Village of Lions Bay

Infrastructure Master Plan

Prepared by:

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Project Number:

60437708

Date:

July 28, 2016

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July 28, 2016

Peter DeJong, BA, LLB, CRM
Chief Administrative Officer
Village of Lions Bay
400 Centre Road
Lions Bay, BC V0N 2E0

Dear Peter

Regarding: **Infrastructure Master Plan**

AECOM Project No: **60437708**

Please find enclosed our revised Infrastructure Master Plan for the Village of Lions Bay. If you have any questions, please contact David Main at 604.444.6400.

Sincerely,
AECOM Canada Ltd.

Graham Walker
Infrastructure Planning Engineer
graham.walker2@aecom.com

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Version Log

Version #	By	Date	Description
A	JB	2016-01-19	Draft for Review
B	JB	2016-01-29	Draft for Review
C	NH	2016-03-04	Draft for Review
D	NH	2016-03-10	Report for Council Submission
E	NH	2016-04-29	Revised Council Submission (prior to PCI inclusion)
F	GW	2016-06-29	Final
G	**GW**	**2016-07-28**	**Final**

AECOM Signatures

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Nancy Hill, P.Eng.
Project Manager

Executive Summary

The Village of Lions Bay "The Village" owns and manages water, sanitary, stormwater, combined, roads and street-lighting networks that services a community of approximately 1,318 residents (2011 Census). AECOM was retained by the Village to develop an Infrastructure Master Plan (IMP), the objective of which is to maintain the condition, capacity and compliance of the Village's assets through sustainable infrastructure investment. The timeframe of the plan is 2016-2045; however there is a focus on years 2016-2020.

The infrastructure assets included in the scope of the IMP were:

- Water (including treatment plants, pipes);
- Sanitary (including treatment plant, pipes);
- Stormwater (including pipes and roadside channels); and
- Roads and bridges.

The approximate replacement value of the Village's water, sanitary, drainage and road/bridge infrastructure is estimated at $49 million. The asset valuation was performed using current construction costs, but should be considered indicative only due to the level of available detail of on the existing infrastructure.

Based on the estimated services lives of different asset types, the Village should be spending approximately $945,000 per year, on average, on the renewal of its existing infrastructure. If the Village plans to make significant changes to its system (e.g. add filtration to its water treatment plants or expand its sanitary servicing area) then the annual infrastructure renewal costs would increase accordingly. This estimated renewal amount is a starting point from which the Village can begin discussions on desired levels of service and required tax levels to support different levels of service.

The IMP was developed in line with the following process:

- Valuate the asset inventory;
- Assess condition, capacity and regulatory compliance of assets through various investigations;
- Identify capital projects or policy changes to resolve issues; and
- Prioritize and schedule capital projects.

The Village should review the list of recommended capital projects in terms of available budgets, desired levels of service and available staff capacity to manage or deliver the projects listed. Figure E-1 summarizes the proposed projects by years and priorities. All cost estimates are in 2015 Canadian dollars, unless otherwise noted.

Over half of the unscheduled projects are considered high or medium priority and therefore the Village may want to consider scheduling them within the next five (5) years, as budgets allow. This will allow the Village to attain "sustainable" infrastructure renewal rates and prevent the Village from facing a large wave of infrastructure renewal needs in five (5) to fifteen (15) years' time.

In summary, the main types of projects that the Village needs to consider in the short term (i.e. next 5 years) include:

- Replacing drainage culverts that have severely deteriorated;
- Improving the availability of infrastructure data;
- Increasing the capacity of the water system to obtain sufficient fire flow protection;
- Replacing watermains that are in poor condition;
- Completing the high priority bridge repairs;
- Repairing roadways that are in poor condition and have poor drainage;
- Improving safety at the treatment plants;
- Rehabilitating the water reservoirs (high priority repairs and replacements) and determining their seismic vulnerability;
- Deciding whether to expand the sanitary system to service more/all of Lions Bay;
- Commissioning a strategic water supply study in order to determine the long term viability of the creek water supply. Based on the results of the study, undertake any necessary works;
- Investigating funding opportunities (such as provincial and federal infrastructure grants) for proposed projects;
- Implementing zone metering to help identify areas where water consumption can be reduced; and
- Renewing the water intake at Harvey Creek which is in poor condition.

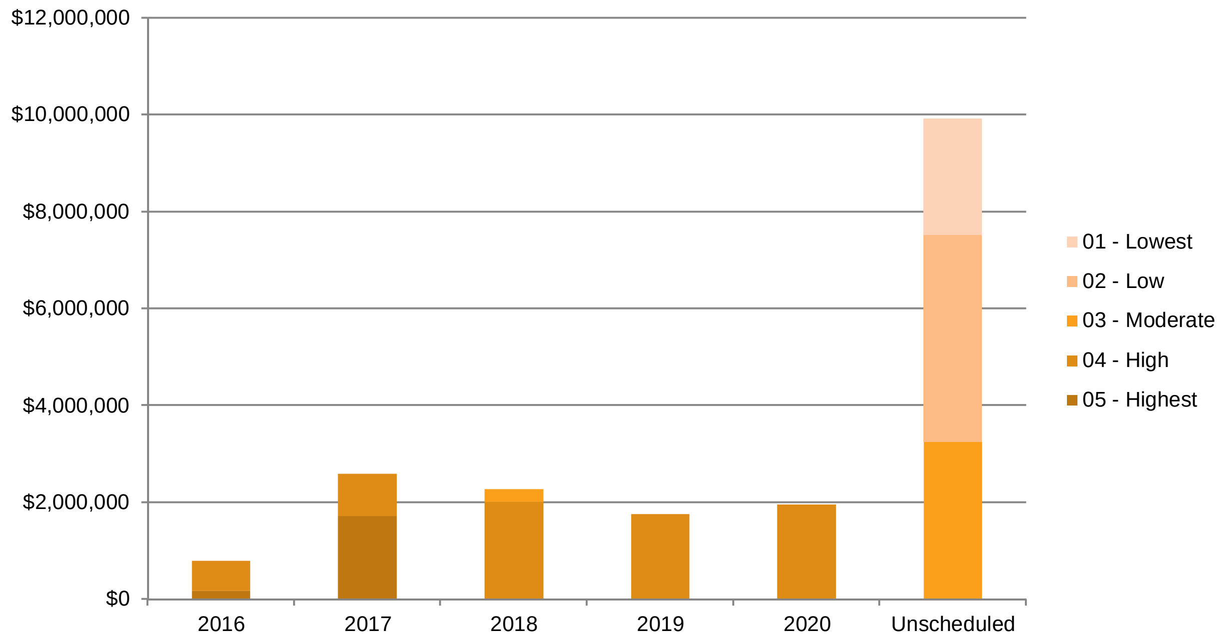

Figure E 1: Capital Cost Estimate Summary

The main types of projects that the Village will likely need to consider in the medium term (5-15 years) include:

- Replacement of the original water reservoirs;
- Improved water treatment (e.g. filtration);
- Continue to replace deteriorating infrastructure (watermains, culverts and roadways); and
- Improved wastewater treatment if flows increase and/or regulatory requirements become more stringent.

The full list of recommended projects summarized in the above figure is provided below in Table E 2. Details including the project maps for each year are located in Section 7.1.

In addition to capital projects, a series of policy recommendations were identified. These recommendations include improved management of the public realm corridor to reduce problems from encroachment, increasing infrastructure investment to sustainable levels; ensuring short-term repair works do not impact long-term infrastructure objectives, leveraging infrastructure grant opportunities and reducing procurement costs. Details of these recommendations are included in Section 7.2.

Minimising infrastructure lifecycle costs and achieving desired levels of service is dependent on a good operating and preventative maintenance program. The Village's infrastructure operation and maintenance (O&M) costs need to be considered in addition to the capital costs highlighted above. Capital and O&M are intricately related as a good O&M program will typically extend the service life of a given asset and reduce overall capital costs.

Table E 2: Capital Projects List

Project No	Schedule	Priority	Predecessor(s)	Project Name	Capital Cost	Drivers / Description	Water	Sanitary	Drainage	Roads & Bridges	General
01	2016	05 - Highest		Survey & Design of 280m Galvanized Drain Replacement & Road Repair on Bayview Rd	$24,000	Existing drain is severely corroded, with water eroding sub-grade below. Has started causing sinkholes. Presents significant safety risk. Adjacent road is poor condition. Concurrent replacement opportunity.					
02	2016	05 - Highest		CCTV, Alignment Confirmation and Condition Assessment of Kelvin Grove Beach Park culvert.	$1,000	Require CCTV of culvert under toilet block at Kelvin Grove Beach Park.					
03	2016	05 - Highest		WWTP Safety and Monitoring Improvements	$25,000	Condition assessment and operations staff consultation identified following critical issues: no fall restraint in WWTP, rotten wooden access bridge, V-notch weir displaced.					
04	2016	04 - High		Purchase of UAV for Water Intake Inspection.	$4,000	Current operating procedure for water intakes restricts access after significant rainfall, but ops staff require method of inspection. UAV identified as low-cost, safe option.					
05	2016	04 - High		Digitize, organize and backup all hard copy engineering drawings.	$1,000	A significant volume of Village infrastructure information is missing, and a large proportion remains in paper format. Many of these plans are deteriorating and the information will be lost if they are not digitized ASAP.					
06	2016	05 - Highest		General Bridge Repairs (Very High Priority)	$14,300	Findings of bridge condition assessment performed in late 2015. Very High Priority items only, includes 7/8 bridges.					
07	2016	04 - High		SCADA Control Strategy Study	$60,000	SCADA links can often go down in poor weather. Previous designers identified that cellular technology and coverage has improved since project was implemented. May be a way to add redundancy and reliability to system. The Villages existing SCADA system is limited in its scope and does not provide operational efficiencies associated with modern systems. Obsolete components and technology results in increased replacement costs and labour intensive down time. Staff propose commissioning a SCADA Control Strategy Study to determine the most efficient and cost effective technology moving forward.					
08	2016	05 - Highest		Survey & Design of Stormwater, Road, Water (Hydrant) work on Oceanview Rd.	$38,000	Culvert blocked in 2015 and caused significant road damage. Road in general vicinity is in poor condition. Hydrant is in very poor condition.					
11	2016	04 - High		Site Investigation and Design for Zone / Branch Water Metering	$2,500	Village water network is currently unmetered, and there is limited information on the water consumption / leakage. Residential metering is long-term objective, however zone metering is likely to provide more immediate benefits in terms of tracking flows, identifying issues and exhibiting a long-term commitment to water conservation.					
33	2016	04 - High		Reservoir rehabilitation and inspection	$150,900	Reservoirs were inspected in 2004 but only the most urgent rehab work was completed. Re-inspect reservoirs, determine seismic vulnerability, and complete high priority rehabilitation work (except for Harvey 400,000 which will be replaced in 2017).					
43	2016	05 - Highest		Strategic water supply study	$75,000	Study to determine the long-term viability of Magnesia and Harvey Creek as sustainable water supply sources into the future with the impacts of climate change.					
45	2016	04 - High		Survey, CCTV and Design to replace deteriorated concrete culvert on Mountain Dr	$33,000	Invert of existing concrete pipe is completely deteriorated and a large sinkhole has formed					
12	2016	04 - High	1	Construction Galvanized Drain Replacement & Road Repair on Bayview Rd (280m)	$364,000	Refer to Project 01					
58	2017	04 - High		PRV Station Replacements	$450,000	Retrofit and upgrade of existing PRVs 1, 2, 8, 9, 10, and 11 including WorkSafe BC compliance and SCADA automation					
10	2017	05 - Highest		Commence Survey of 70 Parcels with Lost Water Connections and potential encroachments and confirm property lines	$105,000	Seventy (70) Parcels have missing water connections that need to be located and surveyed. The Village cadastral information also requires update and realignment. Reclamation of public realm from private encroachment has been identified as crucial factor in managing drainage and utilities over the long-term, and this is an important input.					
13	2017	04 - High	8	Construction of Stormwater, Road, Water (Hydrant) work on Oceanview Rd (200m)	$241,250	Refer to Project 08.					
19	2017	04 - High		Survey and Engineering Design of Upper Bayview Road - road, drainage and water main.	$57,500	The pavement of Upper Bayview Rd is in very poor condition, with large sections likely requiring full pavement repair. The roadside drainage is disconnected, and water typically sheets down roadway. In many locations, roadside drains have been filled in. The road corridor should be surveyed (to establish PLs, driveways, structures) and a holistic engineering design should be prepared. Engineering design should include cost estimating and scoping of construction phases. Should replace old AC/CI water main within the roadway congruently as the Village has already experienced one break.					
44	2017	04 - High	43	Flow monitor stream flows, if recommended by stream study in 2016	$72,000	Install two monitoring stations and collect data for two years to monitor stream flow in Harvey and Magnesia Creek					
46	2017	04 - High	45	Construction to replace deteriorated concrete culvert on Mountain Dr and permanent repair of road	$48,000	Existing concrete pipe has deteriorated to the point that there is no bottom and a large sinkhole has formed. Assume it requires replacement of 40 meters of pipe, extent of required replacement to be confirmed with CCTV.					
51	2017	05 - Highest		Remove danger trees at Alberta Creek water main bridge and inspect 2 water main bridge crossings.	$20,000	Remove danger trees to reduce risk of damage to Alberta Creek water main bridge. Inspect the water main bridge crossings at Alberta and Harvey Creek.					
56	2017	05 - Highest		Design and Construction to replace Harvey Creek 400,000 gallon water reservoir.	$1,600,000	The Harvey Creek water reservoir was constructed in 1980 using concrete panels that incorporated horizontal pre-stressed strands. A 2004 inspection of the plant revealed extensive leakage between the panel joints an indicated potential corrosion of the pre-stressed strands. An attempt to fix the leaks by coating the interior of the tank failed and further remediation has not been attempted. The existing tank does not meet seismic standards.					
20	2018	04 - High	19	Construction of Road Repairs, Water main and Drainage Works along Upper Bayview Rd	$956,250	See Project 19. Staging will be dependent on budget and phasing identified in design component.					
36	2018	04 - High		Survey and Engineering Design of Water main Upsize	$58,750	Mains Identified in GA Hydraulic as not meeting fire flow. Listed by GA as Very High priority. Survey and Engineering Design of Water main Upsize (x2) from Highway Tank, under Highway 1 on Oceanview Road, onto Lions Bay Ave (Upgrade 1 GA Report) (273m), and From PRV 3, under Highway 1 on Oceanview Road, up Isleview Place (Upgrade 2) (630m)					
47	2018	03 - Moderate		Survey, design and construction to replace culvert in poor condition at the bottom of Tidewater Way as well as culvert from Sweetwater Place to Tidewater Way. Confirm with CCTV if the railway crossing needs to be replaced as well. Crack seal and patch poor sections uphill of the culvert replacement.	$272,700	VoLB staff reported that the culvert is severely deteriorated. Assume it requires replacement of 150 meters of pipe, including a railway crossing. Extent of required replacement to be confirmed with CCTV. Pavement on Tidewater is in poor-moderate condition. Repave full width of roadway where culvert is replaced. Crack seal and patch poor sections of roadway uphill of the culvert replacement.					

Project No	Schedule	Priority	Predecessor(s)	Project Name	Capital Cost	Drivers / Description	Water	Sanitary	Drainage	Roads & Bridges	General
49	2018	04 - High		Design for a new Harvey Creek raw water intake structure	$90,000	VoLB staff report that the intake is in poor condition and was constructed in the 1980's.					
57	2018	04 - High		PRV Station Replacements	$900,000	Full replacement to improve performance of PRVs 3, 4, 5, 6, 7, and Bayview including WorkSafe BC compliance and SCADA automation					
16	2019	04 - High		Survey, Design and Construction of Water Main Replacement on Creekview Pl (90m)	$126,250	150 CI water main on Creekview Pl is in very poor condition and requires replacement. High incidence of leaks.					
18	2019	04 - High		Survey, Engineering Design and Construction of Water Main Upsize, Road Repairs, New Drain on Bayview Pl (300m)	$384,400	Parts of Bayview Pl pavement are in poor condition. 150 CI water main is in poor condition and requires upsizing to 200mm to achieve fire flow.					
21	2019	04 - High		Survey and Engineering Design of Water Main Replacement (upsize), Road Repairs, Stormwater reinstatement on Highview Pl & Oceanview Rd	$63,200	150 CI pipe is undersized and in poor condition. Highview Pl roadway is in moderate condition, and Oceanview Rd is in very poor condition. Replace 415 meter of 150 CI water main on Highview Pl/Oceanview Rd and replace entire width of asphalt.					
31	2019	04 - High		High Priority Repairs on Eight (8) Bridges	$99,500	Variety of "High" priority bridge repairs as defined in Bridge Condition assessment.					
37	2019	04 - High	36	Construction to upsize water main (x2) from Highway Tank, under Highway 1 on Oceanview Road, onto Lions Bay Ave (Upgrade 1 GA Report) (273m), and from PRV 3, under Highway 1 on Oceanview Road, up Isleview Place (Upgrade 2) (630m)	$1,020,400	Refer to Project 36.					
38	2019	04 - High		Survey, Design and Construction to upsize Water main on Inlet/Outlet of Phase IV Tank (46 m)	$59,750	Upgrade 4 in GA Modelling Report. Not meeting fire flow. List in report as very high priority.					
22	2020	04 - High	21	Construction to upsize Water Main & Road Repairs on Highview Pl & Oceanview Rd	$752,200	See Project 21					
50	2020	04 - High		Replacement of Harvey Creek raw water intake structure	$1,200,000	VoLB staff report that the intake is in poor condition and was constructed in the mid 1980's.					
09	Unscheduled	03 - Moderate		Subscription to ArcGIS Online (Online GIS for asset data management)	$2,500	Village asset GIS is antiquated and difficult to use. Online system will enable simplification of data management, and enable viewing through multiple devices, systems (inc. web site, phone)					
14	Unscheduled	03 - Moderate	11	Construction of Meters for Zone / Branch Water Metering	$150,000	Refer to Project 11					
15	Unscheduled	03 - Moderate		CCTV of sanitary and storm sewer system	$44,000	Commence regular CCTV inspections and conditions assessment of sanitary pipe network					
17	Unscheduled	03 - Moderate		General Bridge Repairs (Medium Priority)	$89,500	Findings of bridge condition assessment performed in late 2015. Medium priority items only, includes 7 bridges).					
23	Unscheduled	03 - Moderate		Survey, Design and Construction to Reinstate Stormwater Pipe on Oceanview Rd	$250,000	The 600mm stormwater culvert (approx. 100 m plus tie-ins/discharge points) that formally discharged to Rundle Creek requires reinstatement. Replace sections of poor pavement (20 m) of Oceanview Rd					
24	Unscheduled	02 - Low		Desalination Feasibility Study	$12,500	The frequency of turbidity events, smaller snow levels and water intake shutdowns have resulted in concerns about long term viability of existing water supplies. There may be a business case for transitioning to a desalination plant to improve reliability of supply, and there are likely to be significant improvements in small-scale desalination technology in the short term. A feasibility study should be performed within 5 yrs. to categorically determine if this is a suitable solution.					
25	Unscheduled	02 - Low		Survey, Engineering Design and Construction of Drainage Improvements on Brunswick Beach Rd	$75,000	Drainage between 26, 27 & 29 Brunswick Beach Rd is poor. Area is very low and flat. New drain will likely be required.					
26	Unscheduled	02 - Low		Survey, Engineering Design and Construction to upsize water main and improve drainage on Kelvin Grove Way (Upper) (380m)	$361,150	Water main on Kelvin Grove Way (Upper) requires upsizing from 150mm to 200mm to achieve fire flow. Many drains have been filled in, and drainage regime along road should be redesigned and implemented. Road pavement is in poor to moderate condition.					
27	Unscheduled	03 - Moderate		Survey, Design and Construction to upsize Water main on Stewart Road (250m)	$281,250	150 DI water main on Stewart Rd is undersized and requires upsizing to 200mm to meet fire flow requirements. Identified as High Priority replacement by GeoAdvice. Stewart Road pavement is in moderate condition.					
28	Unscheduled	02 - Low		Survey, Engineering Design and Construction of Road repairs and Drainage Improvements on Isleview Pl (1030m2 of distressed pavement)	$45,100	Sections of road are in moderate to poor condition -some patching of fatigue and crack sealing required. Significant drainage issues were identified by operations staff.					
29	Unscheduled	02 - Low		Survey, Engineering Design and Construction of Drainage Improvements on Lions Bay Ave (210m)	$110,000	Ditch on Eastern side of Lions Bay Ave has been infilled and requires reinstatement. Identified by operations staff as issue.					
30	Unscheduled	01 - Lowest		Road Repairs on Crystal Falls Rd (150m)	$65,700	Road is in moderate condition. Lowest priority as the road services very few properties.					
32	Unscheduled	02 - Low		Medium Priority Repairs on Bayview Road (Private Driveway) over Alberta Creek	$62,000	Repairs identified in Bridge Inspection,					
34	Unscheduled	02 - Low		Mill and Overlay poor sections (245 m2) of Crosscreek Road	$10,800	Pavement in poor condition -deep patch of fatigue					
35	Unscheduled	03 - Moderate		Survey, Design and Construction of Water Main Replacement, Drainage Repair on Centre Rd, (100m)	$135,000	Water main identified as Poor condition by operations staff. Drainage on north side of road requires clean up.					
39	Unscheduled	03 - Moderate		Survey, Design and Construction of Road Repairs, and Drainage Improvements on Kelvin Grove Way (150m). Water main upsizing required (545 m).	$746,900	Sections of road in very poor condition. Culvert crossing in poor condition. Water main upsizing is upgrade 8 in GA modeling report (medium priority).					
40	Unscheduled	03 - Moderate		Survey, Design and Construction of Water Main Replacement, Road Repair on Bayview Rd (300m)	$373,750	Water main in poor condition. Identified as priority 2 by operations staff.					
41	Unscheduled	02 - Low		Magnesia Tank requires additional storage capacity for fire flow.	$400,000	Identified as Moderate Priority upgrade in GA report (No. 9). Could be provided elsewhere within the service area.					
42	Unscheduled	03 - Moderate		Survey, Design and Construction of Water main Upsize on Timbertop Rd (126m)	$166,600	Identified as High Priority upgrade in GA report (No. 7). Road in poor condition.					
48	Unscheduled	03 - Moderate		Survey, Design and Construction to replace corroded culvert crossing Bayview Road just north of the school.	$50,400	VoLB staff reported that the culvert has deteriorated.					
52	Unscheduled	03 - Moderate		Reservoir replacement (design and construction of three tanks)	$900,000	Four of the village tanks are in poor condition and reaching the end of their service lives. The Harvey 400,000 gallon tank will be replaced in 2018 but the remaining ones will need replacement in the near future. The condition assessment in 2016 should determine which reservoir poses the highest risk of failure and should be replaced first (probably Brunswick or Tank V).					

Project No	Schedule	Priority	Predecessor(s)	Project Name	Capital Cost	Drivers / Description	Water	Sanitary	Drainage	Roads & Bridges	General
53	Unscheduled	03 - Moderate		Deep patch asphalt on Oceanview Rd between Creekview Place and Highview Pl (250m)	$58,600	Deep patch of fatigue. Pavement in very poor condition.					
54	Unscheduled	01 - Lowest		Upsize the 300 mm CSP culvert from Bayview Rd to Alberta Creek (50m)	$74,400	Existing 300 mm pipe is undersized. Also, the existing pipe is steel, and is therefore probably near the end of its service life.					
55	Unscheduled	01 - Lowest		Install a ditch on the low side of Cloudview Place.	$55,700	Currently only a ditch on the uphill side of the road, which road run-off can't get to.					
59	2019	03 - Moderate		Wastewater Treatment Methodology Review and Phased System Expansion Study	$70,000	Review treatment technologies with consideration for increased capacity of the plant to allow for expansion of the sanitary sewer network. Developing a phased plan for providing sanitary sewers to the currently unserviced areas of the Village. Study will also include review of options for connecting the Oceanview Area to Kelvin Grove likely by pumping that crosses Rundle Creek.					
60	Unscheduled	02 - Low	59	WWTP Replacement	$3,200,000	WWTP replacement to meet existing capacity plus Oceanview with allowances for expansion to accommodate full Villlage servicing. Cost will vary depending on results of review conducted under Project 59.					
61	Unscheduled	01 - Lowest	59	Oceanview Sewer and Pump Station	$2,200,000	Construction of sewers within Oceanview area (above Hwy 99) and connection of system to Kelvin Grove via pumping station and forcemain across Rundle Creek.					

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1 Introduction

1. Introduction

1.1 Background

The Village of Lions Bay ("the Village") is an incorporated municipality located approximately 25km north of Vancouver. The Village has approximately 530 residential properties and a population of 1,318. The Village is effectively split into three separate areas: Kelvin Grove, Lions Bay and Brunswick Beach, from south to north, and bordered by Howe Sound on the west and the North Shore Mountains on the east.

The Village has a consolidated annual budget of approximately $2.2M, funded almost entirely by residential taxes. The Village relies heavily on grant funding from Federal and Provincial government to deliver infrastructure.

AECOM was engaged by the Village to develop an Infrastructure Master Plan (IMP) for the Village. This plan builds upon the previous work completed by the Village. The following studies were reviewed and used in the preparation of this IMP:

- 2014 Village of Lions Bay Land Use Master Plan (Draft);
- 2009 Harvey Creek UV Validation Report;
- 2008 Water Treatment Upgrades Pre-Design Study;
- 2008 Preliminary Geotechnical Assessment Oceanview Road Storm Water Swale;
- 2006 Water Master Plan;
- 2005 Reservoir Assessment;
- 2005 Infrastructure Assessment Report WWTP and PRV Stations;
- 2005 Water Quality Monitoring Report;
- 2004 Alberta Creek Visual Bridge Inspection; and
- 2004 Geotechnical Assessment of Rock Slopes Access Road to Harvey and Magnesia Creek Water Intakes Structures.

1.2 Goal

The broad goal of the IMP is to identify existing and future risks to the condition, capacity and regulatory compliance of the Village's infrastructure, and guide infrastructure investment to manage those risks. This goal includes:

- Continuous provision of a safe, effective, and efficient water supply that can be easily and cost-effectively maintained.
- Continuous provision of a safe, effective, and efficient sanitary system that can be easily and cost-effectively maintained.
- Continuous provision of a safe, effective, environmentally-friendly and efficient drainage system that can be easily and cost-effectively maintained.
- Continuous provision of a safe and efficient road and bridge network, with optimal maintenance and rehabilitation schedules.
- Develop long and short term capital budgets for infrastructure replacement in a prioritized and fiscally responsible manner.

The timeframe to be considered in the IMP was 2015-2045 (30 years), with particular focus on 2016 to 2020 (inclusive).

1.3 Scope

The investigations included in the IMP are summarised in Table 1-1 below. Following completion of the investigations, a list of projects was developed that seeks to resolve issues or capitalise on opportunities identified in the investigations.

Table 1-1: Scope of Works

Infrastructure Component	Investigations
Water	• Review Metering Options • Review Water Rights • Review Supply and Treatment Options • Update Hydraulic Model and Perform Flow / Capacity Analysis • Review SCADA Options
Sanitary	• Condition Assessment • Update Hydraulic Model and Perform Flow / Capacity Analysis • Review Treatment Options • Develop Conceptual plan for Village-wide sanitary system
Drainage	• Condition Assessment • Road Corridor Review
Road & Bridges	• Road Pavement Condition Assessment • Bridge Condition Assessment
General	• Prepare List of Capital Projects • Determine Sustainable Funding Levels • Identify Funding Opportunities • Identify Policy Improvements

Notable Exclusions

It is important to note that the following Village-owned infrastructure items were not included in the scope of the IMP:

- Buildings and Structures (e.g. Offices, Toilet Blocks);
- Parking Areas / Laydowns; and
- Parks and Beaches.

Infrastructure within the Village, but not owned by the Village, was not included in the scope of the IMP. This includes:

- Roads, bridges and concrete channels owned by the Ministry of Transportation and Infrastructure (MOTI);
- Private roads and forestry roads; and
- Telecommunication infrastructure (Telus, Shaw).

1.4 Methodology

1.4.1 General Approach

The IMP included a variety of investigations that had different approaches and outputs; however investigation was broadly approached in line with the process outlined in Figure 1-1.

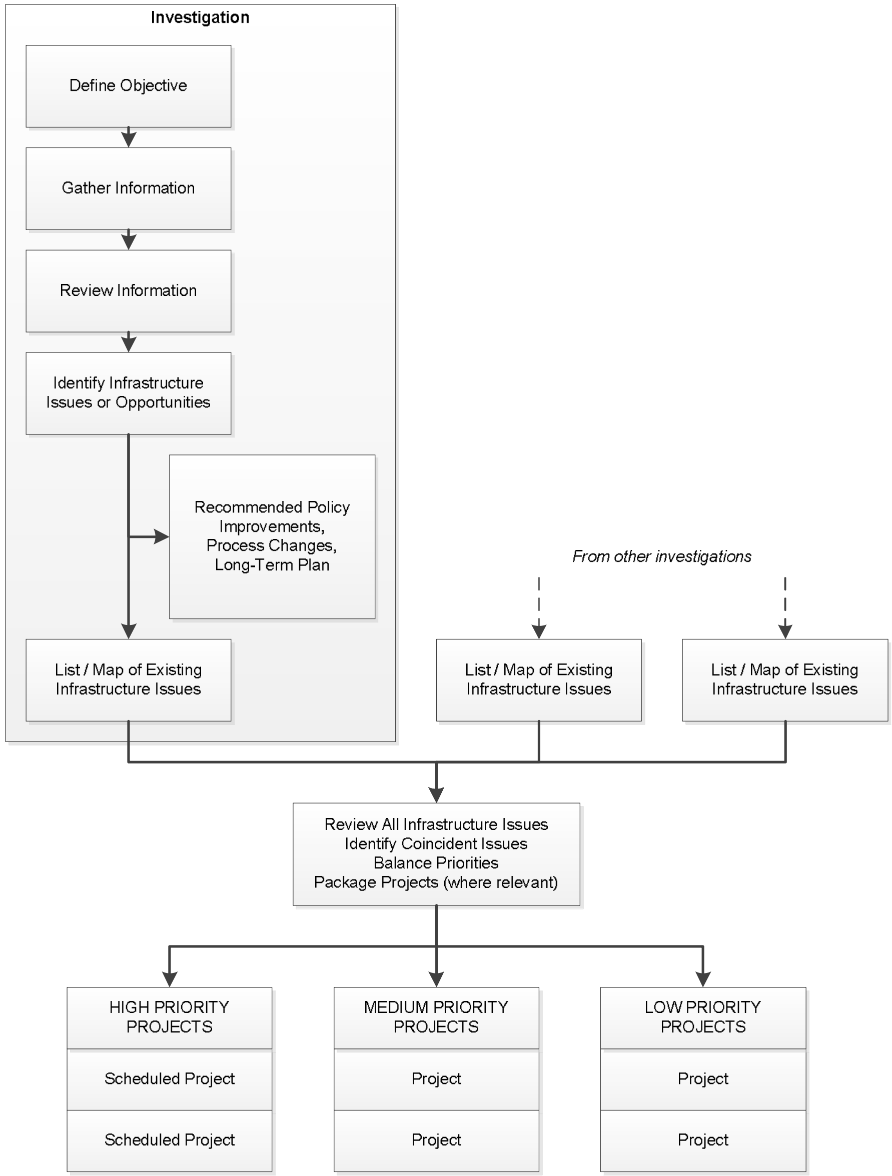


Figure 1-1: General Methodology for the IMP

1.4.2 Engagement

Over the course of the project, several meetings were held with the Village's Infrastructure Committee (IC). The Terms of Reference of the IC is to "advise Council on the establishment of policies, bylaws and matters related to infrastructure planning, development and maintenance in the Village". The intent of these meetings was to ensure that representatives of the Village could provide input and feedback on the findings and recommendations in the plan.

Workshops were held with members of the Village's operations staff. The objectives of these workshops were to:

- Resolve discrepancies between infrastructure shown in the GIS and what was actually installed;
- Develop an understanding of system operations (particularly the water network); and
- Obtain staff input on infrastructure issues and investment priorities.

1.4.3 Cost Estimates

Cost estimates were developed using a variety of different methods and sources depending on the objective of the respective investigation and the information available. All cost estimates were calculated in 2015 Canadian Dollars and should all be interpreted as very high-level and indicative only.

1.5 Assumptions

1.5.1 Population

Statistics Canada recorded 1328 and 1318 residents in the Village in the 2006 and 2011 censuses respectively, a variation of less than 1%, which indicates the Village population was generally quite stable.

1.5.2 Growth

At the commencement of the project, a population increase of 3% every five years (approximately 0.3% per year) was agreed and adopted as a reasonable growth estimate. This rate was assumed to account for the Village's goal to facilitate sustainable development within the planning and geographic constraints, and the community's general desire to remain a "small, close-knit village".

The projected population changes over the course of the IMP planning period are shown in Figure 1-2 below.

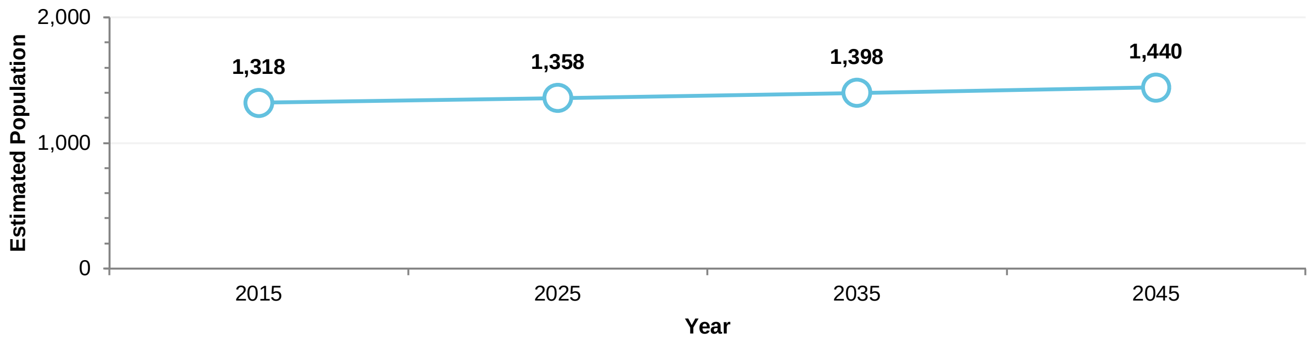


Figure 1-2: Population Growth Forecast (based on 3% growth over five years)

1.5.3 Potential Developments

In December 2015, the IC noted that a potential housing development was being considered in the vicinity of Crystal Falls Rd. Based on available land and potential land uses, it was assumed that the equivalent of an additional thirty (30) single-family homes would be associated with the development, with an approximate population increase of one hundred (100).

It is very important to note that, at the time of this report, the potential development was still being considered at a conceptual level and the aforementioned numbers are very likely to change. The development was not considered in the water modelling component of the IMP, however it was considered in the assessment of the potential Village-wide sanitary system.

2 Water

2. Water

2.1 Overview

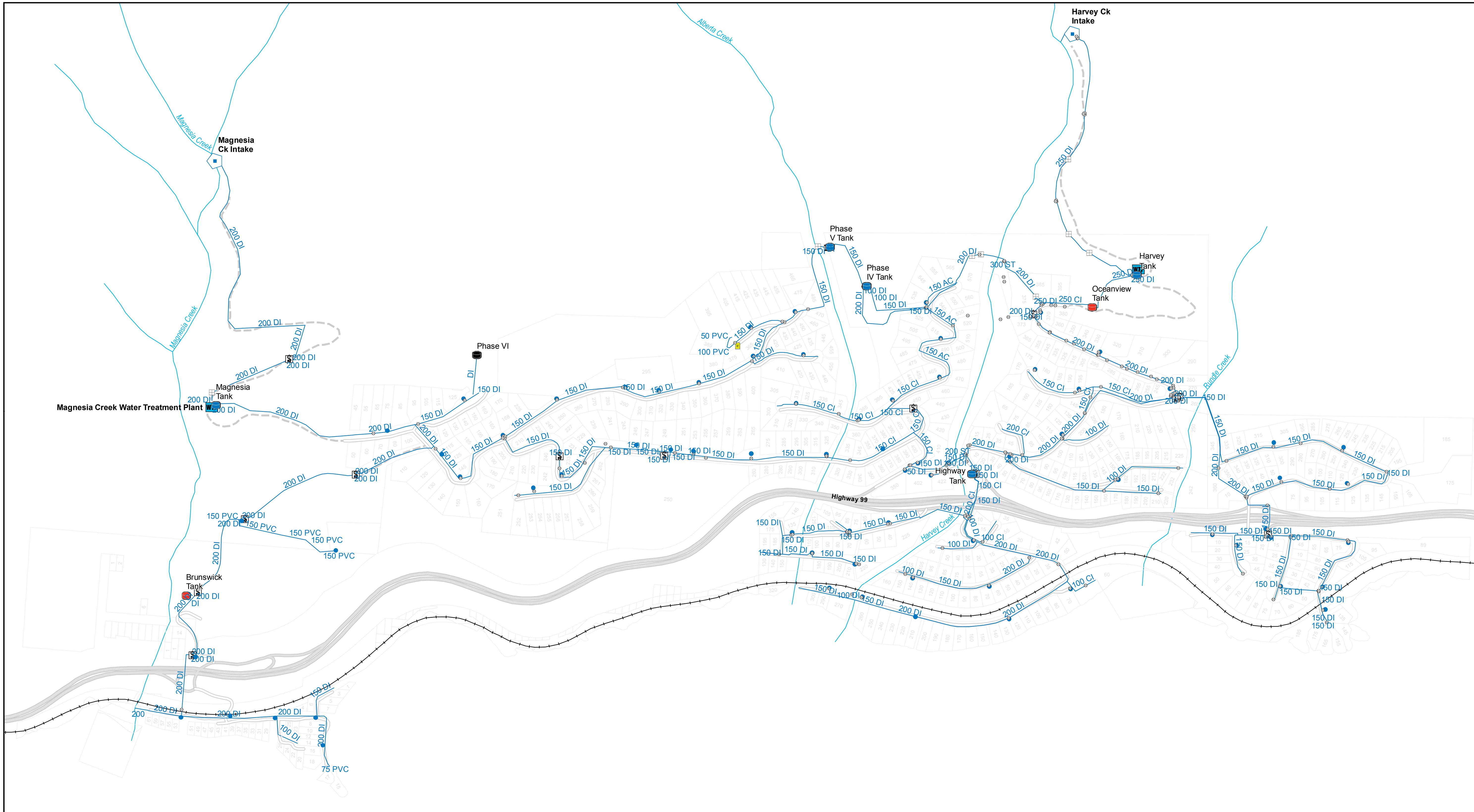
2.1.1 System Description

The Village water treatment and distribution system services all properties in the Village and comprises of the assets listed below.

- 17km of watermain (various sizes and materials)
- 2 water treatment plants (Harvey Creek WTP, Magnesia Creek WTP)
- 8 water tanks (5 of which contain potable water)
- 2 raw water intakes (Harvey Creek, Magnesia Creek)
- 529 property connections
- 13 pressure reducing valve arrangements
- 72 hydrants
- 250 valves

An overview of the Village's water system is shown in Figure 2-1.

The system is separated into eighteen (18) pressure zones. The boundaries along the pressure zones consist of a series of closed valves and pipes, and pressure regulating valve (PRV) stations to decrease the pressure to an acceptable range for delivery of water to users. The layout of the pressure zones are shown in Figure 2-2.



VILLAGE OF LIONS BAY
Infrastructure Master Plan
Figure 2-1 Water System Overview

AECOM

Legend

Property Parcels

Village Roads
- Sealed
- Unsealed

MOTI Roads
- On-Ramp
- Highway

Treatment Plant

Intake

Tanks (by Water Type)
- Not In Service
- Non Potable Water
- Treated Water

Valves (by Type)
- Air Valve
- Check Valve
- Gate Valve
- PRV

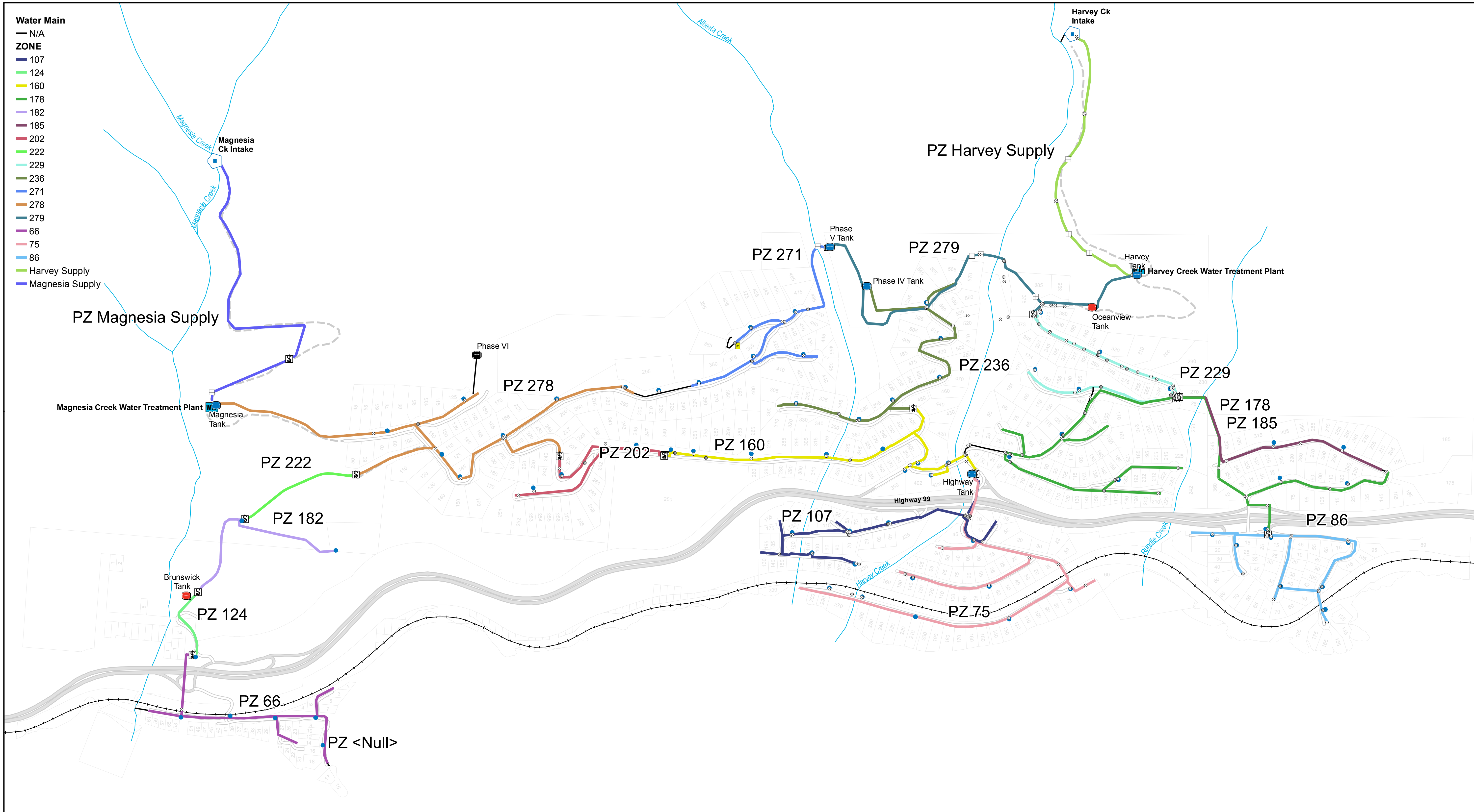
Hydrant

Pump Station

Water Main

0 50 100 200
Metres

Village of Lions Bay



VILLAGE OF LIONS BAY
Infrastructure Master Plan
Figure 2-2 Pressure Zones

AECOM

Legend

Property Parcels

Village Roads
Sealed
Unsealed

MOTI Roads
On-Ramp
Highway

Treatment Plant
Intake

Tanks (by Water Type)
Not In Service
Raw Water
Treated Water

Valves (by Type)
Air Valve
Check Valve
Gate Valve
PRV

Hydrant
Pump Station

0 50 100 200
Metres

Village of Lions Bay

2.1.2 Challenges

The Village has acknowledged the following concerns and challenges relating to water supply, treatment and distribution:

- Turbidity in both Harvey Creek and Magnesia Creek occasionally exceeds the treatment capabilities of the UV plants. Required actions to protect public health result in water shortages and require the implementation of water restrictions.
- Water consumption in the Village is significantly higher than the Metro Vancouver average.
- Water availability increases and decreases with creek flows, and is heavily dependent on snow melt.
- The Village is likely to see a higher frequency of low streamflow summers associated with climate change which may affect the long-term sustainability of creek water supplies.
- The creeks are contained by steep, rocky, unstable terrain which poses accessibility challenges for existing and potential future intakes.
- The steep flowing creeks are subject to debris torrents that can block and damage the intakes.
- The Harvey Creek intake and many of the reservoirs are nearing the end of their service lives and will need replacement in the near future.

Figure 2-3: Photo of the Harvey Intake

2.1.3 Replacement Value

The estimated replacement value of the existing water supply and distribution network is $28 million. A breakdown of this estimate is shown in Table 2-1 below. This estimate is indicative only. The estimated replacement value of the system assumes that each asset will be replaced with a similar asset (i.e. like for like replacement). If any improvements are required, for instance increased capacity of the reservoirs, then this would be an additional cost that needs to be considered in the renewal of the system.

Based on estimated service lives for different asset types, the Village should be investing approximately $545,000 per year on average on the renewal of its water network.

Table 2-1: Asset Value of Water Network

Item	Quantity	Unit	Unit Rate	Replacement Value	Estimated Service Life	Annual Renewal Cost
Water Mains (inc. fittings, valves, hydrants etc.)	16,800	m	$700	$11,760,000	70 years	$168,000
Water Treatment Plant	2	each	$3,000,000	$6,000,000	40 years	$150,000
PRVs	13	each	$150,000	$1,950,000	30 years	$65,000
Tanks	8	each	$700,000	$5,600,000	50 years	$112,000
Intakes	2	each	$1,200,000	$2,400,000	50 years	$48,000
Pump stations	1	each	$90,000	$90,000	40 years	$2,250
SUB-TOTAL (Water)				**$27,800,000**		**$545,250**

2.2 Condition Assessment

The condition of the Village's water distribution system can be estimated based on the age of the asset, history of issues such as water main breaks, visual inspections during repairs and material type. The majority of the Village's water distribution system is comprised of ductile iron water main that is less than 30 years of age. If properly installed, ductile iron pipe should last at least 70 years. However the Village does have some remaining sections of cast iron and asbestos cement water main that were probably installed approximately 50 years ago and will be approaching the end of their service lives. More specifically, Village operations staff identified several water mains and other assets, such as the Harvey Creek water intake, that are in poor condition and/or are approaching an age that is near the end of their theoretical service lives, as described below.

- 96m of 200mm cast iron water main on Creekview Place is in very poor condition.
- 710m of 150mm cast iron water main on Bayview Rd and Bayview Pl was built in the 1960s and is likely nearing the end of its service life.
- 65m of 150mm cast iron water main at the intersection of Oceanview Rd and Highview Pl is in poor condition. This is a dead branch that contains stagnant water and is unable to be isolated.
- 350 m of 150mm cast iron along Oceanview Rd and Highview Place is old, in poor condition and has insufficient capacity
- Harvey Creek water intake was built in the mid 1980's and is in poor condition.
- A water main crosses Alberta Creek attached to a structure that is hard to access and at risk of damage by adjacent overhanging unstable trees.

The water main issues of most significance are shown in Figure 2-5 : System Issues. Projects to resolve these issues have been included in **Section 7.1**.

2.2.1 Reservoirs and Tanks

The Village's reservoirs were inspected in 2004, and recommendations were provided for rehabilitation work. Since then, the only recommended rehabilitation work that was completed was to address leaks on the Phase 5 tank. An attempt to fix the leaks by coating the interior of the Harvey 400 tank failed and further remediation has not been attempted. The existing tank does not meet current seismic standards.

The average expected service life of a reservoir is approximately 50 years. As some of the reservoirs were constructed in the 1960's (Highway, Phase 4, 5, and 6 tanks), they are likely approaching the end of their service lives. The Village should conduct regular inspections of these tanks and conduct recommended rehabilitation work in a timely manner. This will help prevent unexpected failures, extend the service lives of the tanks, reduce their overall life cycle costs and help predict future capital expenditures.

Figure 2-4: Photos of Harvey 400, Harvey, and Magnesia Tanks (left to right)

A summary of the condition assessment and recommended rehabilitation work for the reservoirs from the 2004 assessment is provided below with additional comments incorporated based on Village input. Since eight years has passed since the last assessment in 2004, it is recommended that the tanks get re-inspected in conjunction with the recommended rehabilitation work.

Table 2-2: Reservoir Condition Summary

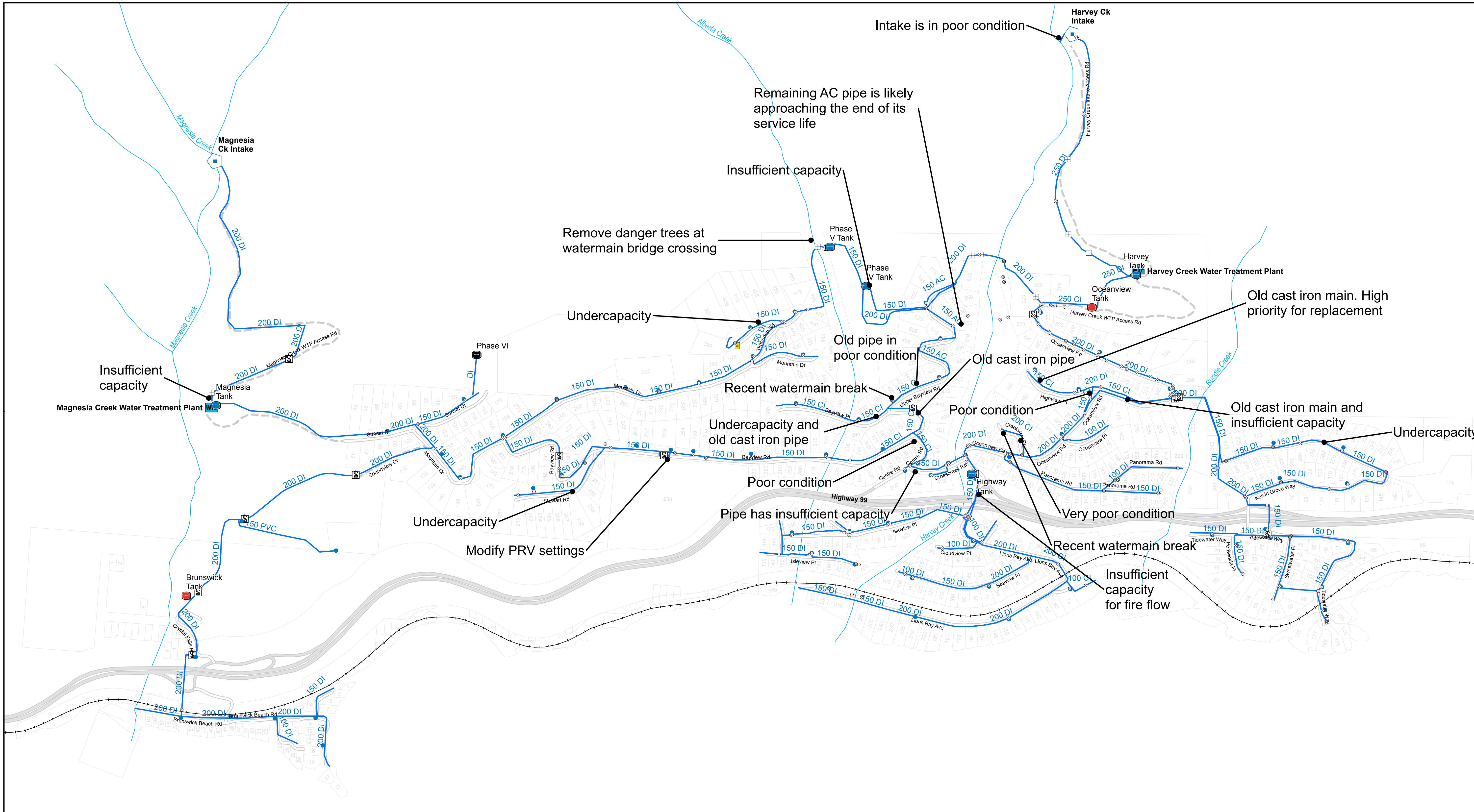
Reservoir	Capacity (ML)	Year Built	Condition	Required Actions
Highway Tank	0.09	1960	Fair	• Inspection required • Confirm leakage has been resolved • Repair roof structure • Replace corroded components
Harvey 400	1.72	1980	Poor	• Inspection required • Attempted repairs did not resolve leakage • Seismic retrofitting required • Consider replacement of tank
Harvey	0.08	1980	Good	• Inspection required • Replace corroded components
Phase IV	0.08	1960	Poor	• Inspection required. Inside of the tank not seen in 2004. • Confirm leakage has been resolved • Valve chamber upgrades required
Phase V	0.10	1960	Poor	• Inspection required • Confirm leakage has been resolved • Piping repair and painting required • Valve chamber upgrades required
Phase VI	0.18	1960	Poor	• Inspection required. Inside of the tank not seen in 2004. • Valve chamber upgrades required
Magnesia Tank	0.44	2002	Good	• Inspection required • Replace corroded components
Brunswick Beach	0.16	Unknown	Poor	• Inspection required • Confirm leakage has been resolved • Replace corroded components

The estimated cost of the remaining reservoir remedial work in 2004 was $170,000. At 2% annual inflation, the estimated cost in 2015 dollars is $220,000. The estimated cost of re-inspecting the eight reservoirs if completed in conjunction with the rehabilitation work is $25,000. The remedial work and tank inspection should be conducted in the short term (0-5 years) but the Village should be preparing to replace its 1960's tanks in the medium term (5-15 years) as they are already showing signs of deterioration and have reached the expected average service life of 50 years. Since the Harvey 400 tank is so critical to the water system and previous repairs did not resolve the leakage, the Village should look to replace this tank as soon as possible (i.e. within the next five years).

2.2.2 Pressure Reducing Vales

There are thirteen (13) PRV stations within the Village and they are reaching the end of their expected service lives. Four (4) are less than 15 years old while the remainder were installed more than 30 years ago. The average life expectancy of a PRV is 30 years. The PRVs within the Village are not operating under ideal condition based on the pressures and velocities within the water distribution network. All thirteen (13) of the PRV stations are noncompliant with current WorkSafe BC standards for worker safety in confined spaces. Required maintenance cannot be completed without placing workers entering the stations at considerable risk of injury and presenting significant liability to the Village.

Review of each PRV station will be required to determine how compliance with WorkSafe BC standards can be met. Through correspondence with Village staff it was estimated that six of the PRV stations will require full replacement while the remaining six stations will require upgrades to replace ageing components such as strainers and valves, and for SCADA improvements to increase system automation while also collecting system performance data. Lastly, many of the existing PRV chambers have drainage issues which should be addressed to increase the lifespan of the PRV components and resolved prior to installation of SCADA equipment.



VILLAGE OF LIONS BAY
Infrastructure Master Plan
Figure 2-5 Water System Issues

AECOM

Legend

- Water Main
- Property Parcels

Village Roads
- Sealed
- Unsealed

MOTI Roads
- On-Ramp
- Highway

- Treatment Plant
- Intake

Tanks (by Water Type)
- Not In Service
- Raw Water
- Treated Water

Valves (by Type)
- Air Valve
- Check Valve
- Gate Valve
- PRV

- Hydrant
- Pump Station

0 50 100 200
Metres

Village of Lions Bay

2.3 Water Usage

Average annual water consumption at the Village has varied significantly over the previous several years; however it has generally trended downwards. The variations in consumption are likely due to a number of factors, including:

- Significant leakage reduction improvements;
- Village-wide water restrictions implemented as a response to reduced flows in supply sources and/or treatment plant issues; and
- Changing attitudes to water conservation within the Village.

The total water volume treated by the water treatment plants is typically recorded by the operations staff on weekdays. Treated water records from January 02, 2014 to August 11, 2015 were obtained from the Village and collated into a single time series table. This information is presented in Figure 2-6.

The average daily demand over this period was 1,779 m^3 per day. This only included records on days where flows at both treatment plants were recorded or days where it was verified that only one plant was supplying the Village.

Significant leakage improvements were made in 2014 and this is represented by the data, which shows the average total demand is lower in 2015 than it was in 2014. The average daily demand for records in 2015 was 1,343 m^3/day, which is equivalent to an average consumption of 1,019 L/day/capita (based on an assumed population of 1,318).

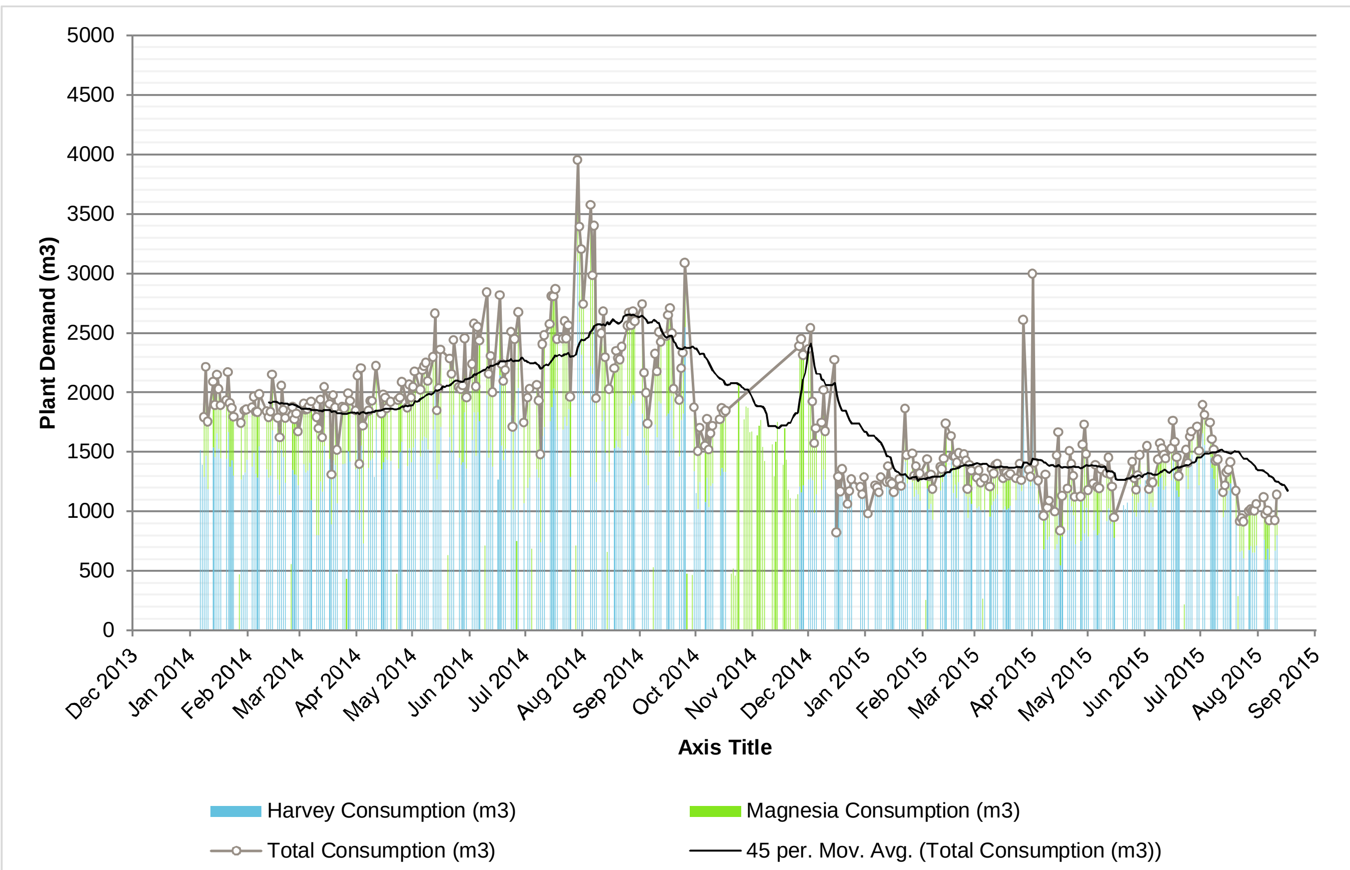


Figure 2-6: Water Demand at Harvey and Magnesia WTPs

During the period shown in Figure 2-6, there were two separate debris slides (November 2014 and January 2015), where one of the water treatment plants was taken off-line and the entire system had to be supplied by the other water treatment plant.

2.4 Hydraulic Capacity Analysis

This component of the IMP was performed by GeoAdvice, and included the following work on the Village's water model:

- Include Village water infrastructure installed up to August 2015, including watermain upgrades around Lions Bay Avenue;
- Modify active tanks and valve closures in the model to reflect actual system operation;
- Modify PRV settings;
- Verify/update pressure zone HGLs;
- Develop future scenarios within the model as the original model did not have any;
- Update demand to match recent flow data, especially in the light of the large number of repaired water leaks and significantly reduced water use within the Village since the time of the previous model;
- Model various demand scenarios;
- Update model elevations;
- Identify water mains, tanks and other assets that do not meet the relevant hydraulic requirements (fire flow, peak demand etc.); and
- With all of the above changes, re-calibrate the model with recent flow information.

In summary, the water distribution network capacity analysis would not have been possible without first updating the model. The existing system representation in the original model was significantly out of date and it would have been impossible to project the presence of deficiencies under future planning horizons without the updated model.

GeoAdvice's detailed technical memo is included in **Appendix A**. In the absence of Village-specific standards, the Master Municipal Construction Documents (MMCD) standards were adopted as the governing standard for flow and capacity. Hydraulic modelling of the network under existing and future demand conditions found that Peak Hour Demand (PHD) and Fire Flow (FF) requirements were not achieved at several locations throughout the water main system. In order to sufficiently meet existing and future demand conditions a total of 2,259 metre of watermain and one tank would need to be upgraded. More details about these proposed upgrades can be found in **Section 7.1** and **Appendix A**. Figure 2-5 shows the issues within the distribution system.

The renewal priorities shown in GeoAdvice's technical memo only consider capacity of the water distribution system. The renewal priorities shown in the project list in **Section 7.1** are based on other considerations such as the age/condition of the water main (or other water asset), the condition of the roadway and competing priorities to address issues within the sanitary sewer and drainage systems. Therefore, when considering the prioritisation of infrastructure renewal projects, we recommend that the Village refer to the priorities provided in the project list in **Section 7.1**

It should also be noted that an operational change is recommended for the PRV near Lions Bay Primary School. Currently, this PRV is only used in the case of extreme emergencies; however, there are several critical fire flow deficiencies south of this station that cannot be alleviated with pipe upgrades. It is recommended that this PRV station be maintained full-time, but its downstream setting lowered to approximately 30 psi (at the assumed elevation of 131.9 m). This will allow PRV-4 to act as the primary feed into the 160-m zone, while also avoiding the mixing of source water under normal operating conditions. At this recommended setting, this emergency PRV will only open in the event of a fire immediately downstream.

The analysis identified that the PRV stations do not have velocity issues during typical operation but that velocities are higher than recommended levels under fire flow conditions. Under fire flow conditions several of the PRV's are undersized and prone to cavitation and water hammer effects. This increases the strain on the water distribution network and may lead to pipe damage. Table 2-3 below provides a summary of the flow under peak hour demand (PHD) and fire flow for each PRV station. Replacement or retrofit is recommended for existing PRV stations 3, 4, 5, 6, 7, and Bayview for compliance with WorkSafe BC, fire flow performance and improved system automation. The temporary PRV at the school should be replaced with a permanent solution. The velocities are based under the PRV diameter given in the Village's database.

Table 2-3: PRV Velocity Summary

PRV Station	Low Flow Diameter (mm)	High Flow Diameter (mm)	Existing Velocity Under PHD (m/s)	2045 Velocity Under PHD (m/s)	Existing Velocity Under Fire Flow (m/s)
PRV-01	100	200	0.71	0.85	2.62
PRV-02	75	150	0.97	1.16	4.37
PRV-03	75	150	0.35	0.42	3.75
PRV-04	50	100	0.17	0.21	7.81
PRV-05	50	100	0.17	0.21	7.81
PRV-06	50	100	0.22	0.26	7.86
PRV-07	50	100	0.57	0.68	8.21
PRV-08	50	150	0.19	0.23	3.59
PRV-09	50	150	0.19	0.23	3.59
PRV-10	50	150	0.14	0.16	3.53
PRV-11	50	150	0.14	0.16	3.53
PRV-MAG	50	150	0.00	0.00	N/A
PRV-SCHOOL	75	-[2]	0.00	0.00	8.80

Although the majority of the fire flow storage comes from the Harvey 400 Tank, the remaining tanks help stabilise water pressure over the day, improve the response time of fire flows reaching the fire hydrants, and provide some additional fire flow capacity. If the Village wanted to consider eliminating one or more of its existing reservoirs then it is recommended that the Village assess the impacts using its water model, and then determine whether the resulting changes (i.e. pressure and fire flow response) are acceptable.

2.5 Water Supply Review

The Village of Lions Bay obtains its drinking water via surface water sources that are vulnerable to climate change influences. The source water creeks are contained within steep slopes that are prone to slides and debris torrents. The impacts associated with these factors include damage and blocking of intake structures and access roads, inability to perform maintenance during inclement weather, and water shortages/outages due to reduced snow pack.

During the spring and summer of 2015, there were significantly reduced stream flows in Magnesia Creek and Harvey Creek. It was noted that the Village along with a commendable effort from the entire community implemented significant water conservation efforts to ration the available water throughout the summer. Without these initiatives and collaboration it is expected that the Village would have run out of water. It was assumed that these reduced flows were a result of reduced snowpack accumulation during the preceding 2014/15 winter, which was quite mild. It can be assumed that climate change will likely have a detrimental impact on consistent snowpack in the catchment.

[2] *150mm diameter high-flow diameter should be installed when PRV is replaced with permanent solution.*

There is currently no continuous creek flow monitoring in either creek, nor has there been a detailed hydrological review of the catchments. Subsequently, there is very limited reliable information on the flow history or expected yield of either creek, particularly under a changing climate.

It is recommended that a strategic water supply study be commissioned to determine the sustainability of the existing creek supply. The long term viability of the water source for the Village should be determined prior to capital investments in creek intakes; filtration and treatment systems to ensure funds are allocated effectively. The cost of a strategic water supply study is estimated at $75,000 which does not include creek flow monitoring in order to reduce the cost of the study and instead would rely on snowfall and snowpack records.

Figure 2-7: Photo of the Lion Peaks without snowpack

2.6 Water Rights Review

2.6.1 Scope

The scope of this IMP component is an analysis of the Village's water rights and permits in conjunction with the operational characteristics and patterns of the respective sources, determination of potential allowable value-added operational scenarios based on available rights (such as micro-hydro opportunities or similar) and identification of any problematic constraints.

2.6.2 Existing Scenario

The Village currently owns six (6) water licences, with one (1) allocated for Alberta Creek, three (3) on Magnesia Creek and two (2) on Harvey Creek. All of the licences are marked for "Waterworks Local Authority" (Figure 2-8).

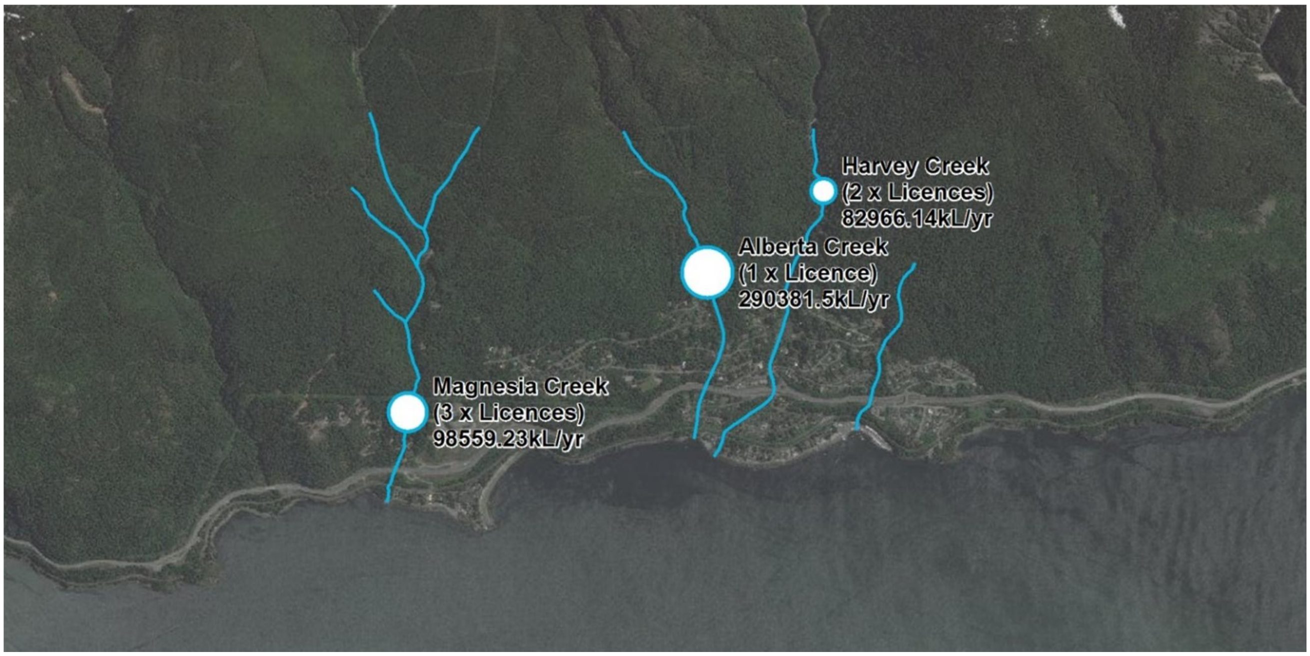


Figure 2-8: Village Water Licences

Unused Alberta Creek Licence

The Alberta Creek licence is not currently in use by the Village. The licence was used for water supply prior to construction of the water treatment plants at Harvey and Magnesia. Village operations staff noted water sampling found there were marginally elevated levels of arsenic in the creek water and it is not considered acceptable for water supply without suitable treatment.

Treatment for arsenic is somewhat common in North America as there are many small groundwater sources used for community supplies that are contaminated with arsenic. Arsenic can be removed from water through both physical and chemical processes included filtration, anionic exchange, and reverse osmosis. The use of the Alberta Creek water source may become increasingly important in the event of water shortages due to climate change. It is recommended that the Alberta Creek be reviewed as part of the Strategic Water Supply Study as the flow may be required for long term sustainability of the community water supply. It is expected that the design of a future water treatment plant with the provision to treat arsenic from the Alberta Creek supply may cost effective in comparison to development of other new water supply source available to the Village.

The topographic and land use constraints in the vicinity of Alberta Creek limit its use. However, based on a typical charge of $1.10 per ML, the maximum total cost of the 89 ML/year Alberta Creek licence is approximately $100 per year, which is not enough to justify relinquishing the licence.

2.7 Water Treatment Review

2.7.1 Objectives

The objective of the Water Treatment and Supply Review was to evaluate the feasibility, return on investment and impacts on existing infrastructure and staffing levels of potential alternatives to the current system.

2.7.2 Review of Existing Scenario

The Harvey Creek and Magnesia Creek water treatment plants are dual-disinfection systems (UV, Chlorine) and they were constructed in 2009/2010. A piping and instrumentation diagram (P&ID) of the Harvey Creek WTP is included over the page and the Magnesia Creek WTP is effectively identical. The locations of the two plants in relation to the Village, and a basic flow chart of the process system, are shown in Figure 2-9.

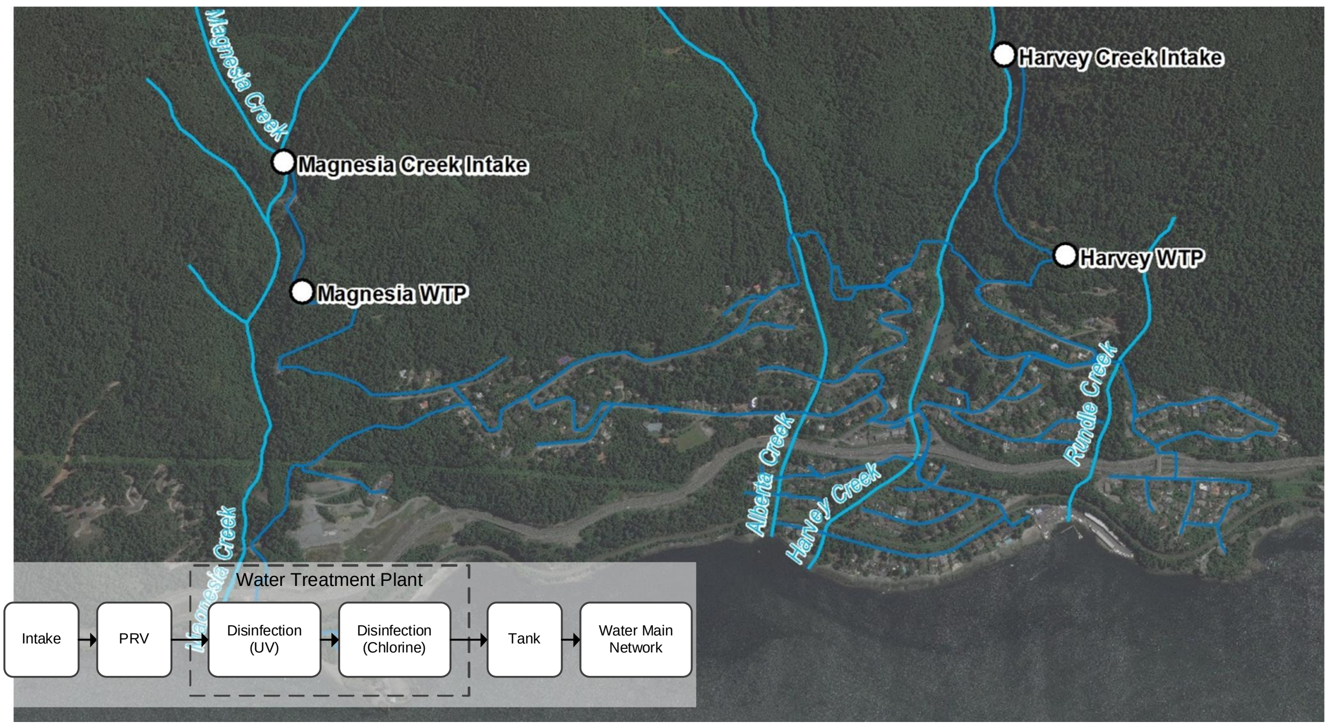
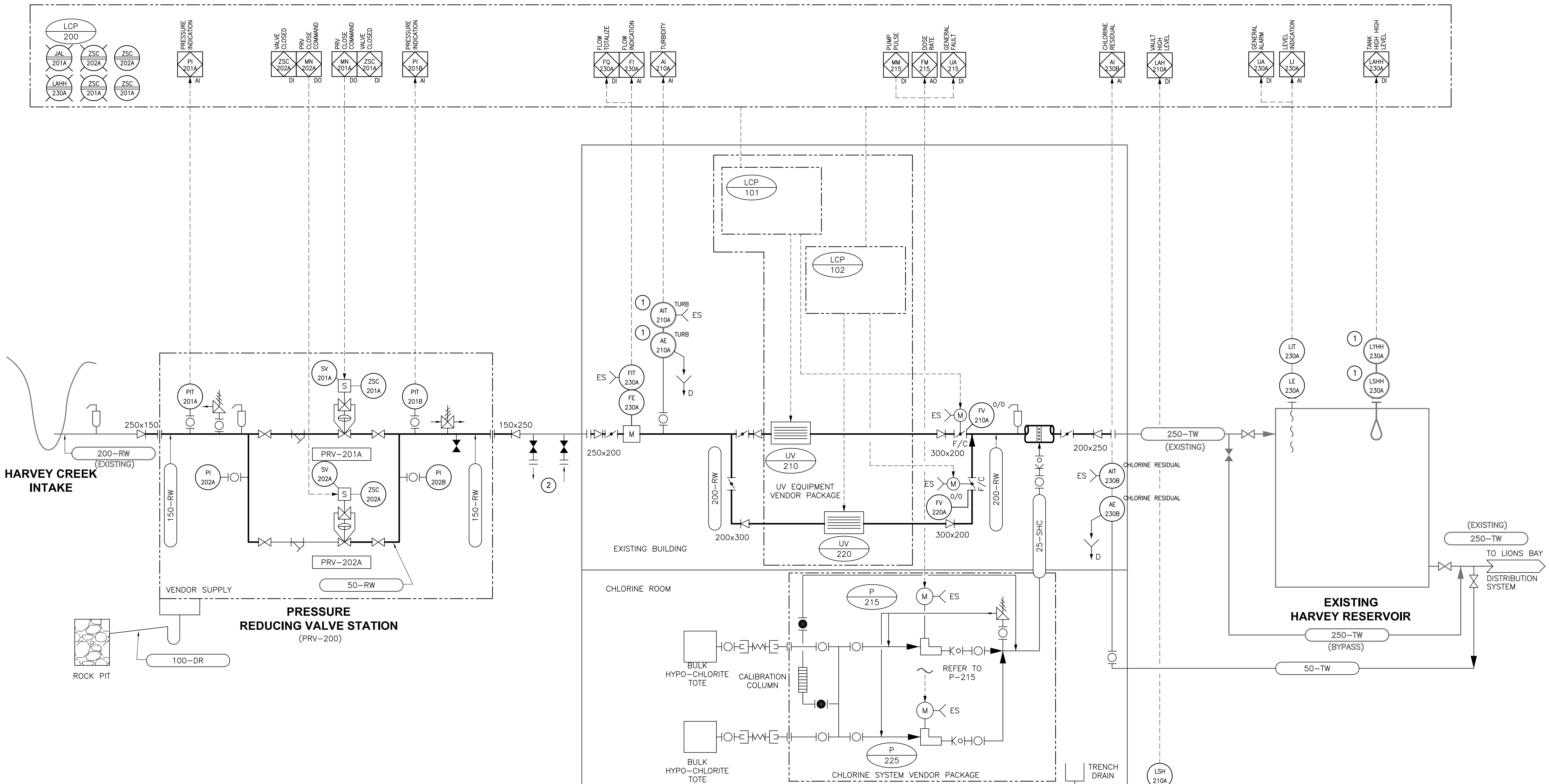


Figure 2-9: Existing Treatment Plants

Flow records taken at the plants from January 2014 to August 2015 (as described in Figure 2-6) show that Harvey Creek WTP provides an average of 72% of the total demand, with Magnesia Creek WTP supplying the remaining 28%, however this can vary significantly on a day to day basis.



GENERAL NOTES:

1. F/C – FAIL CLOSED

KEY NOTES

1. EXISTING EQUIPMENT TO REMAIN, CONNECT TO NEW CONTROL PANEL.
2. FUTURE 250ø CONNECTIONS TO/FROM FUTURE MEMBRANE FILTER BUILDING. (NIC)

PRESSURE REDUCING VALVE STATION

EQUIP No.:	PRV-200
SPEC:	11300
TYPE:	PRESSURE REDUCING
SIZE:	3.25ML/d (MAX. FLOW)

UV REACTOR–DUTY

EQUIP No.:	UV-210
SPEC:	11800
TYPE:	TROJAN UV SWIFT 2L12
POWER:	30.8 Amps
VOLTAGE:	240V, 1 PHASE
DOSE:	15.2 mJ/cm² @ 2.81ML/d

UV REACTOR–STAND BY

EQUIP No.:	UV-220
SPEC:	11800
TYPE:	TROJAN UV SWIFT 2L12
POWER:	30.8Amps
VOLTAGE:	240V, 1 PHASE
DOSE:	15.2 mJ/cm² @ 2.81ML/d

CHLORINE DOSING PUMP #1

EQUIP No.:	P-210
SPEC:	11345
TYPE:	DIAPHRAGM
CAPACITY:	6 LPH (Min.), 60 LPH (Max.)
POWER:	1/3 hp (0.169 Kw)
VOLTAGE:	115 VAC (208 VAC)

CHLORINE DOSING PUMP #2

EQUIP No.:	P-220
SPEC:	11345
TYPE:	DIAPHRAGM
CAPACITY:	6 LPH (Min.), 60 LPH (Max.)
POWER:	1/3 hp (0.169 Kw)
VOLTAGE:	115 VAC (208 VAC)

SPILL CONTAINMENT VAULT

TYPE:	PRE-CAST CONCRETE MH
SIZE:	1500L

EXISTING RESERVOIR

TYPE:	CONCRETE TANK
CAPACITY:	800,000 L
SIZE:	15.78m DIA. x 8.8m H

REV	DESCRIPTION	DRN	CHK	DATE (Y/M/D)
1	ISSUED FOR CONSTRUCTION	PJY	NWB	2009/05/04
0	ISSUED FOR TENDER	KSB	DB	2009/03/26

30 CM — VERIFY SCALE IF PLAN SHEET IS REDUCED

DRN BY: KSB
DES BY: BdW
CHK BY: DB
APP BY: KM

PREPARED FOR: THE MUNICIPALITY OF THE VILLAGE OF LIONS BAY

PREPARED BY: AECOM

VILLAGE OF LIONS BAY WATER TREATMENT UPGRADES LIONS BAY, B.C.

HARVEY CREEK DISINFECTION SYSTEM PROCESS & INSTRUMENTATION DIAGRAM

PROJECT START DATE (M/Y): NOV / 2007
PROJECT NO.: 101658
FILENAME: P-21.dwg
SHEET NO.: Figure 2-10
DRAWING NO.: P-21

Water turbidity in both Harvey Creek and Magnesia Creek occasionally exceeds the treatment capabilities of the UV plants. Operation staff typically responds to this scenario by throttling back the inflows or temporarily shutting down the affected plant. This can result in water shortages and requires the implementation of water restrictions.

The creeks generate a high volume of debris that can block and damage the intakes. The Magnesia Creek intake was recently replaced but the Harvey Creek water intake is nearing the end of its typical service life and has been reported by staff to be in poor condition. If Harvey Creek is going to continue to be a water source in the long term then the intake will need to be replaced in the near future.

The intakes and access roads are particularly unsafe following rainfall due to unstable uphill ground conditions, and the current operating procedure restricts staff from accessing the area for several days following rainfall. Subsequently, it is not possible to assess damage or clear obstructions until several days following heavy rainfall events. Due to the safety and access concerns with the existing water intake locations, it is recommended that the Village review the location of these intakes before simply replacing them in the same location. The right location will need to consider safety, easy access for maintenance, flow volumes and water quality. Due to the physical limitations of the landscape, there will likely be a limited number of options.

2.7.3 Future Treatment Requirements

Early WTP planning documents show that filtration was initially recommended for both WTPs; however a dual disinfection system was eventually selected as the preferred option in order to reduce capital costs. This system was permitted by Vancouver Coastal Health after the presentation of streamflow data showing the source water in both creeks did not exceed 5.0 NTU for more than two days over a 12-month period, implementation of a watershed management plan and the satisfaction of various other criteria.

Figure 2-11 summarises daily NTU readings of raw water at Harvey Creek WTP and Magnesia Creek WTP for 2014. It should be noted that these NTU readings are at the plant and not in the creeks themselves, as the reading is to be taken immediately upstream of the application of disinfection. The Magnesia Creek WTP exceeded 5 NTU twice over this period, with an additional reading at 4.84 NTU. During the period of high NTU readings at Magnesia Creek WTP (Nov / Dec), Harvey Creek was off-line. Had the Harvey Creek WTP been on-line, it may be assumed there would have been high NTU readings there during this time as well.

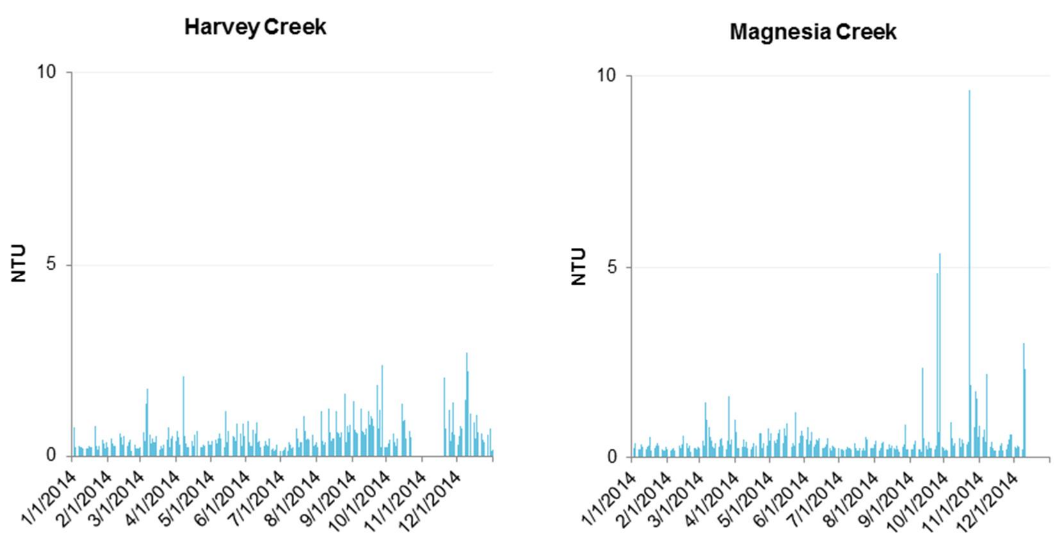


Figure 2-11: Charts of Raw Water NTU in Harvey Creek and Magnesia Creek in 2014

This data suggests that the turbidity of Magnesia Creek is on the border of acceptable NTU limits, and there is a moderate risk that turbidity will exceed the thresholds for exemption from filtration in the near future. The issue may be exacerbated with climate change, where there is likely to be a higher incidence of intense rainfall events preceded by drier weather resulting in high turbidity. If the NTU limits are exceeded then Vancouver Coastal Health may put the Village of Lions Bay on a water quality advisory.

The report *Village of Lions Bay Water Treatment Upgrades Pre-Design Study – Final Report* notes that filtration will likely be required in the future as an additional barrier. Filtration is often the best solution for surface waters with variable water quality such as fast flowing creeks. The study identifies the treatment goals for a future filtration system as:

- Suspended solids/turbidity removal to less than 0.3 NTU
- Virus Removal
- Bacteria Removal
- Giardia Cyst and Cryptosporidium oocyst removal

Further information on water quality standards and recommendations can be found in the *Drinking Water Treatment Objectives (Microbiological) for Surface Water Supplies in British Columbia* (November 2012) at the following web-site: http://www2.gov.bc.ca/assets/gov/environment/air-land-water/surfacewater-treatment-objectives.pdf.

It should be noted that in 2015, the Village of Lions Bay had no boil-water advisories and that the Village has a semi-annual water main flushing program (usually April and October) which will help improve the quality of the water delivered to residents.

Based on the review of existing information, flow data and issues identified by the operations staff, the Village will likely be required to install a filtration system (or similar higher level of treatment) within the next ten years in order to maintain compliance with treatment requirements and provide a satisfactory level of service to residents. The Village would be prudent to begin planning for this requirement and investigate available funding through grants. This will be discussed further in Section 6.3.

2.7.4 Options Identification

Based on previous investigations and consultation with operations staff, the long-term water supply and treatment improvement performance objectives are:

- Improve reliability of supply (both raw water quality and quantity);
- Ensure there is a suitable level of redundancy and flexibility in the system;
- Reduce workplace risks for operations staff;
- Meet current water treatment requirements, and be prepared for future water treatment requirements; and.
- Prepare to have filtration treatment (or higher level of treatment) installed at the water treatment plant(s) within the next ten years.

Several potential water supply and treatment improvement options were assessed. The options included:

- Option 1: No Change
- Option 2: Dual Creek Supply Sources with Dual Filtration
- Option 3: Single Creek Supply Source with Single Filtration
- Option 4: Dual Creek Supply Sources with Single Filtration
- Option 5: Single Desalination Supply Source

Option 2: Dual Creek Supply with Filtration

This option will require the installation of filtration systems at both the Harvey Creek and Magnesia Creek WTPs. Retrofitting filtration systems to existing plants would likely require a new pre-engineered building at each site, and the filters would be installed upstream of the UV lamps (as shown in Figure 2-12).

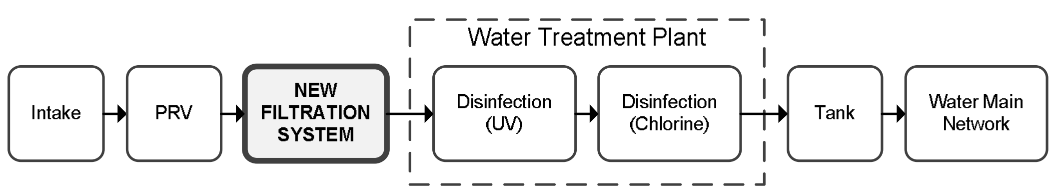


Figure 2-12: Option 2: Flow Chart of Proposed Filtration System

A recommended configuration for the retro-fitted filtration system was previously prepared for the Village by AECOM in the letter dated April 1, 2011. An overview of Option 2 is shown in Figure 2-13.

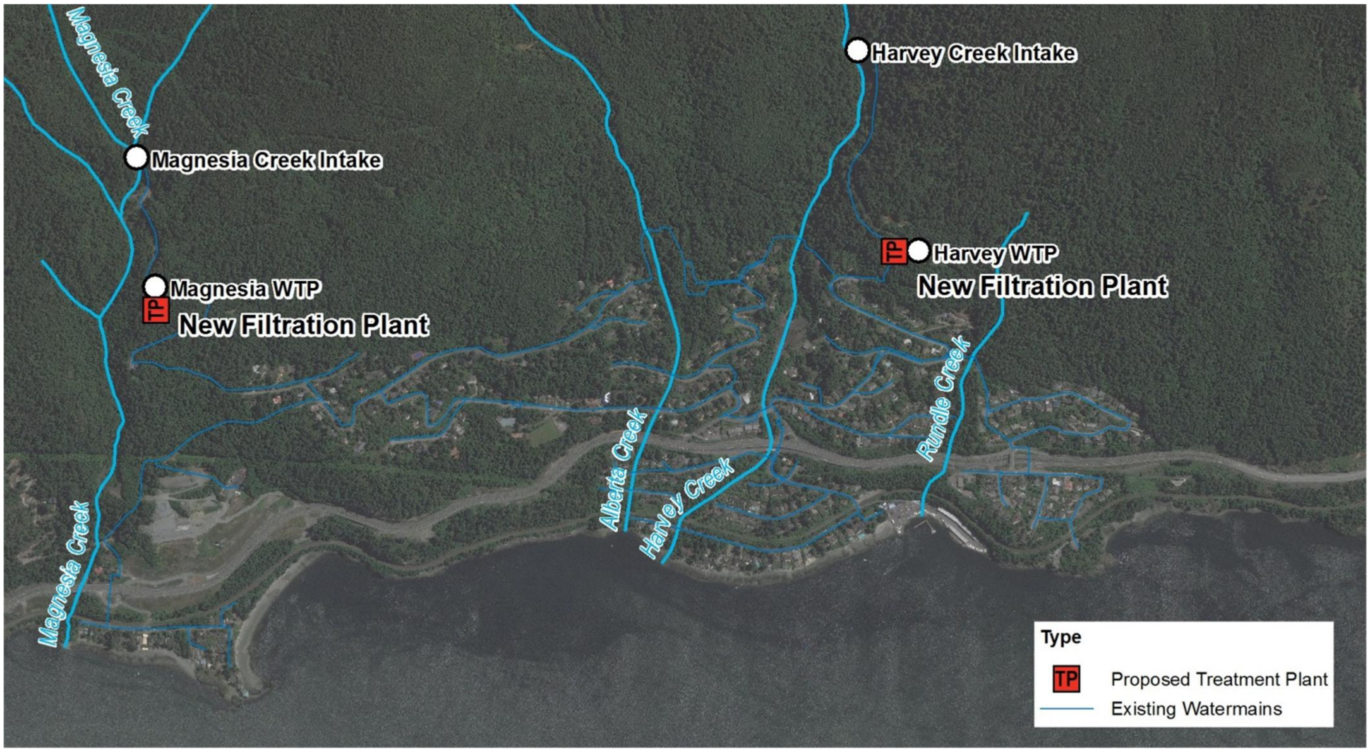


Figure 2-13: Overview map of Option 2: Dual Creek Supply with Dual Filtration

Option 3: Single Creek Supply with Single Filtration

The objective of the single-supply option is to reduce operational costs and resourcing demands associated with keeping two intakes and two plants functioning. A suitable single source scenario was first identified as part of the hydraulic modelling component of the IMP, and this is outlined in **Section 6.0** Alternative Servicing Scenario (Single Supply Source) of the GeoAdvice report Water Distribution System - Model Development and Capacity Analysis (**Appendix A.1**).

Harvey Creek was identified as the preferred single source from a hydrological modeling perspective. It should be noted that there are challenges associated with Harvey Creek as a possible single source, such as: difficult and often unsafe access, the potential for and frequency of debris slides, and low summer flow. A single water treatment plant at Harvey Creek does not have sufficient supply to service the Village in peak times without significant upgrades to the water distribution network. A single water source provides no supply redundancy or flexibility to switch between systems.

If some of these issues were addressed and Harvey Creek became the preferred single source, then the Magnesia Creek WTP and water intake could be decommissioned. The Magnesia Creek tank would remain in use. In order to supply sufficient flows and pressure to the northern part of the Village, the main along Mountain Drive would require upsizing and a booster pump station would be required.

The proposed filtration plant at the Harvey Creek WTP would be installed identically to that specified in Option 2.

An overview of Option 3 is shown in Figure 2-14.

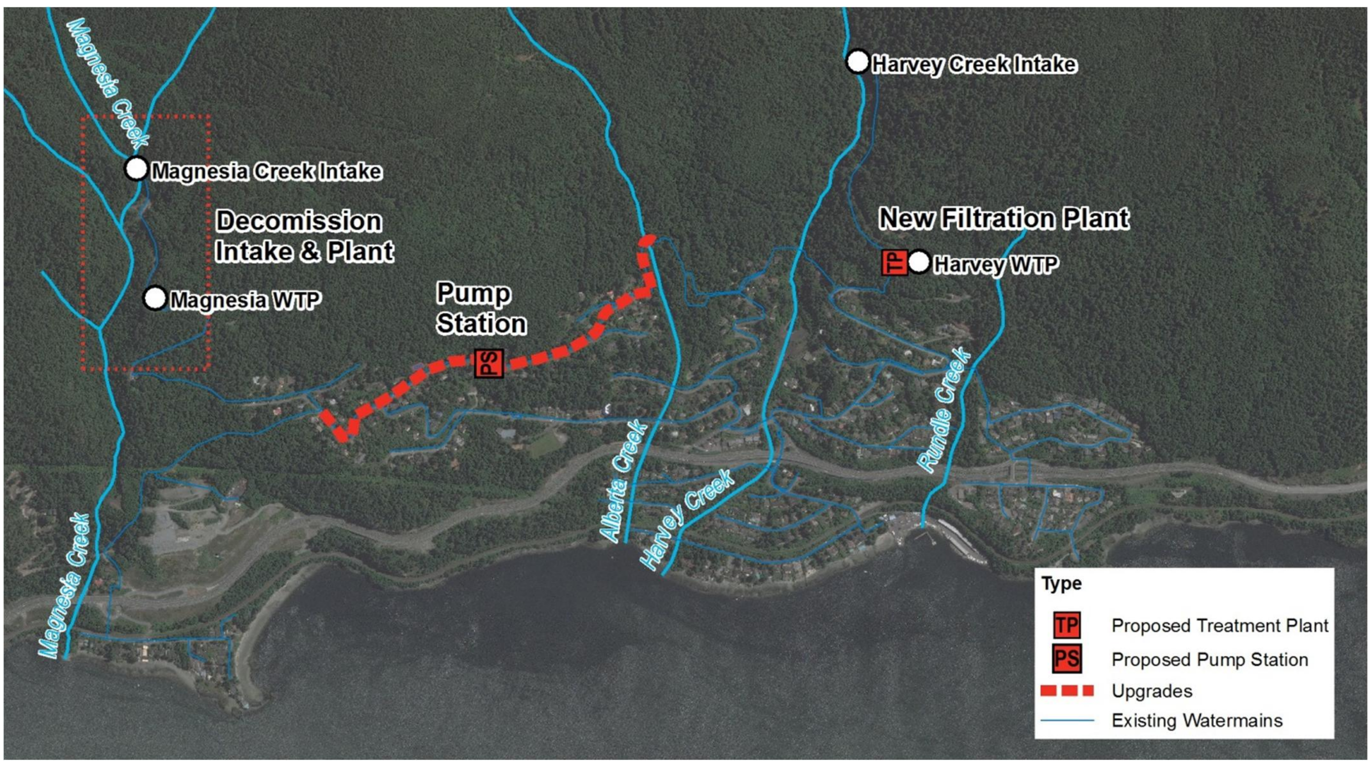


Figure 2-14: Overview Map of Option 3: Single Creek Supply with Filtration

Option 4: Dual Creek Supply with Single Filtration

The dual-supply with a single filtration option was investigated with the objective to reduce operational costs and resourcing demands associated with keeping two plants functioning but to maintain the benefits of two water sources.

It was identified that Harvey Creek was likely the location for the single filtration plant in which case the Magnesia Creek WTP could be decommissioned. The Magnesia and Harvey creek intakes would both be retained which would require the reconfiguration of the Magnesia intake supply pipe once the Magnesia WTP is decommissioned. A non-potable water supply main would be required from Magnesia Creek to the new Harvey WTP which would require a booster pump station.

Once the non-potable water is treated at the Harvey WTP the distribution would be identical to that specified within Option 3 with the Magnesia Creek tank being retained. In order to supply sufficient flows and pressure to the northern part of the Village, the main along Mountain Drive would require upsizing and a booster pump station would be required. The proposed filtration plant at the Harvey Creek WTP would be installed identically to that specified in Option 2.

An overview of Option 4 is shown in Figure 2-15.

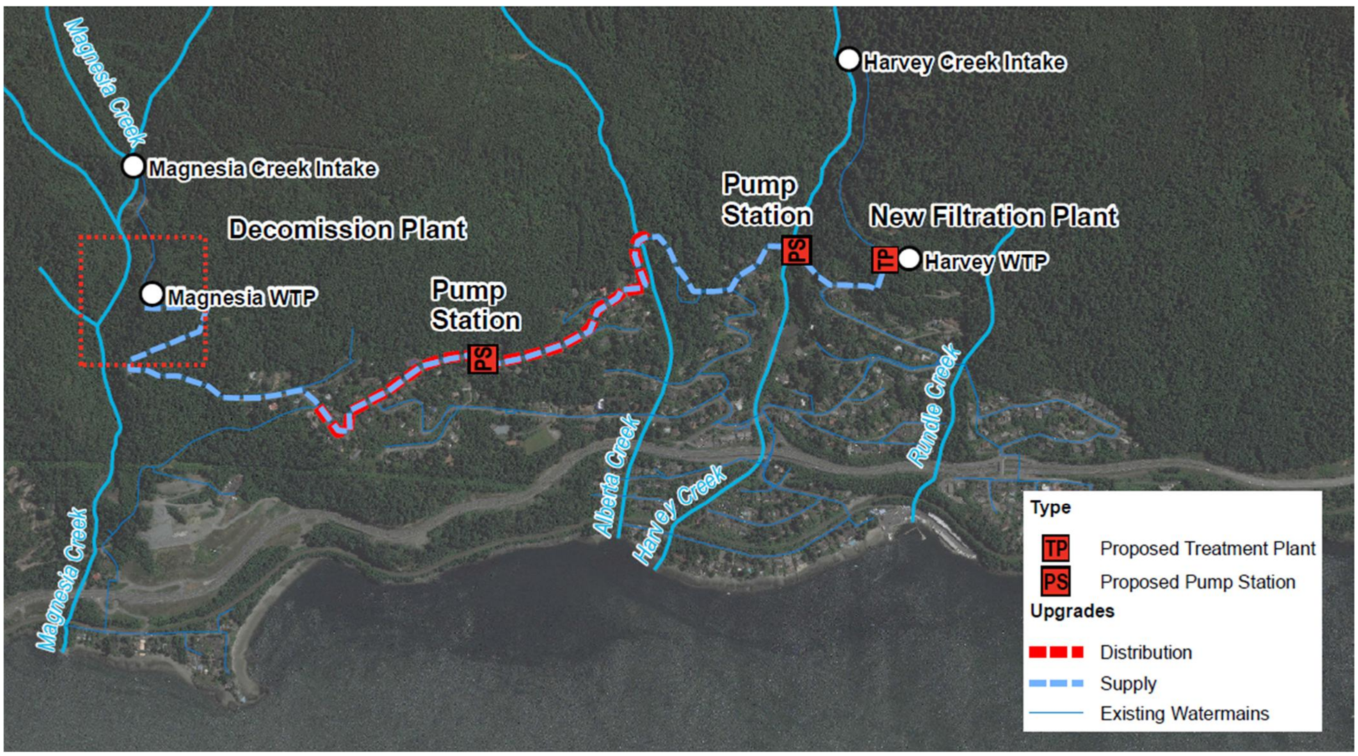


Figure 2-15: Overview Map of Option 4: Dual Creek Supply with Single Filtration

Option 5: Single Desalination Supply

The Village's IC initially identified desalination as an option for meeting higher peak demands in the summer months, however there are significant financial and resourcing costs associated with installation and operation of a desalination plant. Subsequently, it was determined that while it was not appropriate committing capital funds for a *backup* desalination plant operating concurrently with the existing systems, it was worth investigating the cost of implementing a desalination plant as a *replacement* for the existing water intakes and treatment plants.

A conceptual design was developed and is summarised in Figure 2-16. The desalination plant would be located adjacent to Howe Sound. The plant would require both a seawater intake and a brine (concentrated salt water by-product) outfall. The treated water would be pumped twice through 1756m of dedicated main to the existing tank at Harvey WTP. As Magnesia WTP would also be decommissioned under this scenario, a pump station and main upgrade will be required on Mountain Drive, similar to that proposed in Option 2.

Howe Sound is a more reliable water source in terms of quantity than the Harvey and Magnesia Creeks, however the system would be heavily reliant on pumping and success of the option will be dependent on minimising plant and pump downtime through proactive maintenance and a high-quality installation. The reverse osmosis desalination and pumping will also be an energy intensive process and will likely result in significant increases in electricity costs. If the Village is focussed on reducing its carbon footprint, it may consider purchasing carbon offsets to minimise the net greenhouse impact.

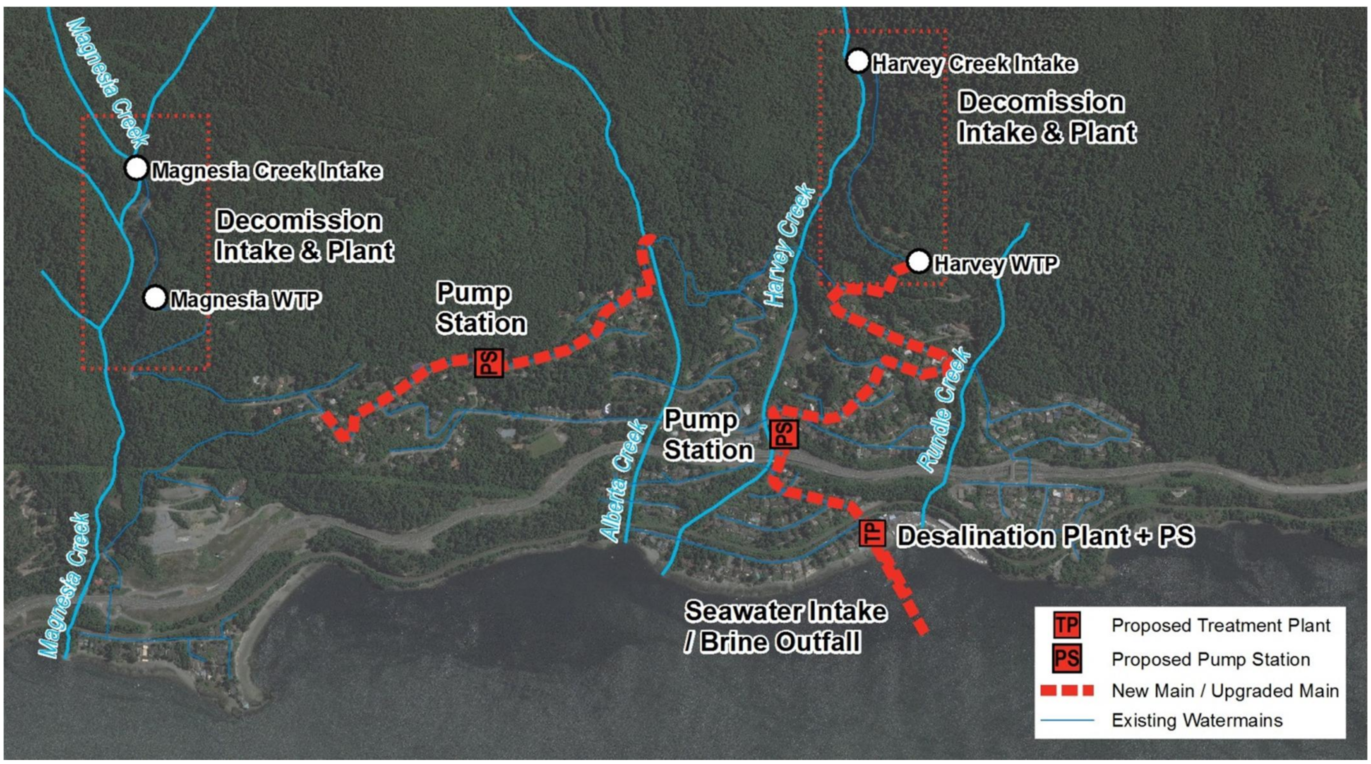


Figure 2-16 : Overview Map of Option 5: Single Desalination Supply

2.7.5 Options Assessment

Since the Village is a small community with limited technical staff it is critical that any future treatment options be simple to manage and operate, unless the Village is willing to consider having a third party operate its WTP. However, even if a third party operates the plant, the Village will need to have sufficient resources and technical know-how to manage and work with the operator.

Cost Estimate

Capital cost estimates were developed for Options 2-5 and are summarised in Table 2-4. The desalination plant option was found to have the highest estimated capital coast.

Based on discussions with desalination manufacturers, there is likely to be further significant improvement in relative costs and reliability of small-scale desalination plants over the short to medium term. Therefore the Village would be prudent to review these costs in the future before committing to a treatment option.

Table 2-4: Capital Cost Estimate for Supply and Treatment Improvement Options

Item	Unit	Quantity	Rate	Cost	Comments
Option 2: Dual Creek Supply with Dual Filtration					
Filtration System	each	2	$2,550,000	$5,100,000	Based on 2011 filtration estimate (+2% index rate)[1]
TOTAL				***$5,100,000***	
Option 3: Single Creek Supply with Single Filtration					
Filtration System	each	1	$2,550,000	$2,550,000	Based on 2011 filtration estimate (+2% index rate)[1]
Potable Water Pump Station	each	1	$400,000	$400,000	-
Potable Water Pipe Upgrades	m	1620	$900	$1,458,000	-
Decommissioning Plant & Intake	each	1	$150,000	$150,000	-
TOTAL				***$4,758,000***	
Option 4: Dual Creek Supply with Single Filtration					
Filtration System	each	1	$2,550,000	$2,550,000	Based on 2011 filtration estimate (+2% index rate)[1]
Non-Potable Water Pump Station	each	1	$400,000	$400,000	-
Non-Potable Water Pipe Upgrades	m	3100	$900	$2,790,000	-
Potable Water Pump Station	each	1	$400,000	$400,000	-
Potable Water Pipe Upgrades	m	1620	$900	$1,458,000	-
Decommissioning Plant and Reconfiguration of Intake	each	1	$150,000	$150,000	-
TOTAL				***$7,748,000***	
Option 5: Single Desalination Supply					
Pipes (New Mains, Upgrades)	m	3100	$900	$2,790,000	-
Intake & Outfall	m	500	$3,000	$1,500,000	-
Pump Stations	each	3	$700,000	$2,100,000	-
Desalination Plant	each	1	$6,000,000	$6,000,000	-
Decommission Plant & Intake	each	2	$150,000	$300,000	-
TOTAL				***$12,690,000***	

[1] *Cost estimate of filtration units provided to Village April 1, 2011 by AECOM from Stephen Bridger*

Strengths and Weaknesses

Table 2-5 summarises the strengths and weaknesses of each water treatment and supply option. Option 2: Dual Creek Supply with Filtration was found to present the best balance between capital cost and satisfaction of the performance objectives. Option 4: Single Desalination Supply was found to satisfy all performance objectives, however the capital and ongoing costs are likely to make this option undesirable.

The existing water treatment system (Option 1), and upgrade Options 2 and 3 all rely on consistent, high quality raw water flow in Harvey Creek and/or Magnesia Creek to supply the treatment plants and potable water system. With each of these scenarios, there is a risk that flows will decreased to unsustainable levels, however it is difficult to quantify this risk as there is very limited information on the existing hydrology and future hydrology under climate change of these catchments.

If it was found through a watershed study and better climate change data that Harvey and Magnesia Creeks would not likely provide sufficient flows in the future under climate change then the Village would need to consider other options such as increased storage, reducing consumption, investigating the use of Alberta Creek or desalination. Desalination could be considered as a permanent option (as was done in this analysis where it replaces Harvey and Magnesia Creeks) or as a temporary option during low-flows where it complements Harvey and Magnesia Creeks. Currently, the temporary desalination option (i.e. permanent filtration at Magnesia, permanent filtration at Harvey and a mobile truck mounted desalination unit at Howe Sound) was found to be prohibitively expensive as it would require three water treatment systems. But if conditions and costs change in the future then these options can be reviewed.

Table 2-5: Strengths and Weaknesss of Water Supply and Treatment Options

Treatment and Supply Option	Strengths	Weaknesses
Option 1: No Change	• No capital cost	• No reduction in risks identified in previous section (high turbidity, debris impacts, safety risks) • Requires significant staff time commitments to maintain operation • High ongoing maintenance and operations cost • Ongoing risk of diminished or unreliable flows in both creeks
Option 2: Dual Creek Supply, Dual Filtration • Install filtration systems at Harvey Creek and Magnesia Creek WTPs	• Significantly improves ability of plant to deal with high turbidity flows (reduce frequency of NTU-related plant shutdowns) • Provides for high level of redundancy and flexibility with dual supply system	• High capital cost (~$5.1M) • Does not reduce supply risk of intake blockage • Does not reduce safety risk of intake access • Ongoing risk of diminished or unreliable flows in both creeks
Option 3: Single Creek Supply, Single Filtration • Install filtration systems at Harvey Creek WTP • Decommission Magnesia Creek WTP and intake (retain Magnesia Tank) • Upgrade pipe section along Mountain Dr • Install potable water pump station on Mountain Dr	• Possible reduction in water treatment operation costs associated with decommissioning Magnesia WTP	• High capital cost (~$4.7M) • Single WTP at Harvey Creek does not have sufficient supply to service Village in peak times without significant upgrades to the water main network. • No supply redundancy or flexibility to switch between systems, for instance if the one and only intake is blocked due to a debris slide. • Ongoing risk of diminished or unreliable flows in a single creek
Option 4: Dual Creek Supply, Single Filtration • Install filtration systems at Harvey	• Significantly improves ability of plant to deal with high turbidity flows (reduce frequency of NTU-related	• High capital cost (~$7.5M) • Does not reduce supply risk of intake blockage

Treatment and Supply Option	Strengths	Weaknesses
Creek WTP • Decommission Magnesia Creek WTP • Reconfigure Magnesia Creek intake (retain Magnesia Tank) • Install non-potable supply pipe between Magnesia Tank and Harvey WTP including pump station. • Upgrade pipe section along Mountain Dr and install potable water pump station on Mountain Dr	plant shutdowns) • Possible reduction in water treatment operation costs associated with decommissioning Magnesia WTP • Provides for high level of redundancy and flexibility with dual supply system	• Does not reduce safety risk of intake access • Ongoing risk of diminished or unreliable flows in both creeks •
Option 5: Single Desalination Supply • Single desalination plant located at sea level • Pipeline upgrades • 3 pump stations • Seawater intake and brine outfall	• Plentiful and reliable water supply • Facilitate decommissioning of existing intakes (reduce workplace risk)	• Very high capital cost (~$12.3m) • Significant power requirements to operate reverse osmosis and pumping system • Generally high operating costs and resourcing needs with specialised expertise.

2.7.6 Recommendations

In addition to the relevant capital projects identified in **Section 7.1**, it is recommended that the Village take the following actions:

- Determine the long term viability of the creek water supplies since a significant investment in water treatment will likely be required in the medium term, and it will be important this investment is based on sufficient reliable data and will support the long term water needs for the Village of Lions Bay.
- Water treatment data (e.g. total consumption, raw water turbidity, dosing rates) is currently digitally recorded by operations staff in a cross-tabulated spreadsheet. A significant amount of manual data manipulation was required to convert this cross-tabulated data into a usable time series. It is recommended that the Village consider transitioning to a time series style recording sheet that allows for easier collation and review of flow and treatment records that is less prone to calculation errors.
- Investigate funding opportunities for future upgrades to water treatment facilities.

2.8 Micro-hydro Review

The water pressure at the PRVs downstream of the Harvey Creek and Magnesia Creek intakes is extremely high due to the vertical drop between the intake and WTP. These locations present a possible micro-hydro power opportunity.

A micro-hydro system may be able to contribute to BC Hydro's Net Metering program (<100kW) to recover energy costs. However this program is typically limited to residential or commercial customers and the Village's eligibility will need to be confirmed. In addition BC Hydro has been reticent to sign new power purchasing agreements for micro-hydro projects because the majority of power is generated when BC Hydro needs it the least (during the spring and late fall). The low price for energy in BC can also make the business case for micro-hydro projects challenging.

Whilst small-scale (run of river) hydro power is a possibility, it is likely that the current financial and resourcing constraints restrict the Village from independently implementing a hydropower system within the medium term; particular when then are other existing infrastructure priorities. An alternative method may be to investigate leasing the potential energy in the existing penstocks (or new dedicated penstocks on any of the creeks) to a third party energy developer. EOIs could be advertised, with the third-party responsible for determining the feasibility; however this will still consume some staff time and financial resources. It should be noted that committing to development of micro-hydro will likely commit the Village to the current water intake arrangement.

It is recommended the Village decide if it wants to commit staff resources and the cost of a study, in consideration of other competing priorities, to investigate micro-hydro opportunities (either internally or with the help of a third party).

2.9 Metering Options Review

2.9.1 Objectives

The objective of the Metering Options Review was to evaluate whether water metering would provide value to the Village, for both a reduction of high water usage and as an integral part of a cross-connection control program.

2.9.2 Existing Scenario

The Village does not currently have metering on their water system, and residents are billed for water use by parcel and connection under the *Water Parcel Tax Bylaw No. 130*, *Water Rates and Regulations Bylaw No. 2* and relevant amendments. At present, there is no consistent method of measuring flows beyond the water treatment plants. This limits the Village's ability to identify leaks, optimise pressure zone operation and identify excessive water users.

There has been a reduction in average consumption over the previous two years due to a variety of efforts towards water conservation. One of these factors is the Village's work to reduce leaks within the water distribution system. Three times per year Village staff inspect the distribution system "listening" for leaks. However the Village has expressed a desire to further reduce water consumption in order to reduce supply risks and operational costs.

Average water consumption per capita (1,019 L/day/capita) is still quite high compared to the Metro Vancouver average. Within our National Water and Wastewater Benchmarking Initiative where we benchmark 45 municipalities across Canada, the average residential water consumption is approximately 200 L/day/capita and the maximum is 600 L/day/capita, as shown in Figure 2-17. Therefore the Village could likely further reduce their water consumption through further conservation efforts.

Efforts to reduce rehabilitate the Village's water resources through repairs and renewal will also likely reduce water leakage and overall water consumption.

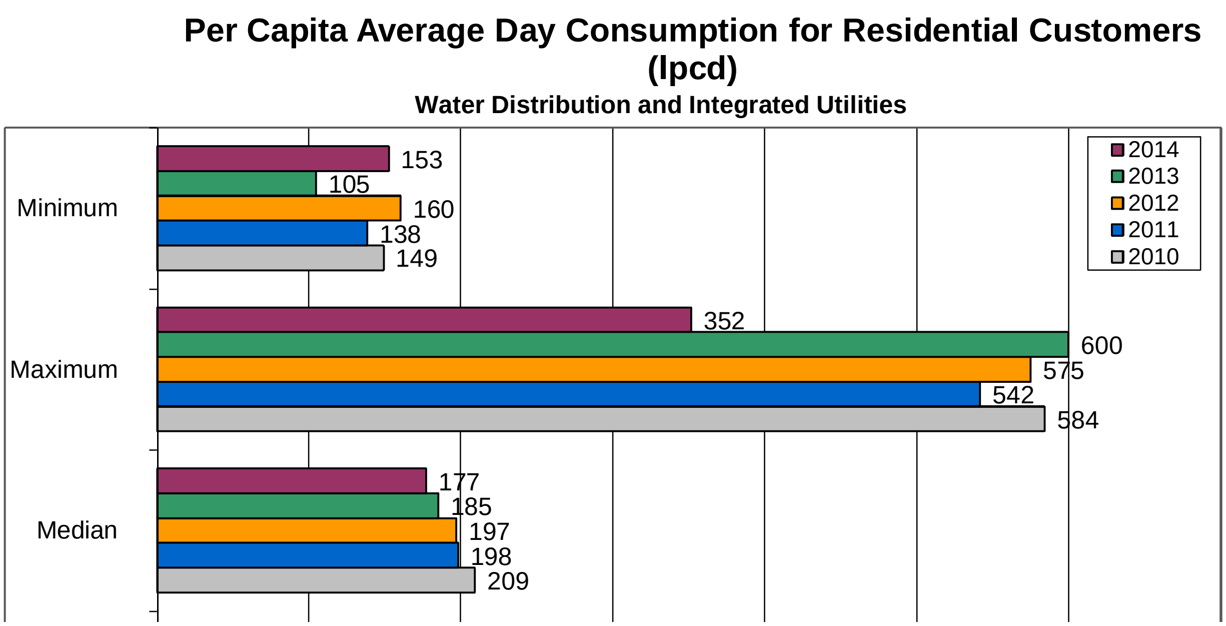


Figure 2-17: Capital Average Day Residential Consumption for 39 Municipalities across Canada

Reducing water consumption during peak (i.e. mid-August) and non-peak times requires different strategies and has different benefits, including pay-back. Reducing year-round water consumption will help to reduce water operating costs but reducing peak water consumption can also potentially delay significant water infrastructure upgrades (e.g. the need for a desalination plant). Measuring flows beyond the water treatment plants through a metering program will help the Village find the most cost-effective strategy for further reducing water consumption. Reducing indoor water consumption will also reduce sanitary flows which could delay required upgrades to the wastewater treatment plant.

Some recent municipal funding grants have required evidence of commitment to water conservation through a metering program. There is a risk that the Village may be ineligible for some future funding sources if a metering program is not implemented.

At present, there is no notable cross connection or backflow control on the water system, which exposes connected users to a risk of backflow contamination and the Village to liability as a result.

What is Cross Connection?
According to the Canadian Standards Association, a **cross connection** is defined as any actual or potential connection between a potable water system and any source of pollution or contamination. Wherever physical cross connections exist between potable and non-potable water, there is the potential for backflow to occur.

Backflow is a flow of solid, liquid or gas from any source opposite to the normal direction of flow, back into the potable water supply or system. There are two types of backflow: backsiphonage and backpressure.

Backsiphonage is caused by negative pressure in the supply piping system. Some common causes of backsiphonage include:

- High velocity in pipeline
- Line repair or a break that is lower than a service point
- Lowered main pressure due to high water withdrawal rate, such as fire-fighting or water main flushing
- Reduced supply pressure on the suction side of a booster pump

Backpressure is caused whenever a potable system is connected to a non-potable supply operating under a higher pressure by means of a pump, boiler, etc. There is a high risk that the non-potable water may be forced into the potable system whenever these cross connections are not properly protected

Source: BC Water and Waste Association

2.9.3 Options Assessment

There are three major metering options available to the Village:

- Existing Scenario (i.e. only metering at the source)
- Pressure Zone / Branch Metering: water meters installed at pressure zones or larger branches
- Full “Residential” Metering: meters install at all property connections (inc. residential, commercial, institutional properties)

Pressure Zone / Branch Metering

There are currently 13 pressure reducing valves located through the Village water network, and many of these valves are a logical location for meters in a pressure zone metering program; however some PRVs are located in areas where the data collected may not be of benefit to the Village. If a pressure zone metering program is pursued by the Village, it is recommended a planning project be commissioned to correctly locate the optimal meter locations, produce basic scoping designs and develop a robust cost estimate.

The capital cost for this metering option was estimated to be approximately $150,000. It was assumed that the Village would install 12 flow meters, at an approximate cost of $12,500 per flow meter. There would be additional costs to regularly inspect and maintain the water meters, collect the data, analyse the results and follow-up on observations (i.e. potential areas of leakage).

The main benefit to a pressure zone/branch metering program is that it may identify “zones” of high use or leakage. The main disadvantages of a zone metering program (as compared to a residential metering program) are that it will not help in the provision of a backflow control system, it will not identify potential locations (properties) with high leakage on the private side and there is less incentive for residents to reduce their own water consumption.

Residential Metering

The estimated capital cost for a full residential metering program was calculated to be approximately $1,851,000. This estimate was based on 529 property connections at approximately $3,500 per connection.

A comparison of the retail water price across several municipalities in the Lower Mainland and Sea-to-Sky region is shown in Figure 2-18 below. Metered rates vary between $0.52 - $1.568 per m^3.

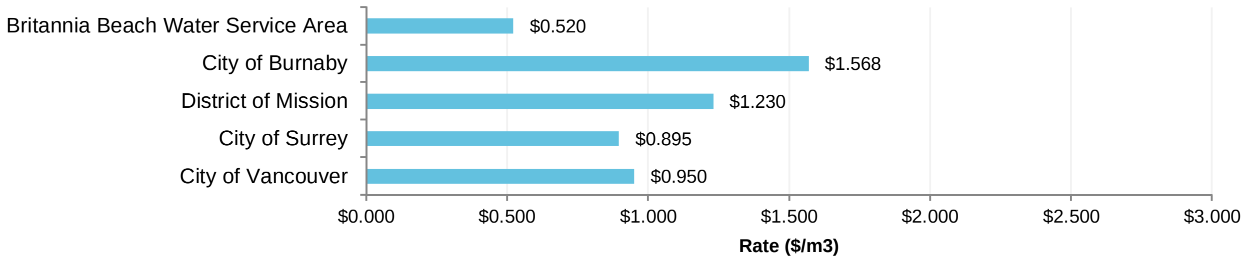


Figure 2-18: Comparison of Metered Water Rates around Vancouver[3]

The present water supply fee for a single family residence is approximately $1,272.88 per year, made up of $484.44 Water Parcel Tax and $788 Water User Rate. This is roughly equivalent to $1.37 / m^3, based on an annual average Village-wide consumption of 490,130m^3 servicing 529 connections. If a full residential metering program is adopted, it is recommended that the rate consider the following:

- Developing reserves for future costs such as the possible introduction of filtration;
- Economic incentive for users to reduce consumption, including block pricing or peak pricing; and
- Fixed versus variable costs.

Historically municipalities charged for water based solely on a variable pricing model; in other words those that consumed twice as much water, paid twice as much. However, as residents reduced their consumption, municipalities were faced with decreased revenues. Since many of the costs to run a water system are fixed (i.e. they don't change significantly with changes in water consumption), municipalities faced insufficient funding to operate their system. Therefore, many municipalities have implemented or are considering water rates that include a "base" rate to address fixed costs.

The Sunshine Coast Regional District recently received $3.4m in provincial and federal funding to deliver a residential metering program through the Small Communities Fund, which is a useful precedent and example of federal and provincial funding support to deliver a large scale residential metering program.

The Village does not currently have any backflow prevention on property connections. This means that there is a risk of water from property connections being drawn back into the reticulation system in certain circumstances. A full residential metering program typically includes installation of one-way valves on property connections which significantly mitigates this risk.

It should be noted that a residential metering program may not necessarily incentivise the majority of customers to significantly reduce their water consumption, as was recently observed in the District of West Vancouver. Residential metering would only cause people to reduce their water consumption if they were sensitive to the cost of the water they consumed. Sensitivity to pricing will vary by customer and will depend on the type of pricing structure in place (i.e. cost per litre, increasing block pricing etc.). If the Village wants to determine the best way to reduce water consumption by residents then it would be best to engage the principles of Community Based Social Marketing which identifies the incentives and barriers for changing behaviour within a particular community.

Since the meters are located near the property line, residential metering is good at identifying leaks on private property but will not help identify leaks within the Village's water distribution system. Other challenges to implementing a residential metering program include the fact that the location of all water services is not known and many residences have encroached onto the public right-of-way. In order to locate the water services and install individual water meters the Village would need to reclaim portions of the road right-of-way, where encroachment is occurring.

[3] *Britannia Beach Water Service Area is within the Squamish-Lillooet Regional District*

Options Assessment Summary

The costs and benefits of each metering option are summarised in Table 2-6.

Table 2-6: Summary of Costs and Benefits for Water Metering Options

Option	Approx. No. Meters	Capital Cost	Benefits	Costs/Disadvantages
No Change	-	-	• No capital cost	• May limit ability to obtain federal and provincial grant funding relating to water infrastructure, as some recent grant applications required evidence of commitment to water conservation through metering as an important input • No data on pressure zone / branch flows for leak identification • No means of identifying excessive water users • No backflow or cross connection control (residual risk of backflow contamination in water network)
Pressure Zone / Branch Metering	12	$150,000	• Data to help identify leaks, high-use areas and optimise operation of pressure zones • Demonstrates some commitment to water conservation	• Moderate capital cost • No backflow or cross connection (residual risk of backflow contamination in water network)
Full Residential Metering	529	$1,851,000	• High quality data to identify leaks on private property, excessive users and tailor operation of pressure zones • Strong evidence of commitment to water conservation • Full back-flow prevention, and an important part of cross-connection control	• Large capital cost • Will require locating existing service connections • Locating of services and installation of meters may impact residents who have encroached on the public right-of-way • Will not help identify leaks within the Village system (i.e. outside of property line)

2.9.4 Summary & Recommendations

In addition to relevant capital projects identified in **Section 7.1**, it is recommended the Village take the following actions:

- Acknowledge and consider whether the risk of backflow contamination is acceptable to the Village;
- Determine which metering option they wish to pursue based on the cost and benefits outlined above; and
- Ensure that Village approval of all new developments and major renovations includes requirements for installation of a backflow prevention device on the water connection.

2.10 SCADA Assessment

2.10.1 Objectives

The objective of the SCADA Assessment was to develop an understanding of issues with the current Supervisory Control and Data Acquisition (SCADA) system and identify high-level opportunities for improving data collection, monitoring, and control of the water system. The assessment included:

- Review of existing information and previous investigations.
- Visual inspection of the SCADA systems at both water treatment plants and the works yard.
- Consultation with operations staff.
- Consultation with the designers of the existing system.
- Discussion with Shaw and Telus cable internet providers.

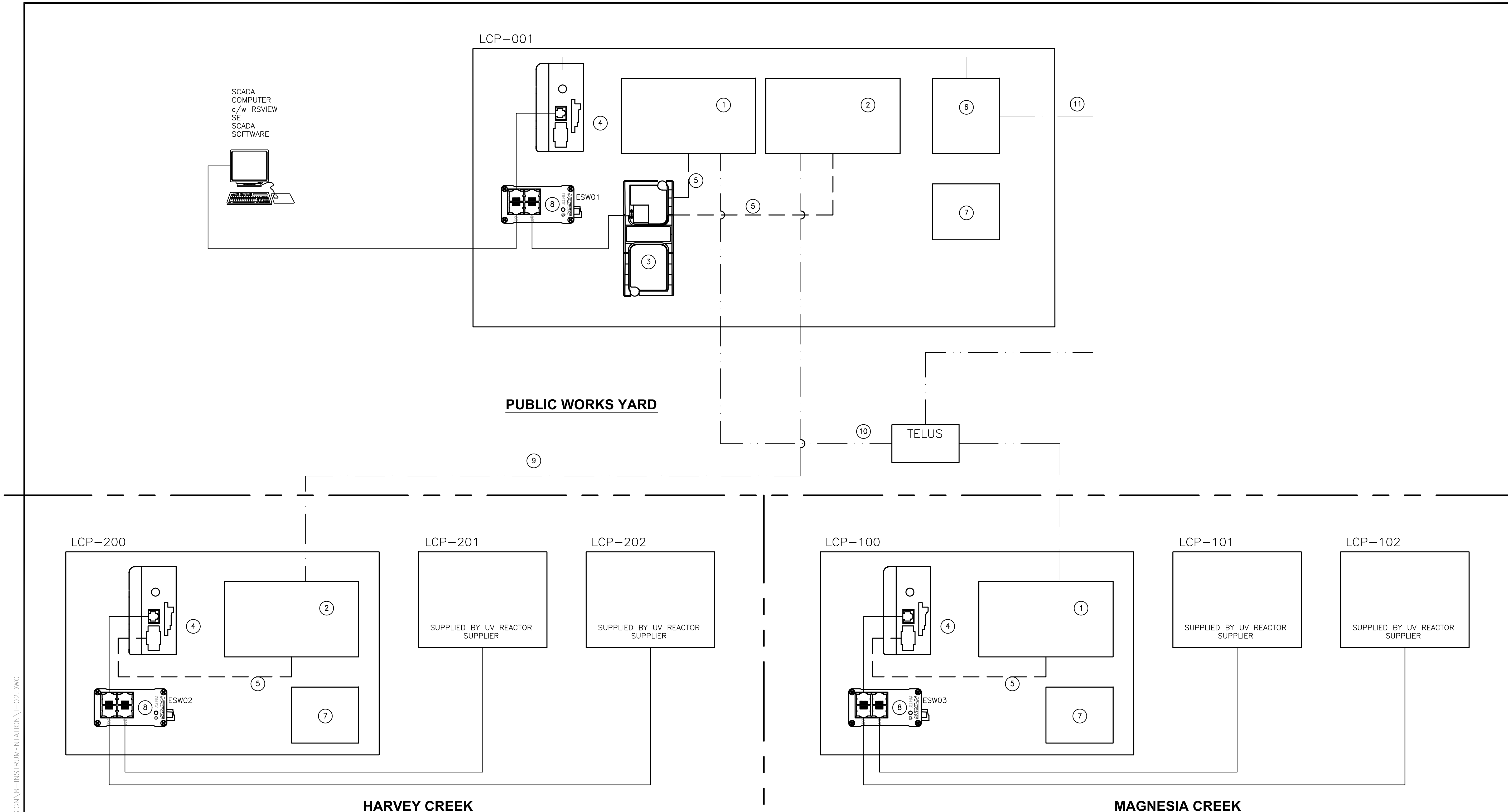
2.10.2 Existing Scenario

The architecture of the existing SCADA system is shown in Figure 2-19. There are three sites connected by the system: the Public Works Yard, Magnesia Creek WTP and Harvey Creek WTP. Connection between the control panel at the works yard and the control panels at the two plants differs: the Harvey Creek WTP connection runs through a dedicated leased line, whereas the Magnesia Creek plant connection uses a typical phone line. The leased line at Harvey Creek is a physical phone line that is not used by TELUS and is leased to the Village. With respect to the conventional phone line at Magnesia the works yard has a phone number that auto dials the phone number at the Magnesia reservoir.

The following actions can be performed remotely using the SCADA computer:

- Shut-down the plants
- Change the chlorine injection rate
- Change system set points (based on Tank Level)

The SCADA systems at both the water treatment plants were observed to be in good condition.



CONTROL SYSTEM ARCHITECTURE

ITEM	DESCRIPTION	REFERENCE MANUFACTURER	NOTES
1	DIAL-UP MODEM (EXTENDED TEMP.)	DATA-LINC DLM4000/DL/AADB	(MODEM SETUP FOR AUTO ANSWER/DIAL BACK)
2	LEASED LINE MODEM	DATA-LINC DLM4500	
3	EtherNet/IP TO DF1 GATEWAY	PROSOFT 5202-DFNT-DFCM4	
4	PLC	ALLEN-BRADLEY COMPACTLOGIX (REFER TO SPECIFICATION 17600)	
5	SERIAL CABLE		CROSSOVER
6	ALARM DIALER	BARNETT PROTALK PLUS B1290 PLUS	c/w EXTENDER
7	UPS	LIEBERT GXT 700VA	c/w INTERFACE CARD FOR RELAY CONTACTS
8	ETHERNET SWITCH	N-TRON 104TX	
9	EXISTING LEASED LINE		
10	EXISTING PHONE LINE		
11	NEW PHONE LINE	BY OWNER	

GENERAL NOTES:

1. SCADA COMPUTER TO BE POWERED BY UPS.

LEGEND:

1. * – EXISTING EQUIPMENT
2. – HARDWIRED
3. – ETHERNET CAT5
4. – SERIAL DF1
5. – PHONE LINE – DIAL-UP OR LEASED

VERIFY SCALE IF PLAN SHEET IS REDUCED — 30 CM

REV	DESCRIPTION	DRN	CHK	DATE (Y/M/D)
1	ISSUED FOR CONSTRUCTION	PJY	NWB	2009/05/04
0	ISSUED FOR TENDER	KSB	PS	2009/03/26

DRN BY: KSB
DES BY: DB
CHK BY: PS
APP BY: KM

PREPARED FOR: THE MUNICIPALITY OF THE VILLAGE OF LIONS BAY

PREPARED BY: AECOM

VILLAGE OF LIONS BAY WATER TREATMENT UPGRADES LIONS BAY, B.C.

INSTRUMENTATION SYSTEM ARCHITECTURE

PROJECT START DATE (M/Y): NOV / 2007
PROJECT NO.: 101658
FILENAME: I-02.dwg
SHEET NO.: Figure 2-19
DRAWING NO.: I-02

Plotted By: govettd
Plot File Date Created: Jun/29/2016 3:44 PM
Layout-Sheet Name: I02
Filename: L:\WORK\101000\101658\02A-CAD\WAT\DETAILED DESIGN\8-INSTRUMENTATION\I-02.DWG

RELEASE 2.0 (JULY 2008)

2.10.3 Previous Investigations

The Pre-Design report for the WTP upgrades (submitted in 2008) includes a review of telemetry options. The options considered were:

- Telus High-Speed Internet (Cable)
- Leased Telephone Lines
- High-Frequency Wireless Radio

The report recommended that a radio connection be used for the Harvey WTP connection and a leased line connection for the Magnesia WTP. A connection using high-speed cable internet was determined to be relatively simple and inexpensive to establish, however it was not selected due to the perceived high on-going subscription cost.

The Telemetry Assessment Report prepared by Signal Clarity Corporation (performed with the Pre-Design study) reviewed the radio telemetry options available. The investigation found that a reliable connection could be established between Harvey Creek WTP and the Works Yard, but not between Magnesia Creek WTP and the Works Yard. The investigation assessed the feasibility of using the Mount Gardner repeater, however it was found to be unsuitable. The investigation did not examine the feasibility of installing a repeater station at an alternative, closer location such as Brunswick Beach.

When the WTPs were installed, a dial-up phone connection was adopted in place of the radio connection originally identified in the Pre-Design Report.

2.10.4 Operations Staff Consultation

The operations staff reports that there are several issues with the existing SCADA system:

- There is limited ability to act swiftly to high NTU events from a remote location, as they can only shut down the plant.
- Whilst the Harvey Creek connection (leased line) is quite reliable, the Magnesia Creek connection (dial-up to dial-up) often goes out during inclement weather.
- There is only one connection method for each plant, with no redundancy.
- There is different connection technology used for both plants.
- The dial up modem is antiquated technology and becoming increasingly difficult to replace.

During higher NTU events, operations staff sometimes switch from the 150 mm intake line to the 50 mm intake line (prior to the UV lamps) to help reduce the NTU levels to be within the range of the treatment capabilities of the UV plant.

The ability to control flows through the UV lamps (by actuating the valves on the 150 mm / 50 mm lines) was identified as a potential modification that would help with functionality.

Designer Consultation

Members of the team involved with the previous installation advised that cellular technology has improved since the original system was installed, and it may be beneficial to assess the potential of using a cellular SCADA link to both plants.

2.10.5 Summary & Recommendations

The Villages existing SCADA system is limited in its scope and does not provide operational efficiencies associated with modern systems. Obsolete components and technology results in increased replacement costs and labour intensive down time. Commissioning of a SCADA Control Strategy Study to determine the most efficient and cost effective technology moving forward is recommended.

The most significant SCADA needs for the Village are to add redundancy, functionality and stability to the existing WTP telemetry connections. Several feasible options for achieving this are summarised below. Sketches of the potential system architecture are included in **Appendix B**.

Table 2-7: Options for Adding Telemetry Redundancy

Option	Considerations
Internet via Cable (Shaw / Telus Cable-internet at street)	• Very high-speed connection • Both Shaw and Telus offer cable internet up to the entrances of the water treatment plant access roads. • Low capital cost • Requires new cable connection from road to WTPs • Relatively simple implementation • Requires network security • Reliant on integrity and performance of external cable network • Enables remote access to/from anywhere on the Internet
Internet via Cellular Connection	• High-speed connection • Low capital cost • Requires cell modem (and probably signal amplifiers) • Can be impacted by weather conditions • Current coverage is poor but can expect future coverage improvements • Requires network security • Reliant on integrity and performance of external cellular network • Enables remote access to/from anywhere on the Internet
VHF/UHF Radio link	• Moderate capital cost • Will likely require repeater and tower at works yard • Signal can be impacted by poor weather • Closed connection (no network security issues) • No monthly service fee

In additional to the relevant capital projects identified in **Section 7.1**, it is recommended that the Village perform the following:

- Investigate the cost and feasibility of a cellular telemetry connection for the water treatment plants.
- Implement an internet-based connection as the second telemetry connection for the WTPs (e.g. cellular or cable-based). This will achieve both short-term redundancy of the telemetry connection, but it will also enable the Village to take advantage of cloud-based SCADA technologies, should they choose, as they proliferate and improve.

3 Sanitary

3. Sanitary

3.1 Overview

3.1.1 System Description

The Village's sanitary pipe system is limited to the Kelvin Grove area. The system comprises of 2,170m of 200mm SDR35 PVC gravity sewer pipe discharging into a Wastewater Treatment Plant (WWTP) adjacent to Kelvin Grove Beach Park on Tidewater Way.

The remainder of the Village is serviced by private septic tanks that are the responsibility of the residents and are not included in the scope of this IMP.

A map of the existing sanitary system is shown in Figure 3-1.

3.1.2 Replacement Value

The total replacement value of the Village's sanitary assets is estimated at $3.3 million. A breakdown of the asset replacement values estimated is shown in Table 3-1. Based on the estimated service lives of different asset types, the Village should be spending (or putting in reserves) an estimated $58,600 per year, on average for the renewal of its sanitary system.

Table 3-1: Asset Value and Average Renewal Cost for Existing Sanitary Assets

Asset Item	Quantity	Unit	Rate ($)	Replacement Value	Estimated Service Life	Annual Renewal Cost
200mm PVC Sanitary Pipes (inc. manholes, property connections etc.)	2,173	m	$900	$1,955,700	75 years	$26,100
Wastewater Treatment Plant	1	each	$1,300,000	$1,300,000	40 years	$32,500
SUB-TOTAL (SANITARY)				**$3,255,700**		**$58,600**

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

GeoAdvice Engineering Inc.

Legend

- Manhole
- Treatment Plant
- Gravity Main

Existing Sanitary Sewer System Overview

Project: Infrastructure Master Plans
Client: Village of Lions Bay, BC
Date: January 2016
Created by: SG
Reviewed by: WdS

DISCLAIMER: GeoAdvice does not warrant in any way the accuracy and completeness of the information shown on this map. Field verification of the accuracy and completeness of the information shown on this map is the sole responsibility of the user.

0 30 60 120
Meters

Figure 3.1

3.2 Infrastructure Planning Objectives

The sanitary infrastructure planning goals were to:

- Determine the condition of the Village's sanitary infrastructure;
- Develop a hydraulic model of the existing sanitary system and assess its capacity;
- Develop a high-level conceptual plan and hydraulic model for a potential Village-wide sanitary sewer system; and
- Review short and long-term suitability of the existing wastewater treatment system.

3.3 Condition Assessment

3.3.1 Objectives

The objective of the sanitary condition assessment was to analyse the condition of the Village's sanitary infrastructure and make recommendations to resolve any significant issues. The condition assessment included the following tasks:

- Visual inspection of the WWTP;
- Desktop review of previous investigations, drawings and reports;
- Consultation with operations staff; and
- CCTV inspection of key sanitary sewers.

3.3.2 Findings

Treatment Plant

A detailed condition assessment of the WWTP was performed by EarthTech in 2005 as part of the previous infrastructure plan. Important points of the 2005 investigation were as follows:

- RBC Disks 1 & 2 were in good condition, as they were replaced in 2004 and 2005 respectively.
- The ROTORDisk drive motor was in good condition and replaced in 2002.

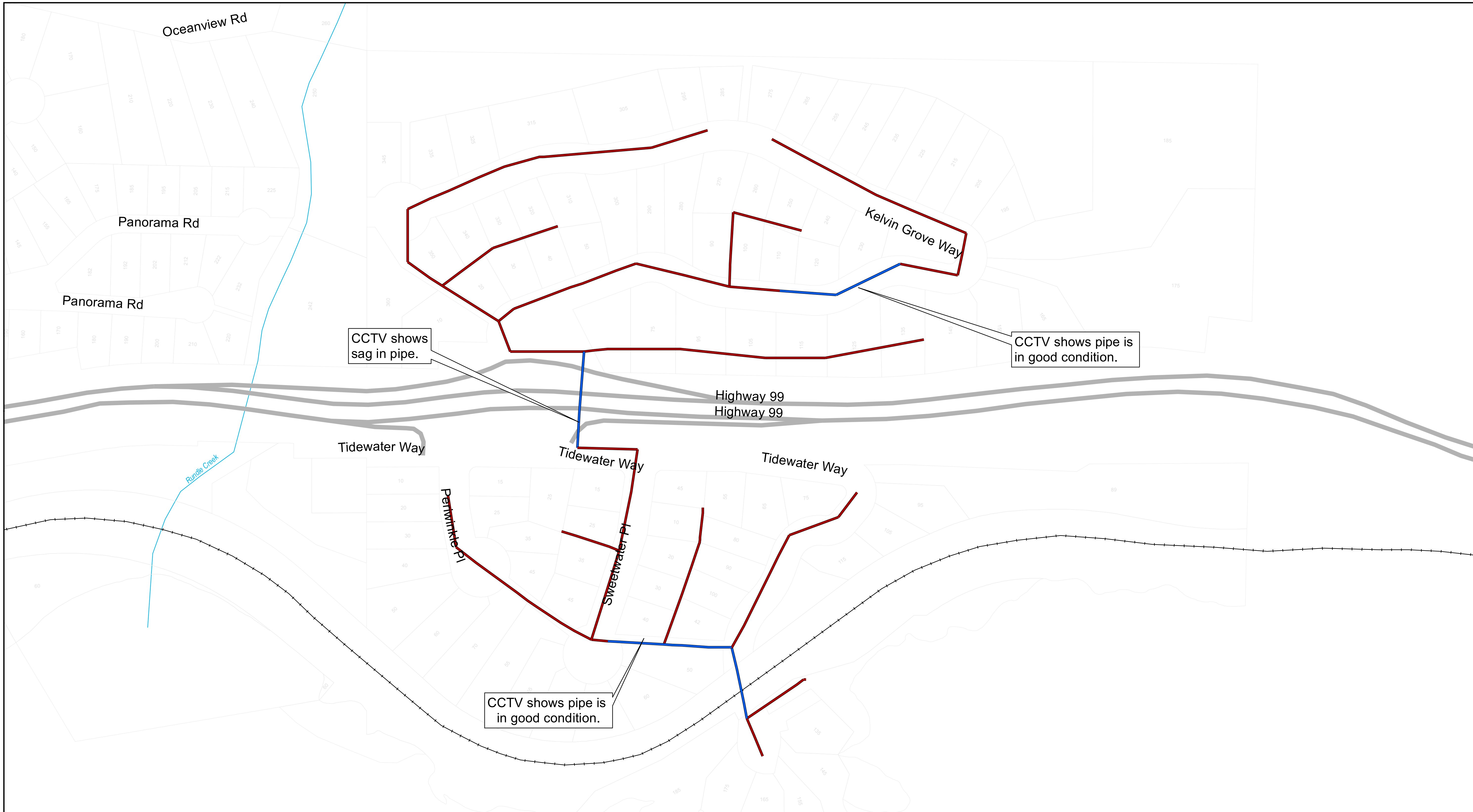
A visual inspection was performed in September 2015. The following was observed:

- The structural components of the WWTP appear to be in relatively good working order.
- RBC Disks 3 & 4 were in working order and staff reported that they were replaced in 2012.
- The V-notch weir had fallen out of the effluent flow meter, which means that the flow record is likely to be under-estimating the flow volume.
- The access components of the WWTP have deteriorated badly and pose a significant safety risk to operations staff.
- The bridge to the RBC (used every two weeks for greasing the bearings) needs immediate replacement.
- There is also no fall restraint on the walkways around the walls of the chamber.
- The WWTP was installed in conjunction with the sewer network in 1981 and is nearing the end of its estimated 40 year service life. It is prudent for the Village to review its long term strategy including expansion of service to other areas or the Village prior to replacement of the WWTP.

Sanitary Sewers

Operations staff reported that the system does not currently appear to have significant infiltration and inflow (I&I) issues. The network was installed in 1981, which means that the PVC pipes are 35 years old. Some PVC pipe manufacturers claim a design life of 100 years; however this is dependent on the quality of construction and environmental conditions such as ground movement.

We conducted CCTV inspection of six sections of sanitary sewer; including: the portions of the system that runs under the highway and the railway tracks. Based on the CCTV inspections the pipe appears to be in good condition. Figure 3-2 shows the sections of sanitary sewer that were inspected and any found defects. The only found defect was a sag in the sewer under the Sea to Sky Highway, which should be monitored during subsequent CCTV inspections. The Village should inspect its entire sanitary sewer network at least every 20 years. That way they can monitor the condition of its sanitary network and be progressive in its renewal as the system begins to age and deteriorate.



VILLAGE OF LIONS BAY
Infrastructure Master Plan
Figure 3-2 Sanitary Sewers Inspected by CCTV

AECOM

Village of Lions Bay

If the system were allowed to deteriorate there would likely be increased risk of sewer main breaks and increased infiltration into the sanitary network. As infiltration increases, the treatment performance of the WWTP is likely to decline. It will also mean that any WWTP replacement will need to be larger to account for the extra flow from infiltration.

3.3.3 Recommendations

In addition to the relevant capital projects identified in **Section 7.1**, it is recommended that the Village perform the following actions:

- Perform safety repairs on the wastewater treatment plant as soon as possible in order to reduce workplace risk.
- Repair the V-notch weir so that flows can be measured accurately at the WWTP.
- Commence regular CCTV inspection and condition assessment of the sanitary pipe network (at least every twenty years and perhaps more frequently depending on the condition and criticality of a given pipe) to ensure that pipe damage is identified and graded. Implement a proactive maintenance and repair regime based on the CCTV inspections and condition assessment findings.

3.4 Hydraulic Model Development and Analysis

A new hydraulic model of the existing sanitary sewer network was developed from GIS data. Hydraulic modelling and analysis of the existing Kelvin Grove sanitary network was performed by GeoAdvice and details of the analysis are included in **Appendix A.2** *Sewer Collection System - Model Development and Capacity Analysis - Draft Technical Memorandum*. Key findings of the assessment were as follows:

- There were no capacity issues identified within the existing network when modelling Peak Wet Weather Flows (PWWF) in the existing (2015) or future population growth scenarios (2020, 2025, 2045).

3.5 Village-Wide Sanitary Strategy

3.5.1 Objective

The objective of the Village-wide Sanitary Strategy was to develop a high-level conceptual plan for a potential Village-wide sanitary sewer network and centralised wastewater treatment plant.

Transitioning to a Village-wide centralised sanitary system was identified by the Village as a potential long-term infrastructure goal. The intent of the expanded system would be to replace the private septic tanks servicing all properties outside of Kelvin Grove.

The Village-Wide Sanitary Strategy included the following steps:

- Develop a high-level alignment plan
- Prepare a cost estimate
- Develop a hydraulic model and perform a flow / capacity analysis
- Identify treatment requirements

3.5.2 Alignment Plan

A concept-level sewer alignment plan was developed around the following assumptions and constraints:

- The system would be a mix of traditional gravity sewers and forcemains.
- Property connections will be at the front of properties.
- Easements through residential properties will be avoided where possible.
- Easements through the rail and highway corridor would be obtained from the relevant parties.
- The centralised wastewater treatment plant would be located at the existing WWTP location.

The high-level alignment plan is shown in Figure 3-3.

The future system included allowance for a possible housing development around Crystal Falls Rd. It was assumed that this development would include the equivalent of approximately thirty (30) single family homes and that wastewater flows would flow by gravity to a pump station at Brunswick Beach. However, the future system doesn't allow for any other future growth areas that were proposed within the Village's Draft Land Use Master Plan (2014).

The layout and topography of the Village will present significant and costly challenges, including:

- Approximately five (5) pump stations and force mains will be required, which is likely to have a significant ongoing operational/maintenance cost and resourcing demand.
- The three Village areas (Brunswick Beach, Lions Bay and Kelvin Grove) are separated by creeks and significant distance that will require multiple stages of pumping to connect. An easement may also be required through either the rail or highway corridor in order to facilitate these connections.
- Properties that are downhill of the sanitary sewer will require a property connection that includes a sewage grinder and pump. Sewage would be pumped to the front of the property (as opposed to gravity mains from the uphill properties).
- There are several very flat areas, (e.g. Brunswick Beach, lower Lions Bay Ave) that may require a low-pressure pumped system instead of gravity sewers in order to reduce manhole depths, particularly where there is a high likelihood of groundwater.

GeoAdvice Engineering Inc.

Legend

- Lift Station
- Manhole
- Treatment Plant
- Gravity Main
- Forcemain

Proposed Full System Expansion Sanitary Sewer System Overview

Project: Infrastructure Master Plans
Client: Village of Lions Bay, BC
Date: January 2016
Created by: SG
Reviewed by: WdS

DISCLAIMER: GeoAdvice does not warrant in any way the accuracy and completeness of the information shown on this map. Field verification of the accuracy and completeness of the information shown on this map is the sole responsibility of the user.

0 0.125 0.25 0.5
Kilometers

N E S W

Figure 3.3

3.5.3 Cost Estimate

The total capital cost for the Village-wide sanitary system was estimated to be $15.6 million. A breakdown of this estimate is included in Table 3-2. This estimate does not include private property costs such as private sewage grinders and pumps for properties that are below the collection sewer.

Table 3-2: Cost Estimate of Proposed Sanitary Network

Item	Unit	Quantity	Rate	Cost
Force Main	m	1568	$700	$1,097,600
Gravity Main	m	8844	$900	$7,959,600
Pump Stations	each	5	$500,000	$2,500,000
WWTP Upgrade	each	1	$4,000,000	$4,000,000
TOTAL				***$15,557,200***

3.5.4 Hydraulic Analysis

Hydraulic modelling of the potential Village-wide sanitary network described above was performed by GeoAdvice and the detailed results are included in **Appendix A2.** The key findings of this assessment were as follows:

- The population being serviced by the expanded network was assumed to be 1,674, which was made up of the existing Village population, population growth within the existing Village and additional population associated with a proposed new housing development adjacent to Crystal Falls Rd.
- The peak wet weather flow (PWWF) was estimated at 61.70 L/s, made up of 41.67 L/s of Peak Dry Weather Flow (PDWF) and 20.03 L/s of inflow and infiltration (I&I).
- This flow estimate was based on the assumption that 80% of the Average Day Demand (ADD) water flows would be converted to wastewater flows.
- Estimates of the PWWF at the pump stations are summarised in Table 3-3.

Table 3-3: PWWF at Pump Stations

Lift Station	Approximate Lift Station Location	PWWF Flow (L/s)
PMP1	North End of Lions Bay Avenue	26.1
PMP2	South End of Panorama Road	2.0
PMP3	Near 3-Way Intersection of Lions Bay Avenue - East of Lions Bay Beach	47.6
PMP4	North End of Brunswick Beach Road	4.6
PMP5	Near 3-Way Intersection of Brunswick Beach Road - West of Northbound Brunswick Road Exit	7.2

3.5.5 Treatment Requirements

Hydraulic modelling of the potential Village-wide sanitary network estimated the PWWF to be 61.70 L/s. The licenced capacity of the existing WWTP at Kelvin Grove is 340m^3/day (3.9 L/s). Whilst the hydraulic modelling was notably conservative, it is obvious that a centralised WWTP for a Village-wide sanitary system will need to have significantly higher capacity than the existing WWTP.

There is likely to be a significant variation in flows reaching the centralised WWTP between the commencement and completion of the Village-wide sanitary system. Subsequently, the Village may consider implementing a WWTP system that can be incrementally expanded as the upstream network expands. Many modern package treatment plants can be expanded in phases with relative ease.

3.5.6 Phasing

Due to the geographic distances and elevation changes involved, and the capital constraints of the Village, it is likely that a Village-wide sanitary network will need to be installed over several stages. Whilst there is a high level of flexibility in rolling out the sanitary network throughout the Village, there are two key steps that will need to be performed at the commencement of the program:

- Upgrade WWTP (may be delayed temporarily if accurate flow measurement shows that the existing WWTP can handle an increase in flows).
- Install Pump Station and Forcemain connecting lower Lions Bay to Kelvin Grove, along with any potential upgrades of the existing Kelvin Grove sanitary sewers.

Development of the system would then “fan out” from the aforementioned pump station.

If the Village seeks to progress with the housing development near Crystal Falls Rd and service the development with a municipal piped sanitary system, then the following items will need to be brought forward:

- Detailed planning and design of potential Village-wide system
- WWTP Upgrade
- All downstream pump stations and gravity mains

It may be possible to service this proposed development, and potentially Brunswick Beach, with a separate smaller package WWTP located in the Brunswick Beach area. This option may negate the need for a long forcemain connecting Brunswick Beach to Lions Bay, however the plant would likely need to be located near the water and would require a new effluent outfall. This option was not considered in detail; however it may be a worthwhile for potential developers to consider this option.

3.6 Sanitary Treatment Review

3.6.1 Objectives

The objective of the Sanitary Treatment Review was to assess current and probable future wastewater quality regulations that will affect the operation and maintenance of the sanitary system through the planning horizon.

3.6.2 Existing Scenario

Treatment System

Raw influent flows from the sanitary pipe network discharge into the Primary Clarifier and “Rotozone”, where heavy solids settle to the bottom of the tank (Primary Sedimentation) and the Rotating Biological Contactor (RBC) performs secondary biological treatment to reduce biological oxygen demand. The supernatant (separated liquid) flows into the secondary clarifier where further sedimentation occurs.

Sludge from the primary and secondary clarifier is annually removed from the bottom of the tanks and disposed of off-site. Effluent flows from the secondary clarifier are measured before being released through an ocean outfall approximately 180m into Howe Sound.

A chlorine contact chamber was also installed at the time of construction, in preparation for possible increased treatment requirements. The chamber has not yet been used but the Village is in a good position to add chlorine injection, should it be required in the future.

The WWTP was initially licenced to operate under permit PE-5188. The treatment train of the existing WWTP is shown diagrammatically in Figure 3-4.

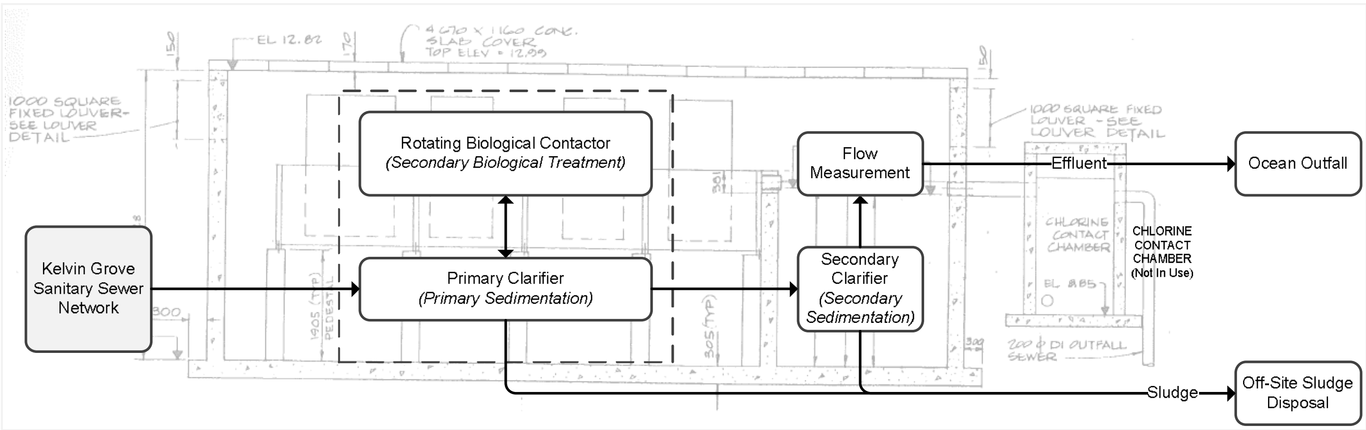


Figure 3-4: WWTP Process Flow Chart

Existing Capacity and Flows

The current WWTP permit allows for an effluent discharge of up to 340m^3/day. The previous WWTP mechanical condition assessment noted that the maximum design capacity of the plant was 218m^3/day; however the origin of this value is not stated.

Effluent data provided by operations staff shows that the average daily flows rarely exceed 100m^3/day (Figure 3-5), however as previously noted in the condition assessment (**Section 3.2**), the weir of the WWTP flow meter was found to have fallen out during the condition assessment and this significantly impacts the reliability of the data. A previous planning project performed for the Village stated that the average flow recorded in the WWTP logbooks was 190 - 200m^3/day. If the average flows were in fact 190-200 m^3/day then the WWTP would be operating at approximately 90% of the assumed design capacity. This means that the plant could accept a small amount of growth in the catchment (i.e. <10 houses) but any significant growth in the catchment (i.e. >9 houses) would require upgrading the WWTP.

It should be noted that an average flow of 190 - 200m^3/day is quite high for the estimated Kelvin Grove population of 257 people. Efforts to reduce indoor water use (i.e. low flush toilets, water efficient appliances etc.) will help to reduce sanitary flows and may delay required treatment plant upgrades.

The WWTP permit (340m^3/day) is sufficient for the current lay-out under existing and future populations but would not be sufficient if the system was expanded to take flow from other areas of the Village that are currently serviced through private septic systems.

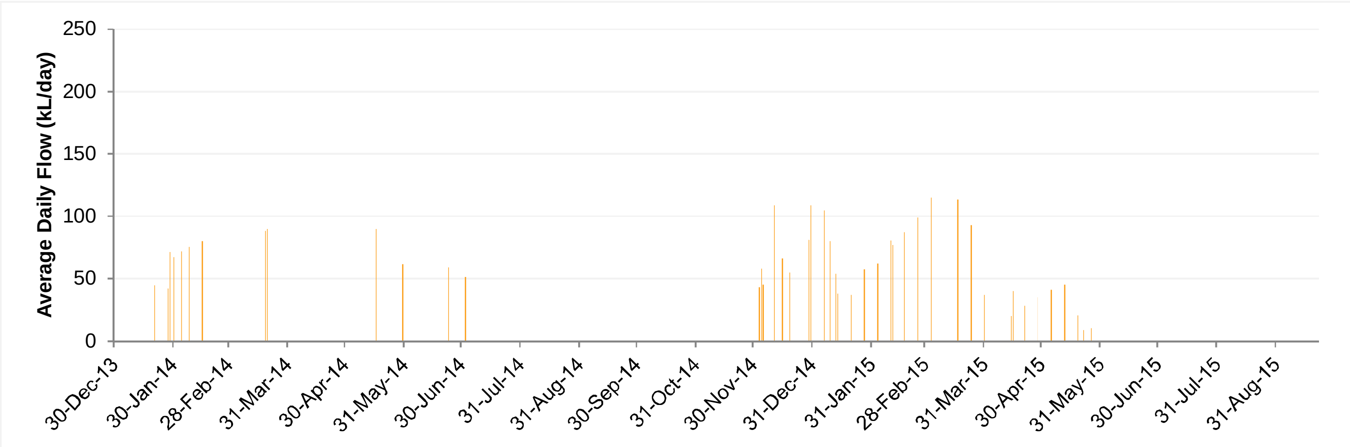


Figure 3-5: Average Daily Effluent Flow (m3/day) measured at WWTP

3.6.3 Wastewater Treatment Requirements

BC Municipal Wastewater Regulation

According to the BC Municipal Wastewater Regulation ("the Wastewater Regulation"), the existing wastewater treatment plant is a secondary treatment plant and the effluent is categorised as Class C.

The effluent requirements for Class C effluent and the requirements listed on the permit are summarised in Table 3-4. It should be noted that the current BC Municipal Wastewater Regulation requires a higher standard of treatment for TSS (45mg/L) than originally listed on the permit (60mg/L).

Table 3-4: BC WWTP Effluent Requirements

Characteristic	Requirement	
	BC Municipal WW Regulation Class C	Ex. Permit
BOD_5 (mg/L)	45	45
TSS (mg/L)	45	60

Federal Wastewater Systems Effluent Regulations

The federal Wastewater Systems Effluent Regulations (published July 18, 2012) established new national standards for Canada's wastewater treatment systems and they are now in force. The regulations set effluent quality standards that can be achieved through secondary treatment, or equivalent, of wastewater prior to discharge.

The regulations apply to wastewater systems designed to collect an average daily flow volume greater than $100m^3$. Whilst the existing flow monitoring data suggests that the plant does not receive an average flow of greater than $100m^3$, the flow data was unreliable and it is possible that the existing WWTP is indeed covered under this regulation.

The regulations have a number of WWTP classifications; however the Village's plant was assessed to be a "Continuously Discharging Wastewater Systems", with an Annual Average Daily Volume of between $100m^3$ and $2500m^3$. It was assumed that the Village does not have a "Transitional or Temporary Authorization". The quality and sampling requirements relating to this classification of plant is shown in Table 3-5 below.

Table 3-5: Federal Wastewater Requirements

B. Effluent Quality Standards – January 1, 2015 Unless Issued a Transitional or Temporary Authorization

Annual Average Daily Volume (m^3)[i]	100 to ≤ 2 500	> 2 500 to ≤ 17 500	> 17 500 to ≤ 50 000	> 50 000
Volume Deposited				
Daily volume determination	continuous measure of influent or effluent volume or measure rate of influent or effluent flow	continuous measure of influent or effluent volume		
Effluent Quality Standards – Carbonaceous Biochemical Oxygen Demand (CBOD), Suspended Solids (SS)				
CBOD (mg/L)	quarterly average ≤ 25		monthly average ≤ 25	
SS (mg/L)	quarterly average ≤ 25		monthly average ≤ 25	
Type of sample	composite or grab	composite		
Sampling frequency	monthly but at least 10 days after any other sample	every 2 weeks but at least 7 days after any other sample	weekly but at least 5 days after any other sample	3 days per week but at least 1 day after any other sample
CBOD test method	5-day BOD test with nitrification inhibition conducted by a lab accredited to do the test			
SS test method	total suspended solids test conducted by a laboratory accredited to do the test			
Effluent Quality Standard – Total Residual Chlorine (TRC)[iii]				
TRC (mg/L)	quarterly average ≤ 0.02		monthly average ≤ 0.02	
Effluent Quality Standard – Un-ionized Ammonia (NH_3)				
NH_3 (mg/L, expressed as nitrogen (N) at 15°C ± 1°C)	maximum concentration in the quarter < 1.25		maximum concentration in the month < 1.25	
Sampling frequency	not specified			
Total ammonia test method	total ammonia test conducted by a laboratory accredited to do the test			
pH test method	pH test conducted by a laboratory accredited to do the test			
Effluent Quality – Acute Lethality				
Acute lethality	non-acutely lethal effluent			
Sample type	grab			
Sampling frequency	not specified	quarterly but at least 60 days after any other sample		monthly but at least 21 days after any other sample
Sampling frequency reduction	not applicable	annually but at least 6 months after any other sample		quarterly but at least 60 days after any other sample
Sampling frequency upon failure	twice a month until 3 consecutive passes			
Procedures	single or multiple concentration with or without pH stabilization			
Reference Method EPS 1/RM/13	Procedure set out in section 5 or 6 of *Biological Test Method: Reference Method for Determining Acute Lethality of Effluents to Rainbow Trout* (EPS 1/RM/13 Second Edition), December 2000 with May 2007 amendments, published by the Department of the Environment, as amended from time to time.			
Procedure for pH Stabilization EPS 1/RM/50	*Procedure for pH Stabilization During the Testing of Acute Lethality of Wastewater Effluent to Rainbow Trout* (EPS 1/RM/50), March 2008, published by the Department of the Environment, as amended from time to time.			
Reporting Requirements				
Reporting frequency	quarterly			
Report due	within 45 days after the end of the quarter			
Information required	a statement that indicates that effluent was not deposited during the quarter or a statement that indicates that effluent was not deposited during any month in the quarter; and, for the quarter: • number of days effluent was deposited • volume (m^3) of effluent deposited • average CBOD • average SS concentration		a statement that indicates that effluent was not deposited during the quarter or a statement that indicates that effluent was not deposited during any month in the quarter; and, for each month during which effluent was deposited in the quarter: • number of days effluent was deposited • volume (m^3) of effluent deposited • average CBOD • average SS concentration	
	for each sample for which a determination of acute lethality was made a statement that indicates: • sampling date • procedure used in Reference Method EPS 1/RM/13 • if the pH stabilization procedure EPS 1/RM/50 was used • if sample was acutely lethal			

3.6.4 Compliance

Treatment Performance

The results of WWTP effluent samples taken between January and July 2015 are shown in Figure 3-6. Based on this limited sample size, the results show that the WWTP appears to be meeting the requirements of the BC Wastewater Regulation, and appears to be compliant with the federal regulations for BOD and TSS.

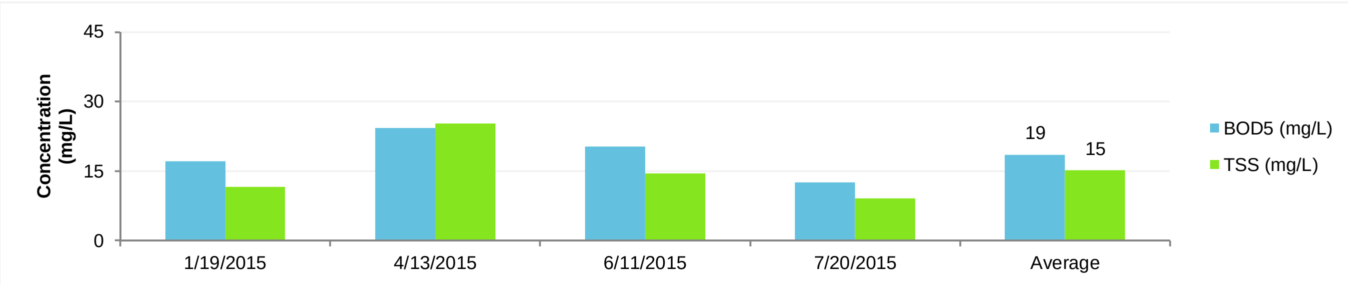


Figure 3-6 : WWTP Effluent Sampling Results

Sampling Compliance

The federal regulations have additional effluent requirements relating to Total Residual Chlorine, Un-iodised Ammonia and Acute Lethality. No information relating to these parameters was provided by the Village. It should be confirmed whether the Village collects this information and whether it is required to do so.

3.6.5 Future Treatment Needs

Catalysts

Whilst the WWTP appears to performing satisfactorily under current conditions, there are several scenarios that should catalyse formal plans to replace or upgrade the existing plant:

- Change in Wastewater effluent legislation that exceeds or approaches treatment capacity of the existing plant.
- Discontinuation of major parts (e.g. RBC drums).
- Age of Plant is 90% of its expected service life.
- Noticeable and consistent decline in treatment performance.
- Measured effluent exceeds 218 m^3/day.
- Plans to add 10 or more connections.

Increased flow to the existing WWTP either through expansion of the existing sanitary sewer network or through increased development within the Kelvin Grove area will likely require an increase in the treatment capacity at the WWTP.

Design Objectives

There are several constraints that will need to be considered in addressing wastewater treatment options over the short and medium term. Table 3-6 outlines the Village-specific constraints that will need to be accounted for when selecting a WWTP upgrade, if and when required.

The design flow capacity of a treatment plant will be highly dependent on the size of the sanitary network feeding it - the capacity of the existing plant is ~300m^3/day whilst hydraulic modelling of the full Village-wide sanitary network shows the final estimated PWWF to be 5,330m^3/day. Subsequently, an incrementally expandable WWTP system should be considered.

Since the Village is a small community with limited technical staff it is critical that any future treatment options be simple to manage and operate, unless the Village is willing to consider having a third party operate its WWTP. However, even if a third party operates the plant, the Village will need to have sufficient resources and technical know-how to manage and work with the operator.

Table 3-6: Constraints and Design Objectives for Future WWTP

Constraint	Design Objective
Existing plant is located in close proximity to residences and recreation areas	• Very low odour • Low visual impact
Outfall located in proximity to swimming, recreational boating areas	• Ensure very high standard of treatment
Limited space available	• Minimise footprint
Small operations team (Village public works staff)	• Simple to operate, with good manufacturer support

4

Drainage

4. Drainage

4.1 System Overview

The Village drainage system is very limited and comprises of a combination of roadside ditches (vegetated and concrete) and driveway culverts connected by galvanised corrugated steel pipes running under the roadway at infrequent intervals. The most significant drainage features in the Village are the concrete drains that line the banks of the creeks running through the Village.

There are four primary drainage catchments within the footprint of the Village: Magnesia Creek, Alberta Creek, Harvey Creek and Rundle Creek (running from north to south).

There was very limited GIS information available relating to the stormwater network and the information that was available did not appear to be accurate. In order to develop a usable dataset, a workshop was held with operations staff to map out the ditches and pipes in the drainage system. Markups from this workshop were used to create a GIS dataset. It should be noted that the location and extents of stormwater infrastructure shown on this map are indicative only.

4.1.1 Challenges

The Village has acknowledged the following concerns and challenges relating to the drainage system:

- Steep topography leading to the majority of rainfall becoming runoff, high flow velocities and corresponding energy capable of transporting debris or causing erosion.
- Encroachments into the public realm which have blocked, infilled, or restricted the development of the drainage system.

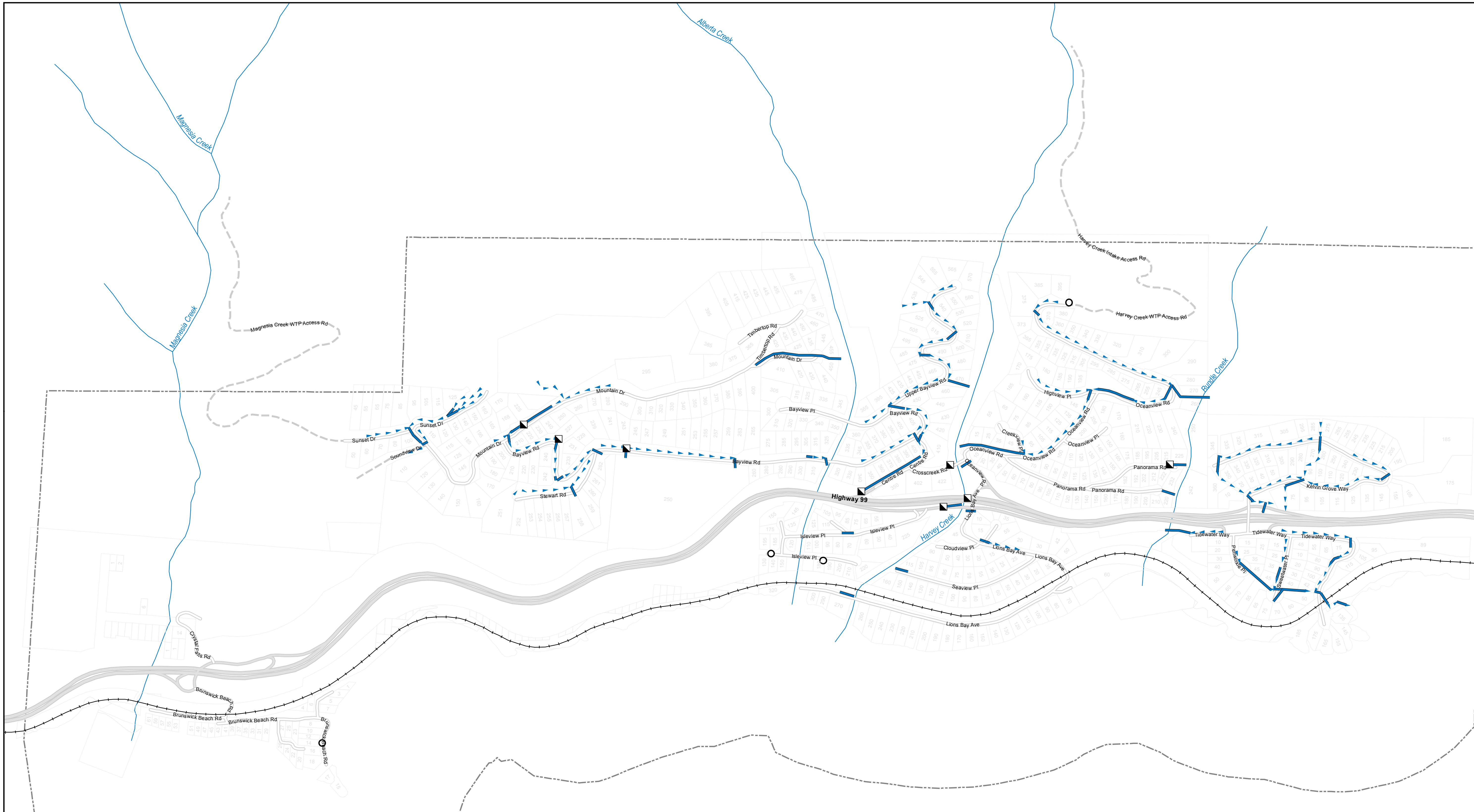
4.1.2 Replacement Value

The estimated replacement value of the existing drainage system is only a rough estimate and probably a low estimate due to the limited GIS information available. The estimated replacement cost of the Village's drainage infrastructure is $2.3 million. This does not include the concrete channels, culverts and other infrastructure within Harvey, Alberta and Magnesia Creeks. A breakdown of this estimate is shown in Table 4-1 below. This estimate is indicative only. Based on estimated service lives for different asset types, the Village should be investing approximately $31,000 per year, on average, on the renewal of its drainage system. The concrete channels which convey the major creek drainage were not included in the asset value calculation.

Newly installed concrete drainage pipe should have a service life of 80 years but older corrugated steel pipe will only have an average service life of 40 years. Therefore an average estimated service life of 60 years was used to determine annual renewal costs.

Table 4-1: Asset Value of Drainage Network

Item	Quantity	Unit	Unit Rate	Replacement Value	Estimated Service Life	Annual Renewal Cost
Pipes and Culverts	2230	m	$800	$1,784,000	60 years	$29,700
Ditches	4,800	m	$100	$480,000	Ditches typically only require maintenance rather than renewal	
Catch basins	8	each	$5,000	$40,000	50 years	$800
Manholes	3	each	$10,000	$30,000	50 years	$600
SUB-TOTAL (Drainage)				**$2,334,000**		**$31,100**



Infrastructure Master Plan
Drainage
Figure 4-1 Drainage Overview

AECOM

Legend

Village Boundary
Property Parcels

MOTI Roads
Highway
On-Ramp
Rail

Village Roads
Sealed
Unsealed

Existing Pipe
Existing Channel
Existing CB
Existing MH

0 50 100 200
Metres

Village of Lions Bay

4.2 Condition Assessment

4.2.1 Objectives

The scope of the condition assessment was “analysis of the existing asset condition of the drainage system, highlighting any deficiencies noted, including an illustrated drawing clearly noting said deficiencies”.

4.2.2 Findings

Condition assessment of the Village drainage system included visual inspection and consultation with the operations staff, as well as CCTV inspection of select culverts. The key findings of the assessment are as follows:

- The drainage system at the Village is in very poor condition and is completely inadequate for the steep and wet conditions common to the Village.
- A significant proportion of the Village does not have any discernable roadside drainage. Many of the roadside drains have been filled in, resulting in water sheeting down the surface of the road rather than the roadside which can cause significant damage to the road pavement.
- Groundwater flows are very significant and can be very unpredictable.
- Many of the existing galvanised corrugated steel culverts have corroded badly which is likely to be causing significant sub-surface erosion.
- Some culverts contain significant amounts of gravel which need to be cleaned to allow for proper inspection and to obtain full culvert flow capacity.
- In November / December 2015, there were several significant rainfall events in the Village. During one of these events, water was witnessed flowing out of the surface of the asphalt road as a result of a blocked culvert under the surface. This was likely causing significant damage to the roadway and evidence of this was visible on the surface.

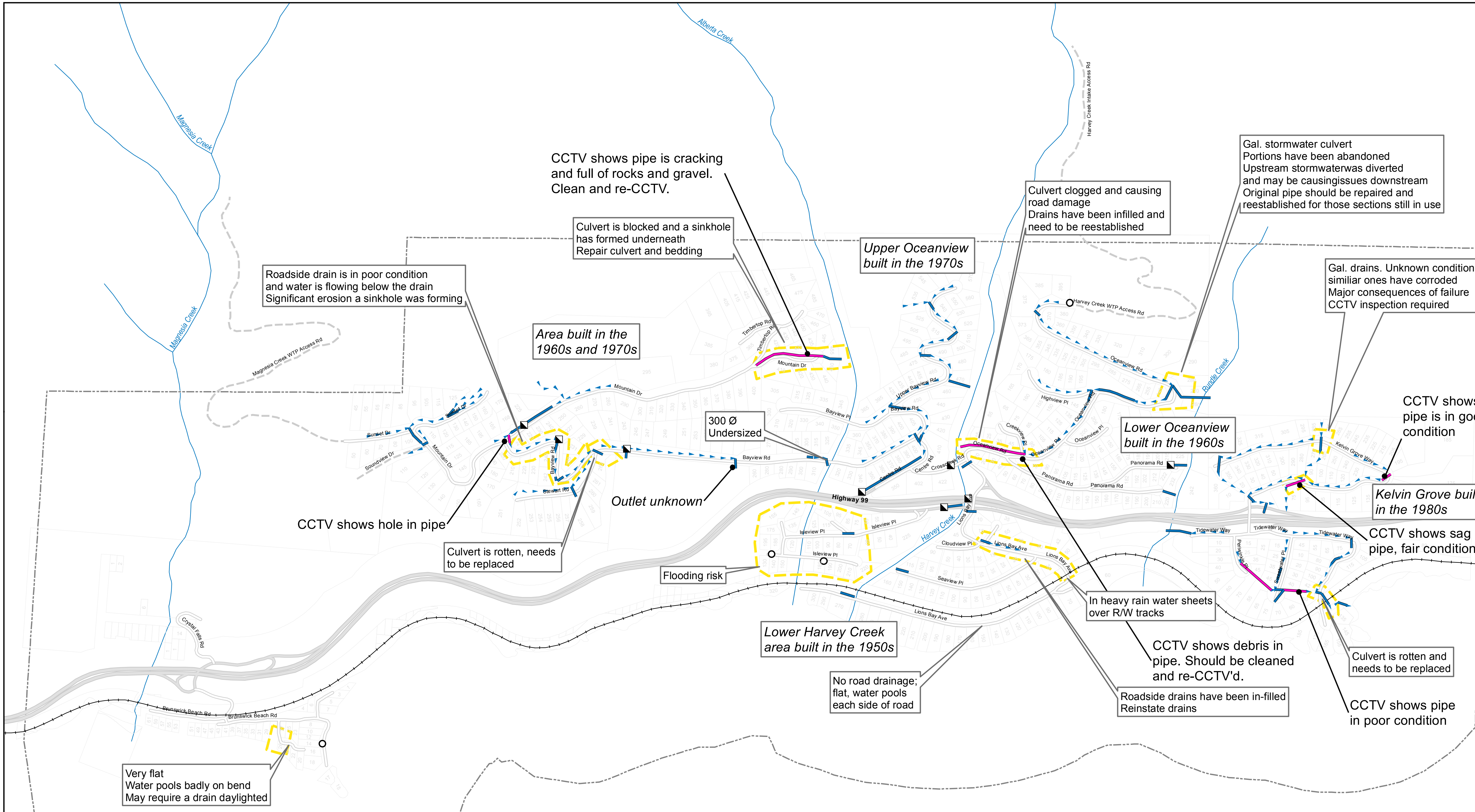
Figure 4-2: Photo of Corrugated Steel Pipe Culverts

Specific locations of concern are summarised in Table 4-2 and in Figure 4-3.

Table 4-2: Major Drainage Condition Issues

Priority	Location	Observation	Potential Resolution
Very High	Bayview Rd	Galvanised steel half-pipe drain has severely corroded and stormwater flows below the invert of the drain. This has caused significant erosion and presents a safety risk.	Remove and replace existing drain. Repair subgrade.
Very High	Oceanview Rd / Panorama Rd	Clogged culvert resulted in water discharging through the surface of the asphalt and causing significant pavement damage. Drains have been infilled.	Reinstate roadside drains. Remove and replace culvert.
Very High	Kelvin Grove Area	Culverts in Lower Kelvin Grove are in poor condition and need replacing. CCTV culverts in upper and Lower Kelvin Grove that have not yet been inspected. Failure of the culverts will have severe consequences due to the high flows, steep grade and proximity to houses.	Repair/replace culverts in poor condition. Perform CCTV Inspection of culverts that have not yet been inspected.
High	Oceanview Rd	A stormwater culvert that previously discharged to Rundle Creek was clogged, and the upstream flows were diverted down Oceanview Rd. They are now likely causing capacity issues downstream.	Original pipe should be repaired and re-established
High	Mountain Dr	Existing concrete pipe has deteriorated to the point that there is no bottom and a large sinkhole has formed.	Repair/replace culvert and bedding.
Medium	Lions Bay Ave	Roadside ditches have been infilled	Reinstate roadside ditches.
Medium	Brunswick Beach Rd	Very flat, low lying area consistently floods	Daylight drain.

Many of the problems highlighted above involve corrugated steel pipes. Corrugated steels pipes are relatively inexpensive and easier to install in comparison to concrete pipes. However, their shorter lifespan can lead to a higher overall life cycle cost. For this reason many municipalities such as the City of Surrey prohibit the installation of corrugated steel pipes.



Infrastructure Master Plan
Drainage
Figure 4-3 Drainage Condition

AECOM

Village of Lions Bay

4.3 Existing Infrastructure Capacity

As part of this Infrastructure Master Plan, it was originally planned to develop a computer model of Lions Bay's drainage system to assess system capacity. It became apparent that the Village did not have a comprehensive inventory of its drainage system. As a result many assumptions and guesswork would have been required to create a model while the results and outputs would have been questionable and unverified.

Due to Lions Bay's topography each roadway must be assessed individually to determine the required size for any ditch or culvert particularly in the design of any roadway rehabilitation project. It is recommended that the minimum size of any culvert at Lions Bay should be 250 mm in order to prevent clogging from roadside debris and gravel. However, most culverts will likely need to be larger than 250 mm to provide the necessary capacity for its catchment area.

The Village has completed a preliminary inventory and recorded the sizes of many of its culverts. The slope of the culvert is also required in order to determine the capacity. Surveying the ends of each culvert would be required to capture this information in order to determine if the capacity of each culvert is sufficient for its catchment area. It was noted by field staff that the 300 mm culvert on Bayview Road that drains to Alberta Creek is under capacity based on visual inspection. Preliminary calculations based on assumed pipe slopes also indicate that a 300 mm sized culvert is not sufficient for the catchment area.

We have reviewed what information is available of the existing drainage system and have noted the following deficiencies outlined below.

- All sections of roadways should be served with some form of drainage (ditches, catch basins, culverts etc.) to avoid high volumes of sheet flow that can damage roadways or risk flooding private properties. Roadways such as Bayview Place, Panorama Road, Lions Bay Avenue, Isleview Place, Cloudview Place, Oceanview Place and the south end of Oceanview Road are not currently serviced sufficiently with drainage infrastructure.
- Several culverts were found to be clogged with gravel, which limits the available capacity. The Village should have a preventative maintenance program which includes regular inspection and cleaning of culverts.
- Several sections of ditches within the road right-of-way have been encroached upon and are infilled.

Figure 4-4: Photos of Roadway Ditch

4.4 System Design Considerations

4.4.1 Climate

Generally the design of stormwater infrastructure is completed using trends from past rainfall data. The Village does not have its own rain gauge and corresponding Intensity-Duration-Frequency (IDF) curves that are typically used in the design of stormwater infrastructure. In the absence of this data the available information from the Greater Vancouver Sewerage and Drainage District's IDF curve for West Vancouver's Municipal Hall and Environment Canada's IDF curve for Squamish were reviewed. The curves are similar but do vary slightly. The West Vancouver curve shows higher rainfall for shorter durations (i.e. 1 hour or less) but the Squamish IDF curve shows higher rainfall for longer durations (i.e. > 1 hour). It is therefore recommended that the

Village of Lions Bay consider adopting both IDF curves, which are included in **Appendix C**, and conservatively use the higher value for a particular storm and duration in their designs.

Historically, most municipalities used the 5 year storm for the design of their minor system (pipes) and the 25 year storm for the design of their major system (overland flow). However, in recognition of climate change and the impact of flooding on residents, municipalities are increasingly using the 10 year storm for the design of their minor system. Therefore, it is recommended that the Village design the ditches and culverts in their minor system with capacity to safely convey the 10 year storm.

4.4.2 Hydrogeology

The Village of Lions Bay is primarily built on bedrock with thin overburden over the majority of the study area. This combined with steep slopes will result in a high proportion of the rainfall being converted to runoff and therefore high runoff coefficients. Localized fluvial deposits and alluvial fans are present in lowland areas where streams discharge to the ocean.

Bedrock is anticipated to exhibit a low porosity and hydraulic conductivity (permeability), with a low potential for infiltration of stormwater, especially during wet weather when bedrock is easily saturated. Alluvial fans and unconsolidated materials may have the capacity to accept some stormwater, but they are limited in area.

In addition, slopes are very steep and the area is prone to landslides. Any stormwater infiltration proposals should be carefully considered and evaluated by a geotechnical engineer.

4.4.3 Infiltration

In order to replicate the natural hydrological cycle, municipalities are increasingly using stormwater best management practices that encourage the detention and infiltration of stormwater into the ground. Not only does this help reduce the volume and rate of stormwater run-off but it also replenishes ground water which can provide base flows to streams and in some cases ground water supplies.

Due to the geology and topography within the Village of Lions Bay, opportunities for infiltrating stormwater are limited and may pose geotechnical concerns. However, there are still stormwater best management practices that can be used to slow down run-off, reduce its volume and even help improve its quality before reaching the receiving waters. Surficial vegetated features such as landscaped ditches and rain gardens can help decrease run-off velocities, reduce the volume through evapo-transpiration and improve water quality through biofiltration. Therefore we recommend that the Village maintain a vegetated ditch system rather than develop a curb and gutter based system and to avoid asphalting or culverting its ditches, except where necessary.

There are a number of advantages and disadvantages in considering a ditch based roadside drainage system versus a curb and gutter based system, as outlined below. Although we would recommend a vegetated ditch based system, it is ultimately for the Village to consider and decide.

	Advantages	Disadvantages
Vegetated ditch system	• Reduce the rate and volume of stormwater run-off. • Could potentially provide some water quality control through biofiltration. • Less expensive to construct. • Complements the natural look of Lions Bay.	• Requires regular maintenance – inspection and cleaning. • Run-off is less controlled (i.e. will potentially infiltrate underground and “pop” up somewhere else.
Curb and gutter	• Considered a tidier more urban look. • Run-off is more controlled (i.e. you know where it is going).	• Some may consider an urban look to be a disadvantage. • Greater impact on encroaching and adjacent properties. • Higher cost of construction • Higher run-off volumes and peak flows. • Requires regular maintenance – inspection and cleaning.

The vegetated ditch system could also be enhanced at periodic locations where grades and roadway easements allow into a more fulsome “rain garden”. Enhancements such as this would further control the flow, volume and quality of stormwater run-off and enhance the aesthetics of the public realm.

There are many examples of enhanced vegetated swales and rain gardens in similar mountain communities on hard soils on Burnaby Mountain, Whistler’s Athletes Village and in Coquitlam. A schematic of a system on Burnaby Mountain is shown below.

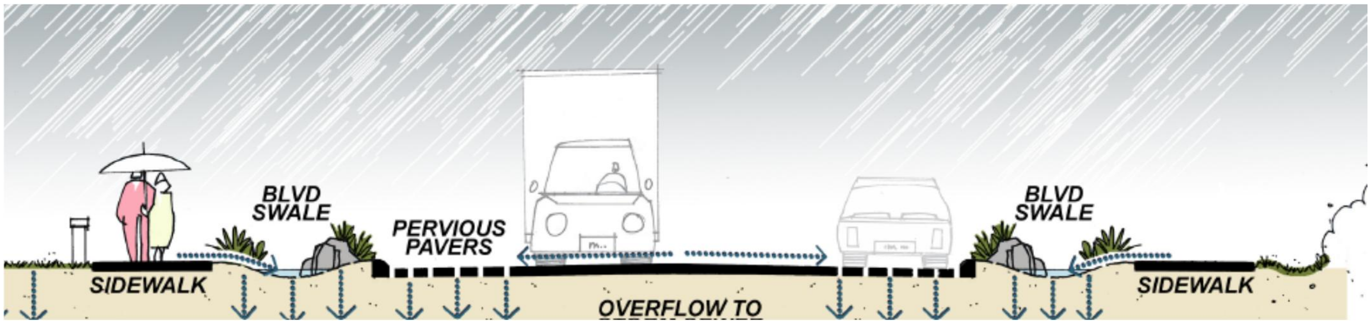


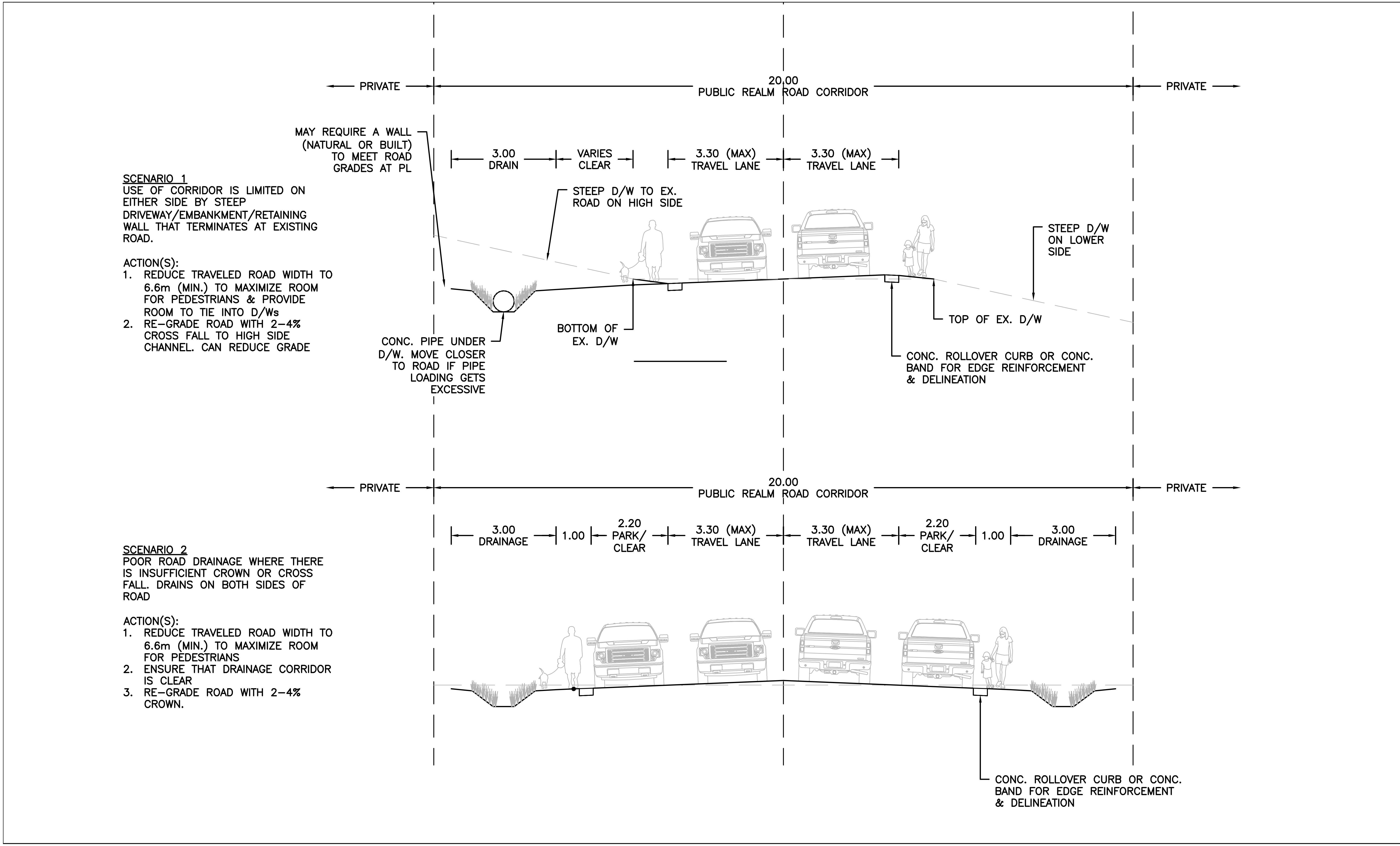
Figure 4-5 shows two alternative typical road sections that use vegetated ditches while seeking to resolve two common encroachment scenarios. Adoption of these typical sections (or similar) into a public corridor management policy may help the Village to manage roadside drainage in addition to improving pedestrian traffic and providing for other utilities in the corridor.

A perforated drain is not typically required for a well-constructed drainage and road system with sufficient road base and sufficient ditch and culvert capacity except for the following circumstances:

- There is not sufficient grade within the ditch to allow for adequate drainage. This would typically only occur along the lower Village Roads; and
- There is a ditch on the downhill side of the road with a potentially unstable slope below, where any infiltration into the soil needs to be avoided. As most ditches are on the uphill side of the road, this would be an exception.

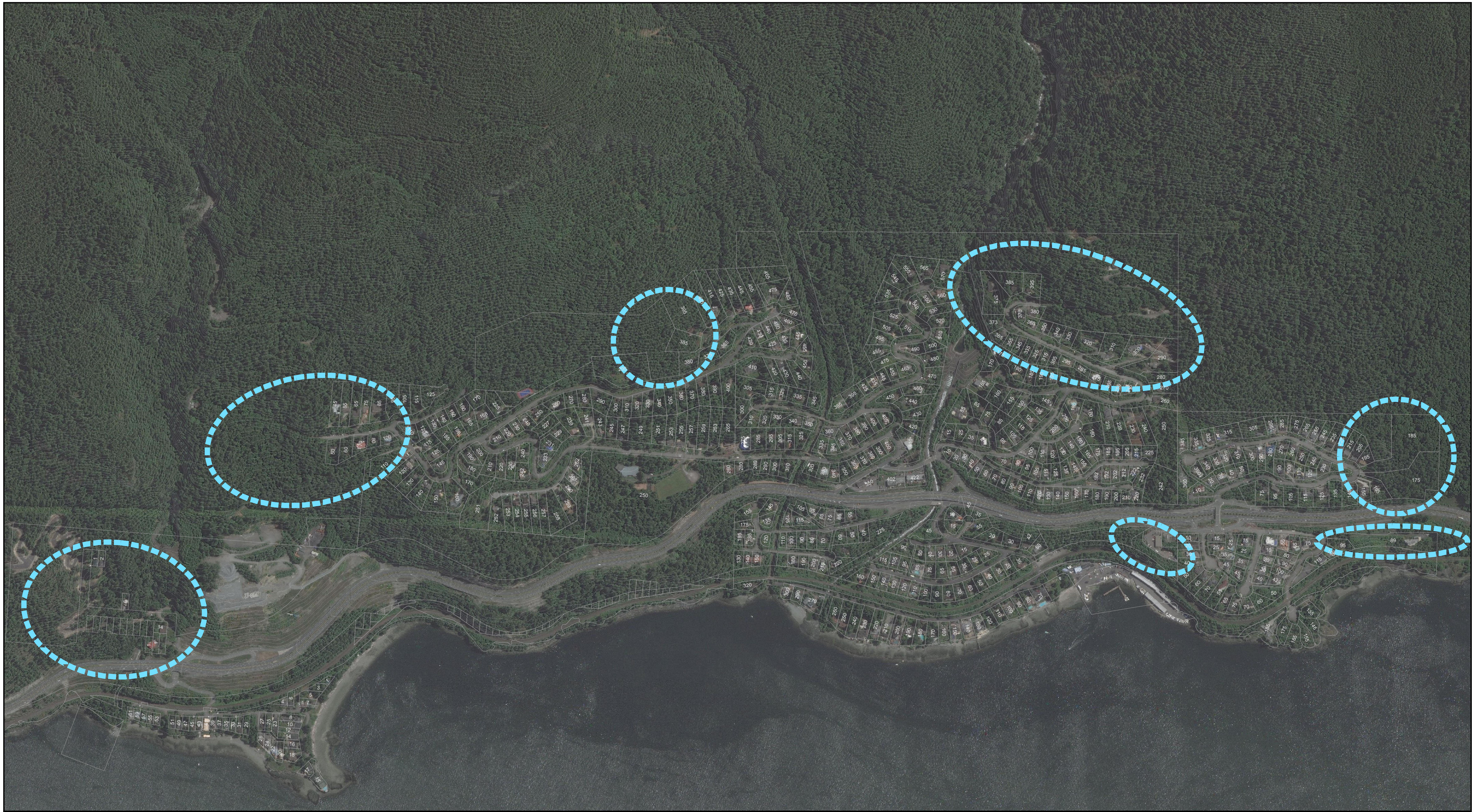
4.5 New Infrastructure

The Village has identified areas for possible expansion, which are shown in the 2014 draft of the Land Use Master Plan. If the Village proceeds with any of this proposed expansion, then it would need to build supporting infrastructure including drainage. Proposed new roadways and associated drainage infrastructure that would be needed to service the proposed expansion, if and when required, are shown in Figure 4-5 and Figure 4-6. If and when proposed expansion areas are confirmed and survey is completed, then the Village can complete the detailed design (e.g. culvert and ditch sizing).



VILLAGE OF LIONS BAY INFRASTRUCTURE MASTER PLAN
TYPICAL CROSS SECTIONS TO RECTIFY ROAD DRAINAGE ISSUES
FIGURE 4.5

AECOM



Infrastructure Master Plan

Drainage

Figure 4-6 Expanded Drainage Network to Service Potentially New Development

AECOM

Legend

Property Parcels

Potential New Development Location

Contours (5m)

0 50 100 200

Metres

Village of Lions Bay

4.6 Recommendations

One of the most significant issues facing the Village is roadside drainage management. At present it is very difficult for the Village to effectively manage runoff due to a number of factors such as:

- Significant private encroachment into the public realm limiting available space to deal with runoff;
- Ditch infilling throughout the Village;
- Culverts under driveways not being maintained and becoming clogged;
- Sections of roadway with little or no drainage infrastructure; and
- Aging infrastructure resulting in deteriorated culverts.

Therefore, it is recommended that the Village:

- Replace deteriorated culverts;
- Enact policies to restrict further private encroachment and commence reclaiming the public realm to assist with drainage management;
- Evaluate and implement required roadside drainage in conjunction with the rehabilitation of existing roadways (e.g. Oceanview Road and Bayview Place) and as encroachments are reclaimed;
- Install interim drainage on existing roadways that currently have insufficient drainage and no impending roadworks are planned (e.g. Lions Bay Ave and Cloudview Place);
- Construct proper roadside drainage with the construction of any new roadways associated with Village expansion;
- Educate residents about the importance of roadside ditches and culverts and the danger of unauthorised infilling of ditches and improper installation of culverts;
- Adopt a vegetated ditch based system for roadside drainage rather than a curb and gutter based system; and
- Limit the use of corrugated steel pipe for drainage culverts.

Drainage related capital projects are identified in **Section 7.1**

Recommended policies, such as dealing with encroachment, are identified in Table 7-3.

5

Roads & Bridges

5. Roads & Bridges

5.1 System Overview

The Village-road network is made up of approximately 11km of asphalt paved road and 8 bridges. There are effectively three sub-networks, Sea-to-Sky Highway, which is owned by BC Ministry of Transport and Infrastructure (MOTI).

A map of the Village road network and bridges is shown in Figure 5-1.

5.1.1 Challenges

The topography and steep slopes within and in proximity to the Village of Lions Bay have led to slope instability, soil creep, and roadway slippage. The downward movement of soil caused by the force of gravity discussed as roadway slippage by Village staff which should not be confused with the interaction of the roadway driving surface with either the underlying granular base or vehicular traffic based on friction which is also termed roadway slippage.

The review of the geology and geotechnical stability of the roadway system is outside the scope of this work. However, soil creep has a considerable impact on all aspects of the infrastructure systems in the Village as it can reduce the lifespan of buried pipe systems and roadway maintenance. Slope stability is influenced by a number of factors including the moisture content of the overburden soil with more saturated soils being more prone to movement. The performance of the buried pipe systems and the surficial drainage systems within the Village may influence soil creep. Exfiltration from buried pipes and infiltration of rainwater influence soil saturation. Furthermore, as soil creep increases the damage to the underlying infrastructure could lead to further exfiltration and result in an exponential deterioration of both systems.

The geotechnical stability of the two access roads to the Magnesia and Harvey Creek intakes was assessed in 2004 by Golder Associates. Since then, some remedial work has been done but not all of the recommendations in the report were implemented. The two recent landslides and fallen tree on the Harvey Creek access road demonstrate that further work is required.

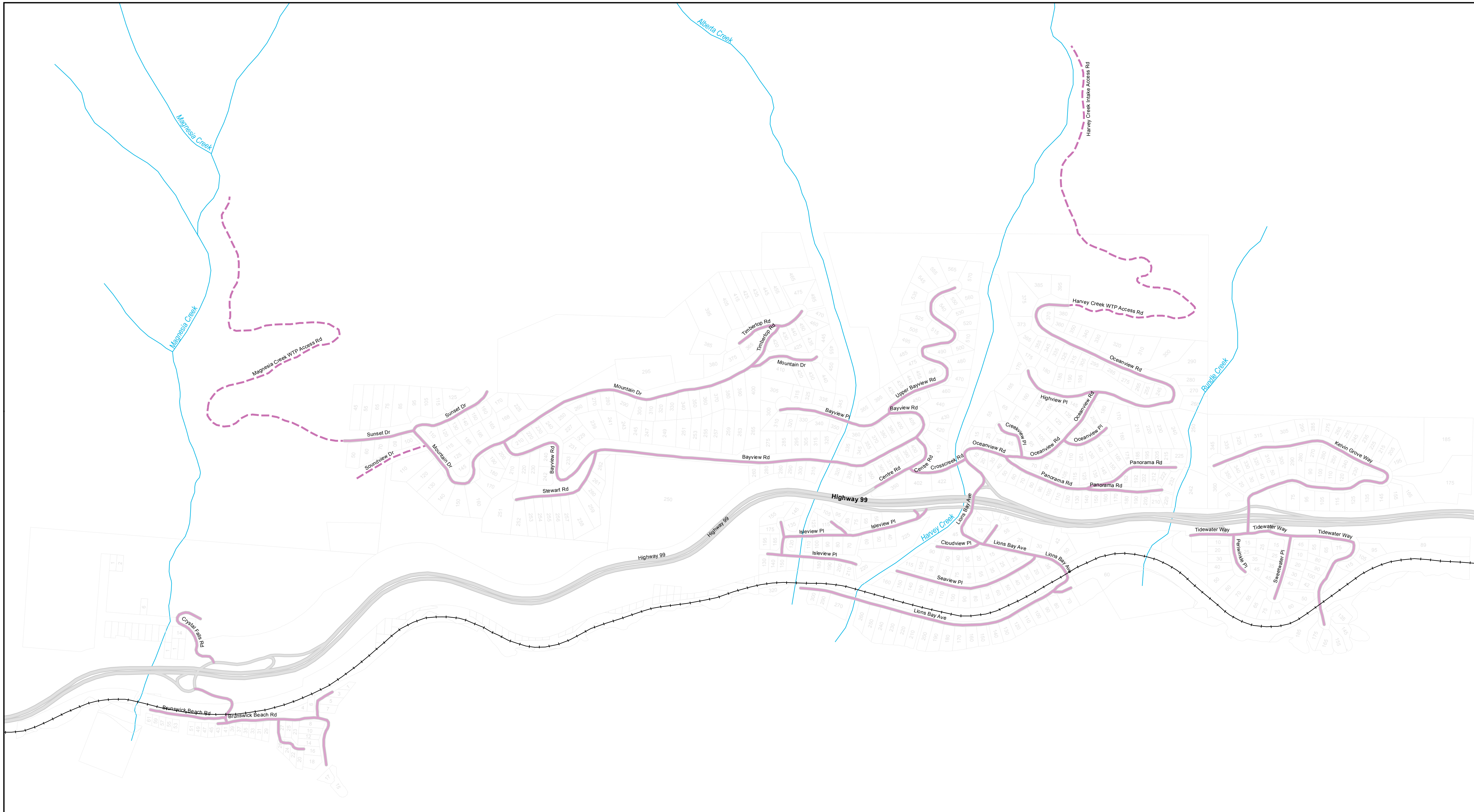
5.2 Replacement Value

The total replacement value of the Village road and bridge assets is estimated at $15.5 million. A breakdown of replacement costs are summarised in Table 5-1. Based on an estimated service life of 50 years, the Village should be spending approximately $310,000 annually on average on the renewal of its roads and bridges.

Table 5-1: Replacement Value of Road and Bridge Assets

Asset Item	Quantity	Unit	Rate ($)	Replacement Cost	Estimated Service Life	Annual Renewal Cost
11,000m of Asphalt Road (~7.5m wide average, full pavement depth) reconstruction	82,500	m^2	$110	$9,075,000	50 years	$181,500
Bridges	8	Each	$800,000	$6,400,000	50 years	$128,000
SUB-TOTAL (Roads and Bridges)				**$15,475,000**		**$309,500**

It should be noted that 50 years is the estimated overall service life for these assets (roads and bridges). Rehabilitation work or replacement of certain components (e.g. crack sealing or patching of asphalt, replacing of guardrails, vegetation control etc.) will typically need to occur before 50 years of service.



VILLAGE OF LIONS BAY
Infrastructure Master Plan
Figure 5-1 Road Network

AECOM

Legend

Property Parcels

Village Roads

- Sealed
- Unsealed

MOTI Roads

- On-Ramp
- Highway

0 50 100 200
Metres

Village of Lions Bay

5.3 Pavement Condition Assessment

5.3.1 Objective

The objective of the Pavement Condition Assessment was to inspect and assess the condition of the Village's road infrastructure, and use this information to develop a financial modelling tool. The condition assessment included the following tasks:

- Field inspection.
- Data processing and condition assessment.
- Identification of road priority.
- Consultation with operations staff to understand major issues.

The condition assessment was conducted in two phases. The first phase, which was conducted in September 2015, was a high level review of the condition of the roads to assist in the preliminary planning of capital projects. The second phase was a more detailed assessment of the road to determine a PCI (Pavement Condition Index) rating for each section of roadway and was conducted in April 2016.

5.3.2 Approach

The detailed pavement assessment was conducted using a specialised vehicle equipped with GPS spatial referencing, a 3D pavement surface profiling system and a 360^{o} LiDAR system. Consistent with *ASTM D6433 (Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys)*, 3D pavement surface distress data was collected and processed to generate ratings for each section of roadway according to severity and extent. Road distress types include:

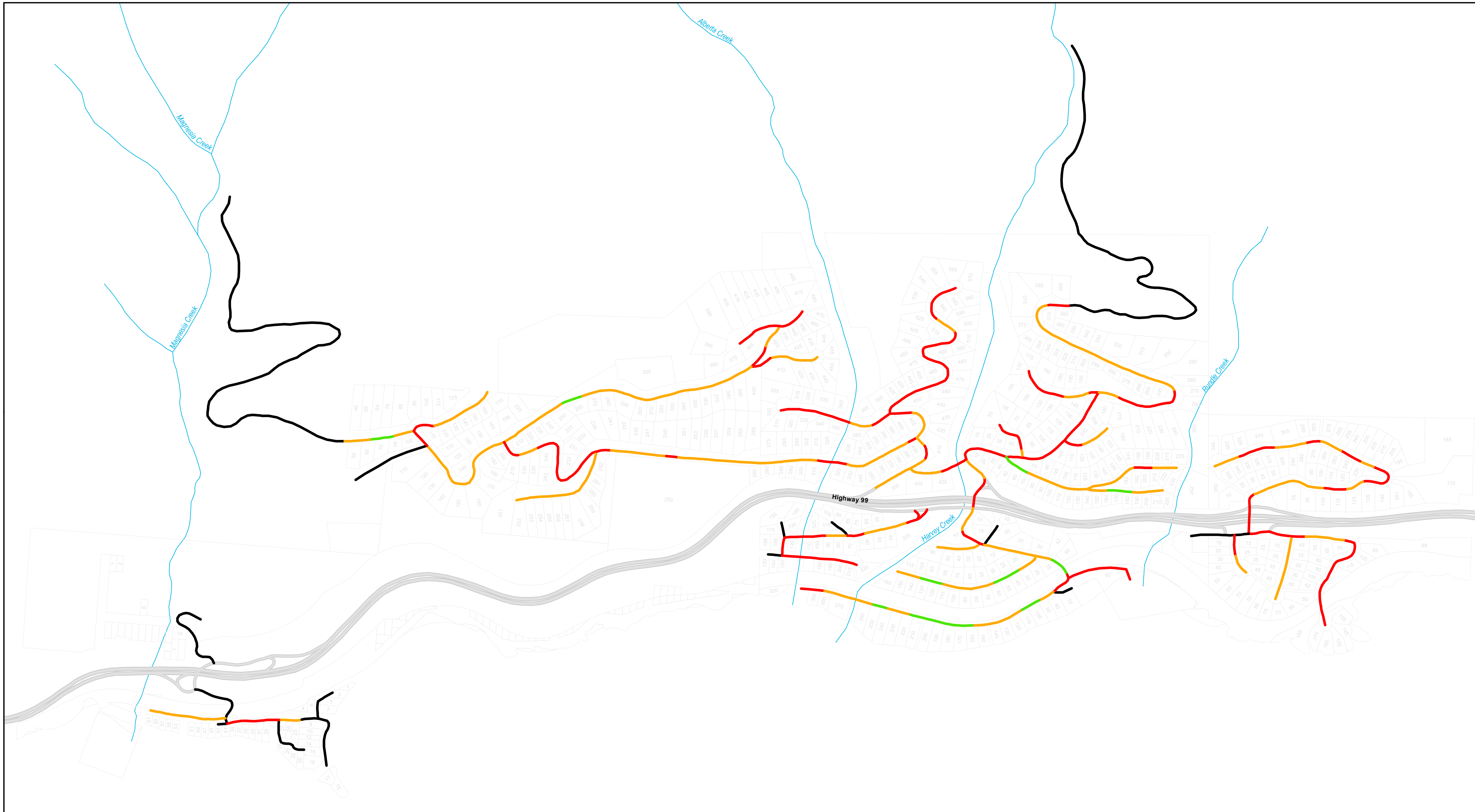
- Alligator cracking;
- Longitudinal cracking;
- Transverse cracking;
- Edge cracking;
- Block cracking;
- Rutting;
- Patching and utility cuts;
- Distortions (bleeding, rippling, shoving, depressions, corrugation, bumps and sags);
- Weathering;
- Ravelling; and
- Potholes.

Figure 5-2: Photo of Edge Cracking

Pavement roughness and rut data (IRI) was collected to provide a measure of rider comfort on all Village roads as shown below in Figure 5-3.

Survey speeds of 25 km/hr are required for IRI/rut measurements and can be difficult to maintain or achieve on local roadways due to lane width, control section length or traffic control signage. Surveys along narrow roads are typically along the centre of the road, adjusting as required to avoid oncoming traffic and parked vehicles on either side, creating a non-repeatable path. Therefore the data for these roads may not be comparable against historical or future IRI/rut data.

The IRI data collection and processing was conducted in conformance with the "Best Practice Guidelines" as described in the Transportation Association of Canada document *Standardization of IRI Data Collection and Reporting in Canada (October 2001).* Exceptions to these guidelines specific to this work include a minimum start-up length reduction to 50 m in recognition of urban roadway environments.



VILLAGE OF LIONS BAY
Infrastructure Master Plan
Figure 5-3 Pavement Condition Assessment - Rider Comfort (IRI)

AECOM

Legend
Highway
IRI Rating (m/km)
< 2.7
2.7 - 6.0
> 6.0
No Data

0 50 100 200
Metres

Village of Lions Bay

The following data was compiled within an Excel spreadsheet for section of roadways generally 50 metres in length:

- Segment location (from and to chainage);
- Lane width;
- Surface area or length of each distress type (see list above) of low, medium and high severity;
- Longitude and latitude;
- Elevation;
- Rider comfort as measured by IRI; and the
- Pavement Condition Index (PCI) according to ASTM D6433.

5.3.3 Findings

The findings of this pavement assessment are shown in Figure 5-4 which shows the condition of each section of roadway based on the pavement condition index (PCI). The ratings are categorised as:

- Very Good (PCI >80)
- Good (60<PCI<80)
- Moderate (40<PCI<60)
- Poor (20<PCI<40)
- Very Poor (PCI<20)

The areas of pavement in the worst condition were found on:

- Bayview Road;
- Upper Bayview Road;
- Oceanview Road; and
- Kelvin Grove Way.

Other roadways where some form of pavement rehabilitation is recommended along sections of the roadway include:

- Brunswick Beach Road;
- Bayview Place;
- Centre Road;
- Creekview Place;
- Crosscreek Road;
- Crystal Falls Road;
- Highview Place;
- Isleview Place;
- Lions Bay Avenue;
- Mountain Drive;
- Oceanview Place;
- Panorama Road;
- Periwinkle Place;
- Southview Place;
- Sunset Drive;
- Sweetwater Place;
- Tidewater Way; and
- Timbertop Road.

Recommended road rehabilitation work based on the condition assessment can be found in Figure 5-5. These recommendations were considered and prioritised with other infrastructure needs (i.e. water main and sewer works) in the development of the capital project list in **Section 7**. Where possible, works were coordinated to reduce overall infrastructure renewal costs.

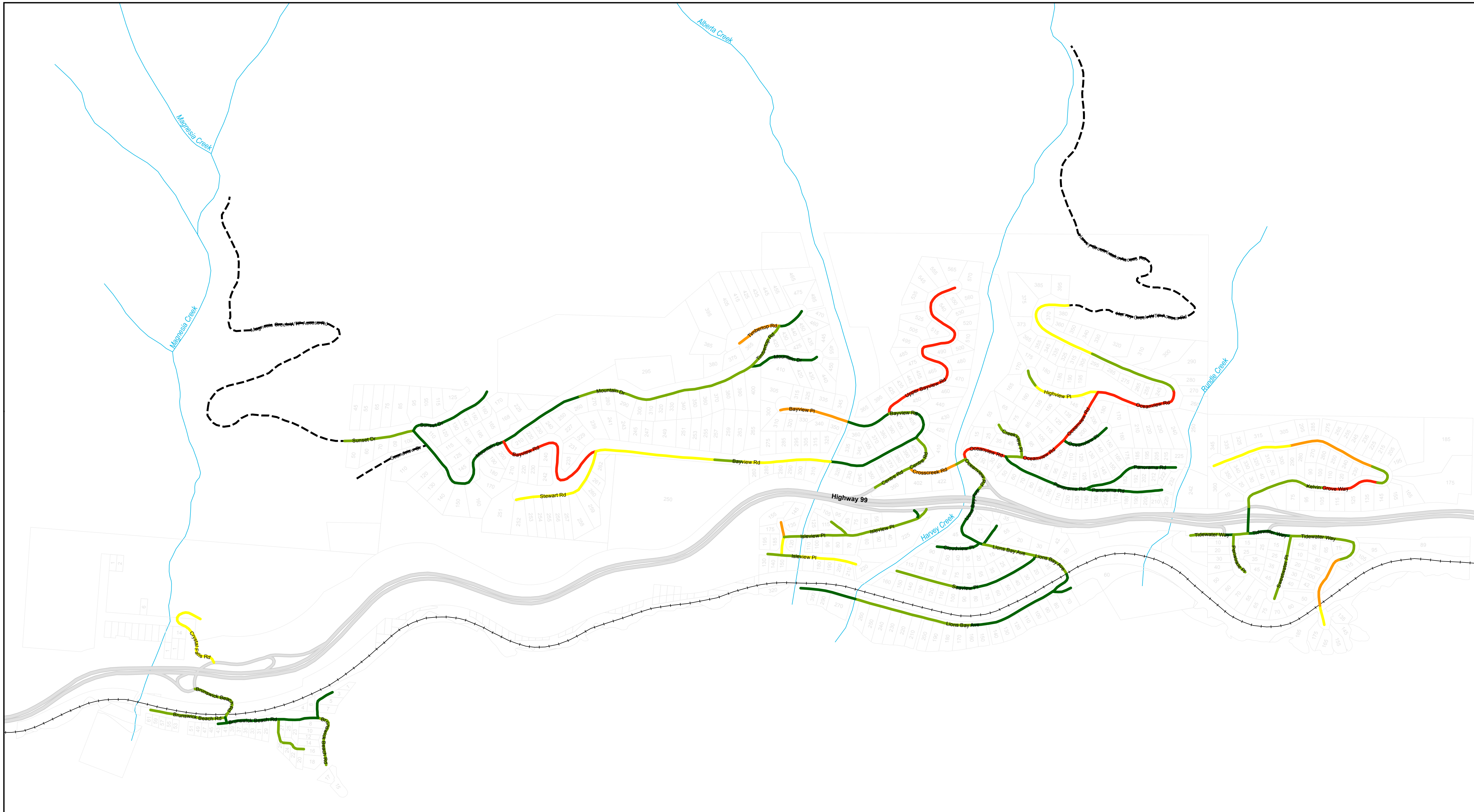
5.3.4 Road Priority Assessment

The unique layout and topography of the Village has resulted in a road network that has effectively no cross-connectivity or looping. This means that residents may be isolated if significant issues result in the closure of a road.

A basic road network analysis was performed to assess the accumulative number of properties that each road segment services. The results of the analysis are shown in Figure 5-6 . This information may be used to prioritise capital projects by selecting projects that mitigate risks to a road that services a larger number of residences.

5.3.5 Recommendations

It is recommended that the Village deliver the road related capital projects identified in **Section 7.1.** Road projects should typically be sequenced to coincide with utility works in order to avoid rework, and most of the road improvements identified in **Section 7.1** adopt this policy.



VILLAGE OF LIONS BAY
Infrastructure Master Plan
Figure 5-4 Tetra Tech Pavement Condition Assessment

AECOM

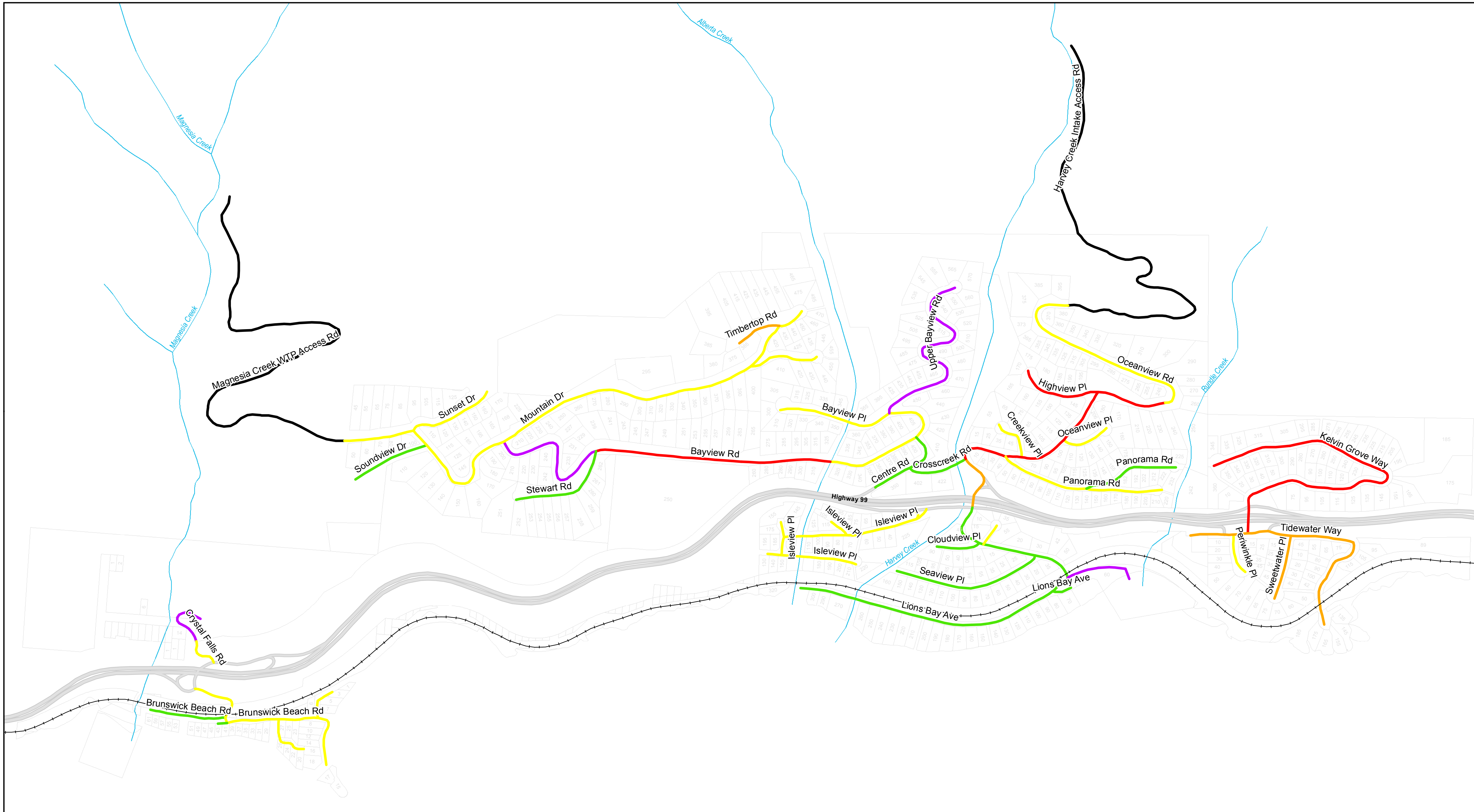
Legend

Tetra Tech Road Condition
- Very Good
- Good
- Moderate
- Poor
- Very Poor

Road Types
- Sealed
- Unsealed
- On-Ramp
- Highway
- Property Parcels

0 50 100 200
Metres

Village of Lions Bay



VILLAGE OF LIONS BAY
Infrastructure Master Plan
Figure 5-5 Recommended Road Treatments

AECOM

Legend
- Deep Patch/Maintenance
- Deep Patch
- Maintenance
- Reconstruction
- No Upgrades Recommended
- No Data Available

0 50 100 200
Metres

Village of Lions Bay

Infrastructure Master Plan
Roads
Figure 5-6 No. of Residential Properties Serviced

AECOM

Legend
Property Parcels
Rail
Village Roads
Sealed
Unsealed

0 50 100 200
Metres

Village of Lions Bay

5.4 Bridge Inspection

5.4.1 Scope

The scope of the bridge inspection component of the Infrastructure Master Plan was as follows:

- Perform a desktop review of the existing information relating to each of the eight (8) Village-owned bridges.
- Inspect and assess the condition of the bridges.
- Use clear and consistent nomenclature to identify each bridge, assess the extent of defects, and categorize the urgency of repairs and maintenance.
- Develop a cost estimate (in 2015 Canadian Dollars) to address immediate (<1yr), short-term (<5yr) and medium-term (<10yr) risks.

Only Village-owned bridges were included in the investigation (Figure 5-7).

Figure 5-7: Village Owned Bridges

5.4.2 Approach

Desktop Review

A desktop review of the Village's information was performed to develop an understanding of age, structural characteristics and inspection / repair history of the bridges. Information sources included anecdotal reports provided by Village operations staff, previous investigations, as-built drawings and previous photos.

Field Inspections

Field inspections of the Village's bridges were performed in late September 2015. The inspections were performed by Asnee Pochanart (Structural Engineer, AECOM) with support provided by Neil Harcus (Senior Structural Technologist, AECOM). The primary focus of the inspections was to identify issues with bridges that would likely need to be addressed in the next ten years.

Budgetary constraints meant that bridge inspections were limited to a visual inspection of the bridge components that were accessible without fall protection. The inspections did not include any form of destructive or non-destructive testing.

Field observations and potential issues were collected on an inspection form, along with photos documenting the inspections. In order to address the lack of as-built information, sketches were developed for each of the bridges. Copies of the inspection forms are included in **Appendix D**.

Repair Recommendation & Cost Estimating

Issues identified at each bridge were categorized into three priority classes: very high, high and medium. Repair or monitoring tasks were then identified for each issue, and cost estimates were developed for each task. Cost estimates were based on rates used in bridge construction or repair projects in Canada.

5.4.3 Findings

Desktop Review

The key findings of the desktop review were as follows:

- There is generally very limited information available about the Village-owned bridges. As-built drawings were only found for one of the bridges.
- The most recent previous inspection was performed in 2004 on Bridge 06 (Bayview Rd over Alberta Creek), a bridge that services a single residential property. The investigation found that the bridge had some significant issues and made several important recommendations for resolving the structural risks. It is understood that most of these recommendations were not implemented. The inspection performed in 2004 was more detailed than the visual inspection performed as part of the IMP, and as such, most of the recommendations identified from the 2004 investigation have carried forward into the recommendations below.

Field Inspections & Recommended Repairs

Detailed findings of the field inspections and recommended repair costs and monitoring tasks are included in **Appendix D**. Table 5-2 summarises the investment recommended to repair issues with the Village-owned bridges. All cost estimates are in 2015 CAD.

Table 5-2: Recommended Bridge Investment

Bridge	Very High Priority (<1yr)	B. High Priority (<5yr)	C. Medium Priority (<10yr)	Total
1. Lions Bay Avenue over Harvey Creek		$5,500		$5,500
2. Isleview Place over Alberta Creek (Lower Bridge)	$1,500	$4,500	$3,000	$9,000
3. Isleview Place over Alberta Creek (Upper Bridge)	$1,500	$6,000	$4,500	$12,000
4. Cross Creek Road over Harvey Creek	$3,000	$2,500	$6,000	$11,500
5. Bayview Road over Alberta Creek	$1,500	$9,000	$3,000	$13,500
6. Bayview Road (Private Driveway) over Alberta Creek	$4,500	$68,000	$62,000	$134,500
7. Bayview Place over Alberta Creek	$2,000	$3,000	$3,000	$8,000
8. Lions Bay Avenue over Alberta Creek (Private driveway end of Lions Bay Avenue)	$300	$1,000	$8,000	$9,300
Grand Total	**$14,300**	**$99,500**	**$89,500**	**$203,300**

General Recommendations

Bridge 06 (Bayview Rd over Alberta Creek) is owned by the Village but only services a single residential property. Some significant structural issues were identified in the previous inspection performed in 2004, the most notable relating to timber bearing beams. These beams have not yet been replaced. Whilst the likelihood of failure is reduced by low volumes of traffic, the potential consequence of failure remains high. Until this beam is replaced, it is recommended that a sign be installed that restricts heavy vehicles from using the bridge.

It is recommended that a long term plan for alternative access for this property be considered by the Village, as it is possible that this bridge becomes a significant financial burden for the Village in the long-term. This is exasperated by the potential for broad community objection to committing significant funds to providing access to a single property.

6

Funding Infrastructure

6. Funding Infrastructure

6.1 Asset Management

Good asset management planning seeks to capitalize on two means of cost savings: preventative maintenance and effective asset renewal planning. This will result in the optimization of lifecycle costs for individual assets as depicted in Figure 6-1 by lowering overall renewal costs and extending the life of a given asset.

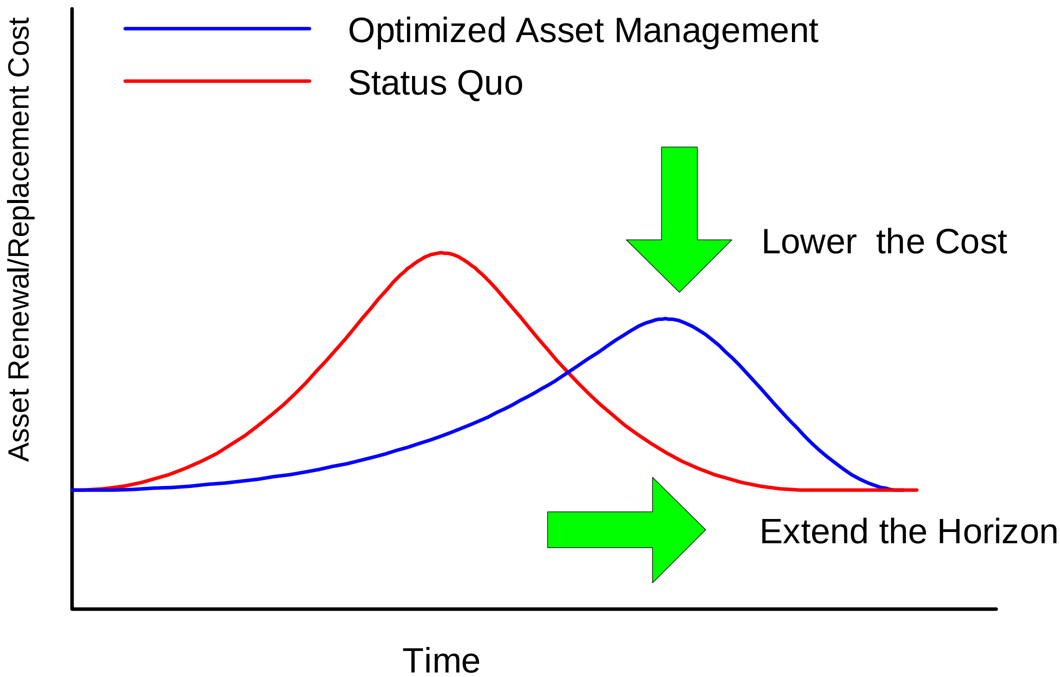


Figure 6-1: Means of Achieving Savings through Asset Management

By continuing with its preventative maintenance program, the Village can attain, and hopefully extend, the expected service life of its infrastructure, and will benefit accordingly. Preventative maintenance activities include regular inspections, testing of equipment (i.e. valve exercising) and regular cleaning (e.g. watermain flushing, removing gravel from sewers, cleaning moss from reservoirs etc.). In addition, the Village needs to support its corrective maintenance program. For instance, crack sealing will slow down the deterioration of road pavement or a concrete reservoir and extend its service life. We recommend that the Village periodically review its preventative maintenance program to ensure that it is gaining maximum benefit from it and to ensure that funding and staff resources are in place to address corrective maintenance needs in a timely manner.

A risk based approach will allow the Village to determine the most cost-effective strategy for maintaining an asset based on the consequences of failure. By identifying the most cost effective renewal and/or replacement strategy for each asset and by integrating capital works of different utilities (water, sewer, road etc.) whenever possible, the Village will optimise its capital renewal budgets. Together this will have the benefit of lowering the actual cost of the renewal program. The capital renewal projects recommended in this IMP have been developed with this in mind.

This study has adhered to present day best practices for performing strategic level asset management. A “needs-based” approach has been taken that gives consideration to our current knowledge of asset life spans, and current replacement costs. Consideration has not been given to factors that might either accelerate renewal efforts (e.g. additional financing, resource levelling), or decelerate renewal efforts (e.g. short term affordability). These additional factors will remain for continued public debate, and provide input into the annual budgeting process. Ultimately, a “budget-based” approach to asset management will govern the extent to which the Village of Lions Bay will manage assets in a sustainable fashion over the short and long term.

6.2 Sustainable Funding Levels

The approximate replacement value of the Village's water, sanitary, drainage and road/bridge infrastructure was estimated at $49 million. The asset valuation was performed using current construction costs, but should be considered indicative only. Based on the estimated services lives of different asset types, the Village should be spending approximately $945,000 per year, on average, on the renewal of its infrastructure. Figure 6-2 below shows sustainable funding levels over the next 15 years and projected funding levels based on recommended projects as outlined in **Section 7**. For illustrative purposes the unscheduled projects have been projected over the time frame 2021-2030 (i.e. 10 years). Note that there remains a gap between the recommended projects and the sustainable funding level and therefore projects will need to be reviewed in accordance with their priority and requirement to maintain the current level of service.

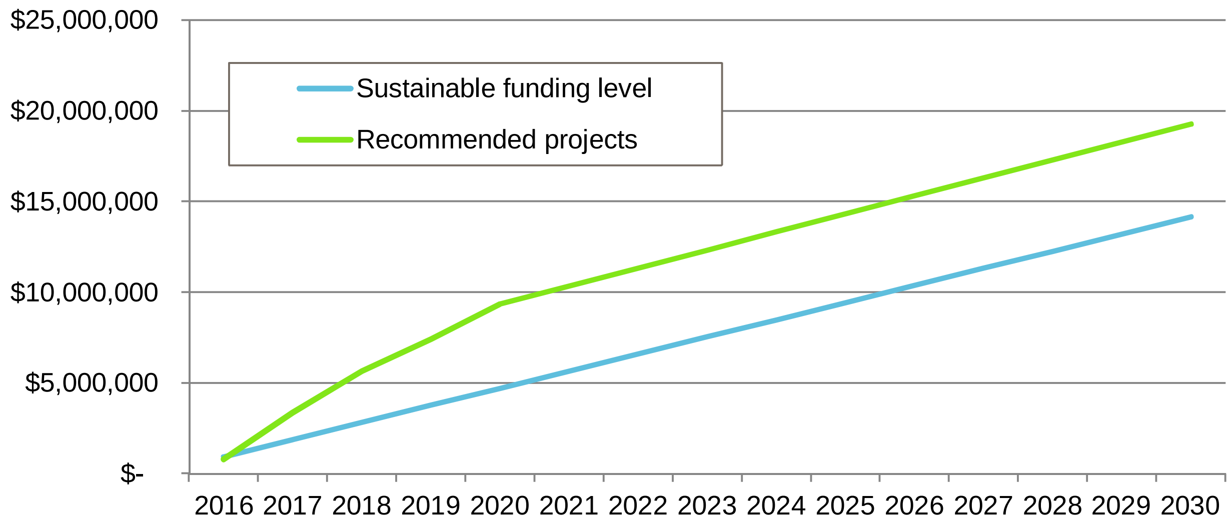


Figure 6-2: Cumulative Costs of Recommended Projects versus Sustainable Funding Levels

The funding of large infrastructure projects is particularly challenging for a small community. The Village has a capital reserve fund that it can use to collect renewal funding each year and then spread costs out over multiple years. This can provide a reliable, predictable and dedicated source of funding and could potentially be supplemented through available grants and loans. However, managing a long-term fund over several Council terms can be challenging, as different Councils may have different project priorities.

6.3 Sources of Funding

There are a number of grants and loan programs available to municipalities. The programs that would be most relevant to the Village of Lions Bay are outlined below.

New Building Canada Fund - Small Communities Fund

Under the NBCF-SCF program, the provincial and the federal governments will each allocate approximately $109 million to support infrastructure projects in communities with a population of less than 100,000 people. This 10 year funding program runs from 2014 to 2024. Relevant eligible projects include drinking water initiatives, highways and major roads, and disaster mitigation infrastructure.

Federation of Canadian Municipalities (FCM)

Green Municipal Fund (GMF)
This GMF targets projects focussed on sustainability. The GMF will provide funding for water projects that aim to reduce end-use water consumption. The Village's proposed metering program may be eligible for this funding. This fund has also recently been expanded to address climate change. It is possible that Lions Bays' studies to estimate the future yield of Magnesia and Harvey Creeks under climate change or to relocate its water intakes could be considered projects to mitigate the impacts of climate change.

Asset Management Capacity Building Program
A new $50 million investment from the federal government will help build the capacity of Canadian municipalities to manage their infrastructure development more strategically. The Village's proposed efforts towards digitising drawings, developing their GIS, and conducting assessments of their infrastructure may be eligible for this funding.

Ministry of Community, Sport & Cultural Development

The Ministry of Community, Sport & Cultural Development manages a number of grants and loan programs for local governments. A summary of the relevant programs is provided below and more details about these programs can be found at the following web-site:
http://www.cscd.gov.bc.ca/lgd/policy_research/local_government_grants.htm

Small Community Grant
The Small community Grant is an unconditional grant for municipalities to assist them in providing basic services. Grant amounts are based on a formula that factors in a base amount, population and assessment values. These grants generally apply to municipalities with populations up to 19,000.

B.C. Community Water Improvement Program
Drinking water and wastewater management were eligible projects under the BCCWIP Program Guide (2005) The Province provided up to two-thirds of the costs of a local government's eligible project. Considerations were given to increasing the amount to 75 percent of the project cost in small communities for high priority projects.

Infrastructure Planning Grant Program
The Infrastructure Planning Grant Program offers grants to support local government in projects related to the development of sustainable community infrastructure. Grants up to $10,000 are available to help improve or develop long-term comprehensive plans that include, but are not limited to: capital asset management plans, community energy plans, integrated stormwater management plans, water master plans and liquid waste management plans. Grants can be used for a range of activities related to assessing the technical, environmental and/or economic feasibility of municipal infrastructure projects.

MFABC (Municipal Finance Authority of BC)

MFABC provides short term borrowing under various pieces of legislation (see below) to help local government with cash flow needs. It allows its members access to lost cost funding and flexibility to borrow and repay on short term notice. More information can be found at the following web-site: http://mfa.bc.ca/clients/short-term-borrowing

Short term capital borrowing – CC Sec. 178 – a Council may, by bylaw, adopted with the approval of the inspector (statutory approval), contract a debt for any purpose of a capital nature. The aggregate, maximum amount allowed under this authority is calculated under BC Reg. 368/2003. The regulation states that the amount is obtained by multiplying $50 by the population of the municipality. The population is as of the last census and will be verified by the Ministry. The debt must be repaid 5 years from the date the money is advanced. No public approval is required but approval of the Inspector of Municipalities is required. The debt servicing under this bylaw must be deducted from the municipality's liability servicing limit.

7 Recommended Projects

7. Recommended Projects

7.1 Capital Projects

All potential capital projects that have been scoped, costed, prioritized and scheduled based on the investigation components of this IMP are listed in Table 7.2. The list of capital projects are shown two ways; the first is a table complete with a description and cost estimate of each project, the second is a Gantt Chart t to show the timing of the proposed projects. Maps of the proposed project locations are included below.

Each project record contains the following information:

- Project No: this is a unique identifying number for that project
- Schedule: recommended start year
- Priority: a ranking to identify which projects are most important in the short term
- Predecessor(s): project number of any projects that need to be delivered prior to this project
- Project Name: one or two sentence description of the project scope
- Capital Cost: very high level capital cost estimate for the project. Cost does not include any precedent or dependent projects.
- Drivers / Descriptions: details of the investigation, findings and risks that resulted in identification of the project, and additional information regarding the project scope.

The types of projects identified included:

- Large and small capital works projects such as replacements, rehabilitations and installation of new infrastructure
- Additional investigations
- Survey and Engineering tasks prior to construction work
- Implementation of maintenance programs
- Improvement of internal systems and processes

Projects were packaged, prioritized and scheduled based on a number of factors:

- Coinciding works in areas to overall reduce overall design and construction costs (e.g. address pavement issues and utility issues in a single project)
- Addressing “Very High” and “High” priority projects first
- Focussing on critical assets (i.e. where the consequences of failure are high)
- Feedback provided by Infrastructure Committee and Public Works operations staff

Figure 7-1:below shows the recommended expenditure over the next four years up to 2020.

Before detailed design of any infrastructure works the Village should review the possible expansion areas (land use and development opportunities) as identified in the Village of Lions Bay Draft Land Use Master Plan. If new development or infill is likely, then the new infrastructure should be designed accordingly both in terms of capacity and configuration.

It should be noted that the ability to complete the recommended project list depends not only on available budgets but also on available capacity of Village staff to manage the projects.

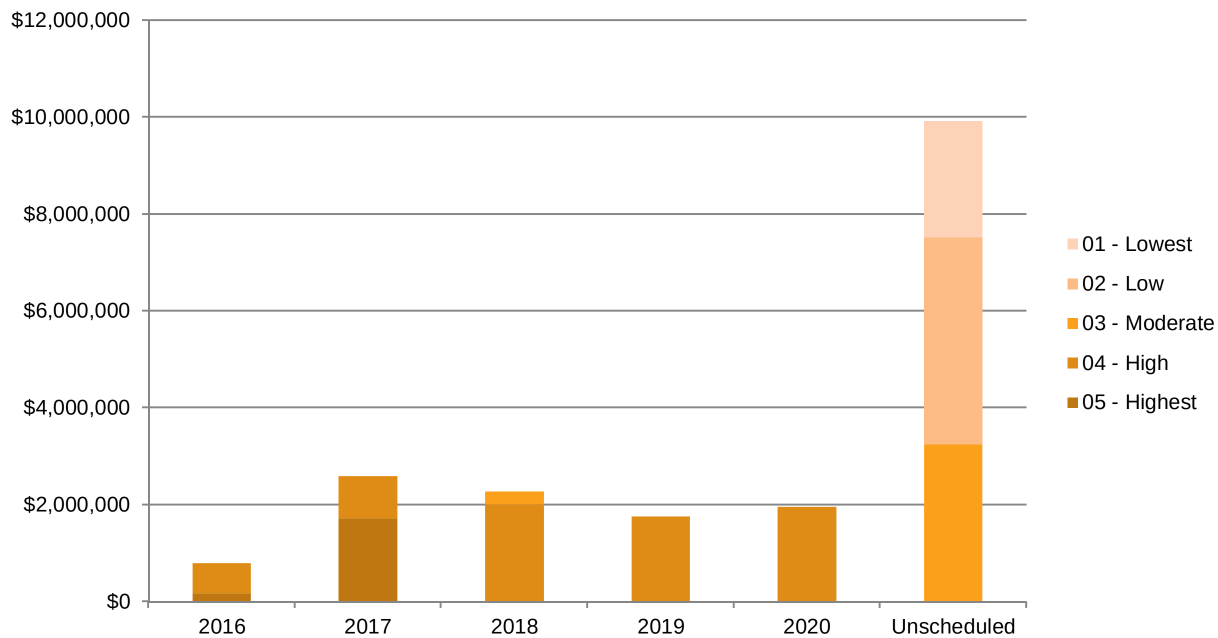


Figure 7-1: Scheduled Capital Project Estimates

A summary of the total project costs is included in the table below. The timing of the projects and associated budgets respond to the criticality of each renewal project (i.e. how soon should it be done) and to approximate sustainable funding levels (see Figure 6-2). If the Village is unable to secure funding at a sustainable funding rate then it needs to look at prioritising and delaying projects, or conducting some projects in phases.

Table 7-1: Summary of Capital Project Cost Estimates and Priority

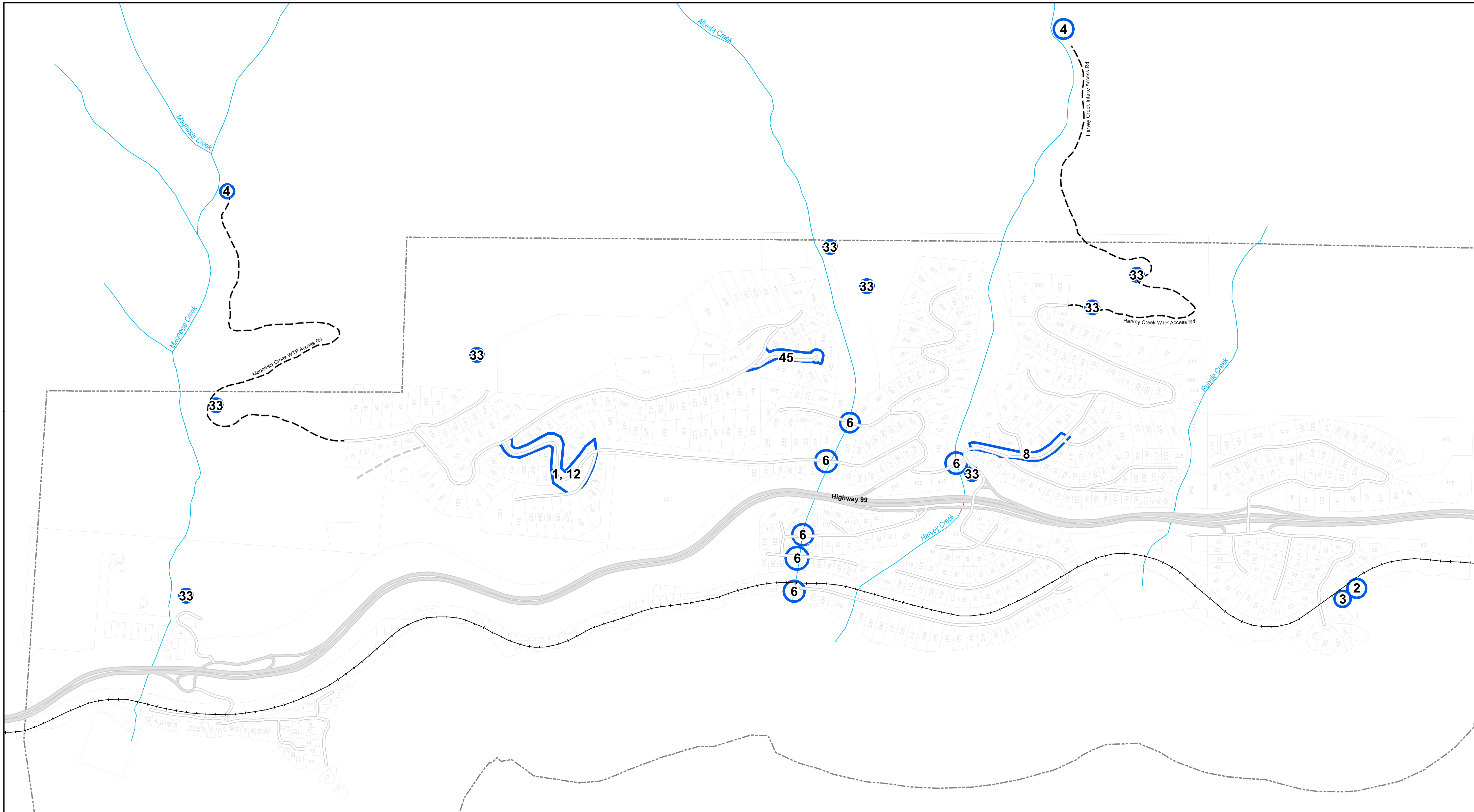
Schedule	05 - Highest	04 - High	03 - Moderate	02 - Low	01 - Lowest	Grand Total
2016	$177,300	$615,400				$792,700
2017	$1,725,000	$868,750				$2,593,750
2018		$2,005,000	$272,700			$2,277,700
2019		$1,753,500				$1,753,500
2020		$1,952,200				$1,952,200
Unscheduled			$3,248,500	$4,276,550	$2,395,800	$9,920,850
Grand Total	**$1,902,300**	**$7,194,850**	**$3,521,200**	**$4,276,550**	**$2,395,800**	**$19,290,700**

Table 7.2: Capital Projects List

Project No	Schedule	Priority	Predecessor(s)	Project Name	Capital Cost	Drivers / Description	Water	Sanitary	Drainage	Roads & Bridges	General
01	2016	05 - Highest		Survey & Design of 280m Galvanized Drain Replacement & Road Repair on Bayview Rd	$24,000	Existing drain is severely corroded, with water eroding sub-grade below. Has started causing sinkholes. Presents significant safety risk. Adjacent road is poor condition. Concurrent replacement opportunity.					
02	2016	05 - Highest		CCTV, Alignment Confirmation and Condition Assessment of Kelvin Grove Beach Park culvert.	$1,000	Require CCTV of culvert under toilet block at Kelvin Grove Beach Park.					
03	2016	05 - Highest		WWTP Safety and Monitoring Improvements	$25,000	Condition assessment and operations staff consultation identified following critical issues: no fall restraint in WWTP, rotten wooden access bridge, V-notch weir displaced.					
04	2016	04 - High		Purchase of UAV for Water Intake Inspection.	$4,000	Current operating procedure for water intakes restricts access after significant rainfall, but ops staff require method of inspection. UAV identified as low-cost, safe option.					
05	2016	04 - High		Digitize, organize and backup all hard copy engineering drawings.	$1,000	A significant volume of Village infrastructure information is missing, and a large proportion remains in paper format. Many of these plans are deteriorating and the information will be lost if they are not digitized ASAP.					
06	2016	05 - Highest		General Bridge Repairs (Very High Priority)	$14,300	Findings of bridge condition assessment performed in late 2015. Very High Priority items only, includes 7/8 bridges.					
07	2016	04 - High		SCADA Control Strategy Study	$60,000	SCADA links can often go down in poor weather. Previous designers identified that cellular technology and coverage has improved since project was implemented. May be a way to add redundancy and reliability to system. The Villages existing SCADA system is limited in its scope and does not provide operational efficiencies associated with modern systems. Obsolete components and technology results in increased replacement costs and labour intensive down time. Staff propose commissioning a SCADA Control Strategy Study to determine the most efficient and cost effective technology moving forward.					
08	2016	05 - Highest		Survey & Design of Stormwater, Road, Water (Hydrant) work on Oceanview Rd.	$38,000	Culvert blocked in 2015 and caused significant road damage. Road in general vicinity is in poor condition. Hydrant is in very poor condition.					
11	2016	04 - High		Site Investigation and Design for Zone / Branch Water Metering	$2,500	Village water network is currently unmetered, and there is limited information on the water consumption / leakage. Residential metering is long-term objective, however zone metering is likely to provide more immediate benefits in terms of tracking flows, identifying issues and exhibiting a long-term commitment to water conservation.					
33	2016	04 - High		Reservoir rehabilitation and inspection	$150,900	Reservoirs were inspected in 2004 but only the most urgent rehab work was completed. Re-inspect reservoirs, determine seismic vulnerability, and complete high priority rehabilitation work (except for Harvey 400,000 which will be replaced in 2017).					
43	2016	05 - Highest		Strategic water supply study	$75,000	Study to determine the long-term viability of Magnesia and Harvey Creek as sustainable water supply sources into the future with the impacts of climate change.					
45	2016	04 - High		Survey, CCTV and Design to replace deteriorated concrete culvert on Mountain Dr	$33,000	Invert of existing concrete pipe is completely deteriorated and a large sinkhole has formed					
12	2016	04 - High	1	Construction Galvanized Drain Replacement & Road Repair on Bayview Rd (280m)	$364,000	Refer to Project 01					
58	2017	04 - High		PRV Station Replacements	$450,000	Retrofit and upgrade of existing PRVs 1, 2, 8, 9, 10, and 11 including WorkSafe BC compliance and SCADA automation					
10	2017	05 - Highest		Commence Survey of 70 Parcels with Lost Water Connections and potential encroachments and confirm property lines	$105,000	Seventy (70) Parcels have missing water connections that need to be located and surveyed. The Village cadastral information also requires update and realignment. Reclamation of public realm from private encroachment has been identified as crucial factor in managing drainage and utilities over the long-term, and this is an important input.					
13	2017	04 - High	8	Construction of Stormwater, Road, Water (Hydrant) work on Oceanview Rd (200m)	$241,250	Refer to Project 08.					
19	2017	04 - High		Survey and Engineering Design of Upper Bayview Road - road, drainage and water main.	$57,500	The pavement of Upper Bayview Rd is in very poor condition, with large sections likely requiring full pavement repair. The roadside drainage is disconnected, and water typically sheets down roadway. In many locations, roadside drains have been filled in. The road corridor should be surveyed (to establish PLs, driveways, structures) and a holistic engineering design should be prepared. Engineering design should include cost estimating and scoping of construction phases. Should replace old AC/CI water main within the roadway congruently as the Village has already experienced one break.					
44	2017	04 - High	43	Flow monitor stream flows, if recommended by stream study in 2016	$72,000	Install two monitoring stations and collect data for two years to monitor stream flow in Harvey and Magnesia Creek					
46	2017	04 - High	45	Construction to replace deteriorated concrete culvert on Mountain Dr and permanent repair of road	$48,000	Existing concrete pipe has deteriorated to the point that there is no bottom and a large sinkhole has formed. Assume it requires replacement of 40 meters of pipe, extent of required replacement to be confirmed with CCTV.					
51	2017	05 - Highest		Remove danger trees at Alberta Creek water main bridge and inspect 2 water main bridge crossings.	$20,000	Remove danger trees to reduce risk of damage to Alberta Creek water main bridge. Inspect the water main bridge crossings at Alberta and Harvey Creek.					
56	2017	05 - Highest		Design and Construction to replace Harvey Creek 400,000 gallon water reservoir.	$1,600,000	The Harvey Creek water reservoir was constructed in 1980 using concrete panels that incorporated horizontal pre-stressed strands. A 2004 inspection of the plant revealed extensive leakage between the panel joints an indicated potential corrosion of the pre-stressed strands. An attempt to fix the leaks by coating the interior of the tank failed and further remediation has not been attempted. The existing tank does not meet seismic standards.					
20	2018	04 - High	19	Construction of Road Repairs, Water main and Drainage Works along Upper Bayview Rd	$956,250	See Project 19. Staging will be dependent on budget and phasing identified in design component.					
36	2018	04 - High		Survey and Engineering Design of Water main Upsize	$58,750	Mains Identified in GA Hydraulic as not meeting fire flow. Listed by GA as Very High priority. Survey and Engineering Design of Water main Upsize (x2) from Highway Tank, under Highway 1 on Oceanview Road, onto Lions Bay Ave (Upgrade 1 GA Report) (273m), and From PRV 3, under Highway 1 on Oceanview Road, up Isleview Place (Upgrade 2) (630m)					
47	2018	03 - Moderate		Survey, design and construction to replace culvert in poor condition at the bottom of Tidewater Way as well as culvert from Sweetwater Place to Tidewater Way. Confirm with CCTV if the railway crossing needs to be replaced as well. Crack seal and patch poor sections uphill of the culvert replacement.	$272,700	VoLB staff reported that the culvert is severely deteriorated. Assume it requires replacement of 150 meters of pipe, including a railway crossing. Extent of required replacement to be confirmed with CCTV. Pavement on Tidewater is in poor-moderate condition. Repave full width of roadway where culvert is replaced. Crack seal and patch poor sections of roadway uphill of the culvert replacement.					

Project No	Schedule	Priority	Predecessor(s)	Project Name	Capital Cost	Drivers / Description	Water	Sanitary	Drainage	Roads & Bridges	General
49	2018	04 - High		Design for a new Harvey Creek raw water intake structure	$90,000	VoLB staff report that the intake is in poor condition and was constructed in the 1980's.					
57	2018	04 - High		PRV Station Replacements	$900,000	Full replacement to improve performance of PRVs 3, 4, 5, 6, 7, and Bayview including WorkSafe BC compliance and SCADA automation					
16	2019	04 - High		Survey, Design and Construction of Water Main Replacement on Creekview Pl (90m)	$126,250	150 CI water main on Creekview Pl is in very poor condition and requires replacement. High incidence of leaks.					
18	2019	04 - High		Survey, Engineering Design and Construction of Water Main Upsize, Road Repairs, New Drain on Bayview Pl (300m)	$384,400	Parts of Bayview Pl pavement are in poor condition. 150 CI water main is in poor condition and requires upsizing to 200mm to achieve fire flow.					
21	2019	04 - High		Survey and Engineering Design of Water Main Replacement (upsize), Road Repairs, Stormwater reinstatement on Highview Pl & Oceanview Rd	$63,200	150 CI pipe is undersized and in poor condition. Highview Pl roadway is in moderate condition, and Oceanview Rd is in very poor condition. Replace 415 meter of 150 CI water main on Highview Pl/Oceanview Rd and replace entire width of asphalt.					
31	2019	04 - High		High Priority Repairs on Eight (8) Bridges	$99,500	Variety of "High" priority bridge repairs as defined in Bridge Condition assessment.					
37	2019	04 - High	36	Construction to upsize water main (x2) from Highway Tank, under Highway 1 on Oceanview Road, onto Lions Bay Ave (Upgrade 1 GA Report) (273m), and from PRV 3, under Highway 1 on Oceanview Road, up Isleview Place (Upgrade 2) (630m)	$1,020,400	Refer to Project 36.					
38	2019	04 - High		Survey, Design and Construction to upsize Water main on Inlet/Outlet of Phase IV Tank (46 m)	$59,750	Upgrade 4 in GA Modelling Report. Not meeting fire flow. List in report as very high priority.					
22	2020	04 - High	21	Construction to upsize Water Main & Road Repairs on Highview Pl & Oceanview Rd	$752,200	See Project 21					
50	2020	04 - High		Replacement of Harvey Creek raw water intake structure	$1,200,000	VoLB staff report that the intake is in poor condition and was constructed in the mid 1980's.					
09	Unscheduled	03 - Moderate		Subscription to ArcGIS Online (Online GIS for asset data management)	$2,500	Village asset GIS is antiquated and difficult to use. Online system will enable simplification of data management, and enable viewing through multiple devices, systems (inc. web site, phone)					
14	Unscheduled	03 - Moderate	11	Construction of Meters for Zone / Branch Water Metering	$150,000	Refer to Project 11					
15	Unscheduled	03 - Moderate		CCTV of sanitary and storm sewer system	$44,000	Commence regular CCTV inspections and conditions assessment of sanitary pipe network					
17	Unscheduled	03 - Moderate		General Bridge Repairs (Medium Priority)	$89,500	Findings of bridge condition assessment performed in late 2015. Medium priority items only, includes 7 bridges).					
23	Unscheduled	03 - Moderate		Survey, Design and Construction to Reinstate Stormwater Pipe on Oceanview Rd	$250,000	The 600mm stormwater culvert (approx. 100 m plus tie-ins/discharge points) that formally discharged to Rundle Creek requires reinstatement. Replace sections of poor pavement (20 m) of Oceanview Rd					
24	Unscheduled	02 - Low		Desalination Feasibility Study	$12,500	The frequency of turbidity events, smaller snow levels and water intake shutdowns have resulted in concerns about long term viability of existing water supplies. There may be a business case for transitioning to a desalination plant to improve reliability of supply, and there are likely to be significant improvements in small-scale desalination technology in the short term. A feasibility study should be performed within 5 yrs. to categorically determine if this is a suitable solution.					
25	Unscheduled	02 - Low		Survey, Engineering Design and Construction of Drainage Improvements on Brunswick Beach Rd	$75,000	Drainage between 26, 27 & 29 Brunswick Beach Rd is poor. Area is very low and flat. New drain will likely be required.					
26	Unscheduled	02 - Low		Survey, Engineering Design and Construction to upsize water main and improve drainage on Kelvin Grove Way (Upper) (380m)	$361,150	Water main on Kelvin Grove Way (Upper) requires upsizing from 150mm to 200mm to achieve fire flow. Many drains have been filled in, and drainage regime along road should be redesigned and implemented. Road pavement is in poor to moderate condition.					
27	Unscheduled	03 - Moderate		Survey, Design and Construction to upsize Water main on Stewart Road (250m)	$281,250	150 DI water main on Stewart Rd is undersized and requires upsizing to 200mm to meet fire flow requirements. Identified as High Priority replacement by GeoAdvice. Stewart Road pavement is in moderate condition.					
28	Unscheduled	02 - Low		Survey, Engineering Design and Construction of Road repairs and Drainage Improvements on Isleview Pl (1030m2 of distressed pavement)	$45,100	Sections of road are in moderate to poor condition -some patching of fatigue and crack sealing required. Significant drainage issues were identified by operations staff.					
29	Unscheduled	02 - Low		Survey, Engineering Design and Construction of Drainage Improvements on Lions Bay Ave (210m)	$110,000	Ditch on Eastern side of Lions Bay Ave has been infilled and requires reinstatement. Identified by operations staff as issue.					
30	Unscheduled	01 - Lowest		Road Repairs on Crystal Falls Rd (150m)	$65,700	Road is in moderate condition. Lowest priority as the road services very few properties.					
32	Unscheduled	02 - Low		Medium Priority Repairs on Bayview Road (Private Driveway) over Alberta Creek	$62,000	Repairs identified in Bridge Inspection,					
34	Unscheduled	02 - Low		Mill and Overlay poor sections (245 m2) of Crosscreek Road	$10,800	Pavement in poor condition -deep patch of fatigue					
35	Unscheduled	03 - Moderate		Survey, Design and Construction of Water Main Replacement, Drainage Repair on Centre Rd, (100m)	$135,000	Water main identified as Poor condition by operations staff. Drainage on north side of road requires clean up.					
39	Unscheduled	03 - Moderate		Survey, Design and Construction of Road Repairs, and Drainage Improvements on Kelvin Grove Way (150m). Water main upsizing required (545 m).	$746,900	Sections of road in very poor condition. Culvert crossing in poor condition. Water main upsizing is upgrade 8 in GA modeling report (medium priority).					
40	Unscheduled	03 - Moderate		Survey, Design and Construction of Water Main Replacement, Road Repair on Bayview Rd (300m)	$373,750	Water main in poor condition. Identified as priority 2 by operations staff.					
41	Unscheduled	02 - Low		Magnesia Tank requires additional storage capacity for fire flow.	$400,000	Identified as Moderate Priority upgrade in GA report (No. 9). Could be provided elsewhere within the service area.					
42	Unscheduled	03 - Moderate		Survey, Design and Construction of Water main Upsize on Timbertop Rd (126m)	$166,600	Identified as High Priority upgrade in GA report (No. 7). Road in poor condition.					
48	Unscheduled	03 - Moderate		Survey, Design and Construction to replace corroded culvert crossing Bayview Road just north of the school.	$50,400	VoLB staff reported that the culvert has deteriorated.					
52	Unscheduled	03 - Moderate		Reservoir replacement (design and construction of three tanks)	$900,000	Four of the village tanks are in poor condition and reaching the end of their service lives. The Harvey 400,000 gallon tank will be replaced in 2018 but the remaining ones will need replacement in the near future. The condition assessment in 2016 should determine which reservoir poses the highest risk of failure and should be replaced first (probably Brunswick or Tank V).					

Project No	Schedule	Priority	Predecessor(s)	Project Name	Capital Cost	Drivers / Description	Water	Sanitary	Drainage	Roads & Bridges	General
53	Unscheduled	03 - Moderate		Deep patch asphalt on Oceanview Rd between Creekview Place and Highview Pl (250m)	$58,600	Deep patch of fatigue. Pavement in very poor condition.					
54	Unscheduled	01 - Lowest		Upsize the 300 mm CSP culvert from Bayview Rd to Alberta Creek (50m)	$74,400	Existing 300 mm pipe is undersized. Also, the existing pipe is steel, and is therefore probably near the end of its service life.					
55	Unscheduled	01 - Lowest		Install a ditch on the low side of Cloudview Place.	$55,700	Currently only a ditch on the uphill side of the road, which road run-off can't get to.					
59	2019	03 - Moderate		Wastewater Treatment Methodology Review and Phased System Expansion Study	$70,000	Review treatment technologies with consideration for increased capacity of the plant to allow for expansion of the sanitary sewer network. Developing a phased plan for providing sanitary sewers to the currently unserviced areas of the Village. Study will also include review of options for connecting the Oceanview Area to Kelvin Grove likely by pumping that crosses Rundle Creek.					
60	Unscheduled	02 - Low	59	WWTP Replacement	$3,200,000	WWTP replacement to meet existing capacity plus Oceanview with allowances for expansion to accommodate full Villlage servicing. Cost will vary depending on results of review conducted under Project 59.					
61	Unscheduled	01 - Lowest	59	Oceanview Sewer and Pump Station	$2,200,000	Construction of sewers within Oceanview area (above Hwy 99) and connection of system to Kelvin Grove via pumping station and forcemain across Rundle Creek.					



Infrastructure Master Plan
Capital Projects
Figure 7-2 2016 Projects

AECOM

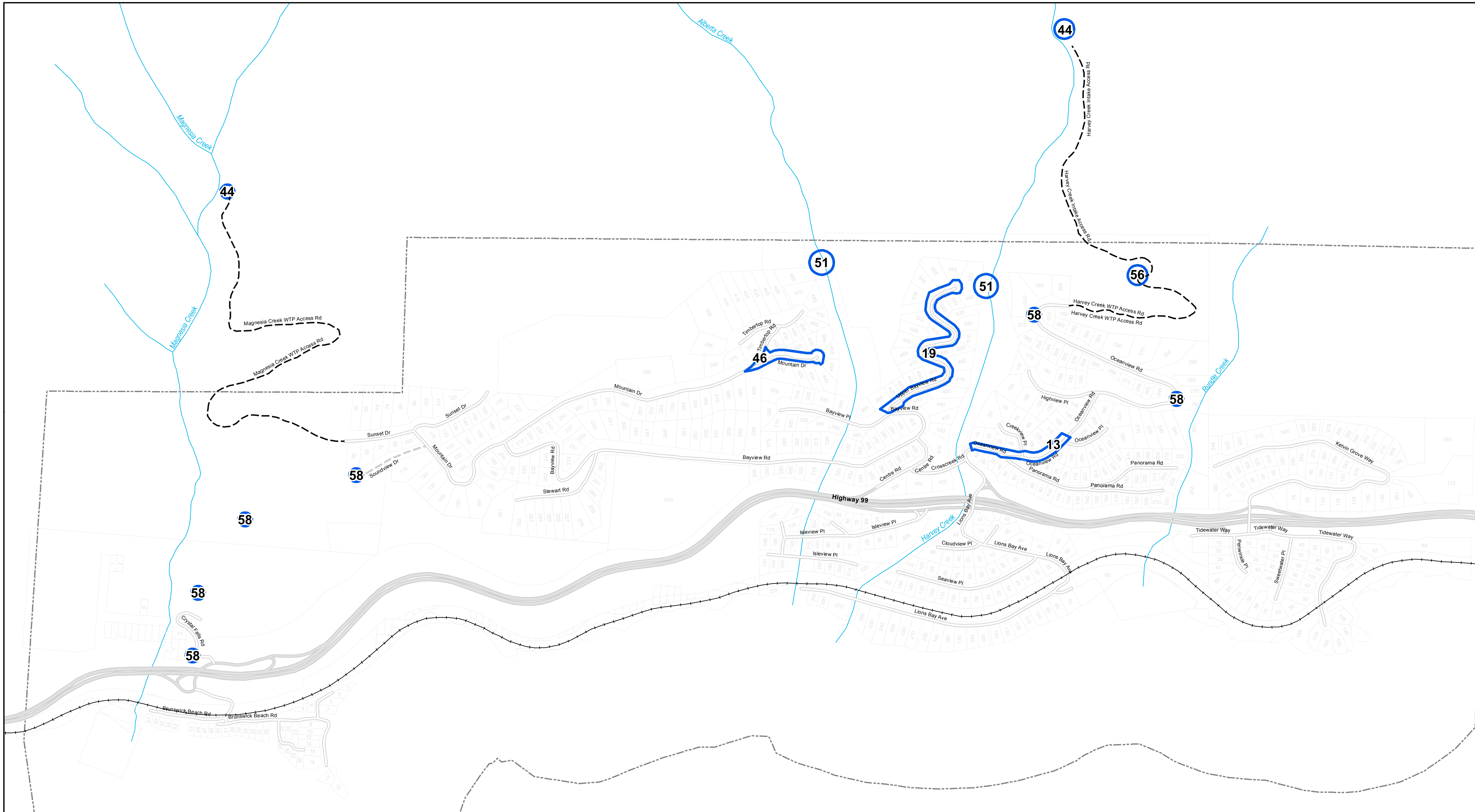
Legend
- Village Boundary
- Property Parcels
- Project Reference Number

MOTI Roads
- Highway
- On-Ramp
- Rail

Village Roads
- Sealed
- Unsealed

0 50 100 200
Metres

Village of Lions Bay



Infrastructure Master Plan
Capital Projects
Figure 7-3 2017 Projects

AECOM

Legend
- Village Boundary
- Property Parcels
- Project Reference Number

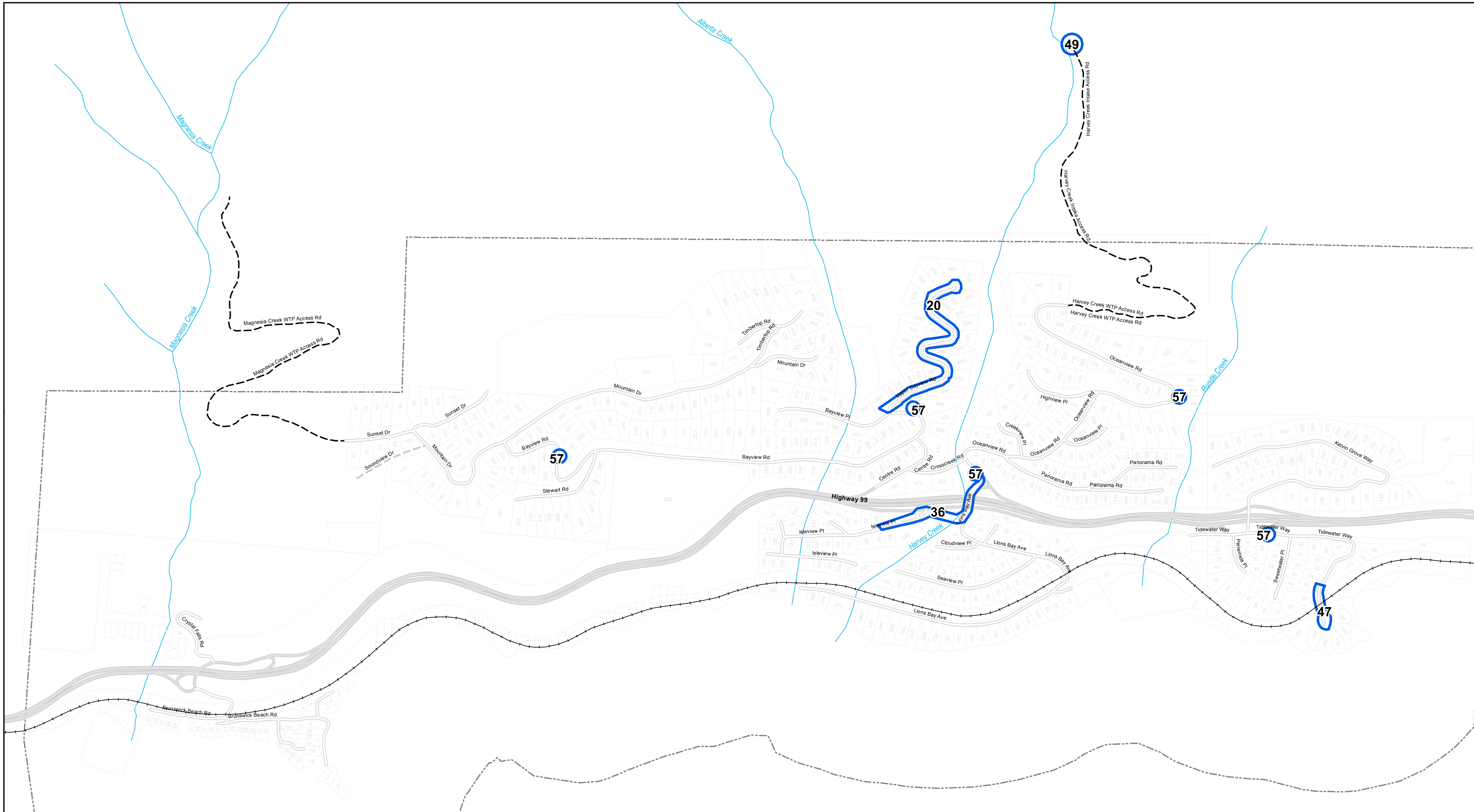
MOTI Roads
- Highway
- On-Ramp
- Rail

Village Roads
- Sealed
- Unsealed

0 50 100 200
Metres

SPLENDOUR IN SERENITY

Village of Lions Bay



Infrastructure Master Plan
Capital Projects
Figure 7-4 2018 Projects

AECOM

Legend

- Village Boundary
- Property Parcels
- Project Reference Number

MOTI Roads

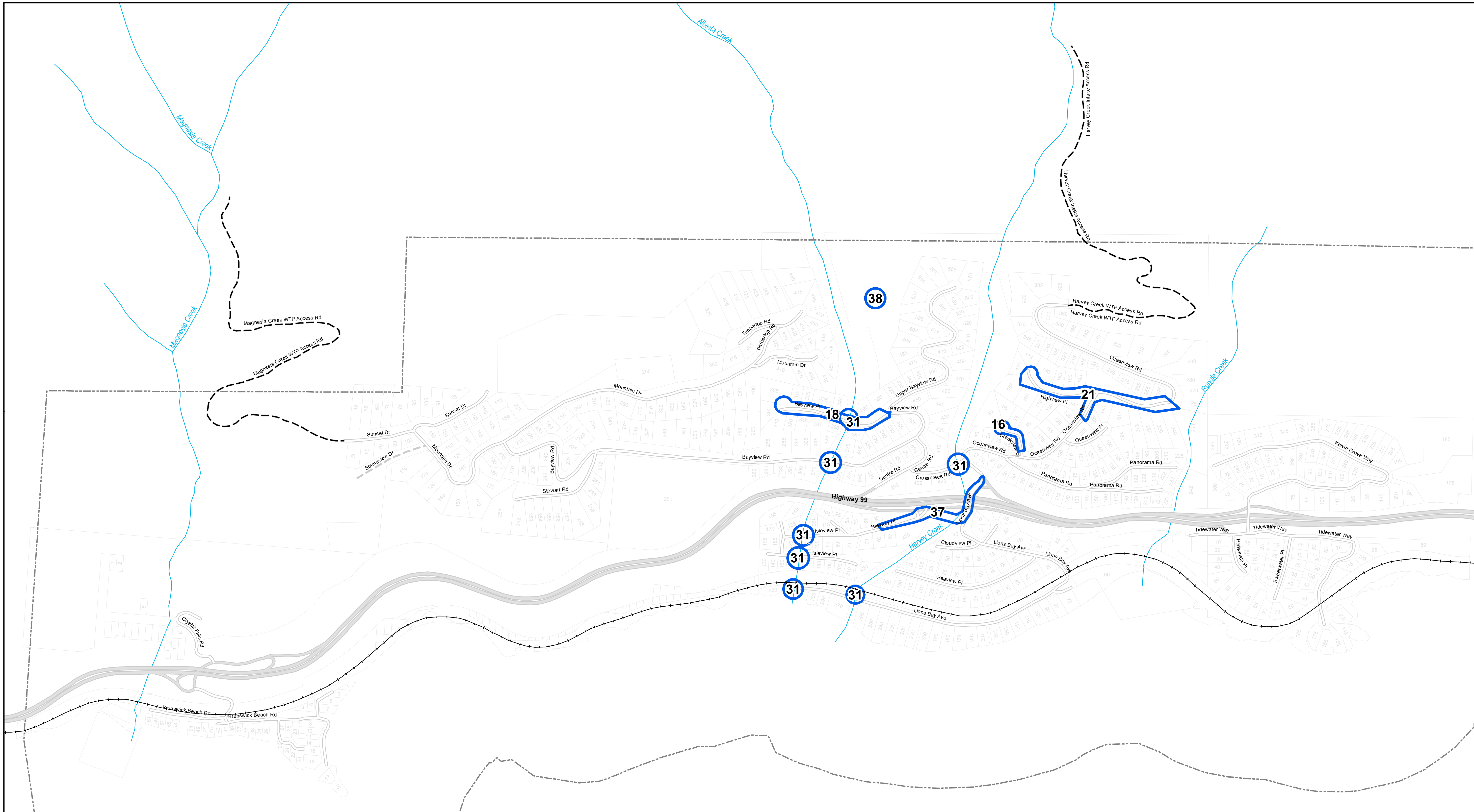
- Highway
- On-Ramp
- Rail

Village Roads

- Sealed
- Unsealed

0 50 100 200
Metres

Village of Lions Bay



Infrastructure Master Plan
Capital Projects
Figure 7-5 2019 Projects

AECOM

Legend

- Village Boundary
- Property Parcels
- Project Reference Number

MOTI Roads

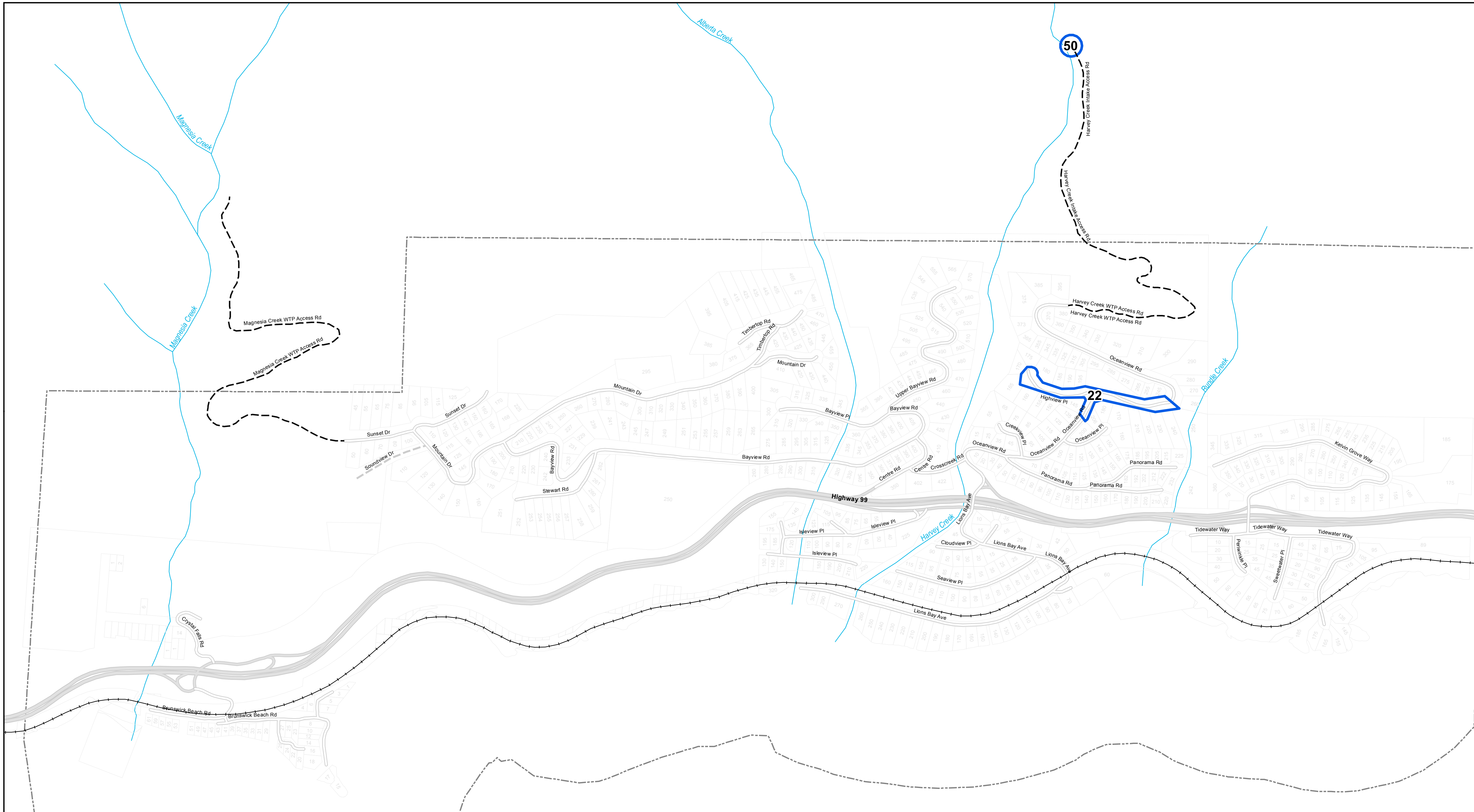
- Highway
- On-Ramp
- Rail

Village Roads

- Sealed
- Unsealed

0 50 100 200
Metres

Village of Lions Bay



Infrastructure Master Plan
Capital Projects
Figure 7-6 2020 Projects

AECOM

Legend

Village Boundary
Property Parcels
MOTI Roads
Highway
On-Ramp
Rail
Project Reference Number
Village Roads
Sealed
Unsealed

0 50 100 200
Metres

SPLENDOUR IN SERENITY

Village of Lions Bay

7.2 Policy and Non-Capital Recommendations

Table 7-3 lists potential policy changes that were identified by contributors to the IMP, including operations staff and Infrastructure Committee.

Table 7-3: Recommended Policy Changes and Improvements

Policy	Drivers and Issue(s)	Recommendations
Private & Public Property		
Restrict Private Encroachment	One of the most significant issues limiting the effective management of utilities, drainage and roads is the encroachment of private property works into the public realm road corridor. It is severely restricting the Village's ability and entitlement to address drainage, utilities, pavement issues and pedestrian traffic within the public corridor. The following issues can be linked to private encroachment: • Utilities are forced into the road pavement footprint, resulting in significantly increased costs when utilities require repair or replacement) • Pedestrian traffic is forced onto the road. Despite the significant grades, there is a relatively high level of pedestrian activity, and a large proportion of this traffic are children (more likely to be hit) or older residents (more likely to be severely injured). These factors mean that there is very high risk of vehicle / pedestrian interaction that needs to be reduced. • Stormwater management opportunities are limited to narrow (or non-existent) drainage corridors to the side of the pavement	• Immediate moratorium on encroachment of private works in the public corridor. Some exceptions may be allowed (e.g. driveways, limited soft-landscaping), however they should be formally defined by a relevant by-law and subject to limitations such as: - require express written approval from Village - require survey of relevant property line (with digital submission) - require a nominal fee commensurate with the long-term cost implications for the Village (i.e. account for possible additional drain, pavement, utility repair costs associated with new works) - subject to restrictions that allow for easy removal / replacement (limit driveway width; constructions joints at defined intervals and PL; non-reinforced concrete • Commence reclamation of public realm by implementing road corridor standards
Obtain Reliable Land Parcel Information	It is extremely difficult to identify the location of the property lines for the vast majority of the properties in the Village, particularly east of the Highway. The existing Village parcel GIS information is quite inaccurate, and will not be useful in helping to identify private / public property extents in its current standard.	• The Village should commence collection of digital property parcel information. • A formal digital standard for survey and design should be implemented. This standard should require that all digital survey and engineering information provided to the Village is provided in CAD format (NAD83 UTM Zone 10 coordinate system) • All development applications should require that property parcels must be surveyed by a licenced surveyor. Extents of a property parcel must be supplied to the Village in both PDF and CAD in line with the aforementioned standard. This will allow the Village to accumulate reliable, georeferenced property information as properties are developed
Enforce Offsets	The topography and layout of the Village is such that it is likely that additional ROWs may be	• By-laws enforcing building offsets should be implemented and enforced. Ensuring that

Policy	Drivers and Issue(s)	Recommendations
	required to facilitate long-term plans such as a fully connected drainage system or a Village-wide sanitary sewer network. This is exacerbated by the dynamic groundwater and geotechnical conditions that mean that the Village may need to quickly install new infrastructure following unforeseen events.	structures and hard-landscaping are a sufficient distance from the PLs will facilitate the attainment of necessary ROWs with a reduced cost and community impact. • Educate residents on the importance of roadside drainage and the risk associated with unauthorised ditch infilling and improper culvert installation.
Project Delivery & Procurement		
Focus on Long-Term Infrastructure Sustainability	Some of problems identified during the IMP investigations can be directly or indirectly linked to previous works that resolved short-term issues at a relatively low capital-cost, but had consequential issues that were significant. An example of this is the diversion of the stormwater culvert between 260 and 270 Oceanview Rd instead of replacement and it is likely impacting downstream stormwater capacity.	• Adopt a policy to avoid construction works that sacrifice long-term infrastructure sustainability for short-term budget objectives
Reduce Quote Requirement Threshold	Operations staff report that all works above >$2,000 require a minimum of three (3) quotes, even if these are regular items (e.g. pavement repairs, pipework). This means approximately four (4) working days per month is taken up obtaining quotes (48 working days per year). This resource commitment is probably offsetting any cost advantages achieved by obtaining quotes at such a low threshold. The Village would likely benefit significantly by increasing this threshold. On-going services agreements (e.g. 2-3yr) based on rates for common items could help ensure competitive tendering whilst reducing the staff time dedicated to achieving this objective.	• Increase cost trigger for obtaining quotes to $6,000 • Advertise to obtain tenders for on-going (3yr) services agreements for reoccurring items (e.g. road materials, piping, planning support)
General Utilities		
Use High-Density Polyethylene (HDPE) Pipes	The Village expressed concern about how the dynamic geotechnical and groundwater conditions might impact the integrity of the sanitary, stormwater and water pipes. There is also evidence of ground movement in the Village. Significant ground movement will often result in the separation of socket / spigot joints used in PVC and DICL pipes, which can result in leaks and subsequent erosion, pavement failure and dangerous geotechnical conditions. These pipe materials make up a significant proportion of the utilities networks.	• Fully-welded HDPE should be the preference for all water, sanitary and stormwater replacement projects delivered by the Village in areas that are likely to see significant ground movement. HDPE Pipe segments are flexible and typically welded together (with butt welding or electro fusion collars), which means they are likely to perform better in locations where ground movement is expected.
Corrugated Steel Pipe	Many of the Village's corrugated steel pipes (CSP) have deteriorated. CSP is known to have	• Wherever possible the Village should avoid the use of CSP.

Policy	Drivers and Issue(s)	Recommendations
	a short lifespan and some municipalities such as the City of Surrey prohibit the installation of CSP.	
Funding		
Grants	There are a number of infrastructure grants and low interest loans available to municipalities that could help the Village achieve its infrastructure renewal program.	• The Village should begin investigating and securing grant money for its upcoming projects • The Village should sufficiently fund its preventative and corrective maintenance programs.

Appendix A

Hydraulic Modelling Reports

A1 Water Distribution System -
Model Development and Capacity Analysis - Technical Memorandum

A2 Sewer Collection System -
Model Development and Capacity Analysis - Technical Memorandum

A1. Water Distribution System - Model Development and Capacity Analysis - Technical Memorandum

The Village of Lions Bay
Water Distribution System
Model Development and Capacity Analysis

Technical Memorandum

Prepared for:
The Village of Lions Bay
400 Center Road
Lions Bay, BC V9N 2E9

And

AECOM
4TH Floor, 3292 Production Way
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Prepared by:
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Submission Date: March 3, 2016

Contact: Mr. Werner de Schaetzen, Ph.D., P.Eng.
Re: Project 2015-031-LIO

Document History and Version Control

Revision No.	Date	Document Description	Revised By	Reviewed By
R0	December 31, 2015	First Draft	Sean Geyer	Werner de Schaetzen
R1	January 26, 2016	Second Draft	Sean Geyer	Werner de Schaetzen
R2	February 16, 2016	Final Draft	Sean Geyer	Werner de Schaetzen
R3	March 3, 2016	Final	Sean Geyer	Werner de Schaetzen

Table of Contents

1.0 Introduction

GeoAdvice Engineering Inc. was retained by the Village of Lions Bay, BC to develop a comprehensive “all pipes” hydraulic model of the Village of Lions Bay (Village) water distribution system. This memo describes the methodology and assumptions used to update, calibrate and analyze the hydraulic model. **Table 1.1** summarizes the main components of the water distribution system model.

Table 1.1: Model Statistics of Current Water Distribution System

Component	Total
Supply Sources	2
Watermains	201
Junctions	173
Pump Stations	0*
PRV Stations	13
Pressure Zones	18

*While there is one small Village-owned booster station on Timbertop Drive, this was not included in the model as it does not affect the overall system hydraulics of the Village system.

The Village’s existing water model was updated using the InfoWater software program (Innovyze). InfoWater is a water distribution system modeling and management software application.

The Village water distribution system is separated into eighteen (18) pressure zones and services an existing population of approximately 1,318 people. The boundaries along the pressure zones consist of a series of closed valves and pipes, and pressure regulating valve (PRV) stations to decrease the pressure to an acceptable range for delivery of water to users.

2.0 Hydraulic Model Update

The updating of the hydraulic network model was divided into multiple tasks to ensure the model is representative of the "real" water distribution system. In sequential order and as discussed in detail below, these tasks include:

- Task 1: Data collection and review
- Task 2: GIS pipe data conversion
- Task 3: Primary water system components import
- Task 4: Node elevation extraction
- Task 5: Pressure zone boundary definition
- Task 6: Demand calculation and allocation
- Task 7: Demand scenario development
- Task 8: Fire flow demand allocation

2.1 Data Collection and Review

Prior to updating the model, information on the Village of Lions Bay water system was compiled, collected and reviewed. This included reviewing the following pertinent information:

- Previous InfoWater hydraulic model
- GIS database
- Land-use and zoning maps
- Planning parcel data
- As-built drawings
- Hydrant pressure data
- Meeting with Operations Staff

2.2 GIS Pipe Data Conversion

The Village's GIS database (received on August 13, 2015) was the primary source of up-to-date information on the water system to update the pipe and node network topology model. Attributes of the water mains, such as diameter and material were extracted from the GIS database. It should also be noted that the Village Operations Staff provided a significant amount of information about the system that was not present in, or superseded, the GIS data. All input from the Operations Staff was recorded on paper maps of the Village's water system and digitized.

Some additional entities have been added to the model in order to satisfy the software requirements for system operation and continuity (e.g. PRV station). The coordinate system used for building the model was UTM NAD 1983 Zone 10.

The model was set-up to use the Hazen-Williams headloss formula to estimate friction loss through water mains based on pipe roughness C-factors.

2.3 Primary Water System Components

One of the most important tasks associated with the model update was incorporating system boundary conditions and all major water system components (e.g. supply points, storage reservoirs and control valves). Detailed information on all of the components was verified and updated in the model, with the parameters and settings listed in **Appendix A.**

2.4 Node Elevation Extraction

The node ground elevations were available in the GIS. A Digital Elevation Model (DEM) was developed from contour data and used to validate node elevations. Ground elevations were assigned to the junction nodes in the model. Elevations of the hydraulic facilities (e.g. storage reservoir and PRV) were determined based on the previous model.

2.5 Pressure Zone Boundary Definition

Water zone valves, Operations staff, and the previous model were used to determine the different pressure zones. Zonal information on all model components was input into the model. The pressure zones defined in the model are as follows:

1. PZ 66 m
2. PZ 75 m
3. PZ 86 m
4. PZ 107 m
5. PZ 124 m
6. PZ 160 m
7. PZ 178 m
8. PZ 182 m
9. PZ 185 m
10. PZ 202 m
11. PZ 222 m
12. PZ 229 m
13. PZ 236 m
14. PZ 271 m
15. PZ 278 m
16. PZ 279 m
17. PZ Harvey Supply
18. PZ Magnesia Supply

Detailed information on the pressure zones can be found in **Appendix B.**

2.6 Demand Calculation and Allocation

Residential users are not metered; however supply records are maintained for both sources (Harvey Creek and Magnesia Creek). The Village provided the supply records for 2014-2015 in two different spreadsheets (2015 Water Use Tracking Analysis.xlsx – September 15, 2015 and Harvey Flow Data 2014 over 2015.xlsx – August 10, 2015) and these were used to determine the 2015 MDD for the Village. It should be noted that due to a significant number of repairs to the Village distribution system to fix known leaks, the overall Village water consumption in 2015 is significantly lower than that of 2014. As such, only data after January 2015 was considered when analyzing system demands.

The maximum day demand (MDD) rate for 2015 was determined to be 1,475.3 L/d/cap. Both data sources agreed on this value.

2.7 Demand Scenarios Development

To assess the existing water distribution system, multiple modeling scenarios were created. The complete list of existing modeling scenarios are:

- 2015-ADD, Steady State Simulation
- 2015-MDD, Steady State Simulation
- 2015-MDD+FF, Fire Flow Simulation
- 2015-PHD, Steady State Simulation

Table 2.1: Existing Demand Data

Scenario	Demand (L/s)
Average Daily Demand (ADD)	11.25*
Maximum Daily Demand (MDD)	22.51**
Peak Hour Demand (PHD)	45.01*

*Theoretical value calculated based on MMCD peaking factors.
Observed value from VoLB supply records (see **Section 2.6).

Table 2.2: Existing Demand Peaking Factors

Scenario	Peaking Factor (MMCD*)
Average Day Demand (ADD)	0.5 x MDD
Peak Hour Demand (PHD)	2.0 x MDD

*Master Municipal Construction Documents

It was assumed that the supply record data would account for all demand types, including non-revenue water. As it was not possible to break the water demand down into individual demand types with the available data, the full demand was divided equally among all demand nodes in the model.

2.8 Fire Flow Demand Allocation

Fire flow demands were assigned to selected nodes located near hydrants in the InfoWater model. Fire flow simulations were only completed on those nodes. As the village does not maintain any specific fire flow requirement, deficiencies were assessed based on a typical single-family residential requirement of 60 L/s and a minimum residual pressure of 20 psi (MMCD).

3.0 Hydraulic Model Calibration

Before describing how the water model was calibrated, it is useful to examine why the model may not match the field test data. Most of the sources of errors or mismatches are:

- Input data errors
- System demand errors
- Node elevation errors
- Skeletonization errors
- Operational control errors
- Poorly calibrated measuring equipment
- Outdated data

The cumulative effect of these areas of uncertainty is that, without verification and calibration of the model's ability to recreate known conditions, there is a high probability that the modeling results would be grossly misleading.

The primary benefits of a calibrated model are listed below:

- **Confidence:** Demonstrate the model's ability to reproduce existing conditions
- **Understanding:** Confirm the understanding of the performance of the system
- **Troubleshooting:** Uncover missing information and misinformation or anomalies about the system, such as incorrect valve settings or gross demand errors

When calibrating the model, the goal was to compare the measured static hydrant pressures against the predicted results from the model, to show that the current model results are in agreement with the observed field data.

Overall, an acceptable correlation is achieved between the model and measured data for the static hydrant pressure results:

- Static pressure agreements range from 0% to 29%, with an average agreement of 5%.
- Of the 63 useable static hydrant readings:
    - An excellent match (within 5%) is achieved at 38 locations (60%).
    - A good match (within 10%) is achieved at 17 additional locations (27%).
    - A poor match (above 10%) is witnessed at 8 locations (13%).
- Of the eight (8) hydrants with poor agreement, seven (7) are located in areas with significant elevation changes. The location of the hydrants in GIS and the accuracy of the Village's elevation data has a significant effect on the model result at these locations. At all seven locations, the elevation required to produce good calibration results is within a logical vicinity of the GIS hydrant location.

The complete calibration results are provided in **Appendix C**.

4.0 Future Modeling Scenario Development

In consultation with the Village, three (3) future modeling scenarios were developed. **Table 4.1** provides a summary of the scenarios to be modeled.

Table 4.1: Summary of Modeling Scenarios

Scenario	Description
Existing 2015	Existing configuration servicing approximately 1,318 people.
Future 2020	Future configuration servicing a total population of approximately 1,358 people.
Future 2025	Future configuration servicing a total population of approximately 1,398 people.
Future 2045	Ultimate future scenario population of approximately 1,574 people.

This study considered population growth from 2015 to 2045. The population in 2015 (calculated based on 2011 Census data) is considered to be the existing base scenario, with 2045 being the future build-out scenario.

Demand and population projections for future scenarios were calculated using the Village's assumption of a 3.0 % growth rate every five years.

4.1 Future Water Demand Calculations

The demand rates in the table below were used based on discussions with the Village.

Table 4.2: Future Demand Rates

Type	Criteria
Average Day Demand (ADD)	738 L/cap/day
Maximum Day Demand (MDD)	1,475 L/cap/day
Peak Hour Demand (PHD)	2,951 L/cap/day
MDD/ADD*	2.00
PHD/ADD*	4.00
PHD/MDD*	2.00

*Theoretical value taken from MMCD.

The future population growth provided by the Village is summarized in **Table 4.3**.

Table 4.3: 2015 to 2045 Population Growth

Growth Type	Growth
Population Growth to 2020	+40
Population Growth to 2025	+80
Population Growth to 2045	+256

5.0 System Performance Capacity Analysis

This section summarizes the results of the system capacity analysis conducted on the existing system. Based on the Village's design specifications and discussions with the Village, the criteria shown below were used.

Table 5.1: Hydraulic Design Criteria

Criteria	MMCD*
Minimum Static Pressure	275 kPa (40 psi)
Minimum Residual Pressure (MDD+FF)	138 kPa (20 psi)
Minimum Diameter New Pipe	200 mm
Roughness Coefficient New Pipe	120

*Master Municipal Construction Documents

The objectives of the capacity assessment were to review the existing system performance under the existing and future flows, and to use these results to make recommendations on system upgrades.

5.1 Storage Reservoir Capacity Analysis

Required reservoir capacities were calculated based on the MMCD standards. The required reservoir capacities were then compared to existing capacities to determine any deficiencies.

According to MMCD standards, a reservoir capacity shall not be less than the summation of the following:

- Fire storage (A) – This is the amount of water required to extinguish fires within the service area of a reservoir. This storage is based on the worst case fire flow land use scenario in the service area.
- Equalization storage (B) – This is the amount of storage required for normal water consumption (25 % of MDD).
- Emergency storage (C) – The emergency storage requirement of 25% of (A) + (B).

The existing storage capacity of each reservoir was compared to the storage requirement for their corresponding service area. Existing and future storage reservoir capacity results are summarized below.

Table 5.2: 2015 Storage Reservoir Capacity Results

Storage Reservoir	Reservoir Capacity (ML)	Capacity Required (ML)	Excess (ML)	Deficient?
Harvey 400,000 Gallon Tank	1.72	1.06	+ 0.66	No
Highway Tank, supported by: • Harvey 400,000 Gallon Tank	0.08 + 1.72	0.49	+ 1.31	No
Magnesia 100,000 Gallon Tank	0.44	0.52	- 0.08	Yes
Phase IV Tank, supported by: • Harvey 400,000 Gallon Tank	0.08 + 1.72	0.58	+ 1.22	No
Phase V Tank, supported by: • Harvey 400,000 Gallon Tank	0.10 + 1.72	0.43	+ 1.39	No

Table 5.3: 2020 Storage Reservoir Capacity Results

Storage Reservoir	Reservoir Capacity (ML)	Capacity Required (ML)	Excess (ML)	Deficient?
Harvey 400,000 Gallon Tank	1.72	1.08	+ 0.64	No
Highway Tank, supported by: • Harvey 400,000 Gallon Tank	0.08 + 1.72	0.49	+ 1.31	No
Magnesia 100,000 Gallon Tank	0.44	0.52	- 0.08	Yes
Phase IV Tank, supported by: • Harvey 400,000 Gallon Tank	0.08 + 1.72	0.58	+ 1.22	No
Phase V Tank, supported by: • Harvey 400,000 Gallon Tank	0.10 + 1.72	0.43	+ 1.39	No

Table 5.4: 2025 Storage Reservoir Capacity Results

Storage Reservoir	Reservoir Capacity (ML)	Capacity Required (ML)	Excess (ML)	Deficient?
Harvey 400,000 Gallon Tank	1.72	1.09	+ 0.63	No
Highway Tank, supported by: • Harvey 400,000 Gallon Tank	0.08 + 1.72	0.49	+ 1.31	No
Magnesia 100,000 Gallon Tank	0.44	0.52	- 0.08	Yes
Phase IV Tank, supported by: • Harvey 400,000 Gallon Tank	0.08 + 1.72	0.59	+ 1.21	No
Phase V Tank, supported by: • Harvey 400,000 Gallon Tank	0.10 + 1.72	0.43	+ 1.39	No

Table 5.5: 2045 Storage Reservoir Capacity Results

Storage Reservoir	Reservoir Capacity (ML)	Capacity Required (ML)	Excess (ML)	Deficient?
Harvey 400,000 Gallon Tank	1.72	1.16	+ 0.56	No
Highway Tank, supported by: • Harvey 400,000 Gallon Tank	0.08 + 1.72	0.50	+ 1.30	No
Magnesia 100,000 Gallon Tank	0.44	0.54	- 0.10	Yes
Phase IV Tank, supported by: • Harvey 400,000 Gallon Tank	0.08 + 1.72	0.61	+ 1.19	No
Phase V Tank, supported by: • Harvey 400,000 Gallon Tank	0.10 + 1.72	0.43	+ 1.39	No

Based on the storage reservoir capacity analysis, only the Magnesia 100,000 Gallon Tank is predicted to be deficient. It is recommended that an additional 0.1 ML is added to the Magnesia Tank, or within the Magnesia service area at the appropriate HGL, to meet the predicted 2045 storage requirements.

5.2 PRV Capacity Analysis

PRV stations were also reviewed in terms of their peak velocities under Peak Hour Demand (PHD) scenarios. To limit the amount of "wear and tear", the recommended peak velocity through a PRV should be less than or equal to 6 m/s. Based on the analysis, there are no PRV stations that become deficient in terms of velocity under PHD conditions, either existing or future. For the full PRV velocity results, please refer to **Appendix D**.

5.3 Pressure and Fire Flow Modeling Results

A summary of the existing modeling results are shown in the table below. The fire flow analysis was only conducted on fire flow nodes (nodes near fire hydrants). Deficiencies within 10% of the requirements were not considered to be critical. Refer to **Figures 5.1 – 5.5** for maps depicting an overview of the water distribution system and the location of pressure and fire flow deficiencies.

Table 5.6: Summary of 2015 Hydraulic Modeling Results

Criteria	Scenario	Existing Network
# of Low Pressure Deficiencies Demand Nodes < 275 kPa (40 psi)	PHD	11
Average Pressure	PHD	83.1 psi
# of Fire Flow Deficiencies Residual Pressure < 138 kPa (20 psi)	MDD + FF	27
Average Available Fire Flows	MDD + FF	79.3 L/s

Hydraulic results indicate that there are 11 demand nodes that experience pressures below 275 kPa (40 psi) under existing conditions, with only six (6) of these considered critical. Fire flow results indicate that 27 fire nodes are unable to satisfy the required fire flow, with only 16 of these deficiencies considered to be critical. As requested by the Village, a summary of the available flow at each hydrant, as predicted by the model, has been provided in **Appendix E**.

Table 5.7: Summary of 2020 Hydraulic Modeling Results

Criteria	Scenario	Existing Network
# of Low Pressure Deficiencies Demand Nodes < 275 kPa (40 psi)	PHD	11
Average Pressure	PHD	83.1 psi
# of Fire Flow Deficiencies Residual Pressure < 138 kPa (20 psi)	MDD + FF	27
Average Available Fire Flows	MDD + FF	79.3 L/s

Hydraulic results indicate that there are 11 demand nodes that experience pressures below 275 kPa (40 psi) under 2020 conditions, with only six (6) of these considered critical. Fire flow results indicate that 27 fire nodes are unable to satisfy the required fire flow, with only 16 of these deficiencies considered to be critical.

Table 5.8: Summary of 2025 Hydraulic Modeling Results

Criteria	Scenario	Existing Network
# of Low Pressure Deficiencies Demand Nodes < 275 kPa (40 psi)	PHD	12
Average Pressure	PHD	83.0 psi
# of Fire Flow Deficiencies Residual Pressure < 138 kPa (20 psi)	MDD + FF	31
Average Available Fire Flows	MDD + FF	76.3 L/s

Hydraulic results indicate that there are 12 demand nodes that experience pressures below 275 kPa (40 psi) under 2025 conditions, with only six (6) of these considered critical. Fire flow results indicate that 31 fire nodes are unable to satisfy the required fire flow, with only 19 of these deficiencies considered to be critical.

Table 5.9: Summary of 2045 Hydraulic Modeling Results

Criteria	Scenario	Existing Network
# of Low Pressure Deficiencies Demand Nodes < 275 kPa (40 psi)	PHD	12
Average Pressure (psi)	PHD	82.7 psi
# of Fire Flow Deficiencies Residual Pressure < 138 kPa (20 psi)	MDD + FF	37
Average Available Fire Flows (L/s)	MDD + FF	69.5 L/s

Hydraulic results indicate that there are 12 demand nodes that experience pressures below 275 kPa (40 psi) under 2045 conditions, with only six (6) of these considered critical. Fire flow results indicate that 37 fire nodes are unable to satisfy the required fire flow, with only 30 of these deficiencies considered to be critical.

The number of fire flow deficiencies increased from 27 in the existing scenario to 37 in the 2045 scenario. All noted deficiencies will be address in **Section 5.4**; system improvements will be required to address the identified capacity deficiencies.

GeoAdvice Engineering Inc.

Legend

- PRV Station
- Storage Tank
- Intake
- Watermain

Water Distribution System Overview

Project: Infrastructure Master Plans
Client: Village of Lions Bay, BC
Date: March 2016
Created by: SG
Reviewed by: WdS

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0 0.125 0.25 0.5
Kilometers

N E S W

Figure 5.1

GeoAdvice Engineering Inc.

Legend

- PRV Station
- Storage Tank
- Intake
- Watermain

Deficiencies

- PHD Deficiency (<40 psi)
- Fire Flow Deficiency (<20 psi)

Peak Hour and Fire Flow Deficiencies

Existing Scenario

Project: Infrastructure Master Plans
Client: Village of Lions Bay, BC
Date: March 2016
Created by: SG
Reviewed by: WdS

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0 0.125 0.25 0.5
Kilometers

Figure 5.2

GeoAdvice Engineering Inc.

Legend

- PRV Station
- Storage Tank
- Intake
- Watermain

Deficiencies

- PHD Deficiency (<40 psi)
- Fire Flow Deficiency (<20 psi)

Peak Hour and Fire Flow Deficiencies

2020 Scenario

Project: Infrastructure Master Plans
Client: Village of Lions Bay, BC
Date: March 2016
Created by: SG
Reviewed by: WdS

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0 0.125 0.25 0.5
Kilometers

Figure 5.3

GeoAdvice Engineering Inc.

Legend

- PRV Station
- Storage Tank
- Intake
- Watermain

Deficiencies

- PHD Deficiency (<40 psi)
- Fire Flow Deficiency (<20 psi)

Peak Hour and Fire Flow Deficiencies

2025 Scenario

Project: Infrastructure Master Plans
Client: Village of Lions Bay, BC
Date: March 2016
Created by: SG
Reviewed by: WdS

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0 0.125 0.25 0.5
Kilometers

Figure 5.4

GeoAdvice Engineering Inc.

Legend

- PRV Station
- Storage Tank
- Intake
- Watermain

Deficiencies

- PHD Deficiency (<40 psi)
- Fire Flow Deficiency (<20 psi)

Peak Hour and Fire Flow Deficiencies

2045 Scenario

Project: Infrastructure Master Plans
Client: Village of Lions Bay, BC
Date: March 2016
Created by: SG
Reviewed by: WdS

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0 0.125 0.25 0.5
Kilometers

N E S W

Figure 5.5

5.4 Proposed Improvements

Each deficiency was individually assessed to determine the required improvement for alleviating the deficiency. During the upgrade assessment, it was determined that all critical PHD deficiencies were due solely to high elevations within their respective pressure zones (**Section 5.3**). As such, there are no feasible improvements to alleviate these PHD deficiencies. However, with respect to fire flow deficiencies, improvements have been recommended with the goal of allowing the distribution system to supply at least 60 L/s to each hydrant while maintaining a minimum residual pressure of 20 psi. Additionally, upgrades have been recommended for any tanks found to be deficient in the storage capacity analysis (**Section 5.1**). While these storage volume upgrades have been recommended for specific tanks, please note that the additional storage could be implemented anywhere within their respective zone at which the zonal HGL could be met.

Additionally, as mentioned in **Section 5.3**, fire flow deficiencies within 10% of the required flow were not assessed and were considered non-critical. A summary of the improvements required through the 2025 planning horizon is shown in **Table 5.10**.

Table 5.10: Improvements Summary

Priority	Number of Projects	Pipe Length (m)	Tanks
Very High (<1 Year)	4	969	0
High (<5 Years)	3	745	0
Medium (<10 Years)	2	545	1
Total	**9**	**2,259**	**1**

It should also be noted that an additional operational change (Upgrade No. 10) is recommended for the PRV near Lions Bay Primary School. Currently, this PRV is only used in the case of extreme emergencies; however, there are several critical fire flow deficiencies south of this station that cannot be alleviated with pipe upgrades. It is recommended that this PRV station be maintained full-time, but its downstream setting lowered to approximately 30 psi (at the assumed elevation of 131.9 m). This will allow PRV-4 to act as the primary feed into the 160-m zone, while also avoiding the mixing of source water under normal operating conditions. At this recommended setting, this emergency PRV will only open in the event of a fire immediately downstream.

A detailed list of recommended improvement is provided in **Tables 5.11** – **5.13**. Refer to **Figure 5.6** for a map depicting the location and priority of all proposed upgrades. The numbers called out on the map refer to the upgrade number noted in **Tables 5.11** – **5.13**.

Table 5.11: Pipe Upgrade Recommendations

Upgrade No.	Priority	Location	Existing Diameter (mm)	Proposed Diameter (mm)	Length (m)
1	Very High (<1yr)	From Highway Tank, under Highway 1 on Oceanview Road, onto Lions Bay Ave	150/200	200	273
2	Very High (<1yr)	From PRV 3, under Highway 1 on Oceanview Road, up Isleview Place	150	200	634
3	Very High (<1yr)	Centre Road	50	150	16
4	Very High (<1yr)	Inlet/Outlet of Phase IV Tank	100/150	150	46
5	High (<5yr)	Oceanview Road / Highview Place	150	150	354
6	High (<5yr)	Bayview Place	150	200	265
7	High (<5yr)	Timbertop Drive	150	200	126
8	Medium (<10yr)	Kelvin Grove Way (Upper)	150	200	545

Table 5.12: Tank Upgrade Recommendations

Upgrade No.	Priority	Tank ID	Existing Volume (ML)	Proposed Capacity Increase (ML)
9	Medium (<10yr)	Magnesia 100,000 Gallon	0.440	+ 0.100

Table 5.13: Operational Change Recommendations

Upgrade No.	Priority	Model ID	Existing Setting (psi)	Recommended Setting (psi)	Elevation (m)
10	Very High (<1yr)	PRV-SCHOOL	-	30	131.9

In an attempt to alleviate some of the noted deficiencies, Village Staff recommended exploring the possibility of reinstating the Oceanview 100,000 Gallon Tank and running a new transmission main south along Harvey Creek. While this would eliminate the noted deficiencies at the end of Highview Place, potential water quality issues not-withstanding, the same hydraulic effect can be achieved more economically by replacing the old cast iron pipes along Highview Place (Upgrade No. 5). Due to the existing pressure zone boundaries, the Oceanview tank would not have any impact on the other identified deficiencies. It should also be noted that with the capacity available at the Harvey 400,000 Tank, the Village does not need additional storage capacity within the half of the distribution system fed by Harvey Creek (refer to **Section 5.1**). However, from a system redundancy perspective, the Oceanview Tank and transmission line may warrant further study.

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

GeoAdvice Engineering Inc.

Legend

- PRV Station
- Intake
- Storage Tank
- Watermain

Watermain Upgrade Priority

- Very High (< 1 Year)
- High (< 5 Years)
- Medium (< 10 Years)

Storage Tank Upgrade Priority

- Medium (< 10 Years)

Upgrade Recommendations and Priority to Address Deficiencies Through 2025

Project: Infrastructure Master Plans
Client: Village of Lions Bay, BC
Date: March 2016
Created by: SG
Reviewed by: WdS

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0 0.125 0.25 0.5
Kilometers

N E S W

Figure 5.6

6.0 Alternate Servicing Scenario (Single Supply Source)

In addition to the analysis of the existing system, the Village requested that the feasibility of eliminating one of the two current supply sources be explored. The Village had particular interest in which high-level system improvements would be required to enable a single source to service the entire system. It was assumed that any potential conversion to a single-source system could not happen before 2045.

On the basis of supply potential alone, it was assumed that Harvey Creek would be the logical choice to operate as the sole supply source for the Village system. In so doing, it was further assumed that, while the Magnesia Creek intake would be closed, the Magnesia 100,000 Gallon Tank would remain in-service as a storage reservoir for the northern-end of the Village system.

The primary change required to operate the Village system from a single source is the opening of the pressure zone boundary along Mountain Drive (currently separating the 278 m pressure zone from the 271 m pressure zone). However, running simulations with this zone boundary open, it is immediately apparent that the headloss and elevation change throughout the system is too great to enable the Harvey 400,000 Gallon Tank (and, subsequently, the Phase 5 Tank) to supply water to the Magnesia 100,000 Gallon Tank and the surrounding distribution system at the northern-end of the system. To resolve this, it will be necessary to construct a pump station along Mountain Road (near the existing pressure zone boundary), capable of boosting water into the Magnesia 100,000 Gallon Tank. Based on an initial sizing analysis, the pump station would consist of two pumps (one duty and one standby) capable of supplying flow at approximately 5 L/s with a head gain of 11 m.

As a result of the proposed pump station, flow along Mountain Highway would increase significantly, resulting in unacceptable headlosses through the existing piping. To overcome this, it would be necessary to upgrade approximately 1.62 km of 150 mm pipe along Mountain Highway (from Phase 4 Tank to the intersection with Soundview Drive) to 200 mm. Refer to **Figure 5.7** for an overview of the required upgrades.

Please note: In conducting this analysis it is assumed that all upgrades recommended herein (see **Section 5.4**) are implemented by the 2045 planning horizon. Furthermore, the recommendations for converting the Village distribution system to a single source should be considered as conceptual-level recommendations only. Additional study would be required to properly analyze all aspects of the distribution system's response to a single source (including water quality) and to ensure that the proposed pump station sizing is optimized. The Village should understand these recommendations to be only a comment on the feasibility of supplying the Village's distribution system from a single source.

GeoAdvice Engineering Inc.

Legend

- Proposed Pump Station
- PRV Station
- Storage Tank
- Intake
- Watermain
- Proposed Watermain Upgrade

Single Source Supply Alternative Servicing

2045 Scenario

Project: Infrastructure Master Plans
Client: Village of Lions Bay, BC
Date: March 2016
Created by: SG
Reviewed by: WdS

DISCLAIMER: GeoAdvice does not warrant in any way the accuracy and completeness of the information shown on this map. Field verification of the accuracy and completeness of the information shown on this map is the sole responsibility of the user.

0 0.125 0.25 0.5
Kilometers

Figure 5.7

7.0 Recommendations Following the Study

Based upon the findings from our analysis, the following is a list of recommendations:

1. **Field Verification of Water Distribution System Information**
   - The Village should undertake verification of the existing diameter information for the proposed pipe upgrades.

2. **Hydrant Testing**
   - The Village should conduct hydrant flow and residual pressure testing to enhance the model calibration results as well as increase confidence in model accuracy.

3. **Water Quality Modeling**
   - Consideration for water quality within the distribution system should be incorporated into the model and analyzed. The water model should be calibrated using water quality field measurements. This would include incorporating the Village's water quality field data (such as chlorine concentrations) into the model.

4. **Unidirectional Flushing Program**
   - While it is understood that the Village already has a unidirectional flushing program in place, GeoAdvice could develop an optimized unidirectional flushing (UDF) program for the Village using the Village's new model. UDF consists of isolating pipe sections by closing appropriate valves and opening hydrants in an organized and sequential manner. Flushing proceeds from flushed to unflushed pipes, from larger to smaller mains, and from the source(s) to the ends of the system. GeoAdvice will create customized field maps for the Village's Operations crews to follow while carrying out the UDF program.

5. **Extended Modeling Support Services**
   - We will assist the Village in maintaining and operating the new model for a period of one (1) year from the date of completion of this assignment and update the Village of its operational status on a quarterly basis via a written status report. It is understood that during this period, we will have to respond to specific queries to model scenarios from the Village for capital planning and operational needs.

6. **Maintenance of Water System Model**
   - Ongoing development, zoning and infrastructure changes dictate that updates should be completed every year. Piping capacities should be updated where investigations indicate discrepancies from assumptions used in the model development.

Submission

Prepared by:

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Approved by:

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Senior Modeling Review / Project Manager

Appendix A Water System Components

Table A.1 summarizes the head properties input into the model.

Table A.1: Reservoir Hydraulic Modeling Data

ID	HGL (m)
RES-HARVEY_CREEK	318.25
RES-MAGNESIA_CREEK	441.00

Table A.2 summarizes the properties of each storage tank input into the model.

Table A.2: Tank Hydraulic Modeling Data

ID	Description	Bottom Elevation (m)	Minimum Level (m)	Maximum Level (m)	Equivalent Diameter (m)	Volume (ML)
TNK-HARVEY	Harvey 400,000 Gallon Tank	270.00	0	8.80	15.78	1.72
TNK-HIGHWAY	Highway Tank	72.00	0	3.35	5.48	0.08
TNK-MAGNESIA	Magnesia 100,000 Gallon Tank	273.50	0	4.40	11.28	0.44
TNK-PHASE_4	Phase IV Tank	233.70	0	2.44	6.34	0.08
TNK-PHASE_5	Phase V Tank	266.40	0	3.15	6.38	0.10

Table A.3 summarizes the properties of each PRV input into the model, with the corresponding downstream pressure setting. A PRV reduces the pressure of an inlet flow to a pre-set value (setting) should the upstream pressure exceed the intended setting. If the upstream pressure is below the setting, then flow through the valve is unrestricted. Should the pressure on the downstream end exceed the pressure on the upstream end, the valve closes to prevent reverse flow.

Table A.3: PRV Hydraulic Modeling Data

ID	From Zone HGL (m)	To Zone HGL (m)	Elevation (m)	Setting (psi)	Minor Loss (K)
PRV-1	279	229	193.63	50.00	10.00
PRV-2	229	178	153.18	35.00	10.00
PRV-3	178	107	79.09	40.00	10.00
PRV-4	236	160	119.22	57.00	10.00
PRV-5	278	202	173.83	40.00	10.00
PRV-6	229	185	153.50	45.00	10.00

ID	From Zone HGL (m)	To Zone HGL (m)	Elevation (m)	Setting (psi)	Minor Loss (K)
PRV-7	178	86	61.50	40.00	10.00
PRV-8	278	222	197.55	35.00	10.00
PRV-9	222	182	157.41	35.00	10.00
PRV-10	182	124	88.54	50.00	10.00
PRV-11	124	66	40.94	25.00	10.00
PRV-MAG	441	338	323.52	20.00	10.00
PRV-SCHOOL	202	160	131.88	Closed	10.00

Appendix B Pressure Zones

Table B.1 lists each pressure zone along with its corresponding HGL, primary imports, primary exports and primary storage.

Table B.1: Village of Lions Bay Pressure Zones

Pressure Zone	HGL (m)	Primary Imports	Primary Exports	Primary Storage
PZ 66 m	66	PRV-11	N/A	N/A
PZ 75 m	75	TNK-HIGHWAY	N/A	TNK-HIGHWAY
PZ 86 m	86	PRV-7	N/A	N/A
PZ 107 m	107	PRV-3	TNK-HIGHWAY	N/A
PZ 124 m	124	PRV-10	PRV-11	N/A
PZ 160 m	160	PRV-4	N/A	N/A
PZ 178 m	178	PRV-2	PRV-7 PRV-3	N/A
PZ 182 m	182	PRV-9	PRV-10	N/A
PZ 185 m	185	PRV-6	N/A	
PZ 202 m	202	PRV-5	N/A	N/A
PZ 222 m	222	PRV-8	PRV-9	N/A
PZ 229 m	229	PRV-1	PRV-2 PRV-6	N/A
PZ 236 m	236	TNK-PHASE_4/PZ 279	PRV-4	TNK-PHASE_4
PZ 271 m	271	TNK-PHASE_5/PZ 279	N/A	TNK-PHASE_5
PZ 278 m	278	TNK-MAGNESIA	PRV-8 PRV-5	TNK-MAGNESIA
PZ 279 m	279	TNK-HARVEY	TNK-PHASE_4 TNK-PHASE_5 PRV-1	TNK-HARVEY
PZ Harvey Supply	318	RES-HARVEY_CREEK	TNK-HARVEY	N/A
PZ Magnesia Supply	441	RES-MAGNESIA_CREEK	TNK-MAGNESIA	N/A

Appendix C Model Calibration Results

Table C.1: Field Data and Model Results

Test ID	Test Hydrant Location	Model ID	Static Pressure Measured (psi)	Static Pressure Modeled (psi)	Difference (%)
1	Tidewater Way #5	460	51	52	3%
2	Periwinkle Place #15	JCT-GA-4	49	39	21%
3	Tidewater Way #25	625	161	165	3%
4	Sweetwater Place #40	495	72	70	2%
5	Tidewater Way #75	800	66	66	0%
6	Tidewater Way #110	505	100	100	0%
7	Tidewater Way #120	505	105	100	4%
8	Upper Kelvin Grove Entrance	Invalid Reading			
9	Kelvin Grove Way #50	1115	127	129	1%
10	Kelvin Grove Way #120	785	105	108	3%
11	Kelvin Grove Arm #245	780	80	79	2%
12	Kelvin Grove Way #305	1120	80	78	2%
13	Oceanview Road #70	240	105	103	2%
14	Panorama Road #115	No Corresponding Location in Model			
15	Panorama Road #200	395	132	123	7%
16	Panorama Place #215	440	114	121	6%
17	Oceanview Road #115	385	74	80	8%
18	Oceanview Place #206	390	78	82	5%
19	Highview Place #195	515	125	110	12%
20	Highview Place #180	515	111	110	1%
21	Oceanview Road #245	940	100	100	0%
22	Oceanview Road #320	770	88	85	3%
23	Oceanview Road #370	Invalid Reading			
24	Crosscreek Road (Bridge)	225	114	115	1%
25	Centre Road #400	220	104	109	5%
26	Centre Road #350	215	107	112	4%
27	Bayview Place #375	750	152	156	3%
28	Bayview Place #315	165	135	127	6%
29	Upper Bayview Road #425	150	158	157	0%
30	Upper Bayview Road #465	755	140	138	1%
31	Upper Bayview Road #515	145	112	109	2%
32	Upper Bayview Road #535	135	86	85	1%

Test ID	Test Hydrant Location	Model ID	Static Pressure Measured (psi)	Static Pressure Modeled (psi)	Difference (%)
33	Bayview Road #380	170	81	85	6%
34	Bayview Road #325	725	102	105	3%
35	Bayview Road #265	720	87	96	10%
36	Bayview Road #255	1070	64	66	4%
37	Bayview Road #247	195	90	81	10%
38	Stewart Road #255	185	70	64	8%
39	Bayview Road #233	210	43	40	7%
40	Bayview Road & Mountain Drive	90	118	115	3%
41	Mountain Drive #260	1065	115	112	3%
42	Mountain Drive #290	715	78	96	24%
43	Mountain Drive #350	1135	75	97	29%
44	Timbertop Road #420	95	88	90	2%
45	Mountain Drive #425	100	98	114	16%
46	Timbertop Road #465	105	69	70	2%
47	Timbertop Road #415	555	59	50	15%
48	Mountain Drive #145	1140	100	95	5%
49	Mountain Drive #115	35	90	86	5%
50	Sunset Drive #49	570	64	60	7%
51	Sunset Drive #85	30	75	77	3%
52	Lions Bay Ave. & Cloudview Place	JCT-GA-44	42	40	6%
53	Lions Bay Avenue #15	JCT-GA-42	55	62	13%
54	Seaview Place #60	JCT-GA-46	65	67	3%
55	Seaview Place #150	JCT-GA-47	76	71	6%
56	Lions Bay Avenue #70	JCT-GA-39	87	85	2%
57	Lions Bay Avenue #120	No Corresponding Location in Model			
58	Lions Bay Avenue #210	JCT-GA-38	95	90	6%
59	Lions Bay Avenue #270	JCT-GA-35	97	91	6%
60	Isleview Place #45	J34	62	59	5%
61	Isleview Place #75	355	71	68	4%
62	Isleview Place #135	J32	90	87	4%
63	Isleview Place #100	J30	112	106	6%
64	Soundview Road	No Corresponding Location in Model			
65	Fire Training Area	Location Too Vague to Locate Hydrant Position			
66	Crystal Falls	Location Too Vague to Locate Hydrant Position			
67	Brunswick Beach #53	40	63	65	3%

Test ID	Test Hydrant Location	Model ID	Static Pressure Measured (psi)	Static Pressure Modeled (psi)	Difference (%)
68	Brunswick Beach #39	No Corresponding Location in Model			
69	Brunswick Beach #27	45	76	76	1%
70	Brunswick Beach #8	60	73	75	2%
71	Brunswick Beach #16	70	76	78	3%

Appendix D PRV Capacity Analysis Results

Table D.1: PRV Capacity Analysis Results (PHD Velocity)

ID	Existing Velocity (m/s)	2020 Velocity (m/s)	2025 Velocity (m/s)	2045 Velocity (m/s)
PRV-1	0.71	0.73	0.75	0.85
PRV-2	0.97	1.00	1.03	1.16
PRV-3	0.35	0.36	0.37	0.42
PRV-4	0.17	0.18	0.19	0.21
PRV-5	0.17	0.18	0.19	0.21
PRV-6	0.22	0.23	0.23	0.26
PRV-7	0.57	0.59	0.60	0.68
PRV-8	0.19	0.20	0.21	0.23
PRV-9	0.19	0.20	0.21	0.23
PRV-2	0.97	1.00	1.03	1.16
PRV-10	0.14	0.14	0.14	0.16
PRV-11	0.14	0.14	0.14	0.16
PRV-MAG*	0.00	0.00	0.00	0.00
PRV-SCHOOL	0.00	0.00	0.00	0.00

*TNK-MAGNESIA assumed full for purpose of steady-state analysis.

Appendix E Existing Fire Flow Capacity Results (No Upgrades)

Table E.1: Existing Available Fire Flow Capacity @ 20 psi (Model Predictions)

Hydrant Location	Predicted Fire Flow Capacity (L/s)
Bayview Place #315	45.09
Bayview Place #375	59.84
Bayview Road #233	63.38
Bayview Road #247	66.49
Bayview Road #255	29.57
Bayview Road #265	45.74
Bayview Road #325	54.98
Bayview Road #380	60.78
Bayview Road & Mountain Drive	84.97
Bayview Road (Near Lions Bay Primary)	20.80
Brunswick Beach #16	115.40
Brunswick Beach #27	122.78
Brunswick Beach #53	125.16
Brunswick Beach #8	120.72
Brunswick Beach Road (South-East End)	85.88
Centre Road #350	22.77
Centre Road #400	59.98
Construction Staging Area (End)	105.76
Crosscreek Road (Bridge)	59.12
Crosscreek Road (In Shopping Center)	58.25
Crystal Falls Road (Near Entrance to Staging Ground)	109.41
Highview Place #195	56.02
Highview Place (Near Oceanview Rd)	81.89
Isleview Place #100	48.00
Isleview Place #135	48.32
Isleview Place #45	43.44
Isleview Place #75	45.23
Isleview Place (End)	46.25
Kelvin Grove Arm #245	54.21
Kelvin Grove Way #120	72.23
Kelvin Grove Way #305	63.85
Kelvin Grove Way #50	99.20
Lions Bay Ave #250	57.54
Lions Bay Ave. & Cloudview Place	33.23
Lions Bay Avenue #15	50.02

Hydrant Location	Predicted Fire Flow Capacity (L/s)
Lions Bay Avenue #210	60.84
Lions Bay Avenue #270	51.73
Lions Bay Avenue #70	62.54
Mountain Drive #115	126.17
Mountain Drive #145	105.55
Mountain Drive #260	71.72
Mountain Drive #290	58.44
Mountain Drive #290	64.61
Mountain Drive #350	71.41
Mountain Drive #425	78.52
Near Crystal Falls Rd #1	128.19
Oceanview Place #206	85.20
Oceanview Road #115	115.94
Oceanview Road #245	218.67
Oceanview Road #270-#292	214.23
Oceanview Road #320	234.52
Oceanview Road #70	119.04
Panorama Place #215	68.59
Panorama Road #200	84.97
Periwinkle Place #15	57.37
Seaview Place #150	48.67
Seaview Place #60	52.09
Stewart Road #255	57.83
Sunset Drive #49	124.97
Sunset Drive #85	125.50
Sunset Drive (South End)	62.41
Sweetwater Place #40	80.22
Tidewater Way #110/120	78.78
Tidewater Way #25	127.95
Tidewater Way #5	75.26
Tidewater Way #75	77.90
Tidewater Way (Near CN)	78.04
Tidewater Way (Near Kelvin Grove Way)	81.58
Timbertop Road #415	50.51
Timbertop Road #420	78.37
Timbertop Road #465	77.14
Upper Bayview Road #425	67.29
Upper Bayview Road #465	71.93

Hydrant Location	Predicted Fire Flow Capacity (L/s)
Upper Bayview Road #515	72.62
Upper Bayview Road #535	67.14

It is assumed that the Village requires a minimum of 60 L/s to meet fire flow requirements.

A2. Sewer Collection System - Model Development and Capacity Analysis - Technical Memorandum

The Village of Lions Bay
Sewer Collection System
Model Development and Capacity Analysis

Draft Technical Memorandum

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Re: Project 2015-031-LIO

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R1	January 13, 2016	Second Draft	Sean Geyer	Werner de Schaetzen
R2	January 14, 2016	Second Draft	Sean Geyer	Werner de Schaezten
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Statement of Qualifications and Limitations

This document represents GeoAdvice Engineering Inc. best professional judgment based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinary exercised by member of the engineering profession currently practicing under similar conditions. No warranty, express or implied is made.

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1.0 Introduction

GeoAdvice Engineering Inc. was retained by the Village of Lions Bay, BC to develop a comprehensive "all pipes" hydraulic model of the Village of Lions Bay (Village) sanitary sewer collection system. This memo describes the methodology and assumptions used to build and analyze the hydraulic model. **Table 1.1** summarizes the main components of the sewer collection system model.

Table 1.1: Model Statistics of Existing Sewer Collection System

Component	Total
Gravity Mains	49 (2.2 km)
Manholes	49
Sewage Catchment Area	19.2 ha

The sewer model was developed using the InfoSewer (Innovyze) software program. InfoSewer is a sewer collection system modeling and management software application.

The Village sewer collection system services a population of about 257 people. The existing system is composed of 49 gravity mains, 49 manholes and one waste water treatment plant (WWTP). Refer to **Figure C.1** for an overview of the existing sanitary system.

2.0 Development of the Hydraulic Model

Development of the hydraulic model was divided into multiple tasks to ensure the model is representative of the "real" sewer collection system. In sequential order and as discussed in detail below, these tasks include:

- Task 1: Data collection and review
- Task 2: GIS pipe data conversion
- Task 3: Primary system components import
- Task 4: Node elevation extraction
- Task 5: Load calculation and allocation
- Task 6: Load scenario development

2.1 Data Collection and Review

Prior to developing the model, information on the Village sewer system was compiled, collected and reviewed. This included reviewing the following pertinent information:

- GIS database
- Access database
- Land-use and zoning maps
- Village's water model demands
- Meeting with Village Operations Staff

2.2 GIS Pipe Data Conversion

The Village's GIS database (received on August 11, 2015) was the primary source of up-to-date information on the system to build the pipe and node topology model. Attributes of the gravity mains, such as length, diameter and slope were extracted from the GIS database.

Pipe inverts were supplied through the Village's GIS database. Manhole rim elevations were supplied through the GIS database, and have been augmented by interpolating from elevation contours where rim elevations were not available.

The model represents a one-to-one match with the Village's GIS database complete with matching unique identification numbers for each asset. Some additional entities have been added to the model in order to satisfy the software requirements for system operation and continuity. The coordinate system used for building the model is UTM NAD 1983 Zone 10N.

2.3 Primary System Components

One of the most important tasks associated with model development is incorporating boundary conditions and all system components. Detailed information on all of the Village's components was input into the model. A list of modeling assumptions for the manholes and pipes is shown in **Table 2.1** below.

Table 2.1: Manhole and Pipe Modeling Data Assumptions

Component	Assumptions
Manhole	Diameter = 1.20 m Headloss = 0
Pipe	Roughness = 0.011 Inverts = GIS Diameter = GIS Length = GIS

2.4 Node Elevation Extraction

An elevation contour shapefile was provided by the Village. Missing rim elevations were then interpolated using GIS tools and assigned to the manholes.

2.5 Load Calculation and Allocation

The next step was the calculation and allocation of sewer loadings. Based on treatment plant data provided by the Village and AECOM, (*wwtp flows.xlsx*, dated September 10, 2015) it was determined that the average dry weather flow (ADWF) at the treatment plant is approximately 200 m^3/day. It should be noted that, while this value appears high, the flow monitoring data provided by the Village is not useable for system analysis as there are too many errors, data gaps, and questionable flow trends. As such, there is no other flow data available for the sanitary system.

Loading data for the existing scenario is summarized in **Table 2.2**.

Table 2.2: Existing Scenario Loading Summary

Criteria	Value
Existing Population*	**257 people**
ADWF	**2.31 L/s** (200 m^3/day)
ADWF/capita	**778 L/day/cap**
Peaking Factor (Harmon)	**4.1**
Peak Dry Weather Flow (PDWF)	ADWF x 4.1 = **9.51 L/s**
Inflow and Infiltration (I&I) Rate**	**15,000 L/ha/day**
Existing Catchment Area	**19.2 ha**
I&I Load	**3.33 L/s**
Peak Wet Weather Flow (PWWF)	PDWF + I&I = **12.85 L/s**

*Calculated based on the known number of service connections and the 2011 Census residential density estimates.
**Taken from the District of Squamish Bylaws.

2.6 Existing Demand Scenarios Development

To assess the existing sewer collection system, multiple modeling scenarios were created. The complete list of existing modeling scenarios are:

- 2015-ADWF, Average Dry Weather Flow Simulation
- 2015-PWWF, Peak Wet Weather Flow Simulation

3.0 Future Modeling Scenario Development

In consultation with the Village, three (3) future modeling scenarios were developed. **Table 3.1** provides a summary of the scenarios to be modeled.

Table 3.1: Summary of Modeling Scenarios

Scenario	Description
2015-PWWF	Existing configuration servicing 257 people.
2020-PWWF	Future configuration servicing a total population of approximately 270 people.
2025-PWWF	Future configuration servicing a total population of approximately 283 people.
2045-PWWF	Ultimate future scenario population of approximately 344 people.

This study considered population growth from 2015 to 2045. The population in 2015 is considered to be the existing base scenario, with 2045 being the future build-out scenario.

Load and population projections were calculated by the Village based on a 5% growth rate every five years. While this differs from the Village's projected growth rate of 3% per five-year period, this rate was chosen to compensate for many of the unknowns in the system, especially at the treatment plant.

3.1 Future Sewer Load Calculations

The load rates in the table below were used based on discussions with the Village.

Table 3.2: Future Demand Rates

Type	Value
Average Dry Weather Flow (ADWF)	778 L/cap/day
PWWF/ADWF (Harmon)	4.1

The future population growth provided by the Village is summarized in **Table 3.3** below.

Table 3.3: 2015 to 2045 Population Growth

Growth Type	Growth
Population Growth to 2020	+13
Population Growth to 2025	+26
Population Growth to 2045	+87

4.0 System Capacity Analysis

This section summarizes the system capacity analysis of the existing system under existing PWWF conditions. Based on the Village's design specifications and discussions with the Village, the criteria shown in **Table 4.1** were used.

Table 4.1: Design Criteria

Criteria	Parameter Value
Design Flow	2045 PWWF
Pipe Deficiency	d/D = 1.0
Criteria for Pipe Upgrades (New Pipes):	
Maximum Capacity	d/D < 0.5
Roughness coefficient	n = 0.013
Minimum pipe diameter	d = 200 mm
Slope	existing slope

Note: d/D = water depth over pipe diameter

The objectives of the assessment were to review the existing system performance under the existing and future flows, and to make recommendations on system upgrades.

As the model only runs steady-state simulations, the model assumes that the peak flows occur at the same time with no delay, attenuation, or storage. Therefore, the assessment of the gravity main capacities is conservative.

4.1 Gravity Main Capacity Analysis

The existing and 2025 scenario model results identified zero (0) deficient (d/D = 1) gravity mains under PWWF conditions.

The model was further used to predict the 2045 system performance. The future scenario model results identified zero (0) deficient (d/D = 1) gravity mains, even under the exceedingly conservative loading, population growth and simulation assumptions.

Based on these results, no system upgrades are necessary to meet the Village's design criteria.

4.2 Sanitary Sewer Expansion Scenario (Servicing the Whole Village)

At the request of the Village, modeling was also completed for a potential 2045 system expansion scenario. For the system expansion scenario, it was assumed that the entire Village would be connected to the existing treatment plant. Refer to **Figure C.2** and AECOM's sanitary system expansion plan for additional details on the proposed service area.

A GIS database of the potential system expansion was developed by AECOM and provided to GeoAdvice to build the pipe and node topology of the expansion scenario. Attributes of the gravity mains, such as length, were extracted from the GIS database. Manhole rim elevations were assigned by interpolating from elevation contours. Pipe inverts were initially assumed based a standard depth of cover (1 m) and were later adjusted to allow for gravity flow, where appropriate. All manholes and pipes were assigned unique ID's consistent with the naming convention in the existing system. Additional entities, such as lift stations and wet wells, were added to the model for system operation and continuity. Pumps were assumed to operate as "ideal" pumps (flow-in is equal to flow-out). Wet well sizing was not considered within the scope of this study. It was determined that five lift stations would be required to realize full-system expansion.

Due to the loading uncertainty inherent in this potential expansion scenario, it was assumed that the expanded sanitary sewer system would service the same 2045 population as the Village's water distribution system, with the addition of a potential development in the Brunswick Beach area consisting of approximately 100 people. System loading was calculated based on an 80% conversion rate from the Village's water demands and distributed equally to all manholes in the sanitary sewer expansion. Furthermore, the potential catchment area for the sanitary sewer expansion area was calculated from the Village's GIS parcel data and I&I loading derived based on the assumption of 15,000 L/day/Ha. I&I loads were applied evenly to all manholes in the sanitary sewer expansion.

Loading data for the expansion scenario is summarized in **Table 4.2**.

Table 4.2: Expansion Scenario Load Calculation Parameters

Parameter	Value
2045 Population	**1,574 + 100 (Brunswick Beach Development)**
2045 ADD (from Water Model)	**13.44 L/s**
Conversion Rate from Water Demand	**80%**
ADWF	**10.75 L/s**
ADWF/capita	**590 L/cap/day**
ADWF (Brunswick Beach Development)	**0.68 L/s**
Peaking Factor (Harmon)	**3.6**
PDWF	ADWF x 3.6 = **41.67 L/s**
I&I Rate	**15,000 L/ha/day**
Potential Catchment Area	**115.4 ha**
I&I Load	**20.03 L/s**
PWWF	PDWF + I&I = **61.70 L/s**

Following the development of the expansion model and scenario, a sizing analysis was conducted on the potential expansion system under PWWF conditions. Under the assumption that 200 mm is the minimum possible diameter for a new gravity main, it was determined that sizing all pipes in the expansion system to a nominal diameter of 200 mm would satisfy the d/D < 0.5 criteria for new pipes, for all but two pipes in the system. The two exceptions (88 m total length), requiring a diameter of 250 mm, occur immediately upstream of the proposed Lift Station near Lions Bay Beach and the three way intersection of Lions Bay Avenue. For the purposes of this study, it was assumed that all forcemains were 150 mm diameter; however, this would likely change following the proper sizing of the required pump stations and wet wells (beyond the scope of the current project) without impacting the recommended sizing of the gravity mains.

5.0 Conclusion

GeoAdvice successfully developed a sanitary sewer model of the Village's existing sanitary sewer system and a proposed full-system expansion. Based on the analysis of existing and future peak wet-weather flow conditions, we have developed the following conclusions:

- There are zero (0) capacity deficiencies present in the existing system under existing loading conditions.
- There are zero (0) capacity deficiencies present in the existing system under predicted 2045 loading conditions.
- Based on the model results and assumptions documented herein, the existing sanitary sewer system does not require any upgrades at this time or at the 2025 planning horizon.
- AECOM's proposed sanitary system expansion plan is feasible. The plan would require the construction of five (5) lift stations, a considerable network of forecemains (3.2 km), 12 km of 200 mm gravity mains and 88 m of 250 mm gravity mains.
- Further studies will be required to properly size the required lift stations, wet wells and forcemains.

6.0 Recommendations Following the Study

Based upon the findings from our analysis, the following is a list of recommendations:

1. **Flow Monitoring Program**
   - It is recommended that the Village undertakes additional data monitoring in order to confirm the accuracy of the model results. A new, permanent flow monitor capable of taking readings every one to five minutes at the WWTP inlet would be ideal. This is critical as the existing monitor is not useable for conducting system capacity analyses.

2. **Extended Modeling Support Services**
   - We will assist the Village in maintaining and operating the new model for a period of one (1) year from the date of completion of this assignment and update the Village of its operational status on a quarterly basis via a written status report. It is understood that during this period, we will have to respond to specific queries to model scenarios from the Village for capital planning and operational needs.

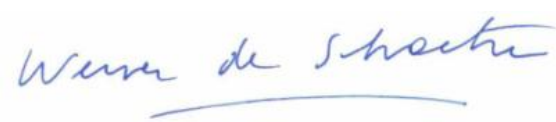
3. **Maintenance of Sewer System Model**
   - Ongoing development, zoning and infrastructure changes dictate that updates should be completed every year. Piping capacities should be updated where investigations indicate discrepancies from assumptions used in the model development.

Submission

Prepared by:

Sean Geyer, E.I.T.
Hydraulic Modeler / Project Engineer

Approved by:



Werner de Schaetzen, Ph.D., P.Eng.
Senior Modeling Review / Project Manager

Appendix A Existing System Model Output Results

	d/D			
Pipe ID	**2015 PWWF**	**2020 PWWF**	**2025 PWWF**	**2045 PWWF**
PPE-0	0.137	0.140	0.142	0.153
PPE-1	0.205	0.209	0.213	0.229
PPE-2	0.037	0.038	0.039	0.041
PPE-3	0.040	0.041	0.041	0.045
PPE-4	0.068	0.069	0.070	0.075
PPE-5	0.215	0.219	0.223	0.241
PPE-6	0.062	0.063	0.064	0.069
PPE-7	0.031	0.032	0.032	0.035
PPE-8	0.042	0.043	0.043	0.047
PPE-9	0.052	0.053	0.054	0.058
PPE-10	0.045	0.046	0.047	0.050
PPE-11	0.070	0.071	0.072	0.077
PPE-12	0.059	0.060	0.061	0.066
PPE-13	0.157	0.160	0.162	0.175
PPE-14	0.171	0.174	0.177	0.191
PPE-15	0.176	0.179	0.182	0.197
PPE-16	0.169	0.172	0.175	0.188
PPE-17	0.212	0.216	0.220	0.237
PPE-18	0.099	0.101	0.103	0.111
PPE-19	0.101	0.103	0.105	0.112
PPE-20	0.141	0.144	0.146	0.158
PPE-21	0.136	0.139	0.141	0.152
PPE-22	0.067	0.068	0.069	0.075
PPE-23	0.065	0.066	0.067	0.072
PPE-24	0.043	0.043	0.044	0.047
PPE-25	0.036	0.036	0.037	0.040
PPE-26	0.085	0.087	0.088	0.095
PPE-27	0.094	0.096	0.097	0.104
PPE-28	0.213	0.217	0.221	0.238
PPE-29	0.182	0.185	0.189	0.203
PPE-30	0.164	0.167	0.170	0.183
PPE-31	0.044	0.044	0.045	0.049

	d/D			
Pipe ID	**2015 PWWF**	**2020 PWWF**	**2025 PWWF**	**2045 PWWF**
PPE-32	0.040	0.041	0.042	0.045
PPE-33	0.031	0.031	0.032	0.034
PPE-34	0.046	0.047	0.047	0.051
PPE-35	0.051	0.052	0.053	0.057
PPE-36	0.064	0.065	0.066	0.071
PPE-37	0.070	0.071	0.073	0.078
PPE-38	0.127	0.129	0.131	0.141
PPE-39	0.048	0.049	0.050	0.053
PPE-40	0.052	0.053	0.054	0.058
PPE-41	0.037	0.038	0.039	0.042
PPE-42	0.043	0.044	0.045	0.048
PPE-43	0.054	0.055	0.056	0.060
PPE-44	0.059	0.060	0.061	0.065
PPE-45	0.062	0.063	0.065	0.070
PPE-46	0.067	0.068	0.070	0.075
PPE-47	0.069	0.070	0.071	0.076
PPE-48	0.028	0.029	0.029	0.031

Appendix B System Expansion Model Output Results

Pipe ID	2045 Expansion PWWF d/D	Pipe ID	2045 Expansion PWWF d/D	Pipe ID	2045 Expansion PWWF d/D
PPE-0	0.299	PPE-32	0.042	PPE-64	0.134
PPE-1	0.470	PPE-33	0.032	PPE-65	0.029
PPE-2	0.039	PPE-34	0.048	PPE-66	0.059
PPE-3	0.042	PPE-35	0.054	PPE-67	0.062
PPE-4	0.071	PPE-36	0.067	PPE-68	0.145
PPE-5	0.507	PPE-37	0.073	PPE-69	0.165
PPE-6	0.065	PPE-38	0.133	PPE-70	0.038
PPE-7	0.033	PPE-39	0.050	PPE-71	0.088
PPE-8	0.044	PPE-40	0.055	PPE-72	0.085
PPE-9	0.054	PPE-41	0.039	PPE-73	0.102
PPE-10	0.336	PPE-42	0.045	PPE-74	0.104
PPE-11	0.740*	PPE-43	0.057	PPE-75	0.113
PPE-12	1.000*	PPE-44	0.061	PPE-76	0.118
PPE-13	0.368	PPE-45	0.064	PPE-77	0.113
PPE-14	0.423	PPE-46	0.069	PPE-78	0.111
PPE-15	0.443	PPE-47	0.071	PPE-79	0.175
PPE-16	0.176	PPE-48	0.030	PPE-80	0.172
PPE-17	0.222	PPE-49	0.037	PPE-81	0.177
PPE-18	0.104	PPE-50	0.044	PPE-82	0.221
PPE-19	0.106	PPE-51	0.057	PPE-83	0.035
PPE-20	0.148	PPE-52	0.058	PPE-84	0.044
PPE-21	0.142	PPE-53	0.074	PPE-85	0.057
PPE-22	0.070	PPE-54	0.077	PPE-86	0.063
PPE-23	0.068	PPE-55	0.094	PPE-87	0.088
PPE-24	0.045	PPE-56	0.082	PPE-88	0.072
PPE-25	0.037	PPE-57	0.092	PPE-89	0.085
PPE-26	0.089	PPE-58	0.116	PPE-90	0.110
PPE-27	0.098	PPE-59	0.035	PPE-91	0.057
PPE-28	0.223	PPE-60	0.101	PPE-92	0.075
PPE-29	0.191	PPE-61	0.140	PPE-93	0.112
PPE-30	0.172	PPE-62	0.145	PPE-94	0.109
PPE-31	0.046	PPE-63	0.159	PPE-95	0.122

Pipe ID	2045 Expansion PWWF d/D	Pipe ID	2045 Expansion PWWF d/D	Pipe ID	2045 Expansion PWWF d/D
PPE-96	0.128	PPE-130	0.036	PPE-169	0.040
PPE-97	0.049	PPE-131	0.051	PPE-170	0.048
PPE-98	0.052	PPE-132	0.102	PPE-171	0.201
PPE-99	0.060	PPE-137	0.183	PPE-172	0.192
PPE-100	0.041	PPE-138	0.050	PPE-173	0.201
PPE-101	0.051	PPE-139	0.043	PPE-174	0.210
PPE-102	0.140	PPE-140	0.062	PPE-175	0.041
PPE-103	0.057	PPE-141	0.093	PPE-176	0.094
PPE-104	0.063	PPE-142	0.419	PPE-177	0.095
PPE-105	0.062	PPE-143	0.032	PPE-178	0.122
PPE-106	0.049	PPE-144	0.040	PPE-179	0.141
PPE-107	0.067	PPE-145	0.242	PPE-180	0.076
PPE-108	0.086	PPE-146	0.248	PPE-181	0.078
PPE-109	0.155	PPE-147	0.286	PPE-182	0.073
PPE-110	0.150	PPE-148	0.495	PPE-183	0.274
PPE-111	0.222	PPE-149	0.055	PPE-184	0.051
PPE-112	0.219	PPE-150	0.173	PPE-185	0.053
PPE-113	0.231	PPE-151	0.175	PPE-186	0.083
PPE-114	0.237	PPE-152	0.054	PPE-187	0.064
PPE-115	0.252	PPE-153	0.117	PPE-188	0.155
PPE-116	0.110	PPE-155	0.122	PPE-189	0.161
PPE-117	0.089	PPE-156	0.100	PPE-190	0.183
PPE-118	0.091	PPE-157	0.042	PPE-191	0.092
PPE-119	0.042	PPE-158	0.057	PPE-194	0.490
PPE-120	0.149	PPE-159	0.052	PPE-195	0.195
PPE-121	0.161	PPE-160	0.058	PPE-196	0.597*
PPE-122	0.181	PPE-161	0.064	PPE-197	0.111
PPE-123	0.169	PPE-162	0.109	PPE-198	0.090
PPE-124	0.035	PPE-163	0.296	PPE-199	0.056
PPE-125	0.063	PPE-164	0.059	PPE-200	0.045
PPE-126	0.044	PPE-165	0.076	PPE-201	0.055
PPE-127	0.042	PPE-166	0.106	PPE-202	0.121
PPE-128	0.052	PPE-167	0.125	PPE-203	0.032
PPE-129	0.063	PPE-168	0.209	PPE-206	0.117

Pipe ID	2045 Expansion PWWF d/D
PPE-207	0.118
PPE-208	0.114
PPE-209	0.090
PPE-210	0.095
PPE-211	0.049
PPE-212	0.062
PPE-213	0.105
PPE-214	0.083
PPE-215	0.064
PPE-216	0.051
PPE-217	0.091

*Results indicate a pipe immediately upstream of a wet well or downstream of a forcemain and are not indicative of capacity deficiencies.

Appendix C System Overview Maps

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

GeoAdvice Engineering Inc.

Legend

- Manhole
- Treatment Plant
- Gravity Main

Existing Sanitary Sewer System Overview

Project: Infrastructure Master Plans
Client: Village of Lions Bay, BC
Date: January 2016
Created by: SG
Reviewed by: WdS

DISCLAIMER: GeoAdvice does not warrant in any way the accuracy and completeness of the information shown on this map. Field verification of the accuracy and completeness of the information shown on this map is the sole responsibility of the user.

0 30 60 120
Meters

N E S W

Figure C.1

GeoAdvice Engineering Inc.

Legend

- Lift Station
- Manhole
- Treatment Plant
- Gravity Main
- Forcemain

Proposed Full System Expansion Sanitary Sewer System Overview

Project:	Infrastructure Master Plans
Client:	Village of Lions Bay, BC
Date:	January 2016
Created by:	SG
Reviewed by:	WdS

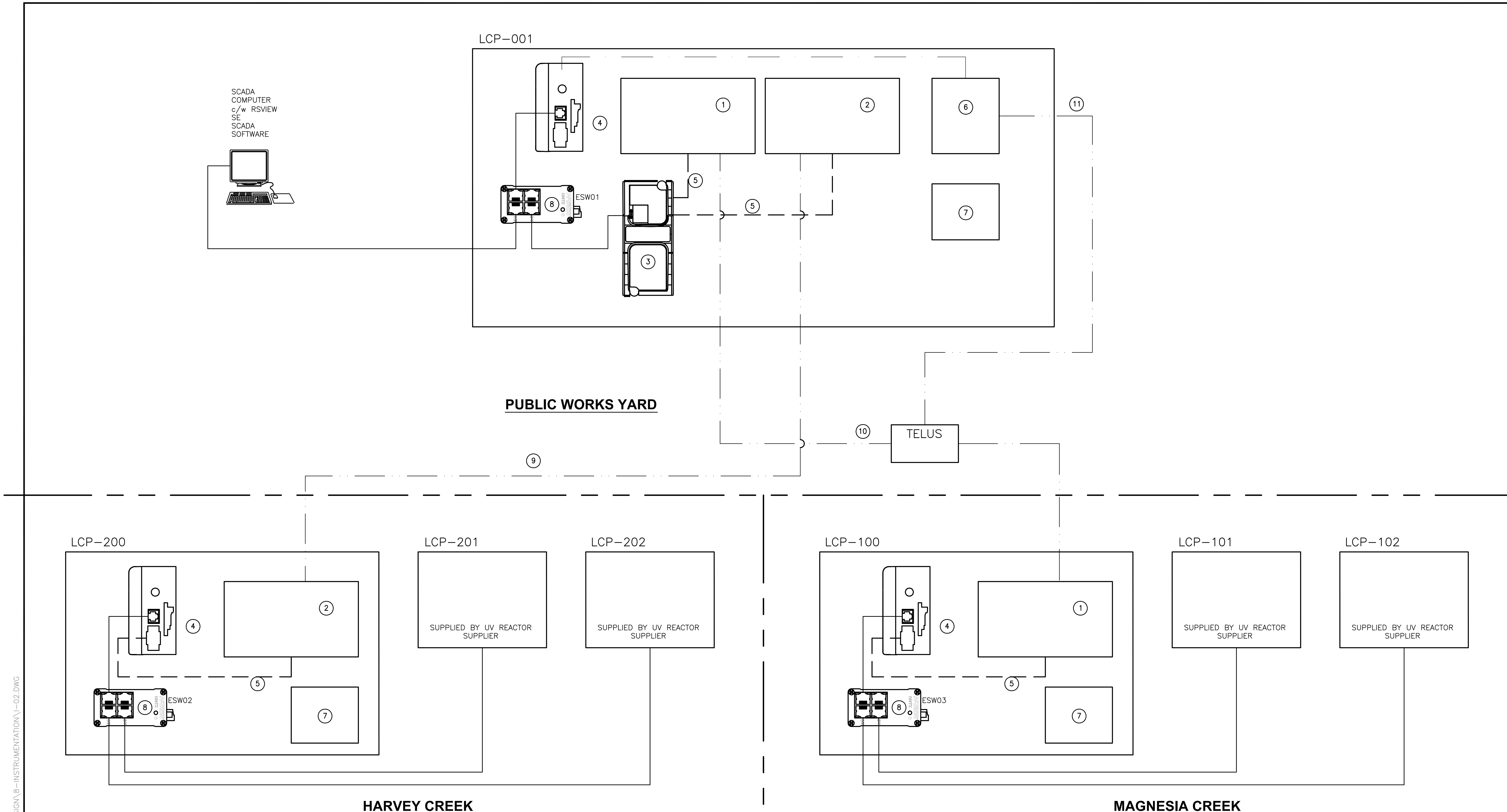
0 0.125 0.25 0.5
Kilometers

Figure C.2

Appendix B

Water System SCADA Architecture P&IDs

B1. Existing SCADA Architecture



CONTROL SYSTEM ARCHITECTURE

ITEM	DESCRIPTION	REFERENCE MANUFACTURER	NOTES
1	DIAL-UP MODEM (EXTENDED TEMP.)	DATA-LINC DLM4000/DL/AADB	(MODEM SETUP FOR AUTO ANSWER/DIAL BACK)
2	LEASED LINE MODEM	DATA-LINC DLM4500	
3	EtherNet/IP TO DF1 GATEWAY	PROSOFT 5202-DFNT-DFCM4	
4	PLC	ALLEN-BRADLEY COMPACTLOGIX (REFER TO SPECIFICATION 17600)	
5	SERIAL CABLE		CROSSOVER
6	ALARM DIALER	BARNETT PROTALK PLUS B1290 PLUS	c/w EXTENDER
7	UPS	LIEBERT GXT 700VA	c/w INTERFACE CARD FOR RELAY CONTACTS
8	ETHERNET SWITCH	N-TRON 104TX	
9	EXISTING LEASED LINE		
10	EXISTING PHONE LINE		
11	NEW PHONE LINE	BY OWNER	

GENERAL NOTES:

1. SCADA COMPUTER TO BE POWERED BY UPS.

LEGEND:

1. * – EXISTING EQUIPMENT
2. — - — - – HARDWIRED
3. ———— – ETHERNET CAT5
4. – – – – – SERIAL DF1
5. — · — · – PHONE LINE – DIAL-UP OR LEASED

VERIFY SCALE IF PLAN SHEET IS REDUCED — 30 CM

REV	DESCRIPTION	DRN	CHK	DATE (Y/M/D)
1	ISSUED FOR CONSTRUCTION	PJY	NWB	2009/05/04
0	ISSUED FOR TENDER	KSB	PS	2009/03/26

DRN BY: KSB
DES BY: DB
CHK BY: PS
APP BY: KM

PREPARED FOR: THE MUNICIPALITY OF THE VILLAGE OF LIONS BAY

PREPARED BY: AECOM

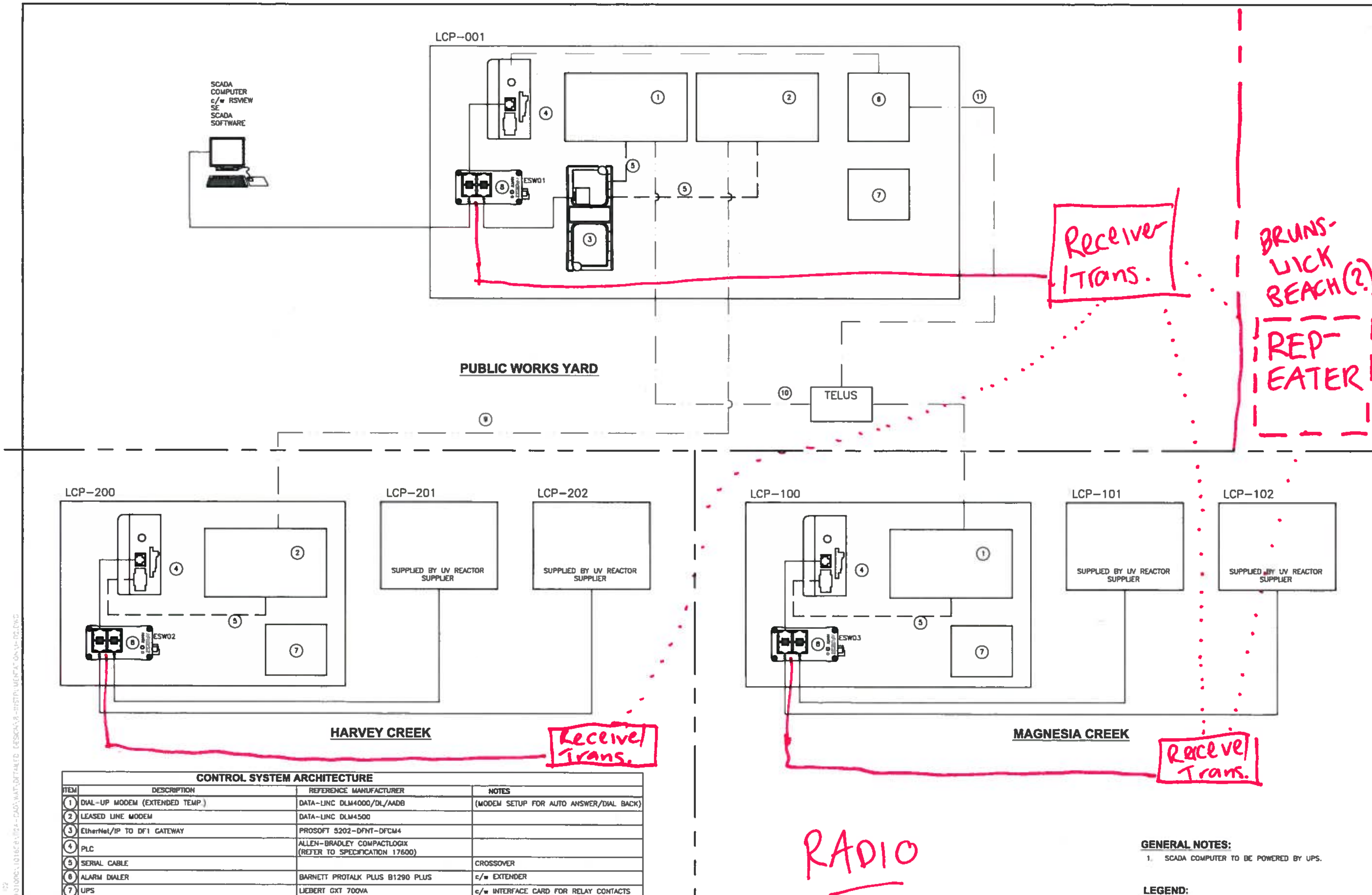
VILLAGE OF LIONS BAY WATER TREATMENT UPGRADES LIONS BAY, B.C.

INSTRUMENTATION SYSTEM ARCHITECTURE

PROJECT START DATE (M / Y): NOV / 2007
PROJECT NO.: 101658
FILENAME: I-02.dwg
SHEET NO.:
DRAWING NO.: I-02

Plotted By: vonigf
Plot File Date Created: May/11/2010 9:53 AM
Layout-Sheet Name: I02
Filename: L:\WORK\101000\101658\02A-CAD\WAT\DETAILED DESIGN\8-INSTRUMENTATION\I-02.DWG
RELEASE 2.0 (JULY 2008)

B2. Future SCADA Architecture



CONTROL SYSTEM ARCHITECTURE

ITEM	DESCRIPTION	REFERENCE MANUFACTURER	NOTES
1	DIAL-UP MODEM (EXTENDED TEMP.)	DATA-LINC DLM4000/DL/AADB	(MODEM SETUP FOR AUTO ANSWER/DIAL BACK)
2	LEASED LINE MODEM	DATA-LINC DLM4500	
3	EtherNet/IP TO DF1 GATEWAY	PROSOFT 5202-DFNT-DFCM4	
4	PLC	ALLEN-BRADLEY COMPACTLOGIX (REFER TO SPECIFICATION 17600)	
5	SERIAL CABLE		CROSSOVER
6	ALARM DIALER	BARNETT PROTALK PLUS B1290 PLUS	c/w EXTENDER
7	UPS	LIEBERT GXT 700VA	c/w INTERFACE CARD FOR RELAY CONTACTS
8	ETHERNET SWITCH	N-TRON 104TX	
9	EXISTING LEASED LINE		
10	EXISTING PHONE LINE		
11	NEW PHONE LINE	BY OWNER	

GENERAL NOTES:

1. SCADA COMPUTER TO BE POWERED BY UPS.

LEGEND:

1. • - EXISTING EQUIPMENT
2. - HARDWIRED
3. - ETHERNET CAT5
4. - SERIAL DF1
5. - PHONE LINE - DIAL-UP OR LEASED

PREPARED FOR: THE MUNICIPALITY OF THE VILLAGE OF LIONS BAY

PREPARED BY: AECOM

VILLAGE OF LIONS BAY
WATER TREATMENT UPGRADES
LIONS BAY, B.C.

INSTRUMENTATION
SYSTEM ARCHITECTURE

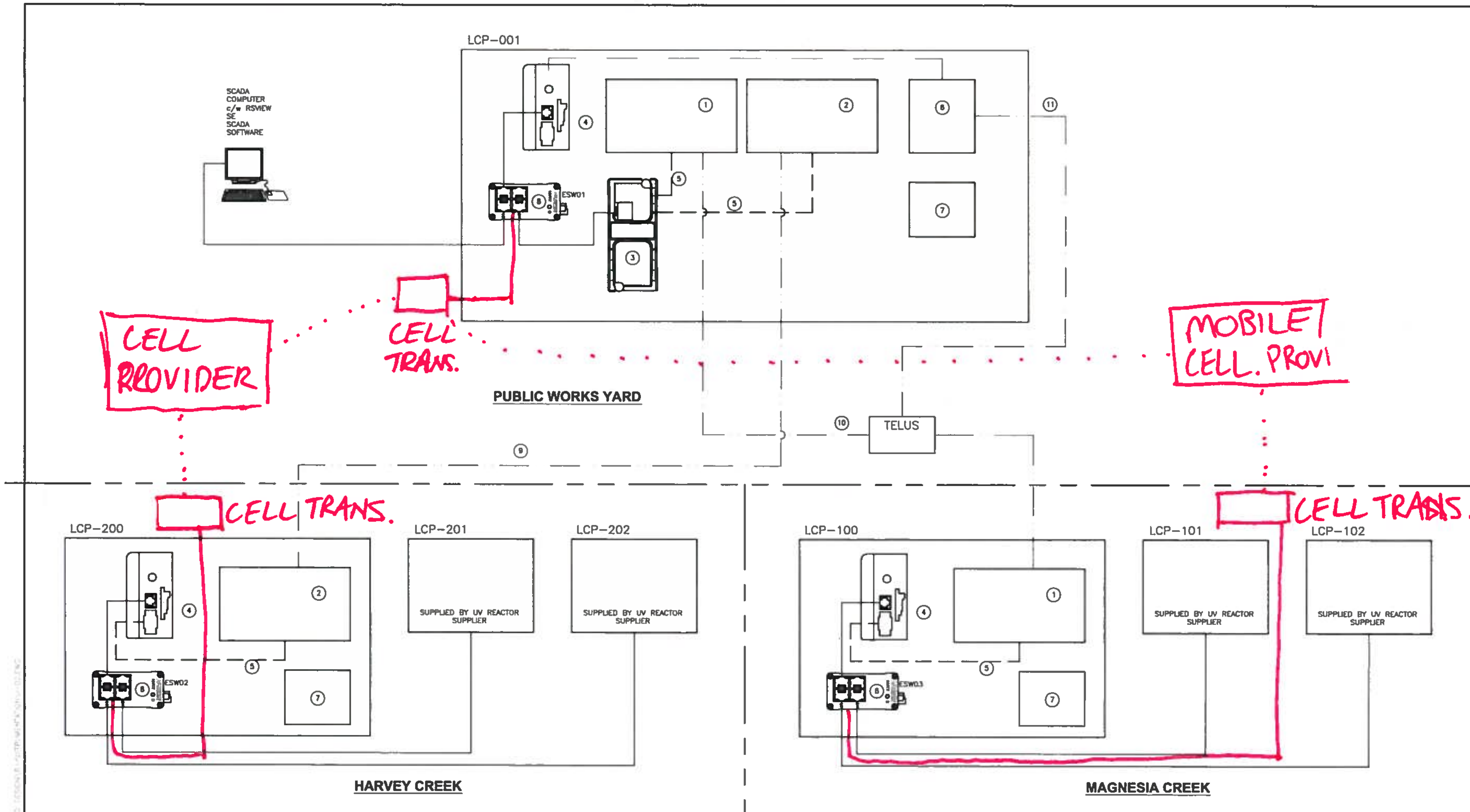
REV	DESCRIPTION	DWN	CHK	DATE (Y/M/D)
1	ISSUED FOR CONSTRUCTION	PJY	NWB	2009/05/04
0	ISSUED FOR TENDER	KSB	PS	2009/03/26

DWN BY KSB · DES BY DB · CHK BY PS · APP BY KM

30 CM — VERIFY SCALE IF PLAN SHEET IS REDUCED

PROJECT START DATE (M/Y): NOV / 2007
PROJECT NO.: 101858
FILENAME: I-02.dwg
SHEET NO.:
DRAWING NO.: I-02

RELEASE 2.0 (JULY 2008)



CONTROL SYSTEM ARCHITECTURE

ITEM	DESCRIPTION	REFERENCE MANUFACTURER	NOTES
1	DIAL−UP MODEM (EXTENDED TEMP.)	DATA−LINC DLM4000/DL/AADB	(MODEM SETUP FOR AUTO ANSWER/DIAL BACK)
2	LEASED LINE MODEM	DATA−LINC DLM4500	
3	EtherNet/IP TO DF1 GATEWAY	PROSOFT 5202−DFNT−DFCM4	
4	PLC	ALLEN−BRADLEY COMPACTLOGIX (REFER TO SPECIFICATION 17600)	
5	SERIAL CABLE		CROSSOVER
6	ALARM DIALER	BARNETT PROTALK PLUS 81290 PLUS	c/w EXTENDER
7	UPS	LIEBERT GXT 700VA	c/w INTERFACE CARD FOR RELAY CONTACTS
8	ETHERNET SWITCH	N−TRON 104TX	
9	EXISTING LEASED LINE		
10	EXISTING PHONE LINE		
11	NEW PHONE LINE	BY OWNER	

GENERAL NOTES:

1. SCADA COMPUTER TO BE POWERED BY UPS.

LEGEND:

1. EXISTING EQUIPMENT
2. HARDWIRED
3. ETHERNET CAT5
4. SERIAL DF1
5. PHONE LINE − DIAL−UP OR LEASED

RELEASE 3.0 (JULY 2006)

VERIFY SCALE IF PLAN SHEET IS REDUCED

REV	DESCRIPTION	DRN	CHK	DATE (Y/M/D)
1	ISSUED FOR CONSTRUCTION	PJY	NWB	2009/05/04
0	ISSUED FOR TENDER	KSB	PS	2009/03/28

DRN BY: KSB
DES BY: DB
CHK BY: PS
APP BY: KM

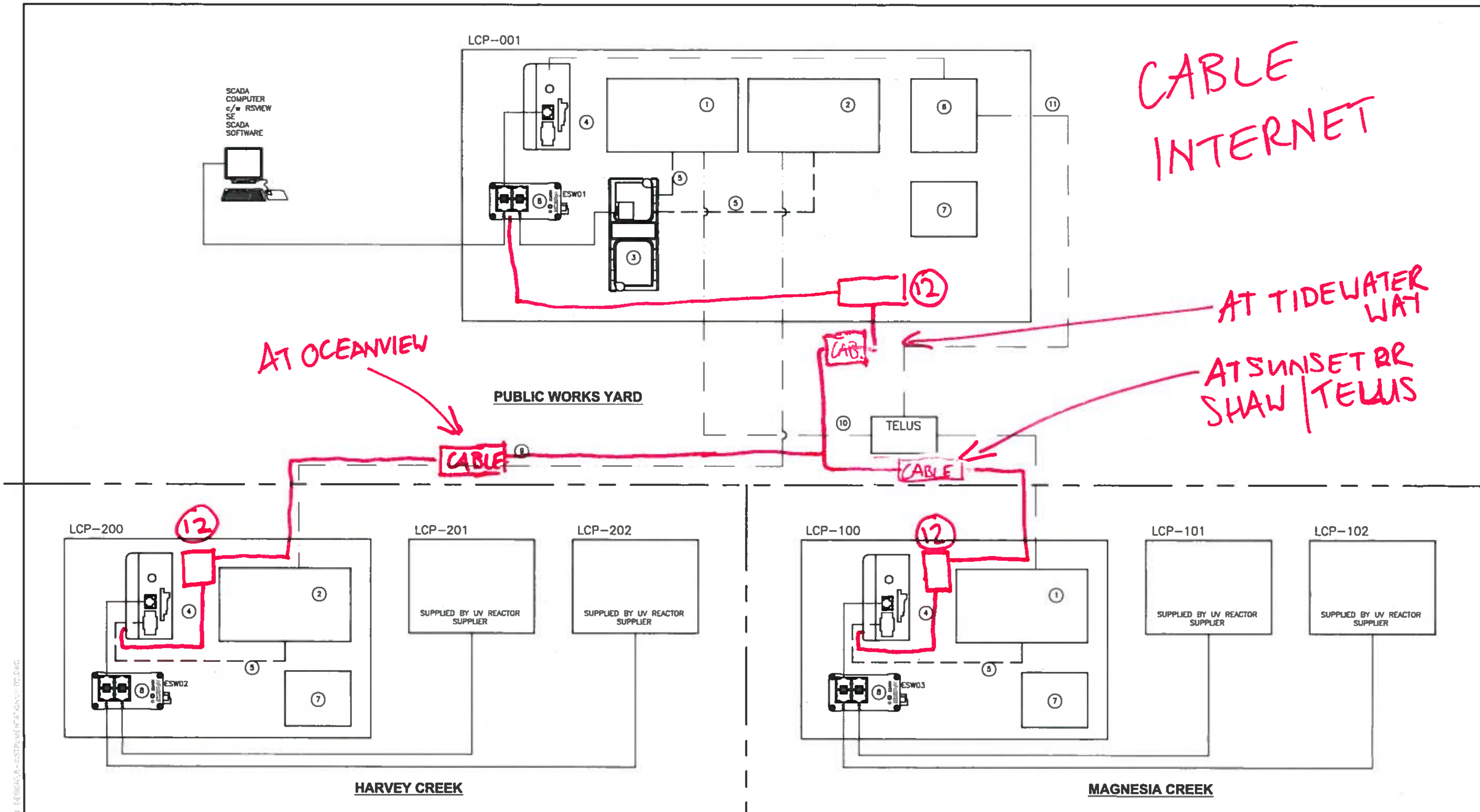
PREPARED FOR: THE MUNICIPALITY OF THE VILLAGE OF LIONS BAY

PREPARED BY: AECOM

VILLAGE OF LIONS BAY
WATER TREATMENT UPGRADES
LIONS BAY, B.C.

INSTRUMENTATION
SYSTEM ARCHITECTURE

PROJECT START DATE (M/Y): NOV / 2007
PROJECT NO.: 101858
FILENAME: I-02.dwg
SHEET NO.:
DRAWING NO.: I-02



ITEM	DESCRIPTION	REFERENCE MANUFACTURER	NOTES
CONTROL SYSTEM ARCHITECTURE			
1	DIAL-UP MODEM (EXTENDED TEMP.)	DATA-LINC DLM4000/DL/AADB	(MODEM SETUP FOR AUTO ANSWER/DIAL BACK)
2	LEASED LINE MODEM	DATA-LINC DLM4500	
3	EtherNet/IP TO DF1 GATEWAY	PROSOFT 5202-DFNT-DFCM4	
4	PLC	ALLEN-BRADLEY COMPACTLOGIX (REFER TO SPECIFICATION 17600)	
5	SERIAL CABLE		CROSSOVER
6	ALARM DIALER	BARNETT PROTALK PLUS B1290 PLUS	c/w EXTENDER
7	UPS	LIEBERT GXT 700VA	c/w INTERFACE CARD FOR RELAY CONTACTS
8	ETHERNET SWITCH	N-TRON 104TX	
9	EXISTING LEASED LINE		
10	EXISTING PHONE LINE		
11	NEW PHONE LINE	BY OWNER	

(12) CABLE MODEM

GENERAL NOTES:

1. SCADA COMPUTER TO BE POWERED BY UPS.

LEGEND:

1. • – EXISTING EQUIPMENT
2. – – – – HARDWIRED
3. ——— – ETHERNET CAT5
4. –·–·– – SERIAL DF1
5. —·—·— – PHONE LINE – DIAL-UP OR LEASED

PREPARED FOR: THE MUNICIPALITY OF THE VILLAGE OF LIONS BAY

PREPARED BY: AECOM

VILLAGE OF LIONS BAY WATER TREATMENT UPGRADES LIONS BAY, B.C.

INSTRUMENTATION SYSTEM ARCHITECTURE

PROJECT START DATE (M/Y)	NOV / 2007
PROJECT NO.	101858
FILENAME	I-02.dwg
SHEET NO.	
DRAWING NO.	I-02

REV	DESCRIPTION	DATE (Y/M/D)
1	ISSUED FOR CONSTRUCTION	2008/05/04
0	ISSUED FOR TENDER	2008/03/28

RELEASE 2.0 (JULY 2006)

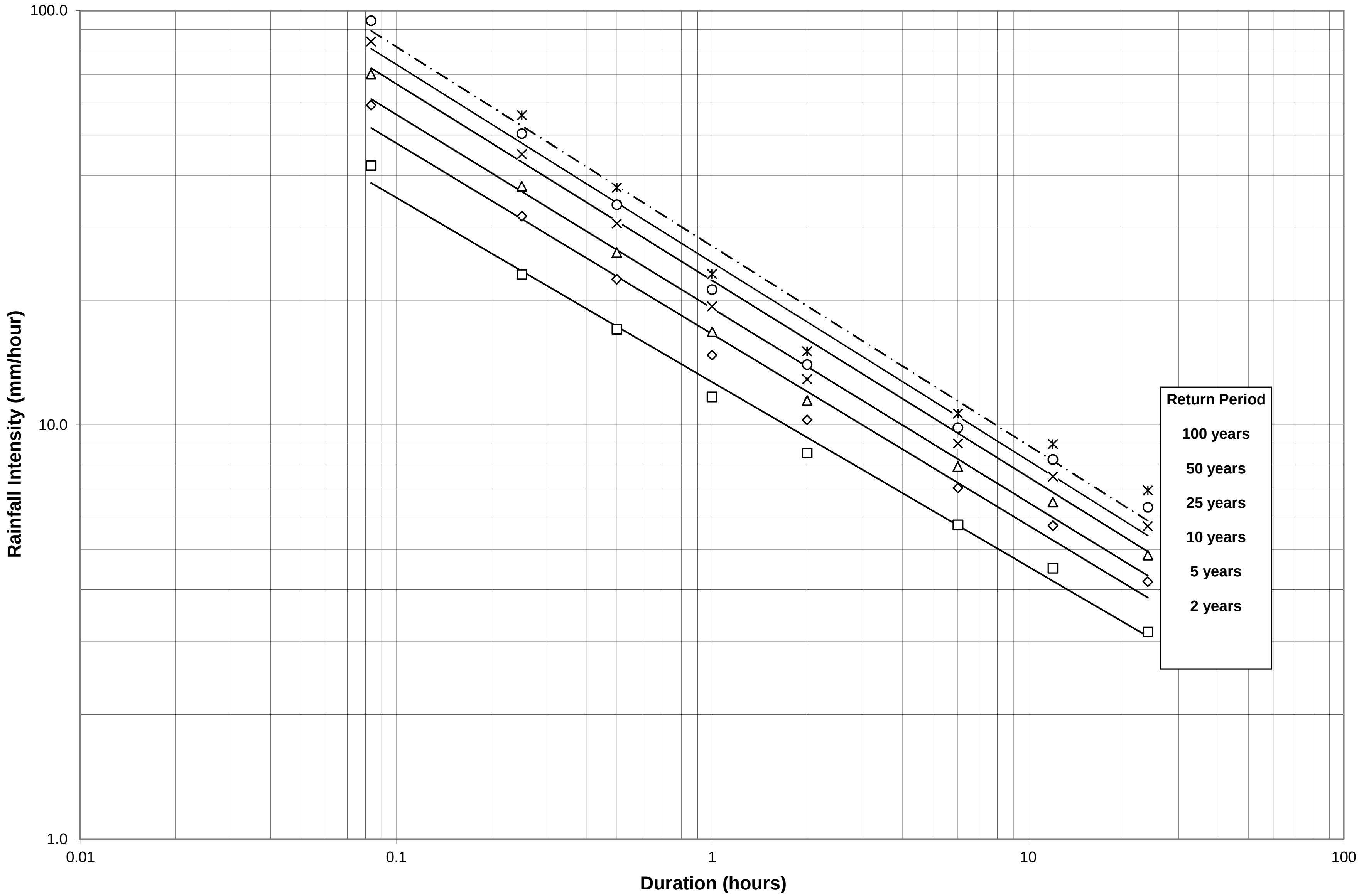
Appendix C

IDF Curves

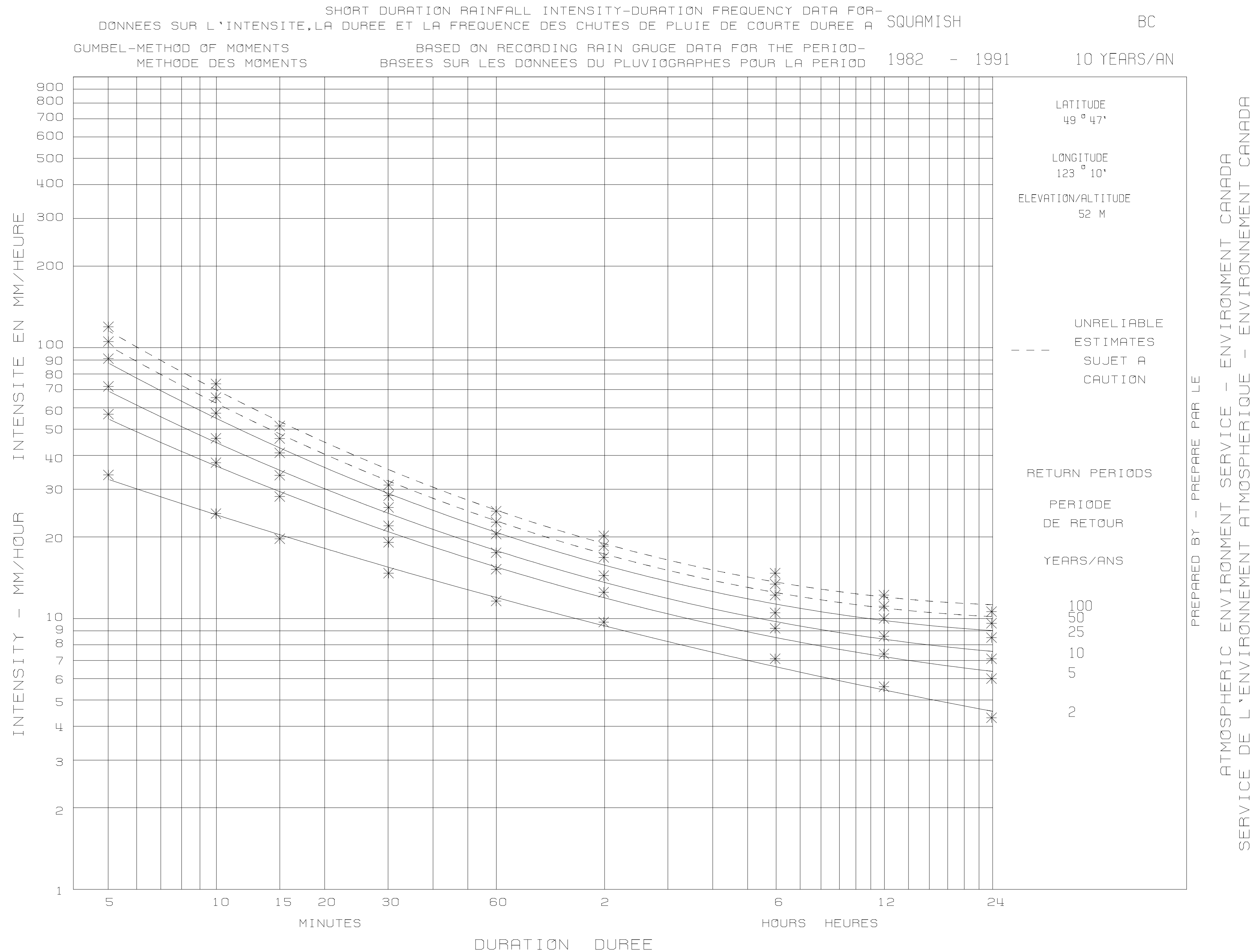
GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Short Duration Rainfall IDF Data for WEST VAN. MUNICIPAL HALL (VW14)

Based on recorded rain gauge data for the period 1959 -2001 (42 Years)



Disclaimer: 100 year return period is an unreliable estimate.


SHORT DURATION RAINFALL INTENSITY-DURATION FREQUENCY DATA FOR-
DONNEES SUR L'INTENSITE,LA DUREE ET LA FREQUENCE DES CHUTES DE PLUIE DE COURTE DUREE A
SQUAMISH
BC
GUMBEL-METHOD OF MOMENTS
METHODE DES MOMENTS
BASED ON RECORDING RAIN GAUGE DATA FOR THE PERIOD-
BASEES SUR LES DONNEES DU PLUVIOGRAPHES POUR LA PERIOD
1982 - 1991
10 YEARS/AN
LATITUDE
49 ° 47'
LONGITUDE
123 ° 10'
ELEVATION/ALTITUDE
52 M
UNRELIABLE ESTIMATES
SUJET A CAUTION
RETURN PERIODS
PERIODE DE RETOUR
YEARS/ANS
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10
5
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INTENSITY - MM/HOUR
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30
60
2
6
12
24
MINUTES
HOURS HEURES
DURATION DUREE
PREPARED BY - PREPARE PAR LE
ATMOSPHERIC ENVIRONMENT SERVICE - ENVIRONMENT CANADA
SERVICE DE L'ENVIRONNEMENT ATMOSPHERIQUE - ENVIRONNEMENT CANADA

Appendix D

Bridge Inspections Documentation

D1 Summary of Repair Recommendations
D2 Detailed Observations and Sketches

D1. Summary of Repair Recommendations

Bridge Repair Summary

Bridge / Priority / Field Observation	Monitoring	Repair	Repair Costs
1. Lions Bay Avenue over Harvey Creek			
B. High Priority			
Crack and spall of interior deck underside above south face of north column	-	Remove spalled concrete. Clean and patch.	$2,000
Crack and spall of interior deck underside near west longitudinal beam (about 3.0 m south of north column)	-	Remove spalled concrete. Clean and patch.	$2,000
Joints between end of bridge and approach roadway need to be re-sealed	-	Remove vegetation and dirt. Seal the joints.	$1,500
Minor decay – horizontal members of wooden railing	Check the railing condition (annually)	-	$0
B. High Priority Total			*$5,500*
1. Lions Bay Avenue over Harvey Creek Total			**$5,500**
2. Isleview Place over Alberta Creek (Lower Bridge)			
A. Very High Priority			
Tripping hazard due to unevenness between bridge sidewalk and sidewalk approaches	-	Regrade (asphalt) sidewalk approaches	$1,500
A. Very High Priority Total			*$1,500*
B. High Priority			
Cracked approach pavement and broken edge of bridge deck near northwest corner	-	Seal the crack, patch, or remove (& rebuild) the cracked portion and its adjacent areas. Remove and patch the broken deck edge. Seal the joint	$1,500
Vegetation growing in joints both ends of deck	-	Remove vegetation and dirt. Seal the joints.	$1,000
Vegetation growing into abutment seats (at both abutments) with potential of growing into girder underside longitudinal joints	-	Remove vegetation	$1,000
Vegetation overgrowing ends of bridge and barriers with potential of growing (or having its roots growing) into the joints between abutment and MSE wing-walls or between MSE wall facial panels	-	Remove vegetation	$1,000
B. High Priority Total			*$4,500*
C. Medium Priority			
Series of transverse cracks (differential shrinkage cracks) on the sidewalk and curb undersides	-	Locate the cracks on the top of sidewalk and curb. Seal the cracks.	$3,000
C. Medium Priority Total			*$3,000*
2. Isleview Place over Alberta Creek (Lower Bridge) Total			**$9,000**
3. Isleview Place over Alberta Creek (Upper Bridge)			
A. Very High Priority			
Tripping hazard due to unevenness between bridge sidewalk and sidewalk approaches	-	Regrade (asphalt) sidewalk approaches	$1,500
A. Very High Priority Total			*$1,500*
B. High Priority			
Cracked approach pavement near edge of bridge deck at northwest corner and southwest corner	-	Seal the crack, patch, or remove (& rebuild) the cracked portion and its adjacent areas. Remove and patch the broken deck edge. Seal the joint	$3,000
Vegetation growing in joints both ends of deck	-	Remove vegetation and dirt. Seal the joints.	$1,000
Vegetation growing into abutment seats (at both abutments) with potential of growing into girder underside longitudinal joints	-	Remove vegetation	$1,000
Vegetation overgrowing ends of bridge and barriers with potential of growing (or having its roots growing) into the joints between abutment and MSE wing-walls or between MSE wall facial panels	-	Remove vegetation	$1,000
B. High Priority Total			*$6,000*
C. Medium Priority			
Misalignment of railing due to the wall settlement and rotation. May deteriorate.	Measure the misalignment (Annually)	Remove and re-install approach railing to align with bridge railing.	$1,500
Series of transverse cracks (differential shrinkage cracks) on the sidewalk and curb undersides	-	Locate the cracks on the top of sidewalk and curb. Seal the cracks.	$3,000
C. Medium Priority Total			*$4,500*
3. Isleview Place over Alberta Creek (Upper Bridge) Total			**$12,000**
4. Cross Creek Road over Harvey Creek			
A. Very High Priority			
Tripping hazard due to unevenness between bridge sidewalk and sidewalk approaches	-	Regrade (asphalt) sidewalk approaches	$3,000
A. Very High Priority Total			*$3,000*
B. High Priority			
Deck longitudinal cracks (crack width 0.3 mm approx.) full length of bridge, at 1.3 m west of bridge centerline	-	Clean and seal the cracks	$2,500
Settlement (50 mm) and rotation (30 mm outward) of CIP retaining wall.	Monitor the settlement and rotation of retaining wall (Annually)	-	$0
B. High Priority Total			*$2,500*
C. Medium Priority			
Maintenance of joints between approach roads and bridge deck	-	Remove vegetation and dirt. Re-seal the joints.	$2,000
Series of transverse cracks (differential shrinkage cracks) on the sidewalk and curb undersides	-	Locate the cracks on the top of sidewalks. Seal the cracks.	$4,000
C. Medium Priority Total			*$6,000*
4. Cross Creek Road over Harvey Creek Total			**$11,500**
5. Bayview Road over Alberta Creek			
A. Very High Priority			
Tripping hazard due to unevenness between bridge sidewalk and sidewalk approaches	-	Regrade (asphalt) sidewalk approaches	$1,500
A. Very High Priority Total			*$1,500*
B. High Priority			
Cracked approach pavement near edge of bridge deck at both ends of the bridge	-	Seal the crack, patch, or remove (& rebuild) the cracked portion and its adjacent areas. Remove and patch the broken deck edge. Seal the joint	$3,000
Deck longitudinal cracks (crack width 0.3 mm approx.) full length of bridge, one at 1.5 m from east curb and another one at 2.1 m from west sidewalk	-	Clean and seal the cracks	$4,000
Vegetation growing in joints both ends of deck	-	Remove vegetation and dirt. Seal the joints.	$1,000
Vegetation growing into abutment seats (at both abutments) with potential of growing into girder underside longitudinal joints	-	Remove vegetation	$1,000
B. High Priority Total			*$9,000*
C. Medium Priority			
Series of transverse cracks (differential shrinkage cracks) on the sidewalk and curb undersides	-	Locate the cracks on the top of sidewalk and curb. Seal the cracks.	$3,000
C. Medium Priority Total			*$3,000*
5. Bayview Road over Alberta Creek Total			**$13,500**
6. Bayview Road (Private Driveway) over Alberta Creek			
A. Very High Priority			
Hole in pavement (Northeast Corner)	-	Clean and repair	$1,000
Safety Improvement (Ref: 2004 Report – Items 1.5) Clearance to overhead wire	-	Install warning sign and safety mirror	$3,500

Bridge / Priority / Field Observation	Monitoring	Repair	Repair Costs
A. Very High Priority Total			*$4,500*
B. High Priority			
Corrosion of steel girders especially at top and bottom flanges (Ref: 2004 Report – Item 4.3)	-	Pressure wash. Inspect and quantify section loss. Re-paint	$20,000
Decayed and cracked bearing beams	-	Replace bearing beams and anchor bolts	$20,000
Displaced modular block wing-wall (Northeast corner) (Ref: 2004 Report – Item 2.3)	-	Reconstruction of displaced wing-wall	$15,000
Extensive corrosion of secondary members (diaphragms and lateral bracing) (Ref: 2004 Report – Item 4.5)	-	Pressure wash. Inspect and quantify section loss. Re-paint	$10,000
Vertical railing posts not replaced recently show signs of extensive decay (5 Posts)	-	Replace railing posts	$3,000
B. High Priority Total			*$68,000*
C. Medium Priority			
Allowance for another deck replacement	-	Replace wooden deck	$30,000
Decayed – timber curb north-west side and horizontal members of wooden guardrail	Check the railing condition (annually)	Replace curbs and guardrails	$12,000
Timber floor joists show sign of rot and decay	Check the condition (annually)	Replace decayed floor joists (removal and reinstallation of deck planks)	$20,000
C. Medium Priority Total			*$62,000*
6. Bayview Road (Private Driveway) over Alberta Creek Total			**$134,500**
7. Bayview Place over Alberta Creek			
A. Very High Priority			
Misaligned approach barrier (North end on the curb side)	-	Align and reconnect the misaligned barrier segment	$500
Tripping hazard due to unevenness between bridge sidewalk and sidewalk approaches	-	Regrade (asphalt) sidewalk approaches	$1,500
A. Very High Priority Total			*$2,000*
B. High Priority			
Vegetation growing in joints both ends of deck	-	Remove vegetation and dirt. Seal the joints.	$1,000
Vegetation growing into abutment seats (at both abutments) with potential of growing into girder underside longitudinal joints	-	Remove vegetation	$1,000
Vegetation overgrowing ends of bridge and barriers	-	Remove vegetation	$1,000
B. High Priority Total			*$3,000*
C. Medium Priority			
Series of transverse cracks (differential shrinkage cracks)on the sidewalk and curb undersides	-	Locate the cracks on the top of sidewalk and curb. Seal the cracks.	$3,000
C. Medium Priority Total			*$3,000*
7. Bayview Place over Alberta Creek Total			**$8,000**
8. Lions Bay Avenue over Alberta Creek (Private driveway end of Lions Bay Avenue)			
A. Very High Priority			
Vertical plank missing (west guardrail)	-	Install the missing plank	$300
A. Very High Priority Total			*$300*
B. High Priority			
Vegetation encroaching (north end)	-	Remove vegetation	$1,000
B. High Priority Total			*$1,000*
C. Medium Priority			
Minor decay – timber curb north-west side, and horizontal members of wooden guardrail	Check the railing condition (annually)	Replace curbs and guardrails	$8,000
C. Medium Priority Total			*$8,000*
8. Lions Bay Avenue over Alberta Creek (Private driveway end of Lions Bay Avenue) Total			**$9,300**

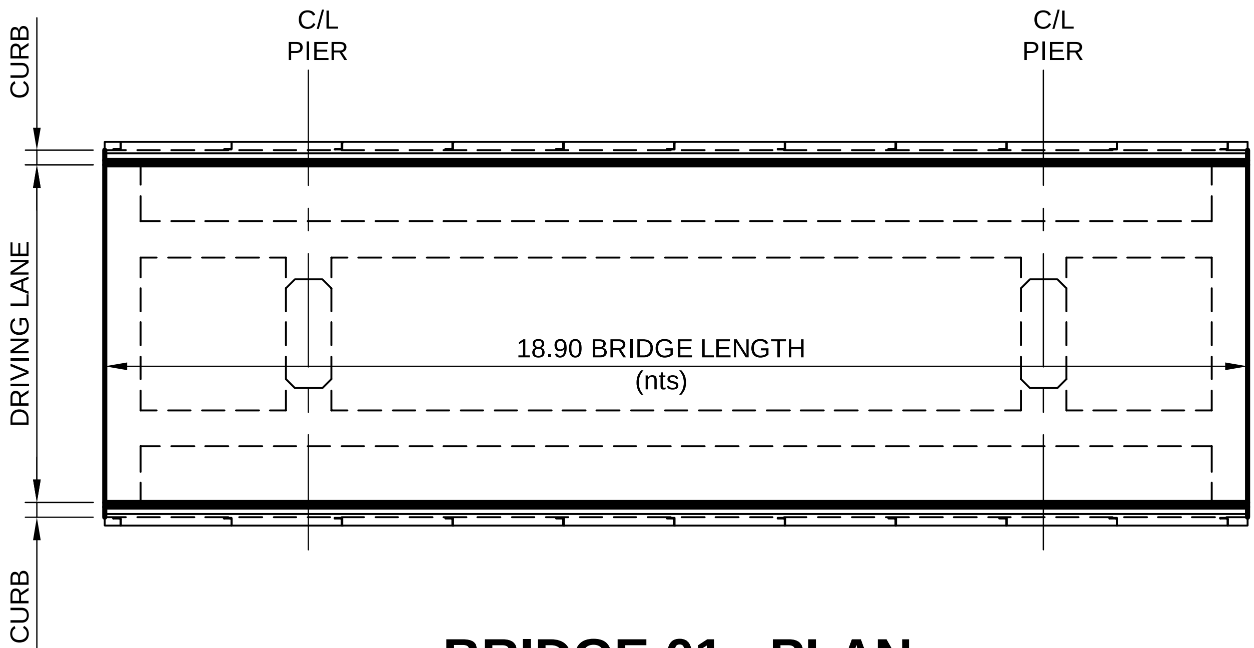
D2. Detailed Observations and Sketches

General Information

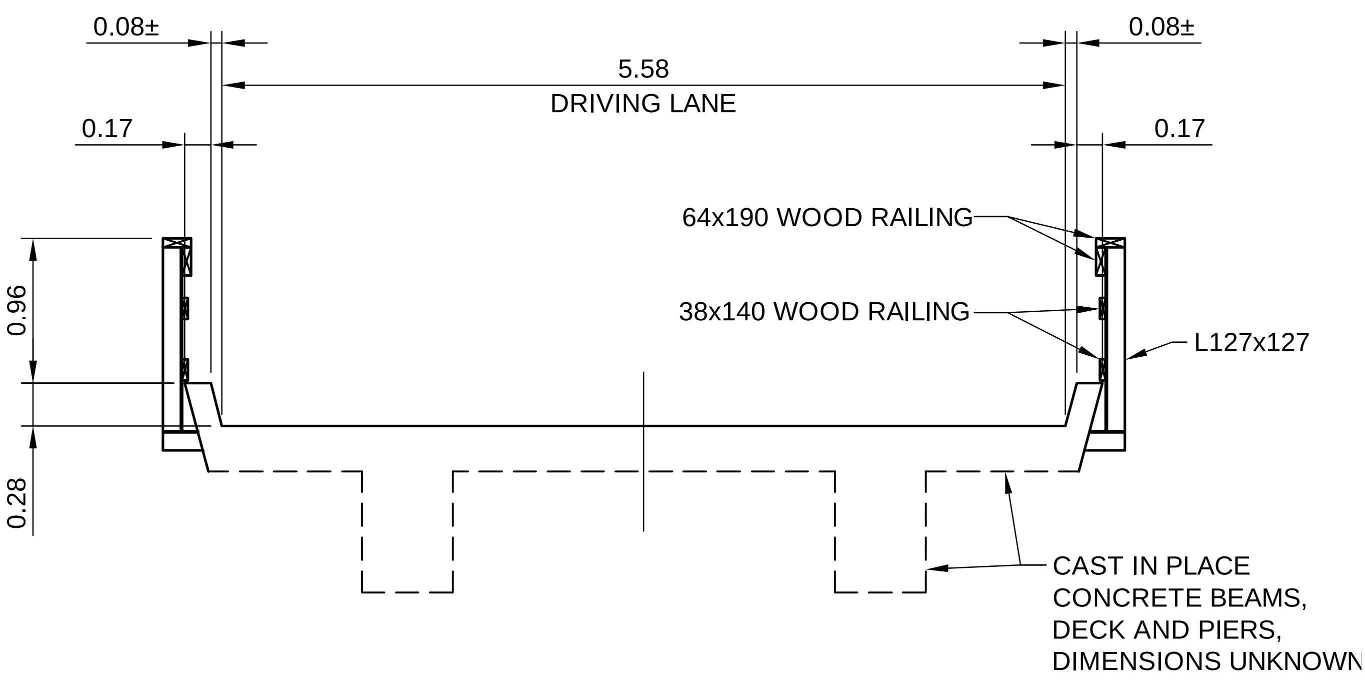
Bridge Reference	Bridge 01 – Lions Bay Avenue over Harvey Creek
Inspection Date / Time	2015-09-21 @ 11:40 a.m.
Inspector(s)	Asnee Pochanart – AECOM & Neil Harcus – AECOM
Basic Description	Three-span Concrete Bridge (long central span with two short end spans)
	Single Traffic Lane with concrete curb and wooden railing on each side
	Concrete curbs – Approx. 170 W x 280 H (sloped face)
	4 deck drains through curbs each side
	Guardrails – L127x127 steel angle vertical posts, horizontal wood railing.
	Top of guardrail 1.24m above deck
	Large pipes both sides of bridge, hung below deck
Superstructure Type(s)	Cast-in place concrete deck on two cast-in-place concrete (longitudinal) beams
Substructure Type(s)	Cast in place transverse beam on cast-in-place concrete column (each pier)
	No abutment visible
	End cross beam appears to sit on rock wall
Length x Width	18.90m Long x 6.10m Wide (0.17 curb + 0.075 offset+ 5.60 lane + 0.075 offset + 0.17 curb)
Observations	
Remarks	

Issues Summary

	Issue	Resolution	Approx. Cost
Very High (Resolve <1yr)			
High (Resolve <5yr)	Joints between end of bridge and approach roadway need to be re-sealed	Remove vegetation and dirt. Seal the joints.	$1,500
	Crack and spall of interior deck underside near west longitudinal beam (about 3.0 m south of north column)	Remove spalled concrete. Clean and patch.	$2,000
	Crack and spall of interior deck underside above south face of north column	Remove spalled concrete. Clean and patch.	$2,000
	Minor decay – horizontal members of wooden railing	Check the railing condition (annually)	$200
Medium (Resolve <10yr)			



BRIDGE 01 - PLAN



BRIDGE 01 - SECTION

LIONS BAY BRIDGE ASSESSMENT

BRIDGE 01
LIONS BAY AVE.

VILLAGE of LIONS BAY, B.C.
Project No.: 60437708 Date: 2015-09-25

AECOM

Figure: BR01

General Information

Bridge Reference	Bridge 02 – Isleview Place over Alberta Creek (Lower Bridge)
Inspection Date / Time	2015-09-21 @ 11:10 a.m.
Inspector(s)	Asnee Pochanart – AECOM & Neil Harcus – AECOM
Basic Description	Single Span Concrete Bridge
	Single Traffic Lane with Pedestrian sidewalk on east side and wide curb west side
	Standard MOT 4-Rail barrier on each side
Superstructure Type(s)	Cast-in place concrete deck (or topping), curb and sidewalk on precast concrete box girders
Substructure Type(s)	Cast in place abutments (both ends)
	Mechanically Stabilized Earth (MSE) wing-walls (both ends) – Precast Concrete Panel Type
Length x Width	18.15m Long x 6.40m Wide (0.85 curb + 3.60 lane + 1.95 sidewalk)
Observations	Pipe hung from underside of sidewalk east side, unable to view west side
	No visible cracks in deck
	Railing south-west end damaged, otherwise railing in good shape
Remarks	

Issues Summary

	Issue	Resolution	Approx. Cost
Very High (Resolve <1yr)	Tripping hazard due to unevenness between bridge sidewalk and sidewalk approaches	Regrade (asphalt) sidewalk approaches	$1,500
High (Resolve <5yr)	Vegetation growing into abutment seats (at both abutments) with potential of growing into girder underside longitudinal joints	Remove vegetation	$1,000
	Vegetation overgrowing ends of bridge and barriers with potential of growing (or having its roots growing) into the joints between abutment and MSE wing-walls or between MSE wall facial panels	Remove vegetation	$1,000
	Cracked approach pavement and broken edge of bridge deck near northwest corner	Seal the crack, patch, or remove (& rebuild) the cracked portion and its adjacent areas. Remove and patch the broken deck edge. Seal the joint	$1,500
	Vegetation growing in joints both ends of deck	Remove vegetation and dirt. Seal the joints.	$1,000
Medium (Resolve <10yr)	Series of transverse cracks (differential shrinkage cracks)on the sidewalk and curb undersides	Locate the cracks on the top of sidewalk and curb. Seal the cracks.	$3,000

ANSI A 215.9mm x 279.4mm

Project Management Initials: Designer: AP Checked: Approved:

Last saved by: HARCUSN(2015-09-23) Last Plotted: 2015-09-24
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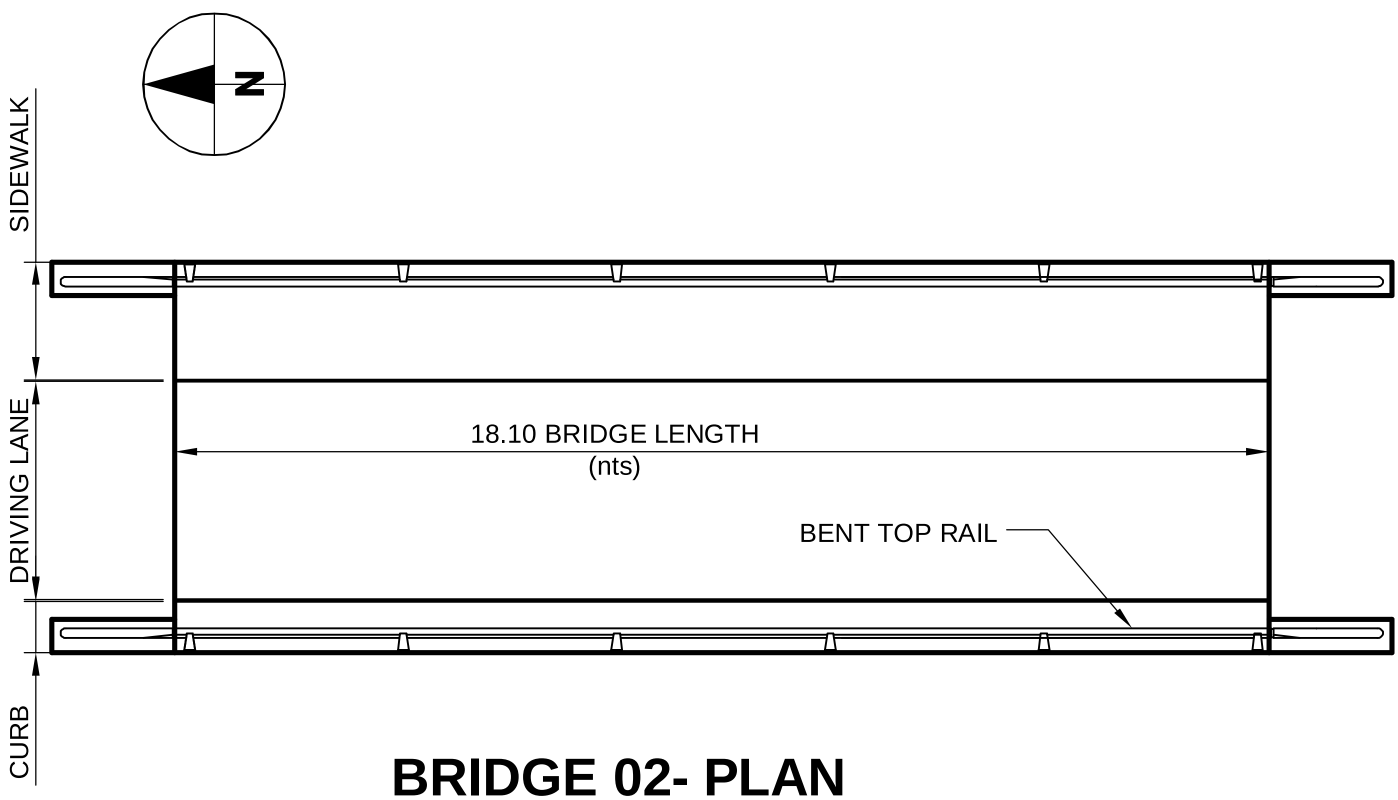
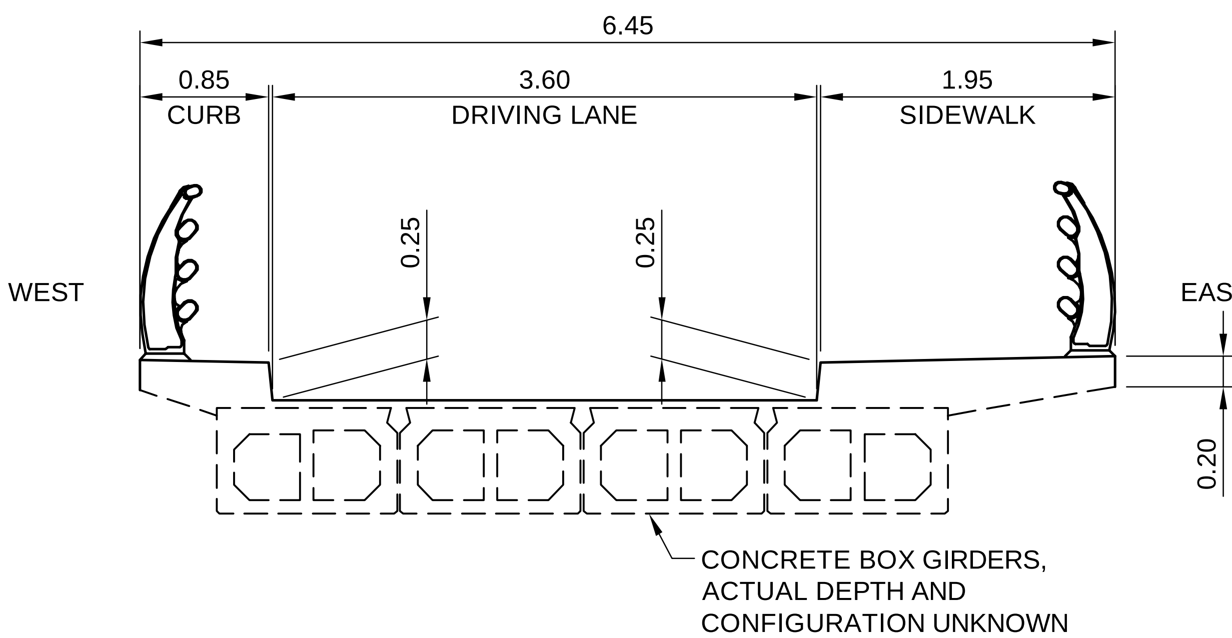


BRIDGE 02- PLAN



BRIDGE 02 - SECTION

LIONS BAY BRIDGE ASSESSMENT

VILLAGE of LIONS BAY, B.C.
Project No.: 60437708 Date: 2015-09-25

BRIDGE 02
ISLEVIEW PL.

AECOM

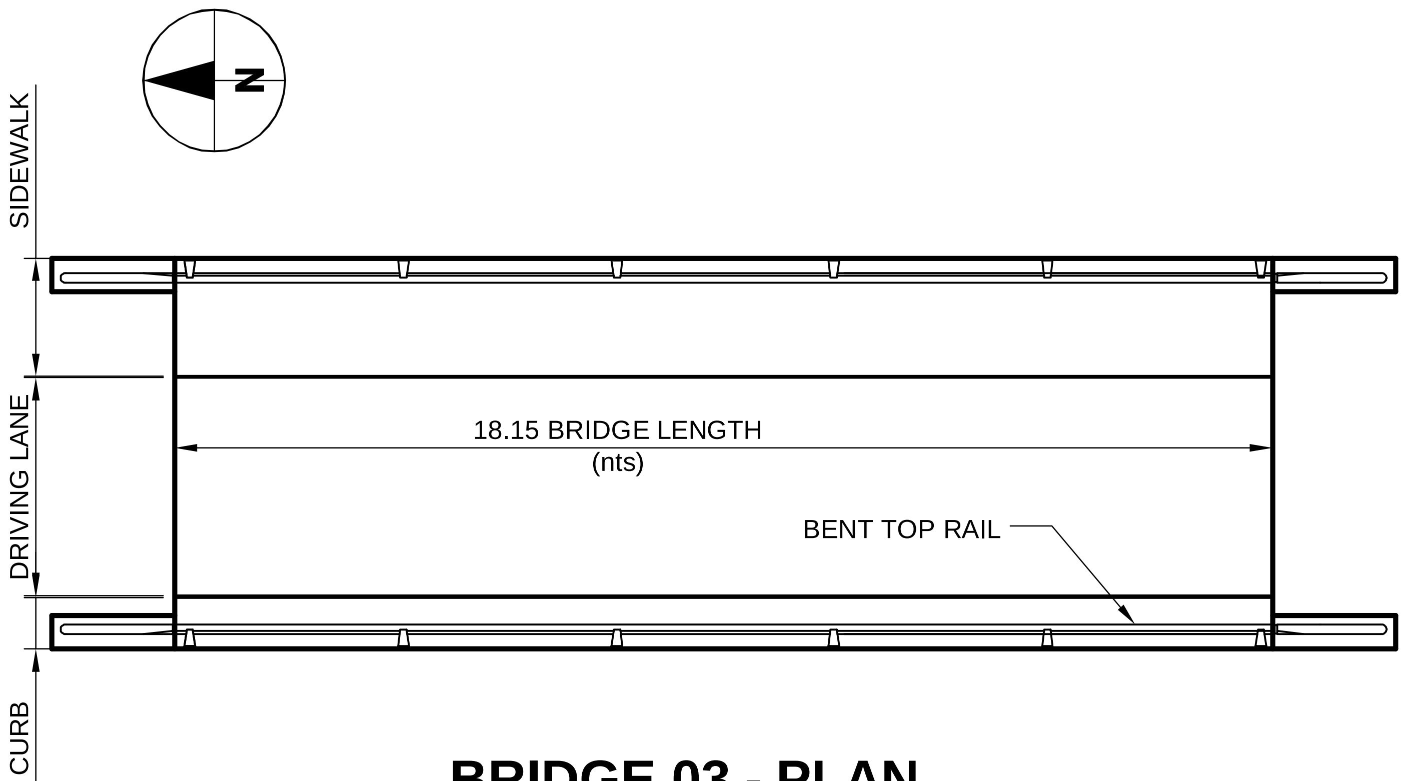
Figure: BR02

General Information

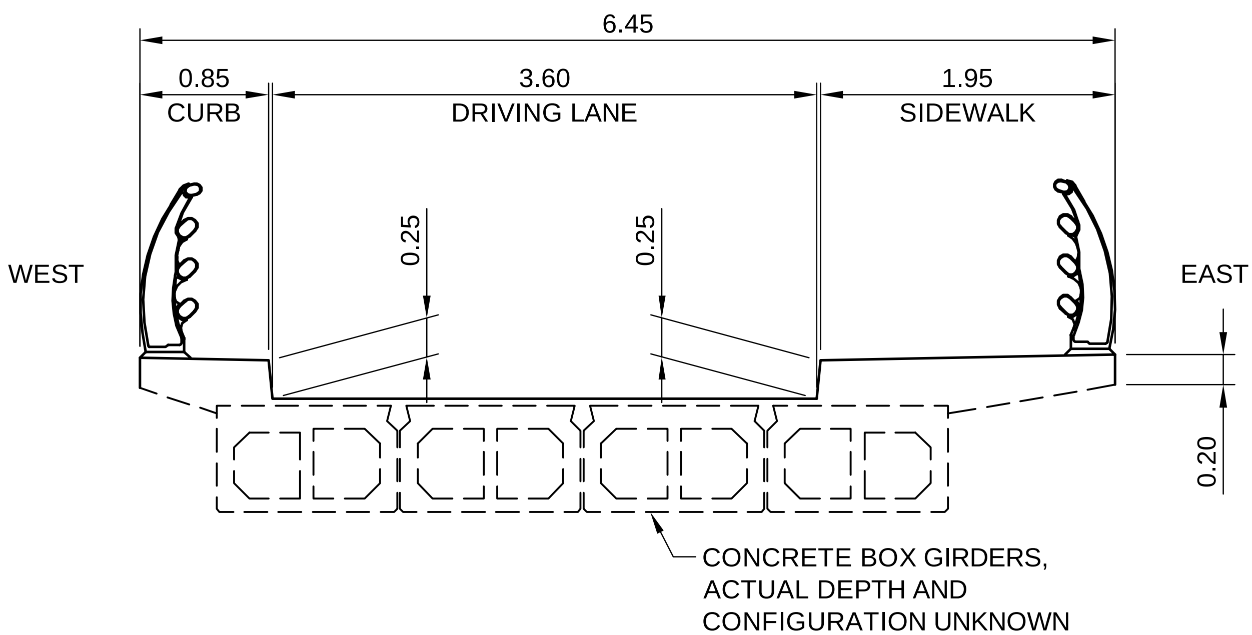
Bridge Reference	Bridge 03 – Isleview Place over Alberta Creek (Upper Bridge)
Inspection Date / Time	2015-09-21 @ 11:30 a.m.
Inspector(s)	Asnee Pochanart – AECOM & Neil Harcus – AECOM
Basic Description	Single Span Concrete Bridge
	Single Traffic Lane with Pedestrian sidewalk on east side and wide curb west side
	Standard MOT 4-Rail barrier on each side
Superstructure Type(s)	Cast-in place concrete deck (or topping), curb and sidewalk on precast concrete box girders
Substructure Type(s)	Cast in place abutments (both ends)
	Mechanically Stabilized Earth (MSE) wing-walls (both ends) – Precast Concrete Panel Type
Length x Width	18.15m Long x 6.40m Wide (0.85 curb + 3.60 lane + 1.95 sidewalk)
Observations	No visible cracks in deck
	Railing in good shape
Remarks	*Unable to determine if there were any pipes under the deck*
	Expect transverse cracks (differential shrinkage cracks) along sidewalk and curb undersides
	Expect Vegetation growing into abutment seats (similar to the nearby Bridge 02)

Issues Summary

	Issue	Resolution	Approx. Cost
Very High (Resolve <1yr)	Tripping hazard due to unevenness between bridge sidewalk and sidewalk approaches	Regrade (asphalt) sidewalk approaches	$1,500
High (Resolve <5yr)	Vegetation growing into abutment seats (at both abutments) with potential of growing into girder underside longitudinal joints	Remove vegetation	$1,000
	Vegetation overgrowing ends of bridge and barriers with potential of growing (or having its roots growing) into the joints between abutment and MSE wing-walls or between MSE wall facial panels	Remove vegetation	$1,000
	Cracked approach pavement near edge of bridge deck at northwest corner and southwest corner	Seal the crack, patch, or remove (& rebuild) the cracked portion and its adjacent areas. Remove and patch the broken deck edge. Seal the joint	$3,000
	Vegetation growing in joints both ends of deck	Remove vegetation and dirt. Seal the joints.	$1,000
Medium (Resolve <10yr)	Series of transverse cracks (differential shrinkage cracks) on the sidewalk and curb undersides	Locate the cracks on the top of sidewalk and curb. Seal the cracks.	$3,000



BRIDGE 03 - PLAN



BRIDGE 03 - SECTION

LIONS BAY BRIDGE ASSESSMENT

VILLAGE of LIONS BAY, B.C.
Project No.: 60437708 Date: 2015-09-25

BRIDGE 03
ISLEVIEW PL.

AECOM

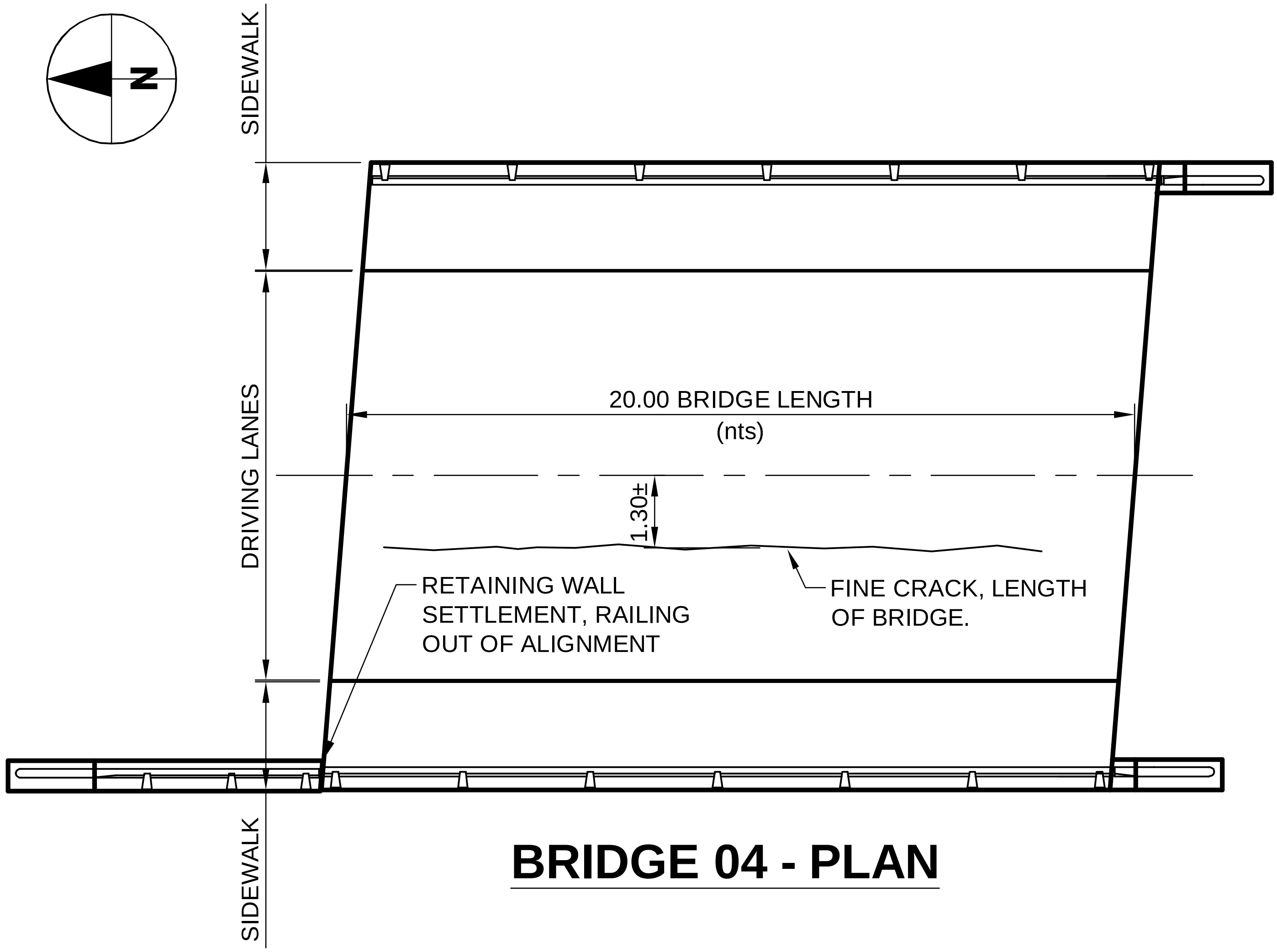
Figure: BR03

General Information

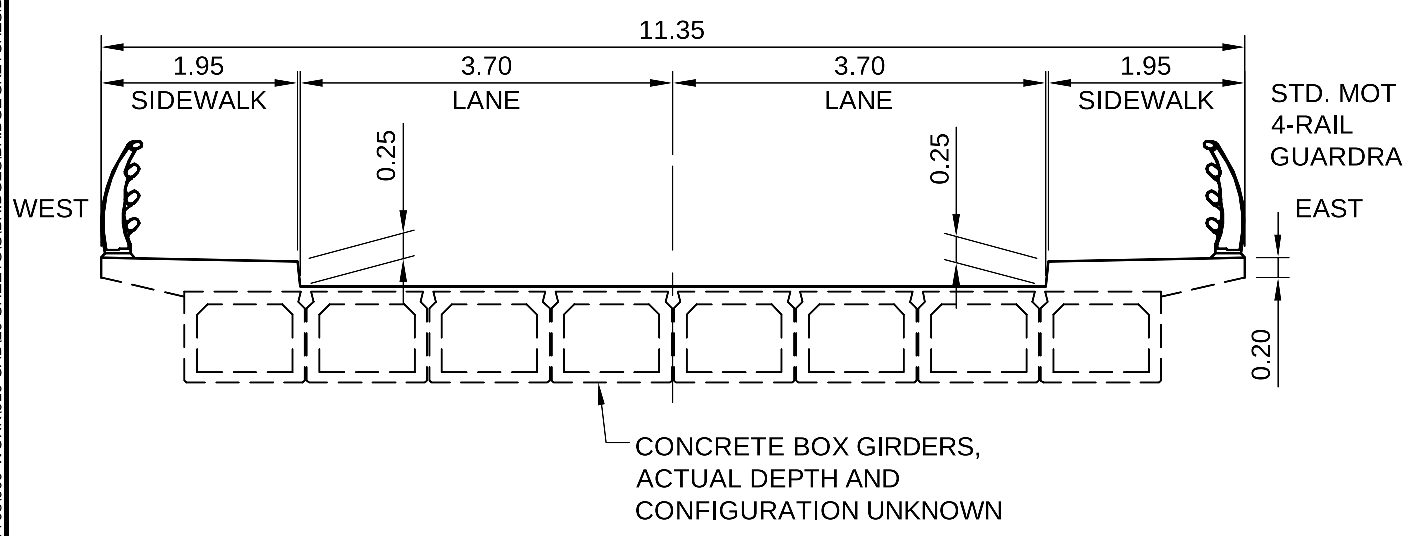
Bridge Reference	Bridge 04 – Cross Creek Road over Harvey Creek
Inspection Date / Time	2015-09-21 @ 9:00 a.m.
Inspector(s)	Asnee Pochanart – AECOM & Neil Harcus – AECOM
Basic Description	Single Span Concrete Bridge
	Two Traffic Lanes with Pedestrian sidewalk on east side and west side
	Standard MOT 4-Rail barrier on each side
Superstructure Type(s)	Cast-in place concrete deck (or topping), curb and sidewalk on precast concrete box girders
Substructure Type(s)	Cast in place abutments (both ends)
	Cast-in-place retaining wall (Northwest corner)
Length x Width	20.00m Long x 11.35m Wide (0.85 curb + 2 x 3.70 lane + 1.95 sidewalk)
Observations	Railing in good shape
	One pipe below deck on the east side
Remarks	*Unable to access the two abutments to inspect their conditions*
	Unable to determine if there were any pipes under the deck on the west side
	Expect transverse cracks (differential shrinkage cracks) along sidewalk undersides

Issues Summary

	Issue	**Resolution**	**Approx. Cost**
Very High (Resolve <1yr)	Tripping hazard due to unevenness between bridge sidewalk and sidewalk approaches	Regrade (asphalt) sidewalk approaches	$3,000
High (Resolve <5yr)	Deck longitudinal cracks (crack width 0.3 mm approx.) full length of bridge, at 1.3 m west of bridge centerline	Clean and seal the cracks	$2,500
	Settlement (50 mm) and rotation (30 mm outward) of CIP retaining wall.	Monitor the settlement and rotation (measure the misalignment annually.)	$500
	Misalignment of railing due to the wall settlement and rotation.	Should the misalignment become excessive, remove and re-install approach railing to align with bridge railing.	$1,500
Medium (Resolve <10yr)	Maintenance of joints between approach roads and bridge deck	Remove vegetation and dirt. Re-seal the joints.	$2,000
	Series of transverse cracks (differential shrinkage cracks) on the sidewalk and curb undersides	Locate the cracks on the top of sidewalks. Seal the cracks.	$4,000



BRIDGE 04 - PLAN



BRIDGE 04 - SECTION

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LIONS BAY BRIDGE ASSESSMENT

BRIDGE 04
CROSSCREEK RD.

AECOM

VILLAGE of LIONS BAY, B.C.
Project No.: 60437708 Date: 2015-09-25

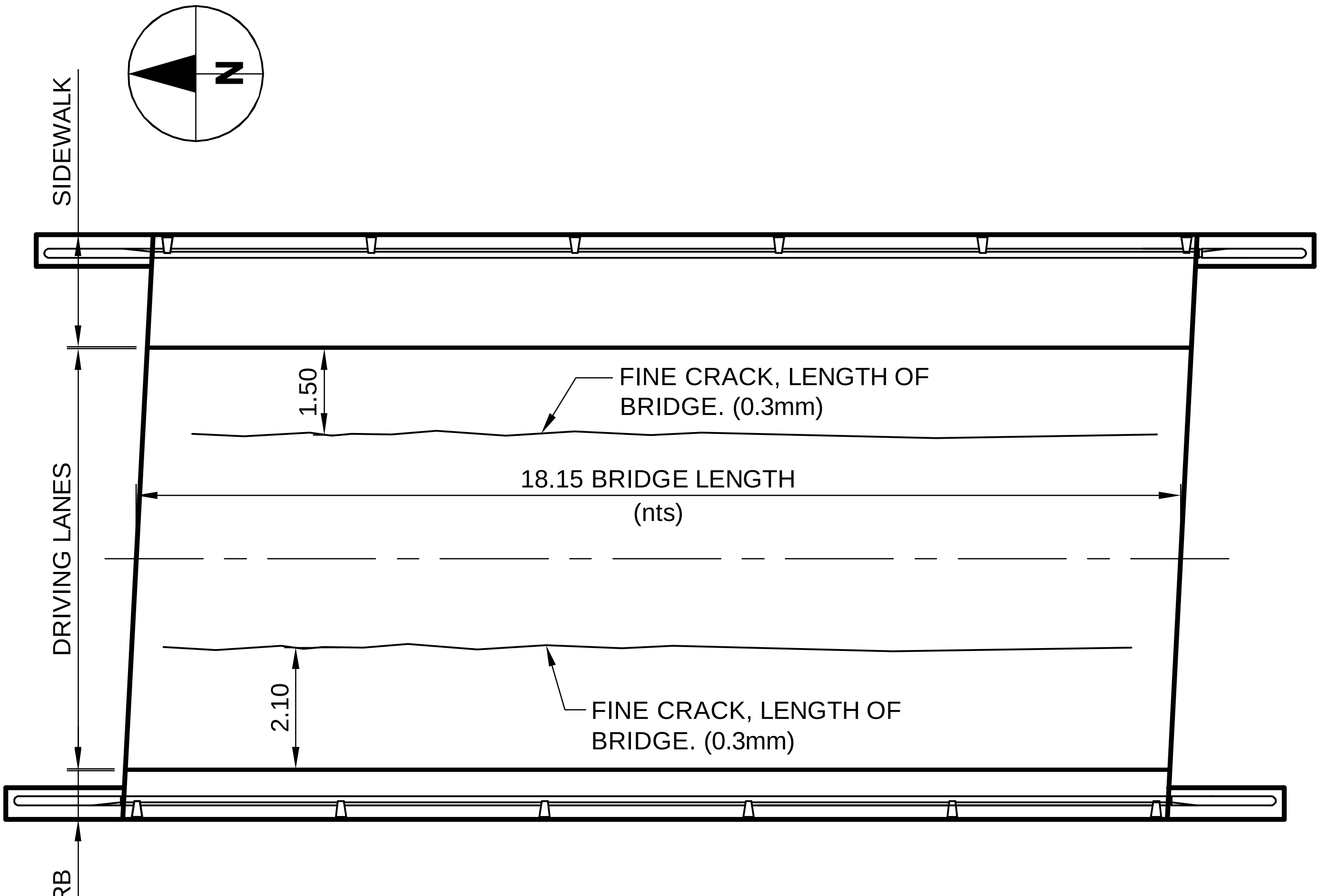
Figure: BR04

General Information

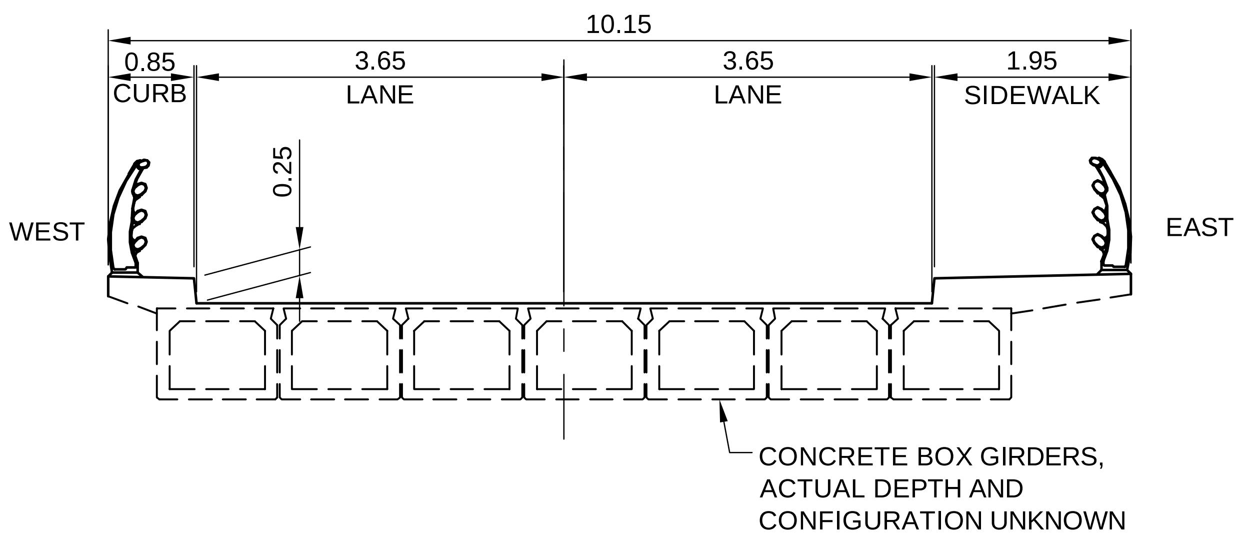
Bridge Reference	Bridge 05 – Bayview Road over Alberta Creek
Inspection Date / Time	2015-09-21 @ 10:30 a.m.
Inspector(s)	Asnee Pochanart – AECOM & Neil Harcus – AECOM
Basic Description	Single Span Concrete Bridge
	Two Traffic Lanes with Pedestrian sidewalk on east side and wide curb west side
	Standard MOT 4-Rail barrier on each side
Superstructure Type(s)	Cast-in place concrete deck (or topping), curb and sidewalk on precast concrete box girders
Substructure Type(s)	Cast in place abutments (both ends)
Length x Width	18.15m Long x 10.15m Wide (0.85 curb + 2 x 3.60 lane + 1.95 sidewalk)
Observations	Railing in good shape
Remarks	*Unable to access the two abutments to inspect their conditions*
	Unable to determine if there were any pipes under the deck
	Expect transverse cracks (differential shrinkage cracks) along sidewalk and curb undersides
	Expect Vegetation growing into abutment seats

Issues Summary

	Issue	**Resolution**	**Approx. Cost**
Very High (Resolve <1yr)	Tripping hazard due to unevenness between bridge sidewalk and sidewalk approaches	Regrade (asphalt) sidewalk approaches	$1,500
High (Resolve <5yr)	Vegetation growing into abutment seats (at both abutments) with potential of growing into girder underside longitudinal joints	Remove vegetation	$1,000
	Deck longitudinal cracks (crack width 0.3 mm approx.) full length of bridge, one at 1.5 m from east curb and another one at 2.1 m from west sidewalk	Clean and seal the cracks	$4,000
	Cracked approach pavement near edge of bridge deck at both ends of the bridge	Seal the crack, patch, or remove (& rebuild) the cracked portion and its adjacent areas. Remove and patch the broken deck edge. Seal the joint	$3,000
	Vegetation growing in joints both ends of deck	Remove vegetation and dirt. Seal the joints.	$1,000
Medium (Resolve <10yr)	Series of transverse cracks (differential shrinkage cracks) on the sidewalk and curb undersides	Locate the cracks on the top of sidewalk and curb. Seal the cracks.	$3,000



BRIDGE 05 - PLAN



BRIDGE 05 - SECTION

LIONS BAY BRIDGE ASSESSMENT

BRIDGE 05
BAYVIEW RD.

VILLAGE of LIONS BAY, B.C.
Project No.: 60437708 Date: 2015-09-25

AECOM

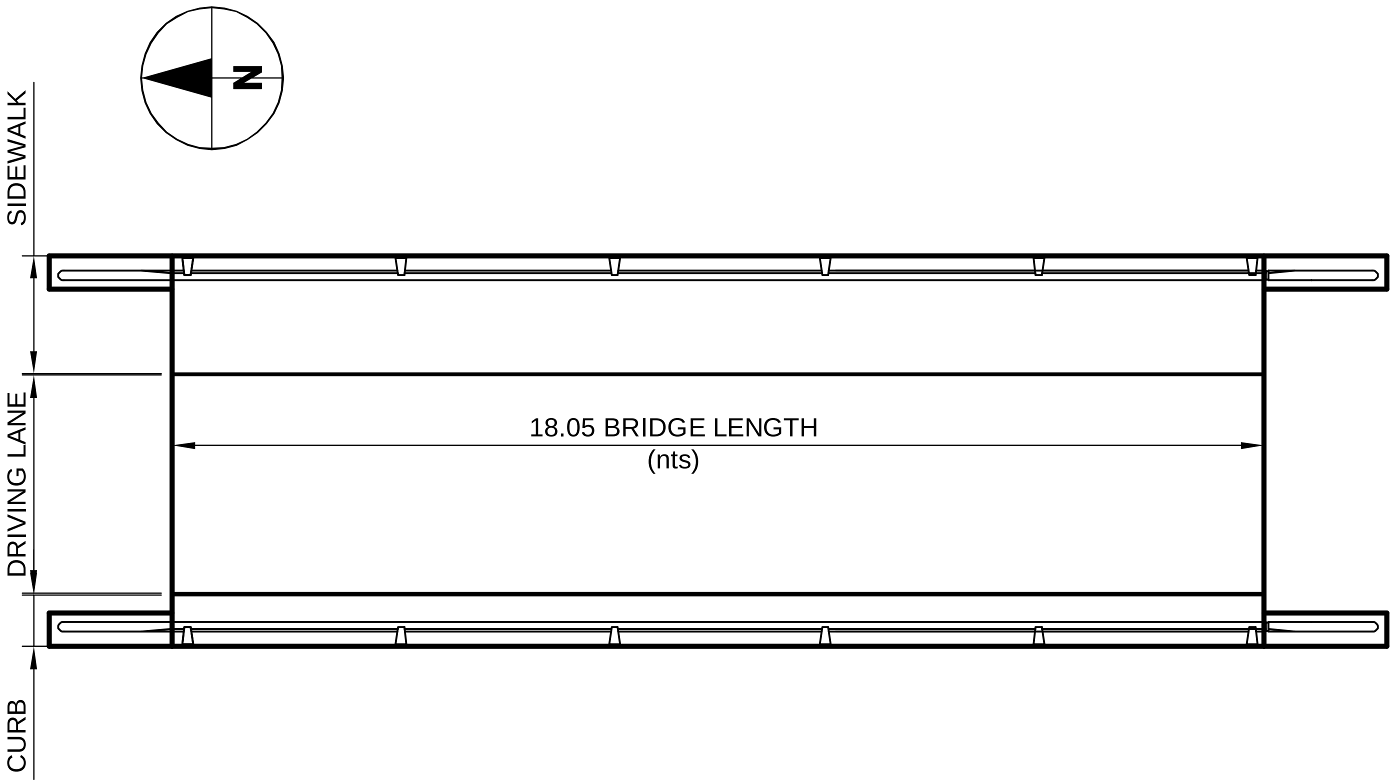
Figure: BR05

General Information

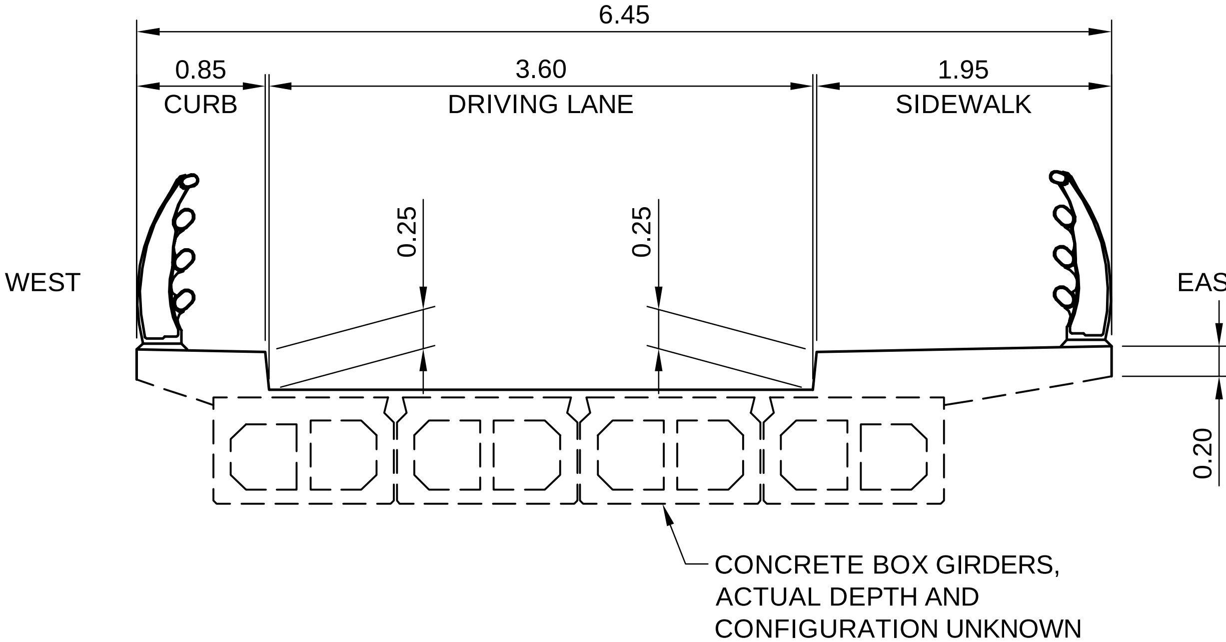
Bridge Reference	Bridge 07 – Bayview Place over Alberta Creek
Inspection Date / Time	2015-09-21 @ 9:30 a.m.
Inspector(s)	Asnee Pochanart – AECOM & Neil Harcus – AECOM
Basic Description	Single Span Concrete Bridge
	Single Traffic Lane with Pedestrian sidewalk on east side and wide curb west side
	Standard MOT 4-Rail barrier on each side
Superstructure Type(s)	Cast-in place concrete deck (or topping), curb and sidewalk on precast concrete box girders
Substructure Type(s)	Cast in place abutments (both ends)
Length x Width	18.15m Long x 6.40m Wide (0.85 curb + 3.60 lane + 1.95 sidewalk)
Observations	No visible cracks in deck
	Railing in good shape
Remarks	*Unable to determine if there were any pipes under the deck*

Issues Summary

	Issue	Resolution	Approx. Cost
Very High (Resolve <1yr)	Tripping hazard due to unevenness between bridge sidewalk and sidewalk approaches	Regrade (asphalt) sidewalk approaches	$1,500
	Misaligned approach barrier (North end on the curb side)	Align and reconnect the misaligned barrier segment	$500
High (Resolve <5yr)	Vegetation growing into abutment seats (at both abutments) with potential of growing into girder underside longitudinal joints	Remove vegetation	$1,000
	Vegetation overgrowing ends of bridge and barriers	Remove vegetation	$1,000
	Vegetation growing in joints both ends of deck	Remove vegetation and dirt. Seal the joints.	$1,000
Medium (Resolve <10yr)	Series of transverse cracks (differential shrinkage cracks)on the sidewalk and curb undersides	Locate the cracks on the top of sidewalk and curb. Seal the cracks.	$3,000



BRIDGE 07- PLAN



BRIDGE 07 - SECTION

LIONS BAY BRIDGE ASSESSMENT

VILLAGE of LIONS BAY, B.C.
Project No.: 60437708 Date: 2015-09-25

BRIDGE 07
BAYVIEW PL.

AECOM

Figure: BR07

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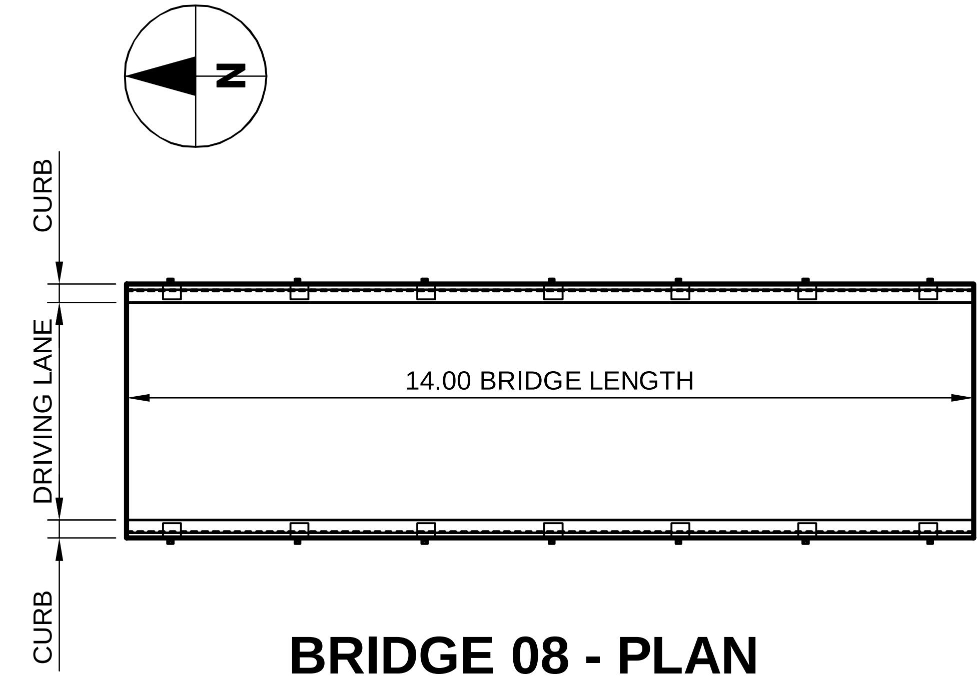
General Information

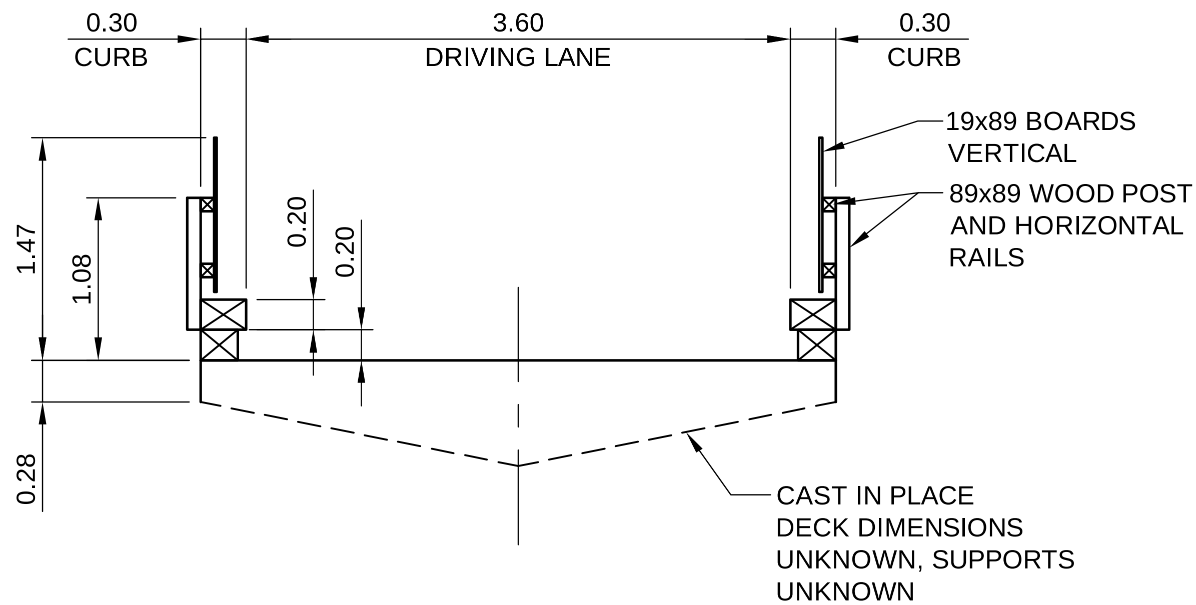
Bridge Reference	Bridge 08 – Lions Bay Avenue over Alberta Creek
	(Private driveway end of Lions Bay Avenue)
Inspection Date / Time	2015-09-21 @ 12:40 p.m.
Inspector(s)	Asnee Pochanart – AECOM & Neil Harcus – AECOM
Basic Description	Single Span Concrete Bridge
	Single Traffic Lane with timber curb and wooden guardrail on each side
	Timber curb = 0.30 m wide x 0.40 m high
	Top of railing = 1.47 m above deck
Superstructure Type(s)	Cast-in place concrete
Substructure Type(s)	Undetermined (unable to view) type of abutment
	Concrete wing-wall (Southwest Corner)
Length x Width	14.00 m Long x 4.20m Wide (0.30 curb + 3.60 lane + 0.30 curb)
Observations	No visible cracks in deck
Remarks	*Unable to determine if there were any pipes under the deck*

Issues Summary

	Issue	Resolution	Approx. Cost
Very High (Resolve <1yr)	Vertical plank missing (west guardrail)	Install the missing plank	$300
High (Resolve <5yr)	Vegetation encroaching (north end)	Remove vegetation	$1,000
	Minor decay – timber curb north-west side Minor decay – horizontal members of wooden guardrail	Check the railing condition (annually)	$200
Medium (Resolve <10yr)	Allowance for complete replacement of curb and railing should the level of decaying warrant it.	Replace curbs and guardrails	$8,000



BRIDGE 08 - PLAN



BRIDGE 08 - SECTION

LIONS BAY BRIDGE ASSESSMENT

VILLAGE of LIONS BAY, B.C.
Project No.: 60437708 Date: 2015-09-25

BRIDGE 08
LIONS BAY AVE.
PRIVATE DRIVEWAY

AECOM

Figure: BR08