625 Fisgard St.,
Victoria, BC V8W 1R7

Capital Regional District

Notice of Meeting and Meeting Agenda

Regional Water Supply Commission

Wednesday, November 17, 2021 **11:30 AM** **6th Floor Boardroom**
625 Fisgard St.
Victoria, BC V8W 1R7

MEMBERS:
L. Szpak (Chair); G. Baird (V. Chair); C. Chambers; Z. De Vries: S. Dubow; S. Duncan;
C. Graham; K. Harper; M. Hicks; B. Isitt; K. Kahakauwila; G. Logan; J. Loveday;
R. Mersereau; T. Morrison; J. Rogers; C. Stock; T. St-Pierre; N. Taylor; R. Wade;
G. Young; E. Wood Zhelka

1. TERRITORIAL ACKNOWLEDGEMENT

2. APPROVAL OF AGENDA

3. ADOPTION OF MINUTES

3.1. 21-829 Draft Minutes of the October 20, 2021 Regional Water Supply Commission meeting.

Recommendation: That the minutes of the October 20, 2021 meeting be adopted.

Attachments: DRAFT Minutes October 20, 2021

4. CHAIR'S REMARKS

5. PRESENTATIONS/DELEGATIONS

This meeting will be held by Live Webcast without the public present.

Presentations and delegations requests can be made online at www.crd.bc.ca/about/board-committees/addressing-the-board, a printable form is also available. Requests must be received no later than 4:30 p.m. two calendar days prior to the meeting.

6. GENERAL MANAGER'S REPORT

7. COMMISSION BUSINESS

7.1. 21-828 Greater Victoria pH & Corrosion Study

Recommendation: The Regional Water Supply Commission receives the Greater Victoria pH & Corrosion Study report for information.

Attachments: Staff Report: Greater Victoria pH & Corrosion Study Update

Appendix A: Greater Victoria pH & Corrosion Study - Final Report - KWL

7.2. [21-827] Water Quality Summary Report for Greater Victoria Drinking Water System - July to September 2021

Recommendation: The Regional Water Supply Commission receives the Water Quality Summary Report for the Greater Victoria Drinking Water System - July to September 2021 for information.

Attachments: Staff Report: Water Quality Summary Report - GVDWS - July-Sept 2021

Appendix A: Water Quality Summary Report - July-Sept 2021 - full report

7.3. [21-830] Summary of Recommendations from Other Water Commissions

Recommendation: That the Regional Water Supply Commission receive the Summary of Recommendations from Other Water Commissions for information.

Attachments: Summary of Recommendations from Other Water Commissions

7.4. [21-831] Water Watch Report

Recommendation: That the Regional Water Supply Commission receives the November 8, 2021 water watch report for information.

Attachments: Water Watch Report

8. NOTICE(S) OF MOTION

9. NEW BUSINESS

10. MOTION TO CLOSE THE MEETING

21-832 Motion to close the meeting.

Recommendation: That the meeting be closed for appointments in accordance with Section 90 (1)(a) of the Community Charter.

11. RISE AND REPORT

12. ADJOURNMENT

Next Meeting: January 19, 2021

To ensure quorum, please contact Denise Dionne at ddionne@crd.bc.ca or 250.360.3087 if you or your alternate cannot attend.

Capital Regional District

Meeting Minutes

Regional Water Supply Commission

Wednesday, October 20, 2021 **11:30 AM** **6th Floor Boardroom**
625 Fisgard St.
Victoria, BC V8W 1R7

PRESENT:
L. Szpak (Chair); G. Baird (V. Chair); N. Chambers; Z. De Vries (EP); S. Dubow (EP); S. Duncan; C. Graham (EP); K. Harper (EP); M. Hicks (EP); B. Isitt (EP); K. Kahakauwila (EP); G. Logan (EP); J. Loveday; R. Mersereau; T. Morrison; J. Rogers (EP); T. St-Pierre (EP); C. Stock; N. Taylor; G. Young (EP); R. Wade (EP); E. Wood Zhelka (EP)

STAFF:
R. Lapham, CAO; T. Robbins, General Manager, Integrated Water Services; A. Constabel, Senior Manager, Watershed Protection; G. Harris, Senior Manager, Environmental Protection; I. Jesney, Senior Manager, Infrastructure Engineering; S. Irg, Senior Manager, Water Infrastructure Operations; K. Vincent, Senior Financial Advisor, Financial Services; M. Bader, Budget Analyst, Financial Services; T. Duthie, Manager, Integrated Water Services Administration Services; D. Dionne, Administrative Coordinator; S. Orr, Senior Committee Clerk; M. Risvold, Committee Clerk

EP = Electronic Participation

The meeting was called to order at 11:30 am

1. TERRITORIAL ACKNOWLEDGEMENT

Vice Chair Baird provided the Territorial Acknowledgement.

2. APPROVAL OF THE AGENDA

MOVED by Commissioner Stock and **SECONDED** by Commissioner Loveday,
That the agenda be approved as circulated.
CARRIED

3. ADOPTION OF MINUTES

3.1. 21-764 Draft Minutes of the July 21, 2021 Meeting

Attachments: July 21, 2021 Draft Minutes

MOVED by Commissioner Stock and **SECONDED** by Commissioner Mersereau,
That the Minutes of the July 21, 2021 meeting be adopted.
CARRIED

4. CHAIR'S REMARKS

The Chair stated that she is happy to be here today and welcomed everyone in attendance. She stated that the reservoir is filling up and it is getting better everyday.

5. PRESENTATIONS/DELEGATIONS

There were no presentations or delegations.

6. GENERAL MANAGER'S REPORT

6.1. Water Supply Outlook [Verbal]

T. Robbins spoke to Item 6.1 noting:

- Rains in September came earlier and heavier than anticipated
- Still expecting the winter rains and at this time there is no concerns with water supply

7. WATER ADVISORY COMMITTEE UPDATE

Vice-Chair Baird provided an update on the Water Advisory Committee noting:

- The Committee met in September
- The Committee continues to see high participation level of members adding quality and value
- Staff provided overview of service impacts of the drought within the region
- the Committee received a presentation from staff on the capacity of the water system to deal with large urban fires as related to the large conflagration fire that occurred in Lytton over the summer

8. COMMISSION BUSINESS

8.1. 21-770 Water Conservation Initiative - Once-Through Cooling Project Reduced Rebates Program

Attachments: Staff Report: Water Conservation Initiative – Once-Through Cooling Project Reduced Rebates Program
Appendix A: Once-Through Cooling Rebates Program Formula

G. Harris spoke to Item 8.1.

Staff answered questions from the Commission regarding:
- Administration of rebate programs
- Climate change communications and outreach
- Benefit of reducing air cooling

Staff to report back at the end of 2022 on the environmental benefits of the once-through cooling equipment replacement rebate program including energy costs of once-through cooling versus forced air cooling.

MOVED by Commissioner Rogers and **SECONDED** by Commissioner Baird;
That staff be directed to advertise and administer a once-through cooling equipment replacement rebate program in the 2022-2026 budgets for a total amount of $20,000 per year up to a maximum of $2,500 per water account.
CARRIED
Opposed: Graham

8.2. 21-264 2022 Service Planning - Water

Attachments: Staff Report: 2022 Service Planning - Water
Appendix A: Community Need Summary – Water
Appendix B: Capital Plan Report
Appendix C: Initiatives Progress Report

T. Robbins spoke to Item 8.2.

Staff answered questions from the Commission regarding:
- Post disaster planning project update
- Hydrological study in Leech Water Supply Area
- Water Supply Master Plan Update
- Water consumption

MOVED by Commissioner Mersereau and **SECONDED** by Commissioner Stock,
The Regional Water Supply Commission recommends the Committee of the Whole recommend to the Capital Regional District Board:
That Appendix A, Community Need Summary - Water be approved as presented and form the basis of the 2022-2026 Financial Plan.
CARRIED

8.3. 21-765 Regional Water Supply Service 2022 Operating and Capital Budget

Attachments: Staff Report: Regional Water Supply Service 2022 Operating and Capital Budget
Appendix A: 2022 Regional Water Supply Service Budget
Appendix B: Long Term Debt Obligations Summary
Appendix C: Agricultural Water Volumes and Rate Payments for 2011 – 2020
Appendix D: Wholesale Water Rate History and Projection

T. Robbins spoke to Item 8.3. and provided a presentation outlining the 2021-2022 budget factors.

Staff answered questions from the Commission regarding:
- Bond rates
- Five year rate projection
- Demand estimates
- Budget
- Agricultural rates
- Long term planning
- Filtration

N. Chambers left the meeting at 12:28

MOVED by Commissioner Stock and **SECONDED** by Commissioner Taylor,
That the Regional Water Supply Commission recommends the Committee of the Whole recommends to the Capital Regional District Board to:
1. Approve the 2022 Operating and Capital Budget and the Five Year Capital Plan;
2. Approve the 2022 wholesale water rate of $0.7332 per cubic metre;
3. Approve the 2022 agricultural water rate of $0.2105 per cubic metre;
4. Direct staff to balance the 2021 actual revenue and expense on the transfer to the water capital fund; and
5. Direct staff to amend the Water Rates Bylaw accordingly.
CARRIED

8.4. [21-769] Water Quality Summary Report for Greater Victoria Drinking Water System - April to June 2021

Attachments: Staff Report: Water Quality Summary Report for Greater Victoria Drinking Water System - April to June 2021
Appendix A: Water Quality Summary Report - April to June 2021

G. Harris spoke to Item 8.4.

Staff answered questions from the Commission regarding:
- Heat dome

MOVED by Commissioner Mersereau and **SECONDED** by Stock,
That the Regional Water Supply Commission receives the Water Quality Summary Report for the Greater Victoria Drinking Water System - April to June 2021 for information.
CARRIED

8.5. [21-766] Summary of Recommendations from Other Water Commissions

Attachments: Summary of Recommendations from Other Water Commissions

MOVED by Commissioner Baird and **SECONDED** by Commissioner Loveday,
That the Regional Water Supply Commission receives the summary of recommendations from other water commissions for information.
CARRIED

8.6. [21-767] Water Watch Report

Attachments: Water Watch Report

MOVED by Commissioner Stock and **SECONDED** by Commissioner Morrison,
That the Regional Water Supply Commission receives the October 11, 2021 water watch report for information.
CARRIED

9. NOTICE(S) OF MOTION

There were no Notices of Motion.

10. NEW BUSINESS

There was no New Business.

11. MOTION TO CLOSE THE MEETING

11.1. 21-768 Motion to Close the Meeting

MOVED by Commissioner Loveday and **SECONDED** by Commissioner Mersereau,
That the meeting be closed for land acquisition in accordance with Section 90 (1)(e) of the Community Charter.
CARRIED

MOVED by Commissioner Loveday and **SECONDED** by Commissioner Mersereau,
That the meeting be closed for appointments in accordance with Section 90 (1) (a) of the Community Charter.
CARRIED

The Regional Water Supply Commission moved into closed session at 12:50 pm.

12. RISE AND REPORT

The Commission rose from its closed session at 1:08 pm without report.

13. ADJOURNMENT

MOVED by Commissioner Meresereau and **SECONDED** by Commissioner Taylor,
That the September 21, 2021 meeting be adjourned at 1:08 pm.
CARRIED

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CHAIR

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SECRETARY

REPORT TO REGIONAL WATER SUPPLY COMMISSION
MEETING OF WEDNESDAY, NOVEMBER 17, 2021

SUBJECT **Greater Victoria pH & Corrosion Study Update**

ISSUE SUMMARY

To submit the report summarizing the 2019-2021 work and findings of the Greater Victoria pH & Corrosion Study.

BACKGROUND

The Capital Regional District (CRD) staff initiated the Greater Victoria pH & Corrosion Study in 2019 to investigate the potential water quality impact of the new hypochlorite chlorination process at the Goldstream Water Treatment Plant that was commissioned in 2018. The original study scope was comprised of investigations, including sampling and testing on the public side of the drinking water infrastructure, to determine whether the water chemistry changes at the treatment plant would impact the corrosivity of the drinking water and, therefore, potentially lead to undesired metal, in particular lead, leaching into the drinking water. The study was commissioned and managed by CRD staff and co-sponsored by the participating Districts of Saanich and Oak Bay, Township of Esquimalt and the City of Victoria. The study areas encompassed the water distribution systems owned and operated by the participating municipalities, the CRD-owned water infrastructure in the Juan de Fuca Distribution System, and the transmission infrastructure in the Regional Water Supply System and Saanich Peninsula System. The CRD retained the consulting services of Kerr Wood Leidal Consulting Engineers Ltd. (KWL) for the design and execution of the study. This study of the water corrosivity and lead and copper concentrations in the public system commenced in September 2019 and carried on through 2020.

In response to new drinking water guidelines issued by the BC Ministry of Health in April 2019, the CRD added a residential tap sampling program to the scope of the Greater Victoria pH & Corrosion Study. While the investigations on the public side of the water infrastructure were completed in 2020, the added scope for investigating lead and copper concentrations at private taps delayed the completion of the study until the middle of 2021. CRD staff provided progress reports to the Regional Water Supply Commission in November 2019 and July 2021. The final report by KWL was issued in August 2021.

Overview of Results

The Greater Victoria pH & Corrosion Study concluded that the drinking water across the study areas has in general a low corrosivity and, therefore, a low potential for leaching metals into the drinking water. Only a few localized areas with high water age, mostly at the far extremities of the piping system, exhibit a slightly higher corrosivity potential. Because the public side of the drinking water system contains very few and only minor lead sources (e.g., older valves, hydrants and some cast iron water mains), lead concentrations were found to be very low across the public systems. A few elevated lead concentrations were investigated in more detail and could subsequently be resolved by removing old copper pipe sampling infrastructure. These results confirmed that the drinking water supplied at the private property lines across the region contains very low concentrations of lead and copper.

The tap sampling program at private taps (typically residential kitchen taps) was conducted following the sampling and testing protocols in the BC Ministry of Health and Health Canada guidelines. A total of 104 tap samples were collected in the study areas. Only one house exceeded the guideline limits for lead concentrations. No house exceeded the guideline limits for copper concentrations. These results indicate that the vast majority of Greater Victoria homes have negligible lead and copper concentrations in their tap water. But the results also show that a few individual houses with lead sources within their plumbing infrastructure may experience lead concentrations in exceedance of the health limits. Overall, these tap sample results indicate that there is no community level health concern in Greater Victoria due to lead in the drinking water.

The report provides a number of recommendations to the study participants on how to further improve corrosion-related water quality in Greater Victoria and how to monitor corrosion related parameters to confirm compliance with the health guidelines. Key recommendations included:

- a centralized corrosion control treatment is currently not recommended for the Greater Victoria Drinking Water Service;
- local water suppliers should develop ongoing lead sampling programs to satisfy lead compliance requirements by the BC Ministry of Health;
- each jurisdiction should develop, in coordination with Island Health, a long-term monitoring program for “at tap” lead concentrations;
- each water supplier should develop lead service line inventories; and
- the CRD should consider corrosion control treatment to proactively better condition the treated water when planning large-scale future treatment upgrades within the Greater Victoria Drinking Water Service.

Next Steps

The report of the Greater Victoria pH & Corrosion Study will be submitted to the study participants and to Island Health for consideration of the recommendations. Due to the relatively small sample size in the completed tap sampling program, and in recognition that not all areas of the region were fully covered (missing Saanich Peninsula municipal water systems), the CRD is currently conducting a supplementary tap sampling program. This program will include areas previously not covered, as well as collect samples from some multi-unit residential and some commercial buildings. The supplemental study will be completed in Q4 of 2021, with a staff report in early 2022.

Water suppliers (i.e., CRD, municipalities) will follow up this study with future tap sampling efforts within their own jurisdiction to meet lead monitoring requirements that will be formulated by the Island Health Authority (likely based on provincial standards). The CRD will ensure the work is done in a coordinated and collaborative process, recognizing that each water supplier is responsible for identifying and removing potential lead service lines and/or communicating with affected customers on risks associated with lead concentrations in tap water. CRD staff will evaluate the regional findings with Island Health to inform a system-wide reevaluation of potential corrosion control treatment needs.

CONCLUSION

The CRD has studied the corrosivity and lead and copper concentrations in the drinking water in Greater Victoria. The report of the Greater Victoria pH & Corrosion Study concludes that the corrosivity of the water is low and lead and copper concentrations in drinking water on the public and private side of the water system are generally very low. The CRD and the municipal water suppliers will continue to study and monitor corrosion related parameters in the drinking water, as per regulatory requirements. After it is received by the Regional Water Supply Commission, the report will be submitted to the participating municipalities and the Island Health Authority for consideration of the recommendations.

RECOMMENDATION

The Regional Water Supply Commission receives the Greater Victoria pH & Corrosion Study report for information.

Submitted by:	Glenn Harris, Ph.D., R.P.Bio., Senior Manager, Environmental Protection
Concurrence:	Larisa Hutcheson, P.Eng., General Manager, Parks & Environmental Services
Concurrence:	Ted Robbins, B.Sc., C.Tech., General Manager, Integrated Water Services
Concurrence:	Robert Lapham, MCIP, RPP, Chief Administrative Officer

ATTACHMENT

Appendix A: Executive Summary – Greater Victoria pH and Corrosion Study – Report (August 31, 2021)

KERR WOOD LEIDAL
consulting engineers

Greater Vancouver
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Burnaby, BC V5C 6G9
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Greater Victoria pH and Corrosion Study

Final Report
August 31, 2021
KWL Project No. 0719.066

Prepared for:

CRD
Making a difference...together

Saanich

THE CITY OF VICTORIA

DISTRICT OF OAK BAY

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Executive Summary

The Greater Victoria Drinking Water System (GVDWS) is supplied by Sooke Lake Reservoir as its water source. After the raw water has been disinfected at the Goldstream Water Treatment Plant (formerly Japan Gulch) and the Sooke River Road Water Treatment Plant, the treated water flows through the Capital Regional District (CRD) transmission system and to municipal distribution systems across the region.

The softness of the treated water provides potential for lead and copper to leach into the water. The several-day water age at the system extremities also provides significant contact time that, should metals be leaching into the water, could allow them to accumulate. Health Canada sets a maximum allowable concentration (MAC) at customers' taps of 5 µg/L for lead, and of 2 mg/L for copper, with lower levels preferred where possible for both.

The CRD and project partners (District of Saanich, City of Victoria, District of Oak Bay) undertook the present study to understand the water's potential to dissolve lead and copper, as well as to assess geographical risks on the public side (across the distribution network) and private side (in private homes and businesses), and evaluate mitigation strategies as needed.

For the public side of the project, base maps were developed to convey information about the existing water system pipe network and water age. Water samples were collected in both warm weather (across GVDWS) and cold weather (repeat sampling in the Sooke focus area) and analyzed for corrosivity based on the calcium carbonate precipitation potential (CCPP) index, lead, and copper. A pipe corrosion index (PCI) was also developed as a predictor of lead presence in the water, based on pipe age/material, water corrosivity, pipe contact, and nearby measured lead concentrations.

In general, the water across the GVDWS is generally passive (CCPP > -5) with some areas, including some far ends of the system, suggesting mildly corrosive (CCPP between -5 and -9.9) or corrosive (<-10) conditions. Water was marginally more corrosive in the winter, and there was no significant relationship between water age and CCPP.

Lead and copper levels were relatively low throughout the distribution system. Despite these generally low levels, lead concentrations above the MAC (i.e., >5 µg/L) were observed in one summer sample and one winter sample. Further investigation was undertaken at three public side sampling sites, including the summer MAC exceedance and two other sites of interest. The results indicated that pipes and fittings within the sampling stations were contributing the lead and did not pose a risk of distribution system contamination. The lead-containing pipes and fittings of the sampling infrastructure in two locations were replaced and repeated testing confirmed a significant reduction in lead concentrations; replacement of the third station is imminent. The CRD will conduct follow-up investigations at the site of the lead exceedance in the winter.

A total of 104 private side locations (single-family homes plus CRD and KWL offices) were sampled for lead and copper in a First Draw sample, following 6 hours of stagnation, and in a 30-minute stagnation (30MS) sample. One site of 104 had a lead concentration over the First Draw action limit (15 µg/L), and the same site had a 30MS lead concentration over the Health Canada MAC (5 µg/L). These levels are lower than in previous studies, which may be due to a change in water treatment chemistry. The homeowner with the high lead concentrations was notified and given advice on corrective actions. No sites sampled had copper concentrations over the aesthetic objective (1 mg/L) or the MAC (2 mg/L). Four potential lead service lines were identified via participant surveys, and the relevant municipalities were notified.

In general, the study results demonstrate that the GVDWS supplies treated water of low corrosivity towards metal pipes. Historically, and compared to other North American drinking water systems, relatively few lead-containing pipe materials were used on the public and private side of the GVDWS. As a result, the study found that lead and copper concentrations system-wide are typically well below the current health limits. Based on the public and private side results from the present study, there is no community-level health concern associated with lead concentrations in the tap water and system-wide corrosion control treatment is not required

at this time. However, it is recommended that the Greater Victoria water suppliers follow up with additional private side sampling programs to solidify their understanding of lead risks within their systems based on a larger sample size than what was included in this study.

A lead compliance monitoring strategy that satisfies the requirements of the BC Ministry of Health guidelines should also be developed in conjunction with the Vancouver Island Health Authority for all Greater Victoria water suppliers. Additional corrosion control monitoring, including private side testing, should be conducted by the CRD with any water-chemistry relevant change to the water treatment or with any change of the source water. The individual water suppliers of the GVDWS should also create and maintain, where applicable, a lead service line inventory, which is to be considered for the design of follow-up private side sampling programs. Any known or detected lead service lines should be prioritized for complete replacement, and strategies developed for customer guidance. Water suppliers with a sizeable lead service line inventory should develop a lead service line replacement strategy that outlines the responsibilities and liabilities associated with the work on private property. On the public side, mains with a high PCI (e.g., cast iron) should be considered for replacement, water age should be minimized, and lead-free hydrants and fittings should be used. Corrosion control treatment to further reduce water corrosivity, though not recommended at present, should be considered when planning substantial upgrades to the existing treatment facilities in the future.

1. Background and Introduction

The Greater Victoria Drinking Water System is supplied by Sooke Lake Reservoir as its water source. The CRD owns and operates the watershed, provides treatment, supplies bulk water to municipal customers, and provides municipal distribution for the Juan de Fuca (JDF) service area. After the raw water has been disinfected at the Goldstream Water Treatment Plant (GWTP - formerly Japan Gulch) and the Sooke River Road Water Treatment Plant (SRRWTP) by means of UV, chlorination and chloramination, the treated water flows through the Capital Regional District (CRD) transmission system and is supplied to a number of municipal distribution systems across the region. The municipal distribution systems in the JDF Area (consisting of the Town of View Royal, City of Colwood, City of Langford, small parts of the District of Metchosin, and the District of Sooke/East Sooke) are owned and operated by the CRD while the municipal distribution systems in the Core Area (City of Victoria/Esquimalt, District of Saanich, District of Oak Bay) and on the Saanich Peninsula (District of Central Saanich, District of North Saanich, and the Town of Sidney) are owned and operated by the municipalities.

The treated water is of neutral pH and very soft. The water system is also expansive; water age can reach several days from the time of treatment to customers' use at the far ends of the system. The CRD recognized that the chemistry of the water they supply to their customers had the potential to be corrosive and leach lead and copper from lead-or copper containing infrastructure. These metals could enter the drinking water on both the public (distribution) side and on the private (domestic plumbing) side prior to being consumed by customers in the region.

In March 2019, the Health Canada lead guidelines changed, reducing the maximum allowable concentration (MAC) at customers' taps from 0.01 mg/L to 0.005 mg/L (i.e.,10 µg/L to 5 µg/L) while also stipulating that the levels should be maintained as low as reasonably achievable (ALARA). This change made Canada's target for lead one of the lowest in the world.

Subsequent to these federal guideline changes, in April 2019 the BC Ministry of Health issued the "Guidelines on Evaluating and Mitigating Lead in Drinking Water Supplies, Schools, Daycares and Other Buildings" which clarify the roles and responsibilities of water suppliers and owners of public institutions around the topic of lead in drinking water.

In June 2019, the Health Canada copper guidelines also changed, adding a new MAC of 2 mg/L for total copper to the existing aesthetic objective (AO) of 1 mg/L.

The new lead and copper limits are a challenge for water suppliers because municipal utilities are being held at least partially responsible for the quality of water tested from consumers' taps, not the water that is delivered to the property line. Understanding that the water supplied by the GVDWS had the potential to cause leaching of lead and copper and that the new disinfection equipment at the upgraded Goldstream Water Treatment Plant would change relevant water chemistry parameters, the CRD, the City of Victoria, the District of Saanich, and the District of Oak Bay decided to work together to determine the actual corrosion potential within the public and the private system and if the water chemistry poses a risk to their customers.

Led by the CRD, the project partners retained Kerr Wood Leidal Associates Ltd. (KWL) in September 2019 to study how the corrosivity of drinking water changes as it travels from the CRD treatment facilities to their customers' homes and businesses and identify the corrosion risks across the distribution systems. In 2020, the scope of the study was expanded to include a private side tap sampling program to determine lead and copper concentrations at the residential consumers' taps in accordance with the BC Ministry of Health guidelines. Based on the findings, possible mitigation strategies were to be developed that would meet the requirements of Health Canada and BC Ministry of Health guidelines, as well as reference requirements under the Lead and Copper Rule by the US Environmental Protection Agency (USEPA).

1.1 Objectives

The objectives of this study were to:

1. Understand how the corrosivity of drinking water changes as it travels from the CRD disinfection facilities to the project partners' customers' homes and businesses;
2. Understand how water chemistry contributes to the leaching of lead both on the public side (distribution) and private side (domestic piping within customer's homes and businesses) by conducting a sampling program that meets the requirements of the Health Canada BC Ministry of Health guidelines and that is cross-referenced to the requirements in the USEPA "Lead and Copper Rule"; and
3. Identify and evaluate mitigation strategies that balance health risk with capital and operating costs.

1.2 Regulatory Framework

Under the British Columbia *Drinking Water Protection Act* (DWPA) and *Drinking Water Protection Regulation* (DWPR) the project partners are required to deliver potable water to users, but there is no clear requirement to test after delivery (i.e., quality must be monitored throughout the distribution system, but not within customer homes). The legislation does not provide a detailed breakdown of treatment expectations, directly referencing only microbiological requirements, but grants drinking water officers powers to govern how water systems are operated and monitored. These powers are manifested through the issuance of construction and operating permits for water treatment and distribution systems by drinking water officers and public health engineers from the local health authority – in this case, the Vancouver Island Health Authority (VIHA).

Construction permits are issued when the public health engineer is satisfied that the proposed facility will produce water that meets the provincial requirements under DWPA and DWPR as well as the federal Health Canada Guidelines for Canadian Drinking Water Quality (GCDWQ). Following construction, an operating permit is issued when the drinking water officer is satisfied that the system will be operated to produce water that meets the intent of the design. The terms and conditions on operating permits may not only include microbiological treatment requirements, but also requirements to address any other health related water conditions.

For large systems, it is common for the local health authority to review the conditions set out in the Permits to Operate regularly (i.e., annually). At their discretion, drinking water officers may, under Section 8 (4) of the DWPA, change the terms and conditions of an operating permit if they consider it advisable. The officer must first consult with the water supplier and consider any comments of the water supplier in response. For example, when the GCDWQ change, the drinking water officer could request an amendment to the operation of an existing facility or change the terms and conditions of its operating permit. A complaint or request for investigation by users of the system could also trigger a review of the system operation, a consultation with the water supplier, an order for additional monitoring, an order for system assessment and/or the amendment to an operating permit.

VIHA and its drinking water officer or designates regularly communicate with the different water suppliers within the GVDWS and Permits to Operate are reviewed and renewed annually for each system. After the Health Canada lead and copper limit changes, VIHA and the CRD had several discussions about the new requirements and the local risk to public health from potential lead in the GVDWS. VIHA has, to date, not issued any official monitoring or operating requirements for lead mitigation in the GVDWS but has opted to await the outcome of the "Greater Victoria pH & Corrosion Study" at hand. The CRD and its study partners chose to act proactively to study and understand the risk of potential leaching of lead due to the chemistry of the supplied drinking water.

1.3 Potential Sources of Lead and Copper

Lead and copper have long been used in water conveyance infrastructure both on the public (distribution) side and the private (domestic plumbing) side.

Table 1-1 provides a list of some of the known potential sources of lead and copper in the public distribution system and on the private side.

Table 1-1: Potential Sources of Lead and Copper in the Distribution System and Private Side

Location	Source	Install Date	Lead	Copper
Public	Cast iron pipe[1]	1929 to 1957	X	
	Steel pipe[2]	up to 1960	X	
Public and Private	Galvanized pipe[3]	up to 2008	X	
	Lead services[4]	up to 1970	X	
	Copper piping (i.e., sampling stations) with lead-containing solder	up to 1989[6]	X	X[5]
	Brass fittings (i.e., hydrant boots, valves)[7]	up to 2013	X	X
	Bronze fittings (i.e., tees, elbows)[7]	up to 2013	X	X
Private	Faucets (typically brass or chrome-plated brass)[6,7]	up 2013	X	X

1. 1991 City of Vancouver Long Range Capital Plan indicates that lead joint steel pipe was installed until the late 1950s and that lead joint cast iron was installed from 1920 to 1957. Vancouver is likely representative of regional trends.
2. CRD operations staff confirmed that there was old CRD steel pipe with lead joints. Much of the large distribution pipe has been replaced, but branch connections are still expected to contain lead (i.e., branch connections off Main No. 2).
3. Per Environmental Engineering Science, Brandi N. Clark, Sheldon Vaughn Masters, and Marc A. Edwards. Environmental Engineering Science, Aug. 2015.713-721.http://doi.org/10.1089/ees.2015.0073.
4. Based on review of lead services removed from City of Victoria (see following section).
5. Copper is allowed under the National Plumbing Code of Canada; plastic pipe is becoming more popular for domestic use.
6. The BC Plumbing Code restricted the use of lead in solder in 1989.
7. Could contain up to 8% lead until 2013 when NSF 61 was updated.

1.3.1 Public Side

Lead Joint Cast Iron and Steel

For the cast iron and non-welded steel pipes noted above, lead may have been used in the pipe joints. This joining process involved packing a rope of oakum (a fibre impregnated with a bituminous compound) into the joint which would expand when wet then sealing the oakum in place using a bead of lead inside the hub/socket. In a well-constructed joint, the lead would not be in contact with the water inside the pipe. However, if the oakum rope did not completely seal the joint, the lead could run past the rope into the interior of the pipe where it would be in direct contact with the potable water.

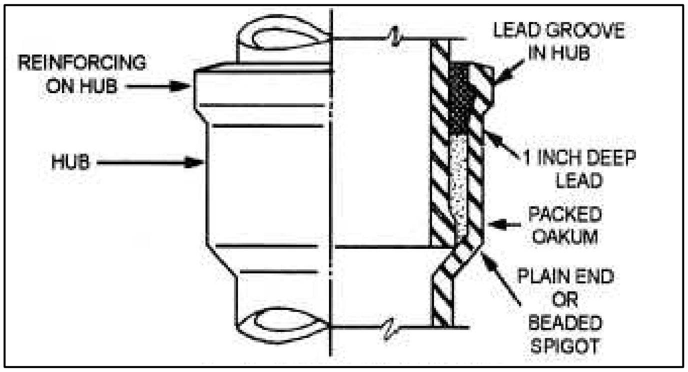

Figure 1-1: Lead and Oakum Joint[1]

As noted in Table 1-1, lead joint steel and cast iron were installed in the City of Vancouver up until the late 1950s. The City of Victoria reported to KWL the use of leaded joints in cast iron up until the late 1950s and also reported that lead has been found in the bottom of cast iron pipes where it leaked through the joint during the lead joint sealing process.

For the purposes of this study, it has been assumed that leaded joints could have been used in the GVDWS up until the late 1950s.

Galvanized Pipe

The zinc used for galvanizing steel can contain lead and leach it into potable water. A 2015 study[2] conducted surface analysis of various galvanized steel pipes and fittings installed from 1950 to 2008 and found the lead concentration in the coating ranged from non-detect (very low) to nearly 2%. This variation in concentration depended on manufacturer and fitting type. Lead particles can also attach to the surface of galvanized pipes. Over time, the particles can dissolve into water through contact.

Lead Services

Water system operators from Victoria, Oak Bay, and Saanich reported that there are very few known lead services and that lead services are very rarely found as part of a water main replacement project or other works. The City of Victoria provided service records that show the history of service replacement dates and materials for the City of Victoria and Town of Esquimalt. The records show a project that removed 1,931 lead services from 1983 to 1996. These services were removed on the public side of the property line and homeowners were notified during this replacement if lead was observed at the property line. When lead services are discovered, the City of Victoria removes them immediately.

The District of Oak Bay reported that a similar lead service removal project occurred at the same time as the Victoria project, but no records exist to show where lead services were removed. Oak Bay provided records of water service materials that included 30 remaining known lead services.

The Records from Victoria and Oak Bay, in combination with a review of the nearby watermain age, suggest that lead services were installed as late as the early 1970s.

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[1] Image from *Utilitiesman Basic -Volume 1, a*ccessed online at *militarynewbie.com/wp-content/uploads/2013/11/US-Navy-course-Utilitiesman-Basic-Volume-1-NAVEDTRA-14265.pdf.*

[2] Brandi N. Clark, Sheldon Vaughn Masters, and Marc A. Edwards. Environmental Engineering Science, Aug. 2015, 713-721. http://doi.org/10.1089/ees.2015.0073

Copper Pipe

Copper pipe exists in various facilities across the distribution system including pump stations, pressure reducing and other valve stations and water quality sampling stations. Any of this piping could contribute copper to the water in the distribution system. Also, the National Plumbing Code of Canada allowed lead as a component of lead solder until 1990 and the BC Plumbing Code restricted the use of lead in plumbing in 1989. Accordingly, any copper piping installed before 1989 could also contribute lead to the system through its solder, especially if the water sits stagnant in the pipe for long periods of time. Solder also has the potential to flow through pipe joints and fittings and pool in the bottom of pipe systems.

1.3.2 Private Side

Brass, Bronze, and Leaded Solder

The National Plumbing Code of Canada allowed lead as a component in plumbing pipes until 1975 and as a component of lead solder until 1990. The BC Plumbing Code restricted the use of lead in 1989. In 2013 NSF 61 was updated to restrict lead content in brass fittings and other water treatment and distribution products. The allowable lead content was decreased from 8% (dependent on product) to less than a weighted average lead content of 0.25% on wetted surfaces.

Copper Piping

Copper is still allowed under the National Plumbing Code and is commonly used in domestic plumbing. More recently plastic pipe (PEX) has become more popular because it is less susceptible to pin hole leaks and damage during freezing.

1.4 Previous CRD Work

The CRD regularly monitors water quality at the source, after treatment and across the distribution systems from more than 130 water quality testing stations across the Greater Victoria Drinking Water System. This monitoring program includes:

- various microbiological, organic, and inorganic parameters (including metals) bi-weekly/monthly or quarterly from the raw water sources and tributaries;
- microbiological parameters daily (i.e., E.coli and total coliform) from a rotating list of sampling stations including raw and treated at the GWTP, weekly at SRRWTP;
- chlorine residuals daily from a rotating list of transmission/distribution system sampling stations;
- pH weekly from the raw and treated water at the GWTP, weekly at the SRRWTP;
- pH, alkalinity and other chemical parameters on a two-week rotation from a selection of transmission/distribution system sampling stations;
- various organic and inorganic parameters monthly from raw and treated at the GWTP;
- metals (including lead and copper) monthly from the treated at the GWTP;
- metals (including lead and copper) bi-monthly from the raw at the GWTP;
- radionuclides and special organic compounds semi-annually from raw at GWTP;
- protozoan parasites 8 time per year from the raw at the GWTP; and

- metals (including lead and copper), hardness, disinfection by-products and total and dissolved organic carbon every two months from a selection of transmission/distribution system sampling stations.

The CRD has also conducted sampling on the private side (approximately 150 single-family homes) to assess the risk of lead leaching within customer homes in 2007 and 2008.

1.4.1 Public Side

During regular monitoring, when parameters exceed the GCDWQ, the CRD conducts follow-up sampling to investigate the cause.

In 2016, the CRD initiated a bi-monthly metals/lead monitoring program on a few selected sampling stations on CRD infrastructure across Greater Victoria. While lead concentrations were generally very low, the CRD then conducted follow-up investigations on high levels of lead found at water sampling stations near Cook Street/Mallek Crescent (City of Victoria) and Lansdowne Road/Foul Bay Road (District of Oak Bay). Colquitz Engineering reviewed the infrastructure and distribution system arrangement in these areas and concluded that backflow from the City of Victoria could be contributing to localized lead levels found in the CRD's trunk supply system, specifically at the Cook/Mallek meter station on Main #3.

In 2018/2019 the CRD also conducted first draw and flushed sample collection from sampling stations and hydrants in the entire JDF system. Again, while lead concentrations were generally very low, they found at a few hydrant sampling points pre-flush levels as high as 309 μg/L which dropped to below 5 μg/L after flushing. Per discussions with CRD staff, the lead measured in the first draw samples was attributed to the bronze components in hydrants. As the first draw water would have been sitting inside/below the hydrant the risk of contributing this lead to the overall distribution system was considered low. Nonetheless, the CRD subsequently implemented a lead-free hydrant installation policy. High lead concentrations found in samples from the Sooke Henlyn Pump Station were mitigated first by changing the pumping frequency (reducing water stagnation) and ultimately eliminated by removing old soldered-copper piping in this station.

1.4.2 Private Side

In 2007/2008 the CRD conducted a private side lead sampling program based on a two-tier sampling approach. The sampling program involved collecting first draw samples after a stagnation period of at least 6 hours in 155 dwellings. A 47-dwelling subset of the total 155 dwellings also completed a 30-minute stagnation test (30MS protocol). The 30MS protocol collects a 2 L sample after flushing for 5 minutes and waiting 30 minutes to collect the sample.

Approximately 5% of the 155 first draw samples collected were found to have a lead concentration over the 15 μg/L action limit (Health Canada, USEPA).

The average lead concentration in 30MS protocol testing samples was 2.7 μg/L and only one sample exceeded 10 μg/L which was the GCDWQ maximum acceptable concentration (MAC) at the time.

Per the Health Canada *Guidance on Controlling Corrosion in Drinking Water Distribution Systems* that was released in 2009, 10% of samples need to exceed the action limit to suggest that the drinking water is corrosive and trigger corrective action by the utility. Given that only 5% of samples exceeded the action limit, the CRD did not implement any corrective actions at that time but recommended repeated private side sampling in the future in particular when changes to the water chemistry would be made as part of planned upgrades to the disinfection process at the GWTP.

1.4.3 Sampling Summary Table

Previous lead-related sampling events in the region, including the present study are summarized as follows:

Table 1-2: Summary of CRD Lead Sampling Events

Date	Organization	Region	Locations	Test Type	CRD Water Condition
2007 – 2008	CRD	GVDWS	Private residences	First Draw & 30MS	Chlorine gas
2016	BC Health Authorities	BC	Schools	Stagnant & Flushed	Chlorine gas
2018 - 2019	CRD	Juan de Fuca	Distribution system	First Draw & Flushed	Chlorine gas
Sept 2019[1]	CRD	GVDWS	Distribution system	First Draw & Flushed	Hypochlorite
Feb 2020[1]	CRD	Sooke	Distribution system	First Draw & Flushed	Hypochlorite
2020	VIHA	Vancouver Island	Daycares & schools	Stagnant & Flushed	Chlorine gas
Mar 2021[1]	CRD	GVDWS	Private residences	First Draw & 30MS	Hypochlorite
Every 2 Months	CRD	GVDWS	Distribution system	Unknown	Varies

[1]These samples were collected as part of the present study.

2. Scope of Work

The CRD decided in 2016 to conduct a system-wide pH & Corrosion Study following the commissioning of the upgraded GWTP. The timing for the project was chosen because the new facility would result in a slight change in water chemistry. The commissioning of the new plant was delayed until June 2019 which led to a postponement of the pH & Corrosion Study until September of 2019. The Flint, Michigan drinking water crisis in 2014 and the increased attention to the potential effects of high lead concentrations in drinking water demonstrated the importance of this study and the need for comprehensive, scientific, and transparent reporting.

The CRD, representing all municipal distribution systems in the JDF area, and the core area municipalities (City of Victoria/ Esquimalt, Saanich, and Oak Bay) formed a partnership to co-fund this multi-jurisdictional project which was led by CRD staff.

KWL was retained to conduct the study with the objective of examining the corrosivity of the drinking water and analyzing how the corrosivity changes as it travels from the CRD disinfection facilities to their customers' homes and businesses. The scope included the identification of the metal corrosion risk across the distribution system. The original scope of work focused on the public (distribution) side, it included:

- Collection and integration of water model information from project partners to:
  - create base maps for reporting measured and calculated values;
  - collect inventory information including pipe age, material, and diameter; and
  - assign water age information (water age and velocity) from each model to the integrated pipe network.
- Collection of warm water samples from across the GVDWS (in September/October) to determine corrosivity in form of a corrosivity index (based on calculated calcium carbonate precipitation potential, CCPP) and directly measure for lead and copper; then follow up with cold water samples (in February) to determine how the theoretical corrosivity of the water changed summer to winter and to see if lead values changed.
- Development of a Pipe Corrosion Index that considered:
  - the potential for lead to be present (based on the pipe age and material);
  - the corrosivity of the water (based on calculated CCPP corrosivity index);
  - the contact with the pipe (based on velocity from water age models); and
  - whether lead was found nearby.
- Secondary investigations of high lead levels at CRD water sampling sites at Cook/Mallek, Lansdowne/Foul Bay and Cecelia.
- Reporting to the project partners through this report.

Due to the new requirements to measure lead compliance at the customer tap in the 2019 BC Ministry of Health guidelines, the scope of the study was expanded to include private side testing to inform any required mitigation. This scope of work included the following:

- Preparation of private side lead analysis map:
  - assignment of expected age to each parcel within the study areas based on the oldest available nearby linear infrastructure (water, sanitary sewer, and stormwater sewer) within a 40 m radius and creating a base map with colour gradations based on age;
  - addition of 2007/2008 CRD lead testing results (first draw samples) to the base map;
  - addition of removed lead services received from City of Victoria; and
  - addition of service information received from Oak Bay.
- Identification of sampling locations across the project partners' jurisdictions with 30 - 40 homes in each area for a total of over 100. Sampling locations were selected based on expected age of property, information about services (where available), historical (2007/2008) water sampling results, and pipe corrosion index of supply piping in the area.
- Preparation of public engagement materials:
  - invitation to participate; and
  - instructions for minimizing exposure to lead brochure.
- Preparation of sampling program materials:
  - Sampling procedure (infographic);
  - Survey (to collect information about the houses in the study area); and
  - Flow chart for identification of lead services.
- Coordination with the laboratory to prepare sampling kits and analyze samples collected;
- Survey processing;
- Analysis of results; and
- Reporting (content added to this report).

2.1 Methodology

Details of the methodology used for technical components of the scope are included below.

2.1.1 Base Map Development

Water age models were collected from each of the project partners. These models included pipe sets with asset information (i.e., pipe age, pipe material, pipe diameter) as well as velocity in each pipe and expected water age at each node between pipes. These pipe sets were merged in GIS to create a complete GIS set for the Greater Victoria Drinking Water System.

Any CRD pipes built into the individual municipalities' water models (i.e., supply piping to the municipality) were flagged in the individual pipe databases (pipe ownership was noted in all water models) and the CRD pipe layer results governed.

This pipe set then became the basis for all mapping and spatial analysis for the study.

2.1.2 Public Side Water Sampling

The distribution system water sampling was conducted in two rounds. In the first round (September/October 2019):

- 45 samples were collected by KWL staff (primarily at hydrants); and
- 130 samples were collected by CRD staff (primarily at water quality sampling stations).

The locations for samples collected by KWL staff were selected following conversations with operations staff from each project partner. These selections considered:

- Pipe material (i.e., targeted collecting samples from old cast iron areas);
- Water age (i.e., targeted collecting samples from dead-end and high-water age areas);
- Historical lead results (i.e., collecting samples from areas where lead has been measured in the past);
- Corrosion-related customer complaints (i.e., collecting samples from areas where customers have complained about copper or iron staining, or pinhole leaks in copper pipe); and
- Poor water quality areas (based on operational knowledge).

In the second round of sampling (February 2020), samples were collected by KWL and the CRD in the same locations as the first round to allow for direct comparison, but only from the Sooke distribution system (District of Sooke and East Sooke).

The Sooke system was chosen because the treatment conditions at the GWTP, which services the rest of Greater Victoria, changed between the first and second round of sampling. During the first round of sampling the GWTP was disinfecting using the newly commissioned hypochlorite system, but the system was taken offline, and the plant returned to using chlorine gas in December 2019. The SRRWTP supplying only the Sooke system did not change any water treatment processes during the study period. The Sooke system was, therefore, chosen to eliminate changing multiple parameters and focus on the impact of changing water temperature. Any trends and findings would be considered representative of the rest of the GVDWS.

The sampling procedure used for both rounds of sampling follows:

(a) Locate sampling point:
   - Confirm Sample ID and Distribution Area with sampling map (refer to Appendix B); and
   - Write description of sampling location for inclusion in sample tracking sheet.

(b) Label sample bottles with sampling location and date as a minimum (follow instructions from the laboratory).

(c) Flush water from sampling point:
   - For hydrants – fully open 2” port and flush for 3 minutes; and
   - For taps in pump station or valve station flush at full flow for 10 minutes.

(d) While water is flushing, measure the temperature of the stream. If the temperature has not stabilized by the end of the designated flushing time, flush for another minute.

(e) Avoid contaminating the sample bottles by opening them immediately before taking the sample and avoiding contact with the mouth of the bottle when taking the sample.

(f) Collect the sample:

- For hydrants:
  - Reduce water flow and rinse the quick-connect;
  - Turn off the hydrant and connect the quick-connect;
  - Turn on the hydrant so that the flow is manageable for collecting the sample; and
  - Fill each of the three bottles to the neck and cap immediately.
- For taps:
  - Reduce water flow to manageable level for collection; and
  - Fill each of the three bottles to the neck and cap immediately.

(g) Measure pH and temperature:

- Rinse then fill a plastic bottle with water and measure pH and temperature. Add values to COC and note for inclusion in attached spreadsheet (orange cells)

(h) Note sample date and time for inclusion in attached spreadsheet (blue cells).

(i) Store each set of sample bottles (from each location) in separate labeled plastic bags to prevent samples from mixing. Deliver samples to the laboratory (460 Tennyson Place, Unit 1, Victoria, B.C.) before 4:30 p.m.

(j) Repeat steps (a) through (g) until samples have been collected from all sample locations.

(k) Drop samples off at the lab.

Samples were analyzed by an accredited laboratory (Bureau Veritas) for the following parameters shown in Table 2-1.

Table 2-1: Water Quality Parameters Measured

Water Quality Parameter	Units
Total dissolved solids (TDS)	mg/L
Temperature	°C
pH	s.u.
Alkalinity (as $CaCO_3$)	mg/L
Calcium (as $CaCO_3$)	mg/L
Chloride (Cl^-)	mg/L
Sulfate (SO_4^{-2})	mg/L
Lead	mg/L
Copper[1]	mg/L

1. Copper was only measured in first round and high levels (i.e., above the AO of 1 mg/L) were not detected. It was excluded from the second round of analysis for cost efficiency.

Sampling QA/QC

Quality Assurance (QA) and Quality Control (QC) protocols are necessary elements for the success of a water monitoring program. To ensure consistency within the water quality monitoring program, the following set of basic QA procedures were employed:

- Properly trained staff collected samples.
- Staff followed all laboratory instructions for sample collection (e.g., bottle labelling, sample storage, etc.)
- Samples were kept cool, and a chain of custody form accompanied each sample set;
- Samples were delivered to the laboratory as soon as possible following collection.
- Field instruments for measuring pH and temperature were calibrated daily.
- All sample points were flushed appropriately for each sampling location arrangement prior to sample collection (i.e., hydrants were flushed for 3 min and taps in pump stations and valve chambers were flushed for 10 minutes) prior to sample collection.

To minimize imprecision and errors, a set of QC procedures was also employed:

- Trip blank samples were used to assess potential contamination to samples during storage and transport.
- Field blank samples were used to assess potential contamination from handling techniques and environmental exposure.
- Replicate samples were collected (minimum one for every 10 samples) to assess laboratory precision in their analysis. Data quality checks are summarized in Section 6.3.
- Field pH and temperature measurements were recorded after confirmation that the output / reading did not change. This was approximately a one-minute duration, and the readings were confirmed as stable over a 20-second duration.

2.1.3 Corrosion Analysis

For many years, water chemists, engineers, operators, and utility owners have tried to predict water aggressiveness and corrosion risk by developing corrosivity indices. In 1982, the US Environmental Protection Agency (UESPA) released a report entitled *Corrosion in Potable Water Systems*. This report identified several corrosivity indices and indicated their limitations; several of the most widely used indices are summarized in Table 2-2.

Table 2-2: Corrosivity Indices Summary

Corrosivity Index	Basis	Target Value	Comment on Use
Langalier Saturation Index (LSI)	Based on theoretical tendency of water to deposit or dissolve calcium carbonate. It is a logarithm of the ratio of the hydrogen ion concentration that the water must have if saturated with calcium carbonate to the actual hydrogen ion concentration.	**>0** Value >0 indicates a tendency to form protective scale.	Inaccurate outside pH range of 6.5-9.5.
Ryznar Index (RI)	Also based on theoretical tendency of water to deposit or dissolve calcium carbonate.	**<6** Value <6 indicates a tendency to form protective scale.	Inaccurate in soft or saline waters.
Larson Index (LI)	Based on conductivity effects of specific ions rather than calcium carbonate precipitation.	**<0.5** Above 0.5 the possibility of corrosive action exists.	Inaccurate in soft or low total dissolved solids (TDS) waters.
Aggressiveness Index (AI)	Developed to determine what water can be transported in asbestos cement (AC) pipe without adverse structural effects.	**>12** Value >12 indicates nonaggressive water.	Does not incorporate temperature or TDS effects.
Calcium Carbonate Precipitation Potential (CCPP)	Based on theoretical quantity of $CaCO_3$ that can be precipitated from oversaturated waters or dissolved by under saturated waters.	**>0** Value >0 indicates a saturated water that will form a protective scale.	Accurate for all waters, but computationally cumbersome.
Source: USEPA Corrosion in Potable Water Systems Final Report.			

When choosing a corrosivity index for analysis, the source water characteristics must be considered. Per the 2018 Greater Victoria Drinking Water Quality annual report, the water chemistry of the treated water from the Sooke Lake Reservoir is soft and has low TDS which limited the choice of corrosivity indices to the Calcium Carbonate Precipitation Potential (CCPP). This index accurately portrays whether a water is oversaturated, saturated or undersaturated over an entire range of pH values[3].

The CCPP is computationally cumbersome to calculate, but it is accurate for a broad range of water chemistries and was used in this study to rate the corrosivity of the drinking water and to help identify corrosion risks. The CCPP can be determined graphically using Caldwell-Lawrence diagrams, analytically through equilibrium equations or by computer analysis.

[3] An evaluation of the calcium carbonate saturation indexes, AWWA 1983 (John R. Rossum, Douglas T. Merrill).

RTW Model

The Rothberg, Tamburini, and Winsor (RTW) Model for Corrosion Control and Process Chemistry is a spreadsheet-based tool which was developed to provide the same pH and $CaCO_3$ equilibrium information as Caldwell-Lawrence (C-L) diagrams while also providing a numerical solution based on specific source water characteristics. The model has been updated over time and the current version is called the Tetra Tech (RTW) Model for Water Process and Corrosion Chemistry. This model also allows calculation of the effects of various chemical additions to a water.

This model was used to assess the source water aggressiveness and identify corrosion-associated risk by calculating CCPP. While the CCPP is considered to be the most accurate guide of a water's tendency to dissolve or precipitate calcium carbonate ($CaCO_3$), it was noted by developers of the model that it may identify an unrealistically high corrosion risk for source waters with low alkalinity. As a result, CCPP was used in this study to predict and track water corrosivity and, in addition, lead and copper were directly measured as an indicator of corrosion in the system. Refer to Section 6 for results of this analysis.

Use of Corrosion Indices

It is now acknowledged that the calculation of a corrosivity index alone, in particular the Langelier Index, is not adequate to determine the full potential for lead or copper exceedances or to show compliance with metal health limits. However, in combination with actual metal tests, an appropriately chosen corrosivity index can be very helpful in investigating the metal leaching potential across large water systems. The use of such a corrosivity index allows for tracking and mapping of how corrosion-relevant water chemistry parameters change or remain stable as the water moves through the system. The Guidelines on Evaluating and Mitigating Lead in Drinking Water Supplies, Schools, Daycares and Other Buildings (BC Ministry of Health, 2019) suggests that "Water supplies with one or more of the following water chemistry characteristics should be prioritized for further evaluation of potential lead risks from corrosion of plumbing in the community:

- Lower pH (<7)
- Low alkalinity (<30 mg/L)
- Low hardness, i.e., "soft water" (<60 mg/L as calcium carbonate $CaCO_3$)"

The consideration of these three parameters is essentially the same as using a very simplified corrosivity index for an initial risk assessment. For the purposes of this study, CCPP was selected to, in combination with other considerations noted in Section 2.1.4, assess risk of lead being introduced to the distribution system. CCPP considers not only the three water chemistry characteristics noted above but also accounts for water temperature and other corrosion-relevant parameters.

2.1.4 Pipe Corrosion Index

A Pipe Corrosion Index (PCI) was developed during this study to allow for a spatial identification of potential lead risk across the distribution system. This index considers:

- the potential for lead to be present (based on the pipe age and material);
- the corrosivity of the water (based on calculated CCPP corrosivity index);
- the contact with the pipe (based on velocity from water age models); and
- whether lead was found nearby.

For each pipe in the network, a series of queries was asked as highlighted in Figure 2-1. The results of each query were used to assign a score to each pipe segment which were then added up so that they could be mapped as illustrated in Figure 2-1. Refer to Figure 7-2 through 7-5 for the pipe corrosion index assignments across the study areas.

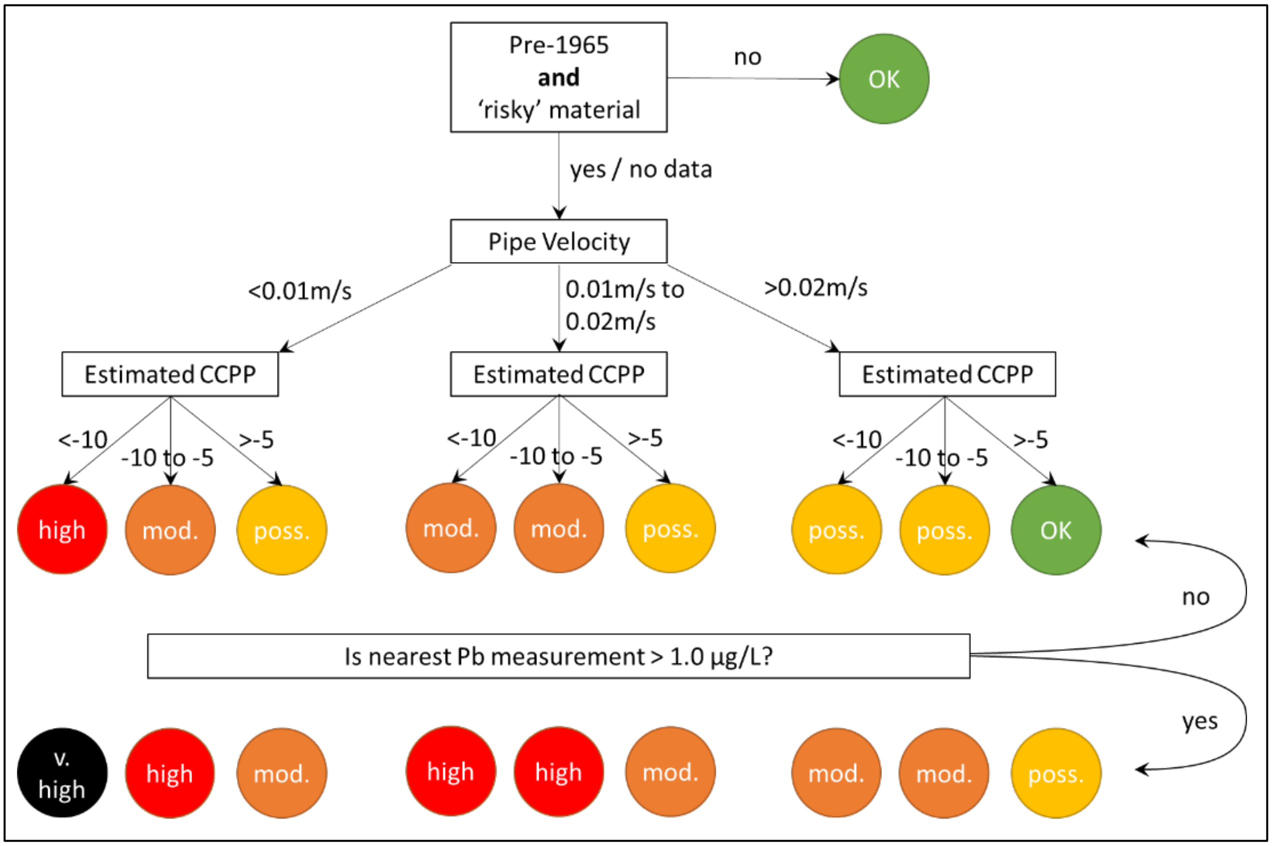

Figure 2-1: Pipe Corrosion Index Logic

Queries:

1. **Is this a 'risky' material and installed before 1965?** Risky materials with associated ages are summarized in Table 1-1, these include brass, cast iron, galvanized, and steel. The year 1965 was selected to be conservative. *Note – if there was no data about age or pipe material it was assumed to be a 'yes' response.*

2. **What is the velocity of water in the pipe?** For lead to leach from a material, there must be contact time in the pipe and water chemistry that will cause the leaching to occur.

   The 2019 Guideline Technical Document for Lead (Health Canada) references many different studies that have investigated levels of lead after set stagnation times but does not reference velocity. Stagnation times are appropriate in a residential/commercial setting where water may not be used for periods of time (i.e., overnight), but not appropriate for a distribution system where water is consistently moving.

A limited literature review was conducted to identify appropriate water velocity bounds for assessing lead leaching risk across a distribution system. The review suggests that there is contradiction in the body of research. Some studies suggest that corrosion rate is higher at high velocities because there is a higher driving force for mass transfer (i.e., more oxidants can reach the surface of the pipe and therefore cause accelerated corrosion)[4]. Others found that corrosion rate is inversely related with flow velocity [5]. A hydraulic transient and advection-dispersion-reaction (ADV) modelling exercise was conducted in 2010 that as flow velocity decreases then corrosion activity increases[6] (refer to Figure 2-2 below).

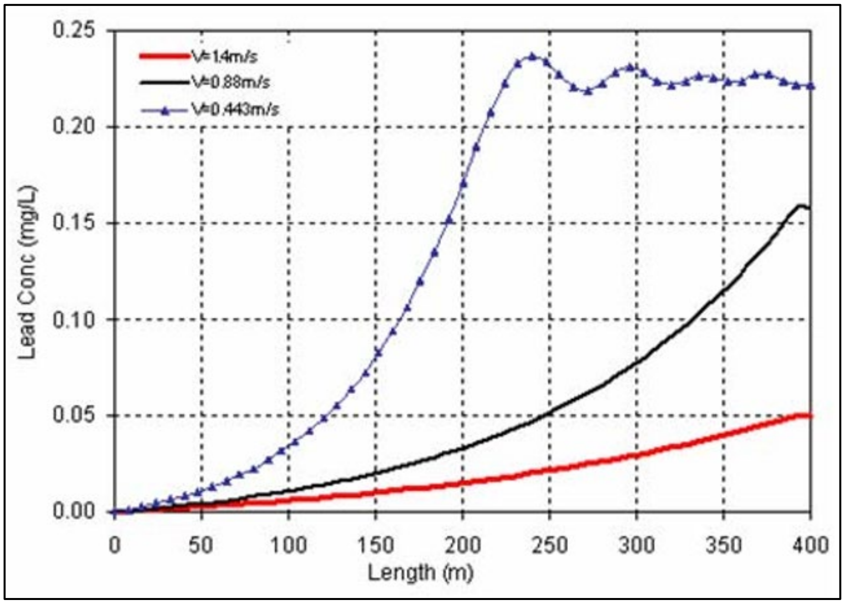

Figure 2-2: Effect of Flow Velocity on Lead Pipe Corrosion[6]

Corrosion rate is also only part of the picture; it represents the amount of lead that is being released into the water. As the flow rate increases, the dilution of this released lead becomes more significant. As noted in the 2002 US EPA Permeation and Leaching Distribution System Issue Paper, "The movement of water through mains acts to dilute contaminants that have permeated the pipe wall."

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[4] Fang, C. S. and Liu, B. (2003). "Hydrodynamic and Temperature Effects on the Flow Induced Local Corrosion Rate in Pipelines", Chemical Engg. Comm., Vol. 190, p1249-66

Efrid, K.D. (2000). "Flow Induced Corrosion", Uhlig's Corrosion Handbook, John Wiley & Sons, USA

[5] Baral, M. P. (2006). "Linking Water Quality and Hydraulics in Distribution Systems Through a Transient 1-D Multi-Component Corrosion Model", M. A. Sc. Thesis, Dept. of Civil Eng., Univ. of Toronto

Pisigan Jr., R.A. and Singley, J. E. (1987). "Influence of Buffer Capacity, Chlorine Residual and Flow Rate on Corrosion of Mild Steel and Copper", Research and Technology, Vol. 79, No. 2, p62-70

Mahato, B.K., Cha, C.Y. and Shemilt, L.W. (1980). "Unsteady Mass Transfer Coefficients Controlling Steel Pipe Corrosion under Isothermal Flow Conditions", Corrosion Science, Vol. 20, No. 3, p421-441

[6] Islam, M. M. (2010) "A Transient Model for Lead Pipe Corrosion in Water Supply Systems, M.A.Sc. Thesis, Dept. of Civil Eng., Univ. of Toronto

In the absence of specific research about the relationship between water velocity and lead concentration for the CRD's water chemistry, the following bounds were selected for the purposes of this study:

- Highest expected contribution: <0.01 m/s;
- Moderate expected contribution: 0.01 m/s to 0.02 m/s; and
- Lowest expected contribution: >0.02 m/s.

The relationship between water velocity and lead concentration could be studied to validate or update these boundary values.

3. **What is the CCPP in the area**? CCPP was calculated for each of the samples collected across the distribution system. These CCPP values were then assigned to each pipe in the system based on how the system operates by delineating the area within which that CCPP is applied.

   The CCPP values tended to decrease (i.e., predict increasing corrosivity) as the water moved to the far ends of the system. To be conservative, it was assumed that the CCPP measured further away from treatment applied until a new CCPP value was measured (i.e., at the next sampling point. This is illustrated in Figure 2-3 below. Refer to Figure 2-4 for the delineation across the system.

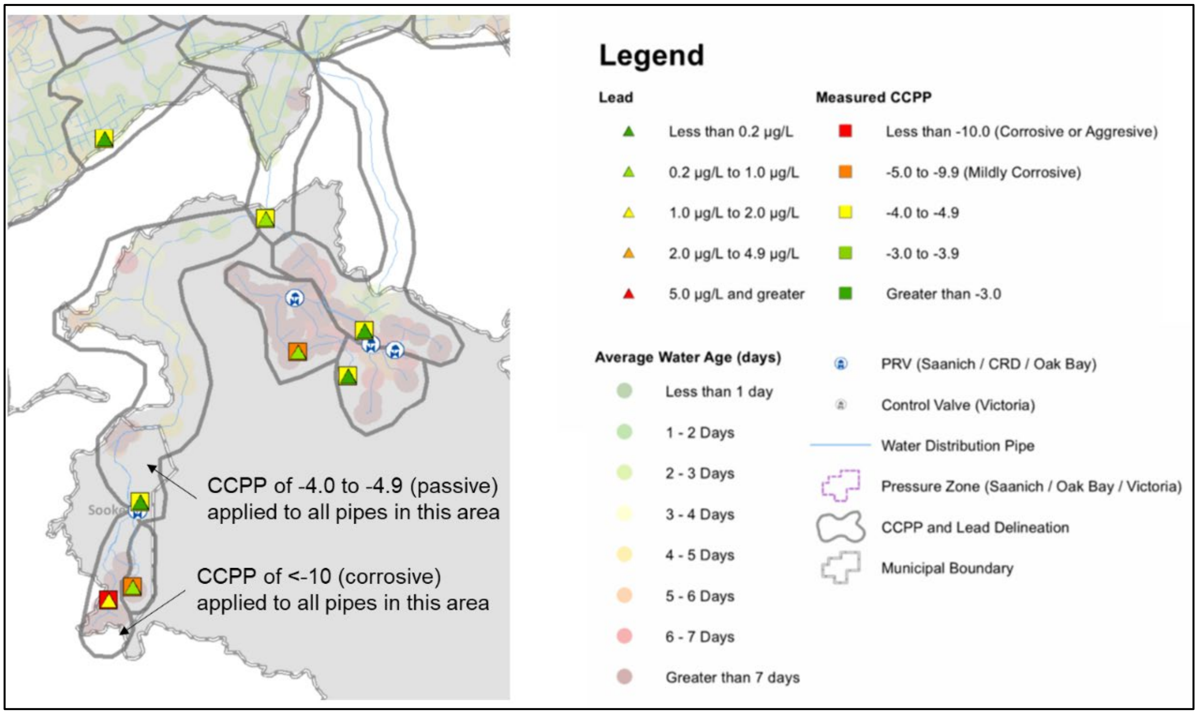

Figure 2-3: CCPP Assignment Illustration

4. **Is there lead above 1 µg/L (0.001 mg/L) nearby**? Similar to CCPP, the measured lead values were assigned to each pipe within each of the delineated areas. If lead was measured nearby, it was assumed that corrosion was occurring in the area which increased the PCI.

Path: V:\0000-0999\0700-0799\719-066\430-GIS\MXD-Rp\Report\719066_Fig2-4_CCPPLeadAssignment.mxd Date Saved: 8/5/2021 1:17:17 AM | Author: TSoh

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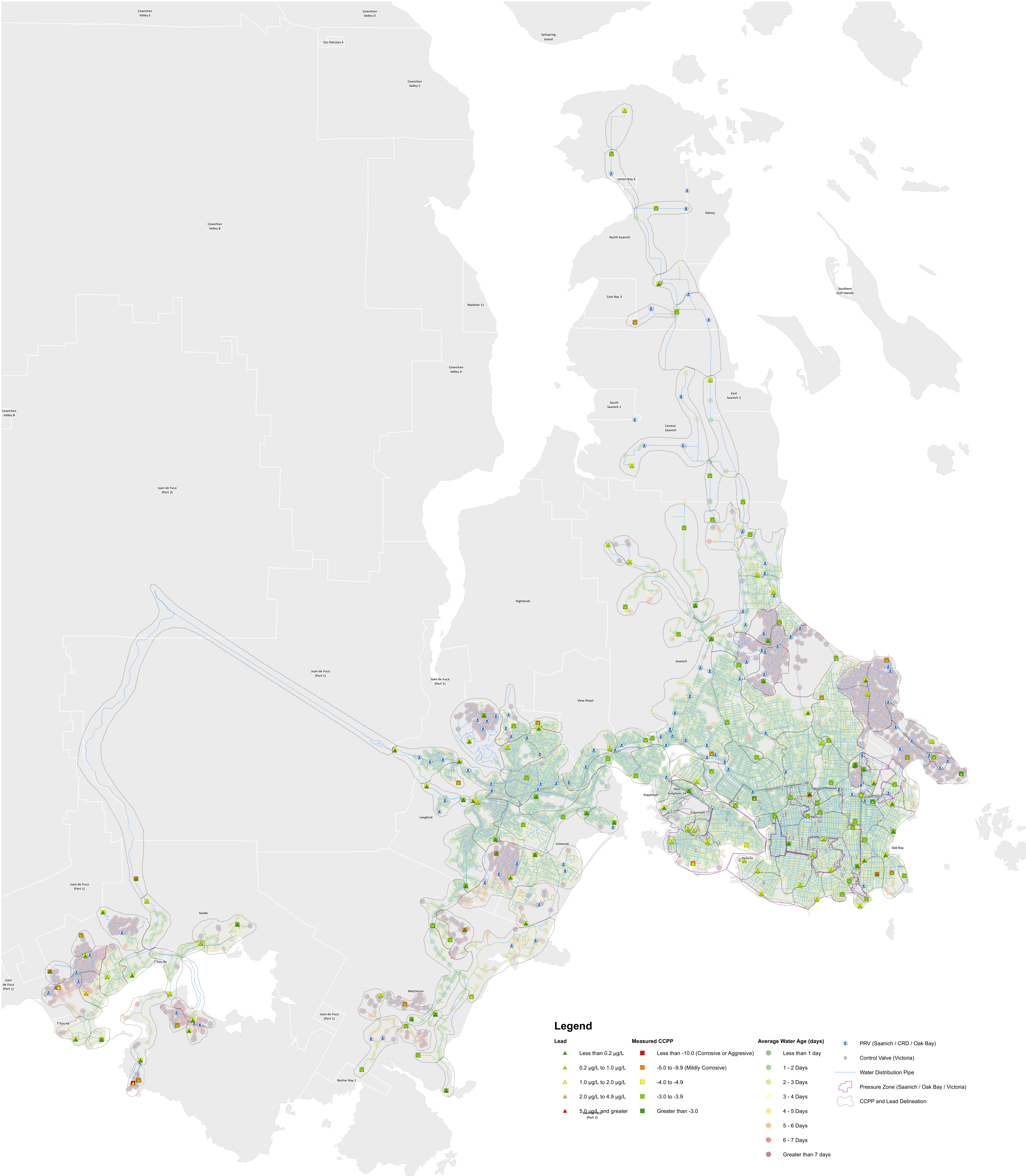


Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:50,000 is only valid on a 22"x34" print.

Project No. 719-066
Date August 2021
Scale 1:50,000
0 250 500 1,000 (m)

Delineation Across the System for CCPP and Lead Assignment to Individual Pipes

Figure 2-4

2.1.5 Secondary Investigations

As identified in Section 1.4, elevated levels of lead had been measured at the Cook Street/Mallek Crescent (metering station for City of Victoria), Lansdowne Road/Foul Bay Road (metering station District of Oak Bay), and on Cecelia Road (metering station for City of Victoria) water sampling stations.

To determine the source of this lead, additional water samples were collected from these stations and pipe materials were also collected for testing. This project focussed on the Cook Street/Mallek Crescent metering station, while the CRD has continued investigations at the other two locations.

Cook Street/Mallek Crescent Investigations

Main #3 Solids Testing

Solid material samples were also collected for the investigation of elevated lead levels at CRD sampling locations off Main #3 at or near Cook/Mallek. The following three physical material samples were collected and sent to Island Environmental Health & Safety Ltd. for analysis:

1. A piece of the Main #3 liner collected from a piece of Main #3 replaced as part of the McKenzie Interchange project;
2. A 50 mm X 50 mm piece of Main #3 steel collected from a piece of Main #3 replaced as part of the McKenzie Interchange project; and
3. Reaming material removed from internal reaming (also known as pigging) of a cast iron pipe with leaded joints in the City of Victoria. The reaming process was done as part of a 2019 pipe lining project for the City of Victoria on Dallas Road.

Main #3 Water Testing

Two rounds of water sampling were conducted.

During the first round of testing, samples were taken at Cook/Mallek from the CRD's water quality sampling line (sampling tap inside an above ground equipment and instrumentation shack, plumbed from below-ground metering chamber) as well as three separate locations within the Cook/Mallek metering chamber and three hydrant locations within the adjacent City of Victoria distribution system.

Samples were also taken at CRD's water quality sampling points at Cecelia Road and Lansdowne Road/Foul Bay Road. At these two locations no additional sampling points could be found to supplement the investigation. A water sample was also taken from Main #3 at a City of Victoria metering chamber at the corner of Tolmie and Douglas.

Water samples taken directly from inside the Cook/Mallek metering chamber had significantly lower lead levels than samples from the water quality sampling line. This suggested that the lead was being contributed locally from the copper sampling line.

A third round of sampling was completed at the Cook and Mallek location to confirm that the lead was from the water sampling station's copper piping. Samples were collected sequentially (turning the tap off between samples) to see the lead and copper profile as the water inside the station plumbing was removed then the station was flushed for 1 minute, then 5 minutes, then 15 minutes with samples collected after each flush.

To determine the number of samples required to clear the station plumbing, the volume of water in the station was estimated based on the drawings for the station and observations from the field. The service for the sampling station was 8.05 m long with a diameter of 19 mm (total volume of 2.3 L). The samples were 250 mL (125 mL for lead then 125 mL for copper); therefore, ten samples were required to clear the station plumbing. Thirteen 250 mL samples total were collected as summarized in the Table 2-3 below.

Table 2-3: Cook and Mallek Investigation Sampling Summary

Sample #	Flush Time Between Samples	Accumulated Volume Flushed (L)
1	No flush	0.25
2	No flush	0.5
3	No flush	0.75
4	No flush	1
5	No flush	1.25
6	No flush	1.5
7	No flush	1.75
8	No flush	2
9	No flush	2.25
10	No flush	2.5
11	1 min. flush	15
12	5 min. flush	75
13	15 min. flush	255

Following the secondary KWL investigation, the CRD replaced the copper sampling line at Cook and Mallek with stainless steel piping to confirm if the copper piping system was the source of the lead.

Results of secondary investigations and post-replacement testing are presented in Section 6.

2.1.6 Private-Side Lead Analysis Map

For lead to leach into water, it must be present in the plumbing materials. The most common sources of lead are:

- domestic plumbing (pre-1989 copper piping with lead-containing solder and pre-2013 brass fittings and fixtures); and
- lead services.

Historical information about lead could also provide clues about where lead could be present.

Building Plumbing

Preparing a complete inventory with plumbing materials and age would require a collection and review of building permit records for each house in the study area (more than 100,000 homes). Such level of detailed inventory development was outside the scope of this study.

To efficiently estimate the risk of old plumbing contributing lead, the age of each parcel was estimated based on the oldest available nearby linear infrastructure (water, sanitary sewer, and stormwater sewer) within a 40 m radius. With the age assigned to each parcel, a base map was created with colour gradations based on these assigned ages.

This methodology assumes that the development of the houses in each area happened no earlier than the installation of linear infrastructure. This approach also does not account for redevelopment in an area with old linear infrastructure and is therefore considered an approximate and conservative estimate of parcel age. This methodology was verified on a few buildings with known construction date and found to be reasonably accurate.

Lead Services

Before this study began, there was much uncertainty about the existence of lead services in Greater Victoria. Anecdotal information had suggested that there was never a time when lead services were a popular installation choice in the region. Upon initiation of the study, records of lead service removals were found by City of Victoria staff and partial records of service material and installation date were found by District of Oak Bay staff. These records were the only documented evidence detected of lead services being installed in a few local areas within the participating jurisdictions. It is no surprise that the subject areas were in older parts of the communities. The chance of other lead service installations within distribution systems that were not included in this study is very low due to the much later development in these areas (Saanich Peninsula municipalities). The uncovered information on lead service removal programs (likely only partial removal) was added to GIS using addresses to geospatially locate the data and mapped on top of the expected parcel age (refer to Appendix A).

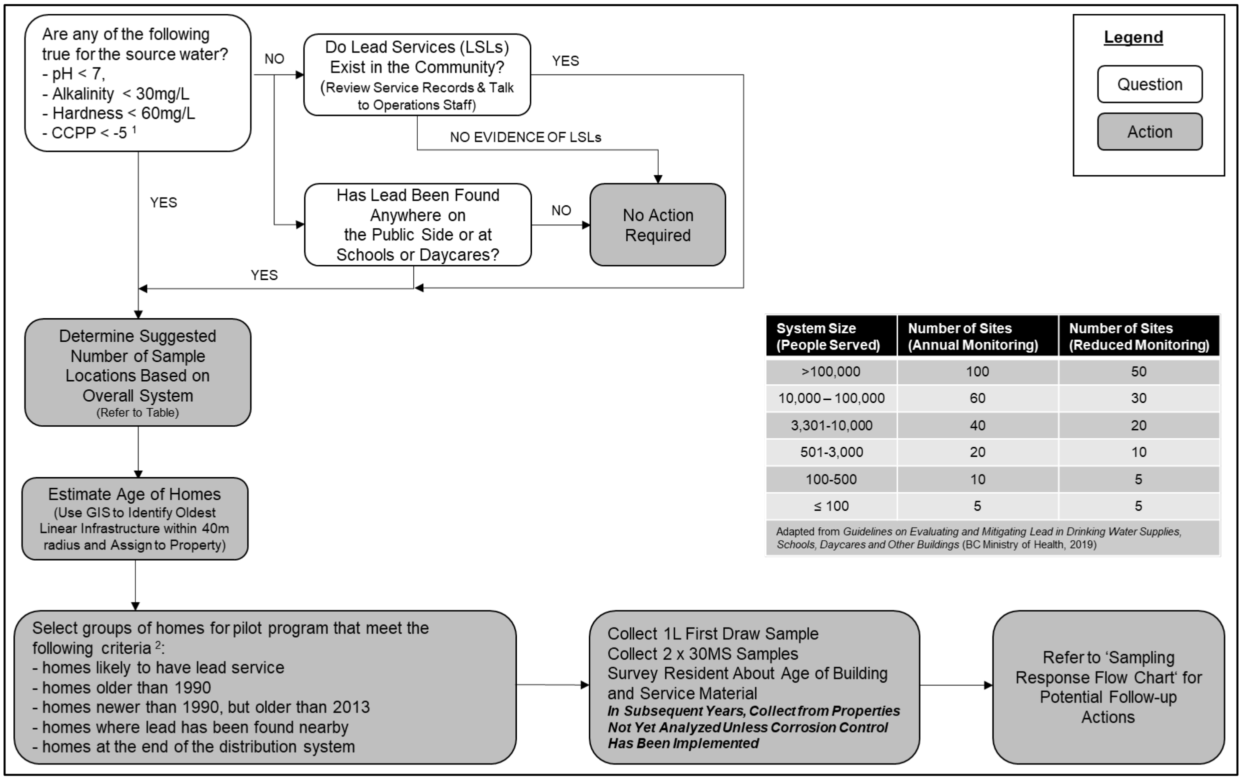
Historical Lead Results

As noted in Section 1.4, in 2007/2008 the CRD conducted a lead and copper tap sampling project. Similar to the lead service information, the project results for the first draw (6-hour stagnation) samples were added to GIS using addresses to geospatially locate the data and mapped on top of the expected parcel age.

The resulting map shows expected parcel age with all known information about lead services and historical test results for first draw lead samples from the CRD's 2007/2008 tap sampling project. Refer to Appendix A for compiled map.

2.1.7 Private Side Sampling Location Identification

Given that the alkalinity and hardness of the supply water are below the thresholds noted in *Guidelines on Evaluating and Mitigating Lead in Drinking Water Supplies, Schools, Daycares and Other Buildings* (BC Ministry of Health, 2019), it was determined that tap samples should be collected as part of a pilot program to assess the lead and copper risk on the private side. Sampling locations for private side testing were selected as outlined in the following flow chart (Figure 2-5).



System Size (People Served)	Number of Sites (Annual Monitoring)	Number of Sites (Reduced Monitoring)
>100,000	100	50
10,000 – 100,000	60	30
3,301-10,000	40	20
501-3,000	20	10
100-500	10	5
≤ 100	5	5

Adapted from *Guidelines on Evaluating and Mitigating Lead in Drinking Water Supplies, Schools, Daycares and Other Buildings* (BC Ministry of Health, 2019)

Notes:

1. Threshold at which water becomes 'mildly corrosive' per Table 5 of Gebbie, Peter. "63rd Annual Water Industry Engineers and Operators' Conference." Water Stability – What Does It Mean and How Do You Measure It?, pp 50 - 58
2. Selecting from various groups will help to establish where lead is most prevalent in the CRD system to inform future sampling program development.

Figure 2-5: Sampling Site Selection Flow Chart for Pilot Sampling Program

As outlined in the flow chart above, samples were selected to assess where lead is most likely to be found on the private side to inform future sampling program development.

This pilot sampling program focused on single-family residential properties to decrease the number of variables (i.e., focus on single building type) and increase the number of samples within each group (served by lead service lines, older than 1990, between 1990 and 2013, near other positive lead samples and near the end of the distribution system) to increase confidence in the identification of where lead is most prevalent within the GVDWS.

To meet the target of 100 sampling locations, 481 residences were invited to participate through door knocking and letter drops (Refer to Appendix A for communication materials). In addition to the 5 criteria noted in the flow chart, the sampling program aimed to collect samples from each of the project partners' supply areas. A total of 8 sampling areas were initially selected (240 homes); however, due to low participation, 6 additional areas were added (241 homes). Overall, the participation rate was 15.2% (73/481). For canvassed properties where only a letter drop occurred (CRD Westshore and Sooke) participation was 8.75% (14/160) and where door knocking occurred (Victoria, Saanich, Oak Bay) participation was 18.4% (59/321).

In addition to the participants reached through area-targeted canvassing, the CRD and KWL office kitchens were also sampled and CRD and KWL staff were invited to participate to increase participation.

Overall:

- 481 locations were invited to participated through door knocking and letter drops;
- 73 area-targeted invitees and 31 staff (CRD and KWL) signed up to participate; and
- 104 locations provided samples for analysis (including both the CRD and KWL office kitchens).

Maps showing the proposed distribution of the sampled properties, as well as the ultimate distribution are presented in Appendix A.

Appendix A also includes private-side sampling communication materials.

In future, it is recommended that sampling locations be selected to prioritize high-risk buildings while also balancing between public and private buildings and buildings of different sizes and uses (i.e., including multi-family residential, commercial, institutional, and industrial)[7]. Refer to Section 8 for recommendations on future sampling program development.

In 2020, VIHA also conducted a tap sampling study on all registered daycare facilities in Greater Victoria. The results of this program provide some insight on institutional buildings (refer to Section 7.3). The sampling protocol appears to have included first draw and 2-minute flush sampling from two locations within each building (kitchen and bathroom)[8].

[7] The BC *Guidelines on Evaluating and Mitigating Lead in Drinking Water Supplies, Schools, Daycares and Other Buildings* (April 2019) recommends that sampling points be selected from consumer's taps that are balanced between public and private buildings.

[8] The CRD was not involved in the development of the sampling program and therefore cannot provide details about sampling methodology.

3. Study Area

The Greater Victoria Drinking Water System (GVDWS) provides drinking water to approximately 390,000 customers across the region. Details about the water system are summarized below:

- Source:
  - The Sooke and Goldstream watersheds supply water to the GVDWS. Combined, these watersheds have an area of 10,921 hectares. The Sooke watershed with Sooke Lake Reservoir is the primary water source. The Goldstream watershed, the backup source, has historically only been used during short periods of scheduled infrastructure maintenance. Approximately 98% of the source water catchment area is owned, managed and access restricted by the CRD.
  - The primary source of raw water is the Sooke Lake Reservoir. It has a total volume of 160.32 million cubic metres, and 92.7 million cubic metres are currently useable for water supply. The reservoir provides about 90% of the total water storage in the total supply system including the Goldstream System reservoirs.
  - The Goldstream Water Supply Area, consisting of four surface water reservoirs, is the backup water source for the GVDWS. The catchment area for the Goldstream Water Supply Area is 2,109 hectares. The combined storage capacity of the four reservoirs is approximately 10 million cubic metres (or approximately 2 months of water supply for the GVDWS depending on time of year).
- Treatment:
  - There are two water treatment facilities that supply water to the GVDWS – the Goldstream Water Treatment Plant (GWTP) and the Sooke River Road Water Treatment Plant (SRRWTP).
  - Both plants disinfect water using UV, chlorination and chloramination.
- Bulk Supply and Distribution:
  - See Figure 3-1 for a map of the study area.
- Serviced Population:
  - The GWTP supplies water to approximately 375,000 people in Victoria, Saanich, Oak Bay, Esquimalt, the Saanich Peninsula municipalities, and the Westshore municipalities.
  - The SRRWTP supplies water to approximately 15,000 people in Sooke and East Sooke.
- Total length:
  - The total length of distribution mains in the study area is approximately 1,700 km. This includes the CRD transmission mains (Regional supply and Peninsula supply pipes), JDF, Sooke/East Sooke, City of Victoria, District of Oak Bay and District of Saanich pipes. It does not include any of the piping in North Saanich, Sidney or Central Saanich or any service connections.

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Capital Regional District

Greater Victoria pH and Corrosion Study

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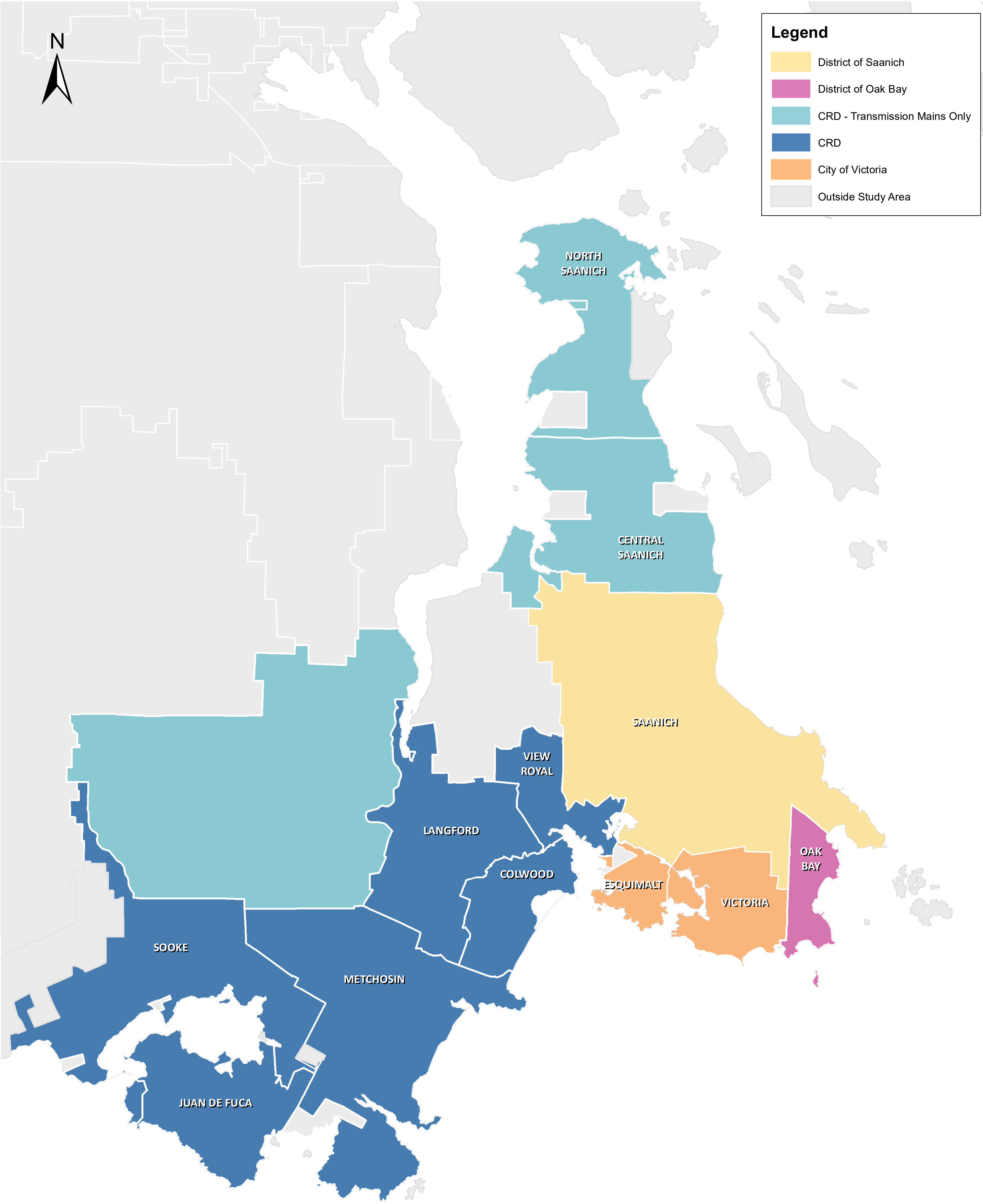

Coordinate System: NAD83 CSRS UTM zone 10N

Scale Disclaimer: The map scale of 1:167,687 is only valid on a 11"x17" print.

Project No. 719-056

Date August 2021

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Study Area

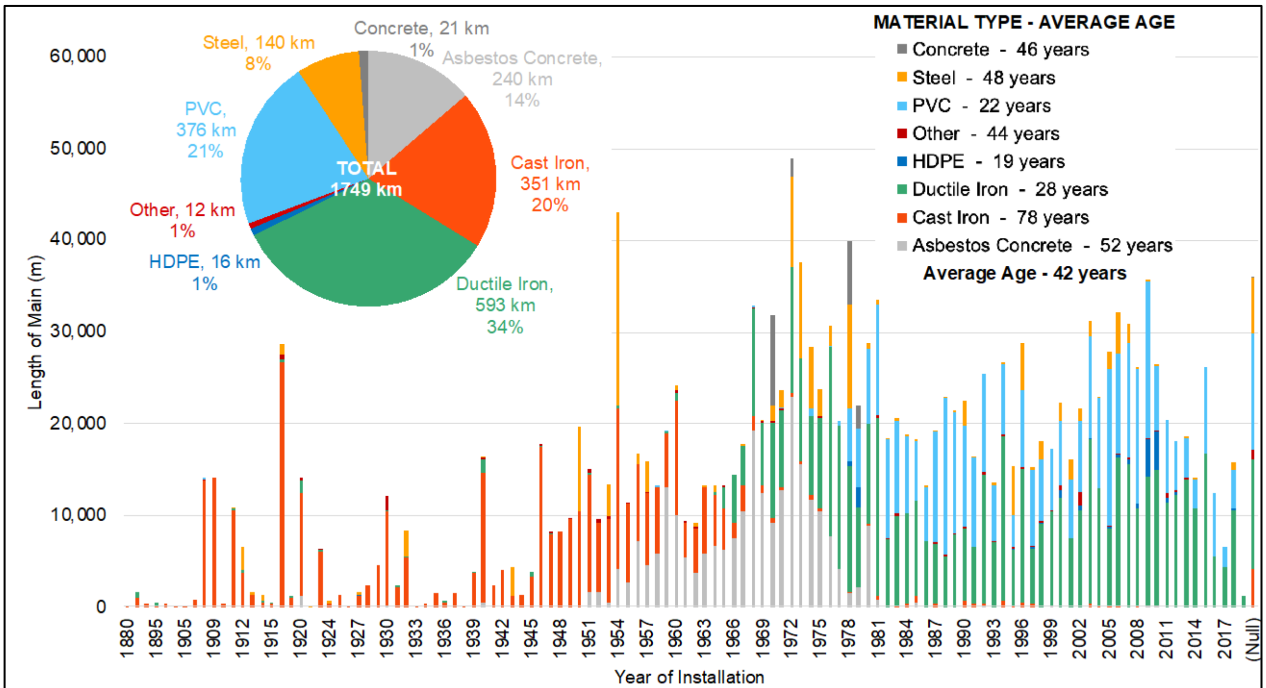
Figure 3-1

4. Pipe Inventory

Pipe characteristics were compiled from available GIS data for the Greater Victoria region, including five jurisdictions: District of Saanich, District of Oak Bay, City of Victoria, and CRD (JDF plus transmission system). These included pipe lengths, materials, ages, locations, and diameters across the network. The GIS pipe inventory model was used to not only identify where lead could leach on the public side, but also to assess the risk of leaching on the private side. The figures in the following section illustrate pipe materials, lengths, ages, and locations, providing a high-level picture of regional pipe network characteristics.

Figure 4-1 illustrates water main ages, lengths, and material types for all regions in Greater Victoria (District of Saanich, District of Oak Bay, City of Victoria, and Capital Regional District). Some pipes date back to the late 1800s, with a length-weighted average age of 42 years. Concrete, HDPE, and other (possible Pb risk – listed in Figure notes) pipe types each account for approximately 1% of the installed length. For the principal pipe types, key observations are as follows:

- cast iron (possible Pb risk) was common from 1880 to the 1960s;
- asbestos concrete was common from the early 1950’s to the early 1980s;
- ductile iron was common from the mid-1960s to present;
- PVC was common from the mid-1960s to present; and
- steel (possible Pb risk) appeared sporadically over the past century.



- "Other" includes: unknown, brass, copper, galvanized, polyethylene, stainless steel, steel-lined-cement, and pipes listed as CML, CP, EL or FG.
- (Null) indicates unknown or invalid installation date.
- For years not included on x-azis, no data was available.

Figure 4-1: Water Main Ages, Lengths and Material Types for All Jurisdictions in Greater Victoria

Figure 4-2 illustrates water main ages, lengths, and material types for CRD supply and distribution piping. Some of the supply pipes date back to the late 1930s, while the CRD distribution pipework services much of the newer development in the capital region. Subsequently, the length-weighted average age of CRD pipework is 28 years, making these the youngest water mains in the study-participating jurisdictions in Greater Victoria. A major difference from the region as a whole is the lack of cast iron pipes in the CRD jurisdiction. Cast iron (possible Pb risk) and other (possible Pb risk – listed in Figure notes) pipe types along with HDPE each account for approximately 1% or less of the installed length.

Concrete accounts for 3% of the installed length, which are larger transmission mains. For the principal pipe types, key observations are as follows:

- asbestos concrete was common from the mid-1950s to the early 1980s;
- ductile iron was common from the late 1980s to present;
- PVC was common from the late 1970s to present; and
- steel (possible Pb risk) appeared sporadically since the 1930s and was associated with the larger transmission mains.

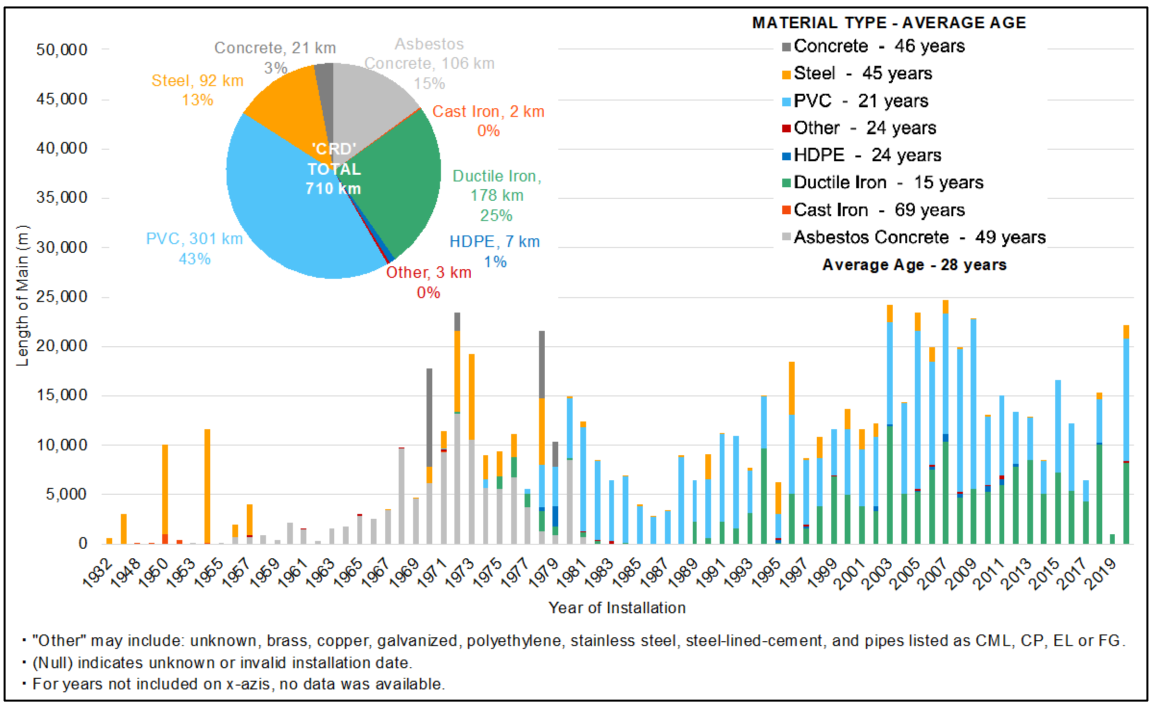
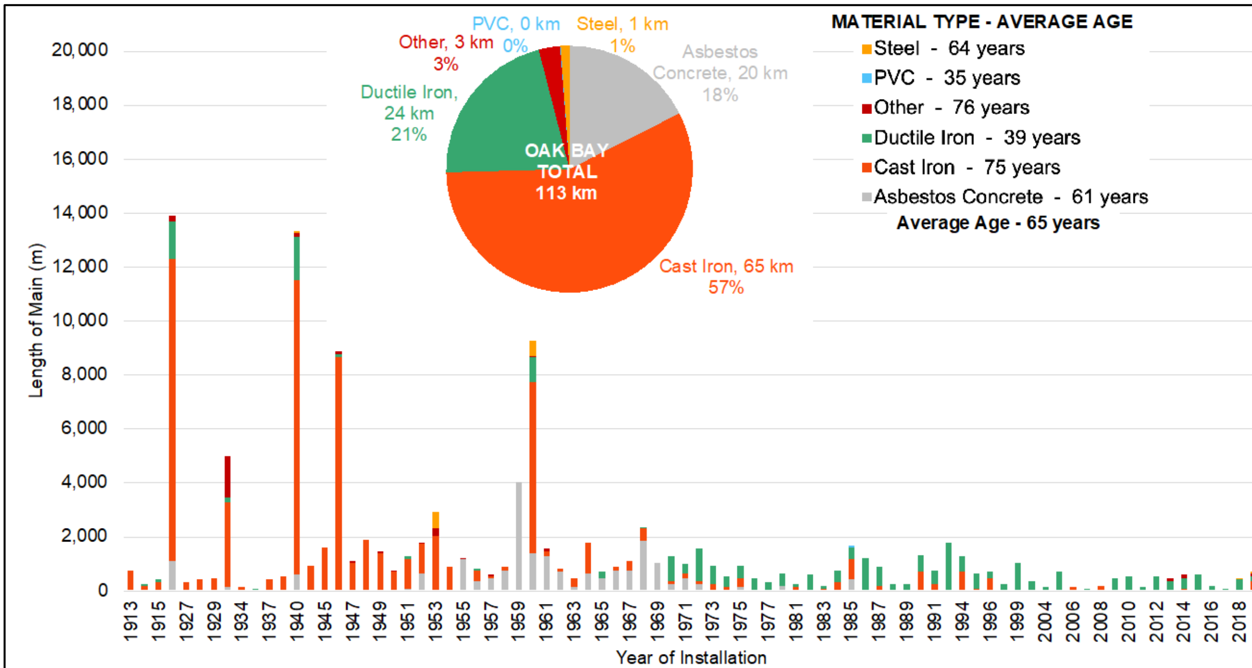


Figure 4-2: Water Main Ages, Lengths and Material Types for CRD Jurisdiction Pipes

Figure 4-3 illustrates water main ages, lengths, and material types for pipes that fall under the District of Oak Bay jurisdiction. Some pipes date back to the 1910s, with a length-weighted average age of 65 years, making these the oldest water mains in Greater Victoria. A major difference from the region as a whole is the dominance of cast iron, and lack of PVC and steel pipes in the Oak Bay jurisdiction. PVC and steel pipe types each account for approximately 1% or less of the installed length, and no HDPE pipes are on record. 'Other' pipe types (possible Pb risk – listed in Figure notes) account for 3% of the installed length. For the principal pipe types, key observations are as follows:

- cast iron (possible Pb risk) was common from the 1910s to 1960s;
- asbestos concrete was common from the mid-1950s to the early 1970s; and
- ductile iron was common from the early 1970s to present.



• "Other" may include: unknown, brass, copper, galvanized, polyethylene, stainless steel, steel-lined-cement, and pipes listed as CML, CP, EL or FG.
• (Null) indicates unknown or invalid installation date.
• For years not included on x-azis, no data was available.

Figure 4-3: Water Main Ages, Lengths and Material Types for District of Oak Bay Jurisdiction Pipes

Figure 4-4 illustrates water main ages, lengths, and material types for pipes that fall under the District of Saanich jurisdiction. Some pipes date back to the 1880s, with a length-weighted average age of 46 years, similar to the regional average. The pipe material trends generally follow those of the region as a whole, except that PVC has not been used significantly in recent years. HDPE and other (possible Pb risk – listed in Figure notes) pipe types each account for approximately 1% or less of the installed length, and no concrete pipes are on record. For the principal pipe types, key observations are as follows:

- cast iron (possible Pb risk) was common from 1880 to the 1960s;
- asbestos concrete was common from the early 1950s to the 1970s;
- ductile iron was common from the late 1960s to present;
- PVC was common from the late 1980s to early 1990s; and
- steel (possible Pb risk) appeared sporadically over the past century.

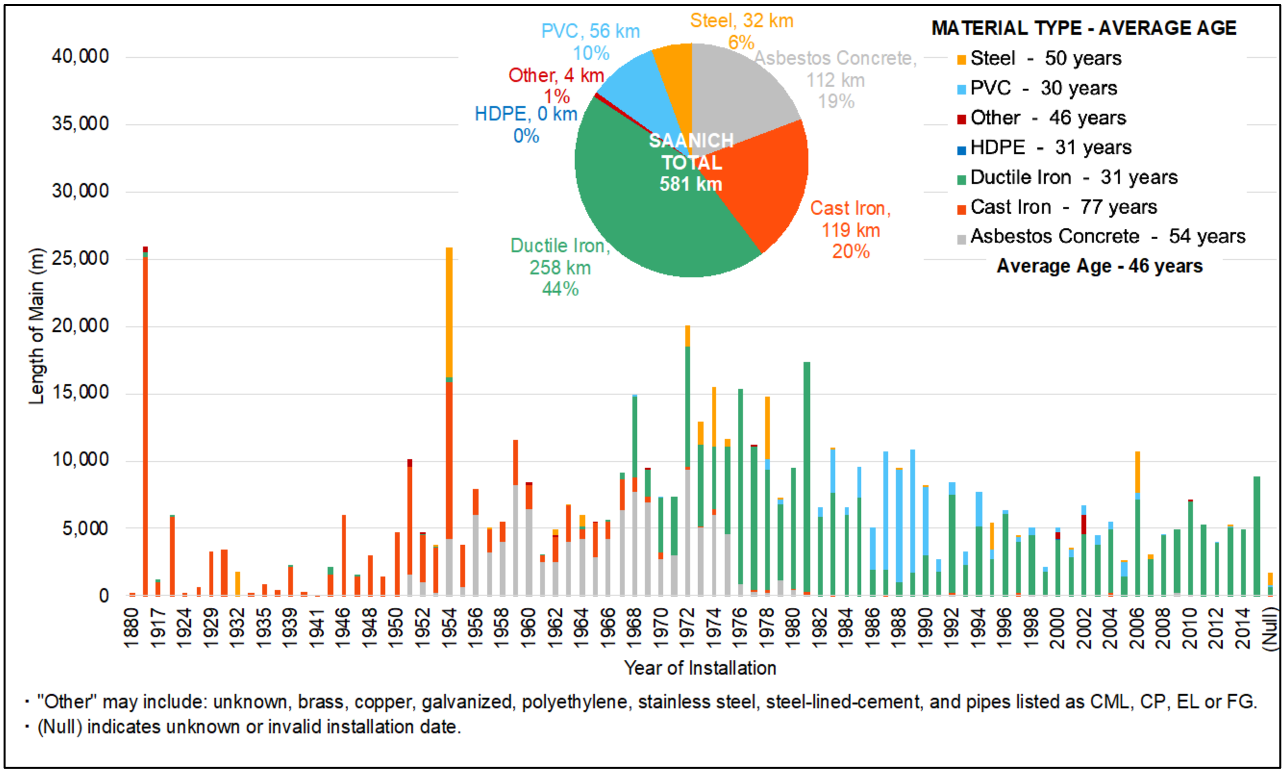
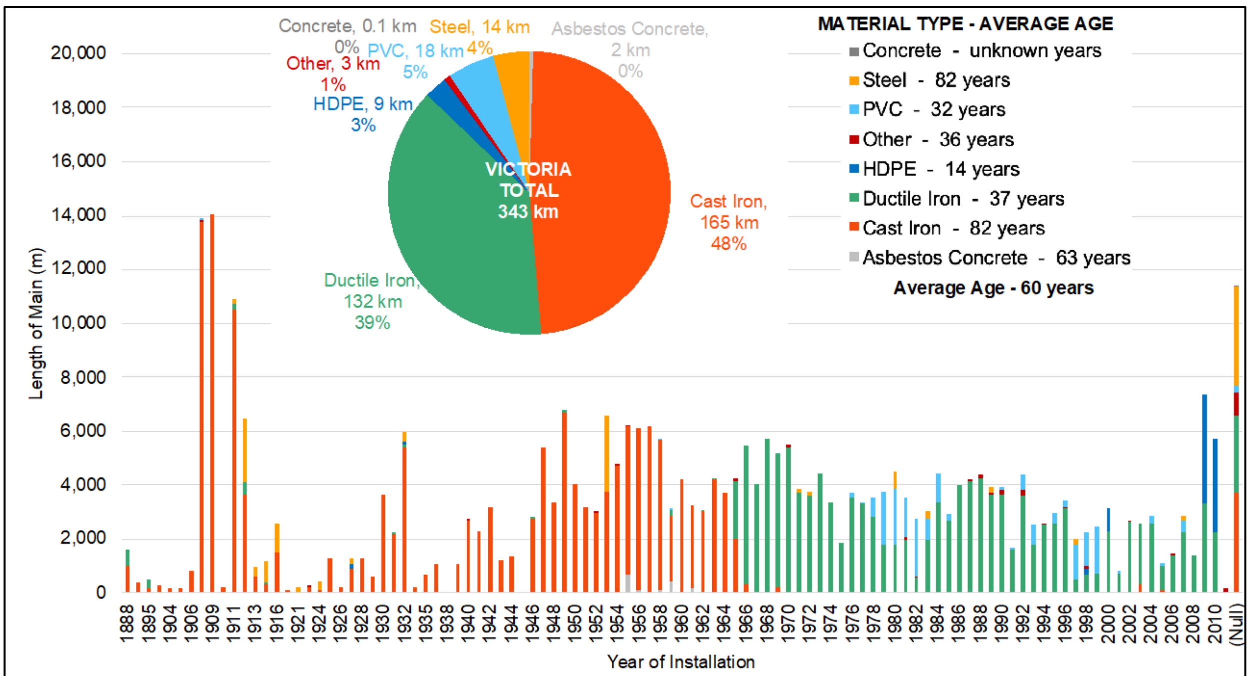


Figure 4-4: Water Main Ages, Lengths and Material Types for District of Saanich Jurisdiction Pipes

Figure 4-5 illustrates water main ages, lengths, and material types for pipes that fall under the City of Victoria jurisdiction. Some pipes date back to the 1880s, with a length-weighted average age of 60 years, making these the second oldest water mains in Greater Victoria. The pipe material trends generally follow those of the region as a whole, except that PVC has not been used significantly in recent years. Concrete, asbestos concrete, and other (possible Pb risk – listed in Figure notes) pipe types each account for approximately 1% or less of the installed length. For the principal pipe types, key observations are as follows:

- cast iron (possible Pb risk) was common from 1880 to the mid-1960s;
- ductile iron was common from the late 1960s to present;
- PVC appeared sporadically from the late 1970s to the 2000s;
- steel (possible Pb risk) appeared sporadically over the past century; and
- HDPE appeared in the 2000s.



- "Other" may include: unknown, brass, copper, galvanized, polyethylene, stainless steel, steel-lined-cement, and pipes listed as CML, CP, EL or FG.
- (Null) indicates unknown or invalid installation date.
- For years not included on x-azis, no data was available.

Figure 4-5: Water Main Ages, Lengths and Material Types for City of Victoria Jurisdiction Pipes

Figure 4-6 illustrates water main ages and installed lengths for the Greater Victoria region and sub-jurisdictions. The jurisdictions with the oldest water mains (Victoria and Oak Bay) also have the least total installed water main length within the available inventory. The jurisdictions with newer water mains (Saanich and CRD) have the greatest water main inventory.

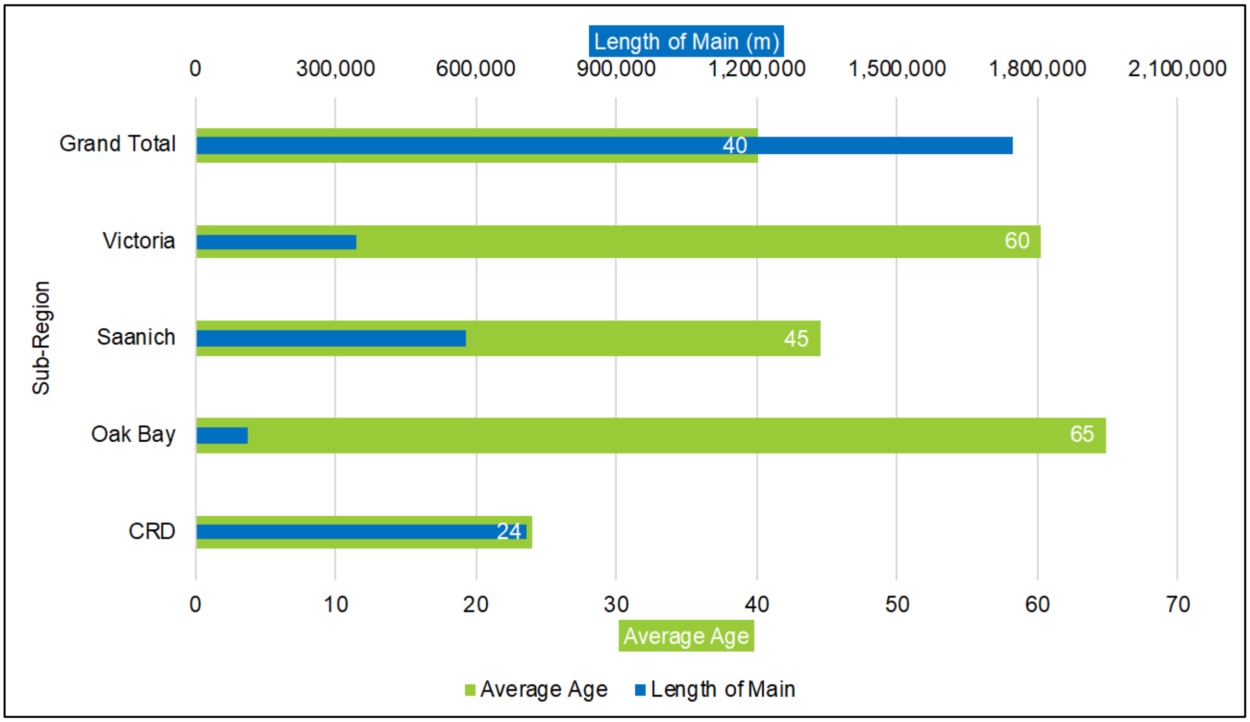


Figure 4-6: Water Main Ages and Installed Lengths for the Greater Victoria Region

Figure 4-7 illustrates water main material types and installed lengths for the Greater Victoria region and sub-jurisdictions. Ductile iron has been used across all jurisdictions. PVC and asbestos concrete were most common for in the CRD and Saanich jurisdictions. Cast iron was common in all jurisdictions except for the CRD.

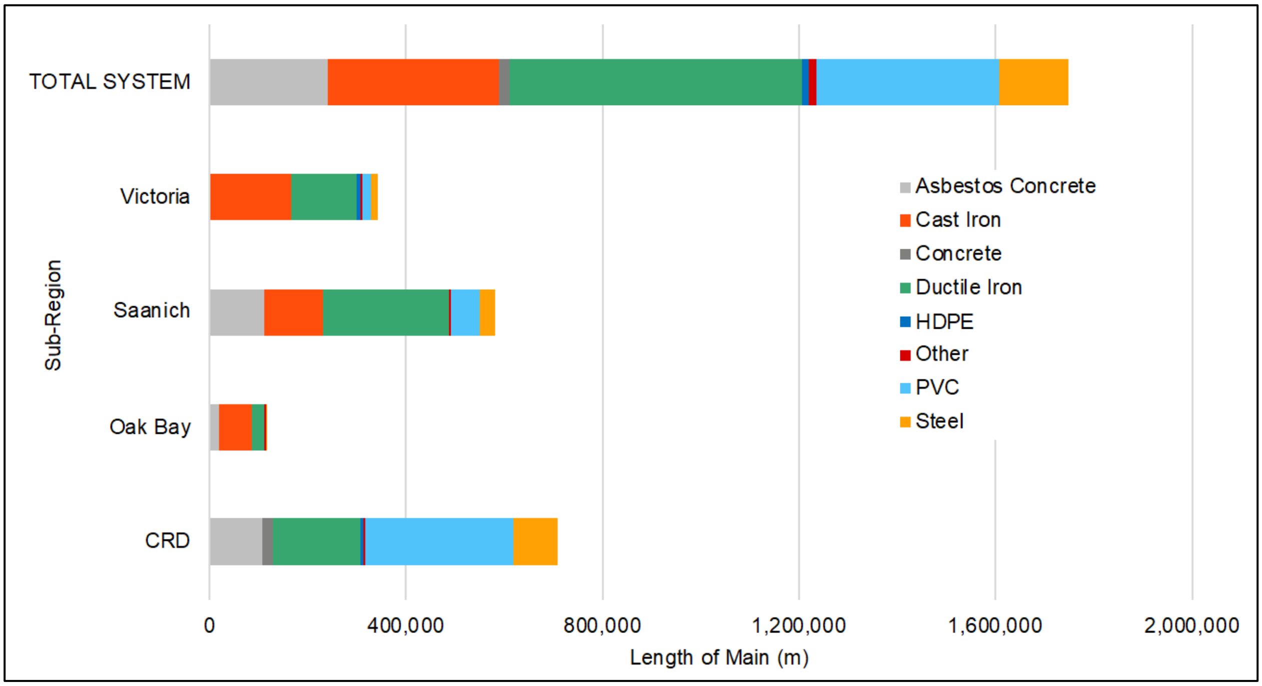


Figure 4-7: Pipe Materials and Installed Lengths for the Greater Victoria Region

5. Water Age Model

Water age models were supplied by each of the participating study partners. This section provides a summary of the models and the assumptions used in the analysis.

The existing water models for each jurisdiction in the region were used to estimate how long it takes water to travel from the supply source to any point throughout the system during existing average day demand (ADD) (i.e., typical flow without irrigation). Since water does not regularly flow through normally closed valve piping, these pipes were removed from the analysis. Figures 5-1 though 5-4 show the modelled water age in the system.

5.1 Capital Regional District Model

The most recent CRD water model was provided to KWL on September 23, 2019 by CRD staff. The model includes all pipes owned and operated by the CRD, namely: the Regional Water Supply (RWS) system, the Saanich Peninsula Water system (SPWS), the JDF distribution system including Sooke distribution system.

The existing 2010 ADD scenario was used to complete a water age model run. The CRD had not previously used the model for water age modelling. It was assumed that the modelled pipe network and control is of sufficient and correct detail to complete water age modelling. The water age results from this model were also used to determine average water age at supply points to each municipality.

Water age in the CRD jurisdiction is generally low. Local reservoirs scattered throughout the system can result in slightly older water such as found in Sooke, parts of Langford, and the SPWS. Additionally, dead-end areas of the systems such as East Sooke and Metchosin have older water. These patterns are consistent with the expected water age in the system.

5.2 City of Victoria (CoV) Model

The most recent CoV water model was provided to KWL on September 23, 2019 by City of Victoria staff. The model results include a 2010 ADD water age model scenario.

The water age from this model was shifted by 28.6 hours based on the average water age derived from the CRD water age model at the CRD supply points at throughout the municipality.

Water age in CoV is generally less than four (4) days throughout the municipality. Small dead-end lines at the edge of the system in Esquimalt and James Bay show slightly older water due to distance from water supply locations. These patterns are consistent with the expected water age in the system.

5.3 District of Saanich Model

KWL developed the Saanich water model as part of the 2017 Water Supply Master Plan. This model included a water age model for 2015 existing base demand scenario. The water age modelling scenario was developed as a 60-day extended period simulation (EPS) model complete with diurnal variations.

The water age from this model was shifted by 26.0 hours based on the average water age derived from the CRD water age model at the CRD supply points to Saanich.

Water age in Saanich is generally less than four (4) days when fed from CRD connection points. Gordon Head, Broadmead, and Cordova Bay areas, fed via local reservoirs, generally have older water on the order of seven (7) days. These patterns are consistent with the expected water age in the system.

5.4 District of Oak Bay Model

Kerr Wood Leidal developed the Oak Bay water model as part of the 2019 Water Supply Master Plan. This model did not include a water age model. A copy of the water model was used to develop a water age model scenario based on the existing base demand scenario. A 60-day EPS model run was chosen.

The water age model was then shifted by 25.4 hours based on the age derived for the CRD supply points at Oak Bay Meters #1, 2, and 3.

Water age in Oak Bay is generally less than four (4) days throughout the municipality. Small pockets of older water can be found in the north and south ends of Oak Bay (furthest points from CRD connection). These patterns are consistent with the expected water age in the system.

Modelled water age for each area is illustrated in Figures 5-1 through 5-4.

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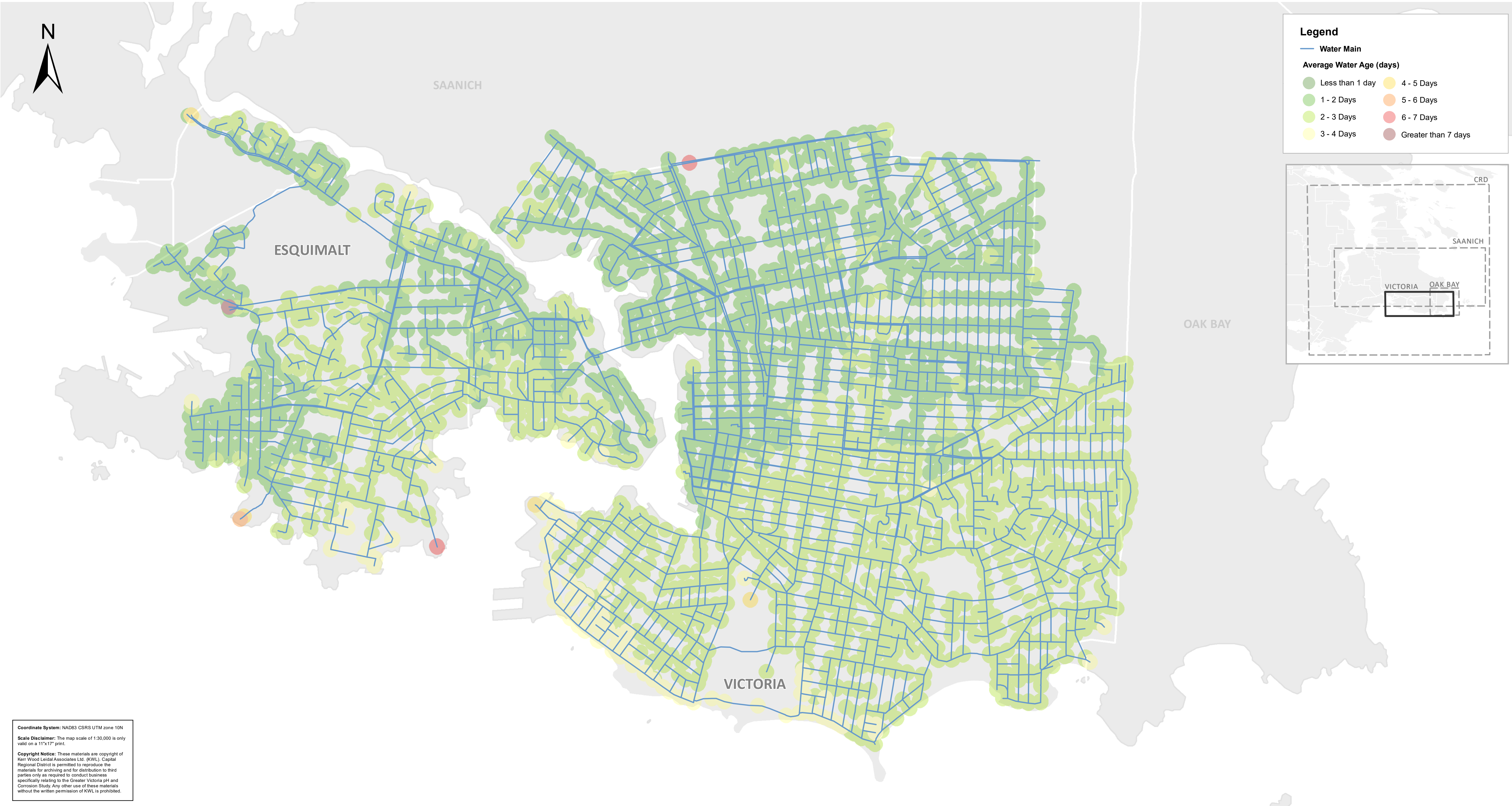
Capital Regional District

Greater Victoria pH and Corrosion Study

KERR WOOD LEIDAL consulting engineers



Coordinate System: NAD83 CSRS UTM zone 10N

Scale Disclaimer: The map scale of 1:30,000 is only valid on a 11"x17" print.

Project No. 719-066

Date August 2021

Scale 1:30,000 0 150 300 600 (m)

Water Age - City of Victoria

Figure 5-1

Capital Regional District

Greater Victoria pH and Corrosion Study

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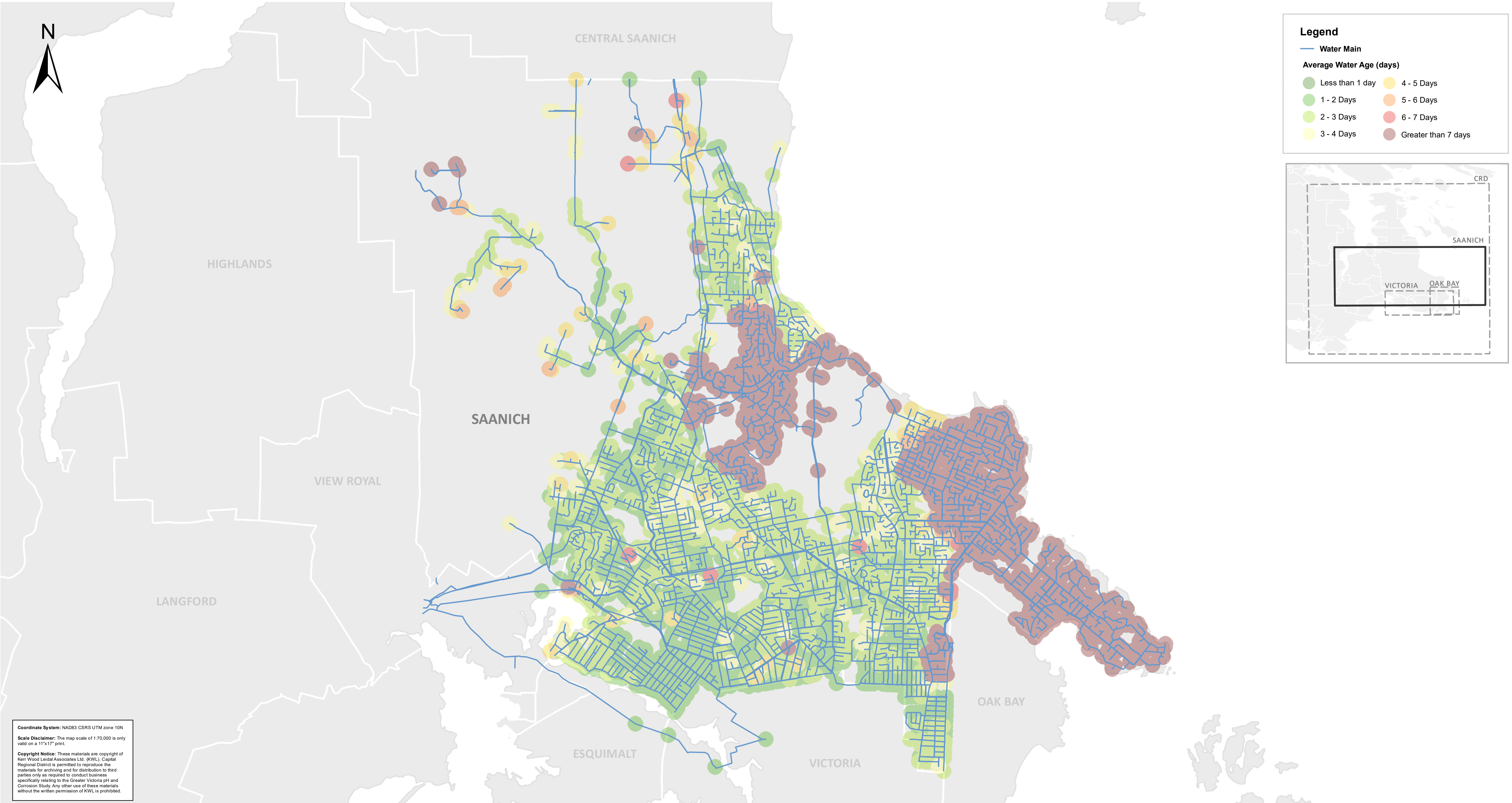
consulting engineers



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Water Age - District of Saanich

Figure 5-2

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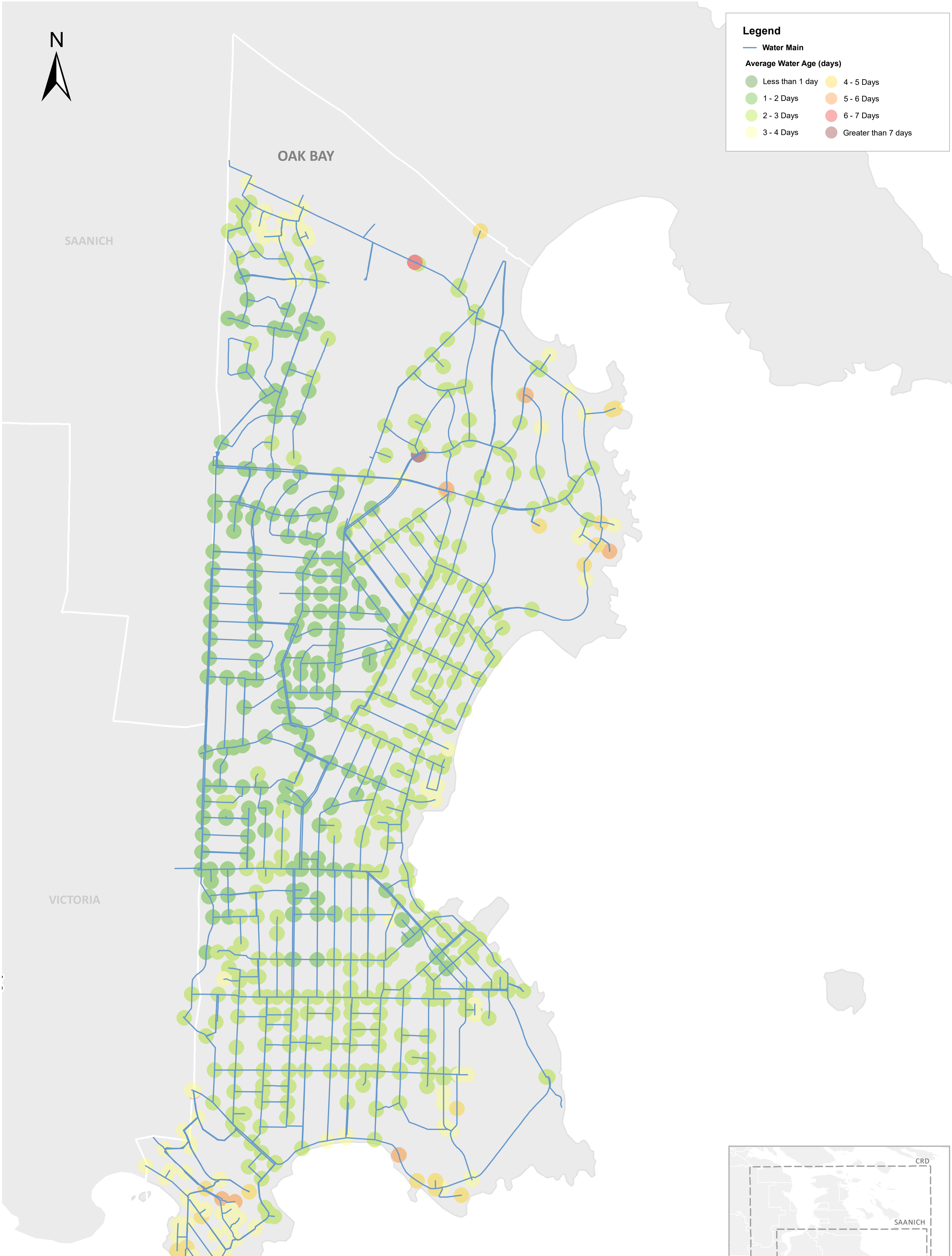

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Date August 2021

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Water Age - District of Oak Bay

Figure 5-3

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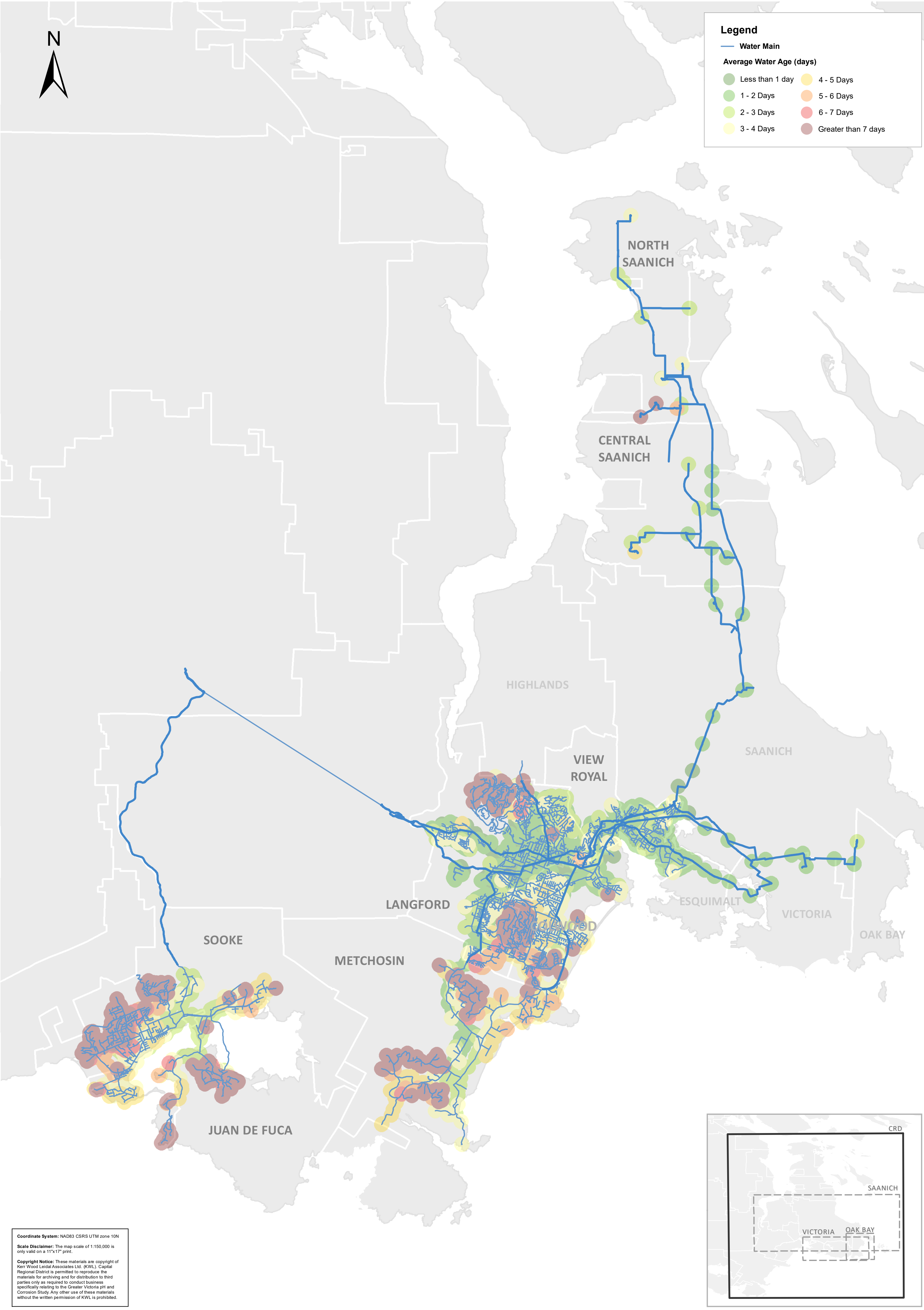

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Water Age - CRD

Figure 5-4

6. Water Sampling Results

As discussed in Section 2.1.2, water sampling was conducted in two rounds with analysis of corrosivity parameters, lead and copper as summarized in Table 6-1.

Table 6-1: Water Quality Parameters Measured with Purpose of Analysis

Water Quality Parameter	Units	Purpose
Total dissolved solids (TDS)	mg/L	CCPP[2] Calculation using RTW Model
Temperature	°C	
pH	s.u.	
Alkalinity (as $CaCO_3$)	mg/L	
Calcium (as $CaCO_3$)	mg/L	
Chloride (Cl^-)	mg/L	
Sulfate (SO_4^{2-})	mg/L	
Lead	mg/L	Direct measurement of leached metals
Copper[1]	mg/L	

1. Copper was only measured in first round and high levels (i.e., above the AO of 1 mg/L) were not detected. It was excluded from the second round of analysis for cost efficiency.
2. Calcium carbonate precipitation potential, an index that estimates water corrosivity.

Results of this analysis are included below.

6.1 Corrosivity Parameters

As discussed in Section 2.1.2, CCPP was selected as the index for estimating water corrosivity. It was calculated using a spreadsheet-based Rothberg, Tamburini and Winsor (RTW) model and spot-checked using Caldwell Lawrence diagrams.

This analysis showed that the water across the Greater Victoria Water System is generally passive (CCPP > -5) with some areas, including some far ends of the system, suggesting mildly corrosive (CCPP between -5 and -9.9) or corrosive (<-10) conditions. Of the 172 samples collected in the first round, approximately 88% of samples suggested passive water, 11% suggested mildly corrosive water and 1% suggested corrosive water.

From a visual spatial inspection (i.e., plotting CCPP with water age), it appeared that CCPP and water age might be correlated. This would suggest that as water age increases, the corrosivity of water may increase, as illustrated in Figures 6-1 through 6-4 below. This slight effect may be due to the variables which impact CCPP (pH, temperature, alkalinity, and hardness) shifting as water age increases.

The results of winter (February) sampling in Sooke showed slightly lower CCPP values on average and therefore a minimal higher corrosivity than the summer sampling results had yielded at the same locations. On average, for the samples collected in Sooke, the summer CCPP was -4.9, while the winter CCPP was -5.7. These values are very close to one another, in the range of passive to mildly corrosive water, with the winter water being slightly more corrosive.

KWL investigated which raw water variables caused the slight decrease in CCPP in the winter months. Though factors impacting the CCPP are closely interrelated, a sensitivity analysis on each variable between summer and winter was performed, by setting the CCPP model to the summer average conditions and adjusting variables individually to match the winter averages. The findings from this analysis were as follows:

- Slightly higher total dissolved solids (TDS) in the winter resulted in a **very small** decrease in CCPP. This is due to the slightly higher solubility of calcium carbonate in water with higher 'activity' or salt content.
- Considerably lower temperature in the winter resulted in a **small** decrease in CCPP. This is due to how the calcium carbonate solubility equilibria are impacted by temperature.
- Slightly lower pH in the winter resulted in a **moderate** decrease in the CCPP. The lower pH is likely due to the increased solubility of CO_2 in colder water, which generates carbonic acid.
- Lower calcium concentrations in the winter resulted in a **moderate** decrease in CCPP. The CCPP compares the observed calcium concentration with the calculated saturation concentration. At lower calcium concentrations, there is more potential for calcium carbonate dissolution, so less potential for precipitation. The reduced level in the winter is likely due to the composition of calcium salts present in the surface water source and their relative solubilities in the summer vs the winter (i.e., at different temperatures).
- Lower alkalinity in winter resulted in a **very small** decrease in CCPP. Alkalinity changes can have either a positive or negative impact on CCPP, depending on the other conditions present.

The above discussion provides a qualitative description of seasonal changes to CCPP. More rigorous analysis would require consideration of inter-sample variability, rather than averages.

The results of the public side corrosivity analysis are included in Figure 6-1 to Figure 6-4 and summarized in Appendix D.

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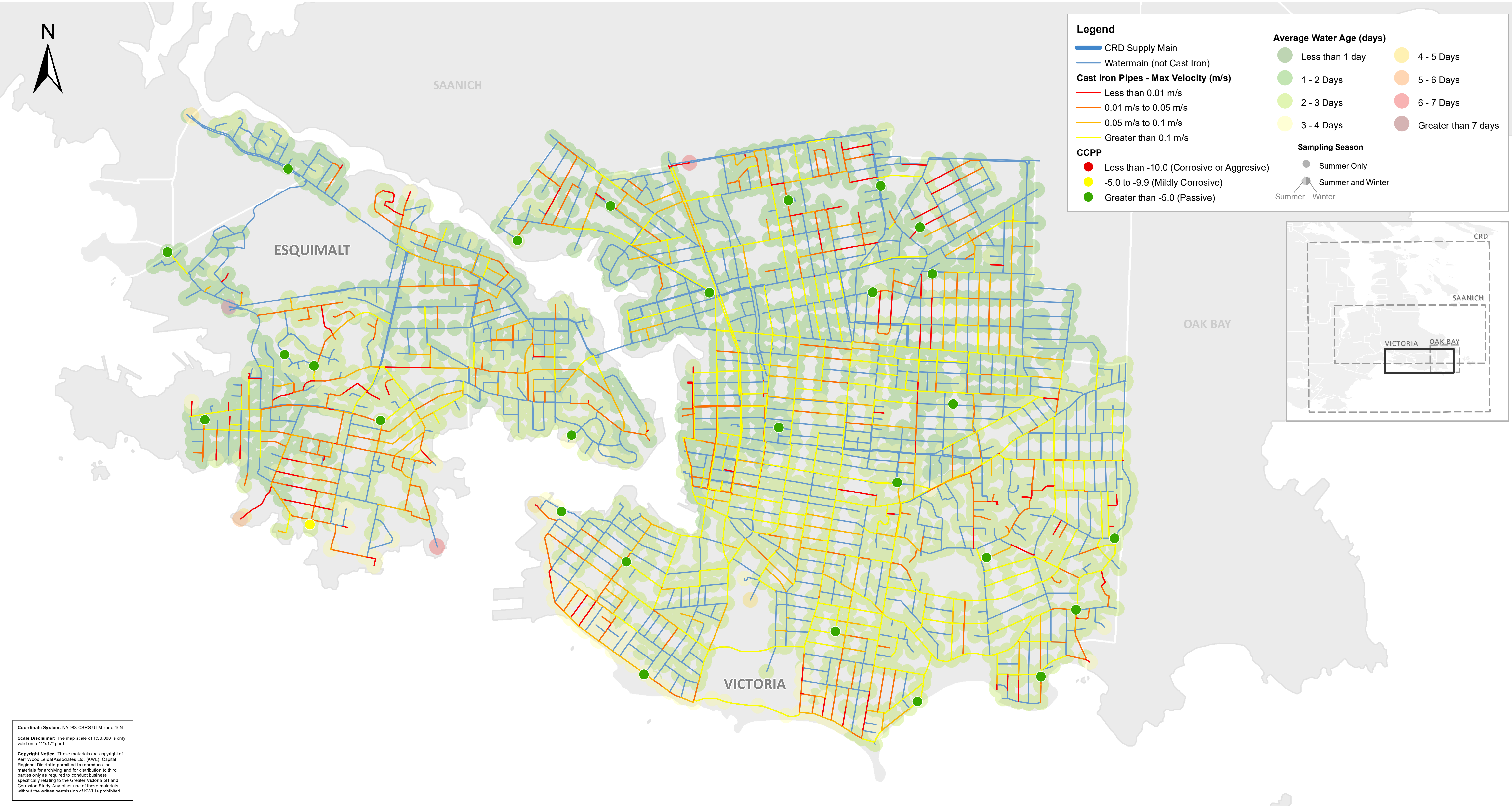
Greater Victoria pH and Corrosion Study

KERR WOOD LEIDAL
consulting engineers



Coordinate System: NAD83 CSRS UTM zone 10N

Scale Disclaimer: The map scale of 1:30,000 is only valid on a 11"x17" print.

Project No. 719-066
Date August 2021
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CCPP with Water Age - City of Victoria

Figure 6-1

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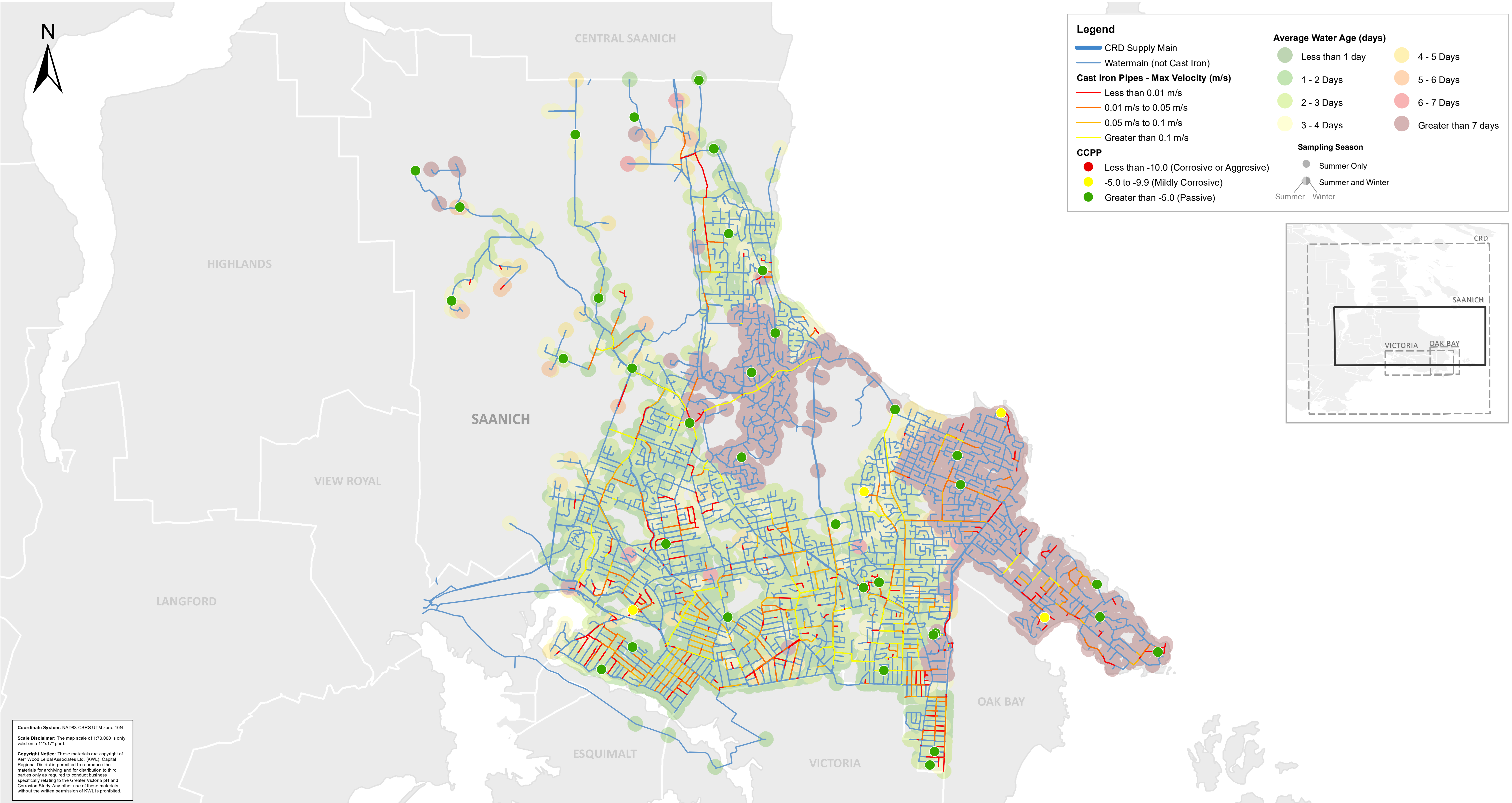

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CCPP with Water Age - District of Saanich

Figure 6-2

Path: \\kwl.ca\vic\0000-0999\0700-0799\719-066\430-GIS\MXD-Rp\Report\719066_Fig6-3_CCPP_OakBay.mxd Date Saved: 8/3/2021 10:23:39 AM | Author: TSoh

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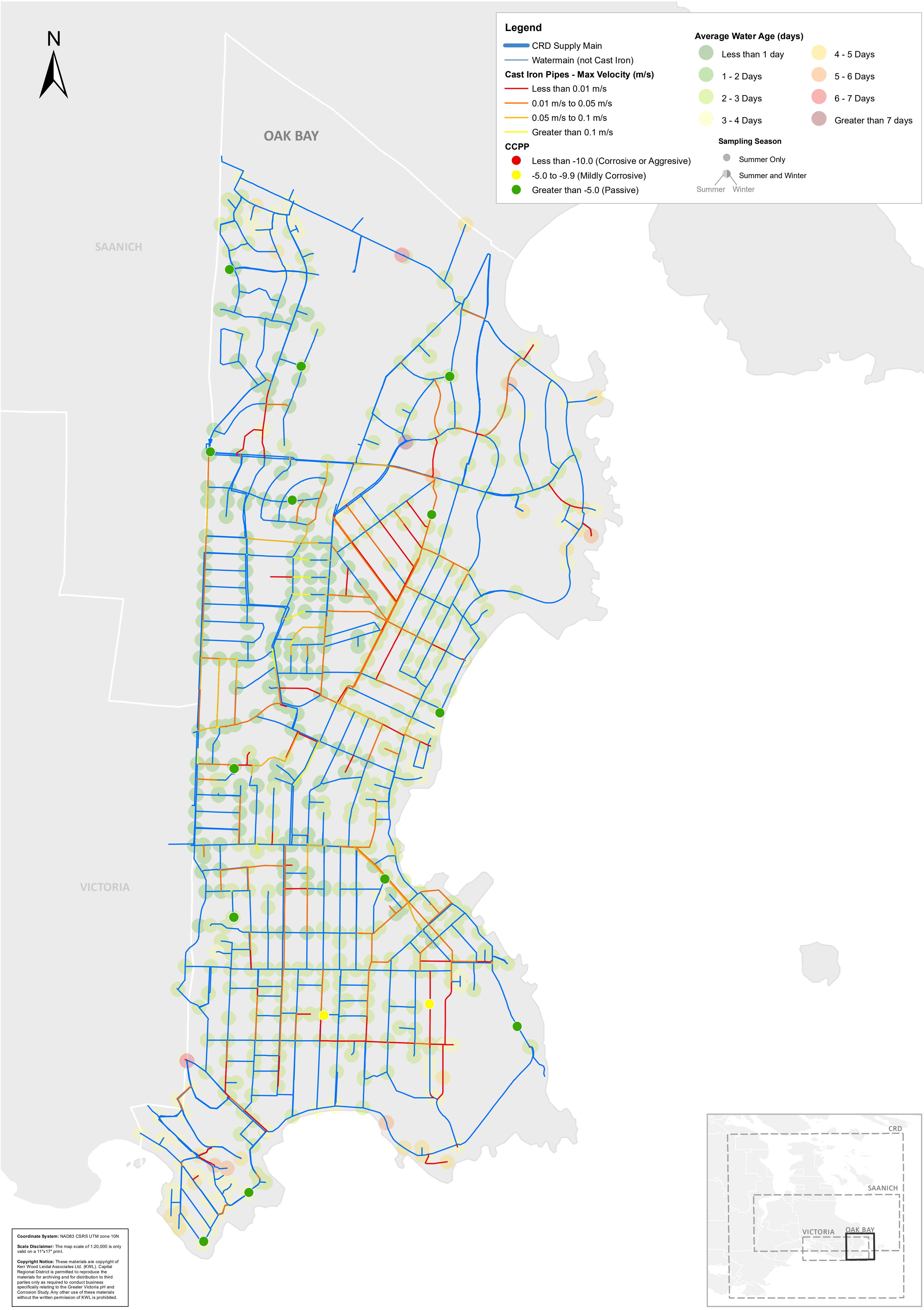

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Date August 2021

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CCPP with Water Age - District of Oak Bay

Figure 6-3

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Greater Victoria pH and Corrosion Study

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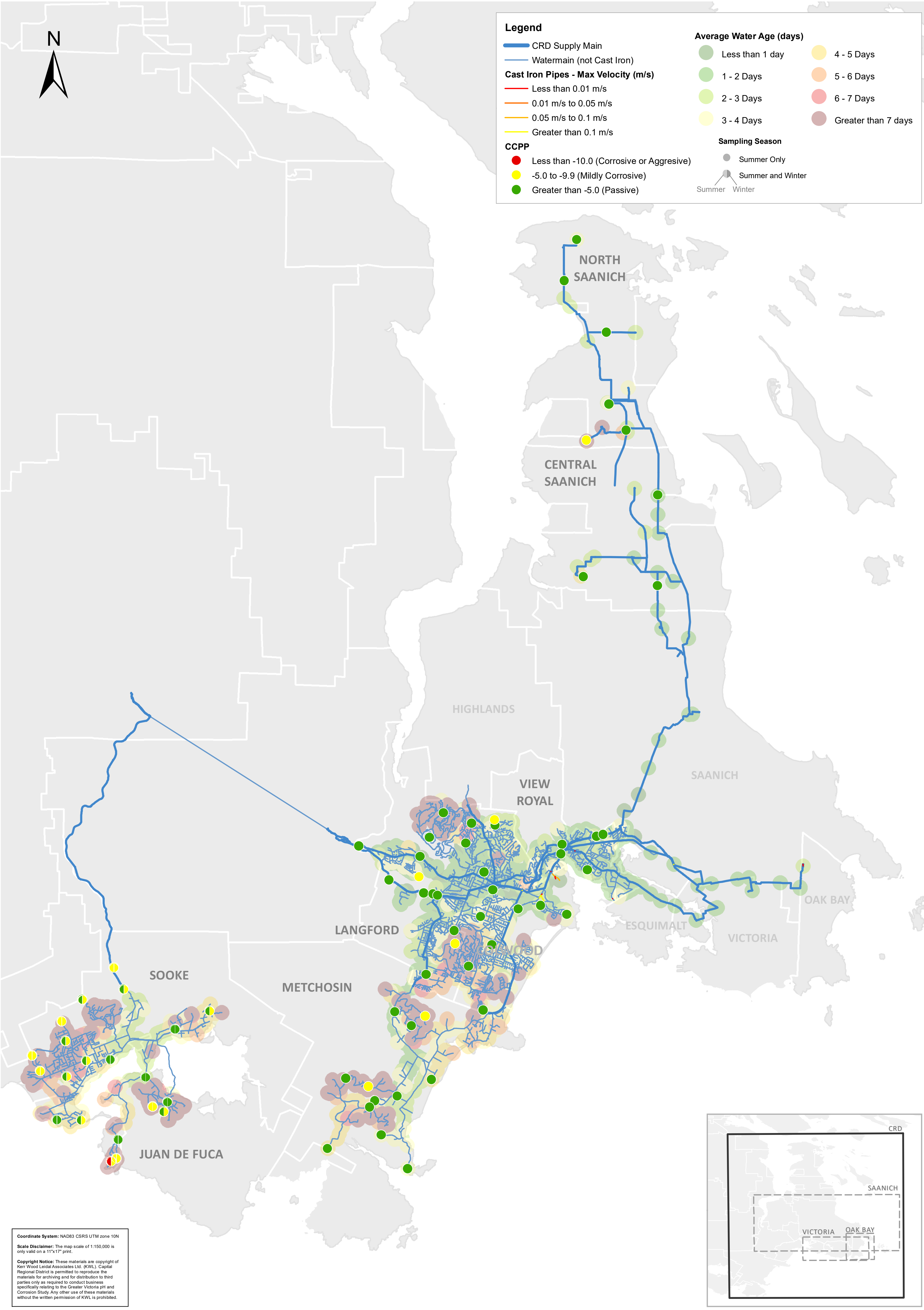

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CCPP with Water Age - CRD

Figure 6-4

6.2 Public Side Lead and Copper

During corrosion analysis, it is important to avoid relying solely on corrosivity indices like the CCPP. While they provide an estimate of water corrosivity, it is also necessary to test for products of corrosion reactions (namely dissolved metals like lead and copper).

At each of the sampling locations in Round 1, lead and copper were measured, and lead was measured in Round 2 at the Sooke sampling locations.

Generally, lead was found to be low (i.e., below the MAC of 5 µg/L) throughout the distribution system with exceptions at Cook Street/Mallek Crescent, during the summer sampling, and on Silver Spray Drive (East Sooke) during the winter sampling. The Cook/Mallek point and two other locations - Lansdowne Road/Foul Bay Road (previous lead observation), and Cecelia Road (moderate lead, just below MAC) - were investigated specifically as described below. Approximately 5% of samples had intermediate lead concentrations, falling between 1 µg/L and 5 µg/L, slightly lower than the MAC. The remaining samples had lead concentrations below 1 µg/L. These results indicate very few and only minor lead sources in the public piping network. A first step in addressing intermediate lead concentrations would likely involve investigating and replacing old copper piping at sampling points as discussed in Section 6.2.1.

Lead sampling results are included in Figure 6-5 to Figure 6-8.

Copper concentrations were measured for samples collected in September. Copper can be used as an indicator of pipe corrosion, though concentrations were low for all samples collected in the present study. Most concentrations were in the range of 0.01 mg/L, with the highest observed copper concentration at 0.14 mg/L. The aesthetic objective for copper is 1 mg/L and the MAC is 2 mg/L.

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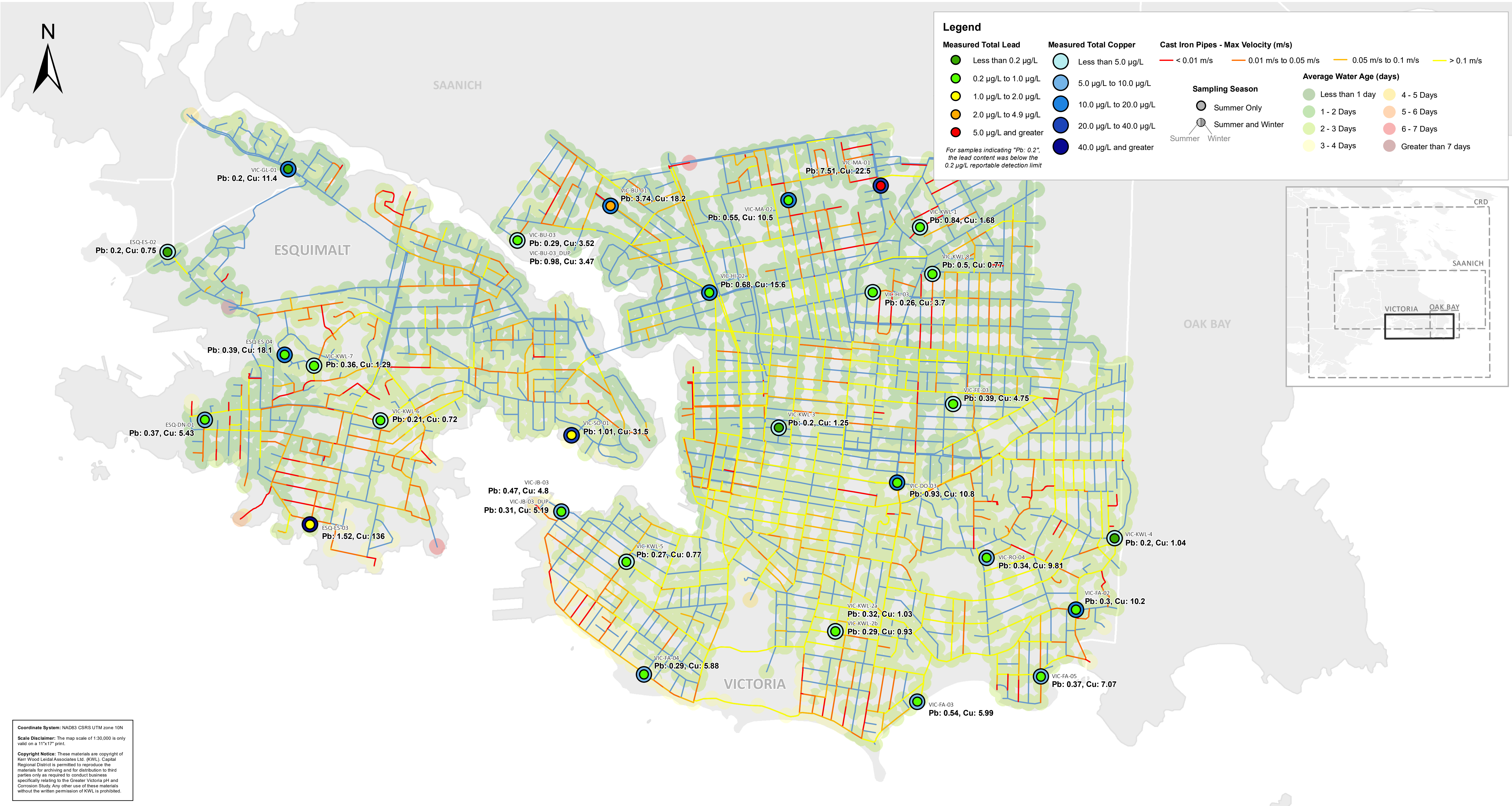

Coordinate System: NAD83 CSRS UTM zone 10N

Scale Disclaimer: The map scale of 1:30,000 is only valid on a 11"x17" print.

Project No. 719-066

Date August 2021

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Lead and Copper with Water Age - City of Victoria

Figure 6-5

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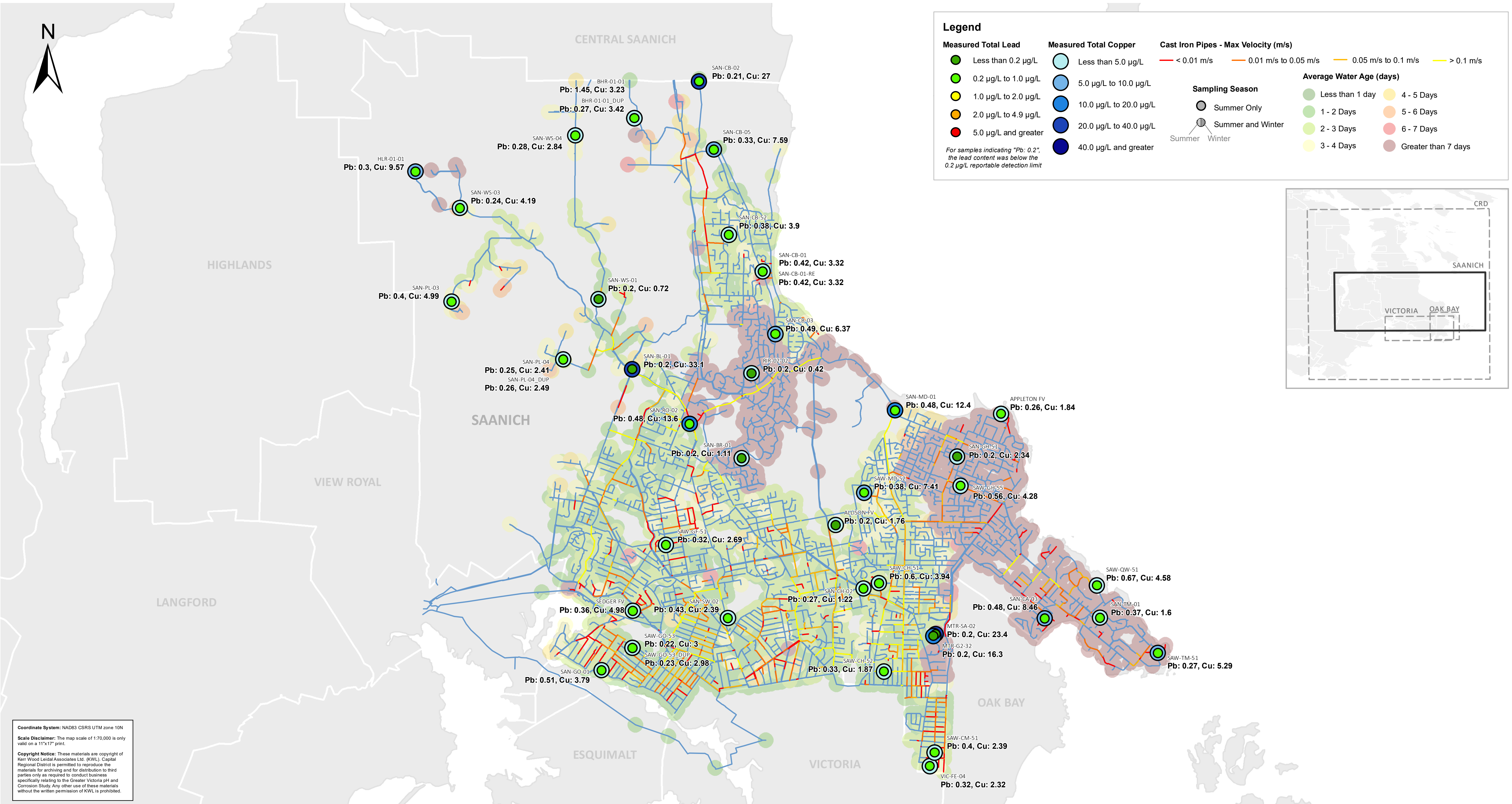

Coordinate System: NAD83 CSRS UTM zone 10N

Scale Disclaimer: The map scale of 1:70,000 is only valid on a 11"x17" print.

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Lead and Copper with Water Age - District of Saanich

Figure 6-6

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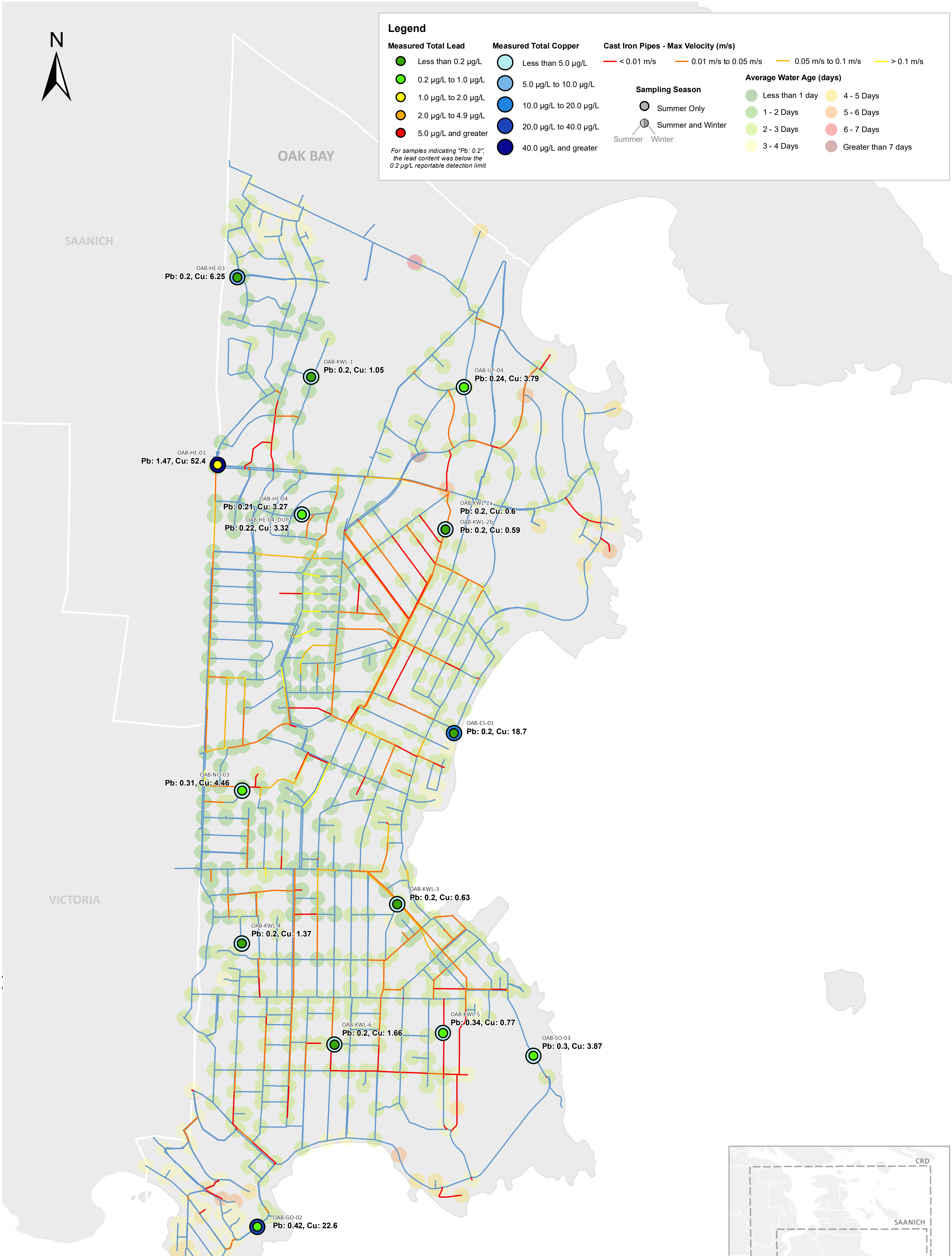

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Project No. 719-056

Date August 2021

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Lead and Copper with Water Age - District of Oak Bay

Figure 6-7

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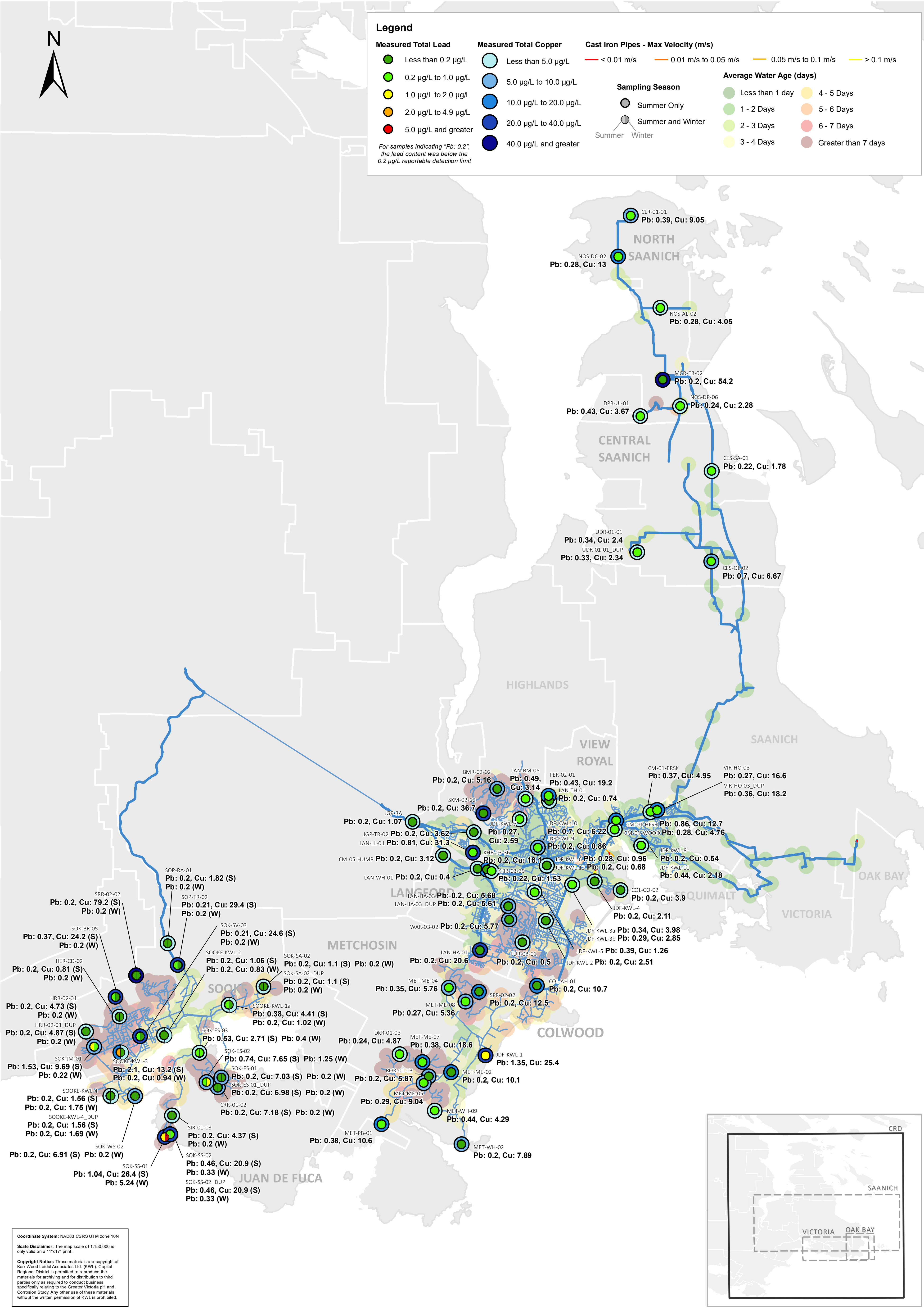

Project No. 719-056

Date August 2021

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Lead and Copper with Water Age - CRD

Figure 6-8

6.2.1 Secondary Investigations

Elevated levels of lead were further investigated at three locations: Cook Street/Mallek Crescent (i.e., in the vicinity of Main #3), Lansdowne Road/Foul Bay Road, and Cecelia Road, as presented with the previous data set.

- Cook Street/Mallek CRD water quality sampling line: 7.51 µg/L;
- Lansdowne Road/Foul Bay Road CRD water quality sampling line: 1.47 µg/L; and
- Cecelia Road CRD water quality sampling line: 3.74 µg/L.

Secondary testing was conducted to investigate the source of this lead and copper.

Results of the secondary investigations at Cook/Mallek, Lansdowne/Foul Bay, and Cecelia are included in Table 6-2 below.

Table 6-2: Results of Secondary Investigations at Locations of Interest

Sample ID	Description of Sample Location (Hydrant, Pump Station Tap, Valve Chamber Tap)	Total Lead (Pb)	Total Copper (Cu)
		ug/L	ug/L
CRD Cook/Mallek Infrastructure			
CRD-VIC-MA-01	CRD Cook/Mallek Sampling Location Collected After Long Flush (15-20 minutes)	5.31	27.80
VL2532	In CRD Mallek Chamber – Tap on CRD Trunk	0.71	1.05
VL2520	In CRD Mallek Chamber – Tap Right Adjacent to CRD-VIC-MA-01 Tap Connection	0.42	1.35
MALEK METER-BYPASS	In CRD Mallek Chamber – On Closed 50MM Copper Bypass (not flushed for long)	2.38	3.41
Hydrants Adjacent to Cook/Mallek Location			
KWL-VIC-1049	Hydrant on Malek Next to Community Activity Centre	0.22	4.71
KWL-VIC-1181	Hydrant at Cook and Kiwanis Way	1.44	5.79
KWL-VIC-0734	Hydrant Near Cook/Malek Sampling Point	0.48	3.50
KWL-VIC-0736	Hydrant at Intersection of McNair and Cook	1.08	5.40
KWL-VIC-1093	Hydrant at Intersection of Lang and Cook	0.50	9.26
Other CRD Locations of Interest			
OAB-HE-01	CRD Sampling Location Near Oak Bay Lansdowne Meter	2.09	75.50
CECELIA SAMPLE LOCATION	CRD Sampling Location Near Cecelia Metering Chamber	2.67	21.20
Municipal Connections off CRD Main #3			
TOLMIE DOUGLAS METER	City of Victoria Meter Chamber at Tolmie/Douglas	<0.2	0.76
Note: All hydrants sampled during secondary investigations were flushed before sampling.			

Cook Street/Mallek Crescent Investigations

Main #3 Solids Testing Results

Three physical material samples were also collected and sent to Island EHS for analysis (refer to Appendix C for materials report):

1. A piece of the Main #3 liner collected from a piece of Main #3 replaced as part of the McKenzie Interchange project;
2. A 50 mm X 50 mm piece of Main #3 steel collected from a piece of Main #3 replaced as part of the McKenzie Interchange project; and
3. Reaming material removed from internal reaming (also known as pigging) of a cast iron pipe with leaded joints in the City of Victoria. The reaming process was done as part of a pipe lining project for the City of Victoria on Dallas Road.

All three samples had low levels of lead (<8 mg/kg for the Main #3 steel, 2.12 mg/kg for the Main #3 liner and 50.5 mg/kg for the reaming material). The reaming material and Main #3 pipe liner were also analyzed using a toxicity characteristic leaching procedure (an extraction method typically used to simulate leaching through a landfill) and found to not contribute a detectable level of lead to the leachate fluid. Accordingly, the watermain materials were found to not be substantial contributors of lead to the system. Refer to Appendix C for the materials test report.

Main #3 Third Round Water Testing Results

A third round of sampling was completed at the Cook and Mallek location to confirm that the lead was being contributed from the copper piping supplying the water sampling station. The lead and copper concentration decrease versus volume removed from the system. Results are shown in Figure 6-9 and Figure 6-10. The results suggest that the source of the lead was the copper sampling station supply line.

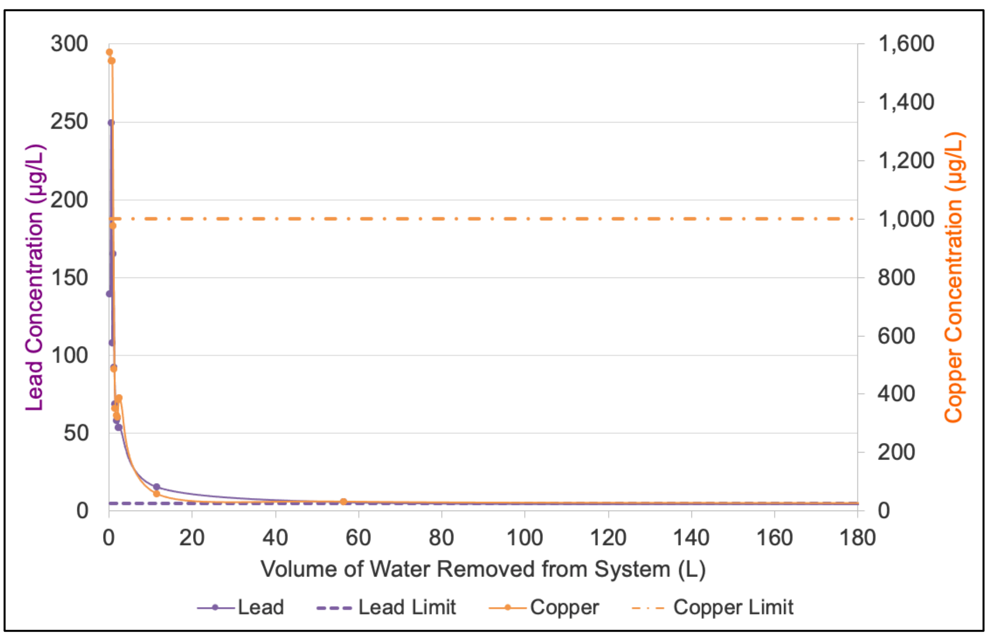

Figure 6-9: Lead and Copper Decline as a Function of Volume Removed

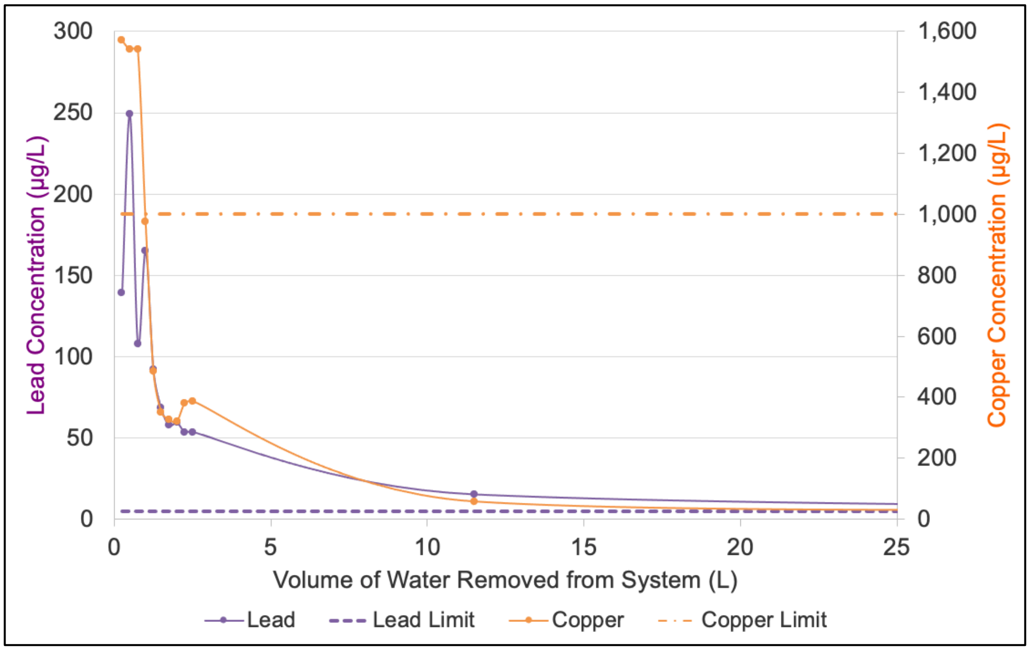

Figure 6-10: Lead and Copper Decline as a Function of Volume Removed (first 25L)

The copper supply line was later removed by the CRD and replaced with stainless steel. Two samples were then collected: a first draw and after a 3-minute flush. The test results from the new stainless-steel pipe showed a first draw lead level of 0.64 µg/L and a post flush lead level of less than 0.02 µg/L which means that the lead level was below the detection limit. This significant reduction in first draw lead (250 µg/L to 0.64 µg/L) strongly supports that the copper piping was the source of lead at this location. The removed copper piping was kept and stored for future tests.

Lansdowne/Foul Bay Investigations

The elevated lead results found at the metering station at the transition from the CRD supply system to the Oak Bay distribution system were investigated by CRD staff. A series of successive lead samples were collected at this sampling station as well as samples from inside the confined space meter station. The results again suggested that the old copper sampling line was the cause of the elevated lead results. Samples taken directly from the supply main demonstrated that the water supplied to Oak Bay was virtually lead free. In December of 2020, CRD staff shortened and replaced the entire sampling line with new copper piping. Lead testing from this new installation confirmed that the lead source was eliminated; the lead result was 0.3 µg/L on March 3, 2021, and 0.27 µg/L on May 13, 2021, down from 2.09 µg/L in fall of 2019.

Cecilia Road Meter Station Investigations

Tests were conducted by CRD staff at this location. Results of this testing also suggested that the sampling infrastructure is likely the source of the elevated lead results. CRD plans to relocate and replace this entire meter station including the sampling infrastructure in near future. The CRD is confident that this will eliminate the lead source at this location, as follow-up investigations near the meter chamber (i.e., bypassing the sampling infrastructure) had a lower lead concentration of 2.67 µg/L.

6.2.2 Data Quality Analysis

For the duplicate samples collected as part of the sampling program, data between duplicate samples was compared for all variables considered. Variability between duplicates was found to be relatively high for TDS and sulfate concentration. Duplicates were consistent ($R^2 > 0.85$) with respect to temperature, pH, alkalinity, calcium, and chloride. Overall, the calculated CCPP was very close between duplicate samples, with $R^2 = 0.99$.

Lead concentrations were scattered for duplicate samples; however, when two particularly poor replicates were removed, the correlation exceeded $R^2 = 0.85$. This indicates that lead is usually relatively consistent within samples, but that sampling variability can be a concern for lead concentration, likely stemming from the variable origin of each sample within the nearby piping. Some samples may have been resting in contact with different lead-impacted pipes or fixtures than the replicate samples drawn from the same sampling point. For example, the first sample collected from a tap could have been sitting in contact with a straight piece of copper pipe while a second sample collected from the same fixture could have been sitting in contact with a soldered 90-degree bend. These two samples could have significantly different lead concentrations, despite being collected from the same fixture. Copper concentration was much more stable than lead, with $R^2 > 0.99$.

Both field blanks and trip blanks were collected during sampling. Most blanks showed concentrations below detection limit for all parameters measured. Of 18 blanks over 7 parameters (72 results total), four results (~5%) were above detection limit. Two field blanks had a TDS of 12 mg/L and 34 mg/L (detection limit = 10 mg/L), the higher of which is in the range of typical sample values. One field blank had a copper concentration of 0.41 μg/L (detection limit = 0.2 μg/L), which was lower than typical sample values. One field blank had a chloride concentration of 7.4 mg/L (detection limit = 1 mg/L), which was in the same range as typical sample chloride concentrations. Despite these findings, the CCPP is relatively insensitive to TDS, and not impacted by chloride. Also, the blank hit for copper was below the typical range for copper. Therefore, it is not anticipated that contamination would have any appreciable impact on the study findings.

6.3 Private Side Sampling Program Lead and Copper Results

At each of the 104 private side sampling locations, lead and copper were measured for both the first draw and 30-minute stagnation (30MS) samples. The results are summarized in Table 6-3, with all sample and survey results included in Appendix D.

Table 6-3: Lead and Copper Concentrations Observed in Private Side Water Samples

	Total Lead Concentration (μg/L)		Total Copper Concentration (μg/L)	
	First Draw	30MS	First Draw	30MS
Action/Health Limit	≥ 15 μg/L	≥ 5 μg/L	≥ 2000 μg/L	≥ 2000 μg/L
Samples ≥ Action Limit	1 of 104 (1%)	1 of 104 (1%)	0 of 104[1] (0%)	0 of 104[1] (0%)
90th Percentile:	1.87	0.90	295	113
85th Percentile:	1.60	0.60	251	98
80th Percentile:	1.30	0.47	212	88
Median:	0.80	0.30	126	48

[1] Note that all samples were also below the Health Canada Aesthetic limit of 1000 and below the USEPA action limit of 1300 μg/L

The median water analysis results were grouped based on responses to six survey questions. These data are presented in Figure 6-11 (lead results), and Figure 6-12 (copper results).

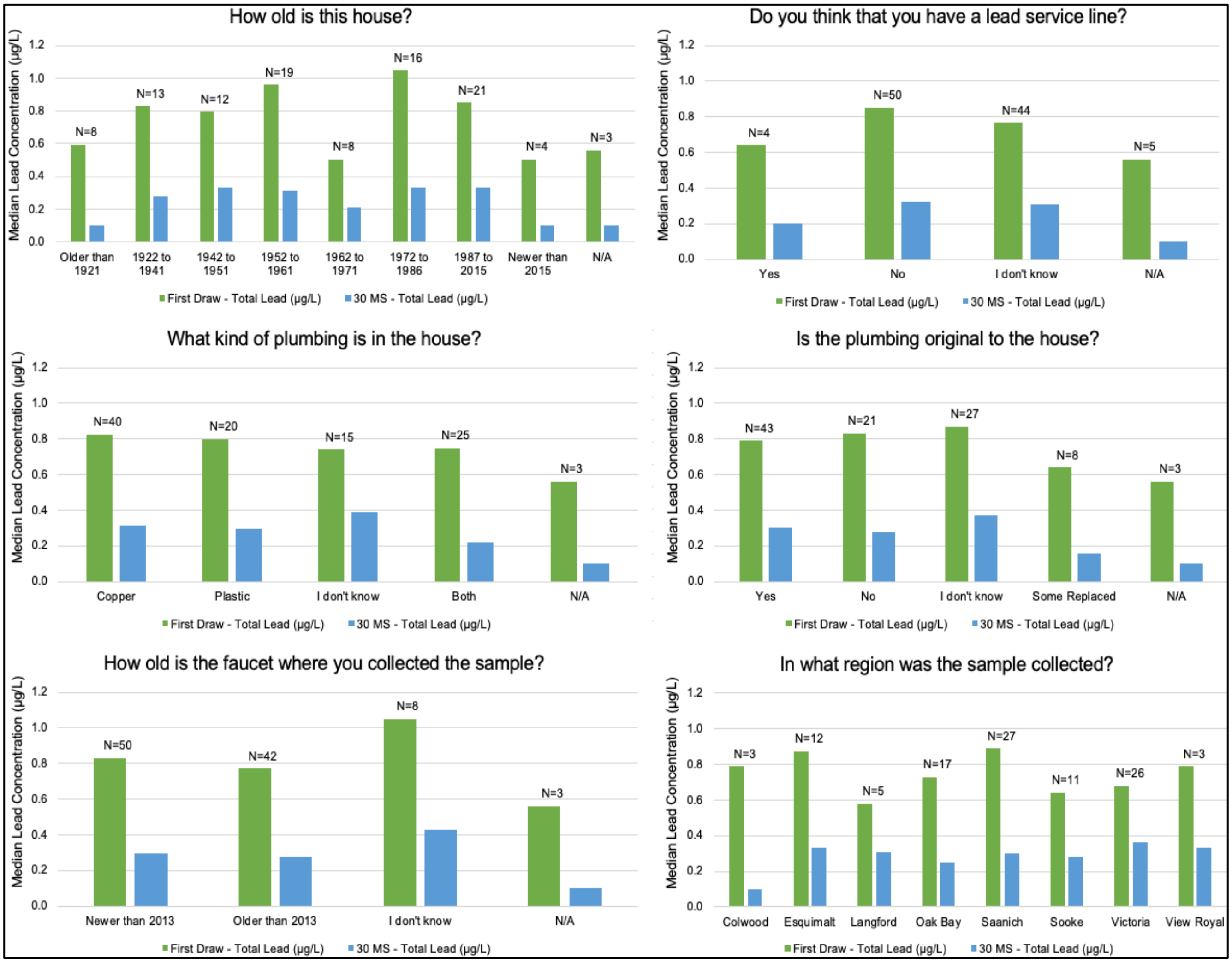

Figure 6-11: Private Side Median Lead Concentrations, Broken Down by Survey Question[9].

[9] The "N" value over each set of bars indicates how many respondents gave this answer. For 30MS samples, an average was found for the two samples from each home and the overall median of these averages is reported.

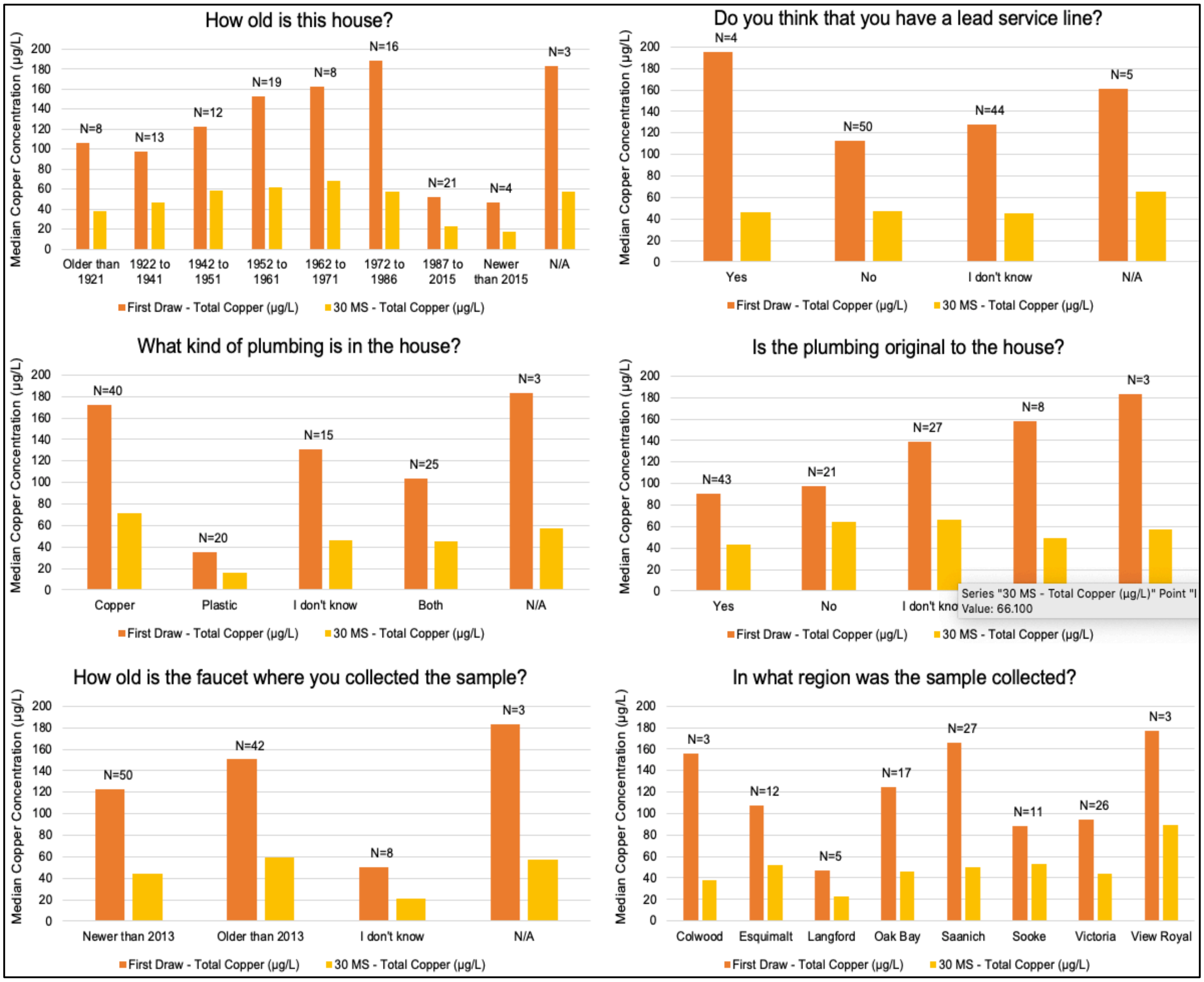

Figure 6-12: Private Side Median Copper Concentrations, Broken-Down by Survey Question[9]

Generally, lead was found to be low across both the First Draw samples (i.e., below the action limit of 15 µg/L) the 30MS samples (i.e., below the MAC of 5 µg/L). Median lead concentrations were 0.8 µg/L for First Draw and 0.3 µg/L for 30MS. The 90th percentile lead concentrations were 1.9 µg/L for First Draw and 0.9 µg/L for 30MS. One site of 104 had a lead concentration over the First Draw action limit, and the same site had a 30MS lead concentration over the Health Canada MAC. The homeowner with high lead concentrations was notified and given advice on corrective actions. No sites sampled had copper concentrations over the aesthetic objective (1 mg/L) or the MAC (2 mg/L).

Copper concentrations were also found to be low across both the First Draw samples and the 30MS samples. Median copper concentrations were 126 µg/L for First Draw and 48 µg/L for 30MS. The 90th percentile copper concentrations were 295 µg/L for First Draw and 113 µg/L for 30MS. No sites sampled had copper concentrations over the aesthetic objective (1 mg/L) or the MAC (2 mg/L).

The results of this sampling program suggest that there is potential for lead and copper to leach into domestic water on the private side, but this leaching appears to be site-specific and not a cause for broad community concern.

Within the four jurisdictions of the present project, the conclusions regarding community risk are the same as for the study area as a whole. Lead and copper results, broken down by partner municipality, are presented in Table 6-4.

Table 6-4: Tabulated Lead and Copper Results by Partner Municipality.

		Total Lead Concentration (µg/L)		Total Copper Concentration (µg/L)	
		First Draw	30MS	First Draw	30MS
	Action/Health Limit	≥ 15 µg/L	≥ 5 µg/L	≥ 2000 µg/L	≥ 2000 µg/L
CRD[1]	Samples ≥ Action Limit	0 of 22	0 of 22	0 of 22[3]	0 of 22[3]
	90th Percentile:	1.50	0.43	279	131
	Median:	0.72	0.30	111	46
Oak Bay	Samples ≥ Action Limit	0 of 17	0 of 17	0 of 17[3]	0 of 17[3]
	90th Percentile:	1.24	0.55	307	116
	Median:	0.73	0.25	125	47
Saanich	Samples ≥ Action Limit	1 of 27	1 of 27	0 of 27[3]	0 of 27[3]
	90th Percentile:	2.58	0.86	294	102
	Median:	0.89	0.30	166	50
Victoria[2]	Samples ≥ Action Limit	0 of 38	0 of 38	0 of 38[3]	0 of 38[3]
	90th Percentile:	2.26	1.03	220	116
	Median:	0.85	0.34	95	46

[1] CRD includes Colwood, Langford, Sooke and View Royal
[2] Victoria includes Victoria and Esquimalt
[3] Note that all samples were also below the Health Canada Aesthetic limit of 1000 and below the USEPA action limit of 1300 µg/L

6.4 Comparison of Lead Levels to Previous Studies

As described in Section 2.1.7, in 2020 VIHA conducted a daycare sampling program. This program appears to have included first draw (i.e., after 6 hr stagnation) and 2-minute flush sampling from two locations within each building (kitchen and bathroom).

The results of the sampling program are included in Table 6-5.

Table 6-5: 2020 VIHA Daycare Sampling Program Results

First Flush Pb Concentration (µg/L)			2-Minute Flush Pb Concentration (µg/L)		
Location #1	Location #2	All Locations	Location #1	Location #2	All Locations
Samples ≥ 15 µg/L:			Samples ≥ 5 µg/L:		
35 of 471 (7.4%)	41 of 467 (8.7%)	**76 of 938 (8.1%)**	17 of 471 (3.6%)	12 of 467 (2.6%)	**29 of 938 (3.1%)**
90th Percentile:			90th Percentile:		
11.0	12.4	**11.7**	2.5	1.9	**2.2**
85th Percentile:			85th Percentile:		
8.3	8.9	**8.6**	1.8	1.5	**1.7**
80th Percentile:			80th Percentile:		
6.5	7.6	**7.0**	1.3	1.3	**1.3**
Median:			Median:		
2.6	3.1	**2.9**	0.5	0.5	**0.5**

The results of the present sampling program were compared with the 2020 VIHA results, and suggest that the CRD's water is less susceptible to lead dissolution in 2021 than it was in 2020. The two studies should be compared with caution as the protocol for the "Flushed" sample in 2020 differed from the "30 MS" samples collected in 2021. The lead concentrations observed for First Draw and Flushed/30 MS samples are plotted in Figure 6-13. In neither case did the 90th percentile exceed the action, health or aesthetic limits, further indicating that community-level lead risk is low.

The decrease in lead concentration may be due to the change in water disinfection method between the 2020 and 2021 sampling events. The 2020 samples, by VIHA, were taken when the GWDF was using chlorine gas, while the 2021 samples were taken when this facility was using its (upgraded) hypochlorite system. The switch from Cl_2 to NaOCl resulted in an increase in pH of roughly 0.5-1 units, and alkalinity from 13 to 16 mg/L. Increasing pH and alkalinity both result in a less corrosive water. The decreased corrosivity may have resulted in a lower propensity to dissolve lead, leading to the observed results; however, to quantify the expected change in corrosivity, a complete CCPP analysis of the water before and after the process change would be required.

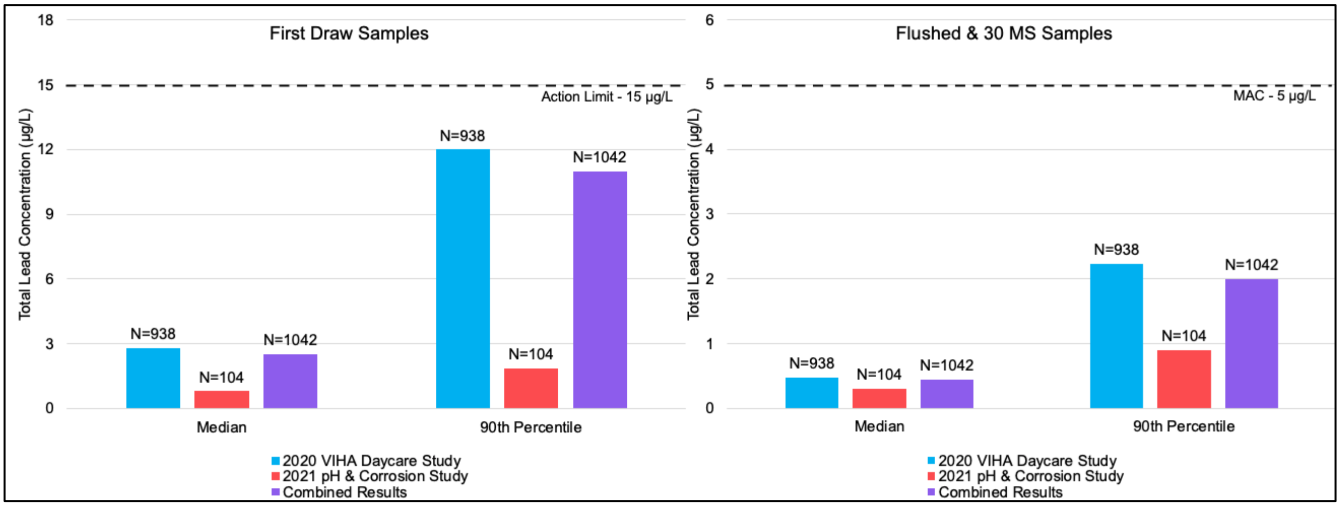

Figure 6-13: Lead Concentrations Present in Standing and Flushed/30 MS Samples for Two Studies

In addition to study-wide comparison with the 2020 data, there was one individual location which was sampled in both 2007 (see study details in Section 1.4.2) and 2021, and there was another individual location that was sampled in both 2020 and 2021. The results at these two locations were compared, as well as the overall medians from the three different studies, as presented in Figure 6-14. Based on our understanding, there have been no changes to residence-specific plumbing at either of the repeated locations. This data further supports the hypothesis that the changed water chemistry in the GVDWS, because of the changes to the disinfection process at the GWTP, is driving the decrease in lead concentrations observed at users' taps.

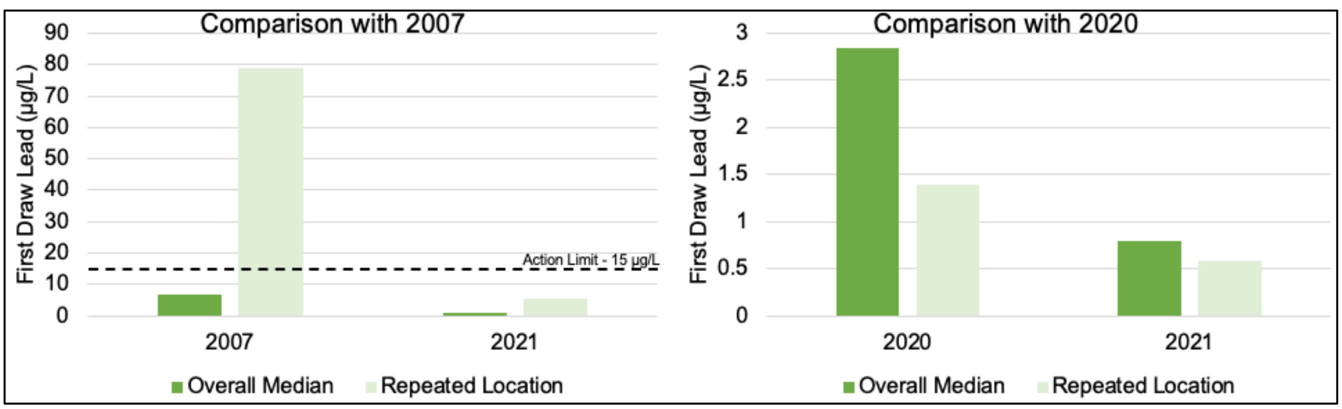

Figure 6-14: Median Lead Concentrations Between Overall Studies and for Repeated Locations

7. Lead Leaching Potential

7.1 Public Side

As noted in Section 2.1.4, a Pipe Corrosion Index was developed to identify pipes that have a higher risk of contributing lead on the public (distribution) side based on:

- the potential for lead to be present (based on the pipe age and material);
- the corrosivity of the water (based on calculated CCPP corrosivity index);
- the contact with the pipe (based on velocity from water age models); and
- whether lead was found nearby.

The analysis was conducted as described in Section 2.1.4 and a risk score was assigned to each pipe in the network as follows (lowest to highest):

- OK;
- Possible;
- Moderate;
- High; and
- Very high.

Of the ~22,000 pipes in the Greater Victoria System the distribution of scores is presented in Figure 7-1 below.

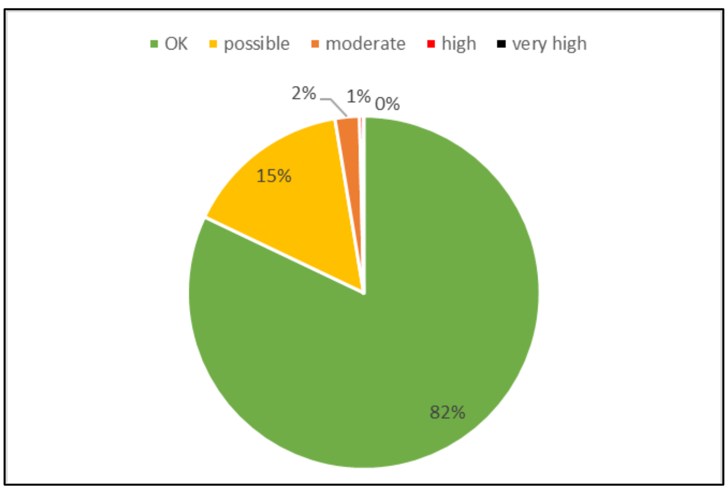

Figure 7-1: Distribution of Pipe Corrosion Index Scores

The 1% of pipes with the highest potential (i.e., those assigned a 'high' score) to contribute lead to the system are found in a small area of Esquimalt (serviced by the City of Victoria).

Combined with the direct measurement of lead and copper across the distribution system, it was concluded that the potential for distribution system components to contribute lead to the system is **low**.

Refer to Figure 7-2 to Figure 7-5 for the pipe corrosion index assignments across the study areas.

Path: \\kwl.ca\vic\0000-0999\0700-0799\719-066\430-GIS\MXD-Rp\Report\719066_Fig7-1_PipeCorrosionIndex_Victoria.mxd Date Saved: 8/3/2021 10:33:42 AM | Author: TSoh

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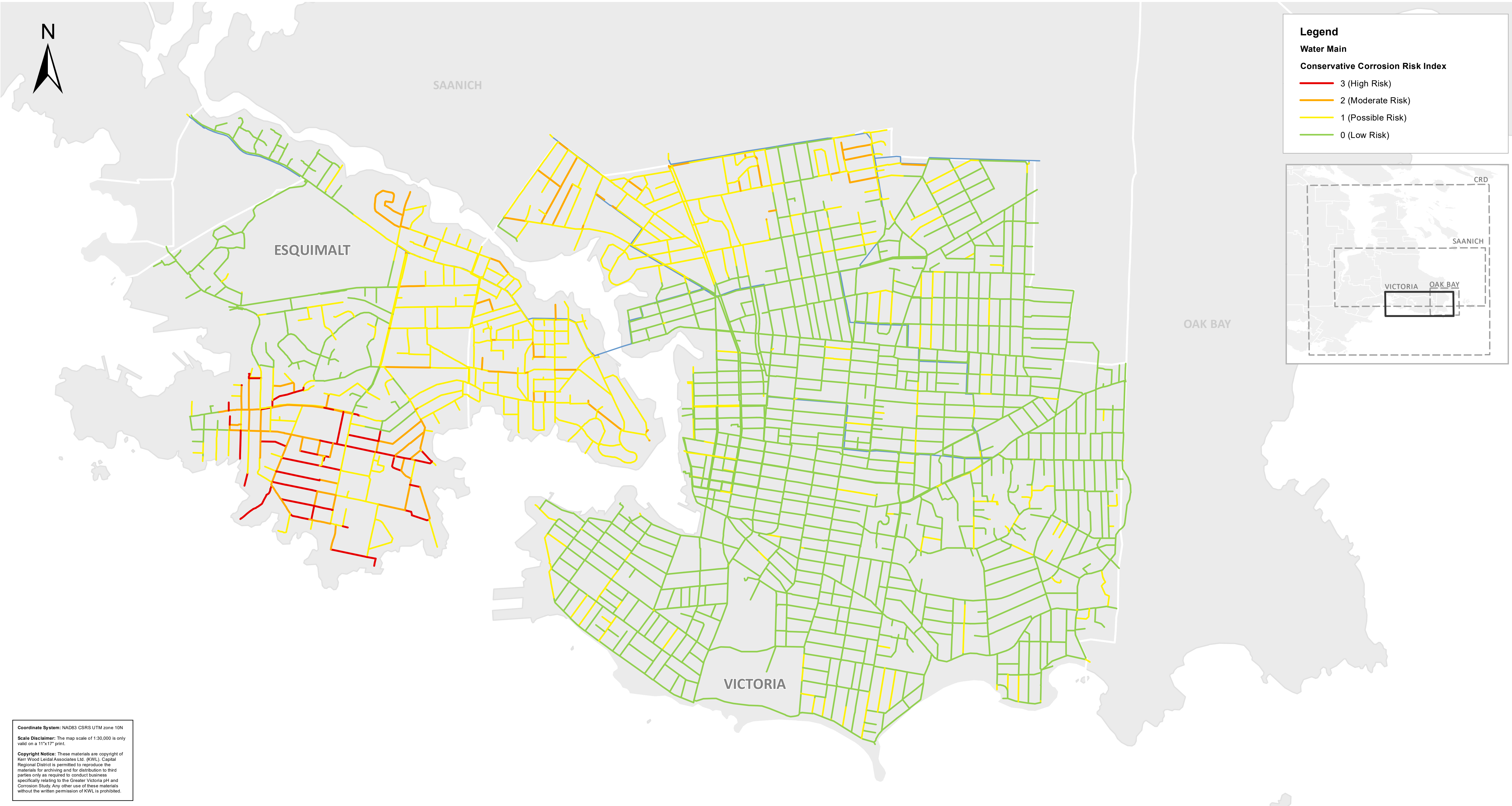

Coordinate System: NAD83 CSRS UTM zone 10N

Scale Disclaimer: The map scale of 1:30,000 is only valid on a 11"x17" print.

Project No. 719-066

Date August 2021

Scale 0 150 300 600 (m)
1:30,000

Pipe Corrosion Index - City of Victoria

Figure 7-2

Path: \\kwl.ca\vic\0000-0999\0700-0799\719-066\430-GIS\MXD-Rp\Report\719066_Fig7-2_PipeCorrosionIndex_Saanich.mxd Date Saved: 8/3/2021 10:35:38 AM | Author: TSoh

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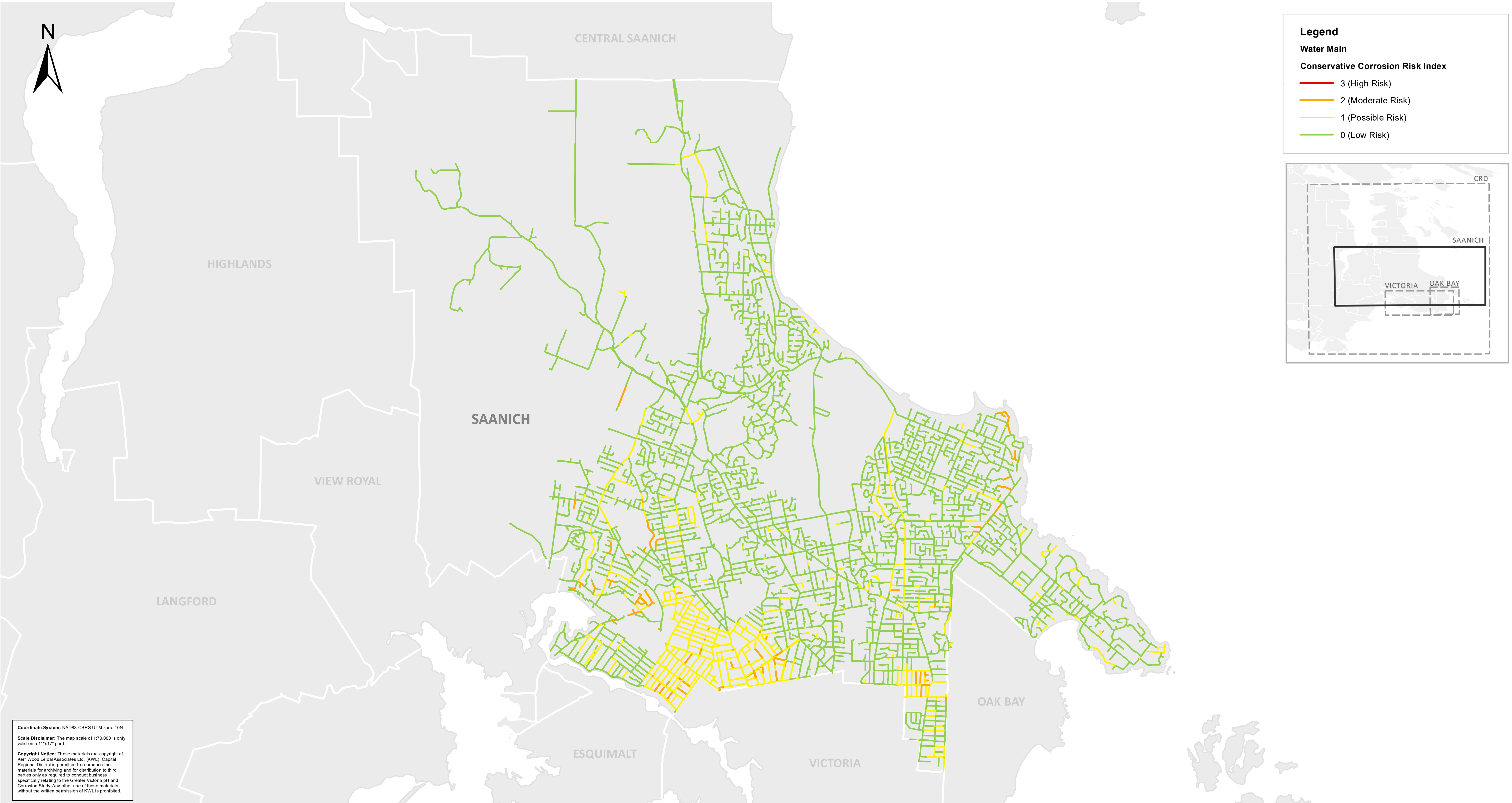

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Scale Disclaimer: The map scale of 1:70,000 is only valid on a 11"x17" print.

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Scale 0 250 500 1,000 (m)

1:70,000

Pipe Corrosion Index - District of Saanich

Figure 7-3

Path: \\kwl.ca\vic\0000-0999\0700-0799\719-066\430-GIS\MXD-Rp\Report\719066_Fig7-3_PipeCorrosionIndex_OakBay.mxd Date Saved: 8/3/2021 10:33:35 AM | Author: TSoh

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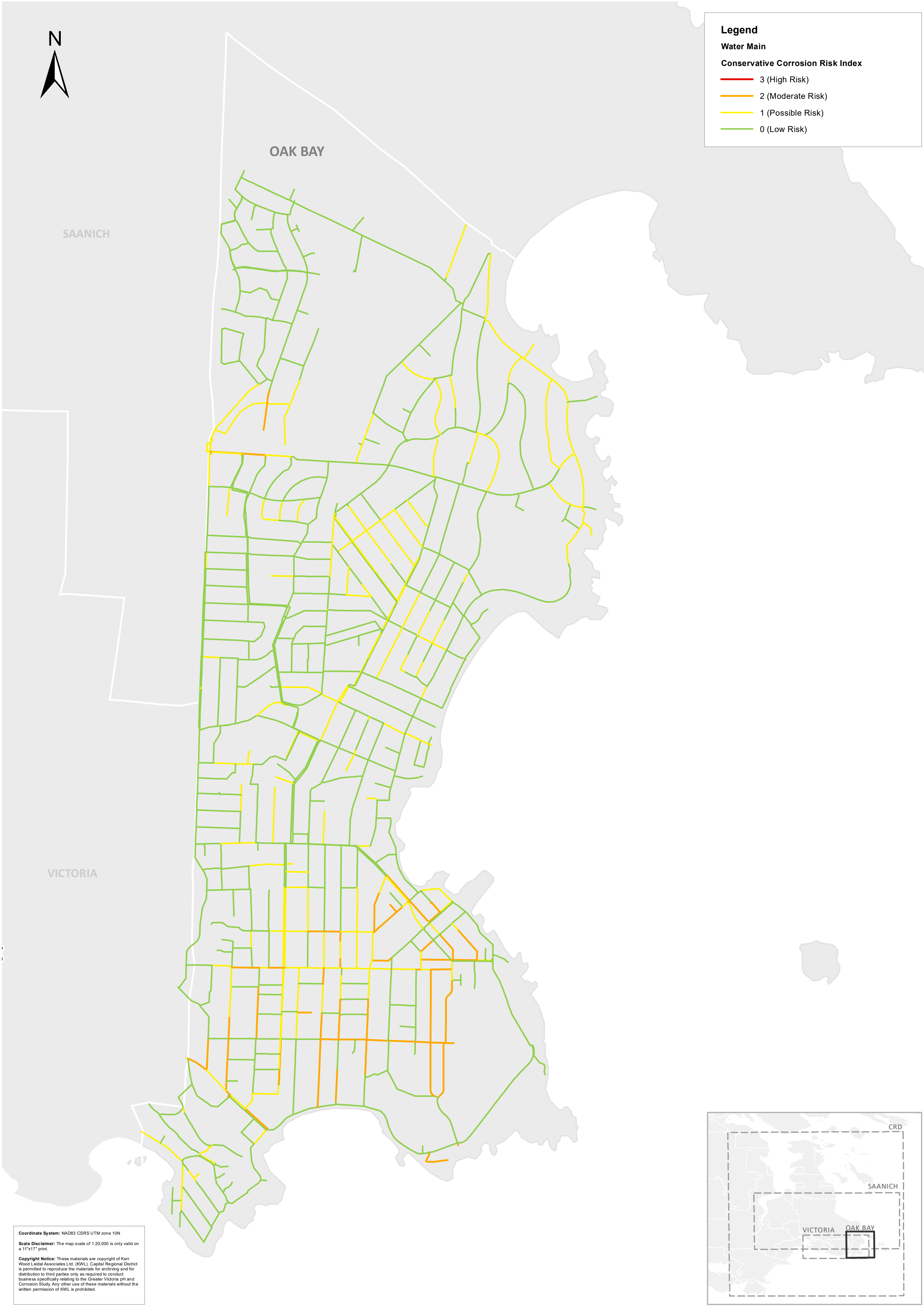

Coordinate System: NAD83 CSRS UTM zone 10N

Scale Disclaimer: The map scale of 1:20,000 is only valid on a 11"x17" print.

Project No. 719-056

Date August 2021

Scale 1:20,000 0 100 200 400 (m)

Pipe Corrosion Index - District of Oak Bay

Figure 7-4

Path: \\kwl.ca\vic\0000-0999\0700-0799\719-066\430-GIS\MXD-Rp\Report\719066_Fig7-4_PipeCorrosionIndex_CRD.mxd Date Saved: 8/3/2021 10:33:54 AM | Author: TSoh

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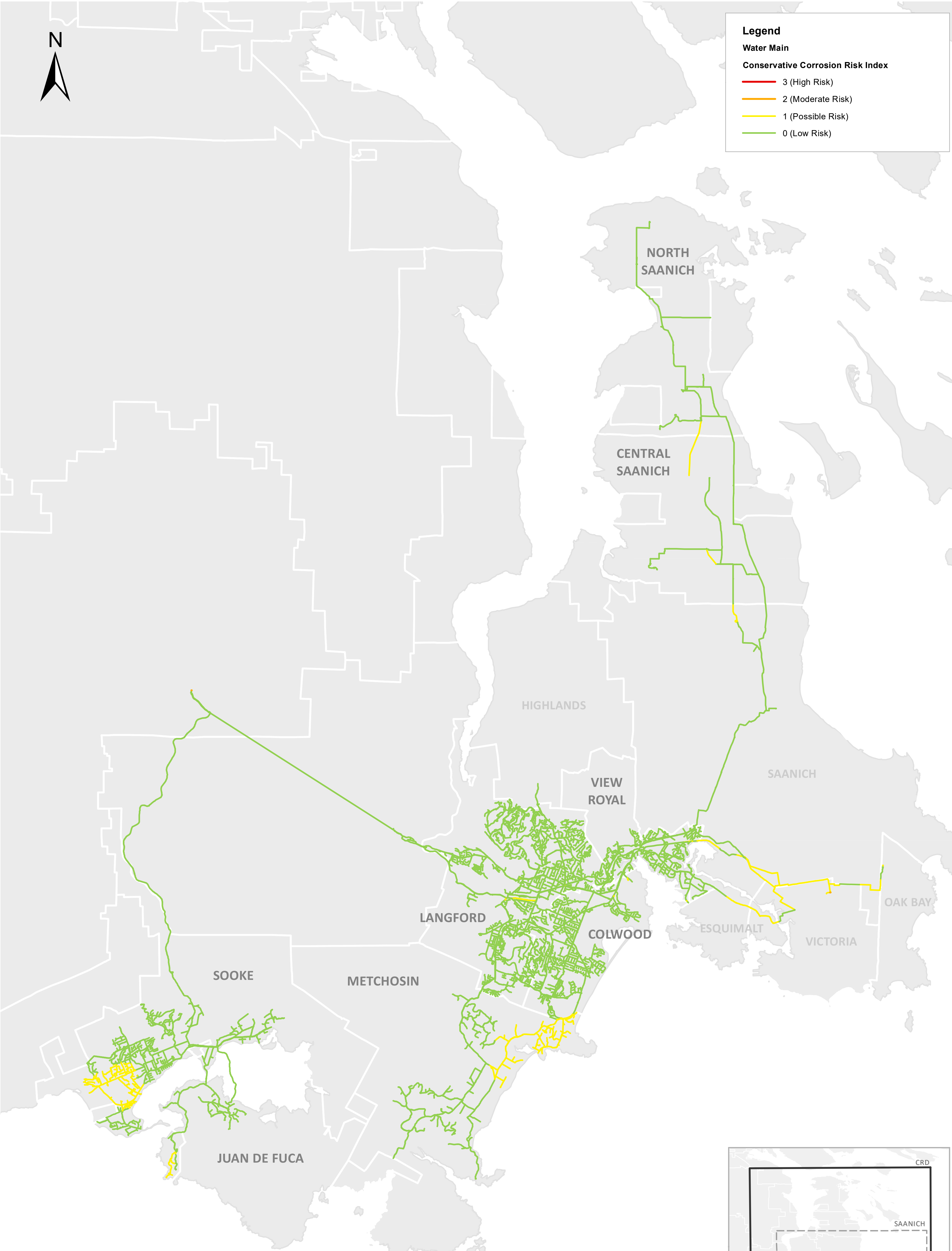


Coordinate System: NAD83 CSRS UTM zone 10N

Scale Disclaimer: The map scale of 1:150,000 is only valid on a 11"x17" print.

Project No. 719-056

Date August 2021

Scale 0 500 1,000 2,000 (m)
1:150,000

Pipe Corrosion Index - CRD

Figure 7-5

7.1.1 City of Victoria Unregulated Pressure Zone and Downtown Fire Protection System

The City of Victoria downtown core area is serviced by two pressure zones / systems encompassing the same area. A regulated (pressure reduced) zone provides water predominately for domestic use and an unregulated (higher pressure) zone is used primarily for building system fire protection. There are known to be some buildings in the downtown core that are serviced for domestic use off the unregulated zone piping. The CRD expressed a concern that the City of Victoria's unregulated pressure zone may present a lead risk due to high water age and a high percentage of pre-1960 cast-iron pipes with leaded joints.

KWL investigated this concern by checking the City of Victoria water model for water age associated with the Fire Protection Area. We found that the unregulated zone also services the Hillside Quadra, Fernwood, and Rockland neighbourhoods, approximately 24% of the total land area in the City of Victoria.

The model indicates that water age is not a concern with the unregulated zone pipework within the downtown core area given the large domestic service area this system also supplies. As such, these system components are not expected to pose a significant lead risk; however, further testing should confirm this and these old cast-iron pipes with higher lead content potential should be prioritized for replacement.

7.2 Private Side Lead Leaching Potential

The results of public side testing showed that minimal lead appears to be entering the water on the public (distribution) side. There was still, however, a risk that lead could be leaching into the drinking water on the private side. As noted in Section 2.1.6, lead services and domestic plumbing components can contribute lead to water within customers' homes. The CRD's 2007/2008 water sampling program also confirmed that, sporadically, lead exists within homes in the study area and that this lead can leach into the water.

As described in Section 2.1.7, a private side lead and copper testing program was developed to collect samples from residential properties across the GVDWS. The results of this testing (as outlined in Section 7.3) suggest that there is potential for lead and copper to leach into domestic water on the private side, but this leaching appears to be site-specific and not a cause for broad community concern. Overall, the risk associated with lead in drinking water in the GVDWS appears to be low. This finding should be confirmed with additional monitoring programs in the future.

7.3 Public Health Risk and Recommended Action Level

As noted in Section 1.2, there are currently no testing or treatment requirements associated with lead or copper for the local water suppliers as conditions on operating permits. There are, however, several guidance documents that individual water suppliers, VIHA and the Regional Water Supply Commission may wish to reference to determine a 'best management practices' response to the levels of lead and copper found as part of the private side testing.

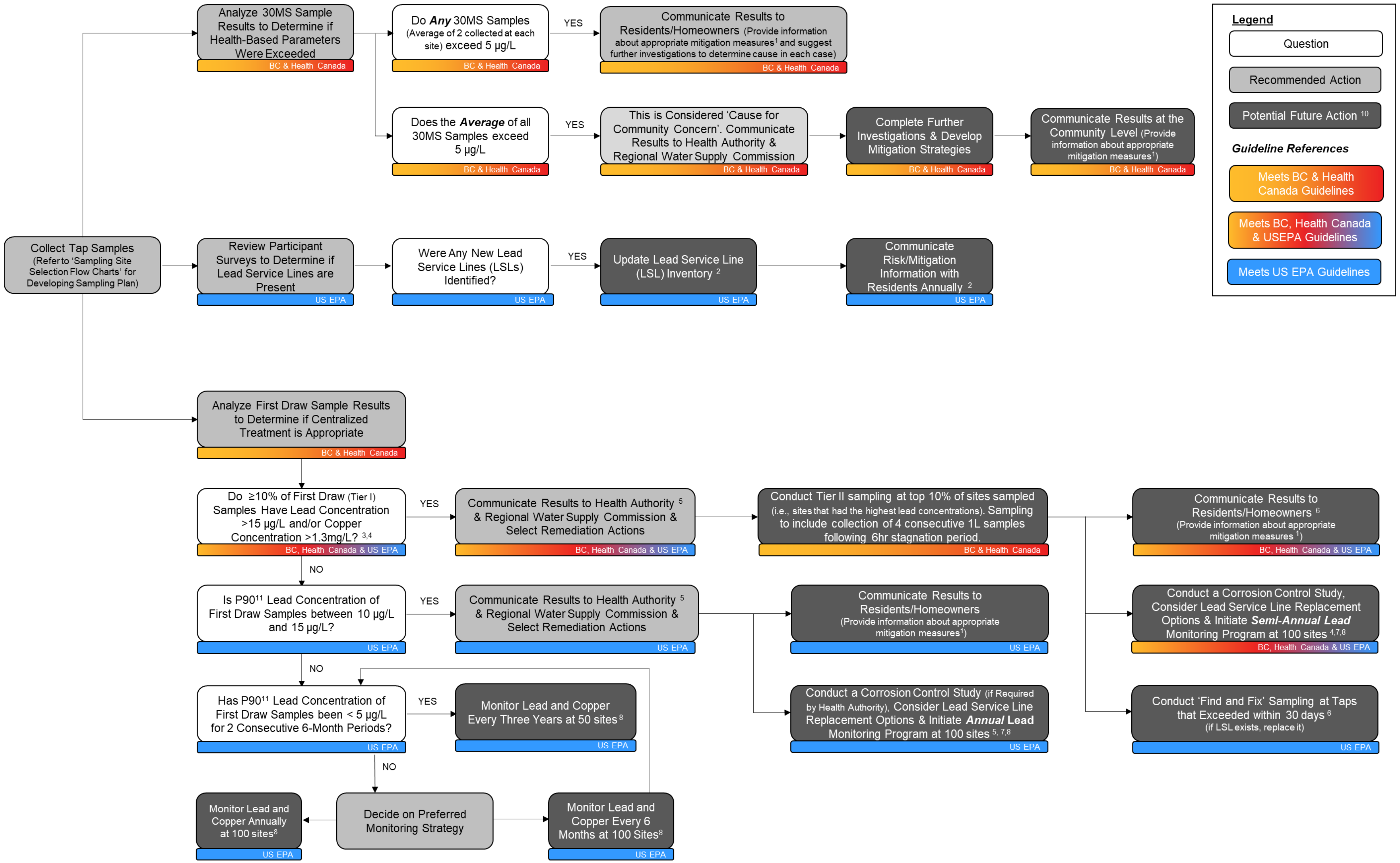
The following guideline documents were reviewed (refer to Appendix E for summary table):

- *Guidelines on Evaluating and Mitigating Lead in Drinking Water Supplies, Schools, Daycares and Other Buildings* (BC Ministry of Health, Health Protection Branch, April 2019)

- *Public School Policy – Testing Lead Content in Drinking Water of School Facilities* (BC Ministry of Health, April 1, 2019)
- *Guidelines for Canadian Drinking Water Quality – Guideline Technical Document – Lead* (Health Canada, March 2019)
- *Guidance on Controlling Corrosion in Drinking Water Distribution Systems* (Health Canada, June 2009)
- *Lead and Copper Rule* (US Environmental Protection Agency (US EPA), Long Term Revisions effective June 17, 2021)

The following Sampling Response Flow Chart (Figure 7-6) identifies recommended responses based on sampling results. This figure also identifies how each of these recommended or potential future actions align with:

1. BC's *Guidelines on Evaluating and Mitigating Lead in Drinking Water Supplies, Schools, Daycares and Other Buildings*
2. Health Canada's *Guidelines for Canadian Drinking Water Quality – Guideline Technical Document – Lead* and *Guidance on Controlling Corrosion in Drinking Water Distribution Systems;* and
3. US EPAs *Lead and Copper Rule*



Notes:

1. Appropriate mitigation measures Include:

1) Flushing of cold-water tap (i.e., until the water feels cold) prior to consuming water
2) Replacement of lead service line (if present)
3) Replacement of brass fittings or in-line devices
4) Use of NSF/ANSI-certified water treatment devices (NSF/ANSI 53, 58, or 62).

2. US EPA Lead and Copper Rule (LCR) requires that LSL inventory be publicly available and prepared by January 16, 2024 (or potentially Sept 16, 2024). Occupants of homes with LSLs must be notified every year about their exposure risks and mitigation options.

3. If <10% of first draw samples are below 15 µg/L there is no requirement in BC to implement corrosion control or communicate broadly with the community. This will, however, be at the discretion of the local health authority and is subject to change. Additionally, there is no copper action limit identified in the BC and Health Canada guidelines.

4. USEPA LCR requires that once >10% of samples exceed 15 µg/L Corrosion Control Treatment must be implemented (or re-optimized if it is already in place)

5. US EPA LCR identifies 'Primacy Agency' not 'Health Authority'. Modified for BC context.

6. US EPA LCR identifies that 'find and fix' sampling is required for ALL first draw samples that exceed 15 µg/L; residents are also to be notified as soon as practicable but no later than 3 days after sample results are received.

7. US EPA LCR requires that, if corrosion control is in place, it must be re-optimized above trigger limit of 10 µg/L (if required by Primacy Agency). Above the trigger limit of 10 µg/L monitoring frequency must also be updated.

8. US EPA LCR identified tap monitoring frequency for systems serving >100,000 people

9. US EPA LCR requires that systems serving ≥50,000 people must conduct regular water quality parameter (WQP) monitoring at entry points (i.e., treated source water) and within the distribution system and at a selection of taps.

10. Potential future actions have been identified in the noted guideline documents (refer to colour bar below each action box). These actions are not required but may be considered as part of communications with Health Authority and Regional Water Supply Commission.

11. P90 is 90th percentile of all collected samples as defined in the US EPA LCR

Figure 7-6: Sampling Response Flow Chart

The sampling response was determined for the data collected from the 2021 private side sampling. The resulting actions are presented in the following three excerpts from Figure 7-6.

With respect to health-based parameters, only one home (of 104) exceeded a lead concentration of 5 µg/L for its mean 30MS lead concentration. As proposed in the flow chart, the results were communicated to the homeowner and appropriate mitigation measure were suggested. As of June 2021, the homeowner had been notified and had taken the corrective actions of adding a point-of-use filter to remove lead and replacing the fixture. The sampling response excerpt relevant to health-based parameters is as follows:

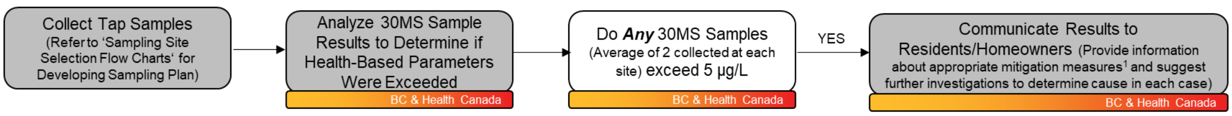


Figure 7-6 (excerpt A): Health-Based Parameters

With respect to lead service line (LSL) identification, four participants responded "yes" to potential lead service lines. Three potential lead service lines were in Saanich and one in Oak Bay. These two municipalities have been notified of the addresses so they can create or update their LSL inventory and communicate risk and mitigation actions with residents. It is recommended that each jurisdiction develop an inventory of known or suspected lead service lines, as well as a strategy for eliminating these lines.

For homes with lead service lines, the present study protocol may not be adequate to capture peak lead concentrations as the sampled volumes may not coincide with water that has been stagnant in the service line. Determination of peak lead concentrations would require more extensive analysis to capture a sample from this particular volume of water. The sampling response excerpt relevant to LSL identification is as follows (based on USEPA):

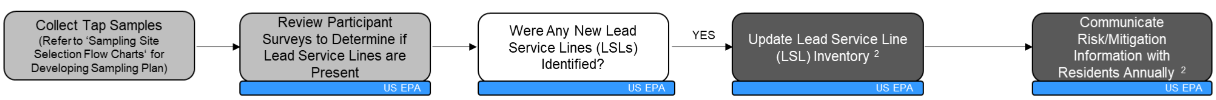


Figure 7-6 (excerpt B): Lead Service Line Identification

With respect to the monitoring program recommendations, lead and copper concentrations were sufficiently low that no immediate remediation actions are recommended. Given that the P90 (90^{th} percentile) of first draw samples is less than 10 µg/L of lead, the US EPA recommendation would be to monitor lead and copper annually at 100 sites until P90 of first draw samples have lead concentrations <5 µg/L for two consecutive 6-month periods. Following that, the US EPA recommendation would be to monitor lead and copper every three years at 50 sites. The sampling response excerpt relevant to the monitoring program is as follows:

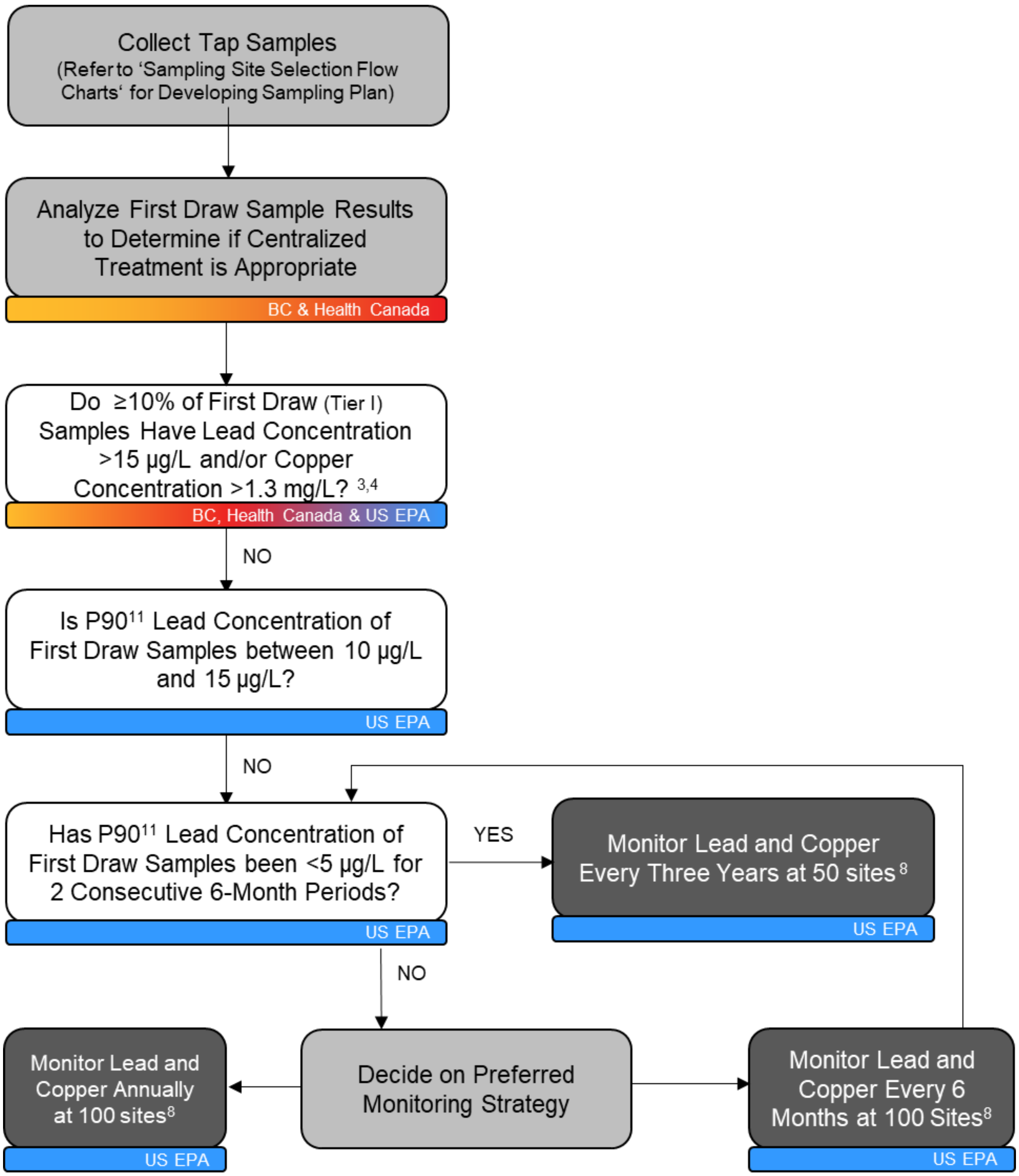
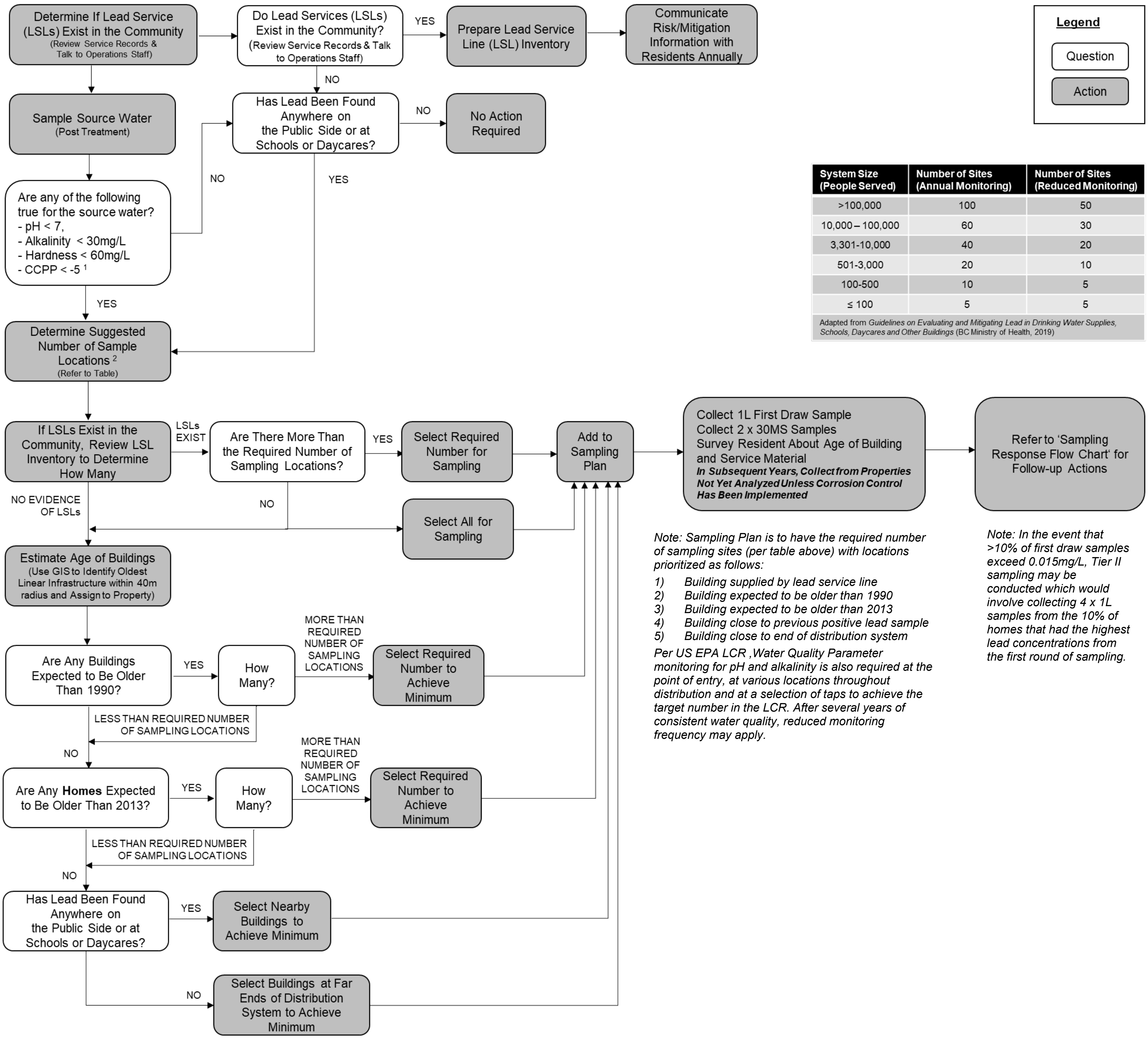


Figure 7-6 (excerpt C): Monitoring Program

As part of the guideline review, a flow chart was developed to aid with the development of future tap sampling programs (refer to Figure 7-7).



System Size (People Served)	Number of Sites (Annual Monitoring)	Number of Sites (Reduced Monitoring)
>100,000	100	50
10,000 – 100,000	60	30
3,301-10,000	40	20
501-3,000	20	10
100-500	10	5
≤ 100	5	5

Adapted from *Guidelines on Evaluating and Mitigating Lead in Drinking Water Supplies, Schools, Daycares and Other Buildings* (BC Ministry of Health, 2019)

Notes:

1. *Threshold at which water becomes 'mildly corrosive' per Table 5 of Gebbie, Peter. "63rd Annual Water Industry Engineers and Operators' Conference." Water Stability – What Does It Mean and How Do You Measure It?, pp 50 – 58*
2. *When selecting sampling locations aim to balance public and private buildings while also including representative numbers of the following building types: single-family residential, multi-family residential, commercial, industrial, institutional. If there are sub-service areas that vary in terms of development age or supply water chemistry a separate sampling program should be developed for each.*

Figure 7-7: Future Sampling Program Studies – Site Selection Flow Chart

7.4 Mitigation Strategy Assessment

North American water suppliers typically address lead leaching issues using one or a combination of the following mitigation strategies:

- public awareness campaigns with recommendations for reducing potential exposure through flushing and replacement of domestic and water service piping;
- replacement of identified lead service lines:
  - this is often combined with a free water sampling program by homeowner/resident request with point of use treatment products being offered where lead levels are found above the GCDWQ;
  - care should be taken with lead service line replacements to avoid partial service line replacements, which have the potential to exacerbate lead leaching.
- chemical conditioning to adjust pH and alkalinity; and
- addition of corrosion inhibitors like orthophosphate.

Based on the flow chart analysis (Figure 7-7) no mitigation strategy is recommended at present for the GVDWS as there does not appear to be a community-level concern and lead action limits for remediation or communication have not been reached or exceeded. Overall, however, each jurisdiction should develop, in coordination with VIHA, a long-term monitoring program for at-tap lead concentrations. This should include recommendations on frequency and number of samples (as per Figure 7-6), as well as targets. Ideally, the municipalities will harmonize the timing and especially the sampling methods of their testing such that the CRD can more easily review the data as a combined set.

Although a centralized corrosion control treatment is not currently recommended, it may be worth incorporating into a new treatment plant if filtration is introduced in the long-term. A concept design for centralized treatment is presented in Appendix F; this provides a basis for future design of such a process. The steps involved would include:

a. Conduct a corrosion control study to determine appropriate corrosion control chemicals and dose rates (either through pH and alkalinity control and/or the use of corrosion inhibitors); then
b. Implement centralized corrosion control downstream of conventional water treatment process.
c. Monitor at the same locations pre and post-implementation of corrosion control to confirm efficacy and optimize treatment.

A Class D cost estimate for a chosen corrosion control treatment option to be installed in three locations (Goldstream Main #4, Goldstream Main #5, and Sooke River Road) has been provided in Appendix F. It is estimated that the total corrosion control treatment cost would amount to $7.7M.

For individual customers who have identified lead concerns, or as these are flagged during monitoring, recommended mitigation measures include:

a. Flushing of cold-water tap (i.e., until the water feels cold) prior to consuming water
b. Replacement of lead service line (if present)
c. Replacement of brass fittings or in-line devices
d. Use of NSF/ANSI-certified water treatment devices (NSF/ANSI 53, 58, or 62).

8. Conclusions & Recommendations

8.1 Public Side Summary

The following **conclusions** are based on the **public** side investigations:

- The drinking water in the GVDWS is characterized as passive to mildly corrosive. While this leaves a certain corrosion potential, the risk of leaching metals into the drinking water is generally low.
- The corrosivity of the water across the GVDWS is fairly consistent. Corrosivity was not found to vary significantly due to water age or seasonal changes in temperature. While increasing water age did not significantly increase corrosivity, it is still beneficial to minimize stagnation of water which provides a longer contact time for metal leaching.
- The risk of metals leaching into the drinking water in the GVDWS is largely dependent on the presence of high-risk metals (lead) in prolonged contact with the drinking water. Few potential lead sources have been identified on the public side such as hydrants, old copper pipe installations and old cast iron water mains. Lead service lines were rarely used in Greater Victoria, but the City of Victoria and District of Oak Bay have some smaller areas where lead service lines were replaced (maybe only partially) in the past or still exist.

The following **recommendations** arise from the above **public** side conclusions:

- Prioritize cast iron water main replacement programs across the GVDWS.
- Consider pipe corrosion index (PCI) as a factor in the development of pipe replacement programs along with probability of failure, pipe capacity (level of service) and replacement cost.
- Avoid dead-end pipe sections with slow-moving or stagnant water; rather, loop water mains to minimize water age.
- Where high lead levels are found on the distribution side, check the supply piping materials and replace old copper piping with stainless steel or non-metallic piping (e.g., PVC, HDPE). Sampling infrastructure should be of lead-free materials to avoid misleading test results (Cook/Mallek, Lansdowne/Foul Bay).
- Install only lead-free hydrants moving forward. Hydrant valves and fittings were found to contribute lead in previous CRD lead assessments.

8.2 Private Side Summary for All Jurisdictions

The following **conclusions** are based on the **private** side investigations:

- Based on the study results, lead levels in the drinking water in the GVDWS do not pose a community health concern.
- Based on the study results, centralized corrosion control treatment is not required at this time.
- Individual houses can experience elevated or high lead concentrations. The study could not identify the exact lead sources in these individual homes. Further follow-up investigations in these houses would be required.

- Lead concentrations at the customers' taps appear to have decreased since the commissioning of the upgraded disinfection process at the GWTP in 2021 (and short-term in 2019). This was found when comparing previous private side sampling results with the subject study results. It was expected that the change to the water chemistry would make the water less corrosive (higher pH and alkalinity).

The following **recommendations** arise from the above **private** side conclusions.

- Supplement the findings of this study using additional private side sampling programs run by individual water suppliers with the objective of achieving a larger and more comprehensive data set. This additional sampling should include any areas outside the study area of this subject study (Saanich Peninsula municipalities). These future sampling programs should also include sampling points which are duplicates of the present study and, ideally, of other previous studies. Sampling locations should be selected to prioritize high-risk buildings while also balancing between public and private buildings of different sizes and uses (i.e., including multi-family residential, commercial institutional, and industrial). If possible, the same sampling methods and protocols should be followed to allow for direct comparison of results.
- Develop ongoing lead sampling programs for the local water suppliers in coordination with the VIHA to satisfy lead compliance requirements by the BC Ministry of Health. This could be based on USEPA recommendations, including 100 samples in 6 months' time, and then 50 samples every 3 years if first-draw P-90 levels are below 5 µg/L.
- Utilize door-knocking (rather than letter-drops) for initiating future private side tap sampling to achieve a higher participation rate.
- Develop lead service line (LSL) inventories for each water supplier. The LSL identification flow chart used in the present study could be used as a resource where data is lacking.
- Develop strategies and policies on how local water suppliers can help customers with lead levels of concern or LSLs. Actions could include allowing homeowners to initiate replacement, opportunistically replacing as part of water/sewer/drainage replacement, and considering rebate/cost reduction for low-income homes. Ideally, these strategies and policies would be consistent throughout the region to avoid confusion by the customers.
- Fully replace LSLs from water main to the residential inhouse plumbing. Water suppliers with known or suspected partially replaced LSLs should investigate and if lead pipes are found they should be replaced completely.
- Train operators to report any LSL potentially found during routine maintenance or system upgrades.
- Consider corrosion control treatment to proactively better condition the treated water when planning large scale future treatment upgrades in the GVDWS. This would put the CRD in a position to influence and control corrosion relevant parameters such as pH and alkalinity. The cost of corrosion control treatment as an add-on to the existing treatment plants was estimated to be $7.7M. As part of a future large scale treatment upgrade (e.g., filtration plant), these costs could be lower if integrated in the overall upgrade design.

8.3 Jurisdiction-Specific Recommendations

In addition to the general recommendations presented above, there are additional recommendations pertaining to partner municipalities in the project, as follows:

- The District of Oak Bay
  - Fully replace services that are known to be lead.
- The City of Victoria
  - Conduct additional lead tests on cast iron mains that are part of the downtown fire suppression system;
  - Prioritize cast iron main replacements for the downtown fire suppression system;
  - Investigate whether former lead service replacement programs were full service-line replacement or only partial and update the LSL inventory; and
  - Fully replace services that are known to be lead;
- The District of Saanich
  - Improve / populate GIS record of service material types and ages and create LSL inventory;
  - Remove any known lead services; and
  - Complete follow up investigation with homeowner where high lead levels were found.
- Capital Regional District (JDF and Sooke)
  - Investigate the slight MAC exceedance location on Silver Spray Drive (East Sooke);
  - Conduct additional corrosion control monitoring, including private side testing, with any water-chemistry relevant change to the water treatment or with any change of source water; and
  - Expand private side tap sampling to previously untested areas of the JDF System.

Jurisdiction-specific data throughout the report was included as follows:

Table 8-1: Jurisdiction-Specific Figures Within Overall Report.

Type of Figure	City of Victoria	District of Saanich	District of Oak Bay	Capital Regional District
Water Main Attributes	Figure 4-5	Figure 4-4	Figure 4-3	Figure 4-2
Water Age	Figure 5-1	Figure 5-2	Figure 5-3	Figure 5-4
CCPP With Water Age	Figure 6-1	Figure 6-2	Figure 6-3	Figure 6-4
Lead and Copper with Water Age	Figure 6-5	Figure 6-6	Figure 6-7	Figure 6-8
Pipe Corrosion Index	Figure 7-2	Figure 7-3	Figure 7-4	Figure 7-5

Report Submission

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Technical Reviewer

Statement of Limitations

This document has been prepared by Kerr Wood Leidal Associates Ltd. (KWL) for the exclusive use and benefit of Capital Regional District, District of Saanich, City of Victoria, District of Oak Bay for the Greater Victoria pH and Corrosion Study. No other party is entitled to rely on any of the conclusions, data, opinions, or any other information contained in this document.

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

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Revision History

Revision #	Date	Status	Revision	Author
1	August 31, 2021	FINAL	Updated as per client comments.	SMR
0	August 6, 2021	FINAL		SMR

OQM CERTIFIED

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Appendix A

Private Side Lead and Copper Testing Materials

Capital Regional District
Greater Victoria pH and Corrosion Study

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Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:60,000 is only valid on a 22"x34" print.

Project No. 719-066
Date August 2021
Scale 1:60,000 — 0 250 500 1,000 (m)

Prior Lead Risk Data Across CRD

Figure A-1

Capital Regional District

Greater Victoria pH and Corrosion Study

KERR WOOD LEIDAL consulting engineers

Figure #	Area
B-3	Victoria
B-4	Saanich
B-5	Oak Bay
B-6	Esquimalt
B-7	Colwood
B-8	Sooke

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:200,000 is only valid on a 8.5"x11" print.

Project No. 719-066

Date August 2021

Scale 1:200,000 — 0 1 2 4 (km)

Private Side Lead & Copper Proposed Sampling Overview

Figure A-2

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Capital Regional District

Greater Victoria pH and Corrosion Study

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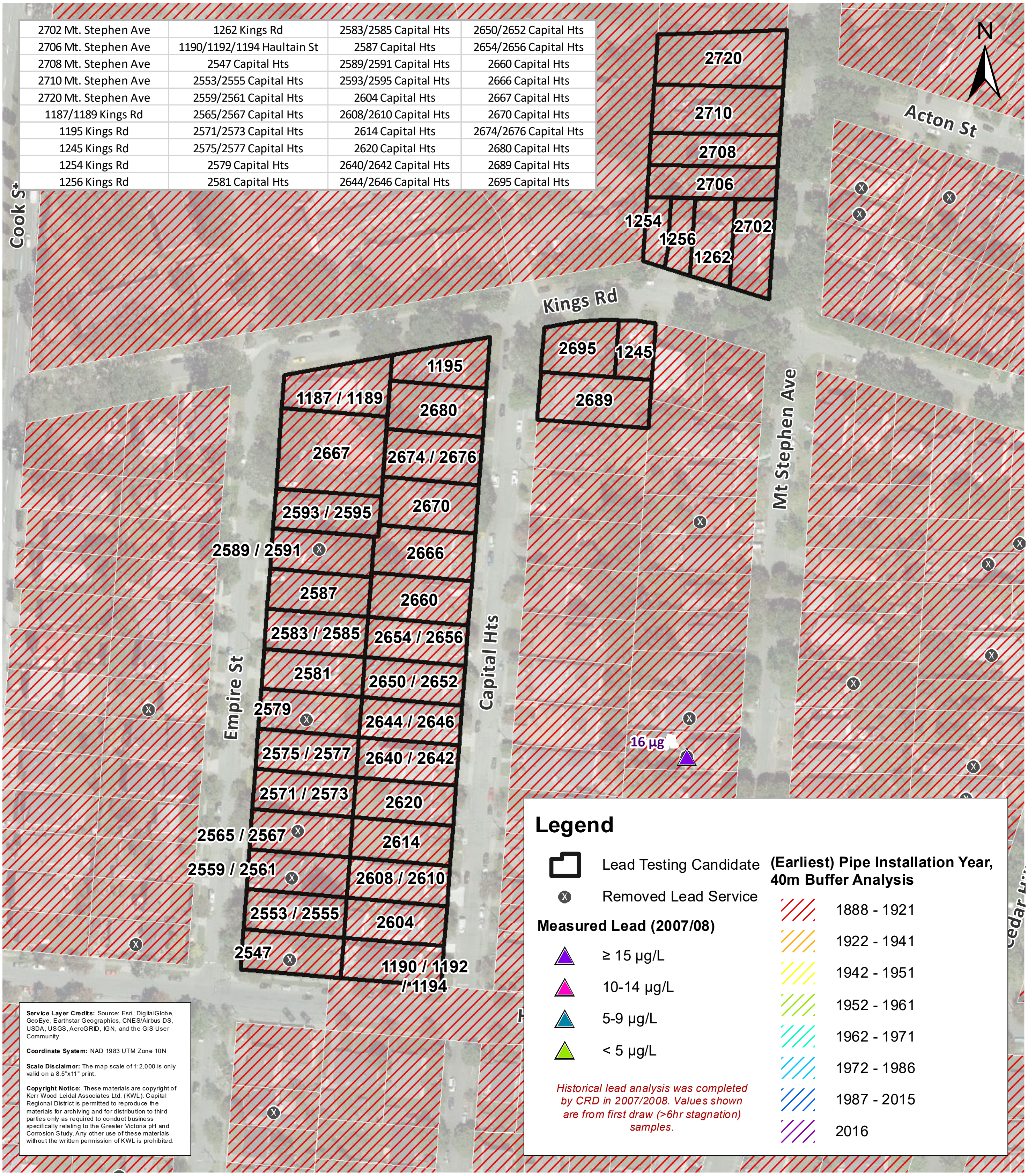
2702 Mt. Stephen Ave	1262 Kings Rd	2583/2585 Capital Hts	2650/2652 Capital Hts
2706 Mt. Stephen Ave	1190/1192/1194 Haultain St	2587 Capital Hts	2654/2656 Capital Hts
2708 Mt. Stephen Ave	2547 Capital Hts	2589/2591 Capital Hts	2660 Capital Hts
2710 Mt. Stephen Ave	2553/2555 Capital Hts	2593/2595 Capital Hts	2666 Capital Hts
2720 Mt. Stephen Ave	2559/2561 Capital Hts	2604 Capital Hts	2667 Capital Hts
1187/1189 Kings Rd	2565/2567 Capital Hts	2608/2610 Capital Hts	2670 Capital Hts
1195 Kings Rd	2571/2573 Capital Hts	2614 Capital Hts	2674/2676 Capital Hts
1245 Kings Rd	2575/2577 Capital Hts	2620 Capital Hts	2680 Capital Hts
1254 Kings Rd	2579 Capital Hts	2640/2642 Capital Hts	2689 Capital Hts
1256 Kings Rd	2581 Capital Hts	2644/2646 Capital Hts	2695 Capital Hts



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:2,000 is only valid on a 8.5"x11" print.

Project No. 719-066

Date August 2021

Scale 1:2,000 — 0 10 20 40 (m)

Lead Copper Sampling - Victoria

Figure A-3

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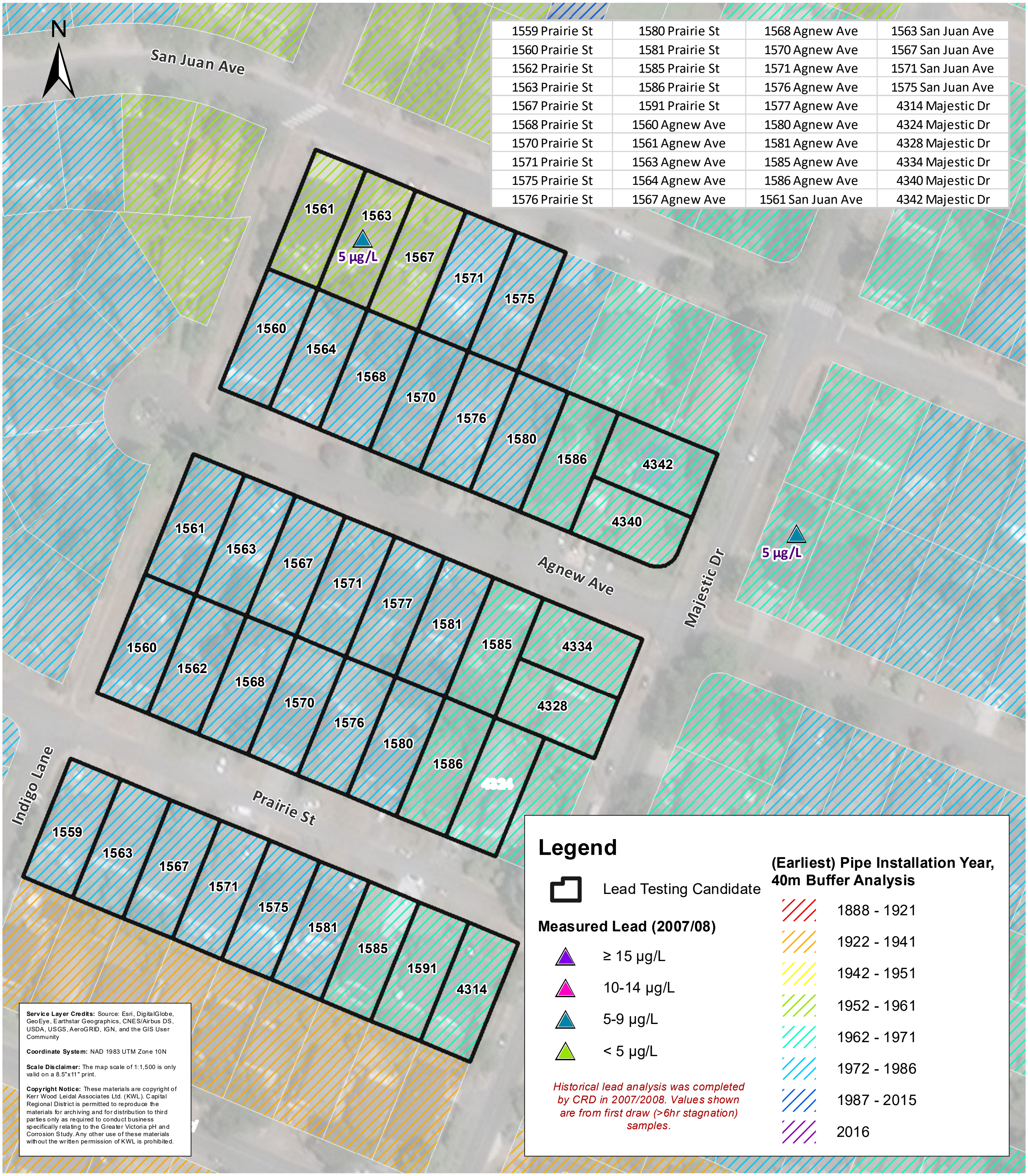
Capital Regional District

Greater Victoria pH and Corrosion Study

KERR WOOD LEIDAL consulting engineers



1559 Prairie St	1580 Prairie St	1568 Agnew Ave	1563 San Juan Ave
1560 Prairie St	1581 Prairie St	1570 Agnew Ave	1567 San Juan Ave
1562 Prairie St	1585 Prairie St	1571 Agnew Ave	1571 San Juan Ave
1563 Prairie St	1586 Prairie St	1576 Agnew Ave	1575 San Juan Ave
1567 Prairie St	1591 Prairie St	1577 Agnew Ave	4314 Majestic Dr
1568 Prairie St	1560 Agnew Ave	1580 Agnew Ave	4324 Majestic Dr
1570 Prairie St	1561 Agnew Ave	1581 Agnew Ave	4328 Majestic Dr
1571 Prairie St	1563 Agnew Ave	1585 Agnew Ave	4334 Majestic Dr
1575 Prairie St	1564 Agnew Ave	1586 Agnew Ave	4340 Majestic Dr
1576 Prairie St	1567 Agnew Ave	1561 San Juan Ave	4342 Majestic Dr

Legend

Lead Testing Candidate

Measured Lead (2007/08)

- ≥ 15 µg/L
- 10-14 µg/L
- 5-9 µg/L
- < 5 µg/L

Historical lead analysis was completed by CRD in 2007/2008. Values shown are from first draw (>6hr stagnation) samples.

(Earliest) Pipe Installation Year, 40m Buffer Analysis

- 1888 - 1921
- 1922 - 1941
- 1942 - 1951
- 1952 - 1961
- 1962 - 1971
- 1972 - 1986
- 1987 - 2015
- 2016

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:1,500 is only valid on a 8.5"x11" print.

Project No. 719-066

Date August 2021

Scale 1:1,500 — 0 10 20 40 (m)

Lead Copper Sampling - Saanich

Figure A-4

Capital Regional District

Greater Victoria pH and Corrosion Study

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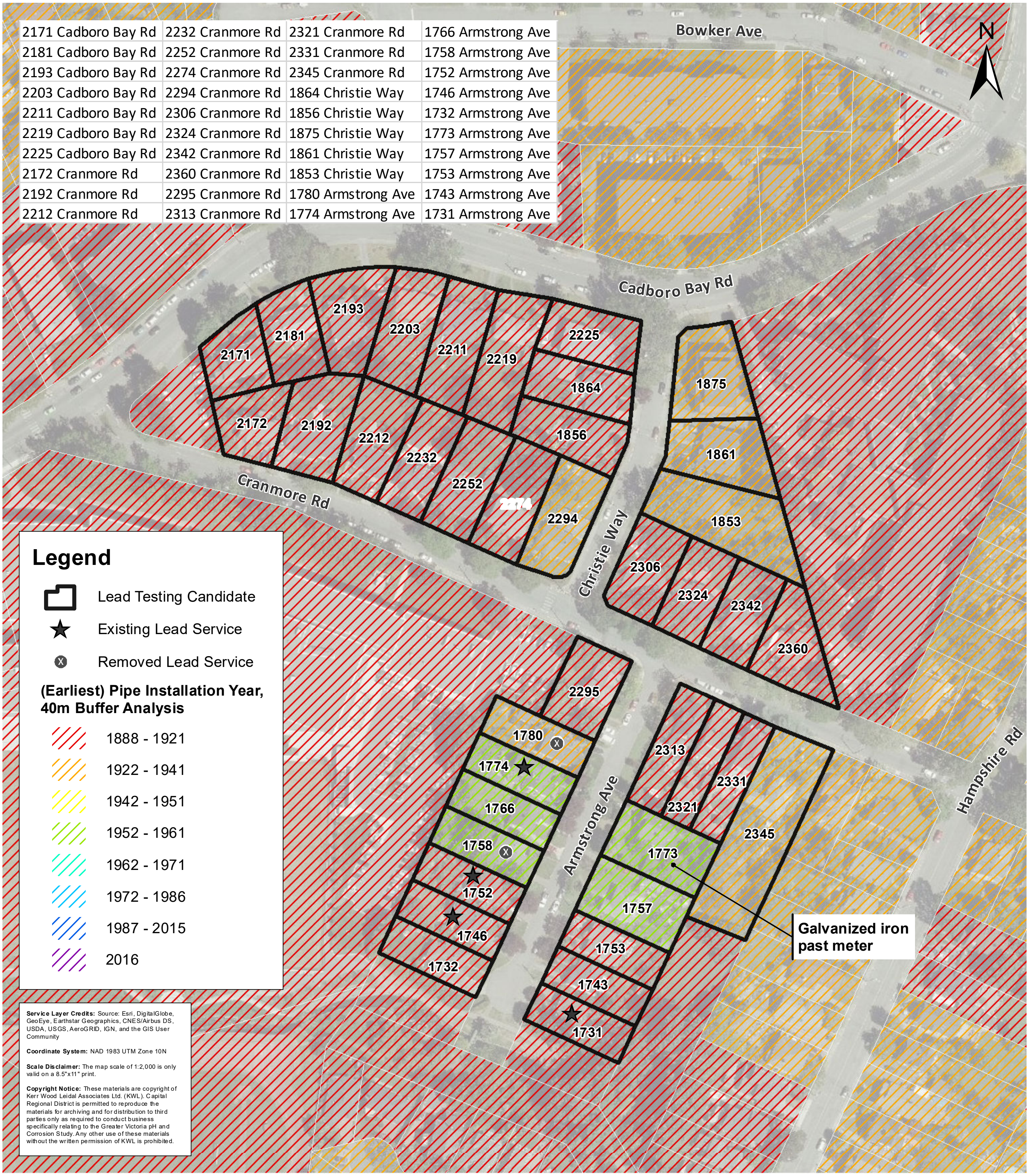
2171 Cadboro Bay Rd	2232 Cranmore Rd	2321 Cranmore Rd	1766 Armstrong Ave
2181 Cadboro Bay Rd	2252 Cranmore Rd	2331 Cranmore Rd	1758 Armstrong Ave
2193 Cadboro Bay Rd	2274 Cranmore Rd	2345 Cranmore Rd	1752 Armstrong Ave
2203 Cadboro Bay Rd	2294 Cranmore Rd	1864 Christie Way	1746 Armstrong Ave
2211 Cadboro Bay Rd	2306 Cranmore Rd	1856 Christie Way	1732 Armstrong Ave
2219 Cadboro Bay Rd	2324 Cranmore Rd	1875 Christie Way	1773 Armstrong Ave
2225 Cadboro Bay Rd	2342 Cranmore Rd	1861 Christie Way	1757 Armstrong Ave
2172 Cranmore Rd	2360 Cranmore Rd	1853 Christie Way	1753 Armstrong Ave
2192 Cranmore Rd	2295 Cranmore Rd	1780 Armstrong Ave	1743 Armstrong Ave
2212 Cranmore Rd	2313 Cranmore Rd	1774 Armstrong Ave	1731 Armstrong Ave



Legend

- Lead Testing Candidate
- Existing Lead Service
- Removed Lead Service

(Earliest) Pipe Installation Year, 40m Buffer Analysis

- 1888 - 1921
- 1922 - 1941
- 1942 - 1951
- 1952 - 1961
- 1962 - 1971
- 1972 - 1986
- 1987 - 2015
- 2016

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:2,000 is only valid on a 8.5"x11" print.

Project No. 719-066

Date August 2021

Scale 0 10 20 40 (m)
1:2,000

Lead Copper Sampling - Oak Bay

Figure A-5

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Capital Regional District

Greater Victoria pH and Corrosion Study

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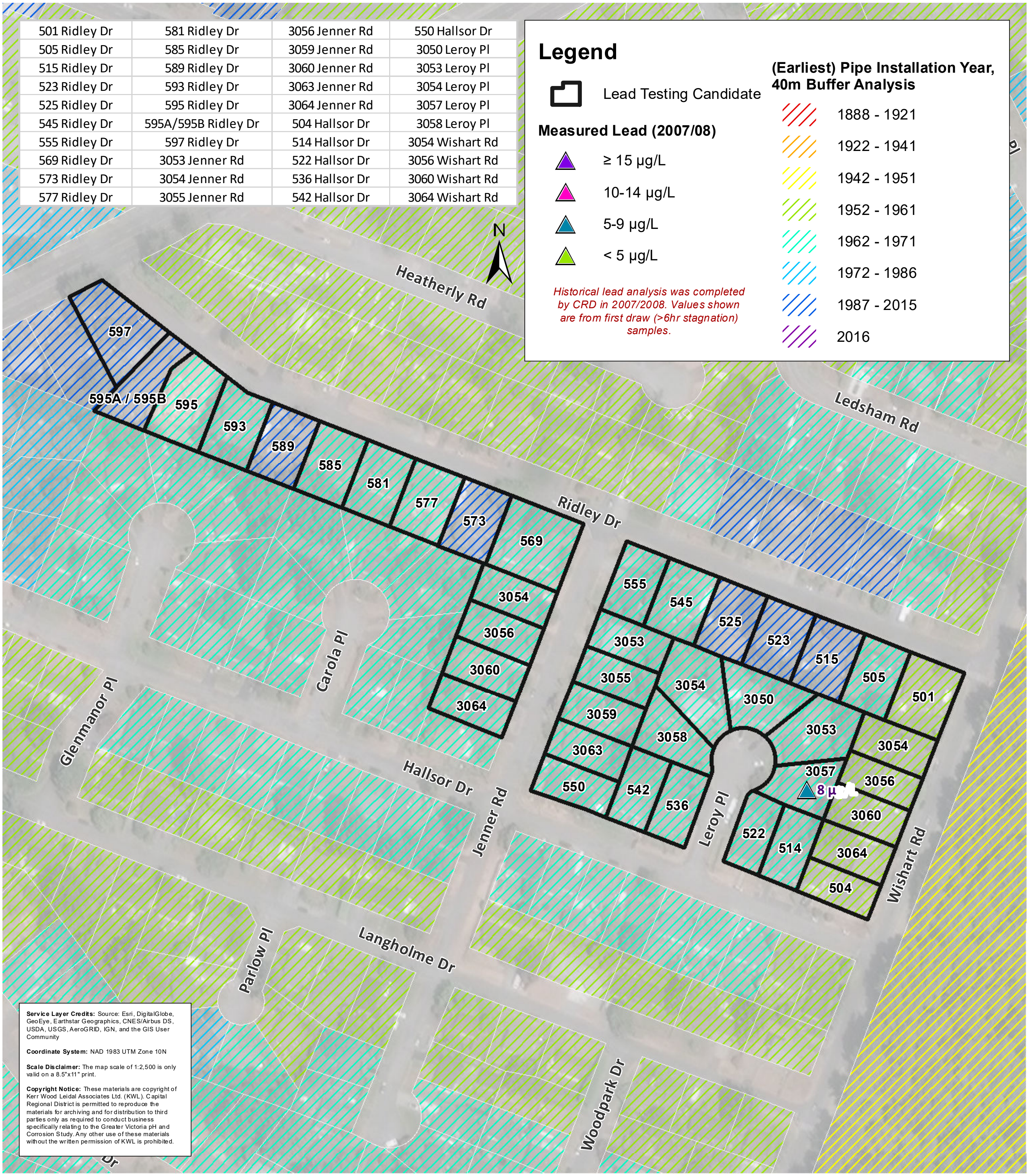
consulting engineers

501 Ridley Dr	581 Ridley Dr	3056 Jenner Rd	550 Hallsor Dr
505 Ridley Dr	585 Ridley Dr	3059 Jenner Rd	3050 Leroy Pl
515 Ridley Dr	589 Ridley Dr	3060 Jenner Rd	3053 Leroy Pl
523 Ridley Dr	593 Ridley Dr	3063 Jenner Rd	3054 Leroy Pl
525 Ridley Dr	595 Ridley Dr	3064 Jenner Rd	3057 Leroy Pl
545 Ridley Dr	595A/595B Ridley Dr	504 Hallsor Dr	3058 Leroy Pl
555 Ridley Dr	597 Ridley Dr	514 Hallsor Dr	3054 Wishart Rd
569 Ridley Dr	3053 Jenner Rd	522 Hallsor Dr	3056 Wishart Rd
573 Ridley Dr	3054 Jenner Rd	536 Hallsor Dr	3060 Wishart Rd
577 Ridley Dr	3055 Jenner Rd	542 Hallsor Dr	3064 Wishart Rd



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:2,500 is only valid on a 8.5"x11" print.

Project No. 719-066

Date August 2021

Scale 1:2,500 0 10 20 40 (m)

Lead Copper Sampling - Colwood

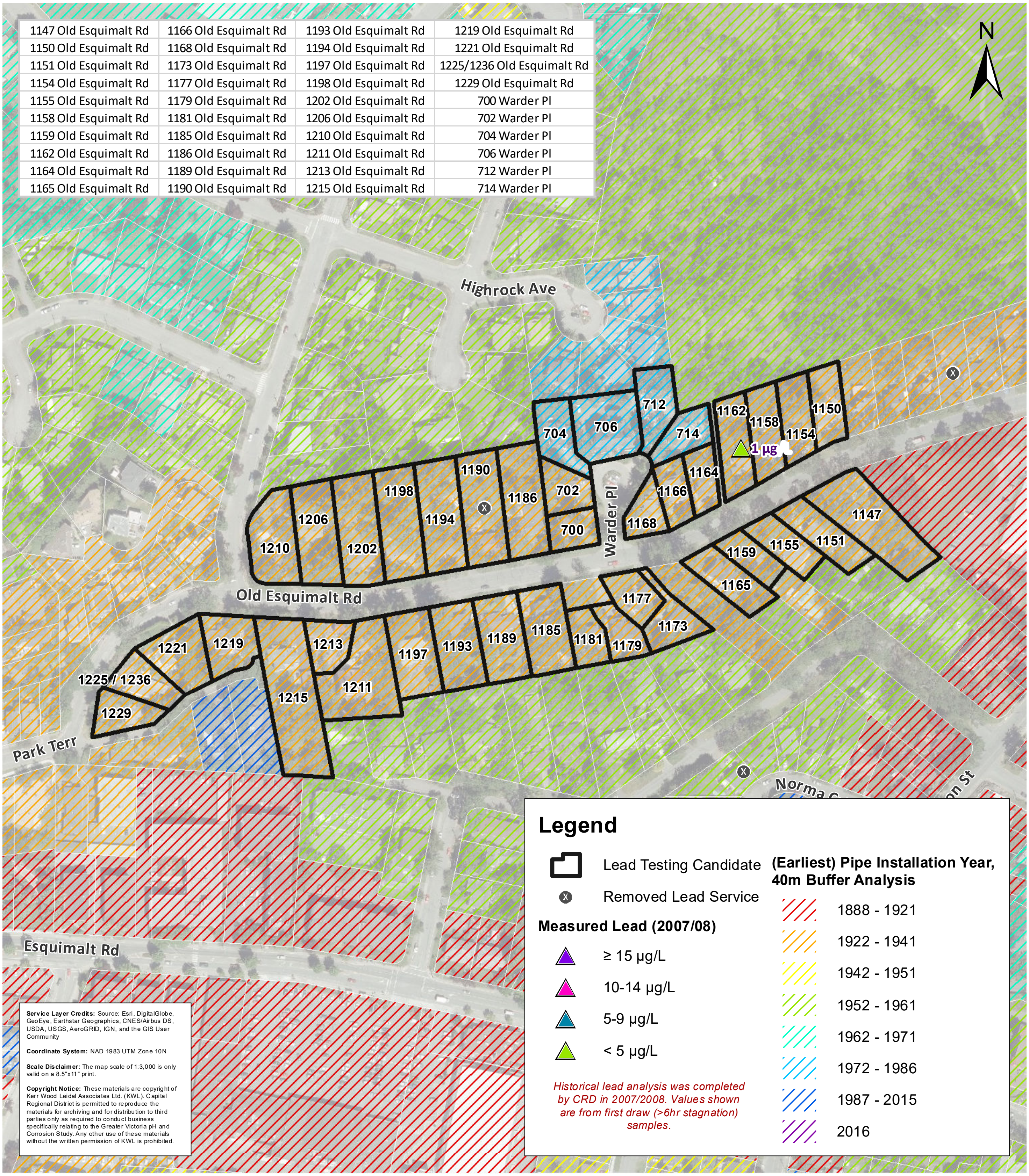
Figure A-6

Capital Regional District

Greater Victoria pH and Corrosion Study

KERR WOOD LEIDAL consulting engineers

1147 Old Esquimalt Rd	1166 Old Esquimalt Rd	1193 Old Esquimalt Rd	1219 Old Esquimalt Rd
1150 Old Esquimalt Rd	1168 Old Esquimalt Rd	1194 Old Esquimalt Rd	1221 Old Esquimalt Rd
1151 Old Esquimalt Rd	1173 Old Esquimalt Rd	1197 Old Esquimalt Rd	1225/1236 Old Esquimalt Rd
1154 Old Esquimalt Rd	1177 Old Esquimalt Rd	1198 Old Esquimalt Rd	1229 Old Esquimalt Rd
1155 Old Esquimalt Rd	1179 Old Esquimalt Rd	1202 Old Esquimalt Rd	700 Warder Pl
1158 Old Esquimalt Rd	1181 Old Esquimalt Rd	1206 Old Esquimalt Rd	702 Warder Pl
1159 Old Esquimalt Rd	1185 Old Esquimalt Rd	1210 Old Esquimalt Rd	704 Warder Pl
1162 Old Esquimalt Rd	1186 Old Esquimalt Rd	1211 Old Esquimalt Rd	706 Warder Pl
1164 Old Esquimalt Rd	1189 Old Esquimalt Rd	1213 Old Esquimalt Rd	712 Warder Pl
1165 Old Esquimalt Rd	1190 Old Esquimalt Rd	1215 Old Esquimalt Rd	714 Warder Pl



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:3,000 is only valid on a 8.5"x11" print.

Project No. 719-066

Date August 2021

Scale 1:3,000 — 0 10 20 40 (m)

Lead Copper Sampling - Esquimalt

Figure A-7

Capital Regional District

Greater Victoria pH and Corrosion Study

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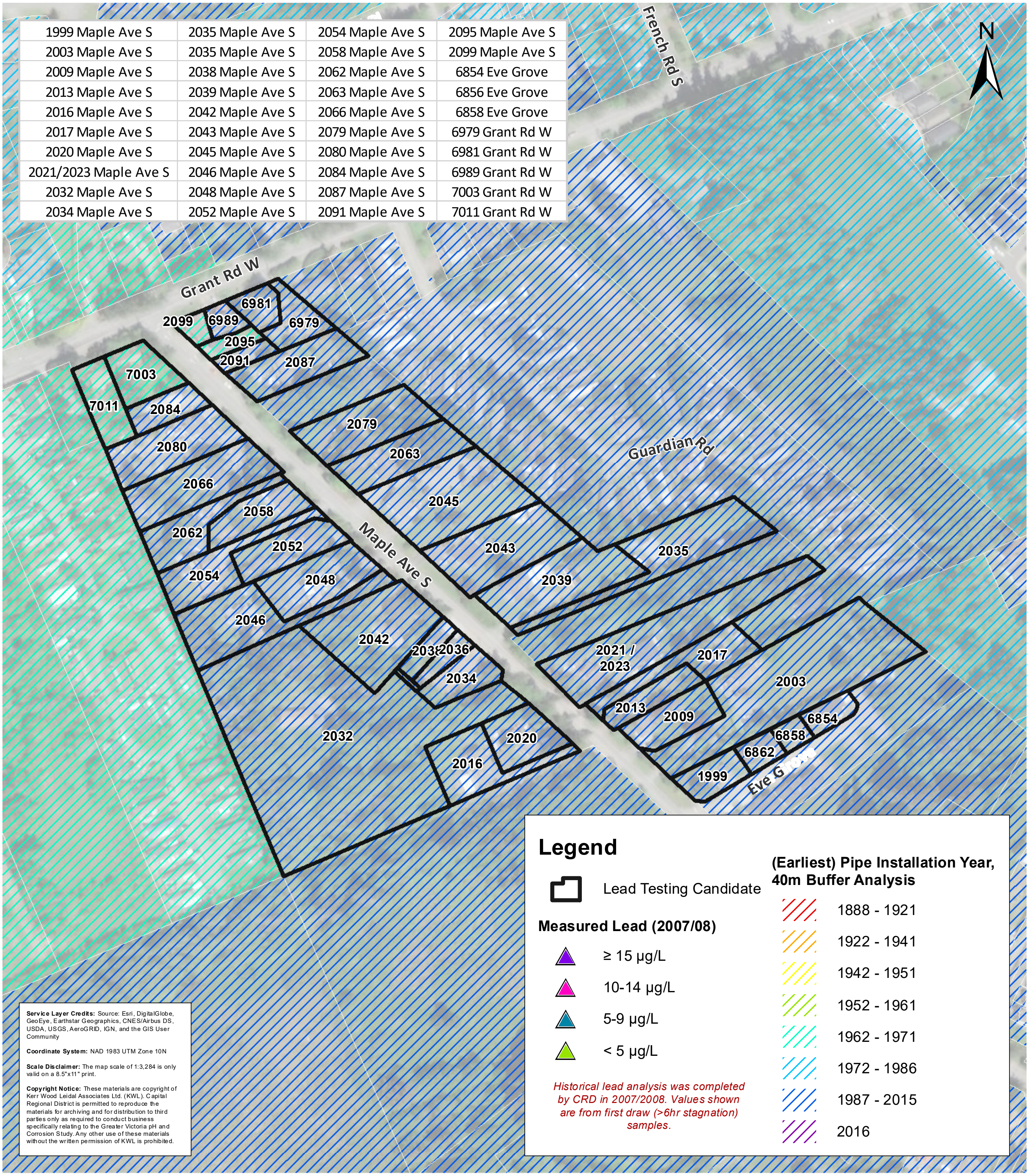
1999 Maple Ave S	2035 Maple Ave S	2054 Maple Ave S	2095 Maple Ave S
2003 Maple Ave S	2035 Maple Ave S	2058 Maple Ave S	2099 Maple Ave S
2009 Maple Ave S	2038 Maple Ave S	2062 Maple Ave S	6854 Eve Grove
2013 Maple Ave S	2039 Maple Ave S	2063 Maple Ave S	6856 Eve Grove
2016 Maple Ave S	2042 Maple Ave S	2066 Maple Ave S	6858 Eve Grove
2017 Maple Ave S	2043 Maple Ave S	2079 Maple Ave S	6979 Grant Rd W
2020 Maple Ave S	2045 Maple Ave S	2080 Maple Ave S	6981 Grant Rd W
2021/2023 Maple Ave S	2046 Maple Ave S	2084 Maple Ave S	6989 Grant Rd W
2032 Maple Ave S	2048 Maple Ave S	2087 Maple Ave S	7003 Grant Rd W
2034 Maple Ave S	2052 Maple Ave S	2091 Maple Ave S	7011 Grant Rd W



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:3,284 is only valid on a 8.5"x11" print.

Project No. 719-066

Date August 2021

Scale 0 10 20 40 (m) 1:3,284

Lead Copper Sampling - Sooke

Figure A-8

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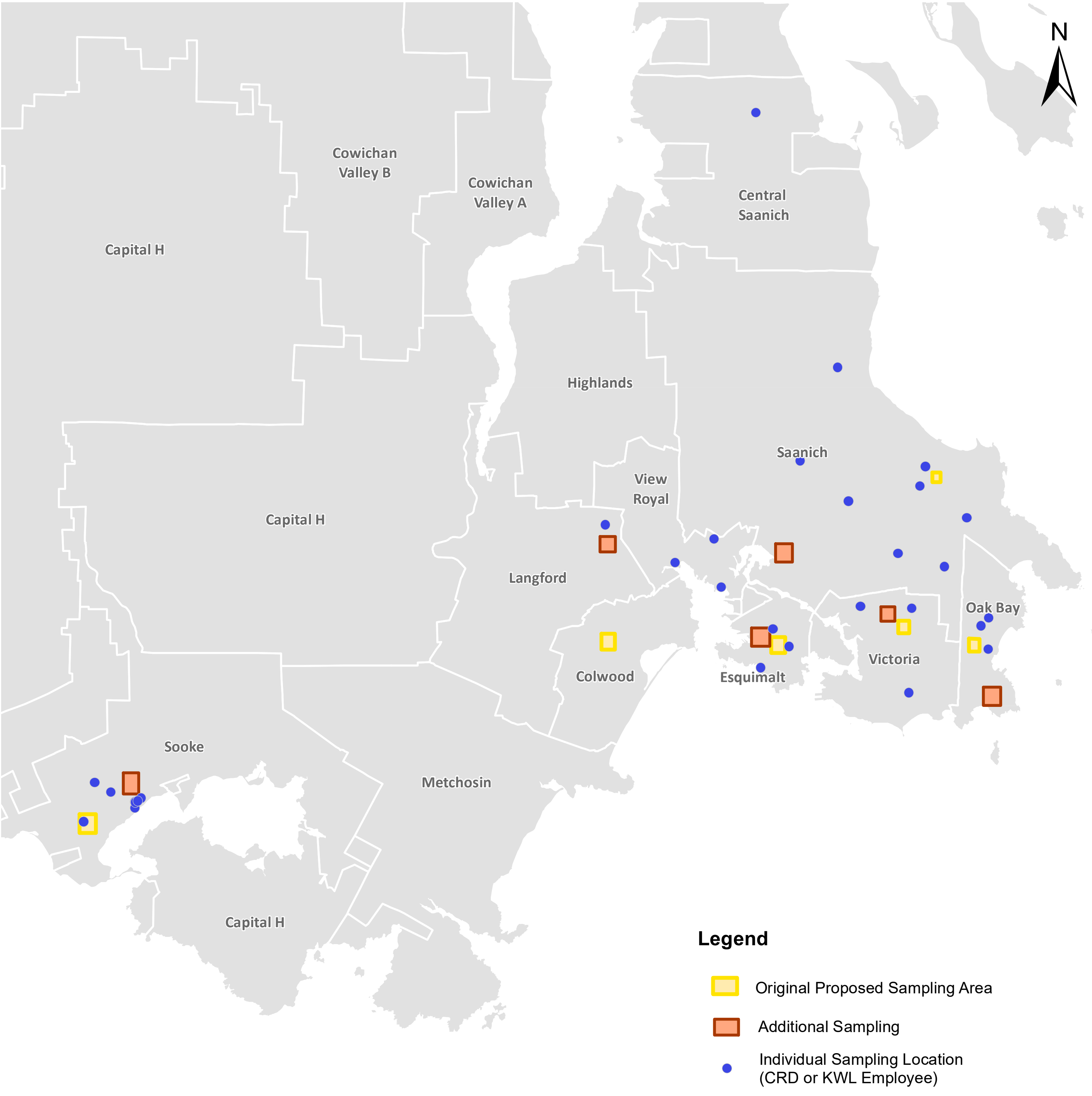
Capital Regional District

Greater Victoria pH and Corrosion Study

KERR WOOD LEIDAL consulting engineers



Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:200,000 is only valid on a 8.5"x11" print.

Project No. 719-066

Date August 2021

Scale 1:200,000 — 0 1 2 4 (km)

Private Side Lead & Copper Ultimate Sampling Overview

Figure A-9

Invitation for Free Lead Sampling

Background

The Capital Regional District (CRD), City of Victoria, District of Saanich and District of Oak Bay are conducting a study to assess the chemistry and corrosivity of our drinking as it travels from the CRD treatment facilities to our customers' homes. The Island Health Authority is aware and supportive of this project. We have completed water sampling and analysis work throughout the public pipe network system and are now sampling water from select homes across the region.

Water supplied by the CRD, City of Victoria, District of Saanich and District of Oak Bay is safe and clean. Our regular and extensive water testing throughout the distribution pipe network ensures that the water we deliver is safe for you and your family to drink.

In March of 2019, the Health Canada lead guideline for lead concentrations measured at the consumers' taps changed. In this update, the maximum acceptable concentration (MAC) was reduced from 0.01 mg/L to 0.005 mg/L and a new target of 'as low as reasonably achievable' (ALARA) was added. The key health driver for reducing the MAC is a linkage between lead and adverse neurodevelopment in children.

Lead is not present in the water as it leaves the treatment plants, but lead may leach into the water when it contacts distribution and plumbing system components that contain lead (namely old solder in copper plumbing, brass fittings, and service lines). Results from previous lead studies indicate that lead levels at residential taps in Greater Victoria are generally low but can be elevated under certain circumstances related to the specific plumbing installations. We would like to collect more data to get a better understanding of any potential risk. This is why we are approaching you to test your tap water.

Free Lead Analysis of Your Drinking Water

We will provide the sampling bottles and instructions and **the analysis will cost you nothing** (doing this personally costs approximately $240). To participate you will need to meet the following conditions:

- You are able and willing to sample during the week of _______________
- You are able to sample after your drinking water has been stagnant in the pipes for a minimum of 6 to 18 hours (no usage including no lawn watering, showers, toilet flushing etc.)
- You are able to leave your samples at your front door or with a building manager for pickup by a CRD employee.

You will be provided with a summary of your test results. If elevated levels of lead are found, recommendations on how to protect yourself and your family will be provided.

Accepting the Invitation

If interested, please email Jessica at jdupuis@crd.bc.ca as soon as possible.

In your email, please provide:

1) your mailing address;
2) full contact details (name, email, phone number)

You can also contact Jessica by phone at 250-474-9643 if you have any questions.

Lead Sampling Procedure for Single Family Homes

This procedure will take approximately 1 hour to complete and must be done first thing in the morning before any water has been used for lawn watering, showers, toilet flushing, etc. Do not run other sources of water while sampling as well.

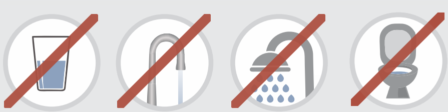
1 Preparation for Sampling

Do prior to sampling (ie. the night before!)

- Fill out the survey form provided in your sampling package (please print)
- Add your address to the Chain of Custody (COC) form next to "Site #" (see COC instructions included in your package)
- Using a pen or fine-tipped marker, print your address on the "Client" line on all sample bottles

2 First Draw Sampling

Collect the 'First Draw' sample after water has been **stagnant in the pipes for 6 to 18 hours**.



No drinking, flushing toilets, running tap water, or showering for 6 to 18 hours. The first draw sample is best done in the morning.

- Fill the First Draw bottle with the tap on low flow
- Add the date and time to the COC on line #1 (First Draw)

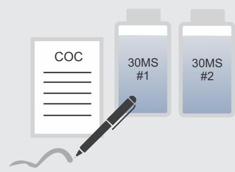
3 Preparation for 30 MS Sampling

Ensure the First Draw Sampling (Step 2) is done first.

- **Run the water for 5 minutes**

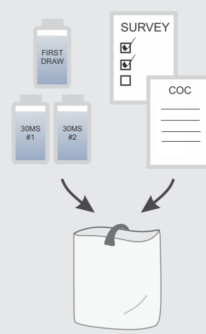
- **Then, turn the tap off and wait 30 minutes**. Do not run water, flush toilets, or shower during this time.

4 30 MS Sampling



- Fill both the 30MS #1 and 30MS #2 bottles with the tap on low flow
- Add the date and time to the COC on line #2 and #3 (30MS #1 and 30MS #2)

5 Assemble the Package



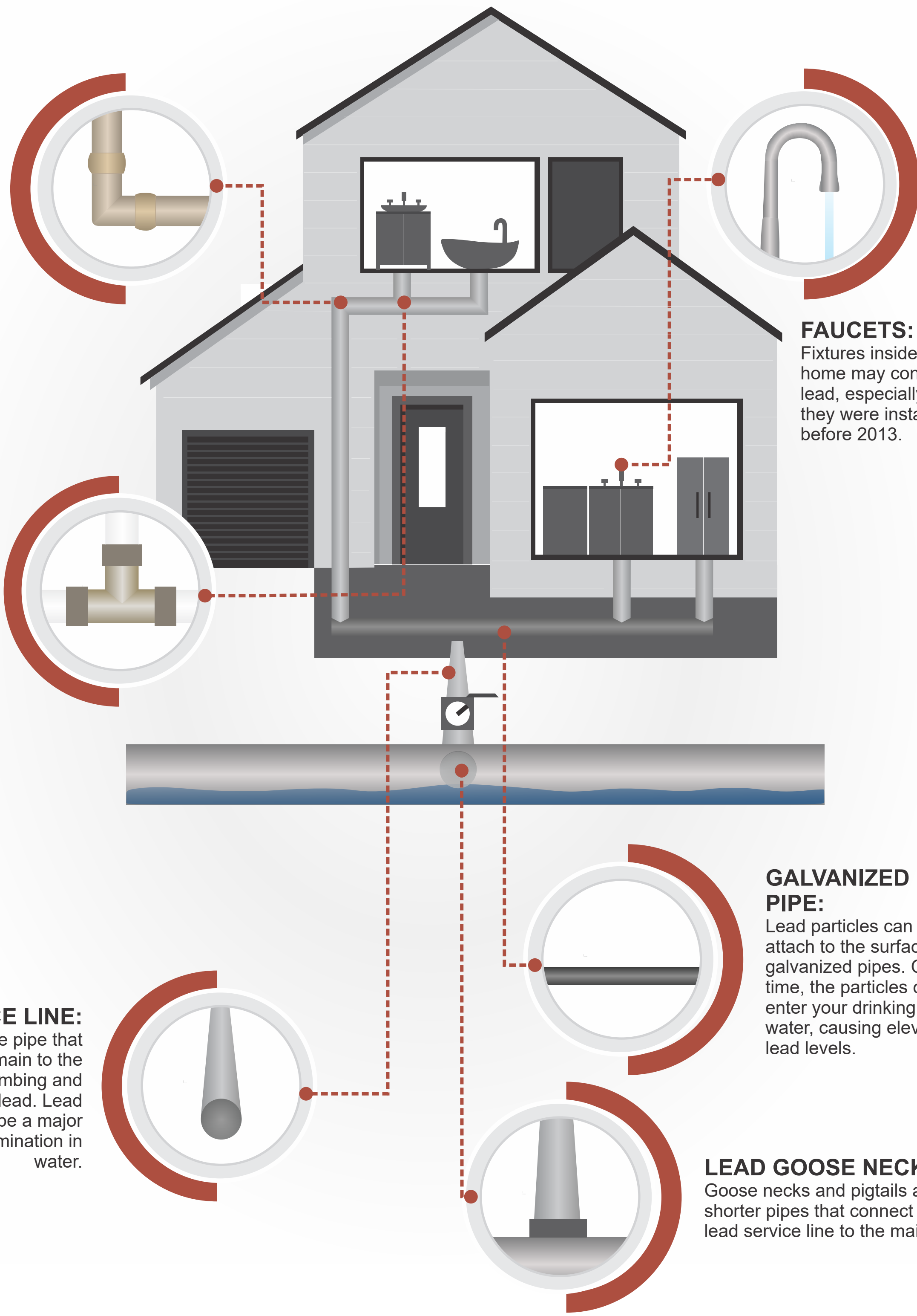
- Place the **Survey**, **COC**, and **bottles** into the bag
- Sign the security seal and use it to seal the bag (across the opening so that it would be obvious if anyone opened it).

6 Leave Package for Pick-Up

- Place the bag outside on your front door out of direct sunlight
- **Email a photo of the package to Jessica Dupuis at jdupuis@crd.bc.ca to let her know!**

CRD Making a difference...together | City of Victoria | Saanich | District of Oak Bay

Potential Sources of Lead in Drinking Water



COPPER PIPE WITH LEAD SOLDER:
Solder made or installed before 1989 contained high lead levels.

FAUCETS:
Fixtures inside your home may contain lead, especially if they were installed before 2013.

BRASS FITTINGS AND VALVES:
Brass could contain up to 8% lead until NSF61 was updated in 2012. These can contribute lead to your water.

GALVANIZED PIPE:
Lead particles can attach to the surface of galvanized pipes. Over time, the particles can enter your drinking water, causing elevated lead levels.

LEAD SERVICE LINE:
The service line is the pipe that runs from the water main to the home's internal plumbing and may be made of lead. Lead service lines can be a major source of lead contamination in water.

LEAD GOOSE NECKS:
Goose necks and pigtails are shorter pipes that connect the lead service line to the main.

To find out for certain if you have lead in drinking water, **have your water tested.**

Reduce Your Exposure to Lead in Drinking Water

Use only cold water for drinking, cooking and making baby formula. *Boiling water does not remove lead from water.*

Regularly clean your faucet's screen (also known as an aerator).

Consider using a water filter certified to remove lead and know when it's time to replace the filter.

Before drinking, flush your pipes by running your tap, taking a shower, doing laundry or a load of dishes.

Replace brass fittings and fixtures that are older than 2013.

Identify Other Lead Sources In Your Home

Lead in homes can also come from sources other than water. If you live in a home built before 1978, you may want to have your paint tested for lead. **Consider contacting your doctor to have your children tested if you are concerned about lead exposure.**

Survey

Please fill this out and put it in the bag with the samples.

Are you the owner of this home?

- ☐ Yes
- ☐ No

How old is your house?

- ☐ Older than 1921
- ☐ 1922 – 1941
- ☐ 1942 – 1951
- ☐ 1952 – 1961
- ☐ 1962 – 1971
- ☐ 1972 – 1986
- ☐ 1987 – 2015
- ☐ Newer than 2015
- ☐ I don't know

Do you think you have a lead service? (see the back of this sheet and feel free to add a note here)

- ☐ Yes
- ☐ No
- ☐ I don't know

What kind of plumbing do you have in your house?

- ☐ Copper
- ☐ Plastic
- ☐ I don't know

Have you ever replaced the plumbing or is it original?

- ☐ Yes. Replaced in ___________
- ☐ No
- ☐ I don't know

How old is the faucet where you collected the sample?

- ☐ Newer than 2013
- ☐ Older than 2013
- ☐ I don't know

If you have any questions about your water, please contact Jessica at **jdupuis@crd.bc.ca**

To receive your water test results, provide your contact details below:

Name: ____

Address: ____

Email: ____

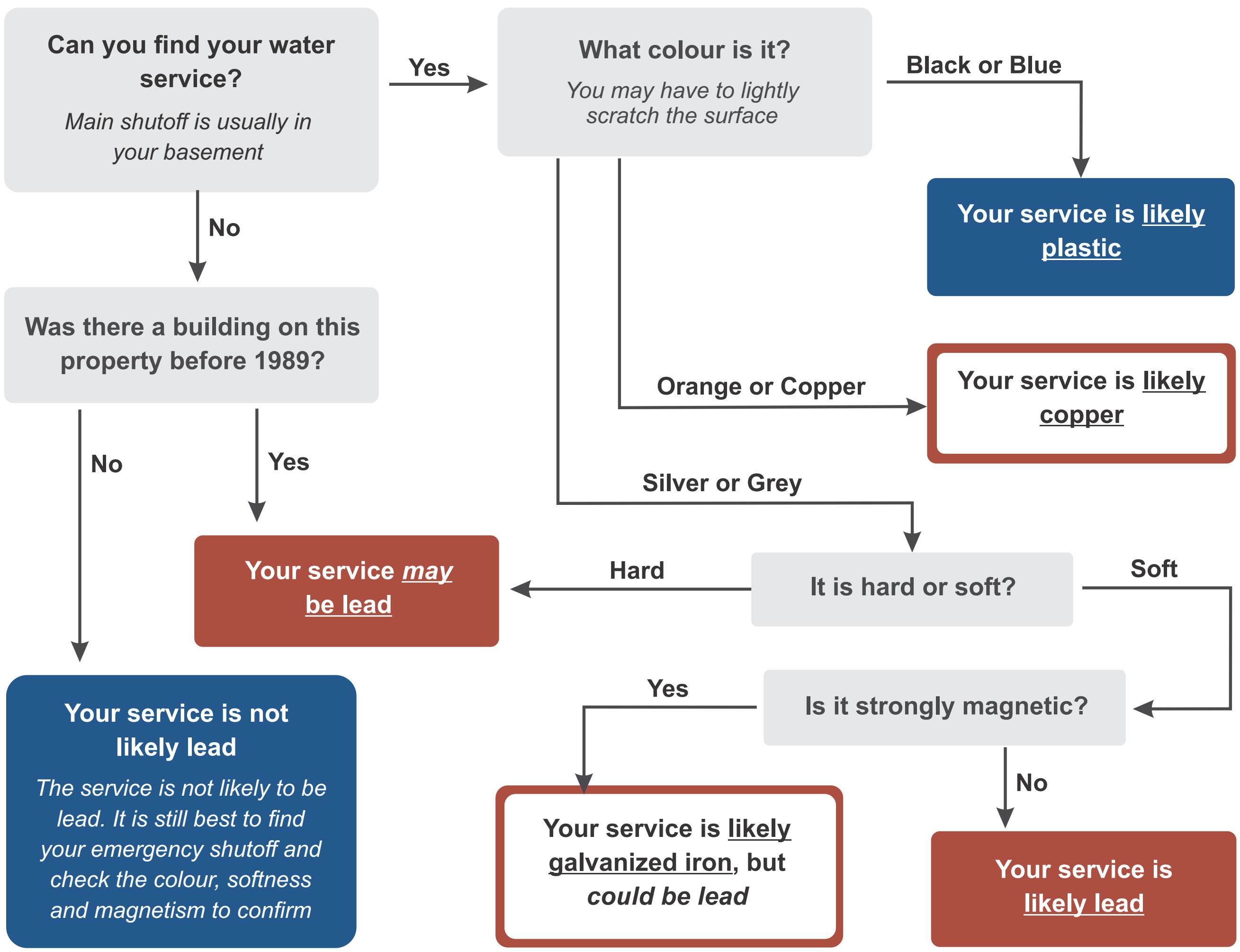
Phone Number: ____

If you are not the owner of the home, please also provide their contact details.

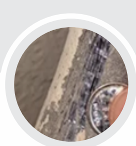
Thank you for your participation in the sampling program!

Do I have a Lead Service?

Answer the questions on the flow chart below to figure out if your service could be lead.

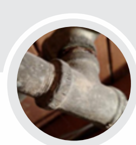


What might it look like?



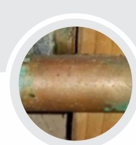
LEAD

Lead is usually dark grey. It is "soft" - you should be able to scratch off the surface with a key or coin and see a bright silver colour. It is only weakly magnetic. A magnet might stick, but much less strongly than steel.



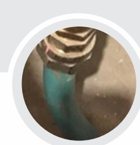
GALVANIZED IRON

Galvanized iron is also usually dark grey, but it is harder than lead and strongly magnetic. A fridge magnet should stick to the pipe.



COPPER

When the surface of a copper pipe is gently scratched or etched, it will be the colour of a Canadian penny. It can also appear green.



PLASTIC

Plastic pipe will appear black, blue or green/blue. You should not test its hardness because this can damage the pipe.

Checklist

- ☐ Survey is filled out complete with your contact details and placed in the sample bag

- ☐ All 3 bottles are
  - ☐ Labelled with your address
  - ☐ Securely closed
  - ☐ In the sample bag

- ☐ Chain of Custody (COC) is filled out and in the sample bag
  - ☐ Building address is filled in next to “Site #” at the top of the form
  - ☐ Sampling location is filled out for each sample (i.e. Kitchen tap)
  - ☐ Sampling date and time are filled out for each sample

When all of the above are checked, please

- ☐ Sign the custody seal
- ☐ Close the sample bag
- ☐ Seal the sample bag with the custody seal to prevent tampering
- ☐ Leave the bag on outside your front door out of direct sunlight
- ☐ Text or email a photo of the bottle to Jessica Dupuis at jdupuis@crd.bc.ca to confirm that the samples are ready for pickup

KERR WOOD LEIDAL
consulting engineers

Appendix B

Public Side Sampling Technical Memorandum

1. Introduction

The objective of this study is to understand how the corrosivity of drinking water changes as it travels from the CRD disinfection facilities to its customers' homes and businesses. The driving force for this study is the changes to the Health Canada lead guidelines and the associated implications for drinking water purveyors who supply water to customers who may have leaded domestic piping components. This is a challenge for the CRD because municipal utilities are being held responsible for the quality of water tested from consumer's taps, not the water that is delivered to their property line.

The CRD wants to understand how water chemistry contributes to the leaching of lead within customer's homes and businesses so that they can change the properties of the water they deliver to make it less aggressive and reduce the risk of lead leaching after it leaves their system. To understand the water chemistry, samples will be collected from across the Greater Victoria drinking water distribution system and these samples will be analyzed for lead and a series of parameters that can be used to estimate the corrosivity of the water.

2. Sample Locations

Samples will be collected by two groups: 1) CRD water quality staff and 2) KWL field staff with the support of operators from the project partners (CRD, City of Victoria, District of Oak Bay, and District of Saanich). The CRD will collect samples from their water quality sampling sites and KWL will collect samples from locations selected in consultation with operations staff from the partner municipalities taking into consideration:

- Pipe material (i.e. collecting samples from old cast iron areas);
- Water age (i.e. collecting samples from dead-end and high water age areas);
- Historical lead results (i.e. collecting samples from areas where lead has been measured in the past);
- Corrosion-related customer complaints (i.e. collecting samples from areas where customers have complained about copper or iron staining, or pinhole leaks in copper pipe); and
- Poor water quality areas (based on operational knowledge).

3. Samples Required

Samples will be analyzed for two purposes:

1. To estimate the corrosivity of the water; and
2. To directly measure lead present in the water.

3.1 Sample Type

Table 1 includes a summary of the water quality parameters that will be analyzed for this study.

Table 1: Water Quality Parameters to be Measured

Water Quality Parameter	Units
Total dissolved solids (TDS)	mg/L
Temperature	° C
pH	s.u.
Alkalinity (as $CaCO_3$)	mg/L
Calcium (as $CaCO_3$)	mg/L
Chloride (Cl^-)	mg/L
Sulfate (SO_4^{-2})	mg/L
Lead	mg/L

3.2 Sampling Laboratories

Samples will be analyzed by Bureau Veritas Laboratory located at 460 Tennyson Place, Unit 1, Victoria, BC.

3.3 Number of Samples Collected

Based on discussions with the project partners, this sampling program will be focused on collecting two snapshots of the water chemistry across the system for analysis: 1) during warm weather and 2) during cold weather.

It is understood that the CRD will be collecting 122 samples from their water quality sampling stations and KWL (with operator support) will be collecting 32 samples from the four study areas. The sampling locations are shown on Figure 1 (Sampling Location Map) and summarized in the attached table.

3.4 Sampling QA/QC

Quality Assurance (QA) and Quality Control (QC) protocols are necessary elements for the success of a water monitoring program (MOE 1998)[1]. To ensure consistency within the water quality monitoring program, the following set of basic QA procedures will be employed:

- Properly trained staff will collect samples;
- Staff will follow all laboratory instructions for sample collection (e.g. bottle labelling, sample storage, etc.);
- Samples will be kept cool and a chain of custody form will accompany each sample set; and
- Samples will be delivered to the laboratory as soon as possible following collection.

[1] Cavanagh, N., R.N. Nordin, L.W. Pommen and L.G. Swain. 1998. Guidelines for Designing and Implementing a Water Quality Monitoring Program in British Columbia. Ministry of Environment, Lands, and Parks.

To minimize imprecision and errors, a set of QC procedures will be employed:

- Trip blank samples will be used to assess potential contamination to samples during storage and transport;
- Field blank samples will be used to assess potential contamination from handling techniques and environmental exposure; and
- Replicate samples will be collected (minimum one for every 10 samples) to assess laboratory precision in their analysis.

3.5 Sampling Procedure

Once per round (i.e. once during warm-weather sampling and once during cold-weather sampling):

(a) Check calibration on the pH meter, recalibrate if necessary.

(b) Put on latex or nitrile gloves then fill a set of sample bottles with distilled water (can be purchased at a grocery store or pharmacy) and label them as ‘Trip Blank’ (remember to add to a separate COC that will be delivered to the lab at the end of the round of sampling);

(c) Pour a small amount of distilled water into a clean container and measure the pH. Add to the ‘Trip Blank’ line on a separate COC (this will be dropped off at the lab at the end of the round).

Note: these bottles are to be carried around in the cooler for the whole round of sampling. They are not to be opened, but just transferred from cooler to cooler as samples are collected and dropped off. They are to be dropped off with the last set of samples in the round.

Once per day:

(a) Check calibration on the pH meter, recalibrate if necessary;

(b) Put on latex or nitrile gloves then fill a set of sample bottles with distilled water and label them as ‘Field Blank’ (remember to add to COC);

(c) Pour a small amount of distilled water into a clean container and measure the pH. Add to the ‘Field Blank’ line on the COC that will be filled out on that day;

(d) Decide where you will collect the replicate sample(s) for the day (make sure you have at least one per day and a minimum of 1 for every 10 samples);

Note: the ‘field blank’ bottles are to be opened and closed at each sampling location when the samples are being collected.

Multiple times per day

(a) Locate sampling point:
   - Confirm Sample ID and Distribution Area with sampling list and map;
   - Write description of sampling location for inclusion in attached spreadsheet (green cells);
   - Collect GIS coordinates (latitude and longitude) for inclusion in attached spreadsheet (purple cells);

(b) Label sample bottles with sampling location and date as a minimum (follow instructions from the laboratory);

(c) Place the field blank bottles on a flat surface near the sampling location and open them;

(d) Flush water from sampling point:

- For Hydrants – fully open 2" port and flush for 3 minutes;
- For taps in pump station or valve station – flush at full flow for 10 minutes;

(e) After 30 seconds of flushing, close the field blank bottles;

(f) At the end of the designated flushing time, measure the temperature of the stream. If the temperature has not stabilized, flush for another minute;

(g) Avoid contaminating the sample bottles by opening them immediately before taking the sample and avoiding contact with the mouth of the bottle when taking the sample;

(h) Collect the sample:

- For hydrants:
  - i. Reduce water flow and rinse the quick-connect;
  - ii. Turn off the hydrant and connect the quick-connect;
  - iii. Turn on the hydrant so that the flow is manageable for collecting the sample;
  - iv. Fill each of the three bottles to the neck and cap immediately.
- For taps:
  - i. Reduce water flow to manageable level for collection;
  - ii. Fill each of the three bottles to the neck and cap immediately.

(i) Measure pH and temperature:

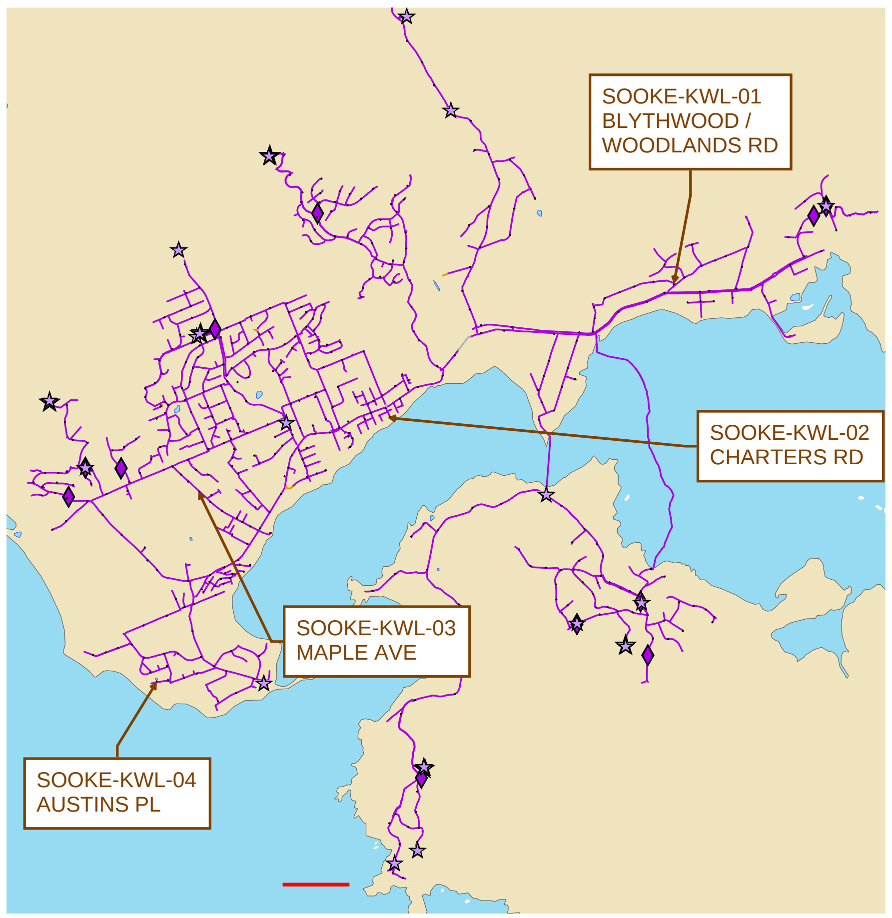
- Rinse then fill a clean plastic bottle with water and measure pH and temperature. Add values to COC and note for inclusion in attached spreadsheet (orange cells)

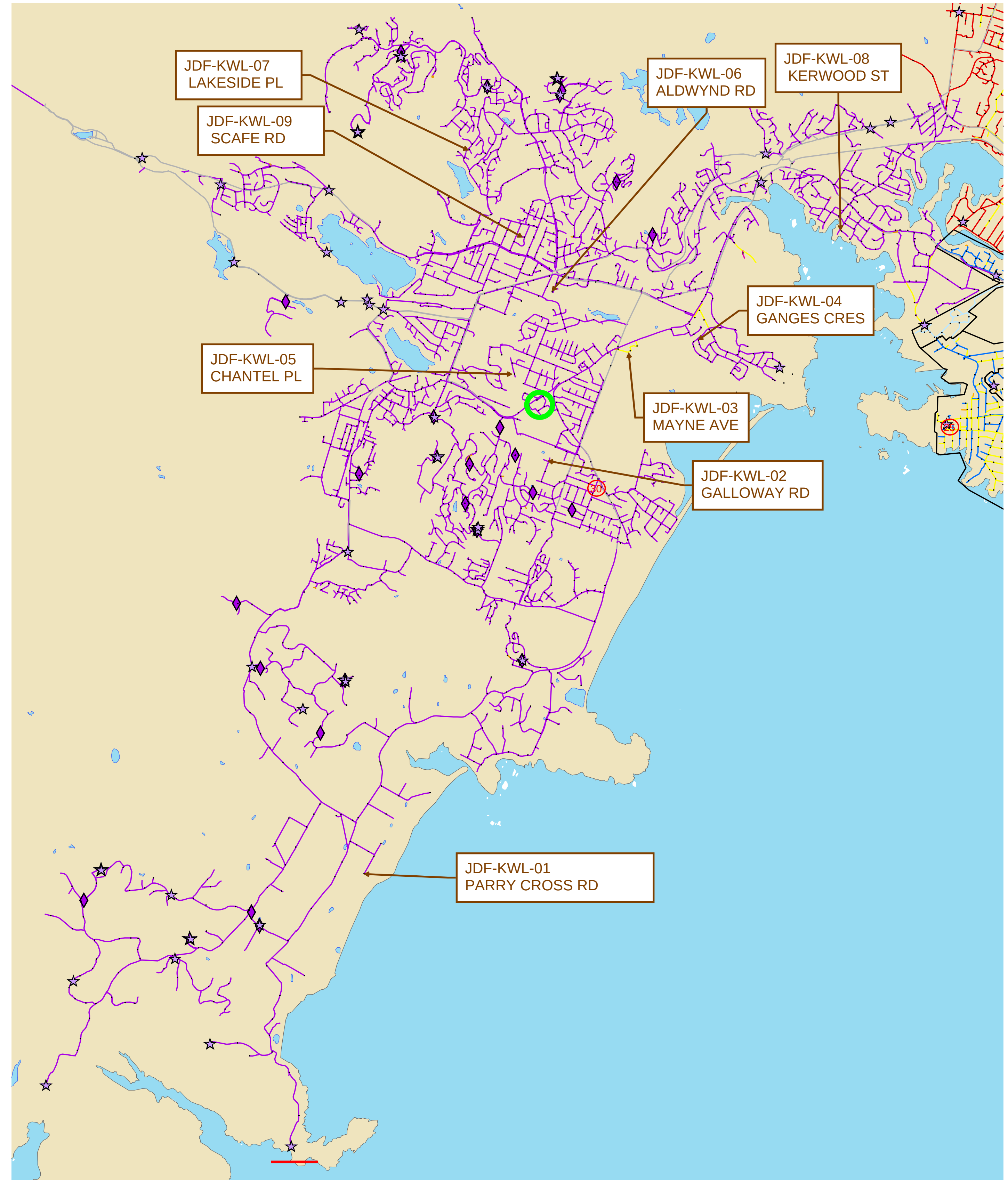
(j) Note sample date and time for inclusion in attached spreadsheet (blue cells).

(k) Repeat steps (h) through (r) until samples have been collected from all sample locations. **Remember to collect at least one replicate sample per day for Quality Control.**

(b) Store each set of sample bottles (from each location) in separate labeled plastic bags to prevent samples from mixing. Deliver samples to the laboratory (460 Tennyson Place, Unit 1, Victoria, BC) before 4:30pm on the sampling day or the following morning after 9:00 am.

KERR WOOD LEIDAL
consulting engineers



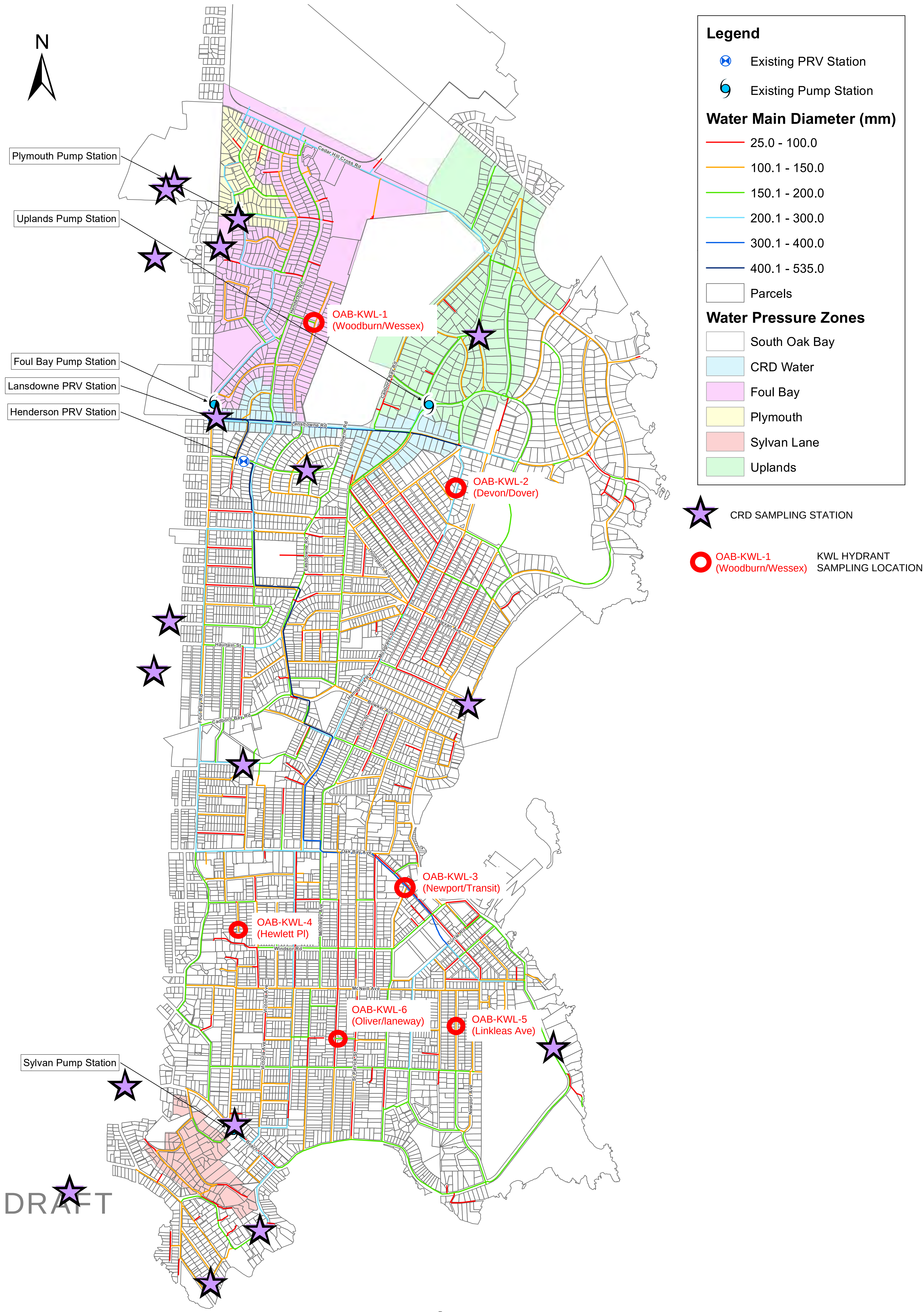


Project No. 719.066

Date SEPT 2019

Scale 1:18,000

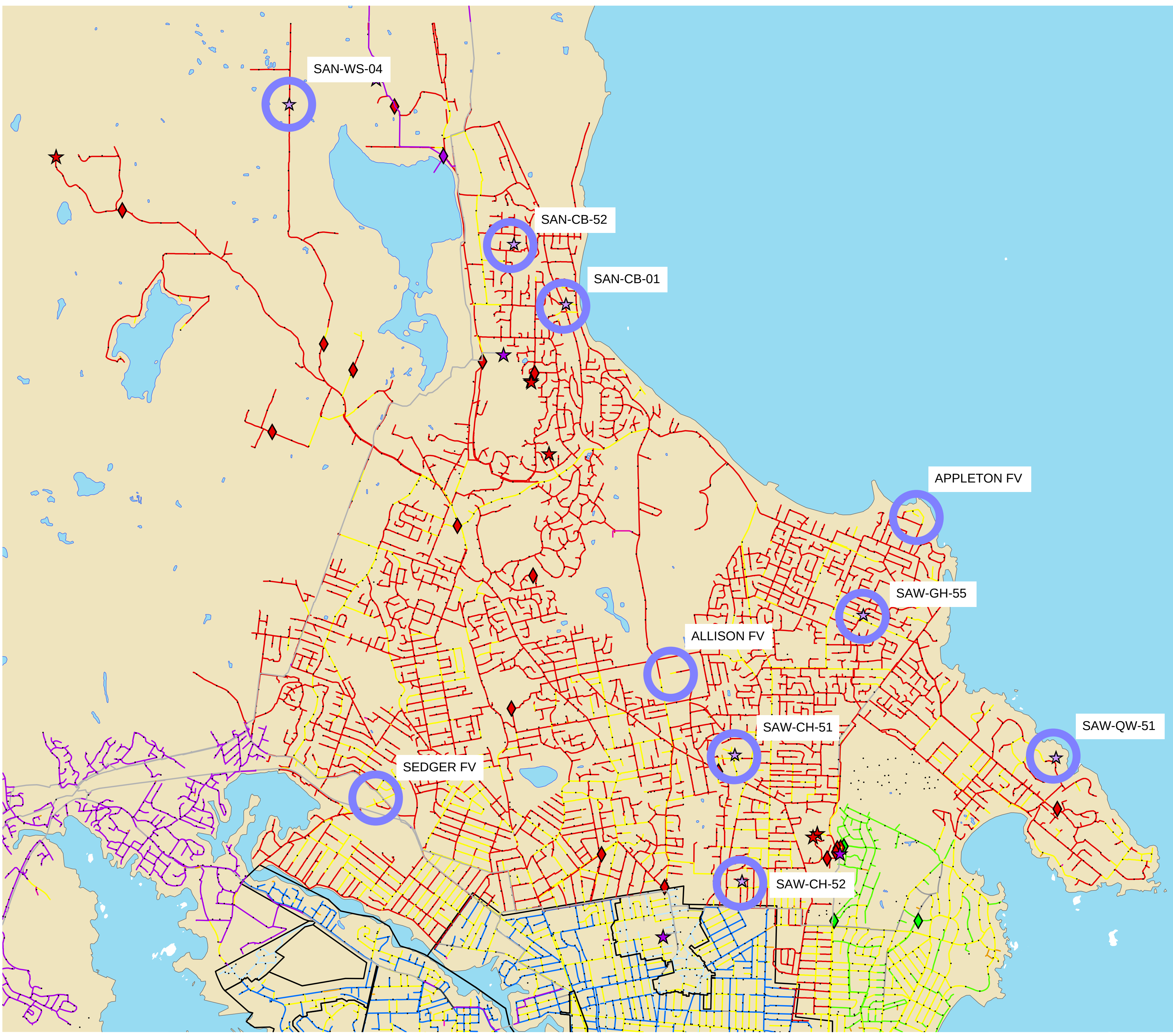
CRD JDF AND SOOKE WATER
SAMPLING LOCATIONS COMPLETED BY KWL



Project No.	719.066
Date	SEPT 2019
Scale	1:18,000

Existing Water System
WITH KWL SAMPLING LOCATIONS

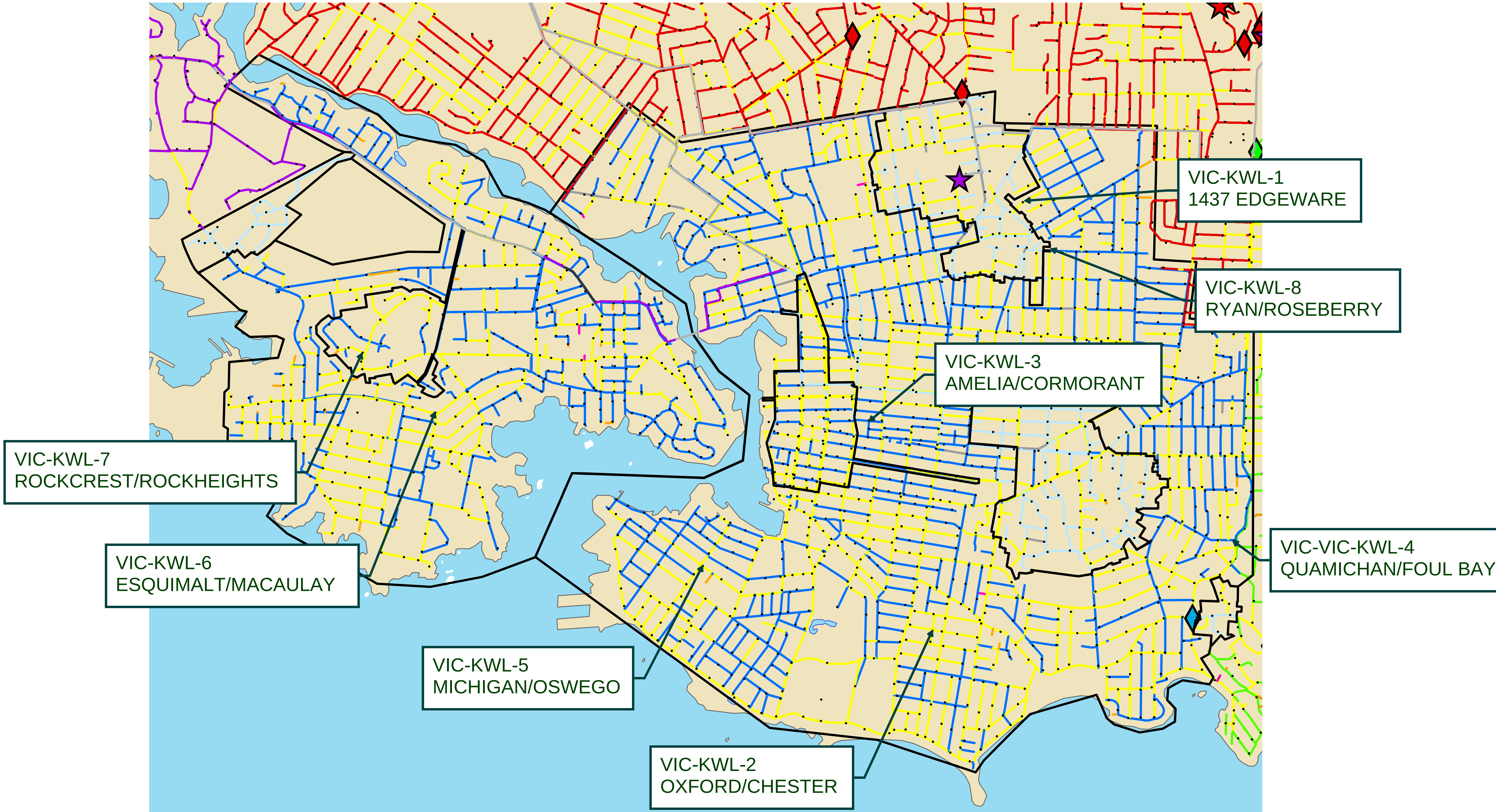
KERR WOOD LEIDAL
consulting engineers



Project No. 547.059
Date September 2019
Scale 1:18,000

DISTRICT OF SAANICH WATER SAMPLING LOCATIONS COMPLETED BY KWL

KERR WOOD LEIDAL consulting engineers



Project No. 719.066

Date SEPT 2019

Scale 1:18,000

CITY OF VICTORIA WATER SAMPLING LOCATIONS
COMPLETED BY KWL

Appendix C

Materials Testing Report

Your Project #: 23558
Site Location: 3045 DOUGLAS STREET
Your C.O.C. #: 573617-38-01

Attention: Scott Nicol

ISLAND EHS
201-990 HILLSIDE AVE
VICTORIA, BC
CANADA V8T 2A1

Report Date: 2019/12/20
Report #: R2826993
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: B9A7419
Received: 2019/12/13, 14:00

Sample Matrix: Sludge
Samples Received: 3

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Elements by ICPMS (total)	2	2019/12/18	2019/12/20	BBY7SOP-00004 / BBY7SOP-00001	EPA 6020b R2 m
ICP-AES Metals in TCLP Leachate	2	2019/12/20	2019/12/20	BBY7SOP-00018	EPA 6010d m
Elements by ICP-AES (acid extr. solid)	1	2019/12/19	2019/12/19	BBY7SOP-00018	EPA 6010d m
pH (2:1 DI Water Extract)	1	2019/12/18	2019/12/18	BBY6SOP-00028	BCMOE BCLM Mar2005 m
pH (2:1 DI Water Extract)	1	2019/12/19	2019/12/19	BBY6SOP-00028	BCMOE BCLM Mar2005 m
TCLP pH Measurements (<100g sample used)	2	N/A	2019/12/20	BBY7SOP-00020	EPA 1311 R1992 m

Remarks:

Bureau Veritas Laboratories are accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by BV Labs are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in BV Labs profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and BV Labs in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

BV Labs liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. BV Labs has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by BV Labs, unless otherwise agreed in writing. BV Labs is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by BV Labs, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

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Your Project #: 23558
Site Location: 3045 DOUGLAS STREET
Your C.O.C. #: 573617-38-01

Attention: Scott Nicol

ISLAND EHS
201-990 HILLSIDE AVE
VICTORIA, BC
CANADA V8T 2A1

Report Date: 2019/12/20
Report #: R2826993
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: B9A7419
Received: 2019/12/13, 14:00

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Customer Solutions, Western Canada Customer Experience Team
Email: customersolutionswest@bvlabs.com
Phone# (604) 734 7276
==
This report has been generated and distributed using a secure automated process.
BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

BV Labs Job #: B9A7419
Report Date: 2019/12/20

ISLAND EHS
Client Project #: 23558
Site Location: 3045 DOUGLAS STREET
Sampler Initials: SN

RESULTS OF CHEMICAL ANALYSES OF SLUDGE

BV Labs ID		XC9445		XC9446	
Sampling Date		2019/12/13		2019/12/13	
COC Number		573617-38-01		573617-38-01	
	UNITS	**23558-3 CAST IRON SLUDGE**	**QC Batch**	**23558-1 MAIN #3 PIPE LINER**	**QC Batch**
Physical Properties					
Soluble (2:1) pH	pH	5.58	9713015	6.92	9714532

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ISLAND EHS
Client Project #: 23558
Site Location: 3045 DOUGLAS STREET
Sampler Initials: SN

ELEMENTS BY ATOMIC SPECTROSCOPY (SLUDGE)

BV Labs ID		XC9444			XC9445		XC9446		
Sampling Date		2019/12/13			2019/12/13		2019/12/13		
COC Number		573617-38-01			573617-38-01		573617-38-01		
	UNITS	**23558-2 MAIN #3 STEEL**	**RDL**	**QC Batch**	**23558-3 CAST IRON SLUDGE**	**QC Batch**	**23558-1 MAIN #3 PIPE LINER**	**RDL**	**QC Batch**
TCLP Extraction Procedure									
Initial pH of Sample	pH				6.77	9715468	6.79	N/A	9715468
pH after HCl	pH				1.44	9715468	1.31	N/A	9715468
Final pH of Leachate	pH				5.18	9715468	5.69	N/A	9715468
pH of Leaching Fluid	pH				4.93	9715468	4.93	N/A	9715468
Total Metals by ICP									
Total Aluminum (Al)	mg/kg	519	12	9714294					
Total Antimony (Sb)	mg/kg	<12	12	9714294					
Total Arsenic (As)	mg/kg	62	12	9714294					
Total Barium (Ba)	mg/kg	3.53	0.20	9714294					
Total Beryllium (Be)	mg/kg	<0.80	0.80	9714294					
Total Boron (B)	mg/kg	<2.0	2.0	9714294					
Total Cadmium (Cd)	mg/kg	4.3	2.0	9714294					
Total Calcium (Ca)	mg/kg	796	12	9714294					
Total Chromium (Cr)	mg/kg	166	2.0	9714294					
Total Cobalt (Co)	mg/kg	29.8	4.0	9714294					
Total Copper (Cu)	mg/kg	347	4.0	9714294					
Total Iron (Fe)	mg/kg	249000	2.0	9714294					
Total Lead (Pb)	mg/kg	<8.0	8.0	9714294					
Total Magnesium (Mg)	mg/kg	4030	12	9714294					
Total Manganese (Mn)	mg/kg	1750	0.80	9714294					
Total Molybdenum (Mo)	mg/kg	12.1	4.0	9714294					
Total Nickel (Ni)	mg/kg	133	4.0	9714294					
Total Phosphorus (P)	mg/kg	64	32	9714294					
Total Potassium (K)	mg/kg	<60	60	9714294					
Total Selenium (Se)	mg/kg	<20	20	9714294					
Total Silver (Ag)	mg/kg	<2.0	2.0	9714294					
Total Sodium (Na)	mg/kg	<20	20	9714294					
Total Strontium (Sr)	mg/kg	9.07	0.20	9714294					
Total Sulphur (S)	mg/kg	429	20	9714294					
Total Tin (Sn)	mg/kg	29.1	8.0	9714294					
Total Titanium (Ti)	mg/kg	9.5	1.2	9714294					

RDL = Reportable Detection Limit
N/A = Not Applicable

BV Labs Job #: B9A7419
Report Date: 2019/12/20

ISLAND EHS
Client Project #: 23558
Site Location: 3045 DOUGLAS STREET
Sampler Initials: SN

ELEMENTS BY ATOMIC SPECTROSCOPY (SLUDGE)

BV Labs ID		XC9444			XC9445		XC9446		
Sampling Date		2019/12/13			2019/12/13		2019/12/13		
COC Number		573617-38-01			573617-38-01		573617-38-01		
	UNITS	**23558-2 MAIN #3 STEEL**	**RDL**	**QC Batch**	**23558-3 CAST IRON SLUDGE**	**QC Batch**	**23558-1 MAIN #3 PIPE LINER**	**RDL**	**QC Batch**
Total Vanadium (V)	mg/kg	2.7	2.0	9714294					
Total Zinc (Zn)	mg/kg	10.3	1.2	9714294					
Total Zirconium (Zr)	mg/kg	7.2	4.0	9714294					
Total Metals by ICPMS									
Total Copper (Cu)	mg/kg				77.7	9713011	18.5	0.50	9713135
Total Lead (Pb)	mg/kg				50.5	9713011	2.12	0.10	9713135
RDL = Reportable Detection Limit									

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TCLP LEAD BY ICP (SLUDGE)

BV Labs ID		XC9445	XC9446		
Sampling Date		2019/12/13	2019/12/13		
COC Number		573617-38-01	573617-38-01		
	UNITS	**23558-3 CAST IRON SLUDGE**	**23558-1 MAIN #3 PIPE LINER**	**RDL**	**QC Batch**
Metals					
Leachate Lead (Pb)	mg/L	<0.30	<0.30	0.30	9716632
RDL = Reportable Detection Limit					

GENERAL COMMENTS

Sample XC9445 [23558-3 CAST IRON SLUDGE] : The minimum weight of 100g for the standard TCLP extraction, as per Reference Method EPA 1311 R1992, could not be achieved due to insufficient sample. Client consent has been received to proceed using the modified TCLP method. The uncertainty of the analysis may be increased, and the reported results may not be suitable for compliance purposes.

Sample XC9446 [23558-1 MAIN #3 PIPE LINER] : The minimum weight of 100g for the standard TCLP extraction, as per Reference Method EPA 1311 R1992, could not be achieved due to insufficient sample. Client consent has been received to proceed using the modified TCLP method. The uncertainty of the analysis may be increased, and the reported results may not be suitable for compliance purposes.

ELEMENTS BY ATOMIC SPECTROSCOPY (SLUDGE) Comments

Sample XC9444 [23558-2 MAIN #3 STEEL] Elements by ICP-AES (acid extr. solid): Detection limits raised due to insufficient sample volume.

Results relate only to the items tested.

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BV Labs Job #: B9A7419
Report Date: 2019/12/20

QUALITY ASSURANCE REPORT

ISLAND EHS
Client Project #: 23558
Site Location: 3045 DOUGLAS STREET
Sampler Initials: SN

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**UNITS**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
9713011	Total Copper (Cu)	2019/12/20	90	75 - 125	103	75 - 125	<0.50	mg/kg	0.010	30	115	70 - 130
9713011	Total Lead (Pb)	2019/12/20	96	75 - 125	101	75 - 125	<0.10	mg/kg	1.9	40	110	70 - 130
9713015	Soluble (2:1) pH	2019/12/18			100	97 - 103			0.25	20		
9713135	Total Copper (Cu)	2019/12/20	94	75 - 125	104	75 - 125	<0.50	mg/kg	2.2	30	114	70 - 130
9713135	Total Lead (Pb)	2019/12/20	99	75 - 125	103	75 - 125	<0.10	mg/kg	1.9	40	108	70 - 130
9714294	Total Aluminum (Al)	2019/12/19			98	75 - 125	<3.0	mg/kg				
9714294	Total Antimony (Sb)	2019/12/19			98	75 - 125	<3.0	mg/kg				
9714294	Total Arsenic (As)	2019/12/19			98	75 - 125	<3.0	mg/kg				
9714294	Total Barium (Ba)	2019/12/19			98	75 - 125	<0.050	mg/kg				
9714294	Total Beryllium (Be)	2019/12/19			95	75 - 125	<0.20	mg/kg				
9714294	Total Boron (B)	2019/12/19			96	75 - 125	<0.50	mg/kg				
9714294	Total Cadmium (Cd)	2019/12/19			96	75 - 125	<0.50	mg/kg				
9714294	Total Calcium (Ca)	2019/12/19			98	75 - 125	<3.0	mg/kg				
9714294	Total Chromium (Cr)	2019/12/19			95	75 - 125	<0.50	mg/kg				
9714294	Total Cobalt (Co)	2019/12/19			96	75 - 125	<1.0	mg/kg				
9714294	Total Copper (Cu)	2019/12/19			97	75 - 125	<1.0	mg/kg				
9714294	Total Iron (Fe)	2019/12/19			98	75 - 125	0.67, RDL=0.50 (1)	mg/kg				
9714294	Total Lead (Pb)	2019/12/19			97	75 - 125	<2.0	mg/kg	14	40	84	70 - 130
9714294	Total Magnesium (Mg)	2019/12/19			98	75 - 125	<3.0	mg/kg				
9714294	Total Manganese (Mn)	2019/12/19			96	75 - 125	<0.20	mg/kg				
9714294	Total Molybdenum (Mo)	2019/12/19			97	75 - 125	<1.0	mg/kg				
9714294	Total Nickel (Ni)	2019/12/19			95	75 - 125	<1.0	mg/kg				
9714294	Total Phosphorus (P)	2019/12/19			112	75 - 125	<8.0	mg/kg				
9714294	Total Potassium (K)	2019/12/19			98	75 - 125	<15	mg/kg				
9714294	Total Selenium (Se)	2019/12/19			98	75 - 125	<5.0	mg/kg				
9714294	Total Silver (Ag)	2019/12/19			91	75 - 125	<0.50	mg/kg				
9714294	Total Sodium (Na)	2019/12/19			100	75 - 125	<5.0	mg/kg				
9714294	Total Strontium (Sr)	2019/12/19			98	75 - 125	<0.050	mg/kg				
9714294	Total Sulphur (S)	2019/12/19			99	75 - 125	<5.0	mg/kg				
9714294	Total Tin (Sn)	2019/12/19			100	75 - 125	<2.0	mg/kg				
9714294	Total Titanium (Ti)	2019/12/19			98	75 - 125	<0.30	mg/kg				

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QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
9714294	Total Vanadium (V)	2019/12/19			97	75 - 125	<0.50	mg/kg				
9714294	Total Zinc (Zn)	2019/12/19			97	75 - 125	<0.30	mg/kg				
9714294	Total Zirconium (Zr)	2019/12/19			98	75 - 125	<1.0	mg/kg				
9714532	Soluble (2:1) pH	2019/12/19			100	97 - 103			0.15	20		
9716632	Leachate Lead (Pb)	2019/12/20	93	75 - 125	89	75 - 125	<0.30	mg/L	NC	40		

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

(1) Method Blank exceeds acceptance limits for (Fe). Sample values for (Fe) are >10x the concentration of the method blank and the contamination is considered irrelevant.

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

David Huang, M.Sc., P.Chem., QP, Scientific Services Manager

BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Bureau Veritas Laboratories
Unit 1 - 460 Tennyson Place, Victoria, British Columbia Canada V8Z 6S8 Tel:(250) 385 6112 Toll-free:800-563-6266 Fax:(250) 382 6364 www.bvlabs.com

Page of

Chain Of Custody Record

INVOICE TO:		Report Information		Project Information		Laboratory Use Only	
Company Name	#11410 ISLAND EHS	Company Name		Quotation #	B60156	BV Labs Job #	Bottle Order #:
Contact Name	ACCOUNTS PAYABLE	Contact Name	Scott Nicol	P.O. #		B9A7419	573617
Address	201-990 HILLSIDE AVE	Address		Project #	23558.	Chain Of Custody Record	Project Manager
	VICTORIA BC V8T 2A1			Project Name		C#573617-38-01	Customer Solutions
Phone	(250) 744-9693 Fax	Phone	Fax	Site #	3045 Douglas St		
Email	accounting@islandehs.ca; admin@islandehs.ca	Email	snicol@islandehs.ca.	Sampled By	Client		

Regulatory Criteria: ☐ CSR ☐ CCME ☐ BC Water Quality ☐ Other ______

Modified TCLP is Ok :)

Special Instructions: Call me if instructions unclear. Do not test pipe metal.

SAMPLES MUST BE KEPT COOL (< 10ºC) FROM TIME OF SAMPLING UNTIL DELIVERY TO BV LABS

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

#	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Metals Field Filtered ? (Y/N)	Lead in Paint Chips	TCLP Metals	TCLP LEAD (ICP-OES)	METALS, FULL ICP SCAN IN AIR	METALS, SINGLE ELEMENT IN AIR (BY ICP)	Total Lead	Total Copper	Leachable Lead	Leachable Copper		# of Bottles	Comments
1	~~23558-1~~	~~Main #3 Sludge~~	~~12/13/19~~	~~———~~														~~Sludge ONLY~~
2	23558-2	Main #3 Steel	↑	–								X	X	X				Test only exterior material.
3	23558-3	Cast Iron Sludge	↓	–								X	X	X				Sludge ONLY Please.
4	23558-1	Main #3 Pipe liner.	12/13/19									X	X	X.				
5																		
6																		
7																		
8																		
9																		
10																		

Turnaround Time (TAT) Required:

Please provide advance notice for rush projects

Regular (Standard) TAT: ☒
(will be applied if Rush TAT is not specified)
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
1 DAY ☐ 2 Day ☐ 3 Day ☐ Date Required: ______ ☐
Rush Confirmation Number: ______ (call lab for #)

B9A7419_COC

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted	Lab Use Only		
Scott Nicol	19/12/13	1400.	M Martin	19/12/13	1400		Time Sensitive ☐	Temperature (°C) on Receipt: N/A	Custody Seal Intact on Cooler? Yes ☐ No ☑ N/A
M Martin	19/12/13	1600	PEDRO TACK	2019/12/14	10:07				

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO BV LABS' STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.BVLABS.COM/TERMS-AND-CONDITIONS.
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Appendix D

Water Sampling and Corrosion Analysis Summary Tables

Appendix D - Water Sampling and Corrosion Analysis Summary Tables

Table D-1: Source Sampling Program (Phase 1 - September Sampling)

		Parameter										
Sample ID	Distribution Area	Total Dissolved Solids (mg/L)	Temperature deg C	Field pH s.u.	Alkalinity as $CaCO_3$ mg/L	Ca as $CaCO_3$ mg/L	Cl mg/L	SO_4 mg/L	Total Lead (Pb) ug/L	Total Copper (Cu) ug/L	AWWA Model CCPP	Sampling Performed By
OAB-KWL-1	Oak Bay	44	19.4	8.1	17	13	4.4	1.1	<0.2	1.05	-4.11	KWL
OAB-KWL-2a	Oak Bay	38	19.2	8.1	17	13	4.5	1.1	<0.2	0.60	-4.12	KWL
OAB-KWL-2b	Oak Bay	40	19.5	8.1	17	13	4.4	1.3	<0.2	0.59	-4.15	KWL
OAB-KWL-4	Oak Bay	53	19.1	7.9	16	13	4.4	1.2	<0.2	1.37	-4.62	KWL
OAB-KWL-5	Oak Bay	50	19.3	7.5	15	13	5.2	2.1	0.34	0.77	-5.65	KWL
OAB-KWL-6	Oak Bay	43	19.1	7.6	16	13	4.6	1.2	<0.2	1.66	-5.29	KWL
OAB-KWL-3	Oak Bay	38	18.9	7.9	17	13	4.5	1.1	<0.2	0.63	-4.50	KWL
JDF-KWL-5	CRD	36	19.6	8.20	16	13	4.4	<1.0	0.39	1.26	-3.91	KWL
JDF-KWL-3a	CRD	36	18.5	8.60	15	15	4.5	1	0.34	3.98	-3.06	KWL
JDF-KWL-4	CRD	22	20.2	8.10	15	14	4.8	<1.0	<0.2	2.11	-3.89	KWL
JDF-KWL-3b	CRD	38	18.4	8.60	16	14	4.6	1.2	0.29	2.85	-3.16	KWL
JDF-KWL-6	CRD	34	18.8	8.70	16	13	4.2	<1.0	0.28	0.96	-3.14	KWL
JDF-KWL-2	CRD	32	19.4	8.20	15	14	4.4	1	<0.2	2.51	-3.80	KWL
JDF-KWL-9	CRD	32	18.6	8.60	16	13	4.1	1.1	<0.2	0.86	-3.28	KWL
JDF-KWL-7	CRD	33	18.4	8.10	15	14	4.2	1.2	0.27	2.59	-4.02	KWL
JDF-KWL-8	CRD	30	18.8	8.70	16	13	4.3	1.1	<0.2	0.54	-3.11	KWL
VIC-KWL-8	Victoria	45	18.3	8.30	18	13	4.5	1	0.50	0.77	-3.75	KWL
VIC-KWL-4	Victoria	42	19.0	8.47	16	14	5.6	<1.0	<0.2	1.04	-3.55	KWL
VIC-KWL-2b	Victoria	42	19.2	8.05	16	13	4.4	1	0.29	0.93	-4.26	KWL
VIC-KWL-2a	Victoria	39	19.2	8.04	16	13	5.7	<1.0	0.32	1.03	-4.27	KWL
VIC-KWL-5	Victoria	44	18.7	8.11	16	13	4.4	1.2	0.27	0.77	-4.14	KWL
VIC-KWL-3	Victoria	32	19.2	8.35	16	13	4.3	<1.0	<0.2	1.25	-3.69	KWL
VIC-KWL-6	Victoria	44	18.9	8.15	16	13	4.2	<1.0	0.21	0.72	-4.14	KWL
VIC-KWL-7	Victoria	45	19.3	8.22	15	13	4.7	<1.0	0.36	1.29	-4.10	KWL
VIC-KWL-1	Victoria	36	19.4	8.40	17	14	4.6	<1.0	0.84	1.68	-3.51	KWL
SOOKE-KWL-2	CRD	38	17.2	8.08	16	13	6.2	1.2	<0.2	1.06	-4.10	KWL
SOOKE-KWL-3	CRD	34	17.6	7.88	16	13	6.3	1.2	2.10	13.20	-4.50	KWL
SOOKE-KWL-4	CRD	32	17.7	7.84	16	14	6.5	1.2	<0.2	1.56	-4.45	KWL
JDF-KWL-10	CRD	38	18.1	8.19	16	13	5.1	1.3	0.70	6.22	-3.93	KWL
JDF-KWL-11	CRD	31	17.8	8.31	17	13	4.8	1.2	0.44	2.18	-3.71	KWL
JDF-KWL-12	CRD	38	17.8	8.37	17	13	4.6	1.3	<0.2	0.68	-3.77	KWL
JDF-KWL-1	CRD	44.00	15.6	8.08	16	14	4.8	1.1	1.35	25.40	-3.98	KWL
SOOKE-KWL-1a	CRD	18.00	17.1	7.90	16	14	6.7	1.2	0.38	4.41	-4.09	KWL
SOOKE-KWL-1b	CRD	40.00	16.9	7.95	16	14	6.8	1.3	0.36	3.84	-4.30	KWL
SAW-QW-51	Saanich	16.00	17.2	7.86	16	14	4.8	1.3	0.67	4.58	-4.19	KWL
Appleton FV	Saanich	31	17.8	7.44	15	13	4.8	1.4	0.26	1.84	-5.85	KWL
SAW-GH-55	Saanich	24	19.4	7.85	16	13	5	1.5	0.56	4.28	-4.44	KWL
Sedger FV	Saanich	33	18.9	7.59	16	12	4.5	1.5	0.36	4.98	-5.40	KWL
SAN-CB-01	Saanich	28	17.8	8.26	16	13	4.4	1.3	0.42	3.32	-3.82	KWL
SAN-CB-01-RE	Saanich	36	18.1	8.24	16	12	4.4	1.3	0.42	3.32	-4.07	KWL
SAN-CB-52	Saanich	40	17.7	7.79	17	13	4.5	1.3	0.38	3.90	-4.69	KWL
Allison FV	Saanich	44	16.9	7.89	16	13	4.5	1.3	<0.2	1.76	-4.54	KWL
SAW-CH-51	Saanich	38	17.1	8.29	16	13	4.5	1.3	0.60	3.94	-3.97	KWL
SAW-CH-52	Saanich	41	18.3	8.25	17	13	4.7	2.1	0.33	1.87	-3.87	KWL
CM-01-ERSK	CRD	48	17.4	8.28	17	13	4.4	1.1	0.37	4.95	-3.99	CRD

Appendix D - Water Sampling and Corrosion Analysis Summary Tables

Table D-1: Source Sampling Program (Phase 1 - September Sampling)

Sample ID	Distribution Area	Parameter									AWWA Model CCPP	Sampling Performed By
		Total Dissolved Solids	Temperature	Field pH	Alkalinity as $CaCO_3$	Ca as $CaCO_3$	Cl	SO_4	Total Lead (Pb)	Total Copper (Cu)		
		(mg/L)	deg C	s.u.	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L		
CM-01-HIGH	CRD	26	17.4	8.04	17	13	4.7	1.8	0.86	12.70	-4.08	CRD
CM-01-WOOD	CRD	30	17.4	8.11	17	13	4.4	1.2	0.28	4.76	-3.96	CRD
CM-05-HUMP	CRD	28	16.8	8.04	17	13	4.4	<1.0	<0.2	3.12	-4.15	CRD
CRR-01-02	CRD	34	15.9	7.79	16	14	6.4	<1.0	<0.2	7.18	-4.60	CRD
DKR-01-03	CRD	32	16.8	7.83	16	14	4.8	<1.0	0.24	4.87	-4.35	CRD
ESQ-ES-02	Victoria	34	17.5	8.14	17	13	4.4	<1.0	<0.2	0.75	-4.03	CRD
FUR-02-01	CRD	33	18.1	7.97	17	13	4.6	1	<0.2	0.50	-4.24	CRD
JGP-RA-01	CRD	28	16.8	7.34	15	13	2.2	<1.0	<0.2	1.07	-4.24	CRD
JGP-TR-02	CRD	37	17.0	7.86	17	13	4.5	1.2	<0.2	3.62	-4.58	CRD
KHB-03-36	CRD	37	17.0	8.01	17	13	4.8	1.1	<0.2	18.10	-4.32	CRD
KHB-03-39	CRD	66	17.0	7.98	17	13	4.4	2	0.22	1.53	-4.52	CRD
MET-ME-02	CRD	26	17.2	8.29	17	14	4.7	<1.0	<0.2	10.10	-3.52	CRD
MET-ME-07	CRD	20	17.0	7.25	15	15	4.9	<1.0	0.38	18.60	-6.71	CRD
MET-WH-02	CRD	33	17.1	8.57	17	14	4.7	<1.0	<0.2	7.89	-3.19	CRD
MET-WH-09	CRD	37	16.8	8.54	17	14	4.6	1.1	0.44	4.29	-3.32	CRD
ROR-01-03	CRD	40	17.0	8.15	17	14	4.7	1.1	<0.2	5.87	-3.85	CRD
SIR-01-03	CRD	40	16.1	7.70	18	15	7.8	1	<0.2	4.37	-4.79	CRD
SOK-ES-01	CRD	27	16.8	7.94	16	13	6.1	<1.0	<0.2	7.03	-4.34	CRD
SOK-ES-01_DUP	CRD	26	16.8	7.94	16	13	6	<1.0	<0.2	6.98	-4.31	CRD
SOK-ES-02	CRD	36	17.1	7.50	15	14	6.8	1.6	0.74	7.65	-5.53	CRD
SOK-ES-03	CRD	30	16.0	7.96	16	13	5.9	1.1	0.53	2.71	-4.35	CRD
SOK-SS-02	CRD	36	17.0	7.40	17	15	7.7	<1.0	0.46	20.90	-6.07	CRD
VIC-GL-01	Victoria	24	17.3	8.13	17	13	4.4	1.2	<0.2	11.40	-3.94	CRD
VIR-HO-03	CRD	37	17.4	8.36	17	13	4.3	<1.0	0.27	16.60	-3.67	CRD
VIR-HO-03_DUP	CRD	23	17.4	8.39	17	13	4.4	<1.0	0.36	18.20	-3.52	CRD
OAB-GO-02	Oak Bay	45	16.2	8.17	15	14	4.5	1.2	0.42	22.60	-3.94	CRD
OAB-GO-04	Oak Bay	48	16.2	8.06	15	14	4.5	<1.0	0.29	9.71	-4.07	CRD
OAB-SO-03	Oak Bay	47	16.0	8.51	16	14	4.7	<1.0	0.30	3.87	-3.53	CRD
OAB-ES-01	Oak Bay	68	16.0	8.54	16	13	4.2	<1.0	<0.2	18.70	-3.73	CRD
OAB-NO-03	Oak Bay	62	16.3	8.57	16	13	4.6	2.3	0.31	4.46	-3.61	CRD
OAB-HE-04	Oak Bay	37	16.0	8.90	17	13	4.2	<1.0	0.21	3.27	-2.66	CRD
OAB-UP-04	Oak Bay	49	15.7	8.78	16	13	4.4	<1.0	0.24	3.79	-3.18	CRD
OAB-HE-03	Oak Bay	48	16.5	8.24	16	14	4.9	<1.0	<0.2	6.25	-3.79	CRD
OAB-HE-04_DUP	Oak Bay	34	16.0	8.90	16	13	4.3	1.2	0.22	3.32	-2.73	CRD
OAB-HE-01	Oak Bay	56	15.6	8.64	16	13	4.4	<1.0	1.47	52.40	-3.49	CRD
MTR-G2-32	Saanich	34	15.6	8.44	16	13	4.6	1.1	<0.2	16.30	-3.60	CRD
SAN-RO-02	Saanich	<10	16.8	8.38	16	12	4.9	<1.0	0.48	13.60	-3.54	CRD
SAN-MD-01	Saanich	<10	16.3	8.20	16	13	4.4	<1.0	0.48	12.40	-3.72	CRD
SAN-GH-51	Saanich	40	16.5	8.21	15	13	4.4	<1.0	<0.2	2.34	-4.03	CRD
SAN-TM-01	Saanich	51	16.9	8.38	16	13	4.4	1.1	0.37	1.60	-3.83	CRD
SAW-TM-51	Saanich	58	15.9	7.31	14	14	4.7	<1.0	0.27	5.29	-2.17	CRD
SAN-CA-03	Saanich	80	17.4	7.67	14	13	4.6	1	0.48	8.46	-5.24	CRD
SAN-CH-02	Saanich	64	16.8	8.35	16	13	4.4	<1.0	0.27	1.22	-4.01	CRD
SAW-MD-52	Saanich	60	15.6	7.40	14	14	4.6	1.1	0.38	7.41	-6.09	CRD
SAN-GO-01	Saanich	56	17.3	8.24	15	14	5.6	1	0.51	3.79	-4.00	CRD

Appendix D - Water Sampling and Corrosion Analysis Summary Tables

Table D-1: Source Sampling Program (Phase 1 - September Sampling)

Sample ID	Distribution Area	Total Dissolved Solids (mg/L)	Temperature deg C	Field pH s.u.	Alkalinity as $CaCO_3$ mg/L	Ca as $CaCO_3$ mg/L	Cl mg/L	SO_4 mg/L	Total Lead (Pb) ug/L	Total Copper (Cu) ug/L	AWWA Model CCPP	Sampling Performed By
SAW-GF-51	Saanich	50	16.6	8.52	16	13	5.9	1.6	0.32	2.69	-3.73	CRD
SAW-GO-53	Saanich	63	16.5	8.82	17	14	4.4	1.2	0.22	3.00	-3.01	CRD
SAN-CB-05	Saanich	49	16.0	8.47	16	13	4.4	1	0.33	7.59	-3.83	CRD
SAW-GO-53_DUP	Saanich	74			17	13	4.4	<1.0	0.23	2.98		CRD
SAW-CM-51	Saanich	49	17.3	8.70	16	13	4.6	1.1	0.40	2.39	-3.33	CRD
SAN-PL-04	Saanich	35	14.8	8.53	16	13	5.1	1.2	0.25	2.41	-3.50	CRD
SAN-WS-01	Saanich	38	15.0	8.46	16	13	5.5	<1.0	<0.2	0.72	-3.64	CRD
SAN-PL-03	Saanich	36	14.5	8.34	16	14	5.1	<1.0	0.40	4.99	-3.65	CRD
HLR-01-01	Saanich	35	13.1	7.90	16	13	6	1.1	0.30	9.57	-4.47	CRD
SAN-WS-03	Saanich	36	13.6	8.23	16	13	5.3	<1.0	0.24	4.19	-4.04	CRD
SAN-WS-04	Saanich	24	13.9	8.47	16	14	4.9	<1.0	0.28	2.84	-3.37	CRD
SAN-CB-03	Saanich	40	14.5	8.33	16	14	5.3	<1.0	0.49	6.37	-3.69	CRD
SAN-BR-01	Saanich	30	18.0	8.16	16	13	5	<1.0	<0.2	1.11	-3.90	CRD
SAN-PL-04_DUP	Saanich	60			16	13	5	<1.0	0.26	2.49		CRD
SAN-SW-02	Saanich	54	15.8	8.36	16	14	5.1	<1.0	0.43	2.39	-3.82	CRD
RIR-02-02	Saanich	32	14.9	8.36	16	13	4.8	<1.0	<0.2	0.42	-3.68	CRD
SOK-SA-02	CRD	23	14.5	8.09	15	14	6.9	<1.0	<0.2	1.10	-3.94	CRD
SOK-WS-02	CRD	36	14.0	8.06	15	15	7.3	<1.0	<0.2	6.91	-3.90	CRD
HRR-02-01	CRD	36	11.8	7.54	15	15	7.8	<1.0	<0.2	4.73	-5.31	CRD
SOK-SV-03	CRD	43	14.9	8.06	15	13	6.9	<1.0	0.21	24.60	-4.28	CRD
HRR-02-01_DUP	CRD	24	11.8	7.54	15	15	6.9	<1.0	<0.2	4.87	-5.21	CRD
LAN-HA-01	CRD	52	16.0	8.29	16	13	5.8	<1.0	<0.2	20.60	-3.94	CRD
MET-ME-04	CRD	46	15.7	8.43	16	13	5.2	<1.0	0.35	5.76	-3.69	CRD
MET-ME-08	CRD	50	15.9	8.59	16	16	5.3	<1.0	0.27	5.36	-3.09	CRD
SPR-02-02	CRD	44	14.7	7.40	13	14	6.3	<1.0	<0.2	12.50	-5.78	CRD
LAN-HA-03	CRD	40	16.5	8.32	16	13	5.3	<1.0	<0.2	5.68	-3.86	CRD
COL-CO-02	CRD	48	17.5	8.35	16	13	5.2	<1.0	<0.2	3.90	-3.80	CRD
COL-AH-01	CRD	48	17.0	8.23	15	13	5.5	<1.0	<0.2	10.70	-4.07	CRD
LAN-HA-03_DUP	CRD	50			16	13	5.4	<1.0	<0.2	5.61		CRD
VIC-BU-01	Victoria	47	14.8	8.88	17	14	4.8	<1.0	3.74	18.20	-2.74	CRD
VIC-HI-02	Victoria	52	15.4	8.77	17	13	5.3	1.1	0.68	15.60	-3.13	CRD
VIC-MA-01	Victoria	32	15.1	8.72	17	13	5.1	<1.0	7.51	22.50	-3.08	CRD
SAN-BL-01	Saanich	50	14.3	8.43	16	13	4.8	<1.0	<0.2	33.10	-3.84	CRD
DPR-UI-01	CRD	66	15.8	7.68	16	14	7.1	<1.0	0.43	3.67	-5.04	CRD
BHR-01-01	Saanich	43	14.9	8.32	17	13	5.1	<1.0	1.45	3.23	-3.81	CRD
VIC-FE-04	Saanich	40	15.2	8.72	17	13	4.9	<1.0	0.32	2.32	-3.11	CRD
VIC-HI-03	Victoria	54	15.8	8.70	16	14	5	<1.0	0.26	3.70	-3.32	CRD
VIC-MA-02	Victoria	59	15.4	8.73	17	14	5.3	<1.0	0.55	10.50	-3.21	CRD
VIC-BU-03	Victoria	53	16.2	8.42	17	13	4.9	<1.0	0.29	3.52	-3.70	CRD
LAN-LL-01	CRD	24	16.3	7.43	15	15	5.7	1.3	0.81	31.30	-5.63	CRD
SOK-SS-01	CRD	31	14.7	6.77	10	16	8.5	<1.0	1.04	26.40	-10.74	CRD
MTR-SA-02	Saanich	21	15.7	8.27	16	14	5.1	<1.0	<0.2	23.40	-3.63	CRD
VIC-BU-03_DUP	Victoria	22	16.2	8.47	17	13	4.7	<1.0	0.98	3.47	-3.42	CRD
BHR-01-01_DUP	Saanich	29	14.9	8.27	17	14	5	<1.0	0.27	3.42	-3.67	CRD
SOP-RA-01	CRD	42	16.0	7.64	14	13	2.2	<1.0	<0.2	1.82	-5.13	CRD

Appendix D - Water Sampling and Corrosion Analysis Summary Tables

Table D-1: Source Sampling Program (Phase 1 - September Sampling)

Sample ID	Distribution Area	Total Dissolved Solids (mg/L)	Temperature deg C	Field pH s.u.	Alkalinity as $CaCO_3$ mg/L	Ca as $CaCO_3$ mg/L	Cl mg/L	SO_4 mg/L	Total Lead (Pb) ug/L	Total Copper (Cu) ug/L	AWWA Model CCPP	Sampling Performed By
SOP-TR-02	CRD	40	15.1	8.27	15	13	6	<1.0	0.21	29.40	-4.00	CRD
SRR-02-02	CRD	37	16.1	7.73	16	14	6.6	1.8	<0.2	79.20	-4.73	CRD
SOK-BR-05	CRD	41	15.9	7.53	14	14	6.2	<1.0	0.37	24.20	-5.33	CRD
HER-CD-02	CRD	44	17.0	7.70	15	14	6.6	1	<0.2	0.81	-4.86	CRD
SOK-JM-01	CRD	48	17.6	7.49	14	15	6.6	1.4	1.53	9.69	-5.41	CRD
SRR-02-02_DUP	CRD	43	16.9	7.73	15	13	6.1	<1.0	<0.2	79.30	-4.83	CRD
SAN-CB-02	Saanich	27	17.7	8.20	17	13	4.4	1	0.21	27.00	-3.85	CRD
CES-SA-01	CRD	25	17.7	8.25	16	12	4.3	<1.0	0.22	1.78	-4.05	CRD
MCR-EB-02	CRD	28	17.6	8.04	16	13	4.3	<1.0	<0.2	54.20	-4.12	CRD
NOS-AL-02	CRD	18	17.7	8.15	17	14	4.7	<1.0	0.28	4.05	-3.68	CRD
NOS-DC-02	CRD	24	17.5	8.08	16	13	4.4	1.5	0.28	13.00	-3.95	CRD
CLR-01-01	CRD	21	17.5	7.84	17	14	4.6	1.5	0.39	9.05	-4.34	CRD
NOS-DP-06	CRD	14	17.8	8.08	17	13	4.3	1.1	0.24	2.28	-3.88	CRD
UDR-01-01	CRD	17	17.0	7.84	16	13	4.5	<1.0	0.34	2.40	-4.35	CRD
CES-OL-02	CRD	19	17.7	8.23	17	13	4.4	<1.0	0.70	6.67	-3.72	CRD
UDR-01-01_DUP	CRD	32	17.0	7.84	17	13	4.5	<1.0	0.33	2.34	-4.53	CRD
LAN-WH-01	CRD	26	15.9	8.43	16	13	4.3	<1.0	<0.2	0.40	-3.60	CRD
MET-ME-05	CRD	30	15.3	8.09	16	15	4.4	<1.0	0.29	9.04	-3.83	CRD
MET-PB-01	CRD	32	15.0	8.07	16	15	4.5	<1.0	0.38	10.60	-3.86	CRD
PER-02-01	CRD	26	15.4	7.31	13	13	4.6	<1.0	0.43	19.20	-6.31	CRD
LAN-TH-01	CRD	36	16.3	8.11	15	13	4.2	<1.0	<0.2	0.74	-4.10	CRD
SKM-02-02	CRD	28	17.0	7.95	16	13	4.4	<1.0	<0.2	36.70	-4.22	CRD
BMR-02-02	CRD	28	16.3	8.19	15	13	4.2	<1.0	<0.2	5.16	-3.92	CRD
LAN-BM-05	CRD	38	16.5	8.27	16	13	4.5	<1.0	0.49	3.14	-3.86	CRD
ESQ-ES-04	Victoria	35	19.2	7.88	17	14	4.8	1.2	0.39	18.10	-4.33	CRD
ESQ-DN-01	Victoria	35	17.9	7.98	17	13	4.7	<1.0	0.37	5.43	-4.27	CRD
ESQ-ES-03	Victoria	25	18.4	7.28	15	13	4.9	<1.0	1.52	136.00	-6.67	CRD
VIC-SO-01	Victoria	57	18.3	7.86	17	13	4.6	<1.0	1.01	31.50	-4.63	CRD
VIC-JB-03	Victoria	45	18.8	7.75	16	14	4.7	<1.0	0.47	4.80	-4.78	CRD
VIC-FA-04	Victoria	42	18.4	7.89	16	13	4.6	<1.0	0.29	5.88	-4.47	CRD
VIC-FA-03	Victoria	43	18.3	8.13	17	14	4.3	<1.0	0.54	5.99	-4.01	CRD
VIC-FA-05	Victoria	38	18.3	8.12	17	14	4.5	<1.0	0.37	7.07	-3.92	CRD
VIC-FA-02	Victoria	34	18.4	8.13	18	14	4.3	<1.0	0.30	10.20	-3.83	CRD
VIC-RO-04	Victoria	20	18.9	7.91	17	13	4.7	1.4	0.34	9.81	-4.23	CRD
VIC-DO-03	Victoria	53	18.0	7.96	17	13	5.1	<1.0	0.93	10.80	-4.41	CRD
VIC-FE-03	Victoria	32	17.7	7.96	17	14	4.4	<1.0	0.39	4.75	-4.21	CRD
VIC-JB-03_DUP	Victoria	43	18.9	7.71	17	13	4.6	1.2	0.31	5.19	-4.91	CRD
WAR-03-02	CRD	52	16.9	7.95	17	15	4.5	1.1	<0.2	5.77	-6.73	CRD

Table D-2: Source Sampling Program (Phase 2 - February Sampling)

Sample ID	Distribution Area	Total Dissolved Solids (mg/L)	Temperature deg C	Field pH s.u.	Alkalinity as $CaCO_3$ mg/L	Ca as $CaCO_3$ mg/L	Cl mg/L	SO_4 mg/L	Total Lead (Pb) ug/L	Total Copper (Cu) ug/L	AWWA Model CCPP	Sampling Performed By
SOOKE-KWL-2	CRD	40	7.1	8.20	13	11.15	6.2	<1.0	<0.2	0.83	-4.48	KWL
SOOKE-KWL-3	CRD	40	8.1	7.64	13	11.43	5.4	<1.0	<0.2	0.94	-5.46	KWL
SOOKE-KWL-4a	CRD	38	11.1	7.85	13	11.95	5.7	<1.0	<0.2	1.75	-4.80	KWL
SOOKE-KWL-4b	CRD	38	11.2	7.83	13	11.78	5.6	<1.0	<0.2	1.69	-4.87	KWL
SOOKE-KWL-1	CRD	40	7.1	8.20	13	11.15	6.2	<1.0	<0.2	1.02	-4.29	KWL
CRR-01-02	CRD	34	6.7	7.20	13	11.93	5.9	<1.0	<0.2		-7.88	CRD
SIR-01-03 [2]	CRD	42	6.6	8.00	13	13.25	6.7	<1.0	<0.2		-4.36	CRD
SOK-ES-01	CRD	28	8.2	8.10	13	11.45	5.4	<1.0	<0.2		-4.41	CRD
SOK-ES-02	CRD	32	7.4	7.60	12	11.48	6.5	<1.0	1.25		-5.45	CRD
SOK-ES-03	CRD	32	7.0	8.00	13	11.95	5.3	1.6	0.4		-4.50	CRD
SOK-SS-02	CRD	30	7.8	7.30	11	13.33	6.9	<1.0	0.33		-6.35	CRD
SOK-SS-02_DUP	CRD	42	7.8	7.30	11	13.33	7	1.1	0.33		-6.43	CRD
SOK-SA-02		26	8.0	7.70	14	11.40	6.3	<1.0	<0.2		-5.20	CRD
SOK-SA-02 (DUP)		30	8.0	7.70	13	11.35	5.9	<1.0	<0.2		-5.20	CRD
SOK-WS-02		34	8.1	7.60	14	12.50	5.5	1	<0.2		-5.42	CRD
HRR-02-01		48	6.0	7.50	12	12.23	6.5	<1.0	<0.2		-5.86	CRD
SOK-SV-03		38	7.0	7.50	13	11.15	5.4	<1.0	<0.2		-6.04	CRD
SOK-SS-01		42	7.5	7.30	12	13.43	6.9	<1.0	5.24		-6.63	CRD
SOP-RA-01		32	6.5	7.50	11	10.85	2.7	<1.0	<0.2		-5.86	CRD
SOP-TR-02		28	6.5	7.60	12	10.78	5.5	1.1	<0.2		-5.56	CRD
SRR-02-02		36	6.5	7.60	13	11.25	6.6	<1.0	<0.2		-5.62	CRD
SOK-BR-05		44	6.8	7.30	12	11.63	6.7	<1.0	<0.2		-6.95	CRD
HER-CD-02 [2]		38	7.0	7.30	12	11.50	5.6	<1.0	<0.2		-6.92	CRD
SOK-JM-01		32	8.1	7.50	13	11.93	5.8	<1.0	0.22		-5.82	CRD
HER-CB-02 [1]		28	6.9	7.30	13	11.18	5.7	1.1	<0.2		-7.11	CRD
HER-CB-02 (DUP) [1]		38	6.9	7.30	13	11.18	5.5	<1.0	<0.2		-7.18	CRD
SRR-01-02		32	6.3	7.60	13	11.35	6	<1.0	<0.2		-5.58	CRD

1. Sample only appears in winter sampling.
2. Sample ID discrepancy between summer & winter; closest sample ID match was selected.

Appendix D - Water Sampling and Corrosion Analysis Summary Tables

Table D-3: Source Sampling Program - Private

Identifier		First Draw		30 MS				Survey Data					
Sample ID	Region	Total Lead (Pb) µg/L	Total Copper (Cu) µg/L	First Bottle (Pb) µg/L	Second Bottle (Pb) µg/L	Average Total Lead (Pb) µg/L	Total Copper (Cu) µg/L	How old is this house?	Do you think that you have a lead service line?	What kind of plumbing is in this house?	Is the plumbing original to the house or has it been replaced?	Year replaced	How old is the faucet where you collected the sample?
001	COL	0.79	164	0.1	0.1	0.1	38.4	1962 to 1971	I don't know	Copper	Yes	0	Older than 2013
002	COL	1.2	156	0.44	0.35	0.4	66.1	1952 to 1961	No	Copper	I don't know	0	Newer than 2013
003	COL	0.4	20.3	0.21	0.1	0.1	10.2	1962 to 1971	I don't know	Both	Most Replaced	0	Newer than 2013
004	ESQ	3.1	532	0.36	0.2	0.28	146	1922 to 1941	No	Copper	No	0	Older than 2013
005	ESQ	0.57	202	0.28	0.39	0.33	76.7	1942 to 1951	No	Copper	I don't know	0	Newer than 2013
006	ESQ	0.98	122	0.71	0.27	0.49	56	1942 to 1951	No	Copper	No	0	Older than 2013
007	ESQ	1.3	123	0.25	0.26	0.26	13.9	1922 to 1941	No	Plastic	Yes	2013	Newer than 2013
008	ESQ	0.48	87.8	0.1	0.24	0.1	45.2	1942 to 1951	No	Both	Yes	2006	Older than 2013
009	ESQ	5.8	235	3.2	2.1	2.6	123	1987 to 2015	No	Both	Yes	0	Newer than 2013
010	ESQ	1.2	54.3	0.52	0.51	0.52	22.7	1922 to 1941	I don't know	Plastic	Yes	~2005	I don't know
011	ESQ	0.88	32.4	0.78	1.1	0.96	49.1	1972 to 1986	No	Plastic	Yes	2014	Newer than 2013
012	ESQ	0.83	171	0.59	0.1	0.29	82.4	1922 to 1941	No	Copper	No	0	Newer than 2013
013	ESQ	0.73	68.5	0.1	0.21	0.1	84.7	Newer than 2015	No	Plastic	No	0	Newer than 2013
014	ESQ	0.87	20	0.35	0.3	0.33	13.3	1987 to 2015	No	Plastic	No	0	Older than 2013
015	ESQ	0.46	92.6	2.2	0.52	1.4	0	1922 to 1941	I don't know	Copper	Yes	0	Older than 2013
016	LAN	3.6	133	2.2	0.78	1.5	133	1952 to 1961	I don't know	I don't know	I don't know	0	Newer than 2013
017	LAN	0.48	38.8	0.31	0.31	0.31	22.6	1987 to 2015	I don't know	Plastic	No	0	Newer than 2013
018	LAN	0.85	282	0.39	0.34	0.37	140	1987 to 2015	I don't know	Copper	I don't know	0	Newer than 2013
019	LAN	0.58	31.4	0.1	0.1	0.1	12.1	1987 to 2015	No	Copper	Yes	0	Newer than 2013
020	LAN	0.27	47.3	0.1	0.1	0.1	22.8	1987 to 2015	I don't know	I don't know	Yes	0	Older than 2013
021	OAK	0.86	123	0.78	0.75	0.77	63.4	1942 to 1951	I don't know	Copper	Some Replaced	2019 - 2020	Newer than 2013
022	OAK	0.73	239	0.39	0.24	0.32	86.1	1962 to 1971	No	Copper	No	0	Newer than 2013
023	OAK	0.53	60.4	0.35	0.22	0.29	34.4	Older than 1921	No	Both	Yes	No Idea	Newer than 2013
024	OAK	0.28	15.8	0.1	0.1	0.1	15.9	Newer than 2015	No	Plastic	Yes	0	Newer than 2013
025	OAK	0.39	98.8	0.24	0.24	0.24	95.4	1942 to 1951	N/A	Copper	I don't know	0	Older than 2013
026	OAK	0.85	337	0.34	0.35	0.34	143	1942 to 1951	Yes	Copper	Yes	0	Newer than 2013
027	OAK	0.71	34.6	0.28	0.21	0.25	46.5	1922 to 1941	I don't know	Plastic	Yes	0	Older than 2013
028	OAK	1.3	303	1.9	1.5	1.7	184	1972 to 1986	No	Copper	Yes	0	Older than 2013
029	OAK	1.2	161	0.24	0.1	0.1	35.4	N/A	N/A	N/A	N/A	0	N/A
030	OAK	0.72	82.2	0.29	0.32	0.31	36.9	1942 to 1951	I don't know	I don't know	I don't know	0	Older than 2013
031	OAK	0.96	64.1	0.32	0.1	0.1	26.9	1922 to 1941	I don't know	Both	Yes	1984 & 2009?	Older than 2013
032	OAK	0.53	193	0.1	0.1	0.1	62.1	1942 to 1951	I don't know	Both	Some Replaced	0	Older than 2013
033	OAK	0.57	312	0.1	0.1	0.1	97.5	Older than 1921	I don't know	Copper	Some Replaced	0	Older than 2013
034	OAK	0.74	152	0.22	0.1	0.1	46.4	1942 to 1951	I don't know	I don't know	I don't know	0	Older than 2013
035	OAK	1.1	131	0.37	0.45	0.41	78	1922 to 1941	I don't know	I don't know	I don't know	0	I don't know

Appendix D - Water Sampling and Corrosion Analysis Summary Tables

Table D-3: Source Sampling Program - Private

Identifier		First Draw		30 MS				Survey Data					
Sample ID	Region	Total Lead (Pb) µg/L	Total Copper (Cu) µg/L	First Bottle (Pb) µg/L	Second Bottle (Pb) µg/L	Average Total Lead (Pb) µg/L	Total Copper (Cu) µg/L	How old is this house?	Do you think that you have a lead service line?	What kind of plumbing is in this house?	Is the plumbing original to the house or has it been replaced?	Year replaced	How old is the faucet where you collected the sample?
036	OAK	0.63	125	0.22	0.1	0.1	42.2	Older than 1921	I don't know	Both	I don't know	0	Older than 2013
037	OAK	1.4	27.8	0.33	0.45	0.39	12.8	1922 to 1941	No	Plastic	Yes	0	Newer than 2013
038	SAA	0.3	35.5	0.45	0.32	0.39	20.2	1987 to 2015	I don't know	I don't know	Yes	0	I don't know
039	SAA	1.6	282	0.51	1.1	0.8	84.1	1972 to 1986	I don't know	Copper	Yes	0	Newer than 2013
040	SAA	0.1	2.53	0.24	0.38	0.31	9.63	1952 to 1961	I don't know	Copper	0	0	0
041	SAA	1.8	209	0.73	1.4	1.1	72.5	1972 to 1986	No	Both	Yes	0	Older than 2013
042	SAA	1.1	50.7	0.35	0.2	0.28	15.2	1987 to 2015	No	Plastic	No	0	Newer than 2013
043	SAA	29	438	9.5	3.6	6.5	157	1987 to 2015	No	Copper	No	0	I don't know
044	SAA	1.2	162	0.3	0.55	0.43	58	1962 to 1971	I don't know	I don't know	Yes	2020	Newer than 2013
045	SAA	5.6	166	1.4	0.49	0.96	49	1952 to 1961	No	Both	Yes	2005	Newer than 2013
046	SAA	1	21.1	0.37	0.47	0.42	12.1	1987 to 2015	No	Plastic	Yes	0	I don't know
047	SAA	2.1	83.4	0.73	0.37	0.55	50	1952 to 1961	I don't know	Both	Yes	~2000	Newer than 2013
048	SAA	0.47	264	0.1	0.1	0.1	77	1952 to 1961	Yes	Copper	Yes	2019 & 2020	Newer than 2013
049	SAA	0.56	399	0.1	0.1	0.1	108	1952 to 1961	No	Copper	No	0	Older than 2013
050	SAA	0.67	25.9	0.1	0.22	0.1	8.12	1952 to 1961	No	Copper	No	0	Newer than 2013
051	SAA	1.2	153	0.59	0.1	0.3	80.8	1952 to 1961	I don't know	Copper	No	0	Newer than 2013
052	SAA	0.75	26.3	0.21	0.29	0.25	11.9	1952 to 1961	No	Both	No	0	Older than 2013
053	SAA	0.56	183	0.31	0.1	0.1	57.2	N/A	N/A	N/A	N/A	0	N/A
054	SAA	0.43	214	0.1	0.21	0.1	77.5	1962 to 1971	I don't know	Copper	No	0	Older than 2013
055	SAA	1.6	313	0.86	0.5	0.68	107	1952 to 1961	I don't know	Copper	Yes	0	Older than 2013
056	SAA	3.3	174	0.3	0.23	0.27	63.9	1972 to 1986	I don't know	Copper	No	0	Older than 2013
057	SAA	0.89	260	0.31	0.3	0.31	98.7	1952 to 1961	No	Both	I don't know	0	Older than 2013
058	SAA	1	245	0.29	0.22	0.26	30.8	1972 to 1986	I don't know	Copper	Some Replaced	2010	Newer than 2013
059	SAA	0.79	187	0.24	0.1	0.1	61.9	1972 to 1986	I don't know	Copper	Yes	0	Older than 2013
060	SAA	0.26	31	0.1	0.28	0.1	9.97	Newer than 2015	Yes	Plastic	Yes	0	Newer than 2013
061	SAA	1.1	139	0.3	0.44	0.37	44.8	1972 to 1986	I don't know	I don't know	I don't know	0	Older than 2013
062	SAA	0.83	211	0.1	0.1	0.1	16.7	1972 to 1986	No	Copper	Yes	0	Newer than 2013
063	SAA	0.26	8.65	0.1	0.1	0.1	4.15	1987 to 2015	I don't know	Plastic	Yes	0	Newer than 2013
064	SAA	0.81	126	0.1	0.61	0.3	15.4	1972 to 1986	Yes	Copper	Yes	0	Newer than 2013
065	SOO	1.5	51.8	0.36	0.29	0.32	11.9	1987 to 2015	No	Plastic	No	0	Newer than 2013
066	SOO	0.4	255	0.1	0.1	0.1	113	1962 to 1971	No	Both	I don't know	0	Newer than 2013
067	SOO	1.5	334	0.47	0.33	0.4	96	1972 to 1986	No	Both	Yes	2017	Older than 2013
068	SOO	1	61.9	0.26	0.3	0.28	19.6	Newer than 2015	No	Both	No	0	Newer than 2013
069	SOO	2	191	0.54	0.3	0.42	53.2	1972 to 1986	I don't know	0	Yes	0	Older than 2013
070	SOO	0.38	76.6	0.24	0.1	0.1	27	1987 to 2015	No	Copper	Yes	0	Newer than 2013

Appendix D - Water Sampling and Corrosion Analysis Summary Tables

Table D-3: Source Sampling Program - Private

Identifier		First Draw		30 MS				Survey Data					
Sample ID	Region	Total Lead (Pb) µg/L	Total Copper (Cu) µg/L	First Bottle (Pb) µg/L	Second Bottle (Pb) µg/L	Average Total Lead (Pb) µg/L	Total Copper (Cu) µg/L	How old is this house?	Do you think that you have a lead service line?	What kind of plumbing is in this house?	Is the plumbing original to the house or has it been replaced?	Year replaced	How old is the faucet where you collected the sample?
071	SOO	0.82	147	0.53	0.24	0.39	84.9	1987 to 2015	No	Copper	No	0	Newer than 2013
072	SOO	0.51	137	0.26	0.31	0.28	77.7	1972 to 1986	I don't know	Plastic	I don't know	0	Newer than 2013
073	SOO	0.25	88.1	0.62	0.24	0.43	98.2	1962 to 1971	No	Copper	Yes	0	Newer than 2013
074	SOO	0.64	46.9	0.23	0.1	0.1	15.2	1922 to 1941	I don't know	I don't know	I don't know	0	I don't know
075	SOO	0.27	34.9	0.1	0.1	0.1	6.44	1987 to 2015	I don't know	Plastic	Some Replaced	0	Newer than 2013
076	VIC	0.65	51.5	0.24	0.1	0.1	24.3	1952 to 1961	I don't know	Both	Yes	2010	Older than 2013
077	VIC	0.1	32.7	0.1	0.9	0.45	33.5	1952 to 1961	I don't know	Copper	I don't know	0	Older than 2013
078	VIC	3.5	63.3	3.4	1.1	2.3	32	1942 to 1951	I don't know	I don't know	I don't know	0	Newer than 2013
079	VIC	1.9	52.5	0.32	0.37	0.34	23.1	1987 to 2015	I don't know	Copper	I don't know	0	Newer than 2013
080	VIC	0.56	97.8	0.22	0.1	0.1	65.7	1922 to 1941	N/A	Both	No	0	Older than 2013
081	VIC	0.44	381	0.1	0.1	0.1	108	1972 to 1986	I don't know	I don't know	I don't know	0	Older than 2013
082	VIC	1	151	0.45	0.35	0.4	52.7	1952 to 1961	No	Copper	I don't know	0	Older than 2013
083	VIC	1.7	301	0.64	0.34	0.49	135	1942 to 1951	No	Copper	I don't know	0	Older than 2013
084	VIC	0.87	87.1	1.2	0.45	0.82	113	Older than 1921	No	Copper	I don't know	0	Older than 2013
085	VIC	0.65	138	0.1	0.1	0.1	22.7	Older than 1921	No	Both	Yes	?	Newer than 2013
086	VIC	0.32	43.5	0.1	0.1	0.1	19.3	Older than 1921	No	Plastic	Yes	1995	Newer than 2013
087	VIC	0.93	150	0.53	0.27	0.4	64.3	1987 to 2015	I don't know	Plastic	I don't know	0	Older than 2013
088	VIC	0.58	12.6	0.1	0.93	0.46	4.57	1962 to 1971	No	Plastic	Yes	+/- 2010	I don't know
089	VIC	1.1	173	0.41	0.66	0.54	42.8	1972 to 1986	No	Copper	Yes	0	Newer than 2013
090	VIC	0.21	61.5	0.1	0.31	0.1	41.4	1987 to 2015	No	Both	No	0	Older than 2013
091	VIC	5.1	213	1.5	0.83	1.2	127	1952 to 1961	0	I don't know	I don't know	0	Older than 2013
092	VIC	0.51	86.9	0.2	0.1	0.1	46	1952 to 1961	No	Copper	Yes	2005?	Newer than 2013
093	VIC	0.62	187	0.1	0.29	0.1	45.6	Older than 1921	No	Copper	Yes	1959	Newer than 2013
094	VIC	0.71	104	0.27	0.1	0.1	36.8	1972 to 1986	No	Both	Some Replaced	0	Newer than 2013
095	VIC	0.45	68.9	0.22	0.21	0.22	31	Older than 1921	I don't know	Both	Some Replaced	1988 & 1994	Older than 2013
096	VIC	0.37	182	0.1	0.1	0.1	57.4	1922 to 1941	I don't know	I don't know	I don't know	0	Older than 2013
097	VIC	0.49	90.9	0.53	0.3	0.42	74.6	1987 to 2015	No	I don't know	Yes	0	Older than 2013
098	VIC	1.1	56.7	0.53	0.32	0.43	27.1	1942 to 1951	No	Both	I don't know	0	I don't know
099	VIC	0.96	167	0.37	0.1	0.1	61.8	1952 to 1961	No	Both	Yes	2003 & 2017	Newer than 2013
100	VIC	1.8	77.6	1.3	0.54	0.93	42.5	1987 to 2015	I don't know	I don't know	I don't know	0	Newer than 2013
101	VIC	1.7	198	0.55	0.23	0.39	63.3	1952 to 1961	I don't know	Both	Some Replaced	2015	Newer than 2013
102	VIE	0.3	358	0.2	0.22	0.21	280	N/A	N/A	N/A	N/A	0	N/A
103	VIE	1.2	35.9	0.42	0.25	0.33	15.9	1987 to 2015	No	Plastic	No	0	Older than 2013
104	VIE	0.79	177	0.56	0.71	0.64	89.8	1922 to 1941	No	Both	I don't know	0	Older than 2013

Appendix E

Lead and Copper Guidance Document Summary Table

Appendix E - Lead and Copper Guidance Document Summary Table

EGuideline Document (Issue or Latest Revision Date, Issuing Body)	Sampling Requirements[2]	Thresholds/action limits	Required/ Recommended actions	Comments
Guidelines on Evaluating and Mitigating Lead in Drinking Water Supplies, Schools, Daycares and Other Buildings (April 2019, BC Ministry of Health, Health Protection Branch)	**To evaluate if Centralized Water System Corrosion Control is Appropriate** (*Note – this is from the 2009 Guidance on Controlling Corrosion in Drinking Water Distribution Systems from Health Canada*): First Tier: Sample to establish whether the community water system has corrosion concerns. - 6 hour stagnation, then collect 1L of water. - If more than 10% of the sampled residential sites have a lead concentration greater than the action level of 15 µg/L, go to second tier. Note that this action level is different than the MAC for lead, as this is a measure of corrosion risk, not health risk. Second Tier: For systems with corrosion concerns, this will provide detailed information about how lead is typically entering the drinking water, and will help plan mitigation measures that most appropriately target the sources found. - Sampling is conducted at 10% of the sites sampled in Tier 1, specifically, the sites in which the highest lead concentrations were measured. - Four consecutive 1L samples should be taken at a consumer's cold drinking water tap after a 6 hour stagnation period. This will provide a detailed profile of the sources of lead from within each building (e.g., the faucet, plumbing (lead in solder, brass and bronze fittings, brass water meters, etc.) and the lead service line. - Each sample should be analyzed separately to determine where the highest lead concentrations come from. Note: Number of recommended sites for a system > 100 000 people = 100 **To Evaluate Health Risk at the Community Level**: either Random Daytime Samples (RDT) or Thirty Minute Stagnation (30MS) samples should be taken at multiple points of consumption. After selection of the taps being sampled, either: a) For RDT programs, the first 1 litre of water, from each tap is sampled without flushing at random times throughout the day, or b) for 30MS programs, flush taps for 5 minutes, let stagnate for 30 minutes, then take two consecutive 1-litre samples.	**To determine whether evaluation is required**: Water supplies with one or more of the following water chemistry characteristics should be prioritized for further evaluation of potential lead risks: - Lower pH (<7) - Low alkalinity (<30 mg/L) - Low hardness (<60 mg/L as $CaCO_3$) **For evaluation of whether a centralized water system corrosion control system is appropriate**: Where the sampling program shows more than 10% of the sampled residential sites 6-hr stagnation samples have a lead concentration greater than the action level of 15 µg/L the water supply system should consider mitigation programs. **For evaluation of health risk at the community level**: Where averaged samples (across all the samples collected) exceed the MAC, the Health Authority should be engaged with the water supplier to further investigate and plan mitigation options.	To assess corrosion risks: - Screen water for indicators of corrosivity - Survey the prevalence of lead service lines in the community - Survey the prevalence of buildings with plumbing and fixtures with elevated lead content; and - Implement testing, including surveys of representative samples taken at consumers' taps to evaluate impact of the corrosivity of the water supply in the community Results of assessment programs should be reviewed with health authorities and, if necessary, plan and implement corrosion control program to minimize leaching. Risk reduction recommendations: - Communicate results of testing programs to consumers and inform them of appropriate mitigation measures (i.e. flushing, lead service line replacement, domestic plumbing component replacement) - Implement appropriate corrective measures (i.e., replacing lead service lines, adjusting pH and alkalinity, adding corrosion inhibitors, remove lead-containing components, flushing/swabbing/pigging of water mains to reduce accumulated sediment and biofilms, and maintain disinfectant residual to avoid reducing conditions and control biofilms.	The *Drinking Water Protection Act* (DWPA) and *Drinking Water Protection Regulation* (DWPR) require that water suppliers deliver potable water to customers, but only define potability in terms of microbiological parameters. Only the governing health authority can require water suppliers to take action to ensure potability **beyond the point of delivery** (i.e. after public side of water service). Health authorities can place conditions on operating permits that require water supplier to adjust chemistry or treat for other parameters that exceed the *Guidelines for Canadian Drinking Water Quality* (GCDWQ). Centralized mitigation alone reduces risk, but does not achieve complete lead reduction. Communication and elimination of lead sources are also essential for minimizing lead risk. Bench-scale and pilot testing should be carried out for any proposed change to distribution water chemistry.

Appendix E - Lead and Copper Guidance Document Summary Table

EGuideline Document (Issue or Latest Revision Date, Issuing Body)	Sampling Requirements[2]	Thresholds/action limits	Required/ Recommended actions	Comments
Public School Policy – Testing Lead Content in Drinking Water of School Facilities (April 1, 2019, BC Ministry of Health)	School districts are to work with their Regional Health Authority to determine a testing program. The testing procedure and number of samples taken at each facility shall be determined in collaboration with the Regional Health Authority, and be based on risk School districts must conduct lead content testing in drinking water if the facility is being regularly utilized by students and/or staff. School districts must complete lead content testing on all school facilities once every 3 years. Therefore a minimum of 1/3 (or 33%) of the school facilities in a school district's inventory must be tested each year and school districts must submit all of their testing results annually to the ministry by March 30.	> 0.005 mg/L	If sample results reveal lead levels above the maximum acceptable concentration of 0.005 mg/L as stated from the Guidelines for Canadian Drinking Water Quality by Health Canada, the school district in consultation with their Regional Health Authority must commence daily flushing immediately, or deactivate and place a "Not in Use" sign on the water source. Should testing result in elevated levels of lead, the school district must immediately inform the Ministry of the issue. School districts shall collaboratively work with their Regional Health Authority to communicate the results of testing lead content in drinking water with parents, students and staff.	
Guidelines for Canadian Drinking Water Quality – Guideline Technical Document – Lead (March 2019, Health Canada)	**Residential Dwellings**: RDT sampling: A 1 L sample should be collected randomly during the day from a drinking water tap in each of the residences. Samples should be collected without prior flushing; no stagnation period is prescribed, to better reflect consumer use. 30MS sampling: The tap should be flushed for 5 minutes, allowed to stand for a 30-minute stagnation period, during which time no water should be drawn from any outlet within the residence (including flushing of toilets). Two 1 L samples should then be collected at a medium to high flow rate (greater than 5 L/minute). The lead concentration is determined by averaging the results from the two samples. **Schools, Multi-dwelling Residences (>6 residences) and Large Buildings**: RDT sampling: Two 125mL samples should be collected at a medium to high flow rate without removing the aerator. For schools and daycares, sampling should be conducted at least once per year at all of the possible points of consumption (drinking and food preparation). In multi-dwelling and large buildings, all drinking water founds and a portion of cold water taps shall be samples with a priority given to sites suspected or known to have full or partial lead services.	> 0.005 mg/L	No required actions are listed in the guideline document. It states that 'strategies for minimizing lead at the tap should focus on controlling corrosion and removing lead-containing components' Notes that removal of lead service lines is likely the most effective and permanent solution for lead exposure reduction. Additionally, replacement of lead-bearing fittings can significantly contribute to reductions in lead exposure. It is recommended that utilities should encourage consumers to replace their portion of the lead service line when the utility is undertaking to replace the public portion. Flushing and cleaning of aerators and potential use of point-of-use devices following replacement is recommended to mitigate short-term increases in lead associated with the removal process. Also identified corrosion control through pH and alkalinity adjustment and the use of corrosion inhibitors as an appropriate mitigation methodology. If water treatment devices are to be employed at the building level, these are recommended to be NSF/ANSI certified. Relevant standards are NSF/ANSI Standard 53 for systems generally based on activated carbon adsorption technology, NSF/ANSI Standard 58 for Reverse Osmosis Drinking Water Treatment Systems, and NSF/ANSI Standard 62 for Distillation Drinking Water Treatment Systems.	Notes that lead service lines typically contribute 50 – 75% of total lead at the tap after extended stagnation times.

Appendix E - Lead and Copper Guidance Document Summary Table

EGuideline Document (Issue or Latest Revision Date, Issuing Body)	Sampling Requirements[2]	Thresholds/action limits	Required/ Recommended actions	Comments
Guidance on Controlling Corrosion in Drinking Water Distribution Systems (June 2009, Health Canada)	**Residential Sites**: Option 1 (two-tier protocol): - Sample after stagnation period of at least 6hr (a minimum of 50% of the sampling sites should target lead service line residents) and collect 1L sample without removing aerator. - If more than 10% of sites from Tier 1 sampling exceeded 0.015mg/L samples are to be collected from 10% of sites where the highest lead concentrations were measured. Four consecutive 1L samples are taken at the cold water tap (without removing aerator) after the water has been stagnant for a minimum of 6 hr. Follow-up sampling can be used to assess effectiveness of any corrosion control programs. Once corrosion control has been optimized, annual monitoring can be resumed. Option 2 (protocol for residential sites with lead service lines). *Note - This is only to be used where a 6-hr stagnation time is not practical or regulatory obligations restrict the use of the two-tier approach.* Four consecutive1-L samples are taken at the consumer's cold drinking water tap (without removing the aerator) after the water has been fully flushed for 5 min and then left to stagnate for 30 min. Each 1-L sample is analyzed individually to obtain a profile of lead contributions from the faucet, plumbing and a portion or all of the lead service line. ***Lead levels should be monitored at the tap at least once a year. Suggested minimum number of monitoring sites for a population > 100 000 is 100.*** **Non-residential sites** two-tier protocol Plumbing profile is to be developed to identify potential sources of lead and areas of stagnation and to assess potential for lead contamination at each point of consumption (fountains, cold water outlets). A sampling plan is then to be developed.	**Residential Sites**: For Option 1 (two-tier) action level of 0.015mg/L in > 10% of samples triggers tier 2 sampling and additional measures (see next column). For Option 2 protocol action level of 0.01mg/L (average of 4 samples) in > 10% of samples triggers tier 2 sampling and additional measures (see next column). **Non-residential Sites**: Concentrations exceeding 0.02mg/L (lead action level) triggers tier 2 protocol and additional measures (see next column) ***Note: at the time this document was drafted, the Health Canada MAC was 0.01mg/L***	**Residential**: When more than 10% of the sites: - in the Option 1 (two-tier) protocol have a lead concentration greater than 0.015 mg/L (lead action level); or - in the Option 2 protocol have an average lead concentration from the four samples collected greater than 0.01mg/L it is recommended that utilities: 1. Initiate a public education program to encourage consumers to flush the water after a period of stagnation while appropriate corrective measures are being assessed or undertaken. Flushing should be conducted so that any water that has been in contact with lead present in faucets, fittings and the associated solders as well as the lead service line following a period of stagnation is removed. 2. Conduct additional sampling (as outlined in the Tier 2 sampling protocol) at 10% of the sites sampled in Tier 1 at which the highest lead concentrations (above 0.015 mg/L) were observed. 3. Communicate the results of the testing to the consumers and inform them of the appropriate measures that they can take to reduce their exposure to lead. Corrective measures that consumers can take may include any or a combination of the following: - flushing the system; - replacing their portion of the lead service line; - replacing brass fittings or in-line devices; and/or - using certified drinking water treatment devices. 4. Implement appropriate corrective measures to control corrosion in the system. Results of the Tier 2 sampling should be used to help determine the best corrective measures for the system, which may include any or a combination of the following: - replacing lead service lines; - adjusting the pH and alkalinity; - adjusting the pH and adding corrosion inhibitors; and/or - replacing brass fittings or in-line devices. 5. Encourage homeowners to periodically clean debris from the screens or aerators of drinking water outlets. If a substantial amount of debris is removed from the aerator or screen, authorities may want to retest the water from these outlets following the same protocol. If results of the retesting show lead concentrations below 0.015 mg/L, utilities should investigate whether particulate lead may be contributing significantly to elevated lead levels and whether regular cleaning of the aerator or screen is an appropriate corrective measure. If less than 10% of sites have lead concentrations above 0.015 mg/L for the Option 1 protocol or 0.010mg/L for the Option 2 protocol, utilities should provide consumers in residences with lead concentrations above 0.010 mg/L with information on methods to reduce their exposure to lead (such as those listed #3 above). It is also recommended that utilities conduct follow-up sampling for these sites to assess the effectiveness of the corrective measures undertaken by consumers.	The recommended sampling protocol found in this guidance uses >6h stagnation times to capture the highest levels of lead to provide the basis for a system-wide assessment of the corrosion control efficacy. When lead service lines are replaced, especially when there is only partial lead service line replacement, extensive initial flushing by the consumer should be encouraged, and weekly or biweekly sampling should be conducted until lead levels stabilize. Once it has been determined that corrosion control is optimized, annual monitoring can be resumed

Appendix E - Lead and Copper Guidance Document Summary Table

EGuideline Document (Issue or Latest Revision Date, Issuing Body)	Sampling Requirements[2]	Thresholds/action limits	Required/ Recommended actions	Comments
Guidance on Controlling Corrosion in Drinking Water Distribution Systems (June 2009, Health Canada)	Tier 1 - Water main samples to be collected from faucet close to service line following 5 min flush. - First draw 250mL sample at all locations identified in sampling plan (stagnant for min 8hr and max 24 hr) without removing aerator. Tier 2 - At those water fountains and cold drinking water outlets with lead concentrations that exceeded 0.020 mg/L for Tier 1, a second 250-mL flushed sample is taken after the water has been stagnant for a minimum of 8 h (but generally not more than 24 h) and then flushed for 30 s. - When the lead concentration in any of these second samples exceeds 0.020 mg/L (lead action level), corrective measures should be undertaken immediately. ***For schools, lead levels should be monitored at the tap so that all sites identified in the sampling plan have been tested within 5-7 year period.*** ***For other non-residential buildings, every priority site should be sampled in the first year.***		**Non-residential**: When concentrations at any of the outlets sampled in Tier 1 measure >0.02mg/L: 1. Conduct additional sampling per Tier 2 protocol 2. Implement interim corrective measures immediately to reduce the exposure of occupants to lead in first-draw water. These measures may include any or a combination of the following: - cleaning debris from the screens or aerators of the outlet; - flushing the plumbing system following periods of stagnation; - taking the outlet out of service; - using certified drinking water treatment devices; and - supplying an alternative water supply. 3. Educate the occupants (e.g., teachers, day care providers, students) of the building and other interested parties (e.g., parents, occupational health and safety committees) on the sampling results and the interim measures that are being undertaken, as well as the plans for additional sampling. 4. Where a substantial amount of debris was removed from the aerator or screen, authorities may want to retest the water from these outlets following the same protocol. If results of the retesting show lead concentrations below 0.020 mg/L authorities should investigate whether particulate lead may be contributing significantly to elevated lead levels and whether regular cleaning of the aerator or screen should be implemented as part of the maintenance or flushing program. When concentrations in any of the samples collected in Tier 2 after flushing for 30s exceeds 0.02mg/L: 1. Implement corrective measures immediately (i.e. routine 5 min flushing at the beginning of the day, removing outlet from service, use of certified treatment device or providing alternate supply). 2. Educate the occupants of the building (e.g., teachers, day care providers, students) and other interested parties (e.g., parents, occupational health and safety committees) on the sampling results and the interim and long-term corrective measures that are being undertaken. 3. Compare the Tier 1 and Tier 2 sampling results to determine whether the source of the lead contamination is the fitting, fixture or internal plumbing. If the results of the Tier 1 and Tier 2 sampling both indicate lead contamination, conduct additional sampling from the interior plumbing within the building to further determine the sources of lead contamination. 4. Flush the outlets. 5. Replace the outlets, fountains or pipes. 6. Remove the outlets from service. 7. Replace leaded brass fittings or in-line components. 8. Work collaboratively with the water supplier to ensure that the water delivered to the building is not aggressive. 9. Install drinking water treatment devices. Distribute an alternative water supply.	

Appendix E - Lead and Copper Guidance Document Summary Table

EGuideline Document (Issue or Latest Revision Date, Issuing Body)	Sampling Requirements[2]	Thresholds/action limits	Required/ Recommended actions	Comments
Lead and Copper Rule (Effective December 16, 2021, Environmental Protection Agency (Compliance date October 16, 2024))	All samples must be collected from sites served by Lead Service Lines (LSL)s, if available. Sampling instructions that include recommendations for aerator cleaning/removal and pre-stagnation flushing prior to sample collection are prohibited. **Homes with LSL**: Fifth-liter sample is to be collected in a wide-mouth bottle after water has sat stagnant for a minimum of 6 hours. Sampler must draw four liters of water before collecting a test sample so that the water is more likely to come from the lead service line. **Homes without LSL**: First-liter sample to be collected in wide mouth bottle after water has sat stagnant for a minimum of 6 hours. **Monitoring Frequency**: Lead monitoring schedule is based on P90 level for systems serving a community > 100K as follows: - P90 >15 µg/L: Semi-annually at 100 sites. - P90 between 10 and 15 µg/L: Annually at 100 sites. - P90 ≤10 µg/L: o Annually at 100 sites and triennially at 50 sites when P90 is less than 0.005mg/L for 2 consecutive 6-month monitoring periods. o Every 9 years based on current rule requirements for a 9-year monitoring waiver applies for systems serving less than 3,300. **Schools and Child Care Facilities:** - Systems must conduct sampling at 20% of elementary schools and 20% of childcare facilities per year and conduct sampling at secondary schools on request for 1 testing cycle (5 years) and conduct sampling on request of all schools and childcare facilities thereafter. - Sample results and public education must be provided to each sampled school/ childcare, primacy agency and local or state health department. - Excludes facilities built or replaced all plumbing after January 1, 2014.	**Action Level**: 90th percentile (P90) level above 15 µg/L for lead or 1.3 mg/L for copper. **Lead Trigger Level**: P90 level between 10 and 15 µg/L. Triggers additional planning, monitoring, and treatment requirements.	**Lead Service Line (LSL) Inventory**: LSL inventories must be developed by January 16, 2024 and provided to the public. Occupants of homes with LSLs must be notified every year about their exposure risks and mitigation options. **LSL Replacements**: Above trigger level but below action level, systems are required to conduct LSL replacements at a goal rate approved by the state. Above the lead action level, systems must replace (full replacement) a minimum of 3% per year (based on 2-year rolling average) of the number of known or potential LSLs in the inventory at the time the action level exceedance occurs. Systems cannot end their replacement program until they demonstrate lead levels less than the action level for 2 years. **LSL Communications**: For all known LSLs, systems must provide awareness annually and replace the water-system owned portion of the LSL when the customer chooses to replace their customer-owned portion. **Corrosion Control Treatment (CCT)**: - Systems with P90 level between 10 and 15 µg/L: o No CCT: must conduct a CCT study if required by primary agency. o With CCT: must follow the steps for re-optimizing CCT, as specified in the rule. - Systems with P90 level >15 µg/L: o No CCT: must complete CCT installation regardless of their subsequent P90 levels. o With CCT: must re-optimize CCT. - CWSs serving ≤10,000 people and non-transient water systems (NTNCWSs) can select an option other than CCT to address lead. **Water Quality Parameters (WQP) Monitoring**: - Systems serving ≥50,000 people must conduct regular WQP monitoring at entry points and within the distribution system. - Systems serving ≤50,000 people must continue WQP monitoring until they no longer exceed lead and/or copper AL for two consecutive 6-month monitoring periods. - To qualify for reduced WQP distribution monitoring, P90 must be ≤10 µg/L and the system must meet its optimal water quality parameters.	These revised requirements provide greater and more effective protection of public health by reducing exposure to lead and copper in drinking water. The rule will better identify high levels of lead, improve the reliability of lead tap sampling results, strengthen corrosion control treatment requirements, expand consumer awareness and improve risk communication. This final rule requires, for the first time, community water systems to conduct lead-in-drinking water testing and public education in schools and childcare facilities. In addition, the rule will accelerate lead service line replacements by closing existing regulatory loopholes, propelling early action, and strengthening replacement requirements. Revised approach focuses on six key areas: 1) Identifying areas most impacted a. Lead service line inventory 2) Strengthening treatment requirements 3) Systematically replacing lead service lines 4) Increasing sampling reliability 5) Improving risk communication 6) Protecting children in schools **Corrosion Control Treatment**: *CCT Options*: Removes calcium hardness as an option and specifies any phosphate inhibitor must be orthophosphate. *Regulated WQPs*: Eliminates WQPs related to calcium hardness (i.e., calcium, conductivity, and temperature)

Appendix E - Lead and Copper Guidance Document Summary Table

EGuideline Document (Issue or Latest Revision Date, Issuing Body)	Sampling Requirements[2]	Thresholds/action limits	Required/ Recommended actions	Comments

Lead and Copper Rule
(Effective December 16, 2021, Environmental Protection Agency (Compliance date October 16, 2024))
	Water Quality Parameters:
	- For systems serving more than 50,000 people or systems serving less than 50,000 people during a monitoring period in which either action limit is exceeded.
	- WQP samples at taps are collected every 6 months.
	- WQPs at entry points to distribution system (EPTDS) are collected every 6 months prior to corrosion control treatment installation, then every 2 weeks
	- For large system (>100K) standard number of sampling sites is 25, reduced is 10.
			Find-and-Fix:
			If individual tap samples >15 µg/L, Find-and-fix steps:
			- Collect tap sample at the same tap sample site within 30 days.
			- For LSL, collect any liter or sample volume.
			- If LSL is not present, collect 1 liter first draw after stagnation.
			- For systems with CCT.
			  ○ Conduct WQP monitoring at or near the site >15 µg/L.
			  ○ Perform needed corrective action.
			- Document customer refusal or non-response after 2 attempts.
			Provide information to local public health officials.
			Public Education and Outreach:
			- CWSs must provide updated health effects language in all public education materials and the Consumer Confidence Report.
			  ○ Customers can contact the System to get public education materials translated in other languages.
			- All systems are required to include information on how to access the LSL inventory and how to access the results of all tap sampling in the Consumer Confidence Report.
			- Revises the mandatory health effects language to improve accuracy and clarity.
			- If P90 > AL:
			    ○ Systems must provide PE to customers
			    ○ about lead sources, health effects, measures to reduce lead exposure, and additional information sources.
			  ○ Systems must notify consumers of P90 > AL within 24 hours.
			- In addition, CWSs must:
			  ○ Deliver notice and educational materials to consumers during water-related work that could disturb LSLs.
			  ○ Provide information to local and state health agencies.
			  ○ Provide lead consumer notice to consumers whose individual tap sample is >15 µg/L as soon as practicable but no later than 3 days.
			Source Water Monitoring:
			- Primacy Agencies can waive continued source water monitoring if the:
			- System has already conducted source water monitoring for a previous P90 > AL;
			- primacy agency has determined that source water treatment is not required; and
			- System has not added any new water sources.
			Primacy Agency Reporting
			- All P90 values for all system sizes.
			- The current number of lead service lines and lead status unknown service lines for every water system.
			optimal corrosion control treatment (OCCT) status of all systems including primacy agency-specified optimal water quality parameters.	

Appendix E - Lead and Copper Guidance Document Summary Table

EGuideline Document (Issue or Latest Revision Date, Issuing Body)	Sampling Requirements[2]	Thresholds/action limits	Required/ Recommended actions	Comments
Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primacy Agencies and Public Water Systems (March 2016, US Environmental Protection Agency)	**Follow-up Lead & Copper Monitoring** - For a community of >100 000 must be conducted at 100 sites. **Follow-up Water Quality Monitoring**: One sample from each entry point at least once every two weeks for: - pH; - When alkalinity is adjusted, a reading of the dosage rate of the chemical used to adjust alkalinity and the concentration of alkalinity; and - When an inhibitor is used, a reading of the dosage rate of the inhibitor used and the concentration of orthophosphate or silicate (whichever is used). AND two sets of samples from a minimum of 25 sites (>50 recommended) during both consecutive 6-month monitoring periods for: - pH; - Alkalinity; - Calcium, when calcium carbonate stabilization is used; - Orthophosphate, when a phosphate-based inhibitor is used; and - Silica, when a silicate-based inhibitor is used.	90th percentile (P90) level above 15 µg/L for lead or 1.3 mg/L for copper. *Note: Document was prepared before LCR update so it only reference AL not Trigger Level*	When required by LCR, plan for and implement Corrosion Control Treatment as follows: - STEP 1. Review Water Quality Data and Other Information. - STEP 2. Evaluate Potential for Scaling. - STEP 3. Select One or More Treatment Option(s). - STEP 4. Identify Possible Limitations for Treatment Options. - STEP 5. Evaluate Feasibility and Cost. Systems performing corrosion control studies must use either pipe rig/loop tests, metal coupon tests, partial-system tests or analyses based on documented analogous treatments with other systems of similar size, water chemistry and distribution system configuration for their CCT study. Because there is less likelihood of truly analogous systems once the population served is more than 50,000 people, EPA recommends that these systems use one of the demonstration study tools (i.e., pipe rig/loop, metal coupon, or partial-system test) to meet CCT requirements.	Target pH should be 8.8 – 10 except for systems with lead service lines that are not using a corrosion inhibitor which should target 9.0 or greater. Orthophosphate treatment should target residual concentrations of 0.33 – 1.0 mg/L as P (1.0 to 3.0 mg/L as PO_4) at the tap when pH is in the rance of 7.2 to 7.8. In general, orthophosphate is more effective at low DIC (<10mg C/L) and pH is less important for lead control in low DIC waters. Passivation doses of 2-3x higher than target maintenance dose are sometimes used to build protective film quickly. Blended phosphate should contain a minimum orthophosphate concentration of 0.5mg/L as P (1.5 mg/L as PO_4) as a starting point for evaluation. It should be noted that phosphate-based corrosion inhibitors can increase phosphorous loading to the WWTP by 10 to 35%.

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Appendix F

Centralized Chemical Conditioning Concept Design

F Centralized Chemical Conditioning Concept Design

Understanding that the CRD may wish to pursue centralized chemical conditioning in the future, a concept design was developed with an associated Class D estimate to inform planning activities. However, as lead risk at the community level appears to be low, based on the private side testing results, it is recommended that centralized conditioning be considered as a long-term plan, to be integrated with water treatment plant upgrades (i.e., to a filtration facility) when the need arises. The outcomes of the following concept design can be used in that eventual planning; in the present context, they provide a benchmark for the concept and cost of immediate action.

The concept design considered the following:

1. Where should the facility or facilities be located?
2. What dosing chemical should be used and at what concentration?
3. How should the chemical(s) be managed and injected into the water?

F.1 Facility Locations

The CRD has two water treatment facilities: the Goldstream Water Treatment Plant (GWTP) and the Sooke River Road Water Treatment Plant(SRRWTP). These plants inject hypochlorite for primary disinfection then inject ammonia downstream. The GWTP injects hypochlorite at a central location then injects ammonia separately in Mains #4 and #5.

In order to avoid interfering with the current disinfection systems (especially as the ammonia will impact pH, causing a change to the water's corrosivity), it was assumed that corrosion control would be implemented downstream of the ammonia injection points on Main #4, Main #5 and Main #15 as illustrated in Figures F-1 and F-2.

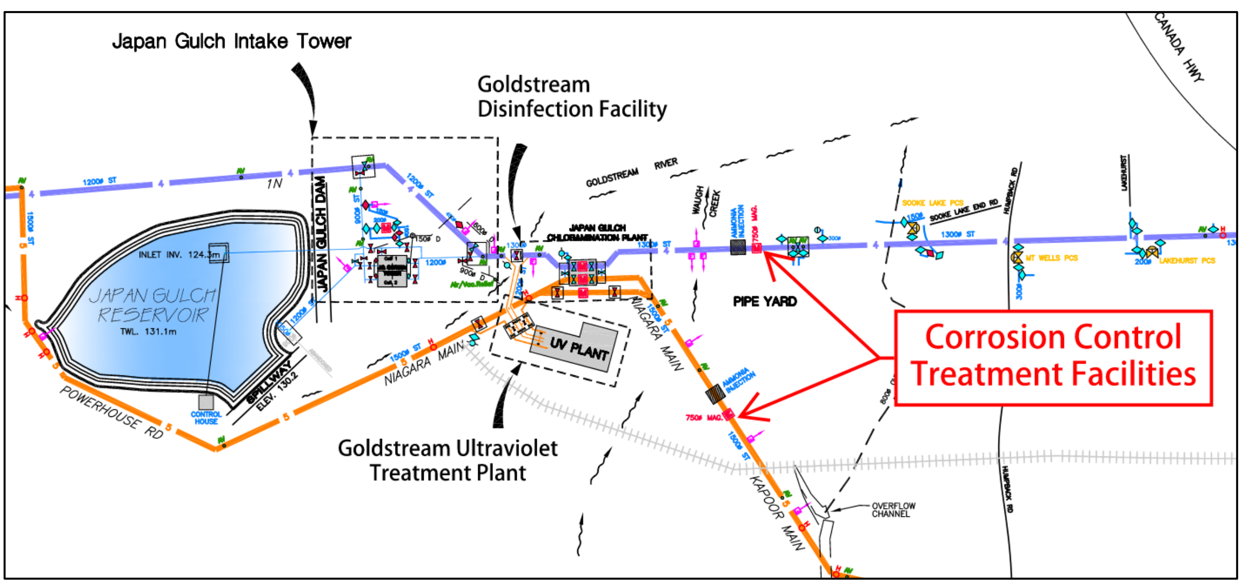

Figure F-1: Proposed Main #4 and Main #5 Corrosion Control Facility Locations

Appendix F - Centralized Chemical Conditioning Concept Design

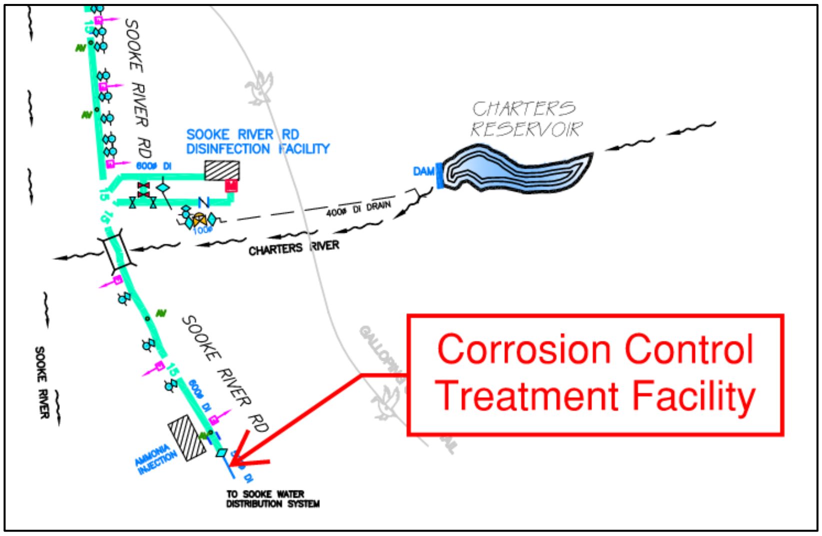

Figure F-2: Proposed Main #15 Corrosion Control Facility Location

It is likely that the CRD may instead wish to implement corrosion control at the primary disinfection facilities as part of a treatment plant upgrade/replacement (i.e., if filtration is required at some point in the future). The integration with other treatment processed and impact on ammonia injection would need to be considered as part of preliminary and detailed design.

F.2 Dosing Chemical and Target Concentration

There are many different options for centralized chemical conditioning including baking soda, soda ash, hydrated lime, potash, orthophosphate, and sodium silicates. Each chemical has its pros and cons including price, ease of use, and compatibility with water chemistry.

For the purposes of this study, *Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primacy Agencies and Public Water Systems* (US EPA, March 2016) was used to identify potential treatment chemicals and target pH. This guidance document leads the user through 5 steps to identify and evaluate treatment options:

1. Review Water Quality Data and Other Information.
2. Evaluation Potential for Scaling.
3. Select One or More Treatment Option(s).
4. Identify Possible Limitations for Treatment Options.
5. Evaluate Feasibility and Cost.

Following the protocols outlined in the US EPA document, the Dissolved Inorganic Carbon (DIC) of the water was first estimated based on post-treatment pH, alkalinity, total dissolved solids, and temperature. For the CRD treated water, the DIC was determined to range between 2 and 9 mg/L as Carbon. The calcium concentration was then determined by dividing the treated water hardness (as mg/L $CaCO_3$) by 2.5. For the CRD treated water, the carbon concentration was determined to range between 4.3 and 6.3 mg/L as Calcium. The saturation pH was then determined using the theoretical saturation pH for Calcium Carbonate Precipitation graph and was determined to range between 9.1 and 9.5 for the treated CRD water.

Appendix F - Centralized Chemical Conditioning Concept Design

Given that there is iron and manganese present in the treated water and the treated water pH ranges from 6.8 to 8.9, flow charts 3a and 3b were used to identify the following treatment chemicals as viable options for further consideration:

- Soda ash;
- Caustic soda; and
- Baking soda and blended phosphate.

For the purposes of this study, a concept design was to be developed based on a single conditioning chemical. If the CRD is to move ahead with centralized corrosion control the dosing chemical and dosing rate will need to be confirmed using loop and coupon tests. To develop a conservative concept design, soda ash was selected as the conditioning chemical for further consideration based on the following:

1. It is difficult to identify appropriate dosing rate for baking soda and blended phosphate due to uncertainties in blended phosphate composition and impact on pH. Additionally, the RTW model used to calculate CCPP earlier in the study could be used to identify an appropriated dosing rate for soda ash and/or caustic soda.
2. It is easier to control pH using soda ash than caustic soda in low alkalinity water.
3. Soda ash requires more equipment (make-down system, mixers, etc.) which would lead to a more conservative concept design.

The RTW model was then used to estimate the required dosing concentration to achieve a pH of 9 (this pH was identified in the US EPA document as a minimum target pH for systems with lead service lines that are not using a corrosion inhibitor). Given that the historical water chemistry in the three water mains varied slightly, the target soda ash dosing concentrations were slightly different for the three facilities as outlined in Table F-1.

Table F-1: Target Soda Ash Concentration to Achieve pH of 9

Facility	Target Soda Ash Concentration (mg/L)
Goldstream Main #4	3.2
Goldstream Main #5	2.65
Sooke River Road Disinfection	1.85
Target dosing concentration was calculated using RTW model based on Sept 2019 water quality results at the first customer station on each main.	

F.3 Chemical Dosing and Management

To determine the dosing rate and size the make-down and dosing equipment the following were considered for each main:

- peak hourly demand,
- maximum day demand, and
- average day demand.

Appendix F - Centralized Chemical Conditioning Concept Design

Assuming a 10% soda ash solution, volumetric dosing rates and daily and monthly required solution volumes were then calculated for each facility (refer to Table F-2).

Table F-2: Target Soda Ash Concentration to Achieve pH of 9

	Facility #1 (Main #4) [2]	Facility #2 (Main #5) [2]	Facility #3 (Main #15)
Peak hourly demand (MLD)[1]	159.9	159.9	11.7
Maximum day demand (MLD)[1]	114.3	114.3	8.0
Average day demand (MLD)[1]	64.0	64.0	4.7
Max dosing rate (mg/L)[3]	3.2	2.7	1.85
Max 10% solution dosing rate (mL/s)[3]	53.8	44.6	2.3
Daily volume required (m^3/d)[4]	3.3	2.8	0.14
Average volume required (m^3/month)[5]	56.6	46.9	2.4

1. Flow rated provided by CRD staff.
2. Assumed an even flow split between Main #4 and Main #5 as directed by CRD staff.
3. Based on peak hour demand
4. Based on maximum daily demand
5. Based on average monthly demand

Given that the Sooke River Road (Main #15) Facility only required approximately two totes worth of 10% soda ash solution per month, it was decided that make-down equipment would be included in the two larger facilities. A 10% solution would then be transferred into totes and conveyed to the smaller facility.

Concept Layouts were developed for the three facilities which include the construction of pipe galleries and pH meter chambers around the existing mains and the installation (while the main is temporarily offline) of in-line static mixers. Soda ash solution would be injected into the main using skid-mounted dosing pumps via the in-line static mixer using a proportional-integral-derivative (PID) control relying on flow rate signals (from existing flow meters) and pH signals (from new pH meters installed in downstream chambers).

As noted above, the larger facilities would also include soda ash make-down systems and a solution storage tank sized to allow operators to fill the tank on a Friday and allow the system to run automatically over a 3-day weekend at max day demand. Mixers are included in the dosing tank and in the totes at the smaller facility to ensure consistency of solution and backup generators have been included to ensure continuity of service. Space has also been included in the larger facilities for soda ash bag storage and spare tote storage.

Health and safety considerations include a hot water tank and eye wash / emergency shower. All chemical storage and make-down systems also include containment to avoid environmental contamination from chemical spills.

Access to the facilities includes a standard access door and an overhead roll-up door. Monorails and hoists are also included to facilitate movement of equipment and chemicals around the space. A desk and chair are also included for operators.

Refer to Figures F-3 through F-5 for concept level facility layouts.

Appendix F - Centralized Chemical Conditioning Concept Design

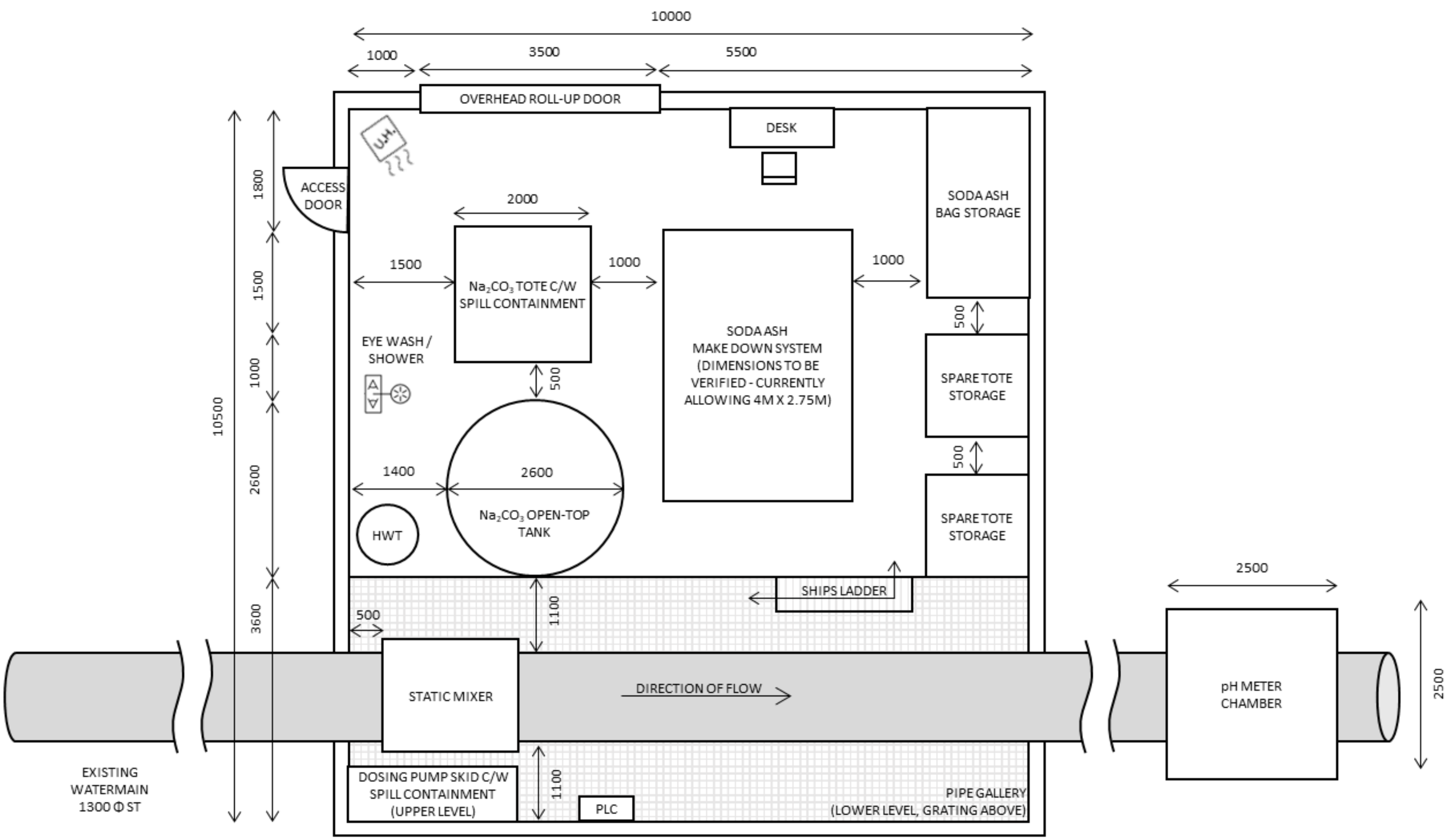

Figure F-3: Proposed Main #4 Facility Layout (Concept Level)

Appendix F - Centralized Chemical Conditioning Concept Design

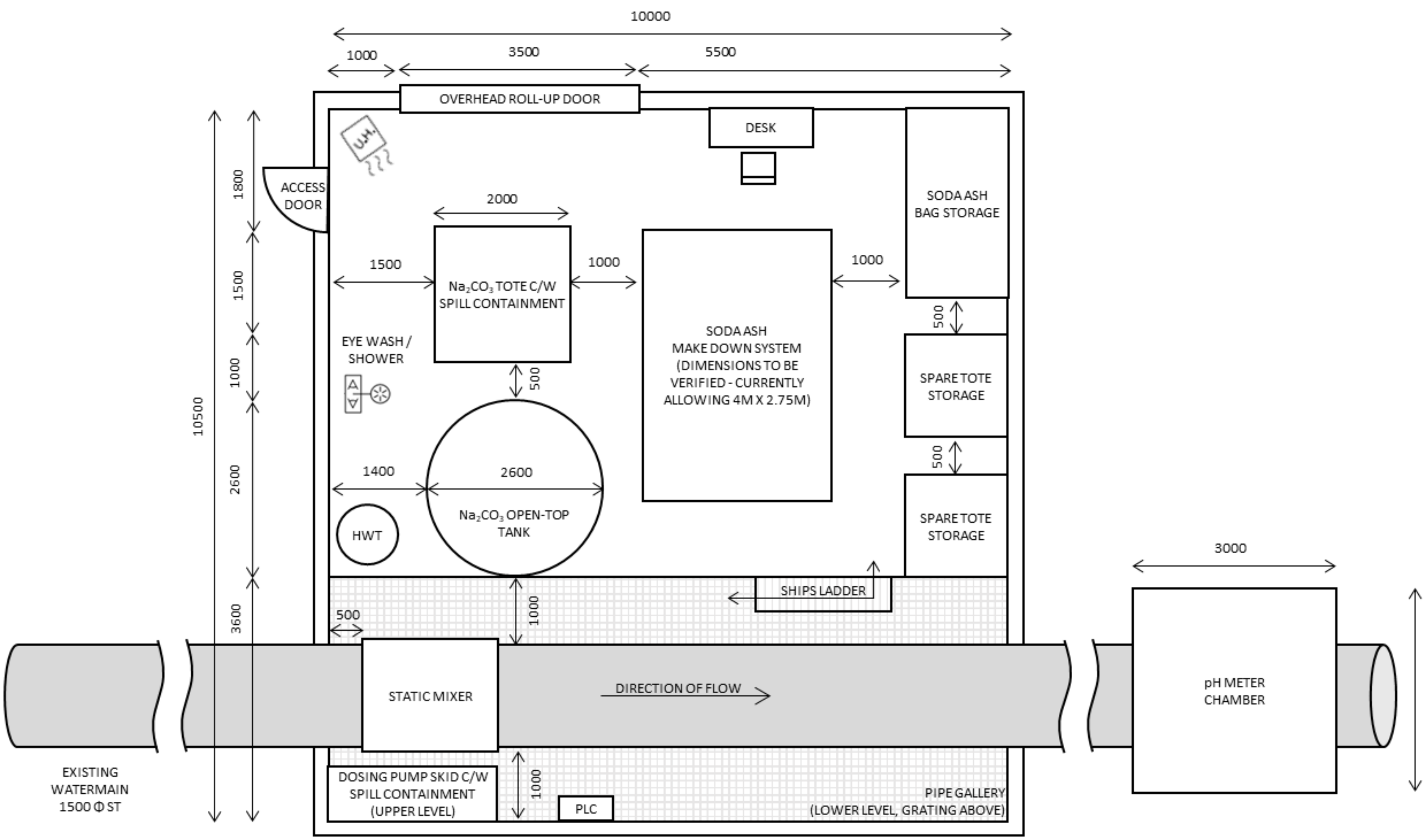

Figure F-4: Proposed Main #5 Facility Layout (Concept Level)

Appendix F - Centralized Chemical Conditioning Concept Design

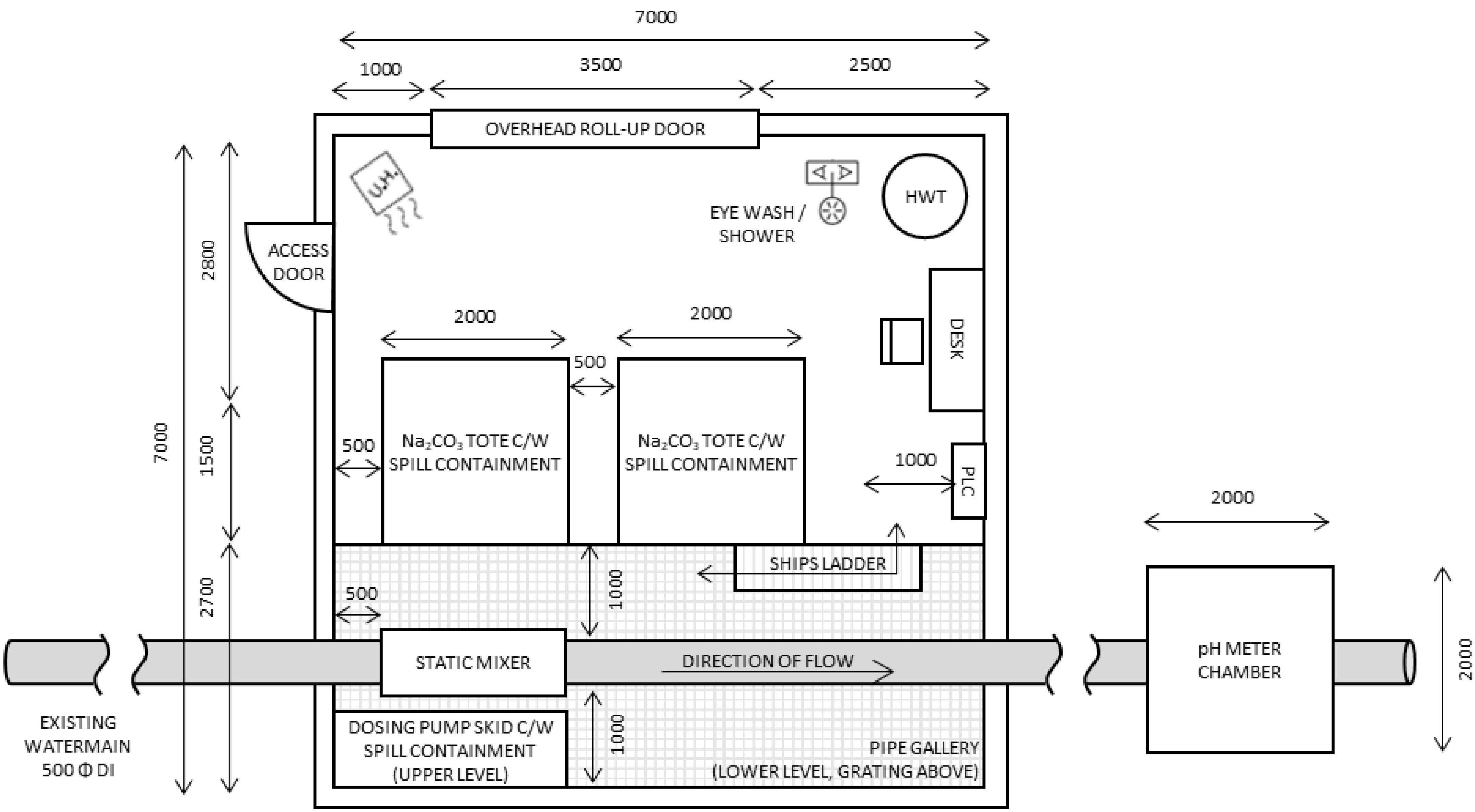

Figure F-5: Proposed Main #15 Facility Layout (Concept Level)

Appendix F - Centralized Chemical Conditioning Concept Design

Class D capital cost estimates for the three facilities are summarized in Table F-3 with more details in Table F-4 and Table F-5.

Table F-3: Target Soda Ash Concentration to Achieve pH of 9

Facility	Class D Capital Cost Estimate
Goldstream Main #4	$ 3.1 million
Goldstream Main #5	$ 3.1 million
Sooke River Road Disinfection	$ 1.5 million
Total Cost	**$ 7.7 million**

Table F-4: Goldstream Main #4 and Goldstream Main #5 Class D Capital Cost Estimate

Class 'D' Cost Opinion for Centralized Chemical Conditioning Facilities

Goldstream Main #4 (1,300 mm dia) and Main #5 (1,500 mm dia) Facilities

Item	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
1	**General**					
1.01	Bonding, Insurance, Mobilization, Demobilization	L.S.	1	177,000	$177,000	10% of subtotal
1.02	Testing & Commissioning	L.S.	1	35,000	$35,000	2% of subtotal
1.03	O&M Manuals & Record Drawings	L.S.	1	35,000	$35,000	2% of subtotal
	Subtotal				**$247,000**	
2	**Site Work**					
2.01	Site clearing	m^2	400	30	$12,000	Assumes that no land acquisition is required
2.02	Excavation & backfilling	m^3	120	500	$60,000	
2.03	pH meter chamber	L.S.	1	500,000	$500,000	Assumes cast-in-place chamber c/w lighting & ventilation
2.04	Site restoration	allow	1	10,000	$10,000	
	Subtotal				**$582,000**	
3	**Building**					
3.01	Building & pipe gallery foundation	cu.m.	50	1,500	$75,000	
3.02	Pipe gallery walls	cu.m.	30	2,500	$75,000	
3.03	Building (lock block) c/w roof, HVAC, lighting & accessories	allow	1	375,000	$375,000	
3.04	Doors & finishes	allow	1	20,000	$20,000	
3.05	Ships ladder	L.S.	1	10,000	$10,000	
	Subtotal				**$555,000**	
4	**Equipment**					
4.01	Makedown equipment	L.S.	1	150,000	$150,000	
4.02	10% solution storage tank (c/w mixer)	L.S.	1	19,000	$19,000	($11k Dynamix + mixer support)
4.03	Tote filling station (c/w containment)	L.S.	1	4,000	$4,000	
4.04	Spare totes	L.S.	2	1,000	$2,000	
4.05	Monorail & hoist	L.S.	1	20,000	$20,000	
4.06	Eyewash station & hot water heater	L.S.	1	4,000	$4,000	Includes PRV
4.07	Solution transfer pumps	L.S.	2	7,500	$15,000	1 duty, 1 shelf spare
4.08	Dosing pumps	L.S.	3	15,000	$45,000	1 duty, 1 spare, 1 shelf spare
4.09	In-line static mixer (c/w flanges)	L.S.	1	250,000	$250,000	Assumes nearby PRVs can be adjusted to accommodate headloss
	Subtotal				**$509,000**	
5	**Electrical & Instrumentation**					
5.01	Intrumentation	L.S.	1	12,000	$12,000	
5.02	Fire alarm and intrusion	L.S.	1	5,000	$5,000	
5.03	BC Hydro Charges	L.S.	1	7,000	$7,000	
5.04	Service and Service equipment	L.S.	1	6,000	$6,000	
5.05	Generator	L.S.	1	25,000	$25,000	15kW pad mount
5.06	Distribution Equipment	L.S.	1	4,000	$4,000	
5.07	Power cabling	L.S.	1	3,200	$3,200	
5.08	Instrumentation cabling	L.S.	1	3,000	$3,000	
5.09	SCADA connection	L.S.	1	3,500	$3,500	CRD to provide radio path study, Programming not included
5.10	PLC, and Controls	L.S.	1	60,000	$60,000	Assumes that flow signals will be available from existing meters
5.11	Building & Pipe Gallery HVAC, lighting & receptacles				$0	Included in Section 3. Heat must be maintained above 10 deg C to prevent crystallization
	Subtotal				**$128,700**	
	SUBTOTAL ITEMS 1 TO 5 (Rounded)				**$2,022,000**	
	Design Engineering (15%)				$303,000	
	Construction Contract Administration (10%)				$202,000	
	Contingency (30%)				$607,000	
	TOTAL PROJECT COST (excl. GST)				**$3,134,000**	

This estimate has been based on items shown on the tender set and reflects an estimate of the expected low tender price for use in evaluation of tenders. As such, a suitable contingency should be added for use for other purposes. The unit prices, production rates and crew rates reflect KWL's recent experience with similar work, and therefore represent the best prediction of actual (2005) costs as of the date prepared. Actual tendered costs will depend on such things as market conditions generally, competitiveness of the tendering process, remoteness factor, the time of year, contractors' work loads, any perceived risk exposure associated with the work, and unknown conditions.

Prepared by:

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Seal

Table F-5: Sooke River Road Class D Capital Cost Estimate

Class 'D' Cost Opinion for Centralized Chemical Conditioning Facilities

Sooke Road Facility (500mm dia DI)

Item	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
1	**General**					
1.01	Bonding, Insurance, Mobilization, Demobilization	L.S.	1	85,000	$85,000	10% of subtotal
1.02	Testing & Commissioning	L.S.	1	17,000	$17,000	2% of subtotal
1.03	O&M Manuals & Record Drawings	L.S.	1	17,000	$17,000	2% of subtotal
	Subtotal				**$119,000**	
2	**Site Work**					
2.01	Site clearing	m²	100	30	$3,000	Assumes that no land acquisition is required
2.02	Excavation & backfilling	m³	60	500	$30,000	
2.03	pH meter chamber	L.S.	1	300,000	$300,000	Assumes cast-in-place chamber c/w lighting & ventilation
2.04	Site restoration	allow	1	10,000	$10,000	
	Subtotal				**$343,000**	
3	**Building**					
3.01	Building & pipe gallery foundation	cu.m.	20	1,500	$30,000	
3.02	Pipe gallery walls	cu.m.	20	2,500	$50,000	
3.03	Building (lock block) c/w roof, HVAC, lighting & accessories	allow	1	150,000	$150,000	
3.04	Doors & finishes	allow	1	20,000	$20,000	
3.05	Ships Ladder	L.S.	1	10,000	$10,000	
	Subtotal				**$260,000**	
4	**Equipment**					
4.01	10% solution totes (c/w containment)	L.S.	2	4,000	$8,000	
4.02	Tote mixers	L.S.	2	6,500	$13,000	($11k Dynamix + mixer support)
4.03	Eyewash station & hot water heater	L.S.	1	4,000	$4,000	Includes PRV
4.04	Dosing pumps	L.S.	3	7,500	$22,500	1 duty, 1 spare, 1 shelf spare
4.05	In-line mixer	L.S.	1	75,000	$75,000	Assumes nearby PRVs can be adjusted to accommodate headloss
	Subtotal				**$122,500**	
5	**Electrical & Instrumentation**					
5.01	Intrumentation	L.S.	1	12,000	$12,000	
5.02	Fire alarm and intrusion	L.S.	1	5,000	$5,000	
5.03	BC Hydro Charges	L.S.	1	7,000	$7,000	
5.04	Generator	L.S.	1	25,000	$25,000	15kW pad mount
5.05	Service and Service equipment	L.S.	1	6,000	$6,000	
5.06	Distribution Equipment	L.S.	1	4,000	$4,000	
5.07	Power cabling	L.S.	1	3,200	$3,200	
5.08	Instrumentation cabling	L.S.	1	3,000	$3,000	
5.09	SCADA connection	L.S.	1	3,500	$3,500	CRD to provide radio path study, Programming not included
5.10	PLC, and Controls	L.S.	1	60,000	$60,000	Assumes that flow signals will be available from existing meters
5.11	Building & Pipe Gallery HVAC, lighting & receptacles				$0	Included in Section 3. Heat must be maintained above 10 deg C to prevent crystallization
	Subtotal				**$128,700**	
	SUBTOTAL ITEMS 1 TO 5 (Rounded)				**$973,000**	
	Design Engineering (15%)				$146,000	
	Construction Contract Administration (10%)				$97,000	
	Contingency (30%)				$292,000	
	TOTAL PROJECT COST (excl. GST)				**$1,508,000**	

This estimate has been based on items shown on the tender set and reflects an estimate of the expected low tender price for use in evaluation of tenders. As such, a suitable contingency should be added for use for other purposes. The unit prices, production rates and crew rates reflect KWL's recent experience with similar work, and therefore represent the best prediction of actual (2005) costs as of the date prepared. Actual tendered costs will depend on such things as market conditions generally, competitiveness of the tendering process, remoteness factor, the time of year, contractors' work loads, any perceived risk exposure associated with the work, and unknown conditions.

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EEP 21-47

REPORT TO REGIONAL WATER SUPPLY COMMISSION
MEETING OF WEDNESDAY, NOVEMBER 17, 2021

SUBJECT **Water Quality Summary Report for Greater Victoria Drinking Water System – July to September 2021**

ISSUE SUMMARY

Staff provide regular updates on the monitoring results for water quality conditions observed in the Greater Victoria Drinking Water System in between annual reporting to the regulator.

BACKGROUND

The Capital Regional District (CRD) supplies drinking water to the water distribution systems across Greater Victoria via the Regional Water Supply System. As a requirement under the *BC Drinking Water Protection Act*, the CRD monitors and reports on water quality to ensure the region's drinking water supply is safe and potable. The results are presented on a regular basis directly to the Commission and Island Health, and to the general public through the CRD website.

All public drinking water systems in BC must comply with the *BC Drinking Water Protection Act* and the *BC Drinking Water Protection Regulation*. In addition, the CRD relies upon water quality parameters in the Guidelines for Canadian Drinking Water Quality and guidelines developed by the US Environmental Protection Agency to inform the CRD's water quality monitoring program.

Water quality monitoring is one of the cornerstones of the multi-barrier approach to providing safe potable drinking water to the region's residents. The monitoring program ensures proper integration of an understanding of source waters, treatment process, distribution infrastructure operations and maintenance, and the delivery of water to customers. The program also ensures that potential risks or concerns are effectively managed to ensure a safe drinking water supply.

Appendix A summarizes the monitoring results for raw water in Sooke Lake Reservoir, the treated water at the two water treatment plants and for the treated water in various parts of the supply and distribution systems for the summer period from July to September 2021.

IMPLICATIONS

Environmental Implications

The system is monitored for physical, chemical and biological water quality parameters. Monitoring results indicate that the CRD continues to meet guidelines for maintaining an unfiltered source water supply. Data from within the distribution systems also indicate a good balance between managing bacterial growth and ensuring good water quality with low concentrations of disinfection byproducts. Metal concentrations, including lead, are very low within the distribution systems, and physiochemical parameters indicate a low metal corrosion potential of the drinking water.

The extreme heat wave leading into this reporting period caused higher than normal water temperatures throughout most of the summer. This resulted in additional operational efforts needed to maintain good drinking water quality in the distribution system, and exacerbated the typical water temperature exceedance of the aesthetic limit during the summer months. But these extreme weather conditions did not have any measurable adverse impact on other water quality parameters in Sooke Lake Reservoir or in the drinking water distribution systems.

Intergovernmental Implications

The CRD provides compliance monitoring and reporting of the municipal systems within the region to deliver effective and efficient oversight of water quality within the overall water system. Any issues that may arise remain the responsibility of the municipalities.

Social Implications

The full disclosure of water quality monitoring data maintains public confidence in the CRD managing the regional drinking water supply effectively. The data and reports are available online through the CRD public website. Staff respond to direct customer concerns and questions, and work with CRD operational staff, municipal staff, small system operators and Island Health officials to ensure good communication and support for the overall system.

CONCLUSIONS

The water quality monitoring program remains an essential component in the delivery of a safe and abundant drinking water supply to the region. Monitoring results for summer 2021 indicate good water quality overall, and all critical parameters indicate stable general conditions.

RECOMMENDATION

The Regional Water Supply Commission receives the Water Quality Summary Report for the Greater Victoria Drinking Water System – July to September 2021 for information.

Submitted by:	Glenn Harris, Ph.D., R.P.Bio., Senior Manager, Environmental Protection
Concurrence:	Larisa Hutcheson, P.Eng., General Manager, Parks & Environmental Services

ATTACHMENT

Appendix A: Water Quality Summary Report for the Greater Victoria Drinking Water System – July to September 2021

WATER QUALITY SUMMARY REPORT FOR THE GREATER VICTORIA DRINKING WATER SYSTEM JULY TO SEPTEMBER 2021

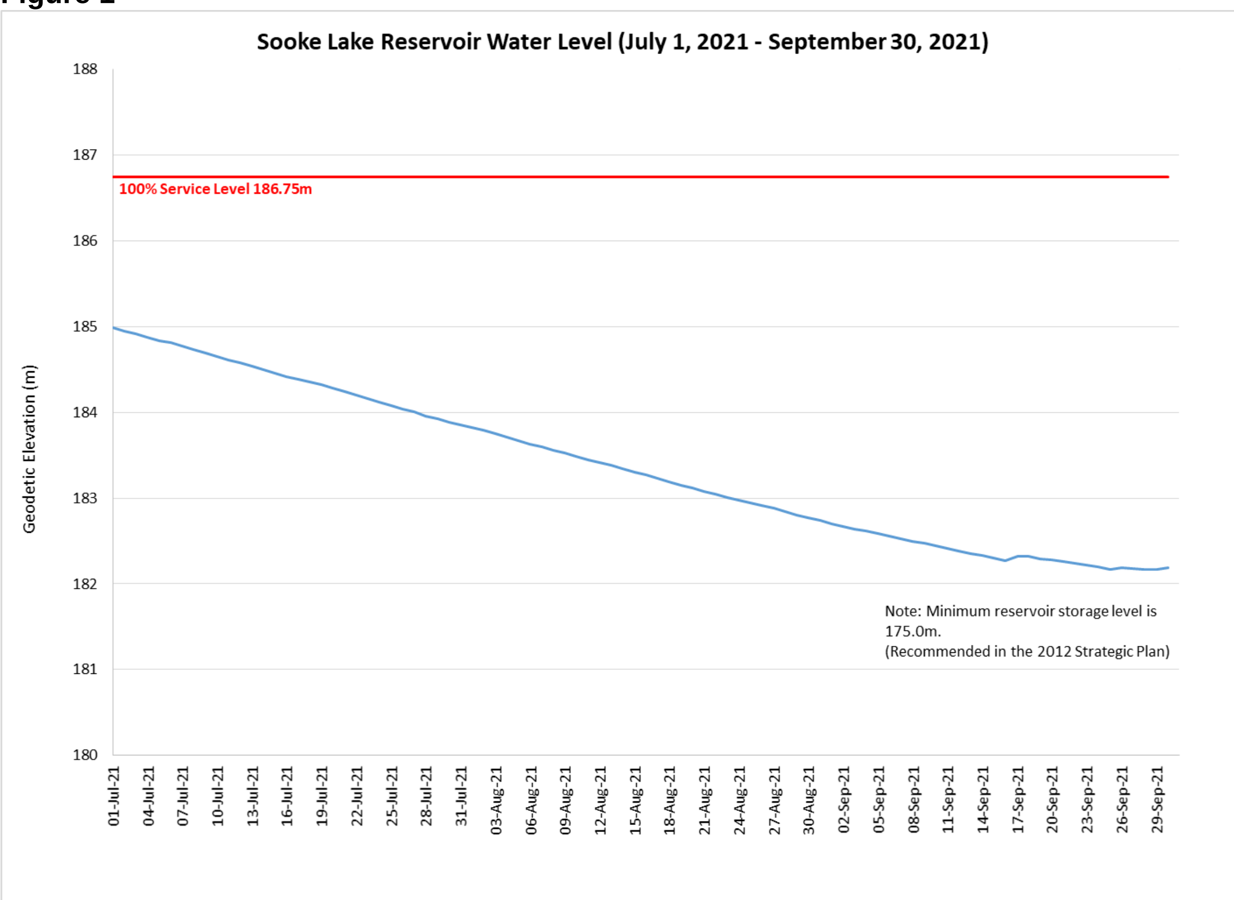
November 2021

SOURCE WATER – SOOKE LAKE RESERVOIR

Physical Parameters

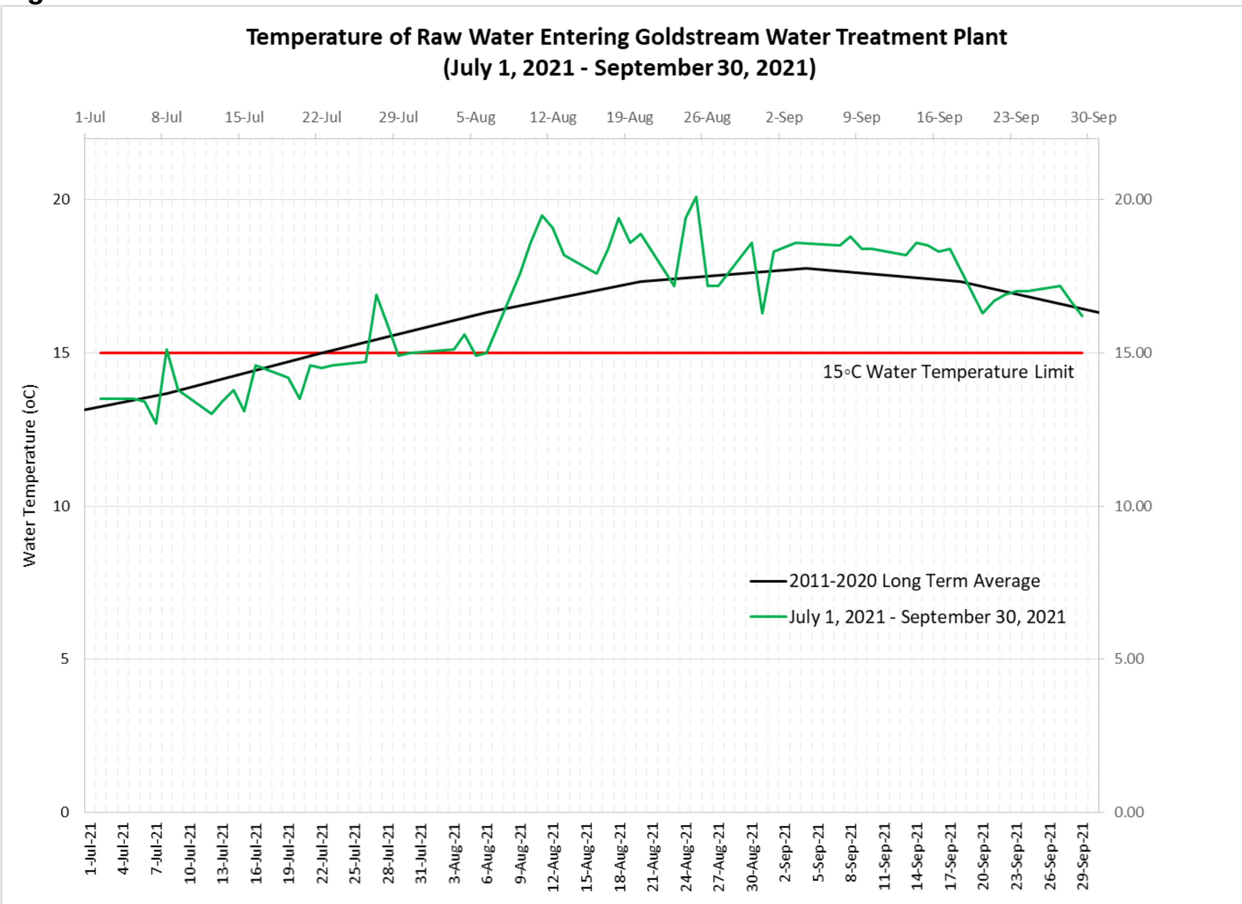
Water Levels. Sooke Lake Reservoir was at 86.7% of full capacity at the start of this reporting period on July 1, 2021 and almost continuously drained until September 30. A significant rainstorm (74 mm precipitation in 24h) on September 17 briefly halted and slightly reversed the downward lake level trend (Figure 1). This summer lake level trend is not unusual but the remaining storage capacity at the end of September 2021 was between 1-6% lower than in the previous five years, and was a direct result from extremely hot and dry summer conditions with high outdoor watering demands in the region.

Figure 1



Water Temperature. The raw water temperature measured at the Goldstream Water Treatment Plant fluctuated closely around the long-term average trend until the beginning of August. From then until the end of September the water temperature entering the plant remained higher than the long-term trend (Figure 2). This was also a result of the extreme air temperatures during the late June – early July heat wave. The water being extracted from the cool water column below the thermocline in the Sooke Lake south basin, and the passage through the deep and cool Kapoor Tunnel, certainly buffered any larger water temperature impact by this extreme heat wave.

Figure 2



Turbidity. Turbidity in the lake near the intake tower remained well below the 1.0 Nephelometric Turbidity Unit (NTU) limit and very consistent for the entire reporting period (Table 1). The heat wave had no impact on the raw water turbidity. This demonstrates the robustness of the Sooke Lake Reservoir in terms of turbidity impacts. The low turbidity of the raw water allows the ultraviolet disinfection stage to remain effective at inactivating bacteria and parasites.

Table 1

Sooke Reservoir, South Basin (1m) - SOL-00-01					
	Samples Collected	Unit of Measure	Minimum	Maximum	Mean
Turbidity	6	NTU	0.25	0.25	0.25

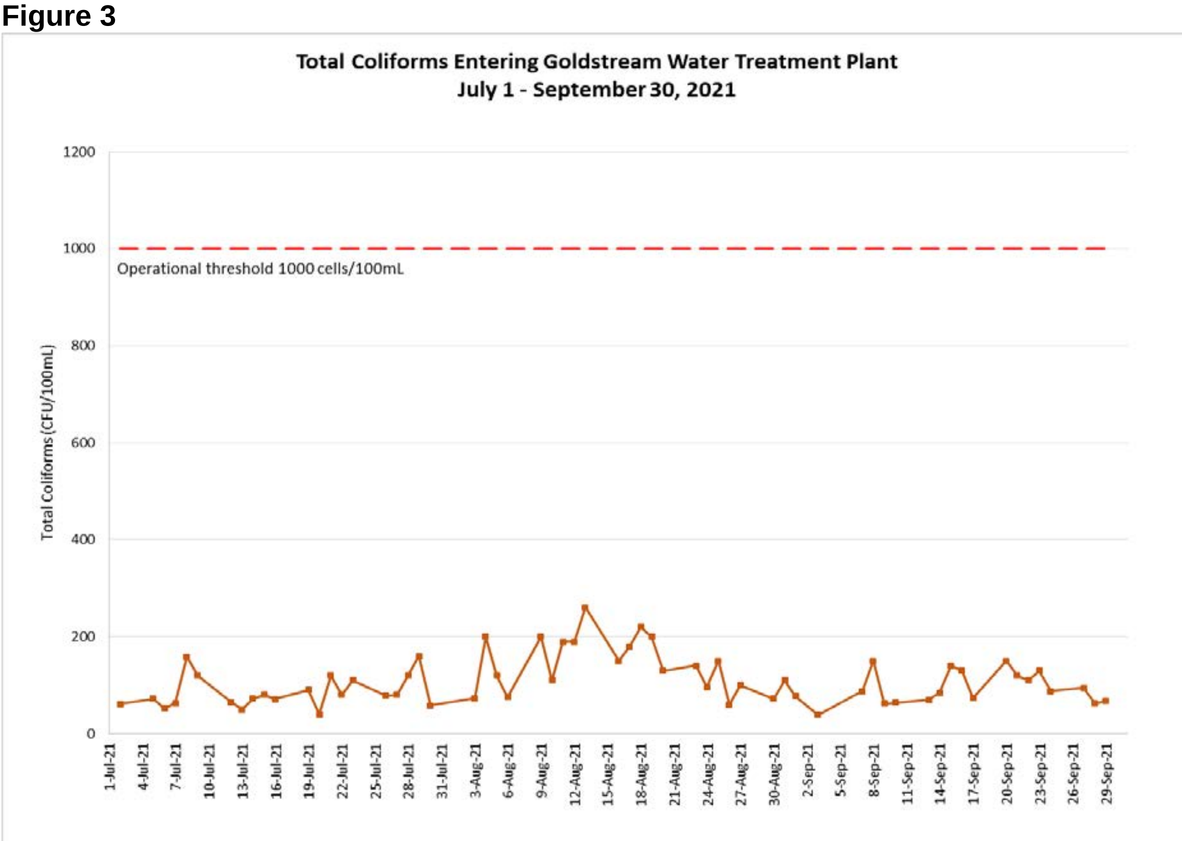
Water Transparency. The transparency of the lake water measured with the Secci Disc in the lake was high (between 6 and 8 m) and consistent with the long-term average. Moderate algal events throughout the reporting period accounted for periods with slightly lower transparency but with no measurable impact on the treatability of the water.

Dissolved Oxygen. The dissolved oxygen concentrations at three lake sampling stations have been consistently between 9-10 mg/L from surface to bottom. This well-oxygenated state prevents internal nutrient loading or metal releases from lake sediments during summer lake stratification, and is another indicator of the oligotrophic status of Sooke Lake.

Bacteria

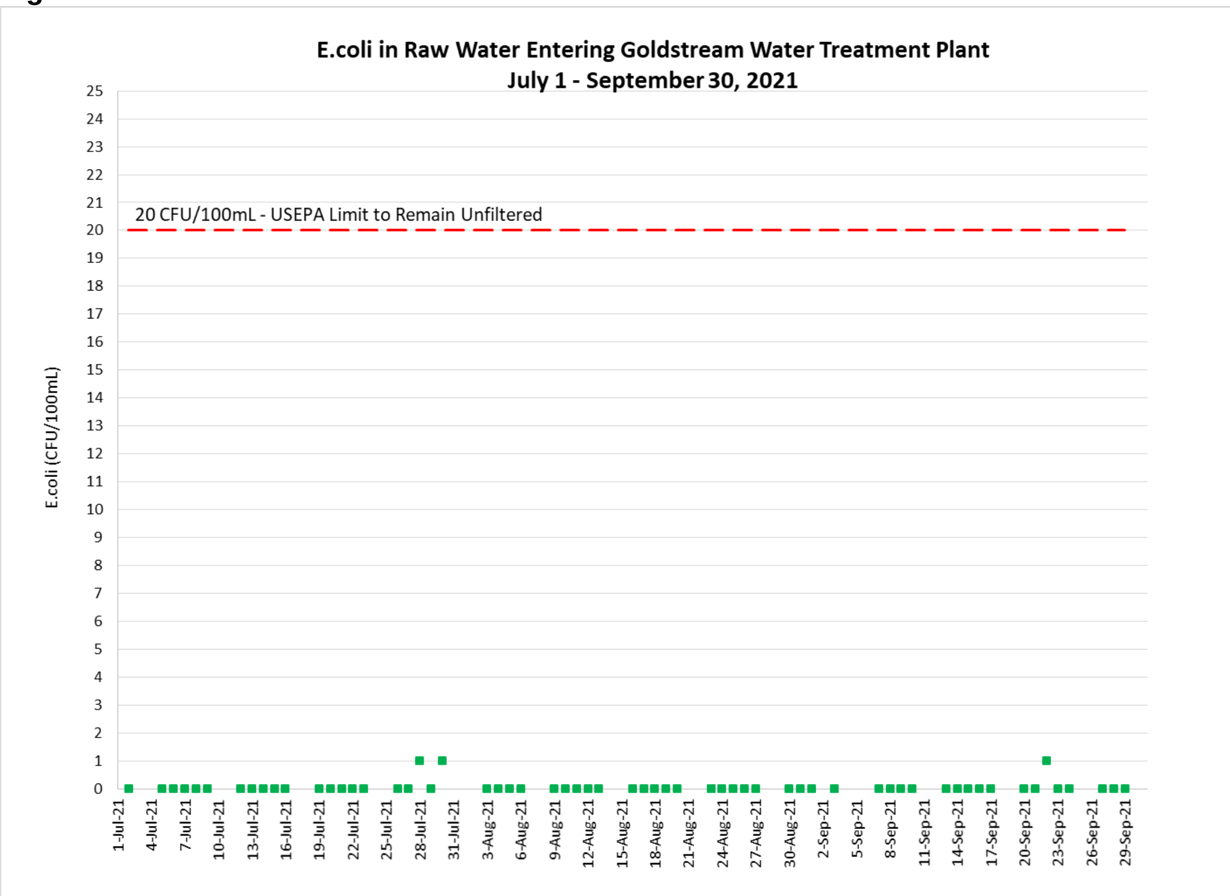
Total Coliform Bacteria and E. coli. The total coliform concentrations in the raw source water entering the Goldstream Water Treatment Plant increased at the beginning of the reporting period with the warming of the raw water (Figure 3). The total coliform concentrations further increased when the thermal stratification in the Sooke Lake south basin dissipated in August and raw water temperatures reached their peak. This is a normal and natural trend directly related to increased bioactivity during the warm water period. The United States Environmental Protection Agency (USEPA) Surface Water Treatment Rule for avoiding filtration has a non-critical total coliform criterion of maximum 100 CFU/100 mL at the 90 percentile of a six-month sample set. The 90 percentile of total coliform concentrations in the raw water between April and September 2021 was 150 CFU/100 mL and was therefore in exceedance with this non-critical USEPA filtration exemption criterion. In context, while the total coliform concentrations were higher than in previous summers, most likely due to the higher than normal water temperatures, they were overall still relatively low and do not indicate any unusual activity or water contamination.

Figure 3



E. coli concentrations during the reporting period were mostly non-detected or extremely low and therefore consistently well under the limit for meeting the critical USEPA filtration exemption criteria for surface water used for drinking water supply (Figure 4). Meeting this criterion means compliance with the USEPA Surface Water Treatment Rule for avoiding filtration. The *E. coli* concentrations are also well below the benchmark used in the *2020 BC Source Drinking Water Quality Guidelines* (90 percentile E. coli ≤ 10 CFU/100mL). These results are very typical for Sooke Lake Reservoir during the summer and fall season.

Figure 4



Nutrients

In general, the nutrient concentrations during the reporting period confirmed the ultra-oligotrophic status of Sooke Lake Reservoir, which is indicative of very low productivity in an upland lake with a virtually undisturbed catchment. This lake status is demonstrated by very low overall nutrient concentrations with a high nitrogen:phosphorus ratio and dissolved organic nitrogen being the dominant constituent of the total nitrogen. These conditions allow only limited biological activity in the lake, thus ensuring a good quality source for unfiltered drinking water. In early fall, rain-induced runoff events (first flush events) usually provide the highest nutrient input to Sooke Lake Reservoir during the course of a year. This effect explains the surface near total nitrogen spike of 936 µg/L in the south basin on September 27 (see Table 2), which was the result of a heavy rainstorm a few days prior. These naturally-added nutrients are then quickly consumed by aquatic organisms, which is demonstrated by the already much reduced total nitrogen concentration in the north basin on the same day (136 µg/L), an area of Sooke Lake Reservoir that receives the vast majority of inflow and nutrient influx first. This natural cycle is an indication of a healthy and functioning food chain in the lakes ecosystem (Tables 2 and 3).

Table 2

Sooke Reservoir, South Basin (1m) - SOL-00-01					
	Samples Collected	Unit of Measure	Minimum	Maximum	Mean
Total Nitrogen	3	ug/L	101	936	380.3
Total Phosphorus	3	ug/L	<1	1.40	1.13

Table 3

Sooke Reservoir, North Basin (1m) - SOL-04-01					
	Samples Collected	Unit of Measure	Minimum	Maximum	Mean
Total Nitrogen	3	ug/L	105	163	134.7
Total Phosphorus	3	ug/L	<1	2.60	1.73

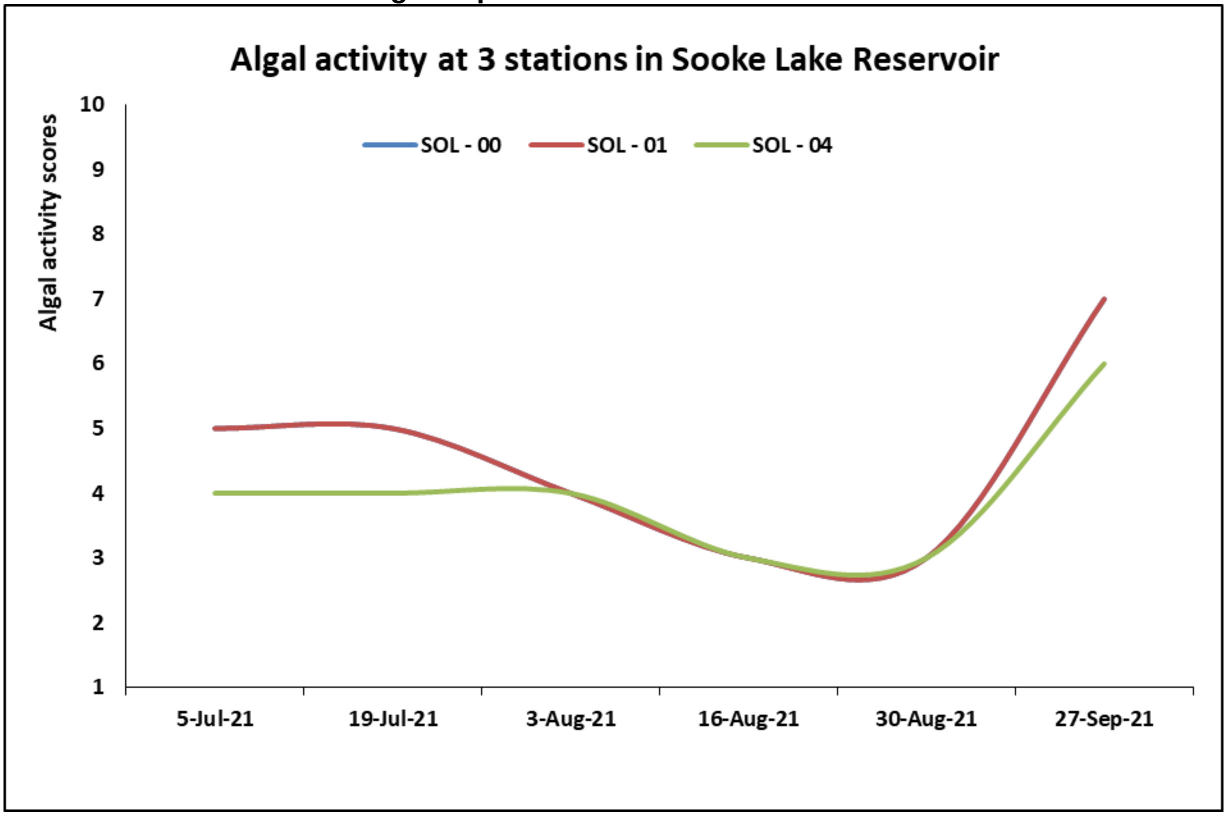
Protozoan Parasites

In one test set during this reporting period on the raw water entering the Goldstream Water Treatment Plant, no *Cryptosporidium* oocysts and no *Giardia* cysts were found.

Algae

To provide a general picture of the algae activity in Sooke Lake Reservoir, algal activity scores were applied, ranging from 1 to 10, which are assessed via towed samples collected biweekly at three stations. The scores declined from July to August and started to increase in September (Figure 5). Low algal activity scores in July and August are likely attributed to depleted nutrient availability in Sooke Lake due to remarkably low precipitation. The extreme heat wave and the negligible precipitation throughout July and August, leading to low reservoir levels, had a subduing impact on the algal community in Sooke Lake. Increasing algal activity scores were observed at the end of summer coinciding with higher precipitation rates. The dominant taxa recorded in most of the sampling events, albeit in overall low concentrations, were cyanobacteria, *Dolichospermum/Anabaena* spp., which can potentially produce toxins when in bloom. Studies have indicated that cyanobacteria like these are able to outcompete other freshwater algae due to their outstanding adaptive ability, (e.g., exploiting extra nutrient sources from the atmosphere by symbiotic association with nitrogen fixing bacteria, and from bottom layers via buoyancy regulation). In in this reporting period, there were no water quality concerns related to algae in Sooke Lake Reservor.

Figure 5: Algal activity scores from July-September 2021, Sooke Lake Reservoir, Intake Location (SOL-00), South Basin (SOL-01) and North Basin (SOL-04). Scores at SOL-00 and SOL-01 were identical during this period.



WATER TREATMENT PLANTS

Goldstream Water Treatment Plant (formerly called Japan Gulch Disinfection Facility)

Turbidity. The raw water entering the Goldstream Water Treatment Plant was consistently well below 1 NTU during the reporting period (Table 4). A more rigorous raw water main flushing procedure in the spring of 2021 was able to eliminate the previously experienced peak watering day turbidity excursions > 1 NTU in this entire reporting period. That is a significant improvement from previous years and CRD staff intend on implementing this new flushing procedure as an annual task in the spring.

Table 4

Goldstream Water Treatment Plant Turbidity - Raw Water	
Samples Collected	61
Minimum	0.20 NTU
Maximum	0.75 NTU
Mean	0.30 NTU

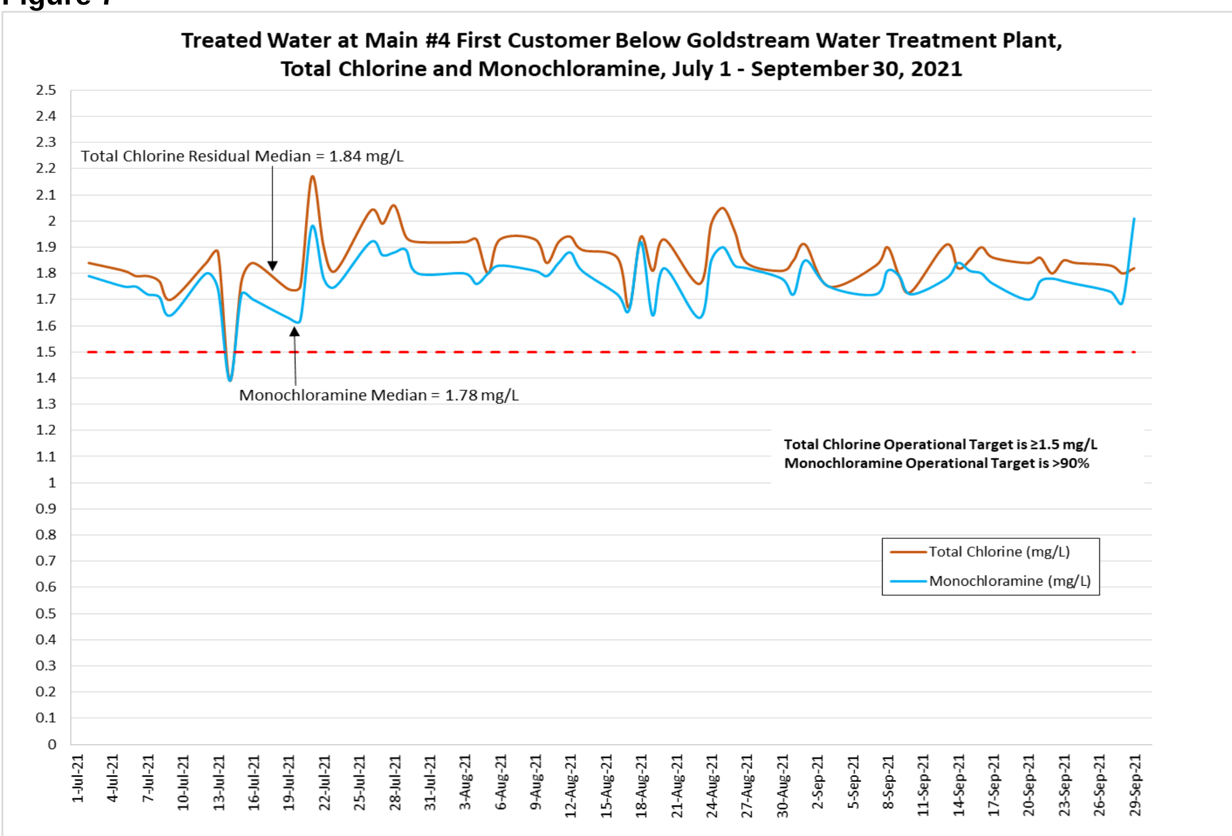
Main #4 First Customer Sampling Station Total Coliform Bacteria and E. Coli
The Main #4 First Customer Sampling Station immediately downstream of the Goldstream Water Treatment Plant is sampled daily to monitor the efficacy of the disinfection treatment process. Only 1 sample (August 25) tested positive for total coliform bacteria during the entire reporting period. A resample did not confirm any water contamination or treatment breakthrough.

Main #5 First Customer Sampling Station Total Coliform Bacteria and E. Coli
The Main #5 First Customer Sampling Station immediately downstream of the Goldstream Water Treatment Plant is also sampled daily to monitor the efficacy of the disinfection treatment process. Only 1 sample (July 26) tested positive for total coliform bacteria during the entire reporting period. A resample did not confirm any water contamination or treatment breakthrough.

These results demonstrate the efficacy of the disinfection process at the Goldstream Water Treatment Plant.

Secondary Disinfection. Figure 7 shows the total chlorine and monochloramine concentrations at the Main #4 First Customer Sampling Station. The target concentration of 1.5 mg/L for total chlorine was consistently achieved, except for on July 14 when the total chlorine concentration was slightly below the target. The target ratio of 90% monochloramine was consistently achieved. This high rate of compliance was possible due to the newly commissioned hypochlorite chlorination equipment (online since March 2021). Adequate and effective secondary disinfection was provided across the entire system throughout the reporting period.

Figure 7



Sooke River Road Water Treatment Plant

Turbidity. The raw water entering the Sooke River Road Water Treatment Plant was consistently well under 1 NTU (Table 5).

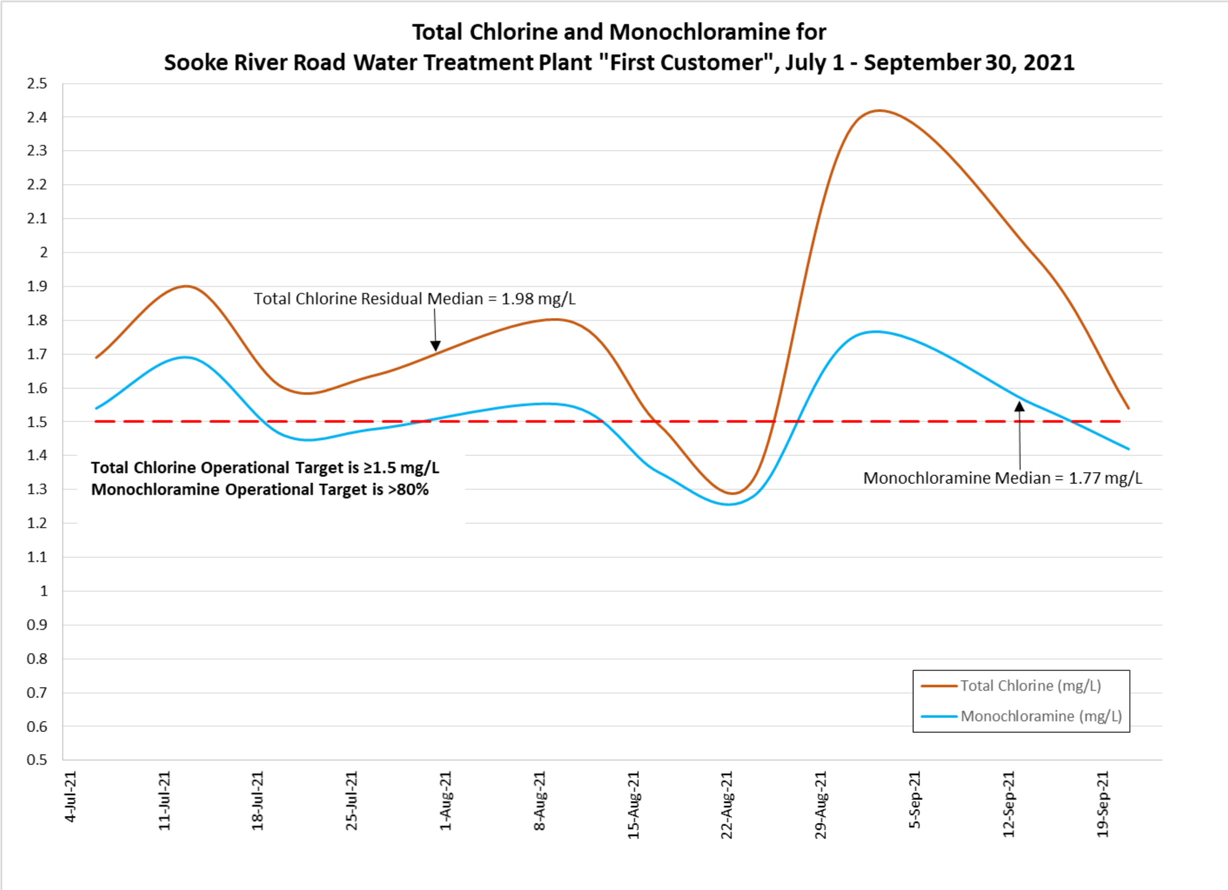
Table 5

Sooke River Road Water Treatment Plant Turbidity - Raw Water	
Samples Collected	10
Minimum	0.20 NTU
Maximum	0.30 NTU
Mean	0.24 NTU

Sooke First Customer Sampling Station Total Coliform Bacteria and E. Coli
The Sooke First Customer Sampling Station immediately downstream of the Sooke Water Treatment Plant is sampled weekly to monitor the efficacy of the disinfection treatment process. No total coliform or *E.coli* bacteria were found in any samples collected from this site. These results demonstrate the efficacy of the disinfection process at the Sooke Water Treatment Plant.

Secondary Disinfection. Figure 8 shows the total chlorine and monochloramine concentrations at the Sooke First Customer Sampling Station. The target concentration of 1.5 mg/L for total chlorine was consistently achieved during the reporting period, except for one short period in mid August. The slightly lower target ratio of 80% monochloramine for this facility was achieved throughout the reporting period, except for a few days at the end of August when the plant operators switched to a different hypochlorite solution. The residual concentrations were adequate to provide effective secondary disinfection across this much smaller distribution system.

Figure 8



DISTRIBUTION SYSTEMS

Goldstream (Japan Gulch) Service Area

Table 6

Goldstream Water Treatment Plant Service Area										
Month/Year	Samples Collected	Total Coliforms (CFU/mL)				E.coli (CFU/100mL)	Turbidity		Chlorine Residual	Water Temp.
		Samples TC > 0	Percent TC > 0	Resamples TC > 0	Samples TC > 10	Samples > 0	Samples Collected	Adverse > 1 NTU	Median mg/L as CL2	Median °C
Jul-21	339	3	0.9	0	0	0	51	0	1.47	17.3
Aug-21	364	4	1.1	0	0	0	48	0	1.48	19.6
Sep-21	349	2	0.6	0	0	0	47	0	1.44	18.3
Total:	1052	9	0.9	0	0	0	146	0	1.47	18.3

Total Coliform Bacteria and E. coli. Only 9 out of 1,052 distribution system samples, or 0.9% of all bacteriological samples during the reporting period, tested positive for total coliform bacteria. No samples registered a total coliform concentration of > 10 CFU/100 mL. In all four cases, the resample was free of total coliform bacteria, indicating that no actual water contamination was the cause of these coliform hits. No *E.coli* bacteria were found (Table 6).

Turbidity. None of the 146 turbidity samples registered higher than 1 NTU (Table 6). Overall, these results are an indication of good drinking water quality.

Total Chlorine Residual. A median total chlorine residual concentration of 1.47 mg/L across the system indicates an effective secondary disinfection protecting the potability of the treated drinking water as it flows throughout the system (Table 6).

Water Temperature. The temperature of the drinking water in the system during this reporting period was consistently above the aesthetic objective in the *Canadian Drinking Water Quality Guidelines*. This resulted in higher operational efforts to maintain good water quality in the distribution systems and left customers with the unpleasant experience of luke warm tap water throughout the summer months.

Water Chemistry. The average pH of the drinking water in the Goldstream Service Area was 7.6 during the reporting period. The pH ranged from 7.1 to 8.2, which is typical when operating the hypochlorite chlorination equipment. The average alkalinity was 17.0 mg/L. Both pH and alkalinity have increased since the commissioning of the hypochlorite chlorination equipment.

Disinfection Byproducts. The three typically monitored disinfection byproducts in a drinking water system have all been well below the Health Canada established health limits in the Goldstream Service Area (Table 7).

Table 7

Disinfection Byproducts - Goldstream WTP Service Area

Parameter	Samples Collected	Unit of Measure	Minimum	Maximum	Mean	MAC (Maximum Acceptable Concentration)
Haloacetic Acids (HAAs)	4	ug/L	<5	14.0	9.8	80
Trihalomethanes (THMs)	4	ug/L	18.0	22.0	19.5	100
NDMA	4	ng/L	<2.0	3.40	2.68	40

Metals. A comprehensive metals analysis was conducted every second month at four different locations in the Goldstream Service Area: (1) where treated water enters the Victoria/Esquimalt System, (2) the Oak Bay System, (3) one in Langford and (4) one in North Saanich. Out of the 32 tested metals, five are monitored particularly closely: iron, manganese, lead, aluminium and copper. All metal concentrations were below the respective Health Canada maximum acceptable concentration or the aesthetic objective (Table 8).

Table 8

Metals - Goldstream WTP Service Area

Parameter	Samples Collected	Unit of Measure	Minimum	Maximum	Mean	AO (Aestetic Objective)		MAC (Maximum Acceptable Concentration)
Aluminum	8	ug/L	7.80	15.60	10.65		100	2900
Copper	8	ug/L	6.46	1.61	36.60	1000		2000
Iron	8	ug/L	20.40	34.30	27.71	300		
Lead	8	ug/L	<0.02	0.35	0.25			5
Manganese	8	ug/L	2.80	3.90	3.49	20		120

Sooke Service Area

Table 9

Sooke River Road Water Treatment Plant Service Area										
Month/Year	Samples Collected	Total Coliforms (CFU/mL)				E.coli (CFU/100mL)	Turbidity		Chlorine Residual	Water Temp.
		Samples TC > 0	Percent TC > 0	Resamples TC > 0	Samples TC > 10	Samples > 0	Samples Collected	Adverse > 1 NTU	Median mg/L as CL2	Median °C
Jul-21	36	0	0.0	0	0	0	8	0	0.97	17.2
Aug-21	30	0	0.0	0	0	0	7	0	0.58	18.9
Sep-21	30	0	0.0	0	0	0	6	0	0.70	17.8
Total:	96	0	0.0	0	0	0	21	0	0.70	17.8

Total Coliform Bacteria and E. coli. In all 96 bacteriological samples during the reporting period, no sample tested positive for total coliform bacteria. No sample contained *E.coli* bacteria (Table 9).

Turbidity. None of the 21 turbidity samples registered above 1 NTU (Table 8). This is an indication of good drinking water quality.

Total Chlorine Residual. A median total chlorine residual concentration of 0.70 mg/L across the system indicates an effective secondary disinfection protecting the potability of the treated drinking water as it flows throughout the system (Table 9).

Water Temperature. The temperature of the drinking water in the system during this reporting period was consistently above the aesthetic objective in the *Canadian Drinking Water Quality Guidelines*. This resulted in higher operational efforts to maintain good water quality in the distribution systems and left customers with the unpleasant experience of luke warm tap water throughout the summer months.

Water Chemistry. The average pH of the drinking water in the Sooke Service Area was 7.5 during the reporting period. The pH ranged from 7.3 to 8.0 and is typically very stable and consistent across this system. The average alkalinity was 16.8 mg/L.

Disinfection Byproducts. The three typically monitored disinfection byproducts in a drinking water system have all been well below the Health Canada established health limits in the Sooke Service Area (Table 10).

Table 10

Disinfection Byproducts - Sooke River Road WTP Service Area						
Parameter	Samples Collected	Unit of Measure	Minimum	Maximum	Mean	MAC (Maximum Acceptable Concentration)
Haloacetic Acids (HAAs)	1	ug/L	18.0	18.0	18.0	80
Trihalomethanes (THMs)	1	ug/L	32.0	32.0	32.0	100
NDMA	1	ng/L	<2.0	<2.0	<2.0	40

Metals. A comprehensive metals analysis was conducted every second month in one location in the Sooke Service Area: at the end of the distribution system near Whiffen Spit. Out of the 32 tested metals, five are monitored particularly closely: iron, manganese, lead, aluminium and copper. All metal concentrations were well below the respective Health Canada maximum acceptable concentration or the aesthetic objective (Table 11).

Table 11

Metals - Sooke River Road WTP Service Area								
Parameter	**Samples Collected**	**Unit of Measure**	**Minimum**	**Maximum**	**Mean**	**AO (Aestetic Objective)**	**OG (Operational Guideline)**	**MAC (Maximum Acceptable Concentration)**
Aluminum	2	ug/L	9.80	11.00	10.40		100	2900
Copper	2	ug/L	5.01	6.05	5.53	1000		2000
Iron	2	ug/L	43.50	51.70	47.60	300		
Lead	2	ug/L	<0.2	<0.2	<0.2			5
Manganese	2	ug/L	2.90	3.40	3.15	20		120

CONCLUSION

During this summer reporting period (July - September 2021), all parameters from source water to treated water indicate stable conditions and good water quality. Most trends are in line with historic data and confirm the adequacy of existing water treatment and performance of all major infrastructure components. The extreme heat wave leading into this reporting period impacted the water temperature, which was above the long-term average trend during most of August and September. This resulted in extra operational effort to maintain good water quality in the distribution system and the unpleasant customer experience of warm tap water during the summer. No other measurable adverse impact on the water quality was recorded. The multi-barrier approach applied to the Greater Victoria Drinking Water System ensures the excellent drinking water quality achieved during the reporting period.

Making a difference...together

SAANICH PENINSULA WATER COMMISSION
Thursday, October 21, 2021 at 9:30 AM

MEETING HOTSHEET (ACTION LIST)

The following is a quick snapshot of the FINAL **Saanich Peninsula Water Commission** decisions made at the meeting. The minutes will represent the official record of the meeting.

3. ADOPTION OF MINUTES

That the minutes of the May 20, 2021 meeting be adopted.

CARRIED

7. COMMISSION BUSINESS

7.1. 2022 Service Planning - Water

The Saanich Peninsula Water Commission recommends the Committee of the Whole recommend to the Capital Regional District Board:
That Appendix A, Community Need Summary – Water be approved as presented and form the basis of the 2022-2026 Financial Plan.

CARRIED

7.2. Saanich Peninsula Water Service – 2022 Operating and Capital Budget

The Saanich Peninsula Water Commission recommends the Committee of the Whole recommend to the Capital Regional District Board to:

1. Approve the 2022 operating and capital budget;
2. Approve the 2022 Saanich Peninsula bulk water rate of $1.0886 per cubic metre, and the Agricultural Research Station water rate of $1.1238 per cubic metre, adjusted if necessary by any changes in the CRD Regional Water Supply wholesale water rate;
3. Direct staff to balance the 2021 actual revenue and expense on the transfer to capital reserve fund; and,
4. Direct staff to amend the Bulk Water Rates Bylaw accordingly.

CARRIED

7.3. Summary of Long-Term Capital Improvements and Operating Programs

That the Saanich Peninsula Water commission receives the report for information.

CARRIED

7.4. Post Disaster Water Supply Update, October 2021

That the Saanich Peninsula Water Commission receive the report for information.

CARRIED

Motion Arising:
That the Saanich Peninsula Water Commission direct staff to refer the Post Disaster Water Supply Technical Working Group information to the four Saanich Peninsula First Nations, being the Pauquachin, Tsartlip, Tsawout and Tseycum Nations, and invite them to send a representative to participate in future meetings.

CARRIED

7.5. Summary of Recommendations from Other Water Commissions

That the Summary of Recommendations from other water commissions be received for information.

CARRIED

7.6. Water Watch Report

That the October 11, 2021 Water Watch Report be received for information.

CARRIED

CAPITAL REGIONAL DISTRICT - INTEGRATED WATER SERVICES

Water Watch

Issued November 08, 2021

Water Supply System Summary:

1. Useable Volume in Storage:

Reservoir	November 30 5 Year Ave		November 30/20		November 7/21		% Existing Full Storage
	ML	MIG	ML	MIG	ML	MIG	
Sooke	77,240	16,993	80,190	17,642	69,626	15,318	75.1%
Goldstream	7,189	1,582	8,989	1,978	8,404	1,849	84.8%
Total	84,429	18,574	89,179	19,619	78,029	17,166	76.1%

2. Average Daily Demand:

For the month of November	108.0 MLD	23.75 MIGD
For week ending November 07, 2021	108.0 MLD	23.76 MIGD
Max. day November 2021, to date:	115.1 MLD	25.33 MIGD

3. Average 5 Year Daily Demand for November

Average (2016 - 2020)	99.7 MLD [1]	21.93 MIGD [2]

[1]MLD = Million Litres Per Day [2]MIGD = Million Imperial Gallons Per Day

4. Rainfall November:

Average (1914 - 2020):	260.7 mm
Actual Rainfall to Date	100.0 mm (38% of monthly average)

5. Rainfall: Sep 1- Nov 7

Average (1914 - 2020):	290.1 mm
2021	490.4 mm (169% of average)

6. Water Conservation Action Required:

To avoid possible leaks this spring, now is the time to winterize your sprinkler system.
Visit our website at www.crd.bc.ca/water for more information.

If you require further information, please contact:

Ted Robbins, B.Sc., C.Tech
General Manager, CRD - Integrated Water Services
or
Glenn Harris, Ph D., RPBio
Senior Manager - Environmental Protection

Capital Regional District Integrated Water Services
479 Island Highway
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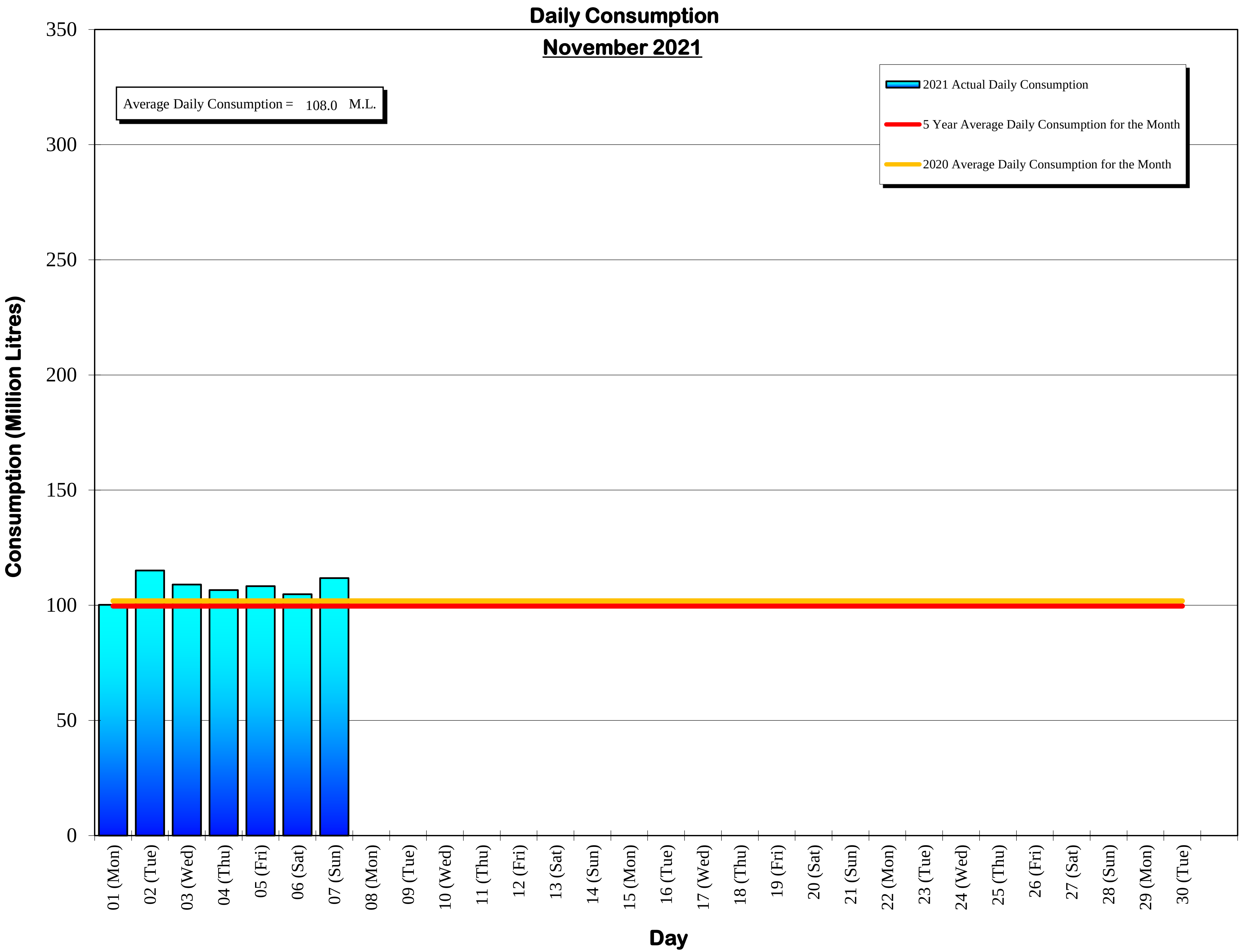
(250) 474-9600


Daily Consumption
November 2021
Average Daily Consumption = 108.0 M.L.
2021 Actual Daily Consumption
5 Year Average Daily Consumption for the Month
2020 Average Daily Consumption for the Month
Consumption (Million Litres)
350
300
250
200
150
100
50
0
01 (Mon)
02 (Tue)
03 (Wed)
04 (Thu)
05 (Fri)
06 (Sat)
07 (Sun)
08 (Mon)
09 (Tue)
10 (Wed)
11 (Thu)
12 (Fri)
13 (Sat)
14 (Sun)
15 (Mon)
16 (Tue)
17 (Wed)
18 (Thu)
19 (Fri)
20 (Sat)
21 (Sun)
22 (Mon)
23 (Tue)
24 (Wed)
25 (Thu)
26 (Fri)
27 (Sat)
28 (Sun)
29 (Mon)
30 (Tue)
Day

Daily Consumptions: - November 2021

Date	Total Consumption (ML) [1]		Total Consumption (MIG) [2]	Air Temperature @ Japan Gulch High (°C)	Air Temperature @ Japan Gulch Low (°C)	Weather Conditions	Precipitation @ Sooke Res.: 12:00am to 12:00am Rainfall (mm)	Snowfall [3] (mm)	Total Precip.
01 (Mon)	100.2	<=Min	22.1	9	3	Sunny / P. Cloudy / Showers	7.6	0.0	7.6
02 (Tue)	115.1	<=Max	25.3	9	6	Rain	24.1	0.0	24.1
03 (Wed)	109.0		24.0	11	9	Rain	18.5	0.0	18.5
04 (Thu)	106.6		23.4	13	6	Cloudy / Showers / P. Sunny	11.7	0.0	11.7
05 (Fri)	108.3		23.8	8	5	Cloudy / Showers / P. Sunny	5.3	0.0	5.3
06 (Sat)	104.8		23.0	7	4	Cloudy / Showers	12.2	0.0	12.2
07 (Sun)	111.8		24.6	6	2	Cloudy / Rain	20.6	0.0	20.6
08 (Mon)									
09 (Tue)									
10 (Wed)									
11 (Thu)									
12 (Fri)									
13 (Sat)									
14 (Sun)									
15 (Mon)									
16 (Tue)									
17 (Wed)									
18 (Thu)									
19 (Fri)									
20 (Sat)									
21 (Sun)									
22 (Mon)									
23 (Tue)									
24 (Wed)									
25 (Thu)									
26 (Fri)									
27 (Sat)									
28 (Sun)									
29 (Mon)									
30 (Tue)									
TOTAL	755.8 ML		166.28 MIG				100.0	0	100.0
MAX	115.1		25.33	13	9		24.1	0	24.1
AVG	108.0		23.75	9.0	5.0		14.3	0	14.3
MIN	100.2		22.05	6	2		5.3	0	5.3

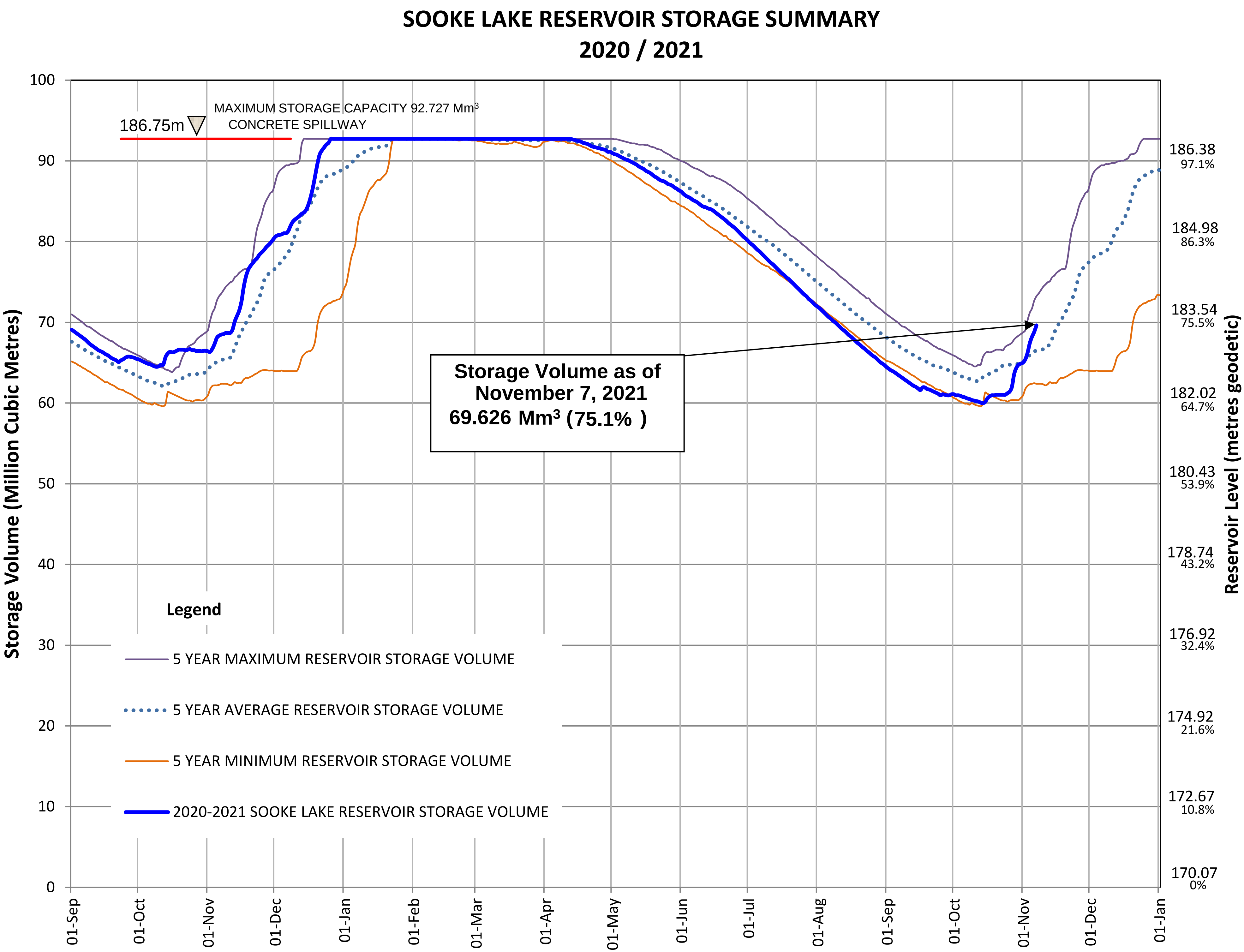
1. ML = Million Litres
2. MIG = Million Imperial Gallons
3. 10% of snow depth applied to rainfall figures for snow to water equivalent.

Average Rainfall for November (1914-2020)	260.7 mm
Actual Rainfall: November	100.0 mm
% of Average	38%
Average Rainfall (1914-2020): Sept 01 - Nov 07	290.1 mm
Actual Rainfall (2021): Sept 01 - Nov 07	490.4 mm
% of Average	169%

Number days with precip. 0.2 or more
7

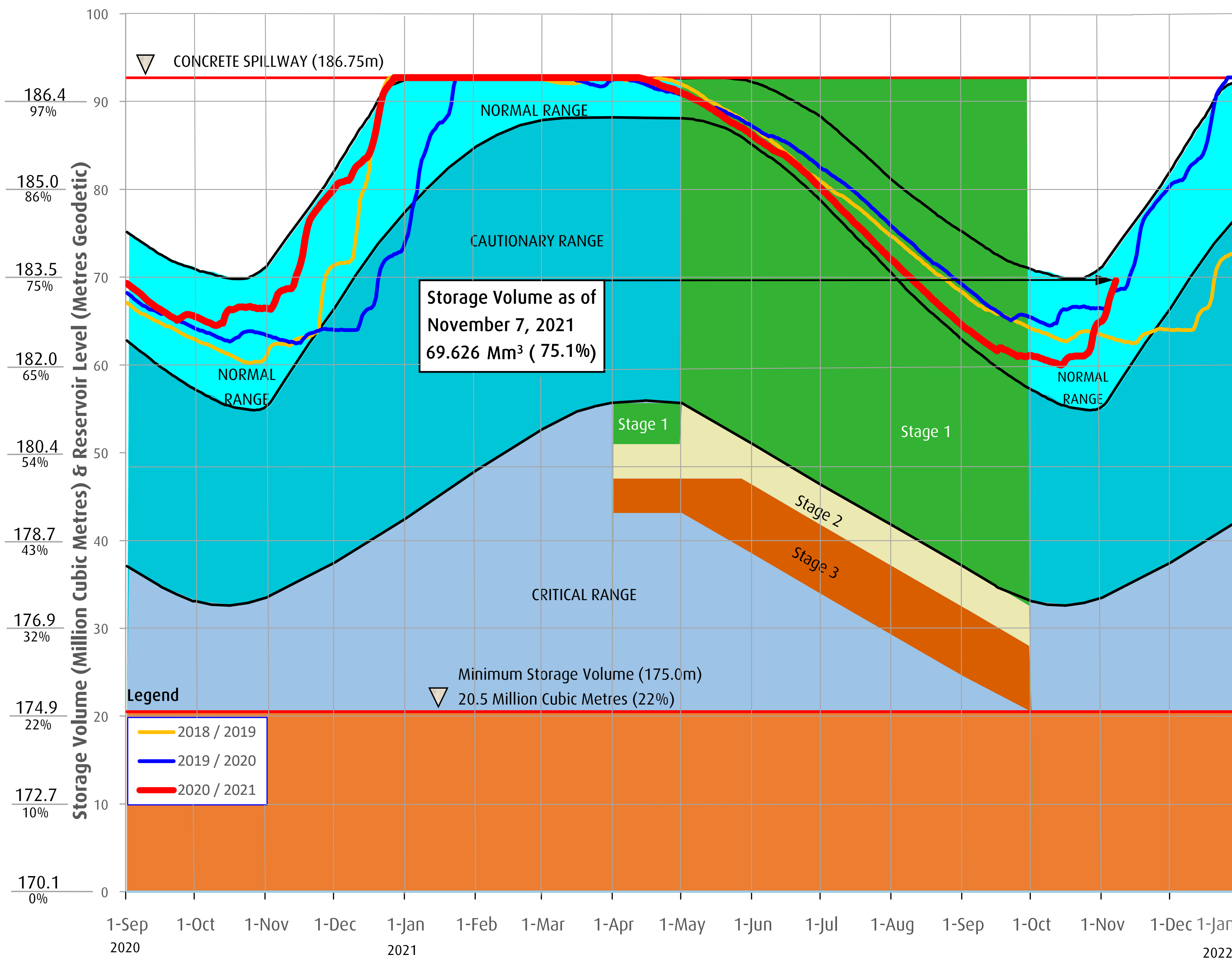
Water spilled at Sooke Reservoir to date (since Sept. 1) = 0.00 Billion Imperial Gallons

= 0.00 Billion Litres


SOOKE LAKE RESERVOIR STORAGE SUMMARY
2020 / 2021
MAXIMUM STORAGE CAPACITY 92.727 Mm³
CONCRETE SPILLWAY
186.75m
Storage Volume as of November 7, 2021
69.626 Mm³ (75.1%)
Legend
5 YEAR MAXIMUM RESERVOIR STORAGE VOLUME
5 YEAR AVERAGE RESERVOIR STORAGE VOLUME
5 YEAR MINIMUM RESERVOIR STORAGE VOLUME
2020-2021 SOOKE LAKE RESERVOIR STORAGE VOLUME
Storage Volume (Million Cubic Metres)
Reservoir Level (metres geodetic)
186.38 97.1%
184.98 86.3%
183.54 75.5%
182.02 64.7%
180.43 53.9%
178.74 43.2%
176.92 32.4%
174.92 21.6%
172.67 10.8%
170.07 0%
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan

Sooke Lake Reservoir Storage Level

Water Supply Management Plan



FAQs

How are water restriction stages determined?

Several factors are considered when determining water use restriction stages, including,

1. Time of year and typical seasonal water demand trends;
2. Precipitation and temperature conditions and forecasts;
3. Storage levels and storage volumes of water reservoirs (Sooke Lake Reservoir and the Goldstream Reservoirs) and draw down rates;
4. Stream flows and inflows into Sooke Lake Reservoir;
5. Water usage, recent consumption and trends; and customer compliance with restriction;
6. Water supply system performance.

The Regional Water Supply Commission will consider the above factors in making a determination to implement stage 2 or 3 restrictions, under the Water Conservation Bylaw.

At any time of the year and regardless of the water use restriction storage, customers are encouraged to limit discretionary water use in order to maximize the amount of water in the Regional Water Supply System Reservoirs available for nondiscretionary potable water use.

Stage 1 is normally initiated every year from May 1 to September 30 to manage outdoor use during the summer months. During this time, lawn watering is permitted twice a week at different times for even and odd numbered addresses.

Stage 2 Is initiated when it is determined that there is an acute water supply shortage. During this time, lawn water is permitted once a week at different times for even and odd numbered addresses.

Stage 3 Is initiated when it is determined that there is a severe water supply shortage. During this time, lawn watering is not permitted. Other outdoor water use activities are restricted as well.

For more information, visit www.crd.bc.ca/drinkingwater

CRD Making a difference...together

Capital Regional District Integrated Water Services

Making a difference...together

Useable Reservoir Volumes in Storage for November 07, 2021