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2017 Water System Master Plan Update

Final Report
October 2017
KWL Project No. 0452-120-300

Prepared for:

City of White Rock

Prepared by:

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WATER STREET ENGINEERING LTD.
INFRASTRUCTURE PLANNING & DESIGN

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1. Introduction

1.1 Scope of Master Plan

Kerr Wood Leidal Associates Ltd. (KWL) and Water Street Engineering (WSE) were retained by the City of White Rock (the City) to prepare an update to the Water System Master Plan. The master plan for White Rock water system was last updated in 2013.

The scope of the 2017 update includes:

- existing system demand development;
- future system demand development;
- hydraulic water model update;
- review of water treatment options;
- system evaluation including water main break history update; and
- recommended upgrades.

1.2 References

The following references have been used in the preparation of this report.

1. City of White Rock, *2016 Water Base Plan*.
2. City of White Rock, *Official Community Plan*, Draft, March 2017.
3. City of White Rock, Open Data Portal, < http://data.whiterockcity.ca/ >.
4. Coriolis Consulting Corp., *Residential and Commercial Development Forecasts as Input to White Rock's Official Community Plan Review*, November 18, 2016.
5. Dayton & Knight Ltd., *Roper Avenue Reservoir*, Roper Reservoir IFT drawings, Dwg. 91.2.1 November 1, 1971.
6. Kerr Wood Leidal Associates Ltd., *Water System Master Plan Update, Final Report*, December 2010.
7. Kerr Wood Leidal Associates Ltd., *2013 Water System Master Plan Update, Final Report*, November 2013.
8. M.A. Morales et al, *Estimating commercial, industrial, and institutional water use on the basis of heated building area*, Journal AWWA, vol. 103, no. 6, pp 84-96, June 2011.
9. Master Municipal Construction Documents Association, *MMCD Design Guidelines*, 2014.
10. SCM Risk Management Services Inc., *Fire Department Operational Study – Fire Underwriters Survey, City of White Rock*, 2009.
11. Stantec, *White Rock Water Utility Water System Upgrade: Phase I – Oxford Site*, File No. 111700444, Record Drawings, June 23, 2016.
12. Stantec, *White Rock Water Utility Water System Upgrade: Phase II – Merklin Site*, File No. 111700444, Re-Issued for Construction Drawings, December 2, 2015.
13. Water Research Foundation, *Residential End Uses of Water, Version 2*, April 2016.

14. Water Street Engineering Ltd., Technical Memorandum - *Operational Advice for Water Quality*, WSE File 68.300, August 2017.
15. NRC/AECOM, *National Water & Wastewater Benchmarking Initiative, 2009 Public Report*, July 23, 2009.
16. RES'EAU-WaterNet, *A Community Circle Approach to Evaluating Water Treatment Solutions for the City of White Rock*, July 2017.
17. Kerr Wood Leidal Associates, *Fraser Health Requirements for Disinfection Implementation, Deferral of Secondary Disinfection Implementation*, June 2016.
18. Insurer's Advisory Organization Inc., *Fire Underwriter's Survey Water Supply for Public Fire Protection*, 1999.
19. Stantec, *White Rock – Reservoir Volumes Memo,* August 2017.
20. Government of British Columbia, Ministry of Forests, Lands & Natural Resource Operations, Utility Regulation Section, Water Management Branch, *Design Guidelines for Rural Residential Community Water Systems*, March 2012.

1.3 Abbreviations

The following abbreviations have been used throughout the report.

AC	Asbestos Cement
BD	Base Demand
ca	Capita (person)
CI	Cast Iron
DI	Ductile Iron
DWM	Distribution Water Main
EPS	Extended Period Simulation
FUS	Fire Underwriters Survey
GCDWQ	Guidelines for Canadian Drinking Water Quality
ha	Hectare
HGL	Hydraulic Grade Line
HZE	High Zone East
HZW	High Zone West
ICI	Industrial Commercial and Institutional
KWL	Kerr Wood Leidal Associates Ltd.
MAC	Maximum Allowable Concentration
MDD	Maximum Day Demand
MF	Multi-Family
ML	Mega Litre (10^6 L)
MMCD	Master Municipal Construction Documents
NWWBI	National Water and Wastewater Benchmarking Initiative
PHD	Peak Hour Demand
PRV	Pressure Reducing Valve
PS	Pump Station
PVC	Polyvinyl Chloride
RES	Residential
RFP	Request for Proposals
RWM	Raw Water Main

SCADA	Supervisory Control and Data Acquisition
SD	Seasonal Demand
SF	Single Family
TWL	Top Water Level
TWM	Treated Water Main
WSE	Water Street Engineering Ltd.
WSMP	Water System Master Plan
WM	Water Main
WTP	Water Treatment Plant

2. Existing Water Demands

Water system demands have been broken down into the following components for the purpose of this study:

- Base demand (BD): Typical water usage on an average winter day. BD includes indoor use for single family residential (SF-RES), multi-family residential (MF-RES), and industrial commercial and institutional (ICI). BD also includes losses due to leakage.
- Seasonal demand (SD): Irrigation use and other seasonally dependant uses (typically relatively small compared to irrigation) on the peak summer day. SD includes irrigation use for SF-RES, MF-RES and ICI.

The Maximum Day Demand (MDD) is the total peak day demand and is the sum of the base and seasonal demand components.

Note that the City executes a water main flushing program annually but these flows are not a component of BD or SD.

The existing water demands and the breakdown between the demand components discussed above have been estimated using a combination of population census blocks, land use mapping, source flow data and customer water meter data. The following table is a summary of the existing demands used for this study. The sections below summarize the development of the existing water demands.

Table 2-1: Existing Demand Summary

Max Day Demand MDD = 124.1 L/s	**Base Demand** BD = 64.8 L/s	**ICI** BD-ICI = 11.7 L/s
		Single-Family Residential BD-SF-RES = 26.0 L/s
		Multi-Family Residential BD-MF-RES = 19.6 L/s
		Losses LOSS =7.5 L/s
	Seasonal Demand SD = 59.3 L/s	**ICI** SD-ICI =7.3 L/s
		Single-Family Residential SD-SF-RES = 47.1 L/s
		Multi-Family Residential SD-MF-RES = 4.9 L/s

2.1 Existing Land Use and Water Service Area Population

The existing land use is derived from zoning information provided by the City. In addition to the City of White Rock, the water system also supplies seventy-three (73) parcels in the City of Surrey and the Semiahmoo First Nation. A figure with the existing land use for the White Rock water service area is shown on Figure 2-3 (end of section). Existing demands were allocated to each parcel based on land use type and the methodology discussed in the sections below.

The 2016 census blocks for White Rock were reviewed and blocks that exclusively included parcels zoned single-family or multi-family were used to calculate an average population per single family (SF) parcel and average population per multi-family (MF) unit. The calculated rates were 2.92 ca/SF parcel and 1.40 ca/MF unit.

The total residential service population for the current White Rock water system is estimated at 20,181 (19,952 in the City of White Rock, 229 in the City of Surrey).

2.2 Source Flow Demands

Source flow information for 2016 was extracted from the City's Supervisory Control and Data Acquisition (SCADA) system. Well 4 does not have a flow meter and is controlled manually. City staff provided an estimate of the daily volumes extracted from Well 4[1].

Total system base demands were estimated using the average flow for the month of December, 2016. The average base demand observed in 2016 was 64.8 L/s.

The maximum day demand in summer 2016 was observed on July 19. The average demand on this day was 114.5 L/s. Subtracting the base demand component, the seasonal demand on the maximum day in 2016 was 49.7 L/s.

The base day and maximum day demands for 2016 were added to the historical record for the White Rock water system. Figure 2-1 shows a comparison of the demands observed on the maximum day for 2006 to 2016.

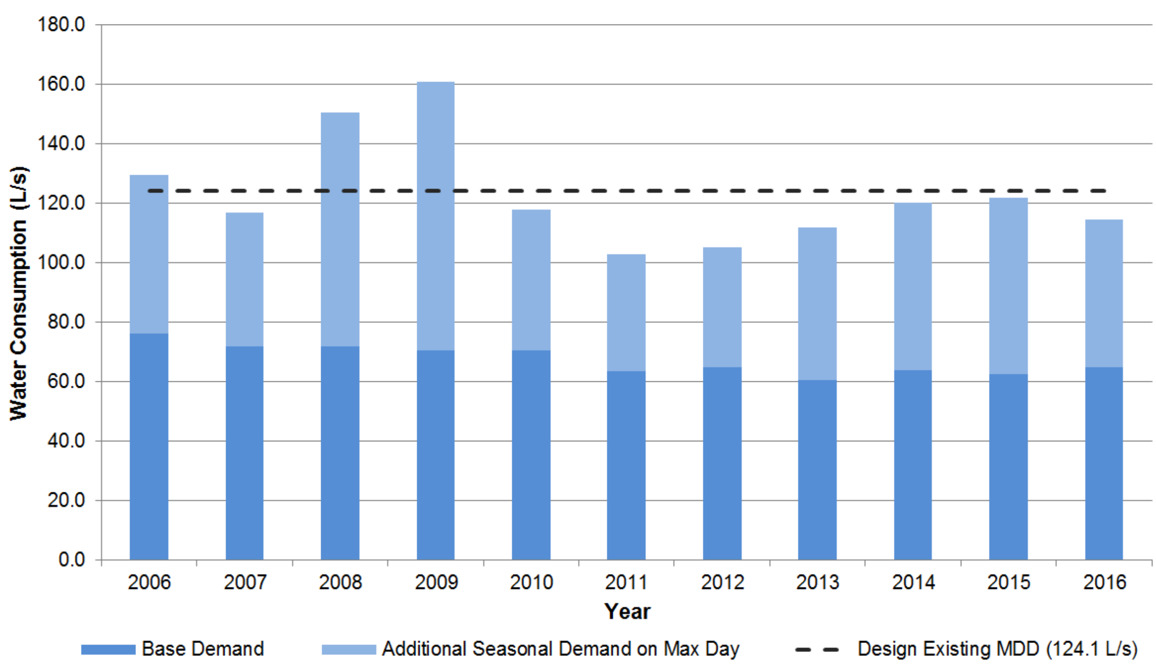


Figure 2-1: 2006 to 2016 Maximum Day Demand Comparison

[1] 2016 Wells Total Flow.xlsx provided Simon Pither on February 28, 2017.

As presented in the figure above, the base demand observed in 2016 was one of the highest in the past five years. However, the seasonal demand component, which is influenced by weather, was lower in 2016 than in previous years. For the purpose of evaluating the water system, using seasonal demands from a representative hot/dry year will provide a conservative yet realistic basis for analysis. The year 2015 had the highest seasonal demand component in recent years (2010 to 2015). Note that Stage 2 watering restrictions were in place in 2015 on maximum day.

A review of the average evapotranspiration (ET) rate for the weeks preceding the maximum water use day was conducted to determine if 2015 could be considered a hot/dry year. Average ET values[2] for each year in the historical water use record is shown on Table 2-2. It can be seen that the ET value observed in 2015 (4.5 mm/day) was the highest in the 11-year record.

Table 2-2: 2006 to 2016 Average Evapotranspiration Rates

Year	Additional Seasonal Demand on Max. Day (L/s)	Four Week Average ET (mm/day)
2006	53.2	3.1
2007	45.1	2.4
2008	78.7	3.8
2009	90.3	3.5
2010	47.5	3.4
2011	39.4	3.5
2012	40.5	3.5
2013	51.2	3.9
2014	56.3	4.1
2015	59.3	4.5
2016	49.7	3.4

For the purposes of this study, the BD value observed in 2016 (64.8 L/s) was combined with the SD value observed in 2015 (59.3 L/s) to obtain a total design existing MDD of 124.1 L/s.

2.3 Metered Water Usage and Existing Base Demand Units Rates

The City's water meter data collected in winter months was used to calculate average base demand unit rates for existing land use types.

All of the City's water services are metered. Meter data provided by the City for 2016 indicates that there is a total of 4,526 water service meters. The water meters in the City's database are classified as single-family, multi-family, or ICI (includes City, Commercial, and Institutional meter types), and are read four times per year. The City's meter database also includes the number of multi-family units associated with each multi-family water meter.

Average base demand unit rates for single-family residential parcels and multi-family residential units were calculated using water meter data. The calculated rates were 195 L/ca/day and 193 L/ca/day for

[2] Average ET values for White Rock obtained from Environment Canada's Farmwest website <http://farmwest.com/climate/et>

single-family and multi-family, respectively. As these rates are very similar, 195 L/ca/day was selected as the existing residential base demand rate for this study.

A selection of ICI meters was assigned to parcels to develop an ICI base demand unit rate. An average rate of 1.45 L/m^2 parcel area/day was calculated for existing ICI parcels.

Water meter records for the Peace Arch Hospital and Semiahmoo First Nation were reviewed individually. The 2016 water meter records indicate that the base demands for the Peace Arch Hospital and Semiahmoo First Nation are 3.43 L/s and 0.36 L/s, respectively.

2.4 Water System Losses

The water system loss component of the base demand was estimated as the difference between observed minimum night flows and theoretical legitimate night usage.

The observed minimum night flow for the month of December, 2016, was 20 L/s, based on information extracted from the City's SCADA system.

The legitimate night usage was calculated based on the following:

- 4 L/hour/dwelling for residential units which roughly equates to 1 toilet flush / hand basin use per dwelling between the hours 2:00 a.m. and 4:00 a.m.; and
- 10% of base ICI usage.

Based on the above, a total legitimate night usage of 12.5 L/s was calculated. Therefore, the system loss component was estimated to be 7.5 L/s.

2.5 Seasonal Demands

The total seasonal demand component for the system (2015, 59.3 L/s) was determined through a review of the source flow data as discussed earlier in this section.

Seasonal demand has been allocated to green/irrigated areas in White Rock for the purpose of this study. A green area analysis was completed by KWL in 2010 [Ref. 6] by examining aerial photos and determining an average green area as a percent of total parcel area for each land use type (single-family residential, multi-family residential, and ICI. The results indicated green area, on average, comprises the following:

- 36% of single family residential parcels;
- 19% of multi-family residential parcels; and
- 22% of ICI parcels.

These percentages were applied to the parcels in the water service area based on land use type and a total green/irrigated area for the system was calculated. As larger lots tend not to be fully landscaped, the irrigated area for single family lots was capped at 1,500 m^2. Using the total calculated irrigated area, the irrigation rate for seasonal demand was calculated as 4.65 L/m^2/day or 4.65 mm/day.

It is useful to compare this irrigation rate to the theoretical rate derived based on crop and climatic conditions [Ref. 20]. The theoretical irrigation rate can be calculated as:

$$IrrigationRate\ (mm/day) = \frac{Et \times CropCoefficient \times AllowableStress}{Irigation\ Efficiency}$$

where:

$$Et = Evapotranspriation\,rate\ (mm/day)$$

$$CropCoefficient = 1\ for\ turf$$

$$AllowableStress = 0.7\ (Default\ for\ turf\ grass\ in\ B.C.\ conditions)$$

$$Irrigation\,Efficiency = 70\%\ for\ metered\ irrigation,\ 50\%\ for\ un-metered$$

Environment Canada's farmwest.com website indicated that the four weeks prior to the maximum day in 2015 had an average ET rate of 4.5 mm/day. Using the above formula, (with a 70% irrigation efficiency), the theoretical expected irrigation rate for White Rock is 4.5 mm/day or 4.5 L/m^2/day, which compares well with the calculated rate of 4.65 L/m^2/day.

2.6 Diurnal Demand Patterns

Diurnal patterns are assigned to each demand component to allow peak hour demands to be estimated. A separate demand pattern is assigned to each demand type (BD-RES, BD-ICI, and SD). The losses demand pattern (LOSSES) is assumed to be consistent throughout a 24-hour period.

The diurnal patterns developed for White Rock in previous studies were calibrated against recent demand data extracted from the SCADA system. Patterns for seasonal and residential base demand were adjusted to capture the peaks observed. The calibrated patterns and resulting comparison between modelled flows and actual observed flows from SCADA are presented in Figure 2-2.

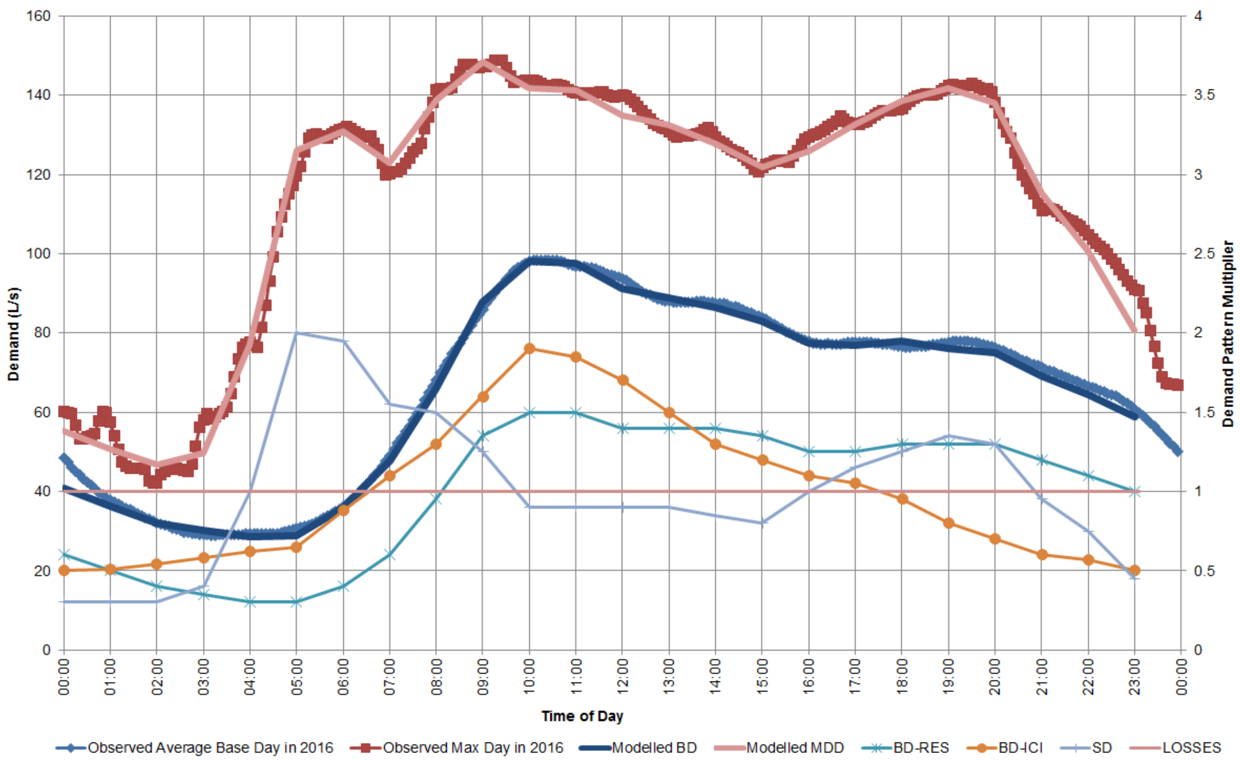


Figure 2-2: Calibrated Diurnal Demand Patterns

2.7 Base Demand Unit Rate Comparison

The residential base demand rate calculated for this study (195 L/ca/day) was compared against other observed rates. Residential base demand rates calculated by KWL for other local jurisdictions are:

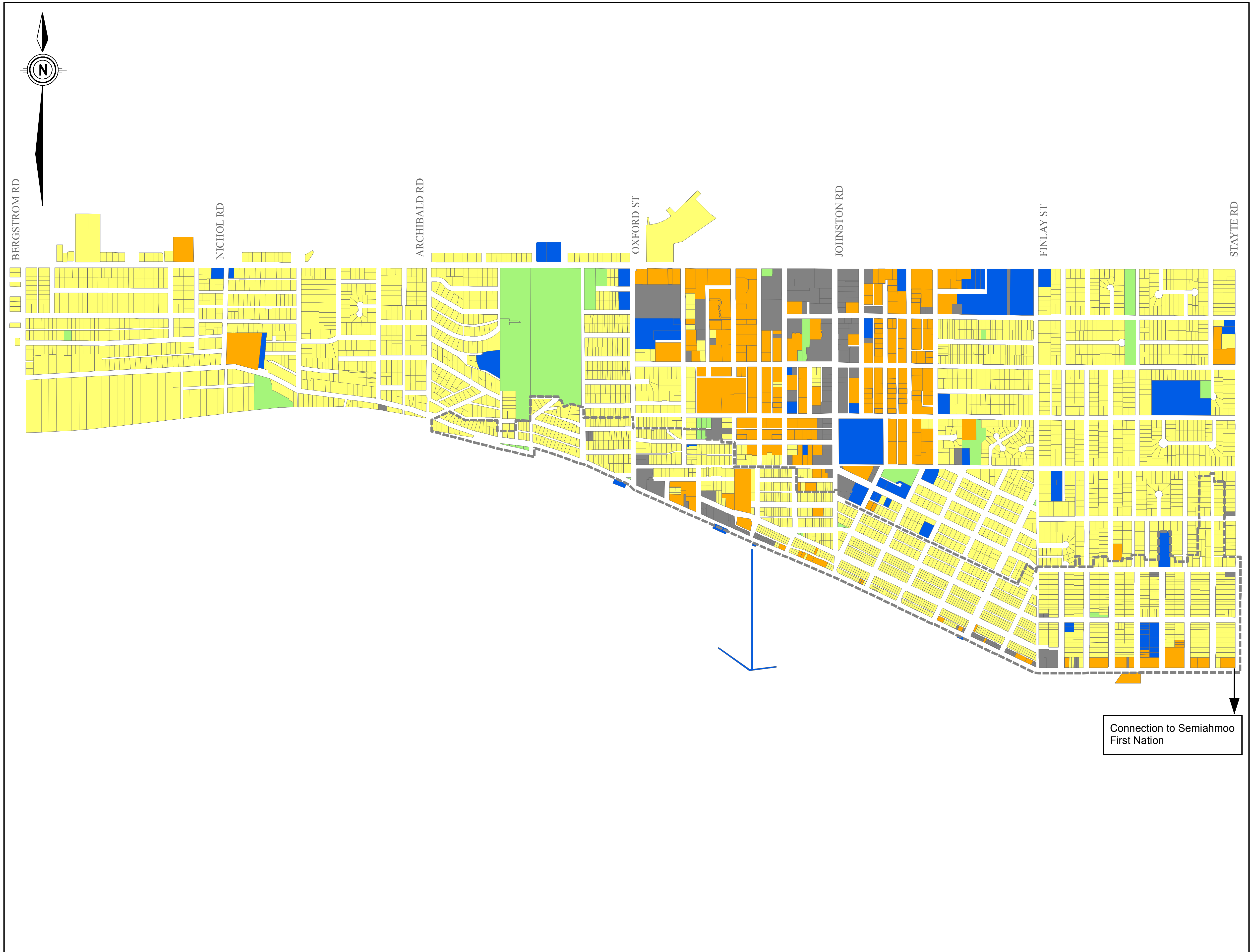
- French Creek – 170 L/ca/day (2013);
- City of Parksville – 156 L/ca/day (2013);
- Regional District of Nanaimo, Nanoose Bay – 163 L/ca/day (2013);
- City of Richmond – 208 L/ca/day (2010);
- District of Saanich – 200 L/ca/day (2009); and
- Town of Sidney – 172 L/ca/day (2014).

Also note that the rates calculated in previous White Rock master plans were 233 L/ca/day and 202 L/ca/day for 2010 and 2013, respectively.

As shown above the residential base demand rates for other local jurisdictions range from 156 – 208 L/s and the existing residential base demand per capita rate of 195 L/ca/day calculated for White Rock is also within this range. The base demand rate for White Rock has declined by 16% since 2010. Reduction in the base demand rate is attributed to increasing use of low flow fixtures and growing awareness of water conservation benefits.

2.8 Existing Water Demand Summary

Table 3-3 in Section 3, includes a summary of populations, customer water meter data, various parameters used for demand development and existing demands broken down by each component for use in this study.



City of White Rock 2017 Water System Master Plan Update

Legend

Pressure Zone Boundary

Existing Land Use

- Single Family
- Multi Family
- Mixed Use
- Institutional / Commercial
- Park

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200 0 600
(m)

Project No.	Date
452-120	August 2017

Existing Land Use

Figure 2-3

3. Future Water Demands

A future demand scenario was developed using population and ICI sector growth projections from the City of White Rock Official Community Plan (OCP) [Ref. 2]. The City has indicated that the growth projections used in the OCP document were based on a report prepared by Coriolis Consulting Corporation [Ref. 4].

A year 2045 future horizon has been used for this Water System Master Plan Update to be consistent with the planning horizon used for the OCP.

The following table is a summary of the future demands used for this study. The sections below summarize the development of the future water demands.

Table 3-1: Future 2045 Demand Summary

Max Day Demand MDD = 143.8 L/s	**Base Demand** BD = 78.6 L/s	**ICI** BD-ICI = 13.6 L/s
		Single-Family Residential BD-SF-RES = 26.0 L/s
		Multi-Family Residential BD-MF-RES = 31.5 L/s
		Losses LOSS =7.5 L/s
	Seasonal Demand SD = 65.2 L/s	**ICI** SD-ICI =8.0 L/s
		Single-Family Residential SD-SF-RES = 51.8 L/s
		Multi-Family Residential SD-MF-RES = 5.4 L/s

3.1 Growth Projections and Future Land Use

The projected year 2045 population and ICI growth is detailed in the 2017 OCP document; a summary of the information used for this study is as follows:

- 7,348 population increase, for a total 2045 population of 27,300; and
- 320,000 ft^2 (29,729 m^2) of additional ICI floor area by 2045, including 209,000 ft^2 of retail and service area, 32,000 ft^2 of additional grocery store area, and 79,000 ft^2 of additional office area.

The OCP document includes a future land use map. In this map, the City is divided into eleven areas as follows:

- Town Centre;
- Town Centre Transition;
- Lower Town Centre;
- Waterfront Village;
- Urban Neighbourhood;
- East Side Large Lot;
- North Bluff East and West;

- Neighbourhood Commercial;
- Mature Neighbourhood Infill;
- Institutional; and
- Open Space and Recreation.

The future land use map has been reproduced for use in this study, and is shown in Figure 3-2 (end of section).

Each area is described in the OCP document including information about allowable densities. This information has been used to distribute a portion of the projected population and ICI growth to the parcels. A summary of the distribution of additional population and ICI floor area to each area is included in Table 3-2.

Note that the planning documents provided indicate that no net increase in single-detached homes is expected. However, the Coriolis report [Ref. 4] indicates that on average there are historically 58 new single-family housing starts in White Rock, and two thirds of the new houses have secondary suites. Assuming this trend continues, a portion of the projected growth (1,515 people) has been allocated to the Mature Neighbourhood Infill area to account for construction of secondary suites.

No growth has been attributed to the City of Surrey lots included in the White Rock service area or the Semiahmoo First Nation.

Table 3-2: Summary of Population and ICI Growth Allocated to Future Land Use Areas

Future Land Use Area	Allowable Development Density (FAR)	Additional Population Added	% of Total Population Growth	Additional ICI Floor Area Added (m^2)	% of Total ICI Growth
Town Centre	5.4	1,951	27%	10,105	34%
Town Centre Transition	2	1,383	19%	7,161	24%
Lower Town Centre	2.5	482	7%	2,496	8%
Waterfront Village	1.75	618	8%	3,203	11%
Urban Neighbourhood	1.5	1,115	15%	5,776	19%
East Side Large Lot	1.5	166	2%	859	3%
North Bluff East & West	0.6	118	2%	0	0%
Neighbourhood Commercial	0.75	0	0%	129	0%
Mature Neighbourhood Infill	N/A	1,515	21%	0	0%
Institutional	N/A	0	0%	0	0%
Open Space & Recreation	N/A	0	0%	0	0%
Total		**7,348**		**29,729**	

3.2 Future Base Demand Unit Rates

A residential base demand unit rate of 195 L/ca/day and an ICI rate of 1.45 L/m^2 parcel area/day was calculated for the existing system as discussed in Section 2. Using existing ICI floor area data available in the OCP (about 72,500 m^2), the ICI base demand rate roughly equates to 3.0 m^3/m^2 floor area/year.

While these base demand rates are considered reasonable for existing construction and compare well with rates observed in other municipalities, lower rates have been selected for future growth to reflect new construction standards that include water efficient fixtures and appliances.

A residential base demand rate of 140 L/ca/day has been applied to additional population growth based on information available from the Water Research Foundation for newly constructed homes [Ref. 13].

An ICI base demand rate of 2.0 m^3/m^2 floor area/year has been applied to additional ICI floor area growth base on published average water use coefficient rates per floor area for various commercial uses [Ref. 8].

Applying these unit rates to the growth projections yields a total base demand of 78.6 L/s for the future demand scenario.

3.3 Future Water System Losses

The water system loss estimate for the existing system is 7.5 L/s as discussed in Section 2.

The magnitude of water losses in a system is a function of the size and age of the system and the rate of infrastructure renewal. The water service area in White Rock is not expected to increase. Furthermore, although the water mains are ageing, water main replacement and ongoing leak management activities can be expected to limit increases in losses. The City has indicated that they are in the process of conducting a water leak inspection. Therefore, the existing water loss estimate (7.5 L/s) has been used as an estimate of future losses.

3.4 Future Seasonal Demand

The seasonal demand estimate for the existing system is 59.3 L/s as discussed in Section 2.

The water service area in White Rock is not expected to increase therefore it has been assumed that irrigated area will not increase. It has also been assumed that White Rock will continue to issue watering restrictions when necessary – the seasonal demand is considered to be consistent with what can be expected under Stage 2 watering restrictions.

To account for potential climate change impacts (potential for higher temperatures and extended drought periods which require greater irrigation) a 10% increase to existing seasonal demands has been applied to estimate future seasonal demands. The future seasonal demand estimate is 65.2 L/s for years beyond the existing demand horizon.

3.5 Future Water Demand Summary

Table 3-3 (end of section) includes a summary of residential and ICI growth, various parameters used for demand development, and future demands broken down by each component for use in this study. The figure below shows a plot of observed demands and populations for previous years, and estimated demands and projected populations for future years.

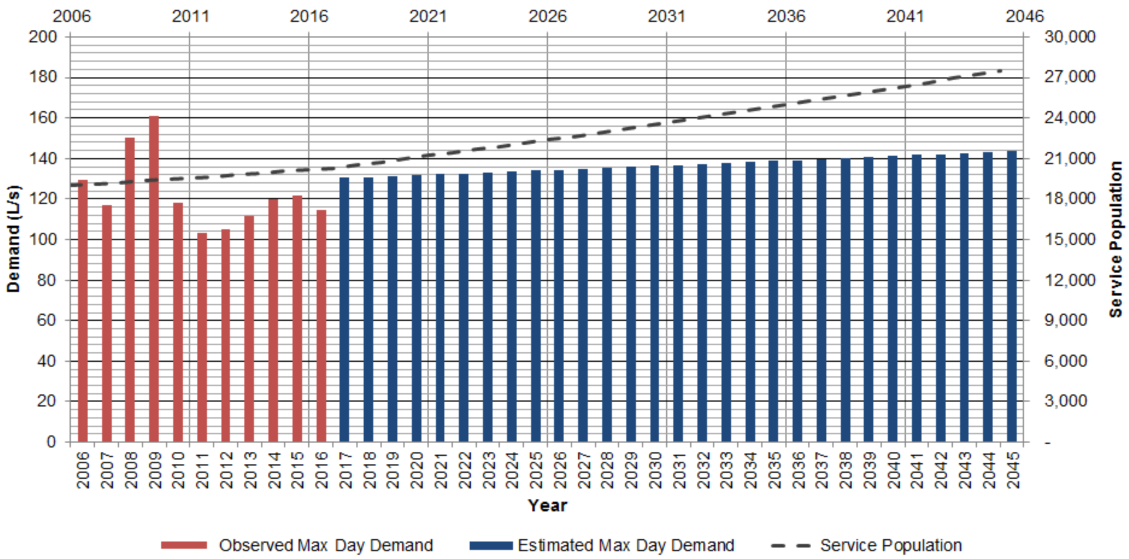
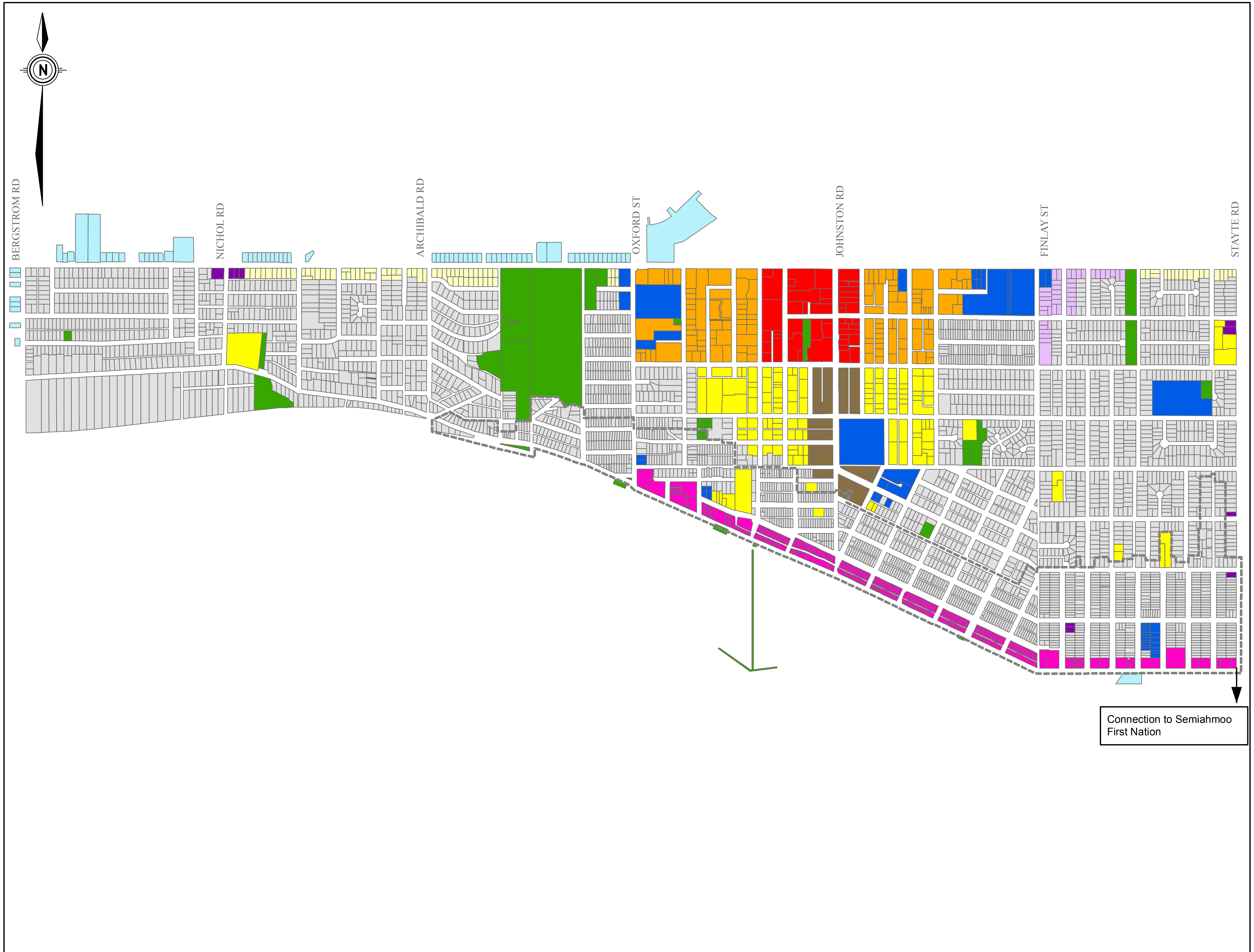


Figure 3-1: Projected Population and Estimated Water Demand Plot



City of White Rock
2017 Water System Master Plan Update

Legend

- Pressure Zone Boundary

Future Land Use

- East Side Large Lot
- Institutional
- Lower Town Centre
- Mature Neighbourhood Infill
- Neighbourhood Commercial
- North Bluff East & West
- Open Space & Recreation
- Surrey
- Town Centre
- Town Centre Transition
- Urban Neighbourhood
- Waterfront Village

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200 0 600
(m)

Project No.	Date
452-120	August 2017

Future Land Use

Figure 3-2

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Table 3-3: 2017 Water System Master Plan Demand Summary

		ICI	SF-RES	MF-RES	Losses	Total	Notes
Existing							
Number of Meters		266	4,024	236		4,526	According to 2016 service meter data records.
Percentage of Total Meters		6%	89%	5%			
Metered Annual Demand (L/s)		13.8	33.5	21.2	-	68.5	
Percentage of Total Annual Meter Use		20%	49%	31%			
Metered Base Demand (L/s)		12.0	26.2	19.2	-	57.4	Average of period 1 and period 4 meter readings.
Percentage of Metered Base Demand		21%	46%	33%			
Base Demand	Residential Population (ca)		11,514	8,667		20,181	2016 White Rock Census Population - 19,952 Estimated City of Surrey Serviced Population - 229 Note, Semiahmoo First Nation is included as ICI demand.
	Base Demand Rate (L/ca/day)	195					Calculated using 2016 service meter data.
	ICI Demand Rate (L/m^2 Land Area/day)	1.45					Calculated using 2016 service meter data.
	Existing Base Demand (L/s)	11.7	26.0	19.6	7.5	64.8	
	% of Total Existing Base Demand	18%	40%	30%	12%		
Seasonal Demand	% Irrigated Area	22%	36%	19%			Based on White Rock green area analysis completed as part of 2009 Master Plan Update. Note, single family residential irrigated area capped at 1,500 m^2.
	Existing Seasonal Demand (L/s)	7.3	47.1	4.9	-	59.3	
	% of Total Existing Seasonal Demand	12%	79%	8%	0%		
Maximum Day Demand	Existing Maximum Day Demand (L/s)	19.0	73.1	24.5	7.5	124.1	
	% of Total Existing Maximum Day Demand	15%	59%	20%	6%		
Future Demands - 2045							
Future Base Demand	Additional Residential Population			7,348		7,348	According to the 2017 Draft OCP. Assumed no additional growth for the lots serviced in City of Surrey or Semiahmoo First Nation.
	Future Demand Rate (L/ca/day)	140					Reduced rate to reflect new construction with water efficient fixtures and appliances, see note 1.
	Additional ICI Floor Area (m^2)	29,729				29,729	
	ICI Demand Floor Area Rate (L/m^2 Floor Area/day)	5.48					Equates to 2.0 m^3/m^2 floor area/year, see note 2.
	Additional Base Demand Due to Growth (L/s)	1.9	-	11.9	-	13.8	
	Total Future Base Demand	13.6	26.0	31.5	7.5	78.6	Assume that losses continue at the same rate as existing.
	% of Total Future Base Demand	17%	33%	40%	10%		
Future Seasonal Demand	Additional Seasonal Demand Due to Growth (L/s)	-	-	-	-	-	No increase in seasonal demand as no additional land area to be serviced in the future.
	Future Seasonal Demand including Climate Change Allowance (L/s)	8.0	51.8	5.4	-	65.2	
	% of Total Future Seasonal Demand	12%	79%	8%	0%		
Future Maximum Day Demand	Future Maximum Day Demand (L/s)	21.7	77.8	36.9	7.5	143.8	
	% of Total Future Maximum Day Demand	15%	54%	26%	5%		

Notes:

1) Reference: Residential End Uses of Water, Version 2, Water Research Foundation, April 2016.

2) Typical average water use coefficient rate per floor area, average of various commercial uses. Reference: M.A. Morales et Al, Estimating commercial, industrial, and institutional water use on the basis of heated building area, *Journal AWWA*, vol. 103, no. 6, pp 84-96, June 2011.

4. Water Model Update

4.1 Water System Overview

The White Rock water system supplies a population of approximately 20,000 residents as well as a small portion of Surrey (located on North Bluff Avenue and Bergstrom Road) and the Semiahmoo First Nation. The major facilities in the water distribution system include:

- Seven groundwater wells (excluding Well 5, taken permanently out of service);
- Oxford Reservoir and Booster Pump Station;
- Merklin Reservoirs (two cells) and Booster Pump Station;
- Roper Reservoir and PRV Station;
- Stevens Street PRV Station; and
- Johnston Road PRV Station.

The water service area is divided into the High Pressure Zone (nominally 142 m HGL) and the Low Pressure Zone (nominally 101 m HGL).

The existing water system network is shown on Figure 4-1 (end of section) and a schematic is shown in Figure 4-2 (end of section).

The City of White Rock is currently conducting a study on the water system to identify and evaluate potential changes to:

1. Reduce/eliminate flow direction changes in the distribution system; and
2. Decrease water stagnation in the system to reduce impact on disinfection residuals.

4.2 Model Updates

A hydraulic water model of the White Rock water system has been created using Bentley's WaterCAD software (version 10). The file version used in the analysis for this report is WR_v52.10.wtg.

Prior to this study, the model was last updated in February 2016. Recent water model updates completed for this report are summarized in Table 4-1. Note that water main construction projects scheduled to be completed in 2017 and 2018 were included in the model update and are considered part of the existing system for the purpose of this study.

Table 4-1: Model Updates

Model Update	Update Description	Project Completion Date
Water Main Upgrades	Included current / upcoming water main upgrade projects: • Beachview Ave.; Johnston Rd. to Foster St.; • Marine Dr.: Vidal St. to Martin St.; • Marine Dr.: Bergstrom Rd. to Nichol Rd.; • Saturna Dr. and segment of Archibald Rd.; and • Magdalen Cres.: Marine Dr. to Sunset Dr.	2017 / 2018
Merklin Reservoir Upgrades	Added new reservoir and booster pump station (2 duty pumps and 2 fire pumps).	2016

Model Update	Update Description	Project Completion Date
Oxford Well 8	Added Well 8 and connecting piping to the Oxford reservoirs.	2017
Buena Vista Well 5	Removed Well 5 from the model per planned decommissioning.	2018
High St. Well Disinfection	Adding disinfection equipment (for chlorine and ammonia) and instrumentation (flow, pressure and well level) and SCADA control to the High St. well.	2017
Roper Reservoir	Updated Roper PRV station to reflect existing settings and valve sizes.	N/A
Demands	Revised existing and future demand scenarios and diurnal patterns as discussed in Sections 2 and 3.	N/A

4.3 Existing Controls

The existing hydraulic controls are used in the water model are summarized in Table 4-2.

Table 4-2: System Controls and Modelling

Facility	Description	System Controls	Modelling Comments
Merklin Booster PS	2 duty pumps and 2 fire pumps	Set at 141.1 m HGL (310 kPa)[3]	
Oxford Booster PS	4 duty pumps on VFDs	Set at 141.7 m HGL (508 kPa)[3]	
High St. Well 4	Single Well	Manual operation, normally off	Initial status = off in model.
Roper Reservoir	1.14 ML, 6 m height, TWL 102.5 m	See Roper PRVs	Observed level range 101.5 – 102.5 m.
Roper PRV (63 mm)	63 mm PRV	102.4 m HGL	
Roper PRV (150 mm)	150 mm PRV	102.5 m HGL	Flow data indicates that the isolation valve on the downstream side of the PRV is partially closed to limit max. fill rate.
Johnston PRV Station	150 mm PRV	Set at 98.45 m HGL (183 kPa)	Model hydraulics under normal operation indicates PRV remains closed.
Stevens St. PRV Station	150 mm PRV	Set at 97.18 m HGL (376 kPa)	Model hydraulics under normal operation indicates PRV remains closed.

[3] Operational set points provided by Dean Brown on May 25, 2017. The City has indicated that the operational set point has since been adjusted to 525 kPa.

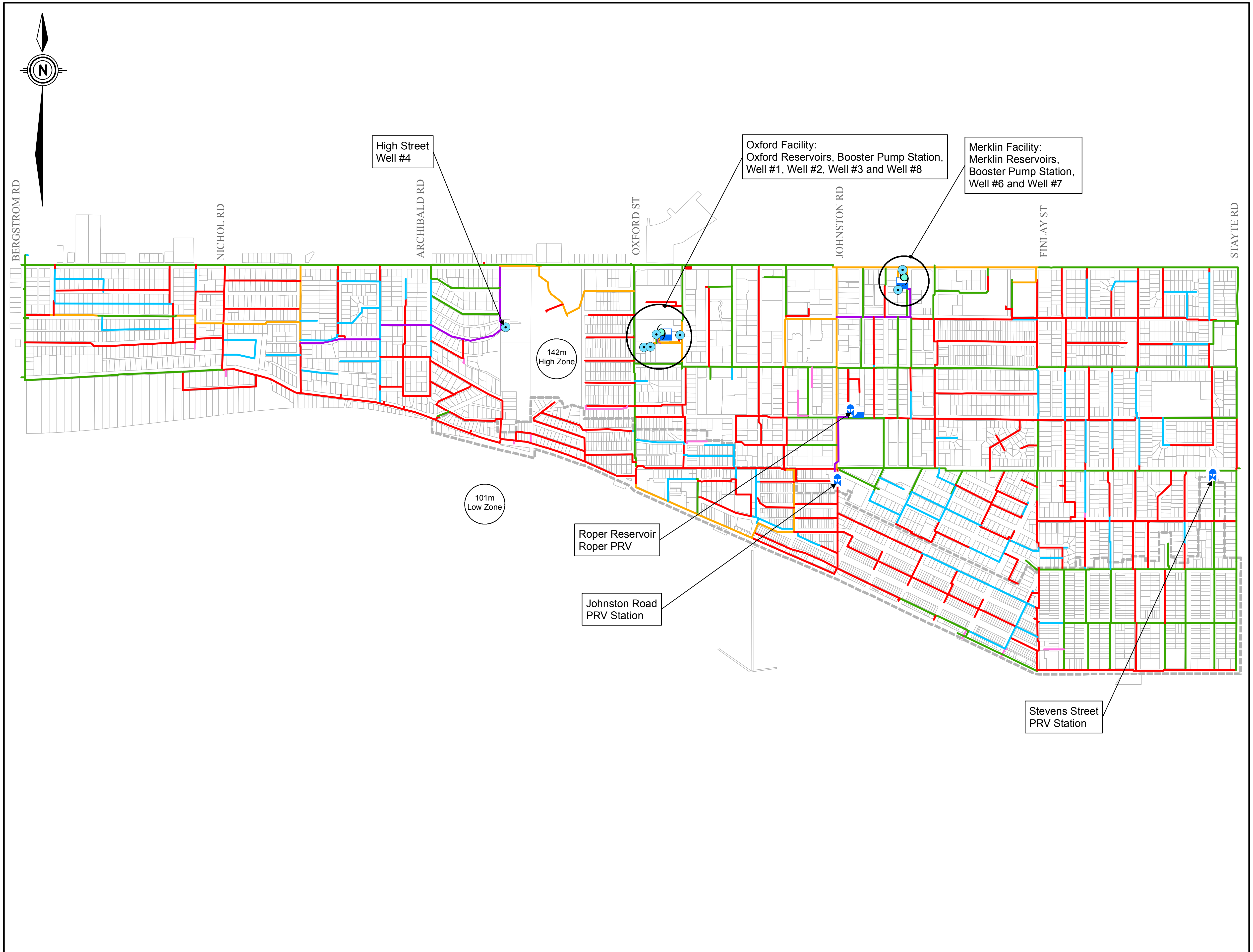
4.4 Water Main Inventory

The size and material of the existing water mains in the model is summarized in Table 4-3. A plan showing the water main material is shown on Figure 6-3 (end of Section 6).

Table 4-3: Inventory of Water Mains (Length in m)

Nominal Diameter (mm)	Cast Iron	Ductile Iron	PVC	Steel	Unknown	All Material	Percent of Total
25		172			26	198	0.3%
50	26	336	184		54	600	0.8%
100	8,634	2,291	45		10	10,980	14.1%
150	7,006	26,924	323	326	262	34,841	44.7%
200	6,565	15,426	1,196	228	91	23,505	30.1%
250	1,612	3,797	339	47		5,795	7.4%
300	-	1,972	-	14		1,987	2.5%
350	-	-		2		2	0.0%
400	-	44		46		90	0.1%
Total	**23,842**	**50,961**	**2,087**	**664**	**443**	**77,997**	
Percent of Total	30.6%	65.3%	2.7%	0.9%	0.6%	100%	

City of White Rock
2017 Water System Master Plan Update



Legend

- Groundwater Well
- Pressure Reducing Valve
- Pump Station
- Reservoir
- Pressure Zone Boundary

Diameter (mm)

- < 100
- 100
- 150
- 200
- 250
- 300
- 350
- 400

KERR WOOD LEIDAL
consulting engineers

200 0 600
(m)

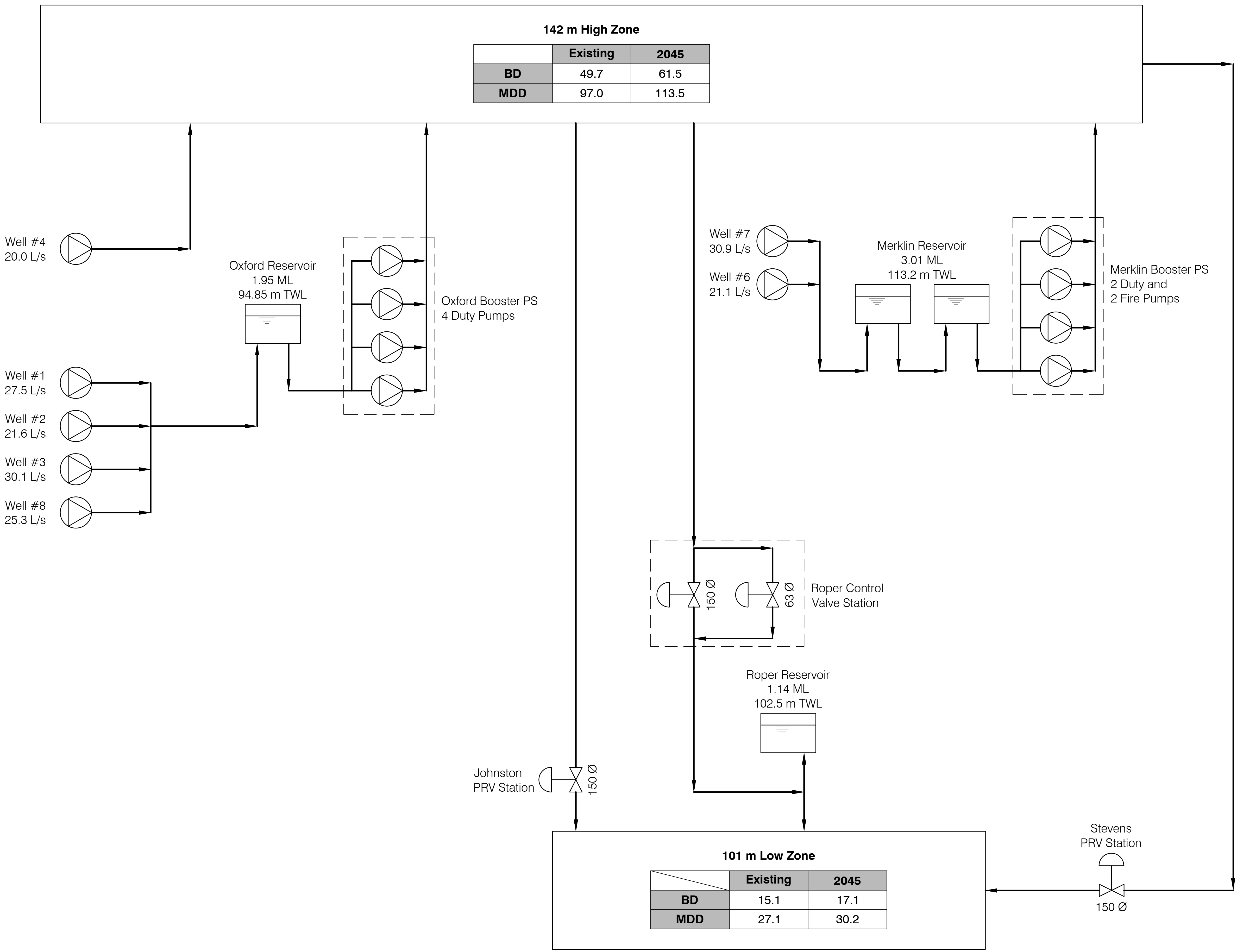
Project No.	Date
452-120	October 2017

White Rock Water System

Figure 4-1

Path: \\bbyfs1.kwl.ca\0000-0999\0400-0499\452-120\430-GIS\MXD-Rp\Figure4-1_WhiteRockWaterSystem_rev1.mxd Date Saved: 23/10/2017 11:48:28 AM
Author: rsinnott

City of White Rock
2017 Water System Master Plan Update



142 m High Zone

	Existing	2045
BD	49.7	61.5
MDD	97.0	113.5

101 m Low Zone

	Existing	2045
BD	15.1	17.1
MDD	27.1	30.2

Legend

Reservoir

Pump

Pressure Reducing Valve

Existing

BD	Base Demand
MDD	Maximum Day Demand
PS	Pump Station
PRV	Pressure Reducing Valve

KERR WOOD LEIDAL
consulting engineers

N.T.S.

Project No.: 452.120

Date: October 2017

Existing System Schematic

Figure 4-2

5. Design Criteria

Design criteria used for system evaluation are primarily from the MMCD Design Guidelines [Ref. 9].

5.1 Supply Capacity

As discussed in Section 3, the year 2045 design maximum day demand is 144 L/s.

5.2 Pressure

The required system water pressures are summarized in the following table.

Table 5-1: Pressure Design Criteria

Description	Required Pressure (kPa (psi))
Maximum pressure	1,035 (150) (1)
Minimum pressure at peak hour demand	300 (43.5)
Minimum pressure coinciding with fire flow and MDD	150 (21.8)
Note 1: MMCD allows for either a max. allowable of 850 kPa (125 psi) or 1,035 kPa (150 psi). The current White Rock system pressure zoning results in static pressures up to 1,100 kPa. Reducing pressures to 850 kPa would require extensive capital works for minor benefit accordingly the higher criteria was selected.	

5.3 Required Fire Flows and Storage

Table 5-2 shows the minimum required fire flows from the 2009 Fire Underwriters Survey (FUS) report for White Rock [Ref. 10], 2014 MMCD Design Guidelines [Ref. 9], FUS Water Supply for Public Fire Protection Guidelines [Ref. 18], and the required fire flows used for this report which have been developed based on these three documents.

Table 5-2: Fire Flow Design Criteria

Type of Construction/Dwelling	Area(s)	Required Fire Flow (L/s)	Fire Storage (ML)
2009 FUS Report for White Rock			
Commercial and Multi-Family Residential	*Town Centre Area*	*212 L/s (2,800 Igpm)*	*1.98 ML (2.6 hr)*
Single-Family Residential	*West of Oxford Street and East of Town Centre*	*60 L/s (800 Igpm)*	*0.32 ML (1.5 hr)*
2014 MMCD Design Guidelines / FUS Storage			
Institutional/Commercial	*N/A*	*150 L/s*	*1.08 ML (2.0 hr)*
Apartments/Townhouses	*N/A*	*90 L/s*	*0.60 ML (1.85 hr)*
Single-Family Residential	*N/A*	*60 L/s*	*0.32 ML (1.5 hr)*
FUS Water Supply for Public Fire Protection Guidelines			
Single-Family Residential	*N/A*	*67 L/s (4,000 L/min)*	*0.36 ML (1.5 hr)*
Used for Evaluation in this Study			
High Density Commercial and Multi-Family Residential	Town Centre Area	212 L/s	1.98 ML (2.6 hr)
Institutional, Commercial, and Multi-Family	Institutional, Waterfront Village, Lower Town Centre, and East Side Large Lot Areas	150 L/s	1.08 ML (2.0 hr)
Lower Density Commercial and Multi-Family	North Bluff East & West, Urban Neighbourhood, Neighbourhood Commercial, and Open Space & Recreation Areas	120 L/s	0.86 ML (2.0 hr)
Single-Family Residential	Mature Neighbourhood Area	67 L/s	0.36 ML (1.5 hr)

It is noted that the selection of fire flow requirements is the responsibility of the City. Different jurisdictions set their own criteria or select standards of protection according to their specific circumstances. In British Columbia, it is common for municipalities to use MMCD Design Guidelines or allow for an alternate fire flow requirement (such as FUS) if detailed information is available or an area specific study has been conducted.

The 2009 FUS report breaks the City into broad fire service areas. The Town Centre area is rated at 212 L/s whereas the remainder of the City is rated at 60 L/s (single-family residential requirement). The FUS report does not consider specific higher fire flow requirements outside the town centre (such as for institutional, commercial or multi-family developments).

For this study, for the areas outside of the Town Centre Area, values consistent with MMCD guidelines were assigned to the future land use areas shown on Figure 3-2. The required fire flow used for system evaluation is shown on Figure 6-2 (end of section 6).

Fire flow requirements for new developments should still be verified with the City of White Rock during the development water servicing review process.

It is noted that both the High-Pressure Zone and Low-Pressure Zone have areas within the Town Centre area so a maximum required fire flow of 212 L/s and fire storage requirement of 1.98 ML applies to both zones.

A fire event occurred on May 15, 2016, in the Town Center area. The fire started at a building under construction at 15219 Royal Avenue and subsequently spread to a neighbouring mixed commercial/multi-family residential building at 15210 Pacific Avenue. Fire flows used by the fire department during the event were in excess of the design criteria. This event illustrated the usefulness of having fire flow capabilities in excess of the minimums noted above. It is noted that fire flows were further supplemented by use of the City's emergency connections to Surrey's water system.

6. Analysis

6.1 Current Supply Capacity

The supply capacity of the groundwater wells in the system is summarized in Table 6-1 below.

Table 6-1: Supply Capacity of Groundwater Wells

Well Number	Location	Capacity (1) (L/s)
Well 1	Oxford Site	27.5
Well 2	Oxford Site	21.6
Well 3	Oxford Site	30.1
Well 4	High St.	20.0
Well 5	Buena Vista Ave. – out of service, to be decommissioned	-
Well 6	Merklin Site	21.1
Well 7	Merklin Site	30.9
Well 8	Oxford Site	25.3
Total (all wells)		**176.5**
Rated Capacity with Largest Well Out of Service (L/s)		**145.5**
Rated Capacity with Well 3 Decommissioned		**115.4**
Well 9 (New, Well 3 Replacement) – required capacity		29
Rated Capacity with New Well 9		**144**
Note 1: From 2016 Well Statistics.xlsx provided by the City on August 2, 2017.		

The supply capacity for a water system must exceed the maximum daily demand for the system to avoid water shortages during peak summer demands. In rating the supply capacity, it is normal practice to exclude the largest well to provide a level of safety to deal with maintenance emergencies that may occur during peak demands. In White Rock's system, the largest capacity well is Well 7 (31 L/s).

Decommissioning of Well 5 (see Project 26) is recommended for the following reasons:

- Well 5 is located in a different pressure zone, and currently pumps to a lower HGL than the other wells;
- Cost considerations related to the need to provide a separate chlorination system (and potentially a future treatment plant); and
- Concerns with the long-term viability of the well.

The existing design demand is 124 L/s and is within the rated supply capacity with the largest well out of service (145.5 L/s). This includes the continued use of the High Street Well 4.

In the year 2045 water system demands are expected to increase marginally to 144 L/s.

Recent redevelopment work with Well 3 shows that (due to its condition) is in need for replacement rather than continued redevelopment. Currently Well 3 use is being curtailed to prolong its life. A replacement well in the same location (Well 9) is recommended in the next five years (see Project 19). A recommended design capacity for the replacement well is 29 L/s or more to bring the total rated supply capacity up to the forecast maximum day demand of 144 L/s. A hydrogeology study would be required to confirm feasibility of a replacement well at the same location.

Note that while there is sufficient well capacity when all the wells are aggregated, modelling indicates that the Merklin Tanks (supplied by Wells 6 and 7) almost empty on existing maximum day because the capacities of Well 6 and 7 are less than the flow supplies from the Merklin Booster Pump Station. However, this will be addressed in the future with the centralized Water Treatment Plant (described in Section 6.2) as the flow from all wells in the system will be combined and distributed to the various reservoirs as needed.

While White Rock's system does have emergency connections to the City of Surrey's water system, the use of these connections has not been included in source capacity calculations. Using these connections cannot be considered as the current agreement with the City of Surrey is for emergency use only. Regular use of these connections to meet peak demands is likely untenable as the peak demands within the City would correspond with Surrey's peak demands. Concerns also exist with control of chlorine residuals in the system when using water from the Surrey system.

However, the retention and further development of the connections as **emergency** connections is recommended (see Project 27).

High Street Well 4 is being updated this year. It is understood that the upgrades include:

- addition of disinfection equipment for storage and injection of chlorine and ammonia;
- addition of instrumentation for flow, pressure and well level; and
- integration of the well control into the City's SCADA system.

The upgrades will allow for use of Well 4 on an ongoing basis. Not included in the upgrades to the well, are relocation of the high-voltage electrical equipment above ground. Currently the transformer and distribution panel for the well are located below grade in a concrete vault. Relocation or replacement of this equipment with above-grade installation is recommended (see Project 28). The scope of this project needs additional definition during design.

6.2 Centralized Water Treatment Plant Concept

The existing water system draws its water from seven groundwater wells which have levels of arsenic that are within, but near, the limit of 0.010 mg/L set by Health Canada in the Guidelines for Canadian Drinking Water Quality (GCDWQ). Several wells have consistent arsenic levels at 0.009 mg/L. In addition to arsenic, the City's water has elevated levels of manganese. Most of the City's wells are consistently over a proposed maximum allowable concentration (MAC) limit of 0.1 mg/L currently being considered by Health Canada. The manganese levels do exceed the aesthetic limit in the GCDWQ of 0.05 mg/L as five of the City's seven wells have manganese levels between 0.05 and 0.18 mg/L.

At the time of completing this report, the City has issued a Request for Proposals (RFP) for three Design-Build teams for construction of a centralized water treatment plant (WTP) located at the Oxford site (see Project 1 described in the following section). The proposed centralized water treatment plant scope also includes the following:

- Interconnecting piping between the Oxford site and the Merklin site;
- Interconnecting piping between Well 4 and the Oxford site;

- Integration and control strategy for interfacing the existing wells with the new water treatment plant, and
- Related infrastructure and appurtenances to treat the source water to remove arsenic and manganese to meet performance specifications defined in the RFP.

RES'EAU-WaterNet has completed a report consisting of a pilot plant evaluation for the City [Ref. 16]. This report summarizes a collaboration between the City of White Rock and RES'EAU-WaterNET, which is based at the University of British Columbia. The report "*A Community Circle Approach to Evaluating Water Treatment Solutions for the City of White Rock*," dated July 2017, summarizes data for pilot testing of some water treatment processes and highlights the extent to which they can remove manganese and arsenic from the City's water supplies. The report work was conducted from December 2016 to June 2017 using a pilot plant facility, consisting of two treatment trains that involved oxidation, filtration and adsorption stages. The report has been provided to the three Design-Build proponents as background for their efforts in the RFP for the design and construction of a new water treatment plant.

The treatment concept at completion of the proposed WTP is understood at this time to be as follows:

- Source water from the Oxford (Wells 1, 2, 3, and 8), Merklin (Wells 6 and 7) and High Street (Well 4) sites to be conveyed to the water treatment plant. For the remote sites (Merklin and High Street), a new raw water supply main is required to connect each site to the Oxford WTP. Refer to Section 6.3 for more details.
- Pre-oxidation; the City selected ozone for the oxidation process.
- The primary arsenic and manganese removal process as selected by the successful Design-Build proponent.
- Treated water from the Oxford WTP would be conveyed to the High Pressure Zone storage reservoirs (Oxford and Merklin). For the Merklin facility a treated water transmission main would be provided; refer to Section 6.3 for more details.
- It is expected that the water treatment plant will be designed with sufficient discharge HGL to convey the treated water to the Merklin facility (TWL 113.2 m).
- Secondary disinfection will take place at the Merklin and Oxford reservoirs.

A schematic showing the proposed arrangement is shown on Figure 7-3 (at end of Section 7).

The City will be evaluating the proposals from the Design-Build teams for the WTP project. The final treatment process and details of Design-Build water treatment plant project and associated works will be subject to the outcome of the RFP process.

6.3 Raw Water and Treated Water Supply Mains

The following supply mains are recommended per the treatment plant concept described in the section above. All of these mains are included in Project 1. The sizing of the mains is preliminary and needs to be confirmed once water treatment plant design details are known. A life-cycle cost analysis to determine the potential benefit of increasing the main sizes to reduce long-term pumping costs should be conducted during detailed design.

Table 6-2: Supply Mains Required for Centralized WTP

Description	Route	Dia. (mm)	Approx. Length (m)
Merklin – Oxford Raw Water Main	Merklin to Oxford via. Thrift Avenue	250	1,350
Oxford – Merklin Treated Water Main	Oxford to Merklin via. Thrift Avenue	350	1,500
High Street Well – Oxford Raw Water Main	High Street to Oxford	150	600

A connection to the Roper Reservoir from the Oxford-Merklin treated water main was considered, but is not recommended as additional changes to the disinfection scheme would be required.

Given the cost of the High Street Well – Oxford Raw Water Main combined with additional work recommended at the High Street Well (Project 28), a cost-benefit analysis is recommended which compares the cost of fully integrating the High Street Well to replacement with a new well closer to the water treatment plant.

6.4 Storage

Capacity

The storage requirements for forecasted demands are as shown in the following table. It is noted that the 16% value for balancing storage is based on past studies estimating the specific balancing requirement needs for the City of White Rock's system [Ref. 6].

The available storage capacity is based on tank volumes provided by Stantec [Ref 19].

Table 6-3: Balancing Storage Required Versus Available

Required Balancing Storage:	12.4 MLD (144 L/s) x 16%	= 1.99 ML
Required Fire Storage:	212 L/s for 2.6 hours	= 1.98 ML
Required Emergency Storage:	25% of above storage	= 0.99 ML
Total Required		**= 4.96 ML**
Available Storage:	Merklin Reservoirs	= 3.01 ML
	Oxford Reservoir	= 1.95 ML
	Roper Reservoir (Low Zone)	= 1.14 ML
Total Available		**= 6.10 ML**
Excess Available for Pump Cycling		**= 1.14 ML**

Based on the assessment, adequate balancing storage is provided by the current system for the forecast future demands.

Reservoir Circulation

Normal current practices to ensure good reservoir circulation and mixing include:

- batch filling operations during normal operation; and
- separate reservoir inlet from the reservoir outlet (typically on opposite sides of the reservoir).

Currently the Roper Reservoir has a single inlet/outlet and reservoir filling controls do not allow for batch filling (control valves are simple PRVs that attempt to keep the reservoir full at all times).

As described in WSE's Technical Memorandum [Ref. 15], the following measures are recommended:

- **New Roper Reservoir Inlet:** Reservoir circulation would be greatly improved with a separate reservoir inlet with a high-velocity nozzle(s) to encourage complete mixing within the tank. A small diameter (nominally 150 mm) inlet line is proposed. The work would require draining the reservoir and constructing a new main from the Roper PRV station to the reservoir and into the reservoir. The new inlet would be located opposite the existing reservoir outlet. See Project 4.
- **Roper Control Valve Station Modifications:** Replacing the existing 63 mm PRV with a 100 mm electronic flow control valve to allow for batch fill/empty cycles. The new valve would control the valve percent open to meet a desired flow value. The flow requirement would be derived from the reservoir level and time of day filling. Addition of a flow meter on the station supply line is also required for the proposed control improvements. See Project 3.

6.5 Pressure Zoning

Currently, the Oxford and Merklin facilities both pump into the High Pressure Zone. The current High Pressure Zone supply HGL is 141.7 m. The Oxford facility is nominally the 'lead' supply to the High Pressure Zone and at night Merklin flows decrease to near zero. During the day, Merklin flows increase and form the majority of the supplied flow. This situation results in considerable mixing of the water from the two sources. It is understood that water supplied by the Merklin Wells (wells 6 and 7) have a higher concentration of manganese than the Oxford wells. Changes in flow direction resulting from the day/night changes in supply source could increase re-suspension of precipitated manganese.

As per WSE's Technical Memorandum [Ref. 15]; splitting the existing High Pressure Zone into a 145 m Merklin Zone (portion of the High Zone east of Everall St.) and a 135 m Oxford Zone (portion of the High Zone west of Everall St.) is recommended. See Project 5.

This rezoning will have the following benefits:

- Improves control of Oxford and Merklin Booster Pump Stations (each has its own service area).
- Reduces pressures (and leak/break potential) in the Oxford Zone. Currently these exceed design criteria in localized areas.
- In the short term, reduces mixing of the Oxford and Merklin sources and improves water quality in the interim (i.e. until the WTP is built).
- Provides for improved separation of the system (as zone mixing is removed except under unusual operational conditions).

The proposed pressure zone split would require:

- A new zone boundary on Thrift Avenue (no cost assuming existing valve is in adequate condition).
- A new Everall Street PRV and check valve station.

The Everall PRV Station would contain a 150 mm diameter PRV to allow for fire flow support from the Merklin Zone to the Oxford Zone. A check valve would also be installed to allow for fire flow support in the opposite direction.

6.6 System Pressures

Figure 6-1 (end of section) shows peak hour pressures with future maximum day demands.

Modelling indicates that there are low pressure deficiencies (< 300 kPa/44 psi) at the following locations:

- Top of the High Pressure Zone in the vicinity of North Bluff Road near the Merklin Booster Station: Minimum pressures in this area are 38 psi. The pressures are governed by the discharge pressure setpoint at the Merklin Booster Pump Station (currently 310 kPa or 141 m HGL). To provide adequate pressures a slightly higher discharge setpoint is required (350 kPa or 145 m HGL).
- Top of the Low Pressure Zone in the vicinity of Beachview Avenue and Johnston Road: Minimum pressure of 29 psi. Low pressures in this area are being addressed with the 2017 Beachview Avenue water main project. This project includes construction of new mains parallel to the existing mains on Beachview Avenue (between Foster and Johnston) and Foster (between Buena Vista and Beachview). The new mains will be located in the High Pressure Zone allowing for connection and servicing at higher pressures.

Pressures in excess of the maximum pressure limit (1,035 kPa/150 psi) are located at the bottom of the High Pressure Zone (West) near Marine Drive and Magdalen Crescent. Maximum pressures are experienced at the zone boundary on Marine Drive and Magdalen Crescent (162 psi) and Marine Drive and High Street (185 psi). Reduction in the High Zone West pressures by 10 m HGL or 14 psi as discussed in Section 6.5 is expected to address this deficiency except for a very short section of main on High Street north of Marine Drive (at the bottom of a steep hill at the zone boundary).

6.7 Available Fire Flow

Figure 6-2 (end of section) shows the available fire flow with future maximum day demands. Modelling indicates that there are fire flow deficiencies or marginal fire flows at the following locations.

Table 6-4: Locations of Fire Flow Deficiencies

Zone	Location	Fire Flow (L/s)		Discussion
		Required	Available	
Oxford (HZE)	North Bluff Rd. & Oxford St.	212	196	Constrained by 200 CI mains supplying location. See projects 7 and 20.
Merklin (HZW)	1400 block Martin St. (Hydrant 129)	212	177	Constrained by 150 CI main on Martin St. See Project 18.
Merklin (HZW)	15400 – 15500 block Russell Avenue (east of Best St.)	212	141	Constrained by 150 CI main on Russell Ave. See Project 29.
Merklin (HZW)	1400 – 1500 block Vidal Street (north of Thrift Ave.)	212	199	Constrained by 150 CI main on Vidal St. See project 32.
Low	Prospect Ave. & Oxford St.	212	82	Existing 200 CI Oxford St. Main is not connected to Prospect Ave. See Project 11.
Low	Blackwood Ln. & Blackwood St.	212	131	Undersized and unlooped local mains. See projects 21 & 22.
Low	Buena Vista Ave. & Martin St.	212	143	Undersized cast iron main. See Project 23.
Low	Columbia Ln. & Balsam St. (Hydrant 91)	67	58	Undersized cast iron main. See Project 12.
Low	15100 block Marine Dr. (west of Johnston Rd.)	212	200	Undersized cast iron main. See project 31.
Low	Johnston Rd. (between Beachview and Royal Ave.)	212	165	Undersized cast iron main. See project 33.

It is noted that in a number of locations small diameter piping has been provided on water mains servicing cul-de-sacs past the last fire hydrant. In these cases, the available fire flow at the hydrant was considered and lower available fire flows beyond the hydrant ignored because the main is not required to provide fire flows.

6.8 Reliability Assessment

Break History Update

The City provided an update of their water main break history from 2013 to February 2017; this was added to the previous break history provided by EPCOR White Rock Water Inc. for breaks going back to 2000. A map showing the past pipe break locations are shown on Figure 6-3 (end of section).

In the last three years of data the City has averaged ten (10) breaks/year. The break rate has remained essentially constant (with some year-to-year statistical variation) over the entire seventeen (17) year period of record.

The following observations are noted:

1. **The break rate is within the typical range**. The City's average break rate is 0.13 breaks/km/year. This compares to average in NWWBI [Ref. 15] of .07 breaks/km/year and range of .01 – 0.30 breaks/km/year. The break rate is within the normal range of the industry benchmark. It is noted that the water system is fairly dense (many service connections), hilly (large pressure

range), and a mature system (includes older infrastructure). As well, the City has a good break recording system in place and has a reasonably low water system losses indicating breaks /leaks are being found and repaired.

2. **Cast Iron Pipe is more susceptible to breaks**. The break rate is much higher on the older cast iron pipe (111 of the breaks or 0.26 breaks/km/yr) than on ductile iron pipes (0.07 breaks/km/yr).
3. Among the cast iron piping, **breaks are more common in higher pressure areas**. The break rate where the normal pressures exceed 100 psi is 0.48 breaks/km/yr. This compares to a break rate of 0.20 breaks/km/yr for other areas.
4. For cast iron piping, **breaks are also slightly more common on slopes**. The break rates are 0.32 breaks/km/yr where the average pipe slope exceeds 3%, whereas it is 0.22 breaks/km/yr when the slope is less than 3%.

Cast Iron Pipe Condition Assessment

As per above the cast iron mains are contributing to the majority of the water mains breaks despite being only a minority portion of the piping system. Accordingly, examination of a replacement program or condition assessment program for the cast iron piping is warranted.

Previous work [Ref. 6] indicated that a global replacement program for all of the cast iron water mains was not warranted on the basis of the observed break rate. The break rate would have to be much higher or average property damage costs very high to justify the cast iron water main replacement program on a financial basis. Note that this analysis considered the break rate remaining stable with time and did not include environmental or socio-economic costs. In fact, some exponential increase is typical with CI piping as corrosion/pitting reduces wall thickness.

It may be that replacement of specific water mains that are either high-risk (of causing property damage) and/or poor condition (extensive break history due to age, soils, etc.) may be warranted. However, no information is available at this time to definitively identify these mains.

Certain geographic clusters of breaks are noted in the break history but it is uncertain whether these are random or linked to the condition of the local main, or other factors (construction methods at the time of install, ground conditions, etc.). Areas with recurring break history of note include:

- 1300 block of Martin St.;
- 13800 block of Coldicutt Ave.;
- Marine Dr. from Vidal St. to Martin St. (replacement underway);
- Stevens St. between North Bluff Rd. and Russell Ave.; and
- Habgood St. between Vine and Russell Ave.

Another potential justification for replacement of specific mains would be adjacent construction by the City of White Rock (which would reduce road reconstruction costs). Typical road reconstruction costs may form 20% of a water main replacement project. With the current break rates and costs, this alone would not be sufficient reason to replace a typical cast iron watermain.

To better manage the cast iron water main asset class, a condition assessment program is recommended. A pilot condition assessment program that includes non-destructive inline inspection using a 'smart pigging' device such as PICA's See Snake is recommended.

A condition assessment program would provide the following benefits:

- identification of current pipe condition;
- identification of leaks;
- pre-emptive point repairs at areas identified with extensive localized wall loss;
- enables informed decisions on pipe rehabilitation versus continuing with point repairs for pipes inspected;
- where pipe rehabilitation is indicated, inspection data provides additional information to determine method of rehabilitation, i.e. lining versus replacement; and
- enables extrapolation of results to a larger area.

A pilot program is recommended in the short term (next 3 years) that evaluates 2 km of cast iron main using non-destructive inline inspection in areas with past pipe break history. See Project 14.

Water Main Asset Management Study

Following the pilot cast iron condition assessment program, a water main asset management study is recommended. The study would review asset classes, maintenance history (breaks, etc.), and condition information (including pilot program results) to determine a sustainable asset management program for the utility's water mains. See Project 14.

Water Main Replacement

Following the condition assessment and asset management programs, it is anticipated that a number of water mains will be recommended for replacement.

Based on the previous break history, the following mains are included for potential replacement. However, these projects are contingent on results of the pilot condition assessment program (i.e. lower priority relative to other projects).

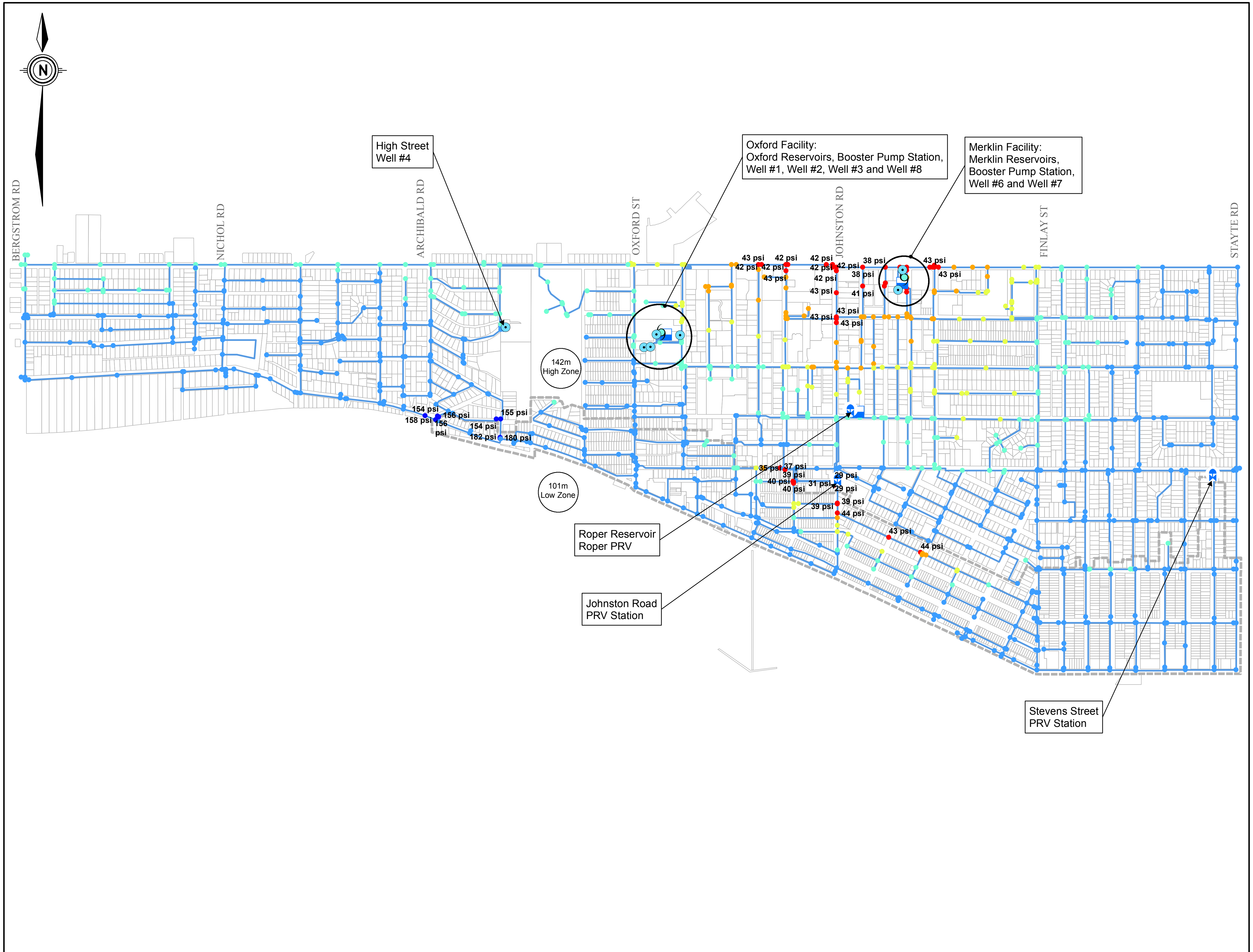
- 1300 block of Martin St. (Project 16);
- 13800 block of Coldicutt Ave. (Project 17);
- Stevens St. between North Bluff Road and Russell Ave. (Project 24); and
- Habgood St. between Vine and Russell Ave. (Project 25).

6.9 Cross Connection Control

As part of a water quality study completed by KWL in 2016 [Ref. 17] it was determined that the following locations have air release (or air/vacuum valves) that are located in underground vaults or chambers with the vent portion terminated inside the chamber:

- Oxford site (2): Well 1 and Well 3;
- High St. Well (1): Well 4 vault;
- Buena Vista site (1): Well 5 vault;
- Mann Park Cres. (1): In manhole;
- Centennial Park and North Bluff (2): In meter boxes;
- Steven PRV station (1): In vault;
- Johnson Rd. PRV (1): In vault; and
- 15476 North Bluff (1): In standpipe buried within road.

These ten locations are potential cross connections as the chambers these valves are located within could potentially become flooded and result in the flood water being drawn into the distribution system. This could potentially occur under localized conditions and remain undetected unless water sample data showed positive results. To mitigate this risk, the vents on all of these air valves should be raised to terminate outside the chamber in a location that is not prone to flooding (min. 600 mm above the ground). See Project 30.



City of White Rock
2017 Water System Master Plan Update

Legend

- Groundwater Well
- Pressure Reducing Valve
- Pump Station
- Reservoir
- Pressure Zone Boundary
- Water Main

Peak Hour Pressure (psi)

- < 43.5
- 43.6 - 50.0
- 50.1 - 60.0
- 60.1 - 80.0
- 80.1 - 150.0
- > 150.0

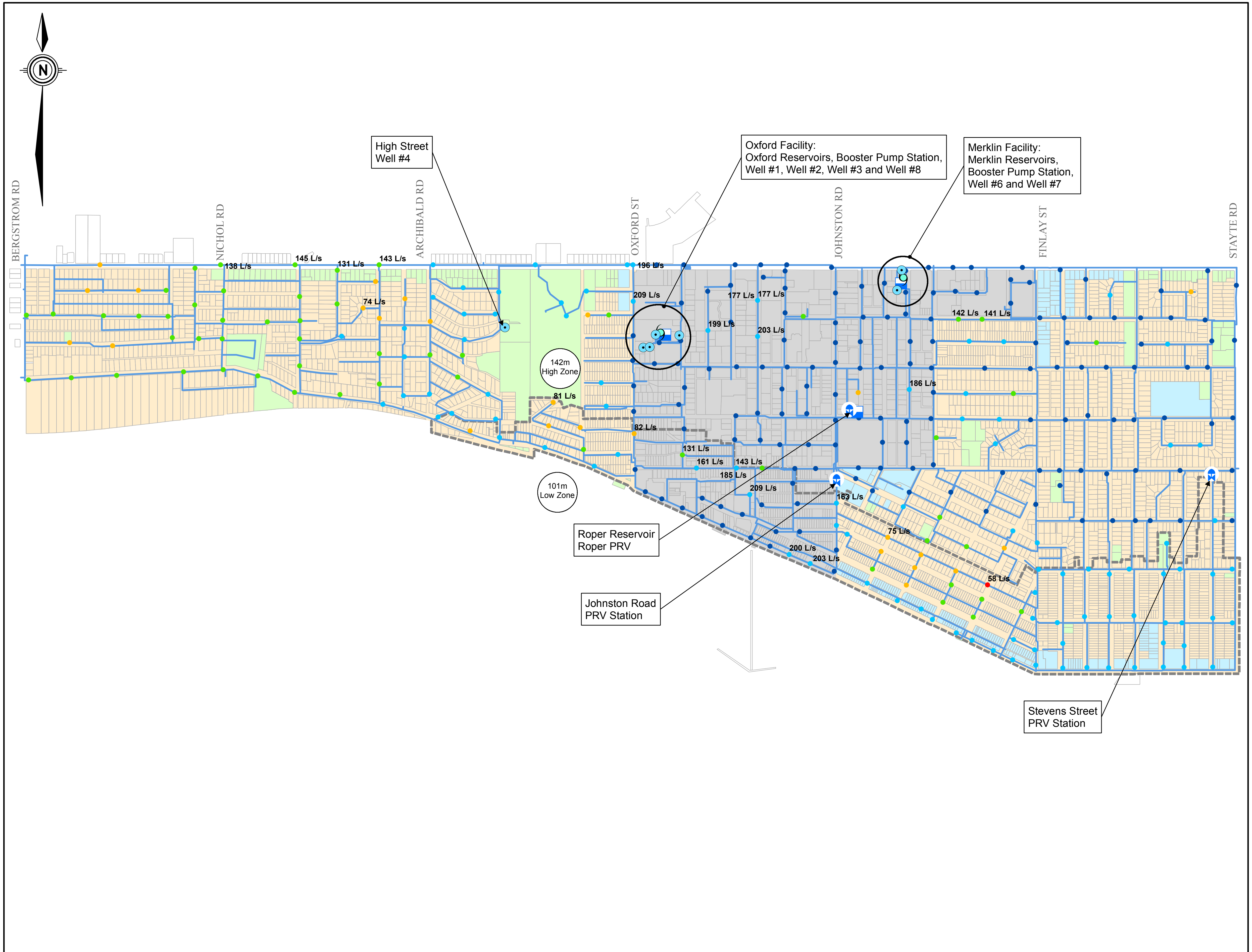
KERR WOOD LEIDAL
consulting engineers

200 0 600
(m)

Project No.	Date
452-120	October 2017

Existing (2018) System with Future Demands Peak Hour Pressure

Figure 6-1



City of White Rock
2017 Water System Master Plan Update

Legend

- Groundwater Well
- Pressure Reducing Valve
- Pump Station
- Reservoir
- Pressure Zone Boundary
- Water Main

Available Fire Flow (L/s)

- < 67
- 68 - 120
- 121 - 150
- 151 - 212
- > 212

Required Fire Flow

- 67 (L/s)
- 120 (L/s)
- 150 (L/s)
- 212 (L/s)

KERR WOOD LEIDAL
consulting engineers

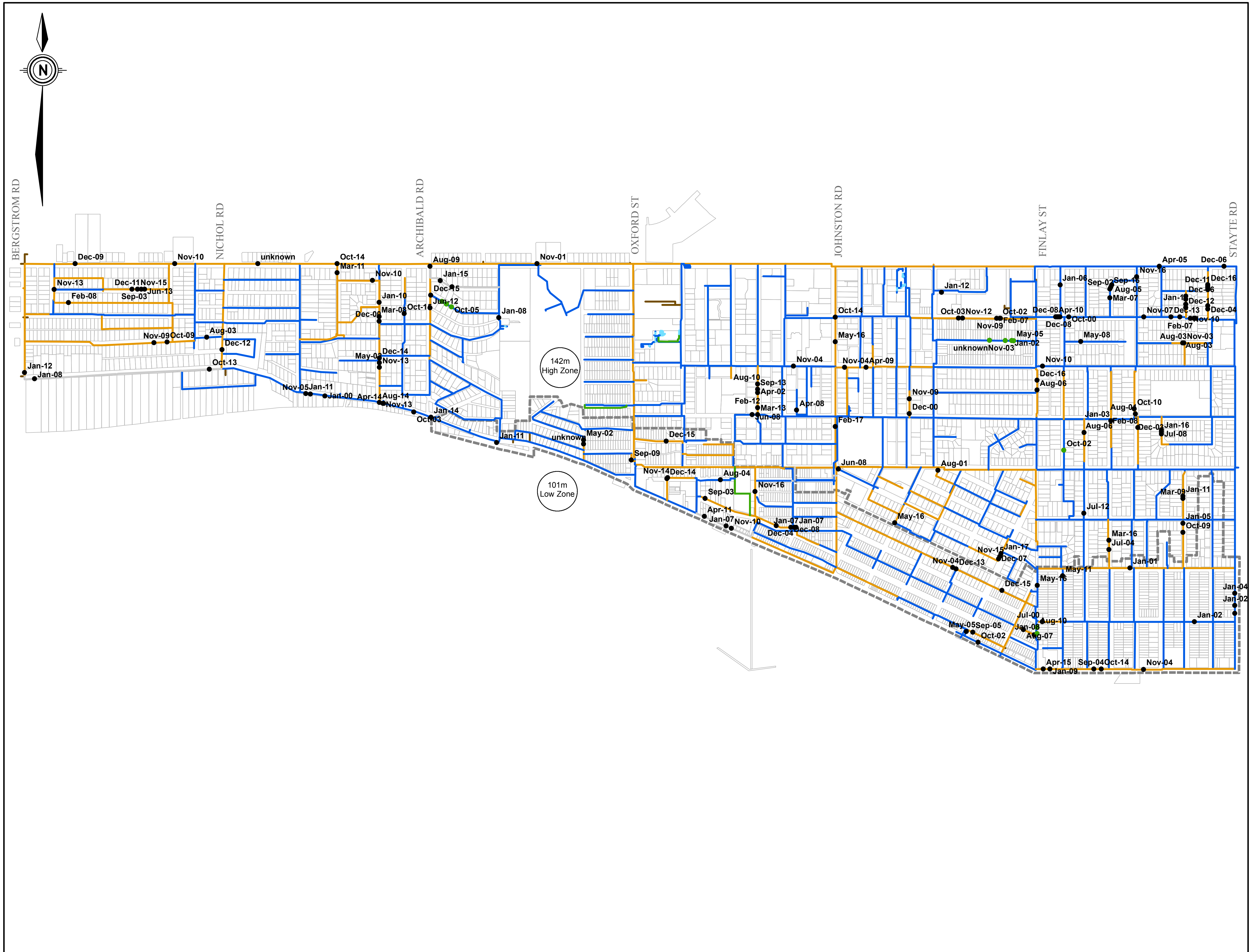
200 0 600
(m)

Project No.	Date
452-120	October 2017

Existing (2018) System with Future Demands Available Fire Flow

Figure 6-2

Path: \\bbyfs1.kwl.ca\0000-0999\0400-0499\452-120\430-GIS\MXD-Rp\Figure6-2_Existing(2018)SystemAvailableFireFlowswithFutureDemands_rev1.mxd Date Saved: 23/10/2017 11:57:15 AM
Author: rsinnott



City of White Rock 2017 Water System Master Plan Update

Legend

Pressure Zone Boundary

Water Main Material

- Cast Iron
- Ductile Iron
- Scheduled 2017 Project
- PVC
- Steel
- Unknown
- Recorded Pipe Breaks (water main replaced since break)
- Recorded Pipe Breaks

KERR WOOD LEIDAL
consulting engineers

200 0 600
(m)

Project No.	Date
452-120	October 2017

Water Main Break Locations 2000-2016

Figure 6-3

Path: \\bbyfs1.kwl.ca\0000-0999\0400-0499\452-120\430-GIS\MXD-Rp\Figure6-3_WaterMainBreakLocations(2000to2016).mxd Date Saved: 08/08/2017 2:50:37 PM
Author: rsinnott

7. Recommended Upgrades and Prioritization

7.1 Capital Plan Tasks

All recommended improvements to be included in the Master Plan are presented on Figure 7-2 (end of section). Capital projects recommended are summarized in Table 7-10 (end of section).

For projects recommended to improve fire flow, the local fire flow requirement should be confirmed prior to construction.

7.2 Exclusions from the Capital Plan

Work scheduled for 2017 completion is not included as discussed in Section 4 – Water Model Update.

The capital plan does not include ongoing operations and maintenance programs such as:

- reservoir cleaning and routine maintenance;
- unidirectional water main flushing;
- water main repairs required due to leaks/emergencies; and
- leak detection program(s).

7.3 Cost Basis

Costs are estimated based on recent City of White Rock construction projects and detailed cost opinions for 2017 work. No allowance has been provided in these figures for escalation in subsequent years. The cost opinions in the report are indicative and have been prepared for long-term budgeting purposes only. Unit prices are based on recent costs for similar facilities; however, no detailed quantity take-offs or equipment selection has been completed.

Costs for water mains reflect typical scope of work for a distribution main. Water main cost opinions include allowances for:

- fittings, and isolation valves including thrust restraint;
- reconnection of existing water services; and
- road restoration.

Cost opinions are Class "D" or provisional estimates. Class "D" estimates are preliminary which, due to little or no site information, indicate the approximate magnitude of cost of the proposed project. These cost opinions may be derived from lump sum or unit costs for a similar project.

The following generic allowance was applied to all water main construction projects:

- 20% for engineering; and
- 20% for contingencies.

Some costs for capital tasks are taken from estimates from previous reports. The cost for the water treatment plant and associated treated and raw water mains (Project 1) as described in sections 6.2 and 6.3 is based on the cost provided by the City of White Rock.

Costs for water main construction tasks were estimated using the unit rates given in Table 7-1.

Table 7-1: Standard Unit Costs

Item	Unit Costs[1]
150 mm dia. water main	$1,035/m
200 mm dia. water main	$1,090/m
250 mm dia. water main	$1,150/m
300 mm dia. water main	$1,300/m
350 mm dia. water main	$1,400/m
1. These unit costs include engineering (20%) and contingency (20%), but exclude GST.	

7.4 Model Results with Upgrades

Figure 7-4 (end of section) shows the pressure at peak hour with the recommended upgrades. Figure 7-5 (end of section) shows the available fire flow with the recommended upgrades.

7.5 Prioritization of Upgrades

The recommended upgrades have been prioritized as either of low, medium, high, and highest priority. The methodology for ranking the projects considers the severity of the deficiency being addressed, the relative cost compared to the service area being impacted by the deficiency, and local area land use. Some consideration has also been given to grouping related work together for cost effectiveness. The following general guideline for completing deficiencies is recommended:

- Highest: Highest priority projects should be initiated in the coming capital budget year and completed within 2 years.
- High: Schedule for completion within 2 to 5-year time-frame.
- Medium: Schedule for completion in 5 to 10-year time frame.
- Low: Schedule for completion in 10 to 20-year time frame.

While the above guidelines are provided for budgeting, the need for the individual projects should be assessed year-to-year. For instance, the well development projects may be increased in priority if water demands increase quicker than forecast. Similarly, break history may indicate the need to re-prioritize certain projects. As well, the City should consider coordination of work with other utilities (sewer, road rehabilitation) when scheduling the projects.

A summary of the projects by priority is shown in the following table.

Table 7-2: Project Prioritization

Priority	Number of Projects	Cost Estimate
Highest	1	$14,200,000
High	9	$1,638,900
Medium	8	$2,319,850
Low	8	$2,035,775
Total	26	$20,194,525

7.6 Current Billing Structure Review

The City's current waterworks budget, billing structure and service levels were reviewed to assess the suitability of the current funding structure and levels for anticipated future needs. This review is conducted with reference to *Principles of Water Rates, Fees and Charges – Manual of Water Supply Practices M1* (AWWA M1), published by the American Water Works Association. The general approach to the review is as follows:

1. Establish **principles and objectives** for the billing structure;
2. Determine the **revenue requirement**, which is the full annual cost of service to be recovered through water rates, including costs of operation, maintenance, administration and capital investment;
3. Conduct a **cost of service analysis** to assess the equity of cost allocation among classes of water utility customer;
4. Review the performance of the **rate design** in recovering costs sufficiently and equitably; and
5. Develop recommendations for phasing in adjustments to the rate structure to meet the City's needs and objectives.

Principles and Objectives

For the purpose of this review, the following general principles and objectives are assumed:

- **Full Cost Recovery** – The full cost of sustainable water service, including renewal of aging infrastructure, is recovered through a structure of taxes, fees and charges specific to the water utility and no other municipal service.
- **User Pay Equity** – Customers in each distinct class pay their fair share of the costs of the service levels they require. Water service levels are related to commodity or base usage (base or annual total use), maximum demands (capacity share), required level of fire hydrant protection, and customer service. Customer classes are defined by grouping customers that require similar service levels (e.g. single-family residential, multi-family residential, commercial, institutional, industrial and agricultural).
- **Water Conservation** – Rates promote prudent use of the City's limited water resources, ensuring sufficient water is available for all primary needs and avoiding unnecessary capital improvements to increase flow capacity.
- **Stable Revenue** – Water taxes, fees and charges reliably cover the essential costs of providing water service in each year. Revenue fluctuations due to changes in consumption (e.g. weather)

should be accommodated through appropriate contingencies, reserve funding mechanisms, and flexibility in scheduling capital projects.

- **Transparency** – The basis for calculating water taxes, fees and charges is understandable to customers, and all assumptions are clearly stated.
- **Administrative Efficiency** – The billing structure is no more complex than necessary to meet the other principles and objectives.

Revenue Requirement

The current annual revenue requirement is the annual average cost to provide the water utility service, including operation, maintenance, administration and customer service, and capital investment. Based on available information[4], the revenue requirement for the City of White Rock Water Service is established in this section.

Operating Expense

It is assumed that the current annual operating budget is sufficient to cover the full annual cost of operation and maintenance of existing infrastructure, customer service, administration and interest on capital debt. It is our understanding that the financial forecast also includes an allowance of approximately $0.3 million annually after 2018 for operation and maintenance of the new water treatment plant; however, it is estimated that plant O&M will cost $0.8 million. Therefore an additional allowance of $0.5 million is added to the plan beginning in 2019. Based on the draft 2017 financial plan[5], as amended, annual operating costs are approximately $3.2 million, and are projected to increase by 6% and 8% in 2018 and 2019, respectively. These increases are driven by higher capital debt expense resulting from the water treatment upgrade project. The 2021 forecast operating expense is $4.3 million and the five-year average is approximately $3.8 million.

Capital Investment

The capital component of the revenue requirement includes transfers to reserves and principal on capital debt. The total capital investment in the draft 2017 budget is approximately $1.6 million, and is projected to increase by 11 to 14% each year until 2021 due to higher principal payments resulting from the water treatment upgrade project. The capital investment rate in 2021 is forecast to be approximately $2.0 million in 2017 dollars. Higher than anticipated grant funding will reduce the debt portion of the capital expense relative to what was estimated in the November 2016 draft financial plan; however, it is the City's intention to apply the difference to contingency. Therefore, no change in the annual capital investment is anticipated.

In addition to the current capital program, new projects recommended in this Master Plan will increase the estimated capital investment requirement after 2017. Table 7-10 (at end of section) includes new projects that are not included in the current five-year financial plan with a total estimated cost of $4.46 million. The annual average cost of these projects over the period of 2018 to 2037 (20 years), is $0.22 million. With the addition of these projects, the forecast 2021 capital investment need would be $2.5 million in 2017 dollars, and the five-year average would be approximately $2.1 million.

A simple check of the long-term sustainability of capital investment is to consider the capital investment rate as a percentage of the total replacement value of the assets. Based on the water main inventory

[4] A final 2017-2022 financial plan for the water utility was not available at the time of writing. Estimates in this section are based on the November 28, 2016 draft, with adjustments as noted based on information presented in a Special Council Agenda for May 4, 2017, and information provided by the City.
[5] http://www.whiterockcity.ca/assets/Committees/Finance~Audit/2016-11-28%20FA%20Agenda%20FULL.pdf#search="2017%20water%20service%20budget"

in Table 4-3 and the unit replacement costs in Table 7-1, the replacement value of water mains between 150 mm and 350 mm diameter is $71 million. Allowing for replacement of larger and smaller mains, wells and treatment facilities, the total replacement value of the water system is likely in the range of $100 million. As a percentage of this value, an annual average investment rate in the range of $2 million is roughly 2% of the total value of the system (45-year replacement cycle), which is likely to be sustainable and consistent with the principle of full cost recovery.

Total Revenue Requirement

Based on the five-year average budget forecast, including projects recommended in this Master Plan, the revenue requirement for the City of White Rock Water Service is approximately $5.9 million.

Forecast Revenue

Total water utility revenue in 2016 was $4.08 million, including $3.73 in user fees, $0.23 million in connection fees, and $0.12 million in other revenue[6]. Budget revenue for 2017 is $4.77 million, including $4.45 million in user fees (17% increase). This is consistent with a 20% increase in all utility rates effective January 1, 2017 in *Water Services Bylaw No. 2117*.

Further increases in user fee revenues included in the five-year forecast are shown in Table 7-3.

Table 7-3: Forecast User Fee Revenue Increases

Year	User Fee Revenue ($)	Increase (%)
2017	4,448,000	-
2018	4,848,500	9.0%
2019	5,284,700	9.0%
2020	5,548,900	5.0%
2021	5,826,300	5.0%

A further increase of 5% (14% total) in 2018 would be necessary to raise the $0.22 million annually to fund the new projects identified in this Master Plan, assuming all currently planned projects will also proceed. Some of the capital cost will be recovered through development cost charges (DCCs), which are recovered under the *White Rock Development Cost Charges Bylaw, 2015, No. 2112.* Also, an additional $0.5 million per year in addition to what was included in the November 2016 draft financial plan is estimated to be required beginning in 2019 to operate and maintain the new water treatment plant.

Cost of Service Analysis

A full cost of service analysis as set out in AWWA M1 involves detailed line-by-line review of operating and capital budgets to assign costs to commodity, demand, direct fire protection and customer service categories, and distribution of each component of the revenue requirement among customer classes based on units of service. This rigorous analysis is beyond the scope of the Water Master Plan. For the purpose of this review, the current cost of service distribution in the City of White Rock is reviewed and qualitatively assessed based on the principles of cost of service analysis as set out in AWWA M1.

[6] Unaudited 2016 financial statements.

The City of White Rock recovers all costs of through user fees, and does not rely on taxation to cover any water service costs. This approach is generally consistent with the principles of user pay equity and transparency.

Connection and extension charges are based on actual costs, in addition to application fees of $350 for single-family and $3,100 for multi-family and duplex accounts to confirm serviceability. These charges reflect the full cost of these services, which comprise roughly 5% of total utility revenue.

The utility is fully metered, and each class of customer is assessed base and excess usage charges based on quarterly water use. User fees are assessed based on three general customer classes: Single-Family, Multi-Family and Non-Residential. The Single-Family and Non-Residential classes are further subdivided by meter size, and base consumption charges and volume thresholds vary by meter size. This customer class structure allows for equitable distribution of service costs among groups of customers having similar servicing needs, and is well aligned with the Base-Extra Capacity approach to cost allocation as set out in AWWA M1. However, providing high base consumption thresholds for single-family customers that have large meters (e.g. 12,000 ft^3/quarter, or 340 m^3/quarter, for a 50 mm meter) does not reflect the needs of a single-family customer and is inconsistent with the principle of conservation-oriented pricing. Meters larger than 25 mm on single-family connections are typically required to supply fire sprinklers, which have no bearing on water demands.

Table 7-4 shows the current distribution of user fees for the City of White Rock based on 2016 data provided by the City.

Table 7-4: Water Consumption and Charge Distribution by Account Type (2016)

Account Type	Base Water Usage (%)	Excess Water Usage (%)	Total Water Usage (%)	Base Charge (%)	Excess Water Charge (%)	Total Charge (%)
Single-Family	50	47	49	59	47	55
Multi-Family	40	21	31	31	21	28
Commercial	7	29	17	7	29	13
City	2	3	2	3	3	3
Institutional	1	0	0	0	0	0

Table 7-5 further breaks down the distribution of user fees by service charge class, including meter size.

Table 7-5: Water Consumption and Charge Distribution by Service Charge Class (2016)

Service Charge Class	Base Water Usage (%)	Excess Water Usage (%)	Total Water Usage (%)	Base Charge (%)	Excess Water Charge (%)	Total Charge (%)
Single-Family Water 5/8"	46	42	44	53	43	50
Single-Family Water 1"	4	2	3	5	2	4
Single-Family Water 1 1/2"	0	1	1	0	1	0
Single-Family Water 2"	0	1	1	0	1	0
Multi-Family Water	40	21	31	31	21	28
Non-Residential Water 5/8"	1	3	2	1	3	2
Non-Residential Water 1"	1	4	2	2	4	2
Non-Residential Water 1 1/2"	2	4	3	2	4	3
Non-Residential Water 2"	2	5	3	3	5	3
Non-Residential Water 3"	2	8	5	2	8	4
Non-Residential Water 4"	0	8	4	0	8	2
Non-Residential Water 6"	1	0	1	1	0	1

As shown in Tables 7-4 and 7-5, the distribution of base and excess usage charges in each account type and service charge class is reasonably similar to the distribution of water usage, indicating that the billing structure is generally equitable. The fact that single family customers are the most expensive class of customer to service per unit of water delivered is reflected in their higher share of total cost relative to total water demand.

In most service charge classes, the majority of customers pay an excess usage charge at least once per year (Table 7-6). However, more than half of single family customers with 1" meters paid no excess usage charge in 2016. This indicates that the threshold for excess usage charges for this customer class is likely too high, and further illustrates the relatively low water conservation incentive for single-family customers with larger meters.

Table 7-6: Accounts with No Excess Charge (2016)

Service Charge Class	Number of Accounts	Accounts with Zero Excess Charge	Zero Excess Charge (% of total)
Single-Family Water 5/8"	3,868	857	22%
Single-Family Water 1"	169	89	53%
Single-Family Water 1 1/2"	5	1	20%
Single-Family Water 2"	3	1	33%
Multi-Family Water	237	34	14%
Non-Residential Water 5/8"	114	44	39%
Non-Residential Water 1"	64	25	39%
Non-Residential Water 1 1/2"	43	16	37%
Non-Residential Water 2"	31	10	32%
Non-Residential Water 3"	12	2	17%
Non-Residential Water 4"	1	0	0%
Non-Residential Water 6"	1	0	0%
Total	**4,548**	**1,079**	**24%**

Table 7-7 shows the average water usage and cost per customer in each customer class. Single-family customers with large meters use much more water on average than those with smaller meters, again illustrating a water conservation opportunity. The eight single-family customers with meters larger than 1" pay roughly one third less per unit of water than other single-family customers. Together they use 1.25% of the total retail water use in the City, which is thirteen times the single-family residential average. These customers together pay 1.0% of the total user charges, which is nine times the single-family average. The majority of water use by these customers occurs in summer, when the capacity of the City's water supply is lowest (Figure 7-1). In a conservation-oriented rate structure, single-family residential customers who use much more water than average are billed more than other customers per unit of water used. This is typically achieved using an inclining block rate structure, where consumption above a certain threshold is billed at a substantially greater unit rate.

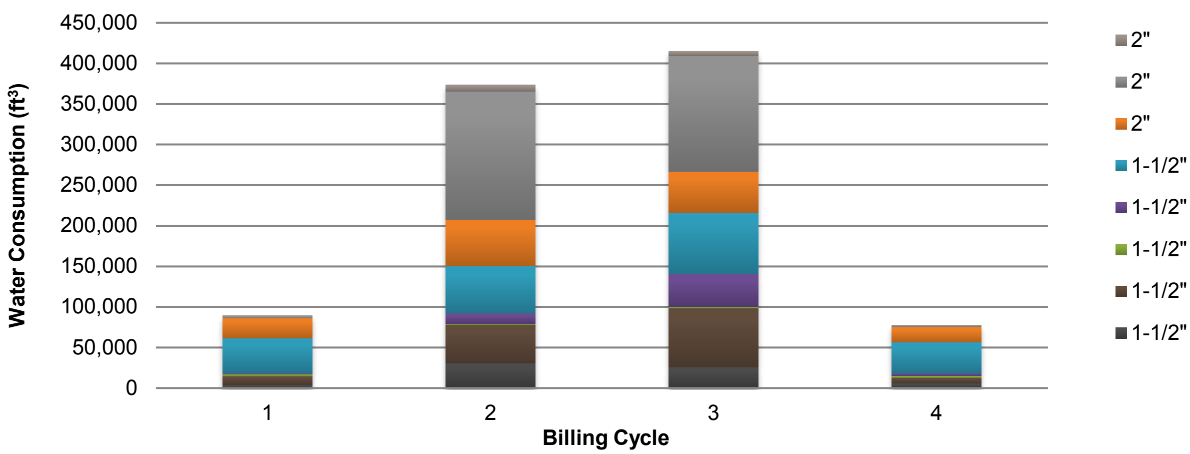


Figure 7-1: Water Use by Single-Family Customers with 1-1/2" and 2" Meters

Table 7-7: Average Billing Parameters Per Account (2016)

Service Charge Class	Base Water Usage (ft^3)	Excess Water Usage (ft^3)	Total Water Usage (ft^3)	Base Charge ($)	Excess Water Charge ($)	Total Charge ($)	Average Unit Cost ($/100 ft^3)
Single-Family Water 5/8"	4,922	3,827	8,749	$376	$110	$486	$5.56
Single-Family Water 1"	9,740	4,943	14,683	$761	$142	$904	$6.15
Single-Family Water 1 1/2"	22,462	74,426	96,888	$1,525	$2,143	$3,669	$3.79
Single-Family Water 2"	30,207	126,560	156,767	$2,441	$3,645	$6,086	$3.88
Multi-Family Water	69,490	30,239	99,729	$3,518	$868	$4,386	$4.40
Non-Residential Water 5/8"	3,820	10,462	14,282	$302	$301	$604	$4.23
Non-Residential Water 1"	9,522	19,665	29,187	$763	$566	$1,329	$4.55
Non-Residential Water 1 1/2"	17,417	34,947	52,364	$1,508	$1,006	$2,514	$4.80
Non-Residential Water 2"	29,563	53,257	82,821	$2,327	$1,534	$3,861	$4.66
Non-Residential Water 3"	75,369	230,349	305,718	$4,386	$6,634	$11,020	$3.60
Non-Residential Water 4"	150,000	2,762,000	2,912,000	$7,628	$79,546	$87,173	$2.99
Non--Residential Water 6"	278,705	158,615	437,320	$15,256	$4,568	$19,824	$4.53

Rate Design

The current rate structure recovers approximately three quarters of user fee revenue on base charges, and the remainder on excess usage charges. This ratio effectively covers fixed costs, which include debt servicing and the large majority of operating expense. As the City phases in revenue increases and larger contributions to reserves for future infrastructure renewal, the financial risk associated with a corresponding increase in the variable portion of revenue can be accommodated year-to-year by varying the contributions to reserves.

The commodity charges for excess usage ($2.88 per 100 ft^3 in 2016 and $3.46 in 2017) are relatively low; approximately $1.02 and $1.22 per m^3, respectively. Excess usage rates in other jurisdictions are typically greater than $2.00/$m^3$, and often several times greater. Although it would increase the complexity of the structure slightly (reducing administrative efficiency), adding a second-rate block for very high usage on single-family residential accounts would further increase the effectiveness of the rate structure, particularly for seasonal demands that drive peak flows in the system.

The City recovered a total of $1.0 million in excess usage charges in 2016. Assuming similar water demands, excess usage charge revenue in 2017 will be $1.2 million. Contributions to reserves are budgeted to increase from about $1.1 million to $1.5 million over the next five years. Increasing the excess charge revenue to $2.00 per m^3 (approximately $6.00 per 100 ft^3) by 2021 would recover roughly $2 million in revenue. Actual revenue will be influenced by gains in water use efficiency as well as the rate of community growth.

Base charge revenue in 2016 was $2.7 million, and is expected to be $3.3 million at 2017 rates. In order to meet the revenue targets indicated in the 5-year financial plan and an additional $0.22 million annually for the Master Plan projects and $0.5 million annually after 2018 for treatment plant O&M, the total annual revenues would be as shown in Table 7-8.

Table 7-8: User Charge Revenue Requirement by Year

Year	Five-Year Plan Revenue ($)	Master Plan Project Funding ($)	Total Revenue Requirement ($)	Excess Usage Charge Revenue ($)	Excess Usage Charge % Increase (%)	Excess Usage Rate ($)	Base Charge Revenue ($)	Base Charge % Increase (%)
2017	$4,448,000		$4,448,000	$1,200,000	20.0%	$3.46	$3,248,000	19.1%
2018	$4,848,500	$223,000	$5,071,500	$1,400,000	16.7%	$4.15	$3,671,500	13.0%
2019	$5,784,700*	$223,000	$6,007,700	$1,600,000	14.3%	$4.84	$4,407,700	20.1%
2020	$6,048,900*	$223,000	$6,271,900	$1,800,000	12.5%	$5.54	$4,471,900	1.5%
2021	$6,326,300*	$223,000	$6,549,300	$2,000,000	11.1%	$6.23	$4,549,300	1.7%

*Increased by $0.5 million for estimated treatment plant O&M expense.

Rate Recommendations

To achieve the forecast revenues shown in Table 7-8 and fully achieve the objectives and principles outlined above, the following adjustments are recommended:

1. Reduce the base charge thresholds for all single-family residential accounts larger than 5/8 inch as shown in Table 7-9, and reduce base charges in proportion to the reduction in the threshold (2017 quarterly rates shown).

   Table 7-9: Recommended Revisions to Residential Base Charges and Thresholds

Meter Size	Existing Excess Usage Charge Threshold	Proposed Excess Usage Charge Threshold	Proposed 2017 Base Charge
1 inch	3,900 cubic feet	2,500 cubic feet	$146.67
1-1/2 inch	7,500 cubic feet	3,000 cubic feet	$183.04
2 inch	12,000 cubic feet	5,000 cubic feet	$305.08

   These adjustments will provide single-family customer with larger meters a stronger incentive to conserve water particularly in summer, and will better align their average unit cost of water with that of other single-family residential customers.

2. Increase the base and excess usage charges at the annual percentage rates as shown in Table 7-8, and increase other fees and charges at the same percentage rates as the base charges.

3. Consider adding a second tier of excess usage charge for single-family residential customers with a unit charge that is two times the excess consumption charge, for consumption above 10,000 ft^3 per quarter. Based on 2016 water use, this would affect 3 % of total consumption and 6.5 % of excess consumption. At the 2017 excess consumption rate of $3.46 per 100 ft^3 it would generate additional revenue of $79,000; however, there is a high likelihood that the consumption and associated revenue would decrease after the charge is imposed.

4. Review actual versus forecast revenues annually and adjust percentage increases as required to achieve reserve contribution targets.

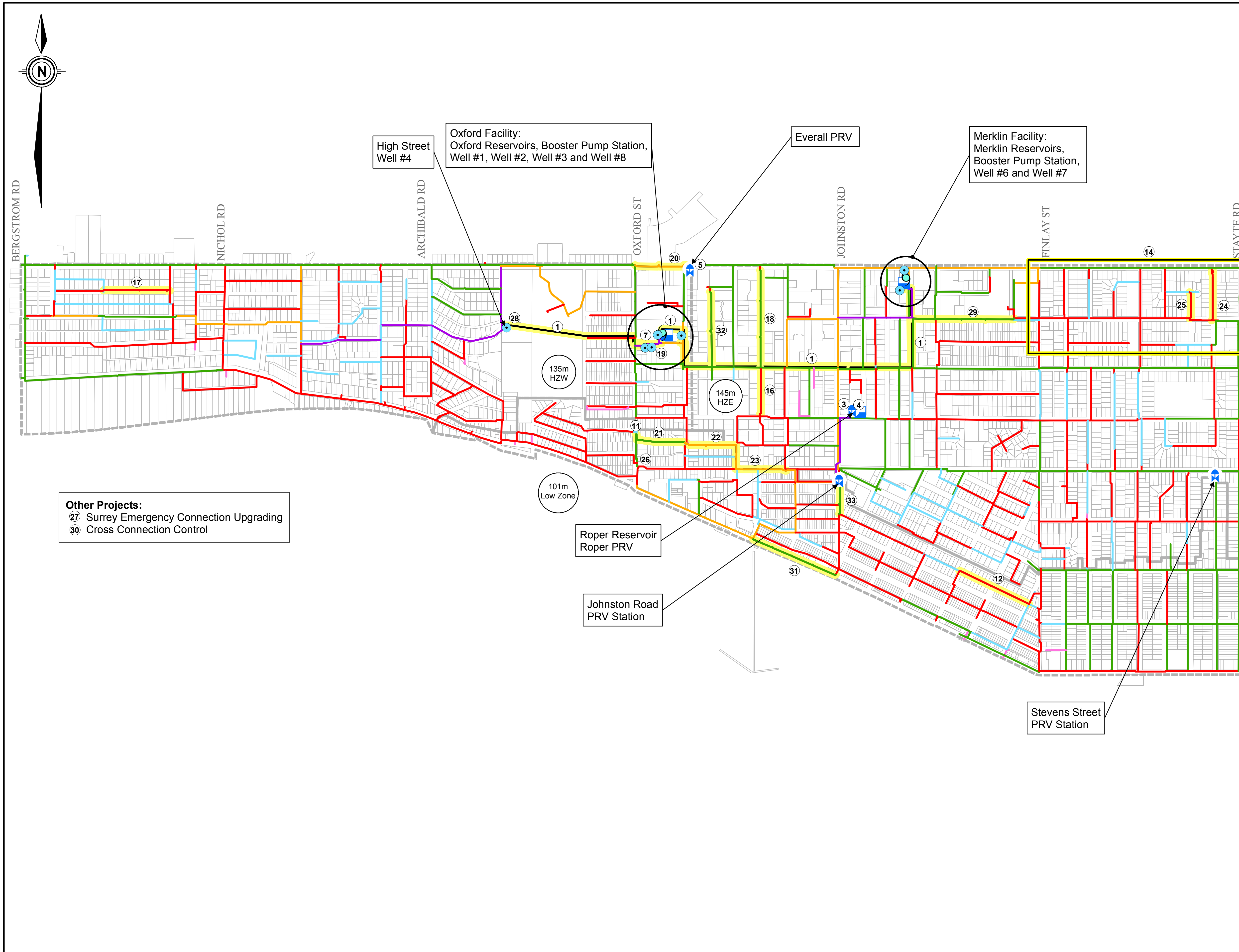
Table 7-10: Recommended Capital Project Summary

ID	Description	Justification Category	Justification[2]	Priority	Location	Length (m)	Size	Cost Rate	Cost Opinion ($)	Included in Existing 5-Year Capital Plan[1] (Y/N)	Notes on Cost
1	Oxford Water Treatment Plant and associated interconnecting piping between the Oxford Facility, the Merklin Facility, and High Street Well 4.	Water Quality	Removal of Arsenic and Manganese.	Highest	Oxford Facility and water mains between Oxford, Merklin and High Street Well 4	N/A	N/A	N/A	$ 14,200,000	Y	Cost provided by the City of White Rock
3	Roper Reservoir Control Upgrades	Mixing / Control	Added instrumentation and control to allow for improved Roper Reservoir control, prevent overflows, use balancing storage.	High	Roper Reservoir	N/A	N/A	N/A	$ 75,000	N	Allowance.
4	Roper Reservoir Dedicated Inlet	Water Quality	Prevent bypassing of reservoir when filling, improve reservoir circulation and turnover.	High	Roper Reservoir	50	150	$1,035	$ 130,000	Y	Table 7-1 Unit Costs and added allowance for reservoir connection and nozzle(s).
5	Everall Street PRV Station	Mixing / Control	Split High Zone to Merklin High Zone East and Oxford High Zone West and provide subsequent fire protection to proposed zones.	Medium	North Bluff Rd., east of Everall St.	N/A	N/A	N/A	$ 250,000	N	Allowance.
7	Goggs St. WM - Oxford to Everall	Redundancy, Fire Flows	Improve supply capacity and redundancy of the distribution system around the Oxford booster PS. Also improves fire flow (196 L/s available vs 212 L/s criteria). This project could be combined with the work required as part of Project ID 1. The local area land use includes Town Centre Transition and Institutional.	High	Goggs St. WM - Oxford to Everall	110	300	$1,300	$ 143,000	N	Table 7-1 Unit Costs, note project costs may be lower as road restoration costs shouldn't be required for entire length.
11	Prospect Ave. & Oxford WM Tie-in, connect existing 200 mm dia. main to Prospect Ave. and relocate Hydrant 30 to larger dia. main. Abandon section of main from Prospect Ave. to Roper Ave.	Redundancy, Fire Flows	Existing 200 mm dia. water main is not in use (closed valve at High Zone connection). This water main is the former Buena Vista Well #5 supply connection to High Zone. This upgrade improves fire flow (82 L/s available vs 212 L/s criteria). The local area land use is Mature Neighbourhood.	High	Oxford St. between Prospect Ave. and Roper Ave.	20	200	N/A	$ 50,000	N	Allowance for abandoning section of existing main and hydrant connection.
12	Columbia Lane WM - Cypress St. to Ash St.	Fire Flows, Asset Management	Replace existing 100 CI main to improve fire flows (currently marginal for SF; 58 L/s available vs 67 L/s criteria), project improves fire flow to 140 L/s. The local area land use is Mature Neighbourhood. Existing main also has break history (2 breaks in last 4 years).	Medium	Columbia Lane - Cypress St. to Ash St.	310	150	$1,035	$ 320,850	N	Table 7-1 Unit Costs.
14	Cast Iron Condition Assessment Pilot Program and WM Asset Mgmt. Strategy	Asset Management	Existing CI mains are potentially nearing the end of their service life. This program will gather more information on pipe condition in the NE corner of the utility.	Medium	NE corner of White Rock	N/A	N/A	N/A	$ 160,000	N	
16	1300 Blk Martin St. WM Replacement	Asset Management	Existing CI main has extensive break history.	Medium	1300 Blk Martin St.	200	150	$1,035	$ 207,000	Y	Table 7-1 Unit Costs.
17	13800 Blk Coldicutt Ave. WM Replacement	Asset Management	Existing CI main has extensive break history. Also will allow for future elimination of main on lane south of Coldicutt.	Medium	13800 Blk Coldicutt Ave.	260	150	$1,035	$ 269,100	Y	Table 7-1 Unit Costs.
18	1400 Blk Martin St. WM Upgrade	Fire Flows	Existing 150 CI main is undersized for high-density multifamily fire flows (177 L/s available vs 212 L/s criteria). The local area land use includes Town Centre and Town Centre Transition.	Medium	1400 Blk Martin St.	410	200	$1,090	$ 446,900	Y	Table 7-1 Unit Costs.
19	Well 9 (Well 3 Replacement)	Supply System	Existing Well 3 requires frequent redevelopment, and capacity is degrading. Concern with well seal and well packer. Increased capacity to address increasing demands from growth. 29 L/s minimum capacity requirement for Well 9.	High	Oxford Facility	N/A	N/A	$1,000,000	$ 1,000,000	N	Cost provided by the City of White Rock, based on costs for Well 8 completion (2017).
20	North Bluff Rd. Oxford - Everall WM Replacement	Redundancy, Fire Flows	Existing 200 CI main is undersized for high-density MF fire flows (196 L/s available vs 212 L/s criteria). The local area land use includes Institutional and Town Centre Transition. Also replaces critical CI pipe on high traffic location.	Medium	North Bluff Rd. from Oxford St. to Everall St.	200	250	$1,150	$ 230,000	N	Table 7-1 Unit Costs.
21	Prospect Ave. - Everall - Oxford WM Replacement	Fire Flows, Asset Management	Replaces existing 100 mm CI undersized for fire flows (131 L/s available vs 212 L/s criteria). The local area land use is Mature Neighbourhood.	Low	Prospect Ave. from Everall St. to Oxford St.	220	200	$1,090	$ 239,800	N	Table 7-1 Unit Costs.

Table 7-10: Recommended Capital Project Summary

ID	Description	Justification Category	Justification[2]	Priority	Location	Length (m)	Size	Cost Rate	Cost Opinion ($)	Included in Existing 5-Year Capital Plan[1] (Y/N)	Notes on Cost
22	Prospect Ave. and Blackwood St. - Everall St. to Buena Vista Ave. WM Completion	Fire Flows, Redundancy	No hydrant coverage for this section of Prospect Ave. (100 mm dia. main is not looped) and improves fire flows (131 L/s available vs 212 L/s criteria). The local area land use is Mature Neighbourhood.	Low	Prospect Ave. and Blackwood St. from Everall St. to Buena Vista Ave.	310	250	$1,150	$ 356,500	N	Table 7-1 Unit Costs. Proposed project is in the vicinity of a ravine. Project viability to be confirmed.
23	Buena Vista Ave. - Foster to Blackwood St. WM	Fire Flows, Asset Management	Replaces existing 150 mm CI undersized for fire flows (143 L/s available vs 212 L/s criteria). The local area land use includes Urban Neighbourhood and Mature Neighbourhood.	Low	Buena Vista Ave. from Foster to Blackwood St.	200	250	$1,150	$ 230,000	N	Table 7-1 Unit Costs.
24	1500 block Stevens St. WM Replacement	Asset Management	Break history. CI pipe. High pressure (100 psi).	Low	Stevens St. between North Bluff Rd. and Russell Ave.	200	150	$1,035	$ 207,000	N	Table 7-1 Unit Costs.
25	1500 block Habgood St. WM Replacement	Asset Management	Break history. CI pipe. High pressure (100 psi).	Low	Habgood St. between Vine and Russell Ave.	105	150	$1,035	$ 108,675	N	Table 7-1 Unit Costs.
26	Well 5 Decommissioning / Sealing	Water Quality	Use of Well 5 has been discontinued. This well should be properly decommissioning and abandoned with well sealed to mitigate aquifer contamination risks.	High	Oxford St. and Buena Vista Ave.	N/A	N/A	N/A	$ 50,000	Y	Allowance.
27	Surrey Emergency Connection Upgrading	Redundancy	The White Rock system has four existing connections to the City of Surrey system. This project would include engineering work to develop operating protocols for use of these connections. The project may also include misc. capital work for the connections.	High	Various	N/A	N/A	N/A	$ 50,000	N	Allowance.
28	High Street Well 4 Electrical Upgrades	Asset Management	The existing electrical power equipment (transformer and distribution panel) for the well is in a confined space. Replacement with new above grade equipment and a kiosk is recommended for reliability and maintainability.	High	High Street Well 4	N/A	N/A	N/A	$ 90,900	N	Allowance from 2010 Master Plan escalated to 2017 dollars.
29	Russell Ave. - Merklin St. to Weatherby St.	Asset Management, Fire Flows	Replaces existing CI pipe undersized for fire flows (141 L/s available vs 212 L/s requirement). The local area land use is Institutional.	Medium	Russell Ave. from Merklin St. to Weatherby St.	400	200	$1,090	$ 436,000	Y	Table 7-1 Unit Costs.
30	Cross Connection Control - raise vents on 10 existing air valves to terminate outside buried chamber.	Water Quality	Eliminates potential cross connections in water system.	High	10 locations throughout the water system.	N/A	N/A	N/A	$ 50,000	N	Allowance.
31	Marine Dr. - Johnston Rd. to Martin St.	Fire Flows, Asset Management	Existing modelled fire flows in area are slightly deficient (200 L/s vs 212 L/s criteria). The local area land use is Waterfront Village. Fire flow requirements and availability should be field tested to confirm. Alternate project to utilize Marine Dr. Lane for fire protection could be considered but would not address pipe condition. This project also replaces aging CI pipe in higher pressure area.	Low	Marine Dr. from Johnston Rd. to Martin	370	200	$1,090	$ 403,300	N	Table 7-1 Unit Costs.
32	Vidal St. - Thrift Ave. to Vine Ave.	Fire Flows	Existing modelled fire flows in area are slightly deficient (199 L/s vs 212 L/s criteria). The local area land use is Town Centre Transition. Fire flow requirements and availability should be field tested to confirm. This project also replaces aging CI pipe.	Low	Vidal St. - Thrift Ave to Vine Ave	310	200	$1,090	$ 337,900	N	Table 7-1 Unit Costs.
33	Johnston Rd. - Beachview to Royal Ave.	Fire Flows	Existing modelled fire flows in area are slightly deficient (165 L/s vs 212 L/s criteria). The local area land use includes Urban Neighbourhood and Mature Neighbourhood. This project also replaces aging CI pipe in steep area. Fire flows should be field tested to confirm.	Low	Johnston Rd. - Beachview to Royal Ave.	140	200	$1,090	$ 152,600	N	Table 7-1 Unit Costs.

Notes:
1) City of White Rock Corporate Report, 2017 to 2021 Draft Financial Plan - Water Utility, November 21, 2016.
2) For projects recommended to improve fire flow, the local fire flow requirement should be confirmed prior to construction.



City of White Rock
2017 Water System Master Plan Update

Legend

- Groundwater Well
- Pressure Reducing Valve
- Pump Station
- Reservoir
- Pressure Zone Boundary

Water Main Diameter (mm)

- < 100
- 100
- 150
- 200
- 250
- 300
- 350
- 400
- 24 Proposed Upgrade (ID)

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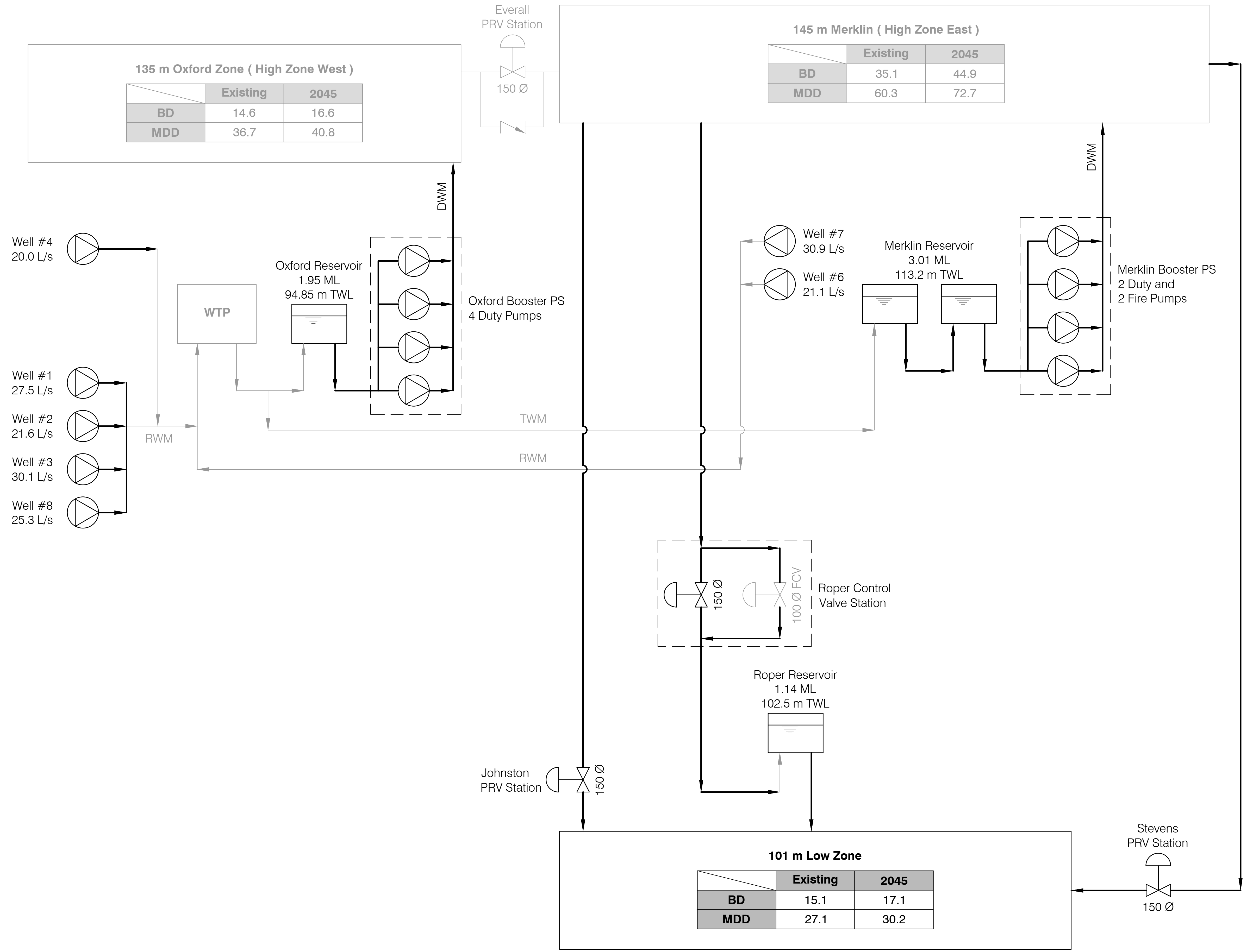
200 0 600
(m)

Project No.	Date
452-120	October 2017

Recommended Water System Upgrades

Figure 7-2

City of White Rock
2017 Water System Master Plan Update



135 m Oxford Zone (High Zone West)

	Existing	2045
BD	14.6	16.6
MDD	36.7	40.8

145 m Merklin (High Zone East)

	Existing	2045
BD	35.1	44.9
MDD	60.3	72.7

101 m Low Zone

	Existing	2045
BD	15.1	17.1
MDD	27.1	30.2

Legend

- Reservoir
- Pump
- Check Valve
- Pressure Reducing Valve
- Existing
- Future / Proposed

BD	Base Demand
MDD	Maximum Day Demand
DWM	Distribution Water Main
RWM	Raw Water Main
TWM	Treated Water Main
PS	Pump Station
WTP	Water Treatment Plant
FCV	Flow Control Valve
PRV	Pressure Reducing Valve

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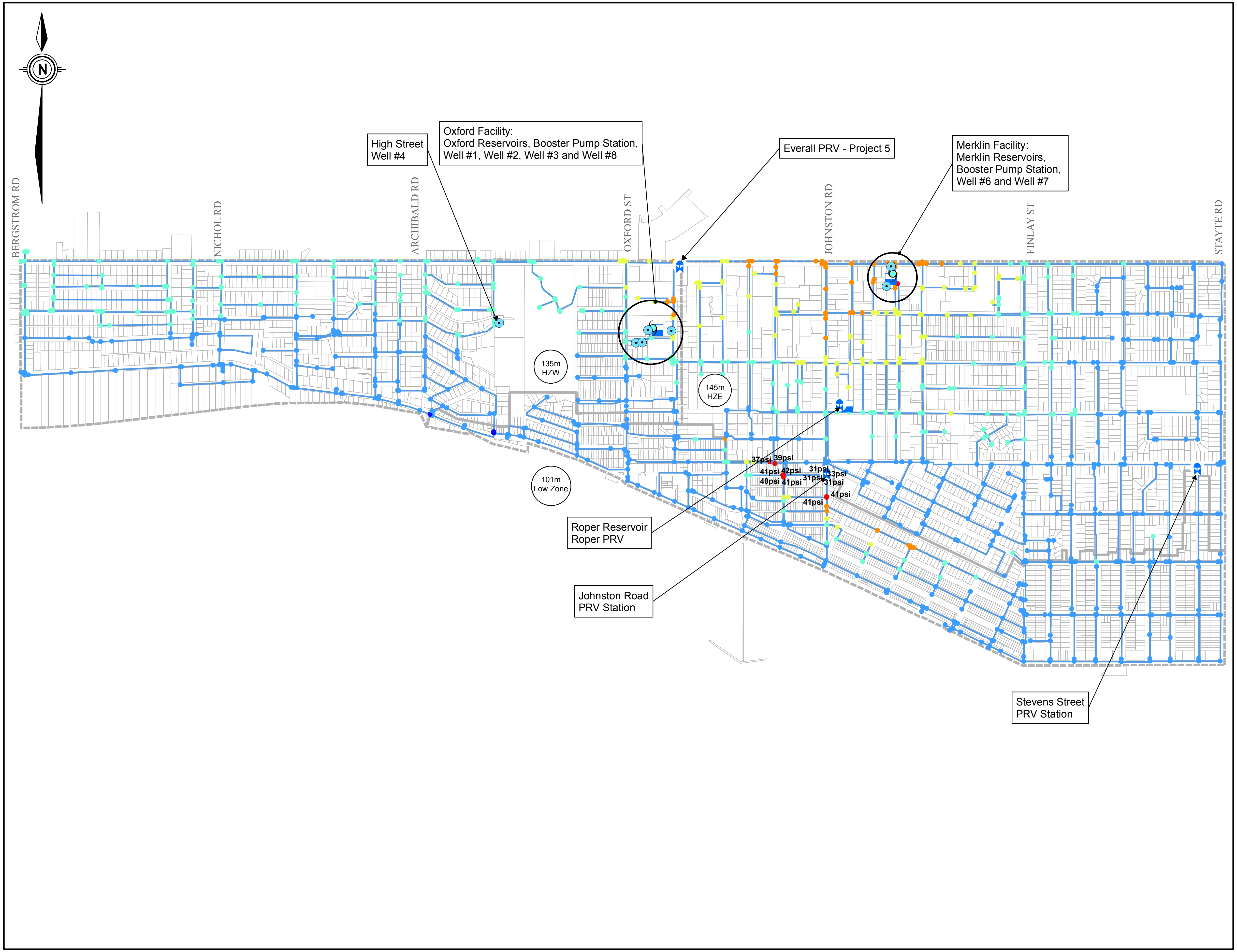
N.T.S.

Project No.: 452.120

Date: October 2017

Future System Schematic With Recommended Projects

Figure 7-3



City of White Rock
2017 Water System Master Plan Update

Legend

- Groundwater Well
- Pressure Reducing Valve
- Pump Station
- Reservoir
- Pressure Zone Boundary
- Water Main

Peak Hour Pressure (psi)

- < 43.5
- 43.6 - 50.0
- 50.1 - 60.0
- 60.1 - 80.0
- 80.1 - 150.0
- > 150

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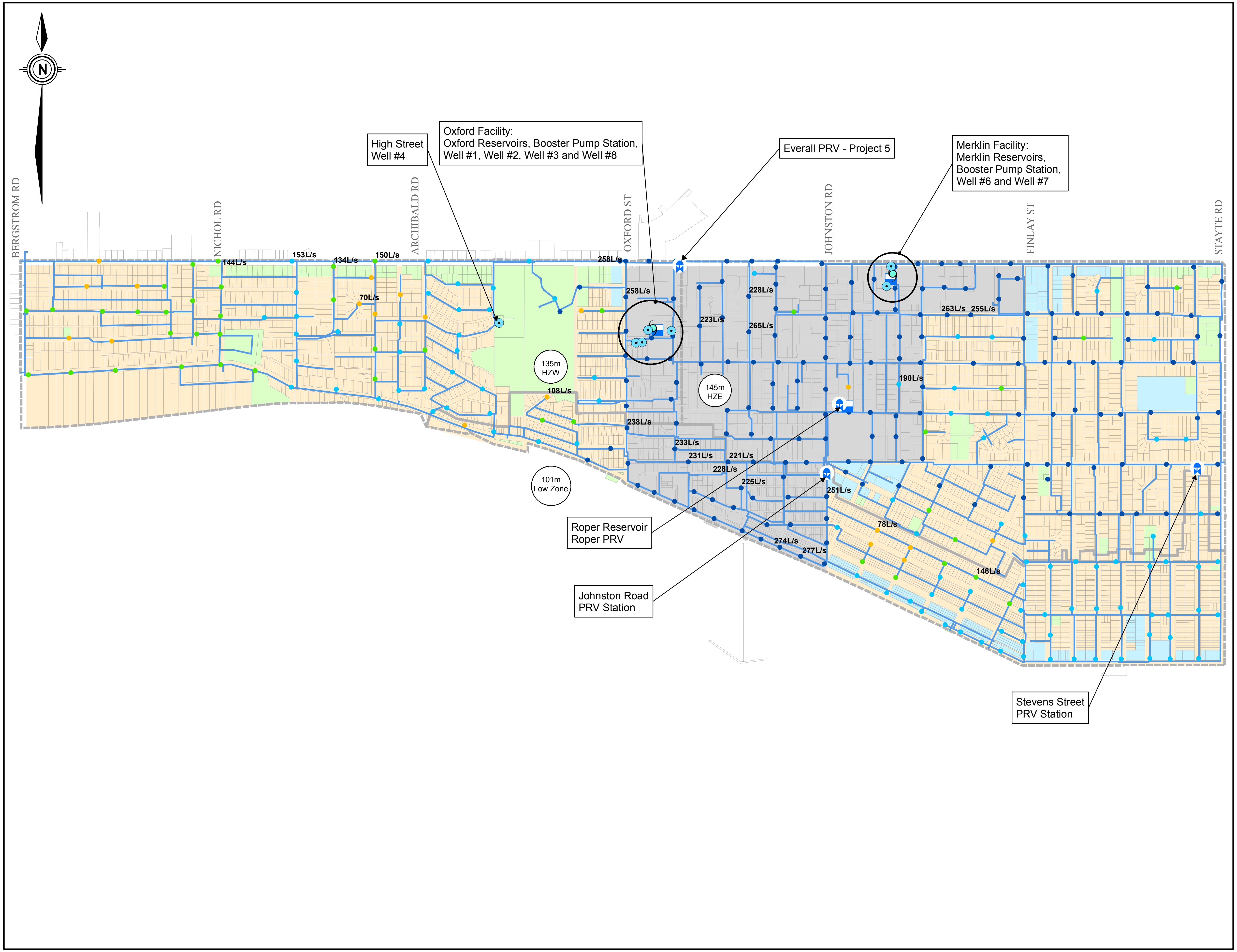
200 0 600
(m)

Project No.	Date
452-120	October 2017

Future (2045) System with Future Demands Peak Hour Pressure

Figure 7-4



City of White Rock
2017 Water System Master Plan Update

Legend

- Groundwater Well
- Pressure Reducing Valve
- Pump Station
- Reservoir
- Pressure Zone Boundary
- Water Main

Available Fire Flow (L/s)

- < 67
- 68 - 120
- 121 - 150
- 151 - 212
- > 212

Required Fire Flow

- 67 L/s
- 120 L/s
- 150 L/s
- 212 L/s

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200 0 600
(m)

Project No.	Date
452-120	October 2017

Future (2045) System with Future Demands Available Fire Flow

Figure 7-5

8. Conclusions

8.1 Summary and Recommendations

Kerr Wood Leidal Associates Ltd. and Water Street Engineering were retained by the City of White Rock to prepare an update to the Water System Master Plan. The key findings and recommendations of the Water System Master Plan Update are summarized below:

- Census data and land use information was reviewed and the total service population for the existing White Rock Water System was estimated at 20,181 (19,952 in the City of White Rock, and 229 in the City of Surrey). Average population rates were calculated as 2.92 ca/SF parcel and 1.40 ca/MF unit.
- Source flow and customer water meter data was analyzed and compared to the historical record for White Rock to determine a design existing maximum day demand of 124.1 L/s. Base demand unit rates for residential and ICI usage were calculated at 195 L/ca/day and 1.45 L/m^2 parcel area/day, respectively. A 4.65 L/m^2 irrigated area/day seasonal demand rate was calculated for the estimated green area in White Rock.
- Based on the 2017 OCP document for White Rock, a 7,348 population increase and 320,000 ft^2 of additional ICI floor area is expected by 2045. Lower base demand unit rates for residential and ICI usage were developed, and 140 L/ca/day and 2.0 m^3/m^2 floor area/year were used to estimate the increase in future base demand. The irrigated area is not expected to increase in the future, but a 10% increase was added to seasonal demand to account for potential impacts of climate change. The design future maximum demand for year 2045 was estimated at 143.8 L/s.
- There are seven wells in the White Rock water system. The total rated supply capacity (with the largest well out of service) is 145.5 L/s. Recent redevelopment work with Well 3 shows that it needs replacement. The rated system capacity without Well 3 is 115.4 L/s; too low to support existing and future MDD. A new well (Well 9) is recommended to replace Well 3 and bring rated system supply capacity to 143.8 L/s (Project 19). A hydrogeology study is recommended to confirm feasibility of a replacement well at the same location as Well 3. It is also recommended to decommission and seal Well 5 (Project 26), which has been taken out of service, and upgrade Well 4 including relocation of high-voltage electrical equipment (Project 28).
- It is recommended that the City maintain the Surrey connections as emergency water connections (Project 27).
- The City has issued an RFP to design-build teams for construction of a centralized water treatment plant at the Oxford Site to reduce concentrations of arsenic and manganese. This RFP includes the interconnecting piping between Oxford, Merklin, and Well 4 (Project 1). Preliminary sizes for the interconnecting piping have been suggested in Table 6-2, but need to be confirmed once water treatment plant details are known. A life cycle cost analysis to determine the potential benefits of increasing the main sizes to reduce long term pumping costs should be considered in detailed design. Given the cost of the Well 4 to Oxford Raw Water Main, combined with additional work recommended at Well 4 (Project 28), a cost-benefit analysis is recommended which compares the cost of fully integrating the High Street Well to replacement with a new well closer to the water treatment plant.

- The total system storage capacity is 6.1 ML in the Oxford, Merklin and Roper reservoirs. The required storage for future 2045 demands is estimated to be 4.96 ML. Adequate storage capacity is provided by the current system for future forecast demands.
- Upgrades at Roper Reservoir are recommended to improve water quality by ensuring reservoir circulation and mixing (Projects 3 and 4).
- The Oxford and Merklin facilities both pump into the High Pressure Zone. The current operation of these pump stations result in considerable mixing of the water from the two sources. It is understood that water supplied by the Merklin Wells (wells 6 and 7) have a higher concentration of manganese than the Oxford wells. Changes in flow direction could increase re-suspension of precipitated manganese. Separation of the High Pressure Zone into a 145 m Merklin Zone and a 135 m Oxford Zone is recommended to improve control of Merklin and Oxford pump stations, reduce high pressure in the Oxford Zone, increase low pressure in the Merklin Zone, and reduce mixing between the Oxford and Merklin wells, in the interim while the WTP is under construction (Project 5).
- Modelling indicates that there are low pressure deficiencies (< 44 psi) in the vicinity of North Bluff Road near the Merklin Pump Station, and in the Low Pressure Zone in the vicinity of Beachview Avenue and Johnston Road. The High Zone separation project discussed in the paragraph above will improve the former. The latter is addressed by a 2017 project (Beachview Avenue) that will allow lots in this area to connect to a higher-pressure main.
- Modelling indicates that there are pressures in excess of the maximum pressure limit (150 psi) near Marine Drive and Magdalen Crescent, and Marine Drive and High Street. The recommended pressure zone split (Project 5) reduces these pressures.
- Modelling indicates that there are fire flow deficiencies, relative to the required fire flow criteria developed in Section 5, in the following locations:
  - North Bluff Road and Oxford Street;
  - 1400 Block of Martin Street;
  - 15400 – 15500 Block of Russell Avenue (east of Best Street);
  - 1400 – 1500 Block of Vidal Street (north of Thrift Avenue);
  - Prospect Avenue and Oxford Street;
  - Blackwood Lane and Blackwood Street;
  - Buena Vista Avenue and Martin Street;
  - Columbia Lane and Balsam Street;
  - 15100 Block of Marine Drive (west of Johnston Road); and
  - Johnston Road (between Beachview and Royal Avenue).

  Water main upgrades (Projects 7, 11, 12, 18, 20, 21, 22, 23, 29, 31, 32, and 33) are recommended to address these fire flow deficiencies as needed.
- The City's break history data was analyzed and it was determined that the break rate is within the typical range according to the average value from the National Water and Wastewater Benchmarking Initiative. It was also determined that cast iron pipes are more susceptible to breaks, and breaks are slightly more common to occur on slopes according to the City's data. A cast iron pipe assessment program is recommended to better manage the cast iron water main asset class (Project 14). It is also recommended to complete water main replacement projects in specific areas that have extensive break history (Projects 16, 17, 24, and 25).

- As part of a previous water quality study it was determined that there are 10 locations that have air release (or air/vacuum valves) that are located in underground vaults or chambers with the vent portion terminated inside the chamber, which have been flagged as potential cross connection locations. To mitigate this risk of cross connections, the vents the air valves chambers identified in Section 6.9 are recommended to be raised to terminate outside the chamber in a location that is not prone to flooding (Project 30).
- The recommended upgrades have been prioritized as either of low, medium, high, and highest priority. The priority of each project is shown on Table 7-10 and a summary is shown on Table 7-2.

Based on a review of the current billing structure, the following summarizes the recommended rate adjustments:

- Reduce the base charge thresholds for all single-family residential accounts larger than 5/8 inch as shown in Table 7-9, and reduce base charges in proportion to the reduction in the threshold (2017 quarterly rates shown).
- Increase the base and excess usage charges at the annual percentage rates as shown in Table 7-8, and increase other fees and charges at the same percentage rates as the base charges.
- Consider adding a second tier of excess usage charge for single-family residential customers with a unit charge that is two times the excess consumption charge, for consumption above 10,000 ft^3 per quarter.
- Review actual versus forecast revenues annually and adjust percentage increases as required to achieve reserve contribution targets.

8.2 Report Submission

Prepared by:

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Oct. 25 2017

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2017-10-25

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Statement of Limitations

This document has been prepared by Kerr Wood Leidal Associates Ltd. (KWL) for the exclusive use and benefit of City of White Rock for the 2017 Water System Master Plan Update. No other party is entitled to rely on any of the conclusions, data, opinions, or any other information contained in this document.

This document represents KWL's best professional judgement based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by members of the engineering profession currently practising under similar conditions. No warranty, express or implied, is made.

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Revision History

Revision #	Date	Status	Revision	Author
3	October 24, 2017	Final	Incorporate comments from the City and finalize.	NW / RS
2	October 4, 2017	Draft 3	Incorporate comments from the City.	NW / RS
1	August 9, 2017	Draft 2	Incorporate comments from the City.	NW / RS
0	July 21, 2017	Draft		NW / RS

OQM | Organizational Quality Management Program