Water Master Plan

District of Hope

March 2019

Project No. 1239-141

ENGINEERING ■ PLANNING ■ URBAN DESIGN ■ LAND SURVEYING

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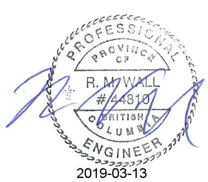

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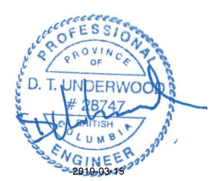

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List of Acronyms

AC	Asbestos Cement
ADD	Average Day Demand
CBD	Central Business District
CPR	Canadian Pacific Railway
FVRD	Fraser Valley Regional District
DFO	Fisheries and Oceans Canada
District	District of Hope
FUS	Fire Underwriters Survey
FWL	Full Water Level
HDPE	High Density Polyethylene
FHA	Fraser Health Authority
MFLNRO	Ministry of Forests, Lands and Natural Resource Operations
MDD	Maximum Day Demand
MMCD	Master Municipal Construction Documents
MOE	Ministry of Environment
NTU	Nephelometric Turbidity Unit
ODK	Opus Dayton Knight
PVC	Polyvinyl Chloride
TRUE	TRUE Consulting
UV	Ultra Violet
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

Units of Measure

ft	feet
Igpm	Imperial gallons per minute
km	kilometre
L/d	Litres per day
L/m	Litres per minute
L/s	Litres per second
lpcd	Litres per capita per day
m	metre
mg/L	milligrams per Litre
mm	millimetre
NTU	Nephelometric Turbidity Units
psi	pounds per square inch
USgpm	US gallons per minute

Referenced Reports

1 Dayton & Knight Ltd. Development Cost Charges for Water, Sewerage and Drainage Facilities. 1994.

2 Golder Associates. Silver Creek Wellhead Protection Plan. 2009.

3 Omega & Associates Engineering Ltd. Condition Assessments of Roadway Structures, Water Mains, Storm Sewers, and Sanitary Sewers. 2016.

4 Opus International Consultants (Canada) Ltd. 753 Water System Study. March 2017

5 Western Water Ltd. District of Hope Water Master Plan. Groundwater Supply Assessment. November 2018.

Executive Summary

The purpose of this Water Master Plan is to identify long term servicing strategies for water servicing within the District of Hope to the year 2040. The scope of work for the Master Plan includes:

- Establishing the capacity and shortcomings of existing infrastructure;
- Identifying infrastructure requirements in the future;
- Evaluating alternatives;
- Preparing cost estimates and a phasing plan for the preferred alternatives

The District relies primarily on wells as its source of drinking water. This water does not receive treatment or disinfection prior to distribution. At this time, Fraser Health are not calling for the implementation of chlorination or other forms of treatment for the well sources. The network is divided into a number of distribution zones. Generally, these are unconnected and water cannot be transferred between them. In recent years there have been efforts to improve aspects of water storage with two new reservoirs replacing an open storage basin and a concrete reservoir at a low elevation. The water network has been extended gradually since the 1940s, generally coinciding with the town's development. The condition of the distribution network is currently acceptable but the age of many watermains means that increasing levels of pipe replacement are on the horizon.

Because the water network has grown with the town, pipeline design does not always meet current requirements. The District's water model has been updated to assist with the analysis of the network. Existing service pressures and fire flow capacity were then evaluated under average day demand (ADD) and maximum day demand (MDD) conditions. Neighbourhoods currently lacking sufficient service pressure and fire flow capacity have been identified.

The capabilities and shortcomings of the water system have been used to identify improvements and prepare a water system capital plan. The capital improvements have been prioritized to improve the capacity of the water supply and meet the projected demands. The general improvements are as follows;

- Increased connection between the systems to allow source capacity to be shared, and as protection against loss of supply;
- Additional water storage to provide for fire flows, and at higher elevation to increase water pressure;
- New wells to replace existing capacity, as many wells are aging;
- Network expansion in support of development;
- Long term programmed replacement of aging watermains.

The study also considers issues relating to the impact of permanently including the 753 Water System in the District water network.

1.0 Introduction

1.1 Background

The District of Hope has called for the preparation of a Water Master Plan in order to provide guidance and direction regarding future capital expenditures, long term financial planning and to understand system constraints and challenges associated with population growth and development initiatives.

The objective of the report is to provide the District with clear direction on the status of the water utility and to recommend system improvements to address deficiencies. As such, this study has the following objectives;

- Prepare a summary of water demands and service capacity of the water system.
- Evaluate and assess the performance of the supply and distribution system.
- Undertake fire flow modelling.
- Assess impacts of adding the private 753 Water System to the municipal utility.
- Identify issues with water quality in both water reservoirs and the distribution system.
- Identify and prioritize capital improvement projects to service projected short, medium- and long-term growth conditions and service extensions.

The District completed a number of drainage, sewer, and water studies in the 1990s. A Development Cost Charge study reviewed the District's infrastructure, recommended a number of upgrades for existing utilities, and identified the need for additional infrastructure. The recommendations were based on a population target of 10,000 people. As there appears to be significant time remaining before this population benchmark is reached, the findings of the earlier studies are generally still relevant. Many of the proposed improvements have been included in this Master Plan.

A study of the feasibility of adding the 753 Water System to the network was completed in 2017. This study included water modeling and made recommendations for upgrades to the 753 Water System. The recommendations of the report have been evaluated and included in this Study.

While there has been significant study of aspects of the system in relation to particular needs, there are many parts of the network that have not been evaluated. The Master Plan primarily focuses on areas where there are knowledge gaps such as the wells, and the integration of the network. While it is recognized that little is known about the condition of buried infrastructure, a detailed condition assessment has not been completed as part of the work.

1.2 Official Community Plan

The District's planning in relation to water infrastructure is guided by the Official Community Plan. Specific objectives related to general infrastructure and to the water system are listed in the following tables.

TABLE 1-1: OCP OBJECTIVES AND POLICIES - GENERAL INFRASTRUCTURE SYSTEMS

Objective 9.1	**To encourage an orderly pattern of development in order to reduce construction, operations and maintenance costs of infrastructure systems while meeting current and future needs.**
Policy 9.1.1	The District will identify the extent, location, and phasing of development for infrastructure, including municipal water and sanitary sewer trunk lines.
Policy 9.1.2	The District does not support the extension of municipal services outside of its municipal boundary.
Policy 9.1.3	Ensure the District's Development Cost Charges Bylaw supports future planned infrastructure upgrades to support economic development.
Policy 9.1.4	Apply a comprehensive and integrated approach to asset management, including the development and ongoing use of an Asset Management Plan.
Objective 9.2	**To require that the costs of upgrading infrastructure and servicing new development are borne by those who benefit.**
Policy 9.2.1	When feasible, the District will enter into latecomer agreements to require benefitting parcels to pay their proportionate share of infrastructure costs when connecting to the extended service.
Policy 9.2.2	Support infrastructure improvements that benefit the municipality as a whole. Where possible, seek provincial cost sharing to reduce the financial impact on ratepayers.
Policy 9.2.3	The costs of upgrading services will be borne primarily by the property owners who benefit. A variety of tools may be used including but not limited to: local service areas, utility charges, and development works service agreements.
Policy 9.2.4	Continue to require new development to contribute to the costs of infrastructure capacity improvements that benefit the entire community. A variety of tools may be used including but not limited to: development works servicing agreements, amenity negotiations, and comprehensive development agreements.
Policy 9.2.5	Support innovative methods for servicing developments that encourage economic growth and environmental sustainability.

TABLE 1-2: OCP OBJECTIVES AND POLICIES - WATER INFRASTRUCTURE

Objective 9.3	**To provide a sufficient supply of water to serve the domestic, irrigation and fire protection needs of the community.**
Policy 9.3.1	Minimize water system leaks by maintaining and upgrading watermains using a Water Loss Management Program and other initiatives as necessary.
Policy 9.3.2	Upgrade watermains to meet fire flow requirements, integrate separate water systems, and provide redundancy in order to meet current and future population needs.
Objective 9.4	**To protect surface and groundwater sources in the community.**
Policy 9.4.1	Explore the possibility of a Source Water Protection program where municipal wells are protected by designated Groundwater Protection Zones that limit recreational, commercial, and agricultural uses on surrounding lands.
Objective 9.5	**To conserve water.**
Policy 9.5.1	Actively promote, coordinate, and implement water conservation practices in the community.
Policy 9.5.2	Integrate ongoing water conservation measures into water system planning.
Policy 9.5.3	Encourage property owners to incorporate xeriscaping or drought-resistant plants in landscape plans.
Policy 9.5.4	Demonstrate leadership by using xeriscaping or drought-resistant landscaping to conserve water on District lands and facilities such as medians, islands, boulevards, and parks.
Policy 9.5.5	Encourage the use of greywater for irrigation.

The Official Community Plan also identifies areas for community expansion which are shown on OCP mapping. These have been considered in this plan for the identification of new service areas.

2.0 Description of Existing Water System

2.1 General System Description

The existing water supply and distribution system has been constructed in the period since the early 1940's. The District operates four water systems, as follows;

1. 87m and 138m pressure zones in the central area;
2. Silver Creek;
3. East Kawkawa Lake;
4. Lake of the Woods.

The system is illustrated on Figure 2-1.

Groundwater is the primary water source used by the District. One exception to this is the Lake of the Woods area, which is a small system using surface water.

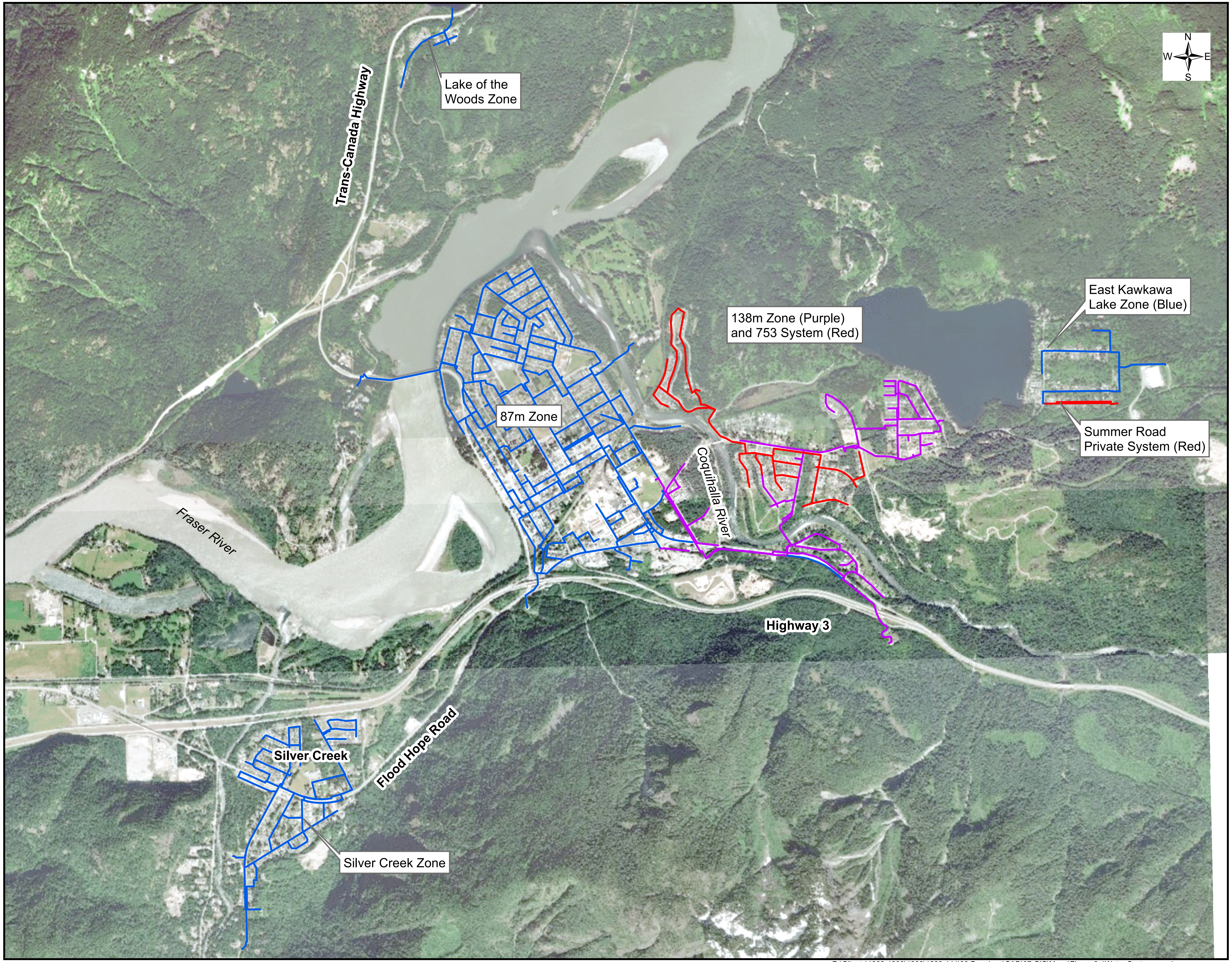
The District of Hope is currently providing water to an independent water system to the west of Kawkawa Lake, called the 753 Water System. As a result, this water system is incorporated into the master plan in order to show what infrastructure would be required to permanently service this area.

Western Water Associates has reviewed the wells. They looked at operation and maintenance concerns, water licensing/registration information and examined the hydrogeology of the wells (*Western Water Ltd. District of Hope Water Master Plan. Groundwater Supply Assessment. November 2018*). Their report and their conclusions as to the capacity and security of the system is provided as an appendix to this document. This general section includes key points from the Western Water study. **The reader is referred to the Western Water report for details of the wells and detailed recommendations for their improvement.**

The District's groundwater supply infrastructure is summarized as follows:

Town 87m Pressure Zone	-	Three wells
Town 138m Pressure Zone and 753 Water System	-	One operational well
Silver Creek	-	Three wells
East Kawkawa Lake	-	One well

The wells are summarized in Table 2-1. The wells pump into the water network, rather than dedicated pipelines feeding the reservoirs. There are four active reservoirs, with one operational reservoir in each water system.



DISTRICT OF HOPE

Water Systems

Legend

Existing Water System

District Network

District Network

Private Network

1:25,000

0 250 500 1,000 Meters

TRUE

Figure 2-1

R:\Clients\1200-1299\1239\1239-141\03 Drawings\CAD\07 GIS\Maps\Figure 2-1Water Systems.mxd

TABLE 2-1: SUMMARY OF EXISTING SUPPLY WELLS

Pressure Zone	87m Zone			138m Zone				East Kawkawa Lake	Silver Creek		
Well Name	**#1**	**#2**	**#3**	**#7**	**#9**	**#10**	**753 Subdivision Well**	**#8**	**#4**	**#5**	**#11**
Facility #	WF-1	WF-2	WF-3	WF-15	WF-19	WF-21	Private	WF-17	WF-8	WF-9	WF-22
Address	865 Third Avenue (Fire Hall basement)	505 Water Avenue	695 Kawkawa Lake Road	65706 DR. Frost Road	Acacia Drive	1050 7th Avenue	Skylark Drive	66700 Othello Road	20004 Silverview Road	19590 Silverhope Road	20118 Beacon Road
Year of Construction	1952	1958	1974	1977	Unknown	2006	2014	1999	1972	1975	2007
Casing Diameter (mm)	250	___	300	200	Unknown	350	200	250	350	250	150
Rated Pump Capacity (L/s)	19	25 @ 73m TDH	32 @ 85m TDH	16 @ 95 m TDH	-	65 @ 113m TDH	NA	27 @ 27.5m TDH	17	9 @ 79m TDH	63 @ 93m TDH
Estimated Actual Flowrate (L/s)	26	30	22	14	-	50	NA	28	23	10	37
Estimated Actual Flowrate (m^3/d)	2,246	2,592	1,901	1,210	-	4,320		2,419	1,987	864	3,197

2.1.1 87m and 138m Pressure Zones

The central Hope water system consists of two pressure zones (at 87m and 138m). Each pressure zone is supplied by wells which pump to steel reservoirs.

87m Zone

The District's 87m pressure zone is serviced by Wells #1, #2 and #3. Flow records indicate that the wells in the 87m zone are used reasonably equally with little change in annual flows in past years (see Figure 2-2 and Figure 2-3). The Well #1 pump was replaced in 2018 and the Well #2 pump was replaced in 2016. Well #3 has been redeveloped twice in the past 15 years.

Western Water noted a number of issues with the 87m zone wells;

- All three wells are relatively old. Wells #1 and #2 should be replaced at some point with a well with a larger casing and a higher capacity.
- Well #1 is located in the basement of the Fire Hall and was recently upgraded. Current standards do not allow new well casings below the ground surface (including basements). Fraser Health has noted that the well casing appears to have been cut flush with the floor, which would create a potential contamination issue in the event of flooding. A sump pump was installed next to the well in accordance with Fraser Health requirements.

138m Zone

The District's 138m pressure zone is currently serviced by Wells #7 and #10. Well #10 is the primary supply source for the 138m pressure zone. The flow to the 138m zone has increased with the addition of the 753 Water System to the network (see Figure 2-4). At 63 L/s, the nominal well capacity of Well #10 is around double the current maximum day demand. At a nominal yield of 4 L/s, Well #7 does not have sufficient capacity to offset a loss of Well #10.

As there is no ability to move water up from the 87m system to the 138m system, this zone is vulnerable to a mechanical failure at Well #10. This would effectively leave the zone without water if a repair cannot be made before the reservoir drains. Alternative water sources are needed.

The 753 Water System is currently within the District of Hope 138m pressure zone as it is being supplied with water through an emergency connection. The 753 Water System was historically supplied by a well on Skylark Drive which has a nominal yield of only 2.5 L/s. A second well was constructed on Skylark Drive for the 753 Water System in 2014. This has a nominal yield of 19 L/s, but it has not been completed and is not connected to the water supply. The new Skylark Drive well could be developed in the future by the 753 Water System owner, or by the District of Hope.

The District also owns an abandoned well nearby at the south end of Acacia Drive (Well #9). It is understood that Well #9, may be useable if a more powerful three phase pump and the supporting electrical systems can be installed. Rather than run three phase power to the site, the upgrade could be based on single phase to three phase power conversion. On this basis, the pump motor size is expected to be limited to 20hp. The costs and benefits of the options need to be more closely investigated as it may be appropriate to bring three phase power to both Skylark Drive and Acacia Drive as part of one project while the subdivision of this area continues.

The options to provide a backup water source to the 138m zone are discussed more broadly in Section 2.1.4.

Cascade from the 138m Zone to the 87m Zone

The maximum day demand in the 87m zone is approximately the same as the combined capacity of well pumps 1, 2 and 3. In order to ensure continuity of supply, a pressure reducing valve station located near Well 10 allows water to enter the 87m zone from the 138m zone. The station has two similar sized pressure reducing valves installed (150mm and a 100mm). The concept is that the larger 150mm valve provides fire flow from the 138m zone when pressure drops to a pre-set level. Commonly a lower capacity pressure reducing valve would open earlier (at a higher pressure) to allow the 138m Zone reservoir to provide for routine peak flows in the 87m Zone. Because the 100mm valve is a similar size to the 150mm valve, a relatively unrestricted flow will enter the 87m system from the 138m system when it activates. In order to better balance network flows, the capacity of this valve should be reduced. This can be achieved by replacing the valve, or by installing a flow restrictor.

High Elevation Areas

The practical maximum flow that can be provided to hydrants to fight a fire in both pressure zones is currently severely restricted by loss of pressure in high elevation areas. These areas are on Thacker Mountain Road, south of Old Hope-Princeton Way and west of the Highway 1 Bridge. They restrict the whole community's fire flow because high flows in the main zone will create low or negative pressure in the elevated areas. While this loss of pressure is a practical issue for the high elevation residents, it is mostly of concern because it creates a risk of backflow into the pipe network. This is a significant contamination risk, particularly in an unchlorinated system. The 1994 Development Cost Charge study identified Thacker Mountain Road and the area west of Highway 1 for upgrades to resolve this situation, including pumped booster stations and dedicated reservoirs.

FIGURE 2-2: ANNUAL WATER VOLUMES TO 87M ZONE (M³)

FIGURE 2-3: WATER FLOWS TO 87M ZONE

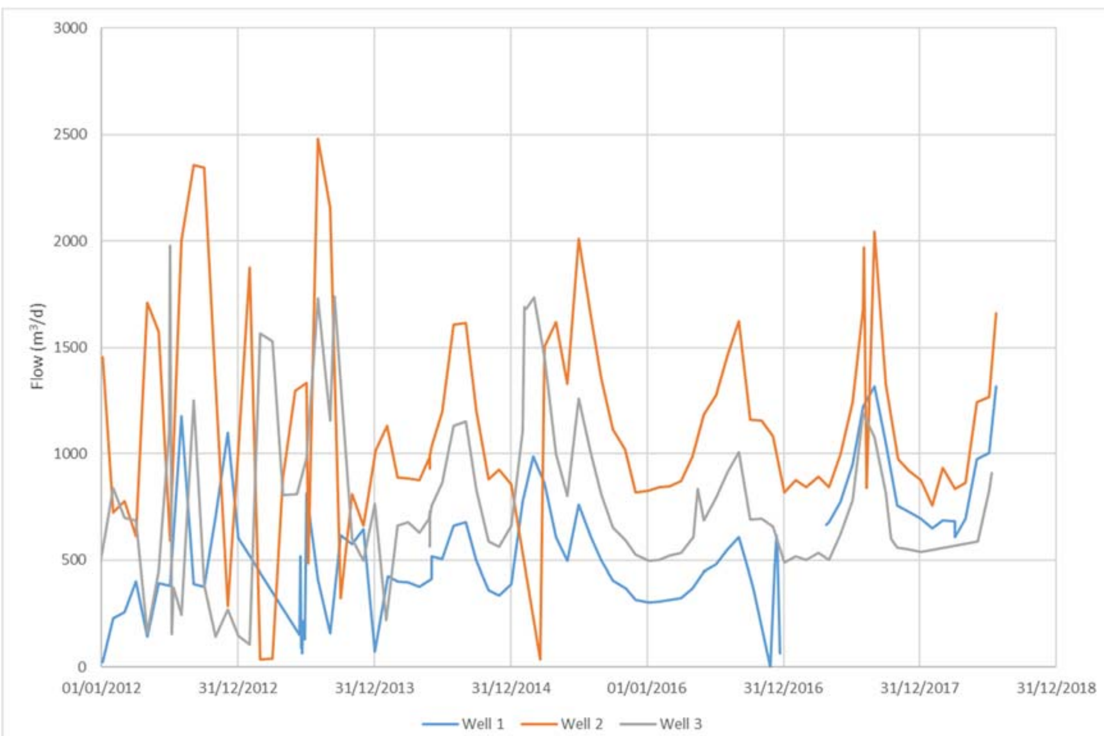


FIGURE 2-4: ANNUAL WATER VOLUMES TO138M ZONE (M3)

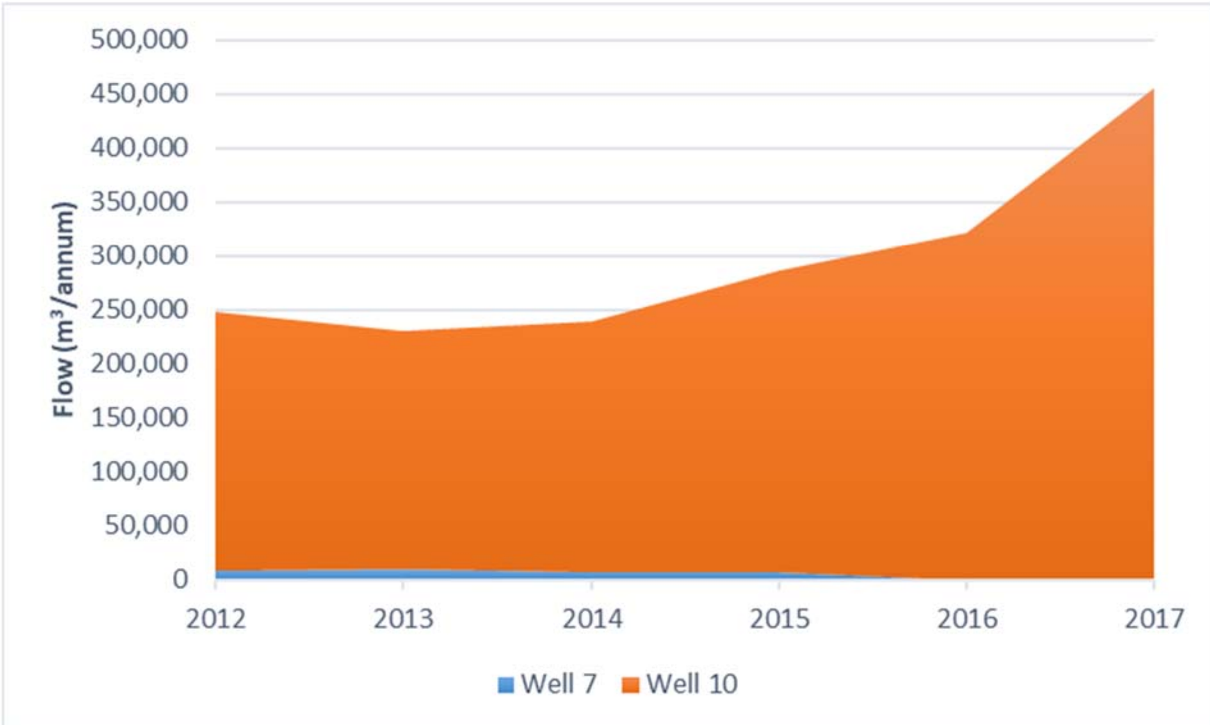
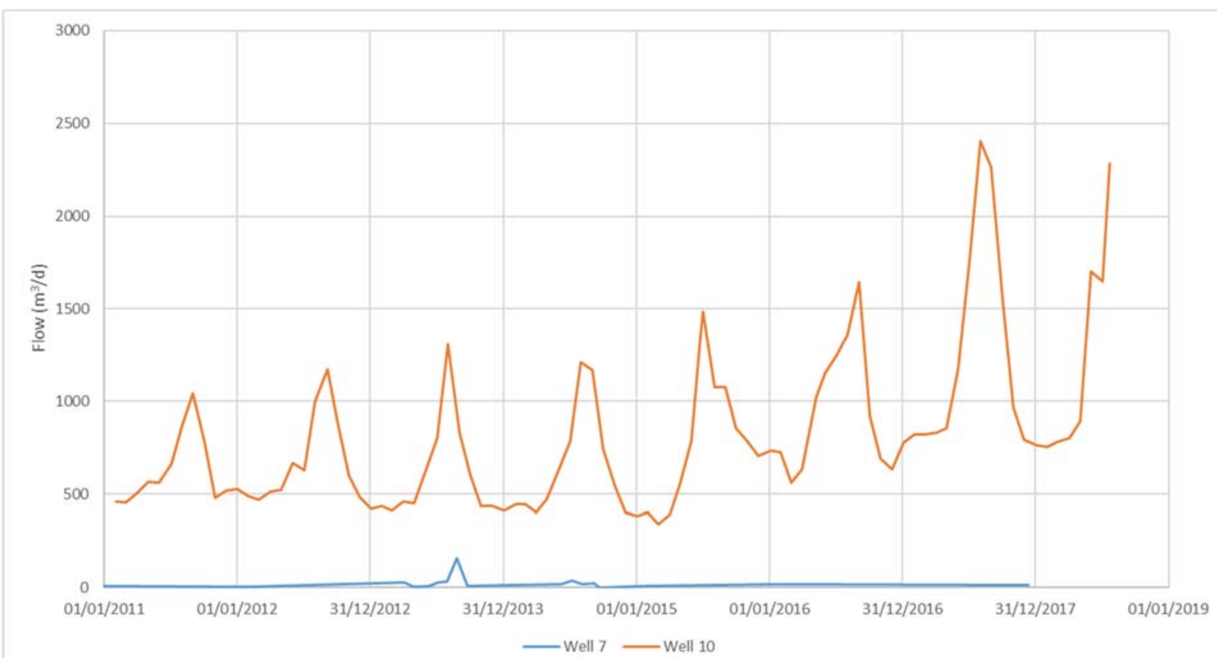


FIGURE 2-5: WATER FLOWS TO 138M ZONE



2.1.2 Silver Creek Water System

The Silver Creek service area is located immediately to the east of Silver Hope Creek and south of the Trans-Canada Highway. A number of streets in this community are served by water mains but are not on sewer. Flows to this area appear to be steadily increasing as a result of ongoing development.

Three wells provide water to the Silver Creek service area. They are described as the North Well (Well #4), South Well (Well #5) and Well #11. Wells #4 and #5 were studied by Golder Associates in 2009. Golder identified that the North and South wells are completed in an unconfined sand and gravel (Provincial Aquifer No.0001), which is assessed by the Province to be productive and vulnerable to contamination. Capture zones were identified at that time. Well #11 was drilled in 2007 and connected to the system in 2009 and takes water from the same aquifer. Water is predominantly provided from wells 4 and 11 (see Figure 2-6 and Figure 2-7).

The wells are located inside the Silverhope Creek Flood Hazard Area, meaning they are vulnerable to impacts from surface flow flooding.

Most of the Silver Creek community is supplied directly from the Silver Creek Reservoir. This reservoir is in good condition, although it would ideally be larger and at a higher elevation in order to adequately provide for fire flows.

The houses to the south of the Reservoir are too high to receive adequate water pressure. A booster pump in well house #5 provides water to these houses. A natural gas powered backup generator is installed to power the pump during an electricity outage. The limited capacity of the pumped system means that this zone cannot supply water to hydrants.

In December 2016, the District experienced a communications equipment failure at the Silver Creek water reservoir that stopped the filling of the reservoir . While there was no contamination within the reservoir, sodium hypochlorite was added at the reservoir to disinfect any potential cross contamination within the system caused by low pressure.

FIGURE 2-6: ANNUAL WATER VOLUMES TO SILVER CREEK ZONE (M^3)

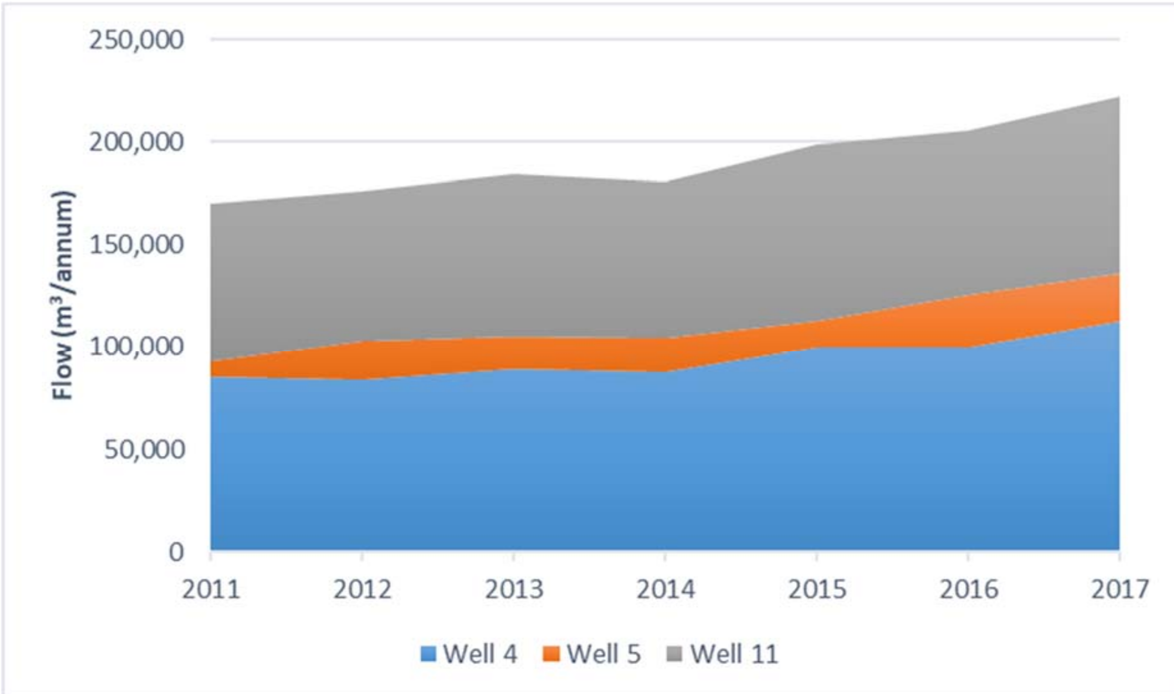
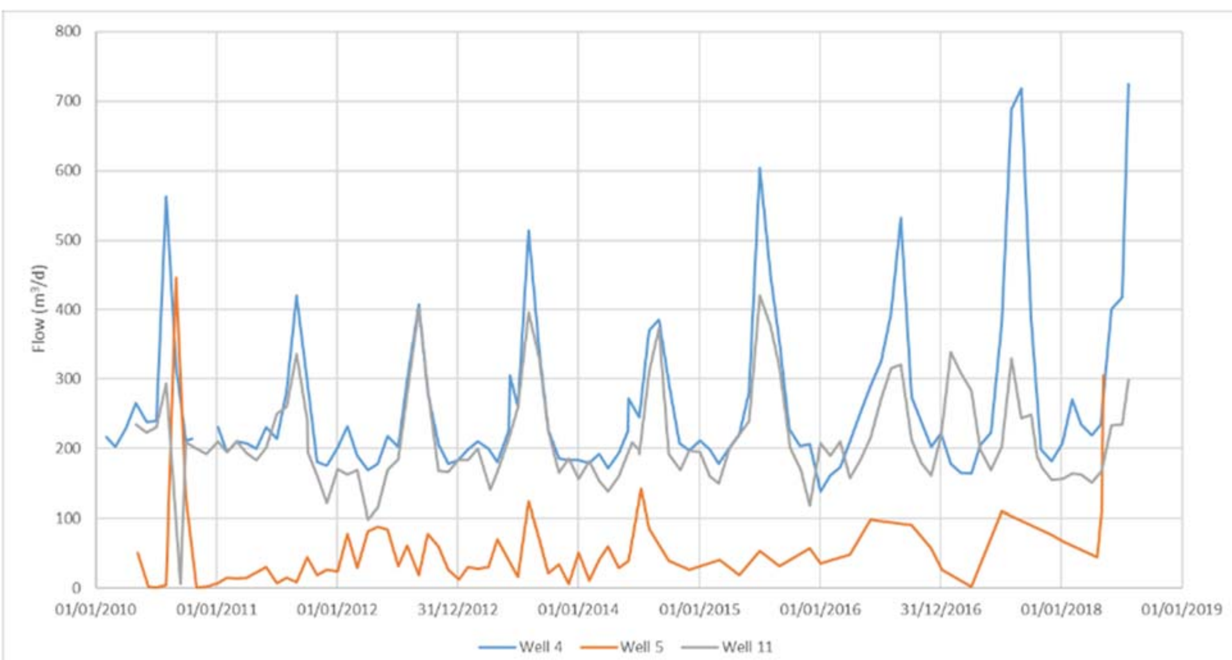


FIGURE 2-7: WATER FLOWS TO SILVER CREEK ZONE



2.1.3 East Kawkawa Lake Water System

The East Kawkawa Lake Water System was previously owned by the Fraser Valley Regional District. It was transferred to the District of Hope in 1992. At that time the water distribution system was vulnerable to contamination, with water lines buried under drainage ditches. The system was upgraded in 2012, including connecting approximately 10 additional residents to the network. Despite this, water demand has declined as a result of reduced demand and leakage.

Substandard infrastructure remains in place on a private branch on Johnson Road with a main that is laid on the surface. The poor design has led to the District responding to complaints about frozen lines in winter. The District has installed a backflow preventer on this branch and a decision is to be made as to whether the main will transfer to public ownership. This pipe will either be replaced with a District main constructed to normal design standards, or it will be left to the residents to manage.

Well 8 is the only well serving the area. A mechanical failure would quickly lead to a loss of water supply. Planned maintenance of the well is also difficult. There is no backup water source in place for this community. Furthermore, the well is located inside an erosion zone identified as part of the East Kawkawa Lake Hazard Area. The well directly feeds a small 53m^3 reservoir. The reservoir is designed to improve well pump operation, but is not suitable for daily flow balancing, emergency storage, or to provide for fire flows.

The well and reservoir are located North East of the Nestlé Waters Canada Ltd site. Power to the site passes through Nestlé property but is separately metered. The site and the pipeline route are protected by an easement. There appears to be no easement over the road access to the well and reservoir. The infrastructure is located on Nestlé Land but is outside the fenced factory site.

There is a hydrant on the Nestlé Waters Canada Ltd site. It has inadequate water pressure or stored water available to meet the applicable fire flow design standards. The water at this hydrant could only be considered as supplementary to any water that Nestlé may have available for fire fighting on their site. It may be best to remove this hydrant to avoid any mistaken expectation that it will perform to normal standards.

FIGURE 2-8: ANNUAL WATER VOLUMES TO EAST KAWKAWA LAKE (M^3)

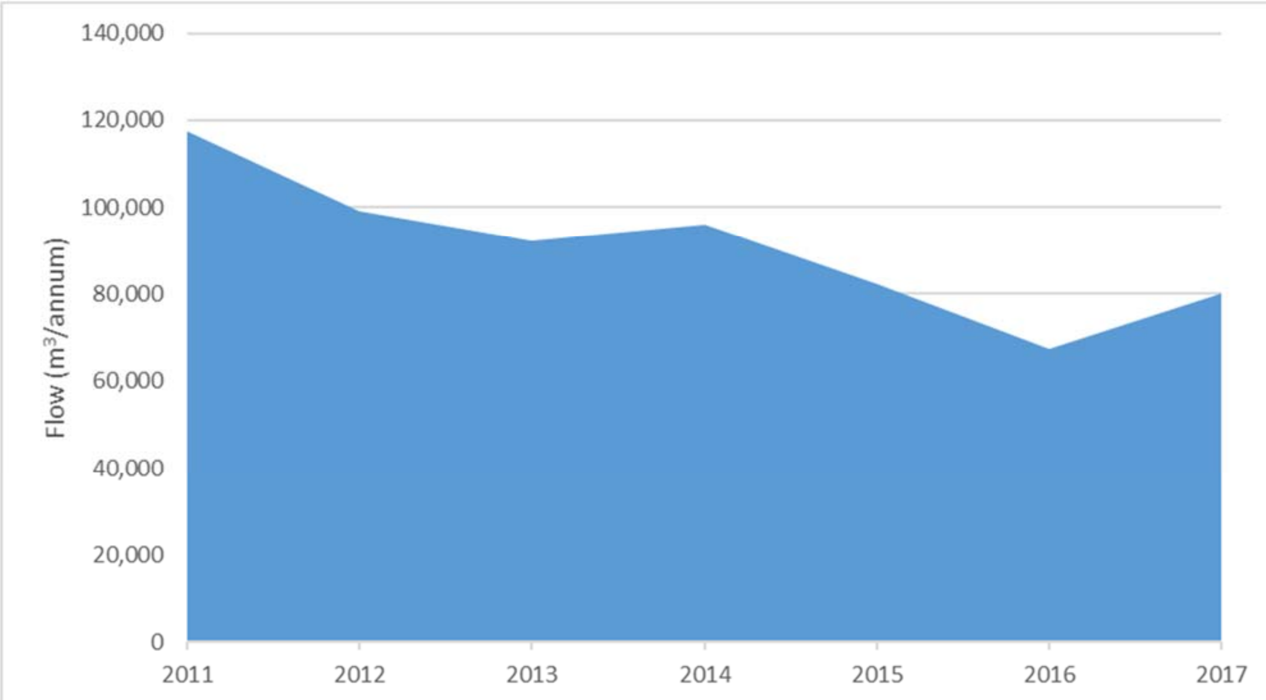
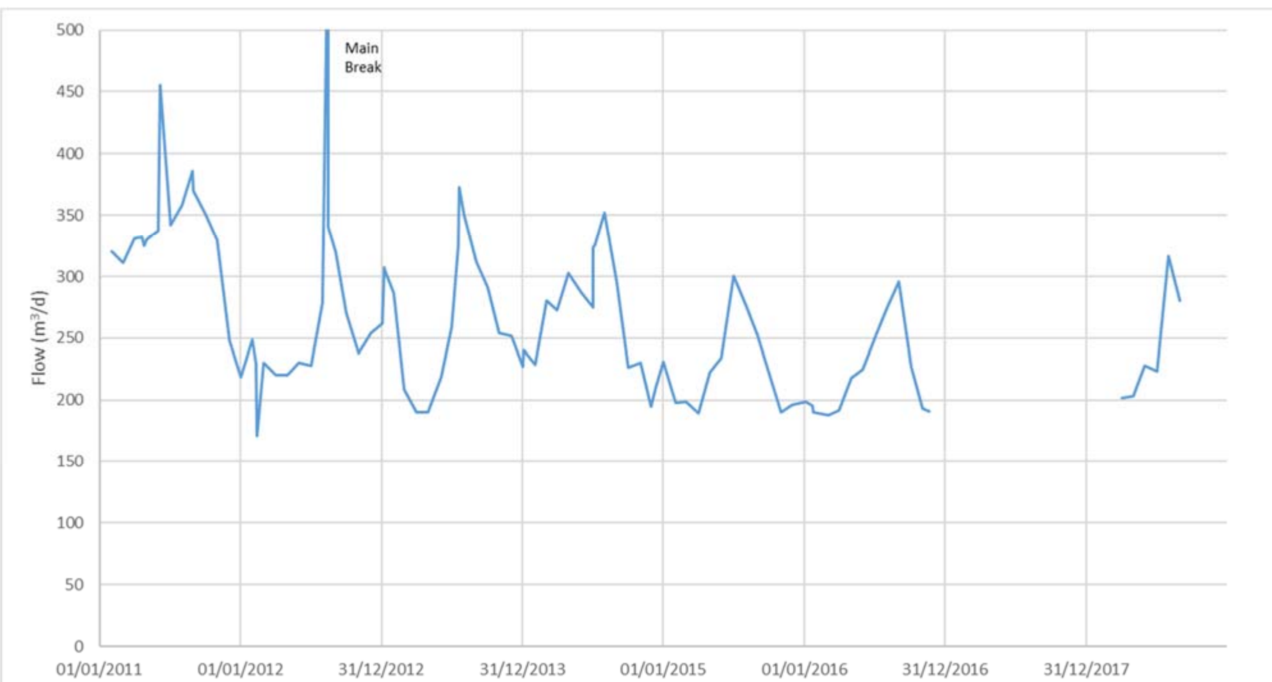


FIGURE 2-9: WATER FLOWS TO EAST KAWKAWA LAKE



2.1.4 Proposed Source Water Consolidation

While the District has ample well capacity, the ability to move water to where it is needed represents a significant risk for reliable operation. The 138m Zone, 753 Water System and East Kawkawa Lake are all at risk in the event of a mechanical failure or general well deterioration. At present the District has limited ability to undertake routine maintenance on certain critical wells. It is also important to take account of risks from aging wells which may need to be replaced in the short to medium term (Wells 1 and 2) and wells that already appear to be failing (Well #7).

TABLE 2-2: WELL CAPACITY WITH EXISTING SYSTEM CONNECTIVITY

Supply Area	**MDD [2040]**	**Well Capacity** (*well ID numbers*)	**Well Capacity with Largest Well out of Service** (*well ID numbers*)
	m^3/d	m^3/d	m^3/d
87m Zone	7,100	11,000 (*1,2,3,10*)	6,700 (*1,2,3*)
138m Zone / 753 Water System	3,000	5,500 (*7,10*)	1,200 (*7*)
Silver Creek	1,500	8,000 (*4,5,11*)	2,900 (*4,5*)
East Kawkawa Lake	360	2,290 (8)	0 (-)

In order to provide the required redundancy, the District could construct new wells in each water supply zone, apart from Silver Creek. The appended hydrogeology report written by Western Water recommends the following;

1. Replace Wells 1 and 2 with a single larger capacity well (due to well age).
2. Replace Well #3 (due to well age).
3. Decommission Well #7 and replace it with a new larger capacity well (due to Well #7 condition and capacity). Alternatively, upgrade a test well constructed for the 753 Water System into a production well (if feasible and available).
4. Duplicate Well #8 (lack of redundancy).
5. Provide three phase power to well #9

The required redundancy can also be achieved by making new connections between the existing systems. For example, by connecting the Silver Creek Zone to the 87m Zone, the available water sources would continue to be sufficient, even with one well out of service. Similarly, by connecting the 138m Zone / 753 Water System with East Kawkawa Lake, both zones would continue to have adequate water, even if one well failed, or needed routine maintenance. This strategy is preferred to the construction of new wells and is illustrated in Table 2-3.

TABLE 2-3: WELL CAPACITY UNDER PROPOSED CONNECTIVITY SCENARIO

Supply Area	**MDD [2040]**	**Well Capacity** (*well numbers*)	**Well Capacity with Largest Well out of Service** (*well numbers*)
	m^3/d	m^3/d	m^3/d
87m Zone	7,100	17,000 (*1,2,3,4,5,10,11*)	12,800 (*1,2,3,4,5,10*)
138m Zone / 753 Water System	3,000	7,800 (*7,8,10*)	3,600 (7,*8*)
Silver Creek	1,500	8,000 (*4,5,11*)	2,900 (*4,5*)
East Kawkawa Lake	360	6,700 (8,10)	2,400 (8)

If the Silver Creek Zone to 87m Zone connection is made, then it would also be feasible to reallocate Well #3 to the 138m Zone / 753 Water System in order to improve the resiliency of this system. This should be considered as a short-term improvement for security of supply. The water from Well #3 can still be cascaded back to the 87m Zone, meaning the water would be available to both pressure zones.

The primary disadvantage of cascading the water back to the 87m Zone is that the District must pay to pump the water to a higher elevation than at present. This issue would generally be avoided outside of the summer months by using Wells #1 and #2 instead. From a technical standpoint, a new higher lift pump would be required for Well #3, along with minor watermain alterations.

It may be practical to partly offset the power consumed in pumping by generating electricity with an in-line turbine. The turbine would be located at the site of the existing pressure reducing station and could provide power to nearby well pumps. The City of Portland generates electricity in this way. These electricity generation systems remain very unusual and would need careful evaluation in terms of cost-benefit.

Rather than reallocate Well #3 to the 138m Zone, it would be feasible to construct a booster pump station to move water from the 87m Zone to the 138m Zone. This would mean that water from Wells #1, #2 and #3 would be available to the 138m Zone. The option would reduce electricity costs, but would have a higher capital cost than a simple well pump replacement and the associated pipework changes. In the event that water from Silver Creek were to be transferred to the 87m Zone, it would also be available to the 138m Zone using this booster station. This would enhance network integration.

2.1.5 Lake of the Woods

The Lake of the Woods system was constructed in 1972 to distribute water to eleven parcels of land on Ross Road from a submerged intake in Schkam Lake. The Lake of the Woods water supply includes the only surface water treatment system operated by the District. The District has attempted to drill a well to develop a groundwater source for this water system, however water quality and quantity concerns have a made this option unfeasible.

The District has a permit to take up to 5,500 imperial gallons (25m^3) per day from the Lake. The demand is generally significantly less than this figure. However, the maximum day demand during August 2017 was 20 m^3/d.

The comprehensive water quality analysis conducted in 2018 showed no evidence of parameters exceeding Canadian Guidelines for Drinking Water Quality values for maximum acceptable concentration. Aesthetic parameters also appear to be acceptable. As this system has a surface water source, the water needs to be disinfected to meet the requirements of the Drinking Water Protection Act. This disinfection includes inactivation / removal of protozoa and chlorination targeting bacteria and viruses.

The treatment system is located at 22533 Ross Road. It is designated as the 'Bottom Pump House' in the log sheets. The existing treatment system consists of two sand filters followed by a 5-micron filter, 1-micron filter and ultraviolet disinfection. The sand filter and the 5-micron filter remove the majority of the particulate material. The 5-micron filter must be changed every 2 – 3 months. The 1-micron filter forms a physical barrier to protozoa and is changed less frequently. The ultraviolet disinfection system is a Hallett 30 unit with a nominal capacity of 104 L/min at 75% UVT. A solenoid shut off valve stops flow in the event of a low reading on the UV intensity sensor. Sodium hypochlorite is dosed as the water leaves the plant. Water leaving the Lake of the Woods treatment system is not routinely chlorinated. Chlorine dosing has not occurred since 2011, apart from annual dosing of the reservoir to control biofilms.

Cartridge filter based systems are commonly prone to frequent filter clogging, particularly if algae are present. This could occur if the lake water becomes polluted by silt or nutrients. If this situation develops, it could be replaced with a backwashed membrane filtration system. However, such a system comes at a significant capital cost and requires chemical handling and backwash disposal. The Schkam Lake water quality should be protected to avoid these issues.

A Grundfos CR5 water pump charges a pressure vessel, which feeds the network at a pressure of around 400 kPa. A backup generator was installed at Lake of the Woods in 2016.

FIGURE 2-10: ANNUAL WATER VOLUMES TO LAKE OF THE WOODS ZONE (M^3)

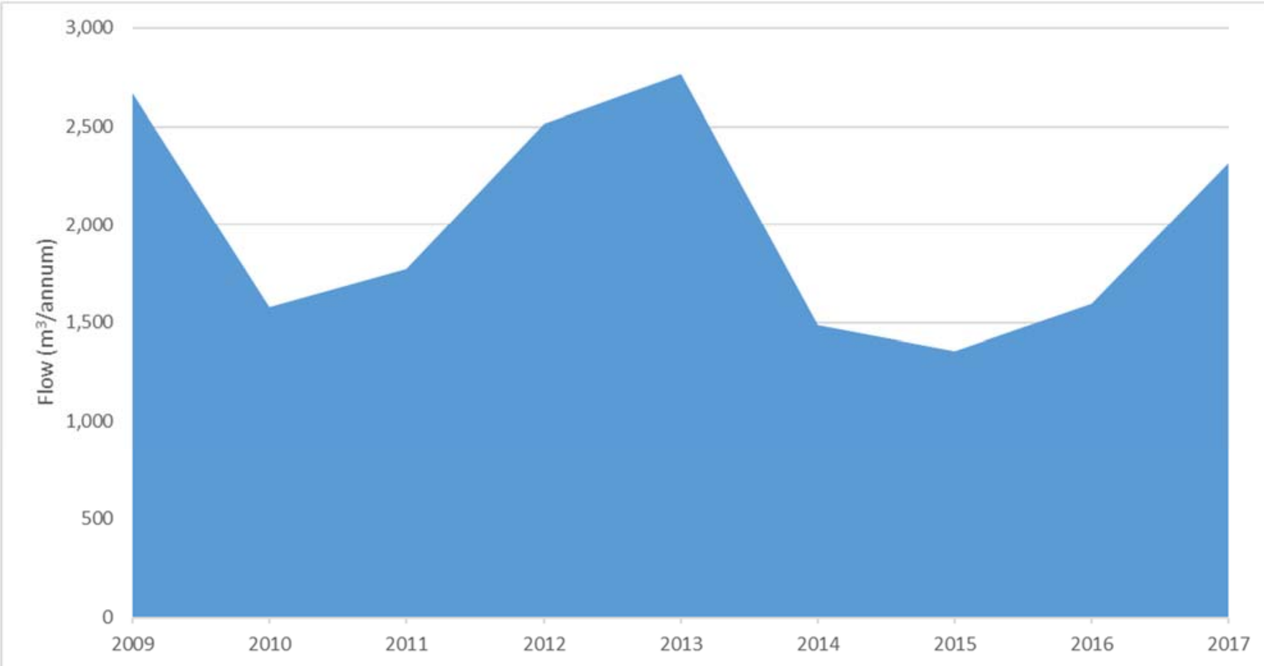
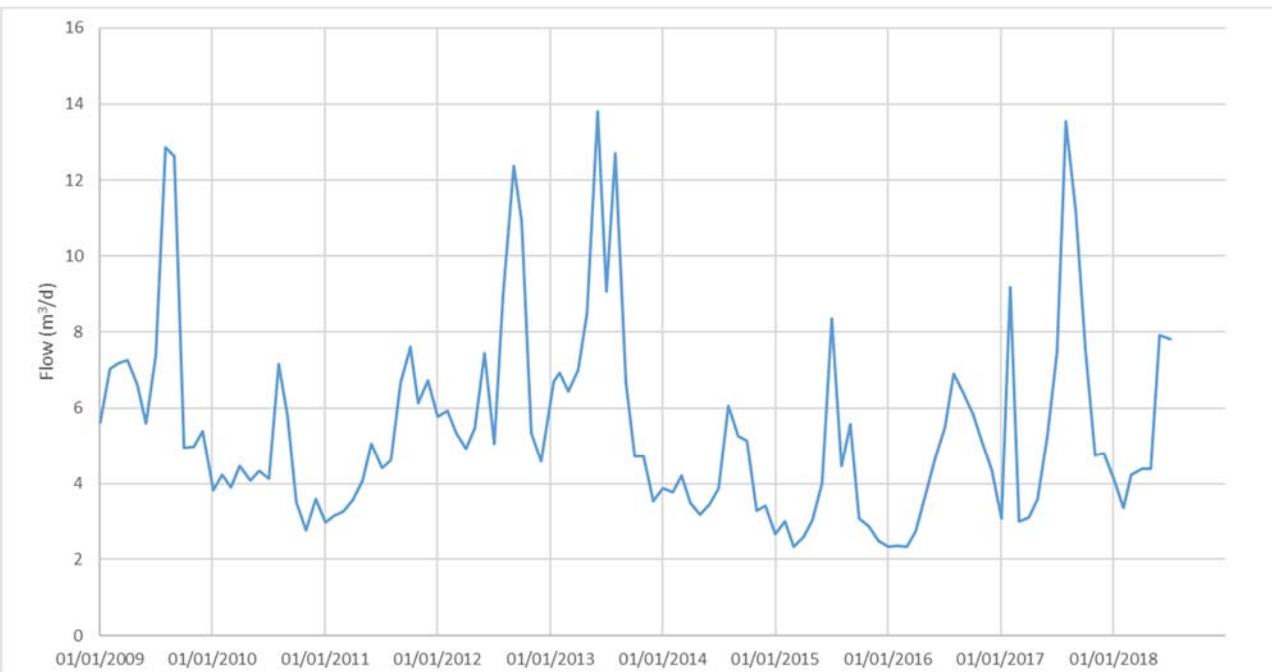


FIGURE 2-11: WATER FLOWS TO LAKE OF THE WOODS ZONE



2.1.6 Private Systems

Figure 2-1 shows the extent of private networks within the system. Private systems are indicated as pink lines. The smaller examples are Strata developments. The standalone water systems are as follows;

753 Water System

The largest private network is the 753 Water System. The '753' water utility was first established in 1978 with 41 lots and was expanded between 1981 and 1994 to add the remaining 191 lots to the service area. The utility currently serves 202 connected lots and is authorized to provide service to an additional 30 vacant lots.

Historically the 753 Waterworks Ltd was privately managed. As a result of issues related to ownership, responsibility passed to the provincial Comptroller of Water Rights in 2017. The water source was groundwater from the Skylark Drive Well. In 2014, the well started showing signs of aging, with reduced capacity and water quality issues. Consequently, a new well was drilled in close proximity to the existing well (753 Subdivision Well, Skylark Drive). The new well has not been connected to the system. The 753 Subdivision was connected to the 753 Reservoir, which is located off Thacker Mountain Road. The reservoir storage volume is 522m^3 and the top water level is 133m. The 753 Reservoir is in poor condition with cracks that require repair.

The problems with the operational well led to the construction of a temporary emergency connection to the District of Hope's water supply in June 2015. Although the original intent was to revert to the new Skylark well source once it was complete, the connection to the District system is still in operation. The 753 Reservoir is not currently connected to the combined system due to the difference in elevation with the 138m reservoir, which causes it to routinely overflow.

Summer Road Water System

The Summer Road water system is adjacent to the East Kawkawa Lake system. The Summer Road system is on a long-term Boil Water Notice due to untreated surface water, which is taken from a spring. The watermain is a looped 63mm main which would not have sufficient capacity for fire fighting. No hydrants are installed apart from one on the District network at the west end of the road. The system operator and Fraser Health have indicated interest in connecting this system to the East Kawkawa Lake System to improve water quality and security. However, there has not been agreement by the stakeholders for pursuing this. Therefore, the District is not planning for the connection of this system.

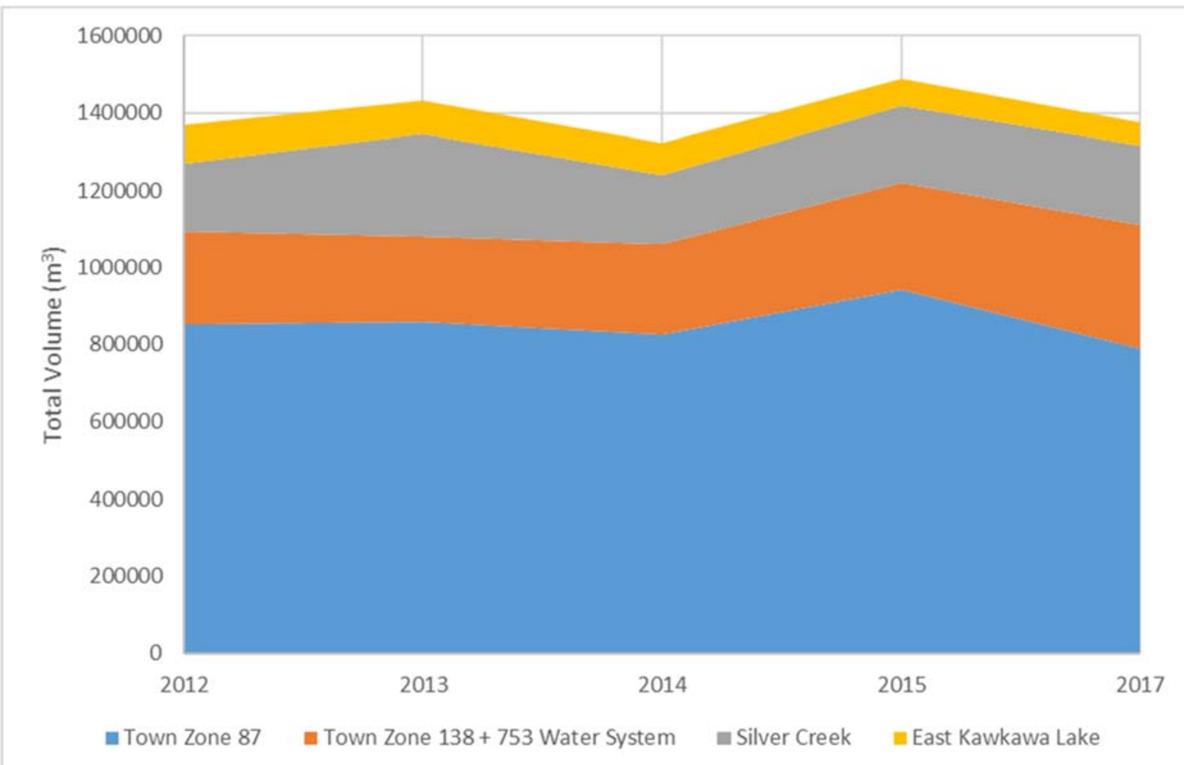
3.0 Historical and Projected Water Demands

3.1 Existing Water Demand

The District of Hope is a growing community within the Fraser Valley, with an estimated population of 6181 residents (2016 Census). The average household size is 2.1 people, predominantly living in single family housing. Based on an annual flow of around 140,000m^3, this equates to a rate of consumption of approximately 600 L/capita/day. This water consumption is typical for a community of this size by Provincial and National Standards.

The following chart shows how water consumption has varied year on year, as well as the relative consumption in each service area of the municipal water system. For comparison, the quantity extracted each year by Nestle Water in East Kawkawa Lake is estimated to be 300,000m^3.

FIGURE 3-1: ANNUAL WATER VOLUME BY SERVICE AREA AND YEAR



Year 2017 summer flows to each zone have been collated from log sheets, including the contribution from each well. The data has been summarized in the following charts. The 2017 summer was unusually dry and most communities had particularly high levels of summer water use in this year. The total well capacity is also indicated for comparison to the water used.

FIGURE 3-2: SUMMER WATER FLOWS TO 87M ZONE

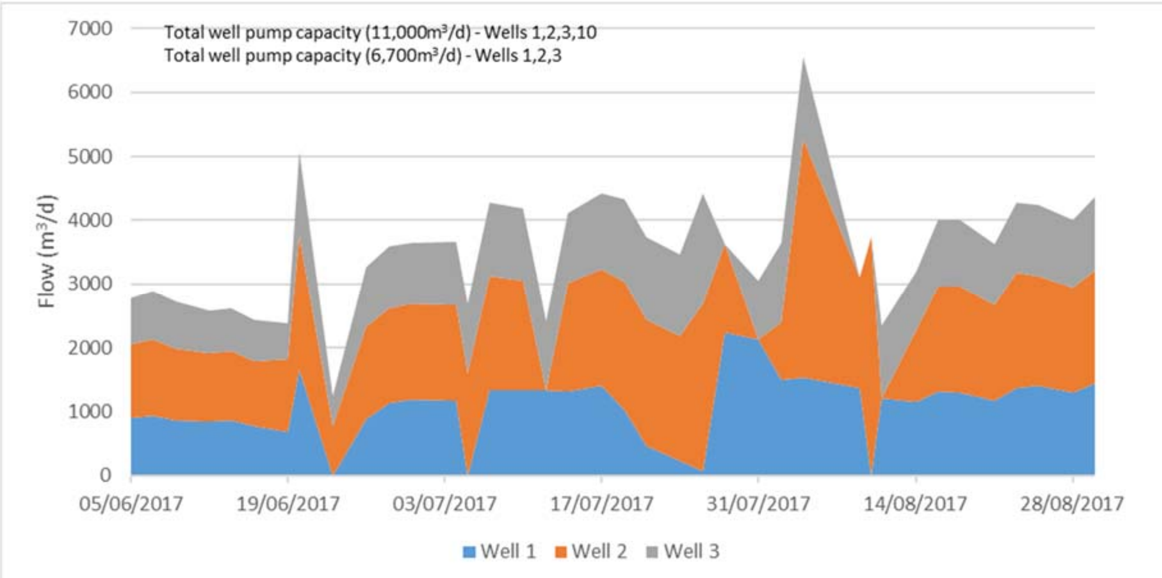


FIGURE 3-3: SUMMER WATER FLOWS TO 138M ZONE

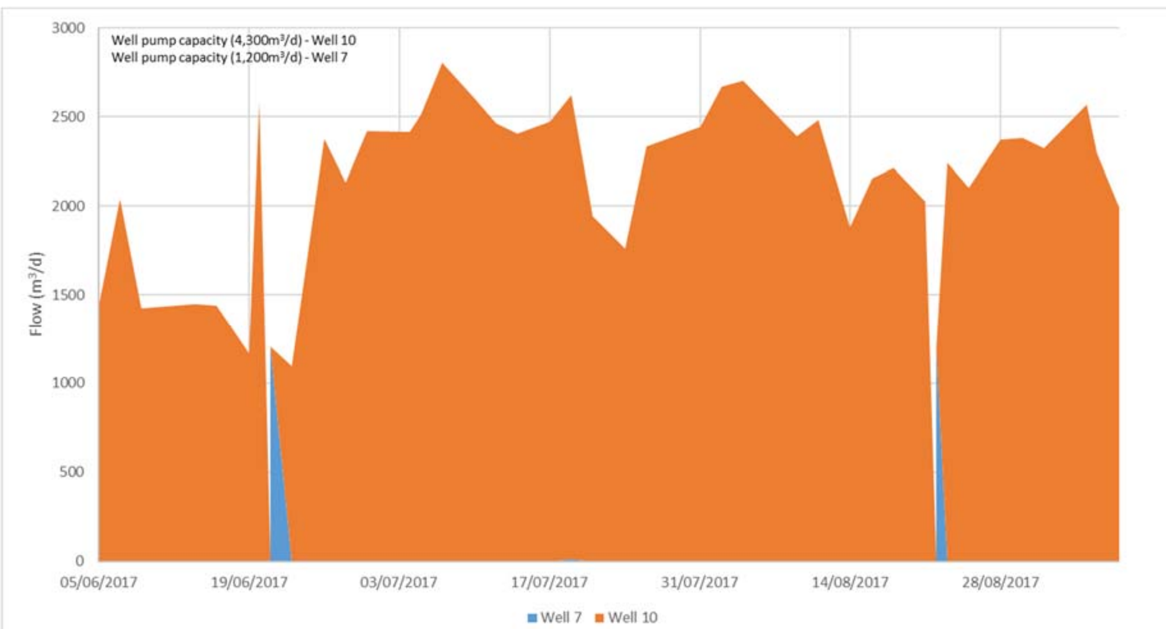


FIGURE 3-4: SUMMER WATER FLOWS TO SILVER CREEK ZONE

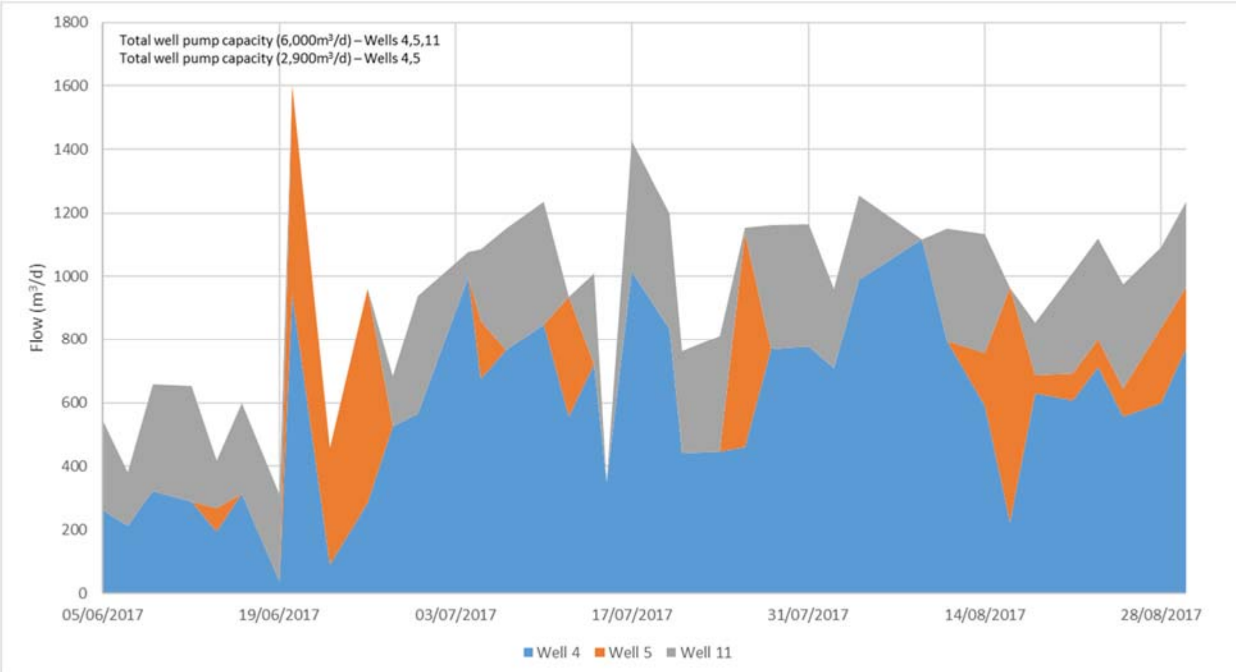
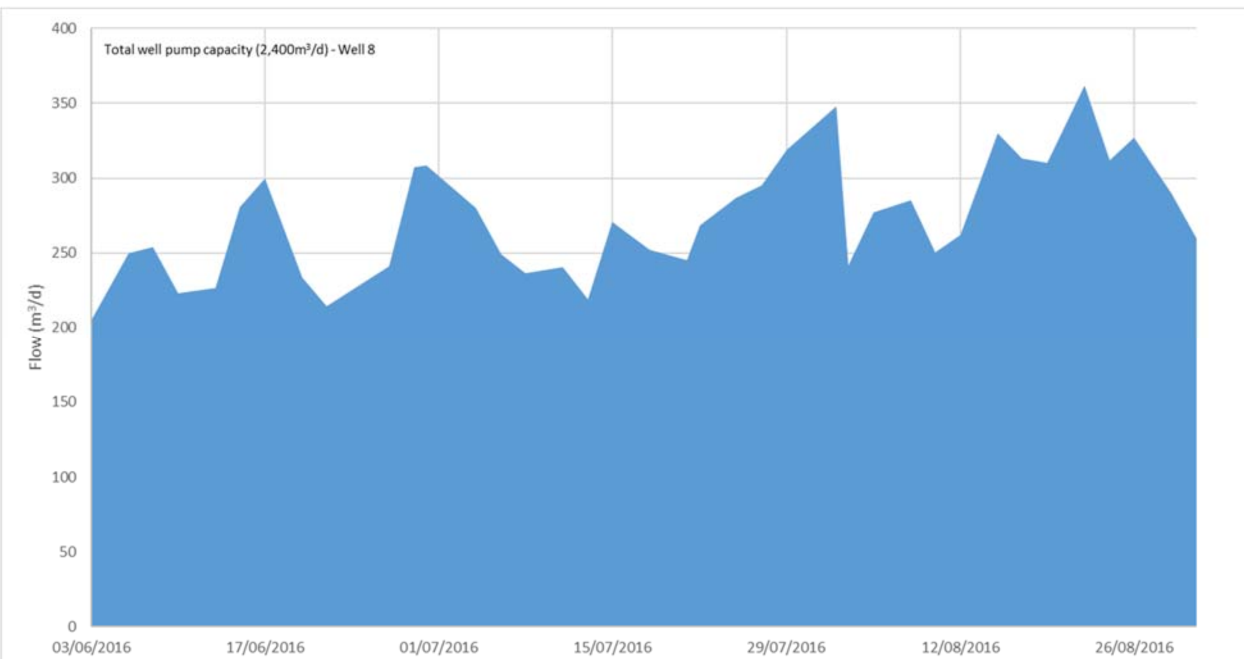


FIGURE 3-5: SUMMER WATER FLOWS TO EAST KAWKAWA LAKE



The 2017 summer flows shown in the previous figures were used to estimate the Maximum Daily Demand. It is important to note that the wells are generally visited three times per week. As a result, unusually high peak days will tend to average out in the records. Based on the figures available, the estimated present-day water demand for each distribution zone is as follows;

TABLE 3-1: ESTIMATED EXISTING MAXIMUM DAY DEMAND

	Winter Flow[1] (m^3/d)	Average Daily Demand (m^3/d)	Maximum Daily Demand[2] (m^3/d)
87m Pressure Zone	2,000	2,400	6,500
138m Pressure Zone plus 753 Water System	800	1,300 (2017 only)	2,750
Silver Creek	330	570	1,400
East Kawkawa Lake	160	220	350
Lake of the Woods	3	5.5	20

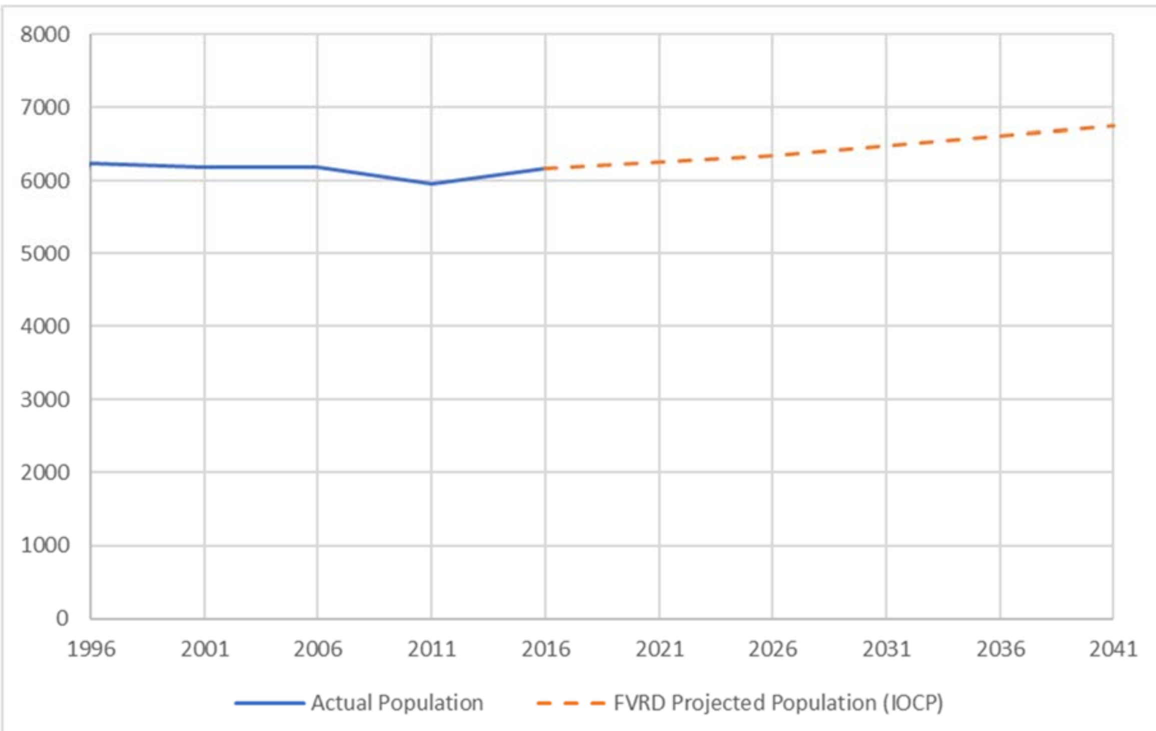
The figures indicate that there is sufficient well capacity for the MDD flows in each zone. The reported well capacity and pump capacity figures have not been used as their reliability is unknown. Instead, the available capacity has been calculated using the reported pumped volumes divided by the hours pumped, to give a flowrate while pumping.

[1] Based on January 2018 figures, except Well 8 which is based on January 2016 due to missing data.
[2] The MDD figures are based on manually recorded totalised individual well data, which means that the true peak daily flow may be higher.

3.2 Water Demand Projections

Realistic population projections are an important basis for Water Master Planning. The District's 2016 Integrated Official Community Plan (IOCP) quotes an FVRD estimate that Hope will reach a population of 6,354 people by 2026 and 6,746 by 2040. As a result, the IOCP assumes a small amount of population growth for Hope over the next ten to fifteen years. This is illustrated in Figure 3-6.

FIGURE 3-6: IOCP POPULATION PROJECTION FOR HOPE CENSUS AREA



It should be noted that the District has recently seen a surge in construction in the community. Anecdotally there has been an uptick in interest in Hope as an affordable place to live, leading to increased demand for housing. In addition, Figure 3-6 indicates growth in population, but doesn't specifically account for extension of service to existing residential areas. These areas are considered separately. The locations where future development will occur are particularly important for this exercise, along with determination of the associated growth potential in each area.

Seasonal population fluctuations must also be considered, as this temporary increase in population represents a demand on the District's infrastructure during the vacation (summer) period. As there are no seasonal population statistics, fluctuations in water consumption and wastewater flows must be used to estimate this effect. The projected increase in MDD based on the percent increase in populations is indicated below.

TABLE 3-2: MAXIMUM DAY DEMAND PROJECTIONS FOR YEAR 2040

87m Zone	7,100 m^3/d
138m Zone	3,000 m^3/d
SC Zone	2,000 m^3/d
East Kawkawa	360 m^3/d
Lake of the Woods	25 m^3/d
Total	11,960 m^3/d

3.3 Possibility of Future Water Treatment

Water quality in the local aquifers is generally similar and has excellent palatability. It is for this reason that Nestlé Waters Canada has a bottling plant extracting water from the Kawkawa Lake subwatershed to the east of Kawkawa Lake.

Recent source water quality reporting and analyses have been reviewed and compared with the Guidelines for Canadian Drinking Water Quality. Well water quality meets Aesthetic Objectives (AO) and Maximum Acceptable Concentrations (MAC) of the Guidelines for Canadian Drinking Water Quality. The Fraser Health Authority has not raised concerns over the well water quality as part of their annual reviews in recent years. TRUE consulted with the Fraser Health Authority to discuss their regulatory concerns or requirements.

Historically there have not been many issues with bacterial contamination of the drinking water. Nevertheless, as a precautionary measure, the District of Hope is equipped with a portable chlorine dosing unit which is compatible with the main wells. In the event of an emergency the District can chlorinate the water within 4 hours of notification. Bi-yearly drills are performed in which the chlorine unit is operated to ensure that staff are properly prepared.

A hydrogeological assessment has been completed by Western Water Ltd as part of this study. Because there is some vulnerability to contamination, they recommend the completion of a Source Protection Plan for the District water sources. In addition, a hazard screening / assessment should be completed based on the Province of B.C. guidance document for determining Ground Water at Risk of Containing Pathogens (GARP). If the water were to be designated as 'GARP-viruses only' in the future, then chlorination and designated contact time would be required.

The Fraser Health Authority have recommended that this Master Plan should consider the possibility of future chlorination of the water supply. At present there are no permanent facilities for disinfection or provision of contact time at any of the well sites. It is likely that this would be achieved by installing sodium hypochlorite storage and dosing at each well upstream of a local 'pipe loop' for contact time with the chlorine. The pipe loop would need to have a volume sufficient for approximately 15min of storage at the well pumping rate. The largest well has a capacity of 50 L/s, which would require a total contact volume of 45m^3 based on a baffle factor of 1. This is equivalent to 160m of 600mm diameter pipe. In some cases, the contact volume could be combined with scheduled pipe replacements, taking care that services are not connected to the new pipe.

Construction of dedicated mains from the wells to the reservoirs would be an alternative to pipe loops. New dedicated mains to the reservoirs would be constructed in new and relatively earthquake resistant materials, which would reduce their vulnerability. The construction of new dedicated mains could be considered when old mains are already being replaced in order to better prepare the District for any future changes in requirements. Due to the pipe length involved, dedicated mains are not expected to be affordable as a standalone project.

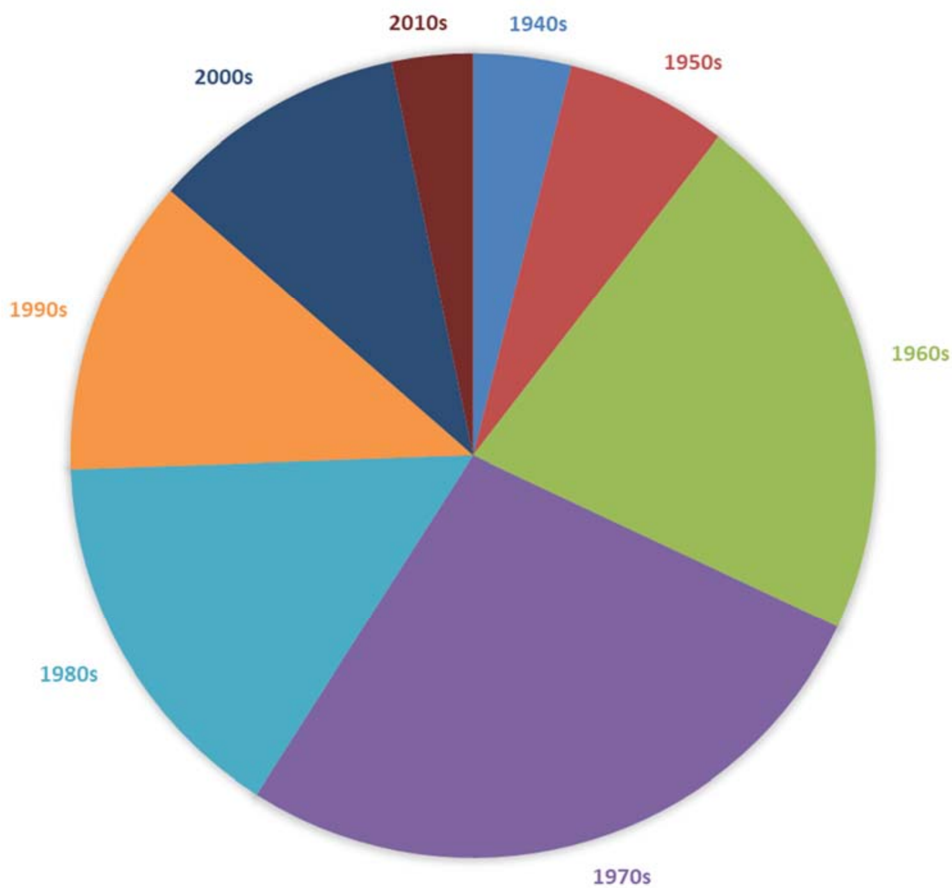
While Well #8 has a dedicated reservoir, the volume is too small to be useful since only 10% of the dedicated contact volume would be applicable due to the

3.4 Existing Water Distribution System

3.4.1 Summary

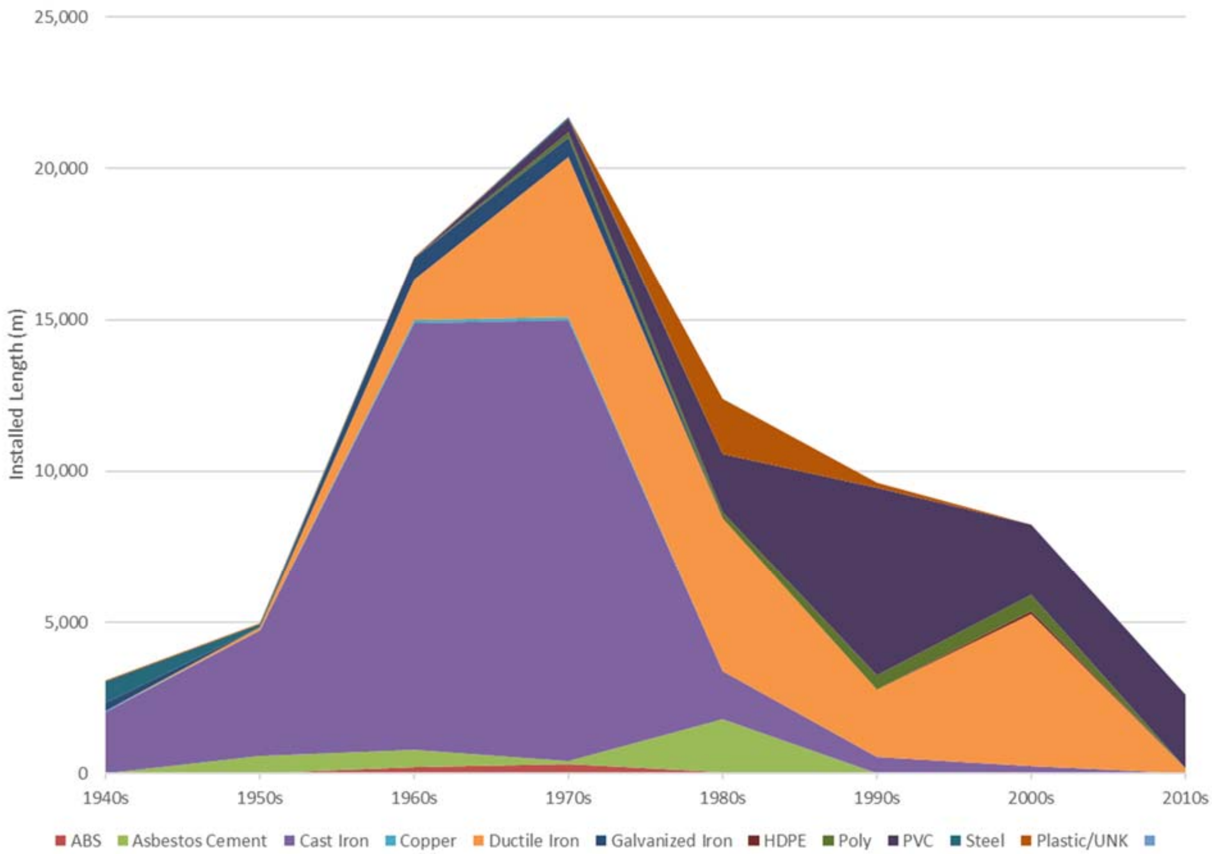
Construction of the existing water distribution system started in the 1940's. A total length of approximately 80,000m of watermain is recorded in the District's database. It is mostly comprised of cast iron, ductile iron and PVC material. The system also includes 229 fire hydrants. Figure 3-7 shows the relative rates of network construction based on length of pipe and decade showing how the system has grown with the community over time.

FIGURE 3-7: DISTRICT OF HOPE PIPE NETWORK BY DECADE



The water distribution system pipe type and age is summarized in Figure 3-8. The changes in preferred material over time can be seen. Cast iron was the favoured until the 1980s. Since then ductile iron and PVC have predominated. PVC has been used almost exclusively in the past decade, which is consistent with national trends.

FIGURE 3-8: AGE OF DISTRIBUTION SYSTEM BY MATERIAL



The distribution system pipe diameter and material makeup is illustrated in Figure 3-9. The figure demonstrates that the greatest part of the network is 100mm and 150mm pipe. The majority of the pipe in those sizes is cast iron and ductile iron. There is also a significant amount of PVC and asbestos cement pipe.

FIGURE 3-9: DIAMETER OF DISTRIBUTION SYSTEM PIPES BY MATERIAL

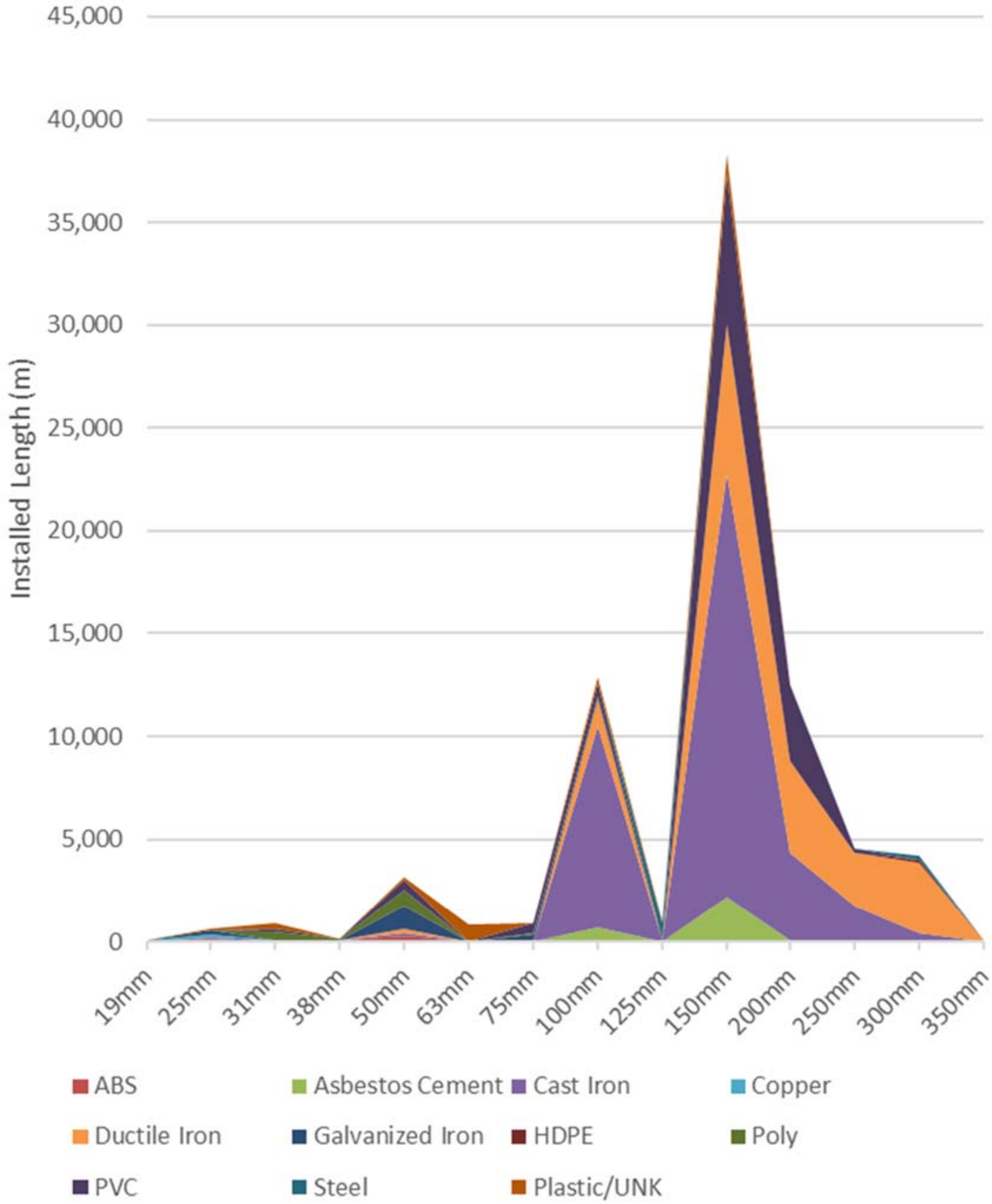


Figure 3-10 and Figure 3-11 show that if the small diameter pipe, less than 100mm is ignored, the overall proportions of each pipe material remain similar.

FIGURE 3-10: OVERALL PROPORTION OF PIPE MATERIALS

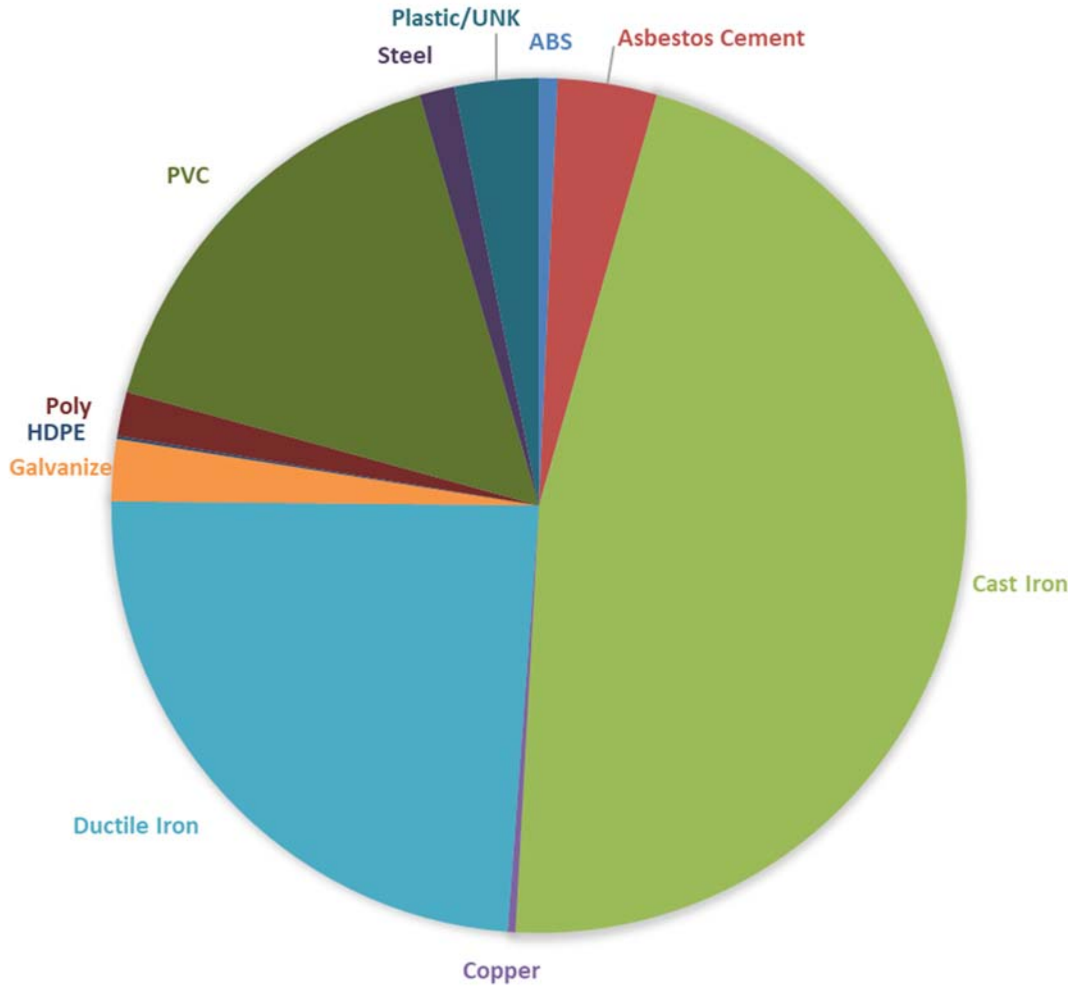
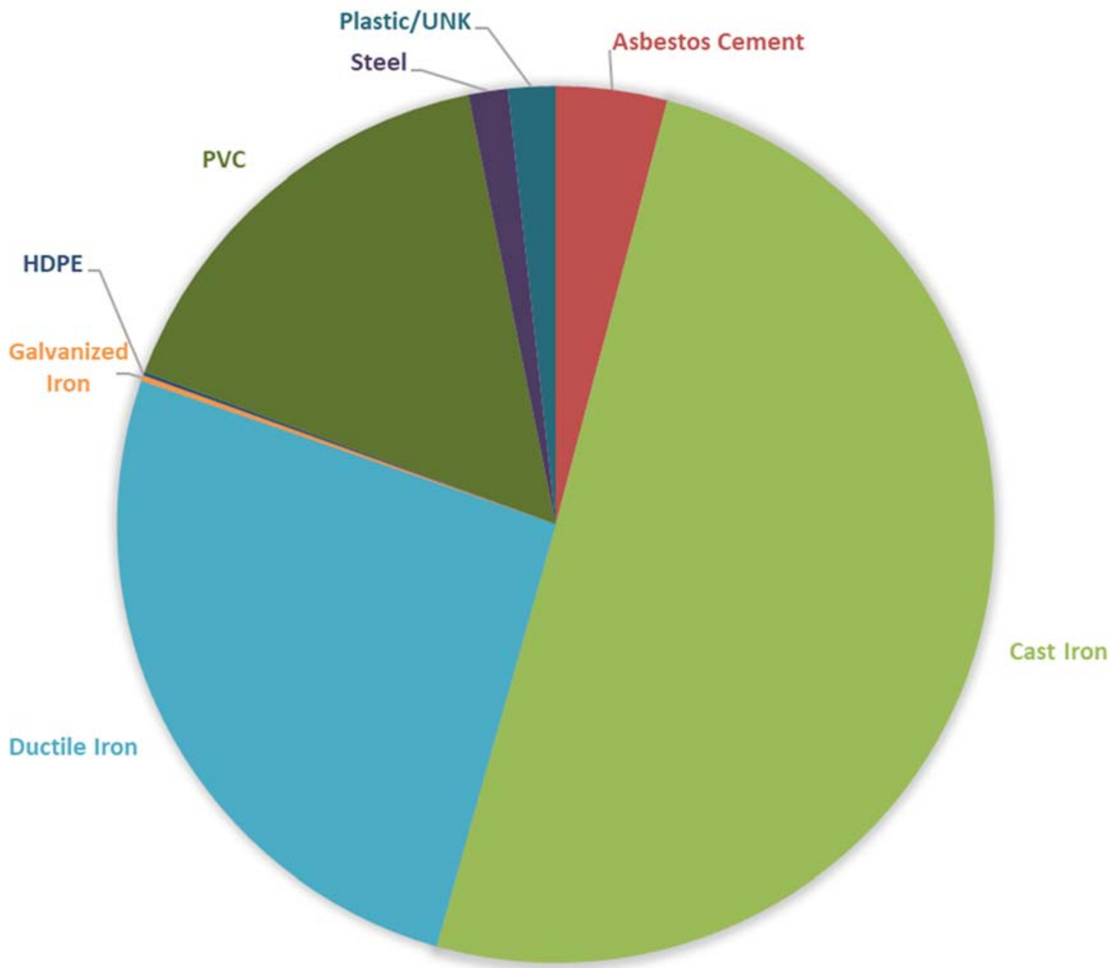


FIGURE 3-11: PROPORTION OF PIPE MATERIAL (≥100MM DIA)



3.4.2 Expectations for Pipe Failure

Factors Affecting Service Life

The age and condition of the District's pipe inventory means that pipe replacement will become an increasingly important part of the water system annual budget. The structural integrity of metallic and cementitious water pipe can be affected by both internal and external degradation.

Externally, corrosion can occur by various mechanisms such as general soil corrosion, bimetallic corrosion, stray currents and microbiological attack. The rate of external corrosion is highly variable, depending on a range of factors including localized issues such as high sulphate soils.

It should be noted that metallic pipes in the vicinity of cathodically protected pipelines are particularly at risk of accelerated corrosion due to stray currents. This may be the case for metallic watermains near the Trans Canada Pipeline and steel gas transmission mains. Methods exist to mitigate stray current issues. A surface potential gradient survey should be conducted if an issue is suspected.

The rate of internal corrosion is correlated with the water chemistry. The water in the distribution system is rated as mildly corrosive based on the Langelier Saturation Index (LSI) and corrosive based on the Calcium Carbonate Precipitation Potential (CCPP) index. This means that the water has a tendency to corrode material from unprotected metallic and cementitious pipe.

Other factors which can affect the service life of watermains include manufacturing quality, workmanship / bedding during installation, and working pressure (including pressure transients). In addition, pipe fittings can be affected differently to the rest of the watermain.

Condition Assessment

Specific study is required to estimate time to failure. A better understanding of the condition, and therefore the remaining service life, of the District's watermains will be needed to prepare a realistic replacement program. It is recommended that the District maintain detailed records of pipe break history. Information to be recorded would include:

- Date and location
- Type of issue (eg. watermain break, service leak)
- Suspected contributing factors
- Observed condition of watermain and appurtenances

In addition, as the District undertakes watermain maintenance, representative pipe samples should be taken, labelled and stored for future analysis.

A study of the road, watermain, storm and sanitary sewer assets was completed in 2016 (Omega and Associates). Samples of representative watermains were taken for laboratory analysis. The consultant indicated that the watermains were generally in fair condition. The precise location of the pipe samples was not listed to enable their information to be linked to specific pipe assets. As a result, the exact age of the samples isn't known. However, based on District records, the mains sampled are likely to date from the 1960s and 1970s, meaning that they represent the greatest proportion of the mains in the network. The older mains would be expected to be in poorer condition.

TABLE 3-3: PIPE SAMPLE CONDITION ASSESSMENT, 2016

Location	Material	Comment
6th Ave	Cast iron	Corrosion on inner pipe wall
6th Ave	Ductile iron	Casting defect on inner pipe wall.
Coquihalla St	Cast iron (assumed)	No deficiencies
Rupert St	Cast iron (assumed)	Corrosion on inner and outer pipe wall. Casting defects on inner pipe wall. Future watermain breaks expected.

The main concern for the District is the inventory of cast iron, asbestos cement and galvanized iron pipe. Each pipe type is discussed below.

Cast Iron

The District's water distribution system includes 37 km of cast iron watermain (50% of the pipe 100m diameter and over). The cast iron watermain was installed in the period since 1945. District records show cast iron being installed up to the 1980s although, generally speaking, ductile iron replaced grey cast iron as a pipe material in the early 1970s.

In favourable circumstances, cast iron can be a long-lasting pipe material. Premature corrosion related failure relates to local conditions and the expected life will need to be evaluated based on ongoing data collection.

Asbestos Cement

The District's water distribution system includes 3 km of asbestos cement (AC) watermain (4% of the pipe 100m diameter and over). The AC watermain was installed in the period 1957 to 1980, with over half of the pipe installed in 1980. While the service life of AC watermain varies significantly, the relatively corrosive water at Hope will mean the pipe life is reduced compared to much of the BC Interior.

To date, there is no indication of imminent failure of the District's AC watermains. The District has not experienced any increase in maintenance issues associated with AC water distribution mains.

Galvanized Iron

There is almost 2km of galvanized iron pipe. Historically, galvanized iron was most commonly used for smaller diameter pipe. As this material is known to have a limited service life, all of this pipe is at an age where failure is expected. As soon as any issues occur on galvanised iron pipe sections, their replacement should be scheduled, taking care to ensure the new pipe diameter is appropriate for current and future needs. Replacement should also be planned where road maintenance or other construction in the road coincides with galvanized pipe.

3.4.3 Operation

The District of Hope conducts uni-directional and dead-end flushing in order to maintain water quality in the distribution system. Regularly flushing water mains removes stagnant water and deposits from pipes. Spot flushing is also conducted on an as required basis due to complaints or poor water quality and sample results indicating total coliforms.

Despite the lack of a chlorine residual, microbial activity is not thought to be having a significant impact on water quality as there are limited nutrients available (eg. assimilable organic carbon).

3.5 Reservoirs

The District operates four reservoirs. Each reservoir is dedicated to a pressure zone or water system. The only system which has no reservoir is the Lake of the Woods system which delivers water directly to supply and has no fire flow capability. The reservoir details are summarized in Table 3-4.

The District has made a number of recent improvements to the reservoirs including fencing around the Silver Creek Reservoir in 2017.

TABLE 3-4: RESERVOIR SUMMARY

Description	Hope Reservoir 87	Hope Reservoir 138	753 Reservoir[3]	Silver Creek Reservoir	East Kawkawa Lake Reservoir
Facility #	WF-6	WF-7	Private	WF-10	WF-18
Address	64600 Trans Canada Highway	1200 Coquihalla Highway	Thacker Mountain Road	19480 Silverhope Road	66700 Othello Road
Type	Bolted steel	Bolted steel	Concrete	Concrete	Concrete
Constructed	2008	2008	1982	1981	1999
Age	10 years	10 years	36 years	37 years	19 years
Expected Remaining Life	40 years	40 years	60 years	60 years	80+ years
Volume (m^3)	1587	1587	522	425	53
Top Water Level (m)	87	138	130	92	131.5
Depth (m)	6.9	6.9	2.1	2.4	2.3

A number of reservoirs have been abandoned in recent years;

- Old Hope Reservoir (Facility # WF-5). This was an open basin reservoir. It was replaced in 2008 with two glass fused to steel reservoirs.
- Old Silver Creek Reservoir (Facility # WF-11). An old 90m^3 reservoir at an elevation of 86m. It was demolished in 2017.
- South Kawkawa Lake Reservoir (Facility # WF-16). A 305m^3 concrete reservoir constructed in 1981 with a 109m top water level. It was demolished in 2017.

[3] Private Reservoir

3.5.1 87m and 138m Pressure Zone Reservoirs

The 87m and 138m Zones are served by 1,587m^3 insulated glass fused to bolted steel reservoirs, which were both constructed in 2008. The tank inlet and outlet are at opposite sides and elevations in the tanks to improve mixing of the water. As they were built relatively recently, these tanks have been designed as post disaster structures with an assumed importance factor of 1.5. Both reservoirs have good vehicle access and are fenced.

As the reservoirs are relatively new, it is assumed that they remain structurally sound. Draining of the reservoirs for inspection of the structures was not undertaken with this study. There is no evidence of leakage or seepage next to the structures to indicate a significant structural defect.

While bolted steel reservoirs are less costly to build, they have a shorter lifespan than concrete reservoirs. The actual life can depend on many factors including water corrosivity and the quality of installation. The manufacturer indicates that glass-fused tanks should last for 40+ years. It would be reasonable to expect a 40 – 50 year design life for the tanks.

The tanks are fitted with sacrificial cathodic protection anodes to protect against internal corrosion. The anodes are reported to be in good condition. The District should plan to check the sacrificial anodes at regular intervals (3-4 years) for the long-term protection of the tanks.

The reservoirs were inspected by remote operated vehicle in 2017. A budget cost for a more comprehensive manual inspection, cleaning and repair would be $25,000 per tank.

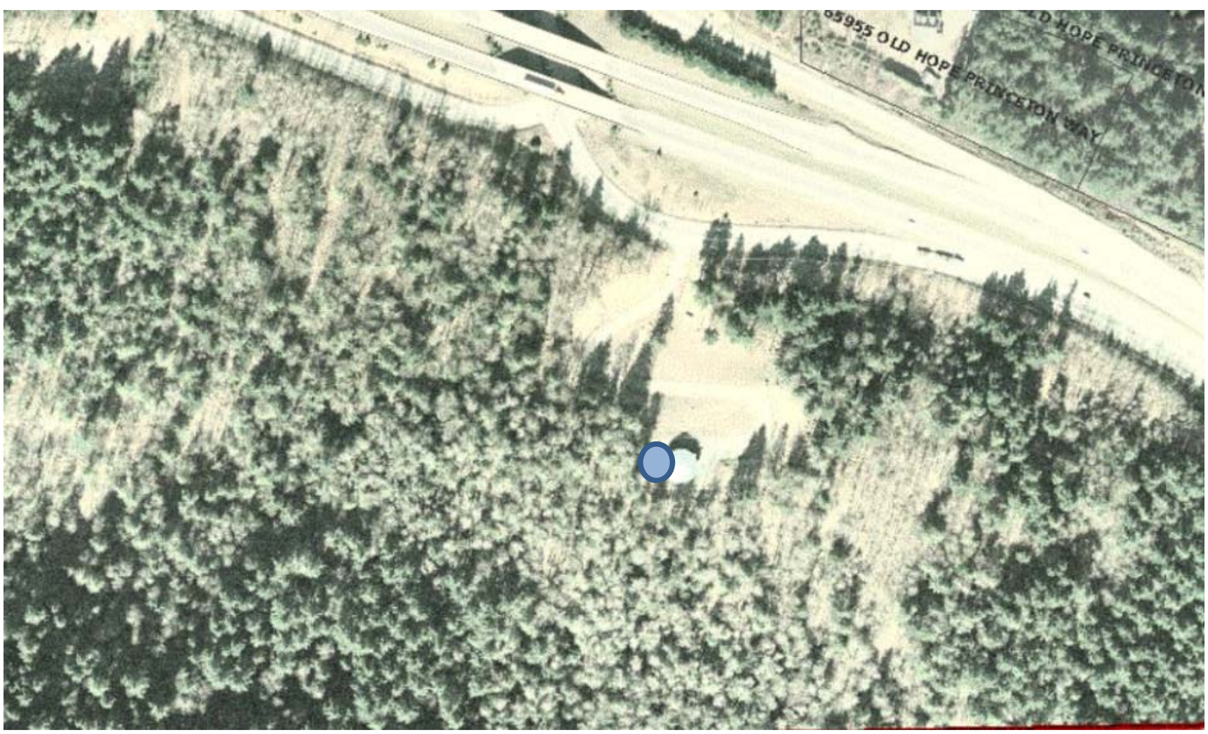
The 87m and 138m reservoirs are filled based on pump control until the reservoir reaches full level. Level monitoring is by pressure transmitter. The reservoirs overflow if there is a communication failure. A magnetic flow meter on the inlet/outlet main measures flow into the reservoir. At present the flow meter on the 138m Reservoir is not functional.

FIGURE 3-12: 87M RESERVOIR

FIGURE 3-13: 87M RESERVOIR SITE PLAN

FIGURE 3-14: 138M RESERVOIR

FIGURE 3-15: 138M RESERVOIR SITE PLAN



3.5.2 753 Reservoir

The 753 Reservoir has a capacity of 522m^3 and was constructed in 1982. The 753 Reservoir overflows when it is fed from the District of Hope water supply. As a result, it has been disconnected from the system until the status of the 753 system is resolved.

In the 753 Water System Study (2017) it was recommended that improvements be made to the 753 Reservoir to address maintenance issues. The recommended upgrades were as follows;

- Install access ladders for the reservoir access hatches
- Provide valve locks
- Repair vertical wall cracks and perform leakage testing
- Install level floats in cell 2 for redundancy
- Replace the telephone pole.

These improvements would be made if the reservoir is reinstated in order to serve a separate Thacker Mountain pressure zone (discussed separately under modeling scenarios). In addition, a dedicated inlet pipeline and altitude valve would be constructed.

FIGURE 3-16: 753 RESERVOIR

FIGURE 3-17: 753 RESERVOIR SITE PLAN

3.5.3 Silver Creek Reservoir

The Silver Creek Reservoir was constructed in 1981. It is a concrete reservoir with a top water elevation of 92m.

There is a legal right of way over the inlet / outlet pipeline, but not over the vehicle access route to the reservoir. The District relies on continued permission of the landowner. A legal right of way is needed to ensure access remains available in the future.

The Silver Creek Reservoir is fitted with a pressure transducer which is used to control pump operation. There are also high and low level float switches to backup the transducer. There is no flow metering at this reservoir.

FIGURE 3-18: SILVER CREEK RESERVOIR

FIGURE 3-19: SILVER CREEK RESERVOIR SITE PLAN

3.5.4 East Kawkawa Lake Reservoir

East Kawkawa Lake is currently served by a 53m^3 concrete reservoir constructed in 1999. The reservoir is too small to provide fire protection and emergency / balancing storage, especially for a community with a single water source. Much more storage would be needed for residential fire fighting, and even more to protect the Nestlé Waters Canada site.

The reservoir is located on the northern boundary of the Nestlé Waters Canada Ltd site. There is a legal right of way over the well / reservoir site and pipe route as it passes across the site. There is no right of way over the access route to the reservoir.

The East Kawkawa Lake Reservoir is fitted with an ultrasonic level transmitter which is used to control pump operation. Flow metering at this reservoir is located on the well outlet.

FIGURE 3-20: EAST KAWKAWA RESERVOIR

FIGURE 3-21: EAST KAWKAWA LAKE RESERVOIR SITE PLAN

4.0 Expectations for Future Network Expansion

There are a number of existing residential areas in the Hope community that are not connected to the community water system. There are also locations which have been identified in the Official Community Plan and by District staff as areas for future development. Many of these may receive water service in the future to improve water safety and access to fire protection.

Significant upgrading and extension of the District's water system may also be triggered by new development. Extensions and upgrading to service new development are typically paid for by the development which benefits and therefore would not be included in the District's Capital Plan. It is important to note that the schedule for development triggered improvements is outside the District's direct control.

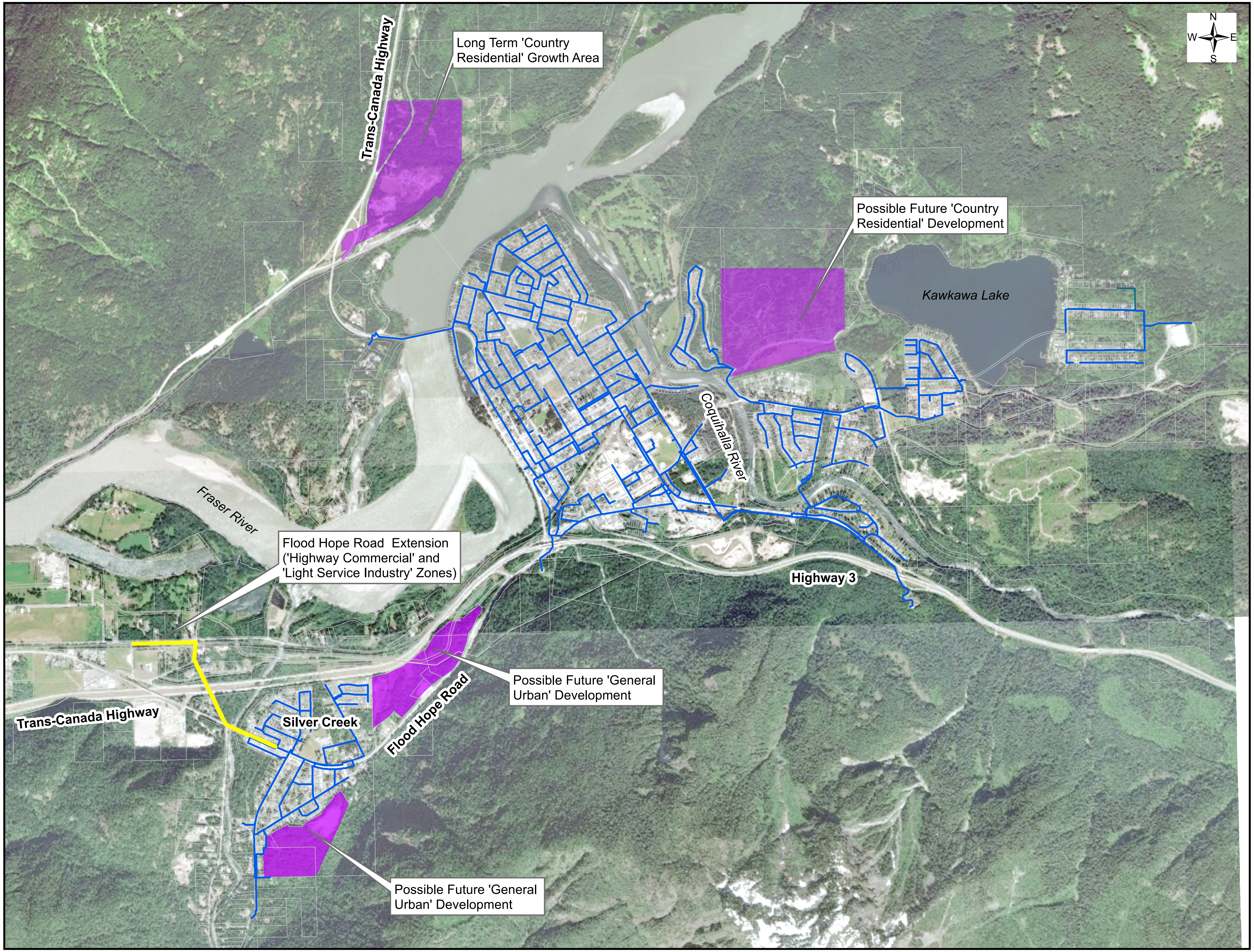
The sections following provide a brief description of likely water system extensions and supply works necessary to service each of the major development proposals. These development servicing strategies have the objective of assisting the District in design decisions supporting water supply works which may ultimately service one or more of the major developments.

The OCP and District staff have identified potential for requests to provide service to major development projects. The current expectations for extension of the system and future development are illustrated on Figure 4-1. They include:

- Potential permanent connection of 753 Water System
- Floods Light Service Industry area
- East of Silver Creek
- Landstrom Road
- Town Centre densification
- Othello Road

DISTRICT OF HOPE

Expected Locations For Water Network Expansion



Legend

Existing Water System

Existing Water System

Water Network Expansion Areas

Hope Flood Road Expansion

1:25,000

0 250 500 1,000 Meters

TRUE

Figure 4-1

R:\Clients\1200-1299\1239\1239-141\03 Drawings\CAD\07 GIS\Maps\Figure 4-1 Expected Expansion Locations.mxd

4.1.1 753 Water System

The 753 Water System is currently connected to the District water system as an emergency measure. The Province wishes to transfer responsibility for the system to the District. In order to protect the District's interests in accepting this transfer of the 753 Water System to District ownership, a number of key infrastructure improvements would first be required. The 753 Water System Study was completed in 2017. It recommended a number of improvements as follows;

A. 753 Reservoir Upgrades (200 mm feed watermain and discharge watermain, reservoir altitude valve, access improvements, crack sealing, controls, etc)
B. 150mm Watermain Extensions (Kettle Valley Rd, Gordon Drive, Dogwood Drive)
C. Hydrant Replacement for Consistency with District System (35 hydrants)
D. Sampling Station Installation (7 stations)

Item A relates to isolation of the Thacker Mountain Subdivision from the 138m Zone in order to improve the performance of the 138m zone. If the existing 753 Reservoir is refurbished as proposed in the 753 Water System Study (2017) then construction of a new high-level reservoir serving Thacker Mountain Road could be avoided. Opus identified that the 753 Reservoir requires access ladders at the entrance hatches, valve locks, a new telephone pole, vertical wall crack sealing / leakage test and level floats in Cell #2 for redundancy. After the upgrade the reservoir would be filled via an altitude valve, rather than the PRV that is recommended in the Study. This proposed design has the advantage of avoiding the construction of a new reservoir. Storage is also adequate for a small residential system. However, water pressure and fire flow at the top of Thacker Mountain Road would remain the same as historical values. As a result, fire flows at hydrants WH0200 and WH0199 and WH0198 would not meet District or FUS design criteria.

The costs allowed for the Thacker Mountain Road upgrades must adequately cover the recommended improvements. Updated costs are provided in Section 7.2.3. A structural inspection should be undertaken prior to acquisition to identify the underlying cause of the cracking. A full membrane liner system should also be considered as part of the crack sealing design.

In order to enable adequate fire protection at the top of Thacker Mountain Road the following would be required instead of the refurbishment of the existing reservoir in Item A (above).

1. Booster pump station.
2. Reservoir with a full water elevation of approximately 150m and a nominal capacity of $500m^3$.
3. Separate inlet and outlet supply mains between the Thacker Mountain Road and the reservoir.

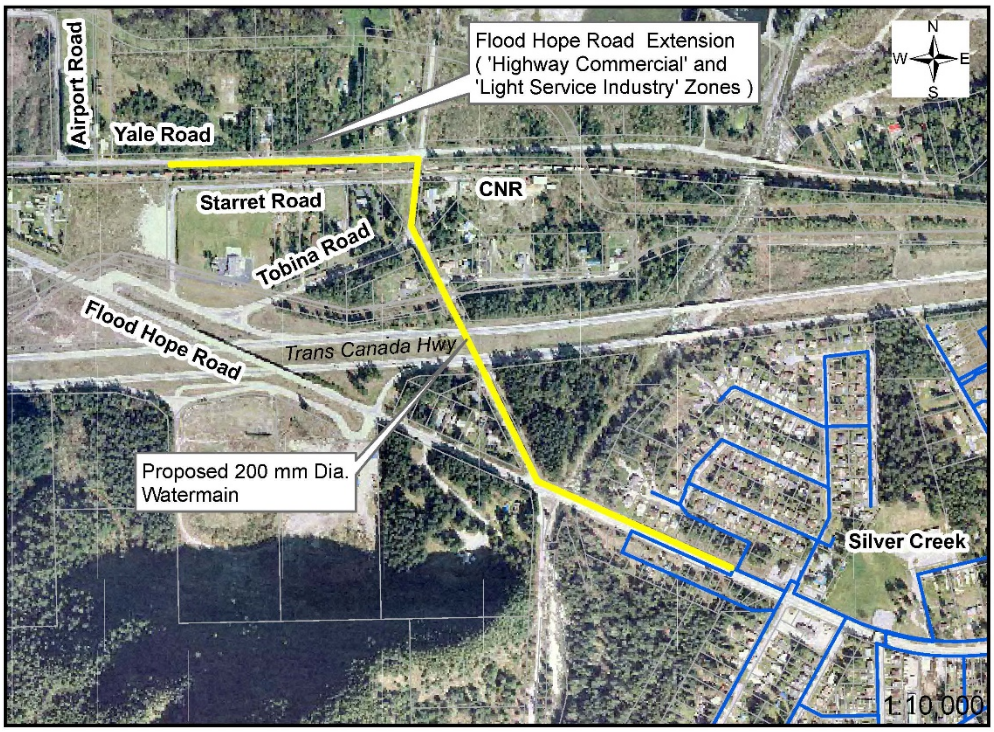
These changes are considered to be cost prohibitive.

4.1.2 Floods Light Service Industry Area

The Floods Light Service Industry Area is located west of the District. A proposed pipeline to the area is illustrated on Figure 4-2. This would provide for future development and fire protection.

Water supply infrastructure that would need to be constructed consists of 1,500m of minimum 200mmØ pipe: A watermain route from the end of the 250mmØ main on Flood Hope Road following Yale Rd under the Trans-Canada Highway was previously proposed as part of the 1994 DCC Study.

FIGURE 4-2: PROPOSED WATERMAIN TO FLOOD LIGHT SERVICE INDUSTRY AREA



4.1.3 Landstrom Road

The District has identified increased density housing on Landstrom Road as a possibility. The extension of a watermain to this area would be a development driven project and would necessitate the construction of a booster station and reservoir. This project would only be initiated based on a call for development in the area and funding would be by the benefiting residents. Project components would include;

- A reservoir having a capacity of approximately 500m^3 and a design full water level of about 100m. The reservoir capacity would be determined on the basis of detailed information on the number of proposed units and fire flow requirements.

- A booster station tentatively located at the east end of the Highway 1 Bridge pumping to the proposed Reservoir.
- Watermain to connect to the new reservoir.

The existing pipeline crossing the Highway 1 Bridge also requires an upgrade from 125mm to at least 200mm.

5.0 SCADA / Operations Assessment

5.1 Communications

5.1.1 Existing Communications

The District's SCADA/operations systems have been upgraded in a piecemeal fashion as the District has grown. Communications throughout the District includes wireless radios of different frequencies as well as phone modem connections. The lack of uniformity has made the existing system difficult to service as a cohesive communications diagram and control narrative is not in place to explain how each piece of the system integrates with the rest.

Many parts of the water system are subject to fading, which means that various radio links will fail in a communication outage condition. Off the shelf equipment has been installed without planning for the addition of future channels or performance in adverse weather conditions. The signal fading can also be attributed to the lack of a site survey for the system. A site survey makes it clear where radios should be aimed and how antennas should be sized and selected for optimal performance. The District should budget approximately $20,000 for a radio survey.

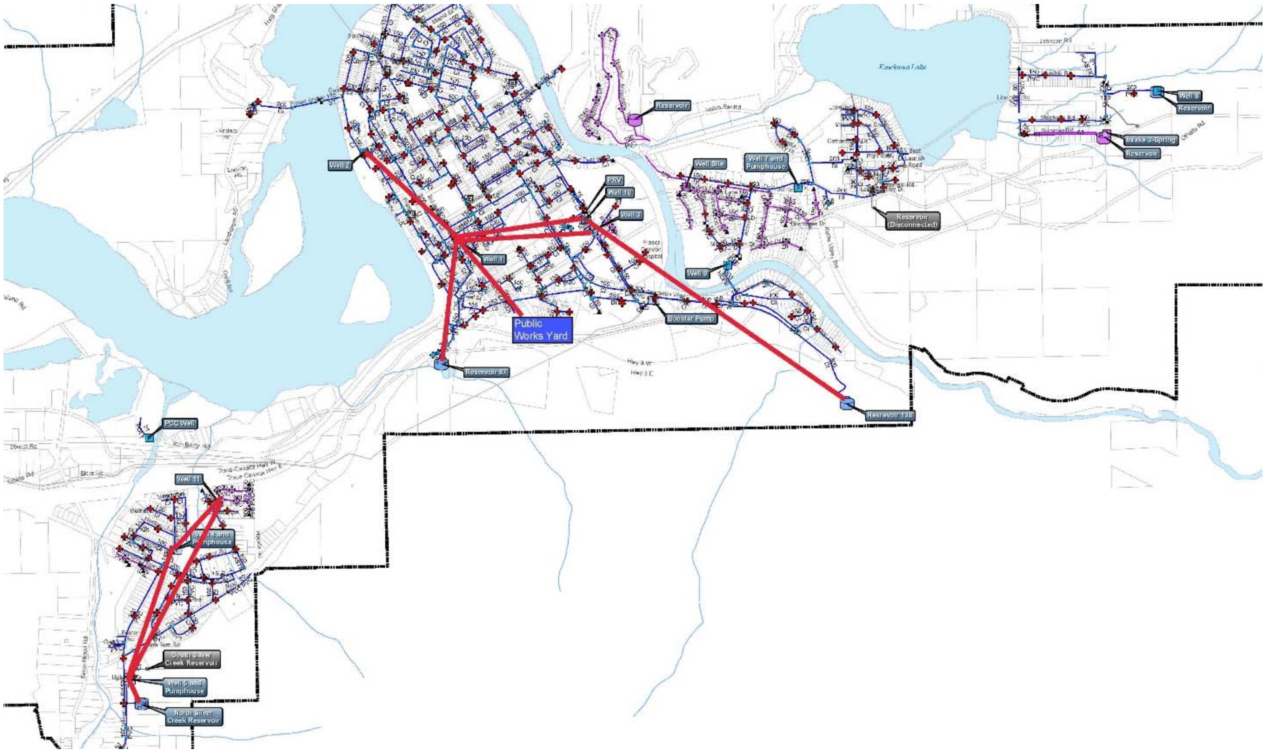
System communications are based on radio links as follows;

- 419 MHz radio link from Wells #2, #3, #10 to Well #1 (Well #3 to Well #1 subject to winter communication failure)
- 419 MHz radio link from Well #1 to Public Works Yard
- 419 MHz radio link from 138 Reservoir to Well 10 (subject to winter communication failure)
- 419 MHz radio link from 87 Reservoir to Well #1.
- Telus leased phone line link from Well #4 to Well #5 (unreliable).
- 900 MHz radio link from Well #5 to Well #11 (unreliable).
- Tech cable from Silver Creek Reservoir to Well #5.
- No communication to public works yard from East Kawkawa Lake, Silver Creek and Well #7.
- No communication to public works yard from wastewater conveyance and treatment system.

The majority of the radios use a 419MHz licensed band. The licensed band means that only the District may transmit on that frequency, which reduces the chance of interference and a shortage of available channels when using a public (ISM) band. Typically, a 400MHz frequency is used in areas where topography is challenging, as it has better penetration abilities than some alternatives. However, a 400MHz radio gives limited bandwidth and speed. This means that the communication system can only transmit basic aggregated SCADA data points. Remote access for viewing local human machine interfaces at each site, or for making remote PLC program changes, could easily overload the channel and temporarily take the link offline.

Because of the mountainous topography, Silver Creek relies on a dial-up modem to communicate pump start and stop conditions. This system has proven very unreliable.

FIGURE 5-1: EXISTING COMMUNICATION LINKS



5.1.2 Recommendations

The radio system should be upgraded to use higher frequencies in the 5.8GHz range. This will allow for remote access and increased communication bandwidth. There are some links where topography limits radio connection reliability such as Silver Creek and periodically to Well 3 and the 138m Reservoir. In these cases, cellular can be used with an internet (Telus or Shaw) backup operating in a fail-safe mode to ensure continuous communications. This would provide the District with a robust system that is mostly internally managed and has a minimal reliance on a third-party internet service provider.

In the immediate future, it is recommended that the Silver Creek communications system be replaced with cellular gateways to eliminate the phone modem and 900MHz radio link. The monthly cost of each of the three nodes in this network would be approximately $10/month for a data plan.

The use of fiber optical cable is another way to increase overall communication system reliability. Unlike copper conductors and radio transmitters, fiber is inexpensive and immune to electrical interference. Fiber is also somewhat future-proof as the optical cable in the ground can support higher speeds without having to change the glass fibers. The District should consider installing fiber cable in trenches whenever new water mains are installed. As the fiber is expanded throughout the District, it would eventually replace problematic radio and modem communication links.

TABLE 5-1: EXISTING AND PROPOSED COMMUNICATION LINKS - WATER

Link Location		**Infrastructure**	
From	**To**	**Existing**	**Proposed**
Well 2	Well 1	419 MHz Radio	5.8 GHz Radio / Cellular Backup
Well 3	Well 1	419 MHz Radio	5.8 GHz Radio / Cellular Backup
138m Reservoir	Well 10	419 MHz Radio	5.8 GHz Radio / Cellular Backup
Well 10	Well 1	419 MHz Radio	5.8 GHz Radio / Cellular Backup
87m Reservoir	Well 1	419 MHz Radio	5.8 GHz Radio / Cellular Backup
Well 1	Public Works	419 MHz Radio	5.8 GHz Radio / Cellular Backup
Well 4	Well 5	Dial Up Modem	5.8 GHz Radio / Cellular Backup
Well 11	Well 5	900 MHz Radio	5.8 GHz Radio / Cellular Backup
Well 5	Public Works Emergency Number	Dial Up Modem	Delete
Well 11	Public Works	-	Fibre optic cable to 87m Reservoir
Existing Silver Creek Reservoir	Well 5	Tech Cable	Tech Cable (no change)
Proposed Silver Creek Reservoir	Public Works	-	Fibre optic cable to 87m Reservoir
Well 8	Public Works		Cellular modem
Well 7	Public Works	None	Cellular modem

5.2 Control

Data collected from the network is ultimately received at the Public Works Yard where the control system generates alarms and records system data. Presently the SCADA system is based on Schneider Electric ClearSCADA. This was installed as an interim platform and has limited functionality. The system is also relatively old and lacks important features including;

- Access to SCADA system using portable devices
- Ability to control equipment remotely
- Ability to acknowledge alarms
- Automatic generation of daily status reports
- Ability to export long term trend data
- Cyber security

Various additional local input features are needed such as an intrusion alarm at the 87m Reservoir and well level probes in several of the wells.

It is proposed that a modern SCADA system be installed to improve the ability of the District to monitor and manage the water and the wastewater systems. A SCADA upgrade would cost around $60,000 including software licenses, hardware and programming, but excluding engineering.

5.3 Sewage Lift Stations

For efficiency and consistency, an upgrade of the water system communications and controls should be combined with improvements to the wastewater system.

The District's sewage lift station communications are stand-alone and don't communicate with a central monitoring system. Each kiosk is fitted with an alarm dialer that calls the operators when a problem arises. An alarm requires an immediate site visit to investigate. A central SCADA monitoring system would permit alarms and process variables to be monitored remotely. The operator can determine whether, or how soon, physical intervention is required. This reduces the frequency and cost of call-outs.

It is recommended that a cellular gateway be added to each station for status monitoring. Since the link would not be used to control the lift station, its reliability does not have to meet utility standards and could be achieved with a cellular device and a small data plan costing less than $10/month. Link reliability can be improved using a second SIM card to allow two networks to be used for backup (eg. Telus and Rogers).

The lift station control is mostly configured using basic relay logic instead of programmable logic controllers (PLC). The benefits of PLC control are:

- Increased process control with the ability to change level setpoints. For example, lift pump start/stop setpoints and alarm conditions may have to be adjusted. This would require an electrician to make physical changes to the instrumentation if changes were necessary.
- Alarm handling – generating specific alarms to alert of problem conditions
- Remote monitoring and control (via cellphone/SCADA PC)
- Increased reliability as problematic mechanical relays would be removed

A PLC retrofit would cost approximately $30,000 per lift station depending on the instrumentation and site requirements.

TABLE 5-2: EXISTING AND PROPOSED COMMUNICATION LINKS - SEWAGE

Link Location		**Infrastructure**	
From	**To**	**Existing**	**Proposed**
Pollution Control Centre	Public Works	-	5.8 GHz Radio / Cellular Backup
Coquihalla PS	Public Works	Autodialler	Cellular modem
Far Grinder PS	Public Works	Autodialler	Cellular modem
Kettle Valley PS	Public Works	Autodialler	Cellular modem
Lindgren PS	Public Works	Autodialler	Cellular modem
Ridge Way Grinder PS	Public Works	Autodialler	Cellular modem
Rupert PS	Public Works	Autodialler	Cellular modem
SST0007 PS	Public Works	Autodialler	Cellular modem
Starret PS	Public Works	Autodialler	Cellular modem
Thacker Mountain PS	Public Works	Autodialler	Cellular modem
Tom Berry PS	Public Works	Autodialler	Cellular modem
Union Bar Grinder PS	Public Works	Autodialler	Cellular modem

5.4 Record Keeping

It would be useful to convert the District flow meters to record in metric units so that consistent measurement units can be used throughout the system. Presently the records are kept in m^3/h, imperial gallons per minute and US gallons per minute. It isn't stated which form of gallons is used, giving a potential for a 20% error when calculating flows.

6.0 Hydraulic Modelling

6.1 District Design Criteria

The design criteria relevant to the District of Hope water supply are generally summarized in the Subdivision and Development Servicing Bylaw. The Bylaw incorporates a Design Criteria Manual. Section 'W' of the Manual describes water system minimum requirements.

6.1.1 Water Demand

Domestic water demands for use in design are listed in the Design Criteria Manual as follows;

Average daily domestic flow	675 liters/capita/day
Peak Day Demand	1575 liters/capita/day
Peak Hour Demand	2500 liters/capita/day

The Bylaw permits the property classifications L-1, RU-1, AG-1, CR-1, AP-1, CHP-1, RRA-1 to use private wells. All other classifications must be connected to the community utility.

6.1.2 Water Pressure

The Design Criteria Manual lists the community service pressure requirements as follows;

Maximum allowable pressure	900 kPa.
Minimum press anywhere in the system during design fire flow (FF) plus Peak Day Demand (PDD)	150 kPa
Minimum pressure at Peak Hour Demand (PH)	300 kPa

6.1.3 Fire Flows

The Design Criteria Manual lists the following standards for acceptable fire flows:

- Insurance Services Office (ISO) "Needed Fire Flow Guide";
- NFPA 1231 "Standard for Water Supply for Suburban and Rural Fire Fighting";
- American Water Works Association "Distribution Requirements for Fire Protection"; and,
- Other standards as approved by the Fire Chief.

6.1.4 Reservoir Storage

The storage required is calculated according to the requirements set out in the MMCD Design Guideline Manual and Fire Underwriters Survey Guideline (Water Supply for Public Fire Protection, 1999).

The required storage, based on MMCD design criteria, is as follows;

A	Calculated fire flow storage requirement
B	Balancing Storage Requirement (25% of MDD)
C	Optional Emergency Storage (25% of A+B)
D	Total Storage Required (A+B+C)

6.2 Water Model Development

A network model has been prepared and calibrated for the assessment of the District's water distribution system. Modeling enables the calculation of the capacity of the distribution to provide fire flow to any pipe intersection or node in the system. The performance of a fire hydrant depends on many factors influencing the local flow including the prevailing water pressures at the hydrant, as well as at high points in the network, which must be kept above a minimum pressure. The modeling can predict the impact that pipe sizes and water consumption can have on the available flow. Modeling can also be used by the District to assess each system's capacity to service new developments.

A functional water model of the water system was first prepared in 2005. It was updated in 2017 to analyze scenarios relating to the connection of the District and 753 Water systems. At that time the water model did not include the Silver Creek and East Kawkawa Lake water systems. These have been added, along with general improvements to the underlying database and model conditions.

The resulting improved model has been used to identify existing system deficiencies, focusing particularly on fire flow, and to assess system improvement options to resolve the deficiencies.

6.3 Existing Fire Flow and Service Pressure Assessment

6.3.1 Fire Flow Requirements

The Fire Underwriters Survey (FUS) is a national organization which provides data on public fire protection for fire insurance statistical work and underwriting purposes of subscribing insurance companies. The FUS collects information on public fire protection efforts in communities all across Canada. A rating based on the FUS's grading system is therefore typically used as a basis in fire insurance underwriting programs and helps these subscribers to assess the amount of risk they are willing to assume within a community. Fire insurance rates are also set for commercial properties using this information. The FUS weighting system for assessing community protection is as follows:

- Fire Department 40%
- Water Supply 30%
- Fire Safety Control 20%
- Fire Service Communication 10%

Since an assessment of the fire department and related communication and controls are outside the project scope, this study focuses on the water supply portion of the weighting system. The suitability of the water supply depends on the ability to provide a sufficient flow, pressure and volume of water to fight a designated fire and sufficient hydrants that water is in close proximity to buildings in the community.

Fire flow requirements are described in a publication titled 'Water Supply for Public Fire Protection' issued by the Fire Underwriters Survey (FUS). The primary factors that determine fire flow required are:

- The size of building;
- Fire resistivity of the type of construction;
- Occupancy hazard;
- Whether or not building has a fire sprinkler system;
- Exposure, i.e. how close is the building to other buildings.

The most widely referenced minimum flow requirements are from the MMCD "Design Guideline Manual" presented in Table 6-1. The minimum requirements specified by MMCD are conservative and used as a guide to indicate where a more detailed assessment may be warranted using the FUS method. Because the MMCD requirements are generalizations, they do not accurately reflect the FUS guidelines for all applications.

TABLE 6-1: MMCD MINIMUM FIRE FLOW REQUIREMENTS

Development type	Fire Flow (L/s)
Single Family Residential	60
Multi-Family, Townhouses	90
Commercial	150
Institutional	150
Industrial	225

It should be understood that friction headloss in fire hydrant assemblies becomes limiting at flows greater than 90 L/s. A fire crew must use more than one hydrant to achieve higher flows.

The FUS guidelines state that the required fire flow should be available when the water system is supplying the maximum day water demand. Maximum day water demands are typically experienced for a one to two-week period in the summer when lawn and garden irrigation usage peaks. The flow should be available with the supply pumps turned off.

The FUS guidelines also require a minimum residual pressure of 140 kPa (20 psi) to be available everywhere in the water system service area. It is important to note that under a fire emergency condition, fire crews use the water they need without consideration for residual pressures elsewhere in the system. Therefore, during emergency conditions, the available fire flow will be greater than shown by modeling.

6.3.2 Modelling Results

Based on these criteria, fire flow modelling was undertaken at maximum day demand with pressures at the test hydrant being at least 140 kPa (20 psi) with no point elsewhere in the distribution system less than 20 psi.

The water model calculates available fire flow for every hydrant in the District's water system based on assumed demand conditions. The demand used was the maximum day demand consistent with FUS guidelines. The modelling results are illustrated in figures as described below. Available fire flow ranges have been assigned a colour which then provides a means to illustrate available fire flow in a neighbourhood. Available fire flows are summarized with comparison to the MMCD fire flow requirements (Table 6-1). Figure 6-1 shows which water system the nodes are part of, as well as the static water pressures that apply to each location. These static pressures represent the systems 'at rest' with no demand for water from the community.

Figure 6-2 illustrates fire flow requirements throughout the community, generally based on the MMCD criteria along with the fire flows that would be expected if the 753 System was not connected to the network. The flows shown for the 753 System are those that would be expected from the 753 Reservoir.

In Figure 6-3 the flows are shown with the 753 System connected to the network, as is currently the case. The model includes connections at Kawkawa Lake Road, Gordon Drive, Dogwood Drive, and Swallow Place. The model assumes the 753 Reservoir is not active in this scenario. The 753 Zone is serviced by the 138m Reservoir. This figure demonstrates that by connecting the 753 Zone to the 138m Zone, the available fire flow throughout the 138m Zone is reduced.

In reference to Figure 6-3, the modelling summary (Table 6-2) indicates many areas of deficient fire flow. The deficiencies relate to both general and hydrant specific issues. These deficiencies are considered further in the next section of the report.

TABLE 6-2: FIRE FLOW MODELLING RESULTS (753 SYSTEM CONNECTED)

Neighbourhood	Available Fire Flow (L/s)
87m Zone	
Single Family Residential (60 L/s)	30 to 147
Institutional & Commercial (150 L/s)	27 to 122
Industrial (225(L/s)	60 – 122
138m Zone / 753 System	
Single Family Residential (60 L/s)	12 to 69
Institutional & Commercial (150 L/s)	37 - 58
East Kawkawa	
Single Family Residential (60 L/s)	7 - 106
Silver Creek	
Single Family Residential[4]	18 to 45

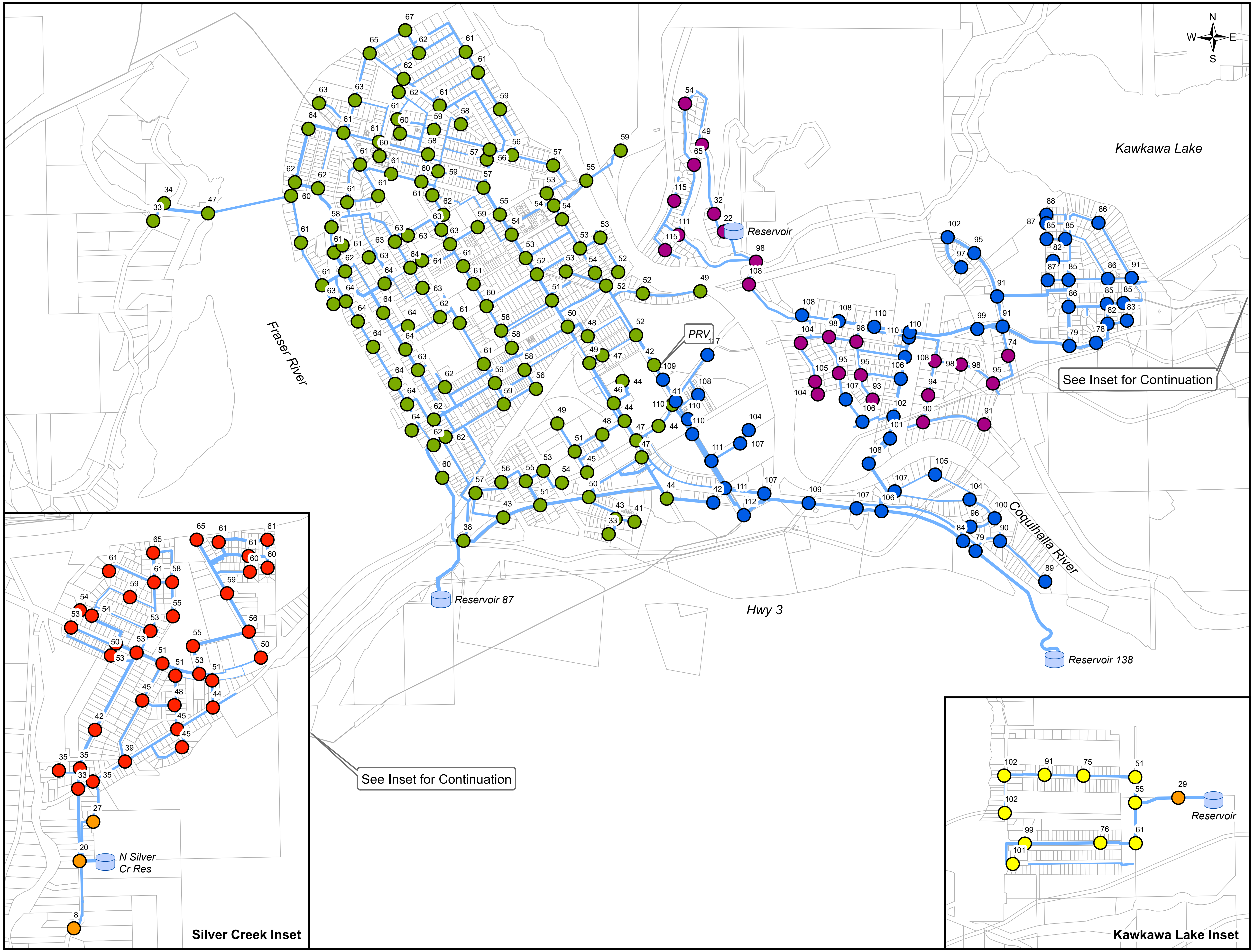
Water pressure is at a minimum at the high point of a zone. Unfortunately, as a result of some isolated high elevation areas, the ability of the District to provide adequate fire flows is generally restricted. In order to fully service these areas for fire protection, reservoirs and pressure booster stations are needed for the elevated areas (eg. Thacker Mountain Road, Landstrom Road and Upper Silver Creek). As they would service small residential areas a nominal 500m^3 reservoir would be likely to be sufficient. Alternatively, a water service with no fire protection could be provided to Thacker Mountain Road and Landstrom Road, based on the pressure booster station design already serving Upper Silver Creek. Either way, Thacker Mountain Road and any future development on Landstrom Road need to be removed from their existing pressure zones to improve the protection of the general community.

Some of the general issues which limit fire flows are as follows:

- <u>87m Zone:</u> The water system extension west of the Fraser River and Ryder Streets limit available fire flow throughout the 87m Zone.

[4] Excluding boosted zone.

- <u>138m Zone / 753 System:</u> The highest extents of this zone limit the available fire flow. This issue greatly affects the 138m Zone when connected to the 753 Zone.
- <u>East Kawkawa Zone:</u> If considered, the fire hydrant adjacent to the Nestle Waters Canada property is the limiting factor for fire flows in this zone. This fire hydrant was not included in the water modeling scenarios. Significant system improvements would be needed to provide for industrial fire flows and storage.
- <u>Silver Creek Zone:</u> The existing boosted zone along the southern extents of Silverhope Road are not included in this assessment. The highest extents of Old Yale Road limit available fire flow throughout the Silver Creek Zone.



DISTRICT OF HOPE

Existing Zones & Static Pressures

Legend

Zone
- 138m Zone
- 87m Zone
- East Kawkawa Zone
- FF Excluded
- SC Zone
- 753 Zone
- Reservoir

Pipe Diameter
- 25 - 50
- 50 - 100
- 100 - 150
- 150 - 300
- > 300

1:15,000

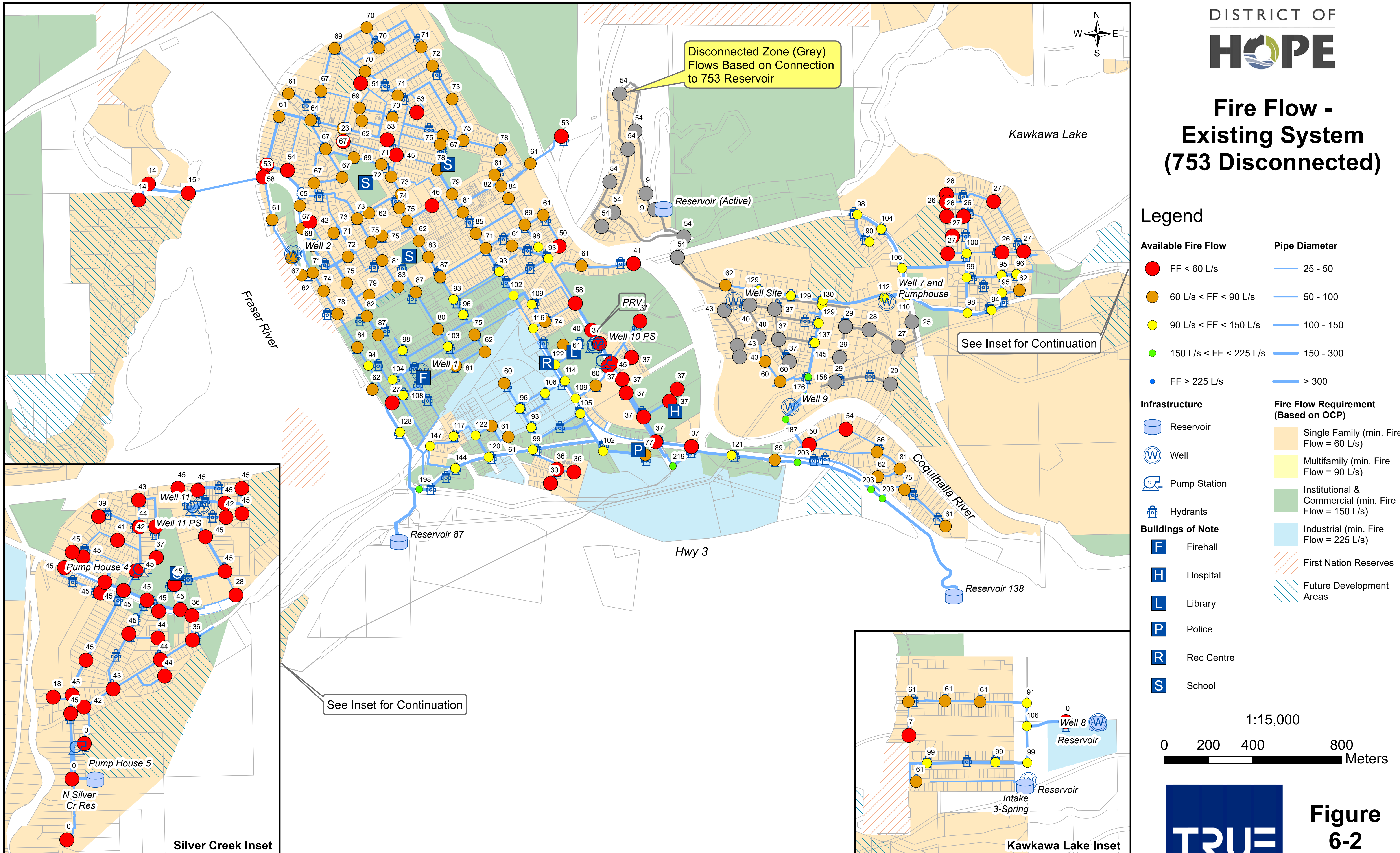
0 200 400 800 Meters

TRUE

Figure 6-1

R:\Clients\1200-1299\1239\1239-141\03 Drawings\CAD\07 GIS\Maps\Figure 7-1 - Existing Zones & Pressures.mxd

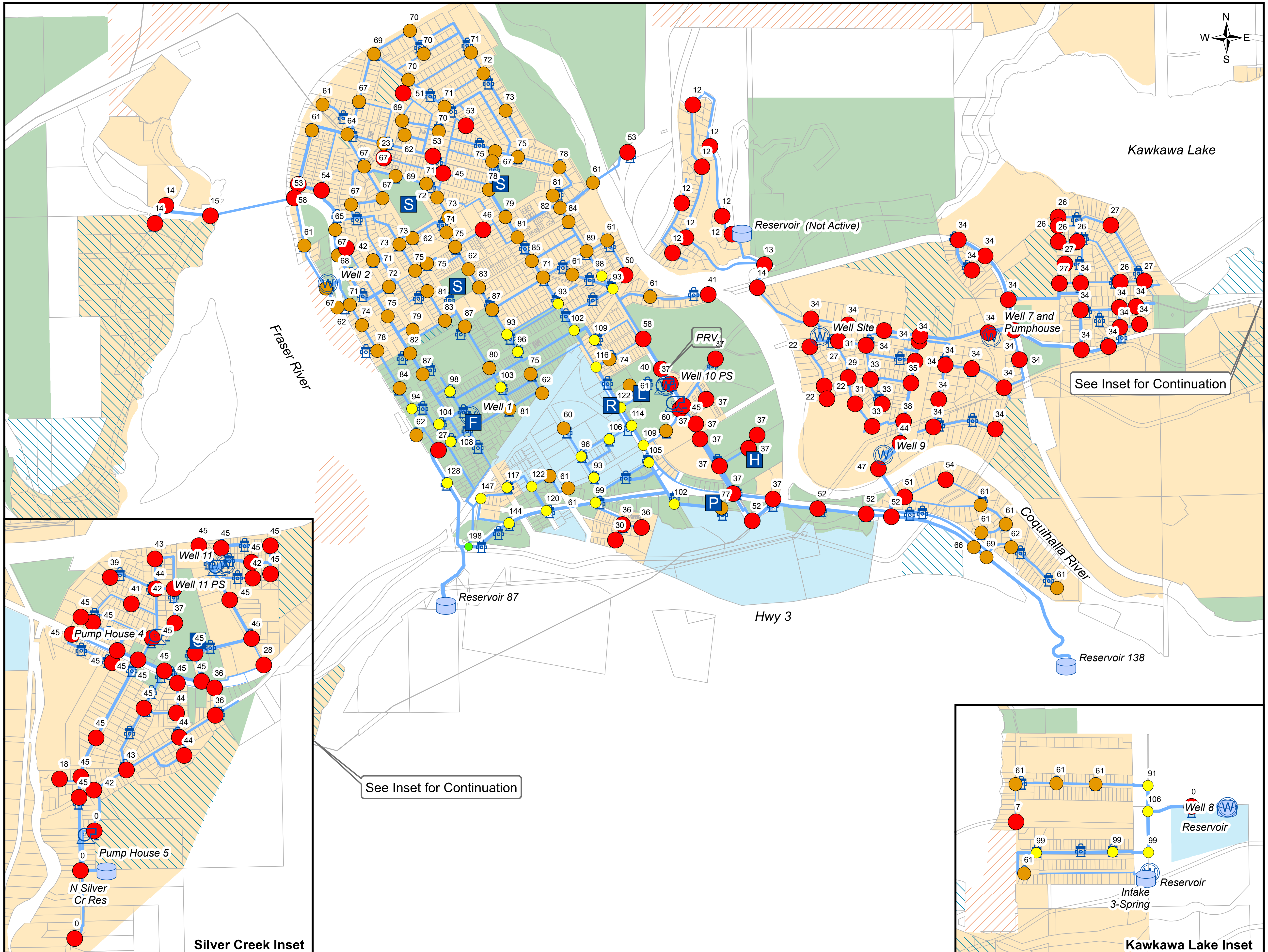
DISTRICT OF HOPE



Fire Flow - Existing System (753 Disconnected)

Figure 6-2

R:\Clients\1200-1299\1239\1239-141\03 Drawings\CAD\07 GIS\Maps\Figure 7-2 - Existing with 753 Disconnected.mxd



DISTRICT OF HOPE

Fire Flow - Existing System (753 Connected)

Legend

Available Fire Flow

- FF < 60 L/s
- 60 L/s < FF < 90 L/s
- 90 L/s < FF < 150 L/s
- 150 L/s < FF < 225 L/s
- FF > 225 L/s

Pipe Diameter

- 25 - 50
- 50 - 100
- 100 - 150
- 150 - 300
- > 300

Infrastructure

- Reservoir
- Well
- Pump Station
- Hydrants

Fire Flow Requirement (Based on OCP)

- Single Family (min. Fire Flow = 60 L/s)
- Multifamily (min. Fire Flow = 90 L/s)
- Institutional & Commercial (min. Fire Flow = 150 L/s)
- Industrial (min. Fire Flow = 225 L/s)
- First Nation Reserves
- Future Development Areas

Buildings of Note

- F Firehall
- H Hospital
- L Library
- P Police
- R Rec Centre
- S School

1:15,000

0 200 400 800 Meters

TRUE

Figure 6-3

R:\Clients\1200-1299\1239\1239-141\03 Drawings\CAD\07 GIS\Maps\Figure 7-3 - Existing with 753 Connected.mxd

6.4 Modelling of Proposed Network Improvements

The network model was used to test and compare distribution system upgrading options with the objective of resolving the deficiencies. Recommended distribution system upgrading projects intended to address fire flow deficiencies are as follows;

6.4.1 7th Avenue Watermain Upgrade

Under this scenario, approximately 75m of 150mm watermain is upgraded to 300mm diameter pipe from the southern end of 7th Avenue. As illustrated in Figure 6-7, the available fire flow for the Fraser Canyon Hospital area increases significantly as a result of this upgrade.

6.4.2 753 Upgrades

This scenario includes upgrades consistent with the 753 Water System Study report produced by Opus International Consultants (Canada). The proposed upgrades include:

- Construct a dedicated supply watermain from lower Thacker Mountain Road to the 753 Reservoir.
- Install an altitude valve on the 753 Reservoir inlet to control filling and prevent overflows.
- Upsize the 753 Reservoir outlet watermain from 150mm to 200mm diameter.

An additional upgrade option is an automated valve that would allow water to return to the 138m network from the Thacker Mountain Road Reservoir in the event of low pressures at the 753 System. This could only be used in the event that the 138m reservoir level drops to a relatively low level (bearing in mind dynamic pressure losses).

The outcome of the modeling is illustrated by Figure 6-4.

6.4.3 Disconnect Area West of Fraser River

The existing water connections in the 87m Zone on the opposite side of the Fraser River are;

1. A Canadian Pacific Rail water connection to the Haig Station.
2. The Hope Garden Centre

This model result assumes that the water system extension to the opposite side of the Fraser River is isolated from the 87m Zone. The result is a significant improvement in fire flows in the 87m zone. The outcome of the modeling is illustrated by Figure 6-5.

Long term, this result would be achieved by installing a booster station and reservoir. With a new dedicated reservoir, the flows available at the existing hydrants on the western side of the bridge would improve to an acceptable level.

As an interim measure, it is suggested that a backflow prevention device be fitted to each service to prevent contamination of the 87m Zone in the event of low pressures at this high point. As a side note, it is assumed that the Mt Hope Seventh Day Adventist Church on Ryder St will also be fitted with a backflow prevention device.

6.4.4 Connection 138m Zone to East Kawkawa Lake

There is a limited practical ability to fight a fire in the East Kawkawa Zone at this time because the East Kawkawa Reservoir only has a capacity of 53m^3. It is designed to store water for efficient pump operation, and not for fire fighting. A nominal reservoir capacity around 500m^3 would be needed for a single-family residential fire. Rather than build this reservoir and a new well to back up well 8, this scenario proposes a new 300mm diameter supply main between the 138 Zone and the East Kawkawa Zone. Wells 8 and 10 would become available to both zones, providing redundancy which is currently a critical shortcoming of both systems. It is likely to be necessary to replace the Well #8 pump to accommodate the change in pumping conditions.

When reviewing Figure 6-6 it should be noted that under this scenario, while flows remain acceptable, available residential fire flows in the 138m and East Kawkawa Zone are reduced. It is assumed that the hydrant on the Nestlé Waters Canada site would be removed due to its impact on available fire flow in the rest of the network, and its limited functionality.

The East Kawkawa reservoir would be decommissioned. Nestlé Waters Canada may find it useful as a source of water to their existing hydrant (noting that the available flow and storage are far less than needed).

6.4.5 Raise Hydraulic Grade in Silver Creek and Connect 87m Zone (Base Option)

This scenario proposes a 300mm diameter watermain connection between the 87m Zone and Silver Creek Zone. Please refer to Figure 6-8. A reservoir is also proposed at a full water elevation of approximately 120m. The reservoir would be filled by the Silver Creek wells and would generally only provide water to the Silver Creek Zone. In order to provide for a shortfall in water storage in the 87m Zone, a PRV station would allow water to flow from the new reservoir to the 87m zone when pressures drop below a pre-set level in the 87m Zone.

This improvement option increases available fire flow within the Silver Creek Zone due to the hydraulic grade of the reservoir increasing from the existing level of 92m to approximately 120m. In addition, the boosted zone at the southern end of Silverhope Road can be eliminated, with this area becoming directly connected to the new Silver Creek pressure zone. This allows the pressure booster station to be decommissioned. It should be noted that the available fire flow in the former boosted zone would be limited to around 30L/s if the proposed reservoir FWL is 120m. At present hydrants cannot be provided in this area, so it is still an improvement.

A booster station could be installed on the 87m Zone side of the proposed reservoir to allow for movement of water from the 87m Zone to the Silver Creek Zone. However, this booster station would be a low priority as Silver Creek has three wells in operation and ample capacity.

One of the most important benefits of this option is the ability to transfer water from Silver Creek to the 87m Zone. Supply capacity is plentiful in the Silver Creek Zone and the 87m Zone is relatively restricted, with relatively old wells in service.

6.4.6 Raise Hydraulic Grade in Silver Creek (Alternative Option)

This scenario consists of a new reservoir at a higher elevation (approximately 120m), located in the vicinity of the existing reservoir. It represents an alternative to constructing a reservoir on Flood-Hope Road. The option may be favoured in the event that topographical challenges, land acquisition or other constraints make construction of the base option unfeasible.

This option does not specifically call for a pipeline linking Silver Creek with the 87m Zone. The pipeline alignment along Flood-Hope Road would require a break pressure tank at the high point. A lower elevation pipe route would be preferable to avoid this requirement.

6.4.7 Reservoir West of Fraser River

This scenario proposes a new pressure zone incorporating a watermain extension along Landstom Road (see Figure 6-10). The zone would be served by a new booster station and a reservoir on the north/west side of the Fraser River. The existing supply main on the Trans-Canada Highway bridge would be upgraded from a 125mm main to a 200mm main. A PRV could also be provided to permit water to return to the 87m pressure zones. We understand that upgrades to the Trans-Canada Highway bridge are currently being considered. The upgraded supply main on the bridge should be coordinated with any future bridge upgrades.

6.4.8 General Replacement of Small Diameter Pipe

This scenario is presented to illustrate water system improvements that can be achieved by upgrading all watermains within the District's water system that are less than 125mm diameter. The majority of this pipe is small diameter cast iron pipe that is likely at or near the end of its' service lifespan. As a result, this upgrade would prioritize the replacement of approximately 10.5 km of aging pipe in accordance with the District's asset management plan. The scale of this project would require completion over an extended time period. The resulting improvements to fire flows are shown on Figure 6-11. It has been assumed that the improvements described previously have already been completed.

6.4.9 Long Term Looping Improvements

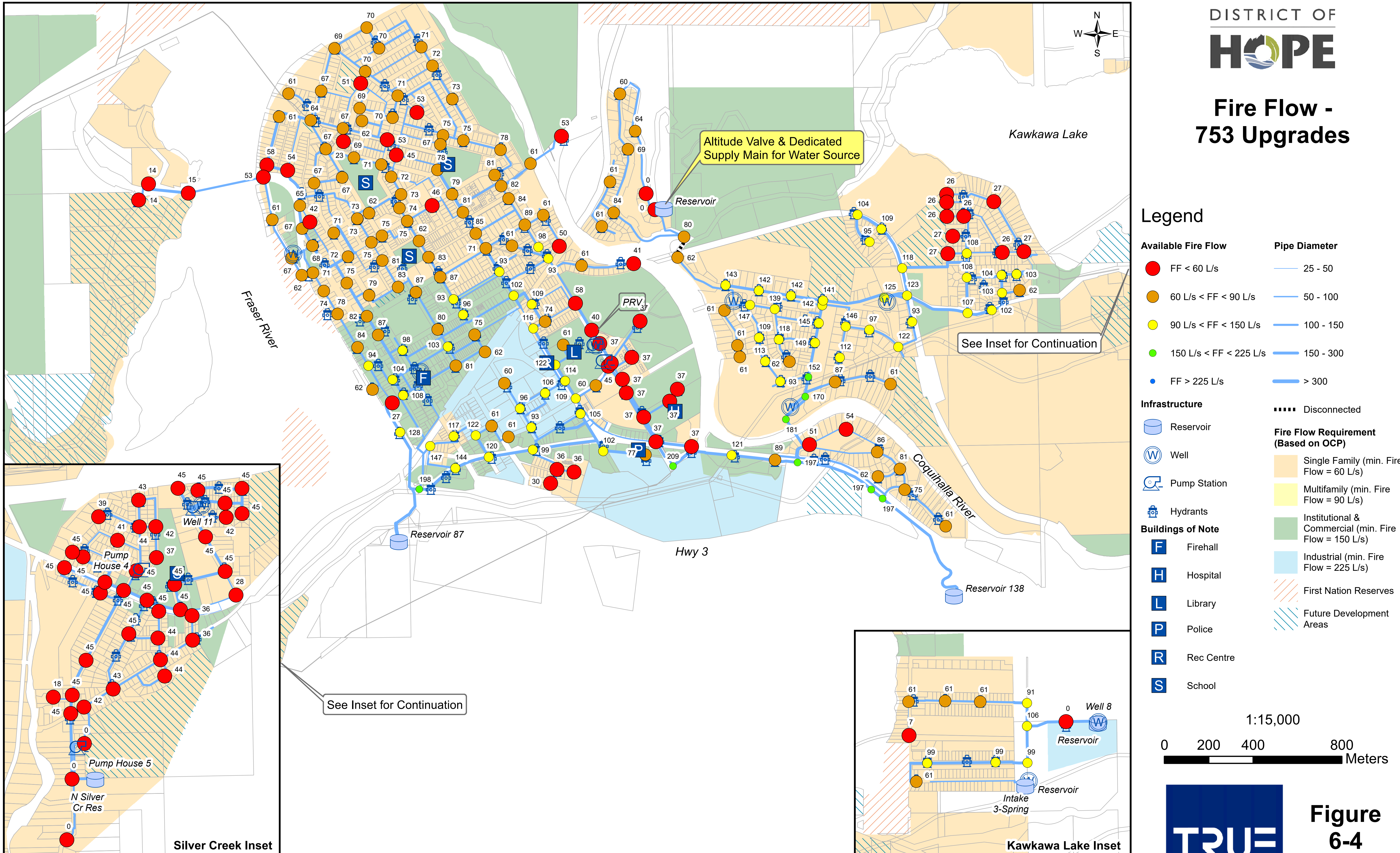
The impact of two proposed pipe loops have been modeled as follows:

- **Silver Creek Zone:** 200mm watermain connection between Beacon Road and Beech Avenue. This loop is expected to be completed in the near future by a private developer.
- **138m Zone:** 250mm watermain connection between Kawkawa Lake Road (west of the Coquihalla River) to Union Bar Road. This improvement improves the reliability of the northern 138m Zone and the 753 System by providing a second path for flow across the Coquihalla River.

An extension of the system to the Flood area is also indicated on Figure 6-12.

DISTRICT OF HOPE

Fire Flow - 753 Upgrades



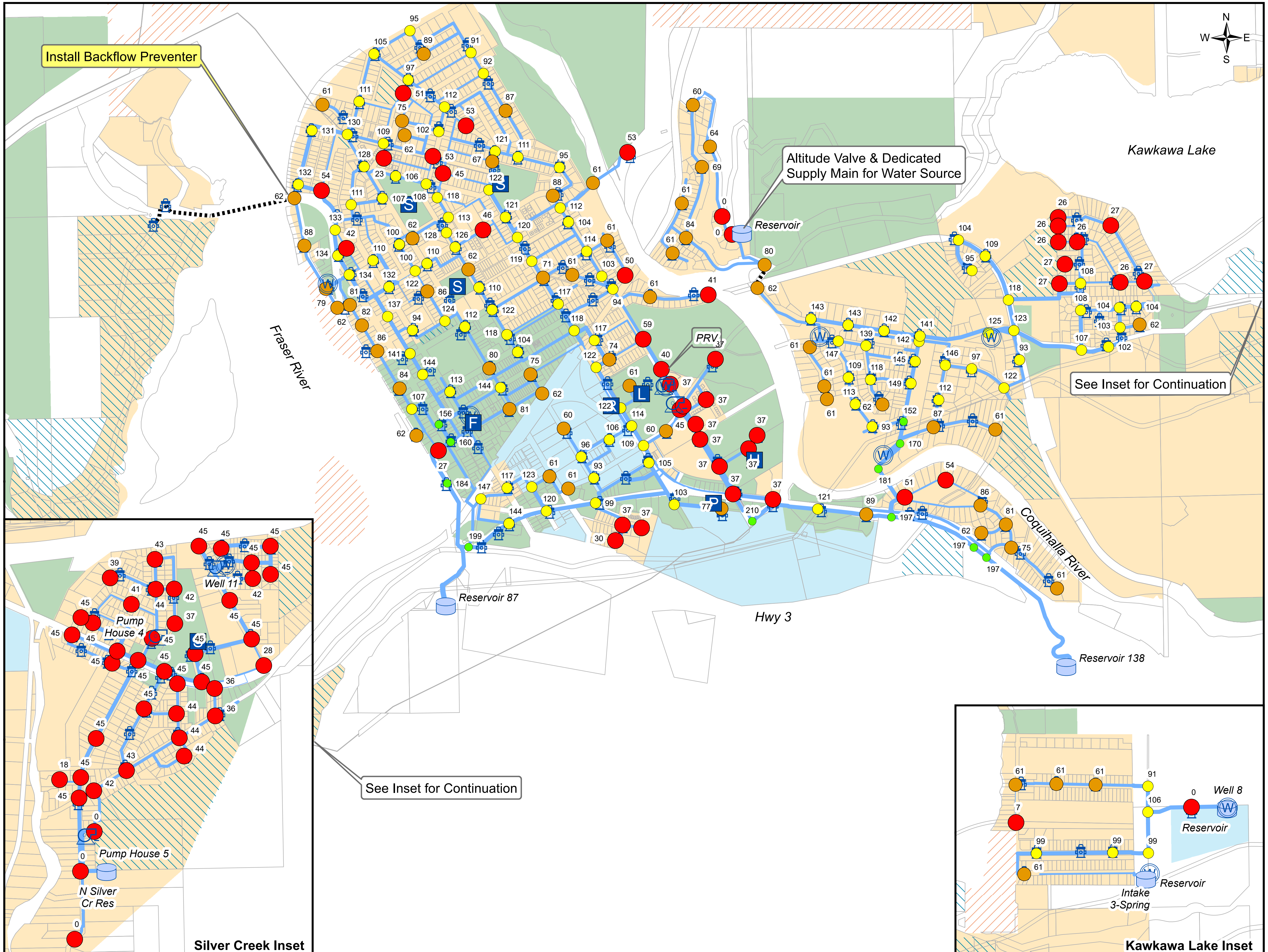
TRUE

Figure 6-4

R:\Clients\1200-1299\1239\1239-141\03 Drawings\CAD\07 GIS\Maps\Figure 7-4 - 753 Upgrades.mxd

DISTRICT OF HOPE

Fire Flow - West of Fraser River Disconnected



Legend

Available Fire Flow

- FF < 60 L/s
- 60 L/s < FF < 90 L/s
- 90 L/s < FF < 150 L/s
- 150 L/s < FF < 225 L/s
- FF > 225 L/s

Pipe Diameter

- 25 - 50
- 50 - 100
- 100 - 150
- 150 - 300
- > 300
- Disconnected

Infrastructure

- Reservoir
- Well
- Pump Station
- Hydrants

Buildings of Note

- F Firehall
- H Hospital
- L Library
- P Police
- R Rec Centre
- S School

Fire Flow Requirement (Based on OCP)

- Single Family (min. Fire Flow = 60 L/s)
- Multifamily (min. Fire Flow = 90 L/s)
- Institutional & Commercial (min. Fire Flow = 150 L/s)
- Industrial (min. Fire Flow = 225 L/s)
- First Nation Reserves
- Future Development Areas

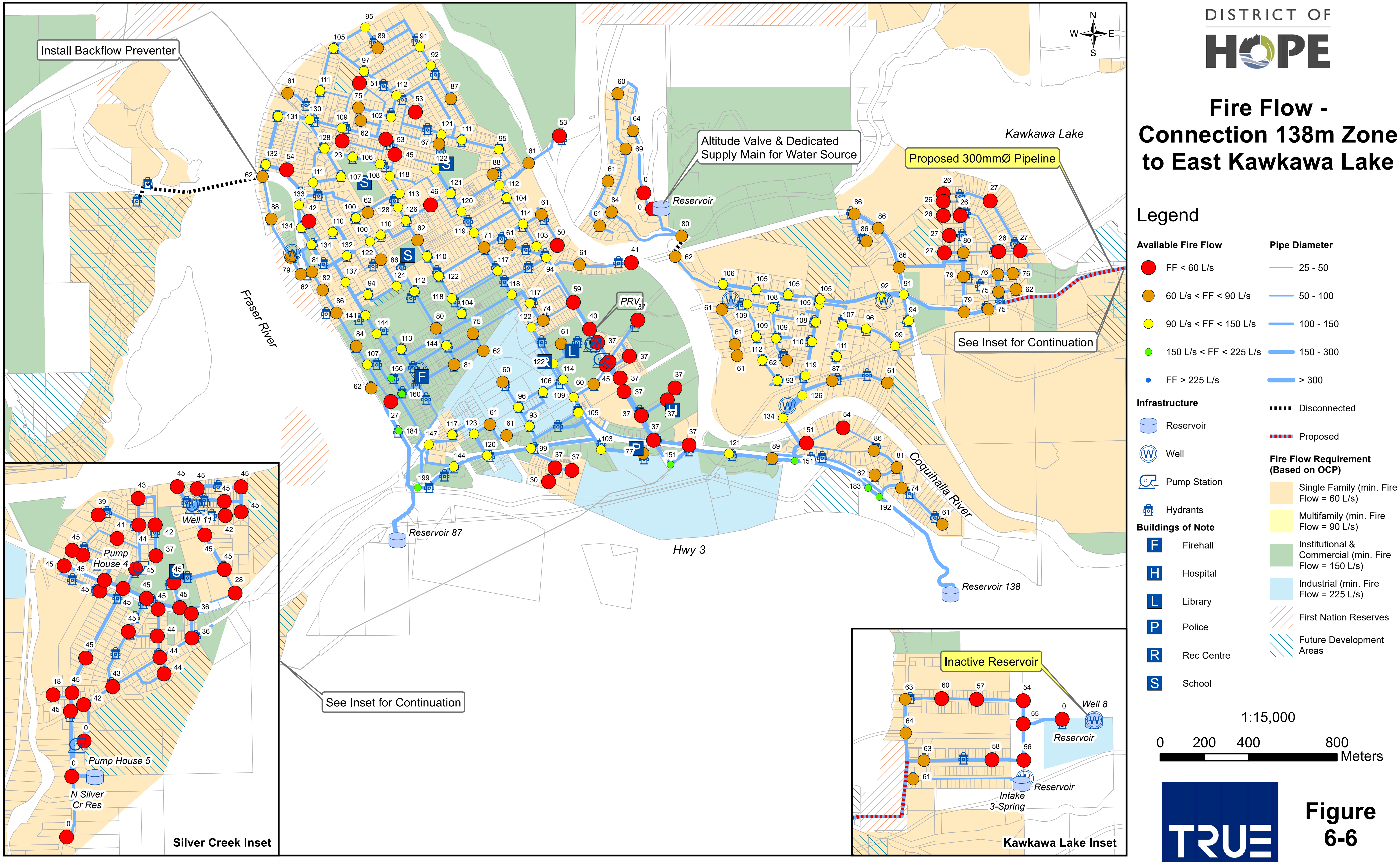
1:15,000

0 200 400 800 Meters

TRUE

Figure 6-5

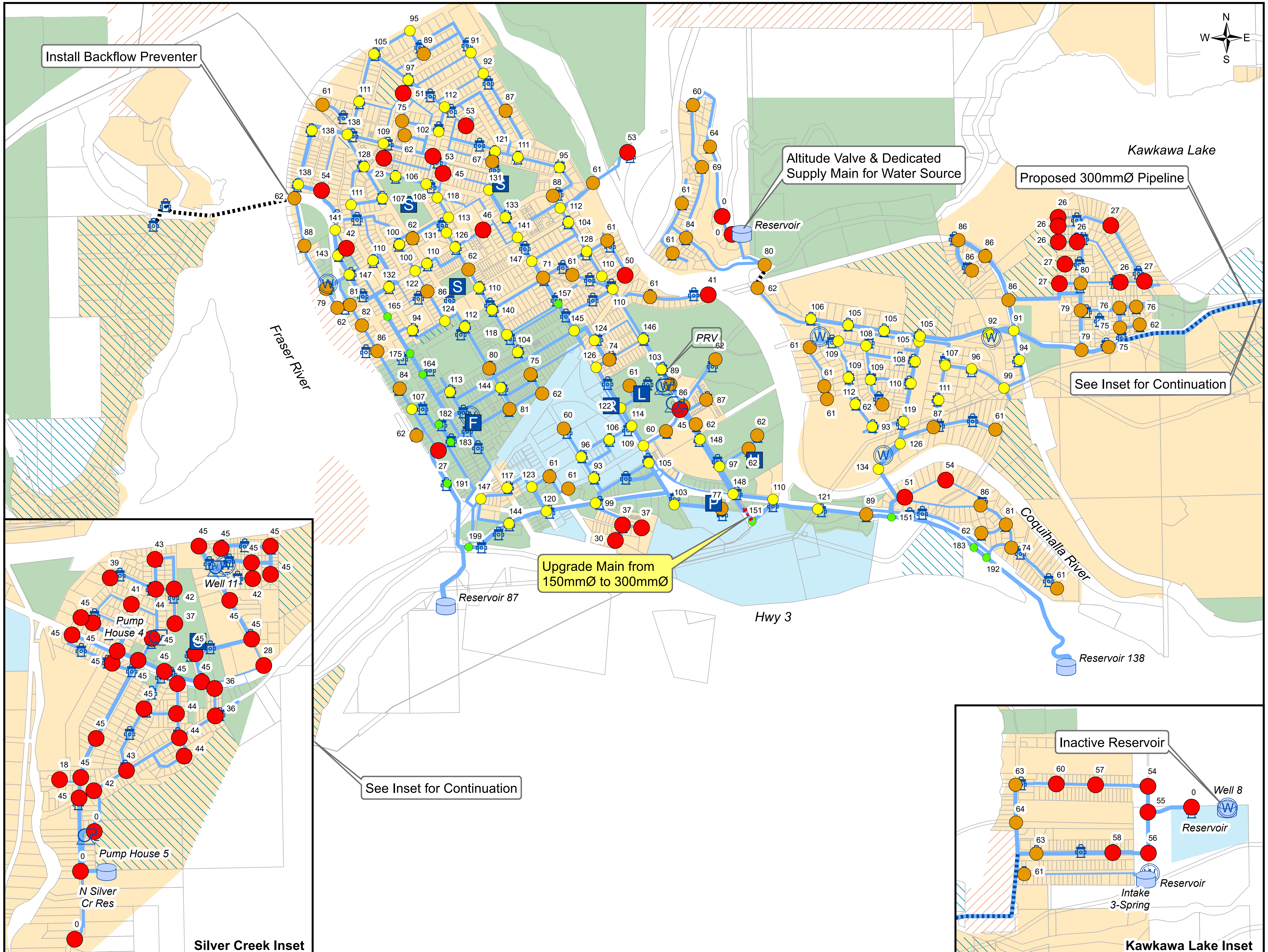
R:\Clients\1200-1299\1239\1239-141\03 Drawings\CAD\07 GIS\Maps\Figure 7-5 - North Fraser Disconnected.mxd



R:\Clients\1200-1299\1239\1239-141\03 Drawings\CAD\07 GIS\Maps\Figure 7-6 - Connection 138 to Kawkawa.mxd

DISTRICT OF HOPE

Fire Flow - 7th Avenue Water Upgrade



Legend

Available Fire Flow
- FF < 60 L/s
- 60 L/s < FF < 90 L/s
- 90 L/s < FF < 150 L/s
- 150 L/s < FF < 225 L/s
- FF > 225 L/s

Pipe Diameter
- 25 - 50
- 50 - 100
- 100 - 150
- 150 - 300
- > 300
- Disconnected
- Proposed
- Previous Upgrade

Infrastructure
- Reservoir
- Well
- Pump Station
- Hydrants

Buildings of Note
- F Firehall
- H Hospital
- L Library
- P Police
- R Rec Centre
- S School

Fire Flow Requirement (Based on OCP)
- Single Family (min. Fire Flow = 60 L/s)
- Multifamily (min. Fire Flow = 90 L/s)
- Institutional & Commercial (min. Fire Flow = 150 L/s)
- Industrial (min. Fire Flow = 225 L/s)
- First Nation Reserves
- Future Development Areas

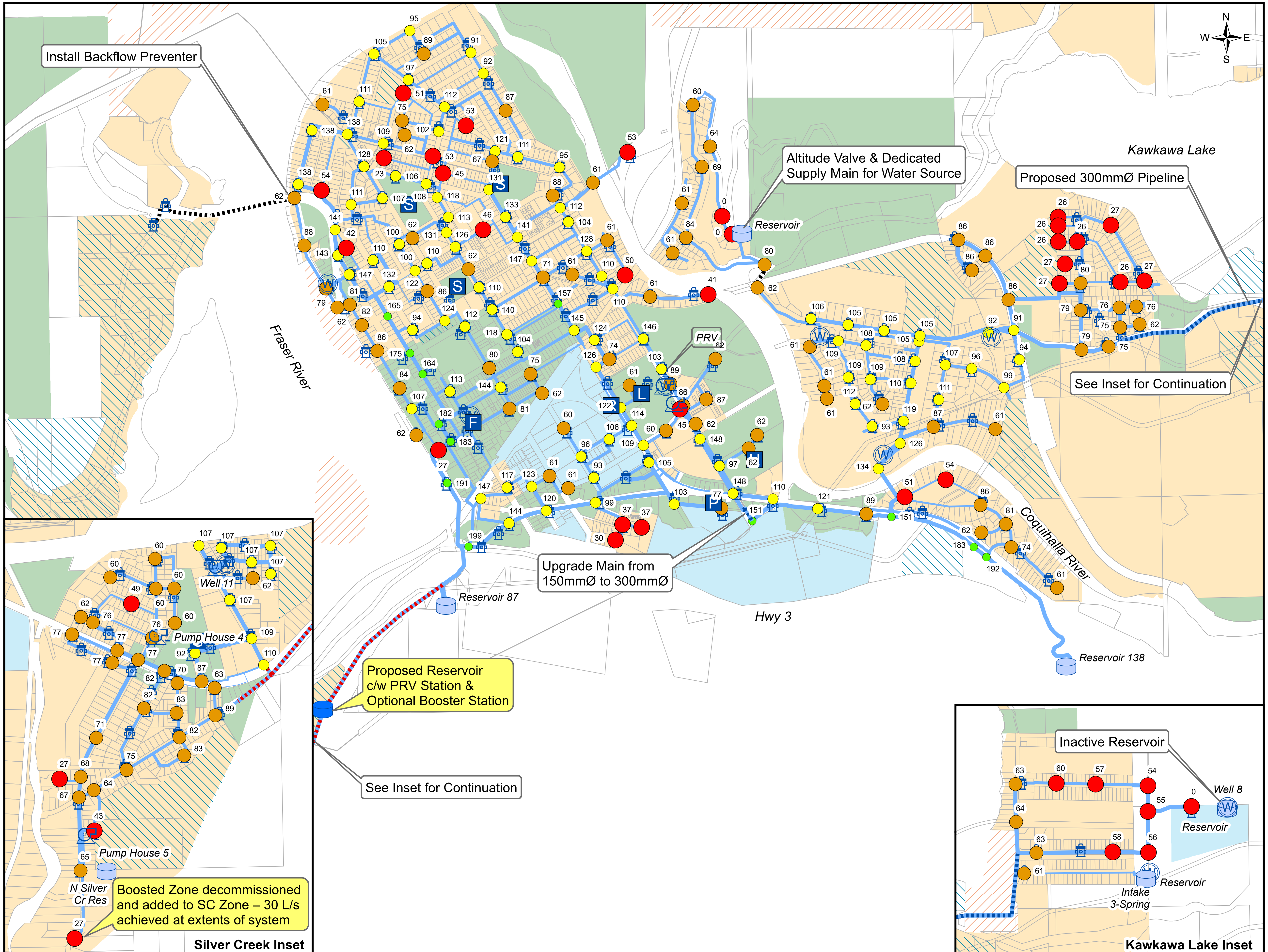
1:15,000

0 200 400 800 Meters

TRUE

Figure 6-7

R:\Clients\1200-1299\1239\1239-141\03 Drawings\CAD\07 GIS\Maps\Figure 7-7 - 138 Constriction Upgrade.mxd



DISTRICT OF HOPE

Fire Flow - Connect 87m Zone to Silver Creek (Base Option)

Legend

Available Fire Flow
- FF < 60 L/s
- 60 L/s < FF < 90 L/s
- 90 L/s < FF < 150 L/s
- 150 L/s < FF < 225 L/s
- FF > 225 L/s

Pipe Diameter
- 25 - 50
- 50 - 100
- 100 - 150
- 150 - 300
- > 300
- Disconnected
- Proposed
- Previous Upgrade

Infrastructure
- Reservoir
- Well
- Pump Station
- Hydrants

Buildings of Note
- F Firehall
- H Hospital
- L Library
- P Police
- R Rec Centre
- S School

Fire Flow Requirement (Based on OCP)
- Single Family (min. Fire Flow = 60 L/s)
- Multifamily (min. Fire Flow = 90 L/s)
- Institutional & Commercial (min. Fire Flow = 150 L/s)
- Industrial (min. Fire Flow = 225 L/s)
- First Nation Reserves
- Future Development Areas

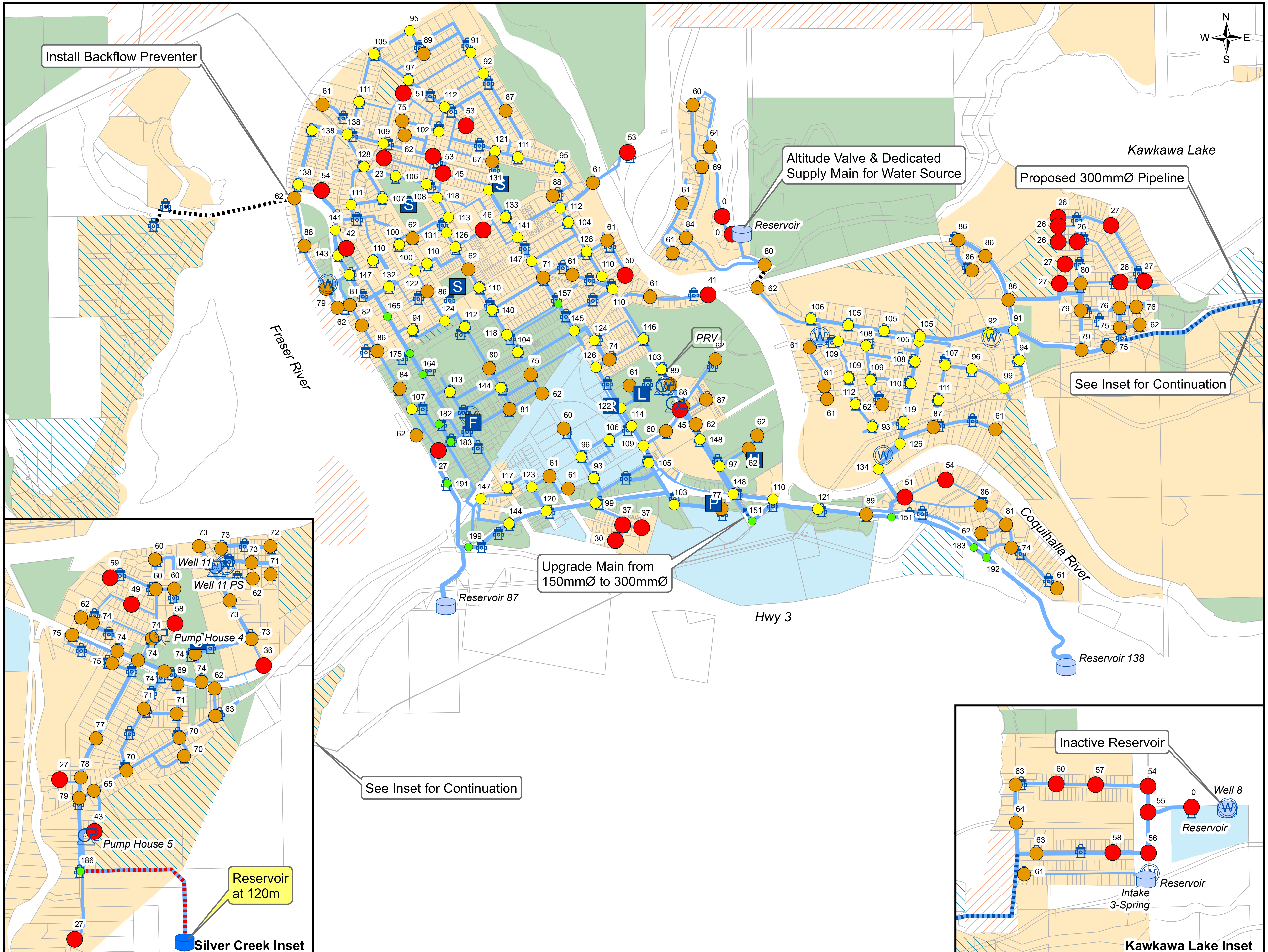
1:15,000

0 200 400 800 Meters

TRUE

Figure 6-8

R:\Clients\1200-1299\1239\1239-141\03 Drawings\CAD\07 GIS\Maps\Figure 7-8 - Connection 87 to SC.mxd



DISTRICT OF HOPE

Fire Flow - Increase HGL @ Silver Creek (Alternative Option)

Legend

Available Fire Flow
- FF < 60 L/s
- 60 L/s < FF < 90 L/s
- 90 L/s < FF < 150 L/s
- 150 L/s < FF < 225 L/s
- FF > 225 L/s

Pipe Diameter
- 25 - 50
- 50 - 100
- 100 - 150
- 150 - 300
- > 300
- Disconnected
- Proposed
- Previous Upgrade

Infrastructure
- Reservoir
- Well
- Pump Station
- Hydrants

Buildings of Note
- F Firehall
- H Hospital
- L Library
- P Police
- R Rec Centre
- S School

Fire Flow Requirement (Based on OCP)
- Single Family (min. Fire Flow = 60 L/s)
- Multifamily (min. Fire Flow = 90 L/s)
- Institutional & Commercial (min. Fire Flow = 150 L/s)
- Industrial (min. Fire Flow = 225 L/s)
- First Nation Reserves
- Future Development Areas

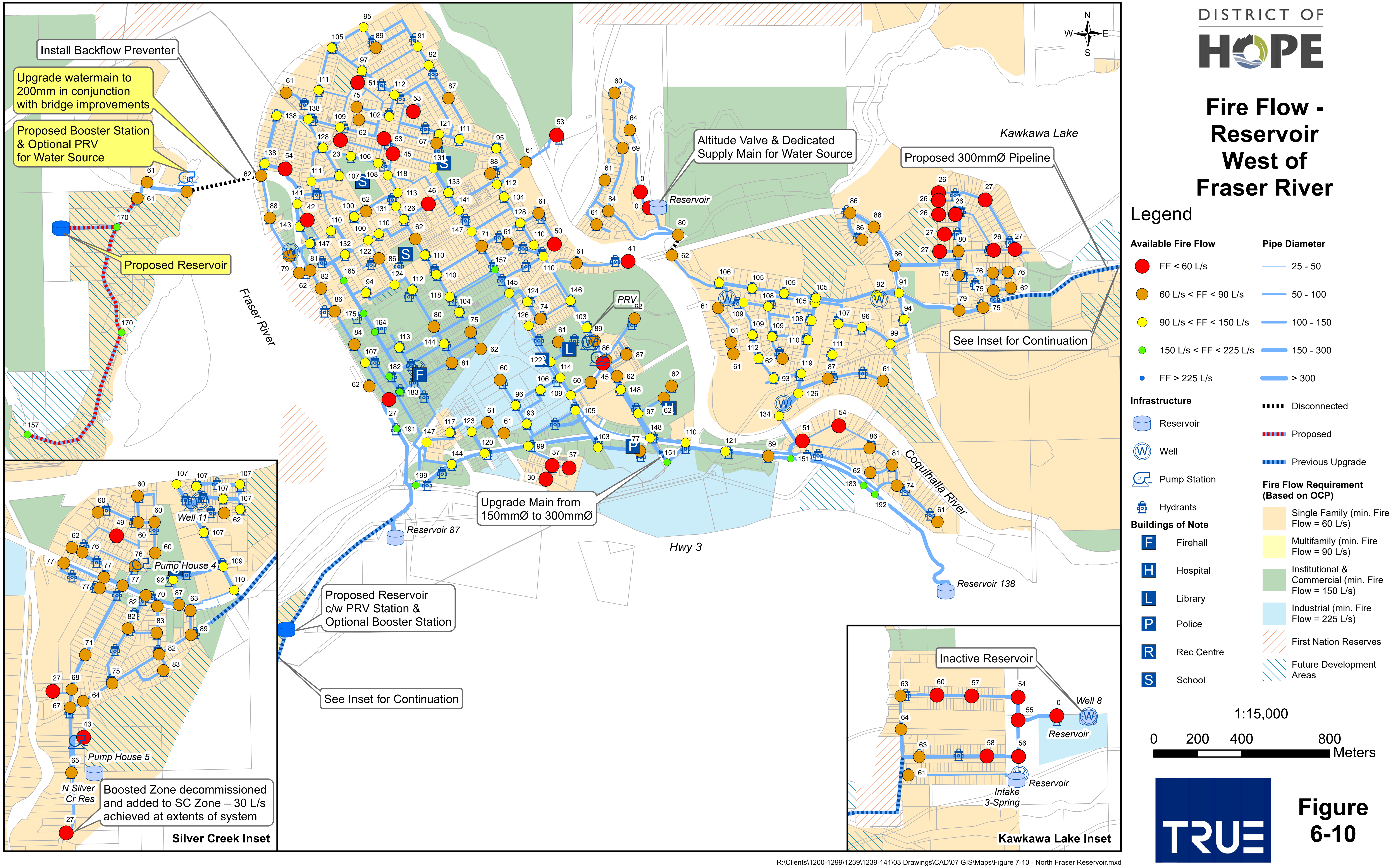
1:15,000

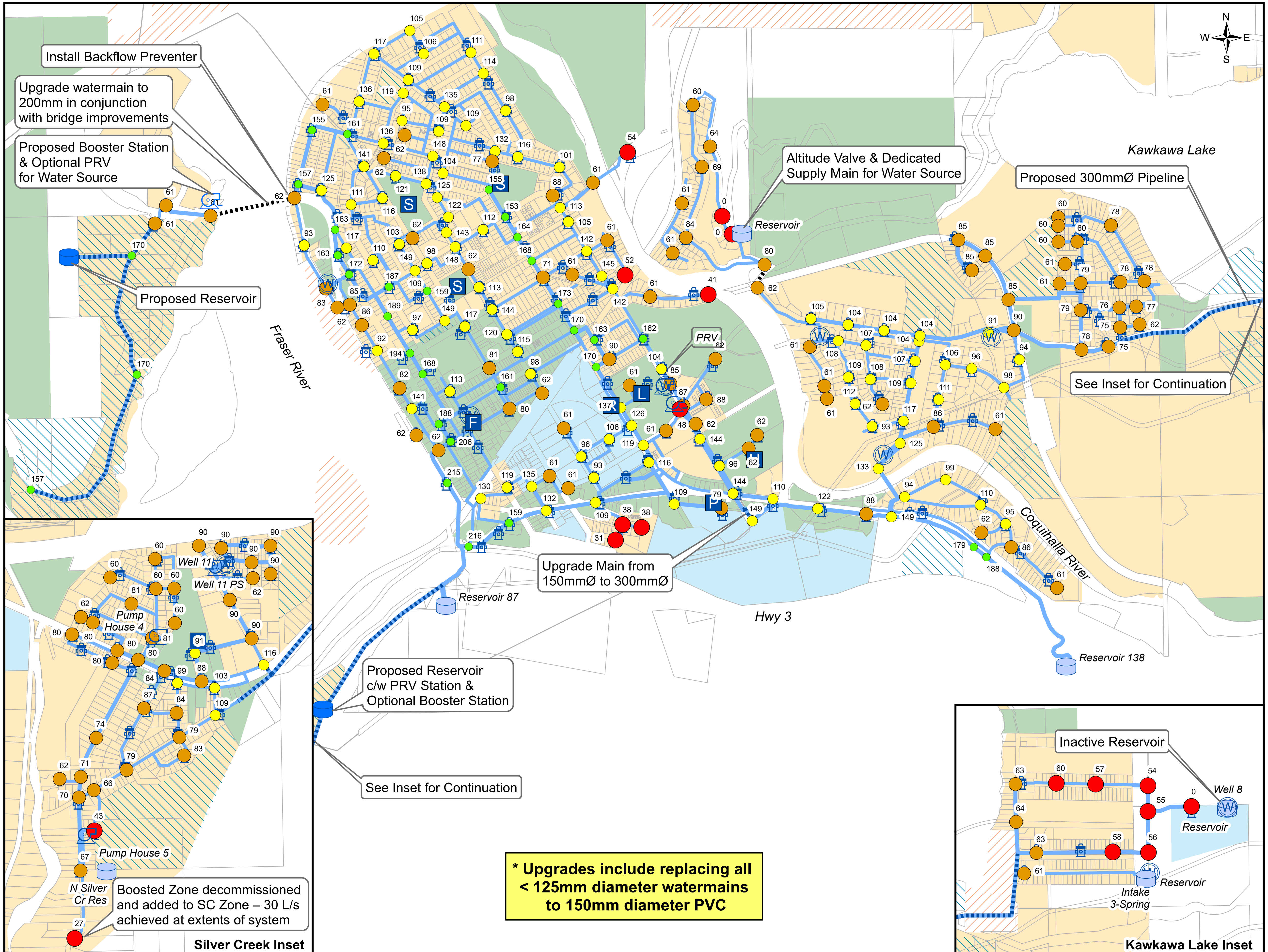
0 200 400 800 Meters

TRUE

Figure 6-9

R:\Clients\1200-1299\1239\1239-141\03 Drawings\CAD\07 GIS\Maps\Figure 7-9 - Connection 138 to SC.mxd


DISTRICT OF HOPE
Fire Flow - Reservoir West of Fraser River
Legend
Available Fire Flow
FF < 60 L/s
60 L/s < FF < 90 L/s
90 L/s < FF < 150 L/s
150 L/s < FF < 225 L/s
FF > 225 L/s
Pipe Diameter
25 - 50
50 - 100
100 - 150
150 - 300
> 300
Disconnected
Proposed
Previous Upgrade
Infrastructure
Reservoir
Well
Pump Station
Hydrants
Buildings of Note
Firehall
Hospital
Library
Police
Rec Centre
School
Fire Flow Requirement (Based on OCP)
Single Family (min. Fire Flow = 60 L/s)
Multifamily (min. Fire Flow = 90 L/s)
Institutional & Commercial (min. Fire Flow = 150 L/s)
Industrial (min. Fire Flow = 225 L/s)
First Nation Reserves
Future Development Areas
1:15,000
0 200 400 800 Meters
Install Backflow Preventer
Upgrade watermain to 200mm in conjunction with bridge improvements
Proposed Booster Station & Optional PRV for Water Source
Proposed Reservoir
Fraser River
Altitude Valve & Dedicated Supply Main for Water Source
Kawkawa Lake
Proposed 300mmØ Pipeline
See Inset for Continuation
PRV
Upgrade Main from 150mmØ to 300mmØ
Reservoir 87
Hwy 3
Reservoir 138
Coquihalla River
Proposed Reservoir c/w PRV Station & Optional Booster Station
See Inset for Continuation
Well 11
Pump House 4
Pump House 5
N Silver Cr Res
Boosted Zone decommissioned and added to SC Zone – 30 L/s achieved at extents of system
Silver Creek Inset
Inactive Reservoir
Well 8
Reservoir
Intake 3-Spring
Kawkawa Lake Inset
TRUE
Figure 6-10
R:\Clients\1200-1299\1239\1239-141\03 Drawings\CAD\07 GIS\Maps\Figure 7-10 - North Fraser Reservoir.mxd



DISTRICT OF HOPE

Fire Flow - General Replacement of Small Diameter Pipe*

Legend

Available Fire Flow
- FF < 60 L/s
- 60 L/s < FF < 90 L/s
- 90 L/s < FF < 150 L/s
- 150 L/s < FF < 225 L/s
- FF > 225 L/s

Pipe Diameter
- 25 - 50
- 50 - 100
- 100 - 150
- 150 - 300
- > 300
- Disconnected
- Proposed
- Previous Upgrade

Infrastructure
- Reservoir
- Well
- Pump Station
- Hydrants

Buildings of Note
- F Firehall
- H Hospital
- L Library
- P Police
- R Rec Centre
- S School

Fire Flow Requirement (Based on OCP)
- Single Family (min. Fire Flow = 60 L/s)
- Multifamily (min. Fire Flow = 90 L/s)
- Institutional & Commercial (min. Fire Flow = 150 L/s)
- Industrial (min. Fire Flow = 225 L/s)
- First Nation Reserves
- Future Development Areas

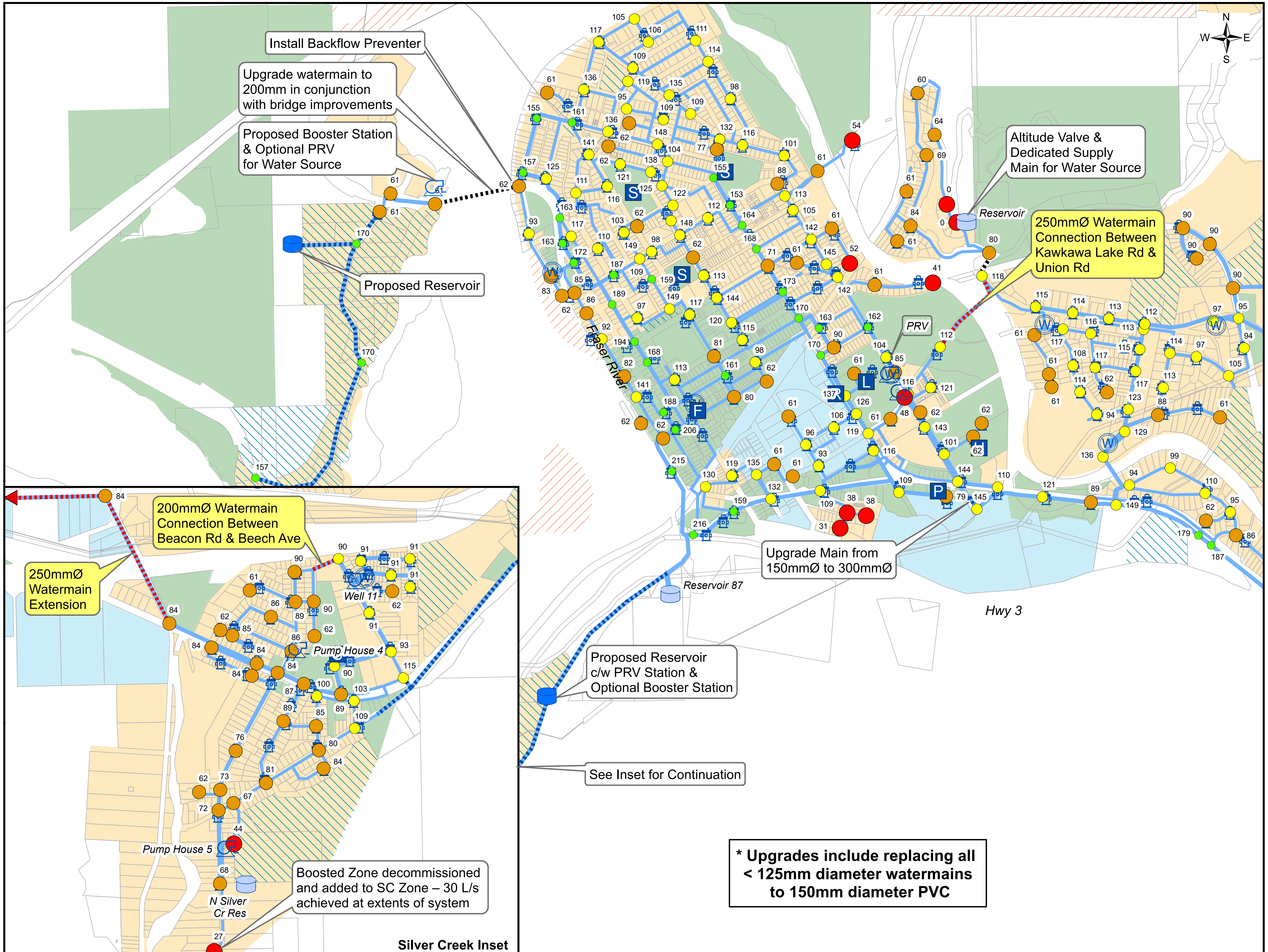
1:15,000

0 200 400 800 Meters

TRUE

Figure 6-11

R:\Clients\1200-1299\1239\1239-141\03 Drawings\CAD\07 GIS\Maps\Figure 7-11 - Long Term Asset Improvements.mxd



DISTRICT OF HOPE

Fire Flow - Long Term Improvements *

Legend

Available Fire Flow

- FF < 60 L/s
- 60 L/s < FF < 90 L/s
- 90 L/s < FF < 150 L/s
- 150 L/s < FF < 225 L/s
- FF > 225 L/s

Pipe Diameter

- 25 - 50
- 50 - 100
- 100 - 150
- 150 - 300
- > 300
- Disconnected
- Proposed
- Previous Upgrade

Infrastructure

- Reservoir
- Well
- Pump Station
- Hydrants

Buildings of Note

- F Firehall
- H Hospital
- L Library
- P Police
- R Rec Centre
- S School

Fire Flow Requirement (Based on OCP)

- Single Family (min. Fire Flow = 60 L/s)
- Multifamily (min. Fire Flow = 90 L/s)
- Institutional & Commercial (min. Fire Flow = 150 L/s)
- Industrial (min. Fire Flow = 225 L/s)
- First Nation Reserves
- Future Development Areas

1:15,000

0 200 400 800 Meters

TRUE

Figure 6-12

R:\Clients\1200-1299\1239\1239-141\03 Drawings\CAD\07 GIS\Maps\Figure 7-12 - Long Term Improvements.mxd

6.5 Water Storage Assessment

6.5.1 Assessment of Existing Storage

The water storage requirements under current and future demand conditions have been calculated according to the requirements set out in the MMCD Design Guideline Manual and the Fire Underwriters Survey Guideline (Water Supply for Public Fire Protection, 1999).

Four service areas within the District have been assessed, as follows:

- East Kawkawa Lake
- Reservoir 138
- Reservoir 87, and
- Silver Creek

The fire flow in the 87m and 138m zones is based upon fighting a commercial or institutional fire at 150 L/s for 2.0 hours.

The fire flow in the Silver Creek area is based on a multi-family residential property with a flow of 90 L/s for 2.0 hours. A nominal single-family residential building has been used to calculate a maximum fire flow requirement for East Kawkawa Lake. MMCD recommend a fire flow of 60 L/s to a single-family residential building. The FUS short method would call for 4,000 L/min (67 L/s) for a structure with a 3 – 10m exposure distance. The required duration at 4,000 L/min is 1.5h.

It should also be noted that these fire flow rates will be used for design but are not necessarily able to be supplied throughout the water system due to limitations in watermain diameter (see previous section).

Balancing storage for reservoirs has been calculated on the basis of 25% of maximum daily demand. The estimates of existing and future maximum daily demand are higher than the figures which have been adopted in previous studies. The existing MDD is based on the 2017 summer peak day flows.

Emergency storage is based on 25% of the sum of fire flow storage and balancing storage.

The storage required is described in Table 6-3. This table is based upon the existing connectivity between zones. This connectivity includes a pressure reducing station between the 138m zone and the 87m zone.

Table 6-3: Estimate of Reservoir Storage Requirements for Future MDD Under Existing Water Supply Configuration

87m Pressure Zone		
A	Calculated fire flow storage requirement (150 L/s for 2.0 hours)	1,080 m^3
	Assumed future MDD	7,100 m^3/d
B	Balancing Storage Requirement (25% of MDD)	1,800 m^3
C	Optional Emergency Storage (25% of A+B)	720 m^3
A+B+C	Total Storage Required	3,580 m^3
	Existing Storage (138m Reservoir + 87m Reservoir)	3,174 m^3
	Shortfall based on existing conditions	*400 m^3*
138m Pressure Zone		
A	Calculated fire flow storage requirement (150 L/s for 2.0 hours)	1,080 m^3
	Assumed future MDD	3,000 m^3/d
B	Balancing Storage Requirement (25% of MDD)	750 m^3
C	Optional Emergency Storage (25% of A+B)	460 m^3
A+B+C	Total Storage Required	2,290 m^3
	Existing Storage (138m Reservoir)	1,587 m^3
	Shortfall based on existing conditions	*700 m^3*
	Shortfall if 753 Reservoir water available	*200 m^3*
Silver Creek		
A	Calculated fire flow storage requirement (90 L/s for 2.0 hours)	650 m^3
	Assumed future MDD	1,500 m^3/d
B	Balancing Storage Requirement (25% of MDD)	380 m^3
C	Optional Emergency Storage (25% of A+B)	250 m^3
A+B+C	Total Storage Required	1,290 m^3
	Existing Storage (Silver Creek Reservoir)	425 m^3
	Shortfall based on existing conditions	*1,025 m^3*
East Kawkawa Lake		
A	Calculated fire flow storage requirement (60 L/s for 1.5 hours)	320 m^3
	Assumed future MDD	360 m^3/d
B	Balancing Storage Requirement (25% of MDD)	90 m^3
C	Optional Emergency Storage (25% of A+B)	100 m^3
A+B+C	Total Storage Required	510 m^3
	Existing Storage (East Kawkawa Lake Reservoir)	53 m^3
	Shortfall based on existing conditions	*460 m^3*

Based on the existing configuration, there is a modest shortfall in capacity in the 87m/138m system. This partly results from adding the 753 Water System to the network, without having the benefit of the 753 Reservoir.

The shortfall also relates to an increase in the estimated maximum daily demand figure based on a new, more detailed, analysis of system flow data as well as an allowance for future increases in flow (to the year 2040). The maximum daily demand used in the previous 753 Water System

Study appear to have been 5,120 m^3/d and 1,560 m^3/d for the 87m and 138m/753 zones. From August 2nd to August 4th 2017, actual flows in the 87m zone were 6,500m^3/d, and 2,700 m^3/d in the 138m/753 zone. An allowance then needs to be added to these flows to allow for future growth, giving design MDD figures of 7,100 m^3/d and 3,000 m^3/d for the two zones.

Based on existing conditions it can be seen that there is a significant shortfall in reservoir storage in the Silver Creek system. Any new storage would ideally be located at a higher elevation and feed a high-level zone.

There is also a severe shortfall in storage in the East Kawkawa Lake system, which currently relies on the water well remaining available to replace water as it is used. The recommended storage of 510 m^3 would be sufficient for single family domestic firefighting. However, it should be noted that the storage required for servicing the hydrant on the Nestle Waters property has been excluded. The future of this hydrant needs to be considered carefully, as much more significant upgrades would be needed to provide true fire protection to this facility, as compared to the East Kawkawa Lake community. This is due to the elevation of the site, as well as the volume and flowrate required. At the 225 L/s nominal flow rate for an industrial fire, the existing reservoir would be empty in less than four minutes. The reality is that a 225 L/s flowrate cannot be achieved because of the relatively low pressure available at that location.

6.5.2 Options for Improved Storage

A number of scenarios have been considered to address shortfalls in existing system water storage, as well as increased requirements as the population grows and the service area is extended in the future.

It has been assumed that East Kawkawa Lake will be linked to the 138m Zone with storage added to address the deficiency across these areas, as well as to serve the other lower zones. This will give East Kawkawa Lake storage for fire protection and both systems would have access to more than one functional well. The obvious location for the new reservoir is at the 138m Zone Reservoir site. The existing East Kawkawa Lake reservoir would probably be abandoned. With the permission of the Union Bar First Nation, the pipe route could follow the Kawkawa Lake Road through Kawkawa Lake IR16. There is already a sewer main in Kawkawa Lake Road so this route is anticipated to be feasible. The water main has potential to benefit IR16 with a potable water supply for any future development and / or for fire fighting. Alternatively, the pipeline would need to follow another route which would either include crossing the Trans Mountain Oil Pipeline or run north of the Lake to service new areas.

If an acceptable level of fire protection were to be provided to the Nestle Waters factory, then a large reservoir dedicated to this purpose would be needed on a new site above East Kawkawa Lake and the Nestlé factory. This would also require a pressure booster station and pressure reducing station to allow it to be linked to the 138m zone. The additional costs of such a reservoir would be something that Nestle would be expected to contribute towards. This has not been assumed as part of the base case.

For the base option shown in Table 6-4, it has been assumed that additional storage is installed at the 138m reservoir site, as well as a new reservoir on the Flood Hope Road (or a location in Silver Creek) at a nominal 120m elevation. The Flood-Hope Road project would address a shortfall in storage in the Silver Creek Zone and well capacity in the 87m Zone. The feasibility of this project needs to be confirmed through pre-design since topographical, land ownership and other constraints will be factors in design. The existing Silver Creek Reservoir would be decommissioned as its low elevation limits fire flows in Silver Creek.

TABLE 6-4: PROPOSED STORAGE

Low Pressure Zone		
A	Calculated fire flow storage requirement (150 L/s for 2.0 hours)	1,080 m^3
	Assumed MDD	8,600 m^3/d
B	Balancing Storage Requirement (25% of MDD)	2,150 m^3
C	Optional Emergency Storage (25% of A+B)	810 m^3
A+B+C	Total Storage Required	4,040 m^3
	Existing Storage (138m Reservoir + 87m Reservoir)	3,174 m^3
	Proposed 120m Reservoir (Based on Silver Creek Requirements)	1,500 m^3
High Pressure Zone		
A	Calculated fire flow storage requirement (150 L/s for 2.0 hours)	1,080 m^3
	Assumed MDD	3,400 m^3/d
B	Balancing Storage Requirement (25% of MDD)	840 m^3
C	Optional Emergency Storage (25% of A+B)	480 m^3
A+B+C	Total Storage Required	2,400 m^3
	Existing Storage (138m Reservoir)	1,587 m^3
	Proposed Additional 138m Reservoir	1,000 m^3

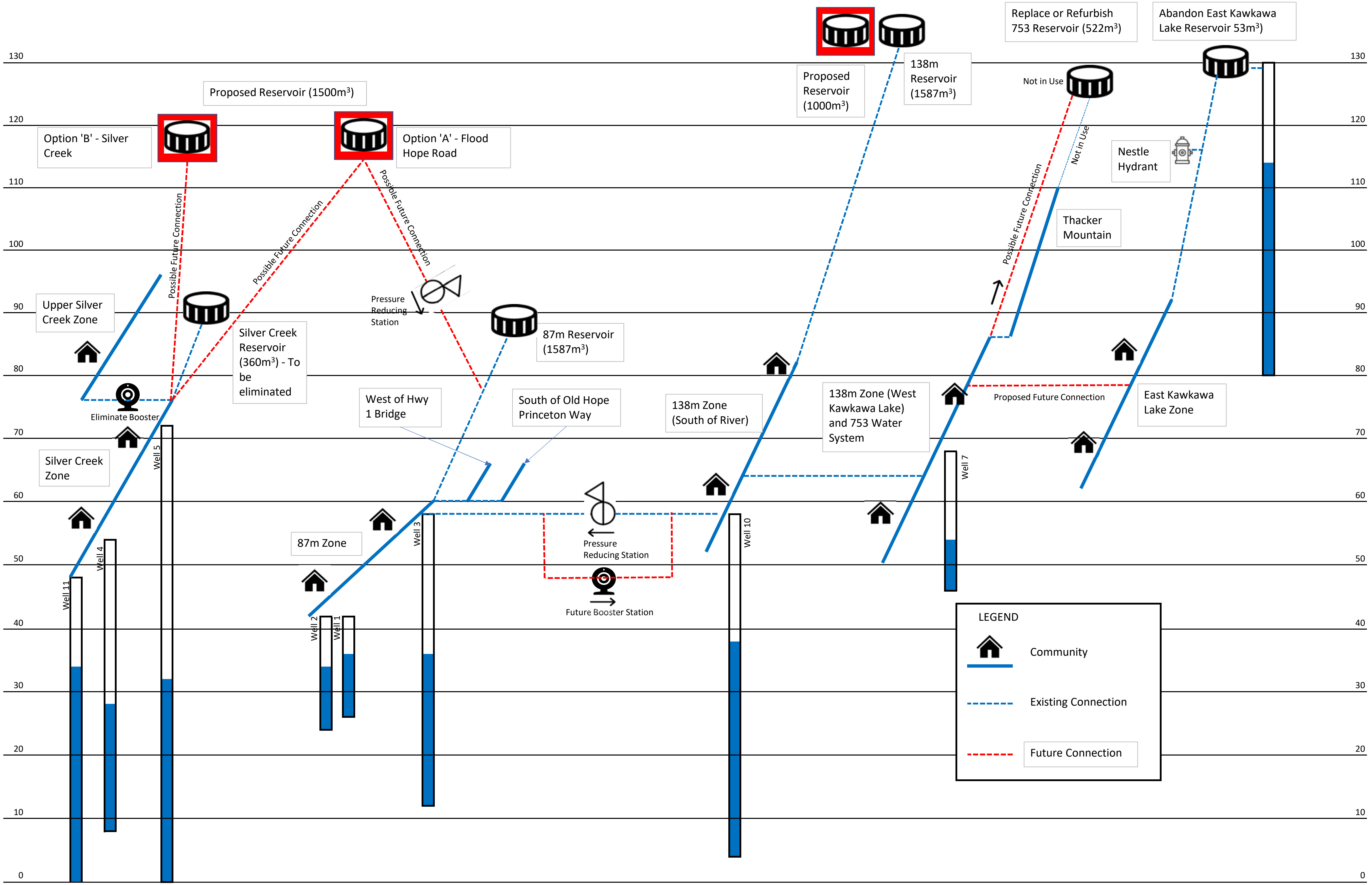
The existing 590m^3 of storage may also be incorporated to supply the Thacker Mountain Road area so that adequate fire flow capacity can be maintained in the 138m zone while maintaining water pressure on Thacker Mountain Road.

<u>Mixing</u>

Some form of active tank mixing is commonly required in new reservoirs where the water is chlorinated. Mixing ensures that a consistent chlorine residual is maintained. If chlorination is implemented in the future, then active or passive mixing systems in the reservoirs would be beneficial. This can be achieved by configuring inflows as jets (passive mixing), or by installing mechanical mixers (active mixing).

The mixing of the 87m and 138m reservoir contents is improved by the high-level inlet being opposite the floor level outlet in order to maximize the flow path.

Figure 6-13: Water System Hydraulic Profile Showing Improvements



6.6 Natural Hazards

6.6.1 Earthquake Resiliency

Based on hazard mapping, the Hope area appears to be at moderate risk of a damaging earthquake. A major earthquake can be expected to affect the water system. There may be damage to above ground structures such as buildings and reservoirs, as well as widespread failure of pipelines underground.

The high proportion of asbestos cement and cast iron pipe in the Hope pipe network will lead to more extensive pipe failure than would otherwise be the case. Asbestos cement pipe is particularly vulnerable. Resiliency is dependant on the mode of the stresses placed on the pipe such as bending, joint separation, etc, but generally falls in the order of asbestos cement < cast iron < PVC < ductile iron < polyethylene[5].

The distributed nature of the Hope water sources generally lends itself to improved recovery of service after a major seismic event. Steel cased wells are relatively resilient against seismic damage, although the related buildings may not be constructed to modern post disaster standards. Since 2005, the National Building Code categorizes water and wastewater facilities as post-disaster. The BC Building Code also categorises public water treatment and storage facilities and pumping stations, as well as sewage treatment facilities as post disaster. Post disaster buildings are considered essential to the provision of services in the event of a disaster. This designation means that the seismic forces used in designing a post-disaster building are 1.5 times greater than those used to design a standard structure. Most District facilities were constructed prior to these and other requirements coming into effect.

It is recommended that recovery of service after a major earthquake is included in the planning of improvements to the route from the wells to the water reservoirs. The design should allow repairs and isolation to be undertaken relatively quickly to get water to each of the reservoirs. Bringing service to the community networks would then be achieved gradually as local repairs are completed.

Distribution valving needs to be configured so that severely leaking parts of the network can be isolated. This would particularly apply to areas prone to liquefaction and landslides. There is currently no liquefaction hazard mapping for the District of Hope. It is also recommended that connectivity between the distribution systems be improved in order to accelerate recovery.

Seismic valves could be considered for the reservoir outlets so that water remains available after an earthquake. As an example, in Yokohama (Japan), emergency shut-off valves have been installed at distribution reservoirs. If an earthquake occurs and if the water level falls to a pre-set

[5] American Lifelines Alliance. Seismic Fragility Formulations for Water Systems. April 2001.

level, software closes an emergency shut-off valve to secure the supply of drinking water. In practice, this stored water will only be available to water trucks. It may be that operating a small well to fill water trucks would be more cost effective than fitting actuated valves and other equipment. Residents can also boil water from rivers or Kawkawa Lake.

6.6.2 Other Natural Hazards

The District's Official Community Plan includes maps showing areas of the community that are at risk of flooding and erosion (District of Hope Floodplain and Erosion Areas – Maps 1 – 5) and geotechnical hazards (District of Hope Geotechnical Hazards – Maps 1 – 5).

The maps indicate known natural hazards affecting the water system. The most significant among these are flooding and landslides. Wells 4, 5 and 11 are in the Silverhope Creek Hazard area (flooding). Well #8 is in the Kawkawa Lake East Hazard Area (erosion) as well as being in a 'high geotechnical hazard' area. The District should consider specific analysis of the hazards affecting water infrastructure in order to mitigate any impacts.

Generally, the buried water network is protected from flooding hazards. However, erosion and landslides can still affect buried pipes.

7.0 Recommendations

7.1 Introduction

The preferred options described in the Master Plan have been summarized in this section. The improvements listed may be categorized as either;

- Projects that have the objective of improving the level of service within the existing service area, or;
- Projects that are triggered by new development, or;
- Administrative improvements, including continuation of existing programs.

7.2 Level of Service Improvements

Level of service upgrades include projects to improve water quality, increase fire flow / water service pressures and to improve system reliability. Projects in this category would be undertaken by the District on behalf of existing users and would therefore be included in the capital plan and budget.

7.2.1 Short Term Improvements

It is recommended that a number of lower cost improvements are made in the short term to improve water supply serviceability and reliability.

TABLE 7-1: SHORT TERM IMPROVEMENTS

	Project	Est. Cost
1	Telemetry / SCADA upgrades	$1,100,000
2a 2b	Connect Well #3 to 138m Zone (Option A) Construct booster station from 87m Zone to 138m Zone (Option B)	$410,000 $850,000
3	Backflow prevention west of Fraser River	$150,000
4	Backflow prevention on Scott Dr	$1,500
5	Replace low flow valve at PRV station (100mm valve)	$6,000
6	7th Avenue watermain upgrade to improve fire flow to hospital	$180,000
7	Replace private overland water service on Johnson Rd (East Kawkawa Lake)	$870,000
8	Remove Nestlé Waters Canada fire hydrant	$1,200

7.2.2 Long Term Improvements

Water system extensions and upgrading likely to be undertaken over the period to 2040 are listed in Table 7-2.

TABLE 7-2: WATER SYSTEM LONG RANGE PLAN

	Project	Est. Cost
1	Pipeline Connecting East Kawkawa Lake to 138m Zone	$1,210,000
	Connect 87m Zone to Silver Creek	
2a	Option A – Figure 6-8	$3,700,000
2b	Option A – Figure 6-9	$2,000,000
3	Looping from Kawkawa Lake Rd to Union Bar Rd	$800,000
4	Future installation of disinfection systems at wells	$2,600,000
5	New well to replace wells #1 and #2 (depending on existing well condition and requirements)	$1,200,000

It is suggested that pre-design work in support of the new reservoir and pipeline primarily serving Silver Creek (Option A or Option B) be conducted in the shorter term in order that appropriate funding can be secured.

There will also be a gradual increase in watermain replacement activity over the coming decades as old mains age and need replacement. This will become a significant operating expense which would ideally be undertaken in coordination with pavement improvement. Many small galvanized iron mains are likely to need replacement in the near term and their condition should be checked in order to effectively schedule this work. Work scheduling will also enable undersized pipelines to be prioritized. Due to the number of projects involved and the uncertainty in timing and cost, these watermain replacement costs have not been included in Table 7-2.

The prioritization of future upgrades to the network should also consider infrastructure resiliency against the various applicable modes of failure. Examples include deterioration, mechanical failure and natural hazards.

7.2.3 753 Water System

A number of improvements need to be made if the District is to accept the 753 Water System as a permanent part of the District water supply. These are largely as described in the 753 Water System Study (2017). The condition of existing watermains and the reservoir will be a significant factor in determining the long-term liabilities represented by the system. Costs for improvements to the 753 Water System are outlined in Table 7-3. The addition of the 753 Water System also contributes to the shortfall in reservoir storage capacity in the 138m Zone, but this can be offset by the 753 Reservoir Storage if it is integrated into the system.

TABLE 7-3: INCORPORATION OF 753 WATER SYSTEM TO DISTRICT NETWORK

Project	**Est. Cost**
Upgrades to allow 753 Reservoir to Supply Thacker Mountain Road Area and completion of well in Skylark Drive	$1,500,000
General distribution network upgrades	$860,000

The next step in the process for transfer of ownership would be to undertake detailed condition assessments and preliminary design for the required improvements.

7.3 Upgrades to Support Development

Projects which would be triggered by new development and not part of the Capital Plan are described in this section. As these projects are triggered by development, for the most part, they will be funded by the developer. Clearly these projects depend on the benefitting new development proceeding.

TABLE 7-4: WATER SYSTEM EXTENSION IN SUPPORT OF DEVELOPMENT

Project	**Est. Cost**
Extension to Landstrom Road including new reservoir	$2,000,000
Extend Service to Flood Light Service Industry Area	$2,300,000

7.4 Administrative Recommendations

7.4.1 Well Licensing under the Water Sustainability Act

Among other things, the Water Sustainability Act (2016) regulates the construction, maintenance, deactivation and decommissioning of wells. Generally, all wells apart from private single-home domestic wells are subject to the licensing provisions in the Act and enabling regulations (Water Sustainability Regulation, 2016). The District of Hope is considered to be an existing non-domestic groundwater user under the Act. Existing users are those who used groundwater for non-domestic purposes before February 29, 2016. The three-year transition period to licence non-domestic groundwater sources (including municipal wells) under the Water Sustainability Act and Regulation is set to expire on March 1, 2019. As of the date of the draft report, we understand applications have been made for the Silver Creek and East Kawkawa wells, and that these were submitted by Hope staff to FrontCounterBC in September 2016. Western Water are preparing an application for submission to licence the wells serving the 87m and 138m pressure zones under the existing groundwater use provisions of the B.C. Water Sustainability Regulations. This application would involve the licensing of Wells 1, 2, 3, 7 and 10. In addition, well log information for Wells 5 and 10 will be submitted to the Ministry, as it appears these two wells are not currently in the government GWELLS database of registered wells. Note that registered wells are those wells for which there is a record in the Ministry database. A licenced well is a well that is associated with a water licence to divert water for a specified purpose as per the terms of the water licence.

No information is available concerning the licensing status of the 753 water system wells. Based on the current status of that water system, this is expected to be the responsibility of the Provincial government.

7.4.2 Well Operation

The operation and management of the wells could be improved in a number ways. These include;

- Undertaking regular controlled pumping tests to keep track of deterioration
- Install well water level monitoring where this is not already in place. Level sensors were being installed in Wells #3, #4 and #5 at the time of writing.
- Well records should be improved, including the electronic storage of flow and pump hour information.
- Consistent flow measurement units should be used across the network.

7.4.3 Source to Tap Assessment / GARP Analysis

The Fraser Health Authority administers the provincial Drinking Water Protection Act's provisions for source water protection. Western Water have indicated that it would be beneficial to prepare a Source Water Protection Plan. Source Water Protection Plans address land use, the environment, habitat, fisheries and the complete hydrologic cycle with a view to safe guarding public health and ensuring safe potable water supplies for the long term. As part of this project the water sources should be investigated, a hazard screening / assessment should be completed based on the Provincial guidelines. Fraser Health would be consulted on the findings of the assessment.

7.4.4 Water Conservation Plan Implementation

A Water Conservation Plan was prepared by the District in 2008. The Water Conservation Plan described a range of initiatives. Many of these represented operational or educational strategies and would not be funded by a capital program. This plan has been partially implemented. The District intends to continue with progress on the implementation of the plan.

Measure	**Status**
Replace the existing open reservoirs with two new enclosed reservoirs to eliminate the need to overflow 70 to 140 million gallons of water annually to ensure a safe supply of potable water to the residents of Hope.	Complete
Implement mandatory metering of all industrial, commercial and institutional buildings	Ongoing
Implement a mandatory metering program of all residential buildings in subdivisions constructed after 2008	Ongoing
Initiate a program for residential water metering on a voluntary basis	Ongoing
Implement retrofit programs - with incentive programs to replace old fixtures with new low flow fixtures.	Ongoing
Implement rainwater harvesting	Ongoing
Educate customers about the value of water	Ongoing

The water conservation initiatives requiring capital expenditure should be part of the capital plan. The relevant water conservation measures are:

- Metering of major institution water users including schools, District Public Works site and irrigation services to District parks.
- Conversion of commercial water meters to “radio read”.

A Water Conservation Plan update is planned for 2020.

7.4.5 Emergency Response Plan

It is recommended that the District update the water system emergency response plan with the planned methodology for well pump replacement for Well 10 and Well 8. The plan should include contingency plans for rapid deployment of resources to maintain supply.

7.4.6 Update DCC Bylaw

The improvements described in this Master Plan should be appropriately considered by the provisions of the Development Cost Charge bylaw. The District should review the bylaw and make appropriate changes. This is also described in the following section (7.5 Financing).

7.4.7 Asset Management Plan

Asset management planning represents a commitment to recording and evaluating asset information in order to develop informed plans for the operation, upkeep, replacement, and financing of community infrastructure. Asset management gives a community tools for efficiently managing assets as well as planning for the costs associated with owning them. Due to the benefits of asset management, adequate asset management planning is increasingly becoming a condition of senior government grants.

An Asset Management Plan (AMP) document describes;

- what information should be recorded,
- where it will be kept,
- who is responsible for the information,
- defines tools to record and manipulate the data, and
- what the information developed from the data will be used for.

An AMP generally results in the creation of a data registry (a location for storing asset data). Along with a registry, tools for analyzing the data are often developed.

The data registry may include the following basic information; Identification, location, age, life expectancy, replacement value. The following additional information is also useful; condition, actual level of service and target level of service.

As an example, asset management planning will be a key tool in scheduling pipeline replacement. To assist in the development of the watermain replacement program, the District's watermains have been inventoried on a segment basis. Each segment represents a length of main between two intersections or connections to other mains which therefore would represent a logical stand-alone replacement project. As part of an asset management plan the District would prioritize the replacement of watermains based on selection criteria. Likely criteria to be used in the replacement of the various segments are briefly described as follows;

Pipe age: Pipe age in relation to the anticipated service life based on pipe type is a straightforward prioritization factor. Pipe age would suggest that the oldest watermains be replaced first. The age distribution of the District's watermains is illustrated in Figure 3-7. At present the District reports a relatively low level of watermain breaks

Asset condition: Relatively little is known about the condition of the water system assets. “Condition Assessments of Roadway Structures, Water Mains, Storm Sewers, and Sanitary Sewers” prepared by Omega & Associates Engineering Ltd in 2015 incorporated a condition assessment of road, water storm and sanitary sewer assets. The study noted cast iron water mains in fair condition along with serious issues with other utilities. Based on the findings it is likely to be common for storm / sewer utility assets to require replacement. When this work is undertaken the cast iron and AC water pipes should also be replaced. Afterwards, a full width road restoration can be completed.

The District does not keep records linked to particular pipe segments. Keeping asset condition records when exposing buried infrastructure will be a valuable resource for the accumulation of asset condition data without the expense of excavation and reinstatement. The history of watermain breaks would also become part of the record for each pipe segment.

Level of Service: The water model indicates that some watermains are undersized for their service and need replacement in order to meet performance criteria.

7.4.8 Cross Connection Control Plan

The Fraser Health Authority administers the provincial Drinking Water Protection Act. The Health Authority has identified that the District of Hope shall develop a detailed Cross Connection Control Program (CCCP) in accordance with Section 15 of the Drinking Water Regulation. Cross connection control is defined as the enforcement of a bylaw regulating cross connections. The program monitors the installation, maintenance and field testing of backflow preventers in accordance with an appurtenant bylaw and industry and regulatory agency standards. The requirement for backflow prevention devices is described in the BC Plumbing Code. All plumbing systems have to comply with the Plumbing Code requirements for backflow prevention devices. An important supporting document to the BC Plumbing Code is a publication by the Canadian Standards Association (CSA) titles “Selection and Installation of Backflow Preventers/Maintenance and Field Testing of Backflow Preventers”. The CSA publication provides a guide rating the hazard of contamination from a range of building occupancies. The hazard ratings are severe, moderate and minor.

7.5 Financing

Water system capital improvements are typically financed from any or combinations of the following:

- User fee / water tax revenue
- Borrowing (Municipal Finance Authority debentures)
- Development cost charges

- Developer contributions
- Grants from senior governments

7.5.1 User Fees

Some portion of the capital improvement program is likely to have to be financed by increasing the user fee rate structure. The District's annual 2017 utilities budget is summarized as follows;

Revenue	
Parcel taxes	$206,540
Sales of Services	$1,120,693
Transfers from other governments	$839,554
Development Cost Charges	$351,182
Total Revenues	$2,517,969
Expenses	
Salaries and benefits	$309,681
Insurance and claims	$24,895
Office and administration	$19,727
Repair and maintenance	$301,589
Utilities	$169,265
Total expenses	$825,157
Subtotal Expenses	**$825,157**
Interest	$34,875
Amortization	$503,921
Operating Budget Surplus	**$1,154,016**

In the above summary, amortization is a non-cash expense and largely represents depreciation of the value of the water infrastructure. To a degree, the allowance for depreciation could be "used" to replace aging infrastructure such as watermains approaching the end of their service life. Recognizing amortization amount as a non-cash expense, the District's water utility has an annual surplus of around $1,600,000 which is typically available for capital projects and/or transfers to reserves. The operating surplus is expected to be allocated to water conservation program implementation, replacement of aging infrastructure as well as improvements to the water system.

Depending on the planned capital works program, the District may choose to set a new funding target and adopt a series of user fee rate structure increases, to eventually reach this goal.

7.5.2 Development Cost Charges

Capital projects having the objective of providing additional capacity and/or improving system reliability are typically eligible projects for a development cost charge bylaw. A report was prepared in 1994 calculating development cost charges for water, sewerage and drainage facilities, this report has not been updated to reflect current projects, although this will be an outcome of this master plan.

The District does not currently have a stand-alone development cost charge bylaw. Development Cost Charges are authorized under the Fees and Charges Bylaw No. 1363.

7.5.3 Gas Tax revenue

Annual Gas Tax revenue can be used for water system rehabilitation projects. The District will need to determine what projects are a priority for use of the Gas Tax revenue. The watermain replacement project would be well suited to this funding.

7.5.4 Senior Government Grants

These projects can be eligible for grants from senior governments if a significant benefit, particularly water quality improvements, can be demonstrated. Senior Government Grant programs attach a higher priority to projects that represent a drinking water quality improvement or have environmental benefits.

Within this category the following projects from the capital plan would be capital grant eligible projects;

- Disinfection / treatment projects
- Water conservation projects
- Well construction or links between the 138m Zone and the East Kawkawa Lake that provide for security of supply.

Given that the Province is looking to divest itself of the 753 Water System, the projects that would facilitate this transfer may also be successful in attracting Provincial funding.

APPENDIX A

Groundwater Supply Assessment

(Western Water Associates)