Village of Cumberland – Surface Water Disinfection and Storage Review

McElhanney

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2231-21268-01

OQM | Organizational Quality Management Program

ISO 9001 Quality Management

Contents

1. Background

The Cumberland water supply system is owned, operated and maintained by the Village of Cumberland and serves a village population of approximately 3,700 people. The village also sells bulk water to the neighbouring community of Royston with a population of approximately 1,700 people.

1.1. Study Objectives

The capacity of this current water system is taxed by the growth demands of local development and aging infrastructure. Several key water works projects have been initiated and delivered in recent years to upgrade this system to meet current and future demands. The purpose of this study is to:

- Identify and assess Water Treatment Options to meet Island Health (IH) objectives;
- Estimate future water demand;
- Recommend a Preferred Treatment Process;
- Assess storage requirements to meet one or more of the following objectives:
    - Contact Time, if required for treatment;
    - System Storage to meet Peak Demand for fire-fighting or Peak Hour Demand; and,
    - Identify and compare potential reservoir siting locations.
- Prepare a Conceptual Design of the Works identified to meet current treatment requirements and to accommodate future growth;
- Prepare a Class “C” cost estimate of the proposed works; and
- Report findings.

1.2. Existing Water System

1.2.1. Water Supply

The main water supply for Cumberland is operated under a Permit to Operate issued by VIHA in May of 2010. A copy of that permit is included in Appendix A. The two principal water sources are Allen Lake and Henderson Lake. Both lakes are located on the hillside south of town. Authorization to draw water from these lake supplies was granted by water licences that date back as far as the 1890’s.

This is a gravity fed surface system with a supply line from each lake that meets at a point of connection that is 750 meters downstream of Allen Lake and 1200 meters downstream of Henderson Lake. The location of key supply system components is shown on Figure 1.1.

Pressure in the system is regulated by the water level in Allen Lake. The overflow from Allen Lake is set at elevation 229.5 meters geodetic which establishes the maximum Hydraulic Grade Line (HGL) in the system during the winter months. This lake level typically drops to 228 +/- meters which establishes a lower HGL during the summer and early fall of each year. Henderson Lake has a top water level of 256 meters. Pressure in the supply line from Henderson Lake is reduced by a Pressure Reducing Valve (PRV) located directly upstream from the point of connection.

Water supplied from Henderson Lake is blended with water supplied from Allen Lake to optimize water quality year round. The Henderson Lake system provides a good reliable supply during the winter months, however based on discussions with village staff it has proven to be an unreliable source during extended periods of drought in the late summer.

An independent ground water supply was developed in 2012 and 2013 to supplement the surface water system. That system includes the following components:

- a deep well that was drilled and developed west of town;
- a submersible pump;
- a supply line; and,
- Disinfection works.

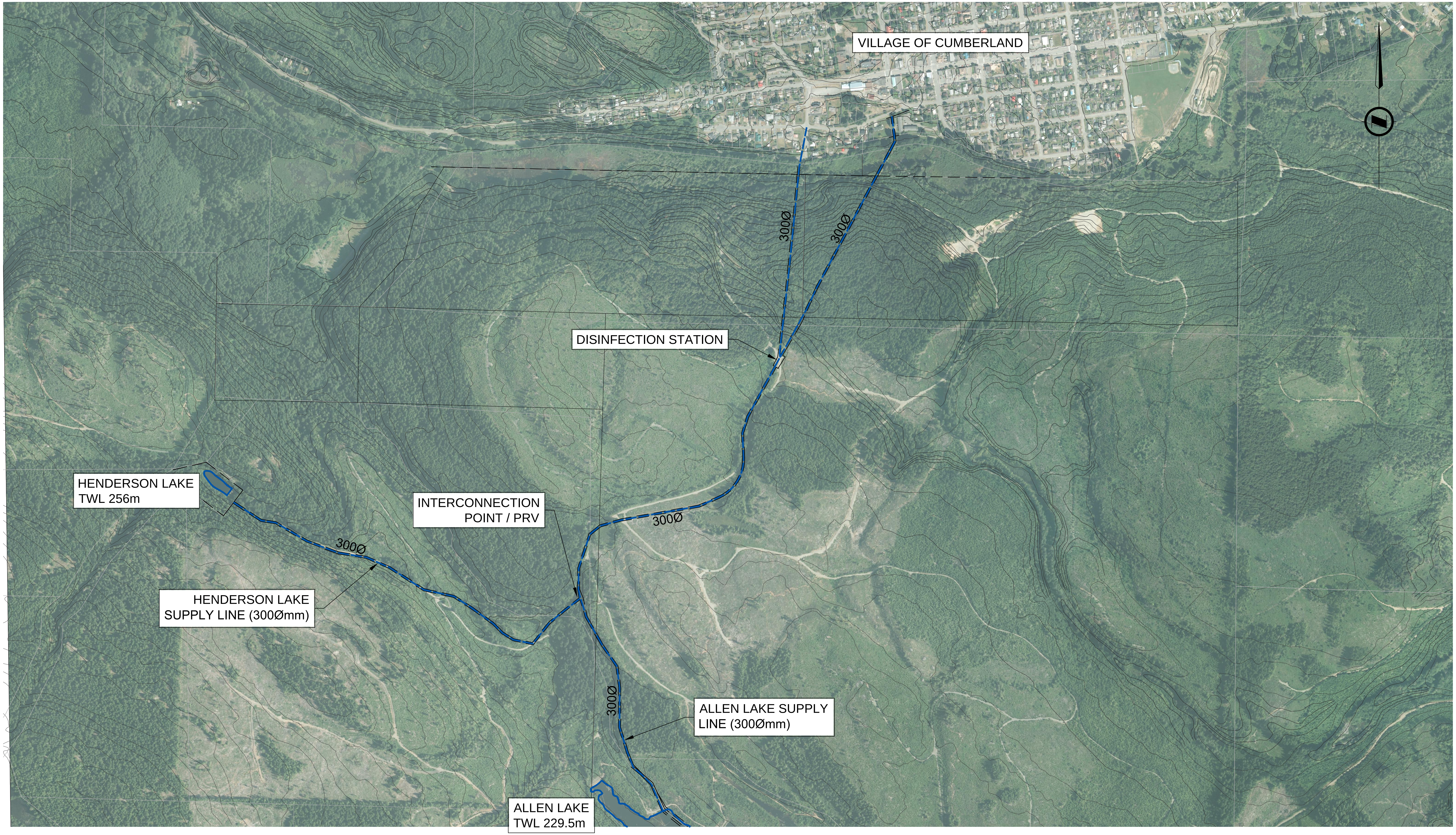
This well provides a good reliable supply during the winter months, however the well system was shut down from the end of September to the end of December in 2014 to address low water levels in the aquifer and associated water quality concerns.

1.2.2. Treatment

The Village of Cumberland currently operates two separate water treatment (disinfection) systems: one serves the surface water supply system and the other serves the ground water supply system. These systems are described as follows:

Surface Water Treatment System

- Surface Water supplied from both Allen Lake and Henderson Lake is treated with primary disinfection by a single chlorine gas facility.
- That chlorine gas facility is located 800 meters downstream from the point of connection between the Allen Lake and Henderson Lake supply lines.



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VILLAGE OF CUMBERLAND
CUMBERLAND, B.C

SURFACE WATER DISINFECTION & STORAGE REVIEW

CONCEPTUAL DESIGN SUPPLY SYSTEM LOCATION PLAN

Client Project No

Client Drawing No

MCSL Project No. 2231-22168

Drawing No. 21268-FIG 1.1

Ground Water Treatment System

- Ground Water from the well is disinfected by a sodium hypochlorite facility located at the west end of Dunsmuir Street at Comox Lake Road.

1.2.3. Distribution and Storage System

Cumberland's water distribution system is a network of pipes that generally follow the grid road system throughout the Village. These pipes vary in size from 100 m diameter to 250 mm diameter. Water storage is limited to the lakes within the supply system.

1.3. Treatment Objectives

Island Health's requirements for water treatment identifies the need to disinfect surface water sources and provide a multi-barrier approach (two or more forms of treatment). Island Health's objectives for the treatment of drinking water from surface supplies are summarized as follows:

- 4-log (99.99%) reduction or inactivation of viruses;
- 3-log (99.9%) reduction or inactivation of *Giardia* and *Cryptosporidium*;
- 2 Treatment processes for surface water;
- Less than, or equal to 1 nephleometric turbidity unit (NTU) of turbidity; and,
- Zero (no detectable) *E.coli*, fecal coliform and total coliform.

Most disinfection systems require clear water, and the *Guidelines for Canadian Drinking Water* recommend that filtration and one form of disinfection be used to meet treatment objectives.

Island Health has established a policy for the treatment of drinking water from surface water supplies (Policy 3.3, November 13, 2007). That policy waives the need for filtration, and allows dual disinfection, if the following conditions are met:

- *E.Coli* in raw water does not exceed 20/100 ml or less in 90% of source water samples;
- Daily average source water turbidity of 1 NTU or less for 95% of days, and not to exceed 5 NTU for more than 2 days in a 12 month period; and,
- Two primary disinfectants are provided, which together achieve .

Appendix A of the Permit to Operate was re-issued in September 2013 and outlines the following implementation plan:

- Undertake an enhanced water quality monitoring program including a continuous turbidity monitor. Turbidity meter installed 2008 and computerized monitoring installed 2010;

- Complete any and all necessary source water quality assessment to determine effectiveness of source protection measures and potential for filtration deferral;
- Complete the evaluation of data collected as per the previous bullet for the purposes of requesting a filtration deferral;
- Install ultraviolet disinfection treatment or other approved disinfectant as a second treatment method for surface supply;
- Complete watershed source protection risk analysis, including inventory of potential impacts.
- Develop, prioritize, and implement mitigation strategies;
- Maintain an enhanced source water quality monitoring program to identify trends and impacts; and,
- Re-assess filtration deferral in consideration of watershed source protection risk assessment and mitigation strategies.

1.4. Anticipated System Growth

1.4.1. Areas of Growth

Cumberland is located in the Comox Valley, a region that has experienced steady growth over the past several decades. Continued growth is anticipated with the following developments planned:

Coal Valley Estates

Coal Valley Estates is a multi-phase residential development project that is located at the north-west corner of the community. Four phases of development have been completed to date and plans show future development of an additional 300 single family lots. The site rises in elevation above the existing community and further development may trigger the need to increase system pressure and fire flows in the local area.

Trilogy Lands

The Trilogy lands consist of 14 large parcels that straddle Highway 19 and the Comox Valley Parkway to the north and east of the existing community. A mixed-use residential, commercial and industrial development is planned with a total equivalent population of 5300 persons at build-out. Preliminary land use planning for this development was carried out in 2011. That work included comprehensive infrastructure planning for waterworks including water main alignments, water main sizing, pressure zones, pumping and storage requirements. That waterworks plan includes the following key components:

- Reservoir(s) located on the hillside west of Dunsmuir Avenue with a base elevation of 218 meters and a top water level of 224 meters;
- 450 mm diameter supply main to run east along Dunsmuir Avenue/Royston Road and north along Small Road;
- 375 mm diameter supply main to run along the Comox Valley Parkway, north of Small Road
- Creation of a low pressure zone east of Union Road (185 meter Zone);
- Creation of a second low pressure zone north of Minto Road (145 meter Zone); and,
- Creation of a pumped high pressure zone to serve residential development south of Dunsmuir Avenue.

Infill and Re-Development

The Village Core area will experience on-going growth through infill development of empty sites, the re-development of new homes and businesses on existing lots, and the addition of carriage homes and secondary suites.

1.4.2. Regional Water Supply

The Comox Valley Regional District has proposed the development of a single water supply, treatment, and distribution system to meet future needs throughout the District. That Regional Water Supply System will draw water from Comox Lake with treatment to serve customers in Comox, Courtenay, Cumberland, Royston and other outlying communities. The final design and schedule for that project is yet to be determined, however the point of delivery to Cumberland is expected to be in the vicinity of Highway 19 and Cumberland Road. The pressures available at that point of delivery are unknown at this time. Pumping may be required to meet the Village of Cumberland Hydraulic Grade Line.

1.4.3. Water Demand Management

The Village of Cumberland implemented a universal metering program over the past 5 years. Water meters were installed on all residential, commercial and industrial services between 2010 and 2011. Consumption based billing was initiated in 2013 with a corresponding decrease to overall water consumption.

2. Technical Review

Three separate technical reviews were completed to establish Design Flows, identify and assess Treatment Options and to analyse the Water Distribution System. Results are included as appendices and summarized in the following sections.

2.1. Design Flows

The Design Flows used in this study are established in a Technical Memo that is included as Appendix B. Key findings and design criteria are summarized as follows:

- Recommendations are based on a review of water consumption data collected for the period 2008 to 2014;
- Water consumption in Cumberland dropped by approximately 25% after the implementation of Universal Metering in 2012;
- Water consumption in Royston was fairly consistent over the period 2008 to 2014;
- Recommended Average Day Demand (ADD) is 550 litres/capita/day;
- Recommended Peaking Factors for Maximum Day Demand (MDD) and Peak Hour Demand (PHD) are 2 and 3 respectively;
- Recommended Fire-flows range from 60 litres per second for Single Family Residential areas to 225 litres per second for industrial areas; and,
- Current Population Served is 5433 persons and the projected 2040 population is 9591 persons.
- Current water consumption levels are 3,000 m^3/day and are projected to increase to 5,300 m^3/day in 2040

2.2. Treatment Options

Disinfection options for treatment of potable water are identified and assessed in a Technical Memo that is included as Appendix C. Key findings are summarized as follows:

- Data collected by the Village confirms that raw water quality from surface sources consistently meets the turbidity and coliform density objectives (reference letter from Vancouver Island Health Association dated September 20, 2013 in Appendix A). On that basis there is currently no need to include filtration in the water treatment process;
- Dual disinfection is a multiple treatment process strategy that is the most direct and effective means of meeting the remaining Island Health objectives;

- The objective of Primary Disinfection is to achieve the necessary microbial inactivation, and the objective of Secondary Disinfection is to introduce and maintain a chlorine residual in the drinking water distribution system;
- Ultra Violet Radiation (UV) and Ozone were assessed and compared as options for Primary Disinfection – UV is the recommended option;
- Chlorine gas, Sodium Hypochlorite, On-site Hypochlorite Generation (OSHG), and Calcium Hypochlorite were assessed and compared as options for Secondary Disinfection – OSHG is the recommended option; and,
- A conventional Sodium Hypochlorite system could be implemented as an interim measure with OSHG to follow at a later date.

2.3. System Analysis

System Analysis for existing conditions and for seven Upgrade Scenarios are presented in a Technical Memo that is included as Appendix D. Key findings are summarized as follows:

2.3.1. Scenarios

The Analysis Scenarios are listed below:

Scenario 0 – 2015 Flows and Existing Conditions

Scenario 1 – 2040 Flows, with a new treatment plant, and a twinned supply line

Scenario 2 – 2040 Flows, with a new treatment plant, a twinned supply line, and a reservoir at Coal Valley

Scenario 3 – 2040 Flows, with a new treatment plant, a twinned supply line, and with a pump station at Kendal Road

Scenario 4 – 2040 Flows, with a new treatment plant, a twinned supply line, and with a pump station at Dunsmuir Avenue

Scenario 5 – 2040 Flows, with a new treatment plant, a twinned supply line, and with the proposed Cayet Reservoir

Scenario 6 – 2040 Flows, with a new treatment plant, a twinned supply line, a reservoir south of the Village (Hillside Reservoir), and a pump station that draws water from the main o Dunsmuir Avenue to supply the reservoir

Scenario 7 - 2040 Flows, with a new treatment plant, a twinned supply line, with a pump station at Dunsmuir Avenue and Sutton and a dedicated discharge line that runs north along Egremont Street to provide a direct supply line to the isolated high pressure zone north of Maryport Avenue.

2.3.2. Flows and Pressures

Key design flows and pressure requirements are listed in Table 2.1. Analysis results for the various scenarios are provided in Table 2.2 and include fire flows that are available at key locations while maintaining a minimum line pressure of 140 kPa throughout the system.

Table 2.1: Design Flow and Pressure Requirements

Demand	Design Flow	Pressure Requirement
Peak Hour	3 x Average Day Demand	Minimum 280 kPa (40 psi) throughout the system
Institutional Fire Flow	150 L/s	Minimum 140 kPa (20 psi) throughout the system
Multi-Family Residential Fire Flow	90 L/s	Minimum 140 kPa (20 psi) throughout the system
Single Family Fire Flow	60 L/s	Minimum 140 kPa (20 psi) throughout the system

Table 2.2: Summary of Analysis Results by Scenario

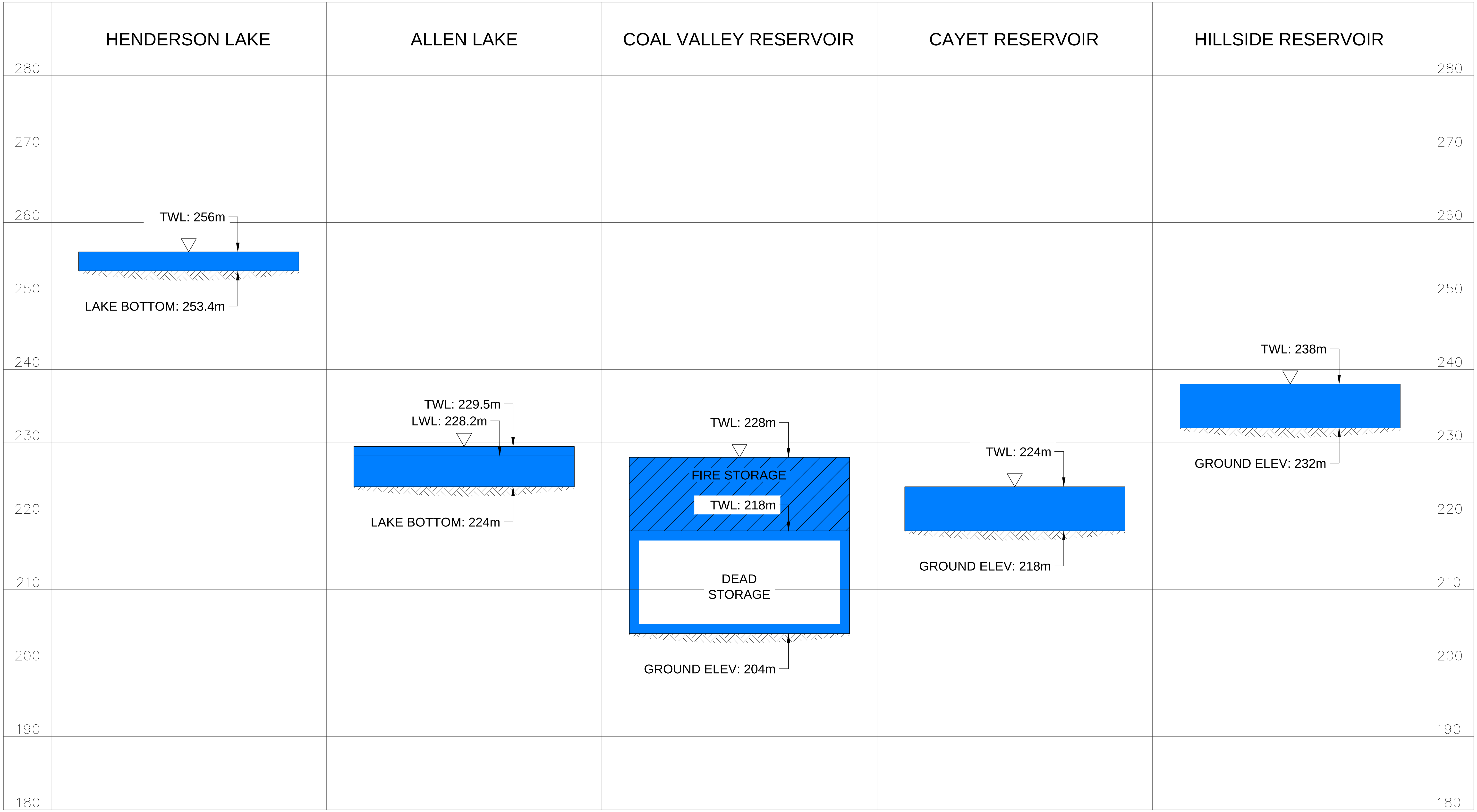
Analysis Scenario	PHD Pressure at Coal Valley Estates	Fire Flows at Cumberland Elementary	Fire Flows at Cumberland Junior Secondary	Fire Flows at Coal Valley Estates
Scenario 0 – 2015 Flows and Existing Conditions		95 L/s @ 300 kPa	108 L/s @ 350 kPa	67 L/s @ 140 kPa
Scenario 1 – 2040 Flows, Treatment Plant and Twinned Supply Line	< 210 kPa	90 L/s @ 350 kPa	100 L/s @ 380 kPa	60 L/s @ 140 kPa
Scenario 2 – 2040 Flows, Treatment Plant, Twinned Supply Line, and Coal Valley Reservoir	260 kPa	90 L/s @ 350 kPa	200 L/s @ 140 kPa	60 L/s @ 170 kPa

Scenario 3 – 2040 Flows, Treatment Plant, Twinned Supply Line and Kendal Road Pump Station	This Scenario Results in Negative System Pressure			
Scenario 4 – 2040 Flows, Treatment Plant, Twinned Supply Line and Dunsmuir Avenue Pump Station	Results will depend on Pump Selection			
Scenario 5 – 2040 Flows, Treatment Plant, Twinned Supply Line and Cayet Reservoir	< 210 kPa	160 L/s @ 320 kPa	200 L/s @ 320 kPa	60 L/s @ 140 kPa
Scenario 6 – 2040 Flows, Treatment Plant, Twinned Supply line, Pump Station and Hillside Reservoir		175 L/s @ 250 kPa	175 L/s @ 250 kPa	60 L/s @ 140 kPa
Scenario 7 – 2040 Flows, Treatment Plant, Twinned Supply Line, and Pump Station at Dunsmuir Road and Sutton Avenue.	Results will depend on Pump Selection			

Consideration was given to supplying the high pressure zone with water from by both Henderson Lake and the well supply to eliminate the need for an additional pump station. That Scenario was not pursued given the unreliable nature of water supply from both Henderson Lake and the well during summer drought conditions.

2.3.3. Reservoirs

System pressure is currently controlled by the Top Water Level (TWL) in Allen Lake. Pressure in the supply line from Henderson Lake is controlled by a Pressure Reducing Valve (PRV) to match the Allen Lake HGL. Three new reservoirs were identified for analysis (Coal Valley Reservoir, Cayet Reservoir and Hillside Reservoir). Reservoir Levels are illustrated for comparison in Figure 2.1.



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VILLAGE OF CUMBERLAND
CUMBERLAND, B.C

SURFACE WATER DISINFECTION & STORAGE REVIEW

SYSTEM ANALYSIS RESERVOIR LEVELS

Client Project No

Client Drawing No

MCSL Project No. 2231-22168

Drawing No. 21268-FIG 2.1

3. Anticipated Future Works

A list of projects that were identified to address Island Health treatment requirements and to accommodate the needs of future development are presented in Table 3.1.

Table 3.1: Anticipated Future Projects

Project Name	Project Description	Responsibility	Trigger
Project 1 – Supply Line Twinning	Twin the existing supply line from Allen Lake and Henderson Lake to the Treatment Plant	Village of Cumberland	In Conjunction with Construction of Treatment Works
Project 2 - Water Treatment Works	Construct new Treatment Works to replace the existing works downstream from Allen Lake and Henderson Lake	Village of Cumberland	VIHA Requirement
Project 3 – Coal Valley High Pressure Zone	Create a High Pressure Zone to service future phases of the Coal Valley Estates Development and to increase fire flows to the area. (Dunsmuir Avenue Pump Station or Hillside Reservoir)	Developer / Village of Cumberland	Development of land above 195 meters +/-
Project 4 – Dunsmuir / Coal Valley Loop	Loop the water distribution system between Dunsmuir Avenue and the Coal Valley Development	Developer	In conjunction with construction of subdivision works
Project 5 – Cayet Reservoir	Construct the reservoir that has been proposed to service the Cayet Development	Developer	In Conjunction with Construction of Dunsmuir Ave. Pump Station
Project 6 - Connection to Regional Supply	Augment or replace one or more of the existing water supplies after connection to a possible future Regional Water Supply	VOC / CVRD	Development of a Regional Water Supply System

4. Conceptual Design

4.1. Treatment Process

The water treatment process will be limited to dual disinfection. Primary disinfection will be provided by ultraviolet light and secondary disinfection will be provided by sodium hypochlorite injection.

Two options are identified for the supply of Sodium Hypochlorite: Bulk Purchase and Onsite Generation. Onsite generation offers the lowest life cycle cost. Both options will utilize the same injection equipment and the cost to supply and install OSG equipment could be deferred by using bulk sodium hypochlorite in the short term.

4.2. Components

A conceptual design and floor plan of the proposed treatment works is shown on Figure 4.1. These new works will include the following main components:

- Two independent treatment streams with 300 mm diameter piping to provide 100% redundancy;
- Flow meters;
- Ultra Violet Reactor for Primary Disinfection;
- Sodium Hypochlorite (NaOCl) injection for Secondary Disinfection with provision for future on-site generation;
- Provision for a third treatment stream to be added in the future; and,
- Associated valves and piping.

4.3. Location

These proposed treatment works will be located south of town, directly upstream of the existing chlorine gas facility. A Site Plan of the proposed treatment works is shown on Figure 4.2. The existing water mains and chlorination building are located within a statutory right of way that crosses the Remainder of Section 3, Nelson District, as shown on Plan No. 42119. That right of way is generally 6 meters wide, but widens to 18 meters in the vicinity of the chlorination building.

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BUILDING NOTES:

FOOTINGS - CONCRETE SPREAD FOOTINGS
FLOORS - CONCRETE SLAB ON GRADE
WALLS - CONCRETE BLOCK
ROOF STRUCTURE - WOOD TRUSS, 5:1 RATIO
ROOFING - PLYWOOD SHEATING/ASPHALT SHINGLES
ALL TO BC BUILDING CODE.

TREATMENT PROCESS

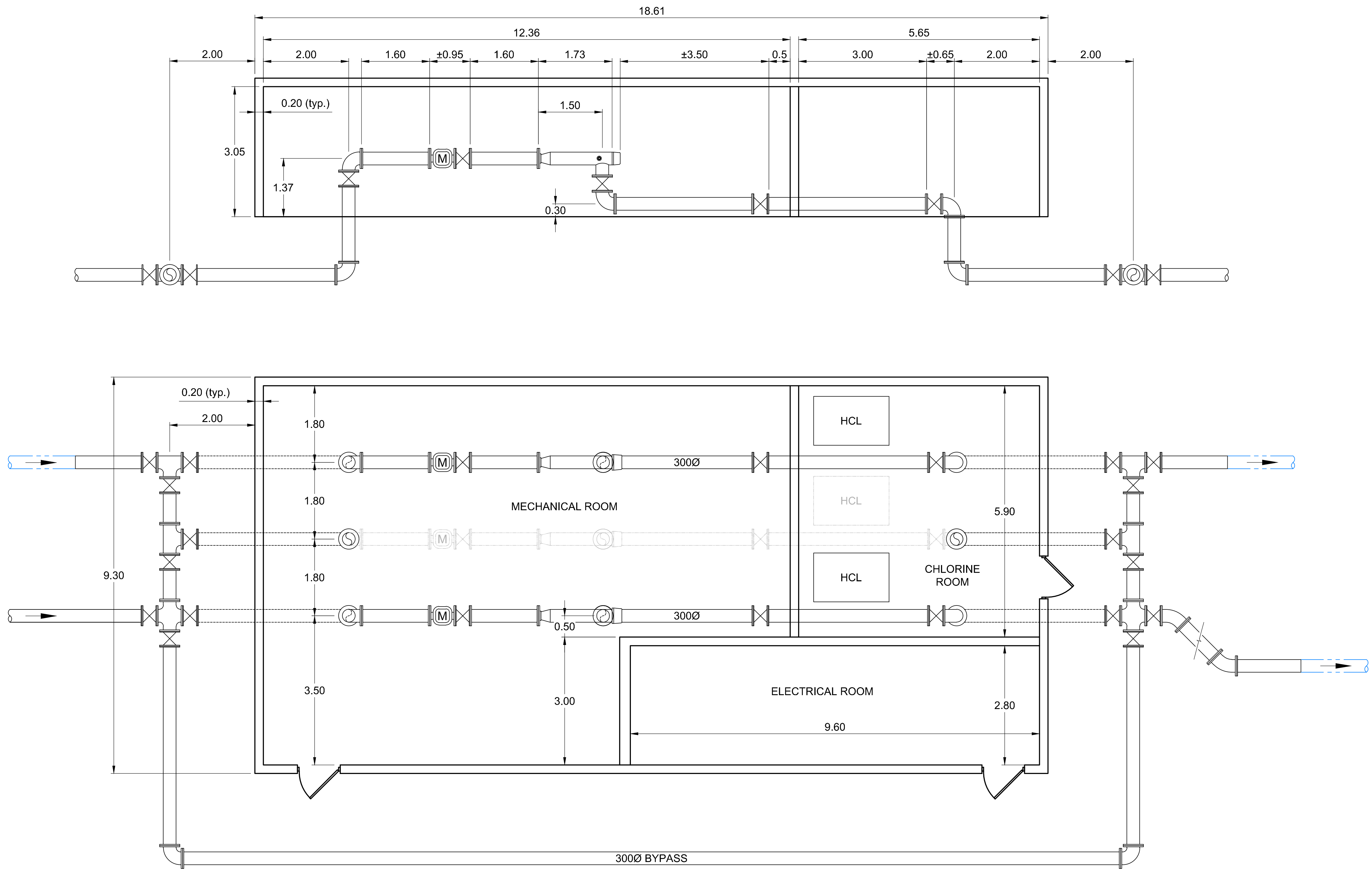
SHORT TERM

- 2 TREATMENT TRAINS
- PRIMARY DISINFECTION
  - LOW PRESSURE ULTRA VIOLET (TROJAN UV SWIFT SCD12 OR APPROVED EQUAL)
- SECONDARY DISINFECTION
  - FLOW PACED SODIUM HYDROCHLORIDE INJECTION

TREATMENT PROCESS

LONG TERM

- 3 TREATMENT TRAINS
- PRIMARY DISINFECTION
  - LOW PRESSURE ULTRA VIOLET (TROJAN UV SWIFT SCD12 OR APPROVED EQUAL)
- SECONDARY DISINFECTION
  - FLOW PACED SODIUM HYDROCHLORIDE WITH ON-SITE GENERATION



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VILLAGE OF CUMBERLAND
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SURFACE WATER DISINFECTION & STORAGE REVIEW

CONCEPTUAL DESIGN
PIPEWORK AND FLOOR PLAN
LOW PRESSURE UV REACTORS

Client Project No

Client Drawing No

MCSL Project No. 2231-22168

Drawing No. 21268-FIG 4.1

4.4. Building Layout

The proposed treatment works will be housed in a single purpose-built building with three rooms to house mechanical, electrical and chlorine equipment. The proposed building is described as follows:

- 18 meter x 12.5 meter (60 foot x 40 foot) purpose-built
- Slab on grade construction with concrete block walls, and an open web steel truss roofing system.
- Power to be provided by an existing three phase overhead Hydro line
- Ample room provided between treatment streams to allow easy access for maintenance and operation.

The proposed building floorplan is shown on Figure 4.1.

4.5. Twin Supply Line

Scenario 1 of the System Analysis shows that the pipework required by the new treatment plant will create additional head loss in the supply system. A second supply line is proposed to mitigate the associated pressure loss and to provide system redundancy. The alignment for that proposed line will run parallel to the existing line as shown on Figure 4.3. The proposed pipe and valve arrangement required to tie this new line into the existing system is detailed on Figures 4.2 and 4.4.

4.6. Construction Staging

The existing supply lines and disinfection works are an integral part of the Village of Cumberland water system. We recommend the following construction sequence to maintain a continuous water supply:

Step 1 – Prepare the existing system by installing a tee and valve between the Henderson Lake PRV and the point of connection between the Allen lake Supply Line and the Henderson lake Supply Line; and, installing a tee and valve on the bypass at the existing disinfection station.

Step 2 – Install, test and disinfect the Twin line and connect into the existing system at both ends.

Step 3 – Shut down the existing supply main and use the twin supply line and the new bypass to supply the village while continuing to operate the existing disinfection station.

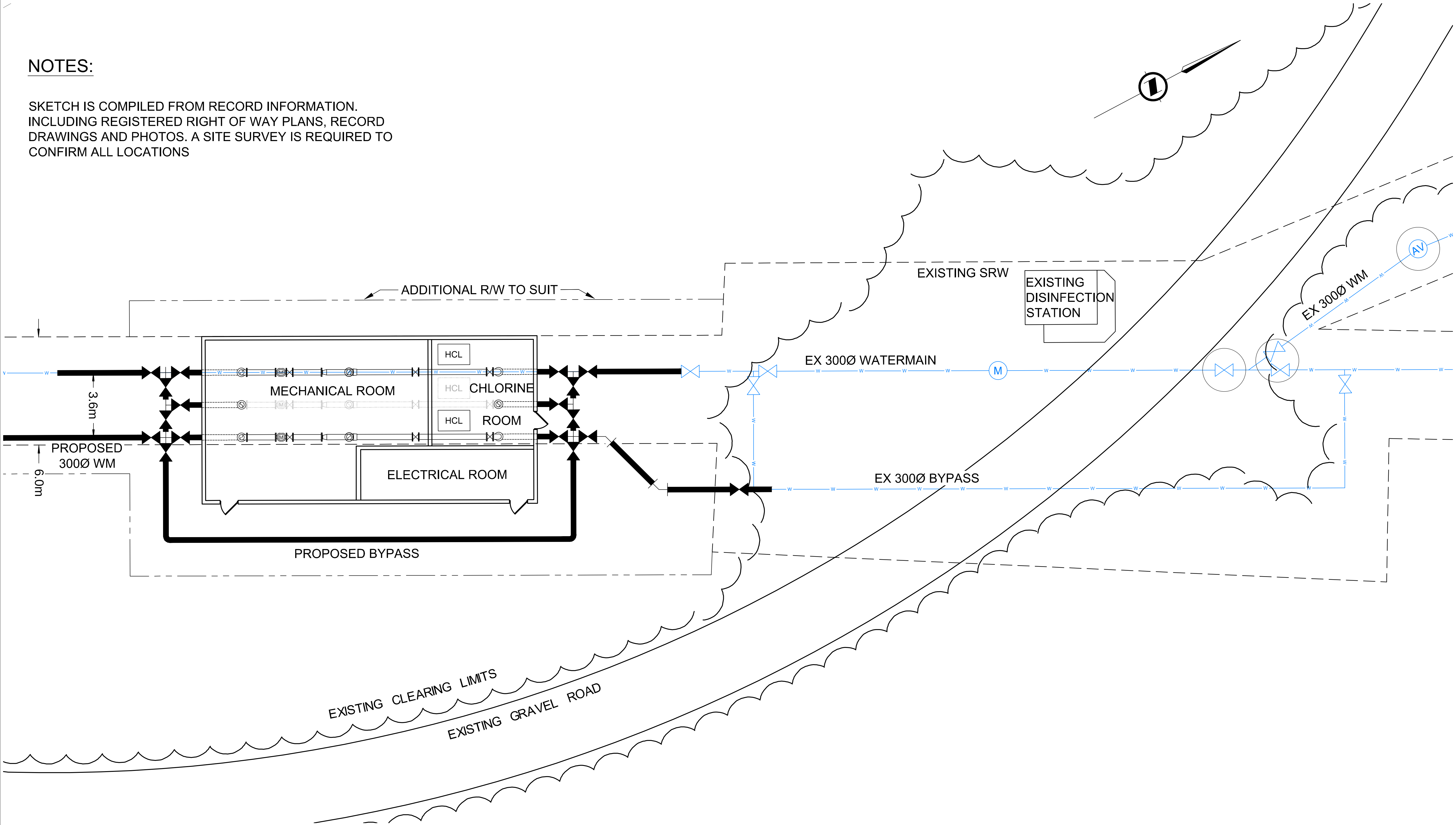
Step 4 – Construct, test and disinfect the new treatment works.

Step 5 – Commission the new treatment works.

Step 6 – Decommission the existing disinfection station.

NOTES:

SKETCH IS COMPILED FROM RECORD INFORMATION. INCLUDING REGISTERED RIGHT OF WAY PLANS, RECORD DRAWINGS AND PHOTOS. A SITE SURVEY IS REQUIRED TO CONFIRM ALL LOCATIONS



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SURFACE WATER DISINFECTION & STORAGE REVIEW

CONCEPTUAL DESIGN SITE PLAN

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Client Drawing No

MCSL Project No. 2231-22168

Drawing No. 21268-FIG 4.2

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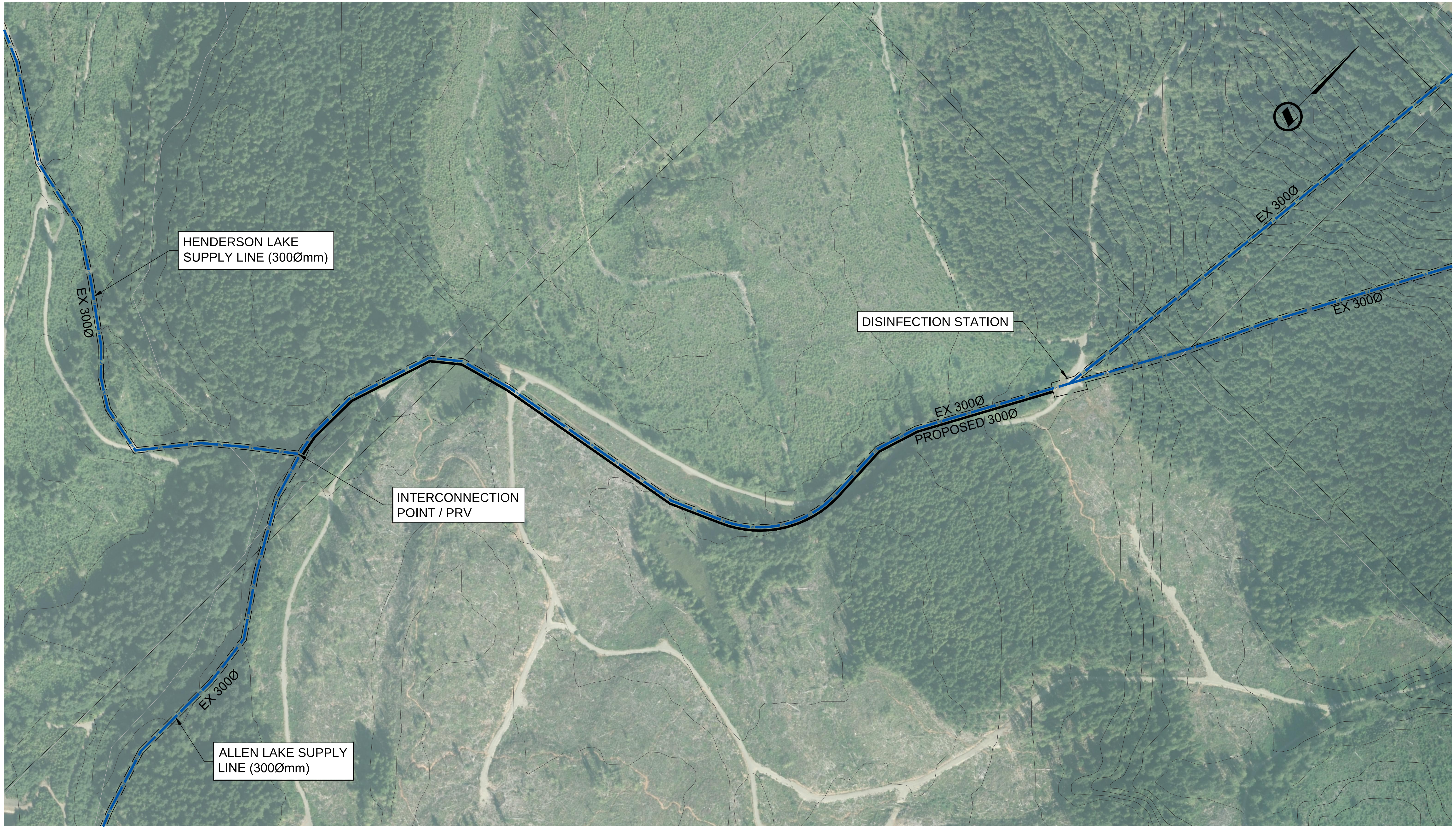

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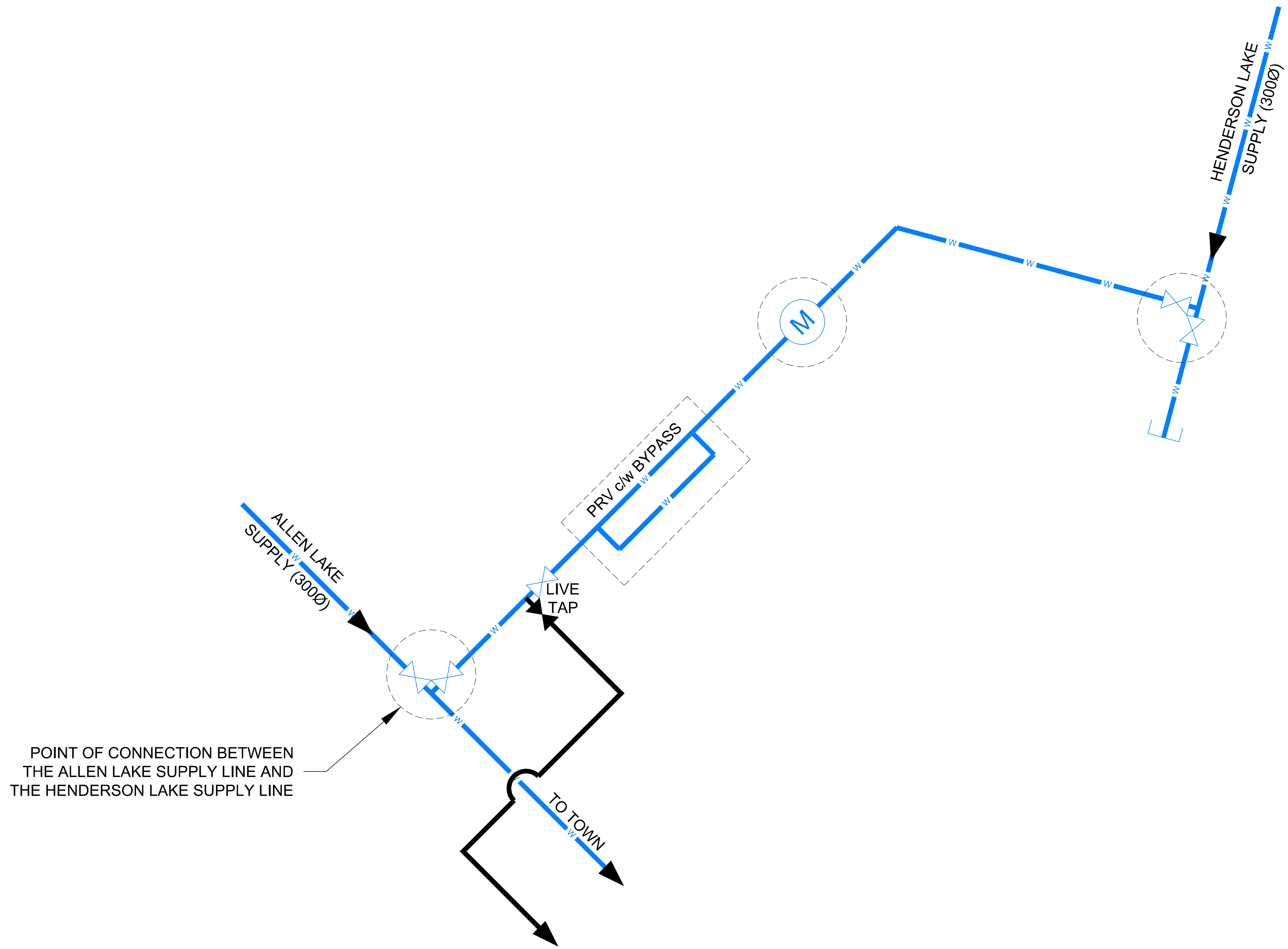
SURFACE WATER DISINFECTION & STORAGE REVIEW

CONCEPTUAL DESIGN
ALIGNMENT OF PROPOSED
TWIN WATER SUPPL LINE

Client Project No
Client Drawing No
MCSL Project No. 2231-22168
Drawing No.
21268-FIG 4.3



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SURFACE WATER DISINFECTION & STORAGE REVIEW

CONCEPTUAL DESIGN
TWIN LINE CONNECTION DETAIL

Client Project No

Client Drawing No

MCSL Project No. 2231-22168

Drawing No. 21268-FIG 4.4

5. Cost Estimate

Class C Cost Estimates for both the proposed Treatment Works and the Twinned Supply Main are included as Appendix E. The total estimated cost of each project includes a 25% contingency and a 15% allowance for Engineering. Cost estimate totals are presented below:

Treatment Works	$1,390,000
Twinned Supply Line	$ 590,000

6. Conclusion & Recommendations

6.1. Conclusions

Following provides a summary of our report conclusions:

6.1.1. Water Consumption

- Water consumption within the Village of Cumberland has dropped by approximately 25% as a direct result of the Village of Cumberland's universal metering program; and,
- Water consumption is projected to increase by 75% to 5300 m^3/day by year 2040.

6.1.2. Water Treatment

- The Village of Cumberland's disinfection system does not meet Island Health's current requirements for surface water treatment;
- Based on historic water quality test results those requirements can be met with Dual Disinfection;
- The recommended option for Primary Disinfection is Ultraviolet Radiation;
- The recommended option for Secondary Disinfection is On-site Generation plus Flow Paced Injection;
- The recommended location for construction of a New Treatment Facility is directly upstream of the existing treatment facility;

- Construction of a New Treatment Facility will introduce additional head loss to the water supply system and will compromise the capacity of the system to deliver fire flows;
- Anticipated head loss can be mitigated by twinning the existing water main upstream of the treatment facilities. This Twin Supply Line is 800 meters in length;
- The estimated cost to design and construct the Twin Water Supply Main is $ 1.84 million;
- The estimated cost to design and construct the New Treatment Facility is $ 0.57 million; and,
- The Twin Water Supply Main must be constructed ahead of the New Treatment Facility to maintain continuous service;

6.1.3. Water Storage

- Water storage in the existing water supply system is limited to lake storage within the Allen Lake and Henderson Lake systems;
- Additional storage is not required at this time, but will be required to service the Cayet development;
- Further development of the Coal Valley Estates Development will require construction of a new high pressure zone;
- A reservoir located on the highest site within the Coal Valley Estates development was assessed and found to be impractical;
- The study identified two practical options for this new high pressure zone:
    - Option 1 – Pump Station at Dunsmuir Avenue and Sutton Road - a pump station located on Dunsmuir Avenue with a dedicated supply line on Egremont Street. This pump station to include both duty pump(s) and fire pump(s).
    - Option 2 Hillside Reservoir and Pump Station - a new reservoir located on the hillside south of the Village that is supplied by a pump station that draws water from the Dunsmuir Avenue water main and has a dedicated discharge line to feed the new pressure zone. Reservoir to maintain pressure in the new zone and provide storage for peak water demand and firefighting;
- Both pressure zone options will improve current fire flow conditions at the Cumberland Elementary School and at the Cumberland Junior Secondary School;

6.2. Recommendations

Report recommendations are listed as follows to provide an outline for implementation:

- Submit this report to Island Health for review and acceptance;
- Prepare preliminary design of the Twin Water Supply Main and the New Treatment Facility;
- Property acquisition;
- Prepare detailed design of the Twin Water Supply Main and the New Treatment Facility;
- Submit both designs to Vancouver Island Health for review and approval;
- Construct those proposed works; and,
- Work with the developers of the Coal Valley Estates Development to select a preferred option for the new high pressure zone to serve that development and augment fire flows in the adjacent area.

Respectfully Submitted:

McElhanney Consulting Services Ltd.

Prepared by Russ Irish, P.Eng.

Reviewed by Chris Pogson, P.Eng.

Appendix A – Permit to Operate

VANCOUVER ISLAND health authority

RECEIVED
SEP 27 2013
MOPS, P/W.

Friday, September 20, 2013

Mr. Rob Crisfield
Manager of Operations
Village of Cumberland
2673 Dunsmuir Avenue
P.O. Box 340
Cumberland, BC V0R 1S0

Dear Mr. Crisfield:

RE: WATER SYSTEM OPERATING CONDITIONS – VILLAGE OF CUMBERLAND WATER SYSTEM

Please find attached an amended Appendix A – Water System Operating Conditions for the Village of Cumberland water supply. These amended operating conditions are consistent with those provided to you on June 26, 2013 and as agreed to during my water system inspection conducted on July 30, 2013.

Please be aware that the filtration deferral has been granted but is contingent upon strict adherence to the operating conditions now established. I further advise that the source water lakes for the Village of Cumberland water supply, and the activities within their watershed are dynamic and can have changing effects on water quality. For these reasons the filtration deferral will remain dynamic and will be re-assessed as required based on ongoing trends in water quality and identified impacts from activities within the watershed.

If you have any questions please contact me directly at 250.331.8518 or by e-mail to keir.cordner@viha.ca .

Sincerely,

Keir Cordner, B.A.A., CPHI(C)
Environmental Health Officer

Attachment: Amended Appendix A – Water System Operating Conditions for the Village of Cumberland Water System dated September 20, 2013

c.c.: Dr. Charmaine Enns, Medical Health Officer
Dwayne Stroh, Supervisor Health Protection
Murray Sexton, Regional Public Health Engineer

VANCOUVER ISLAND health authority

APPENDIX A
WATER SYSTEM OPERATING CONDITIONS FOR

VILLAGE OF CUMBERLAND WATER SUPPLY

2673 Dunsmuir Avenue

Cumberland, BC, V0R 1S0

Village of Cumberland Water Supply System

Compliance with these Operating Permit Terms and Conditions do not relieve the operator of other legislated responsibilities and obligations.

The specific terms and conditions of this operating permit are listed below as:

1.) Treatment Specification

The Water System Owner shall provide two treatment processes acceptable to the Vancouver Island Health Authority, to achieve a 4-log removal/inactivation of viruses; a 3-log removal/inactivation of Giardia cysts and Cryptosporidium oocysts, and produce finished water with less than 1 NTU turbidity.

The water system owner is required to meet the following implementation plan in order to achieve these water quality treatment objectives:

Task	Completion Dates
• Undertake an enhanced water quality monitoring program including continuous turbidity monitor. Turbidity meter installed 2008 computerized monitoring installed 2010.	Completed
• Complete any and all necessary source water quality assessment to determine, effectiveness of source protection measures and potential for filtration deferral.	Completed
• Complete the evaluation of data collected as per the previous bullet for the purposes of requesting a filtration deferral.	Completed
• Install ultraviolet disinfection treatment or other approved disinfectant as a second treatment method for surface supply a. Design b. Construction	 December 31, 2014 September 30, 2015
• Complete watershed source protection risk analysis, including inventory of potential impacts.	July 1, 2014
• Develop, prioritize, and implement mitigation strategies.	July 1, 2015
• Maintain an enhanced source water quality monitoring program to identify trends and impacts.	Ongoing
• Re-assess filtration deferral in consideration of watershed source protection risk assessment and mitigation strategies.	September 30, 2015

September 20, 2013
Effective Date:

Ken Cordner, B.A.A.,C.P.H.I.(C)
Environmental Health Officer
Vancouver Island Health Authority

VANCOUVER ISLAND health authority

HEALTH PROTECTION

PERMIT

to OPERATE

A WATER SUPPLY SYSTEM

Water System Name:	**VILLAGE OF CUMBERLAND WATER SUPPLY**
Premises Number:	1414314
Premises Address:	2673 Dunsmuir Avenue Cumberland, BC V0R 1S0
Water System Owner:	Village of Cumberland

Village of Cumberland is hereby permitted to operate the above potable water supply system and is required to operate this system in accordance with the Drinking Water Protection Act and in accordance with the conditions set out in this operating permit and conditions established as part of any construction permit.

The water supply system for which this operating permit applies is generally described as:

Service Delivery Area:	Village of Cumberland
Source Water:	Allen Lake & Henderson Lake
Water Treatment methods are:	None
Water Disinfection methods are:	Chlorine
Number of Connections	301-10,000 Connections - DWT

Operating conditions specific to this water supply system are in Appendix A.

Date: May 28, 2010

Issued By: ______________________
Environmental Health Officer

This permit must be displayed in a conspicuous place and is not transferable

Place Decal Here

Appendix B – Technical Memo – Design Flows

McElhanney

McElhanney Consulting Services Ltd.
Suite 1, 1351 Estevan Road
Nanaimo, BC V9S 3Y3
Tel: (250) 716-3336
www.mcelhanney.com

M E M O R A N D U M

Village of Cumberland	Surface Water Disinfection and Storage Review Technical Memo – Design Flows
Date:	August 26, 2015
Project Number:	2231 – 21268-2.0, Revision B

To: Village of Cumberland, Mr Rob Crisfield

From: Russ Irish, P.Eng.

1. Purpose

The purpose of this memo is to establish design flows for analysis of the Village of Cumberland's water supply and distribution system. This work is undertaken in support of a current review of the Village of Cumberland's surface water disinfection and storage requirements.

2. Historic Consumption

The Village of Cumberland draws water from the following two sources:

- Surface water catchments located south-west of town; and
- A groundwater well located west of town

In both cases water is disinfected near the source and delivered to a distribution system that serves both the Village of Cumberland and the neighboring community of Royston. Flows delivered to the distribution system are measured on a continuous basis at their respective treatment facilities. Royston is supplied from the Cumberland system through a single water line with flow measured directly upstream of their storage reservoir. In reviewing that data for the period 2008 to 2014 we made the following observations:

- Annual consumption by the Village of Cumberland is fairly consistent for the period 2008 to 2012;

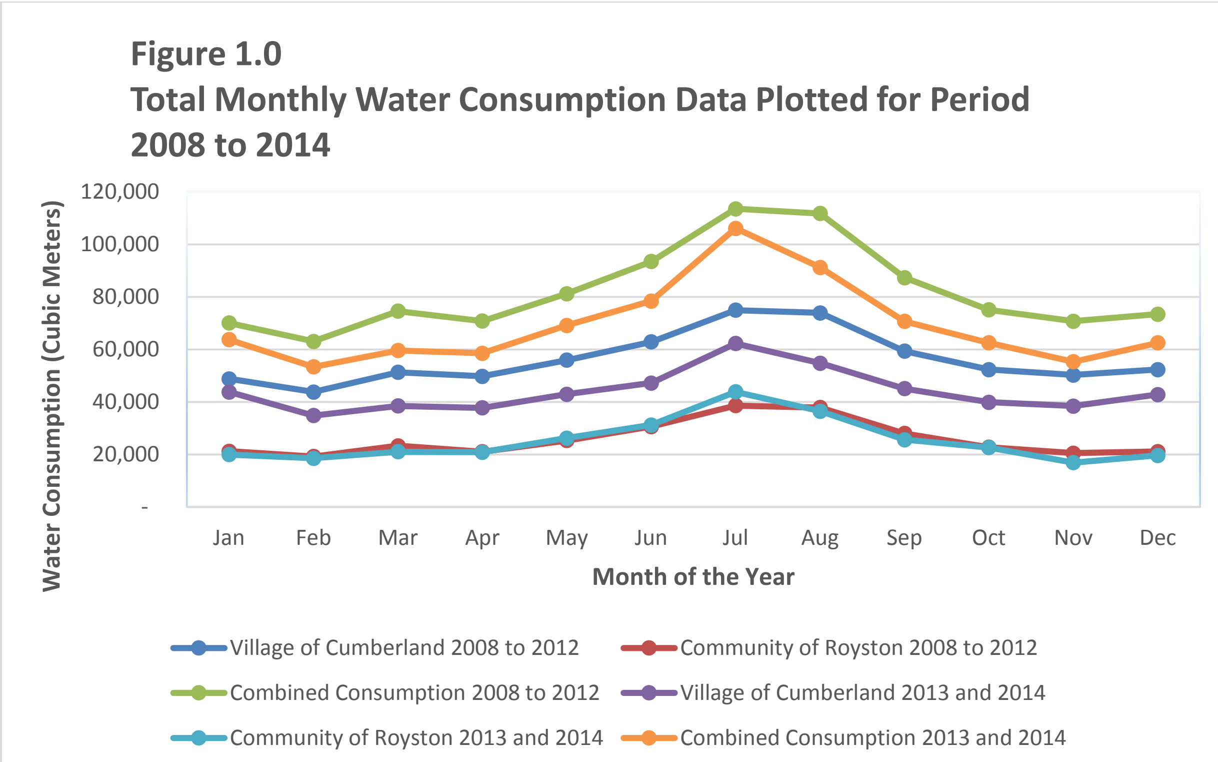
- Annual consumption by the Village of Cumberland takes a significant drop in 2013 and 2014. (This drop in consumption coincides with implementation of universal water metering and consumption based billing); and,
- Annual consumption by the community of Royston is fairly consistent for the period 2008 to 2014. (Royston implemented universal metering and consumption-based billing in 1997).

Water consumption data was processed to develop average monthly flow rates to compare the five year period from 2008 to 2012 against the two year period from 2013 to 2014. Average monthly water consumption data for the period 2008 to 2012 and 2013 to 2014 is presented in Table 1.0.

Table 1.0 – Average Total Monthly Water Consumption Data for the period 2008 to 2014

	2008 to 2012 Averages (m^3)			2013 and 2014 Averages (m^3)		
	Cumberland	**Royston**	**Total**	**Cumberland**	**Royston**	**Total**
Jan	48,832	21,263	70,095	43,783	19,979	63,762
Feb	43,831	19,249	63,080	34,845	18,549	53,394
Mar	51,278	23,327	74,606	38,526	21,051	59,578
Apr	49,760	21,051	70,811	37,747	20,845	58,592
May	55,958	25,306	81,264	42,960	26,222	69,183
Jun	62,874	30,659	93,532	47,195	31,252	78,448
Jul	74,955	38,604	113,559	62,306	43,850	106,156
Aug	73,928	37,881	111,809	54,777	36,500	91,277
Sep	59,376	27,998	87,374	45,075	25,625	70,700
Oct	52,337	22,741	75,078	39,920	22,625	62,545
Nov	50,242	20,516	70,758	38,422	16,925	55,347
Dec	52,317	21,112	73,429	42,829	19,680	62,509
Totals	**675,690**	**309,706**	**985,396**	**528,386**	**303,104**	**831,490**

The results presented in Table 1.0 are graphed in Figure 1.0.



With reference to Figure 1.0 we make the following observations:

- Water consumption is lowest during the month of February and highest during the summer months of July and August;
- Average water consumption by the Village of Royston is consistent for the two periods shown on the graph;
- Water consumption in Cumberland alone dropped by approximately 25% after 2012; and
- Water consumption in the combined system serving both Cumberland and Royston dropped by approximately 15% after 2012.

3. Population Growth

The 2011 Canada Census reports that the Village of Cumberland had a population of 3,398 in 2011 and the community of Royston had a population of 1,562 that same year. Current and future population estimates are provided in Table 2.0 based on an average growth rate of 2.3% reported over the past number of years by the Village of Cumberland.

Table 2.0 – Current and Future Population Estimates

	2011	2015	2040
Cumberland	3,398	3,722	6,571
Royston	1,562	1,711	3,020
Total	4,960	5,433	9,591

4. Water Demand

The Village of Cumberland has adopted the Master Municipal Construction Document (MMCD) as a standard. The MMCD's Design Guidelines 2014 provides recommendations for residential, commercial and industrial demands, but goes on to further recommend that criteria be adjusted based on local water consumption records. The following per capita water demand rates are defined and calculated using current data:

Average Day Demand (ADD) is the average daily rate of consumption in a given year. ADD is calculated by dividing the total consumption from 12 consecutive months of record by the number of days in a year. Given the change in consumption resulting from Cumberland's universal metering program we have used data from 2013 and 2014 to calculate ADD. Results are presented in Table 3.0.

Table 3.0 – Average Day Demand

	Cumberland	Royston	Combined
Total Average Annual Consumption (m^3)	528,386	303,104	831,490
Population (2011)	3398	1562	4960
ADD (litres/person/day)	426	532	459

By comparison, the ADD for the period 1997 to 2006 provided in the Village of Cumberland Water System Master Plan (AndersonCivil 2007) was 830 litres/person/day in Cumberland and 425 litres/person/day in Royston.

ADD for the Village of Cumberland based on two years of data since the implementation universal metering has dropped from 830 litres/capita/day to 426 litres/capita/day, however ADD for Royston has increased from 425 litres/capita/day for the first ten years after metering to 532 litres/capita/day. A similar rebound may be anticipated for Village of Cumberland flows.

We recommend an ADD of 550 litres/capita/day be used for analysis of the Cumberland Water System.

Maximum Month Demand (MMD) is the average daily rate of consumption for the single highest demand month of the year. The MMD is calculated by dividing the total consumption for the highest demand month (July 2013) by the number of days in that record period. Results are presented in Table 4.0.

Table 4.0 – Maximum Month Demand

	Cumberland	Royston	Combined
Consumption in July 2013 (m^3)	63,492	45,850	109,342
Population (2011)	3398	1562	4960
MMD (litres/person/day)	603	947	711

Maximum Month Demand is 1.6 times greater than Average Day Demand based on two years of data.

Maximum Day Demand (MDD) is the rate of consumption during the single highest demand day of the year. The Village of Cumberland does not record daily water consumption; therefore Maximum Day Demand cannot be calculated from available data.

Peak Hour Demand (PHD) is the rate of consumption during the highest demand hour of any day during the year. The Village of Cumberland records instantaneous flow at the surface water supply disinfection station using a circular chart graph. The highest rate of flow recorded in 2013 and 2014 occurred on Tuesday July 29, 2014 at 8:45 pm. The rate of flow recorded on the circular chart graph was 73 litres per second. In calculating PHD we have assumed that the well pump was working at the same time delivering a rated flow of 15 litres per second. The calculation of PHD is summarized in Table 5.0.

Table 5.0 – Peak Hour Demand

	Lake Supply	Well Supply	Combined
Instantaneous Flow (l/s)	73	15	88
Equivalent Daily flow (m^3)	6,300	1,300	7,600
Population (2011)			4960
PHD (litres/person/day)			1533

Peak Hour Demand is 2.8 times greater than Average Day Demand based on two years of data.

Peaking Factors are used to calculate Maximum Day Demand and Peak Hour Demand. These factors vary from one community to the next depending on population, the customer mix (residential, commercial and industrial water users), climate, lifestyle and other factors. A review of the available literature gives a typical range for MDD peaking factor of 1.5 to 3.0. Likewise the typical range for Peak Hour Demand peaking factor is 2.5 to 7.0.

Recommended Peaking Factors for the Village of Cumberland water supply are presented in Table 6.0

Table 6.0 – Recommended Peaking Factors

MMD - Maximum Month Demand	1.6 times Average Day Demand
MDD - Maximum Day Demand	2 times Average Day Demand
PHD - Peak Hour Demand	3 times Average Day Demand

5. Fire Demand

Minimum fire flow requirements provided in the MMCD - Design Guideline Manual for developments without sprinklers are reprinted in Table 7.0.

Table 7.0 – Recommended Minimum Fire Flow Requirements

Developments (without sprinklers)	Minimum Fire Flow
Single Family Residential	60 l/s
Apartments, Townhouses	90 l/s
Commercial	150 l/s
Institutional	150 l/s
Industrial	225 l/s

These numbers are appropriate when used to assess overall system performance, however the designers of individual development projects should use site-specific fire flows that are determined on a case-by-case basis in accordance with recommendations provided in "Water Supply for Public Fire Protection – A Guide to Recommended Practice", published by Fire Underwriters Survey.

6. Projected Water Demand

Current and projected future water demand has been calculated based on the following assumptions:

- Current rates of consumption are maintained;
- Service to both Cumberland and Royston;
- A continuation of recent historic growth rates; and,
- Recommended Peak Factors.

Water demand is presented in Table 8.0.

Table 8.0 – Water Demand

Year	Pop. Served	Average Day Demand (ADD) (m^3/d)	Maximum Month Demand (MMD) (m^3/d)	Maximum Day Demand (MDD) (m^3/d)	Peak Hour Demand (PHD) (m^3/d)
2015	5,433	3,000	4,800	6,000	9,000
2040	9,591	5,300	8,400	10,600	15,800

McElhanney Consulting Services Ltd.

PROVINCE OF R. R. IRISH
Aug 26/15

Prepared by Russ Irish, P.Eng.

G. D. HOOPER
Aug. 26, 2015

Reviewed by Dan Hooper, P.Eng.

Appendix C – Technical Memo - Disinfection Options for Treatment of Potable Water

McElhanney Consulting Services Ltd.
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Tel: (250) 716-3336
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McElhanney

M E M O R A N D U M

Village of Cumberland	Surface Water Disinfection and Storage Review Disinfection Options for Treatment of Potable Water
Date:	August 26, 2015
Project Number:	2231 – 21268-01, Revision B

To: **Village of Cumberland, Mr. Rob Crisfield**

From: **Dan Hooper, P.Eng.**

1.0 Background

The Village of Cumberland (The Village) uses both surface water and groundwater as water sources to meet potable water demands of the community. These investigations focus on the surface water further to the Island Health (IH) instructions that the Village "install ultraviolet disinfection treatment or other approved disinfectant as a second treatment method for surface supply". These instructions note the *permit completion dates of December 31, 2014 (design), and September 30, 2015 (construction) apply to this investigation and associated system upgrades.*

The Province requires disinfection and more broadly the treatment process is to address specific microbiological parameters; namely enteric viruses, pathogenic bacteria, Giardia cysts and Cryptosporidium oocysts. Further to that need, the Province has adopted the following general water quality and treatment system performance objectives:[1]

- 4-log reduction or inactivation of viruses.
- 3-log reduction or inactivation of Giardia and Cryptosporidium.
- Two treatment processes for surface water.
- Less than or equal to (≤) one nephelometric turbidity unit (NTU) of turbidity.
- No detectable E. Coli, fecal coliform and total coliform

The data collected by the Village on waters from their surface sources confirm that raw water quality consistently meets the turbidity and coliform density objectives and on that basis there is no current need to include filtration in the water treatment process. IH does require the Village to address the remaining three objectives. Dual disinfection is a **multiple treatment**

[1] Drinking Water Treatment Objectives (Microbiological) For Surface Water Supplies in British Columbia – Version 1.1 November 2012

process strategy that is the most direct and effective means of meeting the remaining objectives in the IH list.

McElhanney Consulting Services (McElhanney) submitted a proposal and the Village instructed the firm to proceed with the investigation in September 2014. The following treatment methods based in the McElhanney proposal are to be reviewed as options for dual disinfection.

- On-site sodium hypochlorite generation (OSHG),
- Calcium hypochlorite (granular or tablet),
- Sodium hypochlorite (12%),
- Chlorine gas.
- Ultraviolet (UV),
- Ozonation.

The proposal further outlines the scope of the review to include the following tasks and considerations.

- Confirmation of appropriate design criteria based on industry (AWWA) standards, and other regulatory requirements
- Capital Cost (comparative)
- Operating Cost (comparative)
- Operating and Maintenance requirements
- Efficiency
- Hydraulic grade line
- Water storage requirements (refer to Phase 2)
- Reliability
- Safety
- Flexibility
- Power Supply Requirements

The Village currently uses gas chlorination to disinfect waters from the surface water sources. This system has proven to be cost-effective and reliable but outdated equipment needs to be replaced. In this review, gas chlorination is one potential component in the dual disinfection options being considered.

2.0 Disinfection Terminology

Disinfection has two roles in a water supply system; treatment applied to raw water to achieve microbial inactivation (primary disinfection) and when applied to already treated waters to maintain a chlorine residual in the drinking water distribution system (secondary disinfection).

The following excerpts from the federal Ministry of Health, Guideline Technical Document – Chlorine explain these two disinfection roles and labels.

“Primary disinfection is the application of a disinfectant in the drinking water treatment plant, with a primary objective to achieve the necessary microbial inactivation. The efficacy of disinfection using chlorine can be predicted based on knowledge of the residual free chlorine concentration, temperature, pH, and contact time. This relationship is commonly referred to as the CT concept and is used by public drinking water suppliers as one tool for ensuring adequate inactivation of organisms during disinfection.”[2]

“Secondary disinfection may be applied to the treated water as it leaves the treatment plant or at re-chlorination points throughout the distribution system, to introduce and maintain a chlorine residual in the drinking water distribution system. Overall, chlorine residual provides two main benefits:

1. It can limit the growth of biofilm within the distribution system and its associated taste and odour problems (LeChevallier, 1998; Trussell, 1999; White, 1999).

2. A rapid drop in disinfectant residual may provide an immediate indication of treatment process malfunction or a break in the integrity of the distribution system (LeChevallier, 1998; Haas, 1999; Health Canada, 2006a, 2006b).

Chlorine residual may also reduce the risk of widespread microbiological contamination in the event of an intrusion into the distribution system…… In general, a free chlorine residual of 0.2 mg/L is considered a minimum level for the control of bacterial regrowth in the distribution system (LeChevallier et al., 1996).”

When applying these definitions to the list of disinfection options being considered in this investigation, the following role distinctions can be made.

[2] Guidelines for Canadian Drinking Water Quality; Guideline Technical Document Chlorine; Ministry of Health; June 2009

TABLE 1 – DISINFECTION ROLES APPLICABLE TO EACH OPTION

Disinfection Method	Primary Disinfection	Secondary Disinfection	Comments
On-site sodium hypochlorite generation (OSHG)	√	√	Single application point can achieve dual roles depending upon dosage levels
Calcium hypochlorite (granular or tablet)	√	√	Single application point can achieve dual roles depending upon dosage levels
Sodium hypochlorite (12%)	√	√	Single application point can achieve dual roles depending upon dosage levels
Chlorine gas	√	√	Single application point can achieve dual roles depending upon dosage levels
Ultraviolet (UV)	√		UV provides no residual and consequently provides no secondary disinfection
Ozonation (O^3)	√		O^3 residual is limited to a few minutes and consequently provides no effective secondary disinfection

3.0 Treatment Efficiencies

Listed hypochlorite and gas options provide essentially the same treatment efficiencies in terms of the CT concept noted earlier. Multiplying the concentration of chlorine (mg/L) by the contact time (minutes) determines a CT value. Established relationships exist between CT values and log reductions for the microbial organisms of interest. These relationships for chlorine vary with pH and temperature, and Cumberland waters have pHs close to 7.0 and temperatures that range from 5ºC to 20ºC.

Table 2 shows CT values for free chlorine and ozone and mJ/cm^2 values for UV disinfection. Comparing chlorine and ozone effectiveness as primary disinfectants, they have similar levels of effectiveness in inactivation of viruses, but Ozone is much more effective than chlorine in the inactivation of *Giardia*.

TABLE 2 – RELATIVE TREATMENT EFFECTIVENESS OF EACH LISTED OPTION[3]

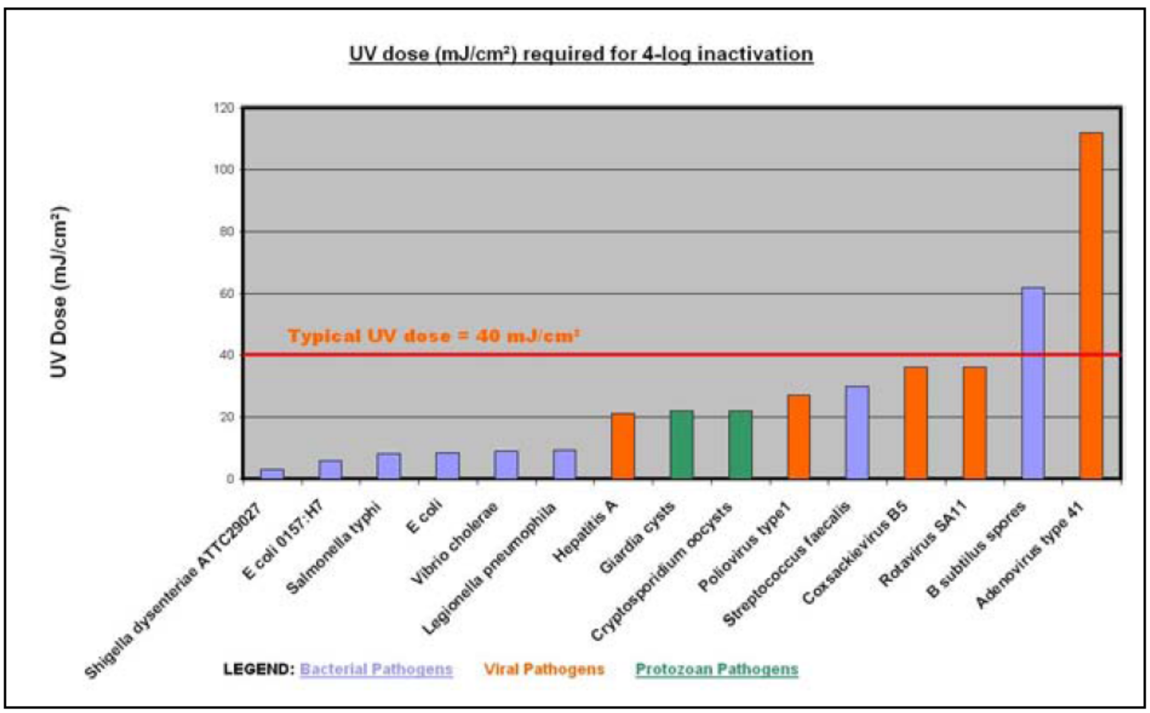
		Viruses Reduction		*Giardia* Reduction	*Cryptosporidium* Reduction
	Temp ºC	CT Values (mg.min/L)			
		4-log	2-log	3-log	3-log
Chlorine 1 mg/L	5	8	4	149	
Chlorine 1 mg/L	20	3	1	56	
Ozone 1 mg/L	5	1.35	0.68	1.90	47
Ozone 1 mg/L	20	0.5	0.25	0.72	12

3 AWWA Water Operator Field Guide; AWWA 2004; Table: "CT Values for Various Types of Contaminants"

		Dosage - Inactivation Levels			
UV – mW-		21			
UV – mJ/cm^2		186	100	11	12

The effectiveness of UV disinfection is measured through dosage - inactivation levels rather than CT values. Table 2 shows UV to be particularly effective in treating *Giardia* and *Cryptosporidium*. Although UV radiation is effective in the inactivation of most viruses, some other relevant viruses (Figure 1 below) required higher UV dosage levels than are typically provided in treatment of municipal potable water. In summary, UV and ozone are highly effective in the inactivation of *Giardia* and *Cryptosporidium*, while inactivation of some pertinent viruses is more effectively accomplished with chlorine and ozone.

FIGURE 1 - Required UV Dose for 4-log Inactivation of Common Waterborne Pathogens[4]



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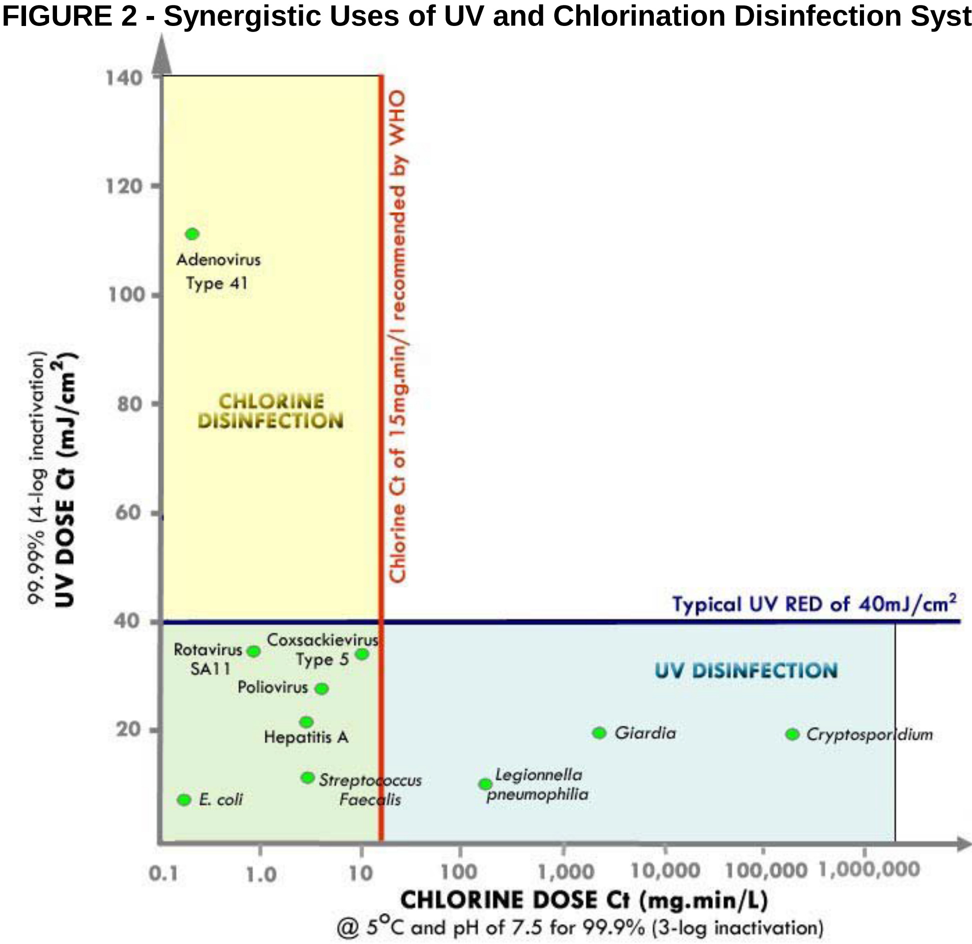
[3] AWWA Water Operator Field Guide; AWWA 2004; Table: "CT Values for Various Types of Contaminants"

[4] Environmental Protection Agency (EPA) 2011; Water Treatment Manual: Disinfection; Figure 2.2

IH requires dual disinfection with Secondary Disinfection providing a residual within the distribution system. Chlorine is the only option under consideration that has the ability to retain a residual and for that reason chlorination of some form will be used for Secondary Disinfection. Given that a multiple-process system is also a project objective to provide greater security assurance; the Primary Disinfectant will be either UV or ozone.

The security assurance aspect of multiple processes is illustrated in Figure 2 that shows the synergy of UV and chlorination in inactivate of a range of common pathogens. A multi-barrier treatment process using both disinfection methods clearly provides benefit in full-spectrum pathogen control.

FIGURE 2 - Synergistic Uses of UV and Chlorination Disinfection Systems[5]



Reduction equivalent dosage (RED)
World Health Organization (WHO)

[5] EPA 2011; Water Treatment Manual: Disinfection; Figure 3.2

4.0 Assessment of UV and Ozone as Primary Disinfection Options

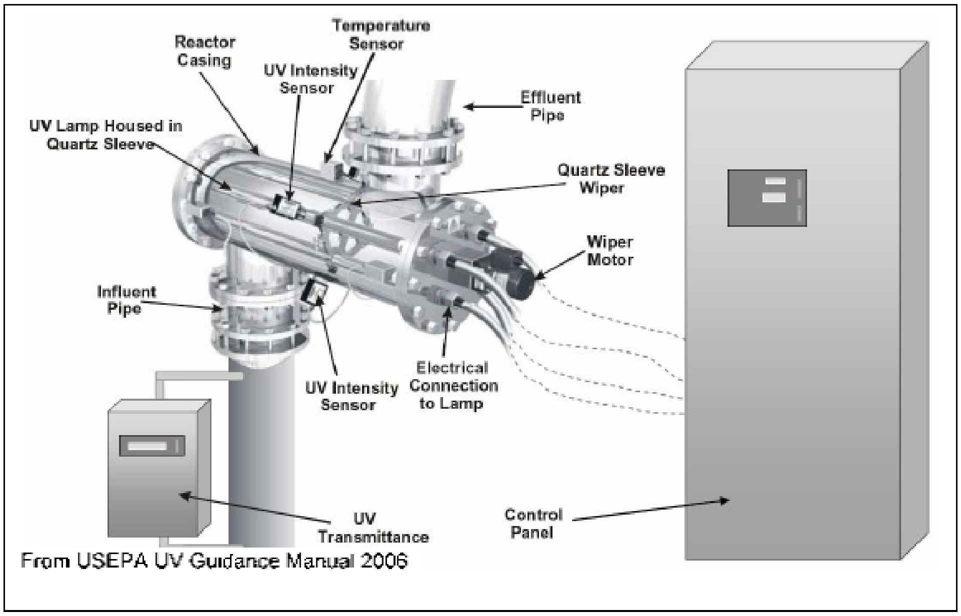
Relevant factors in an assessment of treatment options include compatibility with existing operations, performance reliability, ease of operation, occupational health and environmental considerations and costs. The following assessment of each option begins with a description of features and then addresses these factors.

4.1 UV Radiation

The mechanisms involved in UV radiation are different from those of chemical disinfection. Where chemical disinfectants inactivate microorganisms by destroying or damaging cellular structures, interfering with metabolism, and hindering biosynthesis and growth, UV light inactivates microorganisms by damaging their nucleic acid. Damage to the nucleic acid (DNA, RNA) prevents the microorganism from replicating and infecting a host. UV damage occurs when DNA and RNA which reflects the microorganism's nucleotide composition, absorb radiation at a wavelength peak near 260 nm and a local minimum near 230 nm.[6]

Figure 3 illustrates an UV reactor installation typical of potable water systems. How readily UV light is transmitted through the water is measured as UVT (UV Transmittance), and this is one of the water quality factors impacting performance levels.

FIGURE 3 Schematic of a Typical UV Reactor[7]



[6] EPA Ultraviolet Disinfection Guidance Manual For The Final Long Term 2 Enhanced Surface Water Treatment Rule; November 2006; EPA 815-R-06-007; Section 2.3

[7] EPA 2011; Water Treatment Design Manual: Disinfection; Figure 7.1

Other water quality factors impacting performance of UV reactors include any potential shielding of microorganisms from the radiation, and upstream treatment processes that add oxidants. As examples, fouling of the quartz sleeves reduces UV intensity, so when oxidants such as ozone and chlorine used upstream oxidize and enable precipitation of metals such as iron and manganese, an increase in UTV and effectiveness can occur.

Water quality data are critical where UV disinfection is being considered and consequently should be collected over a period of at least one year. A 12-month sampling period allows coverage of seasonal variations that are to be anticipated with any surface water source. Currently available water quality data for Cumberland are quite limited. Although turbidity is being monitored on a continuous basis, more data are required on colour, temperature and UVT. Table 3 provides a summary of the available records for these other three water quality parameters.

TABLE 3 – RAW WATER QUALITY – UV-RELEVANT PARAMETERS

Colour	5 -9 tcu	Based on 7 VIHA samples Dec 1991-Nov 2002
Temperature		
UVT	85.2%	Oct 12, 2005 NIL 47053
	83.7%	Oct 25, 2006 NIL 54607
	84.1%	2014 Average (R Crisfield)

Capital and operating costs vary significantly with the raw water UV T% and Cumberland's UVT values in the 80-85%. UVT% of 75 is the lower limit generally accepted for UV disinfection and values in Cumberland's UVT range are relatively low compared to most installations. Low enough that some suppliers contacted during these investigations suggested that installing an ozone unit upstream to reduce the size of the UV reactor might be a reasonable approach. The costing assessments that follow, however, do not support use of a hybrid system of this type.

Relevant system features applicable to UV disinfection in Cumberland include hydraulic design capacity based on peak hour demands given the current lack of distribution storage, and use of at least two UV reactors for redundancy (one duty and one standby). UV systems are typically located upstream of the chlorination system for the following reasons where a combination of UV and chlorination disinfection is used:

- UV irradiation reduces chlorine residual concentrations so locating UV downstream is counter to the purpose of secondary disinfection;

- UV often reduces chlorine demand so locating it upstream reduces chlorine dosage rates which in turn provide water quality benefits in terms of lower trihalomethane (THM) production, lower operating costs and lower potential for odour and taste complaints.
- Placing the UV process upstream is physically consistent with the use of chlorination for secondary disinfection. In this case minimum CT values apply and on-site storage for contact time is not necessary because of the length of the supply line before the first service connection.

Trihalomethanes refers to the total of chloroform, bromodichloromethane, dibromochloromethane and bromoform which are chemical by-products in drinking water produced when chlorine reacts with dissolved organic carbons (precursors) in raw water. One of the major advantages of UV disinfection over other potential options is the very limited generation of chemical by-products in treating raw waters of varying quality.

Ultraviolet disinfection is confined within the irradiation chamber and has no effect outside the photoreactor on consumers drinking the water or on biota in receiving waters. Even with high doses of UV, no mutagenic byproducts have been detected.

Operations tasks include calibrating monitoring sensors, checking failsafe devices, cleaning lamp sleeves, inspecting and cleaning reactor inner surfaces, examining seals, replacing aged lamps, and monitoring water quality.

Annual cost of O&M is estimated at $9,000 excluding power costs. The electrical load is 12 kW and based on a unit rate of $0.11/kWh, estimated power consumption at design flow is estimated at $4,000/year. Total O&M costs estimated in 2015 dollars begin at $11,300 per year increasing with water production volumes to $13,000 annually by year 2040.

Based on installation of two UV reactors, capital costs of process equipment before taxes and installation are in the order of $330,000.

Estimated net present value of the UV disinfection option operating over a period of 25 years and based on the costs outlined above is $550,000 excluding installation and building-related costs.

4.2 Ozone

Ozone is an unstable gas which has to be generated as required on site. It decays more rapidly than other disinfectants and for this reason can only be used as a primary disinfectant. A complete disinfection system requires ozone to be coupled with a secondary disinfectant such as chlorination to provide a verifiable residual in the distribution network.

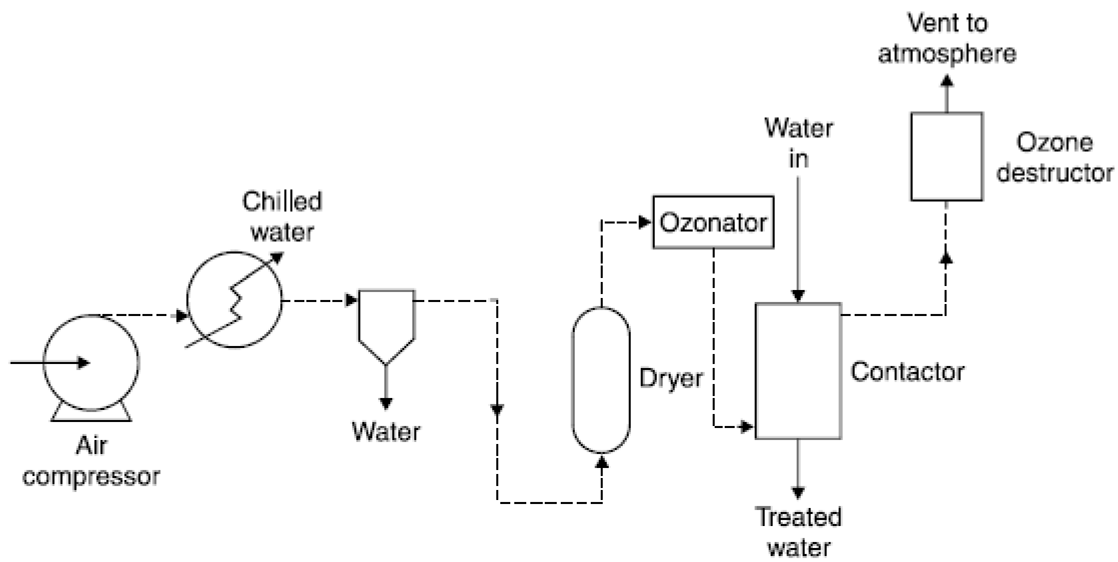
In terms of treatment performance, ozone is more effective as a bactericide and virucide than chlorine; is effective against Giardia; and more effective than any other chemical disinfectants used in water treatment against Cryptosporidium. Ozone oxidizes natural organic matter (NOM) in the water that in turn frequently increases UVT % levels and reduces consumer complaints regarding colour and taste.

Ozone generation is typically achieved by corona discharge of dry air or oxygen, and the main features of an air-fed ozonation plant are illustrated in Figure 4.

Air used for ozone generation must be dry because water vapour causes arcing inside the generator leading to loss of production and energy waste. Moisture can also result in the formation of nitric acid. Nitric acid is very corrosive to critical internal parts of the ozone generator causing premature failure increasing maintenance frequency. To achieve the dryness required, desiccant driers are used and refrigerant driers upstream of the desiccant driers may also be used in larger systems. Feed air must also be free of dust particles which can cause arcing. Dust and hydrocarbons in the air also reduce energy efficiency.

Ozone gas is a toxic, bluish, unstable, potentially explosive gas that is highly corrosive. It is an occupational health concern and requires piping and other equipment constructed of corrosion resistant materials. Ozone leak detectors are required for audible/visible warnings and to shut down the generators in the event of a leak.

FIGURE 4 Schematic of an Air-fed Ozonation System[8]



[8] EPA, 2011; Water Treatment Manual: Disinfection; Figure 5.1

Ozone is generated in the gas phase and is dissolved most commonly using a gas-liquid contactor chamber 5-6 m deep with porous diffusers that produce bubbles of 2-3 mm diameter. Determining the actual CT achieved in a multiple chamber contactor is not straightforward. The solubility of ozone is appreciably lower than that of chlorine and complete ozone transfer is not achieved in practice. The off-gas from contact chambers will contain ozone at toxic concentrations and must be processed to destroy remaining ozone before venting to the atmosphere. Two methods are used: thermal and catalytic.

Occupational health and safety considerations include the off-gas as noted above, and the high voltage electricity involved in ozone generation has associated safety hazards. The ozone production equipment includes various fail-safe protection devices which automatically shut off the equipment when a potential hazard develops.

With respect to impacts on water quality, ozone can either reduce or increase disinfection by-products (DBP) precursors prior to chlorination. Specific changes depend on dose, transfer efficiency, pH, alkalinity, pressure, contact time and the nature of the organic materials. Ozone's oxidation of DBP precursors generally increases the biodegradable fraction, measured as increases in assimilable organic carbon (AOC) or biodegradable dissolved organic carbon (BDOC).This fraction if allowed to enter the supply, can promote growth in the distribution network. Systems using ozone for disinfection, for this reason often include downstream a process like granular activated carbon (GAC) filtration.

Ozone will oxidize the bromide ion (Br-) to form bromate (BrO_3-) a highly toxic substance and Health Canada currently has an interim maximum acceptable concentration (IMAC) of 0.01 mg/L for bromate. The potential to form bromate needs to be investigated further if ozonation receives further consideration. Major factors in bromate formation include bromide concentration in raw water and the impurities in bulk hypochlorite, if that source was used for chlorine residual.

Operations tasks include preventative maintenance on the compressor, filter replacement, pump seal replacement and valve replacement over the course of a year. The equipment supplier estimates an annual cost of $30,000 to $35,000[9]. In addition, the electrical load is 68 kW and estimated power consumption at design flow is estimated at $20,000/year based on a unit rate of $0.11/kWh.

Capital costs of the process equipment before taxes and installation are in the order of $600,000 based on installation of a single ozone generator. The costs of the building structure and services are somewhat greater than for the UV option.

9 VEK Environmental Ltd. Price Quotation dated February 5, 2015, spreadsheet attachment

The ozone option has an estimated net present value of $1.40Million based on operating over a period of 25 years, the costs outlined above, and excluding the building-related costs. Table 4 provides a summary of the advantages and disadvantages of the two Primary Disinfection Options described above.

TABLE 4 – SUMMARY OF UV AND OZONE ADVANTAGES AND DISADVANTAGES

Treatment Process	Advantages	Disadvantages
UV Disinfection	1. Low doses are very effective disinfectant for pathogenic protozoa such as *Cryptosporidium.* 2. No formation of organic disinfection by-products at 40mJ/cm^2 dose level. 3. Small space requirement for reactors, and associated instrumentation and ballast panels; 4. Reduction in chlorine demand in downstream water; 5. Full redundancy capital costs are ≈ 60% lower and NPV costs ≈ 65% lower than for a single ozonation unit.	1. Higher doses required for virus inactivation; 2. Performance dependent on raw water UTV levels; a water quality parameter that varies seasonally;
Ozonation	*1.* Very effective disinfectant for viruses and *Giardia;* 2. Provides other treatment benefits, such as reductions on colour, taste and odour levels.	1. Requires on-site generation and high energy input; 2. Complex plant that requires high-skilled maintenance input. 3. Bromate is a common disinfection by-product. 4. Changes organics potentially increasing biological growth in the downstream distribution system; 5. High capital and O&M costs 6. No equipment redundancy

4.3 Triple Bottom Line Assessment

MCSL conducted triple-bottom-line (TBL) assessments of the two Primary Disinfection options.

MCSL conducted triple-bottom-line (TBL) assessments of the two Primary Disinfection options. As Table 5, illustrates, TBL assessments consider environmental and social, as well economic factors, and the UV disinfection option receives the highest overall rating in all three areas of consideration.

TABLE 5

TRIPLE BOTTOM LINE ASSESSMENT OF PRIMARY DISINFECTION OPTIONS

Criteria	Weight	System Options: UV	System Options: Ozone
Economic			
Capital Cost	1	2 $330k	1 $500k
Operations and Maintenance NPV (25 yr)	0.2	2 $220k	1 $900k
System NPV	1	2 $550K	1 $1,400k
Group Average for The Option		2.0	1.0
Weighting Factor for the Group	1		
Weighted Group Average for the Option		2.0	1.0
Environmental			
Hazards and Risk Levels (gases, electrical)	1	2	1
Carbon footprint (power need)	1	2	1
Group Average for The Option		2.0	1.0
Weighting Factor for the Group	1		
Weighted Group Average for the Option		2.0	1.0
Social			
Public Acceptance (taste & odour)	1	1	2
Disinfection-By- Products	1	2	1
Group Average for The Option		1.5	1.5
Weighting Factor for the Group	1		
Weighted Group Average for the Option		1.5	1.5
Other			
Treatment process complexity	1	2	1
Ease of O&M	1	2	1
Expandability/upgradability	1	2	1
Group Average for The Option		2.0	1.0
Weighting Factor for the Group	0.5		
Weighted Group Average for the Option		1.0	0.5
Weighted TBL for each option		5.5	3.5
TBL plus "Other"		6.5	4.0
Non- Economic Criteria		4.5	3.0

Rating Method: 2 is best; 1 least desirable

5.0 Comparison of Chlorine-Based Options for Secondary Disinfection

Four options for secondary disinfection identified in Table 1 are assessed in this portion of the report. All four options are based on chlorination and treatment performance in terms of disinfection (Table 2) is identical. Table 2 through CT values illustrates the relative level of effectiveness of chlorine compared to other disinfection processes. These CT Values, however, apply to the design of Primary Disinfection systems, but not Secondary Disinfection systems.

Cumberland currently uses chlorine gas and sodium hypochlorite (12%) disinfection systems. The other two other options, on-site sodium hypochlorite generation (OSHG) and calcium hypochlorite (granular or tablet) are used less commonly than sodium hypochlorite (12%) and chlorine gas disinfection systems in treatment of municipal water supplies.

All chemicals used for chlorination should be certified as meeting NSF International (NSF)/American National Standards Institute (ANSI) Standard 60: Drinking Water Treatment Chemicals — Health Effects. This health effects standard for chemicals used to treat drinking water includes certification criteria for chlorine, calcium hypochlorite, sodium hypochlorite, and de-chlorination chemicals.

5.1 Chlorine Gas

Chlorine gas is currently used in disinfection of supply from Cumberland's surface water sources. This system has been in place for more than 35 years and performance could be characterized as cost-effective and generally reliable. Chlorine gas is a hazardous material and in upgrading/expanding the present gas system, the operators' primary concerns are with occupational health and safety issues in transporting and handling the gas.

High risk levels associated with gas leaks means designs of chlorine gas systems and components are highly standardized and subject to close review by regulatory agencies. Regulatory agencies also require extensive operator training to ensure that appropriate safeguards for staff and public safety are in place at all times.

Gas systems compared to the three other chlorination systems under consideration has the second lowest capital and operating costs. Capital costs of the process equipment before taxes and installation are in the order of $40,000. Building size and costs are no more than for other chlorination systems.

Chlorine gas consumptions based on a delivered cost to site of $5.17/kg Cl has an approximate net present value over a 25-year period, of $230,000. Other operations and maintenance cost components like labour and utilities would be similar for all chlorination systems.

5.2 Sodium Hypochlorite

Sodium hypochlorite (12%) chlorination systems are widely used in the municipal water industry. Cumberland currently operates this type of system to disinfect groundwater from their water supply well. Operation of the system relies on scheduled delivery of 200L drums of sodium hypochlorite. Transfer of the hypochlorite solution into the water supply pipeline involves use of solution tanks, flow-paced chemical feed pumps and injectors. Personnel operating this type of chlorination system are required to undertake several tasks including monitoring water quality; transferring hypochlorite solution from drums to solution tanks; cleaning tanks, pumps and piping; calibrating pumps and monitoring sensors.

Chemical feed systems require regular maintenance but are generally very reliable and standby facilities typically provide system redundancy. Issues of concern center on the handling and storage of sodium hypochlorite. Inhalation, skin contact and corrosion are hazards that apply. The duration and conditions of product storage can adversely impact performance levels. Production of chlorate with associated health concerns, and loss of chlorine as chlorine monoxide gas both occur with decay/decomposition sodium hypochlorite.

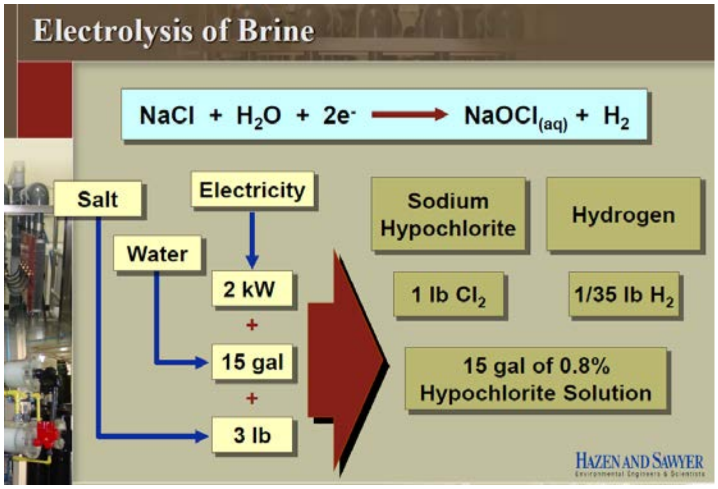
Capital costs of the chemical metering and monitoring equipment and on-site storage before taxes and installation are in the order of $30,000. Building size and costs are no more than for the other chlorination systems.

Consumption of bulk sodium hypochlorite solution based on a delivered cost to site of $6.17/kg Cl has an approximate net present value over a 25-year period, of $270,000. Other operations and maintenance cost components like labour and utilities as previously noted would be similar for all chlorination systems.

5.3 On-site Sodium Hypochlorite Generation (OSHG)

On-site sodium hypochlorite generation (OSHG) is a way to minimize risks associated with both transporting and handling sodium hypochlorite and with onsite bulk storage. On-site generation produces a 0.8% sodium hypochlorite solution on an as-required basis and all tankage, chemical-feed pumps and injectors downstream of the generator are essentially the same as outlined above for the bulk hypochlorite system. Inputs to on-site generation are salt and power as illustrated in Figure 5. In this case salt rather than bulk sodium hypochlorite is being trucked to the site. Storage capacity which is required for normal operations provides an opportunity to use bulk sodium hypochlorite purchases if down time for the generation unit needs to be extended. Installation of a standby generation unit is second option.

FIGURE 5 - Sodium Hypochlorite Production Process



A number of municipalities on Vancouver Island are using on-site hypochlorite generators (Campbell River, Nanoose Bay, Cowichan Valley Regional District, and Sooke). Operators familiar with and using the newest technology enthusiastically express their satisfaction in the systems. Dave Welz, Chief Operator with the Regional District of Nanaimo (RDN) highlights system reliability, low maintenance and the ease of handling salt compared with bulk sodium chlorite. RDN's experience also confirms that with the presence of brine and hypochlorite solution tanks corrosion continues to be an issue and systems of this type should be located within a separate dedicated building area as commonly provided for other chlorination systems.

Capital costs of the process equipment before taxes and installation are in the order of $150,000 based on the installation of a single hypochlorite generator. The costs of the building structure and services are similar to the other chlorination systems.

Salt and electrical energy are the primary consumables but chlorine consumption is identical to that of the gas and sodium hypochlorite options. The estimated combined costs of salt ($0.58/kg) and energy ($0.11/kWh) on site translates to $3.19/kg Cl. The approximate net present value over a 25-year period is $140,000. All other operations and maintenance cost components like labour and utilities are similar to the other chlorination systems being considered.

5.4 Calcium Hypochlorite

Calcium hypochlorite (granular or tablet) use, similar to on-site sodium hypochlorite generation, minimize all risks associated with chemical transport and storage. Calcium hypochlorite is purchased in granular or tablet form that is chemically stable for periods up to one year. It must be stored in a cool, dry place because of its reaction with moisture and heat. Additives mixed with the chemical do form precipitate following mixing with water and removal is a required operations task.

Systems are modular in design and are made up of a series of tablet chlorinators. These modules operate in sequence with the number of on-line modules increasing and decreasing with the water demand. As an example, five modules (Model HTS-280) would be required for a Hammonds Technical Services system to meet MDD. Storage of 0.25% hypochlorite solution would be required to meet PHD.

Capital costs of the five module system before taxes and installation are in the order of $150,000. The costs of the building structure and services would be similar to the other chlorination systems.

Calcium hypochlorite tablets are the primary consumable and chlorine consumption is identical to that of the gas and sodium hypochlorite options. The cost of hypochlorite tablets translates to $9.20/kg Cl. The approximate net present value over a 25-year period is $400,000. All other operations and maintenance cost components like labour and utilities are similar to the other chlorination systems being considered.

5.5 Triple Bottom Line Assessment

MCSL conducted triple-bottom-line (TBL) assessments of these four chlorination options. As illustrated in Table 6, On-site Generation of Sodium Hypochlorite (OSHG) received the highest overall rating. An assessment limited to economic factors alone would give chlorine gas the highest rating, but the TBL is a methodology that recognizes that transporting and handling this poisonous gas presents significant risk to the community and operations personnel.

McElhanney Consulting Services Ltd.

Aug 26, 2015

Prepared by Dan Hooper, P.Eng.

Aug 26/15

Reviewed by Russ Irish, P.Eng.

TABLE 6

TRIPLE BOTTOM LINE ASSESSMENT OF CHLORINATION OPTIONS

Criteria	Weight	Gas	Bulk NaOCl	OSHG	$Ca(OCL)_2$
		SYSTEM OPTIONS			
Economic	***Weight***				
Capital Cost	*1*	**3**	**3**	**1**	**1**
		$40k	$30k	$150k	$150k
Consumables NPV (25 yr)	*0.2*	**2**	**2**	**3**	**1**
		$230k	$270k	$140k	$400k
System NPV	*1*	**3**	**3**	**3**	**1**
		$270K	$300k	$290k	$550k
Group Average for The Option		2.9	2.9	2.1	1
Weighting Factor for the Group	*1*				
Weighted Group Average for the Option		2.9	2.5	1.6	1
Environmental					
Hazards and Risk Levels	*1*	**1**	**1**	**3**	**2**
Carbon footprint (production + transport)	*1*	**2**	**1**	**3**	**2**
Group Average for The Option		1.5	1.0	3.0	2.0
Weighting Factor for the Group	*1*				
Weighted Group Average for the Option		1.5	1.0	3.0	2.0
Social					
Traffic through sensitive areas	*1*	**1**	**1**	**3**	**2**
Public & Stakeholder Acceptance	*1*	**1**	**1**	**3**	**2**
Group Average for The Option		1.0	1.0	3.0	2.0
Weighting Factor for the Group	*1*				
Weighted Group Average for the Option		1.0	1.0	3.0	2.0
Other					
Treatment process complexity	*1*	**1**	**3**	**2**	**1**
Ease of O&M	*1*	**3**	**2**	**2**	**2**
Expandability/upgradability	*1*	**3**	**2**	**2**	**1**
Group Average for The Option		2.3	2.3	2.0	1.3
Weighting Factor for the Group	*0.5*				
Weighted Group Average for the Option		1.2	1.2	1.0	0.7
Weighted TBL for each option		5.4	4.9	8.1	5.0
TBL plus "Other"		6.6	6.1	9.1	5.7
Non- Economic Criteria		3.7	3.2	7.0	4.7

Rating Method: 3 is best; 1 least desirable

Appendix D – Technical Memo – System Analysis

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M E M O R A N D U M

Village of Cumberland	Surface Water Disinfection and Storage Review Technical Memo – System Analysis
Date:	**August 26, 2015**
Project Number:	**2231 – 21268-2.0, Revision B**

To: Village of Cumberland, Mr Rob Crisfield

From: Russ Irish, P.Eng.

1. Purpose

The purpose of this memo is to compare system upgrade scenarios for the Village of Cumberland's water supply and distribution system. This work is undertaken in support of a current review of the Village of Cumberland's surface water disinfection and storage requirements.

2. Water Model

The Village of Cumberland's water distribution system is modelled using WATERCAD software. This model has been maintained and used by McElhanney for the past 10 years to assess:

- Current system operation;
- The impact of proposed upgrades; and,
- The impact of various proposed development projects including the Coal Valley Estates subdivision and the Cayet development.

This model was updated to include recent capital works in the Kentwood Road area at the east end of Cumberland, the Discovery Center, and East Ulverston. In addition, Average Day Demand, Maximum day Demand and Peak Hour Demands were revised to reflect the impacts of universal metering.

3. Upgrade Scenarios Descriptions

3.1. Scenario 0 – 2015 Flows with Existing Conditions

- ADD of 550 L/Capita/Day
- MDD = 2 x ADD
- PHD = 3 x ADD

3.2. Scenario 1 – 2040 Flows with Treatment Plant and Twin Supply Lines (refer to 21268 Fig 1 – Water Modelling Scenario 1)

- New Treatment Plant Located at current site
- Model head loss across the Treatment Plant as 125 meters of 300 mm diameter pipe
- Twin the supply line from the Henderson Lake PRV to the Treatment Plant
- Loop the distribution system through Coal Valley Estates with a connection to the existing line on Dunsmuir Avenue
- No additional storage provided

3.3. Scenario 2 – 2040 Flows with a Coal Valley Reservoir (refer to 21268 Fig 2 – Water Modelling Scenario 2)

- New Treatment Plant Located at current site
- Include an allowance for head loss across the Treatment Plant
- Twin the supply line from the Henderson Lake PRV to the Treatment Plant
- Loop the distribution system through Coal Valley Estates with a connection to the existing line on Dunsmuir Avenue
- Storage provided by a reservoir located west of Coal Valley Estates with a base elevation of 204 meters, a top water level of 228 meters, and a minimum water level of 218 meters during fire flow conditions

3.4. Scenario 3 – 2040 flows with a Pump Station at Kendal Ave. (refer to 21268 Fig 3 – Water Modelling Scenario 3)

- New Treatment Plant Located at current site
- Include an allowance for head loss across the Treatment Plant
- Twin the supply line from the Henderson Lake PRV to the Treatment Plant
- Loop the distribution system through Coal Valley Estates with a connection to the existing line on Dunsmuir Avenue
- Define the Willard Ave. High Pressure Zone by inserting check valves at the following locations:
    - Kendall Avenue between Forest Hall Road and Egremont Road;
    - Rydal Avenue between Forest Hall Road and Egremont Road;

- Ulverston Avenue between First Street and Egremont Road;
- Egremont Road between Windermere Avenue and Ulverston Avenue;
- Penrith Avenue, west of Maryport Avenue; and,
- On the Coal Valley looped connection directly north of Dunsmuir Ave

- Willard Road Area high pressure zone served by pump(s) located on Kendal Ave. at Egremont St.

3.5. Scenario 4 – 2040 Flows with a Pump Station at Dunsmuir Avenue (refer to 21268 Fig 4 – Water Modelling Scenario 4)

- New Treatment Plant Located at current site
- Include an allowance for head loss across the Treatment Plant
- Twin the supply line from the Henderson Lake PRV to the Treatment Plant
- Loop the distribution system through Coal Valley Estates with a connection to the existing line on Dunsmuir Avenue
- Define the Willard Ave. High Pressure Zone by inserting check valves at the following locations:
    - Kendall Avenue between Forest Hall Road and Egremont Road;
    - Rydal Avenue between Forest Hall Road and Egremont Road;
    - Ulverston Avenue between First Street and Egremont Road;
    - Egremont Road between Windermere Avenue and Ulverston Avenue;
    - Penrith Avenue, west of Maryport Avenue; and,
    - On the Coal Valley looped connection directly north of Dunsmuir Ave
- Willard Road Area high pressure zone served by pump(s) located on the looped main at Dunsmuir Avenue.

3.6. Scenario 5 – 2040 Flows with a Cayet Reservoir (refer to 21268 Fig 5 – Water Modelling Scenario 5)

- New Treatment Plant Located at current site
- Include an allowance for head loss across the Treatment Plant
- Twin the supply line from the Henderson Lake PRV to the Treatment Plant
- Loop the distribution system through Coal Valley Estates with a connection to the existing line on Dunsmuir Avenue
- Storage provided by a reservoir located south of the Cayet Development with a base level elevation of 218 meters and a top water level of 224 meters.

3.7. Scenario 6 – 2040 flows with a Hillside Reservoir (refer to 21268 Fig 6 – Water Modelling Scenario 6)

- New Treatment Plant Located at current site

- Include an allowance for head loss across the Treatment Plant
- Twin the supply line from the Henderson Lake PRV to the Treatment Plant
- Loop the distribution system through Coal Valley Estates with a connection to the existing line on Dunsmuir Avenue
- Define the Willard Road High Pressure Zone by inserting check valves at the following locations:
  - Kendall Avenue between Forest Hall Road and Egremont Road;
  - Rydal Avenue between Forest Hall Road and Egremont Road;
  - Ulverston Avenue between First Street and Egremont Road;
  - Egremont Road between Windermere Avenue and Ulverston Avenue;
  - Penrith Avenue, west of Maryport Avenue; and,
  - On the Coal Valley looped connection directly north of Dunsmuir Ave
- Willard Road Area high pressure zone served by a Reservoir on the hillside south of the Comox Lake Road with a base level of 232 meters and a top water level of 238 meters.
- Reservoir is supplied by pump(s) that draw from the Dunsmuir Avenue main, directly east of the well supply disinfection station

3.8. Scenario 7 – 2040 Flows with a Pump Station at Dunsmuir Avenue and Sutton Road (refer to 21268 Fig 7 – Water Modelling Scenario 7)

- New Treatment Plant Located at current site
- Include an allowance for head loss across the Treatment Plant
- Twin the supply line from the Henderson Lake PRV to the Treatment Plant
- Loop the distribution system through Coal Valley Estates with a connection to the existing line on Dunsmuir Avenue
- Define the Willard Ave. High Pressure Zone by inserting check valves at the following locations:
  - Kendall Avenue between Forest Hall Road and Egremont Road;
  - Rydal Avenue between Forest Hall Road and Egremont Road;
  - Ulverston Avenue between First Street and Egremont Road;
  - Egremont Road between Windermere Avenue and Ulverston Avenue;
  - Penrith Avenue, west of Maryport Avenue; and,
  - On the Coal Valley looped connection directly north of Dunsmuir Ave
- Willard Road Area high pressure zone served by pump(s) located at the intersection of Dunsmuir Avenue and Sutton Road with a dedicated discharge line that runs north along Egremont Street to provide a direct supply line to the isolated high pressure zone north of Maryport Avenue.

4. Analysis Results

4.1. Scenario 0 – 2015 Fows with Existing Conditions

This Scenario of Existing Conditions provided the following results:

- 2015 Peak Hour Demand of 103.8 L/s
- 2015 Maximum Day Demand of 69.2 L/s
- System can supply a fire flow 67 L/s with a minimum residual pressure of 140 kPa (20 psi) at the highpoint in the Coal Valley Estates subdivision (Rydal Ave west of Egremont Street 194.5 meters elevation)
- System can provide a fire flow of 95 l/s with a residual pressure of 300 kPa (44 psi) at the intersection of Ulverston and Egremont (Cumberland Elementary School) while maintaining a minimum residual pressure of 140 kPa (20 psi) at the current highpoint in the Coal Valley Estates subdivision
- System can provide a fire flow of 108 l/s with a residual pressure of 350 kPa (50 psi) at Cumberland Junior Secondary School while maintaining a minimum residual pressure of 140 kPa (20 psi) at the current highpoint in the Coal Valley Estates subdivision

4.2. Scenario 1 – 2040 Flows with Treatment Plant and Twin Supply Lines

This Scenario of Future Conditions provided the following results:

- 2040 Peak Hour Demand of 183.2 L/s
- 2040 Max Day Demand of 122.1 L/s
- System pressure at the highpoint in the Coal Valley Estates subdivision during Peak Hour Demand is less than 210 kPa (30 psi)
- System can supply a fire flow of 60 L/s with a residual pressure of 140 kPa at the highpoint in the Coal Valley Estates subdivision (elevation 202 m).
- System can provide a fire flow of 90 l/s with a residual pressure of 350 kPa (50 psi) at Cumberland Elementary School while maintaining a residual pressure of 140 kPa at the future highpoint in the Coal Valley Estates subdivision.
- System can provide a fire flow of 100 l/s with a residual pressure of 380 kPa (55 psi) at Cumberland Junior Secondary School while maintaining a residual pressure of 140 kPa at the highpoint in the Coal Valley Estates subdivision.

4.3. Scenario 2 – 2040 Flows with a Coal Valley Reservoir

This Scenario of Future Conditions provided the following results:

- 2040 Peak Hour Demand of 183.2 L/s
- 2040 Max Day Demand of 122.1 L/s
- System pressure at the high point in Coal Valley Estates subdivision during Peak Hour Demand is greater than 260 kPa (35 psi)
- System can supply a fire flow of 60 L/s with a residual pressure of 170 kPa (24 psi) at a critical point in the Coal Valley Estates subdivision (ground elevation 202 m)
- System can provide a fire flow of 195 l/s with a residual pressure of 260 kPa (37 psi) at Cumberland Elementary School while maintaining a residual pressure of 140 kPa at the future high point in the Coal Valley development on Rydal Avenue.
- System can provide a fire flow of 200 l/s with a residual pressure of 140 kPa at Cumberland Junior Secondary School while maintaining a residual pressure of 140 kPa at the future high point in the Coal Valley development on Rydal Avenue.

4.4. Scenario 3 – 2040 flows with a Pump Station at Kendal Ave.

This Scenario of Future Conditions provided the following results:

- The system was modelled with a pump located on Kendal Avenue to increase water supply to the isolated high pressure zone
- A pump discharge of 60 L/s resulted in negative pressures within the distribution system directly upstream of the pump.

4.5. Scenario 4 – 2040 Flows with a Pump Station at Dunsmuir Avenue

This Scenario of Future Conditions provided the following results:

- The system was modelled with a pump located on Dunsmuir Avenue to increase water supply to the isolated high pressure zone
- Pump(s) to be selected to provide the following flow requirements
    - A single duty pump to meet minimum pressure requirements within the isolated high pressure zone under ADD, MDD and PHD
    - One, or more, fire pumps to meet minimum flow and pressure requirements within the isolated high pressure zone to satisfy existing and possible future fire demand (Existing schools, or possible higher density residential development)
- Model results show that pump operation at this location does not produce negative line pressures within the distribution system.
- Model Results show that the velocity in the existing 200 mm diameter line on Dunsmuir Avenue west of Sutton Road exceeds the maximum allowable design velocity of 3.5 m/s under fire flow conditions.

4.6. Scenario 5 – 2040 Flows with a Cayet Reservoir

This Scenario of Future Conditions provided the following results:

- 2040 Peak Hour Demand of 183.2 L/s
- 2040 Max Day Demand of 122.1 L/s
- System can provide a fire flow of 60 L/s in the Coal Valley Estates development while maintaining a minimum pressure of 140 kPa (20 psi)
- System can provide a fire flow of 160 l/s with a residual pressure of 320 kPa (45 psi) at Cumberland Elementary School while maintaining a minimum pressure of 140 kPa at the highest point in the Coal Valley subdivision
- System can provide a fire flow of 200 l/s with a residual pressure of 320 kPa (45 psi) at Cumberland Junior Secondary School while maintaining a minimum pressure of 140 kPa at the highest point in the Coal Valley subdivision

4.7. Scenario 6 – 2040 flows with a Hillside Reservoir

This Scenario of Future Conditions provided the following results:

- 2040 Peak Hour Demand of 183.2 L/s
- 2040 Max Day Demand of 122.1 L/s
- System can provide a minimum pressure of 270 kPa (35 psi) in the Coal Valley Estates development during Peak Hour Demand.
- System can supply a fire flow of 60 L/s with a residual pressure of 140 kPa at the highpoint in the Coal Valley Estates subdivision
- System can provide a fire flow of 175 l/s with a residual pressure of 250 kPa (35 psi) at Cumberland Elementary School and a minimum system pressure of 140 kPa (20 psi) at the current and the future high points in the Coal Valley Estates development
- In this scenario the Cumberland Junior high school would be serviced by the high pressure zone and have the same fire flow and residual pressure as the Cumberland Elementary School.

4.8. Scenario 7 – 2040 Flows with a Pump Station at Dunsmuir and Sutton Road

This Scenario of Future Conditions provided the following results:

- The system was modelled with a pump located at the intersection of Dunsmuir Avenue and Sutton Road and a dedicated discharge line that runs north along Egremont Street to provide a direct supply line to the isolated high pressure zone north of Maryport Avenue.
- Pump(s) to be selected to provide the following flow requirements
    - A single duty pump to meet minimum pressure requirements within the isolated high pressure zone under ADD, MDD and PHD

  - One, or more, fire pumps to meet minimum flow and pressure requirements within the isolated high pressure zone to satisfy existing and possible future fire demand (Existing schools, or possible higher density residential development)
- Model results show that pump operation at this location does not produce negative line pressures within the distribution system.
- Model Results show that pump operation at this location does not produce excessive line velocities under fire flow conditions.

5. Conclusions

5.1. Scenario 0 – 2015 Fows with Existing Conditions

Analysis shows that:

- The existing system can supplying a minimum residential fire flow of 60 L/s to the existing residential development at Coal Valley Estates
- The existing system cannot supply an institutional fire flow of 150 L/s to either the Cumberland Elementary School or the Cumberland Junior Secondary School.

5.2. Scenario 1 – 2040 Flows with Treatment Plant and Twin Supply Lines

Analysis shows that:

- The head loss anticipated with construction of the proposed Treatment Works can be mitigated by twinning the upstream supply line.
- The upgraded system will be marginally able to supply a residential fire flow of 60 L/s to the expanded residential development at Coal Valley Estates if those new lines are looped through to Dunsmuir Avenue
- The upgraded system cannot supply an institutional fire flow of 150 L/s to either the Cumberland Elementary School or the Cumberland Junior Secondary School.
- This scenario fails to meet the minimum pressure requirements at the highpoint in the Coal Valley Estates subdivision during Peak Hour Demand

5.3. Scenario 2 – 2040 Flows with a Coal Valley Reservoir

Analysis shows that:

- A minimum water level of 223 meters is required at the reservoir to provide residential fire flows within the Coal Valley Estates subdivision
- The upgraded system will supply a fire flows of 225 L/s to the Cumberland Elementary School and to the Cumberland Junior Secondary School.

- The highest point of land that is available to construct the Coal Valley Reservoir is 204 meters, therefore providing an allowance for headloss in th system, all of the water that is required for fire protection must be stored a minimum of 14 meters above ground level.
- This scenario fails to meet the minimum pressure requirements at the highpoint in the Coal Valley Estates subdivision during Peak Hour Demand

The resulting tank is a 25 meter high standpipe, and we conclude that a reservoir within the Coal Valley Estates subdivision is not practical.

5.4. Scenario 3 – 2040 flows with a Pump Station at Kendal Ave.

Analysis shows that:

- A pump station is not practical at this location because it will result in negative suction pressures within the distribution system.

5.5. Scenario 4 – 2040 Flows with a Pump Station at Dunsmuir Avenue

Analysis shows that:

- A pump station at this location can provide the minimum system pressures required during Peak Hour demand conditions
- A pump station at this location can supply fire flows to the Cumberland Elementary School and to the Cumberland Junior Secondary School.
- This scenario meets the minimum pressure requirements at the highpoint in the Coal Valley Estates subdivision during Peak Hour Demand.
- A pump station is not practical at this location because it will result in excessive velocities within the distribution system under fire flow conditions.

5.6. Scenario 5 – 2040 Flows with a Cayet Reservoir

Analysis shows that:

- A reservoir at this location can supply a fire flow of 160 L/s with a residual pressure of 320 kPa to the Cumberland Elementary School while maintaining a minimum line pressure of 150 kPa at the high point in the Coal Valley estates subdivision.
- A reservoir at this location can supply a fire flow of 200 L/s with a residual pressure of 320 kPa to the Cumberland Junior Secondary School while maintaining a minimum line pressure of 150 kPa at the high point in the Coal Valley estates subdivision.

- A reservoir at this location can supply a fire flow of 60 L/s with a residual pressure of 220 kPa at the high point in the Coal Valley Estates subdivision.
- This scenario fails to meet the minimum pressure requirements at the highpoint in the Coal Valley Estates subdivision during Peak Hour Demand

5.7. Scenario 6 – 2040 flows with a Hillside Reservoir

Analysis shows that:

- A reservoir at this location can supply a fire flow of 175 L/s with a residual pressure of 250 kPa to the Cumberland Elementary School while maintaining a minimum line pressure of 140 kPa at the high point in the Coal Valley Estates subdivision.
- A reservoir at this location can supply a fire flow of 60 L/s with a residual pressure of 140 kPa at the high point in the Coal Valley Estates subdivision.
- This scenario meets the minimum pressure requirements at the highpoint in the Coal Valley Estates subdivision during Peak Hour Demand

5.8. Scenario 7 – 2040 Flows with a Pump Station at Dunsmuir and Sutton Road

Analysis shows that:

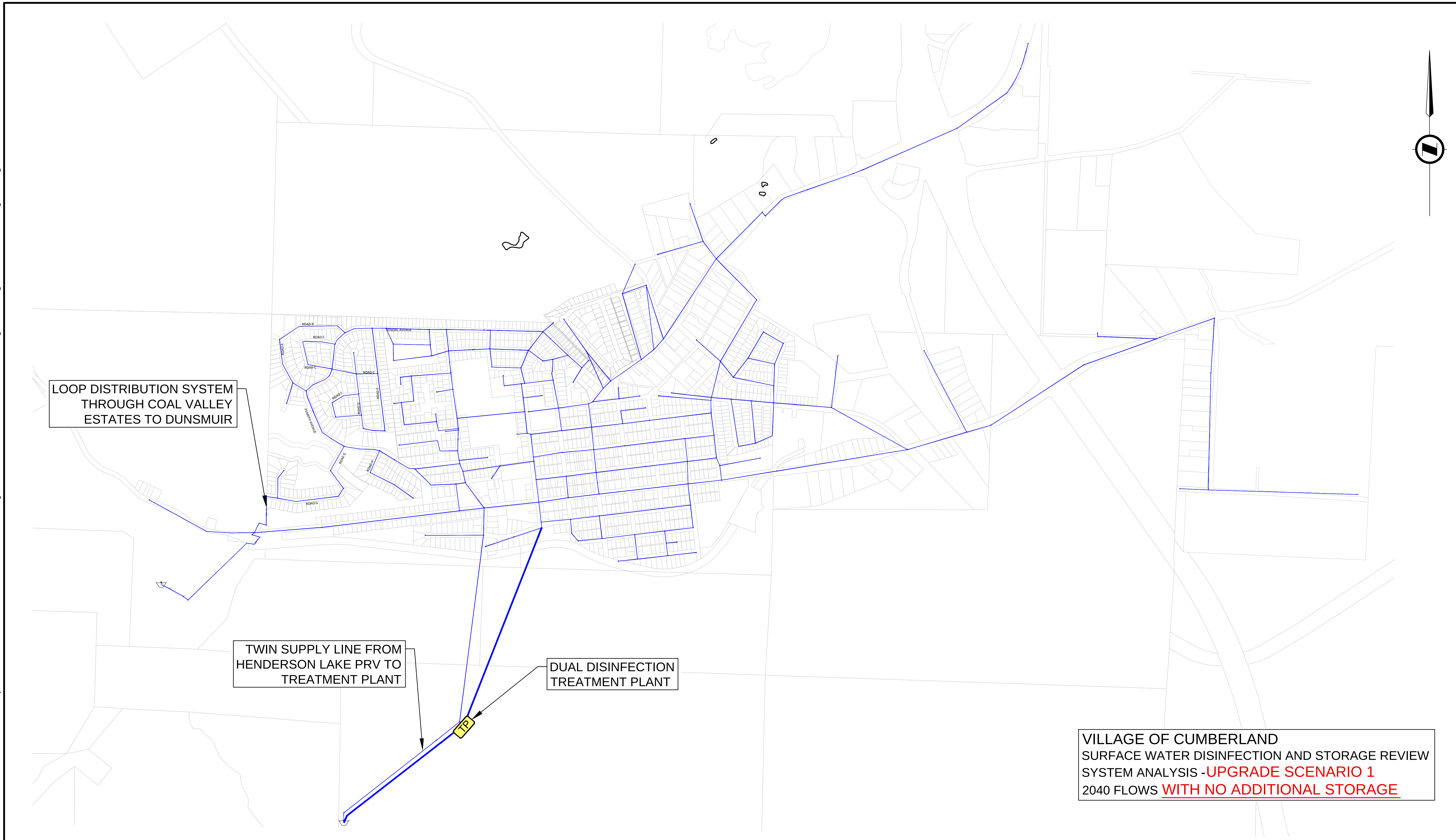
- A pump station at this location can provide the minimum system pressures required during Peak Hour demand conditions
- A pump station at this location can supply fire flows to the Cumberland Elementary School and to the Cumberland Junior Secondary School.
- This scenario meets the minimum pressure requirements at the highpoint in the Coal Valley Estates subdivision during Peak Hour Demand.

McElhanney Consulting Services Ltd.

PROFESSIONAL PROVINCE OF R. R. IRISH BRITISH COLUMBIA ENGINEER
Aug 26/15

PROFESSIONAL PROVINCE OF D. G. TUNNICLIFFE # 30252 BRITISH COLUMBIA ENGINEER
Oct 2/15

Prepared by Russ Irish, P.Eng. | **Reviewed by D. Tunnicliffe, P.Eng.**



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VILLAGE OF CUMBERLAND
CUMBERLAND, B.C

WATER MODELING

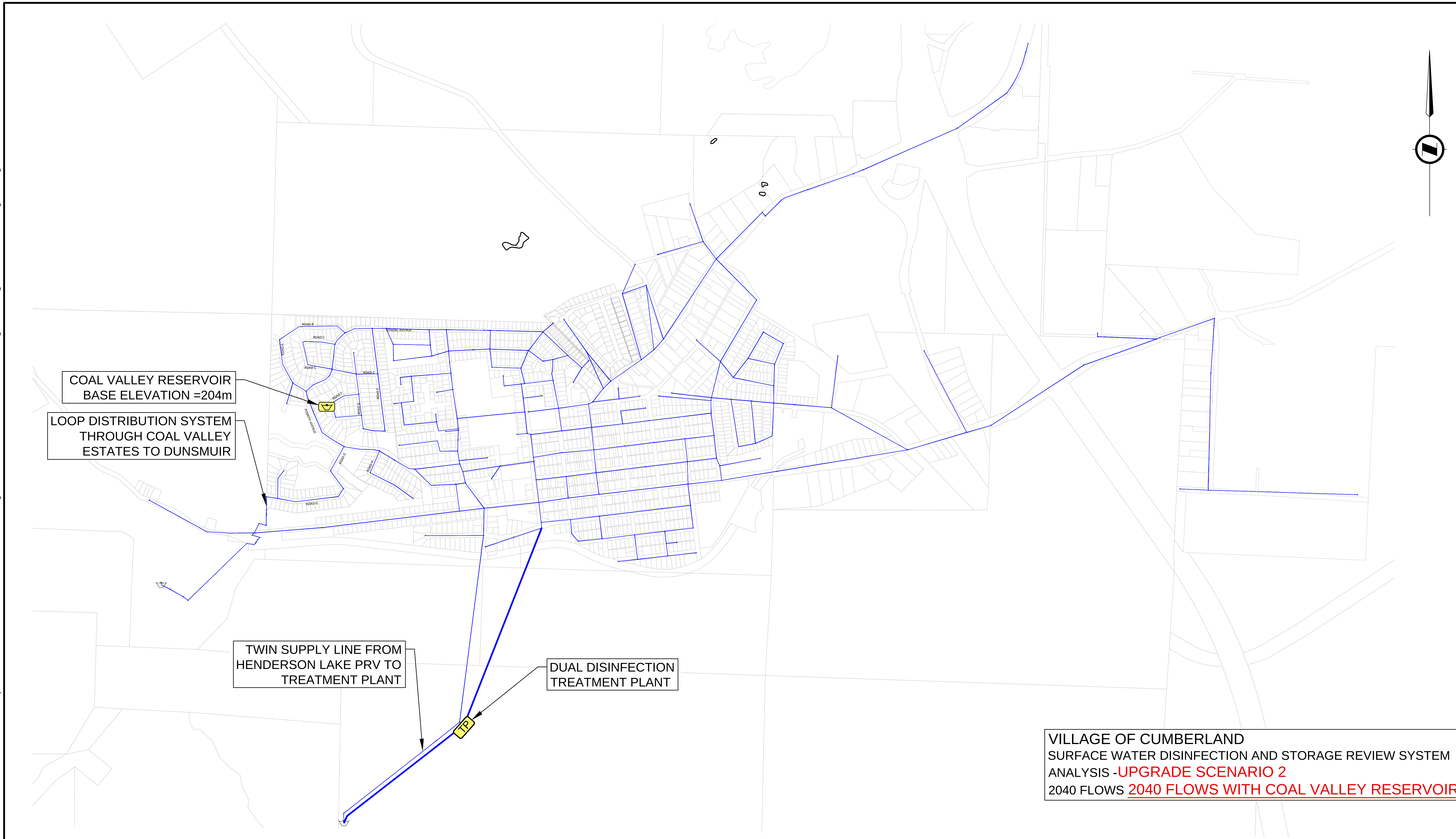
SCENARIO 1

Client Project No

Client Drawing No

MCSL Project No. 2231-22168

Drawing No. 21268-FIG 1



VILLAGE OF CUMBERLAND
SURFACE WATER DISINFECTION AND STORAGE REVIEW SYSTEM
ANALYSIS -UPGRADE SCENARIO 2
2040 FLOWS 2040 FLOWS WITH COAL VALLEY RESERVOIR

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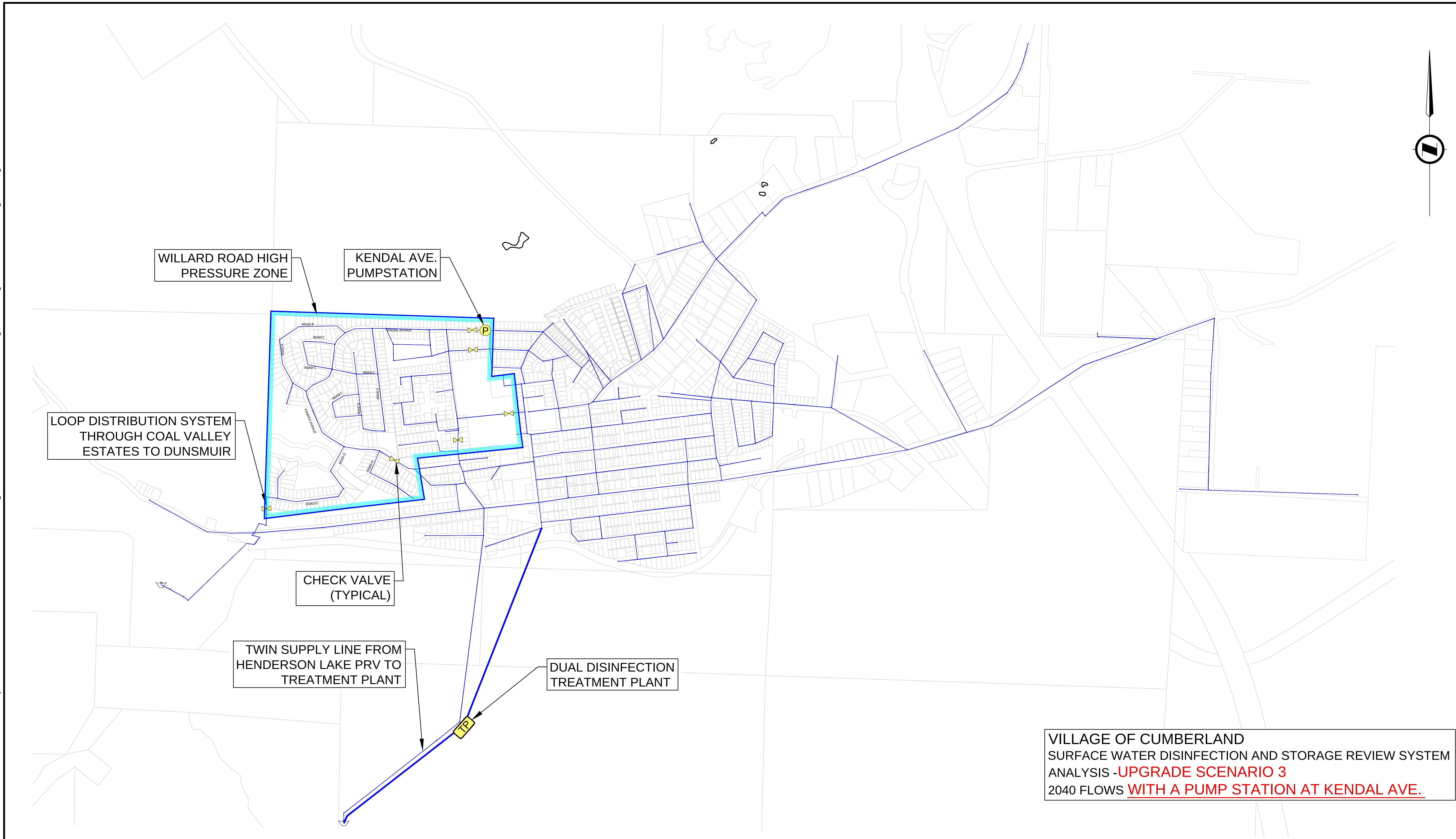
WATER MODELING
SCENARIO 2

Client Project No
Client Drawing No
MCSL Project No. 2231-22168
Drawing No. 21268-FIG 2



VILLAGE OF CUMBERLAND
SURFACE WATER DISINFECTION AND STORAGE REVIEW SYSTEM
ANALYSIS -UPGRADE SCENARIO 3
2040 FLOWS WITH A PUMP STATION AT KENDAL AVE.

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CUMBERLAND, B.C

WATER MODELING
SCENARIO 3

Client Project No
Client Drawing No
MCSL Project No. 2231-22168
Drawing No. 21268-FIG 3

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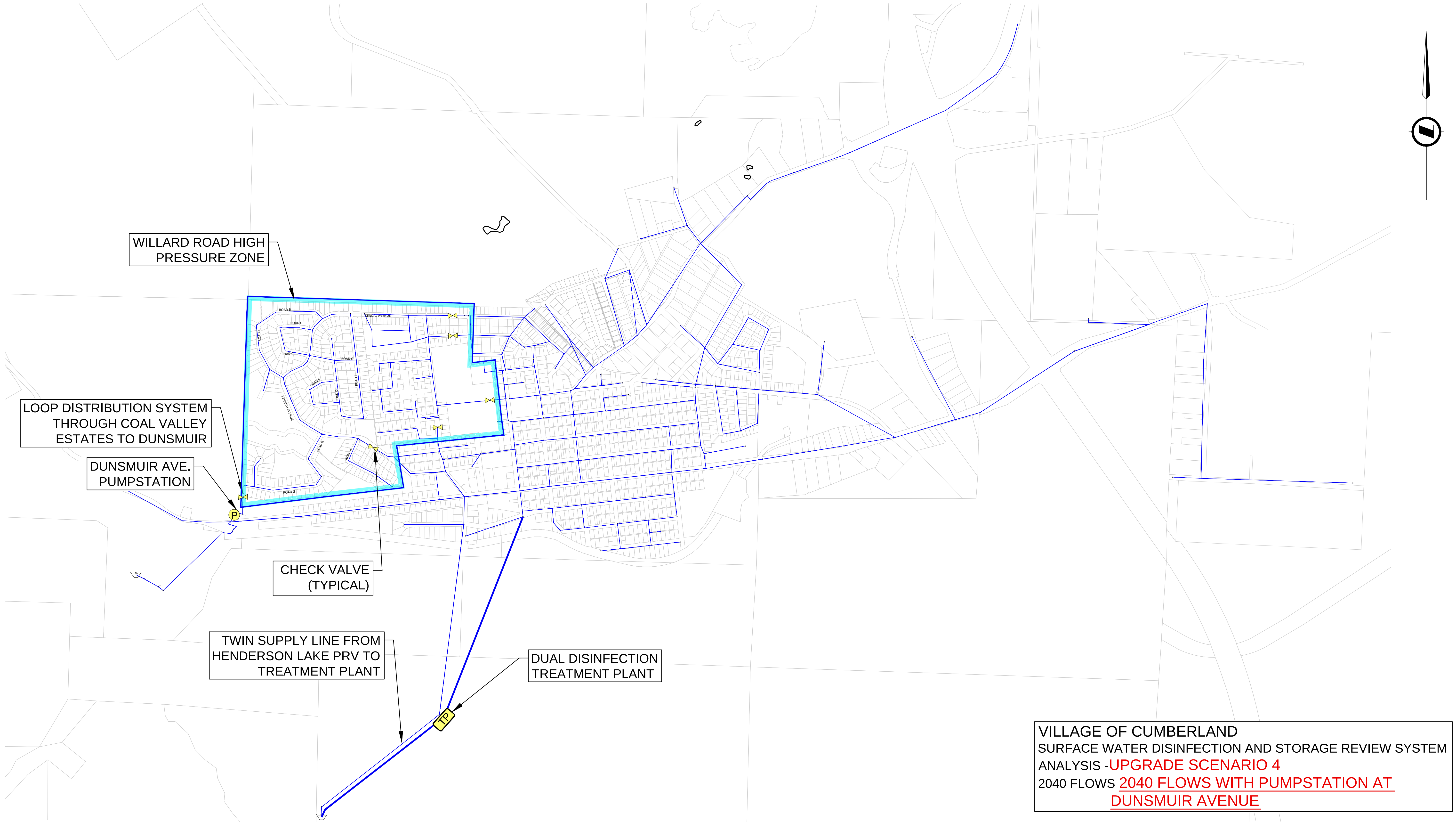

VILLAGE OF CUMBERLAND
SURFACE WATER DISINFECTION AND STORAGE REVIEW SYSTEM
ANALYSIS -UPGRADE SCENARIO 4
2040 FLOWS 2040 FLOWS WITH PUMPSTATION AT DUNSMUIR AVENUE

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CUMBERLAND, B.C

WATER MODELING
SCENARIO 4

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Client Drawing No
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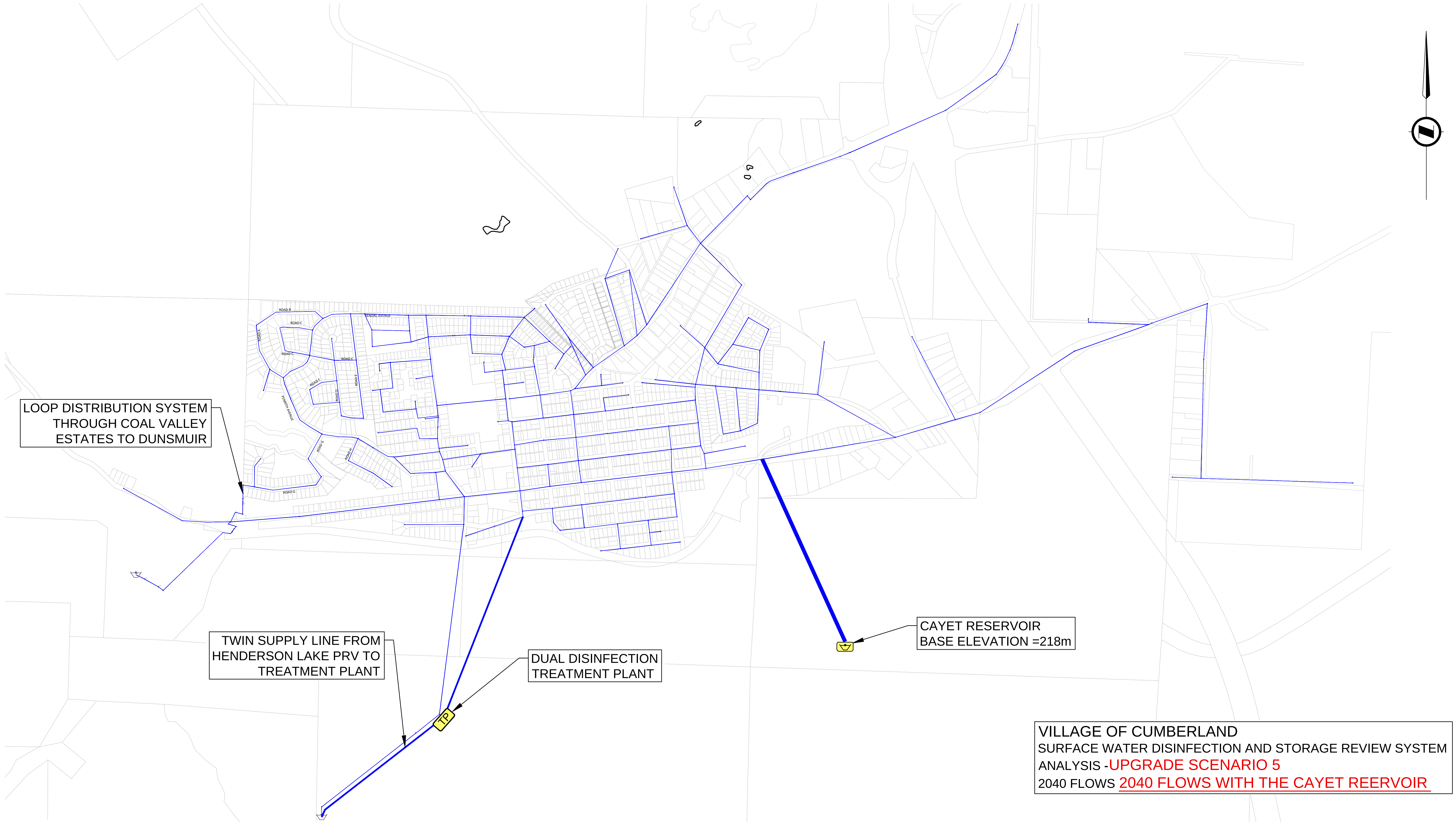
Drawing No. 21268-FIG 4



VILLAGE OF CUMBERLAND
SURFACE WATER DISINFECTION AND STORAGE REVIEW SYSTEM
ANALYSIS -UPGRADE SCENARIO 5
2040 FLOWS 2040 FLOWS WITH THE CAYET REERVOIR

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WATER MODELING

SCENARIO 5

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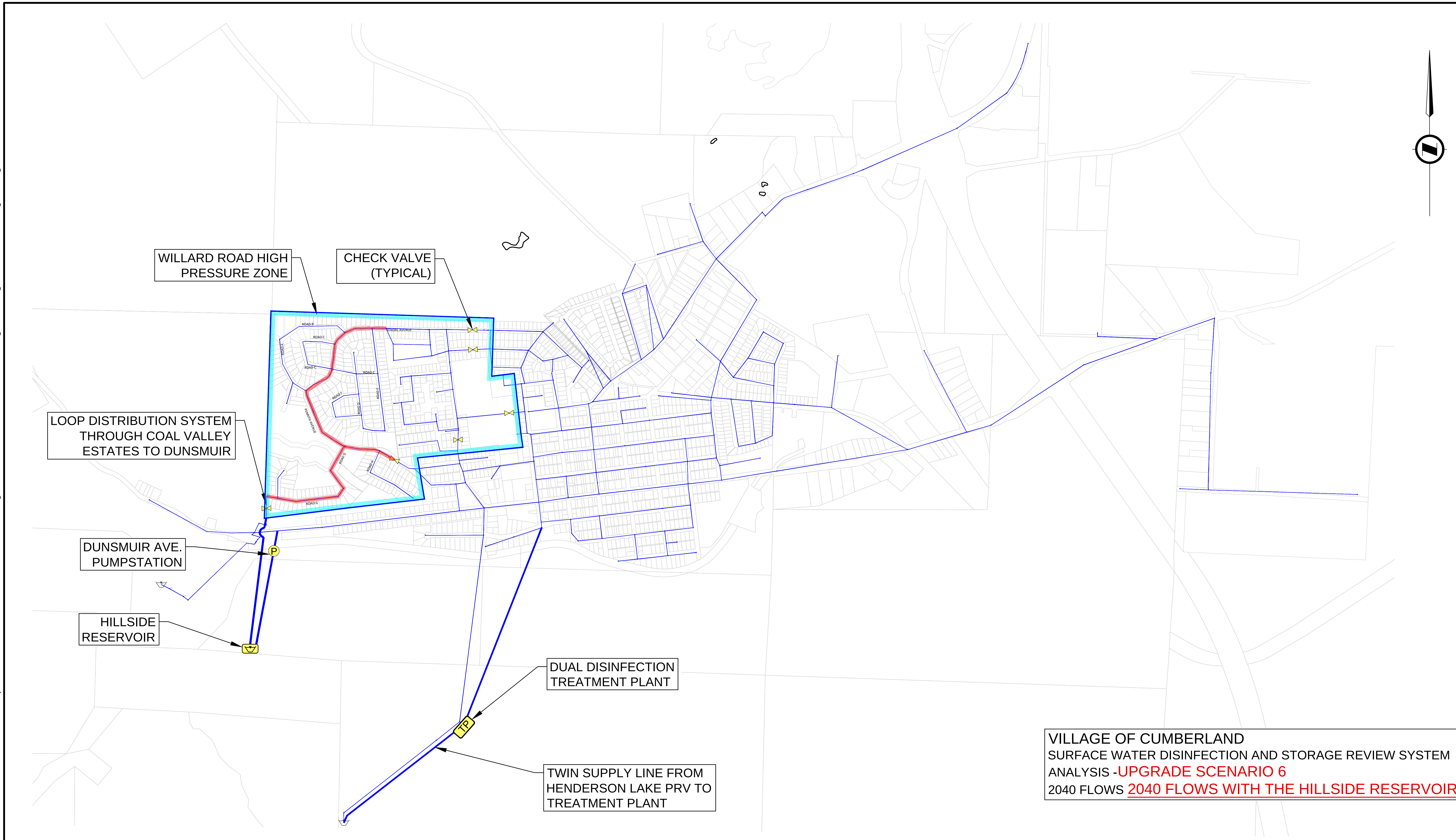
Client Drawing No
MCSL Project No. 2231-22168
Drawing No. 21268-FIG 5



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SURFACE WATER DISINFECTION AND STORAGE REVIEW SYSTEM
ANALYSIS - UPGRADE SCENARIO 6
2040 FLOWS 2040 FLOWS WITH THE HILLSIDE RESERVOIR

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WATER MODELING
SCENARIO 6

Client Project No
Client Drawing No
MCSL Project No. 2231-22168
Drawing No. 21268-FIG 6

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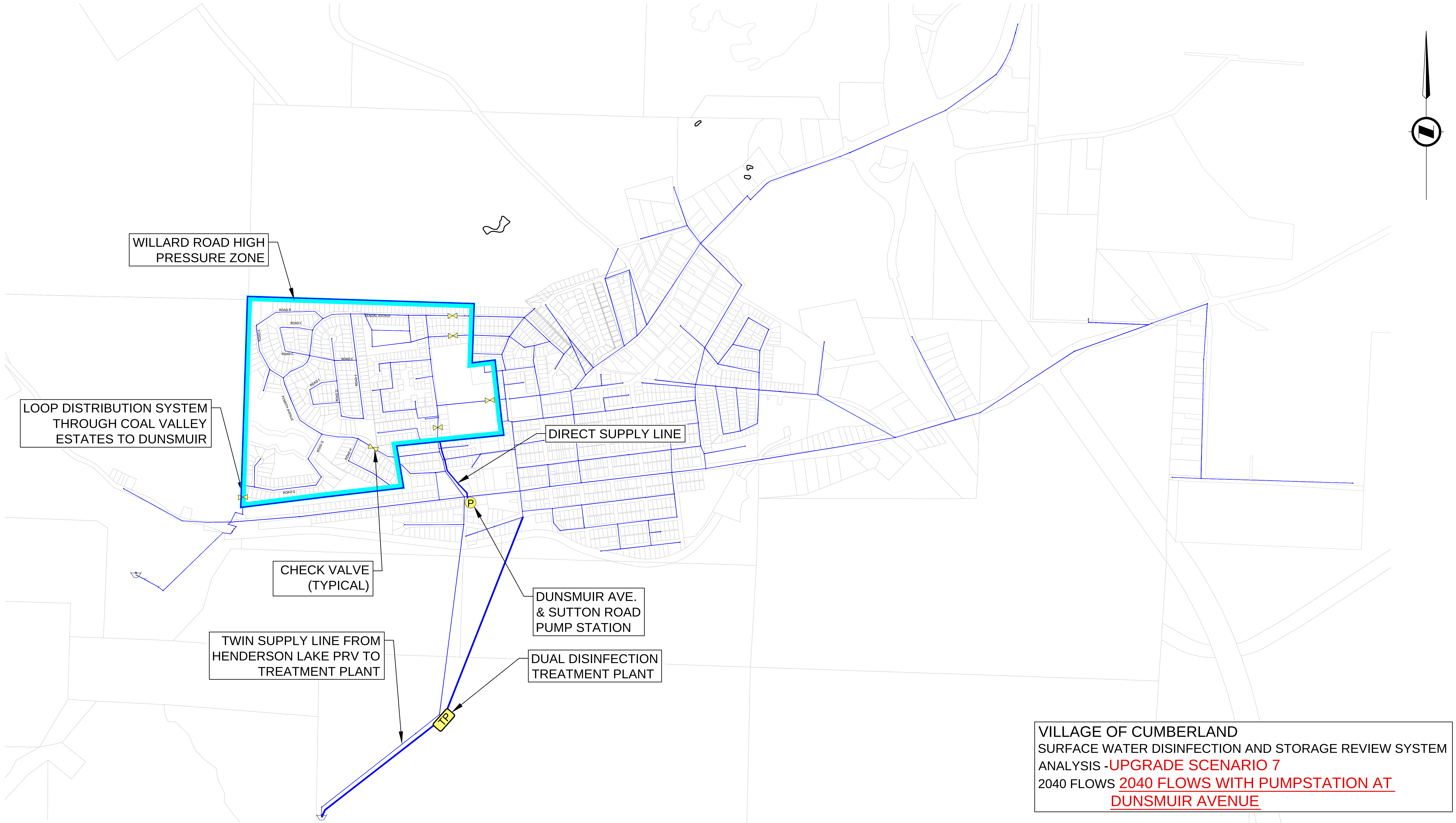

VILLAGE OF CUMBERLAND
SURFACE WATER DISINFECTION AND STORAGE REVIEW SYSTEM
ANALYSIS -UPGRADE SCENARIO 7
2040 FLOWS 2040 FLOWS WITH PUMPSTATION AT DUNSMUIR AVENUE

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VILLAGE OF CUMBERLAND
CUMBERLAND, B.C

WATER MODELING
SCENARIO 7

Client Project No
Client Drawing No
MCSL Project No. 2231-22168
Drawing No. 21268-FIG 7

Appendix E – Cost Estimates

Village of Cumberland
Surface Water Disinfection and Storage Review
Class 'C' Cost Estimate

McElhanney Consulting Services Ltd
2231-21268-4.0
August 27, 2015

1.0 Treatment Works

1.1 Site Works

Description	Quantity	Unit	Rate	Extension	Totals
Mob, Demob	1	LS	$ 15,000	$ 15,000	
Clearing and Grubbing	0.1	Ha	$ 20,000	$ 2,000	
Foundation Preparation	1	LS	$ 2,500	$ 2,500	
Exterior Walkways	40	m2	$ 100	$ 4,000	
Remove Existing Works	1	LS	$ 20,000	$ 20,000	
				Sub Total - Site Works	**$ 43,500**

1.2 Piping

Description	Quantity	Unit	Rate	Extension	
300 Dia PVC (Underground)	25	m	$ 300	$ 7,500	
300 Dia Steel	30	m	$ 500	$ 15,000	
300 Dia Bend	12	each	$ 1,000	$ 12,000	
300 Dia Tee	2	each	$ 1,250	$ 2,500	
300 x 600 Reducer	4	each	$ 1,500	$ 6,000	
300 Dia Gate Valve	16	each	$ 6,000	$ 96,000	
				Sub Total - Piping	**$ 139,000**

1.3 Equipment

Description	Quantity	Unit	Rate	Extension	
300 Dia Flow Meter	2	each	$ 15,000	$ 30,000	
UV Reactor	2	each	$ 150,000	$ 300,000	
NaCl Disinfection Equipment	2	each	$ 50,000	$ 100,000	
Controls	1	each	$ 100,000	$ 100,000	
Back-Up Power Supply	1	LS	$ 100,000	$ 100,000	
CCTV Monitoring Equipment	1	LS	$ 10,000	$ 10,000	
Commissioning	1	LS	$ 30,000	$ 30,000	
				Sub Total - Equipment	**$ 670,000**

1.4 Building Works

Description	Quantity	Unit	Rate	Extension	
Crush Gravel Base	1	LS	$ 2,500	$ 2,500	
Foundation Walls	60	m	$ 300	$ 18,000	
Concrete Floor	180	m2	$ 100	$ 18,000	
Concrete Block Wall	250	m2	$ 110	$ 27,500	
Roof Trusses	32	each	$ 200	$ 6,400	
Roof Deck	240	m2	$ 15	$ 3,600	
Asphalt shingles	240	m2	$ 15	$ 3,600	
Roof Insulation	240	m2	$ 15	$ 3,600	
Flashings and Trim	1	LS	$ 2,000	$ 2,000	
Vapour Barrier	1	LS	$ 1,000	$ 1,000	
Building Electrical	1	LS	$ 10,000	$ 10,000	
Interior Finish	1	LS	$ 10,000	$ 10,000	
Doors	3	each	$ 2,000	$ 6,000	
				Sub Total - Building Works	**$ 112,200**
				Subtotal - Construction Cost	$ 964,700
				Contingency (25%)	$ 241,175
				Subtotal	**$ 1,205,875**
				Engineering (15%)	**$ 180,881**
				Project Budget	**$ 1,386,756**

Note: Cost Estimate Does Not Include Allowance for Property Acquisition

2.0 Twinned Supply Line

Description	Quantity	Unit	Rate	Extension	Totals
Clearing and Grubbing	0.8		$ 20,000	$ 16,000	
300 Dia PVC (Underground)	860	m	$ 300	$ 258,000	
300 Dia Bend	4	each	$ 1,000	$ 4,000	
300 Dia Tee	2	each	$ 1,250	$ 2,500	
300 Dia Cross	2	each	$ 1,500	$ 3,000	
300 Dia Gate Valve	14	each	$ 6,000	$ 84,000	
Hydrant Assemblies	3	each	$ 4,000	$ 12,000	
Live Tap at Interconnection	1	LS	$ 20,000	$ 20,000	
Tie to Existing at Treatment	1	LS	$ 10,000	$ 10,000	
				Sub Total	**$ 409,500**
				Subtotal - Construction Cost	$ 409,500
				Contingency (25%)	$ 102,375
				Subtotal	**$ 511,875**
				Engineering (15%)	**$ 76,781**
				Project Budget	**$ 588,656**

Note: Cost Estimate Does Not Include Allowance for Property Acquisition