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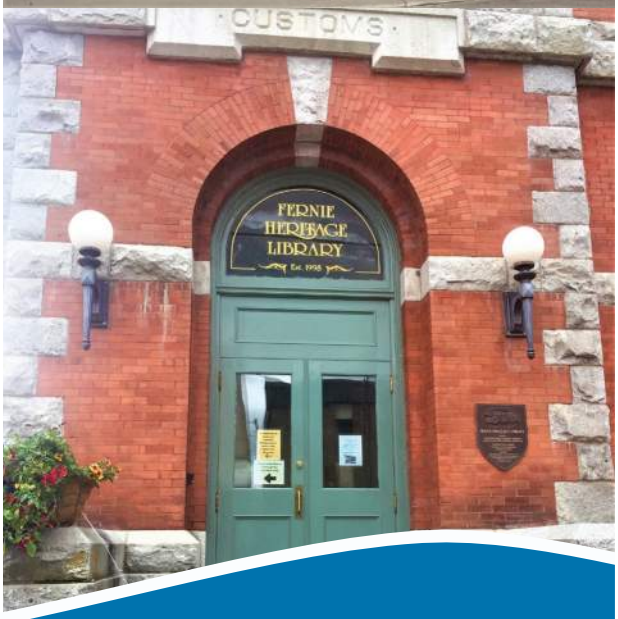












Integrated Infrastructure Capital Plan

ISL Engineering and Land Services

City of Fernie

Final Report

August 2020

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1.0 Executive Summary

The City of Fernie has completed the first steps in its asset management program by assessing its current practices and creating and adopting an Asset Management Investment Plan (AMIP), which is critical in identifying the needs to be set aside now to replace infrastructure in the future based on age and anticipated service life. The Integrated Infrastructure Capital Plan (IICP) incorporates the recommendations of the AMIP and provides a framework that guides decision makers with a prioritized system of infrastructure replacement planning by assessing asset condition, capacity and risk. Conditions are determined through inspections and/or age, and risk through the assets' location and classification including its capacity that is determined through hydraulic modeling.

The IICP framework incorporates the above criteria and provides feedback to the City as to whether the asset requires a prioritized response. The end user can quickly and clearly understand the anticipated condition of individual assets given a current or forecast scenario. This provides the ability to justifiably allow specific assets to exceed their typical service lives because they are understood to pose limited risk exposure. In doing so, the City can strategically plan for timely review and replacement of prioritized infrastructure while monitoring and addressing non-prioritized but poor condition infrastructure as budgeting allows.

Using the framework, we developed a 5-year short-term capital-planning list along with estimated capital costs to budget for the short term. A proactive 20-year long-term assessment was completed to inform long-term projects; however, as data is updated, the short-term recommendations should be reviewed against the framework and new short-term lists developed at a minimum every 5 years.

We completed a facilities' review as part of this project that studied existing documents providing component conditions and replacement values. Multiple data gaps were noted preventing the ability to confidently recommend prioritized upgrades, and therefore we provided a framework for future investigation that would assist the City in developing an updated Facilities Master Plan. A sample framework was completed prioritizing facilities given the existing information available.

In summary, we determined that the current AMIP investment Scenario 2 (Service Life increased by 25%) is adequate for road and utility infrastructure for the next 20 years; however, it will require short-term funding alternatives or project planning scenarios that prolong the short-term projects to meet short-term funding levels. The following table shows the Average Annual Life Cycle Investment Scenario 2 and the short- and long-term IICP project totals.

Table 1.1 IICP Short- and Long-Term Project Totals Comparison to AALCI Funding Scenario 2

Asset Category	AMIP AALCI Annual Funding X5	IICP Short-Term Projects Total (5 year)	AMIP AALCI Annual Funding X20	IICP Long-Term Projects Total (20 Year)
Roads	$6,120,000	$2,613,021	$24,480,000	$8,824,722
Storm	$1,425,000	$ -	$5,700,000	$5,052,979
Water	$3,110,000	$8,276,179	$12,440,000	$7,003,010
Wastewater	$2,300,000	$3,252,408	$9,200,000	$4,370,956
Total	**$12,955,000**	**$14,141,608**	**$51,820,000**	**$25,251,667**

We recommend a facilities master plan to be created that incorporates several goals, such as:

- addressing capacity;
- meeting changing health and safety regulations;
- identifying urgent needs and prioritizing facilities (this can be covered under the primary use categories that we are currently using);
- understanding building condition (this has been started with the current FMP and shown in the IICP);
- including risk consideration in facilities planning that incorporates resilience capacity consideration and mitigates critical impacts;
- achieving financial sustainability with facilities;
- having the ability to modify and adapt in response to revenue generation opportunities; and
- aligning with City mandates.

Most importantly, this document is meant to be a living document and updated accordingly as new information is made available.

2.0 Introduction

In late 2017, the City of Fernie began work on completing an Asset Management Plan that involved the following 4-phased approach.

- **Phase 1: Asset Management Assessment *(Complete)***
  An overall assessment of the current City practices related to asset management with guidance for moving forward with a detailed Asset Management Plan.
- **Phase 2: Asset Management Investment plan (AMIP) *(Complete)***
  An investment plan related to the City assets to guide future investment.
- **Phase 3: Integrated Infrastructure Capital Plan (IICP)**
  A plan that uses the overall plan of the AMIP and ties it to the real-world assets to assist with capital planning.
- **Phase 4: Development of Policy, Implementation Plans and Performance Measures**

The City completed Phase 2 in 2018 and has now completed water, sanitary and storm modelling programs that have been used to inform the IICP. This plan addresses municipal infrastructure and upgrades that will facilitate the City's ability to effectively create a municipal plan and budget for the next 20 years, including a framework for infrastructure replacement decision making beyond the 20-year horizon. The following were used as data sources for the creation of this report.

- EBA Pavement Condition Assessment (2007)
- City of Fernie Facilities Master Plan (2014)
- City of Fernie Official Community Plan (2014)
- **Fernie Assessment of Current Practices to Support Sustainable Service Delivery (2015)**
- **City of Fernie Asset Management Investment Plan (2018)**
- City of Fernie Water Distribution System Modelling and Capacity Analysis (2020)
- City of Fernie Sanitary Sewer Collection System Modelling and Capacity Analysis (2020)
- City of Fernie Storm Water System Modelling (2020)
- City of Fernie CCTV Reports
- City of Fernie Watermain Break Records
- City of Fernie Sanitary Trouble lines Flushing List
- City of Fernie Geographic Information System (GIS) Database

The IICP's overarching purpose is to tie together existing data relating to the City's utility infrastructure, roads and facilities. This plan will allow the City to have a transparent and comprehensive roadmap that will provide guidance on expenditures related to municipal infrastructure systems, and provide a proactive approach to infrastructure renewal, which voids unnecessary costs.

Preparing the IICP is a step forward to becoming a resilient community. The following document should remain as a living document with frequent maintenance and updating as new and relevant information becomes available.

2.1 Desired outcomes

A report/strategy that ties together the Asset Management Investment Plan (AMIP) to the recommended capital projects for the short and long term.

This document will be used to guide the City with capital planning based on an approach that investigates infrastructure condition, capacity, risk and cost and by justifying the collection of funds and strategically allocating reserve funding towards capital projects on a repeatable framework.

The City will forever be changing through population or development fluctuations all the while the infrastructure will be aging. Legislation related to infrastructure use and maintenance will change as well. The IICP will assist in infrastructure planning of the constantly changing world by addressing the following:

- establishing understanding of asset capacity (modelling) completed for water, sanitary, and storm systems;
- using available data to determine existing asset conditions;
- using available data to calculate risk associated with existing assets;
- developing a prioritized list of renewal/replacement projects; and
- knowledge transfer to the City staff to allow future changes and updates.

This document, together with the AMIP, will be the foundation creating short and long-term financial plans and capital plans.

2.2 Guiding Approach

Traditionally, capital upgrades are completed based on an assessment of condition and capacity. This IICP provides a prioritization approach that not only looks at capacity and condition but also risk and consequence of failure. This approach uses data available now to guide future capital planning and is setup in such a way as to be dynamic and ready to adopt future inventory, modelling outputs, and condition assessments.

3.0 Previous Studies

Prior to this IICP, the City completed an asset management assessment and an Asset Management Investment Plan. Each subsequent document builds off findings and recommendations from the previous. The following summarizes the preceding documents to the Integrated Infrastructure Capital Plan.

3.1.1 Asset Management Assessment (Urban Systems, 2015)

This document laid out the framework for developing a sound asset management program for the City of Fernie, aimed at **building a resilient community** – which the study defines as:

> *"[A community] that can manage changes, undesired events and financial shocks while continuing to deliver important services without introducing significant changes to revenues or spending."*

The study defines **Asset Management** as the decision-making process regarding:

> *"The use and care of infrastructure to deliver services in a way that considers current and future needs, manages risks and opportunities, and makes the best use of resources."*

The implementation of a sound asset management program facilitates good stewardship of infrastructure and delivery of services, with equal emphasis on present and future needs – a process built around informed decisions based on an understanding of service, risk, and cost.

The outcome of this plan guided the City towards the next steps completed for their Asset Management program.

3.1.2 Asset Management Investment Plan (AMIP) (Urban Systems, 2018)

Continuing from asset management assessment, the AMIP provided a review of all the City's infrastructure assets to answer the following questions:

- What assets do we own?
- What is the estimated replacement value of our assets?
- What is the estimated remaining life of our assets?
- How much should we invest in assets renewal?
- When do our assets need to be replaced?

Answering these enabled the City to budget and plan for the replacement of their infrastructure, avoid potential situations of service disruptions, emergency repairs, and avoid the need for sudden and significant tax and user fee increases.

The creation of the AMIP involved development and refinement of the City's GIS Database and developing an AMIP model that included key information calculated for each asset category. The Information Developed in the AMIP played a key part in the development of the IICP prioritization framework.

As the City of Fernie owns an estimated $286 million in infrastructure, significant investment will be required to sustain service levels over the next 20 years and beyond. The AMIP provides a comprehensive assessment of the replacement costs and estimated timing of replacement for all the City's water, wastewater, storm, road, building, equipment and fleet assets.

The AMIP Developed Funding Recommendations based on Annual Average Life Cycle Investment (AALCI) of its assets. This represents the investment needed to sustain the infrastructure the City currently owns over its entire service life and has been implemented by the City.

The AMIP also prepares a 20-year funding estimate base on a 20-year Average Annual Investment (AAI). This represents investment needed to pay for expected infrastructure replacements over the next 20 years.

The IICP takes the information and recommendations of the AMIP one step further incorporating individual conditions and risks to each asset to inform strategic and responsible management of the City Assets.

4.0 Modelling Review

As recommend by the asset management assessment and AMIP, understanding capacity of the water, storm and sanitary infrastructure is a key component in the level of service that each utility can provide.

The City commissioned GeoAdvice Engineering Inc. to complete a comprehensive model for water, sanitary and stormwater. The reports are included as appendices A, B, & C.

The following summarizes the detailed modelling reports included in the above listed appendices. The outcome of these capacity analyses is used within the framework discussed in Section 5.0 to assist in decision making for each asset.

4.1 Water

The existing watermain network was modelled to identify any deficient mains or areas within the water network to guide decisions related to future upgrades. The process involved data collection from the City GIS database, application of existing system components into the model, calibration, future scenario development and a system capacity analysis.

Scenarios

Model scenarios included the 2018 existing system, 2032 future system both identifying deficiencies, and recommended upgrade sizing. For the purposes of the IICP, the Existing Scenario was used to guide decisions for the short term.

System Capacity Analysis

The Alpine trails booster station is considered adequate at this time and for the future projections. The PRV capacities are considered adequate for now and the 2032 scenario. The pressure and fire flow have been noted to have low pressure in a few locations, including the Ghostrider neighbourhood, Ridgemont neighbourhood and select small sections in main town. The low-pressure projections are due to inadequate pipe diameters and are recommended to be increased to best practice sizes in future upgrades. The low-pressure deficiencies were interpreted as non-critical according to the analysis. The current reservoir storage capacity based on the bylaw criteria was recommended for review, further considerations related to the existing storage are discussed in Section 7.11.

Uses in the IICP – Decision making Framework

System improvement recommendations are made within this report to either upsize existing mains to improve fire flows or connect dead end mains to create looping. These recommendations are incorporated into the decision-making framework as one of the criteria that make up the prioritization of a specific utility replacement. Refer to section 5.2 for details of the water model analysis into the decision-making framework.

Conclusion and Recommendations

The following recommendations were put forward through this analysis:

- to verify the diameters of the distribution system for proposed upgrade sections;
- complete a ranking and timing analysis;
- consider completing a water quality modelling analysis in the future; and
- create a unidirectional flushing program.

The model also noted that the Ghostrider neighbourhood water supply system currently is unable to meet fire flows required for an industrial development. At the time of writing, the City is currently in the process of upgrading the watermain network within the Ghostrider neighbourhood to improve fire flows.

4.2 Sanitary

The sanitary sewer model was built using existing sewer GIS attributes including nominal diameter, material type and slope. An existing digital elevation model was used to validate rim elevations and determine missing rim elevations. Base flows were used per the Urban Systems Ltd. (USL) Growth Projection Memorandum (July 2019) using an estimated 3,134 residential units and a permanent residential population of 5,148. An additional non-permanent (shadow) population assumed to be 30% of the total population was used giving an average density of 2.14 capita/unit.

Institutional, commercial and industrial demands were based off equivalent populations as per the MMCD design guidelines.

The modelling process involved application of existing system components into the model, calibration, future scenario development, a system capacity analysis providing a Likelihood of Failure scoring outcome.

Scenarios

Flow scenarios considered the 2018 system flows and 2032 system flows. Growth for the future scenario was projected from the USL Memorandum City of Fernie Growth Projections (July 2019). For the purposes of this IICP study, the current scenario recommendations were used.

System Capacity Analysis

Inflow and Infiltration (I&I) was found to be a significant component of the overall loading, population growth was not a significant factor in the future performance. The outcome of the capacity analysis found that the system is adequately sized to convey the existing and future flows.

The system was analyzed using a likelihood of failure (LoF) rating system where by modelled hydraulic capacity, hydraulic grade line and velocity criteria are tabulated to determine a 1-5 rating. Refer to Table 4.1 (Reproduced Table 5.2: from GeoAdvice Sanitary Sewer report) below for convenience. According to the current modelling, there are no LoF ratings of 5 or 4.

Table 4.1 Likelihood of Failure Ratings (Reproduced Table 5.2 from GeoAdvice Sanitary Sewer report)

LoF Rating	Capacity	HGL	Velocity	Description
1	A	A	Pass	Pipe performing as designed
2	A	A	Fail	Adequate capacity, low velocity indicates potential sedimentation
3	A	B or C	Pass or Fail*	Adequate capacity, backwater caused by downstream conditions
	B	A, B or C	Pass or Fail*	Marginal capacity, backwater caused by downstream conditions
	C	A	Pass or Fail*	
4	C	B	Pass or Fail*	Capacity exceeded and surcharging likely
5	C	C	Pass or Fail*	Capacity exceeded and flooding likely

* *LoF ratings from 3-5 are independent of velocity criteria.*

Uses in the IICP

LoF ratings described above were incorporated into the IICP decision making framework as a component of Risk. Refer to Section 5.3 for details of the sanitary model analysis into the decision-making framework.

Conclusion and Recommendations

Additional flow monitoring/metering to verify unmonitored sections is recommended to achieve higher accuracy in the modelling. A review of the lift station data from tables is also recommended to verify the accuracy. More information should be provided regarding missing lift station data. The report also recommends further analysis to create a realistic peak rainfall dependent inflow and infiltration volume and timing. Moving forward, update and upgrades should be completed annually.

4.3 Storm

The stormwater model was built using the existing storm GIS data by the City as well as information collected by USL. It is noted that some key information is missing to complete an all-pipe network. Pipes were added to the model where data was provided. Some interpolation of critical pipes was completed using Digital Elevation Model data and the City drawings, where GIS data was not available. Some invert elevations were assumed for critical connectivity. The storm model has not been calibrated and GeoAdvice recommends further monitoring prior to use for any decision making

System Capacity Analysis

A 10% increase was added to the IDF to account for climate change for the design storms used in the analysis.

Hydraulic Level of Service (HLoS) criteria is summarized in Table 4.2 (Reproduced Table 5.5 from GeoAdvice Stormwater System Modelling report). The HLoS criteria incorporates Hydraulic Capacity, Hydraulic Grade line, time to surcharge and flood volumes to arrive at an HLoS rating from A-F converted to 1-6 for the purposes of the IICP.

Table 4.2 Conduit Hydraulic Level of Service Descriptions (Reproduced Table 5.5 from GeoAdvice Stormwater System Modelling report)

HLoS Rating	Code	Description
A	1-1-1-1	Conduit performing as designed
B	1-2-1-1	Adequate capacity; minimal backwater caused by downstream condition
	1-3-1-1	Adequate capacity; minimal backwater caused by downstream condition (potential for small flood event)
C	1-2-2-1	Adequate capacity; significant backwater caused by downstream condition
	1-3-2-1	Adequate capacity; significant backwater caused by downstream condition (potential for small flood event)
	1-3-2-2	Adequate capacity; significant backwater caused by downstream condition (potential for large flood event)
D	2-1-1-1	Marginal capacity
	2-2-1-1	Marginal capacity; surcharge event < 15 minutes
	2-3-1-1	Marginal capacity; surcharge event < 15 minutes (potential for small flood event)
E	2-2-2-1	Capacity exceeded; significant surcharge (> 15 minute) event likely
	2-3-2-1	Capacity exceeded; significant surcharge (> 15 minute) event likely (potential for small flood event)
F	2-3-2-2	Capacity exceeded; large flood event likely

Uses in the IICP

HLoS ratings described above were incorporated into the IICP decision making framework as a component of Risk. Refer to section 5.4 for details of the storm model analysis into the decision-making framework.

Conclusion and Recommendations

It is recommended to complete an Integrated Stormwater Management Plan for individual catchments. The City should verify any discrepancies noted in the GIS database as well as add missing data. More flow monitoring throughout the network is recommended to increase confidence and help calibrate the model. Specifically, the downtown area listed with a recommendation period of three months during the wet season (March to May). Calibration of the model prior to capital projects relies on the monitoring. Until the modelling data is updated, the model accuracy cannot be entirely relied upon for capital projects. Documentation of potential detention and Low Impact Development and operation notes should be added to GIS.

5.0 Risk Assesment and Capital Prioritization (Long-Term Decision Making Framework)

The system modelling details how pipe performance was determined based on the ability to provide the respective utility's intended service. Using the performance data alone only provides one piece of a much larger system. The following outlines a framework that incorporates the performance discussed in the previous section with condition and risk associated to each asset to give a framework to prioritize the replacement or rehabilitation of each asset.

The following describes the methodology used to complete the long-term decision-making framework for the water, sanitary sewer and storm sewer linear assets as well as paved roadway assets. A Framework for City facilities is discussed in later sections of this report.

5.1 Methodology

The long-term decision-making framework for municipal utilities and roads upgrade planning is based on the specific information available to each asset. The following summarizes the available information used for establishing a decision-making framework for each specific asset. This assessment will be a snapshot in time and once adopted should be reviewed, populated and updated on an ongoing basis by the City.

Within each asset category, criteria are assessed, and scores applied to determine a priority for replacement or rehabilitation. The following describes the available information used in this study to arrive at the various scores for each category. These criteria and final prioritization scores are to be used as a planning tool that would highlight to decision makers that a particular section of utility would require a more in-depth review or further attention. The true risks and costs for utilities under roadways should be evaluated as a composite to ensure that prioritizations are not ad hoc in approach. Refer to Section 6.0 for a proposed description of the holistic approach that would consider utility and roadway projects for efficient short-term planning.

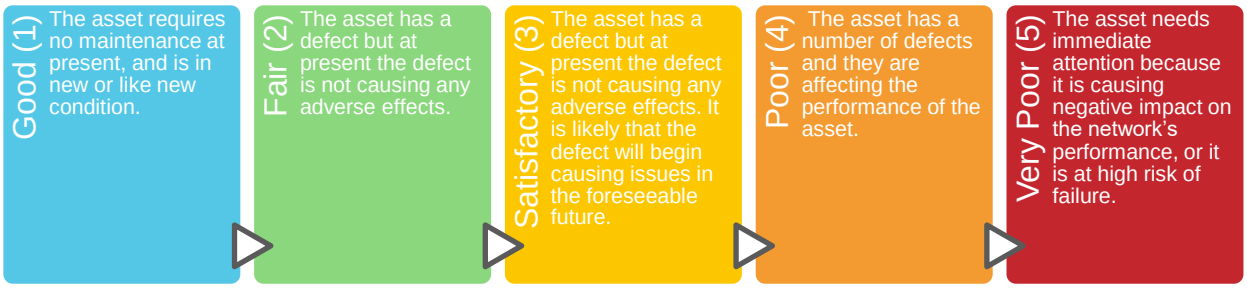
Each asset described in the section below is given a score based on its condition and risk these two scores combine through the matrix shown in Table 5.1 below to provide a prioritization score.

Table 5.1 Roads and Utility Condition – Risk Matrix

Roads & Utility Condition – Risk Matrix					
Condition / Risk	**1**	**2**	**3**	**4**	**5**
1	1	1	2	2	3
2	1	2	2	3	3
3	2	2	3	4	4
4	2	3	4	5	5
5	3	3	4	5	5

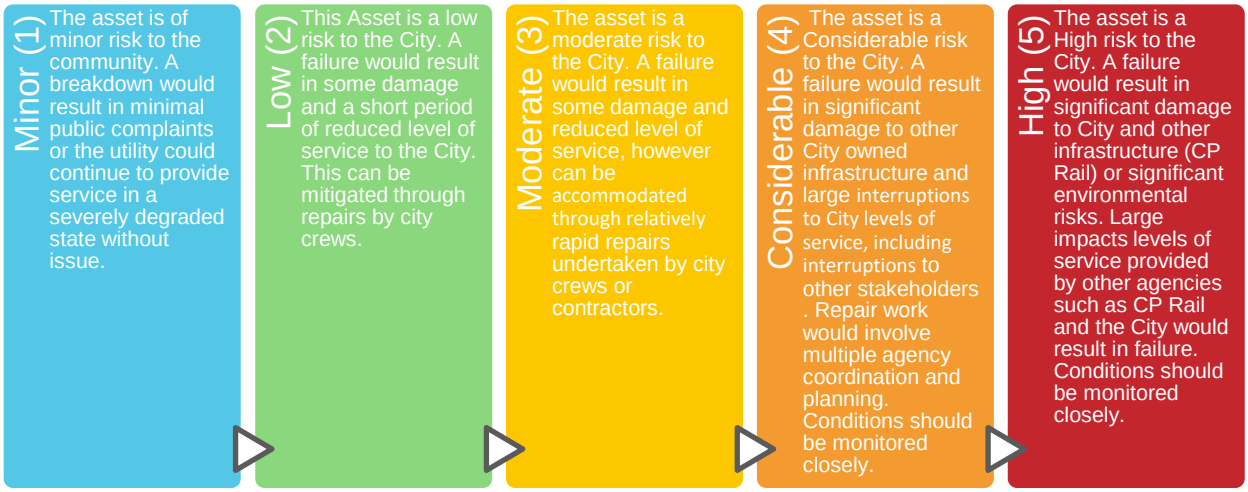
For ease of use, a 1-5 scale is used for condition, risk and prioritization scores. A general description of the rating system scores is provided below. The remainder of this section details out the exact methodology for arriving at each of the scores.

CONDITION

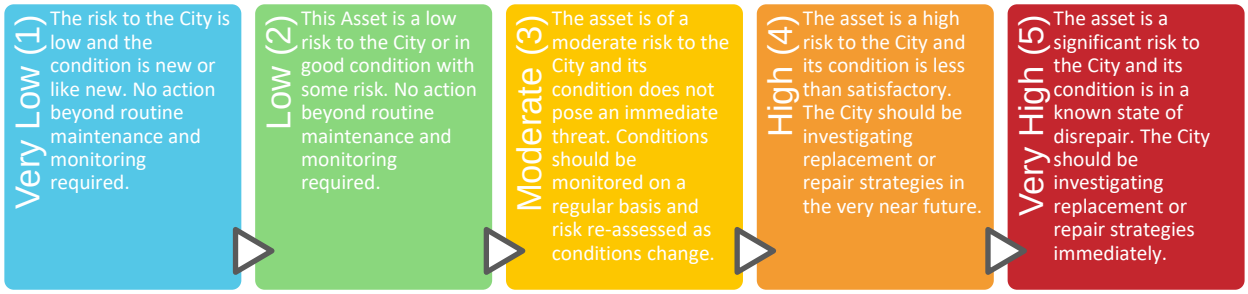


Roads and sanitary sewer infrastructure have had condition assessments completed and their assigned conditions are based on these previous studies. In instances where the assessments did not cover a specific piece of infrastructure age is used as a proxy for condition. Water and storm infrastructure conditions were developed by using their age as a proxy. Further detail regarding condition assigned to each asset type are included in the sections below.

RISK



PRIORITIZATION SCORE



The following details out the framework used to arrive at the final prioritization scores for each asset and specific condition and risk scores applied to each asset type. A sample calculation is provided for one of each utility and roadway in Appendix D.

Through iterations of the IICP prioritization framework it became evident that select utility assets would always be scored with a risk rating of 2 or less due to their locality and hierarchy in their corresponding network. This was potentially problematic as a main that may have well surpassed its service life and have been reported to have operational issues would remain hidden. To resolve this shortcoming of the prioritization framework, the final priority rating is adjusted for the aforementioned assets such that where the condition rating in combination with reported operational issues exceeded the limits of the prioritization matrix, the prioritization score was increased by a value of one (1).

5.2 Watermain

The existing watermain system provides potable water and fire flows to the City of Fernie and consists of approximately 79 km of pipe of varying materials and diameters. For the purposes of this study, service connections and hydrant leads are excluded and assumed to inherit the same condition, risk and prioritization score as the main they are connected to. They are likely of the same age and similar material types.

Refer Figure 5.1 to for a graphical representation of the watermain framework. Further details can then be found in the text following. Figure 5.2 shows the Priority Ratings assigned to each watermain within the City.

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Water Main Rating Process

Condition Rating Process

Water Main type filter (Is the 'main' a hydrant lead or service). This Rating Process only looks at Trunk and Distribution mains

Yes → Exclude from process

No → Assign a Service Life (SL) dependent on the pipe material and relate the pipe age and a percentage of its SL

Material	SL (Years)
AC	70
CI	60
COPP	50
DI	80
GALV	70
HDPE	80
KI	5
MPX	80
PVC	80
PVCO	80
STL	80

SL Score	(Age / SL) %		
1	≤	75%	
2	75%	<>	100%
3	100%	<>	125%
4	125%	<>	150%
5	≥	150%	

+Modifier	Defect / Break Count		
0	≤	1	
1		<≥	2
2	≥	3	

\+ Modify the SL Score if the pipe is known to have operational issues (breaks)

= Condition Score

Risk Rating Process

Water Main type filter (Is the 'main' a hydrant lead or service). This Rating Process only looks at Trunk and Distribution mains

Yes → Exclude from process

No → Determine Water Main Constraint and add Constraint-Score to the Class- Score

Constraint	Score
Lane	1
Local	2
Collector	3
Highway	4
Highway Corridor	4
Dike	4
Structure / Building	4
River Crossing	5
Riverbank Protection Works	5
Rail Crossing	5
Steep Slope	5

\+ Determine Water Main Classification and return Class-Score

Pipe Classification	Score
Trunk Main	1
Distribution Main	0

\+ Modify the Score +1 where modelling recommendation for pipe diameter increase for (fire flow)

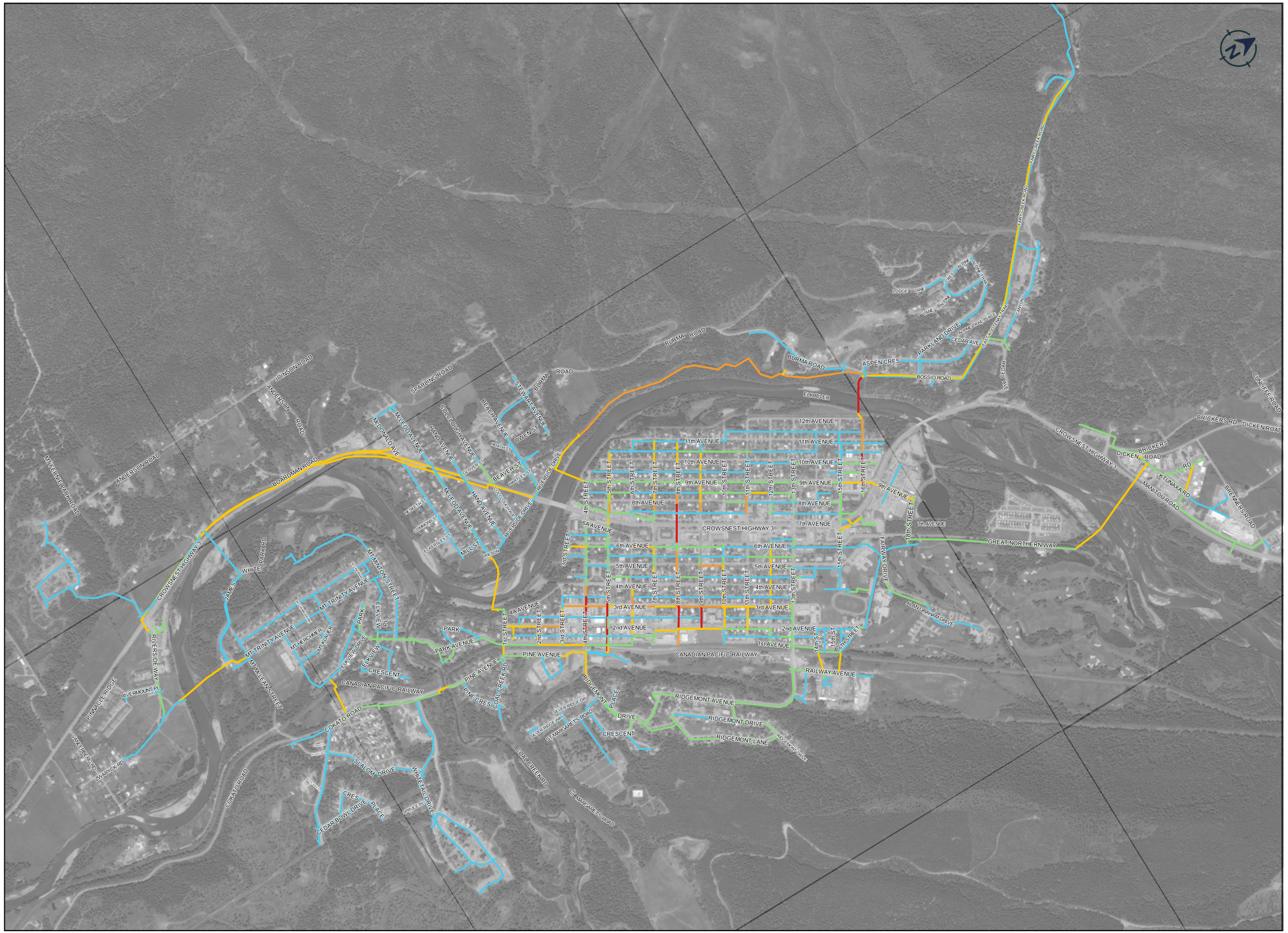
\+ Modify the Score +1 where the following water main is bound by any of the following OCP boundaries:

- M: Historic Downtown
- N: Highway Corridor
- O: Service Commercial
- P: Light Industrial)

= Risk Score (max total 5)

Priority Rating Matrix

Condition \ Risk	1	2	3	4	5
1	1	1	2	2	3
2	1	2	2	3	3
3	2	2	3	4	4
4	2	3	4	5	5
5	3	3	4	5	5



LEGEND

WATER-Priority

- 1 Very Low
- 2 Low
- 3 Moderate
- 4 High
- 5 Very High

Bing Satellite

Fernie IICP

Watermain

IICP Priority Rating

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

Figure 5.2

Service Layer Credits: The City of Fernie

1:17000

0 300 600 900 1200 m

ISL FERNIE
CITY OF FERNIE
BRITISH COLUMBIA

Condition

Condition assessments of watermains can be completed through destructive testing, which due to the amount of disruptive work required to obtain watermain conditions was not completed as part of this project. For this study, age and material are used as a proxy to determine a condition for watermains including data acquired by the City staff related to watermain breaks or issues. Both age and material data were taken from the City's GIS database.

Condition ratings are proposed as shown in Table 5.2 below.

Table 5.2 Watermain Condition by Age Proxy Criteria

Condition	Criteria
5	Asset Age exceeds its Service Life by 50%
4	Asset Age exceeds its Service Life by 25% - 50%
3	Asset Age exceeds its Service Life by 0% - 25%
2	75% of its Service live < Asset Age < 100% of its Service Life
1	Asset age <75% of its service life

Service lives differ depending on material. The following table is adapted from the Fernie AMIP and altered for consistency between the various utility types within the IICP.

Table 5.3 Watermain Service Life by Material

Material	Typical Service Life (Years)
Asbestos Cement	*70
Cast Iron	60
Ductile Iron	**80
Galvanized	70
HDPE	80
PVC	80
Steel	80

* *Asbestos Cement (AC) pipes have been known to exhibit more rapid degradation depending on the influence of groundwater. Without completing a testing program, the condition of the existing AC pipe is unknown and therefore the typical service life shown above is used.*

** *The Lifespan Ductile Iron mains are listed as 100 years in the AMIP and have been reduced to 80 years to be consistent with HDPE and PVC for this study. It is recommended that a general corrosive soils investigation be completed throughout the City to determine areas of corrosive soils and determine expected lifespans DI watermain within the City. If it is found that DI watermain lifespans differ, the service life table should be updated.*

Further to the condition criteria, the City provided historical data of watermain breaks/service calls throughout the water network dating back to 2000. ISL reviewed this list and approximate locations of breaks described. Depending on the frequency of any particular issue described, the condition rating is increased (i.e. the higher condition score represents a worse condition main). Where one issue was noted on a pipe, the condition was left unchanged as a single event could be attributed to a local failure. Where two issues were noted on the same pipe, the condition score was increased by 1, if more than three were found, the condition score was increased by 2 as this would indicate there is a significant defect/deterioration in the pipe.

Most pipes only had 1 or 2 known issues and 1 main had 9 issues reported. This watermain is the C&L ROW trunk main.

Figure 5.3 shows the City's water network based on its material, and Figure 5.4 shows the City's water network based on condition determined through the above criteria.

Risk

A risk score is applied to the watermain via the classification of roadway or feature that it falls under. Water bodies, dikes, structures and any rail crossings are also included in this classification. This information was provided by the City's GIS database.

Table 5.4 Watermain Risk Classification

Roadway Classification/feature	Risk Score
Gravel Lanes	1
Local Road	2
Collector Road	3
Highway/Dike/Structure	4
Elk River/Coal Creek/CP Rail	5

The above risk scores are then modified based on the type of main they are classified as (distribution or trunk), if they fall within the following OCP Development Permit Areas (OCP DPA) and if the water modelling found that upgrades were required to provide adequate flows/pressures. The following table shows the risk modifiers used based on these criteria.

Table 5.5 Watermain Risk Modification Criteria

Risk Modification Criteria	Risk Modifier
Distribution Main	0
Trunk Main	+1
Within OCP DBA (M, N, O, P)	+1
Water Model Upsizing Recommendation	+1

The OCP DPA's all service business within City, the economic impact that would result in service disruption increases the risk associated to watermains within these zones.

The modelling completed by GeoAdvice determined numerous mains throughout the City requiring size upgrades to provide adequate fire flow to various neighborhoods. Where these mains were noted for upgrade, a risk modifier is also included.

For example, a watermain that lies under a local road is classified as a trunk main falls within one of the OCP DBA's listed and is noted for upgrade in the water model would theoretically receive a risk score of 5 (2 based on its locality and 1 for each of the 3 modifiers in Table 5.5).

LEGEND

WATER - Pipe Material

- AC
- CI
- COPP
- DI
- GALV
- HDPE
- MPX
- PVC
- STL
- UNKN

Bing Satellite

Fernie IICP

Water Main

Pipe Material

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

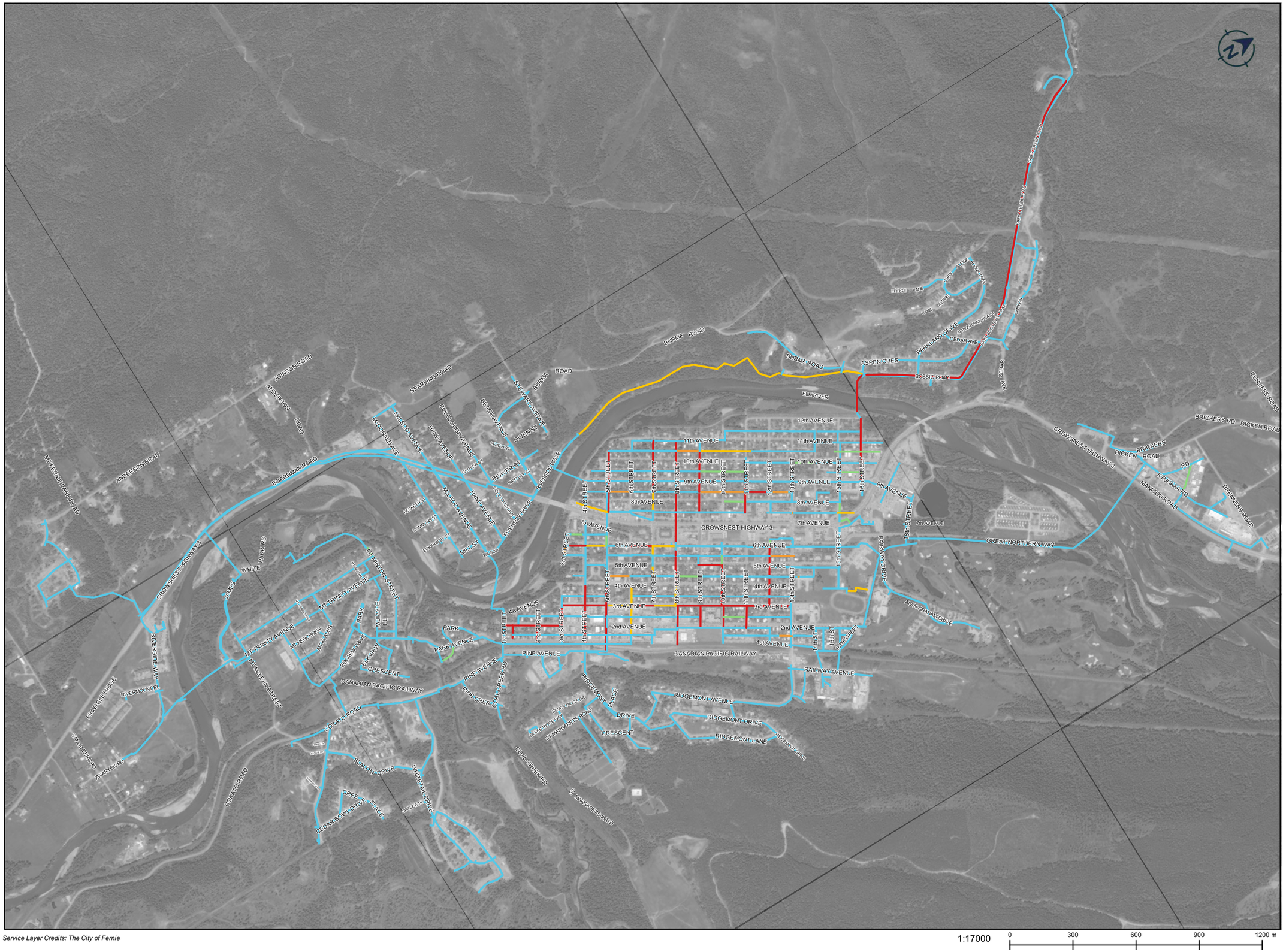
Figure 5.3

CITY OF FERNIE
BRITISH COLUMBIA

Service Layer Credits: The City of Fernie

1:17000

0 300 600 900 1200 m



Service Layer Credits: The City of Fernie

LEGEND

WATER-Condition

- 1 Good
- 2 Fair
- 3 Satisfactory
- 4 Poor
- 5 Very Poor

Bing Satellite

Fernie IICP

Water Main

IICP Condition Rating

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

Figure 5.4

ISL FERNIE
CITY OF FERNIE
BRITISH COLUMBIA

The following Figure 5.5 shows the City's water network classified by distribution or trunk main, and Figure 5.6 shows the locations within the City that are bounded by OCP Area M, N, O and P.

The above modifications are added together to arrive at the risk score while keeping the maximum as 5.

Figure 5.7 shows the watermains within the system that are recommended for upsizing in the water modelling report. This includes approximately 4 km of watermain replacement. The water model report also notes 700 m of new watermain through mainly connectivity to supply looping throughout the system. Refer to the water modelling report in Appendix A for more details.

Figure 5.8 shows the City's water network based on the risk score calculated from the above criteria.

Upgrade Warrants

All watermains with a prioritization score of 4 or 5 based on this framework should be considered for timely replacement or rehabilitation. Refer to Section 6.0 for a holistic review of short-term recommended projects.

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LEGEND

WATER-Class

- Distribution
- Trunk

Bing Satellite

Fernie IICP

Water Main

Pipe Classification

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

Figure 5.5

Service Layer Credits: The City of Fernie

1:17000

0 300 600 900 1200 m

CITY OF FERNIE
BRITISH COLUMBIA

LEGEND

OCP DPA

- Schedule M
- Schedule N
- Schedule O
- Schedule P

Bing Satellite

Fernie IICP

Water Main

OCP DPA Schedules

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

Figure 5.6

CITY OF FERNIE
BRITISH COLUMBIA

Service Layer Credits: The City of Fernie

1:17000

0 300 600 900 1200 m

LEGEND

WATER-Condition copy

- 150 mm Dia.
- 200 mm Dia.
- 250 mm Dia.

Bing Satellite

Fernie IICP

Watermain

Pipe Upsizing Recommendations

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

Figure 5.7

CITY OF FERNIE
BRITISH COLUMBIA

Service Layer Credits: The City of Fernie

1:17000

0 300 600 900 1200 m

LEGEND

WATER-Risk

- No Data
- 1 Minor
- 2 Low
- 3 Moderate
- 4 Considerable
- 5 High

Bing Satellite

Fernie IICP

Water Main

IICP Risk Rating

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

Figure 5.8

CITY OF FERNIE
BRITISH COLUMBIA

Service Layer Credits: The City of Fernie

1:17000

0 300 600 900 1200 m

5.3 Sanitary

The existing sanitary network consists of approximately 58 km of pipe of varying materials and diameters servicing the City. For the purposes of this study, service connections and manholes are excluded and assumed to inherit the same condition, risk and prioritization score as the main they are connected to. Specific trouble manholes are used to adjust risk scores, and these specific manholes are discussed in further detail below.

Refer to Figure 5.9 for a graphical representation of the sanitary framework, further detail can then be found in the text following. Figure 5.10 shows the Priority Ratings assigned to each sanitary main within the City.

The following outlines the criteria for condition and risk ratings.

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Sanitary Sewer Main Rating Process

Condition Rating Process

Sanitary Sewer Main type filter (Is the 'main' a service). This Rating Process only looks at those pipe classifications shown in the 'Pipe Classification Table in the Risk Rating Process below

Yes → Exclude from process

No → Assign a Service Life (SL) dependent on the pipe material and relate the pipe age and a percentage of its SL

Material	SL (Years)
AC	70
CONC	70
HDPE	80
PVC	80
PVCO	80
STL	80
VCT	50

SL Score	(Age / SL) %		
1	≤	75%	
2	75%	<>	100%
3	100%	<>	125%
4	125%	<>	150%
5	≥	150%	

\+ Modify the SL Score +1 if the pipe is known to have operational issues (breaks)

= Condition Score

Risk Rating Process

Sanitary Sewer Main type filter (Is the 'main' a service). This Rating Process only looks at those pipe classifications shown in the 'Pipe Classification Table in the Risk Rating Process below

Yes → Exclude from process

No → Determine Sanitary Sewer Main Constraint and add Constraint-Score to the Class-Score (max @ 5)

Determine Sanitary Sewer Main Classification and return Class-Score

Determine Sanitary Sewer Main Likelihood of Failure (LoF)

Constraint	Score
Lane	1
Local	2
Collector	3
Highway	4
Highway Corridor	4
Dike	4
Structure / Building	4
River Crossing	5
Riverbank Protection Works	5
Rail Crossing	5
Steep Slope	5

Pipe Classification	Score
Sanitary: Trunk Main	1
Sanitary: Collection Main	0
Sanitary: Overflow Bypass	1
Sanitary: Vacuum Forcemain	1
Sanitary: Other	0

LoF Rating Description	LoF Score
Pass Pipe performing as designed	1
Adequate capacity, low velocity indicates potential sedimentation	2
Adequate/Marginal capacity, backwater caused by downstream conditions	3
Capacity exceeded and surcharging likely	4
Capacity exceeded and flooding likely	5

LoF Score

Class+Constraint Risk Score	1	2	3	4	5
1	1	1	2	2	3
2	1	2	2	3	3
3	2	2	3	4	4
4	2	3	4	5	5
5	3	3	4	5	5

\+ Modify the Risk +1 where there is known problematic mains or up/downstream manholes (operational issues)

= Risk Score

Priority Rating Matrix

Condition \ Risk	1	2	3	4	5
1	1	1	2	2	3
2	1	2	2	3	3
3	2	2	3	4	4
4	2	3	4	5	5
5	3	3	4	5	5

Fernie IICP

Sanitary Sewer Main IICP Rating Process

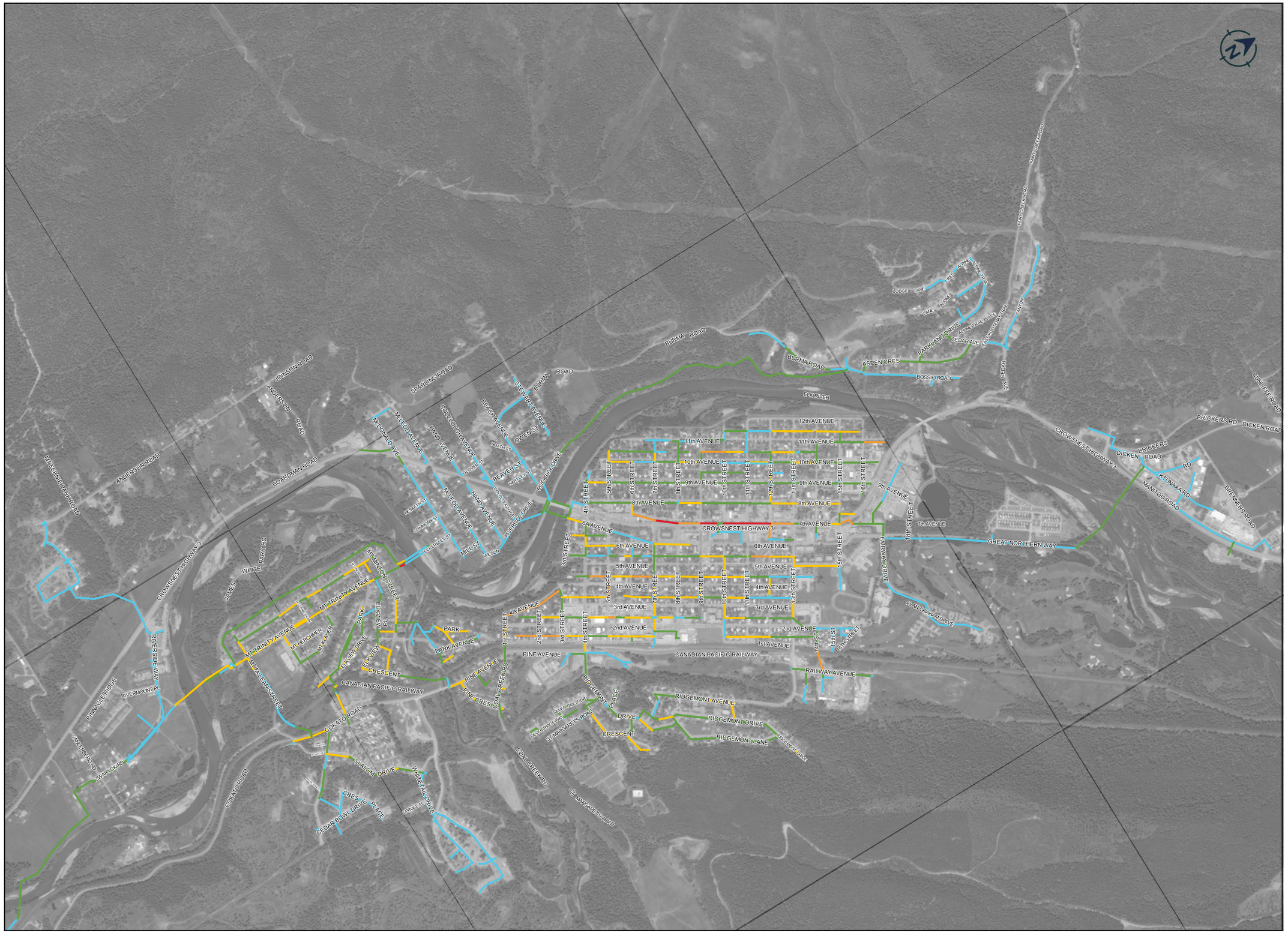
Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

Figure 5.9

The City of Fernie

ISL FERNIE CITY OF FERNIE BRITISH COLUMBIA



Service Layer Credits: The City of Fernie

1:17000

0 300 600 900 1200 m

LEGEND

SANITARY-Priority

- 1 Very Low
- 2 Low
- 3 Moderate
- 4 High
- 5 Very High

Bing Satellite

Fernie IICP

Sanitary Sewer Main

IICP Priority Rating

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

Figure 5.10

ISL FERNIE
CITY OF FERNIE
BRITISH COLUMBIA

Condition

Existing condition assessments have provided for the majority of the City's sewer network. These were determined through CCTV inspections performed in 2010, 2012 and 2016. The CCTV condition scores are given to a main between 1 poor and 5 good, in order to be consistent with the scoring system used in this report these values are inverted (1 becomes 5, 2 becomes 4). These CCTV scores are not changed based on the age of the main. Where the condition scores do not exist, age and material are used as a proxy, similar to the water network. When these mains are inspected in the future, it is recommended that the City update these proxy conditions with actual observed sewer condition. Age and material data were determined from the existing City's GIS database.

Figure 5.11 shows the sanitary sewer system differentiated by method used to determine their condition.

Proxy condition ratings are proposed as shown in the table below.

Table 5.6 Sanitary Sewer Condition by Age Proxy Criteria

Condition	Criteria
5	Asset Age exceeds its Service Life by 50%
4	Asset Age exceeds its Service Life by 25% - 50%
3	Asset Age exceeds its Service Life by 0% - 25%
2	75% of its Service live < Asset Age < 100% of its Service Life
1	Asset age <75% of its service life

Typically, service lives differ depending on material, the following table is adapted from the Fernie Asset Management Investment Plan (AMIP) and altered for consistency between the various utility types within the IICP.

Table 5.7 Sanitary Sewer Service Life by Material

Material	Typical Service Life (Years)
Asbestos Cement	*70
Concrete	70
Vitrified Clay Tile	50
HDPE	80
PVC	80
Steel	80

Figure 5.12 shows the sanitary system based on material.

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LEGEND

SANITARY-C_Method

- No data
- CCTV Reporting
- Age as Proxy

Bing Satellite

Fernie IICP

Sanitary Sewer Main

IICP Condition Rating Method

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

Figure 5.11

CITY OF FERNIE
BRITISH COLUMBIA

Service Layer Credits: The City of Fernie

1:17000

0 300 600 900 1200 m

LEGEND

SANITARY-Material

- AC
- CONC
- HDPE
- PVC
- VCT

Bing Satellite

Fernie IICP

Sanitary Sewer Main

Pipe Material

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

Figure 5.12

CITY OF FERNIE
BRITISH COLUMBIA

Service Layer Credits: The City of Fernie

1:17000

0 300 600 900 1200 m

Further to the condition criteria described above, the City has provided historical data of sanitary breaks/service calls throughout the sanitary network dating back to 2017. The issues were found to not be appropriate for adjusting the condition score of a main. A list of known issues is also contained within the GIS database; however, all these issues were found to be related to the CCTV inspections and assumed to be captured within the CCTV score and therefore no further score manipulation was performed.

There are 11 known brick manholes within the main town area that the City wishes to incorporate into the condition scoring of the mains they are connected to. The proposed criteria assume that a manhole in poor condition is likely to be connected to a main in similar condition and that if the main was to be replaced or repaired, the manhole would also be replaced or repaired at the same time. The proposed criteria increase the condition score of a pipe by 1 (i.e. a higher condition score represents a poorer condition) if it is connected to one of these known manholes. The following figure shows the location of these brick manholes.

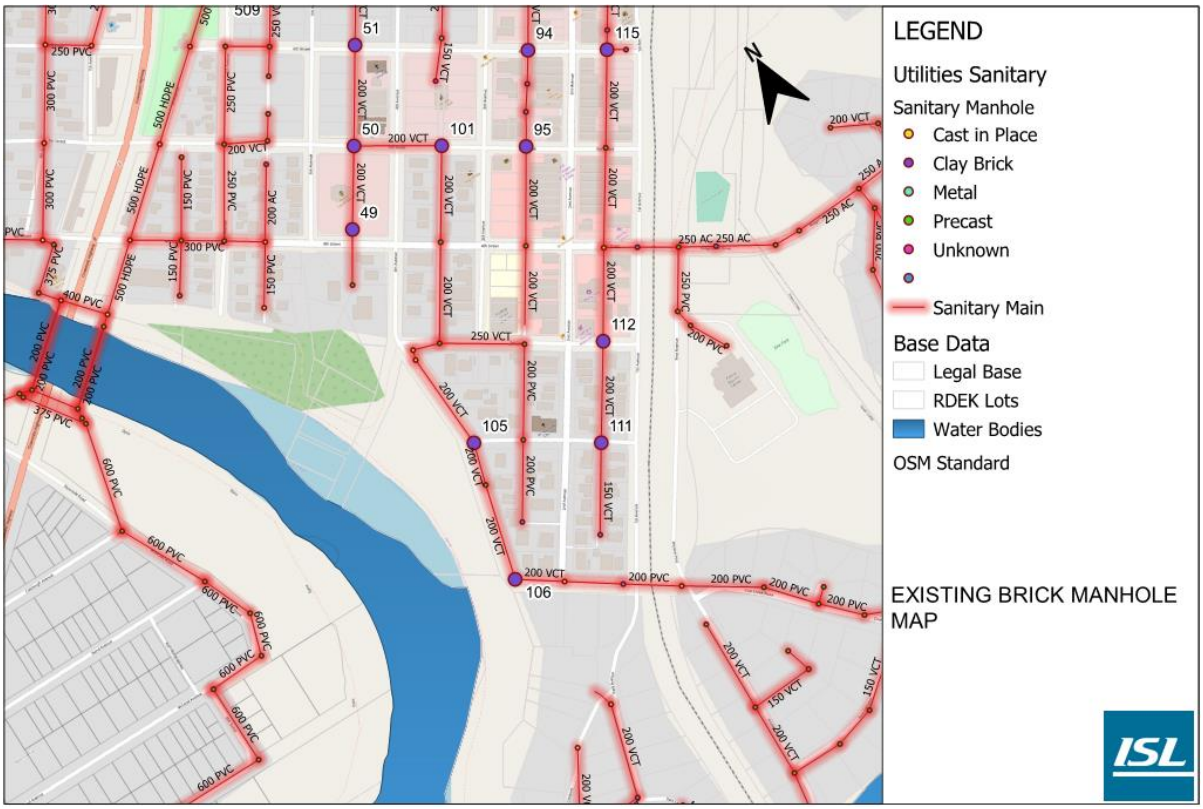
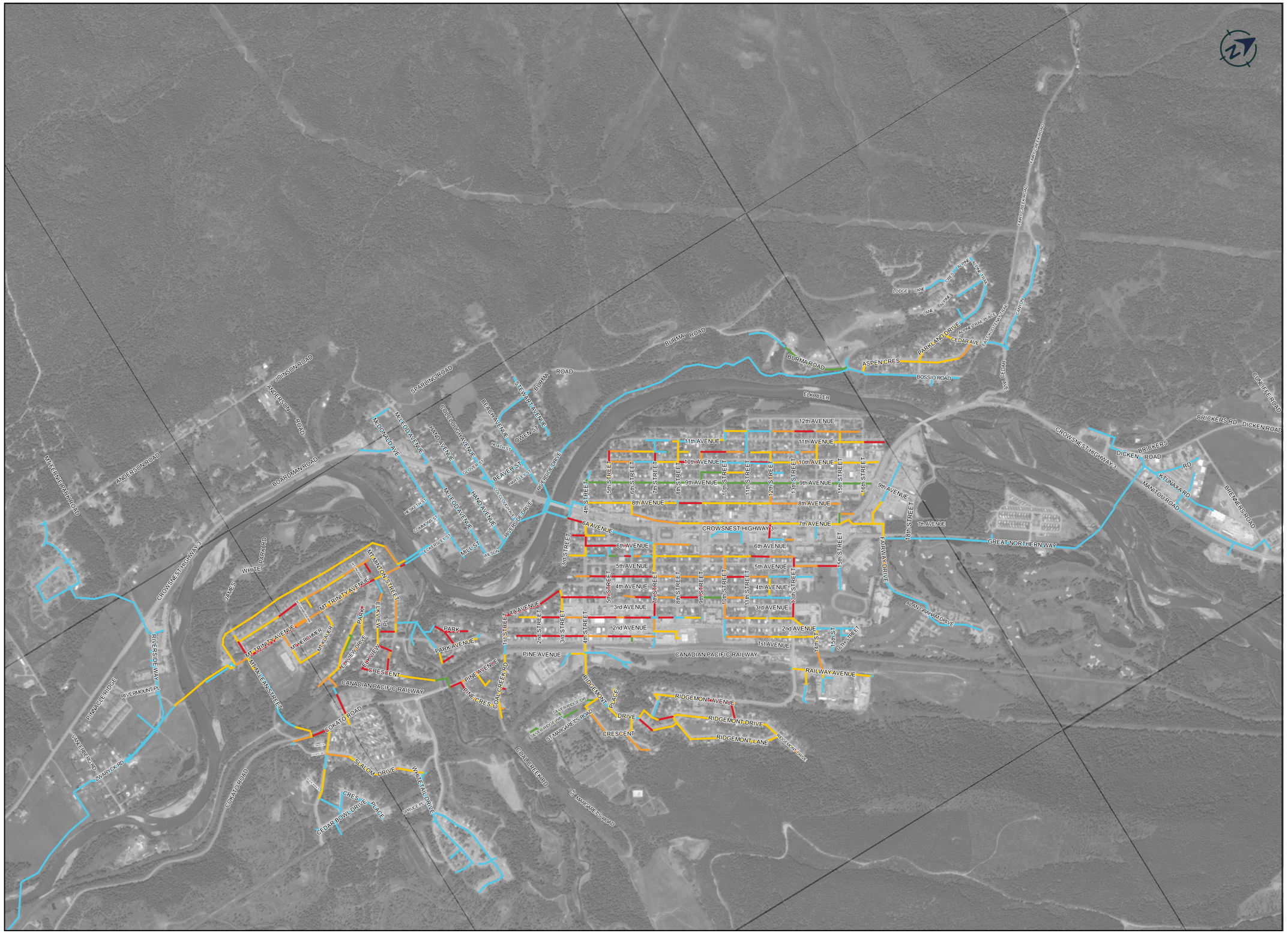


Figure 5.13 Existing Brick Manhole Map

Figure 5.14 shows the final condition rating of the sanitary system developed using the methodology described above.

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Service Layer Credits: The City of Fernie

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0 300 600 900 1200 m

LEGEND

SANITARY-Condition

- 1 Good
- 2 Fair
- 3 Satisfactory
- 4 Poor
- 5 Very Poor

Bing Satellite

Fernie IICP

Sanitary Sewer Main

IICP Condition Rating

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

Figure 5.14

ISL FERNIE
CITY OF FERNIE
BRITISH COLUMBIA

Risk

A Risk score is determined based on the locality of the main determined by the classification of roadway that it falls under and the Likelihood of Failure (LoF). These two values are run through the following matrix to determine the risk score.

Table 5.8 Sanitary Locality – LoF Matrix (Risk Score)

Sanitary Risk Matrix					
Locality/LoF	**1**	**2**	**3**	**4**	**5**
1	1	1	2	2	3
2	1	2	2	3	3
3	2	2	3	4	4
4	2	3	4	5	5
5	3	3	4	5	5

Figure 5.15 shows the sanitary collection network categorized based on the Risk determined from the above matrix.

The following describes how LoF and Locality are determined.

LIKELIHOOD OF FAILURE (LOF)

Through the City's updated sanitary model, a LoF score was developed taking into account capacity, hydraulic grade line, and velocity. A general rating of 1 through 5 was assigned based on the criteria 1 being low LoF and 5 being high LoF. Refer to section 3.2 for details on the LoF criteria.

A list of trouble mains that require frequent flushing was provided by the City. This list was reviewed and the LoF score of trouble mains within this list were increased by 1 (i.e. an increased LoF for mains that require frequent flushing).

LOCALITY

Similar to watermain, the locality was determined by the classification of roadway or feature that it falls within the GIS database. Water bodies, dikes, structures and any rail crossings are also included in this classification.

Table 5.9 Sanitary Locality Classification

Roadway Classification/feature	Locality Score
Lane	1
Local Road	2
Collector Road	3
Highway/Dike/Structure	4
Elk River/Coal Creek/CP Rail	5

The above locality scores are then altered based on the type of main they are classified as. The following table shows the sanitary classification and its corresponding modifier.

Table 5.10 Sanitary Classification Locality Modifier

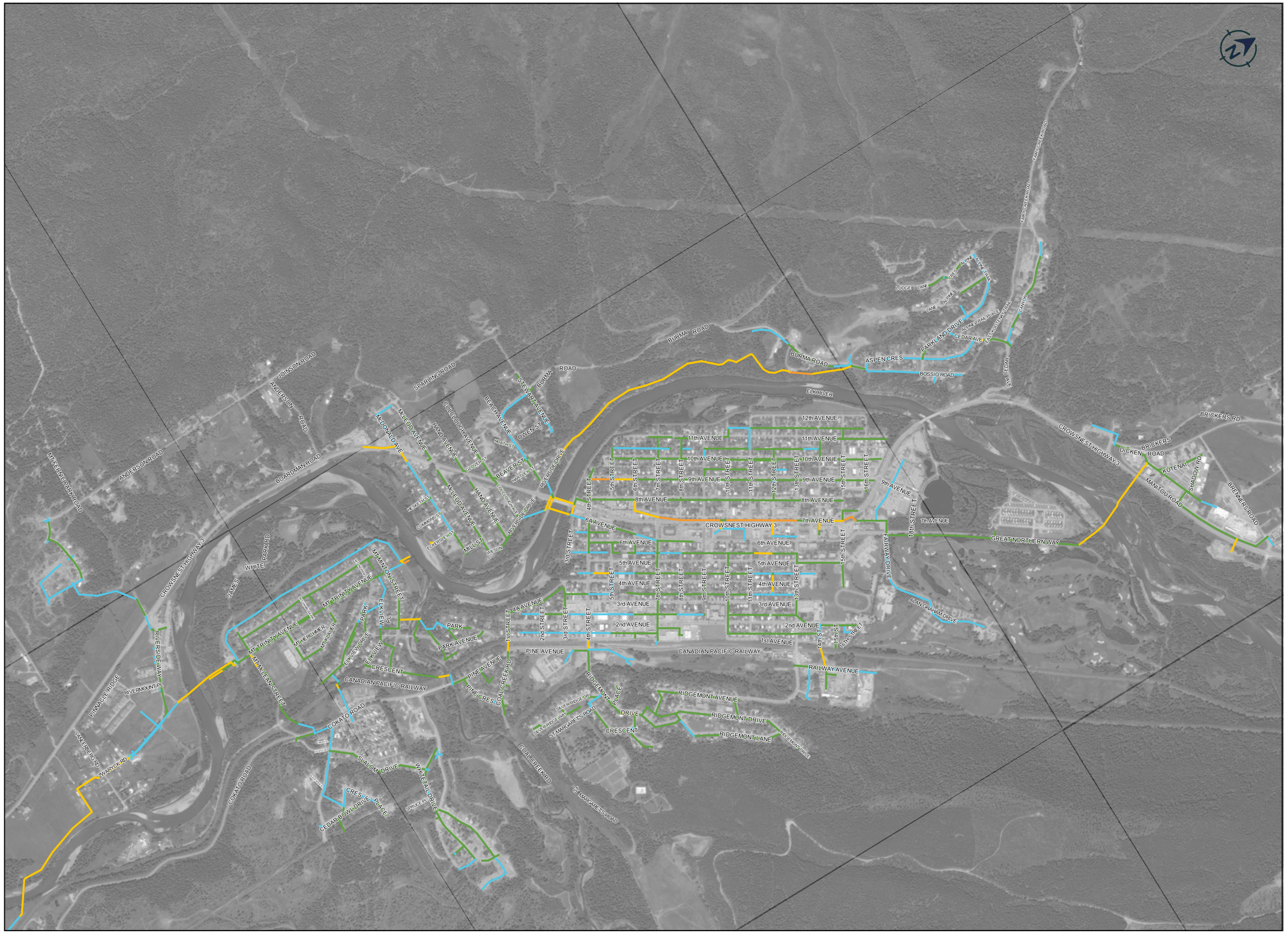
Sanitary Classification	Modifier
Collection Main	0
Overflow Bypass	+1
Trunk Main	+1
Vacuum Forcemain	+1

The modifiers listed in the table above are added to the locality score while keeping the maximum at 5 (i.e. if a main crossing the Elk river is also classified as a trunk main, its locality score is a 5, if a trunk main crosses Hwy#3 its locality score is a 5).

Figure 5.16 shows the sanitary network based on its classification.

Upgrade Warrants

All sanitary mains with a prioritization score of a 4 or 5 based on this framework should be considered for timely replacement or rehabilitation. Refer to Section 6.0 for a holistic review of short-term recommended projects.



LEGEND

SANITARY-Risk

- 1 Minor
- 2 Low
- 3 Moderate
- 4 Considerable

Bing Satellite

Fernie IICP

Sanitary Sewer Main

IICP Risk Rating

The City of Fernie

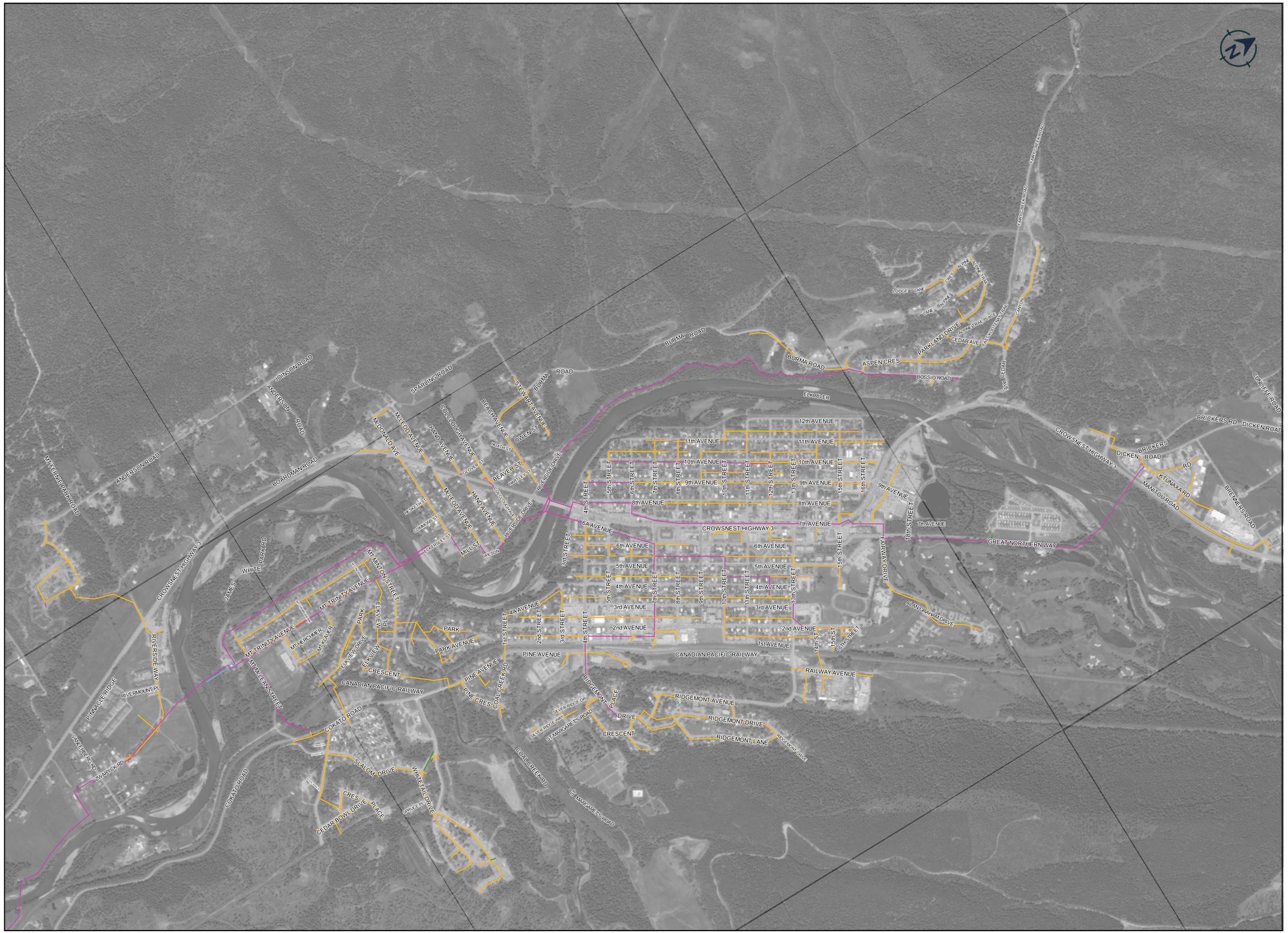
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Figure 5.15

Service Layer Credits: The City of Fernie

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CITY OF FERNIE
BRITISH COLUMBIA



LEGEND

SANITARY-Class

- Trunk Main
- Collection Main
- Overflow Bypass
- Vacuum Forcemain

Bing Satellite

Fernie IICP

Storm Sewer Main

Pipe Classification

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

Figure 5.16

Service Layer Credits: The City of Fernie

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0 300 600 900 1200 m

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CITY OF FERNIE
BRITISH COLUMBIA

5.4 Storm

The existing storm network consists of approximately 10 km of pipe of varying materials and diameters. For the purposes of this study, service connections, catch basins and manholes are excluded and assumed to inherit the same condition, risk, and prioritization score as the main they are connected to. Overland systems were not included in this analysis, ditched and other overland systems should receive ongoing maintenance throughout their life through frequent cleaning and inspection and budgeted for on an annual basis.

Refer to Figure 5.17 for a graphical representation of the storm sewer framework, further detail can then be found in the text following. Figure 5.18 shows the Priority Ratings assigned to each storm main within the City.

The following describes the condition and risk scores determined for the storm main framework.

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Storm Sewer Main Rating Process

Condition Rating Process

Storm Sewer Main type filter (Is the 'main' a service). This Rating Process only looks at those pipe classifications shown in the 'Pipe Classification Table in the Risk Rating Process below

Yes → Exclude from process

No → Assign a Service Life (SL) dependent on the pipe material and relate the pipe age and a percentage of its SL

Material	SL (Years)
AC	70
CMP	60
CSP	60
CONC	70
HDPE	80
PERF	100
PVC	80
PVCO	80
STL	80
VCT	50

SL Score	(Age / SL) %		
1	≤	75%	
2	75%	<>	100%
3	100%	<>	125%
4	125%	<>	150%
5	≥	150%	

\+ Modify the SL Score +1 if the pipe is known to have operational issues (breaks)

= Condition Score

Risk Rating Process

Storm Sewer Main type filter (Is the 'main' a service or lead). This Rating Process only looks at those pipe classifications described in the City GIS as Type '4'.

Yes → Exclude from process

No → Determine Storm Sewer Main Constraint Score

Constraint	Score
Lane	1
Local	2
Collector	3
Highway	4
Highway Corridor	4
Dike	4
Structure / Building	4
River Crossing	5
Riverbank Protection Works	5
Rail Crossing	5
Steep Slope	5

Determine Storm Sewer Main Hydraulic Level of Service (HLoS)

HLoS Rating Description	HLoS Score
Conduit performing as designed	1
Adequate capacity; Minimal backwater caused by downstream condition (potential for small flood event)	2
Adequate capacity; Significant backwater caused by downstream condition (potential for large flood event)	3
Marginal capacity; Surcharge event < 15 minutes (potential for small flood event)	4
Capacity exceeded; Significant surcharge (> 15 minute) event likely (potential for small flood event)	5
Capacity exceeded; Large flood event likely	6

HLoS Score × Constraint Risk Score

Constraint Risk Score \ HLoS Score	1	2	3	4	5	6
1	1	1	2	2	3	4
2	1	2	2	3	3	5
3	2	2	3	4	4	5
4	2	3	4	5	5	5
5	3	3	4	5	5	5

= Risk Score

Priority Rating Matrix

Condition \ Risk	1	2	3	4	5
1	1	1	2	2	3
2	1	2	2	3	3
3	2	2	3	4	4
4	2	3	4	5	5
5	3	3	4	5	5

Fernie IICP Fernie Integrated Infrastructure Capital Plan

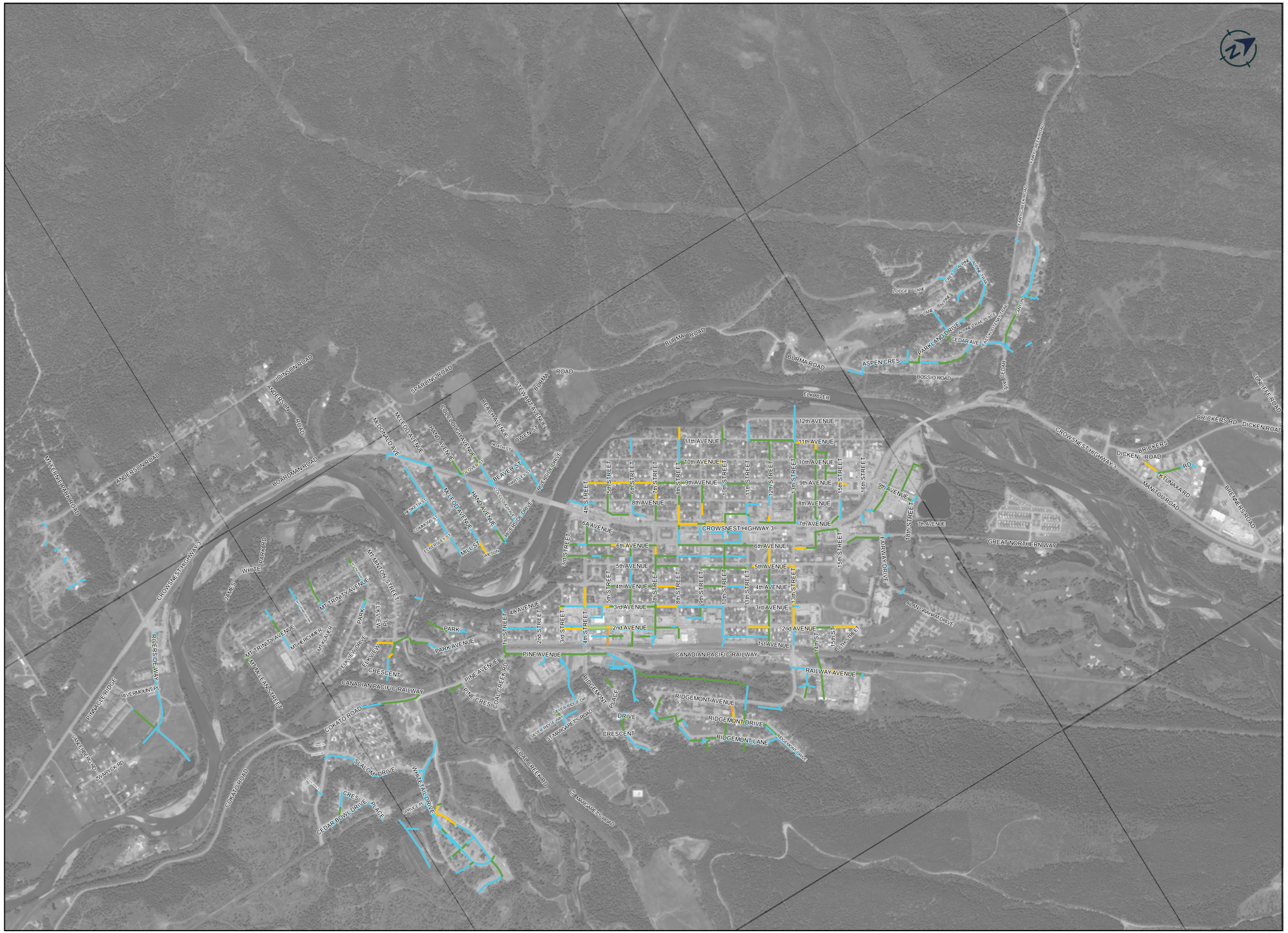
Storm Sewer Main IICP Rating Process

ISL Ref. #32568

Figure 5.17

The City of Fernie

ISL FERNIE CITY OF FERNIE BRITISH COLUMBIA



Service Layer Credits: The City of Fernie

1:17000

0 300 600 900 1200 m

LEGEND

STORM-Priority

- 1 Very Low
- 2 Low
- 3 Moderate
- 4 High

Bing Satellite

Fernie IICP

Storm Sewer Main

IICP Priority Rating

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

Figure 5.18

ISL FERNIE
CITY OF FERNIE
BRITISH COLUMBIA

Condition

Age and material are used as a proxy (like the water network). When these mains are inspected in the future, it is recommended that the City update its proxy conditions with actual observed sewer condition.

Condition ratings are proposed as shown in the table below

Table 5.11 Storm Sewer Condition by Age Proxy Criteria

Condition	Criteria
5	Asset Age exceeds its Service Life by 50%
4	Asset Age exceeds its Service Life by 25% - 50%
3	Asset Age exceeds its Service Life by 0% - 25%
2	75% of its Service live < Asset Age < 100% of its Service Life
1	Asset age <75% of its service life

Typically, service lives differ depending on material. The following table is adapted from the Fernie's AMIP and altered for consistency between the various utility types within the IICP.

Table 5.12 Storm Sewer Service Life by Material

Material	Typical Service Life (Years)
Asbestos Cement	70
Concrete	70
Vitrified Clay Tile	50
HDPE	80
PVC	80
Steel	80
CSP	60
PERF	80

Figure 5.19 shows the storm sewer network based on its material.

Figure 5.20 below shows the storm sewer network based on its condition determined from the above criteria.

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LEGEND

STORM-Material

- AC
- CMP
- CONC
- HDPE
- PERF
- PVC
- STL
- UNKN
- VCT

Bing Satellite

Fernie IICP

Storm Sewer Main

Pipe Material

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

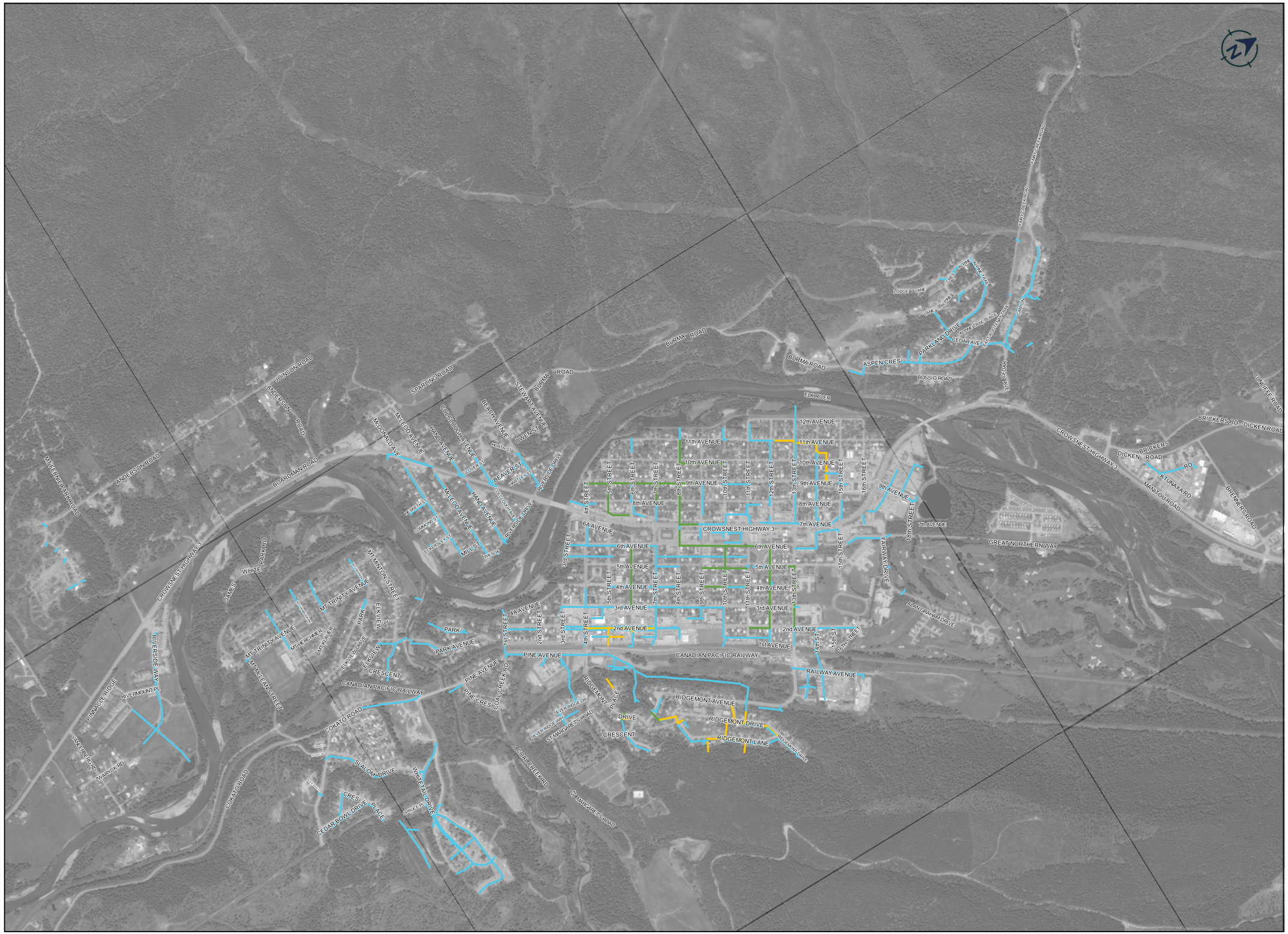
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Figure 5.19

CITY OF FERNIE
BRITISH COLUMBIA

Service Layer Credits: The City of Fernie

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Service Layer Credits: The City of Fernie

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LEGEND

STORM-Condition

- 1 Good
- 2 Fair
- 3 Satisfactory

Bing Satellite

Fernie IICP

Storm Sewer Main

IICP Condition Rating

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

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Figure 5.20

ISL FERNIE
CITY OF FERNIE
BRITISH COLUMBIA

Risk

A Risk score is determined based on the locality of the main determined by the classification of roadway that it falls under and the Hydraulic Level of Service (HLoS). These two values are run through the following matrix to determine the risk score.

Table 5.13 Storm HLoS-Locality Matrix (Risk Score)

Storm Risk Matrix							
		HLoS					
		1	2	3	4	5	6
Locality	1	1	1	2	2	3	4
	2	1	2	2	3	3	5
	3	2	2	3	4	4	5
	4	2	3	4	5	5	5
	5	3	3	4	5	5	5

Figure 5.21 shows the Storm Main Risk associated with each storm asset.

The following describes how HLoS and Locality are determined.

HYDRAULIC LEVEL OF SERVICE (HLOS)

Through the City's updated storm model, a HLoS score was developed. HLoS considers the capacity, hydraulic grade line, surcharge time and flood time under peak flow conditions. A general rating of 1 through 6 was assigned based on the criteria 1 being good (conduit is performing as designed) and 6 being poor (capacity exceeded; large flood event likely). Refer to section 4.3 for further detail on the HLOS criteria.

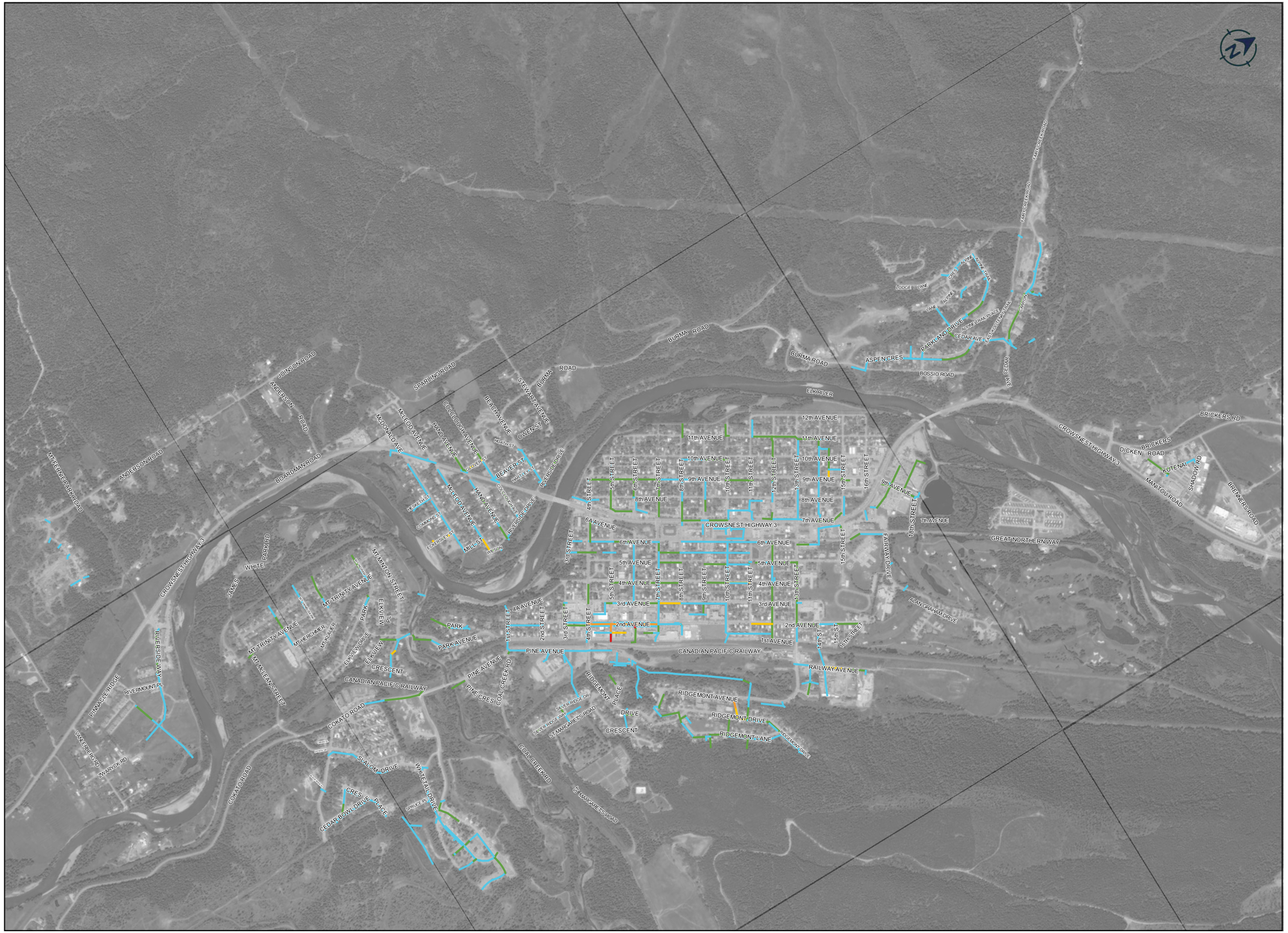
LOCALITY

Similar to water and sanitary mains, the locality was determined by the classification of roadway or feature that it falls under within the GIS database. Water bodies, dikes, structures and any rail crossings are also included in this classification. The following table describes the Locality scores for storm mains used in this framework.

Table 5.14 Storm Locality Classification

Roadway Classification/feature	Locality Score
Lane	1
Local Road	2
Collector Road	3
Highway/Dike/Structure	4
CP Rail	5

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0 300 600 900 1200 m

LEGEND

STORM-Risk

- 1 Minor
- 2 Low
- 3 Moderate
- 4 Considerable
- 5 High

Bing Satellite

Fernie IICP

Storm Sewer Main

IICP Risk Rating

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

Figure 5.21

ISL FERNIE
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BRITISH COLUMBIA

Upgrade Warrants

All storm sewers with a prioritization score of 4 or 5 based on this framework should be considered for timely replacement or rehabilitation. Refer to section 6.0 for a holistic review of short-term recommended projects.

At the time of writing, the storm model has not been calibrated, and it is recommended that a calibration exercise be completed prior to detailed capital planning based off the stormwater model. Refer to Appendix C for details regarding stormwater model calibration.

The un-calibrated model results have been used at this time to prepare a sample list. Once calibration is completed, the revised HLoS scores should be incorporated into the above framework to verify or update this list.

5.5 Roads

The City's roadway networks include approximately 500,000 m^2 of asphalt roads with classifications of collector, local or lane. Most lanes within the City are gravel and are not included in this study. Paved lanes exist behind 1st and 2nd Avenues around the downtown core as well as some within the business areas in the annex. The paved lanes are included in the study. Gravel lanes; however, are used to asses risk based on utilities that lie beneath them. This criterion is described in more detail in the preceding sections related to utility framework.

Refer Figure 5.22 to for a graphical representation of the roads' framework, further detail can then be found in the text following.

The following outlines the criteria for condition and risk ratings used to arrive at the final prioritization score shown in Figure 5.23.

Road Rating Process

Condition Rating Process

Road type filter (Is the road a gravel lane?)

Yes → Exclude from process

No → Was the road provided a condition rating during the Road Condition Assessment (RCA)?

Yes → Degrade RCA Score to Current Year

No → Proxy Score based on Age / Service Lift

= Condition Score

Risk Rating Process

Road type filter (Is the road a gravel lane?)

Yes → Exclude from process

No → Determine Road Classification and return Class-Score

Road Classification	Score
Paved Lane / Access Road	1
Local	2
Collector	3

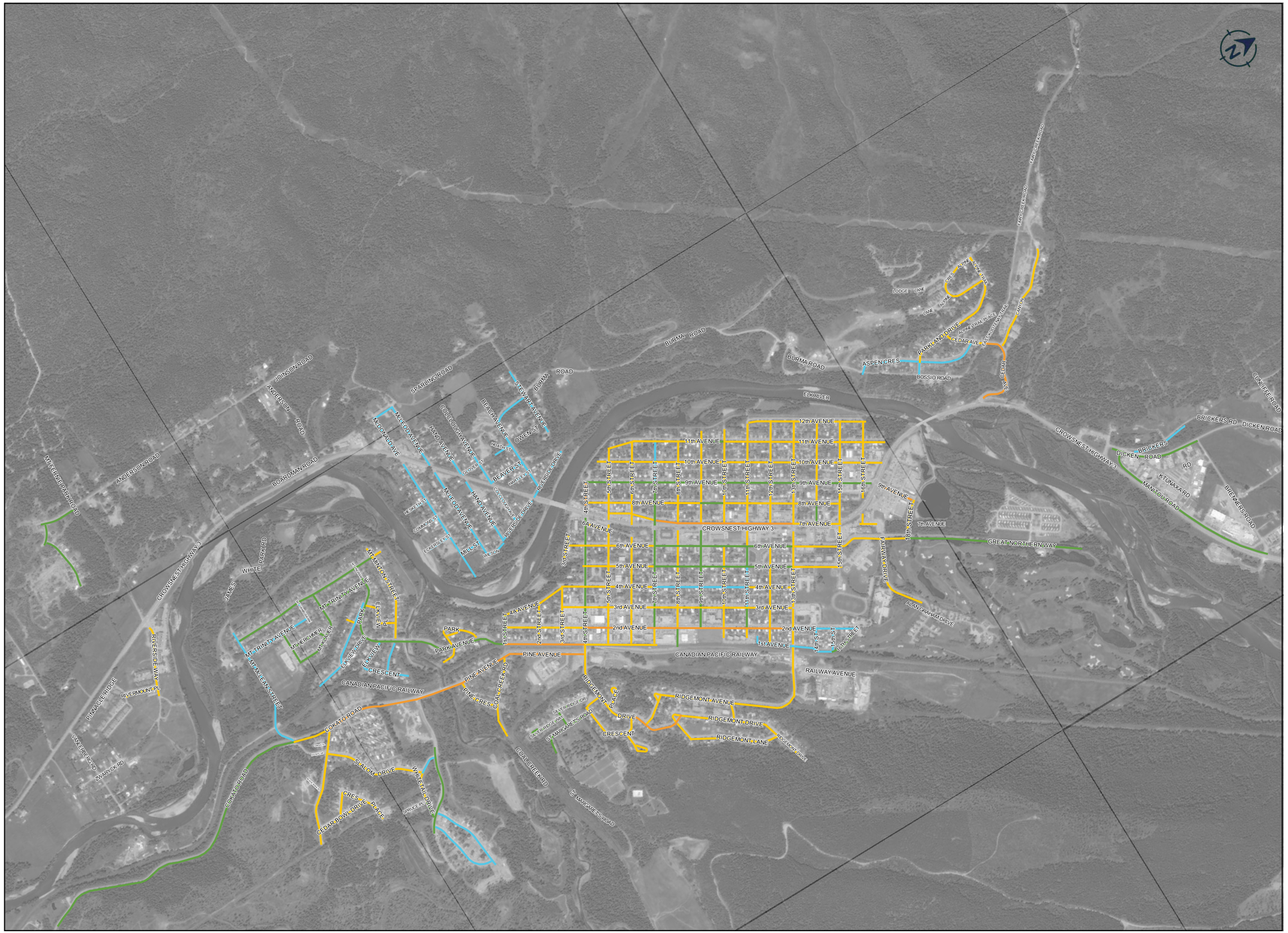
\+ Determine OCP Designation and modify score by +1 where roads are within Schedule E OCP boundaries descriptions:

- Business Access Street
- Downtown Gateway Street
- Historic Main Street

= Risk Score

Priority Rating Matrix

Condition \ Risk	1	2	3	4	5
1	1	1	2	2	3
2	1	2	2	3	3
3	2	2	3	4	4
4	2	3	4	5	5
5	3	3	4	5	5



LEGEND

ROADS-Priority

- 1 Very Low
- 2 Low
- 3 Moderate
- 4 High

Bing Satellite

Fernie IICP

Road Network

IICP Priority Rating

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

Figure 5.23

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ISL FERNIE
CITY OF FERNIE
BRITISH COLUMBIA

Condition

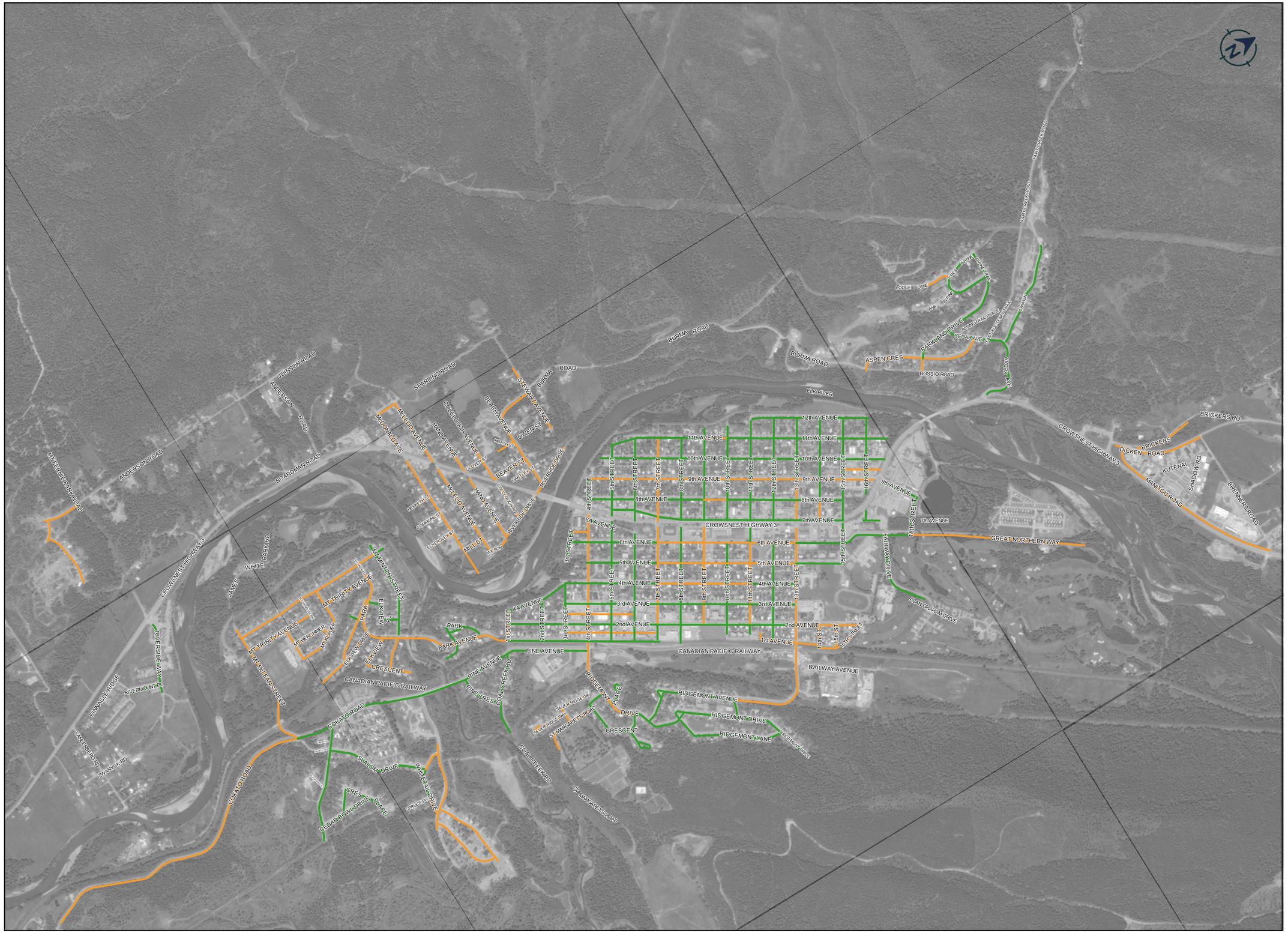
The majority of roadway conditions were determined through a 2007 EBA Pavement Condition Assessment Report. Within this report, conditions were categorized between 1 and 5 where 5 represents a good condition and 1 represents a poor condition. To convert the 2007 condition data to 2020 conditions, a roadway life span of 25 years was agreed on and a linear degradation was applied to the data (i.e. every 5 years it drops 1 condition point) rounding up to the nearest integer for example 2.2 = 3 and 2.6 = 3).

Where the EBA study did not include a specific road or the road was upgraded since 2007, age is used as a proxy assuming the same 25-year standard roadway lifespan and assuming at the time of construction that they would have received a 5.

In order to be consistent with the other decision criteria matrices in this report, the road condition scores are inverted (i.e. 1 becomes 5, 2 becomes 4, and 3 remains 3).

Figure 5.24 shows the road network based on method used to determine condition either the EBA 2007 Report or Age as a proxy. Figure 5.25 shows the conditions that the above criteria provide each road within the City network.

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LEGEND

ROADS_C_Method

- EBA (2007) Report
- Age as Proxy

Bing Satellite

Fernie IICP

Road Network

IICP Condition Rating Method

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

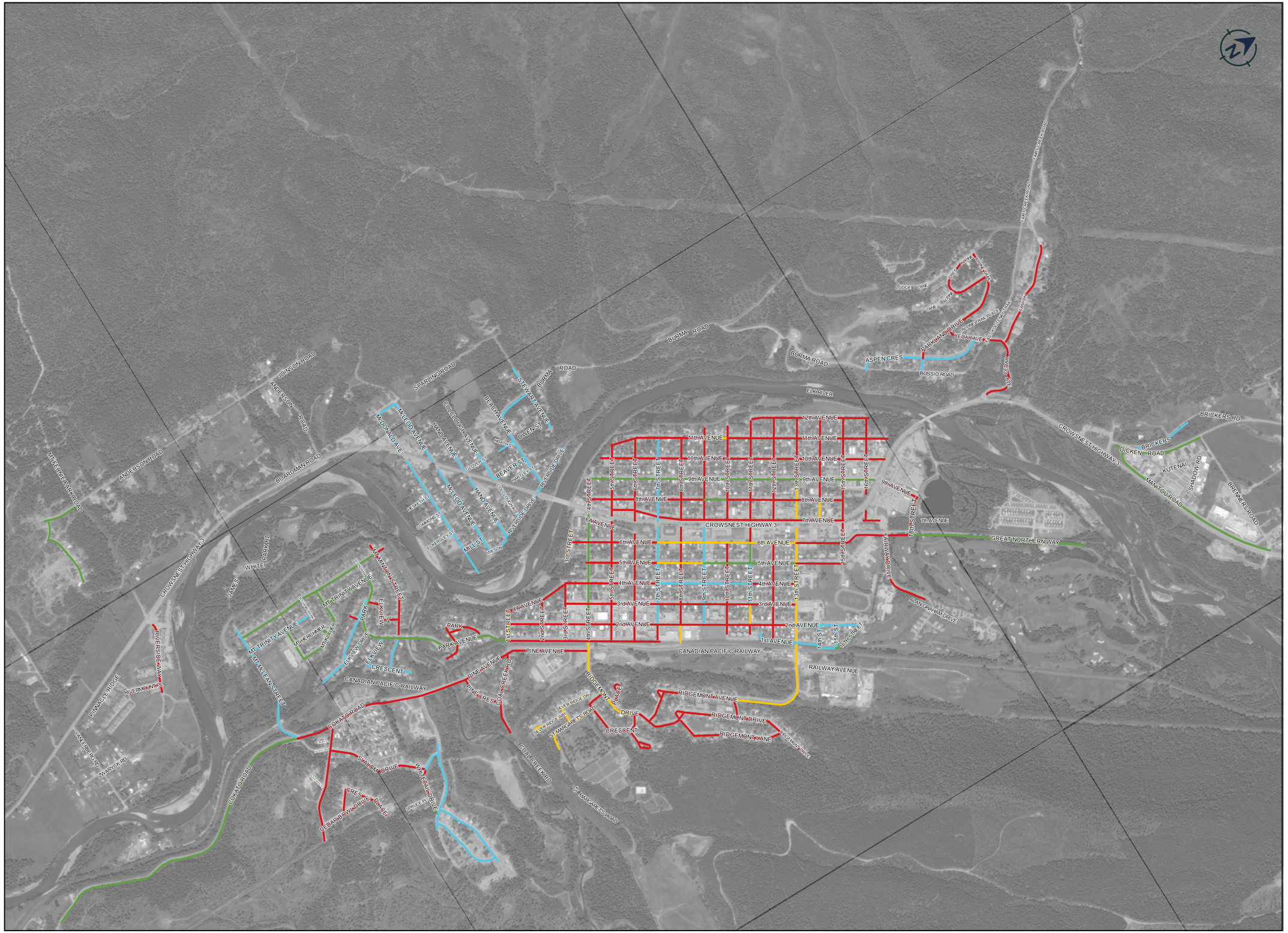
Figure 5.24

Service Layer Credits: The City of Fernie

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0 300 600 900 1200 m

ISL FERNIE
CITY OF FERNIE
BRITISH COLUMBIA



LEGEND

ROADS_Condition

- 1 Good
- 2 Fair
- 3 Satisfactory
- 4 Poor
- 5 Very Poor

Bing Satellite

Fernie IICP

Road Network

IICP Condition Rating

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

Figure 5.25

ISL FERNIE
CITY OF FERNIE
BRITISH COLUMBIA

Service Layer Credits: The City of Fernie

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Risk

The risk of a particular roadway is derived from the roadway classification shown in the following table.

Table 5.15 Road Risk Classification

Roadway Classification	Risk Score
Paved Lane	1
Local Road	2
Collector Road	3

A modification factor of 1 is added to the above based on roads that are within OCP Schedule E.

The City's OCP Schedule E identifies streets by community importance.

- Historic Main Street (2nd Ave from 3rd – 10th St.).
- Downtown Gateway Streets (9th & 4th St. Hwy#3 – 2nd Ave).
- Business Access Streets.

Figure 5.26 shows the roadways that fall within of OCP Schedule E. Figure 5.27 shows the risk rating applied to each roadway within the network.

The City is currently in the process of creating an integrated transportation master plan (ITMP) that would include a revised roadway classification or refinement and possibly changes to the current classification list. Following the completion of the ITMP, the roadway classifications used in this framework should be updated to verify or revise the short-term capital planning list.

Upgrade Warrants

All roadways with a prioritization score of a 4 based on this framework should be considered for timely replacement or rehabilitation. Refer to section 6.0 for a holistic review of short-term recommended projects. The data used to create the roadway prioritization was either based off a pavement evaluation completed in 2007 or through a liner degradation assumption of a 25-year roadway lifespan. It is recommended that an updated pavement condition analysis be completed prior to finalizing any capital planning based on the data used.

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Service Layer Credits: The City of Fernie

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LEGEND

ROADS_Shedule-E

- Business Access Streets
- Downtown Gateway Streets
- Historic Main Street

Bing Satellite

Fernie IICP

Road Network
OCP Schedule E
'Transportation Network'

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

Figure 5.26

ISL FERNIE
CITY OF FERNIE
BRITISH COLUMBIA

LEGEND

ROADS_Risk

- 2 Low
- 3 Moderate
- 4 Considerable

Bing Satellite

Fernie IICP

Road Network

IICP Risk Rating

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

Figure 5.27

CITY OF FERNIE
BRITISH COLUMBIA

Service Layer Credits: The City of Fernie

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6.0 Utility/Roadway Replacement Capital Planning

There is often benefit completing capital projects that are within the same vicinity. For example, if a utility is replaced, it is practical to repair the roadway that is near that utility. When choosing warranted utilities to be repaired, understanding the roadway condition should also makeup part of that decision-making process.

6.1 Short-Term Replacement Plan

Both prioritization scores of 4 and 5 are generalized in section 5.0, requiring the City to investigate replacement or repair strategies either in the very near future or immediately. Figure 6.1 following page 40 shows all roadways and utilities within the City's network that receive either a 4 or 5 as their prioritization score from the decision-making framework outlined in Section 5.0. These assets are then further grouped based on locality and Class 'D' construction costs to prepare a short-term project list.

Through local understanding and practical field validation, some of the utilities or roadway segments within this list are excluded from the short-term projects. These include the following:

7TH STREET WATERMAIN AT 8TH AND 9TH AVENUE

This roadway was redone in 2018, and both watermain segments were determined to not require replacement and are operating with no known issues. The very poor condition given to both mains in the decision-making framework is due to the age of the main (install year 1925). Given that the roadway above these mains is very new, monitoring of the watermain should continue with an upgrade planed when the road is rehabilitated in the future.

9TH AVENUE (HWY 3 – 18TH STREET)

This roadway anecdotally is in relatively good condition and can be monitored closely by the City crews. Should conditions change, this roadway could be incorporated into an annual program.

4TH STREET WATERMAIN (3RD AVENUE – 4TH AVENUE)

Watermain is at a higher risk due to its locality under a collector road and falling within OCP M. Since there are no known issues, it is recommended to re-asses this segment at the time that 4th Street is rehabilitated.

2ND AVENUE STORM SEWER (4TH STREET – 7TH STREET)

All storm sewer projects should be re-evaluated following calibration of the stormwater model. Any storm improvements should coincide with roadway rehabilitation. Roadway cross sectional changes may be recommended along 2nd Avenue in the Integrated Transportation Plan (ITMP) scheduled for completion in 2021.

PINE AVENUE (COKATO ROAD – RIDGEMONT DRIVE)

This roadway anecdotally is in relatively good condition and can be monitored closely by the City crews. Should conditions change, this roadway could be incorporated into an annual program.

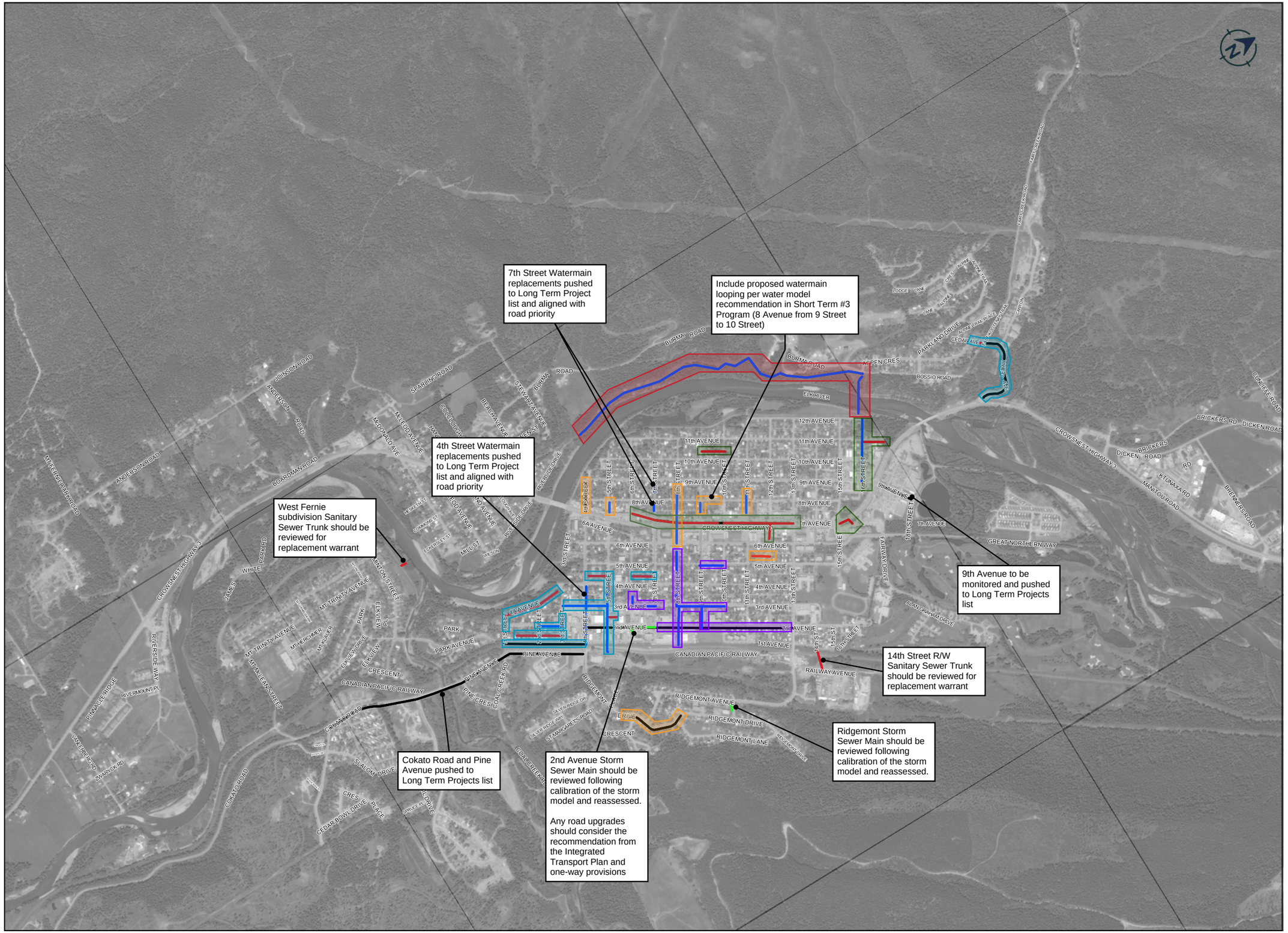
RIDGEMONT STORM MAIN

All storm sewer projects should be re-evaluated following calibration of the stormwater model.

14TH STREET R/W SANITARY SEWER

A higher risk is associated with this main due to the rail crossing and a poor condition score to prioritize this main. The CCTV for this main should be reviewed to confirm condition and requirement for incorporating in a short-term rehabilitation project.

The table below outlines the short-term capital programs derived from the framework described in Section 5.0 and Class ‘D’ & ‘C’; Costs. Detailed Class ‘C’ cost estimates of these projects are included in Appendix E.



LEGEND

WATER-Priority4-5
- 4 High
- 5 Very High

Sanitary-Priority4-5
- 4 High
- 5 Very High

STORM- Priority4-5
- 4 High

ROADS_Priority4-5
- 4 High

Bing Satellite

Short Term Capital Programs
- Short Term Capital Program #1
- Short Term Capital Program #2
- Short Term Capital Program #3
- Short Term Capital Program #4
- Short Term Capital Program #5

Fernie IICP

Road Network & Utilities

IICP 5 Year Priority Infrastructure

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

Figure 6.1

ISL FERNIE
CITY OF FERNIE
BRITISH COLUMBIA

Table 6.1 Short-Term Project List

Short Term Program #	Description	Class 'D' Costs	Class 'C' Cost
1	**Sanitary Main and Road replacement** 7th Avenue (6th Street – 13th Street) **Sanitary replacements** in the 10th Avenue Lane (9th – 10th Street), Hwy #3 at 15th Street and 11th Avenue from 16th Street to Hwy #3. **Watermain Replacements** 16th Street (9th – 12th Ave.)	**$2,638,000**	**$2,738,000**
2	**Road Rehabilitation** Cedar Ave. Including **Sanitary replacement** on Cedar Ave (Aspen Cres. – East Kootenay Trail) **Road Rehabilitation** Park Avenue (1st – 4th St.) **Watermain Replacement** 5th Street (CPR – 4th Ave), 3rd Ave (3rd – 5th St), 2nd Ave (2nd – 3rd St.). **Sanitary Replacement** 2nd Ave. Lane (1st - 3rd St), 1st St. to 4A Ave., 4th avenue lane (4th – 6th ^& 6 – 7th St.)	**$2,888,000**	**$3,419,000**
3	**Road rehabilitation** 4th Street (Hwy#3 - 9th Ave), Ridgemont Dr. (Ridgemont Cres. – Ridgemont Pl.) **Watermain replacement** 5th Street (Hwy #3 – 8th Ave), 8th Street (6th Ave – 9th Ave), 9th Street (7th – 8th Ave.), 11th Street (7th – 9th Ave.) **Sanitary Replacement** 5th Ave. Lane (11th – 12th St), 12th Street (3rd – 4th Ave Lane).	**$1,226,000**	**$1,357,000**
4	C&L ROW (including River Crossing) **Watermain**	**$2,824,000**	**$4,259,000**
5	**Roadway Rehabilitation** 2nd Ave. (7th St – 13th St.) **Watermain Replacement** 3rd Ave. (6th – 7th St., 8th - 10th St.), 6th St. (3rd – 4th Ave.), 8th St. (CPR – 6th Ave.), 9th St. (2nd – 3rd Ave.), 5th Ave. (9th – 10th St.).	**$2,436,000**	**$2,369,000**
Total		**$12,012,000**	**$14,142,000**

The Class 'C' cost estimates compare well with the Class 'D' or lineal rate estimates with the obvious outlier of program #4. ISL has reviewed the C&L ROW project and notes that this particular rehabilitation/replacement project does not 'fit' a typical municipal lineal unit rate due to its locality and importance to the water distribution network in the City. We have input a cost estimate based on our previous desktop analysis of rehabilitation and replacement options to provide a more refined estimate to the above table.

6.2 Long-Term Projects

We set the clock forward to 2040 (i.e. 20 years ahead) to determine proactively those assets, which are prioritized in the IICP rating processes. While the short-term projects are determined in retrospect to play catch up with deteriorated high-risk assets, the long-term planning is best done by setting budgeting goals based on the lifecycle of assets. This is discussed in more detail in the following section.

The long-term project list devised through the IICP rating process verifies the trajectory of capital planning on a longer term. It is worthwhile noting that this long-term project list is deterministic in nature and only identifies assets that are likely to be in poor condition and pose higher level of risk to the City and community as a whole.

- **This does not mean that the City should limit spending to only these assets identified as high priority but rather that these particular assets should be at the forefront of planning.**

For instance, there may be a vast number of roads that are in poor condition (i.e. a condition rating of '5') in 2040 that can be left as is without significant risk or disruption to the operation of the City that will not be identified in this IICP framework. Maintenance or replacement of these types of assets should still be reviewed continuously as budgeting allows and should be planned holistically with other upgrades.

In an effort to bring to bring to the forefront those assets which are expected to meet the criteria for a priority rating of 4 or 5 by the year 2040, we have prepared a long-term project list with corresponding estimates.

Refer to Appendix F for long Term Projects List and Estimates.

6.3 Funding of Capital Projects

Developing a short and long term project list lays the groundwork for funding requirements. However, infrastructure funding can be challenging because funds are finite. Without adequate justification and therefore adequate funding, projects may remain on the sideline indefinitely. By prioritizing projects based on the framework described in this report the justification for funding is more tangible and defendable. Funding should be allocated based on the AMIP recommendations and capital projects based on the priorities determined within the IICP, with a schedule that is consistent with the future financial plan requirements.

Short-Term Funding

ISL reviewed the AALCI & AAI Scenario 2 capital funding budgets to compare how the above short term program aligned. The AALCI and AAI values listed include facilities and components beyond what is calculated for project costs in the IICP short term project lists such as retaining walls, street lights, traffic signals and pedestrian pathways for roads or facilities (pump stations, booster stations, treatment facilities) related to the lineal infrastructure. Following completion of the Facilities Master Plan it is recommended to update the short term project list to create a more accurate comparison of capital projects to the AMIP. Table 6.2 below shows the comparison between the AMIP, AALCI and AAI to the IICP short term projects:

Table 6.2 Short Term Funding and IICP Project Comparison

Asset Category	AALCI X5	AAI X5	IICP Short Term Projects Total
Roads	$6,120,000	$4,850,000	$2,613,021
Storm	$1,425,000	$215,000	$ -
Water	$3,110,000*	$1,985,000*	$8,276,179
Waste water	$2,300,000**	$2,015,000**	$3,252,408
Total	**$12,995,000**	**$9,065,000**	**$14,141,608**

There is an approximate $1.15M deficit required to fund the IICP short term projects as devised through this study. More importantly, the balance of the various asset categories as they relate to funding streams are shown to be in surplus for roads and storm funds and in deficit for water and wastewater funds should the City maintain Scenario 2 funding regime as recommended in the recent AMIP report.

It is important to note; the proposed projects will exceed the current yearly funding allocated to the relevant infrastructure. To fund the short-term projects, the City may wish to distribute the projects or portions thereof across a longer timeframe than 5 years, in order to meet current spending levels. However, this would result in the loss of economies of scale related to larger capital projects and likely result in duplication of efforts, such as paving roadways for trench repairs.

If the City wanted to pursue the project list as presented there are several possible solutions, such as increasing funding levels for the next 5 years to match the required funds or investigate alternative funding. Examples of alternative funding would be utilizing existing reserve funds, borrowing or pursuing grant opportunities.

Long-Term Funding

Table 6.3 below summarizes the IICP long-term project recommendation and the AALCI budgeting.

Table 6.3 Long Term Funding and IICP Project Comparison

Asset Category	AALCI X20	AAI X20	IICP Long Term Projects Total	20-year Difference (AALCI)-IICP
Roads	$24,480,000	$19,400,000	$8,824,722	$15,655,278
Storm	$5,700,000	$860,000	$5,052,979	$647,021
Water	$12,440,000*	$7,940,000*	$7,003,010	$5,436,990
Waste water	$9,200,000**	$8,060,000**	$4,370,956	$4,829,044
Total	**$51,820,000**	**$36,260,000**	**$25,251,667**	**$26,568,333**

AALCI: Average Annual Life Cycle Investment
AAI: Average Annual Investment (over 20-year period used in AMIP)
**Water projects AALCI and AAI include Facilities in the above table and IICP projects do not.*
***Sanitary projects AALCI and AAI include lifts stations and treatment values in the above table and IICP projects do not.*

- **It is important to understand that projects related to capacity of infrastructure due to population growth should be funded through development contributions and not Capital budgets.**

6.4 Results and Discussion

The IICP projects lists short term (1-5 years) and medium/long term (6-20 years) based on the framework discussed in this report highlight the High and Very High Priority projects that should be replaced or rehabilitated based on their condition and risk to the City. The 5-year projects indicate work that needs to be done to "catch up" and are reactive in nature, the medium/long term projects if planned appropriately would be proactive in maintaining the infrastructure within the City. It is recommended that at a minimum in 5 years' time that a revised 5-year capital project list be generated in a similar manner to how it has been completed in this report, considering any updated information that is gathered over the next 5 years that may include:

- additional information on utility breaks;
- information on increased maintenance (sanitary flushing for example);
- updated pavement assessments;
- new CCTV reports; and
- updating the GIS system as projects get completed and conditions change.

Based on this analysis, the current investment levels recommended by the AMIP are adequate to fund the 20-year prioritized upgrades. The intent would be to withdraw from reserves in years where prioritized upgrades are beyond the typical annual budget and replenish reserves in years where projects are below the annual budget. This can be seen clearly, as the 5-year prioritized projects exceed the typical funding amounts; however, over whole study period (20 years) the average funding is in surplus.

The above Table 6.3 shows the AMIP funding scenarios adopted by the City and compares this with the IICP Long term project list.

When planning capital projects the City should also consider cost related to ancillary items that are not included in the IICP estimates roadways for example including items such as sidewalks/pedestrian facilities, street lighting or retaining walls.

While the AMIP excluded West Fernie, it is important to understand that the assets in West Fernie are relatively new and in good condition and therefore do not show up on the IICP short- or long-term project lists. This allows the ability to compare the IICP 20-year plan with the AMIP 20-year AAI. This does not mean that the City does not need to start planning for asset replacement in West Fernie only that replacement of the West Fernie assets are beyond the 20-year horizon.

While this prioritized IICP project list shows a reduction in the need for the longer-term funding in all categories and as an aggregate comparted to the AMIP, the funding recommended in the AMIP should be maintained. The IICP list shows that in the next 20 years, the City may not need to replace as much of its infrastructure; however, as assets age and conditions degrade, the rate of renewal will inevitably increase. Setting aside adequate funding and replenishing reserves in this way is part of responsible asset management.

7.0 Facilities Review

7.1 Introduction

The City of Fernie's facilities make a significant contribution to the quality of life for residents. In recent years, however, the City has identified the need for a more comprehensive and long-term strategy to coordinate and manage its facilities. Although the City has a history of building and maintaining facilities that have increased the capacity to deliver services to residents and guests, there are indications of an increasing gap with the current and projected facilities conditions, capacities and risks.

To understand these gaps, the City has prioritized strategic facilities planning. While the City has done some work in recent years to understand the condition of their facilities, it has lacked a comprehensive facilities master plan. The following section helps identify the needs required to create a comprehensive facility masterplan. As part of this ongoing process, templates for remediation and improvement will be created and ultimately a capital investment program that supports the City's building assets.

With these elements in place, the City will be better able to maintain its publicly owned assets and deliver services citizens pay for and rely upon.

The objective of a facility masterplan is to provide a clearer understanding of how to determine which facilities should be replaced or divested from, and in what priority and ultimately determine if the facility is enhancing the quality of life for the City's residents.

The benefits of this Strategic Facilities Master Plan include the following:

- A renewed portfolio of facilities that address the service and safety needs of the City now and into the future.
- A reinforcement of the City's services mandate that enables the City to meet or exceed service delivery expectations.
- A road map that guides council and staff decisions relating to immediate and long-term capital investments in facility infrastructure.
- Strategies that complement and strengthen the City's approach to using public money prudently and efficiently
- Operational risks and emergency preparedness capacity are considered and well planned
- A baseline understanding for capital investment over the immediate and long-term that allows administration to realize goals effectively and prudently, supported by extensive due diligence.
- An increased capacity to respond to immediate external funding opportunities.

7.2 Background

The management of any asset includes the need for repairs due to physical deterioration, upgrades to meet changing performance and design criteria, and environmental demands. Components of mechanical systems wear out and can result in a decrease in environmental conditions in facilities. Windows and doors break down and no longer provide adequate security or comfort control. The increasing demand for existing and expanding services must be balanced with the need for additional staff to be placed into facilities where there is limited available space. These are normal issues for most property owners, and municipalities are no exception.

The City's portfolio of buildings and services is varied. As a result, strategic facilities management cannot focus on a single building. It must address the entire spectrum. The review of facilities will see departments competing for funds on a year-to-year basis, which can cause friction through a municipality. In the City's planning process, the goal should be to establish a baseline for our critical facilities and to provide some criteria behind the analysis. Ensuring that considerations are made with the "big picture" in mind, this can help user groups achieve consensus around decisions that are made.

7.3 Goals

The City's Strategic Facilities Master Plan should define a 20-year, long-term target of service delivery capacity. These services will be supported through affordable facilities that best mitigate risk. The City's current and anticipated ongoing service delivery areas include:

- Public Safety
- Parks and Public Works
- Recreation
- Government and Municipal Administration

To ensure that in the years to come the City's current delivered services are continuing to be delivered and where possible, improved in a manner that is financially affordable, environmentally sound and delivers best value for residents.

Goal 1: Addressing capacity: Minimize service delivery gaps, anticipate growth

How:

- A clear picture of current and anticipated service delivery gaps.
- Identification of services that are compromised by inadequate space, layout and physical condition.
- Due diligence through stakeholder consultation, use of past services data and long-term growth statistics that inform project planning.

Goal 2: Meet changing health and safety regulations

How:

- Review facilities periodically against current codes.

Goal 3: Identifying urgent needs and prioritizing facilities

How:

- Establish criteria for ranking.
- Provide an outline that responds to opportunities and changing circumstances and ensures flexible ordering of facility implementation.

Goal 4: Understanding building condition and the scope of work needed to reach acceptable levels

How:

- Detailed inventory of physical status of building components; lifecycle of components needing replacement, deterioration and repair of fixed elements (building envelope, structure, etc.).
- Analysis to ensure adherence to both building codes and industry operational standards and practices. In addition to establishing seismic capacity, industry standards for workplaces, equipment storage and handling will inform planning and repair strategies.

Goal 5: Including risk considerations in facilities planning that incorporate resilience capacity considerations and mitigate critical impacts

How:

- Facility capacity and design that addresses responsive and effective service delivery at post disaster/event situations. Risk analyses balance city-wide strategies with reasonable, cost-effective approaches.
- Identification of emergency and event preparedness capacities and plans to mitigate critical effects.
- Business continuity maintained as much as possible.

Goal 6: Achieving financial sustainability with facilities that are affordable to build, operate and maintain

How:

- Design and implementation of facilities reflects sound financial planning and anticipates maintenance and operations costs and requirements for the next 20 years and beyond.
- Established framework for project funding that is affordable and sustainable; that incorporates full lifecycle costs, considers environmental and social costs, which anticipate change.

Goal 7: Ability to modify and adapt in response to revenue generation opportunities

How:

- Create business cases for existing and future facilities and determine the cost benefit for each facility.

Goal 8: Aligning with supporting City mandates

How:

- Divisional operations' service plans, administrative strategic initiatives and objectives are supported and reinforced in decision for the service delivery.

7.4 Current Asset Management

The City currently has two reserve funds for facilities:

1. **General Reserve Fund** – $1,300,000 (current reserve in 2020)
2. **Courthouse Reserve Fund** – $350,000 (current reserve in 2020)

The reserve funds were created in 2019 and funding levels were determined by the AMIP. At present, the AMIP is the sole determining factor for funding levels and individual business cases have not been developed for individual facilities

External Funding Opportunities

Typically, there are external funding opportunities that are open to municipalities. These opportunities can help supplement capital-funding plans. However, typically to be successful with such opportunities, municipalities have to demonstrate they can finance a significant portion of the project.

Some examples of external funding sources include:

- Fortis and BC Hydro rebates.
- Community Energy Leadership Program (CELP).
- Federal and provincial energy saving initiatives.
- Building Canada funds.

7.5 Existing information

The storage of data can play an important role in understanding the current asset landscape of a municipality. Typically, reports/information are gathered on an as and when basis, i.e. a particular building or building component is identified to be replaced for one reason or another an assessment is commissioned. Once a report is generated and the recommendations acted upon, a report is typically seen to be obsolete and "shelved". Once shelved, the information is lost to most staff members. The reports can be an important part of gathering information about a building and understanding a comprehensive picture of the City, i.e. are there geo tech reports that identify potential difficult ground conditions that could cause an increase in building repair/construction?

7.6 Sustainability initiatives

The City has been pursuing a community sustainability initiative, which was adopted in 2011. A community plan exists and refers to what success will look like for the City by 2030.

By the year 2030,

1. New and upgraded municipal buildings demonstrate community leadership and are constructed or renovated to recognized standards for energy efficiency and environmental design.
2. New buildings and developments are sited in locations that minimize environmental impacts and are sited and oriented to maximize environmental benefits.
3. Stormwater and greywater from development sites is managed in a way that minimizes water consumption and impacts to the water table and surrounding watercourses.
4. There is minimal waste from construction and demolition activities.
5. Highway 3 is a community- and pedestrian-friendly corridor which is aesthetically pleasing and has a consistent and attractive architectural theme.
6. Residential and commercial buildings are high quality in design and construction using sustainable local building materials.
7. Buildings and sites are increasingly connected to community energy systems using low impact, renewable energy sources.



Photo: City of Fernie

8. Buildings are designed in a flexible way to accommodate potential current and future sustainability technologies.
9. Existing buildings have been upgraded to increase energy efficiency.

Reference to leisure and recreation

By the year 2030,

1. A wide range of recreation and leisure activities are accessible and available to those with varied interests, incomes and abilities.
2. A hut-to-hut trail system, easily accessed from Fernie, permits access to backcountry activities, such as skiing, hiking and biking.
3. Facilities are designed to be inclusive and multi-generational, providing interactions between people of all ages and abilities.
4. There is a range of education and training programs for sports and other outdoor activities and recreation and leisure is an integral part of education programs.
5. The Elk River and other local water bodies support a range of compatible and low impact recreation activities.



Photo: Joni Krats

6. A network of managed local and backcountry trails are available for use throughout the year that are safe, well maintained and appropriate for a range of abilities.
7. Fernie is known as a four season recreation destination that respects and exists within the limits of the natural environment.
8. A broad range of first class facilities are available for recreation and leisure.
9. Community Partners and the City support expanded recreation and leisure programs within the community.

It is important for the City to decide if it wants to adopt these initiatives into facility masterplan, as the requirements will have a direct impact on the scheduling of renovation and replacements. In addition to scheduling of projects, it is likely that the costs for capital projects will increase. This is based on feedback from industry regarding the construction of LEED certified buildings, and it is estimated that a typical LEED building can cost in the range of 10-30% more in capital costs. However, if designed correctly, the building should have smaller operating costs, which should be considered in a business case scenario.

7.7 Other considerations

- **What does the future hold for the City?**

  This is a very open-ended question, but it is something to consider when forming a master plan. Does the City have any strategic goals that would direct replacement of facilities or even remove facilities in the future?

- **What are the anticipated growth factors of Fernie?**

  The growth of the City is important, as additional residents will apply pressure to existing facilities capacity. Once capacity of a facility is reached, the level of service will start to decrease. In order to mitigate these drops in service, a municipality can plan to add capacity to an existing facility or provide additional facilities to cope with the increase in demand. There are many ways to try and determine growth factors, such as extrapolating out zoning plans, or apply the past to the presence, i.e. predict growth factors based on previous growth?

- **What levels of service does the City want to provide in the future?**

  These factors will take many meetings, public outreach and council decisions. However, this information will be critical in determining the investment level needed for the future.

7.8 Measuring facilities

The development of the Strategic Facilities Master Plan involves collecting and analyzing a variety of facilities data. This will support well-informed decisions that will be implemented over the next 20 years and longer. This process follows the well-tested path of understanding capacity, condition and risk. In addition to the data requirement for building condition, seismic resilience and code compliance, we must look at the data associated with the need for effective service delivery. This is fundamental to planning for a facility's repair, renovation and replacement, as service delivery is their main function. The approach to reviewing Fernie's facilities focuses on three factors:

1. Facility capacity
2. Building condition
3. Risk to services

These factors directly support the program goals of ensuring service delivery, affordable implementation and reducing risk.

7.8.1 Facility Capacity

Service delivery capacity

Once a facilities' capacity is reached and exceeded, the ability of staff to deliver services becomes more difficult. Space may become more constricted, forcing staff to work with inadequate space. The spaces to store equipment may be full. If new programs are demanded, there may be no space to accommodate staff, or in the case of the recreation centres, additional public guests. Being responsive to service demands becomes increasingly difficult, and services may be cut or put on hold.

Determining the capacity of a facility is a little subjective, as there is rarely a formula that provides a facility's capacity. However, some facilities such as recreation centres collect the applications to programs and therefore have some empirical data to determine if the program is over subscribed. Other methods to determine capacity can be based on industry standards, such as number of employees per square floor area.

To help determine the facility capacity, we would recommend a breakdown of a facility into four areas, including public, staff, program, and support.

Public

Does the facility meet the public's services level? An example would be: does the library provide adequate book selection and space for the public to enjoy the experience?

Staff

Do the facilities have enough space available to house the required compliment of staff?

Hypothetical Example

The growth of the City and additional documentation requirements by the province have necessitated the need for additional staff members, to keep up with the day-to-day requirements. The City hall was constructed for 20 staff, but now houses 35. The conditions have become crowded and are causing problems with staff happiness and retention.

Programs

Is the facility able to provide the number of spaces for the public demand and are the facilities providing the right level of service?

Hypothetical Example

The City currently has only one sheet of ice that is used for hockey. There has been an increase in the number of bookings for ice time and the facility is currently operating at above capacity by having the facility open for 20 hours a day. To accommodate youth teams, the City has provided block booking for 7 a.m. or 9 p.m. Neither are ideal for the age group.

Support

Support for a facility would be items that help with delivering a service, such as civil infrastructure, parking etc.

7.8.2 Building Condition

Several factors help determine the building condition. It should not just be the physical condition that determines this factor. The following are good indicators for this section.

Physical Condition

Deficient buildings impact staff productivity — this includes facilities with leaky roofs or those that require significant investment for new mechanical systems. It can also affect personal and corporate safety as staff work to manage these deficiencies.

To help standardize the ratings for buildings, we recommend a method called “Facility Condition Index (FCI)”.

- FCI = Value of maintenance, Repair (M&R)/Replacement Value (RV).

The lower the score the better. Typically, once a value of 0.6 or above is achieved, a facility should be considered for replacement

Conformance to standards

Conformance to standards should be considered when determining the “value” of a building. As they establish minimum requirements for a variety of areas in a building. Some maybe considered more important than others, such as Seismic code requirements, versus current energy code requirements. Both can be considered important; however, one is regarding life safety and other is regarding energy conservation. The City would have to determine which is more important to resolve and prioritize.

Environments

Many departments typically live with less than desirable work conditions. It is important to determine if they have reached the point where the potential negative impacts have become too significant. For example, a poor environment from inadequate HVAC system can include increased sick days, low morale or employee retention challenges.

Site and physical constraints

An existing site layout or size might not afford optimal outcomes. Sites that are small, poorly located could delay or alter a project go-ahead. Another issue for the City to consider is whether the infrastructure/building is located on private property.

Value for money, time and effort

When reviewing potential redevelopment projects, some clearly require less time, fewer stakeholders and less capital investment than others do. However, do these projects have commensurately less impact than larger projects? Alternatively, will the service delivery benefits be significant enough to suggest that faster results and less capital investment should be considered in decision-making?

Building Condition

The City has previously initiated a building review for its facilities. However, the reviews are quite varied, and it's made it difficult to manage the data and rank facilities. Using the information available within the existing Facilities Master Plan a sample ranking system is provided in section 7.10; however, we would recommend a standardized table that is applied to all facilities, with a simple traffic light system be applied, so that each facility can be benched marked equally against each other.

Having reviewed the existing FMP B+H facilities condition report, we recommend the following breakdown for future investigations:

Table 7.1 Breakdown for future investigations

Component	Green	Orange	Red
Interior Finish			
Wall/ceiling			
Flooring			
Fixtures			
Building Envelope			
Siding			
Penetrations			
Roofing			
Mechanical			
External (drains/irrigation)			
Mechanical system			
Mechanical distribution			
Electrical			
Lighting			
Fire system			
Controls			
Electrical distribution			

7.8.3 Risk to Services

Risks

While we cannot eliminate risk, mitigation strategies are essential. For example, though seismic capacity is a concern, ensuring most buildings reach 100% capacity would require significant structural design and great expense. As a result, it is important to establish what level of risk we are willing to accept. In terms of business continuity, is the City prepared for a major or extended weather event? It is important that emergency, front-line delivery agencies – police, fire and public works – be housed in highly resilient facilities. This ensures residents have access to essential services even in the worst circumstances.

In almost any emergency, one or all three divisions of police (patrol), fire (suppression) and public works (road and underground crews) are likely to be called upon. In these circumstances, the protection and safeguarding of life and public safety is the highest priority.

The risk allocations and decisions should tie back to the City's emergency response plan, as it forms the back bone to a response during an emergency. An example of this could be, the City's rec centre is to be used as an Emergency Operation Centre (EoC) during a flood event caused by freshet; however, the sites drainage has failed, and the residents cannot reach the facility. The following figure is taken from the City of Fernie Emergency Response Plan and is an example of how Risk to Services can be prioritized. This example matrix has not been implemented in the sample prioritization framework in section 7.10.

		Consequence			
		Very Low	Low	High	Very High
Likelihood	Frequent or Very Likely				
	Moderate or Likely		• Structural fire • Infrastructure damage due to wind • Flash flooding		
	Occasional or Slight Chance	• Animal attack	• Pipeline explosion • Extended power outage • Extended road closure	• Human pandemic • Hazardous materials release - road	• Freshet flooding / debris flow
	Unlikely or Improbable		• Structural collapse • Hazardous materials release – point source	• Landslide or subsidence	• Interface wildfire • Hazardous materials release - rail
	Highly Unlikely, a Rare Event		• Air crash • Dam failure at Fairy Creek	• Avalanche • Water supply disruption • Train derailment	
	Very Rare Event			• Water contamination	• Earthquake

Low	Acceptable risk: Additional risk treatment not likely required
Moderate	Potentially unacceptable risk: Some risk treatment may be required to reduce risks to lower levels
High	Unacceptable risk: High priority risk treatment measures required
Very high	Unacceptable risk: Immediate risk treatment required

Figure 7.1 Extract from CoF Emergency Response Plan

7.9 Ranking Facilities

To standardize the ranking for each facility, we recommend the following same traffic signal warning system, green, amber and red for the three components:

1. Facility capacity
2. Facility condition
3. Facility risks

The warning system works well as a visual aid and describes why a facility is ranked within the system.

7.10 Sample Facility Prioritization Framework

As an example, a Facilities Prioritization Framework was developed and tested for facilities. It is understood that once the above recommendations are implemented and the data is available, the City would incorporate them into a more advanced framework to better budget for facilities in the short and long term. Similar to the linear infrastructure and roadways, this prioritization framework was developed to rate facilities based on their relative condition and risk to prioritize further investigation and rehabilitation. The following outlines the framework developed for facility prioritization.

The Facilities Master Plan (FMP) was primarily used to determine conditions based on the 6-scale condition rating within the FMP. These condition ratings are simplified to a 3-level rating scale to help simplify any future use with facility condition ratings and align with the above condition recommendations.

Risk used in this sample based on the primary use category of the facility and converted to 1 -5 score the primary use categories are described in more detail below.

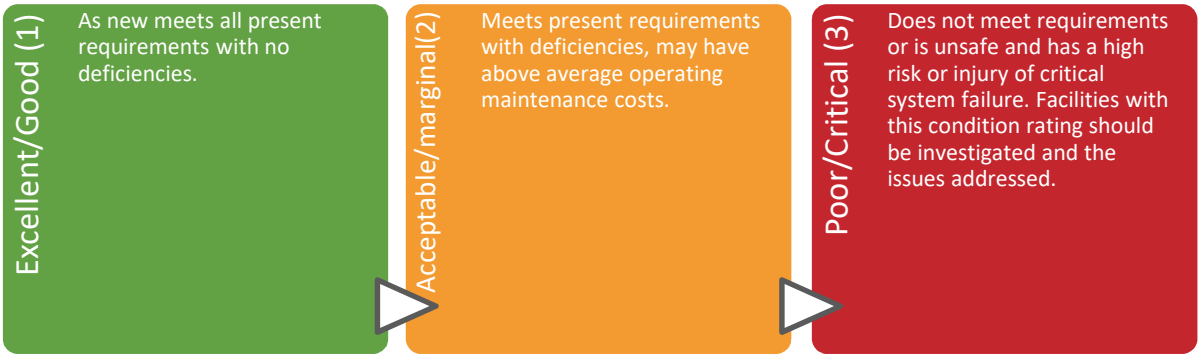
A condition and risk rating are run through the matrix shown in Table 7.2 to arrive at a prioritization score between 1-3.

Table 7.2 Facility Condition Risk Matrix (Prioritization Score)

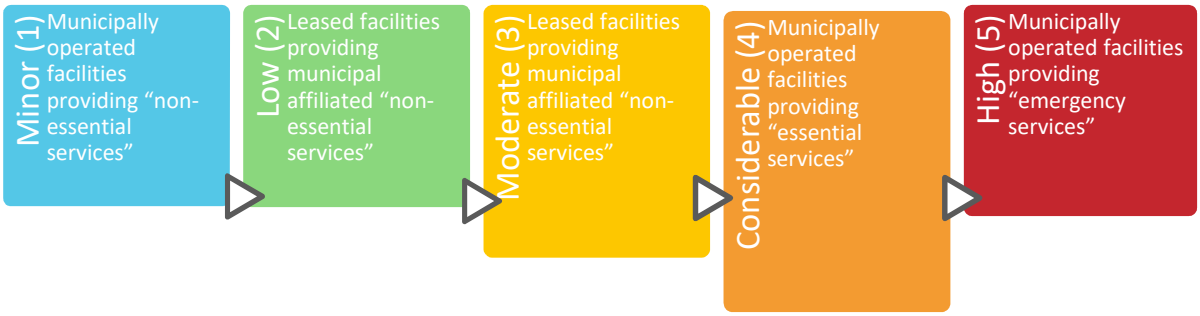
Facility Condition-Risk Matrix Simplified			
Condition/Risk	1	2	3
1	1	1	2
2	1	2	2
3	2	2	3
4	2	3	3
5	2	3	3

A general description of the rating system scores is provided below.

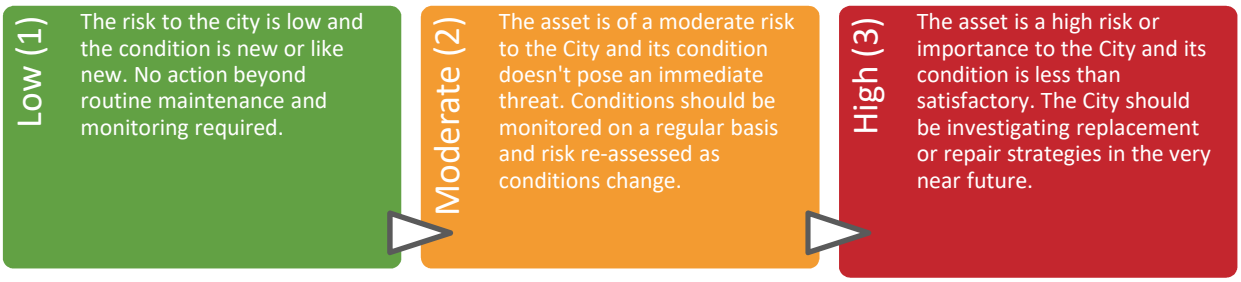
CONDITION



RISK



PRIORITIZATION SCORE



The following describes how condition and risk were determined for each facility. For further detail and an example condition calculation refer to Appendix G.

Condition

Condition ratings are derived from the following 6-scale condition scores used in the FMP:

1. **Critical –** Unsafe, high risk or injury of critical system failure.
2. **Poor** – Does not meet requirements, has significant deficiencies. May have high operating/maintenance costs.
3. **Marginal** – Meets minimum requirements, has significant deficiencies. May have above average operating maintenance costs.
4. **Acceptable** – Meets present requirements, minor deficiencies. Average operating/maintenance costs.
5. **Good** – Meets all present requirements. No deficiencies.
6. **Excellent** – As new/state of the art, meets present and foreseeable requirements.

For consistency with the rest of the IICP where a lower value represents a lower priority, the condition values above are inverted (i.e. 1 becomes 6, 2 becomes 5, 3 Becomes 4). These scores are then combined to create the following simplified condition score (1: Green, 2: Amber, 3: Red) used for facilities.

In order to determine an overall condition score, specific component's condition scores were first derived for the following categories within the FMP:

1. Structural/Architectural
2. HVAC
3. Plumbing
4. Process Plumbing*
5. Electrical

**Not all facilities contain process plumbing and therefore this building component is not included for all facilities.*

The total facility condition was determined using an average of available component conditions listed above. In any case, an individual component has a condition score of 3 the overall facility is given a 3, this is to highlight to decision makers that a particular facility has a component that is in a poor or critical state and requires attention.

Table 7.3 shows conditions of each facility component and the average condition used to determine the prioritization score described above. Facilities with no conditions are not included and a 0 represents no data for that specific component. In the case of determining an average condition, any 0s are excluded from the calculation.

Table 7.3 Facility Component Condition scores (Derived from FMP)

		Facility Component Conditions					
Asset ID	Facility Name	Architectural	HVAC	Plumbing	Process Plumbing	Electrical	Average Condition
B027	Fairy Creek Electrical Building	3	0	0	0	2	3
B011	Curling Club	3	1	1	0	2	3
B003	Fire and Rescue Hall	2	1	1	0	1	2
B031	Alpine Trails Booster Station	0	1	0	1	2	2
B032	Canyon Trail Lift Station	0	1	0	1	2	2
B025	Main Sewage Pump Station	0	1	0	1	2	2
B036	Riverside Lift Station	0	0	0	0	2	2
B024	Court House	1	1	1	0	2	2
B009	Max Turyk Community Facility	2	2	1	0	1	2
B021	Arts Station	1	1	1	0	2	2
B002	Heritage Library	2	1	1	0	1	2
B020	Senior Citizen's Centre	2	1	1	0	2	2
B022	Chamber of Commerce	2	1	2	0	2	2
B012	Signs and Event Storage	1	1	1	0	2	2
B015	Commodities Shop	0	1	0	0	2	2
B039	Dog Pound	0	2	2	0	2	2
B023	Aquatic Centre	1	1	1	0	2	2
B005	Centennial Community Centre	2	1	1	0	2	2
B004	Memorial Arena	2	1	0	0	2	2
B010	Rotary Park Gazebos	0	1	1	0	2	2
B007	Prentice Park Washrooms and Concession	0	2	2	0	2	2
B001	City Hall	1	1	1	0	0	1
B035	Ghostrider Lift Station	0	1	0	1	1	1
B033	Fairy Creek Chlorine and Control Room (and Old Wet Well) Building	0	1	0	1	1	1

		Facility Component Conditions					
Asset ID	Facility Name	Architectural	HVAC	Plumbing	Process Plumbing	Electrical	Average Condition
B029	10th Avenue Lift Station	0	1	0	1	1	1
B030	Parkland PRV Station	0	1	0	0	1	1
B034	Fairy Creek Reservoir	0	1	0	0	0	1
B045	1st Street PRV Station	0	1	0	0	1	1

Risk

The risk associated with each facility is based on the primary use category listed within the City's GIS database, listed below for convenience.

- Municipally operated facilities providing "emergency services"
- Municipally operated facilities providing "Essential Services"
- Leased facilities providing non-municipal "essential services"
- Leased facilities providing municipal affiliated "non-essential services"
- Municipally operated facilities providing "non-essential services"

Prioritization

The following Table 7.4 shows the condition, risk, and overall prioritization rating assigned to each facility based on the sample framework described. Figure 7.2, Figure 7.3 and Figure 7.4 following page 62 replicate this data geographically.

Table 7.4 Total Facility Condition, Risk and Prioritization Score

Asset ID	Facility Name	Average Condition	Primary Use Category/Risk	Prioritization Score
B003	Fire and Rescue Hall	2	5	3
B031	Alpine Trails Booster Station	2	4	3
B032	Canyon Trail Lift Station	2	4	3
B027	Fairy Creek Electrical Building	3	4	3
B025	Main Sewage Pump Station	2	4	3
B036	Riverside Lift Station	2	4	3
B011	Curling Club	3	2	2
B024	Court House	2	3	2
B009	Max Turyk Community Facility	2	3	2
B001	City Hall	1	4	2
B035	Ghostrider Lift Station	1	4	2
B033	Fairy Creek Chlorine and Control Room (and Old Wet Well) Building	1	4	2
B029	10th Avenue Lift Station	1	4	2
B030	Parkland PRV Station	1	4	2

Asset ID	Facility Name	Average Condition	Primary Use Category/Risk	Prioritization Score
B034	Fairy Creek Reservoir	1	4	2
B045	1st Street PRV Station	1	4	2
B021	Arts Station	2	2	2
B002	Heritage Library	2	2	2
B020	Senior Citizen's Centre	2	2	2
B022	Chamber of Commerce	2	2	2
B012	Signs and Event Storage	2	1	1
B015	Commodities Shop	2	1	1
B039	Dog Pound	2	1	1
B023	Aquatic Centre	2	1	1
B005	Centennial Community Centre	2	1	1
B004	Memorial Arena	2	1	1
B010	Rotary Park Gazebos	2	1	1
B007	Prentice Park Washrooms and Concession	2	1	1

The following table identifies facilities that were either not included in this study or where a condition rating was not given in the FMP.

Table 7.5 Facilities with no Condition Rating

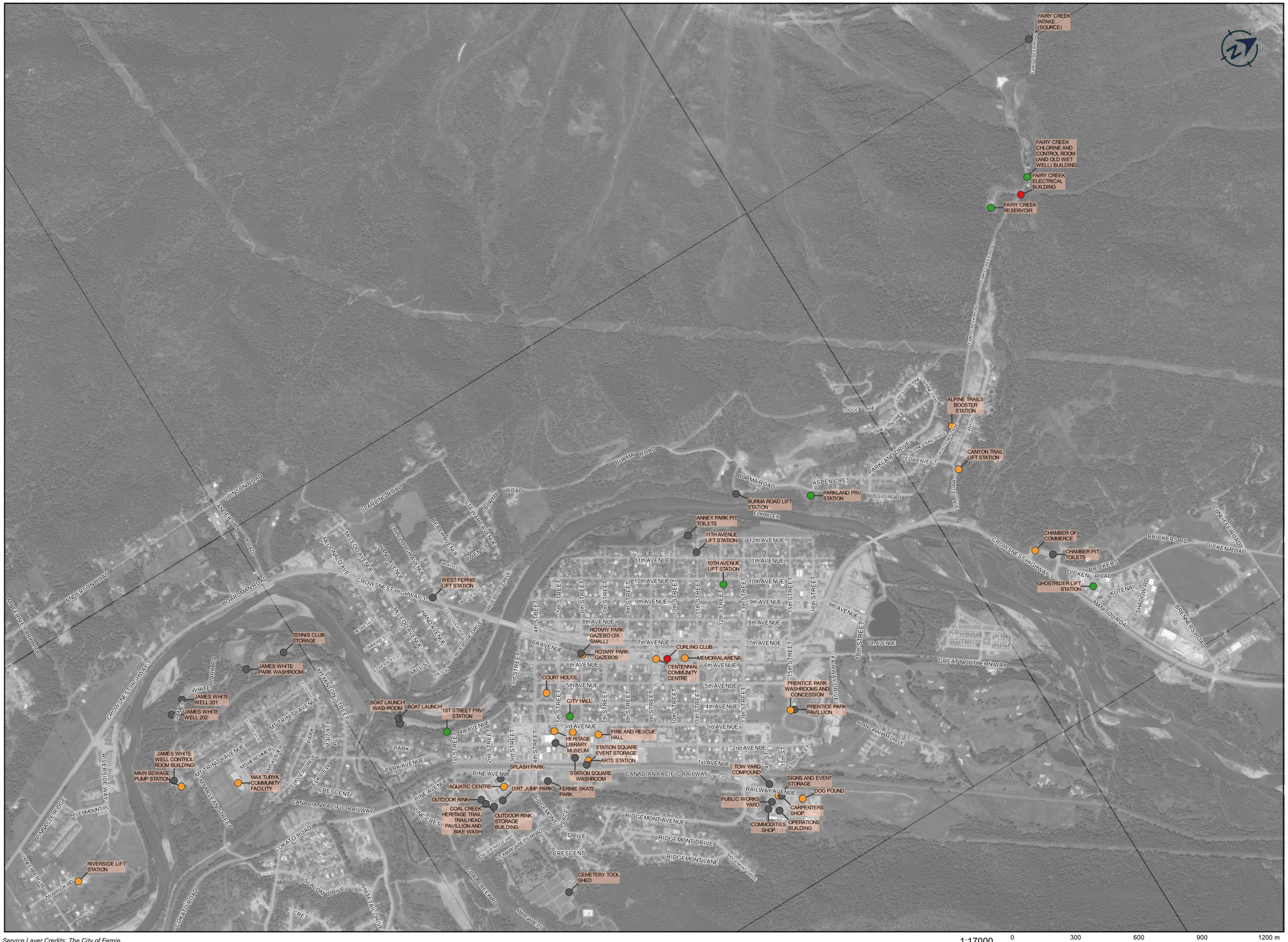
Asset ID	Facility Name	Average Condition	Risk	Prioritization Score
B044	STP Electrical Building	0	4	0
B006	Museum	0	2	0
B061	Dirt Jump Park	0	2	0
B042	UV Disinfection Facility	0	4	0
B043	Blower Building	0	4	0
B026	Alum Dosing Building	0	4	0
B049	James White Well 201	0	4	0
B050	James White Well 202	0	4	0
B051	James White Well Control Room Building	0	4	0
B052	11th Avenue Lift Station	0	4	0
B053	Burma Road Lift Station	0	4	0
B054	West Fernie Lift Station	0	4	0
B017	Carpenters Shop	0	4	0
B040	Public Works Yard	0	4	0
B066	Sewage Treatment Plant	0	4	0
B067	Fairy Creek Intake (Source)	0	4	0
B069	Tow Yard Compound	0	4	0
B008	Prentice Park Pavilion	0	1	0
B046	Cemetery Tool Shed	0	1	0
B037	James White Park Washroom	0	1	0
B038	Boat Launch Washroom	0	1	0
B041	Rotary Park Gazebo (2x Small)	0	1	0
B048	Station Square washroom	0	1	0

Asset ID	Facility Name	Average Condition	Risk	Prioritization Score
B056	Annex Park Pit Toilets	0	1	0
B057	Chamber Pit Toilets	0	1	0
B058	Station Square Event Storage	0	1	0
B059	Fernie Skate Park	0	1	0
B060	Splash Park	0	1	0
B062	Outdoor Rink	0	1	0
B063	Outdoor Rink Storage Building	0	1	0
B064	Boat Launch	0	1	0
B065	Coal Creek Heritage Trail Trailhead Pavilion and Bike Wash	0	1	0
B055	Operations Building	0	4	0
B068	Tennis Club Storage	0	2	0

Of the top 10 listed facilities, it should be noted that five of the facilities are related to the City's utility infrastructure. The main reason they are listed so high is that they are deemed as an essential use, which makes sense, as they are critical to the civil infrastructure of the City.

However, a facility masterplan typically focuses on structures for public use and amenity and not infrastructure. As municipalities typically have reserve funds dedicated to infrastructure renewal.

In addition to these funds, DCCs typically flow directly to these funds also. Therefore, it could be argued that the infrastructure has several revenue streams already provided for. We would recommend that the civil infrastructure facilities be removed from the facilities masterplan and the costs allocated to the appropriate reserve fund. This will ensure other facilities within the City could receive funding.



Service Layer Credits: The City of Fernie

LEGEND

Facilities-Condition

- Null
- 1 Excellent / Good
- 2 Acceptable / Marginal
- 3 Poor / Critical

Bing Satellite

Fernie IICP

Facilities

IICP Condition Rating

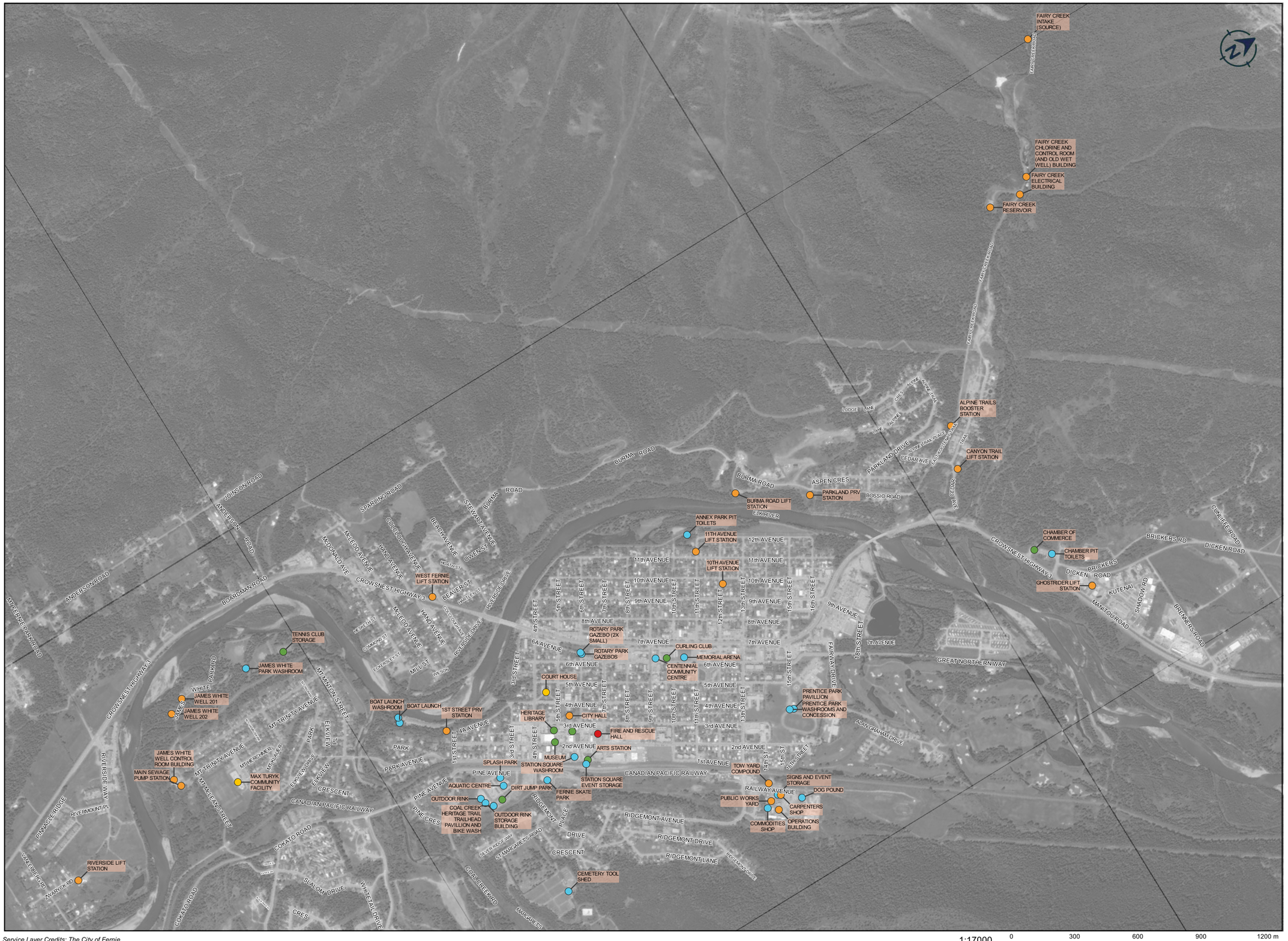
The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

Figure 7.2

ISL FERNIE
CITY OF FERNIE
BRITISH COLUMBIA



LEGEND

Facilities-Risk

- 1 Municipally operated facilities providing “non-essential services”
- 2 Leased facilities providing municipal affiliated “non-essential services”
- 3 Leased facilities providing municipal affiliated “non-essential services”
- 4 Municipally operated facilities providing “essential services”
- 5 Municipally operated facilities providing “emergency services”

Bing Satellite

Fernie IICP

Facilities

IICP Risk Rating

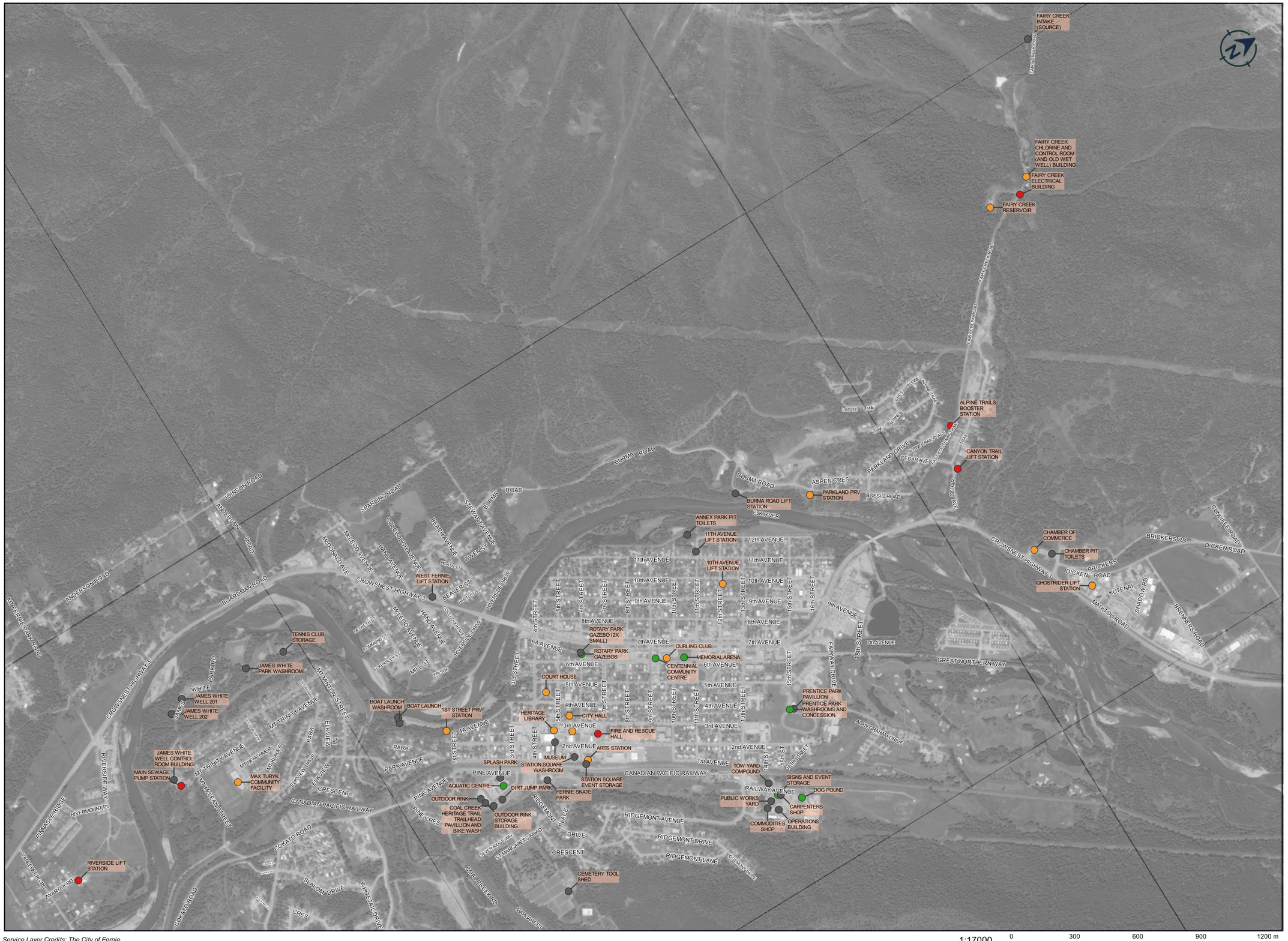
The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

Figure 7.3

ISL FERNIE
CITY OF FERNIE
BRITISH COLUMBIA



Service Layer Credits: The City of Fernie

1:17000

0 300 600 900 1200 m

LEGEND

Facilities-Priority

- Null
- 1 Excellent / Good
- 2 Acceptable / Marginal
- 3 Poor / Critical

Bing Satellite

Fernie IICP

Facilities

IICP Priority Rating

The City of Fernie

Fernie Integrated Infrastructure Capital Plan

ISL Ref. #32568

Figure 7.4

ISL FERNIE
CITY OF FERNIE
BRITISH COLUMBIA

7.11 Facility Sample Project Prioritization

Based on the sample framework above, Table 7.4 includes the following six facilities that received a prioritization score of 3 and highlighted as a high priority.

- Fire and Rescue Hall
- Alpine Trails Booster Station
- Canyon Trail Lift Station
- Fairy Creek Electrical Building
- Main Sewage Lift Pump Station
- Riverside Lift Station

Does the outcome of this prioritization mean that all these facilities need to be replaced? No, the outcome of this exercise is meant to trigger further investigation if justified.

The following details the reasoning behind the higher priority facilities that City should plan for a more detailed investigation in the short term. The modeling report specifically highlights a storage deficiency at the Fairy Creek Reservoir and therefore the reservoir is also included in the discussion below.

The text below summarizes specific facility component conditions noted in Table 7.3 above derived from the FMP.

FIRE AND RESCUE HALL

Component Condition Scores

- Architectural: 2
- HVAC: 1
- Plumbing: 1
- Process Plumbing: None
- Electrical: 1

In general, the condition values would lead us to understand that the facility components are in good working order except for the architectural score noting it has some issues that may impact operational and maintenance costs. Since this facility is classified as providing emergency services, therefore, the highest risk level to the City's prioritization is amplified. The City has already begun investigation of this facility – most recently completing a structural assessment in early 2020.

This is a good example of how the City is already prioritizing facility management and collecting more data on a specific facility condition and investigating options for replacement or remediation.

Given the overall prioritization score of this facility, it is a good candidate for further investigation and a business case regarding its future.

ALPINE TRAILS BOOSTER STATION

Component Condition Scores

- Architectural: None
- HVAC: 1
- Plumbing: None
- Process Plumbing: 1
- Electrical: 2

With the Alpine Trails Booster station being critically important to the City's water infrastructure, specifically providing potable water and fire suppression to the upper Alpine Trails neighbourhood, the condition of this facility should be kept in check. The electrical component of this facility is highlighted as requiring further investigation. From the FMP, the TRV for the electrical component was determined to be $120,000. Before completing a short-term planning for this facility, a review of the electrical system should be completed, beginning with what specifically triggered the lower electrical score.

CAYNON TRAILS LIFT STATION

Component Condition Scores

- Architectural: None
- HVAC 1
- Plumbing: None
- Process Plumbing: 1
- Electrical: 2

Similar to the Alpine Trail Booster station, this facility is critically important to the neighborhood it services. Also like the Alpine Trails Booster station, the electrical component is highlighted as requiring attention. The electrical component TRV was found to be $57,000.

FAIRY CREEK ELECTRICAL BUILDING

Component Condition Scores

- Architectural: 3
- HVAC none
- Plumbing: none
- Process Plumbing: none
- Electrical: 2

This facility provides electrical service to the water reservoir and Fairy Creek Water Treatment Facility and is critically important to the continued operation of the water system. While the City is currently investigating the viability of the Fairy Creek as a long-term water source and if deemed viable extensive upgrades are planned for all the facilities related to the Fairy Creek water source. In the interim, the integrity of this facility specifically should be reviewed and upgraded to ensure safe operation. The architectural TRV was found to be $156,743.



Fairy Creek Electrical Building (July 14, 2020)

POOR/CRITICAL FACILITY CONDITION

In addition to the FMP building condition assessment, clear evidence of the failing roof structure of this facility is apparent.

MAIN SEWAGE LIFT AND PUMPING STATION

Component Condition Scores

- Architectural: None
- HVAC: 1
- Plumbing: None
- Process Plumbing: 1
- Electrical: 2

The Main Sewage Lift Station is responsible for pumping sewage from the entire City, except Riverside and the Cedars, to the wastewater treatment lagoons. Any failure of the facility process would result in environmental issues related to raw sewage discharge into the Elk River. While this facility is a high priority, it is specifically related to the risk associated with the facility. The process-plumbing component of this facility is rated as good condition; and given the facility importance, it should be maintained at this high level. The City has recently completed significant upgrades of this facility with a new screen, pumps, VFDs and HVAC system in 2019. The electrical component and high risk trigger the high priority of this facility and therefore should be the first component to be reviewed.

RIVERSIDE LIFT STATION

Component Condition Scores

- Architectural: None
- HVAC: None
- Plumbing: None
- Process Plumbing: None
- Electrical: 2

The Riverside lift station incorporates wastewater from the riverside and Cedars neighbourhoods into the sewage forcemain out to the wastewater treatment lagoons. The only condition assessment available for this facility is on the electrical components and combined with the risk associated with this facility is what highlights this facility for review.

FAIRY CREEK RESERVOIR

Component Condition Scores

- Architectural: None
- HVAC: 1
- Plumbing: None
- Process Plumbing: None
- Electrical: None

The Fairy Creek Reservoir has only one component reviewed in the FMP and is related to the HVAC system which receives a good condition score and therefore the overall prioritization is moderate based on the importance of this facility in the sample framework.

The water model mentions the City's storage capacity is deficient by approximately 1.5 ML. In order to increase the storage capacity by 1.5ML it would require an approximate investment of $2.5m. Ultimately, the water distribution network services a dual purpose, provide drinking water and provide water to fight fires, the City currently has both.

The current infrastructure within the City has provided residents with the ability to insure their homes against Fire. The public is generally under the impression that there is a standardized level for fire protection, i.e. fire protection in Fernie is identical to Vancouver. However, this is not the case and the costs of insurance reflect this. There are 5 levels of dwelling protection grades, higher the level the better the system and the lower the cost of insurance.

Dwelling Protection Grades.	Simplified "3 tier" system.	Insurance Companies refer to this grade as :
1 2 3A	Table 1	Protected
3B	Table 2	Semi - Protected
4	Table 2 Or Table 3	Semi – Protected Or Unprotected
5	Table 3	Unprotected

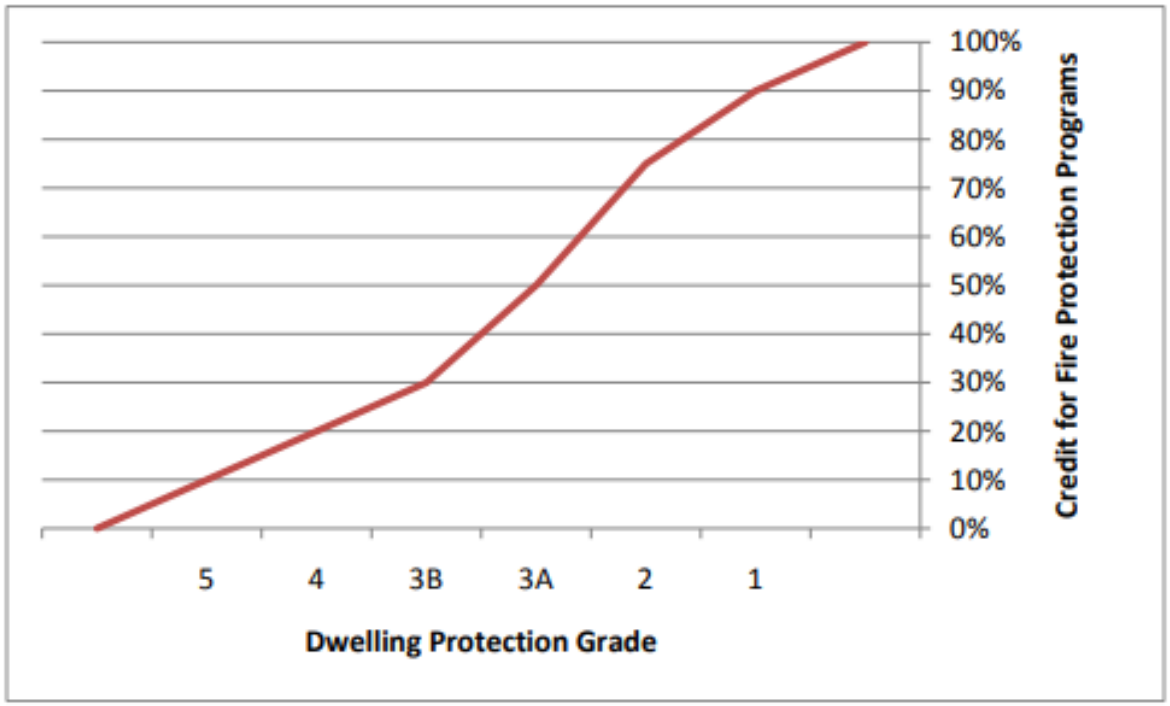


Figure 7.5 Extract from FUS document identifying levels and discounts

The dwelling protection grade is determined by variables associated with the firefighting capability of a Municipality such as; water supply, firefighting apparatus, the fire force and emergency communication capability.

Based on these requirements, the City may wish to conduct a Fire Underwriter Audit prior to investing in the deficient storage. The risk associated with the deficiency of water maybe offset by upgrading equipment or it may be a case the Fire Chief needs to know about the available water source and plan accordingly during a Fire scenario.

Furthermore, the City is currently investigating the viability of Fairy Creek as a long-term water source and if deemed viable extensive upgrades are planned for all the facilities related to the Fairy Creek water source. Any necessary upgrades related to this investigation should be included once determined.

All of the above examples are listed as the highest priority, with the exception of the reservoir in the sample framework described in Section 7.11; however, it can be seen that even these facilities are missing various condition assessments making an overall prioritization against other facilities difficult to compare to. The City should focus first on these higher priority facilities by filling in the gaps of data noted and updating older data where possible. Further discussion on this is included in section 7.13.

7.12 Sample Facility Total Replacement Values

Sample Total Replacement Values (TRV) have been extracted from the FMP where available and AMIP for sanitary or water specific facilities. Values from the FMP are in 2014 dollars and AMIP in 2018 dollars. Table 7.6 indicates where the TRVs were obtained from.

Similar to the conditions, each facility replacement values are broken down into the following categories.

- Architectural
- HVAC
- Plumbing
- Process Plumbing
- Electrical

Refer to Appendix G for further details on how values were allocated to the various categories including an example and complete TRV Table.

Table 7.6 shows the TRVs found for each facility and the corresponding sample prioritization score. Blanks are shown where no data was available in the FMP or AMIP spreadsheet for the respective facilities.

Table 7.6 Facility Total Replacement Values

Asset ID	Facility Name	Prioritization Score	Total Facility TRV	TRV Obtained From
B003	Fire and Rescue Hall	3	$2,731,300.00	FMP
B025	Main Sewage Pump Station	3	$1,690,000.00	AMIP
B031	Alpine Trails Booster Station	3	$538,000.00	AMIP
B036	Riverside Lift Station	3	$332,000.00	AMIP
B032	Canyon Trail Lift Station	3	$212,000.00	AMIP
B027	Fairy Creek Electrical Building	3	$156,743.00	AMIP
B024	Court House	2	$5,716,000.00	FMP
B009	Max Turyk Community Facility	2	$4,469,900.00	FMP
B002	Heritage Library	2	$2,774,300.00	FMP
B001	City Hall	2	$2,731,300.00	FMP
B011	Curling Club	2	$2,627,400.00	FMP
B034	Fairy Creek Reservoir	2	$1,850,000.00	AMIP
B021	Arts Station	2	$1,720,400.00	FMP
B022	Chamber of Commerce	2	$1,345,800.00	FMP
B020	Senior Citizen's Centre	2	$799,700.00	FMP
B033	Fairy Creek Chlorine and Control Room (and Old Wet Well) Building	2	$314,923.60	AMIP
B035	Ghostrider Lift Station	2	$266,000.00	AMIP
B029	10th Avenue Lift Station	2	$137,000.00	AMIP
B030	Parkland PRV Station	2	$135,000.00	AMIP

Asset ID	Facility Name	Prioritization Score	Total Facility TRV	TRV Obtained From
B045	1st Street PRV Station	2	$135,000.00	AMIP
B004	Memorial Arena	1	$7,600,800.00	FMP
B023	Aquatic Centre	1	$6,682,000.00	FMP
B005	Centennial Community Centre	1	$1,777,000.00	FMP
B012	Signs and Event Storage	1	$706,100.00	FMP
B015	Commodities Shop	1	$357,400.00	FMP
B007	Prentice Park Washrooms and Concession	1	$327,400.00	FMP
B039	Dog Pound	1		
B010	Rotary Park Gazebos	1		
B044	STP Electrical Building	0		
B066	Sewage Treatment Plant	0	$1,917,677.00	AMIP
B051	James White Well Control Room Building	0	$1,182,500.00	AMIP
B008	Prentice Park Pavilion	0	$755,600.00	FMP
B049	James White Well 201	0	$348,750.00	AMIP
B050	James White Well 202	0	$348,750.00	AMIP
B053	Burma Road Lift Station	0	$227,841.00	AMIP
B052	11th Avenue Lift Station	0	$68,000.00	AMIP
B042	UV Disinfection Facility	0		
B043	Blower Building	0		
B026	Alum Dosing Building	0		
B054	West Fernie Lift Station	0		
B017	Carpenters Shop	0		
B040	Public Works Yard	0		
B067	Fairy Creek Intake (Source)	0		
B069	Tow Yard Compound	0		
B055	Operations Building	0		
B006	Museum	0		
B061	Dirt Jump Park	0		
B068	Tennis Club Storage	0		
B046	Cemetery Tool Shed	0		
B037	James White Park Washroom	0		
B038	Boat Launch Washroom	0		
B041	Rotary Park Gazebo (2x Small)	0		
B048	Station Square washroom	0		
B056	Annex Park Pit Toilets	0		
B057	Chamber Pit Toilets	0		
B058	Station Square Event Storage	0		
B059	Fernie Skate Park	0		
B060	Splash Park	0		
B062	Outdoor Rink	0		
B063	Outdoor Rink Storage Building	0		

Asset ID	Facility Name	Prioritization Score	Total Facility TRV	TRV Obtained From
B064	Boat Launch	0		
B065	Coal Creek Heritage Trail Trailhead Pavilion and Bike Wash	0		

For a complete breakdown of all facility component condition, risk, prioritization, and respective TRVs, refer to Appendix G.

Given the gaps in data and prioritization scores, it is difficult to appropriately plan for specific facility funding in a similar manner as for infrastructure. It is recommended that the City directs funds to update FMP, which in turn will help determine replacement values and specific deficiencies for components of or a facility as a whole. Considering that a high prioritization of a facility or component doesn't necessarily indicate that that facility needs to be replaced or that the entirety of a component needs to be replaced. The high prioritization is intended to be a flag for staff that further investigation or increased attention is paid to that particular facility or component. As more accurate data becomes available, specific business cases will be able to be developed as outlined in this report, which will allow the City to make with more informed decisions regarding the upkeep and financial planning of their facility infrastructure.

7.13 Facility Summary

There is a lot of information contained within this section, and it can be overwhelming to determine which step should be taken next. To help identify these next steps, we have provided a review of the goals stated in section 7.3:

Goal 1: Addressing capacity: minimize service delivery gaps, anticipate growth

- The City is making progress, but further input is needed.
  - Consult with existing staff to determine existing capacity of facilities.
  - Consult with the staff to identify potential gaps and deficiencies.
  - Apply growth factors to facilities to determine future requirements.
  - Completed a comprehensive public engagement process, which will provide the public an opportunity to help shape their community facilities in the future.

Goal 2: Meeting changing health and safety regulations

- The City is meeting this goal.
  - This is an ongoing requirement; therefore the City should review facilities periodically against current codes.

Goal 3: Identifying urgent needs and prioritizing facilities

- The City is making progress, but further input is needed.
  - Prioritizing facilities has started.
  - Matrices have been created to help determine prioritizing of facilities.

Goal 4: Understanding building condition and the scope of work needed to reach acceptable levels

- The City is making progress, but further input is needed.
  - A matrix for determined condition assessments has been established.
  - The City has conducted a partial review if its facilities, but further review is required to fill in the missing data.
  - It should be noted that once all facilities have been reviewed and scored, the City should review facilities on an ongoing basis.

Goal 5: Including risk considerations in facilities planning that incorporate resilience capacity considerations and mitigate critical impacts

- The City has met this goal.
  - A decision matrix has been established to help identify risk.
  - Future design consideration should be made to help with resilience throughout the Municipality.

Goal 6: Achieving financial sustainability with facilities that are affordable to build, operate and maintain

- The City is moving in the right direction.
  - The City must continue to invest in data collection and analysis.
  - Life cycle analysis should be conducted on all buildings.
  - Set Reserve Funding, based on depreciation level of facilities.

Goal 7: Ability to modify and adapt in response to revenue generation opportunities

- The City is moving in the right direction.
  - Create business cases for existing and future facilities and determine the cost benefit for each facility.
  - Develop high-level concepts for potential grant opportunities.
  - Ensure staff are monitoring external funding opportunities, such as Investing in Canada Infrastructure Programs.

Goal 8: Aligning with supporting City mandates

- City is meeting this goal, but it is an ongoing process.
  - Continue to review the City's strategic initiatives and ensure investment levels and facility renewal is in accordance with these plans.

8.0 Conclusion/Recommendations

The intent of the IICP is to organize projects over 20 years to ensure the level of service that the city expects is maintained and that future funding requirements are understood and planned for. In general, the information the City has collected to date allows for a comprehensive understanding of utilities and roads, further data collection is required for facilities and is outlined is section 7.0.

The IICP includes the following recommendations:

- Ongoing review and update of utility capacity through modelling
- Update AMIP to Include West Fernie assets, and begin planning for their replacement in the long term.
- Update the 2007 EBA Road Condition Assessment and incorporate the results into the decision-making framework.
- Validate the storm model completed to refine/clarify upgrade projects and include revised HLoS data into the decision-making framework.
- Complete Condition assessments of the storm infrastructure and incorporate real world condition scores into the decision-making framework.
- Determine watermain asbestos pipe conditions either through destructive testing or anecdotal evidence from city staff experience.
- Complete corrosive soils testing program to acquire analytical data to justify metallic pipe service lives.
- Continual logging of utility issues and incorporating into the GIS and framework system
- Investigate the reasoning facilities are flagged as a high priority and develop short term strategies to mitigate the issues once found.
- Update the Facilities Master Plan.
- Determine funding scheme to complete the short term identified projects.

The City has come a long way in the process of developing their asset management program and their continued investment in this process will ensure present service levels are maintained into the future, while maximizing the value of each asset.

Finally, asset management is an ongoing process, which requires continuous input and analysis in order to maintain a well-run infrastructure program.

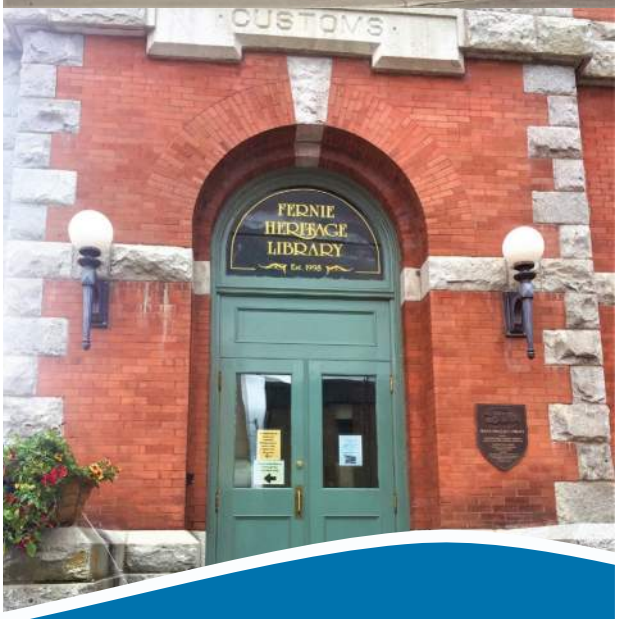












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Appendix A

City of Fernie Water Distribution System Modeling and Capacity Analysis

City of Fernie Water Distribution System Modeling and Capacity Analysis

Final Report

Prepared for:
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1.0 Introduction

GeoAdvice Engineering Inc. (GeoAdvice) was retained by the City of Fernie (City) to build the hydraulic model of the City water distribution system. This report describes the methodology and assumptions used to build, calibrate and analyze the hydraulic model. **Table 1.1** summarizes the main components of the water distribution system model.

Table 1.1: Model Statistics of Current System

Component	Total
Pipes	1,716
Pipe Length	81.4 km
Sources	2
Storage Reservoir	1
Booster Station	1
PRV* Stations	2

***Pressure Reducing Valve**

The water model was built using the InfoWater software program (Innovyze). InfoWater is a water distribution system modeling and management software application.

In the preparation of this report, GeoAdvice would like to acknowledge the support of the following City Staff:

- Ms. Zabrina Pendon
- Ms. Lisa Janssen
- Ms. Jenny Weir

2.0 Model Build

The hydraulic model build was divided into multiple tasks as follows:

- Task 1: Data Collection and Review
- Task 2: GIS Model Build
- Task 3: Data Gaps and Connectivity Analysis
- Task 4: Node Elevation Extraction
- Task 5: Primary System Components
- Task 6: Pressure Zone Boundaries
- Task 7: Existing Demand Calculation and Allocation
- Task 8: Fire Flow Demand

2.1 Data Collection and Review

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

- Previous WaterCAD hydraulic model
- GIS database
- As-built drawings
- PRV station operations
- Pump station operations
- Pressure measurements
- Hydrant test data
- Land-use and zoning maps
- Planning parcel data
- Growth projection data
- Official community plan (OCP)

2.2 GIS Model Build

The City's GIS data was the primary source of up-to-date information on the system to build the pipe and node network topology model. Attributes of the water mains, such as nominal diameter, material and age were extracted from the GIS database. The coordinate system used in the model is UTM NAD 83 Zone 11.

2.3 Data Gaps and Connectivity Analysis

The next task involved reviewing the GIS water data, identifying data gaps and checking system connectivity (e.g. orphan pipe). Refer to **Appendix A** for typical connectivity and data gap issues and solutions.

2.4 Node Elevation Extraction

A Digital Elevation Model (DEM) was used to validate ground elevations in the model and to determine missing ground elevations. Elevations are based on the Canadian Geodetic Vertical Datum of 1928 (CGVD28).

2.5 Primary System Components

One of the most important tasks associated with the model build was accurately representing system boundary conditions and all major water system components.

The City system is supplied from two (2) sources:

- Fairy Creek Spring
- James White Park Wells

In addition, the City operates and maintains one (1) storage reservoir, two (2) well pumps, one (1) booster pump station, and two (2) pressure reducing valve (PRV) stations, which act as the primary mechanisms for delivering water throughout the City water distribution system.

The following tables summarize the hydraulic modeling data for all the primary system components.

Table 2.1: Water Source Hydraulic Modeling Data

Source Name	Model ID	HGL (m)
Fairy Creek Spring	RES-FAIRYCREEKSPRING	1,134.0

Table 2.2: Storage Reservoir Hydraulic Modeling Data

Reservoir Name	Model ID	Bottom Elevation (m)	Minimum Level (m)	Maximum Level (m)	Equivalent Diameter (m)	Volume (m^3)
Fairy Creek	TNK-FAIRYCREEK	1,087.3	2.6	5.2	35.0	5,000

Table 2.3: Pump Station Hydraulic Modeling Data

Pump Station Name	Model ID	Elevation (m)	Design Flow (L/s)	Design Head (m)	Target Output Pressure (psi)
Alpine Trail Booster Station	PMP-ALPINETRAIL-1	1,050.0	15.7	62.7	133.6
	PMP-ALPINETRAIL-2	1,050.0	15.7	62.7	133.6
	PMP-ALPINETRAIL-3	1,050.0	106.0	63.6	133.6
James White Park Wells	PMP-JWPWELL-1	964.4	100.0	155.0	N/A
	PMP-JWPWELL-2	970.3	100.0	155.0	N/A

Table 2.4: PRV Station Hydraulic Modeling Data

PRV Station Name	Model ID	Elevation (m)	Diameter (mm)	Pressure Setting (psi)	HGL Setting (m)
Parkland PRV Station	PRV-PARKLAND-1	1,026.8	250	49.1	1,061.3
	PRV-PARKLAND-2	1,026.8	250	44.1*	1,058.8
1st Street PRV Station	PRV-1STSTREET-1	998.9	250	89.7	1,062.0
	PRV-1STSTREET-2	998.9	250	84.7*	1,058.5

***The second valve in each PRV station was assumed to be set 5 psi lower than the lead valve.**

The James White Park wells were included in the model but assumed closed, as they do not supply water to the system on a normal operational basis.

2.6 Pressure Zone Boundaries

The City water distribution system is separated into three (3) pressure zones. Water is supplied to the system from the Fairy Creek Spring into the High Zone, where water is stored in the Fairy Creek Reservoir. The James White Park wells also supplement flow to the system into the High Zone. From the High Zone, water is either pumped to the Alpine Trail Booster System (ATBS) or pressure reduced into the Low Zone.

Table 2.5 provides a breakdown of the pressure zone imports, exports, and storage.

Table 2.5: Pressure Zone Summary

Pressure Zone Name		Theoretical HGL (m)	Import	Export	Storage
1	Low Zone	1,062	Parkland PRV Station	None	None
			1st Street PRV Station		
2	High Zone	1,092	Fairy Creek Spring	Alpine Trail Booster Station	Fairy Creek Reservoir
			James White Park Wells	Parkland PRV Station	
				1st Street PRV Station	
3	Alpine Trail Booster System	1,144	Alpine Trail Booster Station	None	None

Please note that the Lodge Trail booster station pumps to a small private dead-end area extending from the Alpine Trail booster system; however, this area and the Lodge Trail booster station was not included in the model.

2.7 Existing Demand Calculation and Allocation

The existing water demands were calculated on a per parcel basis using the City's cadastral files, existing population, and water consumption data.

Per the Urban Systems Ltd. (USL) *Growth Projection* Memorandum (July 2019), there are an estimated 3,134 residential units as of 2018 (considered to be the existing scenario), with a permanent residential population of 5,148. Based on discussions with the City, the USL memo assumed an additional 30% non-permanent (shadow) population in order to determine an average density of 2.14 capita/unit.

Table 2.6 summarizes the City's existing population data.

Table 2.6: Existing Population Data

Type	Units	Population
Permanent Population	2,411	5,148
Shadow Population	723	1,544
Total	**3,134**	**6,692**

To calculate and allocate institutional, commercial, and industrial (ICI) demands in the model, equivalent populations were calculated for each land use type based on population densities from the Master Municipal Construction Documents (MMCD) design guidelines.

Table 2.7 summarizes the MMCD equivalent population densities.

Table 2.7: Existing ICI Equivalent Population Densities

Type	Density (cap/ha)
Institutional	50
Commercial	90
Industrial	90

The City provided the total water production data for the City system based on 2018 bulk meter data. The water production data is summarized in **Table 2.8**.

Table 2.8: 2018 Water Production Data

Source	Total Annual Flow Volume (m^3)	Maximum Day Flow Volume (m^3)	Peak Hour Flow Volume (m^3)
Fairy Creek Spring	2,453,779	13,127	988
James White Park Wells	447,744	0	0
Total	**2,901,524**	**13,127**	**988**

July 17, 2018 was identified as the day of maximum day demand in 2018, with a peak hour demand occurring at 8 PM. There were days in August of 2018 with higher flow volumes measured; however, these values do not accurately reflect system demands. The initial operations of the James White Park wells started in August, and the wells were flushed for water quality purposes. As such, much higher flow volumes were recorded than would normally be observed in the system.

Based on the water consumption data, the water demand data was developed as summarized in **Table 2.9**.

Table 2.9: 2018 Water Demand Data

Source	Average Day Demand (L/s)	Maximum Day Demand (L/s)	Peak Hour Demand (L/s)
Fairy Creek Spring	77.8	151.9	274.4
James White Park Wells	14.2	0.0	0.0
Total	**92.0**	**151.9**	**274.4**

The City provided an estimated non-revenue water (NRW) demand of approximately 70 L/s. The City further specified that approximately 15 L/s of the NRW is lost to recurring leakage along the Burma Road trunk main. Of the remaining 55 L/s NRW demand, 80% was allocated uniformly to the junctions within the Annex and Maintown areas. The remaining 20% was allocated uniformly to the rest of the City.

Using the population estimates, land use data, and demand calculations, the ADD was distributed amongst the various land use categories. **Table 2.10** summarizes the 2018 ADD, MDD and PHD for each corresponding land use type.

Table 2.10: 2018 Demand Summary

Demand Type	Land Use	ADD (L/s)	MDD (L/s)	PHD (L/s)
1	Single Family Residential	7.8	19.2	47.9
2	Multi-Family Residential	3.1	7.5	18.8
3	Commercial	6.3	43.2	107.7
4	Industrial	0.2	0.4	1.0
5	Institutional	4.7	11.6	29.0
	Subtotal	**22.1**	**81.9**	**204.4**
6	Non-Revenue Water	70.0	70.0	70.0
	Total	**92.1**	**151.9**	**274.4**

As shown in **Table 2.10**, there is a large increase in the commercial demands from ADD to MDD. This large increase is to account for the increased water demands at the Fernie Golf Club for irrigation in the summer months.

Finally, it was assumed that NRW does not scale with demand. As leakage typically decreases with decreasing system pressure (increasing demand), keeping NRW constant is reasonable.

2.8 Fire Flow Demands

Fire flow demands were assigned to selected nodes located near hydrants in the InfoWater model. It is important to note that fire nodes are not hydrants. One fire node can represent multiple hydrants. Furthermore, no fire hydrant laterals or actual hydrants were modeled. Model fire flow results represent the flow available in the pipe network.

The City's Subdivision and Development Servicing Bylaw, No. 1727, stipulates that the required fire flows must be in accordance with the Insurers' Advisory Organization (IAO), now known as the Fire Underwriters Survey (FUS). Since the FUS required fire flow for each building in the City is unknown, fire flows were assigned in the model based on the MMCD design guidelines.

Table 2.11 lists the required fire flow at a residual pressure of 22 psi for each land use type based on the MMCD design guidelines.

Table 2.11: Fire Flow Requirements (@ 22 psi Residual Pressure)

Land Use	Required Fire Flow (L/s)
Single Family	60
Multi Family	90
Institutional	150
Commercial	150
Industrial	225

If the contributing area to a model node contained multiple land-uses (e.g. partially single family residential and partially multi-family residential), the higher fire flow requirement was allocated.

3.0 Model Calibration

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

- Input data errors
- System loading errors
- Operational control errors
- Poorly calibrated measuring equipment
- Outdated data

The cumulative effect of these areas of uncertainty or "approximation" is that, without verification and validation of the model's ability to recreate known conditions, it is likely that the modeling results would be grossly misleading.

The main reasons for and benefits of a well calibrated model are listed below:

- Confidence: Demonstrate the model's ability to reproduce existing conditions.
- Understanding: Confirm the understanding of the performance of the system.
- Troubleshooting: Uncover missing information and misinformation or anomalies about the system.

The model was setup using the Hazen-Williams headloss formula to estimate friction loss through water mains based on pipe roughness coefficients. Roughness coefficients were assigned to pipe groups based on similar characteristics (i.e. diameter, material, and age).

When calibrating the model, the goal was to determine the best set of roughness coefficients that produces the lowest overall deviation between the simulated model results and the observed field data.

The pipe groups and their respective calibrated roughness coefficients are summarized in **Appendix B**.

3.1 Field Data Review

Measured field data was collected through a hydrant testing program; a process of opening a hydrant measuring the flow from it, while recording residual pressures at another hydrant in the area. This field measurement allows the same flow conditions to be simulated in the model while comparing the pressure at another location.

The first round of hydrant testing took place on October 22, 2019, and the field data was provided by USL. Due to some suspicious pressure and flow measurements, a second round of hydrant testing was completed by Bot Corp of February 3, 2020.

A total of seventeen (17) hydrant tests were completed, each having one associated pressure hydrant and one associated flow hydrant. This resulted in fourteen (34) measurements (static and residual) to calibrate the model, with a breakdown shown in **Table 3.1**.

Table 3.1: Number of Hydrant Measurements

Type of Pressure Reading	Number of Readings
Static Pressure	17
Residual Pressure	17
Total	**34**

The results from the hydrant tests were then used to calibrate the water distribution model.

The complete fire flow test results can be found in **Appendix C**.

Measured field data was also provided by the City in the form of static pressure measurements taken at various hydrants throughout the City distribution system. The static pressure measurements were taken in 2018, before and after adjustments were made to the PRV settings in the system. Only the measurements taken after the setting adjustments were used for the model calibration (42 static pressure measurement locations). The static pressure measurements are provided in **Appendix D**.

3.2 Calibration Results

The average day demand scenario was used to represent the demands in the model for the calibration.

First, the static pressure measurements provided by the City were used to calibrate the model. **Table 3.2** summarizes the calibration agreement results between the measured and modeled static pressures.

Table 3.2: Summary of Calibration Results – Static Pressure Measurements

Static Pressure Agreement	Percentage Difference	Number of Pressure Measurements
Excellent	< 5%	26
Good	5% - 10%	12
Satisfactory	10% - 20%	4
Poor	> 20%	0

As shown in **Table 3.2**, almost all of the static pressure measurements have an "Excellent" or "Good" agreement with the model. Only four (4) pressure measurements have a "Satisfactory" agreement. The pressure measurements at these four (4) locations are suspiciously low. Given the elevations of these hydrants, the resulting hydraulic grades are not consistent with the other pressure measurements in each respective pressure zone. For example, hydrants #140 and #151 are at the same elevation and in the same pressure zone; therefore, the measured static pressures should be approximately the same. In addition, the pressure measurement at hydrant #79 is not consistent with the static pressure measurement taken at the same location during the hydrant testing program.

The complete results comparing the model predictions and the field data for the static pressure measurements can be found in **Appendix D**.

Next, the model was further calibrated against the hydrant test results.

Table 3.3 summarizes the model calibration results with the average difference between the field data and the model results. The complete results comparing the model predictions and the field data can be found in **Appendix E**.

Table 3.3: Summary of Calibration Results – Hydrant Tests

Test #	Static Pressure Difference	Residual Pressure Difference
1*	NA	NA
2*	NA	NA
3	1.3%	4.8%
4	3.2%	4.5%
5	2.3%	14.9%
6	0.6%	6.6%
7	0.3%	0.4%
8	1.5%	1.9%
9	2.6%	6.0%
10	1.8%	2.3%
11	3.0%	7.8%
12	0.8%	0.0%
13	0.2%	0.0%
14	2.1%	0.2%
15	3.7%	9.8%
16	0.3%	13.4%
17	0.7%	3.8%
Average	**1.6%**	**5.1%**

***Test 1 replaced by Test 11, and Test 2 replaced by Test 9.**

As shown in **Table 3.3**, an excellent correlation was achieved between the model predictions and the measured data for the static pressure conditions.

For the residual pressure conditions, a good correlation was achieved for most of the tests. The results for Tests 1 and 2 were disregarded as they were retested in the second round of testing. Only a satisfactory agreement was achieved for Test 5 and Test 16.

The model is over predicting the headlosses in the system for Test 5. This test is located in an area serviced by relatively new PVC piping. All other areas of the system tested and serviced by this type of pipe achieved a good correlation. Also, there are no deficiencies predicted by the model in this area; as such, the satisfactory agreement at this location is not critical.

The model is under predicting the headlosses in the system for Test 16. This test is located in close proximity to Tests 10, 14, and 15, which all achieved good or excellent agreements; as such, the satisfactory agreement at this location is not critical.

4.0 Future Scenario Development

This section summarizes the assumptions and calculations used to develop the future modeling scenarios. **Table 4.1** summarizes the modeling scenarios used to assess the City water distribution system capacity.

Table 4.1: Modeling Scenario Summary

Scenario	Description
2018	Identify existing system deficiencies
2032	Identify future system deficiencies and upgrade sizing

4.1 Residential Growth Projections

Residential growth projections were taken from the USL memorandum *City of Fernie Growth Projection* (July 2019). In order to spatially allocate the growth throughout the City, the population projections by neighbourhood were used. Residential growth projections are summarized in **Table 4.2**.

Table 4.2: Residential Growth Projection Summary

Neighbourhood	2018-2032 New Residential Units
Alpine Parkland	+ 20
Annex	+ 56
Castle Mountain	+ 107
Cedar Valley	+ 70
Ghostrider	+ 0
Main Town	+ 135
Mountview	+ 8
Northlands	+ 11
Ridgemont	+ 31
Riverside	+ 47
West Fernie	+ 101
Total	**+ 586**

Growth was uniformly distributed to all demand junctions within each respective neighbourhood.

4.2 ICI Development Projections

As with the residential growth projections, ICI development projections were taken from the USL memorandum *City of Fernie Growth Projection* (July 2019). ICI development projections are summarized in **Table 4.3**.

Table 4.3: ICI Development Projection Summary

Land Use	2032 ICI Development Area (m^2)	MMCD Population Density (cap/ha)	2032 ICI Equivalent Population
Commercial	+ 15,450	90	+ 139
Industrial	+ 2,684	90	+ 24
Institutional	+ 3,122	50	+ 16
Total	**+ 21,256**		**+ 179**

Based on discussions with the City, it was determined that the commercial and industrial development is most likely to occur to the north and northeast, in the Ghostrider neighbourhood, and the industrial growth is likely to occur near Coal Creek Road and Cokato Road, in the Castle Mountain neighbourhood.

4.3 Future Water Demand Calculations

The future residential and ICI demands were estimated using the rates summarized in **Table 4.4**, which are based on the MMCD design guidelines. Based on discussions with the City, the unmetered demand rates were applied to the population growth.

Table 4.4: Future Demand Rates

Scenario	Demand Rate
ADD	450 L/cap/day
MDD	900 L/cap/day
PHD	1,350 L/cap/day

Table 4.5 shows the existing and future population and loading data.

Table 4.5: Existing and Future Population and Demand Summary

Parameter	2018	2032
Total Units	3,134	3,720
Total Population	6,692	7,944*
ADD	92.0 L/s	99.4 L/s
MDD	151.9 L/s	166.8 L/s
PHD	274.4 L/s	296.8 L/s

***Growth population calculated at 2.14 capita/unit, as per the USL memorandum.**

5.0 Hydraulic Performance and Design Criteria

Based discussions with the City, the analysis and design criteria shown in **Table 5.1** were used to assess the capacity of the City water distribution. These criteria are based on the City's Subdivision and Development Servicing Bylaw, No. 1727 and the MMCD design guidelines.

Table 5.1: Hydraulic Performance and Design Criteria

Criteria	Parameter Value
Maximum Static Pressure	95 psi
Minimum Static Pressure	44 psi
Minimum Residual Pressure (MDD+FF)	22 psi
Maximum Velocity: New Pipe (PHD)	2 m/s
Maximum Velocity: New Pipe (MDD+FF)	4 m/s
Material: New Pipe	PVC
Roughness Coefficient: New Pipe	130
Minimum Diameter: New Pipe	150 mm
Maximum PRV Velocity	6.0 m/s

The storage reservoir capacity was also assessed based on the City's Subdivision and Development Servicing Bylaw, No. 1727.

Total Required Storage = A + B + C

where A = Fire Storage
B = Equalization Storage (25% of MDD)
C = Emergency Storage (15% of A + B)

Table 5.2 summarizes the reservoir levels used for each analysis scenario based on the City's Subdivision and Development Servicing Bylaw, No. 1727.

Table 5.2: Reservoir Level Assumptions

Scenario	Reservoir Level Percent Full
ADD	100%
MDD, MDD+FF, PHD	50%

Pump stations feeding an on-line equalization reservoir must meet the downstream service area MDD with the largest pump out of service. If equalization storage is not on-line, pump station capacity must meet the downstream service area PHD or MDD+FF (whichever is greater) with the largest pump out of service.

6.0 System Capacity Analysis

This section summarizes the City water distribution system capacity analysis under the existing and future conditions.

6.1 Storage Capacity Analysis

There is one storage reservoir in the City water distribution system, the Fairy Creek reservoir, which services the entire distribution system.

Table 6.1 summarizes the components of the required storage and the total required storage.

Table 6.1: Required Storage Capacity

Scenario	Fire Storage "A" (ML)	Equalization Storage "B" (ML)	Emergency Storage "C" (ML)	Total Required Storage (ML)
2018	2.33	3.28	0.84	6.45
2032	2.33	3.60	0.86	6.82

Table 6.1 summarizes the components of the required storage and the total required storage.

Table 6.2: Storage Capacity Analysis

Scenario	Existing Storage Capacity (ML)	Required Storage Capacity (ML)	Excess (ML)	Deficient
2018	5.00	6.45	- 1.45	**Yes**
2032	5.00	6.82	- 1.82	**Yes**

As shown in **Table 6.2**, the storage capacity is deficient in the 2018 and 2032 scenarios.

6.2 Pump Station Capacity Analysis

There is one pump station in the City water distribution system, the Alpine Trail booster station. The station pumps water from the High Zone to the Alpine Trail Booster System at a fixed outlet pressure of 134 psi (HGL = 1,144 m).

There are three (3) pumps in the Alpine Trail booster station, two (2) variable frequency drive (VFD) booster pumps and one (1) emergency natural gas-powered pump. The pump capacity assumes two (2) pumps in service, with one pump out of service in accordance with the Fire Underwriters Survey.

The Alpine Trail booster station services a dead-end system without storage; therefore, the required capacity is the greater of the service area PHD and MDD+FF. The MDD+FF, with a required fire flow of 90 L/s, governs the required pump station capacity.

The existing and future pump capacity analysis results are summarized in **Table 6.3**.

Table 6.3: Alpine Trail Booster Station Capacity Results

Scenario	Firm Capacity (L/s)	Required Capacity (L/s)	Excess (L/s)	Deficient?
2018	121.8	91.3	+ 30.5	No
2032	121.8	91.6	+ 30.2	No

As shown in **Table 6.3**, the Alpine Trail booster station is able to meet the required capacity under the 2018 and 2032 scenarios.

Note that the Lodge Trail booster station is a private station and was not modeled or analyzed.

6.3 PRV Capacity Analysis

PRVs were reviewed for peak velocities under PHD and MDD+FF conditions for the existing and future scenarios. The recommended peak velocity through a PRV should be less than or equal to 6.0 m/s.

Table 6.4 summarizes the PRV velocity results under PHD for the existing and future scenarios.

Table 6.4: PHD PRV Velocity Modeling Results

PRV ID	Diameter (mm)	PHD Velocity (m/s)	
		2018	2032
PRV-PARKLAND-1	250	2.41	2.58
PRV-PARKLAND-2	250	0.00	0.00
PRV-1STSTREET-1	250	2.21	2.34
PRV-1STSTREET-2	250	0.00	0.00

As shown in **Table 6.4**, the velocity through all PRVs is expected to remain below 6 m/s in the 2018 and 2032 PHD scenarios.

Table 6.5 summarizes the PRV velocity results under MDD+FF for the existing and future scenarios.

Table 6.5: MDD+FF PRV Velocity Modeling Results

PRV ID	Diameter (mm)	MDD+FF Velocity (m/s)	
		2018	2032
PRV-PARKLAND-1	250	4.15	4.26
PRV-PARKLAND-2	250	0.00	0.00
PRV-1STSTREET-1	250	2.93	3.01
PRV-1STSTREET-2	250	0.00	0.00

As shown in **Table 6.5**, the velocity through all PRVs is expected to remain below 6 m/s in the 2018 and 2032 MDD+FF scenarios.

6.4 Network Capacity Analysis

The City network capacity was analyzed by assessing system pressures and flows under existing and future demand conditions. A summary of the modeling results is shown in **Table 6.6** below. The fire flow analysis was only conducted on fire flow nodes (nodes near fire hydrants).

Table 6.6: Pressure and Fire Flow Modeling Results Summary

Criteria	Scenario	2018	2032
# of Low-Pressure Deficiencies Demand Nodes < 44 psi	PHD	19	19
PHD Average Pressure	PHD	83.4 psi	82.8 psi
# of Fire Flow Deficiencies Fire Nodes < 22 psi	MDD+FF	28	28
Average Available Fire Flow	MDD+FF	232 L/s	231 L/s

Hydraulic results indicate that 19 demand nodes experience low pressures under the 2018 and 2032 PHD scenarios (< 44 psi). PHD pressure deficiencies within 10% were considered non-critical and were not addressed. Typically, a range of +/- 10% can be considered within “model accuracy” and would not act as a trigger for system upgrades.

The 2018 and 2032 PHD pressure modeling results are illustrated in **Figure 6.1** and **Figure 6.2**, respectively. The PHD pressure deficiencies are summarized in **Appendix F**.

Fire flow results indicate 28 fire nodes are unable to satisfy the required fire flow in the 2018 and 2032 MDD+FF scenarios (< 22 psi). Fire flow deficiencies within 10% were not assessed and were considered non-critical. Typically, a range of +/- 10% can be considered within “model accuracy” and would not act as a trigger for system upgrades.

One area of particular concern is the Ghostrider neighbourhood. This is a commercial area, where the network is primarily composed of 150 mm pipes, which are not large enough to supply the required fire flow of 150 L/s for commercial properties. Moving forward, the City should note that best practices typically recommend diameters no less than 200 mm (if not 250 mm) in commercial, industrial, and institutional areas.

The 2018 and 2032 fire flow modeling results are illustrated in **Figure 6.3** and **Figure 6.4**, respectively. The MDD+FF fire flow deficiencies are summarized in **Appendix G**.

GeoAdvice Engineering Inc.

Legend

PHD Pressure

- < 40 psi
- 40 psi - 44 psi
- > 44 psi

Water Main Pressure Zone

- Low Pressure Zone
- High Pressure Zone
- Alpine Trail Booster System
- Fairy Creek Spring
- James White Park Well
- Fairy Creek Storage Reservoir
- Alpine Trail Booster Station
- PRV Station

2018 PHD Pressure Modeling Results

CITY OF FERNIE
BRITISH COLUMBIA

Project: **Water Model Development, Calibration, and Capacity Analysis**
Client: **City of Fernie**
Date: **February 2020**
Created by: **AKd'A**
Reviewed by: **WdS**

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

0 0.375 0.75 1.5
Kilometers

N E S W

Figure 6.1

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GeoAdvice Engineering Inc.

Legend

PHD Pressure

- < 40 psi
- 40 psi - 44 psi
- > 44 psi

Water Main Pressure Zone

- Low Pressure Zone
- High Pressure Zone
- Alpine Trail Booster System
- Fairy Creek Spring
- James White Park Well
- Alpine Trail Booster Station
- Fairy Creek Storage Reservoir
- PRV Station

2032 PHD Pressure Modeling Results

CITY OF FERNIE
BRITISH COLUMBIA

Project: **Water Model Development, Calibration, and Capacity Analysis**
Client: **City of Fernie**
Date: **February 2020**
Created by: **AKd'A**
Reviewed by: **WdS**

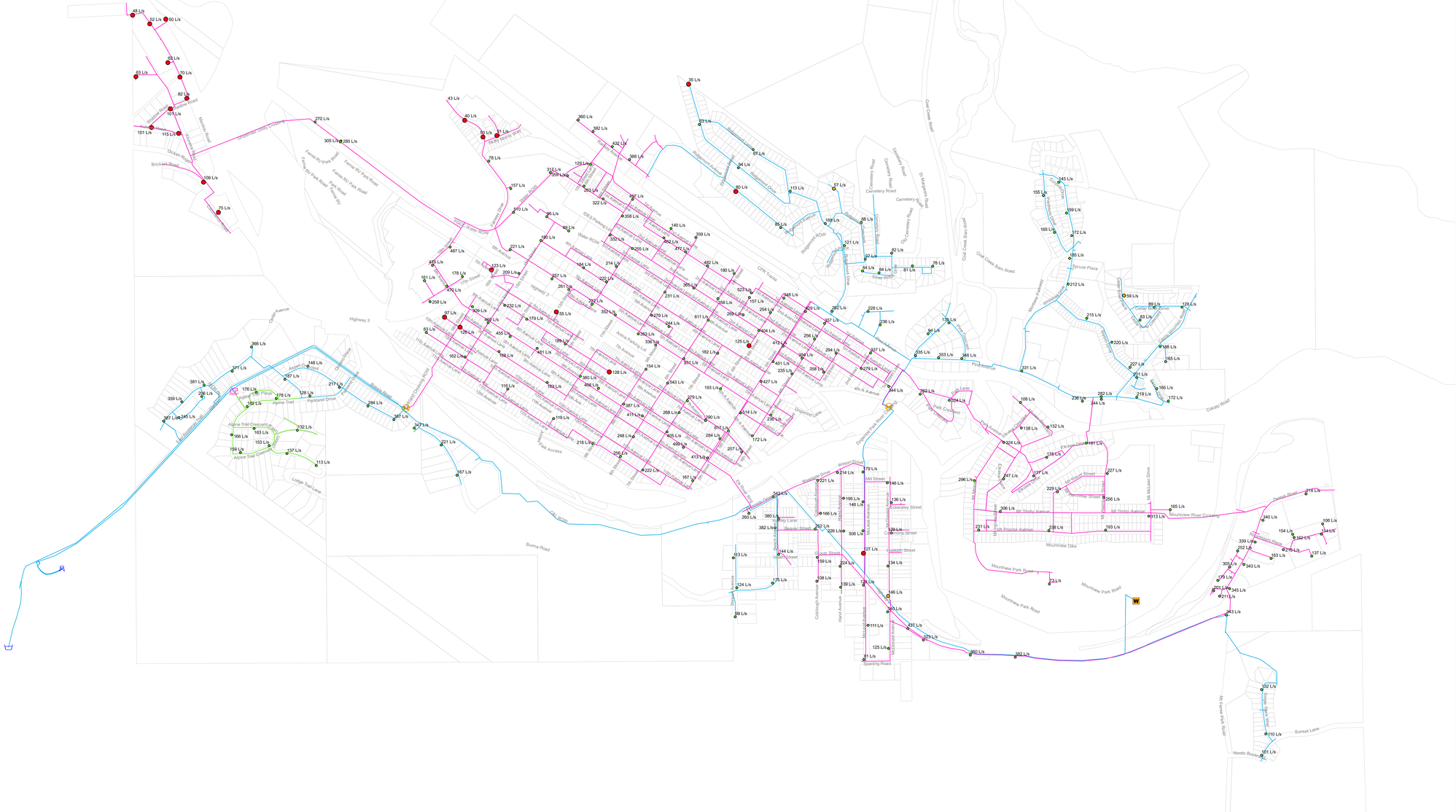
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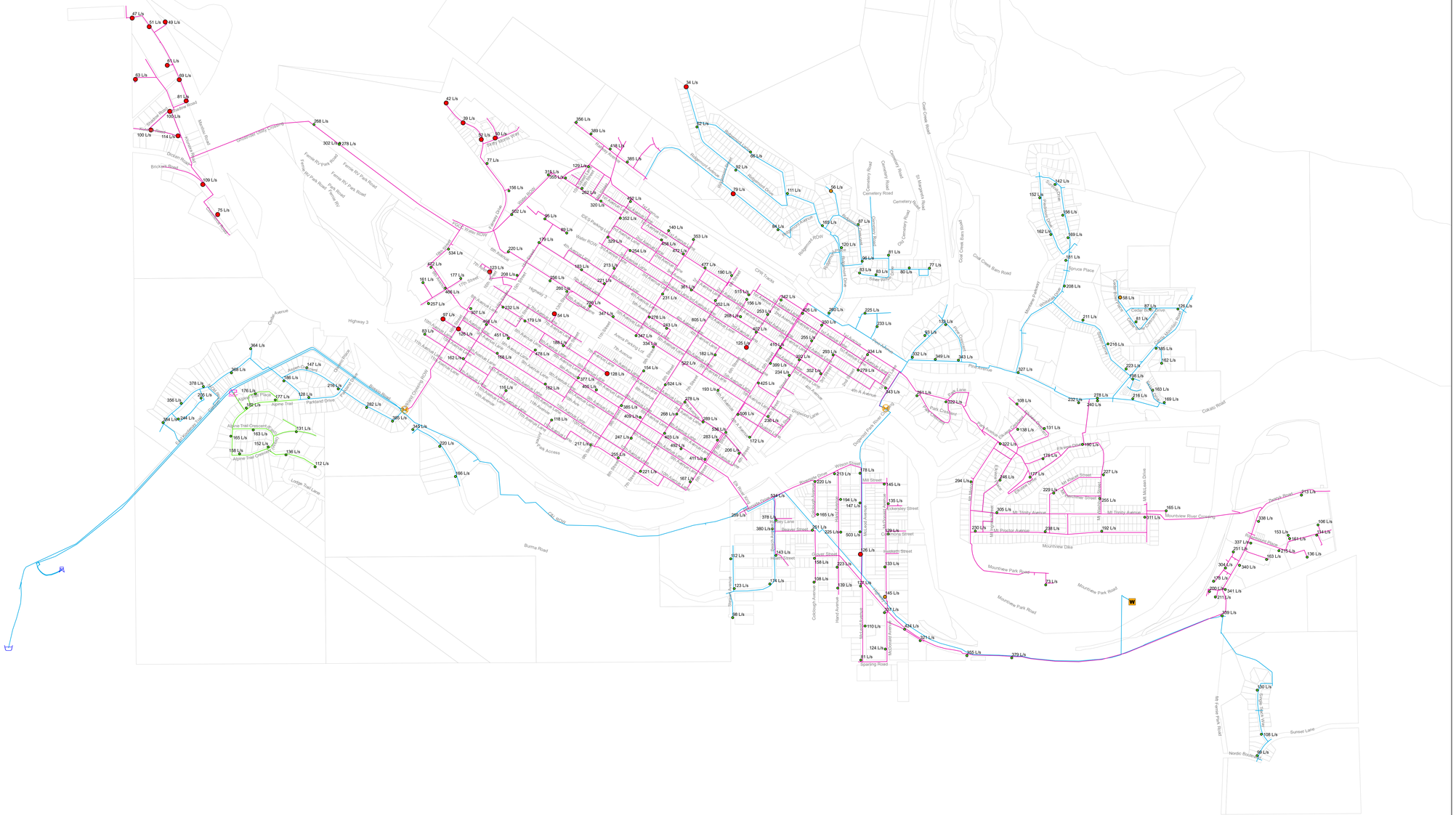
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Kilometers

N E S W

Figure 6.2

Document Path: W:\2018-041-FER\02\Mapping\2018-041-FER_2032PHDResults_r1_2020-02-19.mxd


Highway 3
Coleman Road
Dicken Road
Brickwell Road
Fernie RV Park Road
Fernie RV Park Road
Fernie RV Park


Highway 3
Burma Road
Coal Creek Road
Coal Creek Barn Road
Cemetery Road
Old Cemetery Road
St Margarets Road
Dicken Road
Brickmakers Road
Morrison Road
Chisholm Dairy Driveway
Fernie RV Park Road
Fernie RV Park Road
Fernie RV Park Road

7.0 Proposed System Improvements

Water system improvements were recommended based on the assessment of the City water distribution system under future growth conditions. Water system improvement projects were developed to satisfy the 2032 pressure and flow requirements of the City.

The system improvements are summarized in **Table 7.1** and shown in **Figure 7.1**. Details on the proposed improvements can be found in **Appendix H**.

Table 7.1: Summary of Proposed Improvements Projects

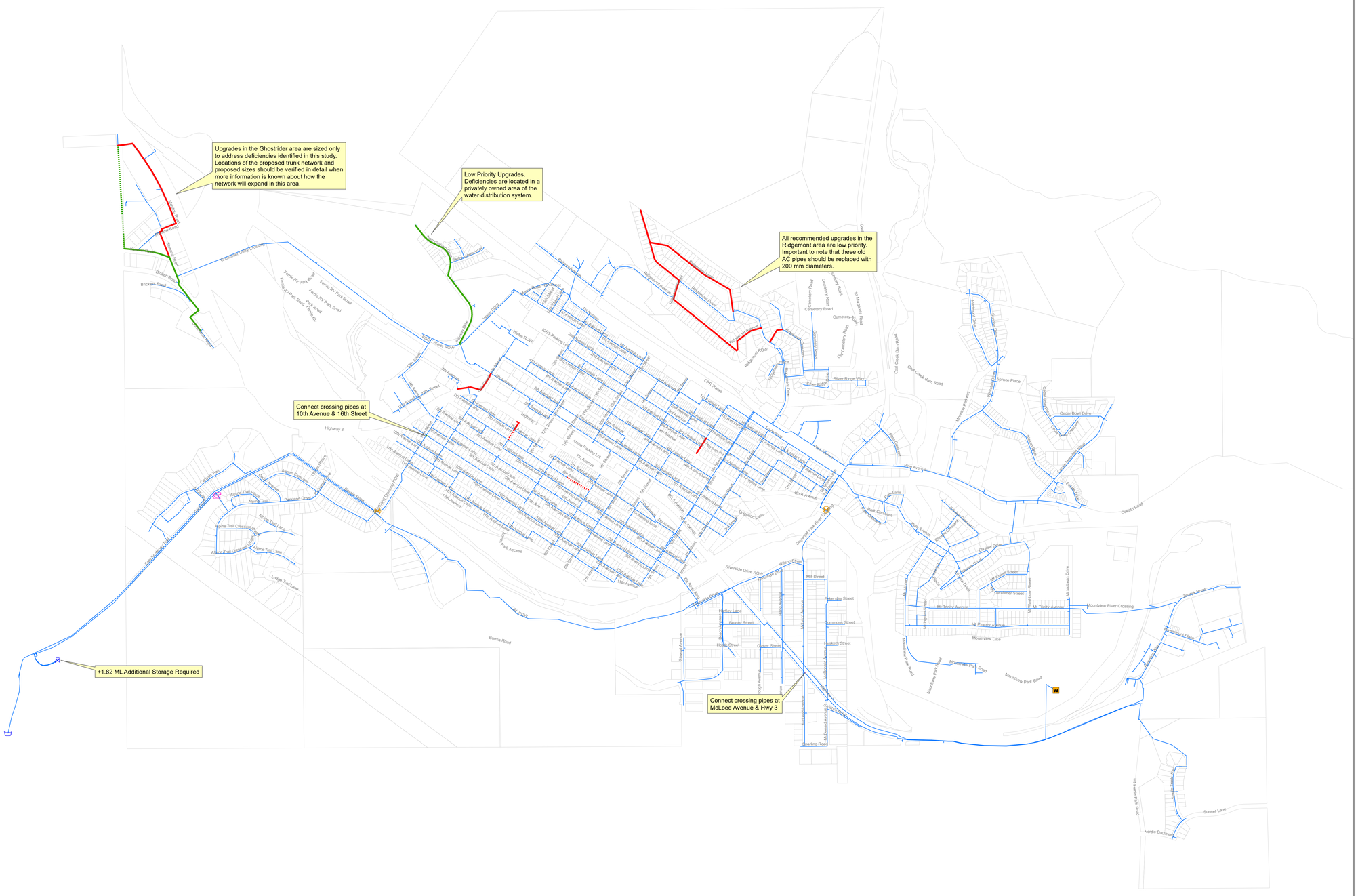
Improvement Type	Quantity
New Water Mains	0.7 km
Water Main Upgrades	4.0 km
Additional Storage	+ 1.8 ML

It should be noted that the City is planning to extend the water service boundary in the Ghostrider neighbourhood; however, at the time of this analysis details on how the water main network will be extended were not available. As such, the water main network improvements recommended in the Ghostrider neighbourhood were sized only to address the fire flow deficiencies identified as part of this study. The water main network improvements were not sized to provide adequate fire flows in the future network that will extend beyond the current water service boundary. When the layout of the proposed water main extensions are known, the recommended pipe sizes in the Ghostrider neighbourhood should be reviewed to ensure that fire flows can be provided in the new network.

Furthermore, as noted in **Section 6.4**, best practices typically recommend diameters no less than 200 mm (if not 250 mm) in commercial, industrial, and institutional areas.

Note that the additional recommended storage does not have to be located at the Fairy Creek reservoir site.

With the proposed system improvements, there are some remaining pressure and fire flow deficiencies. The remaining deficiencies and explanations for why they were not addressed are described in **Appendix F** and **Appendix G**.



Legend

- Fairy Creek Spring
- James White Park Well
- Alpine Trail Booster Station
- Fairy Creek Storage Reservoir
- Existing PRV Station
- Existing Water Main

New Water Main

- 200 mm
- 250 mm
- 400 mm

Water Main Upgrade

- 200 mm
- 250 mm

System Improvements

GeoAdvice Engineering Inc.

Project: **Water Model Development, Calibration, and Capacity Analysis**
Client: **City of Fernie**
Date: **February 2020**
Created by: **AKd'A**
Reviewed by: **WdS**

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0 0.375 0.75 1.5
Kilometers

N E S W

Figure 7.1

8.0 Redundancy Analysis

The "criticality" of a pipe measures how critical the pipe is in effect to the overall system if a pipe ruptures, breaks, or is abandoned. The redundancy analysis simulated how the water distribution system would respond in the event of a pipe failure/abandonment in the system.

The criteria levels of Low/Medium/High were then defined as shown in **Table 8.1**.

Table 8.1: Criticality Level Criteria

Criticality Level	Flow Condition	Pressure Condition
Low	OK	OK
Medium	Cannot supply demand to dead end pipes	OK
High	Cannot supply demand to looped pipes	Cannot maintain minimum pressure

The "Flow Condition" criterion consists of three possible results:

- A result of "OK" indicates that the system remains hydraulically connected after the abandonment of the corresponding pipe.
- A result of "Cannot supply demand to dead end pipes" occurs when abandoning the corresponding pipe causes a system disconnection (dead end pipes being disconnected).
- A result of "Cannot supply demand to looped pipes" occurs when abandoning the corresponding pipe causes a system disconnection (looped pipes being disconnected).

The "Pressure Condition" criterion consists of two possible results:

- A result of "OK" indicates that the system pressure remains above 44 psi under PHD after the abandonment of the corresponding pipe.
- A result of "Cannot maintain minimum pressure" indicates that the system pressure falls below 44 psi under PHD after the abandonment of the corresponding pipe.

The criticality analysis was completed on the future (2032) PHD scenario. The redundancy analysis results are summarized in **Table 8.2**.

Table 8.2: Criticality Analysis Results

Criticality Level	Number of Pipes
Low	888
Medium	777
High	39



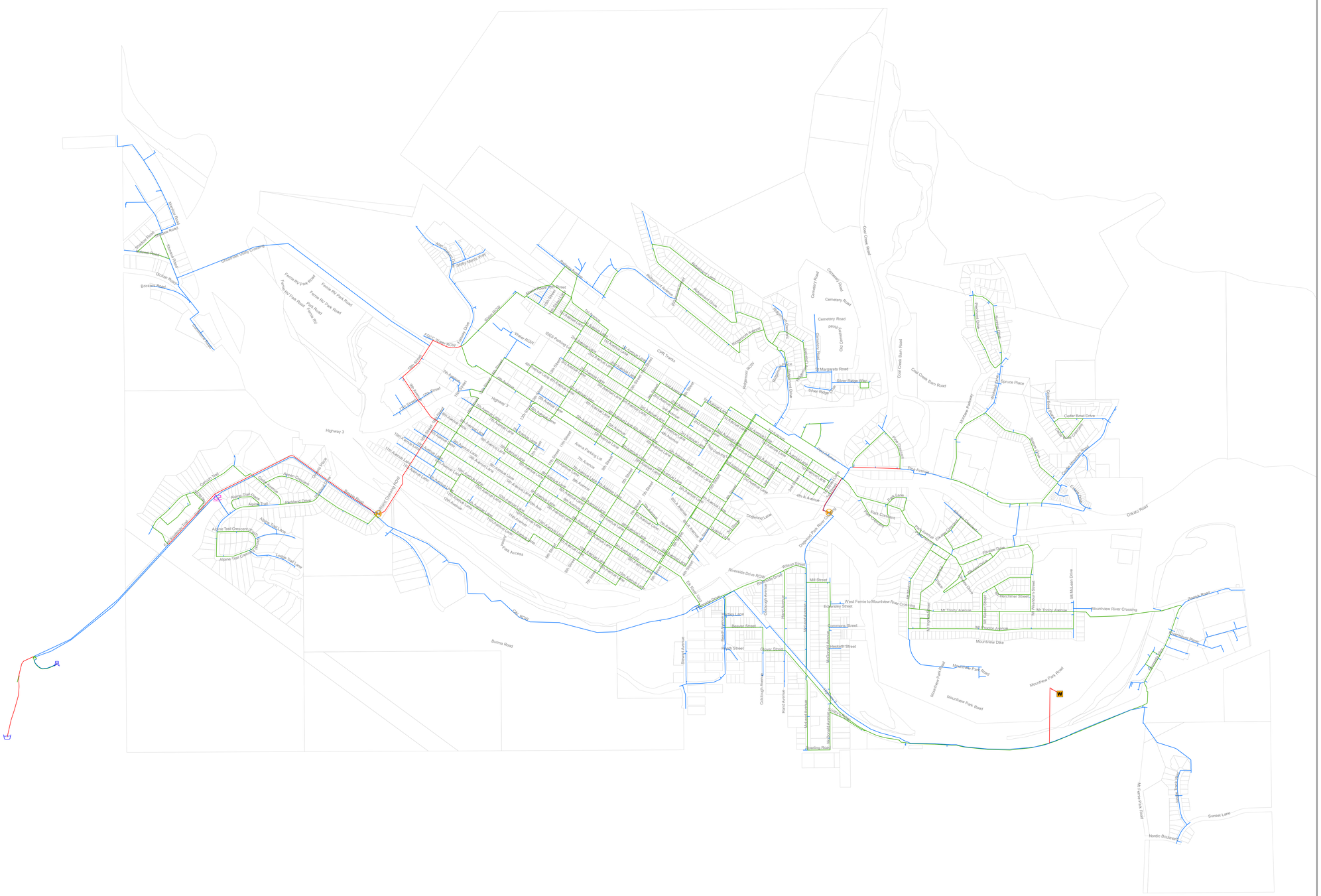
As shown in **Table 8.2**, there are 888 pipes with a "Low" criticality level. If a pipe is marked with a "Low" criticality, it is a candidate for abandonment. That is to say, if all of the pipes along a segment of water main, located between two tees or two crosses, have a "Low" criticality, that entire segment could be abandoned without triggering any new pressure or fire flow deficiencies in the system.

It is important to note that the redundancy analysis assumes that only one pipe segment is abandoned at a time. Therefore, if the City intends to abandon multiple water main segments, further analysis should be conducted to assess the combined impact of all planned abandonments.

The redundancy analysis also shows that there are 39 pipes with a "High" criticality level. These are areas where the City should consider adding redundancy to the system in the form of additional looping or twinning of key mains.

The redundancy analysis results are shown in **Figure 8.1**.

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Highway 3
Fairy Creek Spring
James White Park Well
Alpine Trail Booster Station
Fairy Creek Storage Reservoir
Existing PRV Station
Fairy Creek
Coal Creek Ban Road
Cemetery Road
Cemetery Road
Cemetery Road
Old Cemetery Road
Cemetery Road
Cemetery Road

9.0 Conclusions and Recommendations

9.1 Summary of Study Findings

GeoAdvice Engineering was retained by the City of Fernie to build and calibrate the hydraulic model of the City's water distribution system using InfoWater. Using the new hydraulic model, GeoAdvice analyzed the hydraulic capacity of the City's water distribution system and recommended improvements necessary to service the projected future 2032 growth scenario.

The following is a list of key conclusions drawn while performing this study:

- GIS data was the primary source of up-to-date information on the water distribution system to build the model.
- Field measurements from 17 hydrant tests and 42 static pressure measurements were used to calibrate the model.
- Water demand data was determined based on bulk meter water usage and anecdotal data provided by the City. The City's 2018 ADD is 92 L/s, including demand from the shadow population.
- Future water demands were estimated based on 2032 residential unit projections. There are currently 3,134 serviced residential units, and the total future serviced residential units are predicted to be 3,720 by 2032.
- The hydraulic modeling results (with no system improvements) indicate that 19 demand nodes experience low pressures under the 2018 and 2032 PHD scenarios (< 44 psi), and 28 fire nodes are unable to satisfy the required fire flow in the 2018 and 2032 MDD+FF scenarios (< 22 psi).
- The pump station and PRV station capacity analyses indicate that all of the City's pump station and PRV stations have sufficient capacity under the existing and future scenarios.
- The proposed system improvements to eliminate the system capacity deficiencies are summarized below:
    - 0.7 km of new mains
    - 4.0 km of water main upgrades
    - 1.8 ML of additional storage
- A redundancy analysis was performed to identify areas where pipes could be abandoned and where additional redundancy should be added to the system. 888 pipes were identified as having a "Low" criticality level and are candidates for abandonment. 39 pipes were identified as having a "High" criticality level and represent areas where additional redundancy may be required.

9.2 Recommendations Following the Study

Based upon the findings from this analysis, GeoAdvice recommends that the City plan to undertake the proposed improvement projects to relieve system deficiencies and prepare for future development. In addition, GeoAdvice recommends the following:

1. **Field Verification of Water Distribution System Information**
   The City should undertake verification of the existing diameter information for the proposed pipe upgrades summarized in **Appendix H** prior to detailed design.

2. **Upgrade Timing and Ranking Analyses**
   Timing and ranking analyses should be performed for the system improvement recommendations identified in this report.

3. **EPS Model Calibration**
   Utilizing the calibrated steady state model and the information collected in the field from a multi-day flow and pressure monitoring program, a detailed extended period simulation (EPS) model calibration should be completed.

4. **Water Quality Modeling**
   Consideration of water quality within the distribution system should be incorporated into the modeling and analyzed.

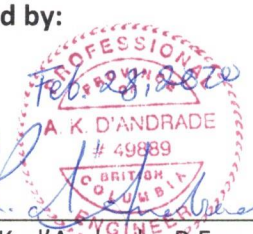
5. **Unidirectional Flushing Program**
   A unidirectional flushing (UDF) program should be developed for the City's water distribution system. GeoAdvice can use the City's model to design flushing sequences and validate the sequences to ensure key flushing criteria are met (e.g. minimum flushing velocities achieved, system pressures maintained, unidirectional flow achieved, etc.).

6. **Development of Modeling Standards, Conventions and Guidelines**
   Modeling rules should be established for the City to observe when updating and running the model.

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

Submission

Prepared by:

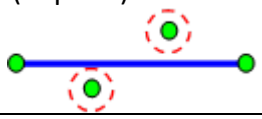
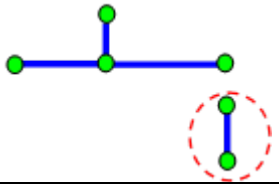
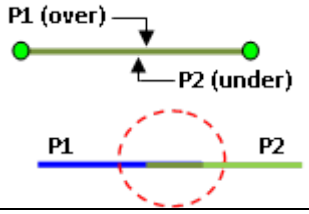
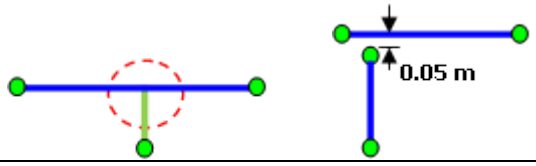
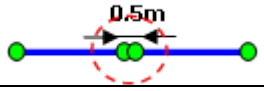
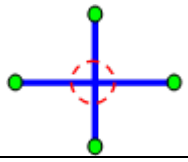
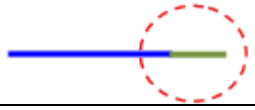


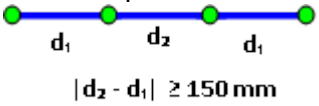
Andrea K. d'Andrade, P.Eng.
Senior Water Resources Engineer

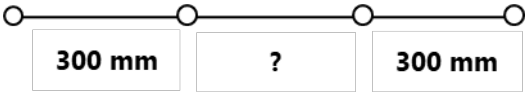
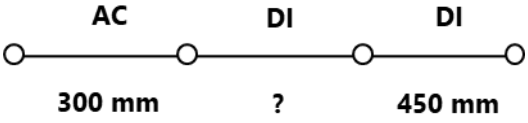
Reviewed and Approved by:

Werner de Schaetzen, Ph.D., P.Eng.
Project Manager

Appendix A Data Gaps and Connectivity Fixes

Connectivity Issue Type	Solution
Disconnected (Orphan) Nodes 	Checked for proper connectivity in GIS. No orphan nodes in GIS. Deleted orphan nodes.
Disconnected (Orphan) Links 	Checked for proper connectivity in GIS. No orphan links in GIS. Deleted orphan links.
Overlapping Links 	Checked for proper connectivity in GIS. No overlapping links in GIS. Deleted links in model not in GIS.
Parallel Links 	Checked GIS for proper connectivity. Deleted links in model not in GIS.
Link Split Candidates 	Fixed connectivity based on GIS.
Nodes in Close Proximity 	Fixed connectivity based on GIS.
Crossing Links, Not Connected 	Fixed connectivity based on GIS.
Self-Overlap Links 	Checked GIS for proper connectivity. Redrew links.

Connectivity Issue Type	Solution
Self-Intersect Links 	Checked GIS for proper connectivity. Redrew links.
Link Diameter Discrepancies 	Checked GIS for correct diameter.

Data Gap Issue Type	Solution
Missing Pipe Diameter or Material	**Rule 1:** Identical upstream and downstream pipe diameter then use same diameter;  Diameter: 1 = 3, 2 unknown, then 1 = 2 = 3  The missing pipe diameter would be inferred as 300 mm. **Rule 2:** Different diameter but same upstream and/or downstream material then use the same diameter as the pipe matching material;  Material: 2 = 1, or 2 = 3 Diameter: 2 = 1, or 2 = 3 (Respectively)  The missing pipe diameter would be inferred as 450 mm.

Appendix B Calibrated Pipe Roughness Coefficients

Pipe Group	Material	Diameter (mm)	Installation Year	C-Factor
1	AC	All	All	90
2	CI	≤ 200	All	95
3	CI	200 - 350	All	100
4	CI	> 350	All	105
5	COPP	All	All	105
6	DI	≤ 200	1940 - 1959	115
7	DI	≤ 200	1960 - 1979	120
8	DI	≤ 200	1980 - 1999	125
9	DI	≤ 200	≥ 2000	130
10	DI	200 - 350	1920 - 1939	120
11	DI	200 - 350	≥ 1980	140
12	DI	> 350	1980 - 1999	145
13	DI	> 350	≥ 2000	150
14	GALV	All	All	115
15	HDPE	All	All	150
16	MPX	All	All	125
17	PVC	≤ 200	1980 - 1999	135
18	PVC	≤ 200	≥ 2000	140
19	PVC	200 - 350	1980 - 1999	140
20	PVC	200 - 350	≥ 2000	145
21	PVC	> 350	1980 - 1999	145
22	PVC	> 350	≥ 2000	150
23	STL	All	All	150
24	UNKN	All	All	125

Appendix C Hydrant Test Data

Test #	Flow Hydrant Location	Pressure Zone	Date	Time	Flow Hydrant	Pressure Hydrant	Flow (L/s)	Static Pressure (psi)	Residual Pressure (psi)	Pressure Drop (psi)
1	Ghostrider	1	2019-10-22	9:41 AM	288	287	48	76	56	20
2	Ridgemont	2	2019-10-22	11:10 AM	78	79	48	66	60	6
3	Castle Mountain	2	2019-10-22	1:50 PM	204	203	48	75	70	5
4	River Side	1	2019-10-22	3:26 PM	211	210	52	102	99	3
5	Cedars	2	2019-10-22	12:58 PM	298	299	58	90	80	10
6	West Fernie	2	2019-10-22	11:55 AM	N/A	N/A	58	107	102	5
7	Parkland	2	2019-10-22	10:52 AM	319	301	57	86	85	1
8	Silver Ridge	2	2020-02-03	9:30 AM	274	268	64	74	44	30
9	Ridgemont (retest of Test 2)	2	2020-02-03	9:08 AM	78	79	26	68	48	20
10	Fairway	1	2020-02-03	10:22 AM	169	168	69	80	70	10
11	Ghostrider (retest of Test 1)	1	2020-02-03	10:54 AM	288	287	45	78	34	44
12	Alpine Trail	3	2020-02-03	11:30 AM	195	196	64	106	50	56
13	Alpine Trail Cres	3	2020-02-03	11:54 AM	250	221	50	84	50	34
14	13th St	1	2020-02-03	1:30 PM	269	54	73	89	80	9
15	10th Ave	1	2020-02-03	1:53 PM	291	70	73	89	70	19
16	15th Street	1	2020-02-03	2:21 PM	69	296	75	84	72	12
17	McLoad	1	2020-02-03	2:46 PM	N/A	N/A	61	81	66	15

Appendix D Model Calibration Results – Static Pressures

Hydrant #	Pressure Zone	Elevation (m)	Static Pressure (psi)		Static Pressure Difference	
			Measured	Modeled	(psi)	(%)
2	1	1012.2	75	70	+ 4.6	+ 6%
151	1	998.2	90	90	+ 0.3	+ 0%
18	1	1005.2	85	80	+ 5.2	+ 6%
20	1	1007.8	80	76	+ 3.9	+ 5%
11	1	1010.9	75	72	+ 3.3	+ 4%
3	1	1013.0	73	69	+ 4.0	+ 5%
5	1	1011.3	75	71	+ 3.7	+ 5%
140	1	998.0	80	90	- 10.0	- 13%
36	1	1005.0	80	80	- 0.1	- 0%
23	1	1006.0	85	79	+ 6.3	+ 7%
44	1	1007.9	80	76	+ 4.1	+ 5%
149	1	1009.3	78	74	+ 4.0	+ 5%
226	1	1006.0	80	79	+ 1.3	+ 2%
43	1	1006.0	80	79	+ 1.4	+ 2%
47	1	1004.0	85	81	+ 3.5	+ 4%
49	1	1008.0	80	76	+ 4.2	+ 5%
63	1	1006.0	85	79	+ 6.4	+ 8%
321	1	1006.0	80	79	+ 1.4	+ 2%
138	1	1002.6	85	83	+ 1.6	+ 2%
135	1	1003.0	85	83	+ 2.1	+ 3%
165	1	1004.7	80	81	- 0.5	- 1%
164	1	1005.5	80	79	+ 0.7	+ 1%

Hydrant #	Pressure Zone	Elevation (m)	Static Pressure (psi)		Static Pressure Difference	
			Measured	Modeled	(psi)	(%)
141	1	1004.6	85	81	+ 4.3	+ 5%
152	1	1003.3	85	83	+ 2.5	+ 3%
46	1	1003.0	85	83	+ 2.2	+ 3%
136	1	1004.2	82	81	+ 0.9	+ 1%
219	1	1009.7	70	73	- 3.4	- 5%
234	1	995.4	95	94	+ 1.3	+ 1%
79	2	1043.4	60	66	- 6.2	- 10%
78	2	1054.4	50	51	- 0.7	- 1%
84	2	1040.1	70	71	- 1.0	- 1%
80	2	1037.2	75	75	+ 0.0	- 0%
85	2	1035.1	75	78	- 3.1	- 4%
82	2	1032.5	80	82	- 1.7	- 2%
87	2	1038.4	80	74	+ 6.6	+ 8%
88	2	1031.0	70	84	- 13.9	- 20%
272	2	1030.6	75	85	- 9.5	- 13%
275	2	1035.0	80	78	+ 1.8	+ 2%
100	2	1015.5	110	106	+ 4.1	+ 4%
243	2	1014.9	110	107	+ 3.3	+ 3%
155	2	1012.3	120	111	+ 9.6	+ 8%
177	2	1014.5	115	108	+ 7.6	+ 7%

Appendix E Model Calibration Results – Hydrant Tests

Test #	Flow Hydrant	Flow (L/s)	Pressure Hydrant	Pressure Hydrant Elevation (m)	Static Head			Residual Head		
					Measured (m)	Modeled (m)	Difference (%)	Measured (m)	Modeled (m)	Difference (%)
1*	288	N/A	287	1008.0	N/A	N/A	N/A	N/A	N/A	N/A
2*	78	N/A	79	1043.4	N/A	N/A	N/A	N/A	N/A	N/A
3	204	47.7	203	1036.5	1089.3	1090.0	- 0.1%	1085.8	1083.4	+ 0.2%
4	211	51.7	210	987.3	1059.0	1061.4	- 0.2%	1056.9	1060.1	- 0.3%
5	298	57.8	299	1028.6	1091.9	1090.4	+ 0.1%	1084.8	1076.4	+ 0.8%
6	N/A	58.1	N/A	1016.0	1091.2	1090.8	+ 0.0%	1087.7	1082.9	+ 0.4%
7	319	57.2	279	1030.4	1090.8	1091.0	- 0.0%	1090.1	1089.9	+ 0.0%
8	274	63.5	268	1031.2	1083.2	1090.0	- 0.6%	1062.1	1062.7	- 0.1%
9	78	25.9	79	1043.4	1091.2	1090.0	+ 0.1%	1077.2	1079.2	- 0.2%
10	169	69.4	168	1006.6	1062.9	1061.3	+ 0.2%	1055.9	1057.0	- 0.1%
11	288	44.9	287	1008.0	1062.9	1061.3	+ 0.2%	1031.9	1033.8	- 0.2%
12	195	64.4	196	1076.8	1151.3	1144.0	+ 0.6%	1112.0	1112.0	+ 0.0%
13	250	49.7	221	1085.9	1144.9	1144.0	+ 0.1%	1121.0	1121.0	+ 0.0%
14	269	72.6	54	1000.0	1062.6	1061.3	+ 0.1%	1056.3	1056.4	- 0.0%
15	291	72.6	70	1001.0	1063.6	1061.3	+ 0.2%	1050.2	1045.4	+ 0.5%
16	69	74.9	296	1002.5	1061.6	1061.3	+ 0.0%	1053.2	1059.9	- 0.6%
17	N/A	60.8	N/A	1002.5	1059.5	1061.3	- 0.2%	1048.9	1047.2	+ 0.2%

***Test 1 replaced by Test 11, and Test 2 replaced by Test 9.**

Test #	Flow Hydrant	Flow (L/s)	Pressure Hydrant	Pressure Hydrant Elevation (m)	Static Pressure			Residual Pressure		
					Measured (m)	Modeled (m)	Difference (%)	Measured (m)	Modeled (m)	Difference (%)
1*	288	N/A	287	1008.0	N/A	N/A	N/A	N/A	N/A	N/A
2*	78	N/A	79	1043.4	N/A	N/A	N/A	N/A	N/A	N/A
3	204	47.7	203	1036.5	52.7	53.5	- 1.3%	49.2	46.9	+ 4.8%
4	211	51.7	210	987.3	71.7	74.0	- 3.2%	69.6	72.8	- 4.5%
5	298	57.8	299	1028.6	63.3	61.8	+ 2.3%	56.3	47.9	+ 14.9%
6	N/A	58.1	N/A	1016.0	75.2	74.8	+ 0.6%	71.7	67.0	+ 6.6%
7	319	57.2	279	1030.4	60.5	60.7	- 0.3%	59.8	59.6	+ 0.4%
8	274	63.5	268	1031.2	52.0	52.8	- 1.5%	30.9	31.5	- 1.9%
9	78	25.9	79	1043.4	47.8	46.6	+ 2.6%	33.8	35.8	- 6.0%
10	169	69.4	168	1006.6	56.3	55.3	+ 1.8%	49.2	50.4	- 2.3%
11	288	44.9	287	1008.0	54.9	53.2	+ 3.0%	23.9	25.8	- 7.8%
12	195	64.4	196	1076.8	74.5	75.2	- 0.8%	35.2	35.2	- 0.0%
13	250	49.7	221	1085.9	59.1	59.2	- 0.2%	35.2	35.2	- 0.0%
14	269	72.6	54	1000.0	62.6	61.3	+ 2.1%	56.3	56.4	- 0.2%
15	291	72.6	70	1001.0	62.6	60.3	+ 3.7%	49.2	44.4	+ 9.8%
16	69	74.9	296	1002.5	59.1	59.3	- 0.3%	50.6	57.4	- 13.4%
17	N/A	60.8	N/A	1002.5	57.0	56.6	+ 0.7%	46.4	44.6	+ 3.8%

***Test 1 replaced by Test 11, and Test 2 replaced by Test 9.**

Appendix F PHD Pressure Deficiencies

ID	PHD Pressure (psi)			Notes
	2018	2032	2032 w/Upgrades	
JCT-0195	1.4	-1.5	65.2	Addressed by proposed system improvements.
JCT-0196	1.5	-1.4	65.3	Addressed by proposed system improvements.
JCT-0197	16.6	14.3	67.1	Addressed by proposed system improvements.
JCT-0198	16.6	14.3	67.1	Addressed by proposed system improvements.
JCT-0200	42.3	40.9	69.5	Addressed by proposed system improvements.
JCT-0203	35.6	33.8	69.8	Addressed by proposed system improvements.
JCT-0204	35.6	33.8	69.8	Addressed by proposed system improvements.
JCT-0205	35.6	33.8	69.8	Addressed by proposed system improvements.
JCT-0206	33.4	31.7	67.7	Addressed by proposed system improvements.
JCT-0212	35.6	33.8	69.8	Addressed by proposed system improvements.
JCT-0213	35.6	33.8	69.8	Addressed by proposed system improvements.
JCT-0248	43.5	41.9	42.1	The deficiency is caused by high elevation. It is non-critical, since pressure is larger than 40 psi.
JCT-0249	43.0	41.4	41.6	The deficiency is caused by high elevation. It is non-critical, since pressure is larger than 40 psi.
JCT-0300	35.8	34.2	34.3	The deficiency is caused by high elevation. It is non-critical, since this is located on an irrigation line for the cemetery.
JCT-0303	35.7	34.1	34.3	The deficiency is caused by high elevation. It is non-critical, since this is located on an irrigation line for the cemetery.
JCT-0304	35.9	34.3	34.4	The deficiency is caused by high elevation. It is non-critical, since this is located on an irrigation line for the cemetery.
JCT-1302	32.9	31.1	69.6	Addressed by proposed system improvements.
JCT-1303	1.7	-1.2	65.5	Addressed by proposed system improvements.
JCT-1304	32.9	31.1	69.6	Addressed by proposed system improvements.

Appendix G MDD+FF Fire Flow Deficiencies

ID	Required Fire Flow (L/s)	MDD+FF Available Fire Flow (L/s)			Notes
		2018	2032	2032 w/Upgrades	
JCT-0018	150	48	47	158	Addressed by proposed system improvements.
JCT-0020	150	52	51	154	Addressed by proposed system improvements.
JCT-0021	150	50	49	111	The hydrant is located on a dead end, where the required fire flow is available upstream, within 100 m.
JCT-0024	150	70	69	161	Addressed by proposed system improvements.
JCT-0025	150	82	81	165	Addressed by proposed system improvements.
JCT-0029	150	63	63	79	The hydrant is located on a long dead end. New hydrants should be installed on the proposed water main along Brenners Road to supplement adequate fire flow to this location.
JCT-0039	150	101	100	190	Addressed by proposed system improvements.
JCT-0041	150	101	100	177	Addressed by proposed system improvements.
JCT-0043	150	115	114	197	Addressed by proposed system improvements.
JCT-0047	150	75	75	165	Addressed by proposed system improvements.
JCT-0049	150	109	109	188	Addressed by proposed system improvements.
JCT-0195	150	43	42	183	Addressed by proposed system improvements.
JCT-0197	60	40	39	192	Addressed by proposed system improvements.
JCT-0212	60	51	50	127	Addressed by proposed system improvements.
JCT-0248	60	35	34	67	Addressed by proposed system improvements.
JCT-0264	60	57	56	63	Addressed by proposed system improvements.
JCT-0324	90	80	79	119	Addressed by proposed system improvements.
JCT-0466	150	125	125	313	Addressed by proposed system improvements.

ID	Required Fire Flow (L/s)	MDD+FF Available Fire Flow (L/s)			Notes
		2018	2032	2032 w/Upgrades	
JCT-0704	150	128	128	278	Addressed by proposed system improvements.
JCT-0843	150	55	54	177	Addressed by proposed system improvements.
JCT-0862	150	123	123	176	Addressed by proposed system improvements.
JCT-0874	150	126	126	599	Addressed by proposed system improvements.
JCT-0881	150	97	97	159	Addressed by proposed system improvements.
JCT-1161	60	59	58	58	The hydrant is located on a dead end, where the required fire flow is available upstream, within 100 m.
JCT-1254	150	62	61	140	The hydrant has a long lead; the required fire flow is available upstream, within 100 m.
JCT-1304	60	53	52	217	Addressed by proposed system improvements.
JCT-1448	150	146	145	170	Addressed by proposed system improvements.
JCT-1458	150	127	126	202	Addressed by proposed system improvements.

Appendix H Proposed System Improvements

Water Main Improvements

Pipe ID	Location	Type	Length (m)	Existing Diameter (mm)	Upgrade Diameter (mm)
PPE-GA-0002	10th Avenue	New Pipe Loop	9.3	-	250
PPE-3010689	13th Street	Pipe Upgrade	47.5	150	200
PPE-GA-0003	13th Street	New Pipe Loop	53.6	-	200
PPE-3010540_1	15th Street	Pipe Upgrade	19.5	150	200
PPE-3010269	6th Street	Pipe Upgrade	36.3	150	200
PPE-3010365_1	6th Street	Pipe Upgrade	40.9	150	200
PPE-3010365_2	6th Street	Pipe Upgrade	4.3	150	200
PPE-GA-0004	8th Avenue	New Pipe Loop	122.8	-	200
PPE-3010149_1	Alan Graham Drive	Pipe Upgrade	57.3	150	250
PPE-3010149_2	Alan Graham Drive	Pipe Upgrade	114.0	150	250
PPE-3010149_4	Alan Graham Drive	Pipe Upgrade	20.2	150	250
PPE-3010149_5	Alan Graham Drive	Pipe Upgrade	111.3	150	250
PPE-GA-0001	Brenners Road	New Pipe Loop	472.0	-	250
PPE-3010011	Brenners Road	Pipe Upgrade	1.9	150	250
PPE-3010035_1	Commercial Road/Dicken Road	Pipe Upgrade	190.6	150	250
PPE-3010008_1	Dicken Road	Pipe Upgrade	1.5	150	250
PPE-3010008_2	Dicken Road	Pipe Upgrade	97.2	150	250
PPE-3010039_2	Dicken Road	Pipe Upgrade	31.5	150	250
PPE-3010152_1	Fairway Drive	Pipe Upgrade	138.5	150	250
PPE-3010152_2	Fairway Drive	Pipe Upgrade	39.2	150	250
PPE-3010457	Fairway Drive	Pipe Upgrade	184.5	200	250



Pipe ID	Location	Type	Length (m)	Existing Diameter (mm)	Upgrade Diameter (mm)
PPE-3010541_1	Highway 3	Pipe Upgrade	56.5	150	200
PPE-3010541_2	Highway 3	Pipe Upgrade	3.6	150	200
PPE-3010704_1	Highway 3	Pipe Upgrade	49.8	150	200
PPE-3010028	Ktunaxa Road	Pipe Upgrade	123.6	150	200
PPE-3010038_1	Ktunaxa Road	Pipe Upgrade	0.5	150	200
PPE-3010039	Ktunaxa Road	Pipe Upgrade	94.1	150	250
PPE-3010029	Kutenai Road	Pipe Upgrade	62.4	150	250
PPE-3010034_1	Kutenai Road	Pipe Upgrade	14.1	150	250
PPE-3010034_2	Kutenai Road	Pipe Upgrade	118.0	150	250
PPE-3010034_3	Kutenai Road	Pipe Upgrade	17.0	150	250
PPE-3010001	Manitou Road	Pipe Upgrade	98.9	150	200
PPE-3010002	Manitou Road	Pipe Upgrade	55.1	150	200
PPE-3010003_1	Manitou Road	Pipe Upgrade	70.4	150	200
PPE-3010042	Manitou Road	Pipe Upgrade	7.0	150	200
PPE-GA-0005	McLeod Avenue	New Pipe Loop	0.6	-	400
PPE-3010182_1	Ridgemont Avenue	Pipe Upgrade	133.9	150	200
PPE-3010182_2	Ridgemont Avenue	Pipe Upgrade	59.9	150	200
PPE-3010232	Ridgemont Avenue	Pipe Upgrade	175.6	150	200
PPE-3010238_1	Ridgemont Avenue	Pipe Upgrade	111.6	150	200
PPE-3010238_2	Ridgemont Avenue	Pipe Upgrade	77.2	150	200
PPE-3010229	Ridgemont Crescent	Pipe Upgrade	88.5	150	200
PPE-3010242_1	Ridgemont Drive	Pipe Upgrade	207.7	150	200
PPE-3010242_2	Ridgemont Drive	Pipe Upgrade	14.2	150	200
PPE-3010245_1	Ridgemont Drive	Pipe Upgrade	153.2	150	200

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Pipe ID	Location	Type	Length (m)	Existing Diameter (mm)	Upgrade Diameter (mm)
PPE-3010245_2	Ridgemont Drive	Pipe Upgrade	6.8	150	200
PPE-3010234_1	Ridgemont Lane	Pipe Upgrade	263.7	150	200
PPE-3010234_2	Ridgemont Lane	Pipe Upgrade	19.8	150	200
PPE-3010246	Ridgemont Lane	Pipe Upgrade	250.0	150	200
PPE-3010239	Ridgemont Street	Pipe Upgrade	80.8	150	200
PPE-3010006	Shadow Road	Pipe Upgrade	61.9	150	200
PPE-3010027_1	Shadow Road	Pipe Upgrade	21.8	150	200
PPE-3010030_1	Shadow Road	Pipe Upgrade	1.0	150	200
PPE-3010043	Shadow Road	Pipe Upgrade	9.0	150	200
PPE-GA-0002	10th Avenue	New Pipe Loop	9.3	-	250
PPE-3010689	13th Street	Pipe Upgrade	47.5	150	200
PPE-GA-0003	13th Street	New Pipe Loop	53.6	-	200
PPE-3010540_1	15th Street	Pipe Upgrade	19.5	150	200
PPE-3010540_2	15th Street	Pipe Upgrade	69.8	150	200
PPE-3010269	6th Street	Pipe Upgrade	36.3	150	200
PPE-3010365_1	6th Street	Pipe Upgrade	40.9	150	200

Storage Improvements

Additional Required Storage (ML)
+ 1.82



Appendix B

City of Fernie Sanitary Sewer Collection System Modeling and Capacity Analysis

City of Fernie Sanitary Sewer Collection System Modeling and Capacity Analysis

Final Report

Prepared for:
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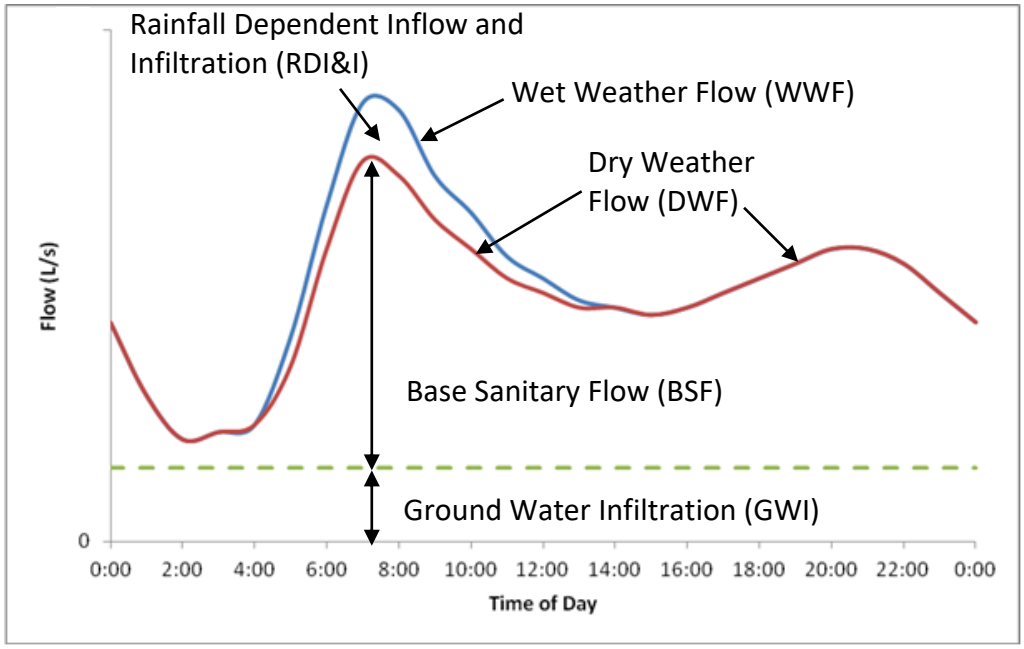
Definitions

Daily flow conveyed in a sanitary sewer system can be generally divided into five (5) components:

1 Ground Water Infiltration (GWI)
2 Base Sanitary Flow (BSF)
3 Dry Weather Flow (DWF)
4 Rainfall Dependent Inflow and Infiltration (RDI&I)
5 Wet Weather Flow (WWF)

Their relationship is shown in **Figure 1**.

Figure 1: Flow Components Hydrograph



Ground Water Infiltration (GWI) – Ground water infiltration results from the movement of ground water in the saturated zone into the sewer system through defects in the components of the sewer system located below the water table.

Base Sanitary Flow (BSF) – All wastewater from residential, commercial, institutional, and industrial sources that the sanitary sewer system is intended to convey.

Dry Weather Flow (DWF) – The portion of the total flow that is composed of BSF and GWI. DWF = GWI + BSF.

Average Dry Weather Flow (ADWF) – The value of the diurnally varying Dry Weather Flow, averaged over a 24-hour period.

Rainfall Dependent I&I (RDI&I) – Rainfall dependent inflow and infiltration equals rainfall-induced infiltration plus all sources of inflow.

Wet Weather Flow (WWF) – All flow contributions carried by the sanitary sewer system during wet weather. WWF = GWI + BSF + RDI&I.

Peak Wet Weather Flow (PWWF) – All flow contributions carried by the sanitary sewer system during peak wet weather.

1.0 Introduction

GeoAdvice Engineering Inc. (GeoAdvice) was retained by the City of Fernie, BC (City) to build the hydraulic model of the City sanitary sewer collection system. This report describes the methodology and assumptions used to build, calibrate and analyze the hydraulic model. **Table 1.1** summarizes the main components of the sanitary sewer collection system model.

Table 1.1: Model Statistics of Current System

Component	Total
Manholes	749
Gravity Mains	51.6 km
Forcemains	3.0 km
Lift Stations	8

The sewer model was built using the InfoSWMM software program (Innovyze). InfoSWMM is a sanitary sewer system modeling and management software application.

In the preparation of this report, GeoAdvice would like to acknowledge the support of the following City Staff:

- Ms. Zabrina Pendon
- Ms. Lisa Janssen
- Ms. Jenny Weir

2.0 Model Build

The hydraulic model build was divided into multiple tasks as follows:

- Task 1: Data Collection and Review
- Task 2: GIS Model Build
- Task 3: Data Gaps and Connectivity Analysis
- Task 4: Primary System Components
- Task 5: Node Elevation Extraction
- Task 6: Existing Base Sanitary Flow (BSF) Calculation and Allocation
- Task 7: Field Data Review and Analysis
- Task 8: Inflow & Infiltration

2.1 Data Collection and Review

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

- Previous MIKE URBAN hydraulic model
- GIS database
- As-built drawings
- Lift station operations
- Flow monitoring data
- Land-use and zoning maps
- Planning parcel data
- Previously completed I&I studies
- Growth projection data
- Official community plan (OCP)

2.2 GIS Model Build

The City's GIS data was the primary source of up-to-date information on the system to build the pipe and node network topology model. Attributes of the sewer mains, such as nominal diameter, material and age were extracted from the GIS database. The coordinate system used in the model is UTM NAD 83 Zone 11.

Pipe roughness values are summarized in **Table 2.1**.

Table 2.1: Model Roughness Coefficients

Parameter	Value
Manning's Roughness Coefficient (Gravity Mains)	n = 0.013
Hazen-Williams Roughness Coefficient (Force Mains)	C = 120

2.3 Data Gaps and Connectivity Analysis

The next task involved reviewing the GIS sanitary sewer data, identifying data gaps (e.g. missing diameter, invert etc.) and checking system connectivity (e.g. orphan pipes, orphan nodes etc.). Refer to **Appendix A** for typical connectivity and data gap issues and solutions.

2.4 Primary System Components

The City operates and maintains eight (8) sanitary lift stations throughout the sanitary network. **Table 2.2** and **Table 2.3** summarize the pump and wet well hydraulic modeling data, respectively.

Table 2.2: Pump Hydraulic Modeling Data

Lift Station Name	Model ID	Firm Capacity* (L/s)	Pump On Level (m)	Pump Off Level (m)
10th Avenue	PMP-10THAVENUE-1	25.0	0.76	0.41
	PMP-10THAVENUE-2		1.06**	0.41**
11th Street	PMP-11THSTREET-1	IP***	N/A	N/A
	PMP-11THSTREET-2		N/A	N/A
Burma Road	PMP-BURMAROAD-1	40.0	1.50	0.30
	PMP-BURMAROAD-2		1.70	0.30
Canyon Trail	PMP-CANYONTRAIL-1	17.0	1.25**	0.50**
	PMP-CANYONTRAIL-2		1.50**	0.50**
Ghostrider	PMP-GHOSTRIDER-1	25.0	1.15	0.20
	PMP-GHOSTRIDER-2		1.40	0.20
Main Sewage	PMP-MAINSEWAGE-1	189.0	1.40	0.70
	PMP-MAINSEWAGE-2		1.40	0.70
	PMP-MAINSEWAGE-3		1.60	1.00
Riverside	PMP-RIVERSIDE-1	50.0	1.25**	0.50**
	PMP-RIVERSIDE-2		1.50**	0.50**
	PMP-RIVERSIDE-3		1.75**	0.50**
West Fernie	PMP-WESTFERNIE-1	19.0	1.20	0.65
	PMP-WESTFERNIE-2		1.30	0.65

***Firm capacity determined by the model's predicted operating point based on the pump curve and forcemain parameters. Assumes the largest pump out of service.**
****On/Off levels not available. Assumed values.**
*****Pump curve not available. Modeled as an "Ideal Pump" (inflow = outflow).**

Table 2.3: Wet Well Hydraulic Modeling Data

Lift Station Name	Model ID	Dimensions	Bottom Elevation (m)	Maximum Depth (m)
10th Avenue	WW-10THAVENUE	Ø 2.00 m*	992.80*	5.00*
11th Street	WW-11THSTREET	Ø 1.82 m	992.93*	5.00*
Burma Road	WW-BURMAROAD	Ø 1.82 m	1,019.20	2.35
Canyon Trail	WW-CANYONTRAIL	Ø 1.82 m	1,028.12	4.63
Ghostrider	WW-GHOSTRIDER	Ø 1.20 m	1,001.56	4.45
Main Sewage	WW-MAINSEWAGE	5.7 m x 5.7 m	984.66	6.96
Riverside	WW-RIVERSIDE	Ø 2.44 m*	977.00*	5.00*
West Fernie	WW-WESTFERNIE	Ø 2.00 m*	989.93	5.57

***Data unavailable. Assumed values.**

2.5 Node Elevation Extraction

A Digital Elevation Model (DEM) was used to validate rim elevations in the model and to determine missing rim elevations. Elevations are based on the Canadian Geodetic Vertical Datum of 1928 (CGVD28).

2.6 Existing Base Sanitary Flow (BSF) Calculation and Allocation

Per the Urban Systems Ltd. (USL) *Growth Projection* Memorandum (July 2019), there are an estimated 3,134 residential units as of 2018 (considered to be the existing scenario), with a permanent residential population of 5,148. Based on discussions with the City, the USL memo assumed an additional 30% non-permanent (shadow) population in order to determine an average density of 2.14 capita/unit.

Table 2.6 summarizes the City's existing population data.

Table 2.4: Existing Population Data

Type	Units	Population
Permanent Population	2,411	5,148
Shadow Population	723	1,544
Total	**3,134**	**6,692**

To calculate and allocate institutional, commercial, and industrial (ICI) demands in the model, equivalent populations were calculated for each land use type based on population densities from the Master Municipal Construction Documents (MMCD) design guidelines.

Table 2.5 summarizes the MMCD equivalent population densities.

Table 2.5: Existing ICI Equivalent Population Densities

Type	Density (cap/ha)
Institutional	50
Commercial	90
Industrial	90

Sewer loads were estimated from water demands using conversion rates for each load type. These conversion rates were initially derived from past experience with other B.C. municipalities and then further adjusted during the calibration process. **Table 2.6** summarizes the existing BSF loading.

Table 2.6: Existing BSF Load Summary (Calibrated)

Land Use	Water Consumption (L/s)	Conversion Rate (%)	Base Sanitary Flow (L/s)
Single Family	7.8	85%	6.6
Multi-Family	3.1	85%	2.6
Commercial	6.3	75%	4.7
Industrial	0.2	75%	0.1
Institutional	4.7	75%	3.5
Total	**22.1**		**17.5**

Note that the calibrated BSF does not include load from the shadow population since it is matching the average dry weather flow over the course of a year. In order to determine the load from the shadow population, the MMCD loading rate for unmetered systems (350 L/cap/day) was used. The estimated total shadow population load is 6.3 L/s. The shadow population load was peaked using the single family residential pattern and was uniformly distributed throughout the City.

The next step was the allocation of sewer loads in the model. This step consisted of spatially allocating loads using the "Closest Pipe – Upstream Manhole" method. The spatial allocation was verified against the service lines provided in the City's GIS and updated if needed to ensure that loads were being directed along the correct flow path.

Figure 2.1 to **Figure 2.5** provide the loading patterns used to peak the BSF loads. The patterns provided are based on those used in other local municipalities and were adjusted to match observed field data patterns. Adjustments were made to achieve good calibration results at the

flow monitoring locations, based on the relative weighting of each land use type in their respective catchments.

Figure 2.1: Single Family Residential Load Pattern (Calibrated)

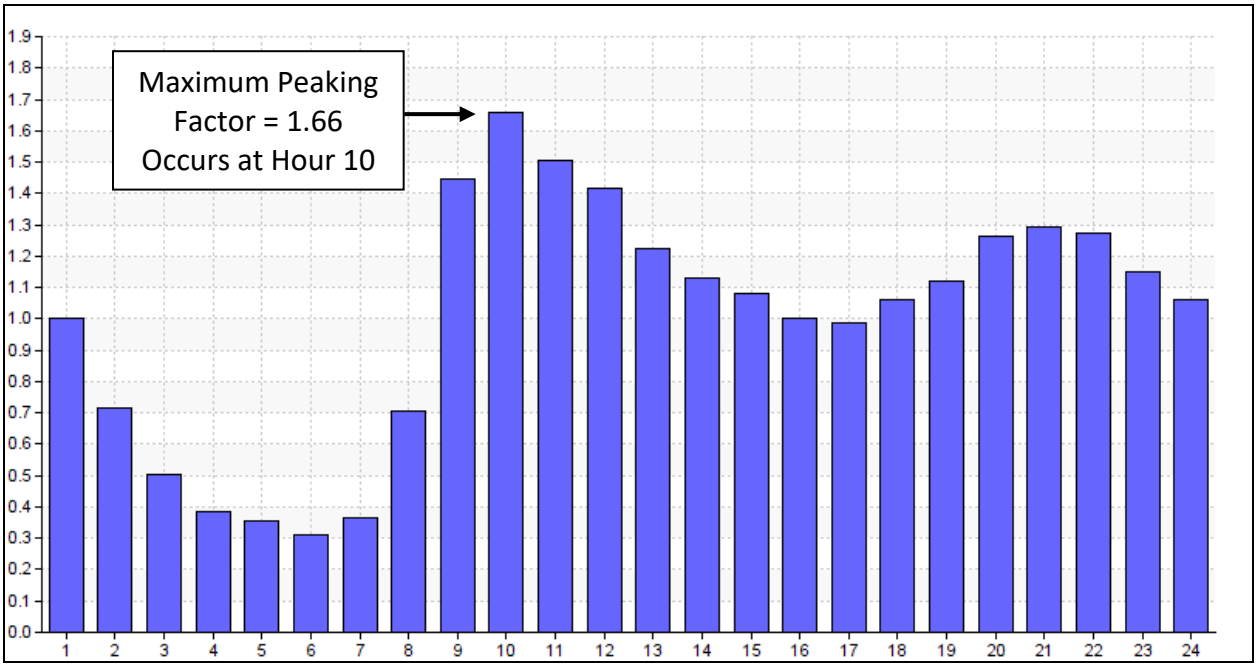


Figure 2.2: Multi-Family Residential Load Pattern (Calibrated)

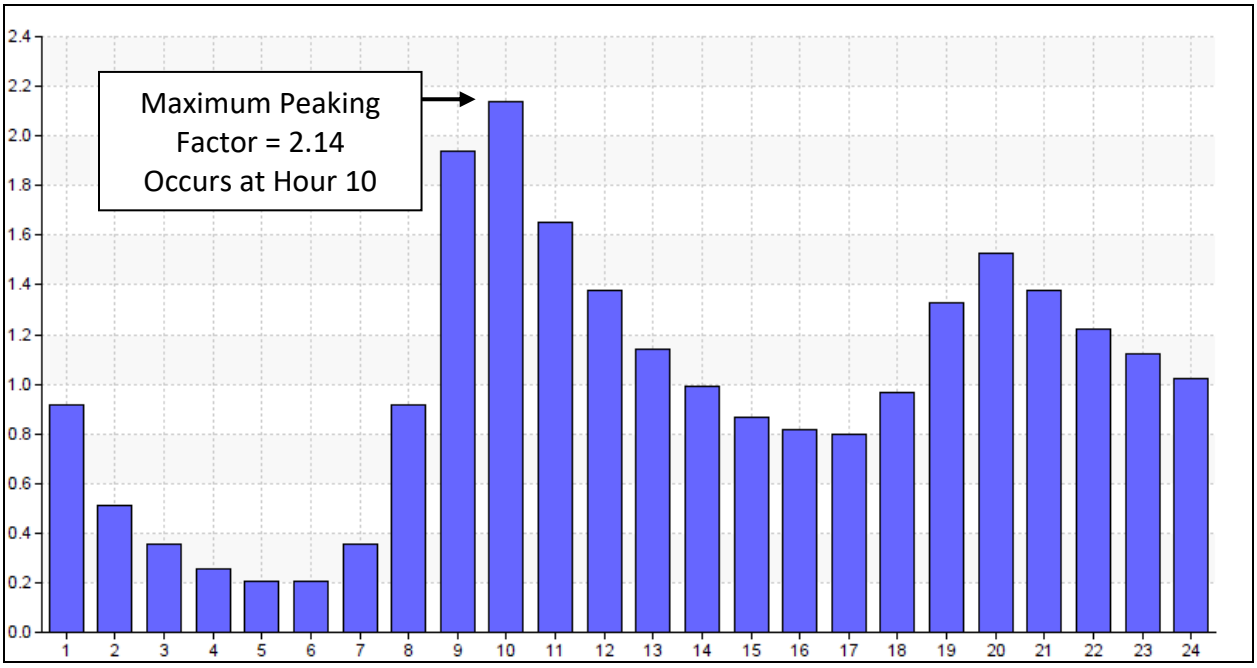


Figure 2.3: Commercial Load Pattern (Calibrated)

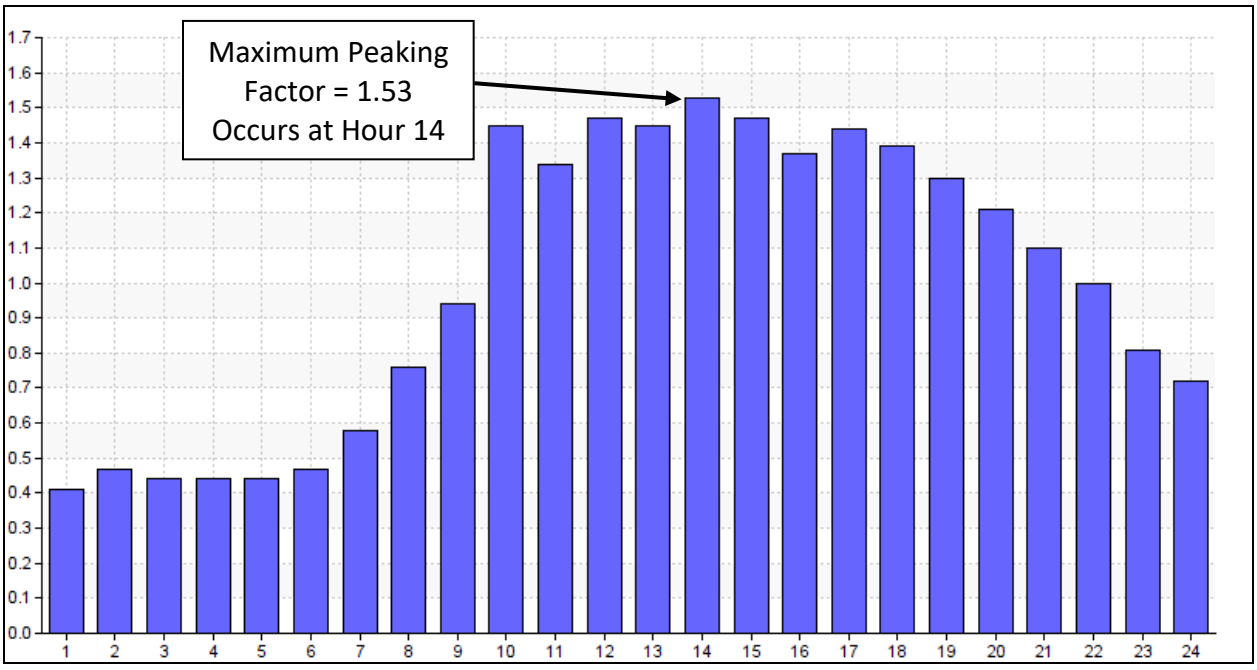


Figure 2.4: Institutional Load Pattern (Calibrated)

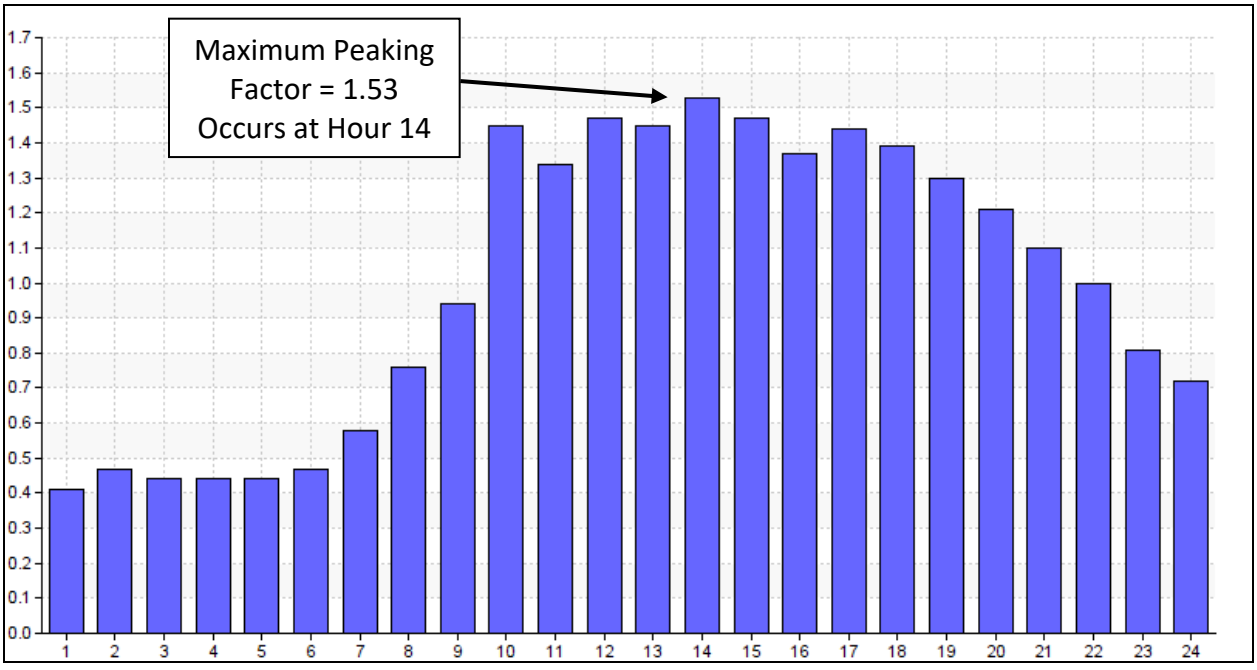
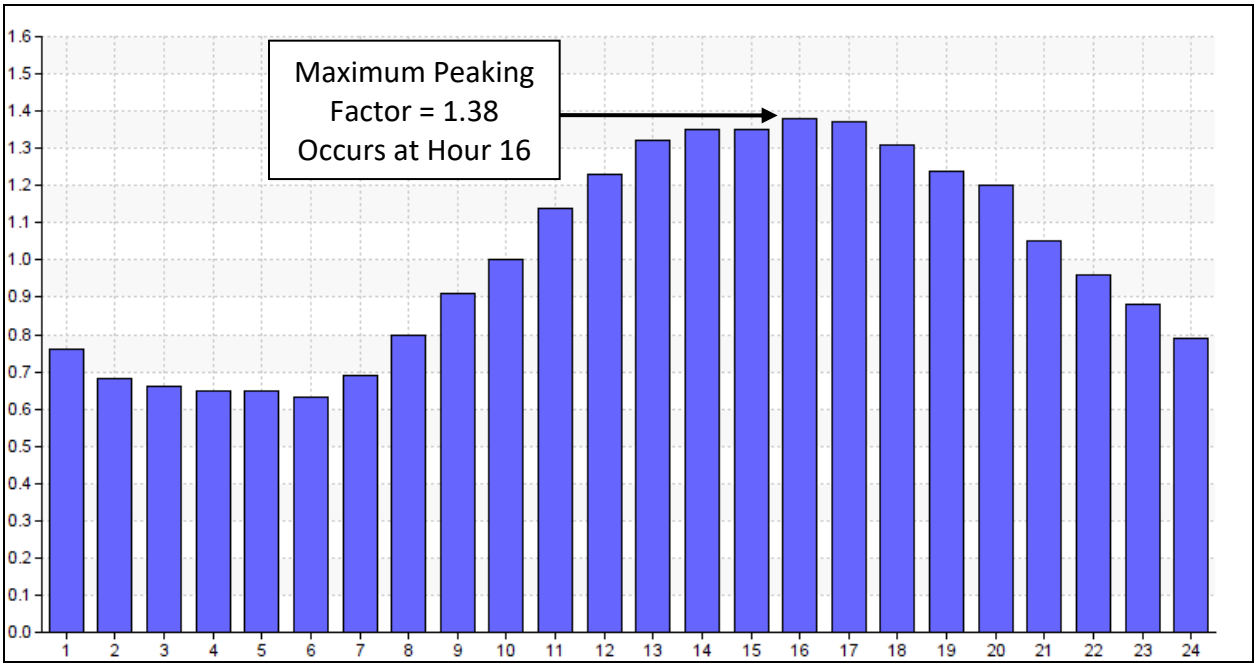


Figure 2.5: Industrial Load Pattern (Calibrated)



2.7 Field Data Review and Analysis

Flow data at five (5) locations were provided by the City:

- Main Sewage Lift Station
- Riverside Lift Station
- Burma Road Lift Station
- West Fernie Lift Station
- Lagoons Outfall

Data for 2018 were reviewed to determine the average dry weather flow (ADWF). Hourly flow data was available at each location to determine dry weather flow hydrographs for model calibration. **Table 2.7** summarizes the ADWF at each flow monitoring site.

Table 2.7: Flow Monitor Locations

Flow Monitoring Site	Average Dry Weather Flow
Main Sewage Lift Station	38.2 L/s
Riverside Lift Station	1.4 L/s
Burma Road Lift Station	0.2 L/s
West Fernie Lift Station	0.2 L/s
Lagoons Outfall	N/A

ADWF could not be calculated for the Lagoons Outfall as this is an overflow from the Main Sewage lift station. Overflow only occurs during peak flow conditions.

Note that due to the low average dry weather flows (<1 L/s) at the Burma Road and West Fernie lift stations, these sites were not used for the model calibration. Flow monitors are generally less accurate at lower flows (<1 L/s). Additionally, when reviewing the field date at these two (2) sites, flow recordings were found to be inconsistent (i.e. “0” value readings). Overall, it was not reasonable to use these low flow sites for calibration; however, the two (2) remaining sites were deemed acceptable to calibrate the model. Refer to **Section 3.0** for more details on the model calibration.

2.8 Inflow & Infiltration Allocation

Inflow and Infiltration (I&I) represent additional loading on the sanitary sewer system during dry and wet weather. They are categorized into the following:

- Ground Water Infiltration (GWI)
- Rainfall Dependent Inflow and Infiltration (RDI&I)

2.8.1. Ground Water Infiltration

In order to perform the average dry weather flow (ADWF) calibration, GWI loads were calculated using the Main Sewage lift station and Riverside lift station flow data. The rates used to convert minimum nightly flow (MNF) to GWI are standard values, derived from typical system performance in B.C. GWI rates were then further adjusted during calibration to match the field data.

Table 2.8 summarizes the GWI allocated to the Main Sewage lift station and Riverside lift station catchments.

Table 2.8: GWI Rates per Catchment (Calibrated)

Catchment	Catchment Area (ha)	Calibrated GWI (L/ha/day)
Main Sewage Lift Station	439	4,700
Riverside Lift Station	24	2,300

2.8.2. Inflow & Infiltration

The I&I rates used in the analysis were taken from the USL report *Inflow and Infiltration Reduction Program* (May 2011). **Table 2.9** summarizes the modeled I&I rates.

Table 2.9: Modeled I&I Rates per Catchment

USL Report Catchment	Corresponding Model Node ID	Area (ha)	I&I Rate (L/ha/day)	I&I (L/s)
Manhole 52	SMH-1063	11.6	108,000	14.4
11th Street LS	WW-11THSTREET	3.8	32,000	1.4
Manhole 630	SMH-0630	38.7	25,100	11.2
Alpine Trails LS	WW-CANYONTRAIL	11.0	19,900	2.5
All Other Areas	WW-MAINSEWAGE	192.2	19,000	42.3
Burma Rd LS	WW-BURMAROAD	23.6	7,800	2.1
Manhole 59	SMH-0638	35.4	6,900	2.8
Ghostrider LS	WW-GHOSTRIDER	16.4	6,900	1.3
10th Ave LS	WW-10THAVENUE	22.8	5,200	1.4
Riverside LS	WW-RIVERSIDE	24.5	100	0.0
Manhole 165	SMH-0165	45.2	19,900	10.4
Manhole 173	SMH-0176	38.4	18,900	8.4
	Total	**463.6**		**98.3**

Please refer to the USL report for further details regarding the I&I calculations.

3.0 Model Calibration

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

- Input data errors
- System loading errors
- Operational control errors
- Poorly calibrated measuring equipment
- Outdated data

The cumulative effect of these areas of uncertainty or "approximation" is that, without verification and validation of the model's ability to recreate known conditions, it is likely that the modeling results would be grossly misleading.

The main reasons for and benefits of a well calibrated model are listed below:

- Confidence: Demonstrate the model's ability to reproduce existing conditions.
- Understanding: Confirm the understanding of the performance of the system.
- Troubleshooting: Uncover missing information and misinformation or anomalies about the system.

3.1 Dry Weather Flow Calibration Results

Modeling results were first reviewed, and then key model parameters were adjusted until the model results closely matched the dry weather flow field data provided by the City for 2018. A summary of the calibration changes is shown in **Table 3.1**.

Table 3.1: Calibration Adjustments

Parameter	Adjustment
BSF	Adjusted water consumption to sanitary load conversion for all load types (see **Table 2.6)**
GWI	Increased GWI by 40%.

Figure 3.1: Dry Weather Calibration Hydrograph – Main Sewage Lift Station

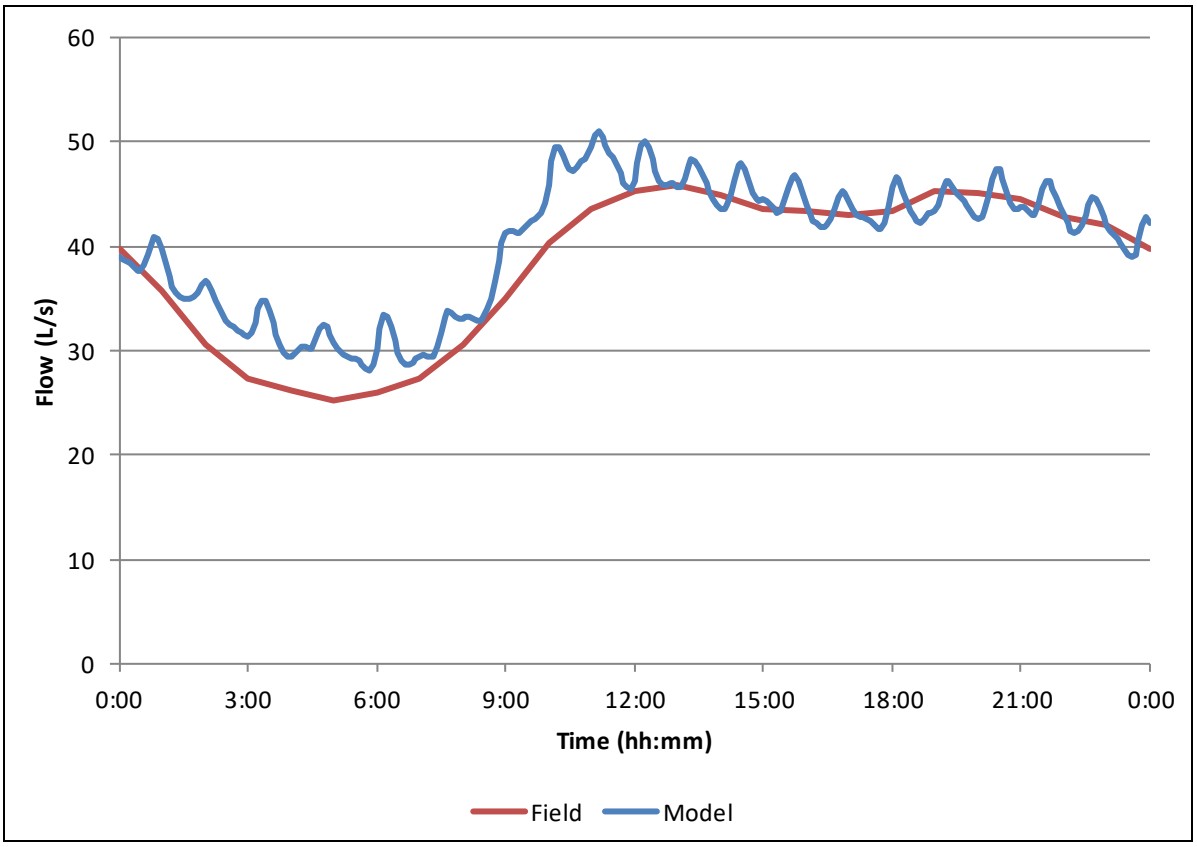


Table 3.2: Calibration Results – Main Sewage Lift Station

	Field	Model	Difference	Comments
Average	38.2 L/s	40.3 L/s	+5%	Average flow difference within 5% and peak flow difference within 10%.
Peak	45.9 L/s	51.1 L/s	+10%	

Figure 3.2: Dry Weather Calibration Hydrograph – Riverside Lift Station

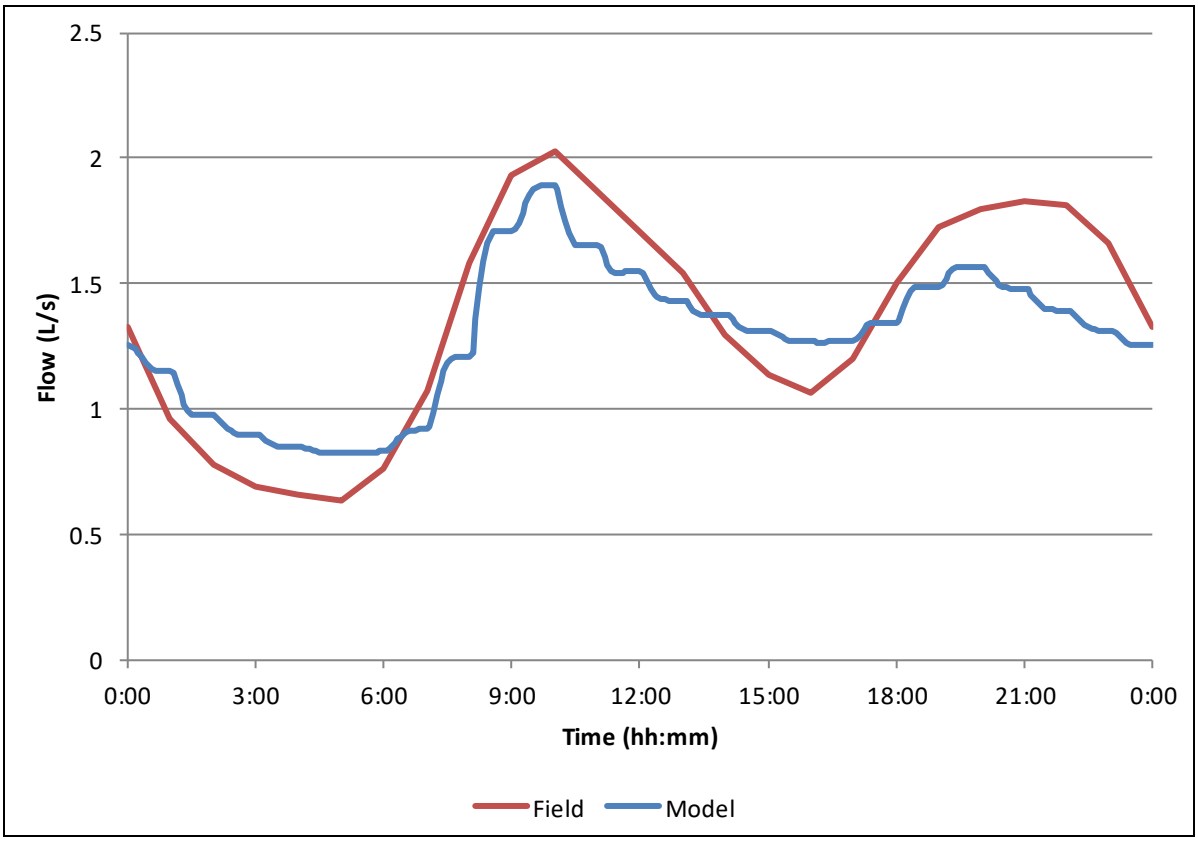


Table 3.3: Calibration Results – Riverside Lift Station

	Field	Model	Difference	Comments
Average	1.4 L/s	1.3 L/s	-5%	Average flow difference within 5% and peak flow difference within 10%.
Peak	2.0 L/s	1.9 L/s	-7%	

Overall the model predicts a good agreement with the dry weather field data.

4.0 Future Scenario Development

This section summarizes the assumptions and calculations used to develop the future modeling scenarios. **Table 4.1** summarizes the modeling scenarios used to assess the City sanitary sewer collection system capacity.

Table 4.1: Modeling Scenario Summary

Scenario	Description
2018	Identify existing system deficiencies
2032	Identify future system deficiencies and upgrade sizing

4.1 Residential Growth Projections

Residential growth projections were taken from the USL memorandum *City of Fernie Growth Projection* (July 2019). In order to spatially allocate the growth throughout the City, the population projections by neighbourhood were used. Residential growth projections are summarized in **Table 4.2**.

Table 4.2: Residential Growth Projection Summary

Neighbourhood	2018-2032 New Residential Units
Alpine Parkland	+ 20
Annex	+ 56
Castle Mountain	+ 107
Cedar Valley	+ 70
Ghostrider	+ 0
Main Town	+ 135
Mountview	+ 8
Northlands	+ 11
Ridgemont	+ 31
Riverside	+ 47
West Fernie	+ 101
Total	**+ 586**

Growth was uniformly distributed to all loading manholes within each respective neighbourhood.

4.2 ICI Development Projections

As with the residential growth projections, ICI development projections were taken from the USL memorandum *City of Fernie Growth Projection* (July 2019). ICI development projections are summarized in **Table 4.3**.

Table 4.3: ICI Development Projection Summary

Land Use	2032 ICI Development Area (m^2)	MMCD Population Density (cap/ha)	2032 ICI Equivalent Population
Commercial	+ 15,450	90	+ 139
Industrial	+ 2,684	90	+ 24
Institutional	+ 3,122	50	+ 16
Total	**+ 21,256**		**+ 179**

Based on discussions with the City, it was determined that the commercial and industrial development is most likely to occur to the north and northeast, in the Ghostrider neighbourhood, and the industrial growth is likely to occur near Coal Creek Road and Cokato Road, in the Castle Mountain neighbourhood.

4.3 Future Sewer Load Calculations

The future residential and ICI loads were estimated using the rates summarized in **Table 4.4**, which are based on the Master Municipal Construction Documents (MMCD) design guidelines. Based on discussions with the City, the unmetered loading rate was applied to the population growth.

Table 4.4: Future Loading Rate

Loading Type	Loading Rate
Residential BSF Rate (Unmetered Systems)	350 L/cap/day
ICI BSF Rate (Based on Equivalent Population)	350 L/cap/day

Table 4.5 shows the existing and future population and loading data.

Table 4.5: Existing and Future Population and Loading Summary

Parameter	2018-WWF	2032-WWF
Total Units	3,134	3,720
Total Population	6,692	7,944*
BSF	23.8 L/s	29.6 L/s
I&I	93.8 L/s	93.8 L/s
Average Wet Weather Flow	**117.6 L/s**	**123.4 L/s**

***Growth population calculated at 2.14 capita/unit, as per the USL memorandum.**

5.0 System Capacity Analysis

Model results for gravity mains and lift stations were assessed using a likelihood of failure (LoF) rating system. This section describes the methodology and results for the LoF capacity analysis of the City's gravity mains and lift stations.

5.1 Gravity Main Capacity Analysis

Model results for gravity mains were first analyzed to determine deficiencies and assign a LoF rating. **Table 5.1** and **Table 5.2** summarize the criteria used to define the LoF rating for each gravity main. The criteria below were developed based on MMCD guidelines and experience with local municipalities.

Table 5.1: Likelihood of Failure Criteria Scoring (Gravity Main)

Criteria	Score
Hydraulic Capacity (q/Q*)	
q/Q < 0.7**	A
0.7 ≤ q/Q < 1.0	B
q/Q ≥ 1.0	C
Hydraulic Grade Line (HGL)	
HGL < Crown	A
Crown ≤ HGL < Rim Elevation	B
HGL > Rim Elevation	C
Velocity (v)	
v < 0.6 m/s	Fail
v >= 0.6 m/s	Pass

***q/Q = peak flow / full pipe flow.**
****q/Q = 0.7 is analogous to a pipe flow 2/3 to 3/4 full. This is a typical value for differing mains between LoF values of '1' and '3'. Deficiencies are not triggered until q/Q ≥ 1.0.**

Table 5.2: Likelihood of Failuire Ratings

LoF Rating	Capacity	HGL	Velocity	Description
1	A	A	Pass	Pipe performing as designed
2	A	A	Fail	Adequate capacity, low velocity indicates potential sedimentation
3	A	B or C	Pass or Fail*	Adequate capacity, backwater caused by downstream conditions
	B	A, B or C	Pass or Fail*	Marginal capacity, backwater caused by downstream conditions
	C	A	Pass or Fail*	
4	C	B	Pass or Fail*	Capacity exceeded and surcharging likely
5	C	C	Pass or Fail*	Capacity exceeded and flooding likely

***LoF ratings from 3-5 are independent of velocity criteria.**

In general, ratings of '1', '2' and '3' will not trigger an upgrade as there is capacity available in the gravity main to convey flows.

Only gravity mains receiving an LoF rating of '4' and '5' were considered for upgrade. A gravity main receiving a '4' rating requires an upgrade as the hydraulic capacity has been exceeded and is likely causing surcharging to occur. A gravity main receiving a '5' rating indicates that surcharging to the manhole rim is likely, increasing the priority of the upgrade.

Table 5.3 summarizes the existing and future gravity main LoF results under each scenario.

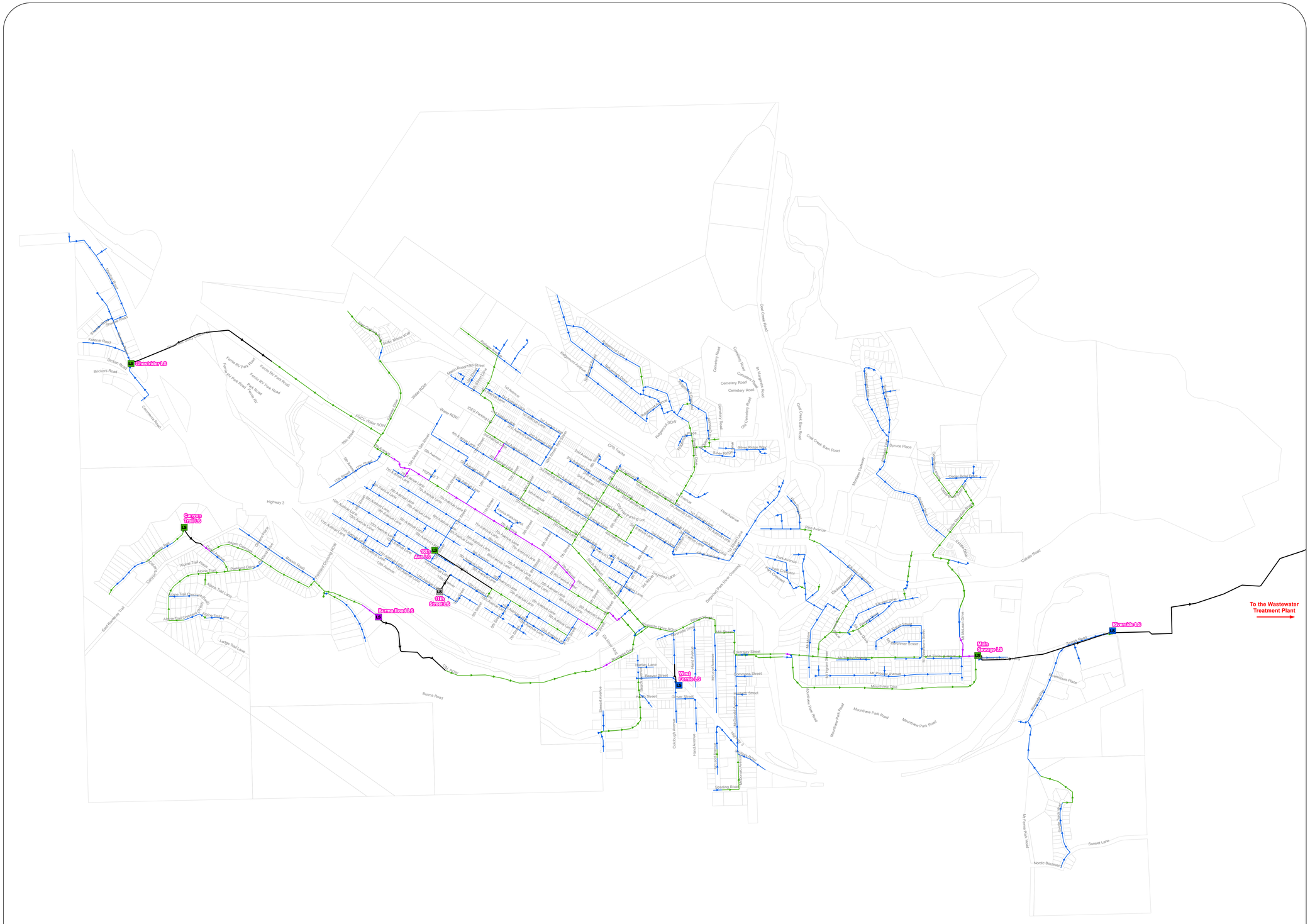
Table 5.3: Gravity Main LoF Results (Number of Pipes)

LoF Rating	2018 PWWF	2032 PWWF
1	230	235
2	493	486
3	26	28
4	**0**	**0**
5	**0**	**0**

It is worth noting that the I&I load is approximately 85% of the overall loading on the system. As such, population growth is not predicted to significantly impact system performance.

The results in **Table 5.3** show that the sanitary sewer collection system is adequately sized to convey the existing and future flows. No LoF '4' or '5' deficiencies requiring upgrades were identified.

Figure 5.1 and **Figure 5.2** show the gravity main LoF results.



GeoAdvice Engineering Inc.

Legend

Parcel

Forcemain

Gravity Main LoF Rating (# of Pipes)

1 (230) *Gravity main performing as designed*

2 (493) *Adequate capacity, low velocity indicates potential sedimentation*

3 (26) *Adequate capacity, downstream condition causing backwater OR Marginal Capacity*

4 (0) *Capacity exceeded and surcharging likely*

5 (0) *Capacity exceeded and overflow likely*

Lift Station LoF Rating (# of Lift Stations)

1 (4) *Lift station performing as designed*

2 (3) *Forcemain velocity outside of design range*

3 (1) *Inlet pipe invert within pump operating range and backup likely (submerged inlet)*

4 (0) *Pump capacity exceeded*

5 (0) *Pump capacity and wet well capacity exceeded and overflow likely*

"Ideal Pump"

2018 PWWF Gravity Main and Lift Station Likelihood of Failure Results

CITY OF FERNIE
BRITISH COLUMBIA

Project: **Sewer Model Development, Calibration, and Capacity Analysis**
Client: **City of Fernie, BC**
Date: **January 2020**
Created by: **Ad'A**
Reviewed by: **WdS**

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

0 0.375 0.75 1.5
Kilometers

N E S W

Figure 5.1

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GeoAdvice Engineering Inc.

Legend

- Parcel
- Forcemain

Gravity Main LoF Rating (# of Pipes)

- 1 (235) — *Gravity main performing as designed*
- 2 (486) — *Adequate capacity, low velocity indicates potential sedimentation*
- 3 (28) — *Adequate capacity, downstream condition causing backwater OR Marginal Capacity*
- 4 (0) — *Capacity exceeded and surcharging likely*
- 5 (0) — *Capacity exceeded and overflow likely*

Lift Station LoF Rating (# of Lift Stations)

- LS 1 (4) — *Lift station performing as designed*
- LS 2 (3) — *Forcemain velocity outside of design range*
- LS 3 (1) — *Inlet pipe invert within pump operating range and backup likely (submerged inlet)*
- LS 4 (0) — *Pump capacity exceeded*
- LS 5 (0) — *Pump capacity and wet well capacity exceeded and overflow likely*
- LS "Ideal Pump"

To the Wastewater Treatment Plant

2032 PWWF Gravity Main and Lift Station Likelihood of Failure Results

Project: **Sewer Model Development, Calibration, and Capacity Analysis**
Client: **City of Fernie, BC**
Date: **January 2020**
Created by: **Ad'A**
Reviewed by: **WdS**

CITY OF FERNIE
BRITISH COLUMBIA

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

0 0.375 0.75 1.5
Kilometers

N E S W

Figure 5.2

Document Path: W:\2018-041-FER\02\Mapping\2018-041-FER_2032-PWWF_LoFResults.mxd

5.2 Lift Station Capacity Analysis

A lift station is comprised of three (3) components: pump(s), wet well and downstream forcemain. Each component was assessed to determine the overall lift station LoF rating.

Table 5.4 and **Table 5.5** provide a summary of the criteria used to assess the City's lift stations. The criteria below are based on MMCD guidelines and experience with local municipalities.

Table 5.4: Likelihood of Failure Criteria Scoring (Lift Station)

Criteria	Result
Pump Capacity	
PWWF ≤ Firm Capacity*	Pass
PWWF > Firm Capacity*	Fail
Wet Well Capacity	
Max. Operating Level < Inlet Pipe Invert	A
Max. Operating Level ≥ Inlet Pipe Invert (Submerged Inlet)	B
Max. Operating Level >= Max. Physical Depth	C
Forcemain Velocity	
v < 0.75 m/s	Fail
0.75 m/s ≤ v ≤ 3.50 m/s*	Pass
v > 3.50 m/s	Fail

***The Lift Station firm capacity was determined with the station's largest pump out of service.**
****MMCD does not provide a maximum forcemain velocity. v = 3.5 m/s is a typical maximum forcemain velocity used for analysis; however, forcemain upgrades are only triggered if pump upgrades required.**

Table 5.5: Likelihood of Failure Ratings (Lift Station)

LoF Rating	Lift Station Capacity	Wet Well Capacity	Forcemain Velocity	Description
1	Pass	A	Pass	Lift station performing as designed
2	Pass	A	Fail	Forcemain velocity outside of design range
3	Pass	B	Pass or Fail	Inlet pipe invert within pump operating range and backup likely
4	Fail	A	Pass or Fail	Pump capacity exceeded but sufficient wet well capacity to attenuate additional flow
	Fail	A or B	Pass or Fail	Pump capacity exceeded and backup likely
5	Pass or Fail	C	Pass or Fail	Wet well capacity exceeded and overflow likely

Lift stations receiving a LoF rating of '3' indicate that the lead pump on-level is higher than the inlet pipe invert, causing backup to occur in the upstream pipes. The City should assess these lift stations and adjust the operating conditions as required. Lift stations receiving a LoF rating of '4' or '5' were considered for upgrade.

Table 5.6 and **Table 5.7** summarize the existing and future lift station LoF results for the City owned lift stations.

Table 5.6: 2018-WWF Lift Station LoF Results

Lift Station	Firm Capacity (L/s)	Peak Inflow (L/s)	Excess Capacity (L/s)	Forcemain Velocity (m/s)	LoF Rating
10th Avenue	25.0	3.4	+ 21.7	1.4	1
11th Street	IP*	1.7	IP*	IP*	IP*
Burma Road	40.0	8.1	+ 31.9	**0.6**	3
Canyon Trail	17.0	3.1	+ 13.9	1.0	1
Ghostrider	25.0	3.6	+ 21.4	3.2	1
Main Sewage	180.0	137.9	+ 42.1	1.1	1
Riverside	50.0	2.0	+ 48.0	**6.4**	2
West Fernie	19.0	2.8	+ 16.2	**4.3**	2

***Pump curve not available. Modeled as an "Ideal Pump" (inflow = outflow). Capacity not assessed.**

Table 5.7: 2032-WWF Lift Station LoF Results

Lift Station	Firm Capacity (L/s)	Peak Inflow (L/s)	Excess Capacity (L/s)	Forcemain Velocity (m/s)	LoF Rating
10th Avenue	25.0	4.1	+ 20.9	1.4	1
11th Street	IP*	1.9	IP*	IP*	IP*
Burma Road	40.0	8.9	+ 31.1	**0.6**	3
Canyon Trail	17.0	3.2	+ 13.8	1.0	1
Ghostrider	25.0	4.1	+ 20.9	3.2	1
Main Sewage	189.0	151.4	+ 37.6	1.2	1
Riverside	50.0	4.7	+ 45.3	**6.4**	2
West Fernie	19.0	3.7	+ 15.3	**4.3**	2

***Pump curve not available. Modeled as an "Ideal Pump" (inflow = outflow). Capacity not assessed.**

As shown in the above tables, all of the City's lift stations are predicted to have sufficient capacity in the existing and future scenarios.



The Burma Road lift station is predicted to have low forcemain velocity. The Riverside and West Fernie lift stations are predicted to have high forcemain velocities. The City should confirm the forcemain diameters and lift station capacities to verify the velocity results above.

The Burma Road lift station is operating with a submerged inlet; however, based on as-built drawings, the station appears to be operating as designed.

The lift station LoF results are also shown on **Figure 5.1** and **Figure 5.2**.





6.0 Conclusions and Recommendations

6.1 Summary of Study Findings

GeoAdvice Engineering was retained by the City of Fernie to build and calibrate the hydraulic model of the City's sanitary sewer collection system using InfoSWMM. Using the new hydraulic model, GeoAdvice analyzed the hydraulic capacity of the City's sanitary sewer collection system under the existing scenario and future 2032 growth scenario.

The following is a list of key conclusions drawn while performing this study:

- GIS data was the primary source of up-to-date information on the sanitary sewer collection system to build the model.
- Flow monitoring at five (5) lift stations was provided by the City. Flow data from two (2) these sites (Main Sewage lift station and Riverside lift station) were used to calibrate the model.
- Sewer load data was determined based on metered water usage and calibrated conversion rates based on observed data provided by the City. The City's calibrated 2018 BSF load is 17.5 L/s with an additional 6.3 L/s to represent the impact of the shadow population.
- Future sewer loads were estimated based on 2032 unit projections. There are currently 3,134 serviced residential units, and the total future serviced residential units are predicted to be 3,720 by 2032.
- The hydraulic modeling results (with no system improvements) indicate that the sanitary sewer collection system is adequately sized to convey the existing and future flows. No LoF '4' or '5' deficiencies requiring upgrades were identified.
- The lift station capacity analysis indicates that all of the City's lift stations have sufficient capacity under the existing and future scenarios.

6.2 Recommendations Following the Study

Based upon the findings from this analysis, GeoAdvice recommends the following:

1. **Additional Flow Monitoring**
   The City should undertake additional flow monitoring to confirm the inflow and infiltration assumptions made for the unmonitored areas and enhance model accuracy.

2. **Lift Station Data Review**
   The City should review the lift station data presented in **Table 2.2** and **Table 2.3** and verify its accuracy. For stations where data was not available at the time of this report, the City

should undertake pump testing and a survey of the wet well dimensions and invert levels to fill the data gaps.

3. **Conduct RDI&I – RTK (Variable I&I) Impact Study (Sensitivity Analysis)**
   The City's existing model assumes constant I&I point loads at each manhole. While this is typically sufficient for conservative capacity analysis, it often over-estimates total flow volume and may misrepresent peak wet weather flow values. This is especially critical in the City's system where I&I contributes about 70% of the peak load. The RTK methodology would allow the model to represent realistic peak RDI&I timing and RDI&I volume based on real or design storm events and terrain characteristics.

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

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

Submission

Prepared by:

Adrien d'Andrade, E.I.T.
Hydraulic Modeler / Project Engineer

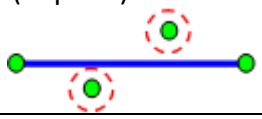
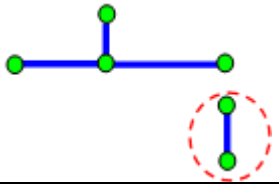
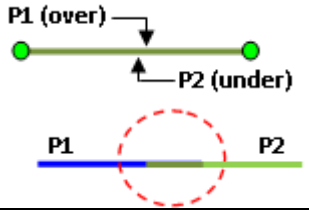
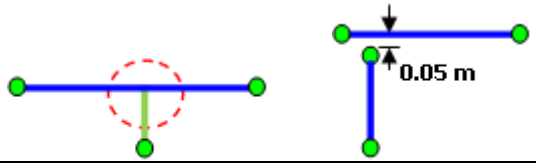
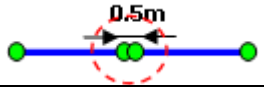
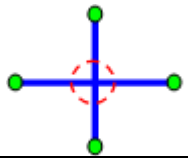
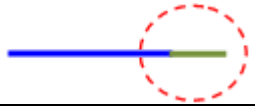
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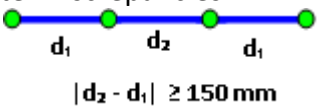
PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
Feb 2021
W. de SCHAETZEN
30059

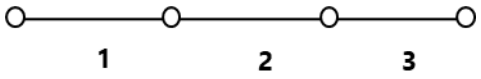
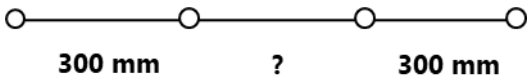
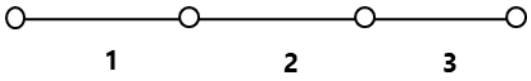
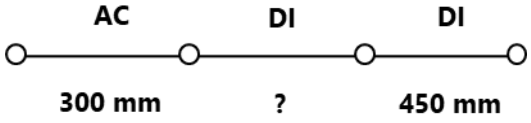
Werner de Schaetzen, Ph.D., P.Eng.
Project Manager

ENGINEERS & GEOSCIENTISTS BRITISH COLUMBIA
OQM CERTIFIED
GeoADVICE

Appendix A Data Gaps and Connectivity Fixes

Connectivity Issue Type	Solution
Disconnected (Orphan) Nodes 	Checked for proper connectivity in GIS. No orphan nodes in GIS. Deleted orphan nodes.
Disconnected (Orphan) Links 	Checked for proper connectivity in GIS. No orphan links in GIS. Deleted orphan links.
Overlapping Links 	Checked for proper connectivity in GIS. No overlapping links in GIS. Deleted links in model not in GIS.
Parallel Links 	Checked GIS for proper connectivity. Deleted links in model not in GIS.
Link Split Candidates 	Fixed connectivity based on GIS.
Nodes in Close Proximity 	Fixed connectivity based on GIS.
Crossing Links, Not Connected 	Fixed connectivity based on GIS.
Self-Overlap Links 	Checked GIS for proper connectivity. Redrew links.

Connectivity Issue Type	Solution
Self-Intersect Links 	Checked GIS for proper connectivity. Redrew links.
Link Diameter Discrepancies 	Checked GIS for correct diameter.

Data Gap Issue Type	Solution
Missing Pipe Diameter or Material	**Rule 1:** Identical upstream and downstream pipe diameter then use same diameter;  Diameter: 1 = 3, 2 unknown, then 1 = 2 = 3  The missing pipe diameter would be inferred as 300 mm. **Rule 2:** Different diameter but same upstream and/or downstream material then use the same diameter as the pipe matching material;  Material: 2 = 1, or 2 = 3 Diameter: 2 = 1, or 2 = 3 (Respectively)  The missing pipe diameter would be inferred as 450 mm.



Appendix C

City of Fernie
Stormwater Modeling

City of Fernie Stormwater System Modeling

Final Report

Prepared for:
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Submission Date: March 11, 2020

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Project ID: 2020-005-FER

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Document History and Version Control

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R1	March 11, 2020	Final	Sean Geyer	Werner de Schaetzen

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1.0 Introduction

The City of Fernie, BC (City) retained GeoAdvice Engineering Inc. (GeoAdvice) to develop a model of their stormwater system. The scope of work for GeoAdvice was to develop a hydrologic and hydraulic model of the City's stormwater system, assess system performance under varying storm events and land use conditions, and develop upgrade recommendations to address identified deficiencies.

The model was developed using the InfoSWMM software program. InfoSWMM is a fully dynamic stormwater management modeling software package from Innovyze Inc.

The stormwater system, as modeled, is presented in **Figure 1.1**.

The main components of the stormwater system model are summarized in **Table 1.1**.

Table 1.1: Model Statistics of Current System

Component	Total
Study Area	907 ha
Subcatchments	495
Storm Conduits	Ditches: • 33 (3.55 km) Gravity Mains & Culverts: • 712 (36.64 km)
Junctions	734
Outfalls	63
Dry Wells	16

In the preparation of this report, GeoAdvice would like to acknowledge the support of the following City Staff:

- Jenny Weir, P.Eng.

GeoAdvice Engineering Inc.

Legend

- Subcatchment
- Ditch
- Dry Well
- Outfall
- Gravity Main - 5 Year
- Gravity Main - 10 Year
- Culvert

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Co...

City of Fernie Drainage Network Overview

CITY OF FERNIE
BRITISH COLUMBIA

Project: **Storm Model Development, Capacity Analysis**
Client: **City of Fernie, BC**
Date: **February 2020**
Created by: **SG**
Reviewed by: **WdS**

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

0 0.325 0.65 1.3
Kilometers

N E S W

Figure 1.1

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2.0 Stormwater Model Build

2.1 Data Collection and Review

The City and their previous consultant, Urban System Ltd., provided all available GIS data, as-built drawings, and operational data related to their stormwater system. The following data was provided:

- City storm utility GIS data – Urbans System Ltd. (January 8, 2020);
- City cadastral GIS data – Urban System Ltd. (January 8, 2020);
- City contour GIS Data – Urban Systems Ltd. (January 8, 2020);
- City preliminary stormwater model in PCSWMM – Urban Systems Ltd. (January 8, 2020);
- Model build progress report – Urban System Ltd. – Email (January 8, 2020);
- *Subdivision _ Development Servicing Bylaw No. 1727, 1998 (Consolidated Version).pdf* – Online (January 10, 2020);
- *2017 NHC Elk River and Fairy Creek Flood Mapping Final Report.pdf* (January 17, 2020);
- *32246_OptionsAssessment_JN-Rev2-TwoOptions.pdf* (January 17, 2020);
- *Hwy 3 Storm.pdf* (January 17, 2020);
- *ISL 14th Street Drainage Improvements Memo.pdf* (January 17, 2020);
- *PrelimDesign-OptionsAssessment_JN-Rev1 (1).pdf* (January 17, 2020);
- Existing Landuse: Zoning_Bylaw_1750_Schedule_A.shp (January 17, 2020);
- OCP Landuse: Schedule_B_Landuse_Designations.shp (January 17, 2020); and
- Soil GIS data – BC Soil Survey – Online (February 6, 2020).

2.2 Hydraulic Model Development

The City's previous consultant, Urban Systems Ltd., provided GeoAdvice with a preliminary model (in PCSWMM) and updated GIS data for the City's storm utility. The GIS dataset was used to define the stormwater system network model. It was understood that this dataset was not complete and lacked key information for the development of an all-pipe model. As such, pipes were added to the model to the extent that data was available. Where GIS data was not available, interpolation of critical pipes was attempted using DEM data or City-provided drawings. Due to variations in data completeness, some areas of the model are more detailed than others; furthermore, some areas required the assumption of invert elevations for critical connectivity purposes. These changes, omissions, and assumptions were tracked during the model build process. The preliminary model developed by Urban System Ltd. was provided to GeoAdvice in a functional state: network connectivity was fully defined, and design storm simulations could run successfully.

GeoAdvice reviewed the preliminary model to identify critical modeling errors, data gaps, or suspicious data. Key questions were conveyed to the City in emails on January 14, 2020 and

February 13, 2020. The model was updated in accordance with City feedback and GeoAdvice modeling standards. In taking over the preliminary model, GeoAdvice reviewed and updated (where appropriate) all pipe profiles, network connectivity, pipe roughness assumptions, culvert parameters, ditch/creek transects, and subcatchment boundaries and parameters. Assumptions previously made by Urban Systems Ltd. to fill data gaps or missing connectivity information in the GIS data were upheld unless obvious errors or improved assumptions were identified.

Gravity Main & Culvert Data

Modeled gravity mains and culverts with an inlet or outlet (to/from an open channel) were assigned an entrance loss coefficient of 0.5 (averaged from typical entrance loss values) and a theoretical exit loss coefficient of 1.0. Specific details on each inlet and outlet structure were not confirmed.

Culverts were specifically defined in model in accordance with the City GIS. As details on culvert headwall structures were not available, culvert codes were assumed based on culvert material as summarized in **Table 2.1**.

Table 2.1: Culvert Code Assumptions

Material Type	Culvert Code*	Code Description
CMP/Steel	6	Circular Corrugated Metal Pipe, Projecting
PVC/HDPE	48	Circular Culvert, Smooth tapered inlet throat
Concrete	3	Circular Concrete, Groove end projecting

**Culvert codes defined by U.S. Department of Transportation Federal Highway Administration (https://www.fhwa.dot.gov/engineering/hydraulics/pubs/12026/hif12026.pdf)*

Manning's "n" roughness coefficients were assigned to the gravity mains and culverts according to **Table 2.2**.

Table 2.2: Gravity Main and Culvert Roughness Coefficients

Material Code	Material Name	Manning's Roughness Coefficient*
AC	Asbestos Cement	0.015
CMP	Corrugated Metal Pipe	12" (300 mm): 0.011 16" (400 mm): 0.013 18"-20" (450-500 mm): 0.014 24" (600 mm): 0.016 30"-32" (750-800 mm): 0.018 36" (900 mm): 0.019 48" (1200 mm): 0.023
CONC	Concrete	0.015

Material Code	Material Name	Manning's Roughness Coefficient*
HDPE	High-Density Polyethylene	0.013
PERF	Perforated Plastic Pipe	0.022
PVC	Polyvinyl Chloride	0.013
STL	Steel	0.016
VCT	Vitrified Clay Tile	0.014
UNKN	Unknown	0.013

**Roughness coefficients based on average value for a range of materials and ages (http://www.fsl.orst.edu/geowater/FX3/help/8_Hydraulic_Reference/Mannings_n_Tables.htm)*

Minor losses were applied to all sharp pipe bends in which velocities were predicted to meet or exceed 3.13 m/s under all design storms. This velocity roughly equates to a 0.5 m hydraulic jump. The loss coefficients, applied to the model as a pipe exit loss, assumed that all manholes in the City system are fully benched. The minor losses and associated bend angle are summarized in **Table 2.3**.

Table 2.3: Pipe Bend Minor Loss Coefficients

Bend Angle	Manning's Roughness Coefficient*
0° – 45°	0.00
45° – 59°	0.65
60° – 74°	0.81
75° – 89°	0.92
90° +	1.00

**Maple Ridge Design Criteria Manual, Section D: https://www.mapleridge.ca/DocumentCenter/View/6033/Part-1?bidId=*

Open Channel Data

Ditch locations, transects and invert elevations were extracted from a digital elevation model (DEM), developed from contour data by GeoAdvice, which tends to provide accurate geometry above the water level, but will leave uncertainty below the water level. It should also be understood that, in some instances, the City's ditch network was excluded from their GIS data and had to be inferred from contour data.

When reasonable transect profiles could not be generated using the DEM, or when a synthetic ditch liner was used, the ditch geometries defined in **Table 2.4** were applied.

Table 2.4: Open Channel Geometry

Storm System Component	Shape	Shape Description	Manning's Roughness Coefficient
Ditch	Irregular	Averaged from transects derived from DEM	0.05*
Ditch	Triangular	Top Width: 0.6 m Maximum Depth: 0.3 m	0.05*
SmartDitch	Trapezoidal	Bed Width = 0.292 m Maximum Depth = 0.629 m Side Slopes = 1:0.98	0.022**

**Roughness coefficients based on standard values for a manmade ditch (http://www.fsl.orst.edu/geowater/FX3/help/8_Hydraulic_Reference/Mannings_n_Tables.htm).*
***Dimensions and roughness coefficients per product literature: https://www.smartditch.com/products-trapezoidal.html*

Manhole, Model Junction, and Storage Node Data

Junctions were used in the model to provide connectivity where transitions between different physical attributes, such as size and slope, occur and to represent manholes, catch basins, outfalls and catchment load points. Missing rim elevations for junctions were extracted from the DEM.

A number of drywells are utilized in the City's drainage network to address areas with known ponding issues; however, physical attributes for most of these structures are unknown and their performance is not well understood. For the sake of this study, dry wells were assumed to be of sufficient capacity to contain the 10-year, 24-hour storm and capacity was not assessed.

Detention ponds have not been included in the City's model. Their absence is due to a lack of information regarding physical attributes and outlet/inlet control structures. While these should eventually be incorporated into the City model, a cursory investigation of satellite imagery did not reveal the presence of any obvious upstream detention ponds that would impact capacity results in the City's piped network. All observed detention structures (and those contained in the City's GIS) appeared to occur at the downstream end of a piped network as an outlet control before discharge into larger creeks/rivers. As such, it was assumed that these detention ponds were not critical to the capacity analysis of the City's stormwater utility. Furthermore, due to a lack of anecdotal data regarding detention pond capacity failures, it was assumed that these structures had sufficient capacity. As the City's data is updated through site investigation, detention and control structures should be included in the hydraulic model and GIS and assessed under climate change conditions.

All outfall nodes were modeled as "free" outfalls and were assumed to be free of influence from downstream receiving waters.

2.3 Hydrologic Model Development

Model subcatchments were delineated based on surface topography and the configuration of conveyance features. The granularity of the delineation was determined in a manner such that no dry pipes would exist during a storm event.

Subcatchment widths were estimated using the following formula:

$$Width = \frac{Area}{Length}$$

$$\text{where } Length = 1.7 * \sqrt{Area}$$

These subcatchment width calculations should be viewed as a starting-point only. The subcatchment width parameter is variable and must be calibrated. While width is the primary model input, it may be easier to understand width in terms of how it impacts the length of the subcatchment. Subcatchment length affects the time of concentration of a subcatchment and, in turn, the time available for infiltration processes to occur. Subcatchment widths were estimated in the following manner:

- For entirely urban, developed subcatchments without any special stormwater conveyance features, the initial width abstraction from the formulas (noted above) was used without alteration.
- For subcatchments with special conveyance features (e.g. unmodeled ditch and/or perforated pipe networks), widths were manually adjusted to represent the influence these networks would have on infiltration and routing time. These subcatchment widths were estimated by manually measuring the mean flow path through the unmodeled infrastructure to determine an estimate of subcatchment length. The associated width was then calculated using the formula *Area = Width x Length*.
- For larger rural, forested and/or mountainous catchments without infrastructure, widths were adjusted to better represent the expected flow path and time of concentration. These subcatchment widths were estimated by manually measuring the mean flow paths to determine an estimate of subcatchment length. The associated width was then calculated using the formula *Area = Width x Length*.

Subcatchment slopes, the average slope over each catchment area in the direction of the expected flow path, were determined using the DEM.

The hydrologic parameters that were uniformly applied to all the subcatchments are summarized in **Table 2.5**. These values were selected based on industry standards and previous experience with similar topography.

Table 2.5: Subcatchment Hydrologic Modeling Parameters

Hydrologic Parameter	Value
Depression Storage	
Pervious Area	5.0 mm (developed) 12.0 mm (undeveloped)
Impervious Area	2.0 mm (non-commercial) 4.0 mm (commercial)*
Manning's "n" Overland Roughness Coefficient	
Pervious Area "n"	0.200 (Turf) 0.400 (Forested)
Impervious Area "n"	0.013

*Depression storage is increased in highly commercial areas to represent the additional storage that is typically present in large paved parking lots and commercial buildings with flat roofs.

Pervious area depression storage was manually adjusted for catchments in which GIS data clearly indicated that catch basins were located in bioswales. The City commented that these catch basins were elevated two inches above the bottom surface of the bioswale. It was assumed that each bioswale covered a four-square meter (4 m^2) area with 50.8 mm of depression storage.

The impervious percentage for each subcatchment was estimated based on existing zoning coverage and satellite imagery. Each landuse designation was sorted into high-level categories that generally maintain similar properties. The impervious percentage for each existing zoning category is defined in **Table 2.6**. Zoning was not always a good indicator of actual development and impervious area; therefore, impervious assumptions were manually adjusted to match observations where significant discrepancies between zoning and development existed.

Table 2.6: Subcatchment Imperviousness and Routing Estimates (Existing Zoning)*

Landuse Category	Total Imperviousness (%)	Runoff Routed to Pervious Area (%)
Low Density Residential	35	90
Medium Density Residential	50	80
Forested	5	100
Commercial	70	40
Light Industrial	20	100
Agricultural Zone	20	100
Parks	5	100
Institutional	60	60
Comprehensive Development	50	80
Road	80	50

*Adopted values generally in line with Master Municipal Construction Documents (MMCD) recommendations but tailored to suit our understanding of the City's zoning descriptions and our observations of imperviousness from satellite imagery.

MOTI infrastructure, and the subcatchments associated with it, was included in the model; however, the infrastructure was not included in the capacity analysis. Regarding the subcatchments covering the MOTI highway corridor, parameters were manually adjusted from the typical "Road" assumptions to account for the increased presence of landscaped surface and ditches on the sides of the paved surface. For these subcatchments specifically, imperviousness was decreased by 6% and percent routed to pervious was increased by 20% based on observations from satellite imagery.

Subcatchment soil and infiltration parameters were defined in accordance with the majority soil type contained in each subcatchment. Soil data was taken from the BC Soil Survey online database (https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/agricultural-land-and-environment/soil-nutrients/mapping-and-classification). Each soil was classified by their sand/silt/clay composition within a depth of 20 meters. The "Modified Horton" infiltration process was used to characterize soil infiltration characteristics in the model. The "Modified Horton" infiltration parameters are summarized in **Table 2.7**.

Table 2.7: Modified Horton Infiltration Parameters

Soil Name	Minimum Infiltration Rate (mm/hr)	Maximum Infiltration Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
Abruzzi	25.8	12.3	4.14	7
Coal Creek	25.5	12.2	4.14	7
Cokato	20.1	10.1	4.14	7
Crowsnest	25.5	12.2	4.14	7
Michel	25.5	12.2	4.14	7

Note: *Infiltration parameters determined by Urban Systems Ltd. using BC Irrigation and CDM Smith calculators and verified by GeoAdvice. Please note that infiltration parameters are highly subjective and can vary significantly across both spatial and temporal variables. Without calibration, nothing more can be done to verify these assumptions.*

Groundwater was not modeled under this scope of work; however, it is possible that groundwater has a significant influence on runoff and infiltration as it relates to the City's drainage utility. The City should first undertake a flow monitoring program and model calibration effort to assess the current accuracy of the model (refer to **Section 4**). If significant discrepancies still exist, the City should consider undertaking the necessary field testing and monitoring to develop and calibrate a groundwater model within the existing InfoSWMM model.

3.0 Future Scenarios

The modeled future scenarios differ from the existing scenarios only in the design storms, which account for climate change (refer to **Section 5.1**), and subcatchment impervious percentage estimates, which are based on OCP Land Use data (provided by the City).

The future impervious percentage for each subcatchment was estimated based on the City's OCP land use plan. As with the existing landuse data, each OCP landuse designation was sorted into high-level categories that generally maintain similar properties. It was necessary to assume that at the OCP horizon all lands would be fully developed in accordance with their zoning. The exception to this assumption was the "Institutional" land indicated to the south and east of the Ridgemont Neighbourhood (partly containing the existing cemetery). It was assumed that this area would remain undeveloped. The impervious percentage for each OCP land use category is defined in **Table 3.1** and is consistent with values used for existing conditions (refer to **Table 2.6**).

Table 3.1: Subcatchment Imperviousness and Routing Estimates (OCP Landuse)*

Landuse Category	Total Imperviousness (%)	Runoff Routed to Pervious Area (%)
Low Density Residential	35	90
Medium Density Residential	50	80
Forested	5	100
Commercial	70	40
Light Industrial	20	100
Agriculture	20	100
Parks	5	100
Institutional	60	60
Comprehensive Development	50	80
Road	80	50

*Adopted values generally in line with MMCD recommendations but tailored to suit our understanding of the City's OCP landuse descriptions.

4.0 Model Calibration & Validation

IMPORTANT: This model has not been calibrated. However, model validation was attempted for the only anecdotal data available, relating to flooding concerns along 14th Street west of the highway. Previous modeling of the storm infrastructure along this street had been conducted by another engineer and the modeled behaviour generally agreed with previous reporting.

Before using this model for any planning or decision-making purposes, it is imperative that a flow monitoring program is undertaken to collect storm flows in the City's drainage utility network for a period of at least three months using at least four monitors strategically placed to capture a range of different landuse and terrain properties. This data should then be used to calibrate the model to ensure that the predicted model behavior, especially subcatchment runoff, is in line with physical system performance.

We recommend the City pursue the installation of at least four temporary flow monitors and a rain gauge. The City's tributary area spans four major soil groups (the Crowsnest soil group is limited to a single catchment area with few predicted deficiencies), for which properties are not well defined, and a wide variety of land-uses, both developed and undeveloped. The initial flow monitoring should be conducted to capture as many landuses and soil groups as possible, while also concentrating on the areas predicting the most significant capacity deficiencies, namely the downtown area to the north and east of the Elk River. If the City's monitoring budget allows, two additional monitors could be installed to capture two of the satellite areas to the west and south of the river; currently few deficiencies were predicted in these areas, but it would be good to confirm these findings. All monitoring efforts should be focused on the wet season from March to May as it is imperative that the chance of capturing rain-on-snow events is minimized.

Preliminary monitor locations have been recommended in **Table 4.1**.

Table 4.1: Preliminary Flow Monitoring Recommendations

Monitor	Manhole ID	Approximate Location	Catchment Area (hc)	Upstream Pipe Size (mm)
1	STMN0772	8th Street at 8th Avenue	83.5	750
2	STMN0174	Coal Discovery Trail (approx. where 8th Street would intersect)	31.9	600
3	STMN0355	6th Avenue at 4th Street (on 6th Ave.)	36.8	600
4	STMN0752	11th Avenue at 13th Street (on 11th Ave. north of 13th St.)	11.7	600

5.0 System Capacity Analysis

This section summarizes the City stormwater system capacity analysis under existing and future conditions.

5.1 Design Storms

IDF curves for use in the model were taken from the City's Subdivision Development Servicing Bylaw No. 1727 (*Subdivision _ Development Servicing Bylaw No. 1727, 1998 (Consolidated Version).pdf*).

Climate change was accounted for by simply scaling the City's existing IDF curves up by 10%. It should be understood that there is no factual basis for this assumption in this region; however, this approach was deemed acceptable by the City as there was no better data available. A number of alternative approaches were attempted to develop more nuanced projections; however, these attempts ultimately proved inconclusive due to significant variations in rainfall observations across the region and a lack of Environment Canada weather stations within the City limits. This conclusion was also supported by work done for the City by another consultant for a floodplain analysis project (*Elk River and Fairy Creek Flood Mapping Final Report*, Northwest Hydraulic Consultants, 2017).

As the City does not have a specific design storm distribution defined, GeoAdvice chose to develop several separate design storm distributions for analysis. The Modified Chicago design storm (r = 0.3, 24-hour), the SCS Type II (6, 12 and 24-hour), and the AES BC Interior (1-hour) design storms were created for the different stresses they place on a stormwater system.

The Modified Chicago distribution is described as an "all-durations" design storm, corresponding to all points on a single return period of an IDF curve. This distribution results in a design event that contains all durations and intensities defined for a given return period in some interval of the design event. This distribution ensures that all naturally occurring intensities and durations in the rainfall records are contained in the storm. The AES and SCS design events are intended to represent an event associated with a single duration (e.g. 1-hour, 6-hour, etc.) and are developed using a fixed distribution that ensures a total specified rainfall depth occurs over the event duration. The rainfall depths for the specific events are derived from the City's IDF curves. These design storms were created for both 5 and 10-year return periods.

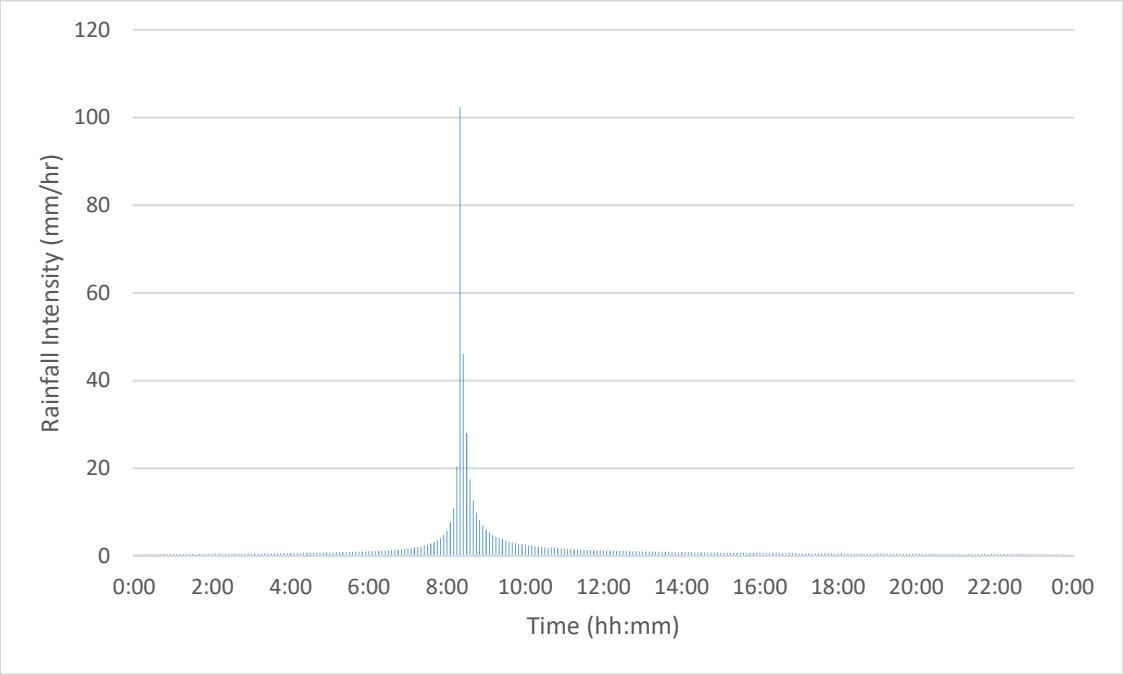
After conducting a series of initial analyses, it was determined that the Chicago adequately captured the impact of the other specific design storms while also resulting in slightly more conservative results. Therefore, especially given the uncertainty regarding model calibration,

only the Chicago distribution was used for the results and recommendations presented herein. The other design events have been kept in the model for future use, should the City need them.

An example of these design storms is provided in **Figure 5.1**.

The City's Subdivision Development Servicing bylaw states that infrastructure servicing ICI properties must be sized to contain a 10-year storm, while all other infrastructure must be sized to contain a 5-year storm. Each pipe was assigned to either the "10-year system" or the "5-year system" based on its local and/or upstream servicing requirements. All culverts were assumed to be part of the "10-year system". Refer to **Figure 1.1** for a breakdown of the two systems.

Figure 5.1: 5-Year, 24-hour Modified Chicago Design Storm (Without Climate Change)



The design storms used in the model are summarized in **Table 5.1** and **Table 5.2**.

Table 5.1: City of Fernie Desing Storms (Existing IDF)

Return Period	Distribution	Duration (hours)	Total Rainfall (mm)	Average Intensity (mm/hr)	Peak Rainfall Intensity (mm/hr)
5-Year	Chicago	24	45.45	1.90	102.33
10-Year	Chicago	24	52.60	2.19	123.48

Table 5.2: City of Fernie Design Storms (+10% for Climate Change)

Return Period	Distribution	Duration (hours)	Total Rainfall (mm)	Average Intensity (mm/hr)	Peak Rainfall Intensity (mm/hr)
5-Year	Chicago	24	50.00	2.09	112.56
10-Year	Chicago	24	57.86	2.41	135.83

5.2 Hydraulic Level of Service (HLoS) Criteria

Capacity HLoS was determined using the hydraulic capacity (q/Q), hydraulic grade line (HGL), surcharge time and flood time model results under peak conditions. **Table 5.3** and **Table 5.4** summarize the criteria used to define the capacity HLoS ratings.

Table 5.3: Conduit Hydraulic Level of Service Criteria Scoring

Criteria	Score
Hydraulic Capacity (q/Q*)	
q/Q < 1.0	1
q/Q ≥ 1.0	2
Hydraulic Grade Line (HGL)	
HGL < Crown	1
Crown ≤ HGL < Rim Elevation	2
HGL ≥ Rim Elevation	3
Surcharge	
Surcharge Time <= 15 minutes	1
Surcharge Time > 15 minutes	2
Flood	
Flood Volume <= Critical Volume**	1
Flood Volume > Critical Volume**	2

*q/Q = peak flow/full pipe flow.
**Critical Volume = acceptable flood volume from each conduit. See explanation below.

The 15-minute cutoff time for surcharge and the critical flood volume were chosen to differentiate between deficiencies caused by short-duration, high-intensity events (5, 10 and 15-minute storms) and those resulting from longer duration events (longer than 15 minutes). Addressing deficiencies identified under short-duration events through pipe capacity upgrades may not always be the most practical or cost-effective solution.

The critical flood volume was determined by creating an average road cross section (defined as two lanes at 4.25 m each, with a curb height of 0.14 m, with each lane sloping away from the centerline) and multiplying this area by the downstream pipe length (equating to 0.595 m^2 x *L*). This was assumed to be the volume of overland flow that would be acceptable under a peak storm event. This assumption was developed as the City's current model does not account for a dual drainage system as it excludes overland flow and catch basin interactions. As such, all runoff is routed directly into the piped (minor) system. Typically, it is expected that the overland (major) system will carry a substantial amount of flow either directly to a discharge location, allow water to enter into catch basins (according to a rating curve), or pond water for inflow to the piped system. The "critical flood volume" is a conservative attempt to differentiate significant, severe flood events and deficiencies from overland flow that would be more acceptable.

Each individual criterion from **Table 5.3** is categorized into an HLoS ranking in accordance with the criteria summarized in **Table 5.4**.

Table 5.4: Conduit Hydraulic Level of Service Ratings

HLoS Rating	Capacity	HGL	Surcharge	Flood
A	1	1	1	1
B	1	2	1	1
	1	3	1	1
C	1	2	2	1
	1	3	2	1
	1	3	2	2
D	2	1	1	1
	2	2	1	1
	2	3	1	1
E	2	2	2	1
	2	3	2	1
F	**2**	**3**	**2**	**2**

Detailed descriptions of how each HLoS category relates, in practical terms, to the performance of the City stormwater system are presented in **Table 5.5**.

Table 5.5: Conduit Hydraulic Level of Service Descriptions

HLoS Rating	Code	Description
A	1-1-1-1	Conduit performing as designed
B	1-2-1-1	Adequate capacity; Minimal backwater caused by downstream condition
	1-3-1-1	Adequate capacity; Minimal backwater caused by downstream condition (potential for small flood event)
C	1-2-2-1	Adequate capacity; Significant backwater caused by downstream condition
	1-3-2-1	Adequate capacity; Significant backwater caused by downstream condition (potential for small flood event)
	1-3-2-2	Adequate capacity; Significant backwater caused by downstream condition (potential for large flood event)
D	2-1-1-1	Marginal capacity
	2-2-1-1	Marginal capacity; Surcharge event < 15 minutes
	2-3-1-1	Marginal capacity; Surcharge event < 15 minutes (potential for small flood event)
E	2-2-2-1	Capacity exceeded; Significant surcharge (> 15 minute) event likely
	2-3-2-1	Capacity exceeded; Significant surcharge (> 15 minute) event likely (potential for small flood event)
F	**2-3-2-2**	Capacity exceeded; Large flood event likely

When conducting the capacity analysis, ditches, Ministry of Transportation and Infrastructure (MOTI)-owned utilities, dry wells, and detention structures were not assessed.

5.3 Conduit Capacity Analysis

To provide the City with the clearest possible understanding of their stormwater system performance, a number of different scenarios were simulated.

Existing Landuse without Climate Change:

- 5-Year Existing System Performance with Existing Land Use (Chicago)
- 10-Year Existing System Performance with Existing Land Use (Chicago)

OCP Landuse with Climate Change:

- 5-Year Existing System Performance with OCP Land Use + Climate Change (Chicago)
- 10-Year Existing System Performance with OCP Land Use + Climate Change (Chicago)

The existing and future conduit HLoS results under each scenario are summarized in **Table 5.6** and **Table 5.7**.

Table 5.6: Conduit HLoS Results (Number of Mains) – Existing Landuse

HLoS Rating	5 Yr. Gravity Mains	10 Yr. Gravity Mains	10 yr. Culverts
A	232	56	22
B	8	7	2
C	47	70	1
D	15	12	2
E	52	129	1
F	**4**	**36**	**0**
Total	**358**	**310**	**28**

Table 5.7: Conduit HLoS Results (Number of Mains) – OCP Landuse + Climate Change

HLoS Rating	5 Yr. Gravity Mains	10 Yr. Gravity Mains	10 yr. Culverts
A	184	39	16
B	11	8	4
C	63	66	3
D	18	10	4
E	63	136	1
F	**19**	**51**	**0**
Total	**358**	**310**	**28**

Please Note: Ditches and Ministry of Transportation and Infrastructure (MOTI) mains have been excluded from this analysis.

Maps depicting model results for existing landuse scenarios have been provided in **Appendix A**. Please refer to **Appendix B** for maps of results under OCP landuse with climate change.

For the City's stormwater network, we would not recommend pipe upgrades for HLoS ratings of 'A', 'B', 'C' and 'D' as there is capacity available in the conduit to convey flows or the capacity deficiency is not predicted to be detrimental to overall system operation. Conduits receiving an HLoS rating of 'B', 'C' or 'D' may show surcharging or flooding on connected nodes; however, these cases would indicate that the surcharged condition is due to downstream hydraulic deficiencies (case 'B' or 'C') or not significant enough to be of concern (case 'D').



For 5 and 10-year return period storms, we would recommend that only conduits receiving a HLoS rating of 'F' are considered for upgrade. For a conduit receiving an 'E' rating, its hydraulic capacity has been exceeded and is likely causing surcharging to occur and minor flooding to occur; however, this flood volume has been deemed acceptable for the sake of this analysis (refer to **Section 5.2** for the discussion regarding the critical flood volume). A conduit receiving an 'F' rating indicates that significant flooding is likely, increasing the priority of the upgrade. To eliminate an 'F' pipe, it will likely be required to also upgrade downstream 'E' pipes. Due to the lack of model calibration, it was also decided to upgrade any culverts with HLoS 'D', 'E' or 'F' rankings, due to the increased risk associated with failure in these elements.

Please Note: When flooding occurs, a portion of the storm flow is lost. This results in reduced flow reaching downstream conduits. As such, if deficiencies were resolved to eliminate flood losses, the performance of downstream links would change. As shown in the figures, there is significant flooding predicted under all storm events.

With respect to the results, the City will find that a significant number of 'E' and 'F' rankings are predicted under all storm events. In investigating these results, several factors stand out:

- The model has not been calibrated. While we have done our best to ensure that catchment and soil parameters are accurate, there is truly no way to know without calibrating the model to field data. Furthermore, the City is missing a significant amount of data in their GIS and there are also a number of errors in the GIS data that should be corrected. All of these variables could significantly impact the findings presented herein.
- The City's stormwater system includes a large number (~50%) of smaller diameter mains (<= 300 mm), which are quickly overwhelmed by typical runoff volumes. In reality, some additional storage would be available in the unmodeled catch basins and catch basin leads; it is also possible that modeled subcatchments have been directed into small diameter mains when, in reality, flow would route overland into catch basins located further downstream.
    - The City should investigate these areas to determine if heavy overland flow is typical under 5/10-year storm events. If significant overland flow does not typically occur under these events, the modeled subcatchment discretization and allocation may require additional refinement during future model updates.
- It is possible that, especially in the downtown area, there exist unmodeled runoff controls (natural ponding areas, overland flow routes, etc.) that were not accounted for in the model. These could have a significant impact on how/where runoff enters the storm network.

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6.0 System Improvement Recommendations

This section summarizes the conduit improvement recommendations required to resolve deficiencies associated with hydraulic level of service (HLoS) 'F' pipes identified under 5 and 10-year design storms, considering both existing and OCP landuse, with and without climate change. All recommendations were sized so that the HGL corresponding to the appropriate design storm with climate change (5 or 10-year, depending on the servicing requirements) would result in a $d/D \leq 0.9$.

Recommendations have been made to eliminate all HLoS 'F' pipes, and HLoS 'D', 'E' and 'F' culverts, identified in **Section 5**. It should be understood that only pipe capacity upgrades were considered for this study. This decision was made due to the lack of model calibration and the time constraints placed on this study. Following model calibration, it may be possible to locate land to implement upstream or inline detention storage and control structures to attenuate peak storm flows and reduce pipe capacity upgrade requirements.

Please Note: The recommendations herein should not be used to inform capital projects as the model has not been calibrated. Instead, these recommendations should be used to guide future investigatory and monitoring efforts. The pipe capacity restrictions noted herein represent real bottlenecks in the City system (assuming GIS data is accurate); however, without calibration the runoff entering the system is uncertain.

The recommended capacity improvements are summarized in **Table 6.1**.

Table 6.1: Summary of System Improvement Recommendations

Design System	Gravity Mains	Culverts
5-Year	2.52 km (48 pipes)	-
10-Year	8.95 km (140 pipes)	0.21 km (5 culverts)

A map depicting the improvement recommendations has been provided in **Appendix C**. Detailed recommendations have been provided in the supplemental spreadsheet, *Appendix D – System Improvement Recommendations.xlsx*.

6.1 System Performance with Recommended Improvements

The system was analyzed assuming that all recommended improvements are implemented to verify the impact of the recommendations on the HLoS grading. As before, scenarios were run for both existing and OCP landuses, with and without climate change. The existing and future conduit HLoS results under each scenario are summarized in **Tables 6.2** and **6.3**.

Table 6.2: Conduit HLoS Results (Number of Mains) – Existing Landuse

HLoS Rating	5 Yr. Gravity Mains	10 Yr. Gravity Mains	10 yr. Culverts
A	288	193	25
B	4	11	1
C	21	20	1
D	16	32	1
E	29	54	0
F	**0**	**0**	**0**
Total	**358**	**310**	**28**

Table 6.3: Conduit HLoS Results (Number of Mains) – OCP Landuse + Climate Change

HLoS Rating	5 Yr. Gravity Mains	10 Yr. Gravity Mains	10 yr. Culverts
A	241	132	20
B	11	10	4
C	32	36	3
D	27	50	1
E	47	82	0
F	**0**	**0**	**0**
Total	**358**	**310**	**28**

Please Note: Ditches and Ministry of Transportation and Infrastructure (MOTI) mains have been excluded from this analysis.

As can be seen in **Tables 6.2** and **6.3**, the recommended system improvements successfully eliminate all HLoS 'F' pipes under both existing and OCP landuse with climate change conditions. **Please note:** All recommended upgrades should be verified with flow monitoring and field observations.

7.0 Conclusions and Recommendations

GeoAdvice Engineering was retained by the City of Fernie to build and analyze a hydraulic model of the City's stormwater water system using InfoSWMM. The model was used to produce a preliminary set of system improvement recommendations that should guide the City's future investigative efforts. The model should be considered as a good basis for further study and refinement. Before using the model to inform any significant capital works, we have provided a few recommendations for further studies and model improvements that should be undertaken as the City's time and budget allow.

1. **Undertake Integrated Stormwater Management Plans (ISMP) For Individual Catchments**
   The City should consider undertaking more detailed ISMP work on a catchment by catchment basis. The smaller study area associated with these projects would allow the City to focus their field investigation, monitoring and model calibration efforts (see recommendations below) while spreading out costs across several years. This approach would reduce financial strain within the City while also reducing the data collection and project management efforts to more manageable time investments. Each of the following recommendations could be undertaken on a catchment by catchment basis.

2. **Field Verification of Stormwater System Information**
   Using the flagged GIS data as a starting point, the City should verify any noted discrepancies and work to fill any missing system data.

3. **Flow Monitoring**
   The City should undertake flow monitoring to capture a wide-range of catchment parameters and to verify model operation and deficiency identification. Flow monitoring is required for model calibration. Four initial monitoring locations have been provided, in **Section 4.0**, that would capture the majority of the deficiencies identified in Downtown Fernie and the other developed areas east and north of the Elk River. Flow monitoring should be conducted during the typical wet season (March through May) for a duration of at least three months.

4. **Model Calibration**
   Following the flow monitoring program, the City must calibrate the model prior to using it to inform any significant capital projects. Without calibration, there is no telling if the model is a reasonable representation of the City system.

5. **Detention, Control and LID Structures**
   The City should undertake a detailed survey to identify any potential detention, control and/or LID structures that may be missing from the GIS. It would be beneficial to also capture field notes pertaining to the operation of said structures.



6. Extended Modeling Support Services

We will assist the City in maintaining and operating the updated model for a period of one (1) year from the date of completion of this assignment and update the City of its operational status on a quarterly basis via a written status report. It is understood that during this period, we will have to respond to specific queries to model scenarios from the City for capital planning and operational needs. GeoAdvice is available to assist the City with executing a flow monitoring program and the subsequent model calibration.

7. Maintenance of Stormwater System Model

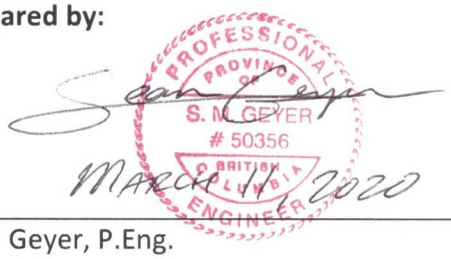
Ongoing development, zoning and infrastructure changes dictate that updates should be completed every year. Piping capacities should be updated where investigations indicate discrepancies from assumptions used in the model development.





Submission

Prepared by:



Sean Geyer, P.Eng.
Project Engineer

Reviewed and Approved by:

Werner de Schaetzen, Ph.D., P.Eng.
Project Manager

Appendix A HLoS Results – Existing Landuse, No Climate Change

GeoAdvice Engineering Inc.

Legend

- Subcatchment (495)
- Ditch
- Outfall
- Gravity Main

Junction

Note: Predicted flood volume defined on map

- Flooding < Critical Volume (19)
- Flooding > Critical Volume (9)
- Surcharged < 15 min - No Flooding (4)
- Surcharged > 15 min - No Flooding (77)

Gravity Main HLoS - 5 Year

- A (232)
- B (8)
- C (47)
- D (15)
- E (52)
- F (4)

Gravity Main Hydraulic Level of Service (HLoS)

- A *Gravity main performing as designed*
- B *Adequate capacity; Minimal backwater caused by downstream condition (potential for small flood event)*
- C *Adequate capacity; Significant backwater caused by downstream condition (potential for flood event)*
- D *Marginal capacity; Surcharge event < 15 min. likely (potential for small flood event)*
- E *Capacity exceeded; Significant surcharge event likely (potential for small flood event)*
- F *Capacity exceeded; Large flood event likely*

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

5-Year Chicago Existing Landuse Hydraulic Level of Service

CITY OF FERNIE
BRITISH COLUMBIA

Project: **Storm Model Development, Capacity Analysis**
Client: **City of Fernie, BC**
Date: **March 2020**
Created by: **SG**
Reviewed by: **WdS**

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

0 0.25 0.5 1
Kilometers

N E S W

Figure A.1

Document Path: W:\2020-005-FER\02\Mapping\2020-005-FER-HLoS_5yr_Existing.mxd

GeoAdvice Engineering Inc.

Legend

- Subcatchment (495)
- Ditch
- Outfall
- Gravity Main

Junction

Note: Predicted flood volume defined on map

- Flooding < Critical Volume (54)
- Flooding > Critical Volume (46)
- Surcharged < 15 min - No Flooding (5)
- Surcharged > 15 min - No Flooding (152)

Gravity Main HLoS - 10 Year

- A (56)
- B (7)
- C (70)
- D (12)
- E (129)
- F (36)

Culvert HLoS

- A - Culvert performing as designed (22)
- B - Adequate capacity; Minimal backwater (2)
- C - Adequate capacity; Significant backwater (1)
- D - Marginal capacity (2)
- E - Capacity exceeded; Signficiant surcharge (1)

Gravity Main Hydraulic Level of Service (HLoS)

- A *Gravity main performing as designed*
- B *Adequate capacity; Minimal backwater caused by downstream condition (potential for small flood event)*
- C *Adequate capacity; Significant backwater caused by downstream condition (potential for flood event)*
- D *Marginal capacity; Surcharge event < 15 min. likely (potential for small flood event)*
- E *Capacity exceeded; Significant surcharge event likely (potential for small. flood event)*
- F *Capacity exceeded; Large flood event likely*

10-Year Chicago Existing Landuse Hydraulic Level of Service

CITY OF FERNIE
BRITISH COLUMBIA

Project: **Storm Model Development, Capacity Analysis**
Client: **City of Fernie, BC**
Date: **March 2020**
Created by: **SG**
Reviewed by: **WdS**

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

0 0.25 0.5 1
Kilometers

N E S W

Figure A.2

Document Path: W:\2020-005-FER\02\Mapping\2020-005-FER-HLoS_10yr_Existing.mxd

Appendix B HLoS Results – OCP Landuse, With Climate Change

GeoAdvice Engineering Inc.

Legend

- Subcatchment (495)
- Ditch
- Outfall
- Gravity Main

Junction

Note: Predicted flood volume defined on map

- Flooding < Critical Volume (22)
- Flooding > Critical Volume (26)
- Surcharged < 15 min - No Flooding (11)
- Surcharged > 15 min - No Flooding (98)

Gravity Main HLoS - 5 Year

- A (184)
- B (11)
- C (63)
- D (18)
- E (63)
- F (19)

Gravity Main Hydraulic Level of Service (HLoS)

- A *Gravity main performing as designed*
- B *Adequate capacity; Minimal backwater caused by downstream condition (potential for small flood event)*
- C *Adequate capacity; Significant backwater caused by downstream condition (potential for flood event)*
- D *Marginal capacity; Surcharge event < 15 min. likely (potential for small flood event)*
- E *Capacity exceeded; Significant surcharge event likely (potential for small flood event)*
- F *Capacity exceeded; Large flood event likely*

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

5-Year Chicago + CC
OCP Landuse
Hydraulic Level of Service

CITY OF FERNIE
BRITISH COLUMBIA

Project: **Storm Model Development, Capacity Analysis**
Client: **City of Fernie, BC**
Date: **March 2020**
Created by: **SG**
Reviewed by: **WdS**

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

0 0.25 0.5 1
Kilometers

N E S W

Figure B.1

Document Path: W:\2020-005-FER\02\Mapping\2020-005-FER-HLoS_5yr_OCP.mxd

GeoAdvice Engineering Inc.

Legend

- Subcatchment (495)
- Ditch
- Outfall
- Gravity Main

Junction

Note: Predicted flood volume defined on map

- Flooding < Critical Volume (54)
- Flooding > Critical Volume (67)
- Surcharged < 15 min - No Flooding (5)
- Surcharged > 15 min - No Flooding (151)

Gravity Main HLoS - 10 Year

- A (39)
- B (8)
- C (66)
- D (10)
- E (136)
- F (51)

Culvert HLoS

- A - Culvert performing as designed (16)
- B - Adequate capacity; Minimal backwater (4)
- C - Adequate capacity; Significant backwater (3)
- D - Marginal capacity (4)
- E - Capacity exceeded; Signficiant surcharge (1)

Gravity Main Hydraulic Level of Service (HLoS)

- A *Gravity main performing as designed*
- B *Adequate capacity; Minimal backwater caused by downstream condition (potential for small flood event)*
- C *Adequate capacity; Significant backwater caused by downstream condition (potential for flood event)*
- D *Marginal capacity; Surcharge event < 15 min. likely (potential for small flood event)*
- E *Capacity exceeded; Significant surcharge event likely (potential for small. flood event)*
- F *Capacity exceeded; Large flood event likely*

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

10-Year Chicago + CC
OCP Landuse
Hydraulic Level of Service

CITY OF FERNIE
BRITISH COLUMBIA

Project: **Storm Model Development, Capacity Analysis**
Client: **City of Fernie, BC**
Date: **March 2020**
Created by: **SG**
Reviewed by: **WdS**

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

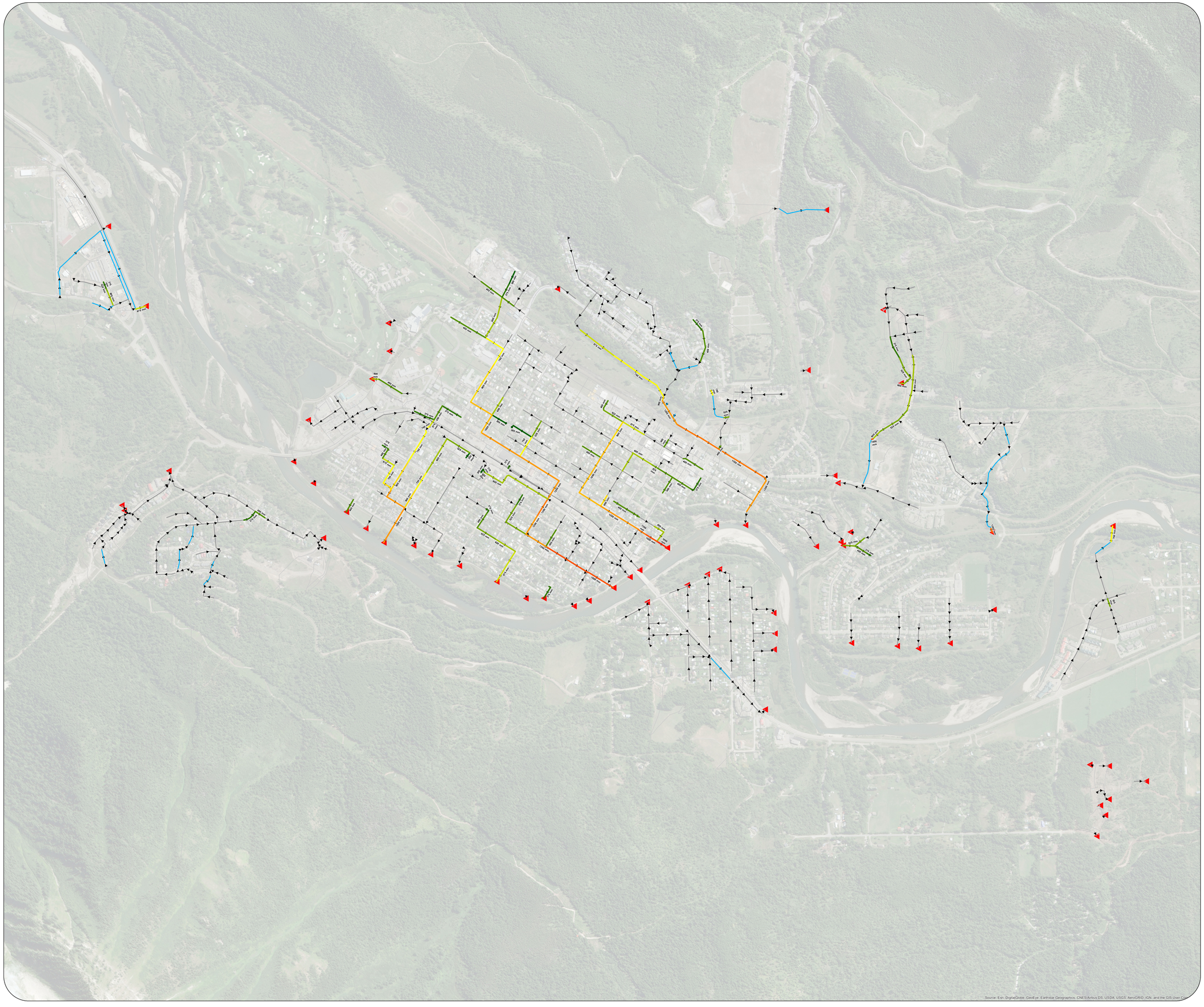
0 0.25 0.5 1
Kilometers

N E S W

Figure B.2

Document Path: W:\2020-005-FER\02\Mapping\2020-005-FER-HLoS_10yr_OCP.mxd

Appendix C System Improvement Recommendations



GeoAdvice Engineering Inc.

Legend

- Subcatchment
- Ditch
- Outfall
- Gravity Main

Conduit Upgrade Diameter

- 300 mm
- 375 mm
- 450 mm
- 525 mm
- 600 mm
- 675 mm
- 750 mm
- 900 mm
- 1,050 mm
- 1,200 mm
- 1,350 mm
- 1,500 mm
- 1,650 mm

Improvement Recommendations

CITY OF FERNIE
BRITISH COLUMBIA

Project: **Storm Model Development, Capacity Analysis**
Client: **City of Fernie, BC**
Date: **February 2020**
Created by: **SG**
Reviewed by: **WdS**

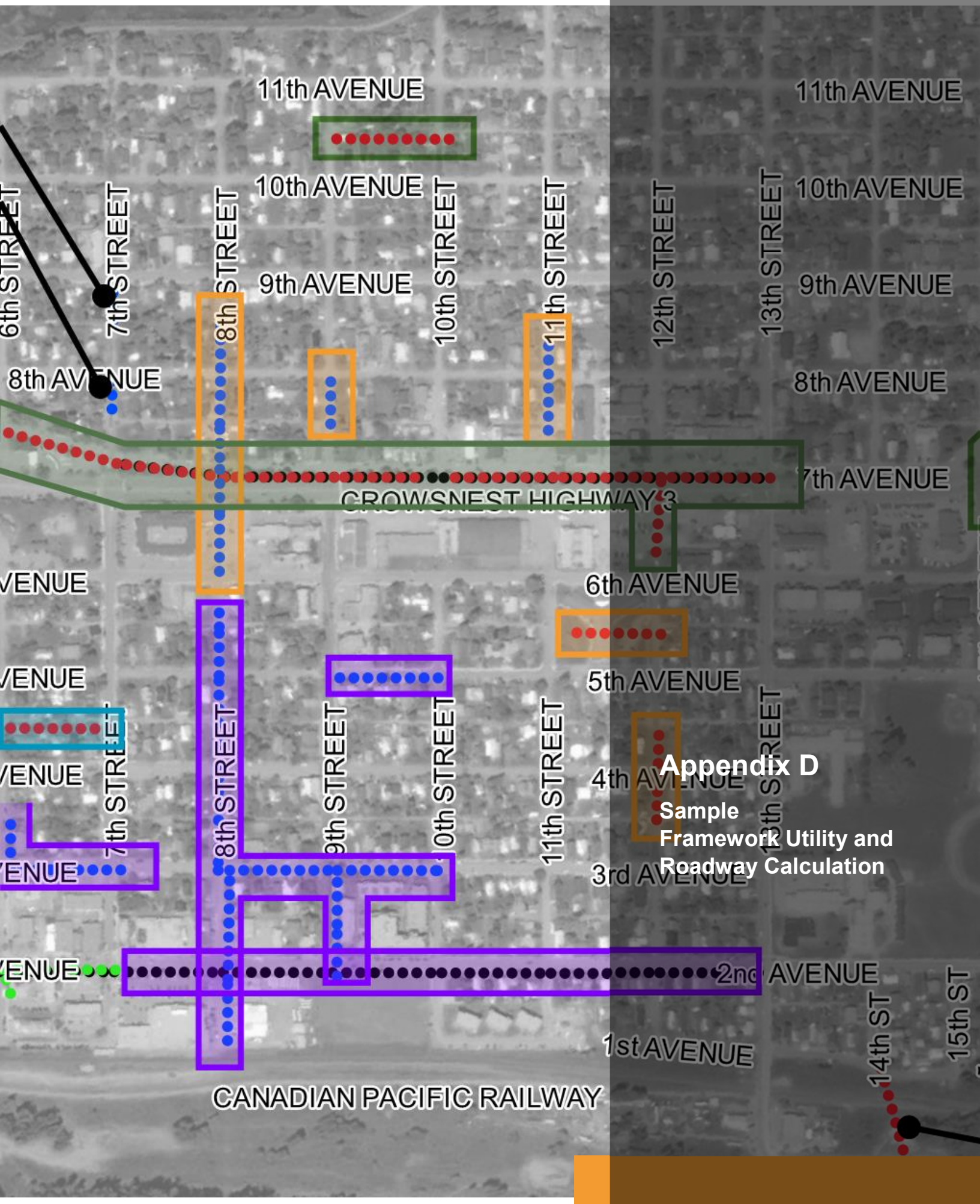
DISCLAIMER: GeoAdvice does not warrant in any way the accuracy and completeness of the information shown on this map. Field verification of the accuracy and completeness of the information shown on this map is the sole responsibility of the user.

0 0.25 0.5 1
Kilometers

N E S W

Figure C.1

Document Path: W:\2020-005-FER\02\Mapping\2020-005-FER-ImprovementRecommendations.mxd



Appendix D

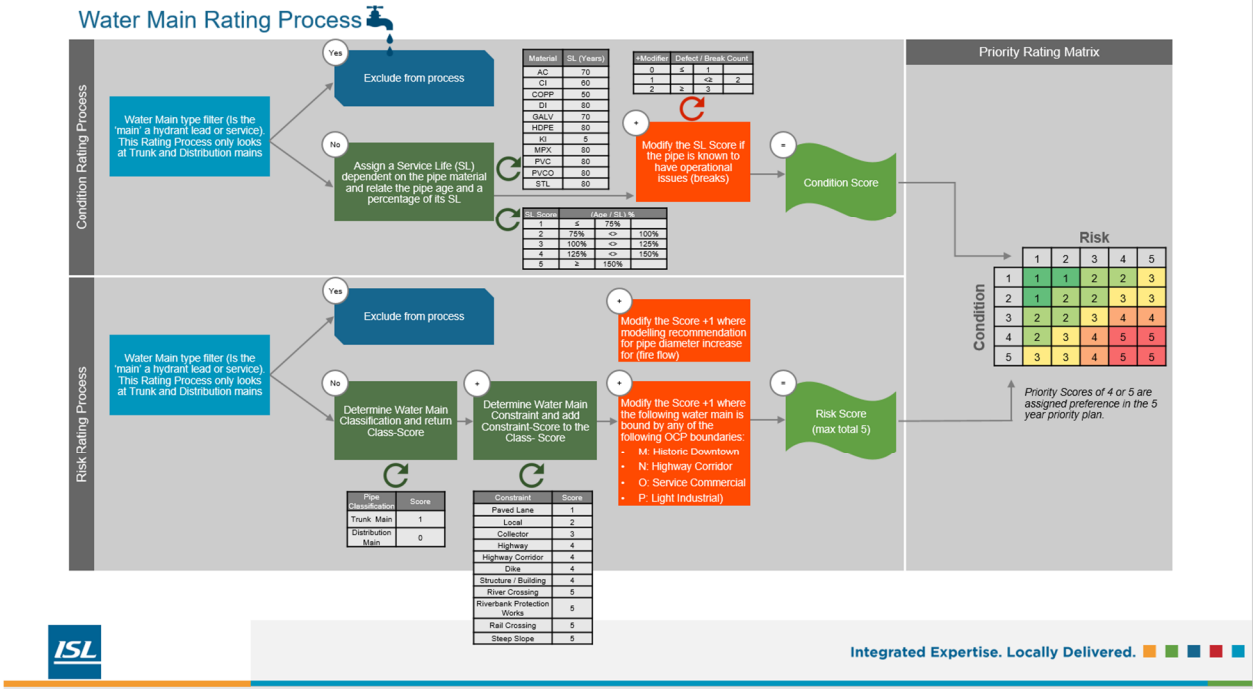
Sample Framework Utility and Roadway Calculation

Appendix D Table of Contents

1.0 Watermain Rating Process 2
2.0 Sanitary Sewer Main Rating Process 6
3.0 Storm Rating Process 10
4.0 Road Rating Process 14

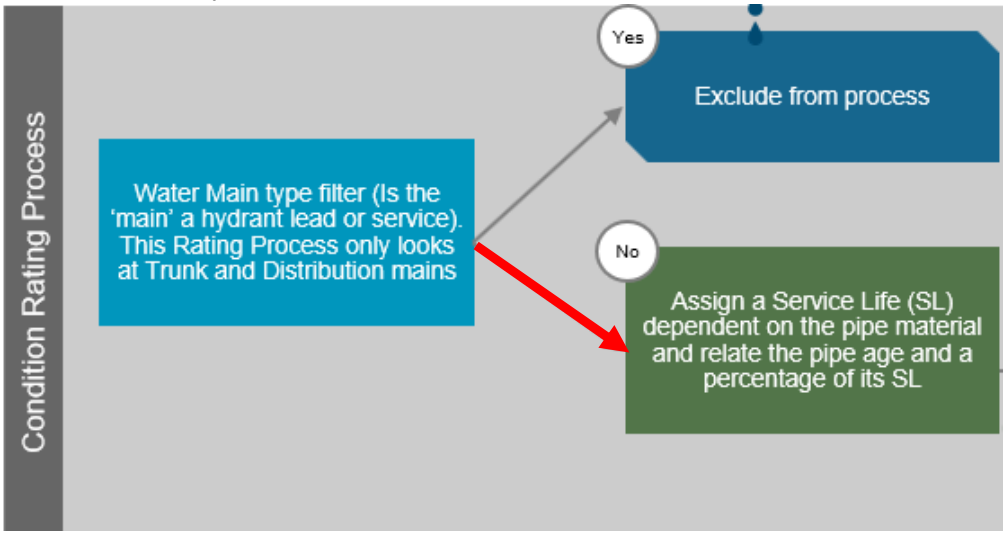
1.0 Watermain Rating Process

This is an example of how to use the water Main Rating Risk matrix. In this example we will asses Asset ID 3010144 the C&L right of way water main. This steel trunk main was installed in 1981. It is located on a steep slope and has known operational issues.



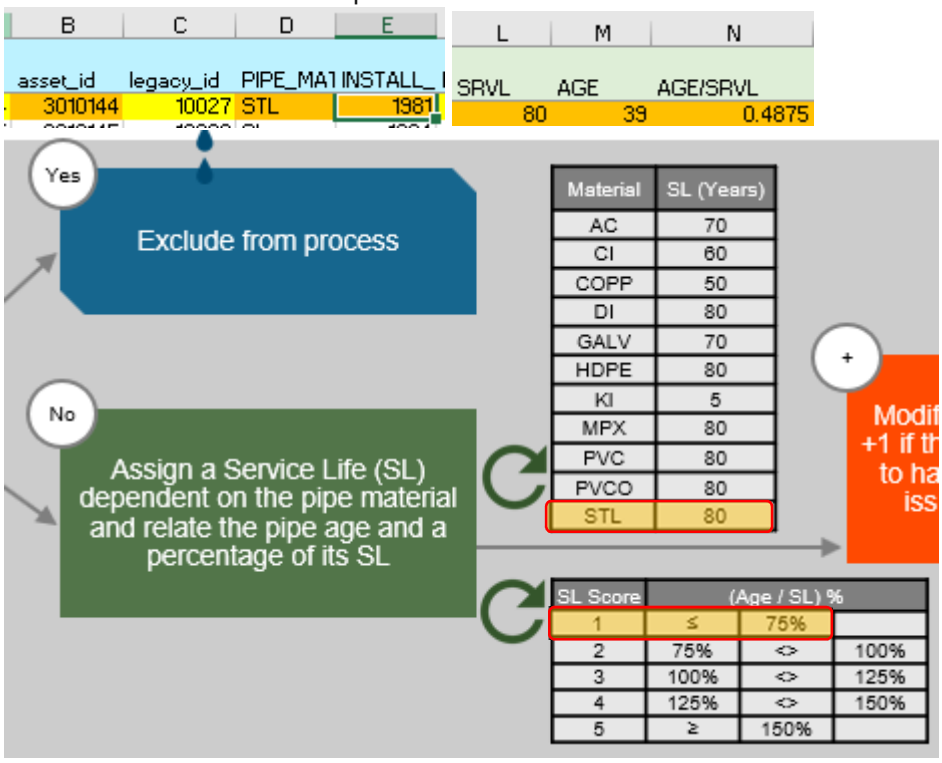
Condition Rating Processes

1. Answer question one. In this case there is no fire hydrant lead and it is not a service. Follow the arrow down to the next question.

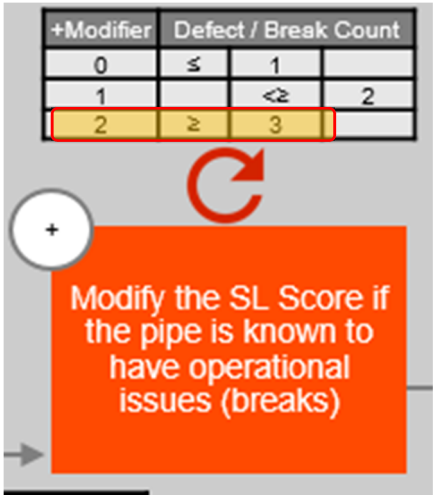


2. Next assign a Service life (SL) value from the provided column. In this case we have a steel (STL) pipe with a SL value of 80 years. The installation date was 1981. The age of the pipe is 2020-1981= 39 years. The SL score is then calculated by dividing the age by the SL x 100. (39 / 80) x 100 =

48.75%. The result falls into the equal to or less than 75% row with a SL score of "1".

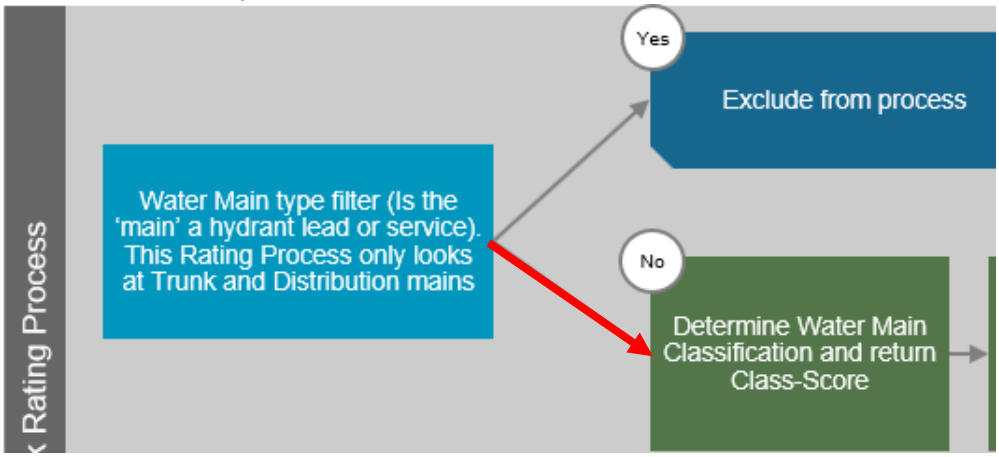


3. Next add a modifier to the SL score to lines having any know operational issues or breaks. In this case there are 9 recorded issues so "2" is added to the score. We now have a total condition score of "3".

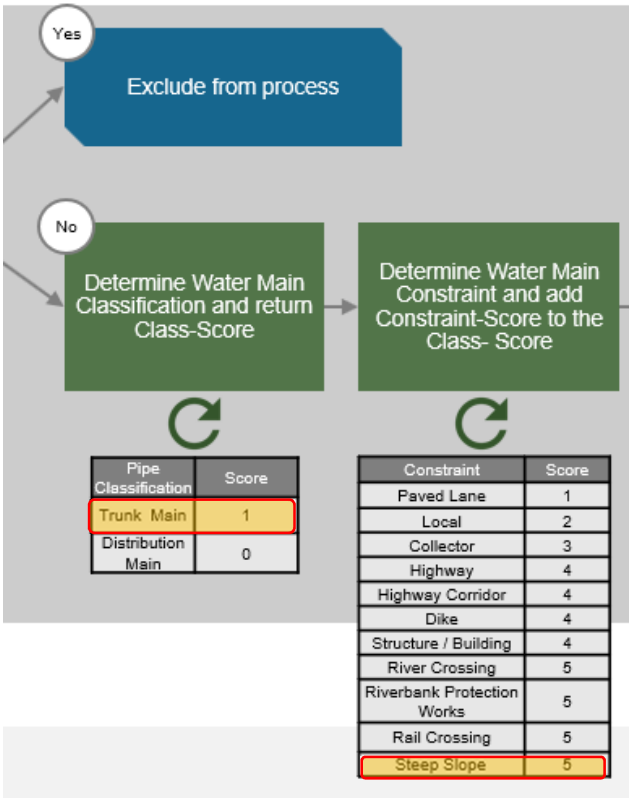


Risk rating process

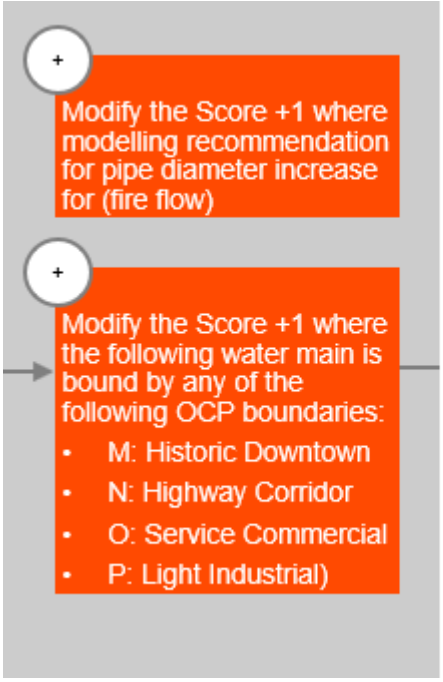
4. Answer question one. In this case there is not fire hydrant lead and it is not a service. Follow the arrow down to the next question.



5. Assign a score of "0" or "1" depending on the pipe classification. In this case it is a trunk main equaling "1". At this point add any constraint scores listed. In this example the main is on a steep slope giving the constraint score a "5", summing to "6".



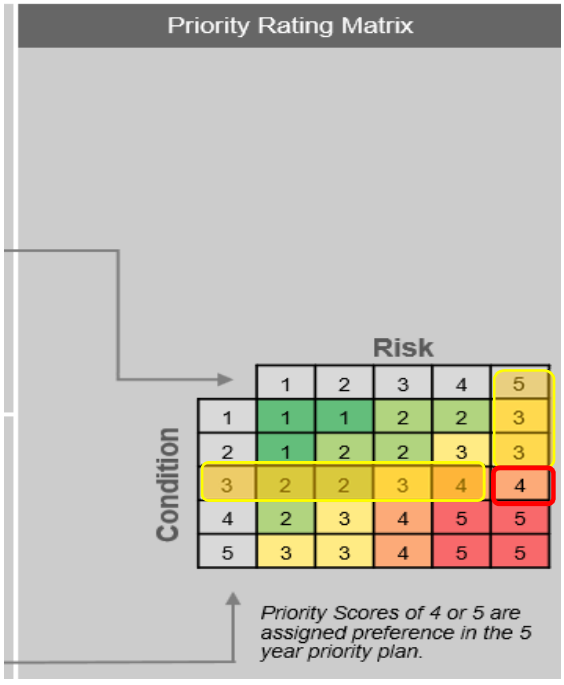
6. Additional modifiers of “+1” are added at this point if modelling recommends a pipe diameter increase. As well as add “+1” if the water main is bound by any of the following OCP boundaries Historic Downtown (m), Highway Corridor (N), Service Commercial (O), or Light Industrial (P).



In this case the pipe has not been recommended for a size increase and is not bounded by any of the OCP boundaries listed, the risk score remains a “6” however the maximum risk score is 5 therefore this example remains as a “5”

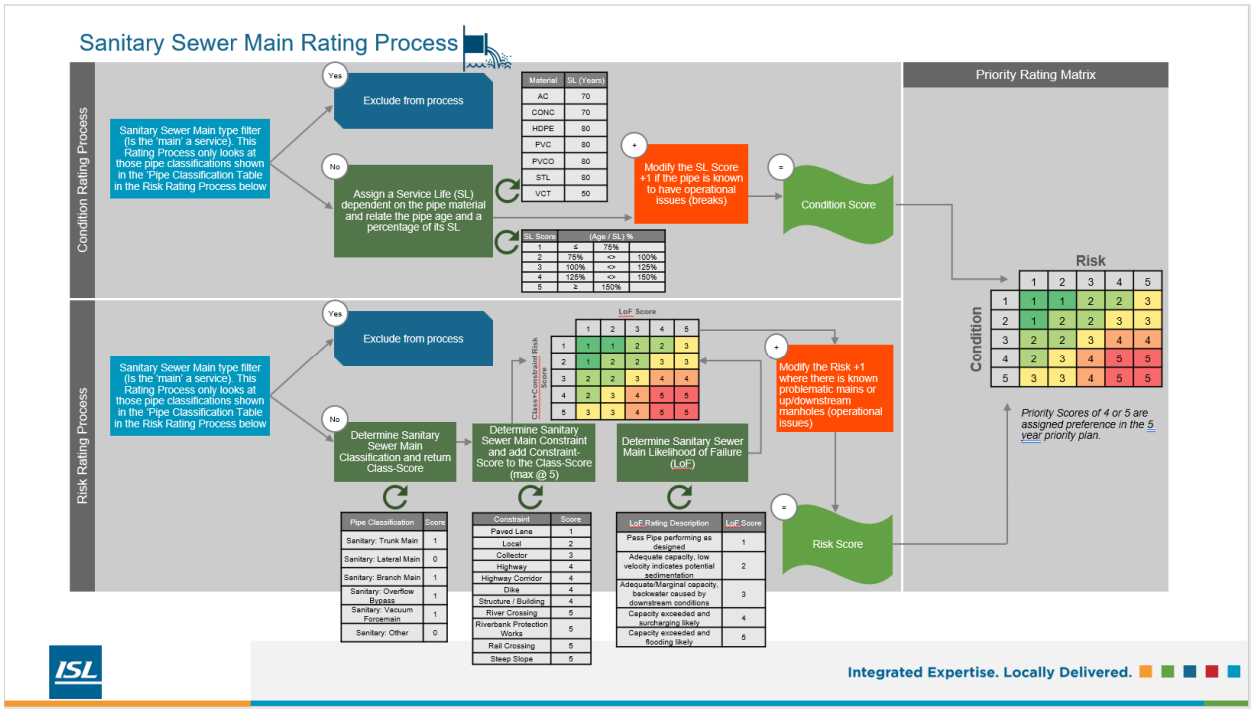
Totaling up the results or risk and condition

Our result is a condition of “3” and a risk of “5”. Next follow row 3 right and column 5 down. The priority rating is a “4”.



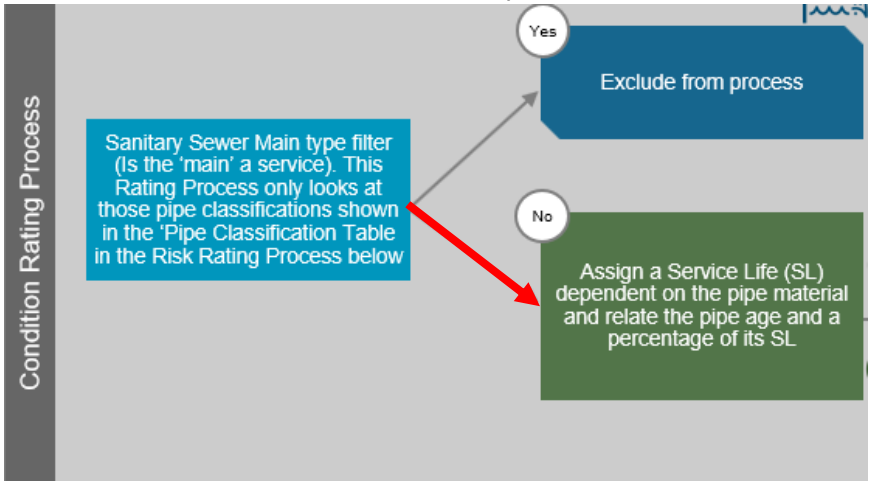
2.0 Sanitary Sewer Main Rating Process

This is an example of how to use sanitary sewer main matrix. This example uses the sewer main on 7th Ave. between 9th and 10th street (ASSET_ID 201324). This PVC Trunk Main was installed in 1980 and has a service life of 80 years.

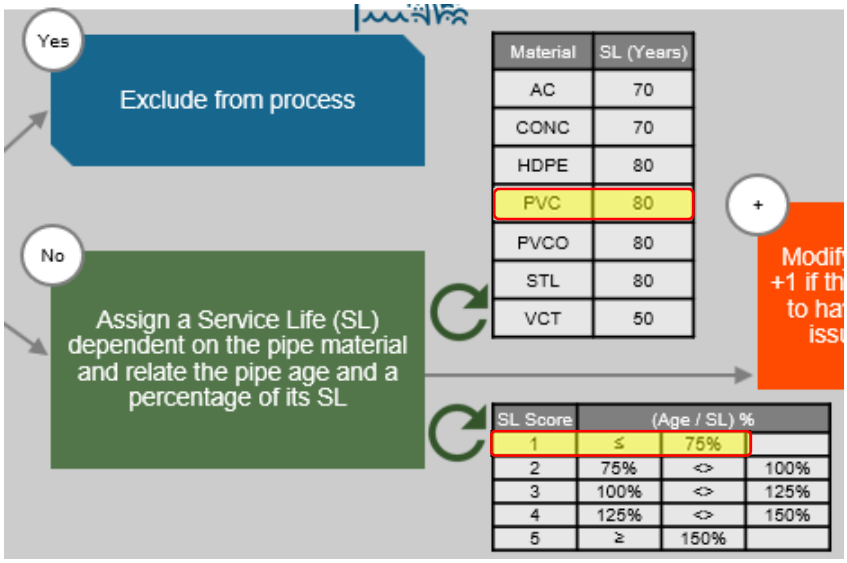


Condition rating process

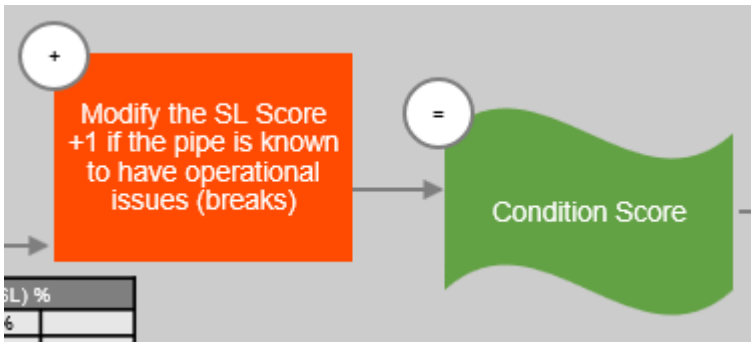
1. Determine if the line is a “service main”. If not, proceed down to the service life.



2. Next assign a Service life (SL) value from the provided column. In our case we have a PVC pipe with a value of 80 years. The installation date was 1980. The age of the pipe is 2020-1980= 40 years. The SL score is then calculated by dividing the age by the SL x 100. (40 / 80) x 100 = 50.0%. The result falls into the equal to or less than 75% row with a SL score of "1".

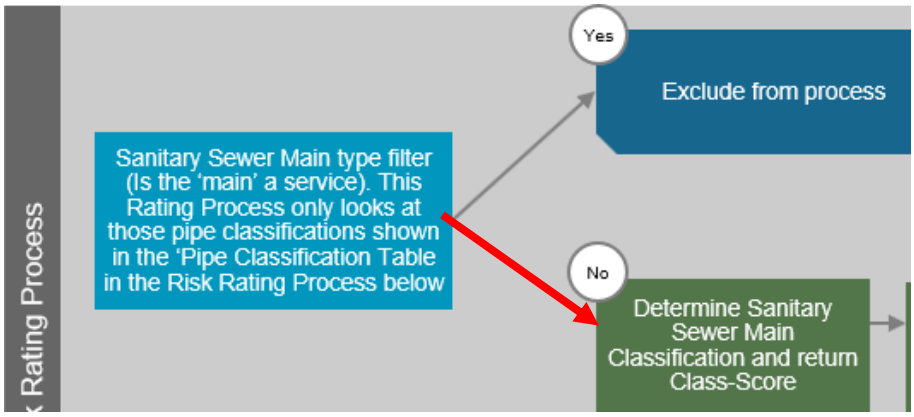


3. Next add "+1" to lines having any know operational issues or breaks. In this case there are no known issues We now have a total condition score of "1".



Risk rating prosses.

4. Determine if the line is a "service main". If not, proceed down to the service life.

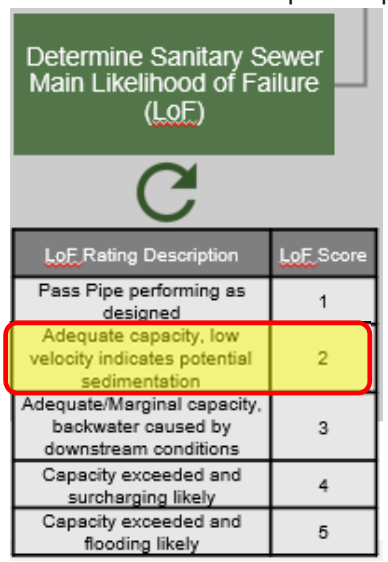


5. Assign a score of "0" or "1" depending on the pipe classification. In this case it is a Trunk Main which receives a "1". Next determine the constraint and add it to the class rating score. In this case it is considered under a collector with a score of "3". The sum for classification and constraint is "4".

Pipe Classification	Score
Sanitary: Trunk Main	1
Sanitary: Collector Main	0
Sanitary: Overflow Bypass	1
Sanitary: Vacuum Forcemain	1
Sanitary: Other	0

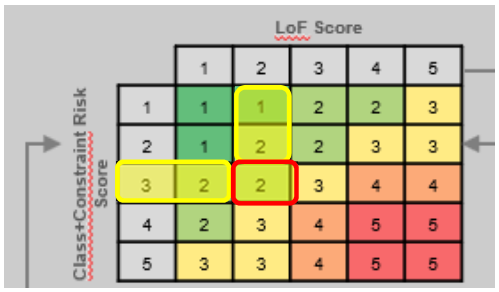
Constraint	Score
Paved Lane	1
Local	2
Collector	3
Highway	4
Highway Corridor	4
Dike	4
Structure / Building	4
River Crossing	5
Riverbank Protection Works	5
Rail Crossing	5
Steep Slope	5

6. Now determin the LoF rating by selecting the approproiate description and score. This sanitary line was cosidered to have adequate capacity and low velocity with a LoF score of "2".

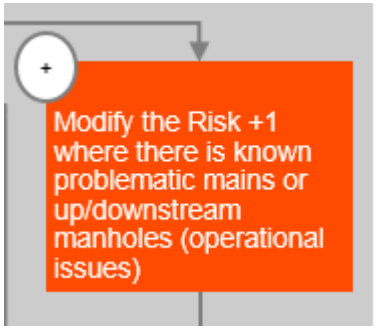


LoF Rating Description	LoF Score
Pass Pipe performing as designed	1
Adequate capacity, low velocity indicates potential sedimentation	2
Adequate/Marginal capacity, backwater caused by downstream conditions	3
Capacity exceeded and surcharging likely	4
Capacity exceeded and flooding likely	5

7. Now use the risk matrix to determine the combination results. Our result for class & condition was a "3" and for LoF it is "2". Next follow row 3 right and column 2 down. The priority rating is a "2".

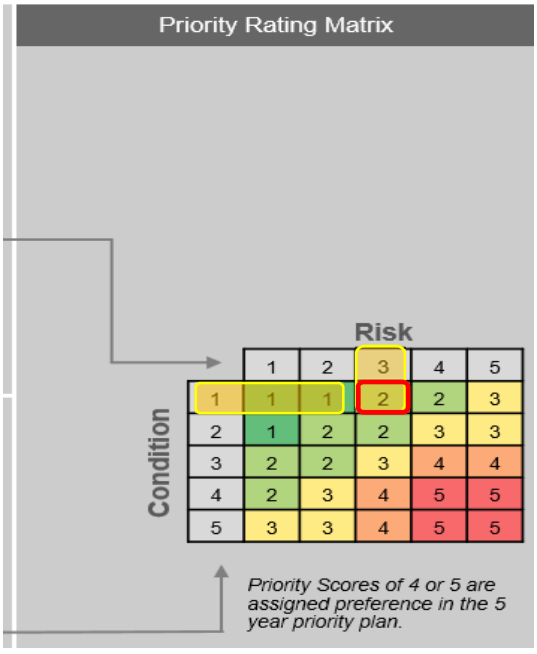


8. Add an additional modifiers of "+1" if there are problematic mains or manhole operations issues. In this case there are no issues.



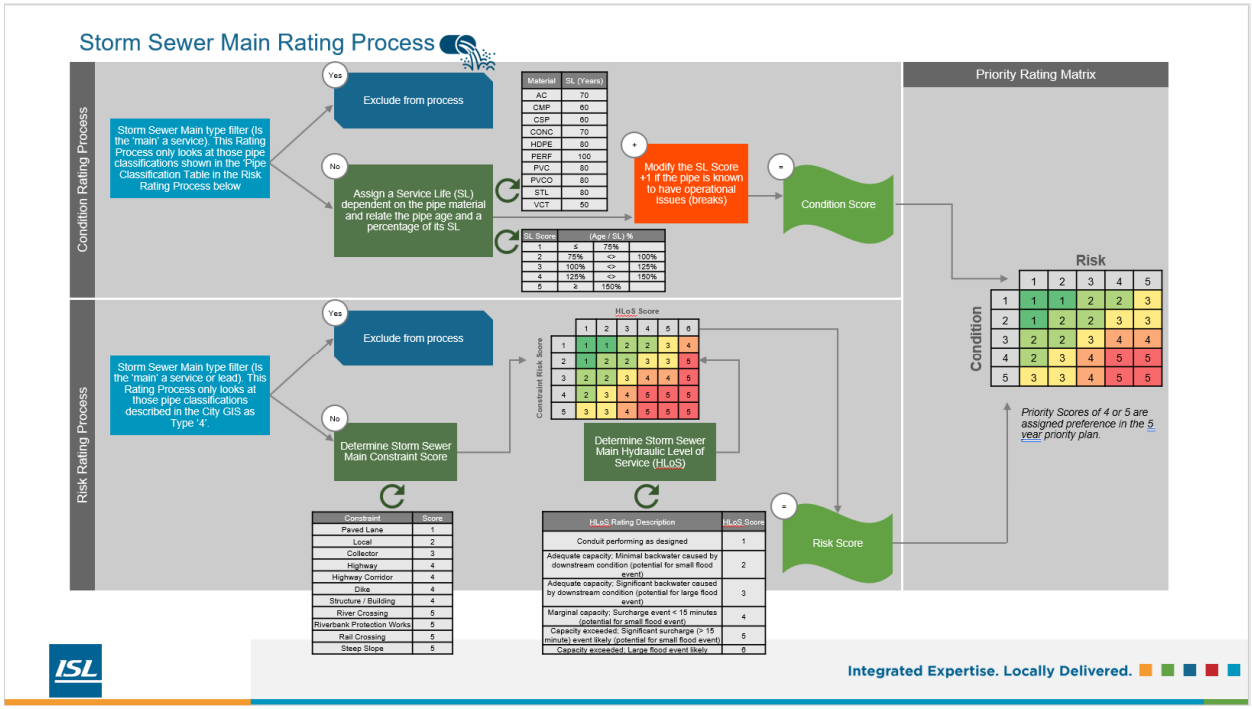
Totaling up the results of risk and condition

Our result for condition was a "1" and for risk it is "3". Next follow row 1 right and column 3 down. The priority rating is a "2".



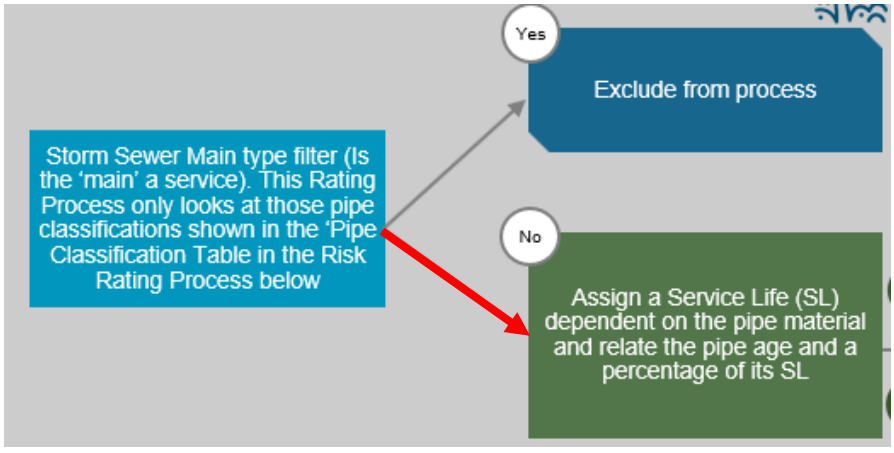
3.0 Storm Rating Process

This is an example of how to use storm sewer main matrix. This example uses the storm sewer main located at 5th street between 1st and 2nd. (OBJECT_ID 422). This concrete branch main was installed in 1950 and has a service life of 70 years. The modeled capacity of this main is has been exceeded.

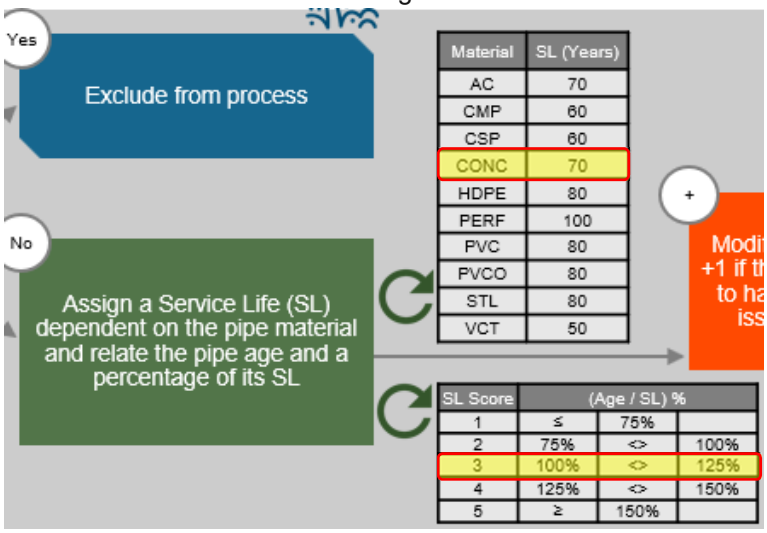


Condition rating process

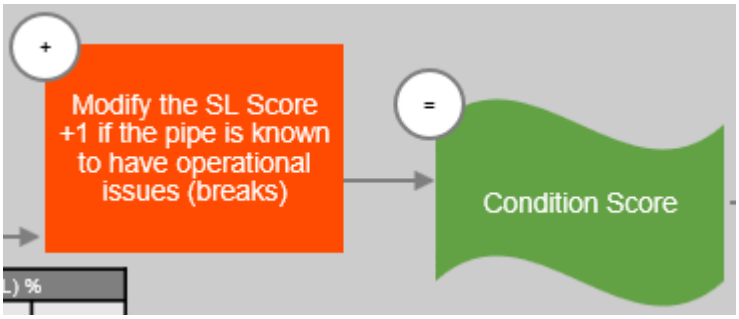
1. Determine if the line is a listed in the classification table.



2. Next assign a Service life (SL) value from the provided column. In this case we have a concrete (conc) pipe with a value of 70 years. The installation date was 1950. The age of the pipe is 2020-1950= 70 years. The SL score is then calculated by dividing the AGE by the SL x 100. (70 / 70) x 100 = 100.0%. The result falls into the range of 100% - 125% with a SL score of "3".

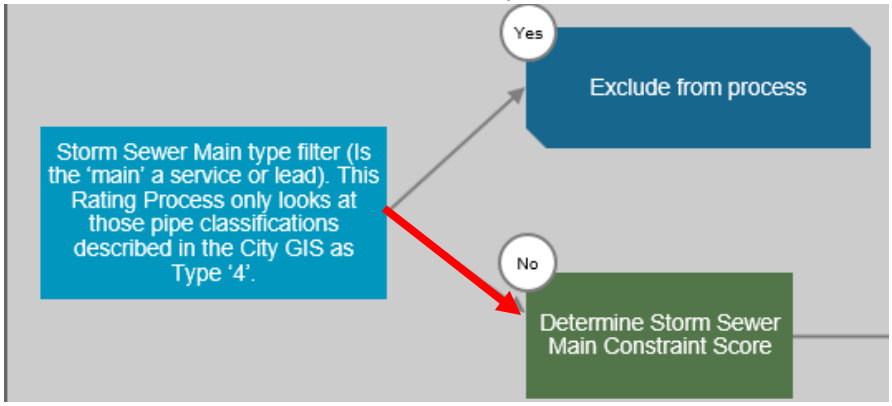


3. Next add "+1" to lines having any know operational issues or breaks. In this case there are no known issues We now have a total condition score of "3".

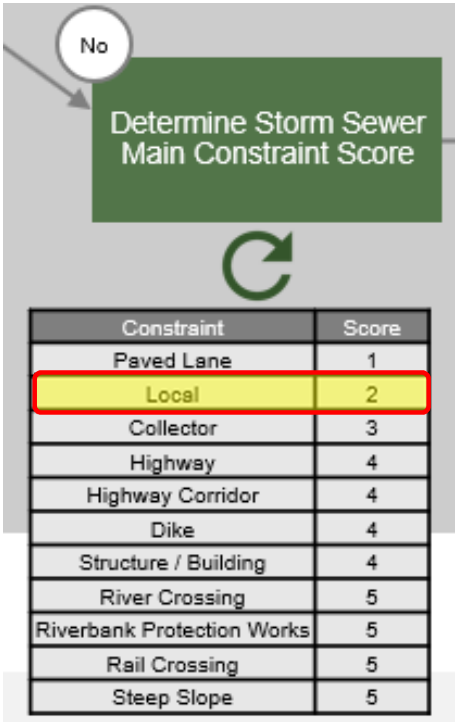


Risk rating process.

4. Determine if the line is a "service main". If not, proceed down to the service life.

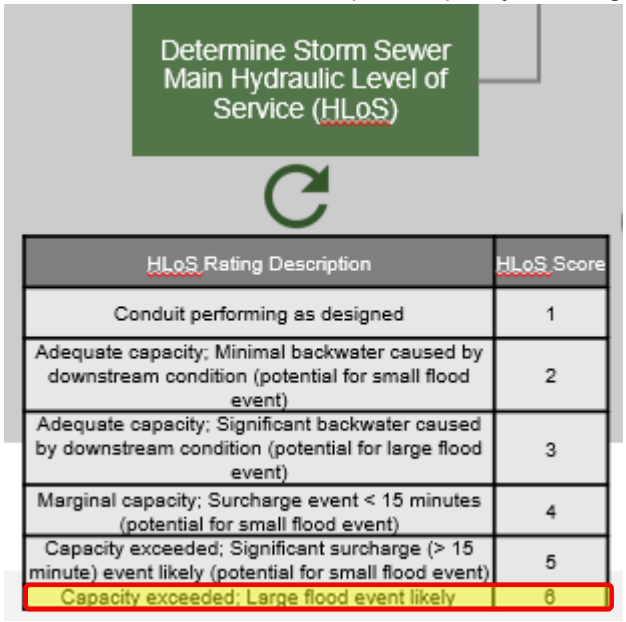


5. Assign a score of “1” through “5” depending on the applicable pipe constraints. In this case it is under a local road “2”. The total for constraint is “2”.



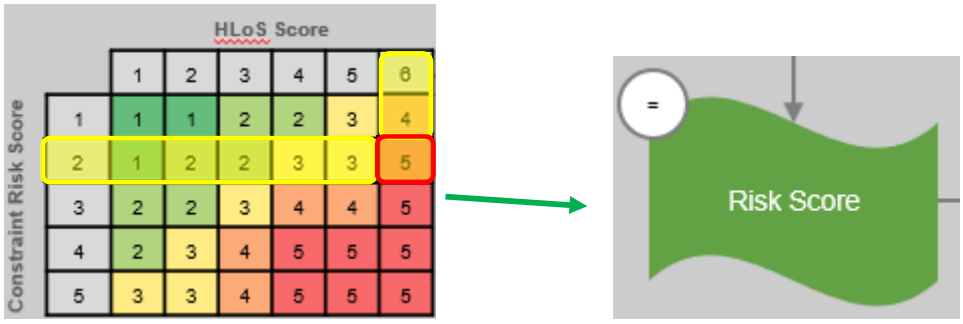
Constraint	Score
Paved Lane	1
Local	2
Collector	3
Highway	4
Highway Corridor	4
Dike	4
Structure / Building	4
River Crossing	5
Riverbank Protection Works	5
Rail Crossing	5
Steep Slope	5

6. Now determin the HLoS rating by selecting the approproiate description and score. This storm sewer line was cosidered to have inadequate capacity resulting in a score of “6”.



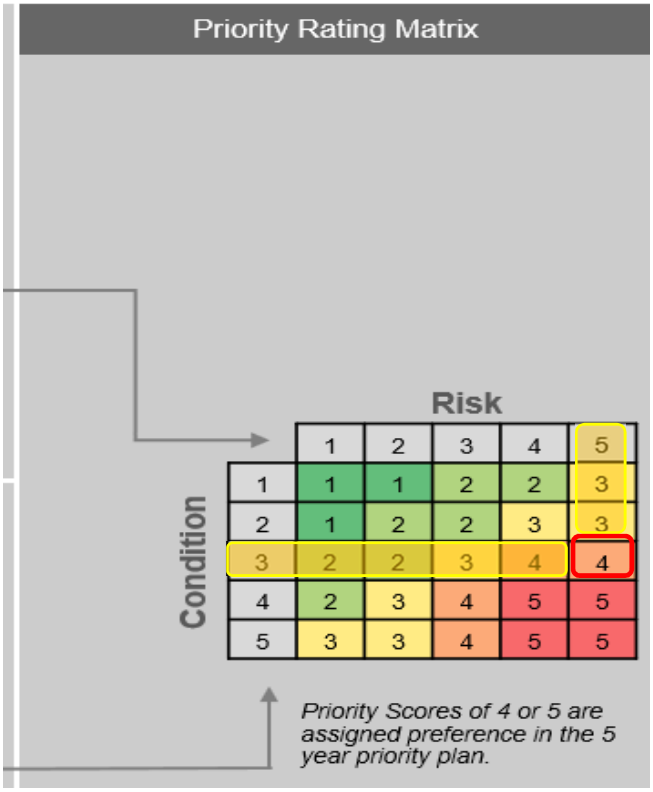
HLoS Rating Description	HLoS Score
Conduit performing as designed	1
Adequate capacity; Minimal backwater caused by downstream condition (potential for small flood event)	2
Adequate capacity; Significant backwater caused by downstream condition (potential for large flood event)	3
Marginal capacity; Surcharge event < 15 minutes (potential for small flood event)	4
Capacity exceeded; Significant surcharge (> 15 minute) event likely (potential for small flood event)	5
Capacity exceeded; Large flood event likely	6

7. Now use the risk matrix to determine the combination results. Our result for constraints was a “2” and for HLoS it is “6”. Next follow row 2 right and column 6 down. The priority rating is a “5”.



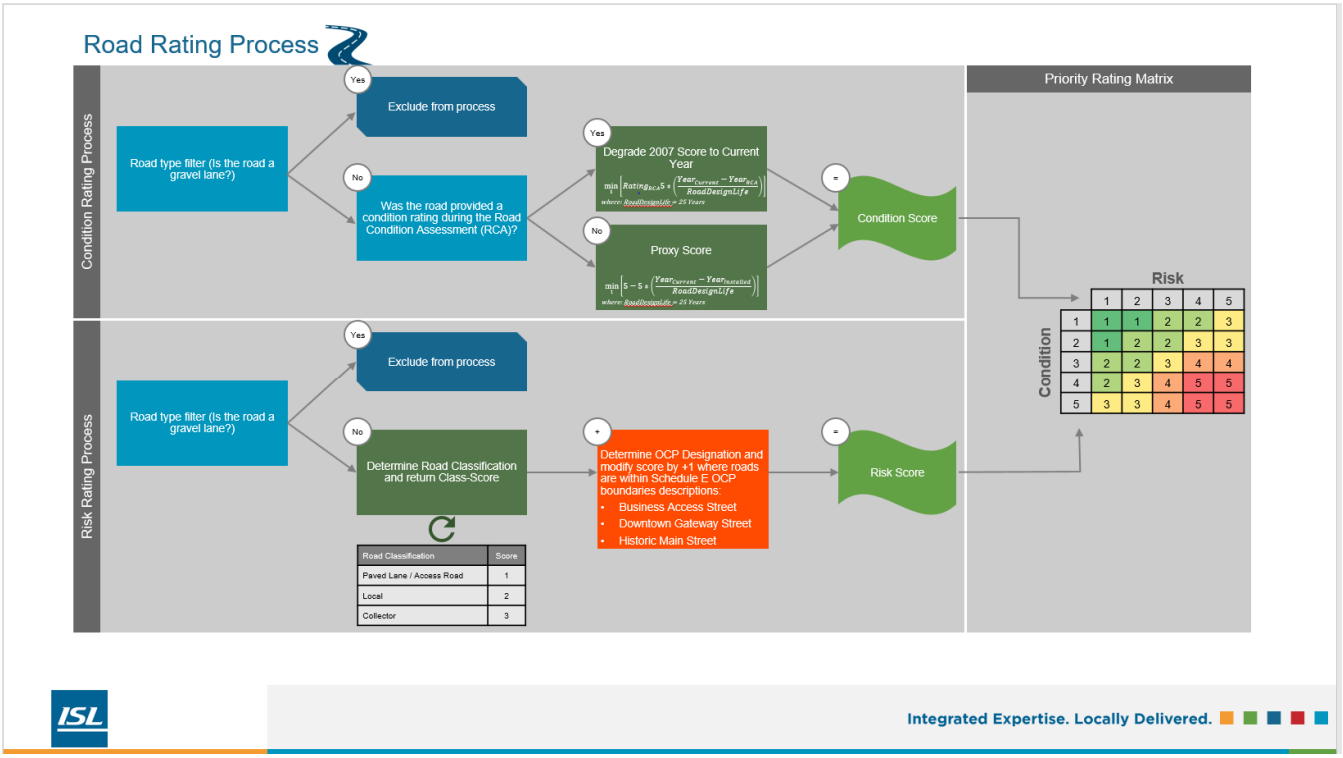
Totaling up the results of risk and condition

Our result for condition was a "3" and for risk it is "5". Next follow row 3 right and column 5 down. The priority rating is a "4".



4.0 Road Rating Process

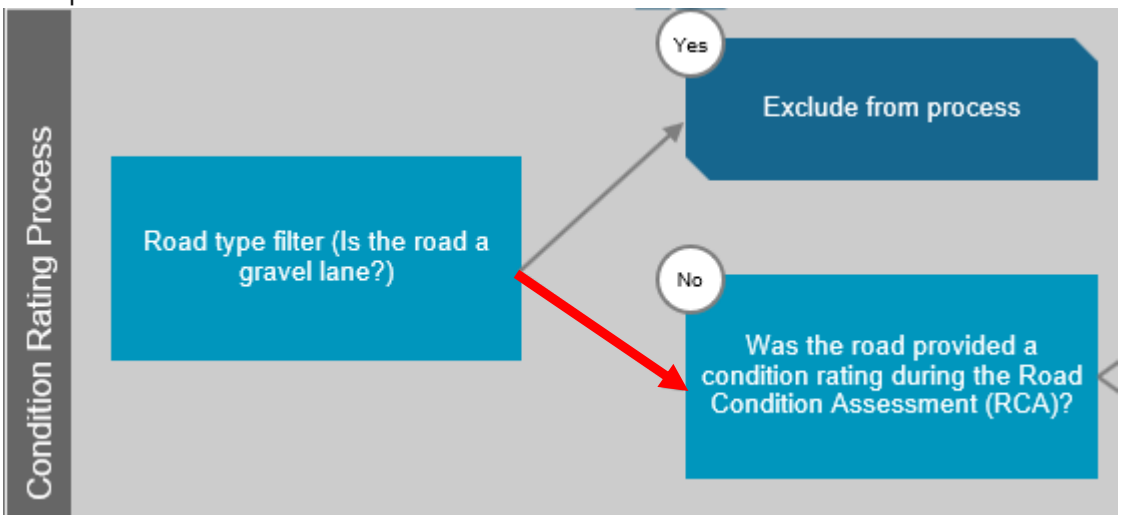
This is an example of how to use the Road Rating Matrix with 4th Street between 8th and 9th Ave as our example (Object ID 309). This paved collector road was installed in 1990 and was last assessed in 2007 with a rating of "1". In order to be consistent with the other decision criteria matrices in this report, the road condition scores from the 2007 report are inverted (i.e. 1 becomes 5, 2 becomes 4, and 3 remains 3). Therefore the condition used in this example is "5"



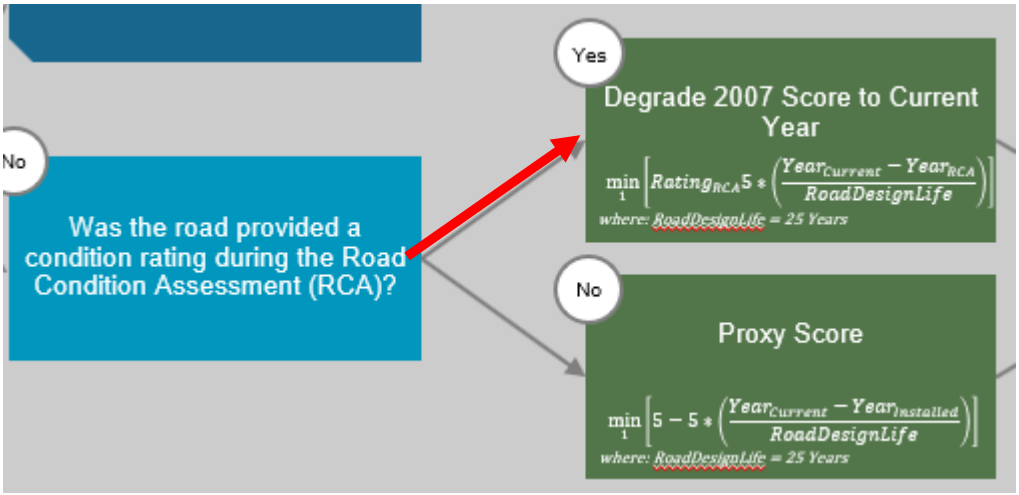
Integrated Expertise. Locally Delivered.

Condition Rating Processes

8. Answer question one. In this case the road is paved and not a lane. Follow the arrow down to the next question.



9. Next choose whether the road was assigned a condition rating "5" as discussed above.

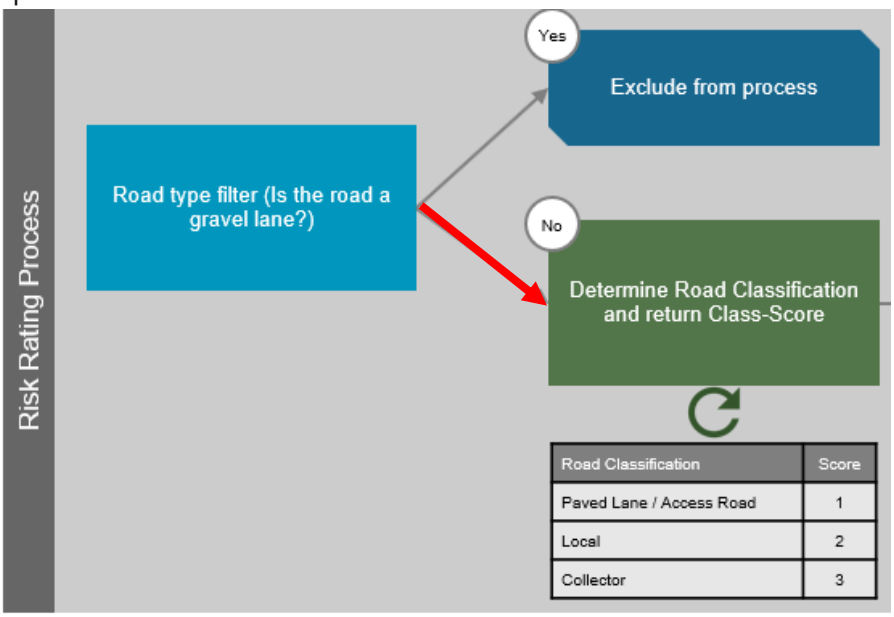


$$\max_{5} \left[5 + 5 * \left(\frac{2020 - 2007}{25} \right) \right]$$

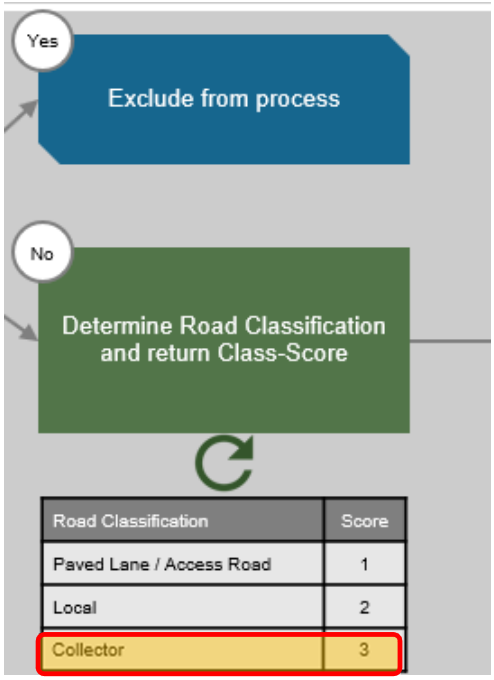
10. Sum up the values for conditions. Gives 7.6 however he poorest conditions score available is 5 therefore this road receives a 5 for condition.

Risk rating prosses.

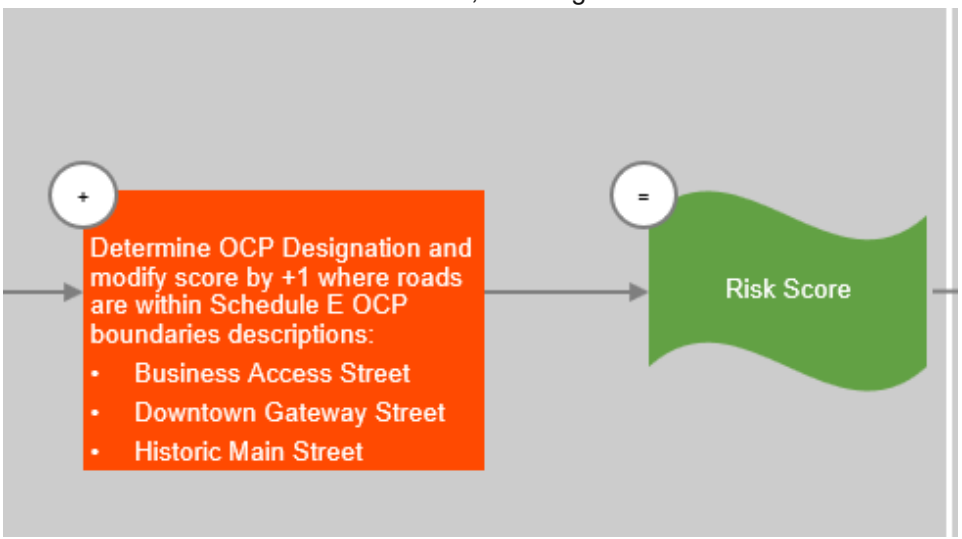
11. Answer question one. In this case the road is paved and not a lane. Follow the arrow down to the next question.



12. Assign a score of “1”, “2” or “3” depending on the road classification. In this case it is a collector equaling “3”.

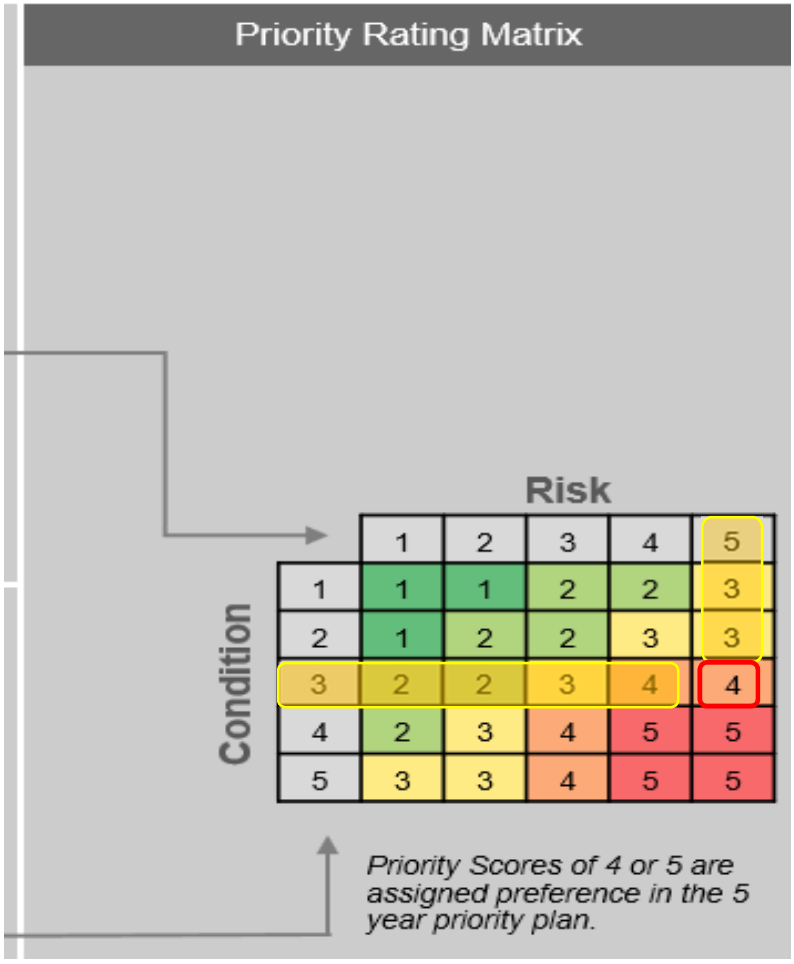


13. Additional modifiers of “+1” are added at this point if the roads are within the schedule E OCP boundaries of Business Access Street, Downtown Gateway Street, or Historic Main Street. In this case there are no additions to the score, resulting in a final risk score of “3”.



Totaling up the results of risk and condition

Our result for condition was a "5" and for risk it is "3". Next follow row 5 right and column 3 down. The priority rating is a "4".





Appendix E

Utility and Roads Short Term Project Cost Estimates

PROGRAM #:
ASSET TYPE:
ASSET ID:
LOCATION:
FROM/TO:
WM/JUNT S:

DESCRIPTION	UNIT	$
CONTINGENCY	20%	
ENGINEERING (DESIGN AND CONSTRUCTION SERVICES)	15%	
GENERAL REQUIREMENTS (CONTRACTOR)	5%	
Infrastructure Subtotal		
EXCAVATING TRENCHING AND BACKFILLING		
Remove and dispose offsite excavation including materials including backfilling with Gravel or granular mix (1575 @ 3.5m2 trench & section)	Cubic Meters	$ 60.00
WATERWORKS		
Under Rail/River (additional cost)	Linear Metres	$ 1,500.00
Under Hwy (additional cost)	Linear Metres	$ 500.00
Under Paved Road (additional cost)	Linear Metres	$ 200.00
Watermain 150 mm	Linear Metres	$ 800.00
Watermain 200 mm	Linear Metres	$ 675.00
Watermain 300 mm	Linear Metres	$ 600.00
Watermain 400 mm	Linear Metres	$ 550.00
Watermain 250 mm	Linear Metres	$ 500.00
Watermain 100 mm	Linear Metres	$ 450.00
In-line Gate Valves ≤200 mm	Each	$ 3,000.00
In-line Gate Valves ≥250 mm	Each	$ 3,000.00
Tee ≤200 mm	Each	$ 1,800.00
Tee ≥250 mm	Each	$ 1,800.00
Bend ≤200 mm	Each	$ 500.00
Bend ≥250 mm	Each	$ 500.00
Coupler ≤200 mm	Each	$ 1,200.00
Coupler ≥250 mm	Each	$ 2,400.00
Water Service Connections 50 mm	Each	$ 2,400.00
Water Service Connections 25 mm	Each	$ 2,150.00
Water Service Connections 19 mm	Each	$ 1,800.00
Hydrant Assembly	Each	$ 4,000.00
Watermain Valve	Lump Sum	$ 6,000.00
SANITARY SEWER		
Sanitary Main ≤350 mm (Under Hwy)	Linear Metres	$ 1,250.00
Sanitary Main ≤350 mm (Under Paved Road)	Linear Metres	$ 750.00
Sanitary Main ≤350 mm (Under Paved Road)C	Linear Metres	$ 550.00
Sanitary Main ≤350 mm (Under Gravel Lane)	Linear Metres	$ 500.00
Sanitary Service Connections 100 mm	Linear Metres	$ 2,750.00
Sanitary Tie-in	Linear Metres	$ 5,000.00
STORM SEWER		
Pipe ≤375 mm (Under Paved Road)	Linear Metres	$ 650.00
Pipe ≥400 mm (Under Paved Road)	Linear Metres	$ 700.00
Pipe ≤375 mm (Under Gravel Lane)	Linear Metres	$ 400.00
Pipe ≥400 mm (Under Gravel Lane)	Linear Metres	$ 500.00
PIPE CULVERT		
Culvert Pipe 375 mm diameter CPP for all depths of culvert (Imported Backfill)	Linear Metres	$ 230.00
MANOLES AND CATCHBASINS		
Manhole 1050 Dia. Base, slab, frame and Cover	Each	$ 7,000.00
Manhole Risers 1050 Dia.	Vert. Meter	$ 1,000.00
Manhole 1530 Dia.	Each	$ 11,000.00
Manhole 1800 TBM 1800 Dia	Each	$ 12,000.00
Catchbasin	Each	$ 2,500.00
Catchbasin Lead 250 mm	Linear Metres	$ 180.00
ROADS	LINEAL MT	
Local Road	Square Metre	$ 98.50
Schedule 'B' significant roads with existing c&g	Square Metre	$ 66.50
ROADWAY EXCAVATION, EMBANKMENT AND COMPACTION		
Commencating including bedding/fills with 19mm minus granular base	Cubic Metre	$ 60.00
Common Excavation - Off-Site Disposal for Local Roads	Square Metre	$ 22.00
Subgrade Preparation	Square Metre	$ 5.50
GRANULAR SUB-BASE		
Granular Sub-Base 150mm Thickness for Local Roads	Square Metre	$ 20.00
GRANULAR BASE		
Granular Base 225mm Thickness for Local Roads	Square Metre	$ 25.00
Granular Base 50mm Thickness for OCP Roads	Square Metre	$ 6.00
HOT MIX ASPHALT CONCRETE PAVING		
Saw cutting	10mm depth/after	
Asphalt Pavement 50 mm	Square Metre	$ 28.00
Asphalt Pavement 100 mm	Square Metre	$ 56.00

1SEWER	1SEWER	1SEWER	1SEWER	1SEWER	1SEWER	1SEWER	1SEWER	1SEWER	1SEWER	1SEWER	1SEWER	1SEWER	1WATER	1WATER	1WATER	1WATER	1ROAD	1ROAD	1ROAD	1ROAD	1ROAD	1ROAD	1ROAD
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SEWER	SEWER	SEWER	SEWER	SEWER	SEWER	SEWER	SEWER	SEWER	SEWER	SEWER	SEWER	SEWER	WATER	WATER	WATER	WATER	ROAD	ROAD	ROAD	ROAD	ROAD	ROAD	ROAD
201430	201495	201467	201459	201086	201440	201443	201442	201320	201399	201394	201393	3010566	3010565	3050552	3010718	74	75	76	77	78	79		
10 Ave L	11 Ave	7 Ave	7 Ave	7 Ave	7 Ave	7 Ave	7 Ave	12 St	7 Ave	7 Ave	Hwy	16 St	16 St	16 St	16 St	7 Ave	7 Ave	7 Ave	7 Ave	7 Ave	7 Ave	7 Ave	7 Ave
9 St - 10 St	16 St - Hwy	6 St - 7 St	7 St - 8 St	8 St - 9 St	9 St - 10 St	10 St - 11 St	11 St - 12 St	6 Ave Lane - 7 Ave	12 St - 13 St	15 St - Hwy	BostonPizza - 7 Ave	1 Ave - 9 Ave Lane	9 Ave Lane - 10 Ave	10 Ave - 10 Ave Lane	10 Ave Lane - 12 Ave	7 St - 8 St	8 St - 9 St	9 St - 10 St	10 St - 11 St	11 St - 12 St	12 St - 13 St	
$ 173,870	$ 181,424	$ 177,495	$ 136,924	$ 141,709	$ 149,974	$ 123,453	$ 116,986	$ 159,718	$ 148,524	$ 137,469	$ 80,330	$ 94,105	$ 73,586	$ 96,251	$ 222,459	$ 86,522	$ 93,550	$ 94,215	$ 83,008	$ 82,818	$ 83,673		
$ 29,577.50	$ 31,280.00	$ 30,602.50	$ 23,607.50	$ 24,432.50	$ 25,857.50	$ 21,285.00	$ 20,170.00	$ 27,537.50	$ 25,607.50	$ 23,705.00	$ 13,850.00	$ 16,225.00	$ 12,687.50	$ 16,595.00	$ 38,355.00	$ 14,917.63	$ 16,129.38	$ 16,244.00	$ 14,311.75	$ 14,279.00	$ 14,426.38		
$ 17,086.50	$ 18,768.00	$ 18,361.50	$ 14,164.50	$ 14,659.50	$ 15,514.50	$ 12,771.00	$ 12,102.00	$ 16,522.50	$ 15,364.50	$ 14,223.00	$ 8,310.00	$ 9,735.00	$ 7,612.50	$ 9,957.00	$ 23,013.00	$ 8,950.58	$ 9,677.63	$ 9,746.40	$ 8,587.05	$ 8,567.40	$ 8,655.83		
$ 5,996.50	$ 6,256.00	$ 6,120.50	$ 4,721.50	$ 4,886.50	$ 5,171.50	$ 4,257.00	$ 4,034.00	$ 5,507.50	$ 5,121.50	$ 4,741.00	$ 2,770.00	$ 3,245.00	$ 2,537.50	$ 3,319.00	$ 7,671.00	$ 2,983.53	$ 3,225.88	$ 3,248.80	$ 2,862.35	$ 2,855.80	$ 2,885.28		
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		
$ 119,910.00	$ 125,120.00	$ 122,410.00	$ 94,430.00	$ 97,730.00	$ 103,430.00	$ 85,140.00	$ 80,680.00	$ 110,150.00	$ 102,430.00	$ 94,820.00	$ 55,400.00	$ 64,900.00	$ 50,750.00	$ 66,380.00	$ 153,420.00	$ 59,670.50	$ 64,517.50	$ 64,976.00	$ 57,247.00	$ 57,116.00	$ 57,705.50		
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61 $ 3,660.00	52 $ 3,120.00	61 $ 3,660.00	58 $ 3,480.00	58 $ 3,480.00	48 $ 2,880.00	59 $ 3,540.00	58 $ 3,480.00	40 $ 2,400.00	58 $ 3,480.00	52 $ 3,120.00	15 $ 900.00	25 $ 1,500.00	25 $ 1,500.00	28 $ 1,680.00	82 $ 4,920.00	$ -	$ -	$ -	$ -	$ -	$ -		
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15 $ 11,250.00	99 $ 74,250.00	114 $ 85,500.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	49 $ 36,750.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		
$ -	$ -	$ -	109 $ 59,950.00	110 $ 60,500.00	91 $ 50,050.00	112 $ 61,600.00	109 $ 59,950.00	$ -	109 $ 59,950.00	49 $ 26,950.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		
100 $ 55,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		
9 $ 22,050.00	9 $ 24,750.00	7 $ 19,250.00	8 $ 22,000.00	9 $ 24,750.00	10 $ 27,500.00	4 $ 11,000.00	3 $ 8,250.00	$ -	4 $ 11,000.00	$ -	1 $ 2,750.00	$ -	$ -	$ -	2 $ 1,800.00	$ -	$ -	$ -	$ -	$ -	$ -		
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						4WATER		4WATER	
					PROGRAM #:	4		4	
					ASSET TYPE:	WATER		WATER	
					ASSET ID:	3010144		3010145	
					LOCATION:	C&L RW		C&L RW	
					FROM/TO:	Parallel Burma		River Crossing	
					AMOUNT $:		$ 3,625,000		$ 634,404
	DESCRIPTION	UNIT	$						
	CONTINGENCY	20%					$ 625,000.00		$ 109,380.00
	ENGINEERING (DESIGN AND CONSTRUCTION SERVICES)	15%					$ 375,000.00		$ 65,628.00
	GENERAL REQUIREMENTS (CONTRACTOR)	5%					$ 125,000.00		$ 21,876.00
							$ -		$ -
	Infrastructure Subtotal					Based on prev	##########		$ 437,520.00
	EXCAVATING TRENCHING AND BACKFILLING						$ -		$ -
	Remove and dispose offsite excavate backfill materials including backfilling with Rimun or granular mix (10% @ 3-5m3 trench x section)	Cubic Meters	$ 60.00			0	$ -	97	$ 5,820.00
							$ -		$ -
	WATERWORKS	LINEAL M					$ -		$ -
	Under Rail/River (additional cost)	Lineal Metres	$ 1,500.00				$ -	184	$ 276,000.00
	Under Hwy (additional cost)	Lineal Metres	$ 500.00				$ -		$ -
	Under Paved Road (additional cost)	Lineal Metres	$ 200.00				$ -		$ -
	Watermain 550 mm	Lineal Metres	$ 800.00				$ -	184	$ 147,200.00
	Watermain 450 mm	Lineal Metres	$ 675.00				$ -		$ -
	Watermain 350 mm	Lineal Metres	$ 550.00				$ -		$ -
	Watermain 300 mm	Lineal Metres	$ 500.00				$ -		$ -
	Watermain 250 mm	Lineal Metres	$ 500.00				$ -		$ -
	Watermain 150 mm	Lineal Metres	$ 450.00				$ -		$ -
	In-line Gate Valves ≥250 mm	Each	$ 3,000.00				$ -		$ -
	In-line Gate Valves ≥250 mm	Each	$ 3,000.00				$ -		$ -
	Tee ≥250 mm	Each	$ 1,800.00				$ -		$ -
	Tee ≥250 mm	Each	$ 1,800.00				$ -		$ -
	Bend ≥250 mm	Each	$ 1,000.00				$ -		$ -
	Coupller ≥250 mm	Each	$ 1,200.00				$ -		$ -
	Coupller ≥250	Each	$ 2,500.00			1	$ -	1	$ 2,500.00
	Water Service Connections 50 mm	Each	$ 2,500.00				$ -		$ -
	Water Service Connections 25 mm	Each	$ 2,150.00				$ -		$ -
	Water Service Connections 19 mm	Each	$ 1,800.00				$ -		$ -
	Hydrant Assembly	Each	$ 4,000.00				$ -		$ -
	ENDWORKS Allowance	Lump Sum	$ 6,000.00			1	$ -	1	$ 6,000.00
							$ -		$ -
	SANITARY SEWER	LINEAL M					$ -		$ -
	Sanitary Main ≤350 mm (Under Hwy)	Lineal Metres	$ 1,250.00				$ -		$ -
	Sanitary Main ≤350 mm (Under Paved Road)	Lineal Metres	$ 750.00				$ -		$ -
	Sanitary Main ≤250 mm (Under Paved Road)*	Lineal Metres	$ 550.00				$ -		$ -
	Sanitary Main ≤350 mm (Under Gravel Lane)	Lineal Metres	$ 700.00				$ -		$ -
	Sanitary Service Connections 100 mm	Lineal Metres	$ 2,000.00				$ -		$ -
	Sanitary Tie-in	Lineal Metres	$ 5,000.00				$ -		$ -
							$ -		$ -
	STORM SEWER	LINEAL M					$ -		$ -
	Pipe ≤375 mm (Under Paved Road)	Lineal Metres	$ 650.00				$ -		$ -
	Pipe ≥450 mm (Under Paved Road)	Lineal Metres	$ 700.00				$ -		$ -
	Pipe ≤375 mm (Under Gravel Lane)	Lineal Metres	$ 450.00				$ -		$ -
	Pipe ≥450 mm (Under Gravel Lane)	Lineal Metres	$ 500.00				$ -		$ -
							$ -		$ -
	PIPE CULVERT	LINEAL M					$ -		$ -
	Culvert Pipe 375 mm diameter CPP for all depths of culvert (Imported Backfill)	Lineal Metres	$ 230.00				$ -		$ -
							$ -		$ -
	MANOLES AND CATCHBASINS						$ -		$ -
	Manhole 1050 Dia. Base, slab, frame and Cover	Each	$ 7,000.00				$ -		$ -
	Manhole Risers 1050 Dia.	Vert. Meter	$ 1,000.00				$ -		$ -
	Manhole 1500 Dia.	Each	$ 11,000.00				$ -		$ -
	Manhole Risers 1500 Dia.	Vert. Meter	$ 1,500.00				$ -		$ -
	Catchbasin	Each	$ 4,500.00				$ -		$ -
	Catchbasin Lead 250 mm	Lineal Metres	$ 180.00				$ -		$ -
							$ -		$ -
	ROADS	LINEAL M					$ -		$ -
	Local Road	Square Metre	$ 98.50				$ -		$ -
	Schedule "E" significant roads with existing c&g	Square Metre	$ 65.50				$ -		$ -
							$ -		$ -
	ROADWAY EXCAVATION, EMBANKMENT AND COMPACTION						$ -		$ -
	Cross-excavate including backfilling with 19mm minus granular base	Cubic Metre	$ 60.00				$ -		$ -
	Common Excavation - Off-Site Disposal for Local Roads	Square Metre	$ 22.00				$ -		$ -
	Subgrade Preparation	Square Metre	$ 5.50				$ -		$ -
							$ -		$ -
	GRANULAR SUB-BASE						$ -		$ -
	Granular Sub-Base 150mm Thickness for Local Roads	Square Metre	$ 20.00				$ -		$ -
							$ -		$ -
	GRANULAR BASE						$ -		$ -
	Granular Base 225mm Thickness for Local Roads	Square Metre	$ 25.00				$ -		$ -
	Granular Base 300m Thickness for OOP Roads	Square Metre	$ 6.00				$ -		$ -
							$ -		$ -
	HOT MIX ASPHALT CONCRETE PAVING						$ -		$ -
	Tack coating	****** excluded ******					$ -		$ -
	Asphalt Pavement 50 mm	Square Metre	$ 38.50				$ -		$ -
	Asphalt Pavement 100 mm	Square Metre	$ 56.00				$ -		$ -

PROGRAM #:		
ASSET TYPE:		
ASSET ID:		
LOCATION:		
FRONTTO:		
AMOUNT S:		

DESCRIPTION	UNIT	$
CONTINGENCY	20%	
ENGINEERING (DESIGN AND CONSTRUCTION SERVICES)	15%	
GENERAL REQUIREMENTS (CONTRACTOR)	5%	
0.6 subbase Subtotal		
EXCAVATING TRENCHING AND BACKFILLING		
Remove and dispose offsite excavate backfill materials including backfilling with Rimun or granular mix (10% @ 3-5m3 trench x section)	Cubic Meters	$ 60.00
WATERWORKS		
Under Rd/Floor (additional cost)	Lineal Metres	$ 1,500.00
Under Hwy (additional cost)	Lineal Metres	$ 500.00
Under Paved Road (additional cost)	Lineal Metres	$ 200.00
Watermain 150 mm	Lineal Metres	$ 800.00
Watermain 200 mm	Lineal Metres	$ 875.00
Watermain 250 mm	Lineal Metres	$ 950.00
Watermain 300 mm	Lineal Metres	$ 1,025.00
Watermain 350 mm	Lineal Metres	$ 500.00
Watermain 150 mm	Lineal Metres	$ 450.00
In-line Gate Valves ≤200 mm	Each	$ 3,000.00
In-line Gate Valves ≥250 mm	Each	$ 3,000.00
Tee ≤200 mm	Each	$ 1,800.00
Tee ≥250 mm	Each	$ 1,800.00
Bend ≤200 mm	Each	$ 1,800.00
Bend ≥250 mm	Each	$ 900.00
Coupller ≤200 mm	Each	$ 1,200.00
Coupller ≥250	Each	$ 2,500.00
Water Service Connections 50 mm	Each	$ 2,500.00
Water Service Connections 25 mm	Each	$ 2,150.00
Water Service Connections 19 mm	Each	$ 1,800.00
Hydrant Assembly	Each	$ 2,000.00
Abandonment	Lump Sum	$ 6,000.00
SANITARY SEWER		
Sanitary Main ≤350 mm (Under Hwy)	Lineal Metres	$ 1,250.00
Sanitary Main ≤350 mm (Under Paved Road)	Lineal Metres	$ 750.00
Sanitary Main ≤350 mm (Under Paved Road)*	Lineal Metres	$ 550.00
Sanitary Main ≤350 mm (Under Gravel Lane)	Lineal Metres	$ 500.00
Sanitary Service Connections 100 mm	Lineal Metres	$ 2,500.00
Sanitary Tie-in	Lineal Metres	$ 5,000.00
STORM SEWER		
Pipe ≤375 mm (Under Paved Road)	Lineal Metres	$ 650.00
Pipe ≥450 mm (Under Paved Road)	Lineal Metres	$ 700.00
Pipe ≤375 mm (Under Gravel Lane)	Lineal Metres	$ 450.00
Pipe ≥450 mm (Under Gravel Lane)	Lineal Metres	$ 500.00
PIPE CULVERT		
Culvert Pipe 375 mm diameter CPP for all depths of culvert (Imported Backfill)	Lineal Metres	$ 230.00
MANOLES AND CATCHBASINS		
Manhole 1050 Dia. Base, slab, frame and Cover	Each	$ 7,000.00
Manhole Risers 1050 Dia.	Vert. Meter	$ 1,000.00
Manhole 1500 Dia.	Each	$ 11,000.00
Manhole Risers 1500 Dia.	Vert. Meter	$ 1,500.00
Catchbasin	Each	$ 4,500.00
Catchbasin Lead 250 mm	Lineal Metres	$ 180.00
ROADS	LINEAL M	
Local Road	Square Metre	$ 98.50
Schedule "E" significant roads with existing c&g	Square Metre	$ 66.50
ROADWAY EXCAVATION, EMBANKMENT AND COMPACTION		
Cross-excavating including backfilling with 19mm minus granular base	Cubic Metre	$ 60.00
Common Excavation - Off-Site Disposal for Local Roads	Square Metre	$ 22.00
Subgrade Preparation	Square Metre	$ 9.50
GRANULAR SUB-BASE		
Granular Sub-Base 150mm Thickness for Local Roads	Square Metre	$ 20.00
GRANULAR BASE		
Granular Base 225mm Thickness for Local Roads	Square Metre	$ 25.00
Granular Base 300m Thickness for COP Roads	Square Metre	$ 6.00
HOT MIX ASPHALT CONCRETE PAVING		
Tack coat(s)	****** accepted ******	
Asphalt Pavement 50 mm	Square Metre	$ 28.00
Asphalt Pavement 100 mm	Square Metre	$ 56.00

SWATER	SWATER	SWATER	SWATER	SWATER	SWATER	SWATER	SWATER	SWATER	SWATER	SWATER	SWATER	SWATER	SWATER	SROAD	SROAD	SROAD	SROAD	SROAD	SROAD
$	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$
WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	ROAD 17	ROAD 18	ROAD 19	ROAD 20	ROAD 21	ROAD 22
3010065	3010272	3010253	3010409	3010253	3010409	3010253	3010250	3010403	3010400	3010398	3010254	3010255	3010395						
6 St	3 Ave	3 Ave	3 Ave	8 St	8 St	8 St	8 St	8 St	8 St	8 St	8 St	2 Ave	8 St	2 Ave	2 Ave	2 Ave	2 Ave	2 Ave	2 Ave
3 Ave - 3 Ave Lane	8 St - 7 St	8 St - 9 St	9 St - 10 St	9 St - 8 St	2 Ave - 2 Ave Lane	2 Ave Lane - 3 Ave	1 Ave - 2 Ave	2 Ave - 2 Ave Lane	2 Ave Lane - 3 Ave	3 Ave - 4 Ave	4 Ave - 5 Ave	5 Ave - 5 Ave Lane	5 Ave Line - 6 Ave	7 St - 8 St	8 St - 9 St	9 St - 10 St	10 St - 11 St	11 St - 12 St	12 St - 13 St
$ 84,593	$ 173,609	$ 148,799	$ 150,191	$ 102,153	$ 79,286	$ 71,833	$ 116,464	$ 100,456	$ 93,859	$ 128,927	$ 127,506	$ 93,032	$ 54,317	$ 140,658	$ 140,658	$ 140,658	$ 140,658	$ 140,658	$ 140,658
$ 14,585.00	$ 29,932.50	$ 25,655.00	$ 25,895.00	$ 17,612.50	$ 13,670.00	$ 12,385.00	$ 20,080.00	$ 17,320.00	$ 16,182.50	$ 22,228.75	$ 21,983.75	$ 16,040.00	$ 9,365.00	$ 24,251.38	$ 24,251.38	$ 24,251.38	$ 24,251.38	$ 24,251.38	$ 24,251.38
$ 8,751.00	$ 17,959.50	$ 15,393.00	$ 15,537.00	$ 10,567.50	$ 8,202.00	$ 7,431.00	$ 12,048.00	$ 10,392.00	$ 9,709.50	$ 13,337.25	$ 13,190.25	$ 9,624.00	$ 5,619.00	$ 14,550.83	$ 14,550.83	$ 14,550.83	$ 14,550.83	$ 14,550.83	$ 14,550.83
$ 2,917.00	$ 5,986.50	$ 5,131.00	$ 5,179.00	$ 3,522.50	$ 2,734.00	$ 2,477.00	$ 4,016.00	$ 3,464.00	$ 3,236.50	$ 4,445.75	$ 4,396.75	$ 3,208.00	$ 1,873.00	$ 4,850.28	$ 4,850.28	$ 4,850.28	$ 4,850.28	$ 4,850.28	$ 4,850.28
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ 58,340.00	$ 119,730.00	$ 102,620.00	$ 103,580.00	$ 70,450.00	$ 54,680.00	$ 49,540.00	$ 80,320.00	$ 69,280.00	$ 64,730.00	$ 88,915.00	$ 87,935.00	$ 64,160.00	$ 37,460.00	$ 97,005.50	$ 97,005.50	$ 97,005.50	$ 97,005.50	$ 97,005.50	$ 97,005.50
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
24 $ 1,440.00	58 $ 3,480.00	57 $ 3,420.00	53 $ 3,180.00	60 $ 3,600.00	28 $ 1,680.00	29 $ 1,740.00	37 $ 2,220.00	33 $ 1,980.00	28 $ 1,680.00	49 $ 2,940.00	51 $ 3,060.00	26 $ 1,560.00	11 $ 660.00	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
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46 $ 9,000.00	110 $ 22,000.00	108 $ 21,600.00	100 $ 20,000.00	52 $ 10,400.00	54 $ 10,800.00	70 $ 14,000.00	62 $ 12,400.00	53 $ 10,600.00	62 $ 12,400.00	97 $ 19,400.00	48 $ 9,600.00	20 $ 4,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	110 $ 74,250.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	93 $ 62,775.00	97 $ 65,475.00	48 $ 32,400.00	20 $ 13,500.00	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
46 $ 22,500.00	$ -	108 $ 54,000.00	100 $ 50,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	113 $ 50,850.00	52 $ 23,400.00	54 $ 24,300.00	70 $ 31,500.00	62 $ 27,900.00	53 $ 23,850.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ 3,000.00	1 $ 3,000.00	2 $ 6,000.00	$ -	1 $ 3,000.00	1 $ 3,000.00	3 $ 9,000.00	3 $ 9,000.00	1 $ 3,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ 3,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	1 $ 3,000.00	$ -	$ -	3 $ 9,000.00	$ -	$ -	$ -	$ -	$ -	$ -
1 $ 1,800.00	$ -	1 $ 1,800.00	$ -	$ -	1 $ 1,800.00	$ -	1 $ 1,800.00	1 $ 1,800.00	1 $ 1,800.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	1 $ 1,800.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ -	2 $ 2,000.00	$ -	2 $ 2,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	2 $ 1,800.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3 $ 3,600.00	$ -	$ -	$ -	$ -	2 $ 2,400.00	1 $ 1,200.00	2 $ 2,400.00	2 $ 2,400.00	2 $ 2,400.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	2 $ 5,000.00	2 $ 5,000.00	2 $ 5,000.00	$ -	$ -	1 $ 2,500.00	$ -	$ -	$ -	$ -	$ -	2 $ 5,000.00	1 $ 2,500.00	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	2 $ 3,600.00	1 $ 3,600.00	$ -	$ -	$ -	3 $ 5,400.00	1 $ 1,800.00	3 $ 5,400.00	1 $ 1,800.00	1 $ 1,800.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	2 $ 2,000.00	2 $ 4,000.00	$ -	$ -	$ -	$ -	2 $ 4,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
1 $ 2,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
1 $ 16,000.00	2 $ 12,000.00	2 $ 12,000.00	2 $ 12,000.00	2 $ 12,030.00	2 $ 12,000.00	1 $ 6,000.00	2 $ 12,000.00	2 $ 12,000.00	2 $ 12,000.00	1 $ 6,000.00	$ -	2 $ 12,000.00	1 $ 6,000.00	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -

Appendix F

Utility and Roads Long Term Projects

Long Term Road Projects

Street ID	Location	From	To	Priority Rating	Replacement Cost	Program #
296	Cokato Road	Whitetail Drive	Castle Mountain Rd	4	$ 475,217	6-20
295	Cokato Road	Coal Creek Bridge	Whitetail Dr	4	$ 244,835	6-20
294	Pine Avenue	Coal Creek Rd	Pine Cres	4	$ 389,845	6-20
293	Pine Avenue	4th Street	Coal Creek Rd	4	$ 583,810	6-20
282	Ridgemont Drive	Ridgemont Cres	Ridgemont Ave	4	$ 127,691	3
283	Ridgemont Drive	Ridgemont Ave	Cul de Sac	4	$ 240,860	3
284	Ridgemont Drive	Cul De Sac	Cul De Sac	4	$ 74,815	3
14	2nd Avenue	4th St	5th St	4	$ 203,260	6-20
15	2nd Avenue	5th St	6th St	4	$ 203,260	6-20
16	2nd Avenue	6th St	7th St	4	$ 203,260	6-20
17	2nd Avenue	7th Street	8th Street	4	$ 203,260	5
18	2nd Avenue	8th Street	9th Street	4	$ 203,260	5
19	2nd Avenue	9th Street	10th Street	4	$ 203,260	5
20	2nd Avenue	10th Street	11th Street	4	$ 203,260	5
21	2nd Avenue	11th Street	12th Street	4	$ 203,260	5
22	2nd Avenue	12th Street	13th Street	4	$ 203,260	5
1	1st Avenue	1st St	2nd St	4	$ 170,149	2
2	1st Avenue	2nd St	3rd St	4	$ 115,300	2
3	1st Avenue	3rd St	4th St	4	$ 166,525	2
619	9th Avenue	Hwy 3	18th Street	4	$ 250,317	6-20
255	Cedar Avenue	Hwy 3	Fairy Creek Road?	4	$ 173,347	2
256	Cedar Avenue	North End	East Kootenay Trail	4	$ 246,741	2
618	4th Street	8th Ave	Hwy 3	4	$ 38,759	3
147	4th Street	8th Ave	9th Ave	4	$ 87,071	3
167	7th Street	2nd Ave	3rd Ave	4	$ 156,531	6-20
168	7th Street	3rd Ave	4th Ave	4	$ 156,531	6-20
169	7th Street	4th Ave	5th Ave	4	$ 156,531	6-20
170	7th Street	5th Ave	6th Ave	4	$ 156,926	6-20
171	7th Street	6th Ave	Hwy 3	4	$ 120,363	6-20
172	7th Street	7th Ave	8th Ave	4	$ 102,004	6-20
173	7th Street	8th Avenue	9th Avenue	4	$ 86,852	6-20
187	9th Street	2nd Ave	3rd Ave	4	$ 156,531	6-20
188	9th Street	3rd Ave	4th Ave	4	$ 156,531	6-20
189	9th Street	4th Ave	5th Ave	4	$ 154,357	6-20
190	9th Street	5th Ave	6th Ave	4	$ 155,136	6-20
191	9th Street	6th Ave	Hwy 3	4	$ 118,691	6-20
74	7th Avenue	7th St	8th St	4	$ 125,007	1
75	7th Avenue	8th St	9th St	4	$ 135,260	1
76	7th Avenue	9th St	10th St	4	$ 136,125	1
77	7th Avenue	10th St	11th St	4	$ 120,011	1
78	7th Avenue	11th St	12th St	4	$ 119,682	1
79	7th Avenue	12th St	13th St	4	$ 120,890	1
660	Montane Parkway	Whitetail Drive	End	4	$ 397,558	6-20
187	9th Street	2nd Ave	3rd Ave	4	$ 125,007	6-20
189	9th Street	4th Ave	5th Ave	4	$ 125,007	6-20
172	7th Street	7th Ave	8th Ave	4	$ 94,354	6-20
173	7th Street	8th Avenue	9th Avenue	4	$ 80,338	6-20
191	9th Street	6th Ave	Hwy 3	4	$ 103,228	6-20
188	9th Street	3rd Ave	4th Ave	4	$ 125,007	6-20
190	9th Street	5th Ave	6th Ave	4	$ 125,639	6-20
Total					$ 8,824,722	

Long Term Watermain Projects

Pipe ID	Location	From / Between	To / Between	Priority Rating	Upgrade Dia.	Replacement Cost	Program #
3010030	Shadow Road	Ktunaxa Road	Kutenai Road	4	200	$ 138,833	6-20
3010144				4		$ 2,554,622	4
3010145				5		$ 269,070	4
3010207	5th Street	1st Ave	2nd Ave	5		$ 100,659	2
3010248	8th Street	6th Ave	Hwy 3	5		$ 82,442	3
3010249				5		$ 64,762	3
3010250	8th Street	1st Avenue	2nd Avenue	4		$ 69,798	5
3010252	3rd Avenue	7th St	8th St	5		$ 16,233	5
3010253	3rd Avenue	8th St	9th St	4		$ 114,115	5
3010254	8th Street	4th Ave	5th Ave	4		$ 137,397	5
3010255	8th Street	5th Ave	6th Ave	4		$ 67,369	5
3010256	7th Street	4th Ave	5th Ave	4		$ 49,233	6-20
3010269	6th Street	3rd Ave	4th Ave	4	200	$ 38,338	6-20
3010272	3rd Avenue	6th St	7th St	4		$ 156,263	5
3010274	5th Street	1st Ave	2nd Ave	5		$ 50,338	2
3010275	5th Street	2nd Ave	3rd Ave	5		$ 62,755	2
3010276	3rd Avenue	4th St	5th St	4		$ 3,961	2
3010279	3rd Street	2nd Avenue	3rd Avenue	4		$ 47,067	2
3010281	4th Street	2nd Ave	3rd Avenue	5		$ 49,430	6-20
3010306	2nd Avenue	2nd St	3rd St	4		$ 123,314	2
3010307	3rd Avenue	3rd St	4th St	4		$ 142,895	2
3010313	4th Street	3rd Ave	4th Ave	4		$ 41,852	6-20
3010314	4th Street	3rd Ave	4th Ave	4		$ 6,670	6-20
3010319	4th Street	3rd Ave	4th Ave	5		$ 43,635	6-20
3010320	4th Street	2nd Ave	3rd Avenue	5		$ 52,362	6-20
3010324	4th Street	1st Avenue	2nd Ave	5		$ 38,975	6-20
3010325	4th Street	1st Avenue	2nd Ave	5		$ 42,807	6-20
3010330	3rd Avenue	5th St	6th St	4		$ 164,897	6-20
3010333	3rd Avenue	4th St	5th St	4		$ 129,377	2
3010334	5th Street	3rd Ave	4th Ave	5		$ 43,641	2
3010335	5th Street	2nd Ave	3rd Ave	5		$ 68,701	2
3010337	5th Street	3rd Ave	4th Ave	4		$ 44,623	2
3010365	6th Street	3rd Ave	4th Ave	5	200	$ 47,733	5
3010367	6th Street	2nd Ave	3rd Ave	4		$ 54,070	6-20
3010369	6th Street	2nd Ave	3rd Ave	4		$ 47,724	6-20
3010373	6th Street	1st Ave	2nd Ave	4		$ 38,976	6-20
3010381	3rd Avenue	7th St	8th St	4		$ 137,894	6-20
3010386	7th Street	5th Ave	6th Ave	4		$ 44,807	6-20
3010395	8th Street	5th Ave	6th Ave	4		$ 28,967	5
3010398	8th Street	3rd Ave	4th Ave	5		$ 130,586	5
3010400	8th Street	2nd Ave	3rd Ave	5		$ 52,605	5
3010403	8th Street	2nd Ave	3rd Ave	5		$ 61,314	5
3010407	9th Street	2nd Ave	3rd Ave	5		$ 51,757	5
3010408	9th Street	2nd Ave	3rd Ave	5		$ 53,947	5
3010409	3rd Avenue	9th St	10th St	4		$ 105,956	5
3010413	5th Avenue	9th St	10th St	4		$ 112,171	5
3010446	3rd Avenue	9th St	10th St	4	200	$ 10,505	5
3010548	8th Street	7th Ave	8th Ave	5		$ 56,649	3
3010552	16th Street	10th Ave	11th Ave	5		$ 78,331	1
3010558				4		$ 31,137	6-20
3010565	16th Street	9th Ave	10th Ave	5		$ 69,215	6-20
3010566	16th Street	9th Ave	10th Ave	5		$ 68,916	1
3010576	8th Street	7th Ave	8th Ave	5		$ 67,935	3
3010578	9th Street	7th Ave	8th Ave	4		$ 47,778	3
3010581	7th Street	8th Avenue	9th Avenue	4		$ 48,552	6-20
3010625	5th Street	7th Ave	8th Ave	4		$ 46,207	3
3010641	7th Street	7th Ave	8th Ave	5		$ 40,693	6-20
3010677	11th Street	8th Ave	9th Ave	4		$ 97,166	3
3010718	16th Street	11th Ave	12th Ave	4		$ 236,880	1
3010731	7th Street	8th Avenue	9th Avenue	4		$ 39,350	6-20
3010733	8th Street	8th Ave	9th Ave	4		$ 78,755	3
Total						$ 7,003,010	

Long Term Sanitary Sewer Projects

Pipe ID	Location	From / Between	To / Between	Priority Rating	Replacement Cost	Program #
201100	Mt Minton	East Portion	Unknown	5	$ 35,422	6-20
201393	7th Avenue	14th St	15th St	5	$ 36,160	1
201394	7th Avenue	14th St	15th St	5	$ 66,264	1
201440	7th Avenue	9th St	10th St	5	$ 110,446	1
201442	7th Avenue	11th St	12th St	5	$ 148,546	1
201443	7th Avenue	10th St	11th St	5	$ 152,177	1
201459	7th Avenue	7th St	8th St	5	$ 148,906	1
201238	4th A Avenue	1st St	2nd St	4	$ 64,724	2
201239	4th A Avenue	2nd St	3rd St	4	$ 150,203	2
201243	1st Avenue Lane	1st St	2nd St	4	$ 121,836	2
201244	1st Avenue Lane	2nd St	3rd St	4	$ 150,440	2
201245	1st Avenue Lane	3rd St	4th St	4	$ 138,653	6-20
201248	2nd Avenue Lane	4th Street	5th Street	4	$ 147,374	6-20
201250	6th Street	1st Ave	2nd Ave	4	$ 145,414	6-20
201252	7th Street	2nd Ave	3rd Ave	4	$ 125,702	6-20
201253	7th Street	3rd Ave	4th Ave	4	$ 109,044	6-20
201255	3rd Avenue Lane	4th St	5th St	4	$ 142,812	6-20
201256	5th Street	4th Ave	5th Ave	4	$ 130,144	2
201257	4th Avenue Lane	3rd St	4th St	4	$ 123,751	2
201259	6th Street	4th Ave	5th Ave	4	$ 149,577	6-20
201260	7th Street	4th Ave	5th Ave	4	$ 131,278	2
201285	7th Street	3rd Ave	4th Ave	4	$ 113,277	6-20
201286	7th Street	4th Ave	5th Ave	4	$ 122,130	6-20
201302	4th Street	1st Avenue	2nd Ave	4	$ 63,362	6-20
201304	4th A Avenue	1st St	2nd St	4	$ 146,532	2
201305	1st Street	2nd Ave	3rd Ave	4	$ 73,470	2
201307	2nd Avenue Lane	5th St	6th St	4	$ 51,312	2
201320				4	$ 98,514	1
201327	11th Street	5th Ave	6th Ave	4	$ 114,802	3
201339	12th Street	4th Ave	5th Ave	4	$ 110,635	3
201365	1st Avenue	14th St	15th Street	4	$ 157,091	6-20
201386	7th Avenue	8th St	9th St	4	$ 150,606	1
201399	7th Avenue	12th St	13th St	4	$ 149,096	1
201405	11th Avenue	16th St	17th St	4	$ 130,475	1
201430	8th Street	10th Ave	11th Ave	4	$ 150,243	1
201467	7th Avenue	6th St	7th St	4	$ 155,607	1
201625	Cedar Avenue	Hwy 3	Fairy Creek Road?	4	$ 54,931	2
Total					$ 4,370,956	

Long Term Storm Sewer Projects

Pipe ID	Location	From / Between	To / Between	Priority Rating	Replacement Cost	Program #
stm00658	Ridgemont Street	Ridgemont Ave	Ridgemont Drive	5	$ 60,211	6-20
stm00523	2nd Avenue	6th St	7th St	5	$ 238,433	6-20
stm00531	2nd Avenue	6th St	7th St	5	$ 39,685	6-20
stm00543	5th Street	1st Ave	2nd Ave	5	$ 65,375	6-20
stm00544	5th Street	1st Ave	2nd Ave	5	$ 62,401	6-20
stm00657	Ridgemont Street	Ridgemont Ave	Ridgemont Drive	4	$ 79,913	6-20
stm00660	Ridgemont Drive	Ridgemont Drive from Apartments	Cul De Sac	4	$ 73,603	6-20
stm00539	2nd Avenue	5th St	6th St	4	$ 167,887	6-20
stm00549	2nd Avenue	4th St	5th St	4	$ 163,046	6-20
stm00323	13th Street	4th Ave	5th Ave	4	$ 277,862	6-20
stm00360	2nd Avenue	11th Street	12th Street	4	$ 152,671	6-20
stm01212	13th Street	2nd Ave	3rd Ave	4	$ 181,107	6-20
stm00326	13th Street	3rd Ave	4th Ave	4	$ 228,388	6-20
stm00377	4th Avenue	10th Street	11th Street	4	$ 152,611	6-20
stm00320	12th Street	5th Ave	6th Ave	4	$ 265,949	6-20
stm00321	5th Avenue	12th St	13th St	4	$ 318,103	6-20
stm00144	11th Avenue	13th St	14th St	4	$ 292,013	6-20
stm00148	14th Street	10th Ave	11th Ave	4	$ 107,732	6-20
stm00149	14th Street	10th Ave	11th Ave	4	$ 6,350	6-20
stm00250	8th Street	7th Ave	8th Ave	4	$ 310,324	6-20
stm00252	7th Avenue	8th St	9th St	4	$ 184,462	6-20
stm00270	7th Street	8th Avenue	9th Avenue	4	$ 144,054	6-20
stm00237	9th Avenue	4th Street	5th Street	4	$ 31,526	6-20
stm00238	9th Avenue	5th St	6th St	4	$ 388,239	6-20
stm00239	9th Avenue	6th St	7th St	4	$ 384,368	6-20
stm00225	10th Ave	9th St	10th St	4	$ 174,930	6-20
stm01581	9th Avenue	4th Street	5th Street	4	$ 35,310	6-20
stm00232	9th Avenue	4th Street	5th Street	4	$ 318,090	6-20
stm00728	Elkview Crescent	Western Entrance	Unknown	4	$ 44,204	6-20
stm00739	Park Avenue	Bridge	Elkview Place	4	$ 26,712	6-20
stm00740	Park Avenue	Bridge	Elkview Place	4	$ 77,420	6-20
Total					$ 5,052,979	



Appendix G

Sample Facilities Framework Calculation

Integrated Expertise. Locally Delivered.

Memorandum

542B - 2 Avenue, P.O. Box 1815, Fernie, BC V0B 1M0 T: 250.423.2015 F: 604.629.2698

To:	**City of Fernie**	Date:	**July 10, 2020**
Attention:	**Jenny Weir, P.Eng.**	Project No.:	**32568**
Cc:			
Reference:	**Fernie IICP, Facilities Methodology**		
From:	**Andrew Baird**		

The Following memorandum outlines the IICP project Facilities sample calculation for Conditions and Total Replacement Values (TRV).

The Data has been compiled in a spreadsheet (pdf's attached) for use in further phases of the IICP project. The remainder of this memorandum outlines the methodology to determine the various condition scores and costs associated to each facility and facility category component. A list of remaining tasks is also provided to summarize the information required to complete the risk assessment.

Data Used:

There were two sources of data used in creating the Facilities Condition Table and TRV's.

1) City of Fernie Facilities Master Plan (FMP)
   - Facility Assessment Reports
   - Capital Cost Assessment & Life Cycle Cost Analysis

2) Fernie Asset Management Investment Plan (AMIP) Excel Spreadsheet

Condition Score Review

The Facilities Master List was broken out into 5 categories for each facility:

1) Architectural Total Rating
2) HVAC Total Rating
3) Plumbing Total Rating
4) Process Plumbing Rating
5) Electrical Total Rating

The total ratings are derived from the individual assessments from the FMP for each facility. HVAC, Plumbing, Process plumbing where available and Electrical scores are determined by averaging the individual components assessed in the FMP.

The Architectural review uses the sub categories as listed below to arrive at the final condition score. An average is taken from each of the sub categories and the sub categories are weighted to give the Architectural condition. We have chosen the weighting listed next to the sub-categories below.

- Roofing - 25%
- Glazing – 10%
- Above Grade Walls – 25%
- Below Grade Walls – 25%
- Interior Public Areas – 7.5%
- Office Areas – 7.5%

The Ratings Assigned per the FMP are the following:

1. Critical - Unsafe, high risk or injury of critical system failure.
2. Poor - Does not meet requirements, has significant deficiencies. May have high operating/maintenance costs.
3. Marginal - Meets minimum requirements, has significant deficiencies. May have above average operating maintenance costs.
4. Acceptable - Meets present requirements, minor deficiencies. Average operating/maintenance costs.
5. Good - Meets all present requirements. No deficiencies.
6. Excellent - As new/state of the art, meets present and foreseeable requirements.

An example methodology for the Court House (FMP ID B12, Asset ID B024) is provided below

Each component and 1-6 rating shown in the tables below are taken from the FMP TAB 1: Facility Assessment Reports – for Facility B12

Methodology Example Court House

HVAC

Unit Name	Rating
B-1	5
B-2	5
Electric Base Heater	5
Radiator	4
MUA-01	3
P-01	5
P-02	5
P-03	5
UH-01	5
AVERAGE	**5**

Plumbing

UnitName	Rating
DHW-1	5
AVERAGE	**5**

Electrical

Unit Name	Rating
Panel A	4
Panel B	4
Panel C	4
Panel T	4
Panel XX	4
Main Service Switch	4
AVERAGE	**4**

Architectural/Structural

Roofing	
Rating	**Component**
5	Roof Structure
5	Roofing Assembly
3	Insulation
5	Flashing
5	Drains
76.6%	**% of Total Score**

Above Grade Walls	
Rating	**Component**
5	Wall Components
5	Exterior Finish
5	Interior Finish
5	Insulation Type
83.3	**% of Total Score**

Below Grade Walls	
Rating	**Component**
5	Below Grade Wall Components
83.3	**% of Total Score**

Glazing	
Rating	**Component**
5	Frames
5	Glass
5	Interior Sills/Jambs
83.3	**% of Total Score**

Public Areas	
Rating	**Component**
3	Exit Stairs
5	Corridors
5	Lobbies
3	Public Washrooms
66.6	**% of Total Score**

Office Areas	
Rating	**Component**
5	Wall finishes
5	Floor finishes
5	Ceiling finishes
5	Entry Doors
83.3	**% of Total Score**

From the Architectural subcategory the weightings as listed above are applied to arrive at the final Architectural score of **80.4%**, using this % grade an equal step criteria is applied be applied to convert this to the same 1 – 6 score as the other components as per the table below.

FMP Architectural % Score Range	FMP Rating Conversion
0 – 16.67	1
16.68 – 33.35	2
33.36 – 50.03	3
50.04 – 66.71	4
66.72 – 83.38	5
83.39 - 100	6

In this example 80.4% is converted to an FMP Condition Score of 5, Good - Meets all present requirements. No deficiencies.

In order to be consistent with the other IICP scoring systems where a low number represents a better condition all the condition ratings are inverted (i.e. 1 becomes 6, 2 becomes 5, 3 becomes 4).

Further to the condition score inversion the facilities ratings are simplified a 3 level rating system to do this the inverted scores of 5 and 6 become 3, 3 and 4 become 2 and 1 and 2 become 1 which can generaly be described as follows.

1. Excellent / Good -
   - As new/state of the art, meets present and foreseeable requirements.
   - Meets all present requirements. No deficiencies.

2. Marginal / Acceptable
   - Meets minimum requirements, has significant deficiencies. May have above average operating
   - Meets present requirements, minor deficiencies. Average operating/maintenance costs.

3. Poor / Critical
   - Does not meet requirements, has significant deficiencies. May have high operating/maintenance costs.
   - Unsafe, high risk or injury of critical system failure.

The Court house component condition ratings determined above are shown in the table below.

Courthouse Condition Ratings				
Component	**Percent score**	**FMP Rating**	**Inverted Rating**	**Simplified Facility Condition score**
Arch	80.4	5	2	1
HVAC	N/A	4	3	2
Plumbing	N/A	5	2	1
Electrical	N/A	4	3	2
Average rating (rounded up to nearest value)				**2**

The average of the Simplification Facility Scores is used to rate the building. If any component Simplification Facility Scores are “3”, then the buildings final score becomes a “3” and the average is not used.

Total Replacement Value Review

Total Replacement Values (TRV) have been extracted from the FMP where available and AMIP for sanitary or water specific facilities.

Similar to the conditions each facility replacement values are broken down into the following categories.

1) Architectural
2) HVAC
3) Plumbing
4) Process Plumbing
5) Electrical

FMP Derived Example

The prices taken from the FMP Capital Cost Assessments were extracted from the Life Cycle Costs Tables with the following criteria and assigned to their respective Category shown below:

Architectural includes the sum of the following sections

- A1 Substructure
- A2 Structure
- A3 Exterior Enclosure
- A4 Partitions and Doors
- A5 Finishes
- A6 Fittings and Equipment

Electrical includes only one section

- C2 Electrical

HVAC includes the following two sections

- C13: HVAC
- C14: Controls

Plumbing includes the following two sections

- C11 Plumbing and Drainage
- C12 Fire Protection

Sections D (Site Work), includes allowance for the following site work

- Site Preparation
- Concrete sidewalk and curb
- Landscaping
- Mechanical sites service

- Electrical site service

These categories were related to the site and not the Building/facility cost and therefore excluded from the calculation.

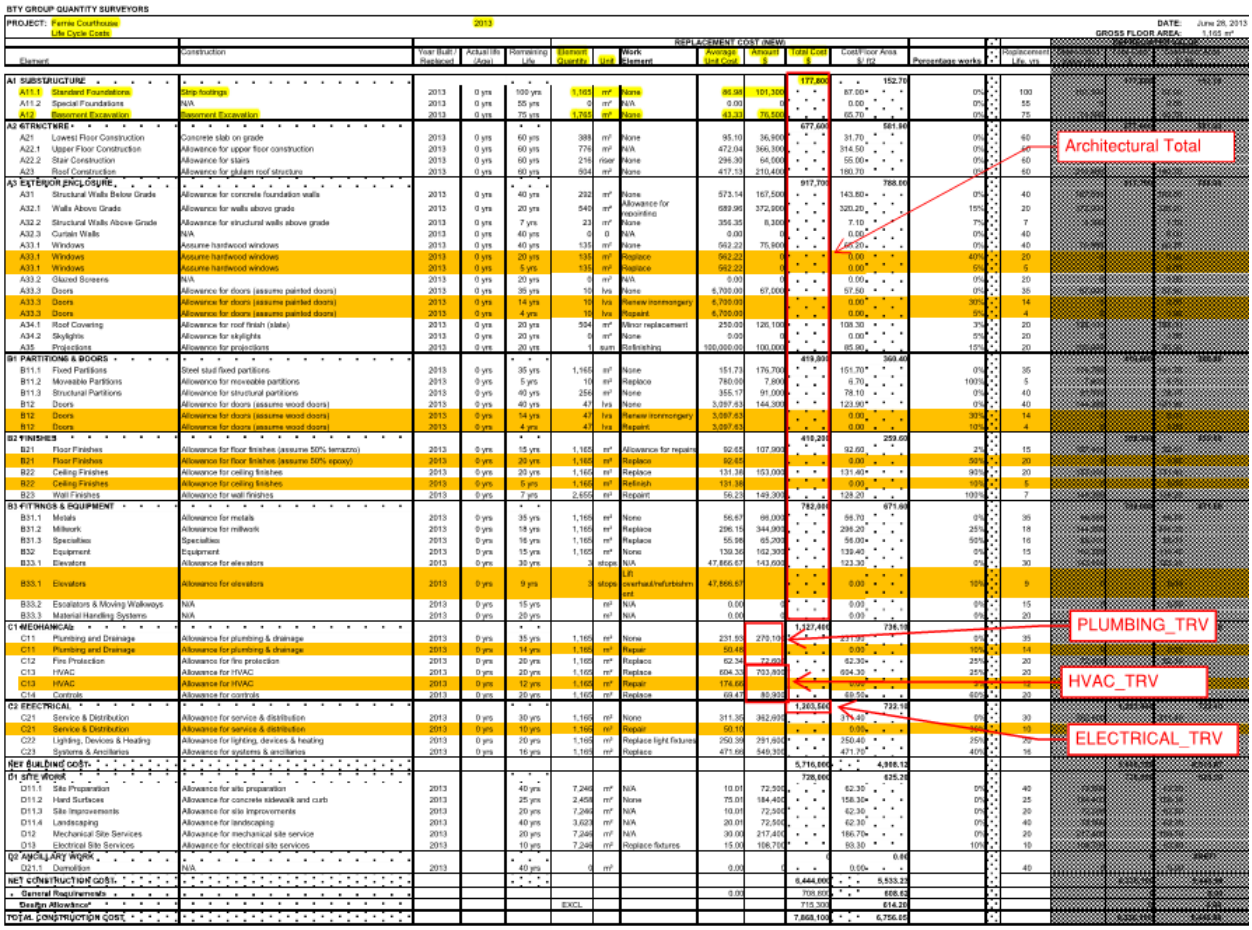
Section Z (Ancillary Work) included Demolition and was excluded from this calculation.

The individual components are summed to provide a Total Replacement Value (TRV) for each facility.

An example methodology for the Court House (B12) is provided below

Methodology Example Court House (B12)

The TRV pricing was taken from the City of Fernie Facilities master plan. (Aug 11, 2014). The base for the pricing takes the average unit cost and multiplies it by the area (m^2) or just the unit price. Then sums the totals of each category.



CoF Facility Master Plan Fernie Courthouse Life Cycle Costs (Pg. 1123)

The following highlights the values used from each section of the above table.

Architecture TRV

Element	Sub Total	Total
Sub-structure A1	$177,800	
Structure A2	$677,600	
Exterior Encloser A3	$917,700	
Partitions and Doors A4	$419,800	
Finishes A5	$410,200	
Fittings and equipment A6	$782,200	
		$3,385,100

Plumbing TRV

Element	Sub Total	Total
Plumbing and Drainage C11	$270,100	
Fire Protection C12	$72,600	
		$342,700

HVAC TRV

Element	Sub Total	Total
HVAC C13	$703,800	
Controls C14	$80,900	
		$784,700

Electrical TRV

Element	Sub Total	Total
Service & Distribution C2	$362,600	
Lighting, Devices & Heating C2	$291,600	
System & Ancillaries C2	$549,300	
		$1,203,500

TRV Total

The category totals are summed to reach the final TRV value for that Facility.

Element	Sub Total	Total
Architecture (TRV)	$3,385,100	
Plumbing (TRV)	$342,700	
HVAC (TRV)	$784,700	
Electrical (TRV)	$1,203,500	
		$5,716,000

Similar to condition ratings some facilities do not include replacement values for various components. In most cases this is where that facility does not contain that component. Some examples where data is missing include the dog pound where no Architectural condition score or TRV is provided.

Where Life Cycle Cost Tables were not included in the FMP, the Fernie Asset Management Investment Plan (AMIP) Excel Spreadsheet was used to obtain values for Water or Sanitary infrastructure related Facilities.

AMIP Derived Example

The following example is shown for the Ghostrider Lift Station FMP ID PS2 (Object ID B035)
Component values for Sanitary facility infrastructure can be found under the "lift Station" tab in the AMIP spreadsheet, watermain facility infrastructure can be found under the "booster Station" tab.

The following table is reproduced from the AMIP spreadsheet and shown below with cells removed for clarity.

Ghostrider Lift Station

Description_3	Description_4	Quantity	Unit	Current Replacement Cost
Mechancial	Pipes and Valves	1	Each	$18,000
Mechancial	Other	1	Each	
Mechanical	Pump	5	HP	$9,000
Mechanical	Pump	5	HP	$9,000
Mechanical	Pump		HP	
Electrical	Controls and Kiosk		Each	$20,000
Electrical	Backup Power		KW	$10,000
Electrical	SCADA		Each	$10,000
Structural	Wetwell		m3	$30,000
Structural	Building	31.5	m2	$160,000
Sub-Total				**$266,000**

Structural elements are used for the Architectural totaling $190,000
Mechanical Items with a description_4 of "Pipes and valves" are used for Plumbing totaling $18,000
Mechanical Items with a description_4 of "pump" are used for Process Plumbing totaling: $18,000
Electrical items are used for Electrical totaling: $40,000

No HVAC items are available from this list and therefore no HVAC TRV is included in the IICP for this facility.

Values from the FMP are assumed to be provided in 2013 dollars. The AMIP values are assumed to be provided in 2018 dollars.

		CONDITION							PRIORITIZATION SCORE					
Asset_ID	Facility_Name	Architectural	HVAC	Plumbing	Process Plumbing	Electrical	Total_Facility	RISK	Architectural	HVAC	Plumbing	Process Plumbing	Electrical	Total_Facility
B003	Fire and Rescue Hall	2	1	1		1	2	5	3	2	2		2	3
B025	Main Sewage Pump Station		1		1	2	2	4		2		2	3	3
B031	Alpine Trails Booster Station		1		1	2	2	4		2		2	3	3
B036	Riverside Lift Station					2	2	4					3	3
B032	Canyon Trail Lift Station		1		1	2	2	4		2		2	3	3
B027	Fairy Creek Electrical Building	3				2	3	4	3				3	3
B024	Court House	1	1	1		2	2	3	2	2	2		2	2
B009	Max Turyk Community Facility	2	2	1		1	2	3	2	2	2		2	2
B002	Heritage Library	2	1	1		1	2	2	2	1	1		1	2
B001	City Hall	1	1	1			1	4	2	2	2			2
B011	Curling Club	3	1	1		2	3	2	2	1	1		2	2
B034	Fairy Creek Reservoir		1				1	4		2				2
B021	Arts Station	1	1	1		2	2	2	1	1	1		2	2
B022	Chamber of Commerce	2	1	2		2	2	2	2	1	2		2	2
B020	Senior Citizen's Centre	2	1	1		2	2	2	2	1	1		2	2
B033	Fairy Creek Chlorine and Control Room (and Old Wet V		1		1	1	1	4		2		2	2	2
B035	Ghostrider Lift Station		1		1	1	1	4		2		2	2	2
B029	10th Avenue Lift Station		1		1	1	1	4		2		2	2	2
B030	Parkland PRV Station		1			1	1	4		2			2	2
B045	1st Street PRV Station		1			1	1	4		2			2	2
B004	Memorial Arena	2	1			2	2	1	1	1			1	1
B023	Aquatic Centre	1	1	1		2	2	1	1	1	1		1	1
B005	Centennial Community Centre	2	1	1		2	2	1	1	1	1		1	1
B012	Signs and Event Storage	1	1	1		2	2	1	1	1	1		1	1
B015	Commodities Shop		1			2	2	1		1			1	1
B007	Prentice Park Washrooms and Concession		2	2		2	2	1		1	1		1	1
B039	Dog Pound		2	2		2	2	1		1	1		1	1
B010	Rotary Park Gazebos		1	1		2	2	1		1	1		1	1
B044	STP Electrical Building							4						
B066	Sewage Treatment Plant							4						
B051	James White Well Control Room Building							4						
B008	Prentice Park Pavillion							1						
B049	James White Well 201							4						
B050	James White Well 202							4						
B053	Burma Road Lift Station							4						
B052	11th Avenue Lift Station							4						
B042	UV Disinfection Facility							4						
B043	Blower Building							4						
B026	Alum Dosing Building							4						
B054	West Fernie Lift Station							4						
B017	Carpenters Shop							4						
B040	Public Works Yard							4						
B067	Fairy Creek Intake (Source)							4						
B069	Tow Yard Compound							4						
B055	Operations Building							4						
B006	Museum							2						
B061	Dirt Jump Park							2						
B068	Tennis Club Storage							2						
B046	Cemetery Tool Shed							1						
B037	James White Park Washroom							1						
B038	Boat Launch Washroom							1						
B041	Rotary Park Gazebo (2x Small)							1						
B048	Station Square washroom							1						
B056	Annex Park Pit Toilets							1						
B057	Chamber Pit Toilets							1						
B058	Station Square Event Storage							1						
B059	Fernie Skate Park							1						
B060	Splash Park							1						
B062	Outdoor Rink							1						
B063	Outdoor Rink Storage Building							1						
B064	Boat Launch							1						
B065	Coal Creek Heritage Trail Trailhead Pavillion and Bike V							1						

		TOTAL REPLACEMENT VALUES (TRV)						
Asset_ID	**Facility_Name**	**Architectural**	**HVAC**	**Plumbing**	**Process Plumbing**	**Electrical**	**Total Facility TRV**	**AMIP Insurance Values**
B003	Fire and Rescue Hall	$1,716,400.00	$311,300.00	$129,100.00		$574,500.00	$2,731,300.00	$1,984,202.00
B025	Main Sewage Pump Station	$540,000.00		$470,000.00	$380,000.00	$300,000.00	$1,690,000.00	
B031	Alpine Trails Booster Station	$180,000.00		$50,000.00	$188,000.00	$120,000.00	$538,000.00	
B036	Riverside Lift Station	$120,000.00		$36,000.00	$66,000.00	$110,000.00	$332,000.00	
B032	Canyon Trail Lift Station	$100,000.00		$25,000.00	$30,000.00	$57,000.00	$212,000.00	
B027	Fairy Creek Electrical Building	$156,743.00					$156,743.00	
B024	Court House	$3,385,100.00	$784,700.00	$342,700.00		$1,203,500.00	$5,716,000.00	$5,598,510.50
B009	Max Turyk Community Facility	$3,443,700.00	$465,300.00	$169,300.00		$391,600.00	$4,469,900.00	$8,983,726.40
B002	Heritage Library	$2,102,400.00	$298,900.00	$86,300.00		$286,700.00	$2,774,300.00	$4,049,857.90
B001	City Hall	$1,716,400.00	$311,300.00	$129,100.00		$574,500.00	$2,731,300.00	$4,260,597.00
B011	Curling Club	$1,819,200.00	$312,900.00	$195,200.00		$300,100.00	$2,627,400.00	$4,916,560.00
B034	Fairy Creek Reservoir	$1,850,000.00					$1,850,000.00	
B021	Arts Station	$1,082,600.00	$300,100.00	$85,000.00		$252,700.00	$1,720,400.00	$2,664,537.70
B022	Chamber of Commerce	$1,092,300.00	$114,900.00	$41,800.00		$96,800.00	$1,345,800.00	$2,476,139.60
B020	Senior Citizen's Centre	$621,700.00	$80,600.00	$29,400.00		$68,000.00	$799,700.00	$1,868,722.90
B033	Fairy Creek Chlorine and Control Room (and Old Wet V	$124,923.60			$120,000.00	$70,000.00	$314,923.60	
B035	Ghostrider Lift Station	$190,000.00		$18,000.00	$18,000.00	$40,000.00	$266,000.00	
B029	10th Avenue Lift Station	$70,000.00		$18,000.00	$14,000.00	$35,000.00	$137,000.00	
B030	Parkland PRV Station	$50,000.00		$25,000.00	$40,000.00	$20,000.00	$135,000.00	
B045	1st Street PRV Station	$50,000.00		$65,000.00		$20,000.00	$135,000.00	
B004	Memorial Arena	$5,500,400.00	$872,300.00	$391,500.00		$836,600.00	$7,600,800.00	$17,242,929.00
B023	Aquatic Centre	$3,975,700.00	$550,900.00	$1,569,000.00		$586,400.00	$6,682,000.00	$13,033,852.70
B005	Centennial Community Centre	$1,372,400.00	$183,400.00	$66,800.00		$154,400.00	$1,777,000.00	$4,114,877.80
B012	Signs and Event Storage	$547,700.00	$71,800.00	$26,200.00		$60,400.00	$706,100.00	$862,277.90
B015	Commodities Shop	$281,800.00	$7,300.00	$20,600.00		$47,700.00	$357,400.00	$916,454.00
B007	Prentice Park Washrooms and Concession	$251,200.00	$3,500.00	$46,600.00		$26,100.00	$327,400.00	$273,890.10
B039	Dog Pound							$169,849.90
B010	Rotary Park Gazebos							$812,157.50
B044	STP Electrical Building							
B066	Sewage Treatment Plant	$1,257,802.00		$47,273.00	$594,240.00	$18,362.00	$1,917,677.00	
B051	James White Well Control Room Building	$408,500.00		$11,000.00	$442,000.00	$321,000.00	$1,182,500.00	
B008	Prentice Park Pavillion	$583,700.00	$77,900.00	$28,400.00		$65,600.00	$755,600.00	$501,205.10
B049	James White Well 201	$105,250.00		$29,500.00	$193,000.00	$21,000.00	$348,750.00	
B050	James White Well 202	$105,250.00		$29,500.00	$193,000.00	$21,000.00	$348,750.00	
B053	Burma Road Lift Station	$57,500.00		$24,000.00	$35,000.00	$111,341.00	$227,841.00	
B052	11th Avenue Lift Station	$20,000.00		$12,000.00	$10,000.00	$26,000.00	$68,000.00	
B042	UV Disinfection Facility							
B043	Blower Building							
B026	Alum Dosing Building							
B054	West Fernie Lift Station							
B017	Carpenters Shop							
B040	Public Works Yard							
B067	Fairy Creek Intake (Source)							
B069	Tow Yard Compound							
B055	Operations Building							
B006	Museum							$2,186,331.40
B061	Dirt Jump Park							
B068	Tennis Club Storage							
B046	Cemetery Tool Shed							$6,147.75
B037	James White Park Washroom							
B038	Boat Launch Washroom							
B041	Rotary Park Gazebo (2x Small)							
B048	Station Square washroom							
B056	Annex Park Pit Toilets							
B057	Chamber Pit Toilets							
B058	Station Square Event Storage							
B059	Fernie Skate Park							$302,500.00
B060	Splash Park							
B062	Outdoor Rink							
B063	Outdoor Rink Storage Building							
B064	Boat Launch							
B065	Coal Creek Heritage Trail Trailhead Pavillion and Bike V							