the Capital Plan.
The upstream pressure at PW-611 (Randle PRV) is 150 psi.	Noted.

Discussions on Pressure Zones 15, 16, 21, 22, and 23	Addressed by
The recently constructed 600mm transmission line in East	Improvement Project R-3

Prince George (specifically in Pressure Zone 22) will require a new reservoir.	
As developments occur along the Boundary Road stretch in Pressure Zone 22, the requirement for a new reservoir will be more and more pressing. If the new reservoir in Pressure Zone 22 is properly sized, it could service Pressure Zones 15 and 16 and could eliminate the need of the Danson and BCR reservoirs.	A Conceptual Design to assess the possible decommissioning of PW-827 and PW-806 (Danson and BCR reservoirs) after a new reservoir is constructed in Pressure Zone 22 has been added to the Capital Plan.
There is limited to no chlorine residuals measured at the well PW-627 (Willow Cale Wells). The new reservoir will need a chlorination injection station.	A Pre-Design Investigation to construct a chlorination station at the new reservoir constructed in Pressure Zone 22 has been added to the Capital Plan.

Discussions on Pressure Zone 25	Addressed by
There is currently no backup water supply to PW-625 (Corral Wells) that service the Western Acres water system. Options to construct additional well supplies have been identified in the McElhanney reports for the area. It is important to resolve the water supply issues in the Western Acres water system and waiting on development will not suffice.	A Procurement Strategy and subsequent Detailed Design Investigation to incorporate the existing private well into the current Western Acres system has been added to the Capital Plan.



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