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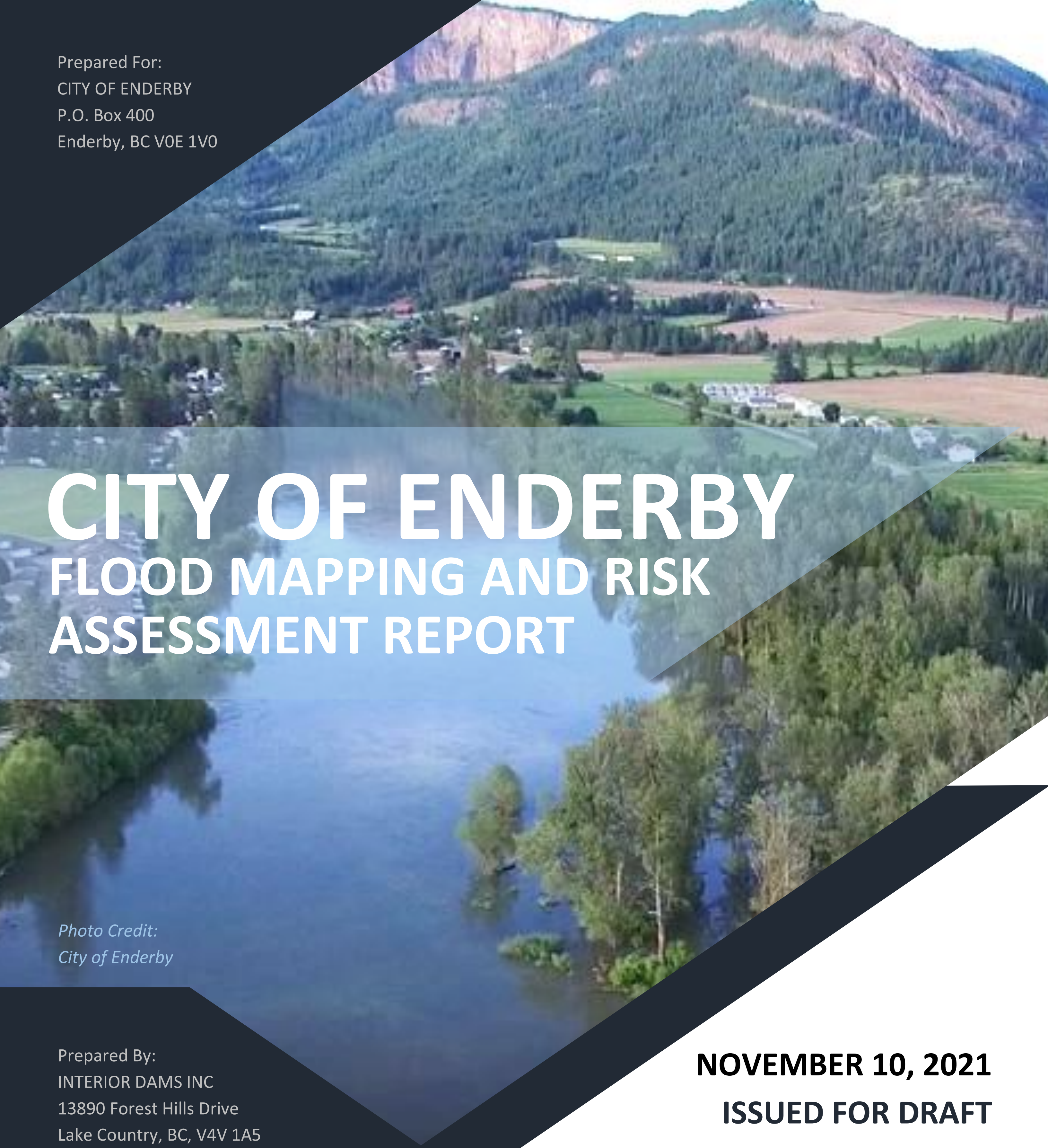

CITY OF ENDERBY
FLOOD MAPPING AND RISK ASSESSMENT REPORT

Photo Credit:
City of Enderby

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NOVEMBER 10, 2021

ISSUED FOR DRAFT

ENGINEERS & GEOSCIENTISTS BRITISH COLUMBIA

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Interior Dams

Revision History

Date	Section/Page	Description
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May 11, 2021		Issued for draft
July 30, 2021	Addressed City comments in Section 3 and Section 4.	Issued for draft
November 9, 2021		Issued for use
November 10, 2021	Updated linework on Figure 4-4	Issued for use

EXECUTIVE SUMMARY

This report intends to support and direct the development and implementation of an integrated flood management plan (IFMP) by providing the City with flood mapping, a risk assessment, and other flood risk mitigation information. This information is to be used by the City to inform decision-makers and facilitate stakeholder engagement.

The following information is included in this report:

- City-wide flood inundation maps (floodplain maps);
- City-wide flood hazard maps;
- Flood risk assessment information;
- Summary of flood risk mitigation progress;
- Discussion of future flood risk mitigation strategies; and
- Summary of findings and recommendations.

Based on the information reviewed and analysis conducted, the following information summarizes key findings:

1. The resulting climate-factored 1/200-year and 1/20-year annual daily maximum flows for the Shuswap River[1] are estimated to be 781.3 m^3/s and 613.8 m^3/s, respectively (refer to Section 2.5 for confidence intervals and determination methods);
2. The estimated impact from the 1/200-year flood to individuals and organizations of the community of Enderby include:
    - Total monetary losses of $54,092,823 (People and Society - $43,133,043, Local Economy - $5,626,270, and Local Infrastructure - $5,333,510) (Section 3.3),
    - Loss of functionality (full or partial) to the following infrastructure systems: electrical power, local roads, wastewater, and potable water systems (Section 3.5),
    - Contamination of water and wetland and possible impact to red-listed species (no permanent environmental loss) (Section 3.1)
    - Direct impact to three heritage sites and recreational sites including Tuey Park and the Jim Watt Heritage River Walk (days to weeks of recovery) (Section 3.2), and
    - Risk to human health and safety due to increased potential for water contamination and drowning (Section 3.3.2);
3. The City of Enderby Official Community Plan Bylaw No. 1549 (“the OCP”), Zoning Bylaw No. 1550 (“the Zoning Bylaw”), and Subdivision Servicing and Development Bylaw No. 1278 (“the Development Bylaw”) pre-date the flood mapping and risk assessment work contained within this report has become out-of-date (Section 4.3.3 and 4.3.4).

In support of further development and implementation of existing flood management planning and risk mitigation initiatives, Interior Dams provides the following recommendations:

[1] At the location of the Bawtree Bridge (Enderby Mabel Lake Road Bridge).

1. Develop a balanced[2] and dedicated integrated flood management plan (IFMP)[3] to include achievable and prioritized objectives to improve flood protection and explore grant opportunities for the preparation and implementation of this plan (Section 4.2, 4.3.6, 4.1.3), and:
    - In the interim to receiving any grants or completing an IFMP, prepare Class D cost estimates for priority flood mitigation options and activities[4], with priority given to areas of elevated flood risk demonstrated by the flood mapping and risk assessment (Section 2.8 and 3.6);
2. Review and update the OCP as follows:
    - Adopt the designated floodplain in Schedule "C" using the new 1/200-year flood maps (Section 4.3.3),
    - Amend flood-related references[5], definitions, and terminology to remain consistent across City bylaws (Section 4.3.3), and
    - Review the designated growth areas in the context of flood risk and IFMP goals and update if necessary (Section 4.3.3);
3. Review and update the following City bylaws:
    - The Zoning Bylaw's Schedules "G.1" and "G.2" should include both the 1/200-year and 1/20-year flood mapping information (Section 4.3.4),
    - The Zoning Bylaw's flood-specific definitions should include both the 1/200-year and 1/20-year flood mapping information (Section 4.3.4),
    - The Zoning Bylaw and the Development Bylaw should have their flood-related and regulatory references updated to maintain consistency with the OCP (Section 4.3.4), and
    - Evaluate whether there are cases where the Zoning Bylaw and/or the Development Bylaw should be altered to use the 1/20-year flood map as a more appropriate risk tolerance;
4. Review and investigate all structural risk mitigation options, and if appropriate, set achievable and measurable targets to implement options within the IFMP (Section 4.4.1 and 4.3.6);
5. Update the City of Enderby Emergency Plan's Hazard, Risk and Vulnerability Analysis (HRVA) for flooding based on the findings in this report, and make any consequential changes to the Emergency Plan that may result from the HRVA update (Section 4.3.5); and
6. Conduct a formal review of the IFMP, flood mapping, risk assessment, land use planning, regulation, and development bylaws every ten (10) years and update if necessary.

[2] The IFMP needs to be balanced between other regulatory, community, or stakeholder objectives (i.e., Riparian Areas Protection Act, budgetary constraints, etcetera).
[3] An IFMP does not need to be a large document; rather, it may be short or even just a few pages so long as it is practical and facilitates execution of flood protection and mitigation objectives. The document is intended to be a living City document that sets practical objectives and prioritized achievable tasks (such as the recommendations provided in this document, if adopted).
[4] This includes structural and non-structural mitigation options and also includes the preparation of the IFMP.
[5] Includes regulatory, City or other references.

CERTIFICATION

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Acknowledgements

Interior Dams Incorporated (Interior Dams) is grateful for support received from Kurt Ingles and Tate Bengtson of the City of Enderby (City), and recognize them for their dedication and contribution to the project. We also acknowledge the support staff of the Ministry of Forests, Lands, and Natural Resource Operations' Regional Water Management Branch (FLNRORD), Emergency Management BC (EMBC) and the National Disaster Mitigation Program (NDMP).

Limitations & Qualifications

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This report and its contents represent the professional judgement of Interior Dams based on current available information, including inputs required for the development of the flood hydrology, existing drainage basin conditions, current climate conditions, and existing natural and unnatural hydraulic features in the area and at the time of the study. As information is subject to change, reliance upon this report and its contents for any purpose may or may not be valid if one or more inputs are reasonably compromised. No warranty, implied or expressed, is made.

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LIST OF ABBREVIATIONS

AAR	Automobiles at risk
AEP	Annual exceedance probability
BC	British Columbia
CDA	Canadian Dam Association
CEPF	Community Emergency Preparedness Fund
CFA	Consolidated Frequency Analysis software
CGVD28	Canadian Geodetic Vertical Datum of 1928
City	City of Enderby
EMA	Expected moments algorithm
DEM	Digital elevation model
DV	Product of depth-velocity
EGBC	Engineers and Geoscientists of British Columbia
EP	Emergency Plan
FCL	Flood construction level
FERC	Federal Energy Regulatory Commission
FEMA	Federal Emergency Management Agency
FLNRORD	Ministry of Forests Lands and Natural Resource Operations
FSR	Forestry service road
FTD	Functionality threshold depth
GIS	Graphical interface system
GPS	Global positioning system
GSC	Geological Survey of Canada
HR	Hazard rating or maximum water hazard

HRVA	Emergency Plan Hazard, Risk and Vulnerability Analysis
HEC-RAS	Hydrologic Engineering Centre's Hydrologic Modelling System v4.2.1
HSFA	Hydrological statistical frequency analysis
HY-8	Culvert Hydraulic Analysis Program v7.50
ICSP	Integrated Community Sustainability Plan
IFMP	Integrated flood management plan or planning
Interior Dams	Interior Dams Incorporated
LiDAR	Light detection and ranging
LoL	Loss of life
LoW	Loss of wages
LoBP	Loss of business profit
LoRI	Loss of rental income
NAD83	North American Datum of 1983
NDMP	National Disaster Mitigation Program
NRC	National Research Council of Canada
OCP	Official Community Plan Bylaw No. 1549
PCIC	Pacific Climate Impacts Consortium
PAR	Population at risk
QGIS	Quantum Geographic Information System software
RAAD	Remote Access to Archaeological Data
RCEM	Reclamation Consequence Estimating Methodology
RFP	Request for proposal
SAR	Structures at risk
SRA	Shuswap River Ambassadors
SSA	Streamflow simulation analysis
SSDB	Subdivision Servicing and Development Bylaw No. 1278
TRIM	Terrain Resource Information Management
UBCM	Union of BC Municipalities
USACE	US Army Corps of Engineers
USBR	United States Bureau of Reclamation
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
WSA	Water Sustainability Act
WSC	Water Survey Canada
WTP	Water treatment plant
WWTP	Wastewater treatment plant

1 INTRODUCTION

Under provincial funding from the Union of British Columbia Municipalities (UBCM) Community Emergency Preparedness Fund (CEPF)[6], the City of Enderby (City) retained Interior Dams Incorporated (Interior Dams) to explore preliminary flood risk mitigation strategies and complete flood mapping[7] and risk assessment for the Shuswap River at Enderby, BC.

1.1 Background and Historical Flooding

The City is located in the North Okanagan of British Columbia and is positioned at the elbow of the Shuswap River at the confluence of Fortune Creek. The City was founded and incorporated at this location in the mid to late 1800s. The river provided a natural transportation route for trade and travel between Enderby, Grindrod, and Mara, and Enderby was the last stop for those travelling further south to the paddle wheelers of the South Okanagan. Since then, the City has developed into a rich community full of history and now consists of mixed land uses, including residential, commercial, industrial, institutional, and agricultural (City of Enderby, 2020). To this day, the City is characterized by the Shuswap River as it was at its beginning. Even the naming[8] of “Enderby” was chosen on the banks of the rising Shuswap (B. Cowan, 2020) (B. Cowan, 1998).

The City is susceptible to flooding from the Shuswap River, and it has experienced several large floods occur over the past 100 years. Large floods of note occurred in 1885, 1913, 1928, 1948, 1972, 1974, 1997, 2012, and 2018. The largest event on record and in the memory of the city’s residents is the flood of 1928. Photos from the Enderby Museum archive show the extent of the flooding, as shown below (Figure 1-1, Figure 1-2, and Figure 1-3).

Figure 1-1: Howard Avenue flooded with Enderby cliffs shown in the background (1928)

[6] The CEPF is a provincial suite of funding programs administered by the UBCM that is intended to enhance the resiliency of local governments and their residents in responding to emergencies.
[7] *Flood mapping* refers to both inundation maps (also know as floodplain maps) and hazard maps. For more information see Section 2 of this report.
[8] Based on records from the Enderby & District Museum & Archives, these words inspired the naming of Enderby in 1887: "What danger lowers by land or sea? They ring the tune of Enderby". It is a poem about the great peril from a monster tide of water, which was publicly read to the citizens of Enderby while the Shuswap River was at flood.

Figure 1-2: Houses on Howard Avenue surrounded by water (1928)

Figure 1-3: Baird Street flooded with Bill McSherry and Tom Kneale standing on a floating section of boardwalk (1928)

Figure 1-4: Brickyard Road flooded with two girls on a raft (1928)

In recent years, high water on the Shuswap River has impacted residential property, caused park and road closures, initiated boil water advisories, and posed a danger to residents. Figure 1-5 and Figure 1-6 depict the high river stage of 2018. Figure 1-7 illustrates the overbank flooding of 2020.

Figure 1-5: Photo of Enderby Mabel Lake Road Bridge at flood (Our Enderby, 2018)

Figure 1-6: City of Enderby, May 21, 2018 (City of Enderby)

Figure 1-7: Riverdale Drive, June 7, 2020 (Global, 2020)

In response to recent flooding, the City applied for grant funding made available through the Union of British Columbia Municipalities (UBCM) Community Emergency Preparedness Fund (CEPF). The grant funding was successfully secured, and the City contracted Interior Dams to complete flood mapping and risk assessment services (City of Enderby, 2018-2019) (City of Enderby, 2020).

1.2 Purpose and Scope of Work

This flood mapping and risk assessment report is intended to support the City's integrated flood management planning (IFMP) by providing the tools necessary for informed decision making, including flood mapping, a risk assessment, and other flood risk mitigation information. In addition, this information is intended to be used by the City to inform decision-makers and facilitate stakeholder engagement.

The following summarizes the objectives and deliverables of this project:

- Prepare city-wide flood inundation maps (floodplain maps);
- Prepare city-wide flood hazard maps;
- Complete a flood risk assessment;
- Review current flood risk mitigation progress and discuss future strategies; and
- Provide and present findings and recommendations.

1.3 Conventional and Non-conventional Flooding

According to the flood assessment professional practice guidelines, a *flood* is a "condition in which a watercourse or body of water overtops its natural or artificial confines and covers land not normally under water." A flood can be both *conventional* and *non-conventional*. A conventional flood is comprised of only water[9] and is generated by rainfall, snowmelt, ice jams or combinations of these causal mechanisms. A non-conventional flood is generated by other causal mechanisms (such as a flood wave generated by a breach of a natural or constructed water impoundment, landslide, etcetera) or is comprised of a significant concentration of sediment load or debris (such as a debris flow, debris flood or hyperconcentrated flow) (EGBC, 2018).

This report does not directly address, assess, or make conclusions based on non-conventional floods or their hazards; however, non-conventional floods were considered to the extent reasonably required in order to support the completion of flood mapping. For clarity, the word *flood* in this report refers only to a conventional flood caused by snowmelt, rainfall or a combination of the two causal mechanisms[10]. As a result, all *hazards* or *risks* discussed in this report refer only to hazards and risks associated with conventional flooding as defined in this section.

[9] Water that does not have a significant sediment load (less than 4% by volume).
[10] Ice jams were omitted from the analysis due to the absence of any historical issues with ice jams.

2 FLOOD MAPPING

According to the Flood Hazard Area Land Use Management Guidelines, flood mapping is an important first step in developing an IFMP (FLNRORD, 2018). Flood mapping is useful to aid flood mitigation planning as it delineates the potential of flooding and supports estimates of flooding impacts to structures, people and assets, infrastructure, etcetera (Public Safety Canada 2016).

In accordance with provincial legislated guidelines, engineering best practices, and CEPF funding requirements, a variety of tasks were completed to support the preparation of flood maps. This section provides a summary of the completed tasks, supporting information, model data input, employed methodologies, and assumptions and decisions used in the preparation of the work.

2.1 Geographic Area and Investigation

The geographic area covered by this investigation includes the Shuswap River drainage basin within and upstream of the City's jurisdictional boundary.

2.2 Basin Drainage Areas

Interior Dams measured the total Shuswap River drainage area above the City of Enderby to be 5,012 square kilometres (km^2) using provincially available 1:20000-scale TRIM contour and water line maps (Province of British Columbia, 2014). This value was audited and confirmed by comparing other mapped watershed boundaries of the river to the new delineated boundary used for measurement.

The Shuswap River watershed is bound by two key geographic features: the steeply-sloped Monashee Mountains to the east and the Shuswap Highlands to the west, and stems from Joss Pass between Joss Mountain and Davis Peak in the Sawtooth Range of the Monashee Mountains. From its headwaters, the Shuswap River flows approximately 150 kilometres (km) down into the Shuswap Highlands and through Sugar Lake and Mabel Lake, before discharging into Mara Lake, which is an extension of Shuswap Lake. The watershed is commonly divided into three different sections: Upper Shuswap (headwaters to Sugar Lake outlet), Middle Shuswap (Sugar Lake outlet to Mabel Lake), and Lower Shuswap (Mabel Lake outlet to Mara Lake inlet) (Golder, 2012) (SEC, 1996). The following sub-sections describe these catchments.

2.2.1 Upper Shuswap

The Upper Shuswap River watershed is the most upstream portion of the Shuswap River watershed. It stretches approximately 60 kilometres between its headwaters (~1,675 m) and the Sugar Lake outlet (~602 m). The headwaters of the Shuswap River originate between Joss Mountain and Davis Peak in the Sawtooth Range of the Monashee Mountains. Within the headwater reaches, the stream has a relatively steep channel gradient of 4% to 9.3%, with average channel widths of 8 to 10 m, and a channel bottom consisting of cobbles and gravels.

Below the headwater reaches, the Upper Shuswap River parallels Greenbush Creek within a wide, low-gradient valley before their confluence. Greenbush Creek is the most upstream of the major tributaries to the Upper Shuswap River; water flows downstream of the confluence of these two streams are substantially greater than upstream in the system. Below Greenbush Creek, the Upper Shuswap River is again confined to a narrow valley with a gradient between 0.5% and 2.4% and a floodplain width of approximately 70 m. Key sub-drainages within this section of the stream include Lindmark Creek, Vanwyk Creek, and Gagney Creek.

Downstream, the Upper Shuswap River broadens and meanders irregularly. Significant sub-drainages in this area include Gates Creek and Vigue Creek. Below the Vigue Creek sub-drainage, the Shuswap River floodplain widens to up to 2 km wide with a channel width of 40 to 50 m. Throughout this section, multiple remnant oxbows are present, as well as side-channel, island, and gravel bar features. The channel substrates consist of cobbles and gravels with some fine materials, while the grade is less than 1%. The most downstream sub-drainages connecting to the Upper Shuswap River above Sugar Lake are Spectrum Creek and Kate Creek.

2.2.1.1 Sugar Lake

The Upper Shuswap River flows through Sugar Lake, with key lake sub-drainages including Sugar Creek, Sitkum Creek, and Outlet Creek on the eastern side of the lake, and Sprockton Creek on the western side of the lake. Located at the outlet of Sugar Lake is Sugar Lake Dam. Sugar Lake Dam is a storage dam, originally constructed in 1929 and raised to its current height of 13 metres in 1942 (BC Hydro, 2005). The dam is a concrete buttress dam with low-level sluices. Contrary to popular belief, Sugar Lake Dam does not control the release of flood waters; the dam is an uncontrolled overflow structure, and during freshet, it passes any flow greater than the capacity of the sluice gates. As a result, Sugar Lake only stores about 11 percent of its annual average inflow.

Note: Photograph taken on May 23, 2020. Flow over dam is approximately 180 m^3/s.

Figure 2-1: Sugar Lake Dam (May 23, 2020)

2.2.2 Middle Shuswap

The Middle Shuswap River watershed is the portion of the watershed between the Sugar Lake outlet (~602 m) and the Mabel Lake outlet (~393 m). Mabel Lake is located approximately 54 km downstream of the Sugar Lake Dam outlet. The Shuswap River flows southwest for 15 km to Cherryville between the Silver Hills area of the Shuswap Highlands to the west and the Cherry Ridge area of the Monashee Mountains to the east. Through this section, the Shuswap River has channel widths of 20 to 30 m, gradients of 3 to 4%, and a bottom composed of coarse gravel and small cobbles. Notable sub-drainages within this section of the Shuswap River include Reiter Creek, Holstein Creek, and Cherry Creek.

The Shuswap River travels northwest through Cherryville to Shuswap Falls and Wilsey Dam. Within this section, channel widths are within the range of 40 to 70 m with an average gradient of approximately 2% and bottom substrate consisting of small cobbles and coarse gravel. Wilsey Dam is a run-of-river hydroelectric dam owned and operated by BC Hydro. The dam is 30 m high and 40 m long and was constructed in 1929. The dam spills any flows greater than the combined capacity of the turbines, 31.6 m^3/s (BC Hydro, 2005). Key sub-drainages between Cherryville and Wilsey Dam include Ferry Creek, Bonneau Creek, and Woodward Creek.

Downstream of Wilsey Dam, the Shuswap River flows north to Mabel Lake around the Silver Hills area of the Shuswap Highlands. Gradients within this section are less than 1%, and the channel flows through a wide floodplain with various side channel and oxbow features. Sub-drainages of note in this reach of the Shuswap are Bessette Creek, Tsuius Creek, Wap Creek, and Noisy Creek.

In the area of Duteau Creek, surface water flows are diverted out of the watershed and into the Okanagan Basin watershed. Use is highest in the Duteau Creek tributary, where an estimated 33% of the naturalized flow is diverted on an annual basis (Golder, 2012). The flows in Duteau Creek, and as a result, Bessette Creek below the Duteau confluence at Lumby, are highly regulated by releases from storage reservoirs in upper Duteau Creek.

2.2.3 Lower Shuswap

The Lower Shuswap River watershed is the portion of the watershed between the Mabel Lake outlet (~393 m) and the end of the Shuswap River at the Mara Lake inlet (~347 m), located approximately 73 km downstream of the Mabel Lake outlet. The Shuswap River flows southwest from the Mabel Lake outlet at Kingfisher and through the Skookumchuck Rapids and the Shuswap River Islands before flowing west to the City of Enderby. Along this route it passes between the northerly Hunters Range area and the southerly Trinity Hills area of the Shuswap Highland. The channel gradient in this section ranges from 4% at the rapids to 0.3% at the City of Enderby, with the bottom composition transitioning from cobbles and gravels to gravel and sands in the downstream direction (Ecoscape, 2011). Sub-drainages of note within this section are Kingfisher Creek, Trinity Creek, Ashton Creek, Brash Creek, and Fortune Creek.

From Enderby, the Shuswap River flows northeast around the Hunters Range within a wide floodplain, through Grindrod to Mara Lake. The composition of the channel bottom in this area is primarily sand and silt, with channel gradients less than 0.1% (Ecoscape, 2011). Notable sub-drainages within this section of the Shuswap River are Blurton Creek and Johnson Creek.

2.2.3.1 City of Enderby

The City of Enderby is situated on the left bank of the Shuswap River, where the river meanders through a relatively flat, three-kilometre-wide valley bottom. The City is constructed on deposits of post-glacial alluvium between valley slopes consisting of outcropping bedrock (Fulton, 1974). The channel is relatively stable immediately upstream and downstream of the City; however, the existence of scroll bars[11] on the Enderby floodplain is evidence that the river has migrated back and forth across the valley bottom since the Fraser deglaciation (Figure 2-2). Additionally, the channel upstream of Enderby has changed significantly since 1975; however, this area provides little attenuation for the area of interest, and recent change does not impact the hydraulic characteristics of the river at the point of interest of this study.

Note: LiDAR is shaded by elevation to demonstrate terrain features (Yellow-lowest elevation, Red-highest elevation)

Figure 2-2: Evidence of scroll bars demonstrating past meandering of the river channel

2.3 Supporting Information and Input Data

Interior Dams conducted a detailed background investigation of all water conveyance infrastructure, road crossings, and bridges along creek channels. Where possible, the investigation utilized record drawings, infrastructure mapping, and reports collected from City archives, the provincial government, and private data sources.

For portions of the drainage basins that are outside of the City's jurisdictional boundary, the investigation relied on desktop investigation supported by field verification of critical cross-sections, channel conditions, and other field conditions previously identified. Desktop exercises

[11] A scroll bar is a ridge on the inside of a meander bend which parallels the curvature of a channel and is separated from the inner bank by a swale.

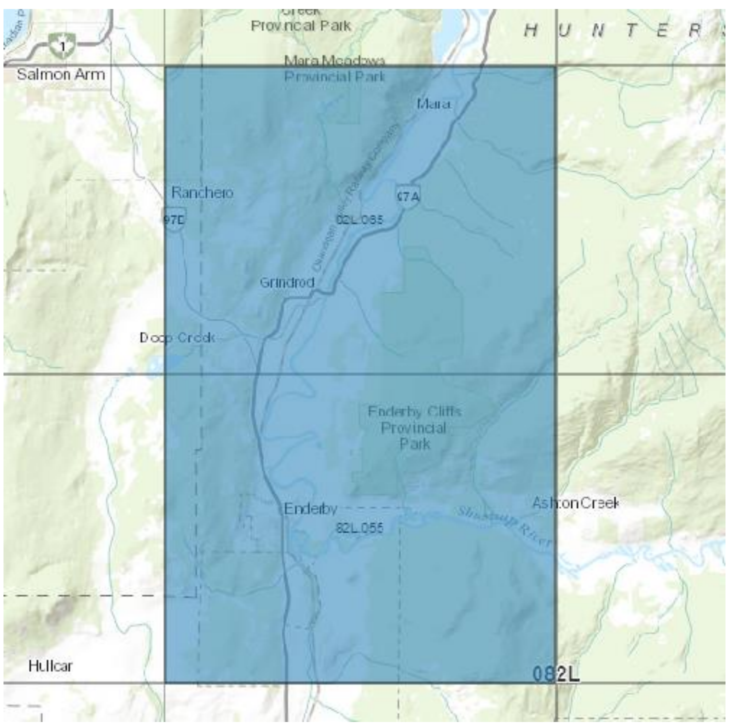
included the review of available reports, climate station data, hydrometric streamflow data, aerial and satellite photo data, and other supporting environmental and hydroclimatic data.

The following sub-sections provide key supporting data used in the flood mapping analysis. For a list of sources, refer to Section 6 of this report.

2.3.1 LiDAR Elevation Data

LiDAR was sourced by the City through the LiDARBC Data Discovery and Distribution Service for Emergency Management BC (EMBC). The LiDAR data was collected between September and November of 2019 using a Riegl LMS-Q780 LiDAR system. With a point density of 16.0 points per square metre (pts/m^2), the processing of data achieved a fundamental vertical accuracy[12] of 0.14 metres (m). Tiles 82L055 and 82L065 were acquired and incorporated into the flood model.

Careful inspection of the digital elevation model (DEM) was conducted prior to importation to the flood model. As the data collection took place during "leaf-off" conditions, the generated surface contained only a small amount of cropping of densely vegetated areas. All identified cropping and inaccurate elevations in critical flood areas were corrected using field survey data. See Figure 2.3 for an illustration of the area collected. Appendix VI provides a summary of the LiDAR specifications and terms of use.



Note: Acquired LiDAR area highlighted in blue.

Figure 2-3: LiDAR data extents

[12] Fundamental vertical accuracy refers to the accuracy for smooth or hardened surfaces.

2.3.2 Bathymetric Mapping

Bathymetric mapping was completed for the Shuswap River within the jurisdictional boundary of the City. The collected bathymetry covers all areas critical for hydraulic modelling and encompasses approximately 11 kilometres of river reach and a bed area of 1.5 km^2. Bathymetry was collected using a Lowrance Elite-5ti equipped with CHIRP sonar and a Topcon RTK GR-5. Bathymetric mapping was completed over seven days, from September 14 to September 21. Flows in the Shuswap River during this period were in the range of 35 to 40 m^3/s.

The GR5 base station was set up on the river banks while the surveying boat was driven both up and down the river and zig-zagged back and forth to achieve maximum coverage. The GR5 receiver was attached directly over top of the sonar receiver. This allowed for a correlation of the easting, northing, and elevation collected by the GR5 to the depth measurements collected by the sonar equipment. The described setup is shown below in Figure 2-4.

Figure 2-4: GR5 base station in foreground with GR5 rover and Lowrance Sonar set up in background, attached to boat.

A total of 342,149 individual points were collected using sonar equipment. These consisted of easting, northing, and depth measurement relative to the sonar receiver. Using the known offset between the GR5 receiver and the sonar receiver, the points were corrected to obtain georeferenced coordinates of the channel bottom. Contours generated using the bathymetric points can be seen below for a small sample area of the collected bathymetry.

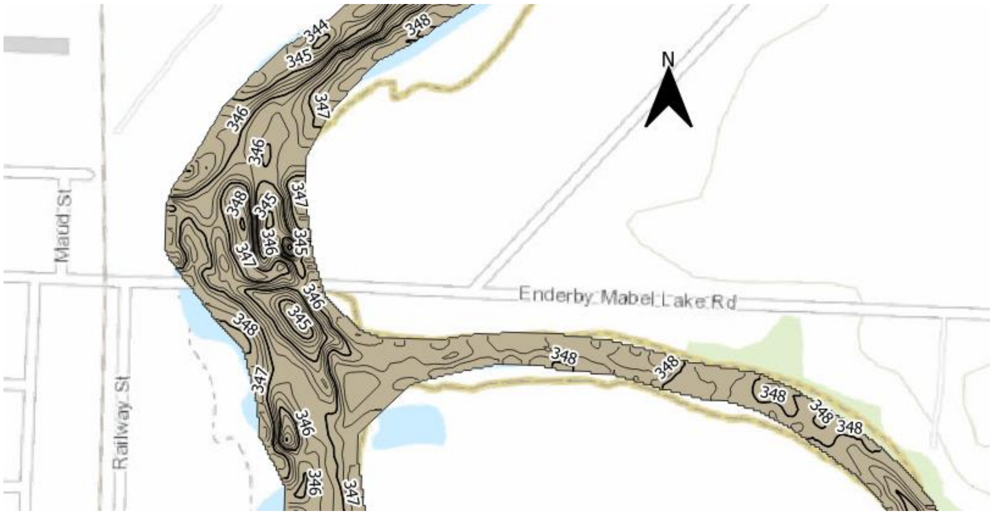


Figure 2-5: Sample section of the Shuswap River bathymetric data

2.3.3 Base mapping

Graphical interface system (GIS) base mapping and other publicly available spatial data were collected and used for the flood mapping and background investigation. Data collection included property parcel geometry and parcel information (Ministry of Citizens' Services, 2020) (BC Land Title & Survey, 2020), property assessment information (BC Assessment, 2021), Terrain Resource Information Management (TRIM) contour and water line mapping (Province of BC, 2014a), ortho and satellite imagery (RDNO, 2012) (Digital Globe), elevation contour data (RDNO, 2020), transportation mapping (GeoBC, 2021), and general location mapping for BC healthcare facility, RCMP detachment, fire department and Local Authority offices and public works facilities (Ministry of Health, 2021) (GeoBC, 2021) (Digital Globe).

2.3.4 1980 Shuswap River (Mara Lake to Mabel Lake) Floodplain Mapping and BC Water Surveys Data

Interior Dams reviewed the 1980 provincial flood mapping and supporting data. Supporting information included three types of survey data, including river cross-sections, river thalweg profile, and water surface elevations (WSE). WSE elevations were measured[13] on June 13, 1975.

The provincial mapping data references the 1928 vertical datum; therefore, it may be compared to the sourced LiDAR and bathymetry data which references the 2013 vertical datum. For horizontal reference, the 1975 provincial mapping data did not provide exact coordinate reference points. Despite this, cross-sections are labelled on the 1975 flood maps; therefore, horizontal reference to the 1975 survey data was visually referenced to within a couple of metres using available satellite imagery.

[13] On the date of survey, the hydrometric station upstream of Enderby (08LC002) measured the average daily average flowrate in the Shuswap River to be 303 m^3/s.

Once spatially referenced, Interior Dams reviewed the 1975 survey data. When comparing the 1975 thalweg survey to the 1975 cross-section data, there is some considerable discrepancy between the two surveys. Additionally, comparing the 1975 cross-section station references to measured distances in GIS, the difference varied as much as 10%.

Despite some discrepancies with the cross-section stationing, spatially-referenced 1975 cross-section survey data was compared to the collected 2020 bathymetric survey data to examine how the channel bottom has changed over the last 45 years. As a result, the river bottom within overlapping areas was found to be remarkably similar[14].

In regards to integrating the 1975 sections into the DEM, this was only done outside of the area of the bathymetric survey. Within the bathymetric survey, only sections sampled from the bathymetric surface were inputted. The 1975 sections were compared to the sections created using the bathymetry to verify location and to exam how the channel bottom had changed. In general, apart from the difference in vertical datum, they were remarkably similar.

2.3.5 Infrastructure

Within the area of interest, the Shuswap River is relatively free of hydraulic infrastructure in the mainstem channel. At Enderby, there is the Enderby Mabel Lake Road Bridge, also known as the Bawtree Bridge. At Grindrod, there is the Highway 97A/Young Street Bridge. Record drawings were collected and reviewed, and ample information was identified to support the construction of flood modelling. Interior Dams audited all on-file information used for the construction of the model.

2.3.6 Climate Data

Table 2-1 below summarizes the climate data reviewed. Figure 2-6 illustrates the location of the Climate Stations.

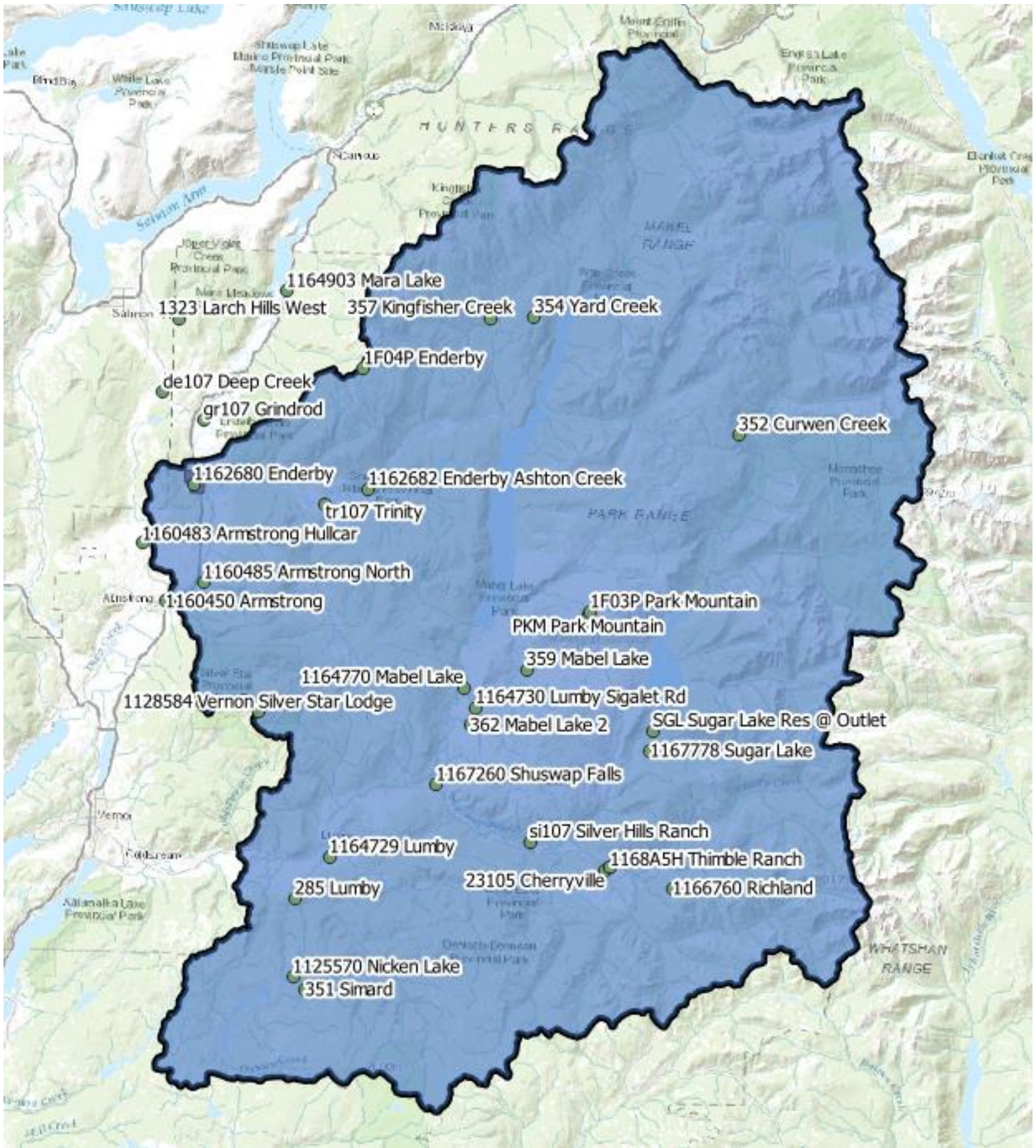
Table 2-1: Climate stations

Station ID	Station Name	Station Period (yrs)	Record Type	Elevation (m)	Distance (km)
gr107	Grindrod	12 (2006-2018)	Daily	355.0	6.2
si107	Silver Hills Ranch	2 (2008-2010)	Daily	495.0	45.8
de107	Deep Creek	12 (2006-2018)	Daily	517.0	9.5
tr107	Trinity	1 (2006-2007)	Daily	362.0	11.9
SGL	Sugar Lake Res @ Outlet	21 (1999-2020)	Daily	675	48.6
PKM	Park Mountain	8 (2000-2008)	Daily	1890	38.6
1F04P	Enderby	1 (2019-2020)	Daily/hourly	1950	18.9
1F03P	Park Mountain	26 (1984-2020)	Daily/hourly	1890	38.7
23105	Cherryville	16 (1988-2004)	Daily	670	52.7
1323	Larch Hills West	2 (2018-2020)	Hourly	892	15.9

[14] Areas upstream of Enderby and collected bathymetric areas have not remained constant. Refer to Section 2.2.3.1.

Table 2-1: Climate stations

Station ID	Station Name	Station Period (yrs)	Record Type	Elevation (m)	Distance (km)
362	Mabel Lake 2	116 (1904-2020)	Daily and Hourly	488	34.0
359	Mabel Lake	4 (1984-1988)	Daily	N/A	35.3
357	Kingfisher Creek	7 (1990-1997)	Daily	640	31.6
352	Curwen Creek	30 (1990-2020)	Daily/hourly	1250	51.1
354	Yard Creek	4 (1979-1983)	Daily	N/A	35.3
351	Simard	5 (1991-1996)	Daily	1402	48.7
285	Lumby	6 (1977-1983)	Daily	N/A	40.1
1168A5H	Thimble Ranch	3 (1975-1978)	Daily	425	52.9
1125570	Nicken Lake	7 (1990-1997)	Daily	1317	47.3
1167778	Sugar Lake	7 (1957-1964)	Daily	610	49.3
1167260	Shuswap Falls	42 (1930-1972)	Daily	427	36.0
1166760	Richland	12 (1962-1975)	Daily	716.0	58.6
1164903	Mara Lake	4 (1965-1969)	Daily	354	20.1
1164730	Lumby Sigalet Rd	29 (1970-1999)	Daily	560	33.4
1164770	Mabel Lake	51 (1924-1975)	Daily	399	31.3
1164729	Lumby	51 (1959-2010)	Daily	500	37.2
1160483	Armstrong Hullcar	17 (1971-1998)	Daily	505	7.8
1128584	Vernon Silver Star Lodge	50 (1970-2020)	Daily/hourly	1572	22.1
1160450	Armstrong	80 (1912-1992)	Daily	359	11.5
1160485	Armstrong North	21 (1972-1993)	Daily	373	9.2
1161506	Cherryville	2 (1959-1961)	Daily	665	52.9
1162682	Enderby Ashton Creek	10 (1965-1975)	Daily	351	15.8
1162680	Enderby	13 (1984-1997)	Daily	354	0.8



Note: Catchment area above Enderby shown in blue.

Figure 2-6: Location of climate stations

Data from six (6) snow weather stations within the Shuswap watershed were reviewed. The location of the Silver Star Mountain snow course station (ID 2F10) is at an elevation of 1840 m near the Silver Star Mountain Resort east of Vernon, BC. The station includes manually collected data that is available for the period of 1960 to 2015. As of 2015, the station became automated and renamed ID 2F10P. The Park Mountain snow course station (ID 1F03) is located within the Park Mountain Range, between Mabel Lake and Sugar Lake, at an elevation of 1890 m. From 1957 to 1996, the station was operated manually. From 2003 onward, the station has been automated and renamed ID 1F03P.

The Enderby snow course station (ID 1F04) is located at an elevation of 1900 m and is operated manually. Stations 1F04P and 1F04P2 are automated stations located in the near vicinity of 1F04 and were established in 2016 and 2017, respectively. It was noted during the review of these stations that an inconsistency existed, with Station 1F04P typically measuring 30% lower in typical snowpack years. Per correspondence with the Snow Survey Program, station 1F04P has an analog snow scale while 1F04P2 has a digital scale, explaining the discrepancy between the data. Table 2-2 provides a summary of the snow course station data.

Table 2-2: Snow weather stations

Station ID	Station Name	Station Period (yrs)	Record Type	Mean Max. Snow (mm water eq)	Elevation (m)	Distance to City core (km)
2F10(P)	Silver Star Mountain	56 (1960-2014) 6 (2015-2020)	Manual Continuous	783.4	1840	20.5
1F03 1F03(P)	Park Mountain	39 (1957-1996) 17 (2003-2020)	Manual Continuous	966.5	1890	38.8 38.3
1F04	Enderby	56 (1963-2019)	Manual	1139.3	1900	19.2
1F04(P)	Enderby	4 (2016-2020)	Continuous	1096	1950	18.9
1F04P(2)	Enderby Tower 2	3 (2017-2020)	Continuous	1249	1950	18.0

2.3.7 Hydrometric Data

Presently there are three (3) active hydrometric stations located on the Shuswap River above Enderby. A total of 42 stations, both historical and current, were identified within the Shuswap watershed above Enderby. Of these, the most pertinent station is the Shuswap River Near Enderby (08LC002) Water Survey Canada (WSC) station. The station is located approximately 9.0 km directly upstream of the City, is currently active, and contains streamflow records dating back to 1911. A complete list of hydrometric stations reviewed is summarized in Table 2-3.

Table 2-3: Hydrometric stations

Station ID and Name	Area (km^2)	Period of Record (years)	Data Collection Type	Elevation (m)	Distance (km)
08LC002 Shuswap River Near Enderby	4720	(1911-1913) (1914-1915) (1916-1917) (1918-1936) (1960-1991) (1992-2010) (2011-2020)	Flow, Manual, Seasonal Flow, Manual, Continuous Flow, manual, seasonal Flow, manual, continuous Flow, manual, continuous Flow, recorder, continuous Flow & level, recorder, continuous	351	9.0
08LC003 Shuswap River Near Lumby	2000	(1913 - 1913) (1917 - 1918) (1919 - 1924) (1925 - 1925) (1926 - 1936) (1945 - 1972) (1973 - 1973) (1984 - 1986)	Flow, Continuous, Manual Flow, Seasonal, Manual Flow, Continuous, Manual Flow, Seasonal, Manual Flow, Continuous, Manual Flow, Continuous, Manual Flow, Seasonal, Manual Flow, Continuous, Recorder	410	35.6

Table 2-3: Hydrometric stations

Station ID and Name	Area (km^2)	Period of Record (years)	Data Collection Type	Elevation (m)	Distance (km)
		(1989 - 2010) (2011 - 2020)	Flow, Continuous, Recorder Flow & Level, Continuous, Recorder		
08LC004 Brash Creek Near Enderby	32.6	(1915 – 1917) (1928 - 1929) (1931 - 1931) (1959 - 1959) (1960 - 1967) (1968 - 1968)	Flow, Continuous, Manual Flow, Miscellaneous Flow, Miscellaneous Flow, Seasonal, Manual Flow, Continuous, Manual Flow, Miscellaneous, Manual	N/A	7.2
08LC005 Bessette Creek Near Lumby	253	(1919 - 1919) (1943 - 1948) (1965 - 1972) (1974 - 1983)	Flow, Seasonal, Manual Flow, Seasonal, Manual Flow, Seasonal, Manual Flow, Seasonal, Manual	N/A	37.0
08LC006 Duteau Creek Near Lavington	N/A	(1919 - 1921) (1928 - 1928) (1935 - 1951) (1959 - 1966) (1967 - 1967) (1968 - 1973) (1974 - 1975)	Flow, Seasonal, Manual Flow, Miscellaneous, Manual Flow, Seasonal, Manual Flow, Seasonal, Manual Flow, Miscellaneous, Manual Flow, Seasonal, Manual Flow, Continuous, Manual Flow, Continuous, Recorder	N/A	39.9
08LC007 Vernon Irrigation District Diversion Near Lavington	N/A	(1919 - 1921) (1922 - 1922) (1935 - 1951) (1964 - 1966)	Flow, Seasonal, Manual Flow, Miscellaneous, Manual Flow, Seasonal, Manual Flow, Seasonal, Manual	N/A	39.8
08LC008 Nicklen Creek Near Lumby	30.8	(1920-1920)	Flow, Seasonal, Manual	N/A	40.2
08LC009 McAuley Creek Near Lumby	32.6	(1920-1920)	Flow Seasonal, Recorder	N/A	46.6
08LC010 Nicklen Creek Near Lumby (Upper Station)	11.9	(1921-1921)	Flow, Seasonal, Recorder	N/A	46.2
08LC014 Duteau Creek at Outlet of Haddo Lake	81.1	(1910 - 1911) (1921 - 1921) (1973 - 1979)	Flow, Miscellaneous Flow, Seasonal, Manual Flow, Seasonal, Manual	N/A	50.5
08LC015 Paradise Creek Near Lumby	13.5	(1921-1921)	Flow, Seasonal, Recorder	N/A	55.9

Table 2-3: Hydrometric stations

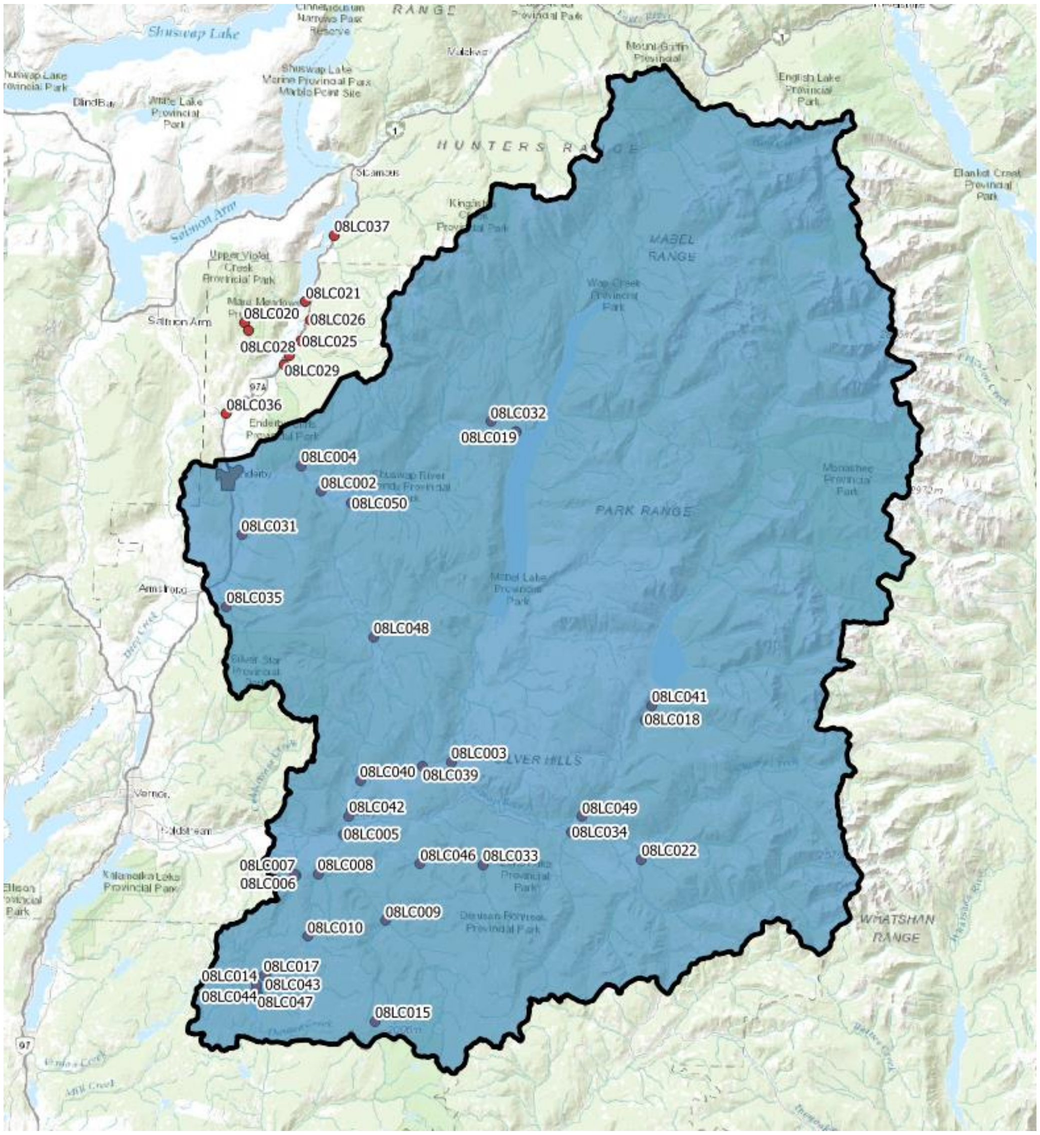
Station ID and Name	Area (km^2)	Period of Record (years)	Data Collection Type	Elevation (m)	Distance (km)
08LC017 Dermon Creek Near Lavington	N/A	(1921-1921)	Flow, Seasonal, Manual	N/A	49.5
08LC018 Shuswap River at Outlet of Sugar Lake Reservoir	1130	(1926 - 1936) (1938 - 1940) (1941 - 1941) (1970 - 1979) (1984 - 1986) (1989 - 2010) (2011 - 2020)	Flow, Continuous, Manual Flow, Seasonal, Manual Level, Seasonal, Manual Flow, Continuous, Recorder Flow, Continuous, Recorder Flow, Continuous, Recorder Flow & Level, Continuous, Recorder	579	47.7
08LC019 Shuswap River at Outlet of Mabel Lake	4040	(1927 - 1936) (1951 - 1969) (1970 - 1979)	Flow, Continuous, Manual Flow, Continuous, Manual Flow, Continuous, Recorder	N/A	29.0
08LC020 Violet Creek Near Grindrod (Upper Station)	13.0	(1934 - 1934) (1945 - 1949)	Flow, Seasonal, Manual Flow, Seasonal, Manual	N/A	16.2
08LC021 Larch Hills Creek Near Mara	13.0	(1934 - 1934) (1945 - 1948) (1951 - 1953)	Flow, Seasonal, Manual Flow, Seasonal, Manual Flow, Seasonal, Manual	N/A	19.7
08LC022 Monashee Creek Near Cherryville	311	(1938-1939)	Flow, Seasonal, Manual	N/A	55.8
08LC025 Blurton Creek Near Mara	19.2	(1946 - 1948) (1951 - 1953)	Flow, Seasonal, Manual Flow, Seasonal, Manual	N/A	15.8
08LC026 Johnson Creek Near Mara	20.7	(1946 - 1948) (1951 - 1953)	Flow, Seasonal, Manual Flow, Seasonal, Manual	N/A	18.2
08LC028 Ptarmigan Creek Near Mara	N/A	(1946-1946)	Flow, Seasonal, Manual	N/A	14.0
08LC029 Bongard Creek Near Mara	13.0	(1946-1946)	Flow, Seasonal, Manual	N/A	13.0
08LC030 Violet Creek Near Grindrod	N/A	(1946-1949) (1951-1953)	Flow, Seasonal, Manual Flow, Seasonal, Manual	N/A	15.5
08LC031 Fortune Creek at Stepney	132.0	1(1949) 10(1950-1959) 1(1960) 1(1961)	Flow, Miscellaneous Manual, Seasonal Manual, Continuous Miscellaneous	~356	5.3
08LC032 Shuswap River	N/A	(1955-1956)	Level, Continuous, Manual	N/A	26.7

Table 2-3: Hydrometric stations

Station ID and Name	Area (km^2)	Period of Record (years)	Data Collection Type	Elevation (m)	Distance (km)
Below Skookumchuck Rapids					
08LC033 Creighton Creek Near Lumby	37.6	(1959 - 1965) (1966 - 1966)	Flow, Seasonal, Manual Flow, Miscellaneous, Manual	N/A	45.9
08LC034 Ferry Creek Near Lumby	145	(1928 - 1928) (1959 - 1971) (1972 - 1975) (1977 – 1977)	Flow, Miscellaneous Flow, Seasonal, Manual Flow, Continuous, Manual Flow, Seasonal, Manual	N/A	48.9
08LC035 Fortune Creek Near Armstrong	41.2	(1911 - 1912) (1959 - 1960) (1961 - 1968) (1969 - 1969) (1970 - 1972) (1973 - 1974) (1977 – 1984)	Flow, Continuous, Manual Flow, Seasonal, Manual Flow, Continuous, Manual Flow, Seasonal, Manual Flow, Continuous, Manual Flow, Seasonal, Manual Flow, Continuous, Manual	N/A	12.4
08LC036 Gardom Creek Near Grindrod	25.9	(1960-1964)	Flow, Seasonal, Manual	N/A	7.0
08LC037 Mara Lake Near Sicamous	N/A	(1961 - 1961) (1962 - 1963) (1964 - 1974)	Level, Seasonal, Manual Level, Continuous, Manual Level, Continuous, Recorder	344.046	27.0
08LC038 Mabel Lake at the Outlet	N/A	(1970 - 1975) (1976 - 1976) (1977 - 1979)	Level, Continuous, Recorder Level, Seasonal, Recorder Level, Continuous, Recorder	N/A	29.0
08LC039 Bessette Creek Above Beaverjack Creek	769	(1970 - 1972) (1975 - 1976) (1977 - 2010) (2011 - 2020)	Flow, Seasonal, Manual Flow, Continuous, Manual Flow, Continuous, Recorder Flow & Level, Continuous, Recorder	N/A	34.3
08LC040 Vance Creek Below Deafies Creek	70.9	(1970 - 1977) (1978 - 2002) (2003 - 2010) (2011 - 2020)	Flow, Seasonal, Manual Flow, Continuous, Manual Flow, Continuous, Recorder Flow & Level, Continuous, Recorder	N/A	32.5
08LC041 Sugar Lake reservoir at the Outlet	N/A	(1970-1975) (1976-2020)	Level, Continuous, Manual Level, Continuous, Recorder	592.0	47.7
08LC042 Bessette Creek Above Lumby Lagoon Outfall	632	(1973 - 1989) (1990 - 2010) (2011 - 2020)	Flow, Continuous, Manual Flow, Continuous, Recorder Flow & Level, Continuous, Recorder	N/A	35.4

Table 2-3: Hydrometric stations

Station ID and Name	Area (km^2)	Period of Record (years)	Data Collection Type	Elevation (m)	Distance (km)
08LC043 Aberdeen Lake at the Outlet	N/A	(1968 - 1978) (1979 - 1986)	Level, Seasonal, Manual Level, Continuous, Manual	N/A	49.7
08LC044 Haddo Lake at the Outlet	N/A	(1968 - 1976) (1977 - 1986)	Level, Seasonal, Manual Level, Continuous, Manual	N/A	50.8
08LC046 Creighton Creek Near Creighton Valley	N/A	(1977-1977)	Flow, Seasonal, Manual	N/A	42.7
08LC047 Grizzly Swamp Near Haddo Lake	N/A	(1978-1978) (1979-1986)	Flow, Seasonal, Manual Flow, Seasonal, Continuous	N/A	51.4
08LC048 Trinity Creek Above Diversion	42.9	(1981-1984)	Flow, Seasonal, Manual	N/A	21.0
08LC049 Cherry Creek Near Cherryville	503	(1982-1990)	Flow, Seasonal, Manual	N/A	48.6
08LC050 Trinity Creek Near the Mouth	191	(1982-1990)	Flow, Seasonal, Manual	N/A	12.2



Note: Shuswap City of Enderby watershed catchment shown in blue.

Figure 2-7: Location of reviewed hydrometric stations

2.3.8 Aerial Photos, Satellite Photos & Land Use Mapping

Interior Dams reviewed current and historical land use and cover characteristics. Sources included the Regional District of North Okanagan air photo imagery (RDNO, 2020), Google Earth satellite imagery (Digital Globe), range tenure mapping (FLNRORD, 2020d), mineral titles mapping (FLNRORD, 2020b), and the Zoning Bylaw and OCP maps (City of Enderby, 2014) (City of Enderby, 2014a).

The predominant land use in the Upper Shuswap watershed consists of active forest operations and recreational use. There are numerous logging roads within the watershed, with the primary logging road, Sugar Lake Forest Service Road, running parallel to the Upper Shuswap River.

There are also many mineral tenures; however, there were no large-scale mining operations identified in the Upper Shuswap. Multiple provincial recreation sites are present in the Upper Shuswap watershed, and recreational activities include hiking, horseback riding, fishing, hunting, snowmobiling, cat skiing, heli-skiing, and all-terrain vehicle use.

Within the Middle Shuswap River watershed, land use is predominately related to agricultural and hydroelectric power generation, with other land uses including forestry, rural residential, and recreation. Cut blocks, although concentrated in the Silver Hills area between Mabel Lake and the Upper Shuswap River, are present throughout this sub-region. Numerous provincial parks and provincial recreation sites are located in this section of the watershed, facilitating activities such as hiking, camping, wildlife viewing, paddling, fishing, snowmobiling, and all-terrain vehicle use.

At lower elevations in the Lower Shuswap River watershed, agricultural and rural developments are the most significant land uses, particularly downstream of the City. Upstream of the City, land use is predominantly forestry and recreation.

2.3.9 Inherent Flood Knowledge

As recommended by the Engineers and Geoscientists of British Columbia's flood mapping guidelines, inherent flood knowledge was collected from the public, City staff, and available historical news articles where possible (APEGBC, 2017). Interior Dams reviewed archives of historical photographs[15], past media reports, shared knowledge from City staff, and other anecdotal information from past flood events.

To differentiate "large floods" from more common freshet peak flows, Interior Dams assumed a streamflow value of approximately 500 m^3/s to be the criteria for a "large flood" since almost all the flood events occurring within the gauged record that had flow rates higher than the 500 m^3/s threshold were reported on by local newspapers or were noted or photographed in historical records.

Based on the threshold criteria above and gauged streamflow data, Interior Dams identified eight (8) "large floods" that occurred since 1912 within the record of inherent knowledge. These events occurred in 1913, 1928, 1948, 1972, 1974, 1997, 2012, and 2018.

Sample "large flood" photographs are provided in Section 1.1. These photographs and other identified inherent knowledge information were useful for model calibration and output validation.

[15] Most file photographs included reference dates and location descriptions. More recent digital photographs included timestamps and geo-reference data.

2.4 Selection of Flood Return Period and Map Type

In discussion with the City, flood mapping for both the 1/200-year and 1/20-year floods was preferred since it facilitates comprehension of flood variability and provides additional tools[16] to support the development of an IFMP. Additionally, the 1/200-year and 1/20-year flood frequencies are consistent with traditional provincial floodplain mapping[17], recent mapping projects conducted in the region, and requirements for septic systems[18]. As such, the 1/200-year and 1/20-year flood frequencies were adopted for the purposes of this report.

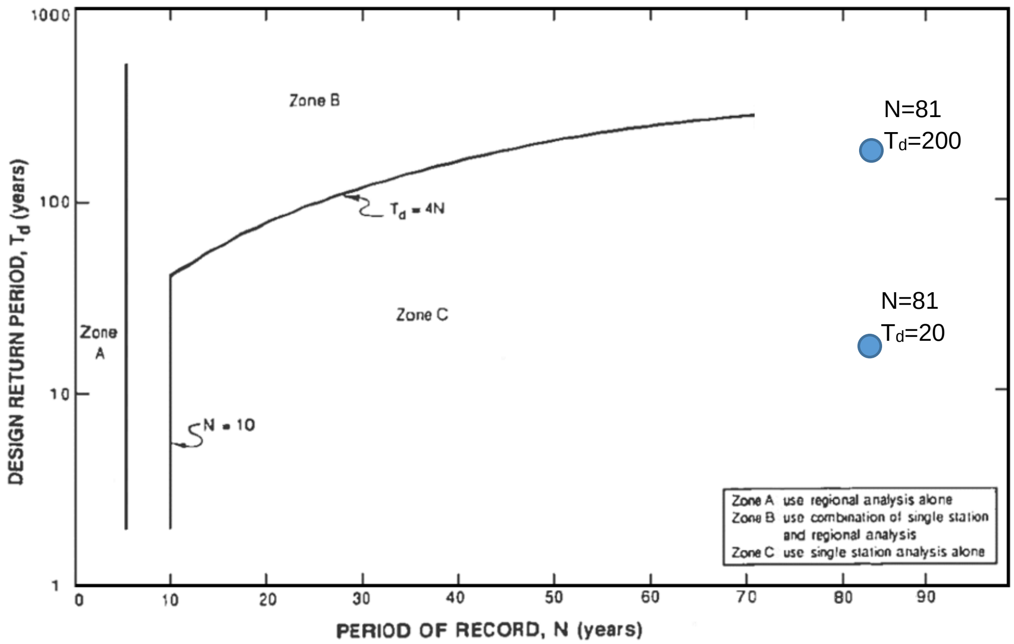
2.5 Design Flood Determination

2.5.1 Selection of a Single Station Hydrologic Statistical Frequency Analysis

There are generally two approaches to estimating the magnitude of a design flood:
1) hydrological statistical frequency analysis (HSFA) of streamflow data, and 2) streamflow simulation analysis[19] (SSA) based on consideration of rainfall and snowmelt (NRC, 1989). SSA is extremely sensitive to engineering judgement due to factors such as antecedent rainfall, soil moisture, volume and infiltration rate, and seasonal runoff response (Bedient, P, et al., 2008). Although SSA has its advantages, the available data described in Section 2.2 was not sufficient to adequately characterize the response of the subject drainage basins to support this approach. As such, an HSFA approach was the preferred and selected method due to the availability of hydrometric data near the point of interest.

The objective of HSFA is to interpret the past record of hydrologic events in terms of future probabilities of occurrence. The procedure involves selecting available hydrometric data samples, fitting them to theoretical probability distributions, and then making hypothetical inferences about the underlying populations based on the fitted distribution (NRC, 1989). According to the National Research Council of Canada (NRC), the HSFA approach should consider whether single station and/or regional analysis should be used based on the length of data record N and the desired return periods T_d. Using WSC hydrometric station data record from the Shuswap River Near Enderby (ID 08LC002) and plotting N = 83 (length of record excluding incomplete or erroneous data points) and T_d = 20 and 200 (desired return periods) on Figure 2-8, both points fall within Zone C. Per NRC guidance, application of only a single site analysis is recommended.

[16] Section 4 of this report explores non-structural risk mitigation options related to development bylaws. By having both the 1/200-year and 1/20-year flood mapping available, setbacks or flood construction levels for different types of construction can be easily specified by referencing one or the other map set.
[17] Provincial floodplain mapping was formerly “designated”.
[18] The 1/20-year flood level is used in applying provincial Health Act requirements for septic tanks.
[19] SSA is an approach that is independent of statistical analysis of streamflow and water level data. SSA requires input of meteorological data (often having a specified return period) into some form of basin model characterizing the response of the subject catchment upstream of the point of interest.



Note: For the Shuswap River Near Enderby (ID 08LC002) hydrometric station, N=81. T_d for the 1/200-year and 1/20-year return periods are 200 and 20, respectively. The desired return period points (N, T_d) are plotted in blue.

Figure 2-8: Guidance for reliance on single station and/or regional estimates - design return period vs period of record (modified from NRC, 1989)

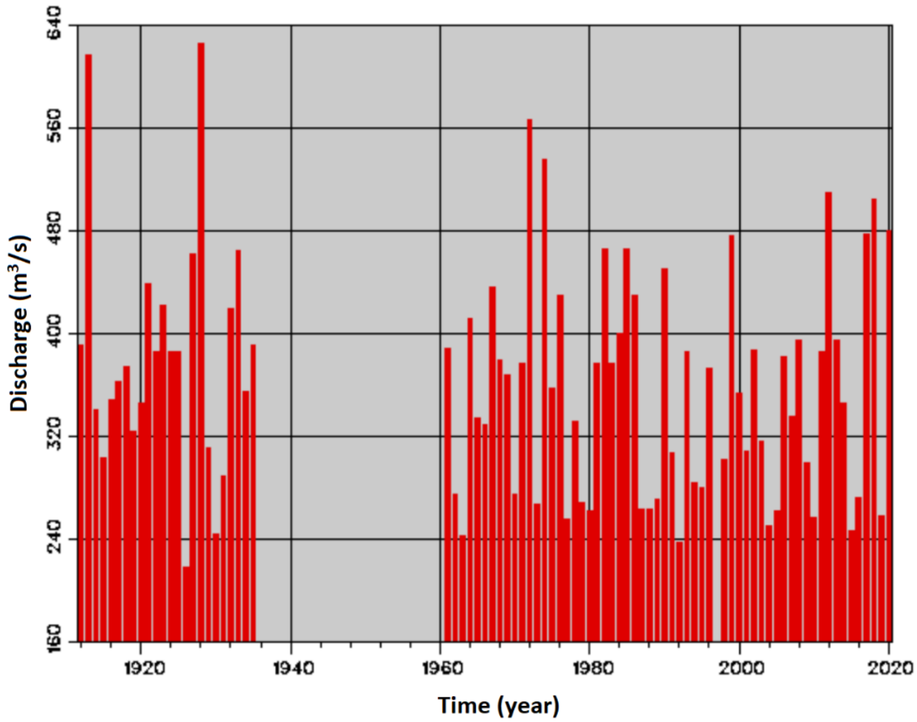
Per NRC guidance, Interior Dams adopted a single site HSFA analysis for the determination of the 1/200-year and 1/20-year design floods. Of note, single site analysis provides a good estimate for the design flood up to a return period of about 1/4N (CDA, 2007-2016). Applying this function criteria to the period of record calculates to 1/332-years. Since 1/332-years exceeds the desired return periods for flood mapping, the single site HSFA approach should provide good and reliable results provided that the dataset is valid.

2.5.2 Statistical Criteria and Tests

Using only the complete annual maximum daily flow records, Interior Dams conducted statistical tests to ensure the data met the criteria for frequency analysis (Environment Canada, 1993) (NRC, 1989). Using the Consolidated Frequency Analysis software version 3.1 (CFA-3) from Environment Canada, statistical checks included the Run Test for General Randomness, Spearman Test for Independence, Mann-Whitney Split Sample Test for Homogeneity, and Spearman Test for Trend (stationarity). Tests and visual checks did not identify any data errors or outliers, and the dataset was confirmed to be significantly random, independent, homogeneous, stationary, and adequate for analysis. Appendix I includes a summary of the CFA-3 statistical test results. Table 2-4 and Figure 2-9 summarize the annual maximum daily flow data values used for analysis.

Table 2-4: Adopted dataset for single station HSFA

Date	Annual Daily Maximum Streamflow (m^3/s)	Date	Annual Daily Maximum Streamflow (m^3/s)
June 17, 1912	391	June 5, 1979	268
June 14, 1913	617	May 12, 1980	261
June 20, 1914	340	May 31, 1981	377
May 1, 1915	303	July 23, 1982	446
June 22, 1916	348	June 2, 1983	376
June 22, 1917	362	July 2, 1984	400
June 18, 1918	374	May 29, 1985	465
May 30, 1919	323	June 4, 1986	429
June 24, 1920	345	May 13, 1987	263
June 10, 1921	439	May 29, 1988	263
June 7, 1922	385	June 15, 1989	271
June 14, 1923	422	June 13, 1990	450
May 23, 1924	385	June 12, 1991	307
May 23, 1925	385	June 2, 1992	237
May 5, 1926	217	May 21, 1993	386
June 15, 1927	462	May 17, 1994	284
May 30, 1928	626	June 7, 1995	280
June 11, 1929	311	June 8, 1996	373
June 11, 1930	243	May 14, 1998	301
June 23, 1931	289	June 24, 1999	476
June 18, 1932	419	June 16, 2000	353
June 20, 1933	464	June 2, 2001	308
May 1, 1934	354	June 29, 2002	387
June 17, 1935	391	June 14, 2003	316
June 9, 1961	388	June 13, 2004	250
June 21, 1962	274	May 19, 2005	261
June 1, 1963	242	May 27, 2006	381
June 17, 1964	411	June 10, 2007	335
June 12, 1965	334	June 8, 2008	394
June 10, 1966	328	June 6, 2009	299
June 24, 1967	436	June 14, 2010	256
June 12, 1968	379	June 24, 2011	385
June 10, 1969	368	June 26, 2012	509
June 10, 1970	275	June 26, 2013	394
June 9, 1971	377	June 17, 2014	345
June 12, 1972	566	June 4, 2015	246
June 29, 1973	266	May 8, 2016	272
June 25, 1974	535	June 3, 2017	477
June 20, 1975	357	May 20, 2018	504
June 23, 1976	430	June 4, 2019	257
June 14, 1977	255	June 3, 2020	480
June 9, 1978	331		



Note: Data from 1935 to 1961 is missing from the record. The 1997 data record was an incomplete and did not capture the annual maximum daily flow rate.

Figure 2-9: Peak annual discharge vs. year – Shuswap River Near Enderby (Station ID 08LC002)

2.5.3 *Considerations for Missing Data*

The Shuswap River Near Enderby (ID 08LC002) dataset is sufficiently long for analysis; however, the record is missing data between 1935 and 1961 (refer to Figure 2-9). In a case where the dataset has missing data, it should be determined whether or not the data is a broken record or an incomplete record[20]. The NRC guidelines suggest that "in the case of a broken record, the different record segments should normally be combined and treated as a continuous record, unless physical changes in the period between segments have produced non-homogeneity in the combined record" (NRC, 1989). Since the dataset is a broken record and statistical checks have confirmed it to be a homogeneous record, Interior Dams combined the data and treated it as a continuous record for analysis.

2.5.4 *Hydrologic Statistical Frequency and Threshold Analysis*

Per guidance, if "large flood" events exist within historical flood records[21] but are outside of the gauged data record, threshold analysis should be considered since it may effectively extend the period of record and increase the confidence of the estimated design flood (NRC, 1989) (USACE, 2016a) (Environment Canada, 1993).

[20] A *broken record* is a record that has missing data due to maintenance issues such as financial or staff restraints. An *incomplete record* is a record that has missing data due to damage or data loss due to unusually large flood events.
[21] A *historical flood record* is a large flood that either predates the existing period of record or is a large flood that was not captured by the data record.

Interior Dams applied the methodology described in the United States Geological Survey (USGS) Bulletin 17C guidance to extend the historical data record and increase solution confidence. Bulletin 17C provides the latest USGS guidance on determining flood flow frequency and includes a generalized representation of flood data that allows for interval and censored data types. It employs a method called the Expected Moments Algorithm (EMA), which extends the method of moments so that it can accommodate interval data and uses an improved method for computing confidence intervals (USGS, 2018).

The EMA is a generalized method of moments procedure to estimate the 3-parameter Log Pearson (LP3) distribution parameters using peak flow intervals to estimate the moments and confidence intervals. Of note, the EMA solution produces different confidence intervals, and in some cases, significantly improves the HSFA results.

Per inherent flood knowledge and other available data from Section 2.3, all “large floods” (floods having a maximum daily flowrate greater than 500 m^3/s) after 1912 occurred in 1913, 1928, 1948, 1972, 1974, 1997, 2012, and 2018. Of these, the largest recorded incident was the May 30, 1928[22] flood which gauged a maximum daily flowrate of 626 m^3/s. All other “large floods” also had maximum daily flow rates in the gauged record except for 1948 and 1997. These two “large floods” are within the historical record but are outside the gauged record, and therefore merit consideration.

Anecdotally, the flood of 1948 was not as extreme as the 1928 flood per newspaper articles from that period. This was confirmed by recorded maximum water elevations at the Bawtree Bridge. Flood levels from the 1948 flood measured approximately 450 mm (1.5 feet) lower than the flood of 1928[23]. The gauged flood of 1972 had a recorded maximum daily flow of 566 m^3/s and was reported to be smaller than the flood of 1948. Based on this information, Interior Dams assumed that the 1948 flood would have had to be greater than 566 m^3/s but less than 626 m^3/s.

The hydrometric station data for the 1997 year is incomplete. The record starts on June 5th, 1997 and is the highest recorded daily flow value recorded that year with a value of 508 m^3/s. Therefore, it is unknown if the record captured the annual maximum flow for the year; however, the maximum value must be at least 508 m^3/s. Since reports indicated the event was smaller than that of the 1972 flood, Interior Dams assumed the 1997 value must be between 508 m^3/s and 566 m^3/s.

Since no other “large floods” were identified in the records of inherent knowledge, all other years outside of the gauged record that occurred between 1912 and 2020 were assumed to have annual maximum daily flow values of less than 500 m^3/s.

[22] Per historical records, this event produced the highest flood water elevations at Enderby within inherent flood knowledge. The “old government” staff gauge at Enderby measured 22 feet, relative to its local datum.
[23] The “old government” staff gauge at Enderby measured 20.5 feet, relative to its local datum.

Using the above information, Interior Dams assigned flow ranges and perception thresholds per the USGS bulletin 17C guidance. Figure 2-10 and Table 2-5 provide a summary of this information. Interior Dams adopted Table 2-5 perception thresholds and observed peak flow values for HSFA analysis.

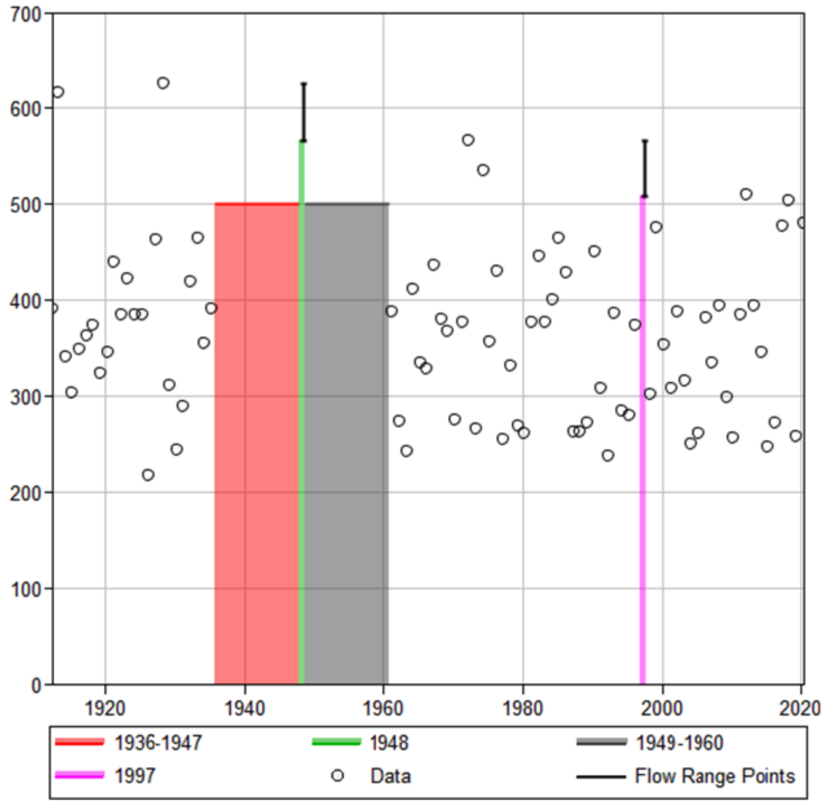


Figure 2-10: Representation of perception thresholds peak flow intervals used in the assessment of an HSFA single-site solution with threshold analysis of historical data

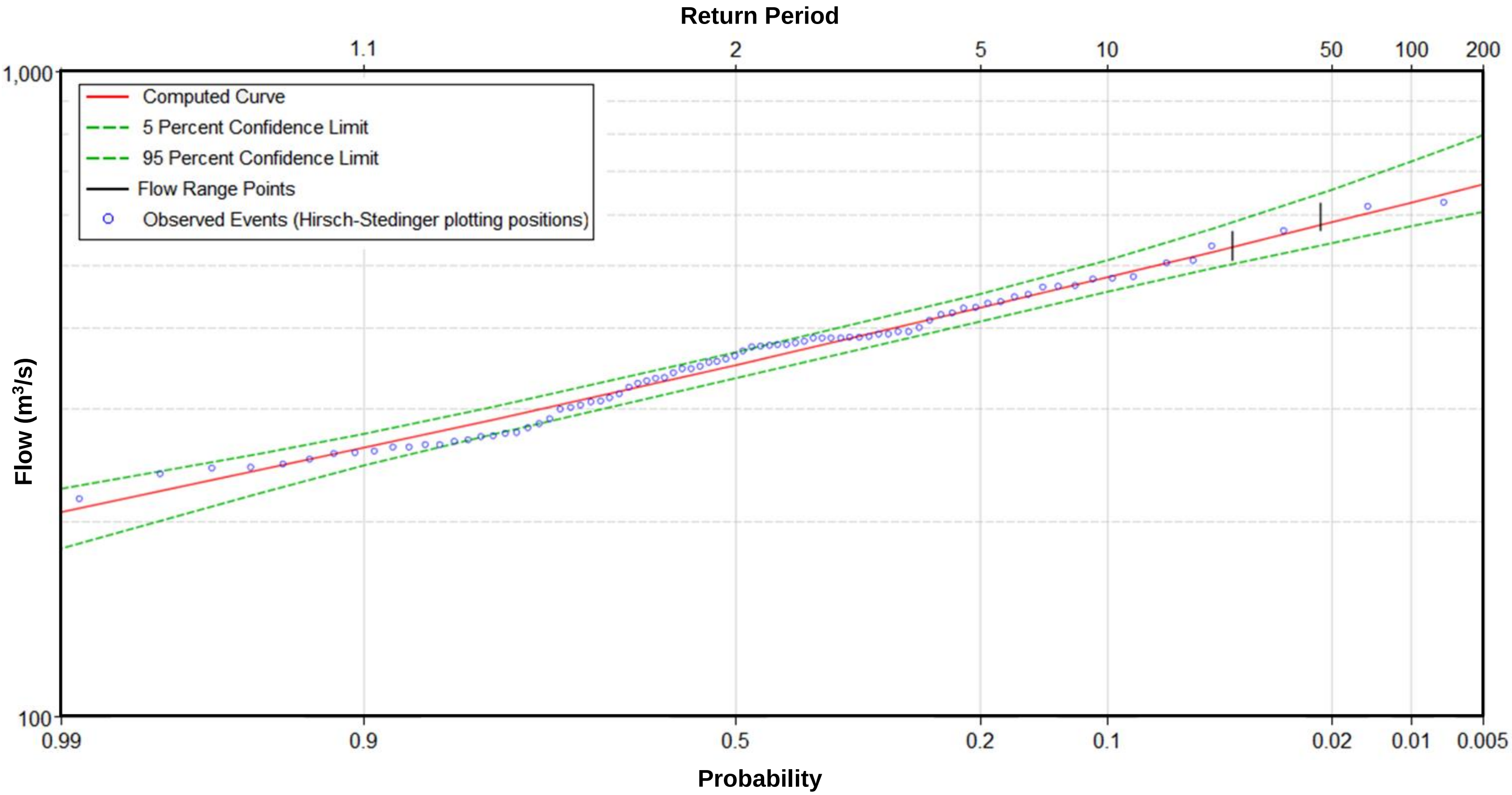
Table 2-5: Perception thresholds and peak flow intervals used in the assessment of an HSFA single-site solution with threshold analysis of historical data

	Perception Threshold		Peak Flow Interval	
Year Range	Low	High	Low	High
1912-1936	0	Infinity	Recorded Value	Recorded Value
1936-1947	500	Infinity	0	500
1948	566	Infinity	566	626
1949-1960	500	Infinity	0	500
1960-1996	0	Infinity	Recorded Value	Recorded Value
1997	508	Infinity	508	566
1998-2020	0	Infinity	Recorded Value	Recorded Value

.

Using the US Army Corps of Engineer's Hydrologic Engineering Center Statistical Software Package version 2.1.1 (HEC-SSP) (USACE, 2016a), Interior Dams completed the HSFA with and without the application of the EMA method and perception thresholds.

As a result, the EMA method improved confidence intervals and calculated expected values for the 1/200-year and 1/20-year annual daily maximum streamflows to be 668.9 m^3/s and 525.5 m^3/s, respectively (Figure 2-11). For clarity, these streamflow values are applicable for the location of the Shuswap River Near Enderby hydrometric station (08LC002), not the point of interest at Enderby, BC. Additionally, these values do not consider climate change or flow contributions from sources downstream of the station and upstream of Enderby, BC.



Note: Streamflow values shown are applicable to the location of hydrometric station 08LC002, not the point of interest at Enderby, BC. Additionally, these values do not consider climate change or flow contributions from sources downstream of the station and upstream of Enderby, BC.

Figure 2-11: Flood Frequency Plot (LP3) – Shuswap River Near Enderby Station ID 08LC002

2.5.5 Inclusion of Flow Contribution Downstream of Hydrometric Station

The area method is a commonly used technique to estimate flow at a location that has a catchment area within 10% of the gauged watershed area and is within the same or similar watershed (Hirsch, 1979). With a total watershed catchment area of 5012 km^2 (upstream of Enderby) and a total gauged area of 4720 km^2 (sub-catchment of Enderby), the ratio of ungauged to gauged area differs by approximately 6% (or 1.06). Since the catchment areas are within the same watershed and differ by less than 10%, Interior Dams applied Equation 1 to estimate the annual daily maximum streamflows at Enderby as follows:

$$Q_{Enderby} = \frac{A_{Enderby}}{A_{gauged}} Q_{gauged} \qquad \text{[Equation 1]}$$

Where:
$Q_{Enderby}$ = ungauged annual daily maximum streamflow (m^3/s),
Q_{gauged} = gauged annual daily maximum streamflow (m^3/s),
$A_{Enderby}$ = ungauged watershed catchment area (m^2), and
A_{gauged} = gauged watershed catchment area (m^2).

Per the above, the 1/200-year and 1/20-year annual daily maximum streamflows at Enderby, BC were calculated as 710.3 m^3/s and 558.0 m^3/s, respectively. For clarity, the point of interest in Enderby is downstream of the confluence of Fortune Creek at the Bawtree Bridge, and the streamflow values do not include the consideration or inclusion of climate change factors.

2.5.6 Consideration of Climate Change

According to the BC flood mapping guidelines, there is a predicted "increase in the frequency and intensity of unusual weather events, including floods and droughts [and] changes in the amount and intensity of rainfall, changes in snowpack and temperature regime, insect infestations, and forest fires" (APEGBC, 2017). The BC Southern Interior Mountains area, which encompasses the Shuswap River watershed, has already experienced significant measurable climate change over the recent century, with much of the observed change taking place within the assessed period of record. Although climate change is difficult to estimate and impossible to accurately predict, the consideration and inclusion of climate change factors merit consideration.

Per the Ministry of Environment (MoE) document "Indicators of Climate Change for British Columbia", the following changing trends[24] have been identified for BC's Southern Interior Mountains and this project's geographic area of study (refer to Appendix I for supporting information) (Province of BC, 2018) (Province of BC, 2016a):

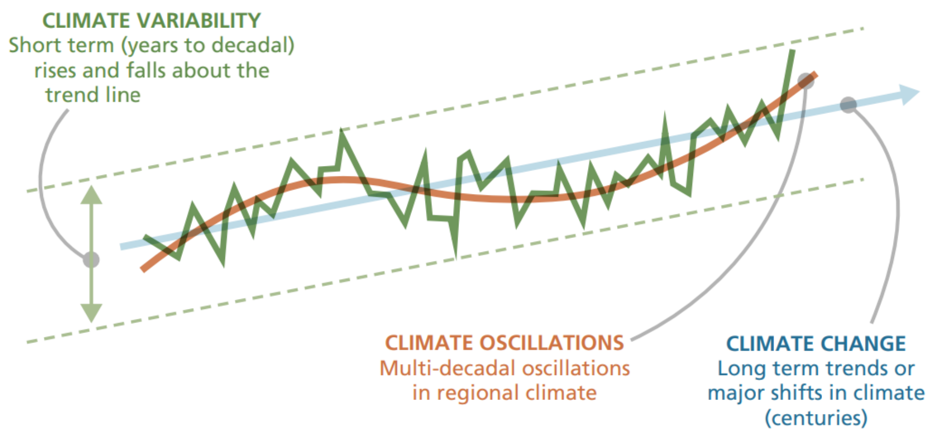
- Based on available April 1st snowpack data, there is a trend of -7% snow depth and -5% snow water equivalent per decade for the Southern Interior Mountains;

[24] Only trends associated with the project's geographic study area that are applicable to spring freshet have been listed.

- The springtime average precipitation increase for the Southern Interior Mountains is +34% per century; and
- The springtime average temperature increase for the Southern Interior Mountains is +1.0˚C per century.

For larger watersheds like the Shuswap, an earlier spring freshet is expected due to an increase in surface runoff in the winter months (EGBC, 2018). If winters continue to warm and snow-water equivalent continues to decrease, freshet flows would occur earlier, and the total freshet volume, and possibly the estimated peak flows, would reduce. Conversely, increasing cumulative springtime rainfall will increase springtime streamflows, which would have the opposite effect. Additionally, increased temperatures will increase the potential for extreme rainfall from short-duration thundershowers. Any prediction regarding the impact on the potential flood magnitude would be difficult to ascertain based on the combined impact of changing temperature, rainfall, and snowpack.

When reflecting on historical climate data, it is important to consider climate variability, climate oscillations, and climate change. Figure 2-12 provides a graphical representation of these below.



Note: Adapted from original.

Figure 2-12: Climate variability, oscillations, and change (modified from Province of BC, 2016)

As shown in Figure 2-12, climate data may have notable short-term increases in streamflow due to climate variability; yet, the effect of climate change may not trend so steeply, and in some cases, may even trend in the other direction. For an upward trend to be identified (such as is shown by the blue line in Figure 2-12), a long-running dataset must identify a statistical upward trend.

Despite identified trends in temperature, rainfall, and snowpack, the HSFA of annual maximum daily streamflow did not identify any upward or downward trend; however, that is not to say that one does not exist or will not exist. According to the BC legislated flood assessment guidelines, “if no historical trend is detectable [and] when local or regional streamflow magnitude frequency relations are used, apply a 10% upward adjustment in design discharge to account for likely future change in water input from precipitation" (EGBC, 2018). As no trend was detected in the statistical analysis, a 10% (1.1 times factor) was applied to the 1/20 and 1/200-year maximum daily streamflows to account for this uncertainty. It should be understood that 10% produces a large increase in flow and may over-estimate the 1/200-year and 1/20-year values. Nonetheless, Interior Dams believes it is appropriate in the context of practice guidelines, current climate variability, and the uncertainty of the combined future impacts of changing temperature, rainfall, and snowpack.

The resulting climate-factored 1/200-year and 1/20-year annual daily maximum streamflows at the City were determined to be 781.3 m^3/s and 613.8 m^3/s, respectively.

2.5.7 Hydrograph Development

A design hydrograph may be chosen using a synthetic hydrograph or a historic hydrograph (CDA, 2007-2016). Due to the availability of real-time and historic hydrometric data just upstream of our point of interest, Interior Dams preferred to use a historic hydrograph from a gauged "large flood."

All instantaneous gauged "large flood" hydrographs were reviewed, and all had similar shapes, durations, and characteristic rising and falling slopes. Of these, preference was given to more recent events with the largest flood volume since these produced the highest flood stage at the point of interest. As such, Interior Dams adopted the hydrograph from the flood of 2018, since it was best suited based on the aforementioned criteria.

The instantaneous 2018 flood hydrograph was scaled up to produce the 1/200-year and 1/20-year instantaneous hydrographs. Interior Dams calculated scale factors using the ratio of the annual maximum daily streamflow of the desired return period (1/200-year or 1/20-year) divided by the 2018 annual maximum daily streamflow.

For the 1/200-year instantaneous hydrograph, a scaling factor of 1.55 (781.3 m^3/s divided by 504 m^3/s) was applied to all points of the 2018 hydrograph. Since this value includes the flow contribution from Fortune Creek, the average daily freshet flow[25] (4.4 m^3/s) was subtracted from all instantaneous points in the hydrographs so that a static instantaneous flow hydrograph for Fortune Creek may be separated out for modelling purposes. The same process was completed for the 20-year event, using a scaling factor of 1.21. The 200-year and 20-year hydrographs are shown below in Figure 2-13.

[25] The daily average flow was assumed to represent a static flow hydrograph and was calculated using the daily streamflow data from the Fortune Creek at Stepney (08LC031) WSC station for the freshet period. This flow accounts for 0.06% of the 1/200-year flow magnitude.

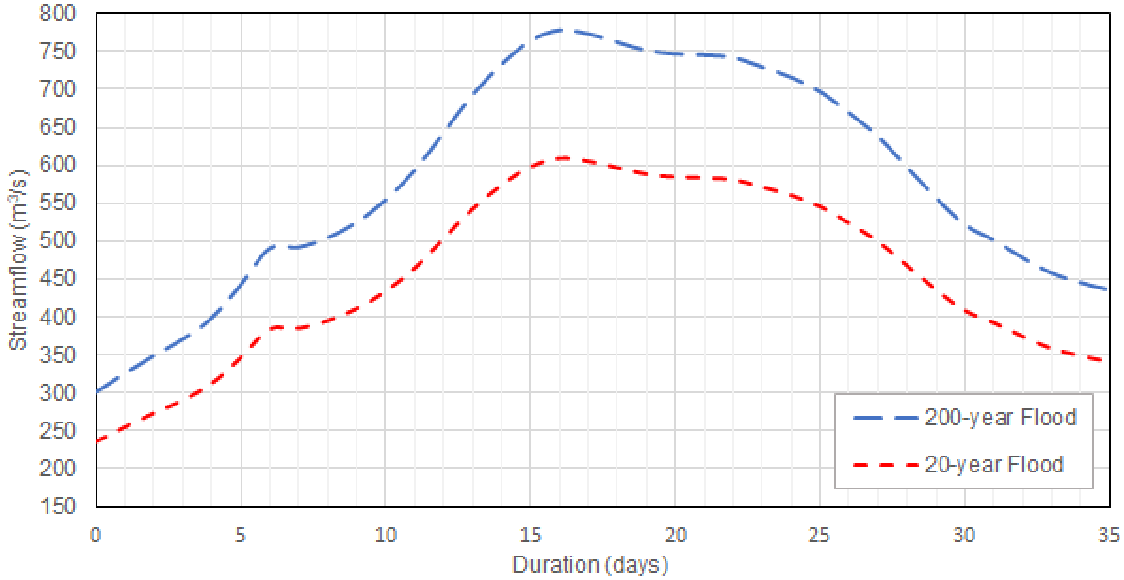


Figure 2-13: 1/200-year and 1/20-year Input Hydrographs for Shuswap River

2.6 Model Development and Construction

For flood mapping, hydraulic models typically range in complexity from steady-state one-dimensional (1D) models to dynamic (unsteady-state) two-dimensional (2D) models, or may be a combination of the two types. As the selection of the model type will vary significantly based on the available input and desired output, so too will the selection of the software package.

2.6.1 Model Type and Software Selection

For this project, an open-source based model was preferred to facilitate data sharing and future use by the City. Additionally, Interior Dams preferred a combined dynamic 1D and 2D model. The 1D components of the model characterized the channel bottom, hydraulic structures of the Shuswap River, and utilize available cross-section data outside of the collected bathymetry area, while the 2D components of the model would characterize the overbank floodplain. This approach facilitated the importation of bathymetric cross-sections that would produce a model that is more flexible for future simulation of sediment removal and accumulation. Additionally, a combined 1D and 2D model would be capable of accurately simulating overbank flooding utilizing the available LiDAR data.

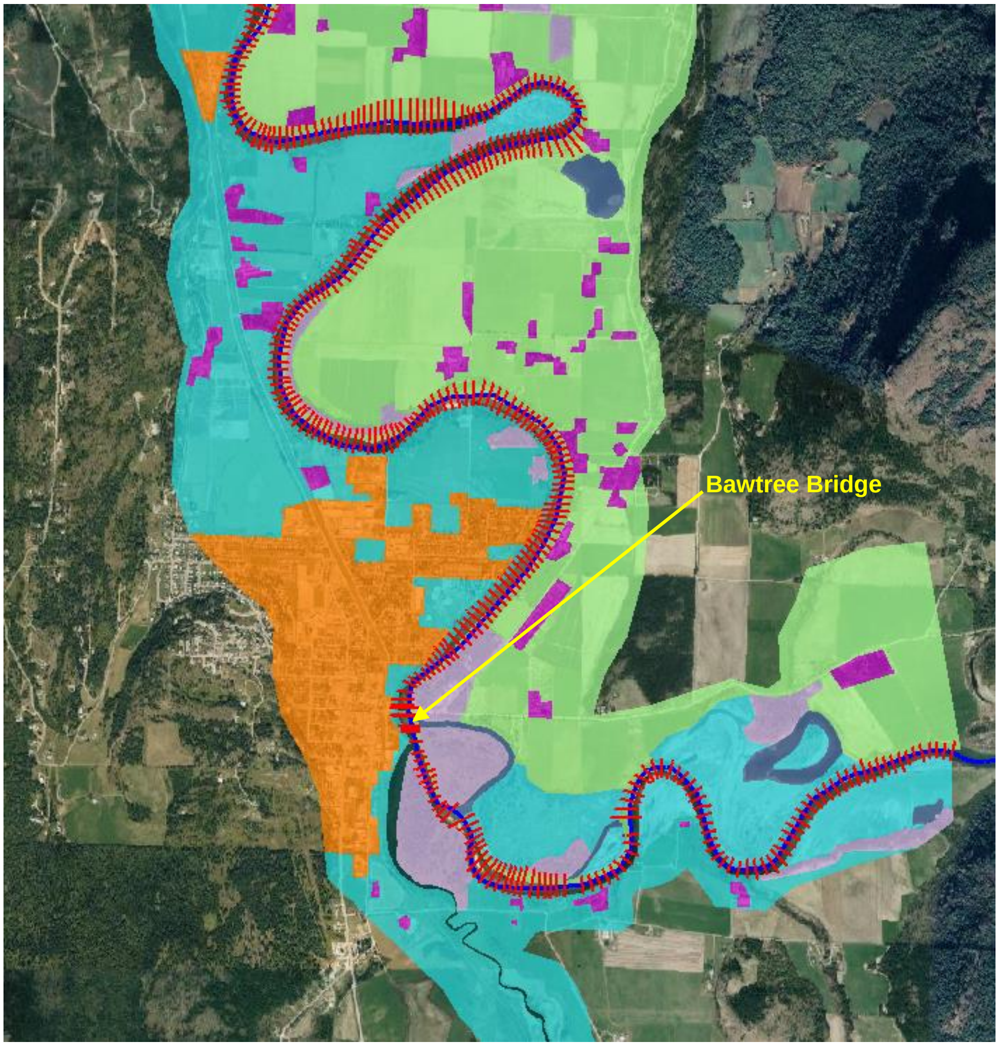
Per the software criteria above, Interior Dams selected the Hydrologic Engineering Centers River Analysis System (HEC-RAS) Version 5.0.7. HEC-RAS is a software package developed by the US Army Corps of Engineers (USACE) is intended for the modeling of rivers, harbours, and other hydraulic structures. The HEC-RAS software is widely accepted among hydraulic engineers and researchers due to its robust channel flow analysis capabilities and its ability to determine floodplain areas using 1D and 2D state modelling routines – thus making the software ideal for this exercise.

2.6.2 1D and 2D Geometry

Interior Dams constructed the model following practice guidance and reference manuals (USACE, 2016) (USACE, 2010) (USACE, 2014). Interior Dams used the surveyed bathymetry to generate 1D river cross-sections at 50-metre intervals. Since bathymetry was very similar to the 1975 cross-section surveys in the area of bathymetry (Section 2.3.2), Interior Dams extended the 1D model cross-sections to the Highway 97A / Young Street Bridge in Grindrod, BC using existing on-file sections from the 1975 survey[26]. All 1975 cross-sections were vertically adjusted to match the GVC2013 datum, which corresponds to the model and LiDAR vertical datum. Interior Dams assigned Manning friction coefficients to the bed and overbank areas in accordance with recommended values. Refer to Appendix I for recommended and assigned Manning coefficients. The assigned calibrated coefficients used are summarized in Table A1-6.3 (refer to Section 2.7.2 for calibration procedure).

Interior Dams modelled 2D floodplains using mesh geometries with grid sizes between 5 and 8 metres. The 2D mesh referenced bare earth LiDAR, and smaller grid sizes were used in critical areas with varied terrain geometry and larger grid sizes used in flatter and less critical areas such as forested and agricultural areas located downstream of the area of interest. Where small natural barriers were identified (such as walls, elevated paths, or other terrain features that may not be adequately captured by the 2D grid mesh), 2D breaklines were used to account for these flow barriers. The 2D mesh was hydraulically connected to the 1D geometry using lateral weirs, and friction factors and other input data were applied. Figure 2-14 illustrates the 1D cross-sections, 2D mesh areas, and Manning friction factors used.

[26] The new flood model references the 1975 survey data from the following on-file cross-sections: XS49 to XS43 (upstream of Enderby) and XS28 to XS19 (downstream of Enderby).

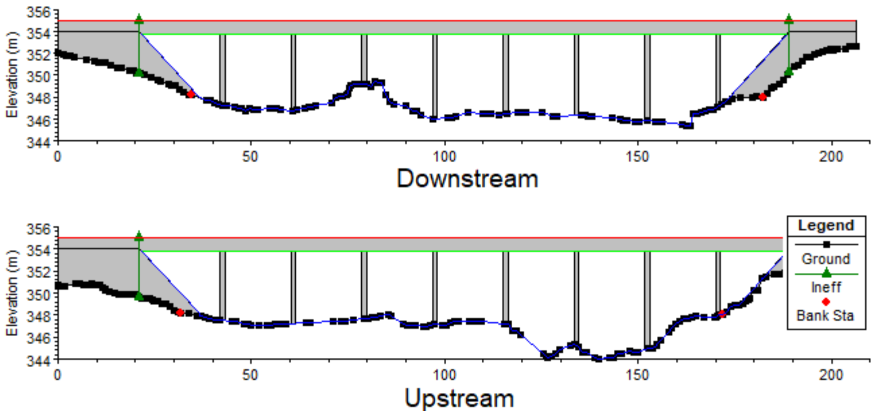


Note: 1D cross-sections are shown in red, n=0.028-0.035. 2D areas are coloured and noted below.

Open water and past side channels, n=0.035
Urban development medium density, n=0.100
Urban development high density, n=0.140
Forested floodplain, n=0.120
Open scrub floodplain, n=0.045
Fortune Creek, n=0.035
Floodplain brush, bunchgrass, agricultural left, n=0.045-0.070
Floodplain brush, bunchgrass, agricultural right, n=0.045-0.070

Figure 2-14: Flood model showing 1D and 2D inputs and Manning values

Interior Dams constructed other 1D geometry, such as channels, culverts, and bridges, per USACE guidelines, using available records and collected field data described in Section 2.2. Figure 2-15 graphically illustrates one of these features as it appears in the hydraulic model.



Note: Bank station and change in Manning n value shown with red dot, hydraulic bridge structure geometry shown in grey, ineffective areas shown with green arrow, and cross-section points generated from bathymetry shown with black dots.

Figure 2-15: Screenshot of model - 1D bridge geometry for the Bawtree Bridge

Interior Dams selected initial (prior to calibration) friction coefficients for culverts, channels, and 2D overland flow based on recommended values from the HEC-RAS user manual (Appendix I). Overland flow areas assumed late-spring to early summer vegetated density for channel banks since the risk of flooding remains elevated as late as early July when vegetation is already well established.

2.6.3 Boundary Conditions

The hydraulic model requires various boundary conditions to control the input and output of water. In general, the input is defined by the flood hydrographs (from Section 2.5.7), and output by the capacity of the downstream channel (1D) and overland flow areas (2D). Interior Dams assigned initial normal depth boundary conditions[27] to the output 1D channel cross-section and 2D overbank boundary lines.

2.6.4 Consideration of Future Floodplain and Channel Adaptation

Future adaptation to the floodplain and stream channels may include sediment deposition, channel erosion or migration, vegetation encroachment, impact from existing or future infrastructure crossings (i.e., bridge works, pipe crossings, etcetera), and the development or change of land use within the floodplain, which may include development or modification of roads, structures, or flood protection works. These adaptations, over time, have the potential to increase, decrease, or transfer the potential impact of floods.

Although the Shuswap River has demonstrated significant meandering migration in the past (Section 2.2.3.1), the river channel, alignment, and sediment load have been relatively stable over the past century. As such, Interior Dams believes the change from sediment deposition, erosion, and natural migration will be limited, as will cumulative impacts from vegetation

[27] Normal depth is the depth of flow, perpendicular to the profile, that would occur if the flow was uniform and steady, and is predicted by the Manning equation.

encroachment, infrastructure crossings, and other adaptations. For this reason, Interior Dams did not incorporate any adaptations in the model.

2.7 Model Calibration and Simulation

Due to project scheduling constraints, the collection of a river profile survey during freshet was not feasible. Based on available and collectable data, Interior Dams determined that the existing 1975 water surface elevation survey supported by available hydrometric data was the best available information for initial calibration. For the date of the water survey collection (June 13, 1975), Interior Dams confirmed that the gauged hydrograph was complete, registered a daily annual flowrate of 303 m^3/s, and river-bottom cross-section data matched the existing sections very closely; therefore, the survey will provide a good basis for calibration and sensitivity analysis.

2.7.1 Model Calibration

The model was calibrated using an iterative two-stage approach. First, the 1D channel Manning friction coefficients (n values) were incrementally adjusted within allowable recommended ranges until simulated water elevations[28] were close to the surveyed WSE profile from the 1975 flow event. Second, the boundary condition was adjusted to match the WSE downstream within a variation of up to 0.1 m. Interior Dams accepted this variation since the on-file WSE survey shots would have been collected over a period of time, and during that period, the WSEs would have varied within approximately that range (due to the flow variation in the hydrograph and the rate at which it travels through the survey area). As such, Interior Dams calibrated the model to the 1975 WSE profile and kept all adopted Manning n values within recommended ranges. Since all flow from the calibration event was contained within the main channel and overbank areas of the 1D cross-sections, no calibration of the 2D mesh was conducted. All 2D mesh friction coefficients assumed values within the recommended range.

Interior Dams audited the model calibration by simulating the gauged hydrograph from the June 2020 “large flood” and compared the calculated model WSE results to known WSEs from the manual staff gauge at Enderby. Known WSEs were established using key time-stamped photographs captured by Members of the Shuswap River Ambassadors (SRA) group on June 2 and June 5 of 2020. Since the gauged historical hydrograph is relatively flat with a slow rise and fall across several days, the WSE at Enderby was expected to have a similar rise and fall with some lag from the peak on June 3, 2020. Interior Dams confirmed that the simulated model WSEs performed as expected and closely matched the known WSEs from the SRA photograph; therefore, the calibration of the model was accepted for the simulation of the developed 1/200-year and 1/20-year hydrographs.

[28] Initial calibration was completed using 1D steady-state simulations of the daily maximum flowrate.

Note: Left - June 2, 2020 12:31, Right - June 5, 2020 10:41.

Figure 2-16: Enderby staff gauge (SRA, 2020)

2.8 Flood Mapping Output

In accordance with the scope of work and requested deliverables, the report includes both inundation and hazard maps for the 1/200-year and 1/20-year floods. Interior Dams prepared all output files and plots using the open-source Quantum Geographic Information System Software Version 3.10.9 (QGIS), and all horizontal and vertical control datums assume the North American Datum of 1983 (NAD83) and the Canadian Geodetic Vertical Datum of 2013 (CGVD2013), respectively. Per BC mapping guidelines, all maps use the Universal Transverse Mercator (UTM) projection for topographic mapping, and coordinate grids are expressed in metres as northings and eastings (APEGBC, 2017).

2.8.1 Inundation Maps

Inundation maps are maps that show the extent of a particular flood. Interior Dams prepared inundation maps to show the maximum water depth and maximum water surface elevation for the 1/200-year and 1/20-year design floods. The following list provides a summary of the inundation plots prepared and included in Appendix II:

- Maximum Water Elevation – 200 Year Inundation Mapping
  - Map No. W_{200} – Shuswap River at Enderby (Scale 1:5000)

- Maximum Water Elevation – 20 Year Inundation Mapping
  - Map No. W_{20} – Shuswap River at Enderby (Scale 1:5000)

- Maximum Water Depth – 200 Year Flood Inundation Area
  - Map No. D_{200} – Shuswap River at Enderby (Scale 1:5000)

- Maximum Water Depth – 20 Year Flood Inundation Area
  - Map No. D_{20} – Shuswap River at Enderby (Scale 1:5000)

Digital copies of the plots have been included on DVD and included with the hard-copy report.

2.8.2 Hazard Maps

Hazard maps go beyond inundation maps. These maps provide information on the hazard associated with a flood event and are intended to convey an understanding of the potential flood severity based on depth and velocity since these two parameters drive the potential of that floodwater to inflict a negative impact. This potential to inflict negative impact is defined by the hazard rating (HR) and is a numerical value defined by the following equation:

$$HR = d \times (v + 0.5) + DF \qquad \text{[Equation 2]}$$

Where:
HR = flood hazard rating,
d = depth of flooding (m),
v = velocity of flood waters (m/s), and
DF = debris factor (0 in this case)

For this project, Interior Dams prepared hazard maps that visually illustrate the severity of the flood by mapping the HR referred to as the maximum water hazard. Interior Dams prepared maximum water hazard maps and provided them in Appendix II as follows:

- Maximum Water Hazard – 200 Year Hazard Mapping
  - Map No. H_{200} – Shuswap River at Enderby (Scale 1:5000)
- Maximum Water Hazard – 20 Year Hazard Mapping
  - Map No. H_{20} – Shuswap River at Enderby (Scale 1:5000)

Digital copies of the plots have been included on DVD and included with the hard-copy report.

2.8.3 GIS Mapping Files

The following GIS data was digitally prepared and exported as follows:

- Maximum Water Depth Files
  - Filename: Enderby - 200YearD – Geotiff Raster Format (NAD83 UTM 11N)
  - Filename: Enderby - 20YearD – Geotiff Raster Format (NAD83 UTM 11N)
- Maximum Water Surface Elevation Files
  - Filename: Enderby - 200YearW – Geotiff Raster Format (NAD83 UTM 11N)
  - Filename: Enderby - 20YearW – Geotiff Raster Format (NAD83 UTM 11N)
- Maximum Water Hazard Files
  - Filename: Enderby - 200YearH – Geotiff Raster Format (NAD83 UTM 11N)
  - Filename: Enderby - 20YearH – Geotiff Raster Format (NAD83 UTM 11N)

Interior Dams included all GIS mapping files on DVD with the hard-copy report.

3 FLOOD RISK ASSESSMENT

According to the Engineers and Geoscientists of British Columbia's flood assessment professional practice guidelines, the *risk* is defined as "a measure of the probability and severity of an adverse effect to health, property, or the environment [and] is often estimated by the product of probability and consequence" (EGBC, 2018).

In alignment with this project's purpose and scope, Interior Dams conducted a risk assessment using the 1/200-year flood hazard and the estimated monetary consequence of that event. The risk assessment is in alignment with the National Disaster Mitigation Program (NDMP) guidelines and other industry best practices and contains the following components (Government of Canada, 2018) (EGBC, 2018):

1) identification of the potential hazard (*risk identification*);
2) determination of the probability of the flood occurring (*risk analysis*);
3) estimation of potential flood impact from the flood hazard (*risk evaluation*);
4) determination of the flood risk (*risk evaluation*); and
5) review of the community's vulnerabilities (*risk evaluation*).

The 1/200-year inundation and hazard maps (from Section 2) provide the *risk identification* and *risk analysis* information required for assessment since 1) the potential hazard is defined by the depth and hazard maps, and 2) the annual probability of the flood occurring is 0.5% (for the 1/200-year flood hazard). This section contains the *risk evaluation* portion of the assessment (components 3, 4, and 5 listed above). The following sub-sections provide high-level evaluations of potential flood impact for various loss categories. These loss categories support the risk assessment for the following *risk evaluation* categories:

- Impact on Environment and Cultural Values;
- Impact on People and Society;
- Impact on Local Economy; and
- Impact on Local Infrastructure.

The information contained in this section is intended to facilitate the implementation and development of a City IFMP. Content in this section is limited to the City of Enderby boundary[29] and is to be used for City flood mitigation planning and decision making only. This information is based on high-level impact estimates from the conventional flood hazard from the Shuswap River; therefore, general information and discussion regarding existing infrastructure components are not to be considered a design review of those components. This assessment is intended to provide a general understanding of potential risk only. If a more detailed assessment is required to assess the resilience of a particular system or infrastructure

[29] Direct loss estimation is geographically limited to the boundary of the City of Enderby; however, indirect loss estimation includes societal losses which impacts a larger population than those living within this boundary.

component, the City should conduct a design review of that component and may use the estimated flood hazards provided in Section 2 to support that review.

3.1 Impact to Environment

A priority for municipal, provincial, and federal governments is to protect Canada's natural environment for current and future generations (Government of Canada, 2018). Although the City cannot be held responsible for protecting the environment from natural conventional flooding[30], developed areas within the City's jurisdiction are expected to negatively impact the environment when subjected to flood conditions. As identified above, the release of pollutants due to overland flooding, erosion, and failure of urban systems is expected.

Reduced water quality can affect fish habitat, vegetation, and wildlife. The potential presence of the North American Racer (blue-listed[31]), Round-leaved Hawthorne (blue-listed), Okanagan Hawthorne (red-listed[32]), Painted Turtle (blue-listed), and Chiselmouth (yellow-listed-S4[33]) was identified by the BC Conservation Data Centre (BC CDC) mapping system (Figure 3-1). Bull Trout (blue-listed), Coho Salmon (yellow-listed-S4), and Chinook Salmon (yellow-listed-S4) have also been reported to have a potential inhabitancy within the flood zone (Ecoscape, 2011).

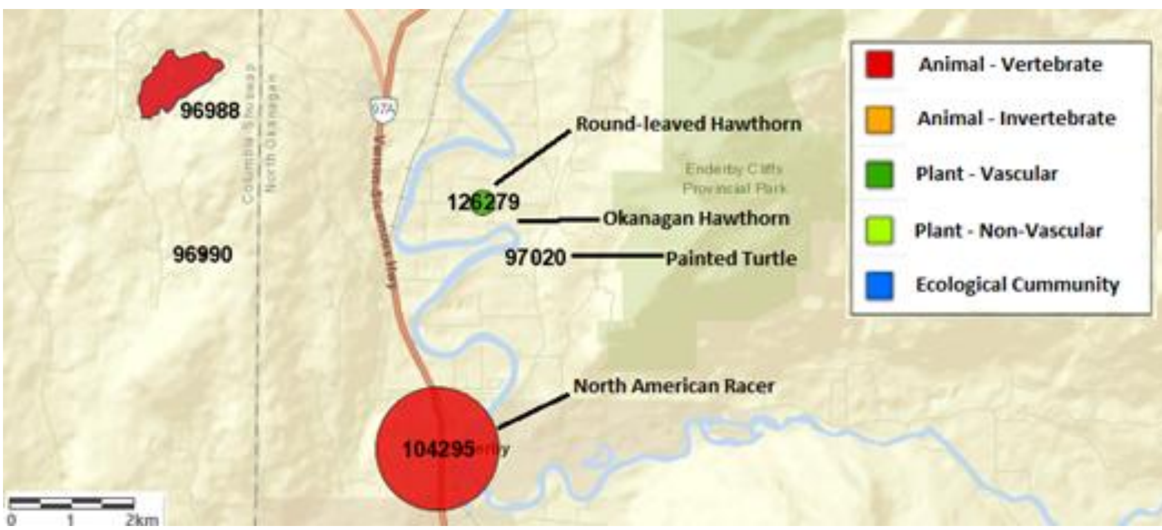


Figure 3-1: BC CDC map of red- and blue-listed species and ecosystems (BC CDC, 2020)

According to the BC guidelines for assessing environmental flood consequences for dam breaches, if red- or blue-listed species are impacted, the consequence is considered *high*[34] (FLNRORD, 2016). The Dam Safety Regulation defines a high environmental consequence as a "significant loss or deterioration of important fisheries habitat or important wildlife habitat, rare

[30] Flooding often plays an integral role in ensuring biological productivity and diversity in the floodplain.
[31] *Blue-listed* is any species or ecosystem that is of special concern.
[32] *Red-listed* species or ecosystems are at risk of being lost (extirpated, endangered, or threatened).
[33] *Yellow-listed* species include species not on the red or blue list. Species ranked S4, like the Chiselmouth, are considered to be of conservation concern and on a watchlist.
[34] *High* is a rating defined by the Dam Safety Regulation which describes consequences that are used for the classification of dams in BC.

or endangered species, or unique landscapes" where "restoration or compensation in kind is highly possible" (BC, 2016). Although a monetary value is not attributed to the environmental losses described above, significant pollution of water quality and potential impact to species at risk is possible; however, there are no expectations of permanent environmental loss.

3.2 Impact to Cultural Values

A review of the impact on sites of cultural significance is an important component of a consequence assessment (FLNRORD, 2016). The study area is located at the confluence of waterways, is an area abundant with natural resources, and comprises lands that are part of the traditional territory of the Splatsin[35]. As such, it is an area with archaeological potential. Interior Dams is not aware of the existence of any archaeological sites within the study area[36]; however, the likelihood of negative flood impact to such sites is low.

In contrast to archaeological sites, more recently constructed landmarks of cultural significance may be impacted. Since the settlement and construction of the City date back to the mid-1800s, several constructed historic sites and heritage buildings remain from the early 1900s (City of Enderby, 2012). Interior Dams identified three sites that have heritage value[37] and compared the location of these sites to the mapped flood hazard. Table 3-1 summarizes the overlap and includes a list of properties at risk. Figure 3-2 shows historical photographs of heritage sites at risk.

Left to right: 908 Maud Street, 513 Mill Avenue and 1004 Belvedere.

Figure 3-2: Photographs of impacted heritage sites (City of Enderby, 2012)

[33] Interior Dams understands that the First Nations with traditional territory or indigenous heritage within the study area may include, but may not be limited to, the Splatsin, Neskonlith, Lower Similkameen, Upper Nicola, SnPink'tn (Penticton), Adams Lake, and the Little Shuswap Lake Band.
[36] Absence of archaeological or valuable cultural sites was not confirmed due to access limitations to the Remote Access to Archaeological Data (RAAD) mapping program (FLNRORD, 2020c).
[37] These existing properties are referenced in the City of Enderby Heritage Walking Brochure. While not necessarily registered in the Community Heritage Register, these properties hold an architectural or historical significance to members of the community.

Table 3-1: Heritage sites at risk of flooding

EXPECTED FLOOD IMPACT
908 Maud Street
513 Mill Avenue
1004 Belvedere Street

Other sites of cultural value that may be impacted include community assets or recreation areas such as Tuey Park or the Jim Watt Heritage River Walk. Fortunately, other identified high-value cultural sites, including the Okanagan Regional Library, Enderby Museum, City Hall, and the Enderby Arena, will not be directly impacted. Despite this, power outages and possible flooding due to drainage backups or other indirect impacts may be possible.

3.3 Impact to People and Society

According to NDMP, impact to people and society should be included in the risk assessment (Government of Canada, 2018). Per NRC guidelines for estimating flood vulnerabilities, the scope of the impacts to people and society was limited to the individuals of the community of Enderby, or those directly impacted by the flood hazard in Enderby. As such, this section provides hypothetical direct loss estimates to individuals for the following categories:

- loss of wages;
- loss of life;
- loss to residential property (automobiles, residential structural and content); and
- loss due to displacement.

3.3.1 Loss of Wages

NDMP guidelines suggest losses to people and society should include a loss of wages (LoW) estimate. Interior Dams compared the flood hazard to the location of all business structures in the City by overlaying the flood hazard GIS files on a spatial point file database (SPFD)[38] of all known structures in the City. Where the flood hazard overlapped the location of businesses, flood depth data was populated to the SPFD, resulting in a populated database of flood-impacted businesses with linked attributes for business type, total structure area, flood depth, etcetera. Interior Dams then used this database to assess the impact of flooding to the business.

According to Federal Emergency Management Agency (FEMA), flood restoration time may be estimated by building type using a simple linear relationship between flood depth and the number of days displaced. Applying the recommended 45 days per 0.30 m of floodwater depth, Interior Dams estimated the duration of business closure in weeks. Supported by a limited telephone survey, anecdotal information and other various sources, the approximate number of employees at each business was based on the building area and business type. Interior Dams assumed an average weekly employment income (on par with the average annual

[38] This database was manually created using recent satellite imagery supplemented by field investigation and Google Street View data.

compensation for all Canadians) since the sample population of businesses represented a non-biased sample selection of employment types. As such, the calculation for LoW assumed an average weekly compensation of $919.67[39] for all employees. Table 3-2 summarizes the results of this calculation.

Based on Table 3-2, Interior Dams calculated a total LoW for all displaced employees to be $668,204 for the 1/200-year flood.

Table 3-2: Estimated loss of wages (LoW) – Businesses and their employees by industry

Structure Use Type[1]	Area	Flood Impact	E[2]	W[3]	EW[4]	LoW[5]
High School	Bass Ave	Bldg, parking lot	30	13.1	391.899	360,417
Retailer	Belvedere St	Bldg, parking lot	3	2.1	6.40736	5,893
Automotive Garage	Brickyard Rd	Bldg, parking lot	3	15.6	46.7351	42,981
Car Wash Facility	George St	Bldg, parking lot	7	7.3	50.904	46,815
Gas Station*	George St	Bldg, parking lot	2	9.0	18.066	16,615
Automotive Garage	Highway 97A	Bldg, parking lot	3	3.3	9.76436	8,980
Retailer	Highway 97A	Bldg, parking lot	11	4.8	52.3545	48,149
Campground	Kildonan Ave	Bldg, parking lot	2	2.1	4.10271	3,773
Upholstery Repair	Maud St	Bldg, parking lot	3	4.8	14.4431	13,283
Public Works Facility	McGowan St	Parking lot	2	4.6	9.25714	8,514
Dentist*	Mill Ave	Bldg, parking lot	4	20.9	83.5431	76,832
Massage Therapist	Mill Ave	Bldg, parking lot	2	19.5	39.093	35,953
					TOTAL	**$668,204**

NOTE1 Structure use type changes over time; however, current structure use types are representative of future use types. Structures marked with an asterisks (*) are considered vital to sustaining a community according to NDMP guidelines: communications technology, finance, healthcare, food, water, transportation, safety, government and manufacturing (Government of Canada, 2018).
NOTE2 The number of working employees represents the number of full 8-hour working days of labour that are required for a typical business day. These numbers are approximate estimates based on building area and industry type.
NOTE3 Weeks represent the approximate time the place of business is disrupted based on the severity of flooding (depth) at that particular business.
NOTE4 EW is the product of the number of working employees to the number of weeks displaced.
NOTE5 LoW is calculated in 2020 dollars.

3.3.2 Loss of Life

Interior Dams used the Reclamation Consequence Estimating Methodology (RCEM) published by the United States Bureau of Reclamation (USBR) to estimate loss of life (LoL). Per the RCEM graphical approach, the selected fatality rates (FR) assumed the upper limit of the suggested range for cases with an adequate flood warning[40]. Figure 3-3 illustrates the selected FR curve used. As this method is most often applied to dam breaches and floods with quickly rising floodwaters, this selection may be conservative.

[39] The average annual income per Statistics Canada data is $47,822 (2017). This value is adjusted for inflation to 2020, and is assumed to represent the average of all employees.
[40] *Adequate warning* is an undefined amount of time that would allow most of the population at risk (PAR) to understand the threat posed by a flood and take reasonable actions to escape the flood (USBR, 2015).

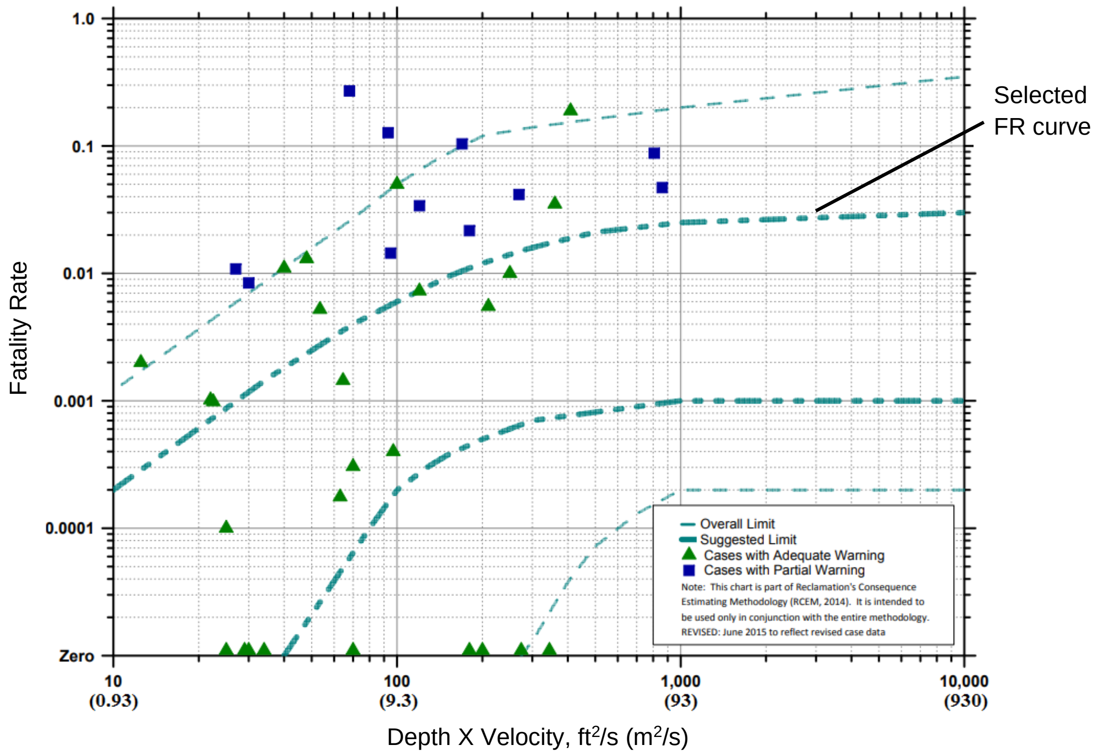


Figure 3-3: Loss of life fatality rates for no warning (USBR, 2015)

The analysis compared the delineated flood hazard and the location of all structures in the City. Using the flood hazard GIS output files described in Section 3.3.1, the SPFD of structures (used in the LoW estimate) was compared to the flood hazard using QGIS. Where overlap existed, QGIS assigned flood hazard attributes for water depth (D) and velocity (V) at the particular location to each structure node. Interior Dams then used this information to calculate the LoL estimate for the population that would be located at or within that structure.

Based on the BC dam break inundation guidelines, all residential structure types should assume a population at risk (PAR) of three (3) people per residence. For businesses, the number of employees from the LoW estimate was used, and where appropriate, the number of customers was added. For all businesses that have customers, Interior Dams assumed a ratio of one-to-one (1:1) for customers to employees. Applying the RCEM equation to the population at risk (PAR), product of depth and velocity (DV), and using the selected fatality rate (FR), Interior Dams calculated the LoL value, where LoL represents the number of lives that will be lost. A summary of these equations is provided in Table AIV-1 entitled “Loss of life (LoL) estimation” in Appendix IV.

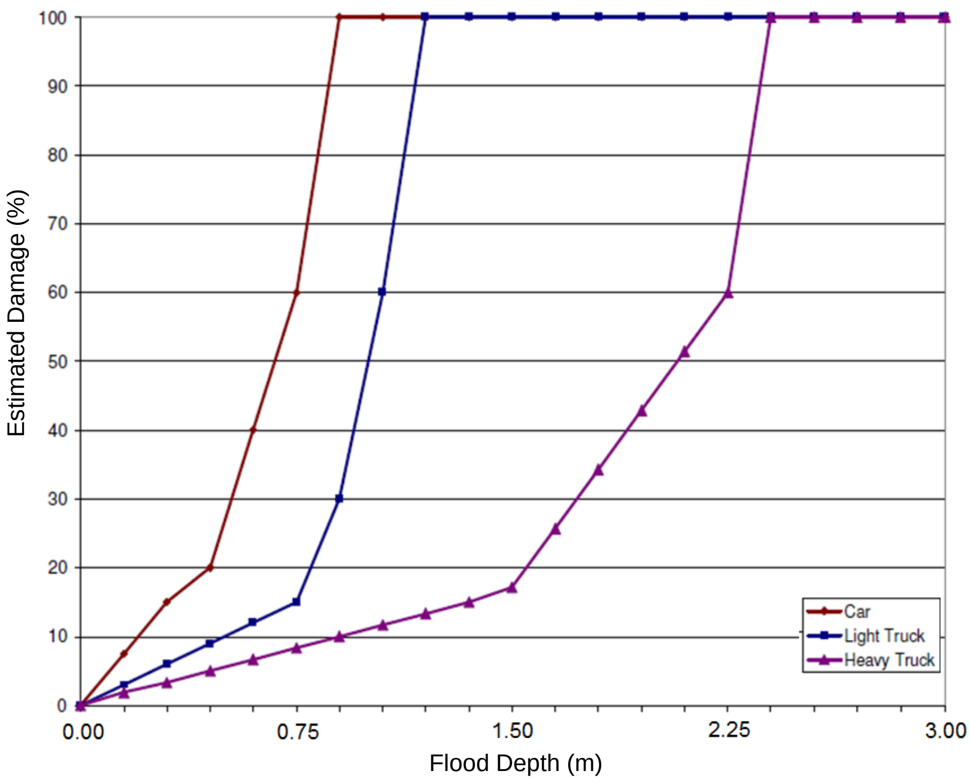
Based on the above, the LoL estimate is 0 for the 1/200-year flood hazard. Although the flood hazard is not expected to result in loss of life, a risk to human safety does exist for the 1/200-year flood.

3.3.3 Loss to Property

The following sub-categories provide estimates for loss to automobiles and residential structural and content damage.

3.3.3.1 Loss to Automobiles

According to NRC guidelines, loss to automobiles can be estimated based on the depth of flooding. Figure 3-4 illustrates some typical loss functions illustrating the potential damage expected to various vehicle types.



Note: Adapted to metric units.

Figure 3-4: Vehicle depth vs. damage curves (NRC, 2017)

If the location of a vehicle is known relative to the flood hazard, the flood depth can be estimated and the loss calculated. Using the spatial SPFD of all structures (refer to Section 3.3.1), Interior Dams assumed that there are 1.43 vehicles per residence[41] and applied this value to all nodes representing residential residences. Spatial distribution of vehicles within the floodplain is based upon previous flood events, rather than the number of observed vehicles (FEMA, 2001). Assuming that automobile loss is proportional to the depth of flooding per Table 3-3, Interior Dams spatially attributed a percentage loss value to each node using the GIS mapping output files and QGIS.

[41] The average number of vehicles owned per residence is based on 2018 StatCan data.

Table 3-3: Adopted loss function for automobile loss estimation

Flood Level (m)	Description	% of Damage
0 – 0.149	Below carpet	0 %
0.150 – 0.456	Between carpet & dashboard	15 %
0.457 – 0.732	At dashboard	60 %
> 0.732	Above dashboard	100 %

Per FEMA guidelines, automobiles not located at residences should also be accounted for. Therefore, Interior Dams assumed a density of 2 automobiles per 1000 ft^2 (93 m^2) for all non-residential parking areas per FEMA guidance and spatially attributed a percentage loss value to these vehicles in the same manner as vehicles parked at residential locations.

The weighted average value of all automobiles was calculated to be $20,361.79 based on the average age and type of all vehicles owned in Canada (Statistics Canada, 2020). Interior Dams used the SPFD database to calculate the product of the value of all impacted automobiles by their appropriate percentage loss estimates (based on the depth of flooding). A summary of these calculations is provided in Table AIV-10.

Based on the results of the above, Interior Dams calculated the total loss to all automobiles to be $5,790,454 for the 1/200-year flood.

3.3.3.2 Impact on Residential Property

Interior Dams estimated residential structures and content loss from flood impact using available NRC damage functions. An example damage function used in this analysis is illustrated in Figure 3-5. For all other damage functions used, refer to Appendix IV.

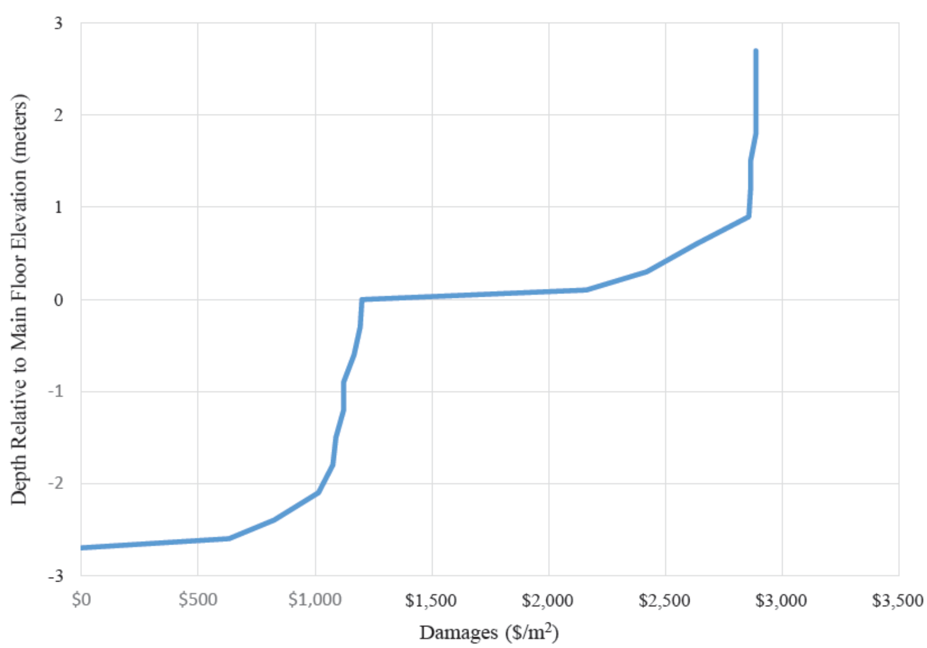


Figure 3-5: Residential one-storey Class A – damage function

Since both structural and content damage vary significantly depending on the class of the structure, type of structure, and whether or not the structure has a basement, population of this data to the SPFD was required.

Per BC Assessment, Interior Dams collected residential structure data, including structure type, finished area, number of stories, presence of a basement, and other information required to determine structure class (BC Assessment, 2021). Using this information and property parcel and geometry data from the Ministry of Citizens' Services, Interior Dams populated parcel geometry attributes and spatially joined the information to the SPFD using QGIS (Ministry of Citizens' Services, 2020).

Interior Dams exported the structure-specific information for each SPFD node to Microsoft Excel and conducted calculations using the damage functions for residential one- and two-storey homes (Class A, B, and C), one-storey mobile homes, and apartment buildings. A summary of the loss calculation results for residential structural and content and residential property cleanup damages is provided in Appendix IV, Tables AIV-11 and AIV-12, respectively.

Based on the above, Interior Dams estimated the total loss to residential structural, content, and property clean-up damages to be $35,749,780 for the 1/200-year flood.

3.3.4 Loss due to Displacement

The FEMA Multi-hazard Loss Estimation Methodology document guides the estimation of flood restoration time by building type. For this analysis, Interior Dams assumed the restoration time to be equal and representative of displacement time.

For typical structures located in the study area, depths up to 1.2 m of floodwater can indicate a large range of restoration times. In some cases, restoration can take between seven and 13 months. In comparison, for flood depths higher than 1.2 m, it is reasonable to assume that the length of disruption time would be reduced since re-construction (a 100% loss) can often be achieved in less than 2 years (FEMA, 2001).

By applying a linear function fitted to the above information, Interior Dams calculated the time that inhabitants would be displaced from all structures by the depth of floodwater at that structure. It was assumed that for every 0.30 m of floodwater, there would be 45 days of displacement to a maximum displacement time of 24 months. Using QGIS, Interior Dams calculated and assigned a displacement time to all residential structure nodes in the SPFD using this linear relationship and the spatial flood depth output from Section 2.8.

According to the Canadian Floodplain Mapping Guidelines, the loss due to displacement is estimated based on the displacement time and typical behaviour of displaced individuals. Assuming three people per household (as per LoL estimate), loss calculations relied on the following typical behaviours:

- Displaced households will spend up to 14 days in a hotel ($150/day per household for the first 14 days);
- In the first 14 days, each individual spends an extra amount per day on personal goods or meals that they otherwise would not have purchased (an additional $100/day per household for the first 14 days);
- People requiring alternate accommodation beyond 14 days will rent ($30.87/day[42] per household for each day in excess of 14 days); and
- Many displaced households will find accommodation with friends or family resulting in a negligible displacement cost for those households (40% assumed to be accommodated, and therefore, a 0.6 factor to the losses was assumed) (NRC, 2017).

Applying the assumptions above, Interior Dams calculated the total loss due to displacement. A summary of these calculations is provided in Appendix IV, Table AIV-13.

Based on the above, Interior Dams calculated the total loss due to displacement to be $924,605 for the 1/200-year flood.

3.4 Impact to Local Economy

According to NDMP guidelines, risk assessment should consider the impact to the local economy and estimation of “losses to local economically productive assets, as well as, disruptions to the normal functioning of the community/region's local economic system” (Government of Canada, 2018).

The following statement from NRC’s Canadian Guidelines and Database of Flood Vulnerability Functions document provides an important perspective on the estimation of impacts to the local economy:

> *“Due to limited budgets, time, and a lack of reliable data, no flood damage estimate can ever be considered complete. Damage estimates are generally utilized to inform decisions that reduce risks, not to reach a conclusion on the economic impact of flooding. As such, the assessment of damages takes a financial impact approach, rather than an economy-wide perspective. Financial impact refers to the sum of losses experienced by individuals or organisations as a result of a flood. The assumed scale of a damage study is the flood-affected area and the goal is to reduce the damages upon impacted properties and individuals”* (NRC, 2017).

Per the above, Interior Dams limited the scale of loss estimation to the loss of rental income (LoRI), the loss of business profit (LoBP), and the impacts to non-residential property (structural and content damage) since these losses are assumed to be the most significant direct economic impacts to individuals and organizations within the City community.

[42] $30.87 is the daily rental cost of a typical rental unit assuming a 30-day month. See Section 3.5.1 for average rental costs per month.

3.4.1 Loss of Rental Income to Landlords

The Tenancy Act in BC requires that landlords maintain their rental properties in a state that is suitable for occupancy (Province of BC, 2018). When a renter's home is no longer habitable and neither the landlord nor tenant is responsible, the tenancy is deemed to be frustrated and neither party has to give notice to end the tenancy, exposing landlords to loss of rental income.

Within the City of Enderby, the 2016 homeownership rate was 75% (City of Enderby, 2020). Assuming 25% of structures in the Enderby flood area are renting and paying an average monthly rate of $725 per month[43], the total potential loss of rental income can be calculated (City of Enderby, 2020). Using the duration of displacement from Section 3.3.4 for all residential structures and the average monthly rental rate, Interior Dams calculated the LoRI. A summary of these calculations is provided in Appendix IV, Table AIV-14.

Based on the above, Interior Dams calculated the total LoRI to landlords to be $182,954 for the 1/200-year flood.

3.4.2 Loss of Profits to Local Businesses

Interior Dams selected LoBP to represent impacts to business activity and lost opportunity costs since other indicators, such as total revenue, do not account for the reduced overhead of inactive businesses (such as frustrated rent/leaseholds, reduced payroll obligations and limited operating expenditures).

Due to the time-sensitive nature and limited scope of this project, an in-depth survey of businesses to support LoBP in Enderby was not feasible. As such, Interior Dams adopted a simple approach to approximating LoBP based on the total LoW estimate from Section 3.4.1.

Primarily, it was assumed that all businesses in Enderby of a particular industry category will have the same ratio of net profit to total employee and labour compensation (NP/C) as the average of all Canadian businesses in the same industry category. Using 2016 StatCan data, Interior Dams calculated the net profit to compensation ratio (NP/C) for each industry category. Table 3-4 summarizes these calculations.

[43] The City of Enderby average rental rate per the 2020 Enderby Housing Needs Assessment Report.

Table 3-4: Ratio of net profit to employee and labour compensation (Statistics Canada, 2016)

Industry Category	TR ($)	C ($)	NP ($)	NP/C ($)
Construction (23)	427.3	108.8	11.5	0.106
Food Services (722)	642.6	193.0	24.4	0.126
Grocery Stores (4451)	782.0	80.7	22.6	0.280
Hotels and Motels (72111)	764.3	210.6	52.0	0.247
Professional & Technical Services (54)	259.3	79.5	77.6	0.976
Retail Trade (44-45)	667.0	99.1	36.7	0.370
Offices of Physicians (6211)	411.1	89.7	235.3	2.623
Offices of Other Health Practitioners (6213)	211.6	47.7	84.4	1.769
Offices of Dentists (6212)	647.0	200.6	213.0	0.941
Slaughtering and Processing (31161)	962.1	205.6	46.0	0.224
Transportation and Warehousing (48-49)	272.6	58.9	38.1	0.647
Nursing & Residential Care (623)	757.7	378.8	39.5	0.104
Calculated Average for All Categories				0.701
All values represent national averages and in thousands of dollars for that category. All data used had quality indicators of *Very Good* or *Excellent* based on StatCan financial performance data statistics. TR – whole industry average total revenue. C – average total wages, including benefits and commission expenses. NP – average total net profit. NP/C – ratio of net profit to compensation				

Assuming LoW from Section 3.3.1 is equal to C, the LoBP was calculated by multiplying LoW by NP/C. Table 3-5 summarizes the results of this calculation.

Table 3-5: Loss of business profit (LoBP) estimation

Business Type	LoW	NP/C	LoBP
Liquor Store	5,893	0.28	1,650
Automotive Garage	42981.2	0.976	41,949
Car Wash Facility**	46814.9	0.701	32,817
Gas Station	16614.8	0.647	10,750
Automotive Garage	8979.99	0.976	8,764
Construction Merchandiser	48148.9	0.106	5,104
Campground	3773.14	0.247	932
Upholstery Repair**	13282.9	0.701	9,311
Dentist*	76832.1	0.941	72,299
Massage Therapist*	35952.7	1.769	63,600
		TOTAL	**$247,177**
*These sectors are considered critical according to NDMP guidelines: communications technology, finance, healthcare, food, water, transportation, safety, government and manufacturing (Government of Canada, 2018). **The average NP/NC for all categories was used. NOTE1 Values are calculated in 2020 dollars.			

Based on the above, the total LoBP was estimated to be $247,177 for the 1/200-year flood.

3.4.3 Impact to Non-Residential Properties

Interior Dams accounted for economic losses related to non-residential structural and content damage using available NRC damage functions. Damage functions used in this analysis for structural and content damage for all industry categories are illustrated in Figure 3-6 and Figure 3-7.

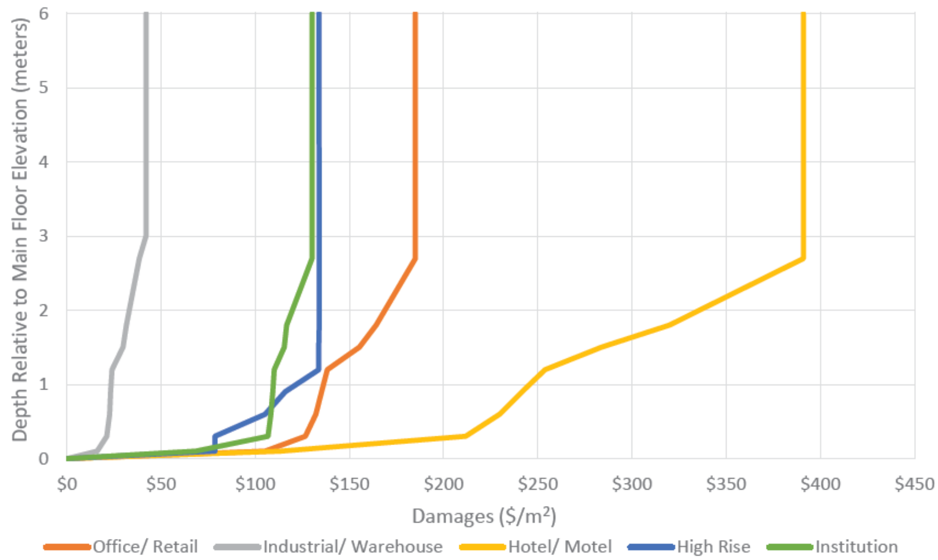


Figure 3-6: Non-residential structural damage function

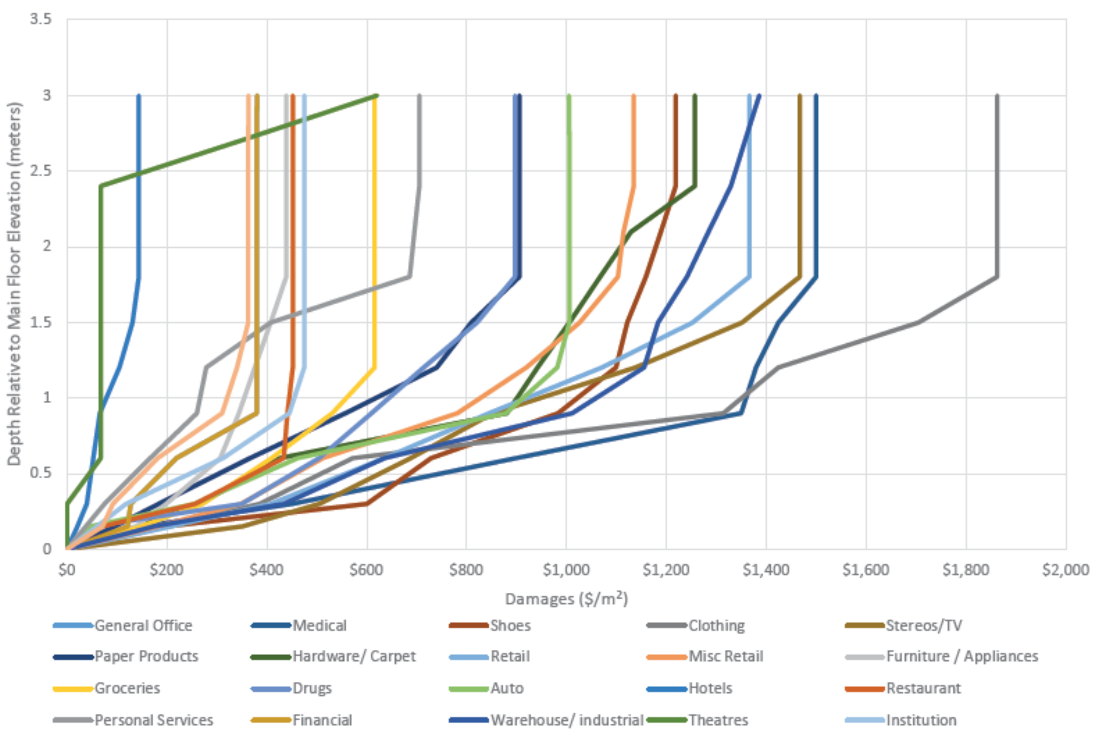


Figure 3-7: Non-residential content damage function

Since both structural and content damage varies significantly depending on the industry category of the structure and the depth of floodwaters, Interior Dams used the SPFD to assign the loss value per square metre for each structure node in the same manner as with residential loss calculations conducted in Section 3.3.3. A summary of the calculations is provided in Appendix IV, Table AIV-15.

Based on the above, Interior Dams estimated the total impact to non-residential property, including structural and content damage, to be $5,196,139 for the 1/200-year flood.

3.5 Impact to Local Infrastructure

Some local infrastructure is fundamental to the viability and sustainability of the City's community. Per NDMP guidance, Interior Dams reviewed risk to infrastructure, including local electrical power, transportation, wastewater, potable water, natural gas and telecommunication systems. The following sub-sections provide a summary of the high-level review.

3.5.1 Electric Power System

Interior Dams assessed the impact to the local electrical power infrastructure using the Department of Homeland Security's Federal Emergency Management Agency's (FEMA) Multi-hazard Loss Estimation Methodology functionality thresholds and damage function. Interior Dams compared the 1/200-year flood hazard maps to known locations of key electrical power infrastructure.

Table 3-6: Electrical power components - Functionality thresholds and damage function

System Component	FTA[1] (m)	Percent Damage by depth of flooding[2] (m)										
		0.0	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0
Key Infrastructure												
Substation (low / medium / high voltage)	0.2	0	2	4	6	7	8	9	10	12	14	15
Power Plants (small / medium / large)	1.2	0	2.5	5	7.5	10	12.5	15	17.5	20	25	30
Electrical Circuits												
Distribution Circuits Elevated Crossings	n/a	0	0	0	1	1	1	1	2	2	2	2
Distribution Circuits Buried Crossings	n/a	0	0	0	0	0	0	0	0	0	0	0
Distribution Circuits (non-crossings)	n/a	0	0	0	0	0	0	0	0	0	0	0

NOTE1 Functionality Threshold Depth (FTA) refers to the depth of water where the water system component ceases to function. Table has been adapted to assume 0.2 m FTA for substation due to the length of warning and the likelihood of a proactive shutdown.
NOTE2 Assumes electrical switch gear is located 1.2 m above grade.

No overlap was identified with key infrastructure; however, floodwaters will be very close to the Enderby Substation (Figure 3-8). Power will be compromised or proactively disconnected to large portions of the City, including at least 318 structures directly impacted by standing water, and many more will be impacted by flooded sub-surface floor spaces or backed-up drains. Of these structures, 278 are residences, and the remaining 16 structures include a school, a community centre, a church, two health service buildings, and many businesses. At least 40 of the residential structures will be surrounded by at least 1.0 metre of standing water.

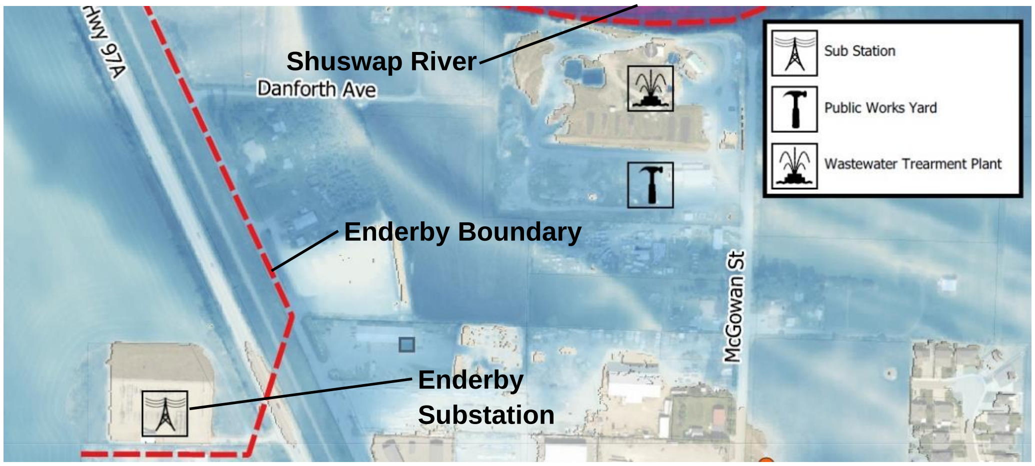


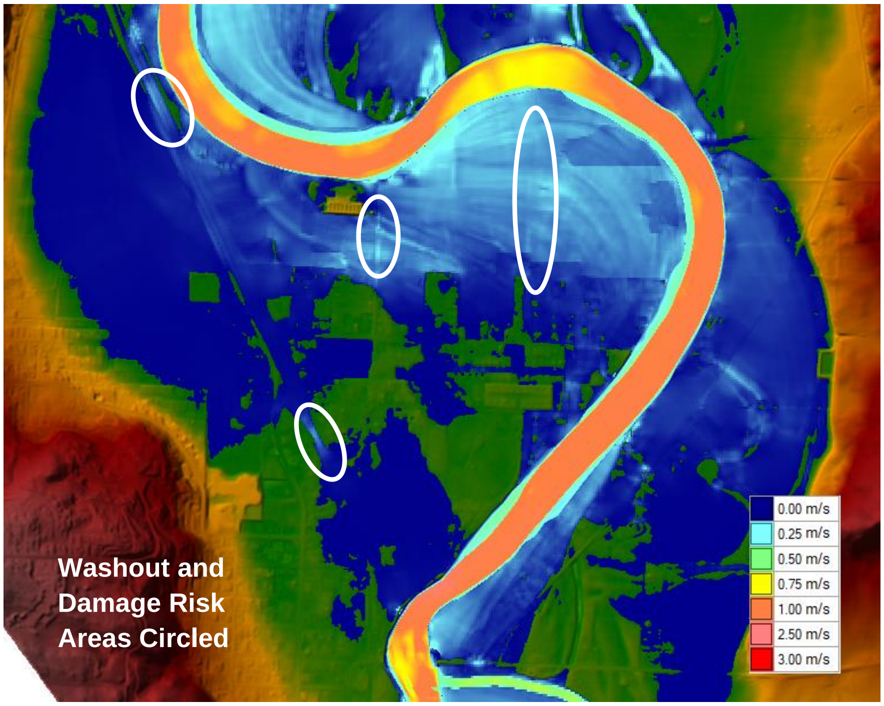
Figure 3-8: Enderby Substation not directly impacted by 1/200-year flood

Despite no anticipated direct loss to the Enderby Substation or other key electrical infrastructure, outages will cause many indirect damages, as well as direct local electrical losses. Since these losses will likely be directly related to the impacted structures, the estimated cost of these losses is assumed to be accounted for in loss to property (Section 3.3.3).

3.5.2 Transportation System

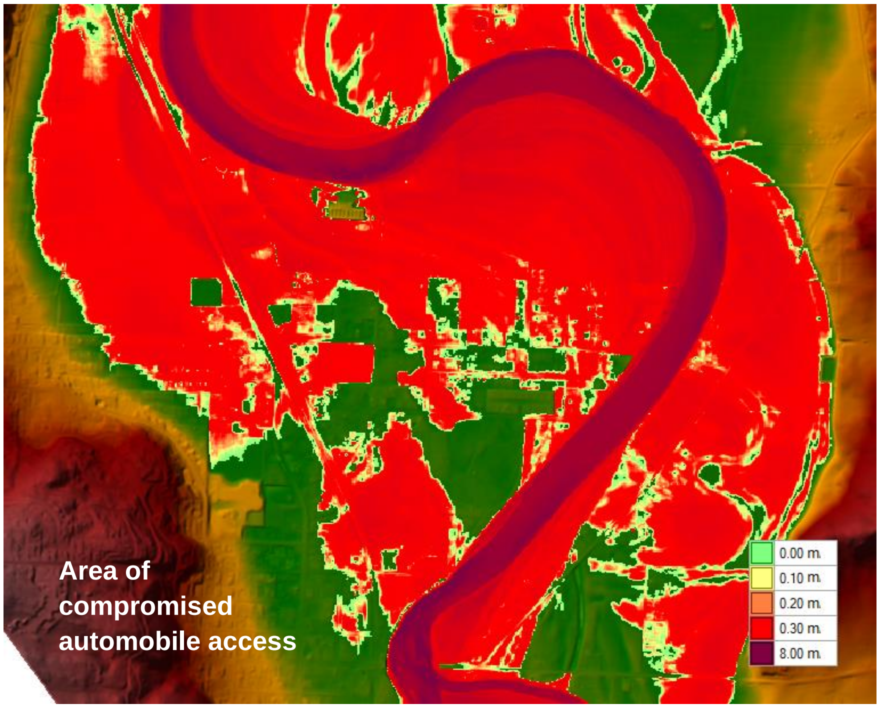
The flood hazard overlaps a network of transportation infrastructure, including numerous City roads and the Vernon-Sicamous Highway 97A[44]. Figure 3-9 and Figure 3-10 illustrate the velocity and depth of the 1/200-year flooding and highlights the damage or compromised access risk locations.

[44] According to the BC provincial consequence guideline for dams, roads are classified differently to facilitate consequence estimation relative to the impact of potential asset losses. Roads are broken up into five classes: 1) primary highways, 2) secondary highways, 3) major roads, 4) minor roads, and 5) local roads.. Compromising a secondary highway automatically assumes a *Very High* consequence.



Note: Roads that experience 0.50 m/s or greater are at risk of damage or wash out.

Figure 3-9: 1/200-year flood maximum velocities (m/s)



Note: Typical car access is compromised at ~0.1 m depth. Typical truck access is compromised at ~0.2 m depth. All red or darker areas are assumed to be inaccessible for automobiles.

Figure 3-10: 1/200-year flood maximum depths, coloured by automobile threshold stages (m)

Based on Figure 3-9 and Figure 3-10, Interior Dams summarized the anticipated impacts to transportation infrastructure in Table 3-7. Of note, Highway 97A (between Baird Ave and Park Ave, and near Danforth Ave), McGowan Street (north of Bass Ave), Waterwheel Street (north of Bass Ave), and Riverdale Drive are at risk of flood damage or washout.

Table 3-7: Impacted roadways – Washout risk identification

Infrastructure/Street Name[NOTE1]	Class	Anticipated Impact [NOTE2]
*George St	Arterial	Flooded – loss of access
*Highway 97A	Highway	Flooded – loss of access, damage or washout
Baird Ave	Local	Flooded – loss of access
*Bass Ave	Local	Flooded – loss of access
*Belvedere St	Local	Flooded – loss of access
Brickyard Rd	Local	Flooded – loss of access
*Cliff Avenue	Local	Flooded – loss of access (see Bawtree Bridge)
Cliff View Lane	Local	Flooded – loss of access
Crescent Dr	Local	Flooded – loss of access
Danforth Ave	Local	Flooded – loss of access
Evergreen St	Local	Flooded – loss of access
Heitman St	Local	Flooded – loss of access
*Howard Ave	Local	Flooded – loss of access
*Kate St	Local	Flooded – loss of access
Kildonan Ave	Local	Flooded – loss of access
Knight Ave	Local	Flooded – loss of access
Larsen Ave	Local	Flooded – loss of access
Maud St	Local	Flooded – loss of access
*McGowan St	Local	Flooded – loss of access, damage or washout
Meadow Cres	Local	Flooded – loss of access
*Mill Ave	Local	Flooded – loss of access
Park Ave	Local	Flooded – loss of access
Pine Crt	Local	Flooded – loss of access
Polson Ave	Local	Flooded – loss of access
Regent Ave	Local	Flooded – loss of access
Riverdale Drive	Local	Flooded – loss of access, damage or washout
Victor St	Local	Flooded – loss of access
Waterwheel St	Local	Flooded – loss of access, damage or washout
Baird Ave	Strata	Flooded – loss of access
Kildonan Ave	Strata	Flooded – loss of access
Regent Ave	Strata	Flooded – loss of access
Salmon Arm Dr	Strata	Flooded – loss of access
*Bawtree Bridge	Collector	Flooded – loss of access, damage to bridge

[NOTE1] Only infrastructure within the study area are listed.
NOTE1 For access details, refer to Figure 3-10 (all red areas are inaccessible to motor vehicle). For possible locations of road damage or washout, refer to Figure 3-9.
*Streets critical for emergency support (provides critical access to City Emergency Operations Centre, Public Works yard, or other critical site) and inter-community transportation or economy (railroad, highway, or major road).

The repair and replacement of roads and bridges is usually one of the largest contributors to loss. Direct damages to infrastructure are typically between 10% and 25% of the direct damages to all residential, commercial and industrial structures combined, and indirect damages due to loss of access typically contribute an additional 15-25% (NRC, 2017). Since the maximum velocities of the floodwaters are relatively low when compared to the depth of water (Figure 3-9 and Figure 3-10), Interior Dams assumed the lower limit of 10% for direct damages to transportation infrastructure (relative to all residential, commercial and industrial structures combined). They assumed a median value of 20% to estimate total direct and indirect losses to transportation infrastructure. Referencing the estimated direct damages to residential, commercial and industrial structures from Section 3.3.3.2 and Section 3.4.3, Table 3-8 provides the loss estimate calculation for the 1/200-year flood.

Table 3-8: Transportation infrastructure loss estimation

Loss Component	Loss Estimate[1]
Direct transportation infrastructure damages	$4,094,592
Indirect infrastructure damages	$818,918
TOTAL	**$4,913,510**

NOTE1 The direct loss estimate is calculated by multiplying the sum of all residential and non-residential structural damage by 10%, and the indirect loss estimate is 20% of this value. All values are calculated in 2020 dollars.

Of note, the total loss estimation value may appear large given the low velocities of the overland flooding; however, impacts to the highway, Mabel Lake Road, and Bawtree Bridge have the potential to contribute significant losses.

Although parts of the highway and Mabel Lake Road are outside of the City limit (outside of the risk assessment area), these will also be flooded under the 1/200-year flood and subject to access limitations and potential damage. Any damage to these main arterials will hinder evacuation and emergency response. Additionally, the Bawtree Bridge piers and abutments could be impacted by scouring and erosion. Repair costs and indirect impacts to the bridge, as well as other unforeseen impacts, could be underestimated in this value.

3.5.3 Wastewater System

The City has approximately 25 km of wastewater distribution piping, including several sanitary sewer lift stations (McGowan St, Brickyard Rd, Meadow Cr, Kildonan Ave, Kate St., Peacher Cr., and Red Rock Cr). This infrastructure conveys wastewater to a Wastewater Treatment Plant (WWTP) located on McGowan Street, adjacent to the Shuswap River. The WWTP services a population of approximately 3,000 and handles an average daily wastewater flow rate of 2,033 m^3/day (City of Enderby, 2014). It is also understood that the maximum daily wastewater flow rate significantly exceeds the average flow rate, especially during a flood year. According to City flow records, the maximum daily flow during the 2018 flood year reached 5,321 m^3/day. This is almost 82% larger than the maximum daily flow recorded the following year, which was a non-flood year (2,928 m^3/day).

Interior Dams compared the 1/200-year delineated flood hazard to the location of existing wastewater infrastructure and conducted a high-level impact estimate using the FEMA Multi-hazard Loss Estimation Methodology data. According to this guideline, the impact to functionality and damage to wastewater infrastructure components can be estimated based on floodwater depth. Functionality thresholds and damage functions used in the analysis are provided in Table 3-9. An image showing the depth of flooding coloured relative to the damage function stages for the WWTP site is shown in Figure 3-11.

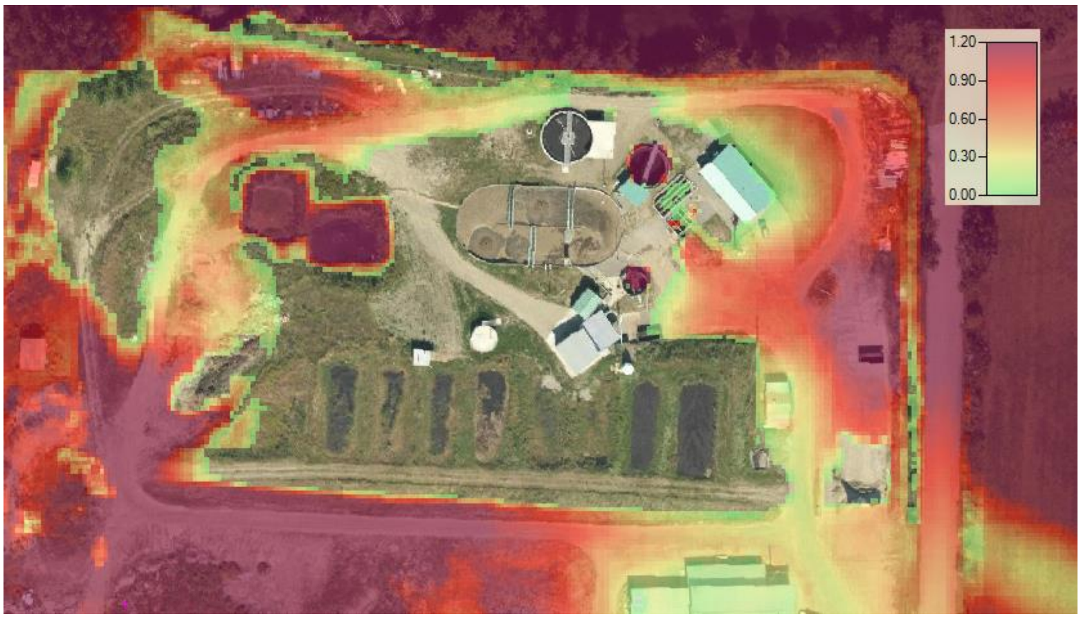


Figure 3-11: 1/200-year flood maximum depths, coloured by wastewater threshold stages (m)

Table 3-9: Wastewater components - Functionality thresholds and damage function (FEMA, 2001)

System Component	FTA[1] (m)	Percent Damage by depth of flooding[2] (m)										
		0.0	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0
Collector at River Crossings (exposed / buried)	n/a	0	0	0	0	0	0	0	0	0	0	0
Pipes at River Crossings	n/a	0	0	0	0	0	0	0	0	0	0	0
Pipes (non-crossings)	n/a	0	0	0	0	0	0	0	0	0	0	0
Wastewater Treatment Plants (small / medium / large)	0	0	5	8	10	17	24	30	30	30	30	40
Control Vaults and Control Stations (all)	0	0	40	40	40	40	40	40	40	40	40	40
Wet Well / Dry Well Lift Station (all)	1.2	0	0	0	0	40	40	40	40	40	40	40
Submersible Lift Station	n/a	0	0	0	0	10	10	10	10	10	10	10

Table 3-9: Wastewater components - Functionality thresholds and damage function (FEMA, 2001)

System Component	FTA[1] (m)	Percent Damage by depth of flooding[2] (m)										
		0.0	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0
(all)												

NOTE1 Functionality Threshold Depth (FTA) refers to the depth of water where the water system component ceases to function.
NOTE2 Assumes electrical switch gear is located 1.2 m above grade.

Applying Table 3-9 functionality thresholds and damage functions for buried pipes, lift stations, and small WWTPs, no damage to the piped distribution network or lift stations are expected; however, there is potential for loss of functionality and damage to the WWTP. Applying a 5% loss and a value of $7,900,000[45] for the capital cost for the WWTP, Interior Dams estimated the loss to the City to be $395,000. Table 3-10 summarizes the monetary loss to City wastewater infrastructure for the 1/200-year flood.

Table 3-10: Wastewater infrastructure loss estimation

Loss Component	Capital Cost	Loss Percent	Loss Estimate
WWTP including equipment	$6,500,000	5%	$395,000
Lift Station	$250,000	0%	$0
Pipes (non-crossings)	n/a	0%	$0
Pipes at River Crossings	n/a	0%	$0
		TOTAL	**$395,000**

NOTE Loss estimate is calculated in 2020 dollars.

Failure of one or more wastewater containments is plausible due to overtopping as a result of direct infiltration (from overland flooding) or from excessive inflows. Any impacted control vaults and control stations will be compromised; however, the lift stations are expected to be functional, but power will likely be shut down (Section 3.5.1). Since the loss of functionality or failure of the wastewater system is expected, uncontrolled release of raw sewage from the WWTP or the piped wastewater network is expected to occur.

3.5.4 Potable and Stormwater Systems

The City's potable water system has an average daily demand of approximately 1,300 m^3/day and approximately 31 km of piping within the distribution system. The entire system operates on a multi-pressure-zoned system and services roughly 3,200 residents. The system has two sources: surface water from the Shuswap River and groundwater from a well approximately 5 km upstream of the Shuswap River intake (City of Enderby, 2019).

As source water intakes are susceptible to damage from flooding, Interior Dams compared the location of this infrastructure with the extent of the 1/200-year flood. Figure 3-12 illustrates the

[45] This value is the City's appraisal adjusted for inflation. The value corresponded to the capital cost estimator for WWTPs based on capacity and treatment type per Ontario Ministry of Public Infrastructure Renewal data (Province of Ontario, 2005).

City limit and the location of the two water sources in relation to the flood hazard. The Water Treatment Plant is not within the 1/200-year flood hazard area and therefore impact is not expected. As the Shuswap Well is outside of the flood mapping area of study, Interior Dams could not review the potential impacts to this infrastructure.

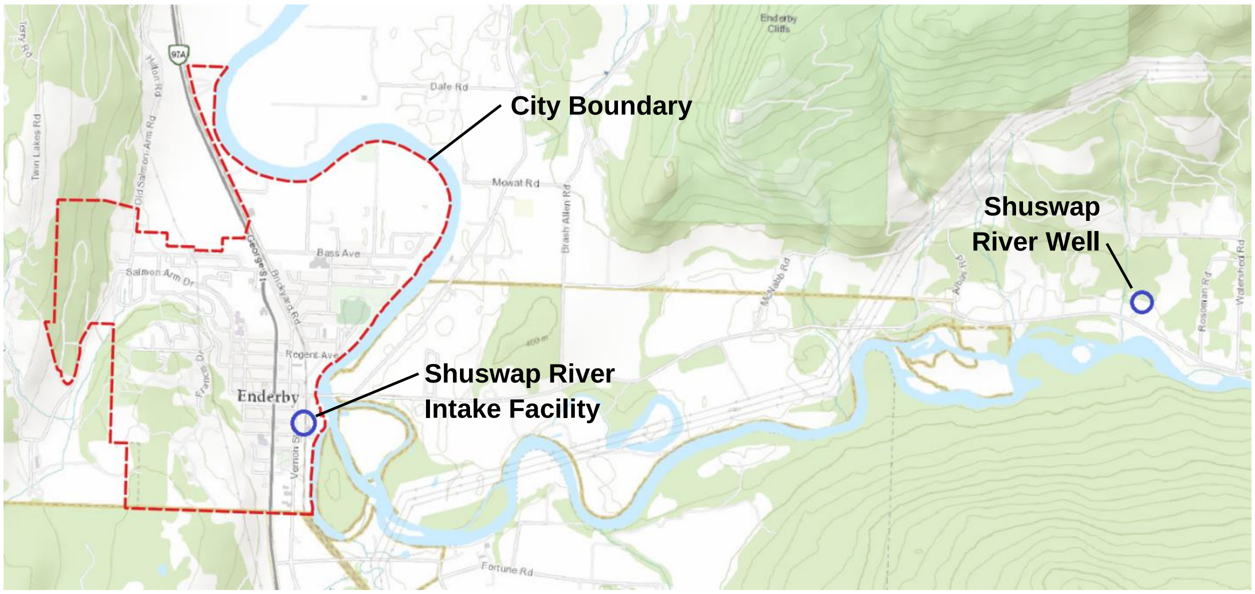


Figure 3-12: Potable water source locations relative to flood

Interior Dams also reviewed the impact to the City stormwater system. The 1/200-year flood hazard impacts a large portion of the stormwater system; however, most of this system consists of a buried gravity stormwater piping system with the exception of one impacted stormwater pump station on Regent Avenue.

Interior Dams used the FEMA Multi-hazard Loss Estimation Methodology guidelines to review other potable water infrastructure (FEMA, 2001). Per FEMA, the impact to functionality and damage to potable water components can be estimated based on floodwater depth. Table 3-11 below provides functionality thresholds and damage functions based on floodwater depth.

Table 3-11: Water components - Functionality thresholds and damage function (FEMA, 2001)

System Component	FTA[1] (m)	Percent Damage by depth of flooding[2] (m)										
		0.0	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0
Exposed Transmission Pipeline Crossing	n/a	0	0	0	0	0	0	0	0	0	0	0
Buried Transmission Pipeline Crossing	n/a	0	0	0	0	0	0	0	0	0	0	0
Buried Pipelines (non-crossing)	n/a	0	0	0	0	0	0	0	0	0	0	0
Small WTP (open / gravity)	0	0	5	8	10	17	24	30	30	30	30	40

Table 3-11: Water components - Functionality thresholds and damage function (FEMA, 2001)

System Component	FTA[1] (m)	Percent Damage by depth of flooding[2] (m)										
		0.0	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0
Medium WTP (open / gravity)	0	0	5	8	10	17	24	30	30	30	30	40
Large Water Treatment Plants (open / gravity)	0	0	5	8	10	17	24	30	30	30	30	40
Small Water Treatment Plants (closed / pressure)	1.2	0	1	2	5	15	30	40	40	40	40	40
Medium Water Treatment Plants (closed / pressure)	1.2	0	1	2	5	15	30	40	40	40	40	40
Large Water Treatment Plants (closed / pressure)	1.2	0	1	2	5	15	30	40	40	40	40	40
Pumping Plants (all / below grade)	1.2	0	0	0	0	40	40	40	40	40	40	40
Pumping Plants (all / above grade)	1.2	0	1	2	5	15	30	40	40	40	40	40
Control Vaults and Stations (all)	0.3	0	40	40	40	40	40	40	40	40	40	40
Water Storage Tanks (at grade conc/steel/wood)	7.3	0	0	0	0	0	0	0	0	0	0	0
Water Storage Tanks (all / below grade)	1.2	0	0	0	0	5	5	5	5	5	5	5
Wells (all)	1.2	0	1	2	5	20	25	30	30	30	30	30

NOTE1 Functionality Threshold Depth (FTA) refers to the depth of water where the system component ceases to function.
NOTE2 Assumes electrical switch gear is located 1.2 m above grade.

Applying the above functionality and damage thresholds to the City water systems, Interior Dams only identified one critical piece of infrastructure, the Regent Avenue stormwater pump station (Figure 3-13 and Figure 3-14). Applying Table 3-11, Interior Dams assumed that only functionality of the pump station would be compromised, and minor loss up to about $25,000 may occur (~5-10% damage).

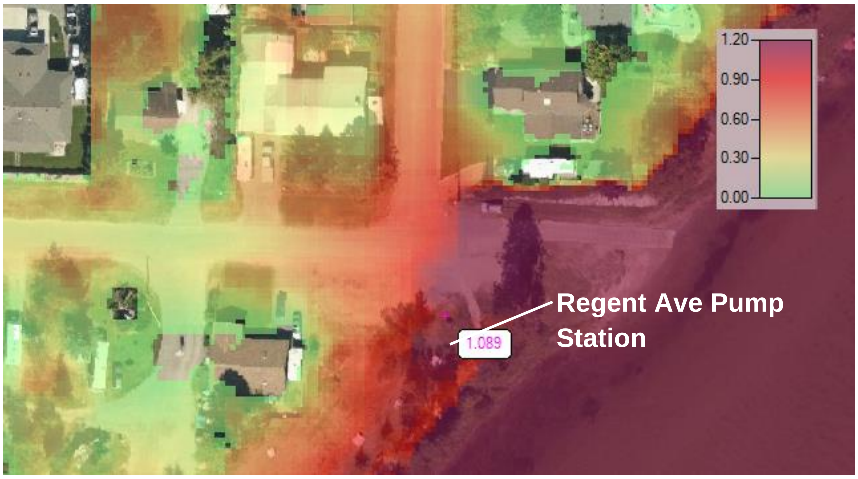


Figure 3-13: 1/200-year flood maximum depths, coloured by water threshold stages (m)

Figure 3-14: Regent Avenue stormwater pumps station

In addition to infrastructure damages, potable water quality will likely be compromised from high source turbidity and source contamination, and there is a risk of main breaks at road washout locations (Section 3.5.2). Also, electrical power outages will occur, which may further compromise the functionality of the water system, including its SCADA system (Section 3.5.1).

Section 3.1.3 identified a potential release of raw sewage and industrial waste to the Shuswap River, and an increased risk of source water contamination and environmental pollution is expected. As pollution can be carried long distances, the contamination of source water downstream of the WWTP may extend as far as Mara Lake. Although not within the study area, a search of the BC Water Atlas identified a total of 325 water licences[46] between the location of the City's WWTP and the mouth of the Shuswap River at Mara Lake (BC Water Resources Atlas, 2020). The risk of potable water contamination to these sources is possible. Table 3-12 summarizes the water licences identified.

[46] Licenses with the Shuswap River as the water source

Table 3-12: List of water licences

Licence Purpose	No. of Licenses	Volume	Units
Camps & Public Facilities	1	2	m^3/day
Comm. Enterprise: Enterprise	1	5	m^3/day
Cooling	1	982	m^3/day
Domestic	127	422	m^3/day
Irrigation: Private	185	7,910,507	m^3/year
Lawn, Fairway & Garden: Watering	1	34,118	m^3/year
Waterworks: Local Provider	1	286,731	m^3/year

3.5.5 Natural Gas System

For natural gas infrastructure, the report relies on FEMA Multi-hazard Loss Estimation Methodology guidelines. According to this guideline, the impact to functionality and damage to natural gas system components can be estimated based on floodwater depth. Table 3-13 below provides functionality thresholds and damage functions based on floodwater depth.

Table 3-13: Natural gas components - Functionality thresholds and damage function (FEMA, 2001)

System Component	FTA[1] (m)	Percent Damage by depth of flooding[2] (m)										
		0.0	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0
Exposed Transmission Pipeline Crossing	n/a	0	0	0	0	0	0	0	0	0	0	0
Buried Transmission Pipeline Crossing	n/a	0	0	0	0	0	0	0	0	0	0	0
Pipelines (non-crossing)	n/a	0	0	0	0	0	0	0	0	0	0	0
Control Valves and Control Stations	0.3	0	40	40	40	40	40	40	40	40	40	40
Compressor Stations	1.2	0	1	2	5	15	30	40	40	40	40	40

NOTE1 Functionality Threshold Depth (FTA) refers to the depth of water where the system component ceases to function (FEMA, 2001).
NOTE2 Assumes electrical switch gear is located 1.2 m above grade.

A single pipeline was identified within the delineated flood hazard. No loss of functionality or damage is expected based on the thresholds and functions of Table 3-13.

3.5.6 Telecommunication System

For telecommunication systems, no FEMA functionality thresholds or damage functions were available to estimate flood impacts. Since there is no key telecommunication infrastructure identified within the delineated flood hazard, it is likely that only communication lines may be exposed. As such, the impact to telecommunication systems is expected to be negligible in comparison to other local infrastructure.

3.6 Summary of Flood Risk

In accordance with best practices, NDMP guidelines and City requests, Interior Dams estimated the total monetary losses to all individuals and organizations for the City of Enderby to be $54,022,823 for the 1/200-year flood hazard. Table 3-14 provides a summary of the estimate and includes descriptions of other non-monetary impacts for each category.

Table 3-14: Summary of 1/200-year flood impact

<table>
<tr><th>Category</th><th>Sub-category</th><th>Section</th><th>Sub-Category Loss ($)</th><th>Total Loss ($)</th></tr>
<tr><td rowspan="2">Impact to Environment</td><td>n/a</td><td>3.1</td><td>-</td><td>-</td></tr>
<tr><td colspan="4">Other non-monetary impacts:
• Risk of impact to red-listed species, no permanent environmental loss
• Contamination of water and pollution of wetlands</td></tr>
<tr><td rowspan="2">Impact to Cultural Values</td><td>n/a</td><td>3.2</td><td>-</td><td>-</td></tr>
<tr><td colspan="4">Other non-monetary impacts:
• Five (5) heritage sites are expected to be impacted by flood
• Two (2) other heritage sites are at risk of flooding
• Impact to community assets and recreational sites including the Okanagan Regional Library (weeks to months of recovery), Tuey Park, or the Jim Watt Heritage River Walk (days to weeks of recovery)</td></tr>
<tr><td rowspan="6">Impact to People and Society</td><td>Loss of Wages</td><td>3.3.1</td><td>$668,204</td><td rowspan="5">$43,133,043</td></tr>
<tr><td>Loss of Life</td><td>3.3.2</td><td>-</td></tr>
<tr><td>Loss of Automobiles</td><td>3.3.3.1</td><td>$5,790,454</td></tr>
<tr><td>Loss of Residential Property (includes structural, content & property)</td><td>3.3.3.2</td><td>$35,749,780</td></tr>
<tr><td>Loss due to Displacement</td><td>3.3.4</td><td>$924,605</td></tr>
<tr><td colspan="4">Other non-monetary impacts:
• Risk to loss of life (low, ~25% chance of one life lost)
• Mental health impacts and other non-monetary hardships related to displacement, property loss, and loss of wages
• Shutdown of vital service providers including a grocery store, two dental clinics, and the senior centre (current COVID-19 vaccine clinic)
• Incremental increase of risk to health and safety due to increased potential of water contamination</td></tr>
<tr><td rowspan="4">Impact to Local Economy</td><td>Loss of Rental Income</td><td>3.4.1</td><td>$182,954</td><td rowspan="3">$5,626,270</td></tr>
<tr><td>Loss of Business Profits</td><td>3.4.2</td><td>$247,177</td></tr>
<tr><td>Impact to Non-Residential Properties</td><td>3.4.3</td><td>$5,196,139</td></tr>
<tr><td colspan="4">Other non-monetary impacts:
• Mental health impacts and other non-monetary hardships related to business displacement, property loss, and loss of profits</td></tr>
<tr><td rowspan="4">Local Infrastructure</td><td>Electrical Power System</td><td>3.5.1</td><td>-</td><td rowspan="4">$5,333,510</td></tr>
<tr><td>Transportation System</td><td>3.5.2</td><td>$4,913,510</td></tr>
<tr><td>Wastewater System</td><td>3.5.3</td><td>$395,000</td></tr>
<tr><td>Potable Water System</td><td>3.5.4</td><td>$25,000</td></tr>
</table>

Table 3-14: Summary of 1/200-year flood impact

	Natural Gas System	3.5.5	-	
	Telecommunication System	3.5.6	-	
	Other non-monetary impacts: • Electrical power outages • Local road, highway, and railroad damage and washout(s) (isolating) • Loss of power to sanitary boosters, water lift stations, and infrastructure • Risk to watermain at road washout locations (not causing extended shutdown) • Increased risk of potable water contamination			
			TOTAL	**$54,092,823**

According to the Engineers and Geoscientists of British Columbia's flood assessment professional practice guidelines, *risk* is defined as "a measure of the probability and severity of an adverse effect to health, property, or the environment" and "is often estimated by the product of probability and consequence" (EGBC, 2018).

Loss estimates provided in Table 3-14 are based on the occurrence of a single event having a magnitude that is equal to the 1/200-year event; and therefore, there is a 1/200 annual probability (0.5% chance per year) that next year's flood will be *equal to or greater than* this 1/200-year event. In the same manner, there is a 1/20 annual probability (5% chance per year) that next year's flood will be *equal to or greater than* the 1/20-year event.

Interior Dams did not estimate the impacts of the 1/20-year event. When evaluating flood risk, the City should recognize that a lower magnitude event will have a higher probability of occurrence. Considering the 1/20-year flood event, this event is ten times (10X) more likely to occur than the 1/200-year event. Although the impact of occurrence is reduced compared to the 1/200-year, the 1/20-year flood mapping clearly demonstrates a significant risk to the City (refer to Appendix II: Flood Maps). For this reason, the estimated impact for the 1/200-year flood event should not be interpreted as the total risk to the City. Additionally, the estimated 1/200-year impact does not include environmental, societal, or other impacts.

4 FLOOD RISK MITIGATION

In alignment with the project purpose, this section is intended to support and direct the development and implementation of an IFMP. It contains contextual information regarding flood management roles and responsibilities, general mitigation strategies, and an overview of the current flood mitigation efforts that are already in place or are currently being implemented. Where Interior Dams identified opportunities to improve flood mitigation efforts, findings are provided at the end of each of their appropriate sub-sections.

This risk mitigation section provides only a screening-level review and is intended to identify new opportunities to improve the City's existing risk mitigation strategies, as well as facilitate the investigation and implementation of new ones.

4.1 Flood Management Roles and Responsibilities

Everyone is affected by flooding. As such, everyone has a role in flood mitigation planning and implementation. For this reason, it is important that all stakeholders work together to develop and implement a balanced and effective IFMP (Province of BC, 1999). This section provides a brief summary of the roles and responsibilities for individuals, local authorities, and provincial agencies and federal government agencies.

4.1.1 Individuals

According to the Flood Planning and Response Guide for BC, "regardless of governmental involvement, the first line of defence against floods always rests with the individual. All homeowners, landlords and individuals, although not mandated by legislation, have a responsibility to protect their homes and families to the greatest extent possible. It is up to each individual to know what to do in an emergency. Individuals living in flood-prone areas should be aware or made aware of that fact so they can take appropriate precautions in regard to their living arrangements and their planned response to a flood event" (Province of BC, 1999). In addition to this, individuals play an important role in supporting their community and local authorities in the effort to implement an IFMP.

4.1.2 Local Authorities

According to the Flood Hazard Area Land Use Management guidelines, local authorities have the responsibility to act on behalf of individuals to coordinate and direct flood management. Local authorities are the conduit through which flood mitigation activities are directed and implemented. For this reason, local governments have been given the authority to:

- Develop flood hazard area bylaws without provincial government approval, but with consideration for their policies and guidelines;
- Grant flood hazard area land development exemptions, provided that the exemptions are consistent with provincial government guidelines, or certified by a suitably qualified professional engineer or geoscientist; and
- Establish the requirements for subdivision in flood-prone areas, which includes engineering reports assessing flood hazards and restrictive covenants (FLNRORD, 2018).

In consideration of the above role and granted authority, local governments must consider the Flood Hazard Area Land Use Management Guidelines when designating floodplains (Local Government Act). The designation of floodplains, as well as management of approvals for residential, commercial, and industrial development, must protect riparian areas as per requirements under the Riparian Areas Protection Act (APEGBC, 2017).

4.1.3 Provincial and Federal Agencies

Relative to the scale of emergencies and the impact of flooding, provincial and federal governments provide emergency response and disaster assistance to both individuals and local governments. In addition, provincial and federal governments are committed to providing support, education, and tools necessary for local authorities to direct and implement flood risk management. As an example of this commitment, this project was funded under the NDMP and CEMP programs, which are federal and provincial programs, respectively.

Although the provincial government still provides a role in development approvals in certain cases, according to the Legislated Flood Assessment guidelines for BC, “the role of the provincial government has lessened in the area of development approvals in Flood Hazard areas, with an increasing role for local governments and consultants.” As such, it is expected that the provincial government will continue to shift towards a supportive role whereby the local government will be responsible for tailoring and implementing local flood risk management.

4.2 Introduction to Flood Risk Mitigation Strategies for Local Authorities

Flood risk mitigation planning “is the process by which a community reflects on its identified risks, and uses this information to make informed planning decisions” (Government of Canada, 2018). According to NDMP guidelines, this process should be led by the Local Authority and should include the following steps:

1. Identification of broad mitigation goals;
2. Identification of feasible strategies which can achieve those goals; and
3. Development of a plan for execution that will clearly state the identified goals and strategies, which identifies key activities to be completed (IFMP).

In alignment with the above process, these flood mitigation steps align with the *risk reduction* components of a risk-based approach according to the Engineers and Geoscientists guidelines (EGBC, 2018). Figure 4-1 below illustrates this risk-based approach.

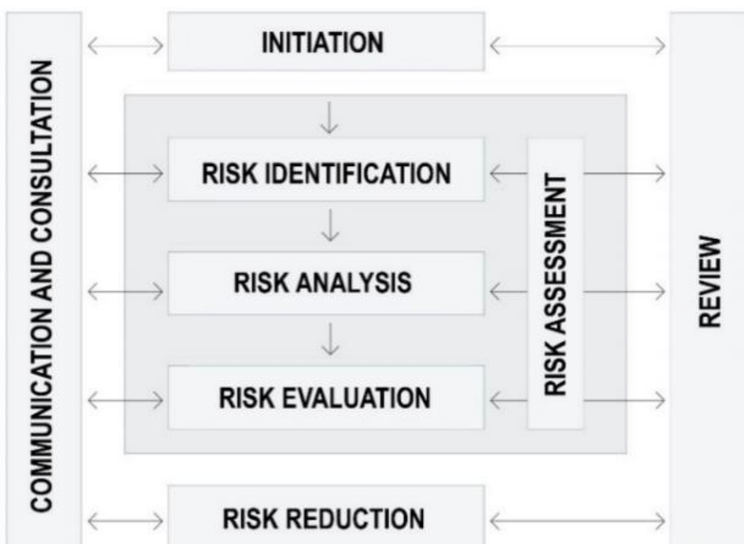


Figure 4-1: Flood risk assessment - Risk-based approach (Adapted from EGBC, 2018)

The components bound by the shaded box in Figure 4-1 are covered in the flood mapping and flood risk assessment portions of this report (Sections 2 and 3). The remainder of this report is intended to focus on *risk reduction.* As such, the following sections provide potential flood risk mitigation strategies that are intended to be reviewed and, if appropriate, implemented following communication and consultation.

At the present time, the City has adopted a risk tolerance and various design-based standards that corresponds with the 1/200-year flood hazard; however, the City has not yet developed an IFMP with a comprehensive set of risk-based flood mitigation goals[47]. As such, mitigation strategies presented in this section are broadly aimed to provide examples and suggestions for IFMP development, and therefore, are not guided by an existing comprehensive set of flood mitigation objectives.

4.3 Non-Structural Mitigation

This section covers non-structural flood risk mitigation (also known as passive mitigation). Non-structural mitigation is defined as "non-physical measures that incorporate the measurement and assessment of the risk environment and contribute to risk reduction" (Government of Canada, 2018). Upon completing a review of the referenced flood-related information, including the results of the flood mapping and flood risk assessments, a discussion is provided for the following non-structural mitigation categories:

- Flood mapping;
- Risk assessment;
- Official community plan;
- City zoning and development bylaws;
- Emergency response and management; and
- Integrated flood management planning.

4.3.1 Flood Mapping

Upon acceptance of a 2020 application for funding, the City initiated the mapping portion of this project. As of the date of this report, current flood mapping is available to the City to guide and support other flood mitigation strategies (Section 2 of this report). This valuable information supports risk assessment and guides the implementation of flood mitigation activities. These are discussed in the following sections.

4.3.1.1 Flood Mapping – Future Strategies

Flood mapping should be reviewed and, if necessary, updated once every 10 years. This ensures that flood mapping is useful and continues to represent current conditions since changes to design criteria, land use, and climate change are expected to occur. Other changes requiring updates may include significant hydrologic or hydraulic change in the upstream watershed, changes to the channel geometry (such as a flood, landslide, or other event), identification of new flood hazards (including the collection and analysis of more recent data),

[47] Goals for risk reduction may be design-based or risk-based. Design-based goals typically involve descriptive targets such as water elevations or flow capacities, whereas risk-based goals typically involve more general thresholds for acceptable impacts.

construction of structural mitigation works, land-use changes and urbanization, or other significant impacts (APEGBC, 2017).

4.3.2 Risk Assessment

Similar to flood mapping, as of the date of this report, a completed risk assessment is available to the City to guide and support other flood mitigation strategies (Section 3 of this report).

4.3.2.1 Risk Assessment – Future Strategies

A risk assessment provides valuable information about the frequency of potential impacts and monetary losses from floods. As this is required to fully understand the ongoing cost to individuals and organizations in the community, a risk assessment may be used to determine the feasibility of flood mitigation options, as well as to set balanced and attainable goals.

Although BC has not developed formal flood risk tolerance criteria, it is important that the adopted risk tolerance for the City reflects the community's level of acceptable risk. This level of risk should be balanced and determined in consultation with stakeholders. At the present time, the City has risk tolerance criteria for new development and infrastructure (corresponds to the 1/200-year flood).

Risk tolerance guides the development and implementation of other feasible mitigation strategies and also dictates acceptable design standards for new and existing infrastructure and development. As Figure 4-2 illustrates, a simple adoption of common design standards from another jurisdiction may not necessarily provide the optimum mitigation plan for the City (often referred to as a design-standard approach). Therefore, the City is encouraged to review and update their current flood mitigation design-standard approach where applicable (refer to Section 4.3.3, 4.3.4, and 5.2 for more details).

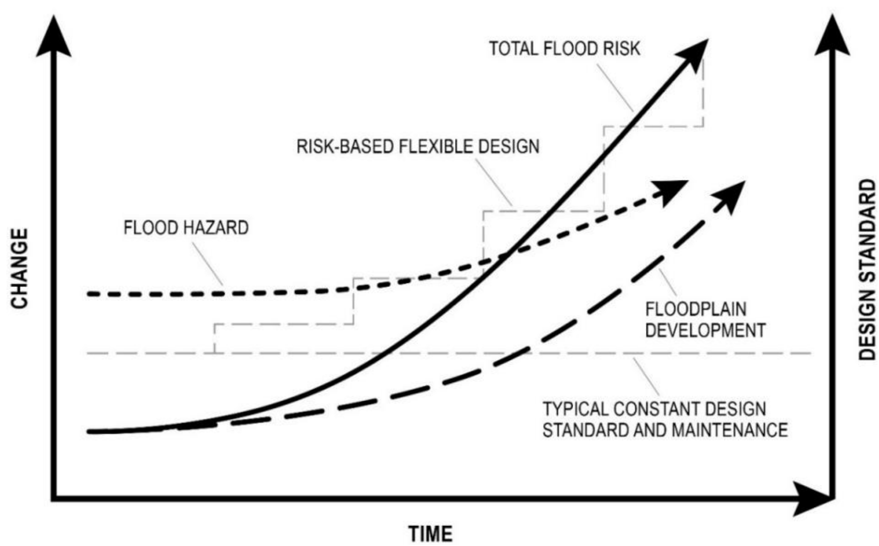


Figure 4-2: Flood risk and design standards vs. time (EGBC, 2018)

Risk assessment also provides the necessary information needed to perform loss estimation analysis. Loss estimation analysis compares the net loss avoidance gained versus the cost of construction between implementing and not implementing any particular mitigation option, and therefore, assists the effectiveness of City efforts by prioritizing cost-effective feasible projects.

According to NDMP guidelines, all structural mitigation options should be assessed for feasibility and effectiveness using loss estimation analysis prior to implementation, ensuring the maximum benefit and prioritization of all flood management activities (Government of Canada, 2018).

4.3.3 Official Community Plan

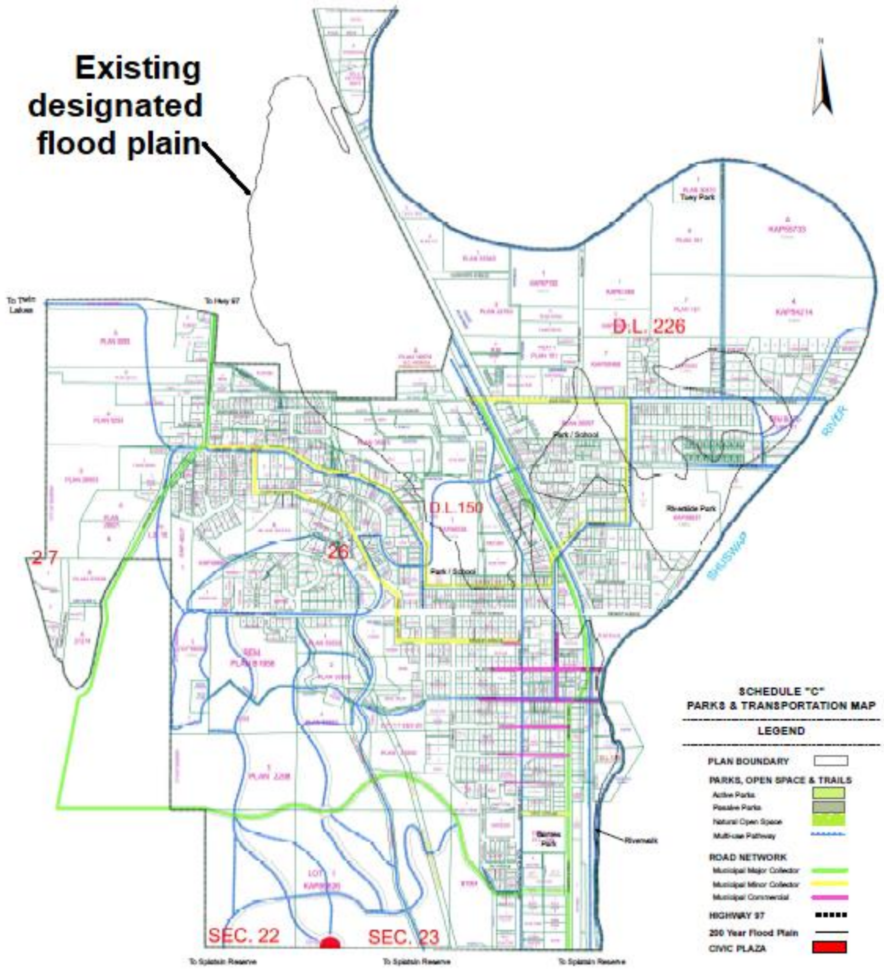
With a considerable investment of time and money, the City has developed and continually revised a robust OCP. The OCP has provisions for land use designation, management of City parks and transportation, growth strategies, and other functions, and includes the following sections:

- OCP Bylaw 1549 (City of Enderby, 2014);
- OCP Report (City of Enderby, 2014a);
- Land Use Designation Map (City of Enderby, 2014b);
- Parks and Transportation Map (City of Enderby, 2014c);
- Regional Growth Strategy Congruency Analysis (City of Enderby, 2014d); and
- Regional Growth Strategy Designation Map (City of Enderby, 2014e).

The OCP has adopted flood mitigation objectives and includes a designated 1/200-year floodplain. Adopted flood mitigation objectives are quoted below, and a copy of the designated floodplain is illustrated in Figure 4-3. Of note, the 1/200-year designated floodplain is very similar to the 1/200-year flood map provided in Section 2. Figure 4-4 illustrates the similarities.

Adopted City Council objectives (quoted from OCP Report):

> *7.2 n. To ensure the safety of citizens and protect development from the hazard of flooding in the designated 200 year floodplain through the application of regulatory standards.*
>
> 7.3 *e. Council will incorporate floodplain management provisions into the Zoning Bylaw to reduce the risk of injury, loss of life, and damage to buildings and structures due to flooding within the 200 Year Floodplain identified on Schedule "C" of this bylaw.*



Note: Map image is cropped from the original

Figure 4-3: Existing designated floodplain defined in Schedule "C" - Parks and Transportation Map (City of Enderby, 2014c)

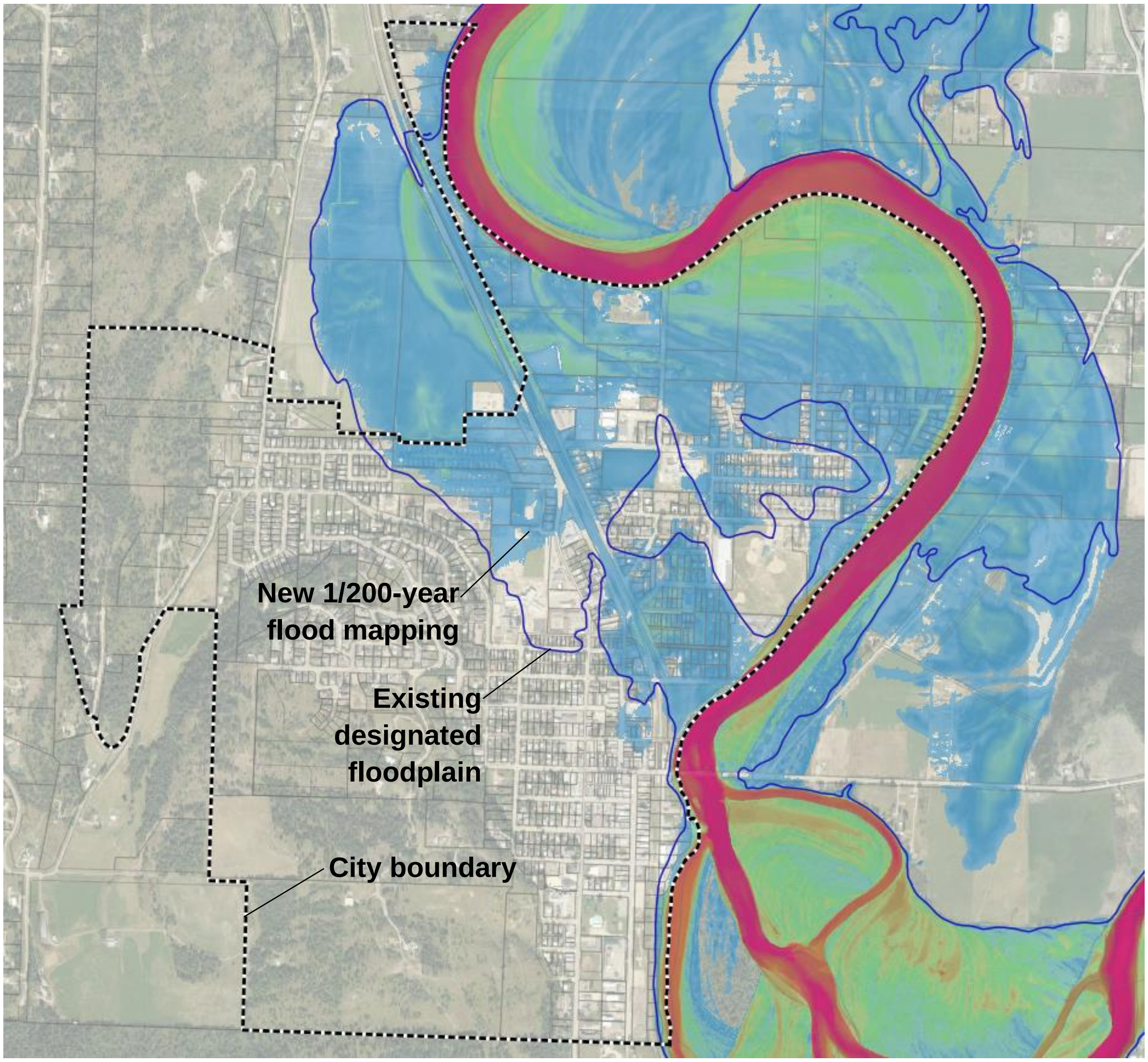


Figure 4-4: Existing designated floodplain compared to new 1/200-year flood mapping (2021)

4.3.3.1 Official Community Plan – Future Strategies

According to the OCP report, "A significant portion of the City lies within the [previously designated 200/year floodplain]. These are hazard lands susceptible to flooding and are established by the Provincial Ministry of Environment" (City of Enderby, 2014a). Although the previously designated floodplain *was* established by the provincial government, the responsibility to designate floodplains now lies with the Local Authority (the City). Per the Local Government Act[48], the Local Authority is now responsible to designate the floodplain via enactment of bylaws (Province of BC, 2015).

Since the City now has new updated flood mapping, the City should update the existing 1/200-year designated floodplain in Schedule "C" using the new 1/200-year flood mapping.

[48] Supporting excerpts from Section 524 of the Local Government Act are provided in Appendix V.

Additionally, all other references to flooding, including flood-related definitions and terminology should be reviewed for consistency across City bylaws.

Since the 1/200-year flood covers “a significant portion of the City” (OCP quoted), much of the City’s existing infrastructure and development is therefore not protected against the corresponding 1/200-year design flood. As this flood also corresponds to the existing risk tolerance for the City (and most other BC municipalities), the City should prioritize the protection, modification, or relocation of existing at-risk infrastructure and development where possible. In support of this initiative, the City may consider an alternate risk tolerance criteria for certain existing works within the 1/200-year floodplain (i.e., adopt a 1/20-year risk tolerance for some existing infrastructure and development where appropriate), since the protection of all existing works to the 1/200-year risk tolerance may not be feasible. This may encourage and facilitate effective resource allocation to existing works that pose the most flood risk.

4.3.4 City Zoning and Development Bylaws

The Zoning Bylaw deems commercial, industrial, residential, rural, and special use zoned property to be subject to setbacks and construction levels as follows:

> *Division Four – Commercial Zones (C.1 / C.2 and C.4), Section 10 e., setbacks (subject to the special building line setback provisions of Section 308.5. of this Bylaw): “Flood Construction Levels and Floodplain Setbacks of building and structures and Riparian Assessment Area setbacks for all development must conform with the provisions of Schedule “G” of this bylaw”*

> *Division Five – Industrial Zones (I.1 and I.2), Section 9 e., setbacks (subject to the special building line setback provisions of Section 308.5. of this Bylaw): “Flood Construction Levels and Floodplain Setbacks of building and structures and Riparian Assessment Area setbacks for all development must conform with the provisions of Schedule “G” of this bylaw”*

> *Division Six – Residential Zones (R.1 / R.1-A / R.2 / R.3 / C.R), Section 10 e. / f., setbacks (subject to the special building line setback provisions of Section 308.5. of this Bylaw): “Flood Construction Levels and Floodplain Setbacks of building and structures and Riparian Assessment Area setbacks for all development must conform with the provisions of Schedule “G” of this bylaw”*

> *Division Seven – Rural Zones (C.R), Section 10 f., setbacks (subject to the special building line setback provisions of Section 308.5. of this Bylaw): “Flood Construction Levels and Floodplain Setbacks of building and structures and Riparian Assessment Area setbacks for all development must conform with the provisions of Schedule “G” of this bylaw”*

> *Division Eight – Special Use Zone (S.1), Section 10 f., setbacks (subject to the special building line setback provisions of Section 308.5. of this Bylaw): “Flood Construction Levels and Floodplain Setbacks of building and structures and Riparian Assessment Area setbacks for all development must conform with the provisions of Schedule “G” of this bylaw”*

Schedule "G" contained in Division Fourteen of the Bylaw provides the City water body provisions. Per that Bylaw, "The purpose of the floodplain management provisions is to reduce the risk of injury, loss of life, and damage to buildings and structures due to flooding". The Schedule includes definitions and provisions to calculate the appropriate setbacks or construction levels, as well as the following supporting attachments: Schedule H, Schedule G.1 and Schedule G.2. Schedule H provides the City of Enderby Zoning map (Figure 4-5). Schedule G.1 and Schedule G.2 reference the designated floodplain of the Bylaw, and consist of copies of Sheet 8 and Sheet 9 of the old provincial designated 1/200-year flood maps. The City Bylaw water body provision definitions are summarized below:

> *DESIGNATED FLOOD means a flood, which may occur in any given year, of such magnitude as to equal a flood having a 200-year recurrence interval, based on a frequency analysis of unregulated historic flood records or by regional analysis where there is inadequate stream flow data available. Where a large watercourse or body of water is controlled by a major dam, the designated flood shall be set on a site specific basis.*
>
> *DESIGNATED FLOOD LEVEL means the observed or calculated elevation for the Designated Flood, which is used in the calculation of the Flood Construction Level.*
>
> *FLOOD CONSTRUCTION LEVEL means a Designated Flood Level plus Freeboard, or where a Designated Flood Level cannot be determined, a specified height above a Natural Boundary, Natural Ground Elevation, or any obstruction that could cause ponding.*
>
> *FLOODPLAIN means an area which is susceptible to flooding from an adjoining watercourse, lake, or other body of water and is designated in Section 1401.2 of this bylaw.*
>
> *FLOODPLAIN SETBACK means the required minimum distance from the Natural Boundary or other reference line of a watercourse, lake, or other body of water to any landfill or structural support required to elevate a floor system or pad above the Flood Construction Level, so as to maintain a floodway and allow for potential land erosion.*

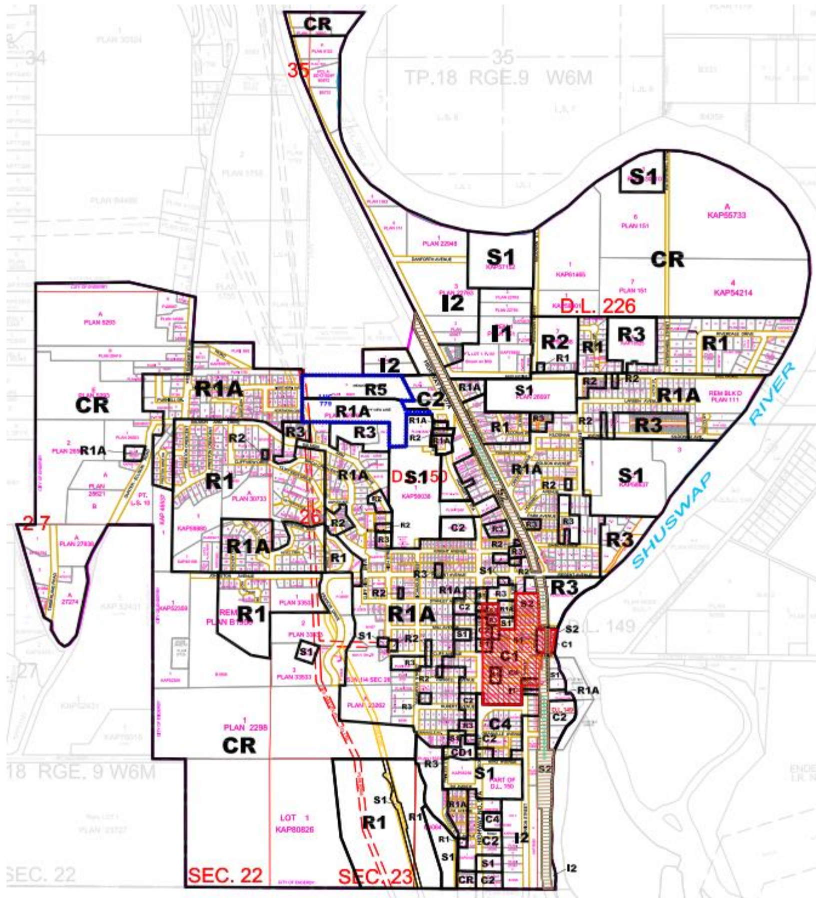


Figure 4-5: Existing zoning bylaw schedule "H" - Zoning map (City of Enderby, 2015b)

The Development Bylaw outlines various standards, specifications, and minimum requirements for all subdivision approvals and building permit applications. Except for some "layout review" checks in Schedule "B", only Schedule "A" of the Development Bylaw directly references riverine flooding. Schedule "A" includes design standards for roads, walkways, water supply, sanitary sewers, storm drainage, and street lighting. The standards address general water management and flooding best practices and are intended to address localized minor and major storm system design, not riverine flooding. Despite this, the bylaw does directly reference and require consideration of "flood level" for the design of pump stations. Additionally, the bylaw requires that all major storm system designs consider the 1/200-year floodplain (City of Enderby, 2000).

4.3.4.1 City Zoning and Development Bylaw – Future Strategies

According to the Flood Hazard Area Land Use Management guidelines, "local governments are responsible for understanding the risks of flooding in their areas and make appropriate land-use decisions so that developments are built in a manner that limits flood damage and ensures public safety." The document goes on to affirm that the incorporation of flood risk management principals and standards into development bylaws may be "the key requirement of land use planning" (FLNRORD, 2018).

City bylaws and provisions for water body requirements are already in place, include consideration of the Flood Hazard Area Land Use Management Guidelines, and give due consideration to responsibilities outlined in applicable Acts (such as the Riparian Areas Protection Act and the Local Government Act). Despite this, new amendments to regulations have occurred since the last amendment to the Zoning Bylaw. Additionally, the new flood mapping information generated as part of this project needs to be referenced in the City's bylaws.

In alignment with the OCP floodplain update recommendations, the Zoning Bylaw's Schedule G.1 and G.2 should be updated to include newly available flood mapping and should include both the 1/200-year and 1/20-year mapping so that more prescriptive and flexible design standards may be made for less critical infrastructure, if required. Additionally, flood definitions[49] should be updated to reference the new mapping in accordance with appropriate design standards or accepted risk tolerances (i.e., either the 1/200-year or 1/20-year). For example, "flood construction level" may be defined for both the 1/200-year or the 1/20-year so that either a 1/200-year or 1/20-year flood construction level may be easily prescribed as a standard in bylaws.

The recommendations above allow the City to incorporate a flexible risk tolerance and standard-based design criteria. For example, a 1/200-year flood level may be specified for most new infrastructure and development; however, reduced design criteria may be defined using the 1/20-year flood for non-critical infrastructure or low-risk components of development. This is also useful in cases where 1/20-year flood level criterion is preferred such as in the design of sewerage (septic) systems. As an example, Section II-4.1.5 of the Sewerage System Standard Practice Manual requires that septic systems be designed to minimum elevations that reference the 1/20-year flood (Province of BC, 2014b). In this case, the City could easily prescribe reduced and commensurate design standards for sewerage systems using the 1/20-year flood mapping.

Finally, the Development Bylaw references the flood definitions in the Zoning Bylaw. Therefore, the Development Bylaw should also be updated to reflect the changes of the Zoning Bylaw and OCP updates, so that all prescriptive design requirements are consistent and correctly referenced.

4.3.5 Emergency Response and Management

The City has legislated emergency management requirements that it fulfills through a program established by bylaw. The program is established with Council as the policy body and an Emergency Program Management Committee as the operational and technical body. Together,

[49] Refers to the terms "designated flood", "designated flood level", "flood construction level", "floodplain", "floodplain setback", etcetera.

these entities are responsible for emergency mitigation, preparedness, response and recovery (City of Enderby, 2016) (City of Enderby, 2020).

Per the City website, “The City of Enderby delivers emergency management during major incidents. This may include Emergency Operations Centre activation, emergency social services (delivered under contract with Red Cross), evacuations, and coordination of resources and agencies involved in response and recovery” (City of Enderby, 2021). The Emergency Program Management Committee is responsible for the operation of the City’s Emergency Operations Centre (EOC) and status updates are provided to the public via the City’s emergency management dashboard, which provides a simple and easy-to-use summary of orders and declarations, closures and restrictions, and situation reports, as well as valuable resources for the community (City of Enderby, 2021). Available links to the flood-related emergency resources are as follows:

- Flood Preparedness Guide
- Household Preparedness Guide
- Home Emergency Plan
- PreparedBC: Guide for Small Businesses
- Household emergency kit and grab-and-go bag

Emergency response is directed by an Emergency Plan (EP) adopted by the City. The EP is periodically reviewed and amended based on updates to the City’s Hazard, Risk and Vulnerability Analysis (HRVA) and the outcomes of After Action Reviews.

4.3.5.1 Emergency Response – Future Strategies

With the new flood mapping and risk assessment information now available, and to the extent of a material change from the previous flood maps and risk assessment, the EP should be updated to consider new potential impacts to infrastructure and vital structures (Section 3.5). Of note, there is risk to electrical power, potable water, wastewater, and road crossings, as well as the Public Works Yard on McGowan Street, which will impact operations staff. Newly delineated areas for potential flood hazards should also be considered when designating suitable sites for the distribution of flood supplies.

The HRVA should be reviewed and, to the extent necessary, updated based on the findings of this report.

4.3.6 Integrated Flood Management Planning

To date, the City has implemented significant passive flood mitigation measures (non-structural), including various bylaws that support flood risk mitigation and emergency response. In fact, when comparing the City to many other BC local governments of a similar size, the City has made relatively good progress in developing and implementing a regulatory framework to support flood risk mitigation. Despite this, the City does not have an IFMP to describe and prioritize its flood mitigation objectives on a comprehensive basis (per Figure 4-1 and Section 4.2).

4.3.6.1 Integrated Flood Management Planning – Future Strategies

As stated above, flood risk mitigation planning "is the process by which a community reflects on its identified risks, and uses this information to make informed planning decisions." As such, it is recommended that an IFMP is developed in the context of the risk assessment findings in this report, such that it achieves a balanced, feasible, and cost-effective approach to flood risk mitigation in accordance with the recommended NDMP steps summarized in Section 4.2.

An IFMP does not need to be overly complicated. Conversely, the IFMP may be simple, so long as it contains a clear definition of the City's tolerable risk supported by objectives. The document should be a living document that evolves and provides a roadmap identifying tangible approaches to achieving measurable target objectives. These objectives typically consist of active mitigation measures first, such that future development and construction meets the City's accepted tolerable risk. Once a clear framework of tolerable risk is developed[50], structural mitigation efforts (physical protections or modifications to existing works) are then prioritized based on feasibility and net benefit[51] (based on loss estimation analysis).

4.4 Structural Mitigation

Structural mitigation is defined as "physical measures designed to mitigate the impact of hazards (e.g., channel improvement [construction of floodways and dykes], flow regulation [diversions, creating upstream storage], flood-proofing measures [reinforcing or raising homes to minimize vulnerability to floods])" (Government of Canada, 2018).

At the present time, the City has registered channel improvements on the Shuswap River between the Enderby Mabel Lake Road (Cliff Avenue) and Regent Avenue (BC Data Catalogue, 2004). Figure 4-6 shows the location of existing elevated diking (red linework) and protection works (purple linework). According to the FLNRORD Dike Safety Program database of "Dikes Listed by Authority", the works are noted as "non-DMA", and the structure type is listed as "Erosion Protection" (Province of BC, 2021). As such, Interior Dams understands that the works are not regulated under the Dike Maintenance Act (DMA). Of note, the 1/200-year flood overtops these works at the north end of the diking near the corner of Regent Avenue. This location is noted on Figure 4-6.

[50] The OCP identifies an accepted flood risk tolerance consistent with the 1/200-year event. Per recommendations in Section 4.3.4, the 1/20-year flood event may be appropriate for certain infrastructure and development.
[51] Each structural mitigation project, whether it be dike construction, modification of existing infrastructure to improve resilience, etcetera, should be evaluated based on the cost of implementation compared to the reduction of risk. Reduction of risk is determined by loss estimation analysis.

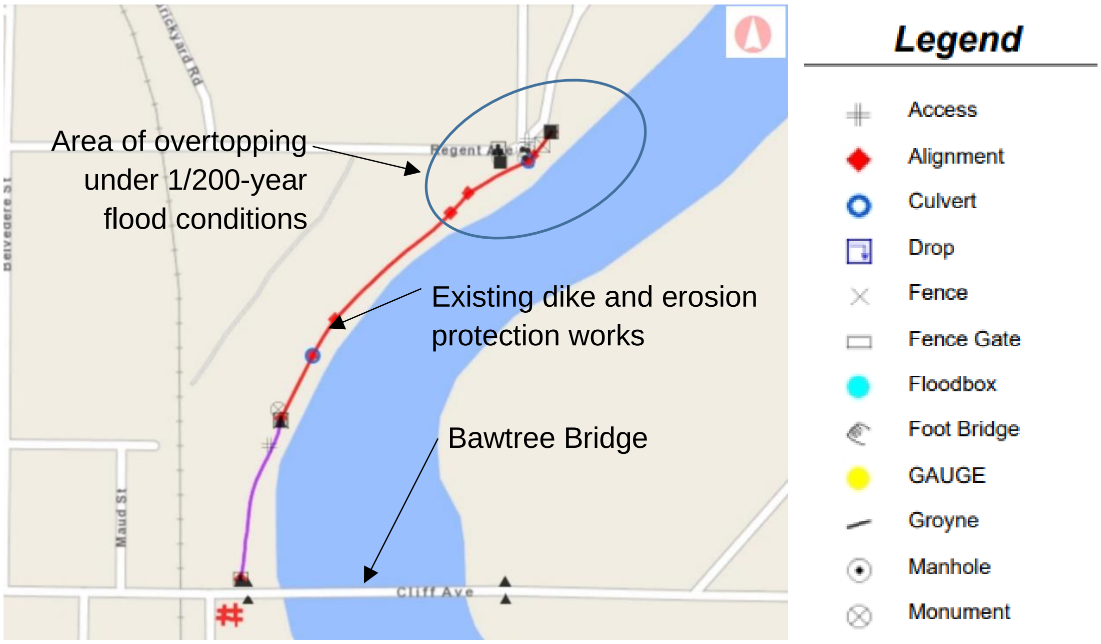


Figure 4-6: Existing erosion protection works, no dikes (BC Data Catalogue, 2004)

4.4.1 Structural Risk Mitigation – Future Strategies

As quoted above, "A significant portion of the City lies within the [previously designated 200/year floodplain]" (City of Enderby, 2014a). If the City were to adopt a risk tolerance that corresponds to the new 1/200-year flood for all types of works in the entire City (includes all existing works, regardless of criticality), this would imply that the entire City should be protected from the mapped 1/200-year flood hazard. Referencing the new flood maps in Appendix II, this level of protection would likely require an extensive diking system across the entire City. The diking system would need to be constructed on land that has various types of ownership (private, municipal, provincial, etcetera), land uses (residential, agricultural, commercial, etcetera), and would extend into other jurisdictional boundaries. The Riverdale Drive area would be particularly challenging since current best practices for dike construction now requires significant riparian setbacks, and land is privately owned up to the banks of the Shuswap River. As such, this level of adopted risk tolerance for all types of works may not be feasible for the City, and merits further consideration in the context of an IFMP development process which may include stakeholder engagement (refer to Section 4.3.6).

As an alternative to the above, the City may adopt a 1/200-year risk tolerance but recognize that it may not be possible or feasible to achieve this for all existing works. Through stakeholder engagement (refer to IFMP discussion Section 4.3.6.1), the City could review the new risk assessment information and prioritize high-risk neighbourhoods and infrastructure that could be protected by localized or focused structural mitigation works. Each structural mitigation project could then be evaluated and prioritized on the merits of cost versus benefit, whereby the project(s) that demonstrate the largest total risk mitigated compared to the total cost of implementation would be constructed.

Based only on a preliminary screening-level review of available options, Interior Dams recommends further investigation into the feasibility of constructing a raised partial diking system where the flood protection works currently exist. Based on the 1/200-year water depth map, the dike may only need to be raised approximately one metre (1 m) or less. The total alignment is 600-metre long, and only approximately 170-metres of this alignment would need to be significantly raised (near the corner of Regent Avenue). Figure 4-7 illustrates the conceptual dike alignment and the expected flood risk mitigation area.

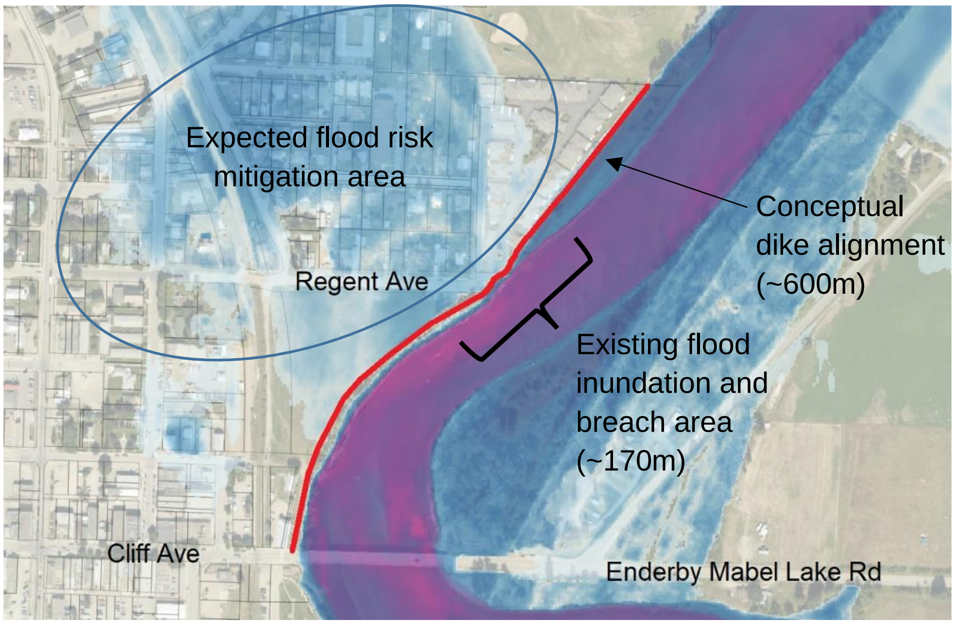


Figure 4-7: Conceptual dike alignment for partial flood risk mitigation

This conceptual partial dike system may have significant advantages due to its reduced cost, simplified approval process (compared to a City-wide dike system), and effectiveness at mitigating flood risk. Although this would not mitigate all risks associated with the 1/200-year hazard, it would significantly reduce potential impacts to the downtown core and would not likely transfer any additional risk to other residents.

Interior Dams believes that the City should further investigate the partial diking system concept, as well as other localized or focused structural mitigation works for other high-risk areas of the City. It is recommended that these active mitigation works be evaluated and prioritized within the framework of an IFMP as it is anticipated that an effective and balanced IFMP will be the key to identifying feasible strategies that will significantly reduce the risk to the community of Enderby.

FINDINGS AND RECOMMENDATIONS

4.5 Key Findings

Based on the information reviewed and analysis conducted, the following information summarizes key findings:

1. The resulting climate-factored 1/200-year and 1/20-year annual daily maximum flows for the Shuswap River[52] are estimated to be 781.3 m^3/s and 613.8 m^3/s, respectively (refer to Section 2.5 for confidence intervals and determination methods);
2. The estimated impact from the 1/200-year flood to individuals and organizations of the community of Enderby include:
    - Total monetary losses of $54,092,823 (People and Society - $43,133,043, Local Economy - $5,626,270, and Local Infrastructure - $5,333,510) (Section 3.3),
    - Loss of functionality (full or partial) to the following infrastructure systems: electrical power, local roads, wastewater, and potable water systems (Section 3.5),
    - Contamination of water and wetland and possible impact to red-listed species (no permanent environmental loss) (Section 3.1)
    - Direct impact to three heritage sites and recreational sites including Tuey Park and the Jim Watt Heritage River Walk (days to weeks of recovery) (Section 3.2), and
    - Risk to human health and safety due to increased potential for water contamination and drowning (Section 3.3.2);
3. The City of Enderby Official Community Plan Bylaw No. 1549 (“the OCP”), Zoning Bylaw No. 1550 (“the Zoning Bylaw”), and Subdivision Servicing and Development Bylaw No. 1278 (“the Development Bylaw”) pre-date the flood mapping and risk assessment work contained within this report has become out-of-date (Section 4.3.3 and 4.3.4).

4.6 Recommendations

In support of further development and implementation of existing flood management planning and risk mitigation initiatives, Interior Dams provides the following recommendations:

1. Develop a balanced[53] and dedicated integrated flood management plan (IFMP)[54] to include achievable and prioritized objectives to improve flood protection and explore grant opportunities for the preparation and implementation of this plan (Section 4.2, 4.3.6, 4.1.3), and:
    - In the interim to receiving any grants or completing an IFMP, prepare Class D cost estimates for priority flood mitigation options and activities[55], with priority

[52] At the location of the Bawtree Bridge (Enderby Mabel Lake Road Bridge).
[53] The IFMP needs to be balanced between other regulatory, community, or stakeholder objectives (i.e., Riparian Areas Protection Act, budgetary constraints, etcetera).
[54] An IFMP does not need to be a large document; rather, it may be short or even just a few pages so long as it is practical and facilitates execution of flood protection and mitigation objectives. The document is intended to be a living City document that sets practical objectives and prioritized achievable tasks (such as the recommendations provided in this document, if adopted).
[55] This includes structural and non-structural mitigation options and also includes the preparation of the IFMP.

given to areas of elevated flood risk demonstrated by the flood mapping and risk assessment (Section 2.8 and 3.6);

2. Review and update the OCP as follows:
    - Adopt the designated floodplain in Schedule "C" using the new 1/200-year flood maps (Section 4.3.3),
    - Amend flood-related references[56], definitions, and terminology to remain consistent across City bylaws (Section 4.3.3), and
    - Review the designated growth areas in the context of flood risk and IFMP goals and update if necessary (Section 4.3.3);
3. Review and update the following City bylaws:
    - The Zoning Bylaw's Schedules "G.1" and "G.2" should include both the 1/200-year and 1/20-year flood mapping information (Section 4.3.4),
    - The Zoning Bylaw's flood-specific definitions should include both the 1/200-year and 1/20-year flood mapping information (Section 4.3.4),
    - The Zoning Bylaw and the Development Bylaw should have their flood-related and regulatory references updated to maintain consistency with the OCP (Section 4.3.4), and
    - Evaluate whether there are cases where the Zoning Bylaw and/or the Development Bylaw should be altered to use the 1/20-year flood map as a more appropriate risk tolerance;
4. Review and investigate all structural risk mitigation options, and if appropriate, set achievable and measurable targets to implement options within the IFMP (Section 4.4.1 and 4.3.6);
5. Update the City of Enderby Emergency Plan's Hazard, Risk and Vulnerability Analysis (HRVA) for flooding based on the findings in this report, and make any consequential changes to the Emergency Plan that may result from the HRVA update (Section 4.3.5); and
6. Conduct a formal review of the IFMP, flood mapping, risk assessment, land use planning, regulation, and development bylaws every ten (10) years and update if necessary.

[56] Includes regulatory, City or other references.

5 REFERENCES

AECOM. (2017). *National Principals, Best Practices and Guidelines - Flood Mapping (Draft).* Natural Resources Canada.

APEGBC. (2017). *Flood Mapping in BC-APEGBC Profesional Practice Guidelines.* Vancouver: Association of Professional Engineers and Geoscientists of BC.

Austin, S. A. (1999). *Streamflow response to forest management: a meta-analysis using published data and flow duration curves.* Fort Collins, CO.: Colorado State University.

B. Cowan. (1998). *A History of Enderby.* Enderby, BC: Enderby & District Museum & Archives.

B. Cowan. (2020, 07 29). *The Naminig of Enderby.* Enderby, BC: Enderby & District Museum & Archives. Retrieved from https://enderbymuseum.ca/snaphist.php

BC. (2016). *British Columbia Dam Safety Regulation - B.C. Reg 40/2016 as amended.* Victoria, British Columbia, Canada: Queens Printer.

BC Assessment. (2021). Retrieved from Property Assessment Data: https://www.bcassessment.ca/Property/AssessmentSearch

BC CDC. (2020, 11 28). *Conservation Data Centre (CDC) iMap Web Application*. Retrieved May 17, 2017, from http://maps.gov.bc.ca/ess/hm/cdc/

BC Data Catalogue. (2004). *Flood Protection Works - Structural Works.* Victoria, BC: Province of British Columbia.

BC Hydro. (2005). *Shuswap River Water Use Plan (Shuswap Falls & Sugar Lake Project).* Burnaby, BC: BC Hydro.

BC Land Title & Survey. (2020). *Parcel Map BC.* Retrieved from myLTSA: https://ltsa.ca/online-services/parcelmap-bc

BC Maps Online. (n.d.). *Orthophoto (various) - Compilation Scale 1:20000.* Victoria, BC: British Columbia Air Photos.

BC Water Resources Atlas. (2020, 10 22). Retrieved from http://maps.gov.bc.ca/ess/hm/wrbc/

Bedient, P, et al. (2008). *Hydrology and Floodplain Analysis - Fourth Edition.* Upper Saddle River, NJ: Prentice Hall.

CDA. (2007-2016). *Dam Safety Guidelines - Technical Bulletins.* Canadian Dam Association.

City of Enderby. (2000). *Subdivision Servicing and Development Bylaw No. 1278, 2000.* Enderby, BC: City of Enderby.

City of Enderby. (2012). *Historical Walking Tour of Enderby.* Enderby: Enderby and District Museum Society.

City of Enderby. (2014). *Corporation of the City of Enderby - Bylaw No. 1549, 2014.* Enderby, BC: City of Enderby.

City of Enderby. (2014). *Wastewater Annual Report 2014.* Enderby: City of Enderby.

City of Enderby. (2014a). *Official Community Plan Report - The Corporation of the City of Enderby - Schedule 'A' to the Corporation of the City of Enderby - OCP Bylaw No. 1549, 2014.* Enderby, BC: City of Enderby.

City of Enderby. (2014b). *Official Community Plan Bylaw No. 1549, 2014 - Schedule 'B' - Land Use Designation Map.* Enderby, BC: City of Enderby.

City of Enderby. (2014c). *Official Community Plan Bylaw No. 1549, 2014 - Schedule 'C' - Parks & Transporation Map.* Enderby, BC: City of Enderby.

City of Enderby. (2014d). *Regional Growth Strategy Congruency Analysis - Schedule 'D' to the Corporation of the City of Enderby OCP Bylaw No. 1549, 2014.* Enderby, BC: City of Enderby.

City of Enderby. (2014e). *Official Community Plan Bylaw No. 1549, 2014 - Schedule 'E" - Regional Growth Strategy Designation Map.* Enderby, BC: City of Enderby.

City of Enderby. (2015b). *Zoning Map.* Enderby, BC: City of Enderby.

City of Enderby. (2016). *Enderby Emergency Program Bylaw No. 1616, 2016.* Enderby, BC.

City of Enderby. (2018, May 21). *Enderby EOC Situation Report*. Retrieved from Historical Situation Reports: https://www.cityofenderby.com/wp-content/uploads/2018/05/May-21-2018-Bench-and-Metal-Fish

City of Enderby. (2018-2019, May). *Enderby EOC Situation Reports*. Retrieved from City of Enderby: https://www.cityofenderby.com/historical-situation-reports/

City of Enderby. (2019). *Drinking Water Annual Report 2019.* Enderby: City of Enderby.

City of Enderby. (2020). *Enderby Housing Needs Assessment Report.* Enderby: City of Enderby.

City of Enderby. (2020). *Request for Proposal - City of Enderby Flood mapping and Risk Mitigation.* Enderby, BC.

City of Enderby. (2020). *The Corporation of the City of Enderby, Bylaw No. 1694 - A bylaw to amend the City of Enderby Emergency Program Bylaw No. 1616, 2016.* Enderby, BC.

City of Enderby. (2021, 02). *Emergency Management*. Retrieved from https://www.cityofenderby.com/city-hall/protective-services/emergency-management/

City of Enderby. (2021, 02). *Protective Services*. Retrieved from City of Enderby Website: https://www.cityofenderby.com/city-hall/protective-services/

City of Enderby. (n.d.). *Emergency Support Services (ESS).* Enderby, BC: City of Enderby.

CN. (2018, 12 7). *CN - Network Map*. Retrieved from http://cnebusiness.geomapguide.ca/

CP. (2018, 12 7). *CP Network Map*. Retrieved from https://www.cpr.ca/en/choose-rail-site/Documents/cp-network-map-2018.pdf

Digital Globe. (n.d.). *Orthophoto (various).* Google Earth Pro v7.3.2.5495.

Digital Globe. (n.d.). *Street Mapping.* Google Earth Pro v7.3.2.5495.

Ecoscape. (2011). *Lower Shuswap River Inventory, Mapping, and Auqatic Habitat Index.* Kelowna, BC: Ecoscpe Environmental Consultants Ltd.

EGBC. (2018). *Legislated Flood Assessments In a Changing Climate In BC.* Vancouver: Engineers and Geoscientists British Columbia.

Environment Canada. (1993). *Consolidated Frequency Analysis Software Version 3.1 - Reference Manual.* Ottawa, Ontario: Surveys and Information Systems Branch.

Environment Canada. (2020). *Environment Canada Data Explorer Version 2.1.8.* Water Survey Canada.

FEMA. (2001). *Multi-hazard Loss Estimation Methodology: Hazus-MH Technical Manual.* Washington, DC: Department of Homeland Security - Mitigation Division.

FLNRORD. (2016). *Downstream Consequence of Failure Classification Interpretation Guideline for Dam Safety Officers.* Dam Safety Program.

FLNRORD. (2017, March). *Forest Tenure Administration.* Retrieved from Farming, Natural Resources & Industry: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/timber-tenures/tfl_tsa_district_map.pdf

FLNRORD. (2018, September 12). *Flood Hazard Area Land Use Management*. Retrieved from https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/drought-flooding-dikes-dams/integrated-flood-hazard-management/flood-hazard-land-use-management

FLNRORD. (2020). *Automated and Manual Snow Survey Data.*

FLNRORD. (2020b, November). *Mineral Titles Online*. Retrieved from https://www.mtonline.gov.bc.ca/mtov/home.do

FLNRORD. (2020c, November 25). *Obtaining Access to RAAD*. Retrieved from Remote Access to Archaeological Data Application: https://www.for.gov.bc.ca/archaeology/accessing_archaeological_data/obtaining_access.htm

FLNRORD. (2020d, November). *Strategic Land Policy and Legislation.* Retrieved from Range Tenure: https://catalogue.data.gov.bc.ca/dataset/range-tenure

Forsite. (2018). *Enderby Community Wildfire Protection Plan.* Salmon Arm, BC: Forsite Consultants Ltd.

Fulton, R. e. (1974). *Surficial Geology - Suswap Lake Map 1391A.* Victoria, BC: Geological Survey of Canada - Department of Energy, Mines and Resources.

GeoBC. (2021, May). *Emergency Social Service Facilities*. Retrieved from BC Data Catalogue: https://catalogue.data.gov.bc.ca/dataset/8473689f-2d06-4e84-ac8b-e91033fd0f0b

GeoBC. (2021, 01). *Trim Transportation Lines.* Retrieved from BC Data Catalogue: https://catalogue.data.gov.bc.ca/dataset/trim-transportation-lines

Global. (2020, June 7). *News: Enderby residents face localized flooding*. Retrieved from Global News: https://globalnews.ca/video/7037515/enderby-residents-face-localized-flooding

Golder. (2012). *Technical Assessment of the Shuswap Watershed.* Vancouver, BC: Golder Associated Ltd.

Government of Canada. (2018, October 20). *Public Safety Canada.* Retrieved from National Disaster Mitigation Program (NDMP) Guidelines: https://www.publicsafety.gc.ca/cnt/mrgnc-mngmnt/dsstr-prvntn-mtgtn/ndmp/prgrm-gdlns-en.aspx#a34

GSR Betts. (2012). *Our Enderby: Building a Sustainable Fugure.* Enderby, BC: GSR Betts Consulting Inc.

Hirsch, R. (1979). An Evaluation of Some Record Reconstruction Techniques. *Water Resources Research*, 1081-1088.

Ministry of Citizens' Services. (2020). *ParcelMap BC Parcel Fabric.* Retrieved from BC Data Catalogue: https://catalogue.data.gov.bc.ca/dataset/4cf233c2-f020-4f7a-9b87-1923252fbc24

Ministry of Environment. (1957). *Conditional Water Licence 23643 (superseded by C066582).* Kamloops, BC: Department of Lands and Forests.

Ministry of Environment. (1989). *Conditional Water Licence 66582 - File No. 0213837.* Kamloops, BC: Water Management Branch.

Ministry of Health. (2021, May). *BC Health Care Facilities*. Retrieved from BC Data Catalogue: https://catalogue.data.gov.bc.ca/dataset/8912ec4f-b87f-4056-a2d0-e019e045b53a

MOE & DFO. (1999). *Environmental Guidelines for Vegatation Management on Flood Protection Works to Protect Public Safety and the Environment.* BC Ministry of Environment, Lands and Parks & Department of Fisheries and Oceans Canada.

MOTI. (2013). *Construction and Rehabilitation Cost Guide.* Ministry of Transportation.

MWLAP. (2004). *Flood Hazard Area Land Use Management Guidelines.* Province of British Columbia: Ministry of Water, Land and Air Protection (2018 Amendment).

NRC. (1989). *Hydrology of Floods in Canada - A Guide to Planning and Design.* Ottawa, ON: Associate Committee on Hydrology.

NRC. (2017). *Canadian Guidelines and Database of Flood Vulnerability Functions (Draft).* Government of Canada: Public Safety Canada.

OBWB. (2012). *Phase 3 Projected Water Supply and Use in the Okanagan Basin (2011-2040) - Okanagan Basin Water Accounting Models.* Victoria, BC: Natural Resources Canada. Retrieved from https://www.obwb.ca/fileadmin/docs/okanagan_instream_flow_needs_analysis_essa.pdf

Our Enderby. (2018). *Our Enderby - Community Facebook Page*. Retrieved from https://www.facebook.com/OurEnderby/

Prepared BC. (n.d.). *Flood Preparedness Guide.* Province of British Columbia.

Province of BC. (1999). *Flood Planning and Response Guide for British Columbia.* Water Management Branch - Provincial Emergency Program.

Province of BC. (2014a). *Terrain Resource Information Management (TRIM) - Contour Mapping (1:20,000 Scale).* Victoria, BC: BC Data Catalogue.

Province of BC. (2014b). *Sewerage System Standard Practice Manual Version 3.0.* Health Protection Branch, Ministry of Environment.

Province of BC. (2015). *Local Government Act [RSBC 2015] Chapter 1.* Victoria, British Columbia: Queen's Printer.

Province of BC. (2016a). *Indicators of Climate Change for British Columbia - 2016 Update.* Ministry of Environment.

Province of BC. (2016b). *Riparian Areas Protection Act.* Victoria, BC: Queen's Printer.

Province of BC. (2018, October 21). *Climate Change - Change in Snowpack BC*. Retrieved from British Columbia - Environmental Reporting BC: http://www.env.gov.bc.ca/soe/indicators/climate-change/snow.html

Province of BC. (2018, November 14). *Residential Tenancy Act [SBC 2002] Chapter 78*. Retrieved from http://www.bclaws.ca/civix/document/id/complete/statreg/02078_01

Province of BC. (2018a). *Water Sustainability Regulation.* Victoria: Queen's Printer.

Province of BC. (2020). *Preliminary Strategic Climate Risk Assessment for British Columbia.* Victoria, BC: cleanBC.

Province of BC. (2021). *Dikes Listed by Authority.* Retrieved from Dike Management: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/integrated-flood-hazard-mgmt/dikes_listed_by_ownerauthority.pdf

Province of British Columbia. (2014). *Terrain Resource Information Management (TRIM) - Contour Mapping (1:20,000 Scale).* Victoria, BC: BC Data Catalogue.

Province of Ontario. (2005). *Water and Wastewater Asset Cost Study.* Orangeville, ON: Ministry of Public Infrastructure Renewal.

RDNO. (2012, July). *Digital Data.* Retrieved from Orthophoto: http://www.rdno.ca/index.php/maps/digital-data/orthos

RDNO. (2020). *Digital Data.* Retrieved from Contours: http://www.rdno.ca/index.php/maps/digital-data/contours

Regional District of North Okanagan. (1975). *Shuswap River Study.* Coldstream, BC: Planning Department, Regional District of North Okanagan.

Schnorbus, M., Bennett, K., Werner, A. (2010). *Quantifying the Water Resource Impacts of Mountain Pine Beetle and Associated Salvage Harvest Operations across a Range of Watershed Scales: Hydrologic Modelling of the Fraser River basin. Information Report: BC-X-423.* Victoria, BC: Natural Resources Canada, Canadian Forestry Service, Pacific Forestry Centre.

Schnorbus, M.A., Winkler, R.D. and Y. Alila. (2004). *Modeling Forest Harvesting Effects on Maximum Daily Peak Flow at Upper Penticton Creek. Extension Note No. 67.* Ministry of Forests - Forest Science Program.

SEC. (1996). *Final Report Watershed Restoration Program Upper Shuswap River Stream Assessment. Prepared for BC Ministry of Environment, Lands, and Parks.* Vernon, BC: Summit Environmental Consultants Ltd.

SRA. (2020, 10). *Shuswap River Ambassadors*. Retrieved from https://www.facebook.com/EnderbyRA/

StatCan. (2017, October 25). Housing in Canada: Key results from the 2016 Census. Ottawa, Canada.

Statistics Canada. (2016). *Canadian Industry Statistics.* Ottawa, ON: Government of Canada.

Statistics Canada. (2020, December 4). *Road Motor Vehicle Registrations by Type of Vehicle*. Retrieved from https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2310006701

U.S. Department of the Interior Bureau of Reclamation. (2015). *Reclamation - Managing Water in the West: Reclamation Consequence Estimating Methodology (RCEM): Guidelines for Estimating Life Loss for Dam Safety Risk Analysis (Interim).*

UACE. (1992). *Hydrologic Engineering Centre - Flood Frequency Analysis (HEC-FFA) User's Manual.* Davis, CA: US Army Corps of Engineers - Institute for Water Resources Hydrologic Engineering Centre.

USACE. (2010, January). HEC-RAS River Analysis System - Hydraulic Reference Manual V4.1. Davis, California, United States.

USACE. (2014). *Using HEC-RAS for Dam Break Studies.* Davis, CA: US Army Corps of Engineers, Institute of Water Resources, Hydrologic Engineering Centre.

USACE. (2016). *HEC-RAS River Analysis System - 2D Modeling User's Manual Version 5.0.* US Army Corps of Engineers.

USACE. (2016a). *HEC-SSP Statistical Software Package - User Manual.* Davis, CA: Institute for Water Resources.

USBR. (1988). *Acer Technical Memorandum No. 11 - Downstream Hazard Classification Guidelines.* Denver, CO: Assistant Commissioner - Engineering and Research.

USBR. (2015). *Reclamation - Managing Water in the West: Reclamation Consequence Estimating Methodology (RCEM): Guidelines for Estimating Life Loss for Dam Safety Risk Analysis (Interim).* U.S. Department of the Interior Bureau of Reclamation.

USGS. (2018). *Guidelines for Determining Flood Flow Frequency Bulletin 17C - Techniques and Methods 4-B5.* Reston, VA: US Department of the Interior & US Geological Survey.

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APPENDIX I: SUPPORTING FLOOD MAPPING DATA

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Field photographs of Shuswap River:

Figure AI-1: Confluence of Fortune Creek and Shuswap River (2020)

Figure AI-2: Bawtree Bridge on Shuswap River in Enderby (2020)

Figure AI-3: Highway 97A/Young Street Bridge on Shuswap River in Grindrod (2020)

Hydrometric Annual Maximum Streamflow – Dataset Checks:

```
       --- SPEARMAN TEST FOR INDEPENDENCE ---

08LC002          Shuswap River Near Enderby
ANNUAL MAXIMUM DAILY FLOW SERIES  1912 TO 2020  DRAINAGE AREA =  4720.000

SPEARMAN RANK ORDER SERIAL CORRELATION COEFF =  .031    D.F.= 78
                   CORRESPONDS TO STUDENTS T =  .278
                CRITICAL T VALUE AT 5% LEVEL = 1.667    NOT SIGNIFICANT
                    -    -    -    -  1%   -  = 2.380    NOT SIGNIFICANT

Interpretation: The null hypothesis is that the correlation is zero.

At the 5% level of significance, the correlation is not significantly
different from zero.  That is, the data do not display significant
serial dependence.



       --- RUN TEST FOR GENERAL RANDOMNESS ---

08LC002          Shuswap River Near Enderby
ANNUAL MAXIMUM DAILY FLOW SERIES  1912 TO 2020  DRAINAGE AREA =  4720.000

THE NUMBER OF RUNS ABOVE AND BELOW THE MEDIAN (RUNAB) = 43
      THE NUMBER OF OBSERVATIONS ABOVE THE MEDIAN(N1) = 41
      THE NUMBER OF OBSERVATIONS BELOW THE MEDIAN(N2) = 41

(NOTE: Z IS THE STANDARD NORMAL VARIATE.)

For this test, Z =   .222
Critical Z value at the 5% level = 1.960            NOT SIGNIFICANT

Interpretation: The null hypothesis is that the data are random.

At the 5% level of significance, the null hypothesis cannot be
rejected. That is, the sample is significantly random.
```

```
  --- MANN-WHITNEY SPLIT SAMPLE TEST FOR HOMOGENEITY ---

08LC002          Shuswap River Near Enderby
ANNUAL MAXIMUM FLOW SERIES  1912 TO 2020   DRAINAGE AREA=  4720.000

SPLIT BY TIME SPAN, SUBSAMPLE 1 SAMPLE SIZE= 24
                    SUBSAMPLE 2 SAMPLE SIZE= 59

(NOTE: Z IS THE STANDARD NORMAL VARIATE.)
                        For this test, Z = -1.195
CRITICAL Z VALUE AT 5% SIGNIFICANT LEVEL = -1.645    NOT SIGNIFICANT
   -     -   -   -  1%      -        -   = -2.326    NOT SIGNIFICANT

Interpretation: The null hypothesis is that there is no
                location difference between the two samples.

At the 5% level of significance, there is no significant
location difference between the two samples. That is, they
appear to be from the same population.


      --- SPEARMAN TEST FOR TREND ---

08LC002          Shuswap River Near Enderby
ANNUAL MAXIMUM DAILY FLOW SERIES  1912 TO 2020  DRAINAGE AREA =  4720.000

SPEARMAN RANK ORDER CORRELATION COEFF =  .102    D.F.= 81
            CORRESPONDS TO STUDENTS T =  .919
        CRITICAL T VALUE AT 5% LEVEL = 1.993    NOT SIGNIFICANT
            -    -   -   -  1%   -   = 2.645    NOT SIGNIFICANT

Interpretation: The null hypothesis is that the serial(lag-one) correlation
                is zero.

At the 5% level of significance, the correlation is not significantly
different from zero. That is, the data do not display significant
trend.
```

Statistical Frequency Analysis – CFA Solution Check:

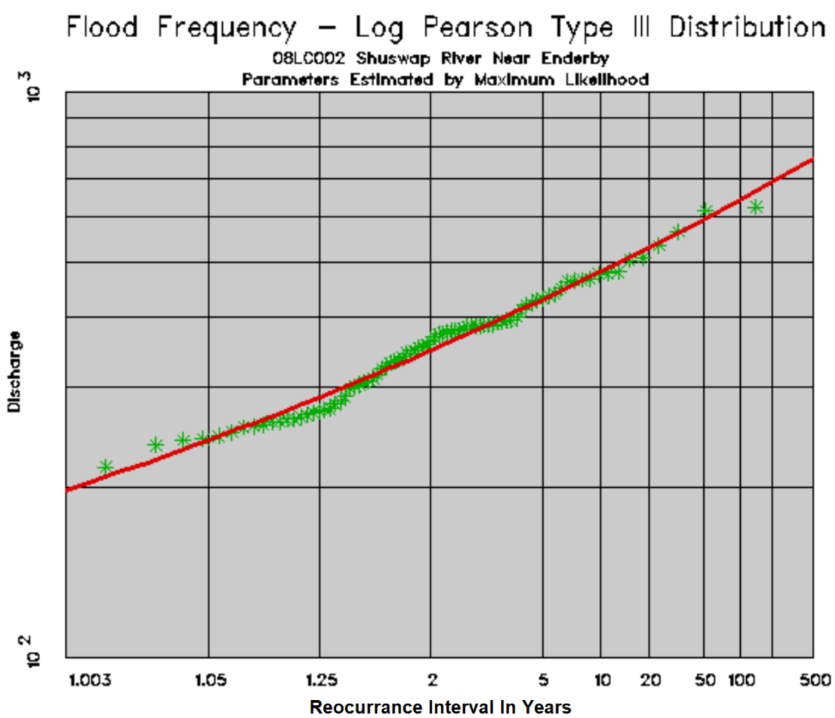
FREQUENCY ANALYSIS - LOG PEARSON TYPE III DISTRIBUTION
08LC002 Shuswap River Near Enderby

SAMPLE STATISTICS

	MEAN	S.D.	C.V	C.S.	C.K.
X SERIES	362.518	88.310	.244	.712	3.559
LN X SERIES	5.865	.238	.041	.144	2.595

X(MIN)= 217.000
X(MAX)= 626.000
LOWER OUTLIER LIMIT OF X= 174.429

TOTAL SAMPLE SIZE= 83
NO. OF LOW OUTLIERS= 0
NO. OF ZERO FLOWS= 0



```
         SOLUTION OBTAINED VIA MAXIMUM LIKELIHOOD
 LP3 PARAMETERS: A=   .3398E-01 B=   48.92      LOG(M)=   4.203
                                                    M =   66.86
```

FLOOD FREQUENCY REGIME

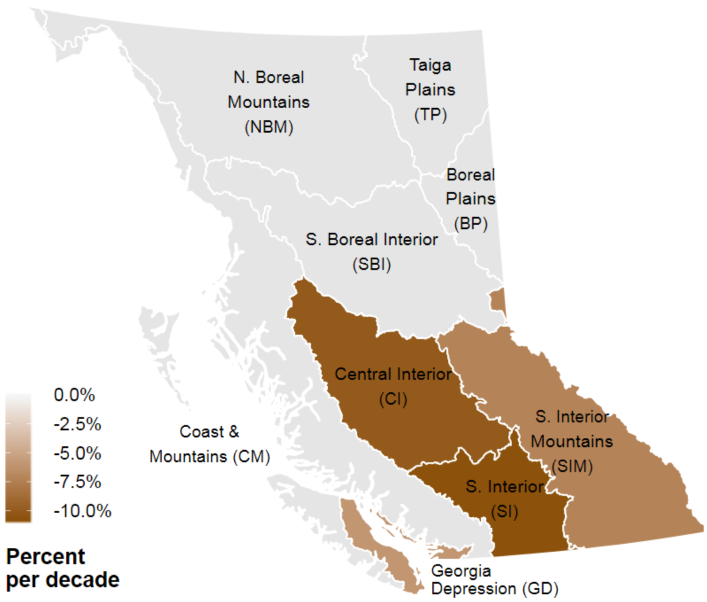
RETURN PERIOD	EXCEEDANCE PROBABILITY	FLOOD
1.003	.997	197
1.050	.952	242
1.250	.800	288
2.000	.500	348
5.000	.200	429
10.000	.100	481
20.000	.050	531
50.000	.020	595
100.000	.010	644
200.000	.005	693
500.000	.002	759

Frequency Analysis Distribution Ranking:

Table AI-1: Ranking of frequency distributions

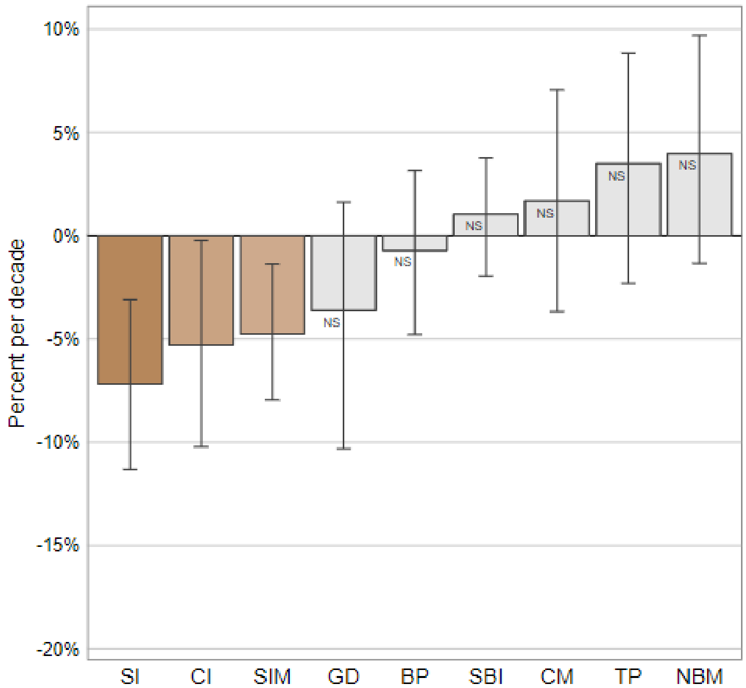
Distribution	Kolmogorov Smirnov		Anderson Darling		Chi-Squared	
	Statistic	Rank	Statistic	Rank	Statistic	Rank
Log-Pearson III (LP3)[NOTE]	0.08595	2	0.60823	2	13.574	3
Lognormal (3P)	0.09653	3	0.6991	3	13.459	2
Gumbel Max	0.10054	4	0.89371	4	14.972	4
General Extreme Value (GEV)	0.07892	1	0.54991	1	11.192	1
Note: The distribution in bold was selected for the design flood determination. The LP3 distribution was selected due to its good fit, wide acceptance for use in North America for flood frequency estimation, and compatibility with USGS Bulletin 17C guidance.						

Observed climate change data for BC:



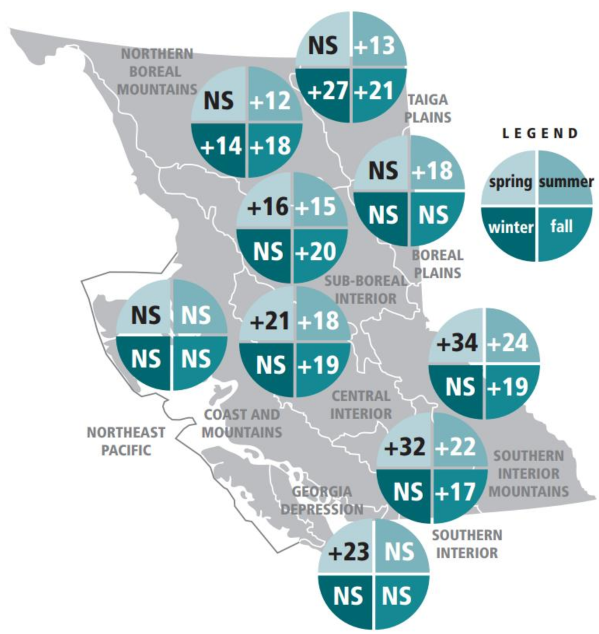
Note: There is a trend of -7% snow depth per decade for the Southern Interior Mountains.

Figure AI-5-4: Observed change in snow depths for 1950-2014 (Province of BC, 2018)



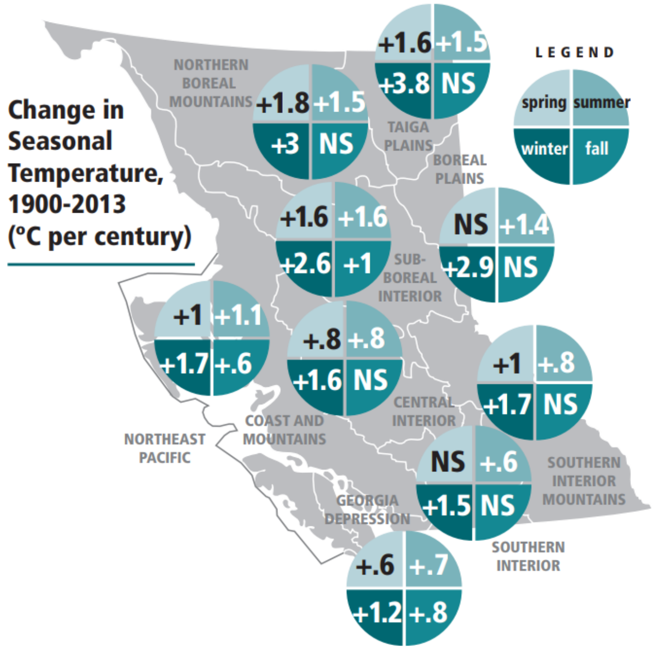
Note: There is a trend of -5% snow water equivalent per decade for the Southern Interior Mountains.

Figure AI-5-5: Observed change in snow water equivalent for 1950-2014 - Graph (Province of BC, 2018)



Note: The springtime average precipitation increase for the Southern Interior Mountains is +34% per century (year-round average increase of +21% per century).

Figure AI-6: Observed change in annual precipitation for 1900-2013 (Province of BC, 2016a)



Note: The springtime average temperature increase for the Southern Interior Mountains is +1.0˚C per century (year-round average increase of +1.1˚C per century).

Figure AI-7: Observed change in annual temperature for 1900-2013 (Province of BC, 2016a)

Model inputs:

Table AI-2: Allowable range for Manning coefficients (USACE, 2010)

	Manning n		
Description	**Minimum**	**Recommended**	**Maximum**
Natural Stream Main Channels			
a. Clean, straight, full, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. Same as "d" but more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. Very weedy reaches or floodways with heavy timber stand and brush	0.070	0.100	0.150
Excavated or Dredged Channels - Earth, Straight and Uniform			
a. Clean, recently completed	**0.016**	**0.018**	**0.020**
b. Clean, after weathering	0.018	0.022	0.025
c. Gravel, uniform section, clean	0.022	0.025	0.030
d. With short grass, few weeds	0.022	0.027	0.033
Excavated or Dredged Channels - Earth, Winding and Sluggish			
a. No vegetation	0.023	0.025	0.030
b. Grass, some weeds	0.025	0.030	0.033
c. Dense weeds or aquatic plants in deep channels	0.030	0.035	0.034

Table AI-2: Allowable range for Manning coefficients (USACE, 2010)

	Manning n		
Description	**Minimum**	**Recommended**	**Maximum**
d. Earth bottom and rubble side	0.028	0.030	0.035
e. Stony bottom and weedy banks	0.025	0.035	0.040
f. Cobble bottom and clean sides	0.030	0.040	0.050
Channels not Maintained, Weeds and Brush			
a. Clean bottom, brush on sides	0.040	0.050	0.080
b. Same as above, highest stage of flow	0.045	0.070	0.110
c. Dense weeds, high as flow depth	0.050	0.080	0.120
d. Dense brush, high stage	0.080	0.100	0.140
Floodplains			
a. Pasture, no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
2. Same as above, but heavy sprouts	0.050	0.060	0.080
3. Heavy stand of timber, little undergrowth, flow below branches	0.080	0.100	0.120
4. Same as above, but with flow into branches	0.100	0.120	0.160
5. Dense willows, summer, straight	0.110	0.150	0.200
Pipe and Conduit Materials			
a. Concrete, steel forms	0.009	0.011	0.013
b. Concrete, wooden forms	0.012	0.015	0.018
c. Concrete, centrifugally spun	0.012	0.013	0.015
d. Corrugated metal	0.020	0.022	0.040
e. Steel, smooth	0.010	0.012	0.014
f. Steel, riveted	0.017	0.019	0.021
g. Wood	0.012	0.014	0.016
h. Masonry	0.022	0.025	0.028

1D Cross-sections and values:

Table AI-3: 1D cross-sections and values

Station	LOB	Channel	ROB	n Value	Station	LOB	Channel	ROB	n Value
114008	36.656	40.700	46.598	0.0319	80801	36.790	37.700	38.401	0.0318
113867	39.077	43.100	47.923	0.0319	80677	45.088	43.800	41.951	0.0318
113726	39.380	44.100	49.235	0.0319	80533	44.955	43.900	42.038	0.0318
113585	40.323	43.600	49.095	0.0319	80390	45.034	43.800	42.114	0.0318
113445	42.162	42.700	44.677	0.0319	80246	43.238	38.800	35.300	0.0295
113304	42.066	42.600	44.780	0.0319	80119	43.212	38.800	35.714	0.0295
113163	44.867	42.900	44.184	0.0319	79992	43.184	38.700	35.918	0.0295

Table AI-3: 1D cross-sections and values

Station	LOB	Channel	ROB	n Value	Station	LOB	Channel	ROB	n Value
113022	42.402	43.100	43.883	0.0319	79865	40.190	38.300	36.916	0.0295
112882	42.941	42.800	42.174	0.0319	79740	40.148	38.200	36.652	0.0295
112741	43.965	42.800	42.901	0.0332	79614	40.115	38.100	36.337	0.0295
112601	45.293	42.800	42.054	0.0332	79489	40.073	37.500	34.895	0.0295
112460	39.787	42.800	46.122	0.0332	79367	40.124	37.900	34.885	0.0295
112320	48.676	47.500	46.160	0.037	79243	39.920	37.400	34.901	0.0295
112166	41.800	47.200	51.327	0.0386	79121	35.118	36.200	37.413	0.0295
112012	42.189	47.200	51.435	0.0386	79002	35.220	36.200	37.415	0.0294
111858	43.904	47.200	49.861	0.0386	78882	35.163	36.300	37.704	0.0294
111704	44.821	47.200	49.025	0.0386	78763	37.679	44.600	52.073	0.0294
111550	45.580	47.200	48.531	0.0386	78617	37.196	44.200	51.291	0.0279
111396	38.501	47.900	54.128	0.0386	78472	30.414	41.000	48.789	0.0279
111239	38.154	46.500	52.076	0.0386	78337	27.988	37.500	44.709	0.0279
111087	43.670	47.100	50.368	0.0386	78211	32.012	36.700	42.240	0.0279
110934	47.689	47.800	48.332	0.0386	78092	32.284	40.400	51.768	0.0279
110780	47.348	46.500	46.102	0.0386	77960	30.887	48.100	60.592	0.0279
110626	47.326	47.400	47.569	0.0386	77803	33.784	50.700	61.748	0.0279
110472	47.194	47.300	47.495	0.0386	77637	29.626	36.600	49.189	0.0279
110318	48.621	48.000	47.428	0.0386	77517	29.994	36.900	44.498	0.0279
110164	55.676	46.000	35.950	0.0386	77396	28.298	34.300	44.426	0.0279
110010	58.096	47.100	34.646	0.0386	77283	29.731	38.100	50.294	0.0279
109858	57.698	51.100	43.602	0.0386	77157	28.041	33.900	41.704	0.0279
109694	56.187	50.600	41.972	0.0386	77048	31.792	37.200	45.318	0.0279
109533	56.889	48.200	39.697	0.0386	76926	32.455	38.800	44.826	0.0279
109371	56.151	48.500	39.829	0.0386	76799	31.819	38.000	42.542	0.0279
109210	54.954	49.700	40.001	0.0386	76674	32.486	38.900	48.240	0.0279
109048	55.923	49.400	36.439	0.0386	76545	34.186	40.000	47.071	0.0279
108887	58.366	49.400	36.075	0.0386	76415	34.830	40.300	48.766	0.0279
108725	52.525	49.400	46.138	0.0386	76283	34.187	35.400	37.449	0.0279
108563	52.033	49.400	46.891	0.0386	76167	34.150	35.500	37.500	0.0279
108402	52.824	49.200	44.199	0.0386	76051	34.152	35.500	37.435	0.0279
108241	48.013	48.300	48.725	0.0386	75934	45.828	42.700	39.059	0.0279
108083	47.388	47.600	48.728	0.0386	75794	45.842	43.100	39.379	0.0279
107928	48.060	47.900	47.310	0.0386	75653	45.341	40.600	33.460	0.0279
107771	46.527	47.900	55.992	0.0386	75521	46.578	40.700	33.566	0.0279
107615	41.537	48.000	50.564	0.0386	75388	38.850	36.300	32.239	0.0279
107459	42.311	46.600	53.238	0.0386	75269	38.729	37.200	33.230	0.0279
107302	48.328	51.700	55.942	0.0386	75146	52.163	49.200	44.854	0.0279
107135	40.399	46.200	55.042	0.0386	74984	51.539	49.800	47.290	0.0279
106986	42.018	46.400	51.692	0.0386	74821	40.599	40.800	40.552	0.0279
106834	35.054	45.200	58.562	0.0386	74687	40.946	41.400	41.853	0.0279
106684	38.108	48.600	60.822	0.0386	74550	39.526	39.700	39.667	0.0279
106525	39.183	48.600	61.081	0.0386	74419	39.764	39.900	39.762	0.0279
106366	35.442	47.500	58.223	0.0386	74288	39.879	39.900	39.700	0.0279
106210	42.663	47.200	49.873	0.0386	74156	50.000	50.400	50.392	0.0279
106053	44.936	47.200	51.787	0.0344	73993	50.120	50.500	50.389	0.0279
105896	41.634	47.200	54.354	0.0344	73828	40.069	40.100	39.666	0.0279
105740	41.301	47.200	53.253	0.0344	73697	40.210	40.400	39.665	0.0279
105583	44.548	46.400	47.995	0.0344	73565	40.172	40.400	39.595	0.0279
105427	98.932	101.800	110.528	0.0344	73433	33.085	34.100	34.450	0.0279
105114	54.015	46.600	40.113	0.0344	73322	33.225	34.600	36.039	0.0279
104961	59.059	49.700	41.994	0.0344	73208	33.169	33.500	33.545	0.0279
104798	56.537	48.100	43.301	0.0344	73097	40.311	42.300	46.673	0.0279
104645	57.449	48.100	41.288	0.0344	72958	40.503	42.900	47.780	0.0279
104488	53.762	48.100	37.549	0.0344	72817	38.976	40.400	42.762	0.0279
104332	53.382	48.100	43.258	0.0344	72686	38.885	40.300	42.802	0.0279
104175	49.969	48.100	48.386	0.0325	72554	46.188	45.500	44.352	0.0279
104019	50.448	48.500	44.447	0.0325	72405	45.998	45.300	44.296	0.0279
103862	52.469	48.600	42.995	0.0325	72255	45.021	43.100	40.631	0.0279

Table AI-3: 1D cross-sections and values

Station	LOB	Channel	ROB	n Value	Station	LOB	Channel	ROB	n Value
103706	101.591	97.100	92.398	0.0325	72115	44.667	42.200	38.693	0.0279
103389	51.090	46.600	41.403	0.0325	71975	43.963	39.600	32.346	0.0279
103237	35.117	33.900	33.318	0.0325	71849	43.001	40.200	32.892	0.0279
103120	35.005	33.700	35.206	0.0325	71722	41.452	40.000	31.984	0.0279
103003	34.615	33.800	33.078	0.0325	71593	38.205	34.100	25.291	0.0279
102886	51.765	47.900	40.158	0.0325	71481	38.534	33.000	25.137	0.0279
102728	51.739	49.000	41.013	0.0325	71372	40.006	33.300	25.161	0.0279
102570	34.143	33.200	28.494	0.0325	71260	53.951	46.000	34.716	0.0279
102459	34.077	33.700	28.295	0.0325	71107	54.051	46.800	34.213	0.0279
102349	33.714	33.900	27.324	0.0325	70953	56.417	48.600	39.936	0.0279
102239	48.082	46.700	31.291	0.0325	70792	56.634	48.800	38.348	0.0279
102086	47.767	45.400	31.257	0.0325	70636	46.290	42.800	36.184	0.0279
101935	46.433	46.100	30.113	0.0325	70493	43.341	38.700	34.742	0.0279
101782	45.515	46.500	34.614	0.0325	70364	46.443	41.000	38.240	0.0279
101627	47.898	46.700	35.960	0.0325	70230	41.842	37.300	34.110	0.0279
101470	51.767	50.600	36.650	0.0325	70103	41.225	38.600	35.490	0.0289
101312	45.306	48.500	31.853	0.0325	69976	44.646	41.600	39.710	0.0283
101159	48.107	47.700	32.889	0.0325	69849	43.326	37.400	32.637	0.0283
101001	43.069	43.700	38.011	0.0325	69724	45.847	44.700	44.802	0.0283
100857	43.379	43.400	45.756	0.0314	69577	46.404	45.800	38.422	0.0283
100714	48.559	43.700	43.982	0.0314	69426	47.137	45.000	40.568	0.0301
100570	60.020	85.600	107.149	0.0314	69278	47.443	44.600	41.679	0.0301
100286	39.837	35.700	53.227	0.0314	69131	43.902	47.200	49.191	0.0301
100171	38.855	38.200	32.276	0.0314	68976	43.011	47.600	48.585	0.0301
100047	50.103	51.000	44.891	0.0314	68822	42.930	46.800	47.030	0.0301
99887	49.723	46.900	46.827	0.0314	68667	46.028	45.700	46.163	0.0301
99726	35.539	34.800	35.445	0.0314	68517	45.964	45.600	45.689	0.0301
99611	34.981	35.000	35.846	0.0314	68366	45.966	45.700	45.617	0.0301
99496	34.896	35.100	35.175	0.0314	68216	45.664	46.500	47.155	0.0301
99381	43.743	43.200	41.602	0.0314	68065	45.408	45.900	46.374	0.0301
99238	44.357	43.100	41.401	0.0314	67913	45.421	46.100	46.753	0.0301
99095	38.169	35.300	30.906	0.0314	67762	48.214	49.100	50.559	0.0307
98981	75.323	69.500	61.885	0.0314	67605	52.922	49.100	47.652	0.0314
98754	66.155	52.300	50.557	0.0314	67448	46.954	49.100	49.417	0.0314
98609	20.807	16.000	14.849	0.0314	67291	49.055	48.500	48.027	0.0314
98543	19.272	16.100	15.557	0.0314	67135	50.129	48.900	48.167	0.0314
98501	58.223	56.500	55.479	0.0314	66978	48.859	48.900	48.819	0.0314
98377	19.303	12.800	12.964	0.0314	66821	48.976	48.900	48.928	0.0314
98318	35.635	37.100	37.208	0.0318	66664	50.709	48.900	45.193	0.0314
98258	Bawtree Bridge				66507	55.072	48.900	44.230	0.0314
98219	16.846	18.600	19.185	0.0318	66350	108.998	97.900	83.116	0.0314
98094	27.297	30.000	31.168	0.0318	66037	58.892	52.800	48.197	0.0314
97968	59.970	40.000	35.037	0.0318	65880	56.495	48.600	38.840	0.0314
97829	61.704	44.900	36.137	0.0318	65723	51.014	48.500	44.009	0.0314
97690	38.565	34.800	29.427	0.0318	65566	51.301	48.600	45.005	0.0314
97573	42.324	35.800	32.119	0.0318	65409	51.259	48.800	45.332	0.0314
97457	41.460	36.700	32.787	0.0318	65252	51.145	48.600	46.730	0.0314
97340	35.373	34.500	33.844	0.0318	65096	49.492	48.700	48.122	0.0322
97227	35.259	34.300	33.407	0.0318	64939	49.251	48.600	47.880	0.0322
97114	34.891	34.100	33.200	0.0318	64782	49.152	48.600	47.995	0.0322
97001	32.532	33.300	34.027	0.0318	64625	52.893	48.600	45.445	0.0322
96891	32.703	33.400	33.882	0.0318	64468	51.848	48.600	44.796	0.0322
96781	32.852	33.500	33.861	0.0318	64306	47.391	45.300	43.267	0.0322
96671	47.198	48.900	50.200	0.0318	64155	55.841	50.400	44.806	0.0322
96513	46.616	47.600	48.551	0.0318	63995	56.621	51.000	45.972	0.0322
96355	40.075	43.200	44.635	0.0318	63841	47.418	49.200	51.346	0.0354
96214	40.768	42.800	44.153	0.0318	63682	55.639	49.300	44.742	0.0354
96073	40.602	40.600	40.627	0.0318	63523	55.816	49.300	44.830	0.0354
95940	40.546	40.600	40.630	0.0318	63364	53.509	49.300	46.691	0.0354

Table AI-3: 1D cross-sections and values

Station	LOB	Channel	ROB	n Value	Station	LOB	Channel	ROB	n Value
95806	40.674	40.600	40.705	0.0318	63204	52.131	49.300	46.925	0.0354
95673	44.339	42.700	42.155	0.0318	63045	53.191	49.300	45.182	0.0354
95533	44.538	42.700	42.136	0.0318	62886	56.515	49.300	43.660	0.0354
95392	44.668	42.700	42.068	0.0318	62727	54.009	49.300	45.147	0.036
95252	40.815	40.600	40.508	0.0318	62568	52.110	49.300	47.830	0.036
95119	40.747	40.600	40.517	0.0318	62409	48.404	49.300	50.509	0.036
94986	40.818	40.600	40.513	0.0318	62249	47.976	49.300	50.791	0.036
94853	39.961	40.000	40.058	0.0318	62090	47.080	49.300	51.941	0.036
94721	39.900	40.300	40.082	0.0318	61931	47.634	49.300	51.525	0.036
94588	40.099	40.700	40.218	0.0318	61772	46.655	49.300	54.311	0.036
94456	38.222	39.300	39.484	0.0318	61613	46.114	52.200	57.462	0.036
94327	38.622	40.300	41.215	0.0318	61454	34.508	51.300	68.582	0.036
94197	38.022	38.600	38.621	0.0318	61283	27.971	43.800	58.584	0.036
94068	31.687	44.500	51.998	0.0318	61138	26.370	48.900	67.478	0.036
93923	33.824	44.000	53.697	0.0318	60976	37.527	47.800	57.196	0.036
93778	33.959	43.600	54.193	0.0318	60817	15.604	50.300	79.974	0.0324
93633	32.740	34.800	37.651	0.0318	60659	29.972	49.200	62.351	0.0324
93522	33.519	33.700	37.103	0.0328	60500	43.784	49.500	57.027	0.0324
93412	33.216	33.200	36.288	0.0328	60342	49.747	49.600	49.027	0.0324
93301	42.868	43.600	47.424	0.0328	60184	49.948	49.600	49.509	0.0324
93159	40.655	42.900	46.454	0.0328	60025	50.056	49.300	50.703	0.0324
93016	35.714	37.700	39.057	0.0328	59868	49.375	49.700	52.141	0.0324
92895	35.034	38.200	38.496	0.0328	59709	48.315	50.000	51.759	0.0324
92773	33.734	35.600	38.392	0.0328	59551	49.768	49.400	49.329	0.0324
92652	36.107	38.100	40.980	0.0328	59393	49.498	48.400	48.325	0.0324
92527	35.928	37.600	39.515	0.0328	59235	49.849	50.500	53.184	0.0324
92401	35.683	38.200	39.683	0.0328	59077	49.435	48.300	45.641	0.0324
92276	29.582	34.700	37.832	0.0328	58918	45.438	50.400	55.511	0.0324
92163	30.088	34.300	37.797	0.0328	58760	44.844	48.000	50.787	0.0324
92049	30.123	34.200	37.714	0.0328	58602	48.856	52.100	56.161	0.0324
91936	36.743	40.000	42.520	0.0328	58444	47.758	48.000	49.162	0.0324
91802	37.251	41.300	43.867	0.0328	58286	50.229	49.600	48.920	0.0324
91668	33.683	41.000	45.133	0.0328	58127	50.931	49.000	45.715	0.0324
91534	36.954	37.500	37.435	0.0328	57969	49.793	50.500	51.452	0.0324
91416	31.469	35.200	37.270	0.0328	57811	50.333	50.700	51.964	0.0324
91297	33.935	36.000	37.478	0.0328	57653	50.288	48.500	47.409	0.0324
91179	45.130	49.400	52.786	0.0328	57494	50.807	52.600	54.560	0.0324
91016	45.897	49.600	52.643	0.0328	57336	48.806	46.500	44.543	0.0324
90853	40.062	44.300	48.188	0.0328	57178	51.951	47.900	44.832	0.0325
90701	39.820	47.500	50.148	0.0344	57025	55.281	47.900	40.025	0.0325
90549	38.736	44.800	47.896	0.0344	56873	54.855	47.900	39.415	0.0325
90397	33.768	43.000	56.883	0.0344	56720	53.831	47.900	44.060	0.0325
90255	29.325	39.800	57.681	0.0344	56568	54.976	47.900	40.733	0.0325
90127	42.881	51.000	60.682	0.0344	56415	53.599	47.900	40.017	0.0325
89963	39.091	44.000	46.950	0.0344	56262	58.479	47.900	37.038	0.0325
89821	42.559	44.800	47.083	0.0344	56110	54.614	47.900	39.960	0.0325
89676	39.917	43.900	48.731	0.0344	55957	56.744	47.900	38.013	0.0325
89532	29.062	37.400	45.180	0.0344	55805	53.663	47.900	42.348	0.0325
89410	27.441	37.600	46.220	0.0344	55652	52.751	46.900	40.602	0.0325
89286	27.650	36.600	45.235	0.0344	55500	51.478	48.400	45.797	0.0325
89165	40.833	36.100	31.840	0.0344	55347	51.187	48.400	46.432	0.0325
89044	41.054	36.900	33.387	0.0344	55194	49.859	47.900	47.320	0.0325
88924	41.506	37.700	34.366	0.0344	55042	47.937	47.900	48.807	0.0325
88801	46.530	38.000	29.591	0.0344	54889	48.085	47.900	48.247	0.0325
88677	44.743	38.300	30.623	0.0344	54737	44.681	47.900	53.247	0.0325
88552	41.906	38.600	30.656	0.0344	54584	53.196	48.700	44.965	0.0322
88426	44.207	40.200	32.659	0.0344	54428	50.028	48.700	47.481	0.0322
88289	45.138	41.600	32.892	0.0344	54271	50.756	48.700	46.047	0.0322
88155	45.211	43.000	32.674	0.0344	54115	49.690	48.700	49.784	0.0322

Table AI-3: 1D cross-sections and values

Station	LOB	Channel	ROB	n Value	Station	LOB	Channel	ROB	n Value
88012	43.514	41.900	38.511	0.0344	53959	48.697	48.700	49.538	0.0322
87872	43.749	42.100	38.166	0.0344	53803	48.834	48.700	48.118	0.0322
87728	43.534	43.100	37.920	0.0344	53646	53.114	48.700	46.428	0.0322
87581	40.278	40.200	36.917	0.0344	53490	52.293	48.700	44.119	0.0322
87444	39.742	39.400	36.732	0.0344	53334	53.136	48.700	42.948	0.0322
87310	39.730	39.000	36.720	0.0344	53178	47.394	48.700	50.595	0.0322
87177	39.495	36.900	32.948	0.0344	53021	47.856	50.300	52.000	0.0322
87061	39.729	36.900	33.029	0.0344	52860	44.882	47.100	49.728	0.0322
86946	39.810	37.100	32.885	0.0344	52709	47.432	48.700	50.309	0.0322
86832	45.319	40.500	33.825	0.0344	52552	41.386	48.700	54.805	0.0322
86707	46.716	40.900	33.797	0.0344	52396	41.285	48.700	53.185	0.0322
86584	45.025	40.000	32.825	0.0344	52240	39.881	48.700	58.101	0.0322
86461	44.122	40.900	35.021	0.0344	52084	44.561	48.700	52.523	0.0322
86328	41.971	38.500	34.465	0.0344	51927	49.461	48.700	49.607	0.0322
86196	42.587	37.900	33.959	0.0344	51771	48.740	48.700	49.737	0.0322
86067	44.516	36.500	30.444	0.0344	51615	48.773	48.700	46.745	0.0322
85946	45.868	37.300	30.746	0.0344	51459	48.695	48.700	46.435	0.0322
85822	42.459	35.200	29.858	0.0344	51302	48.005	48.200	51.443	0.0322
85706	47.746	43.600	40.886	0.0344	51146	40.473	40.200	39.962	0.0322
85561	48.002	44.400	41.487	0.0344	50991	40.828	40.200	40.065	0.0322
85415	47.750	45.100	41.809	0.0344	50836	40.518	40.200	40.035	0.0322
85267	48.027	44.300	42.329	0.0344	50681	40.526	40.200	40.086	0.0322
85121	44.725	39.300	35.338	0.0344	50525	40.624	40.200	40.164	0.0322
84991	44.901	39.400	34.646	0.0318	50370	41.295	40.400	40.119	0.0322
84860	44.190	40.500	34.949	0.0318	50215	40.619	41.100	40.202	0.0322
84730	36.502	34.600	31.583	0.0318	50060	41.446	41.100	40.275	0.0322
84617	36.640	33.700	30.767	0.0318	49905	40.518	41.100	40.140	0.0322
84507	36.549	33.600	30.926	0.0318	49750	40.546	41.200	40.126	0.0322
84396	39.533	37.000	34.271	0.0318	49594	40.515	40.700	40.201	0.0322
84281	40.129	36.900	31.733	0.0318	49440	40.437	40.300	40.738	0.0322
84166	40.144	37.900	34.750	0.0318	49284	40.504	40.300	42.757	0.0322
84043	37.533	34.900	32.086	0.0318	49129	40.626	40.300	41.407	0.0322
83930	37.869	34.600	31.946	0.0318	48974	40.398	40.300	40.176	0.0322
83811	37.744	34.500	31.711	0.0318	48819	40.433	40.300	40.171	0.0322
83693	30.806	37.900	43.804	0.0318	48664	47.038	47.500	49.423	0.0322
83564	32.585	39.900	45.137	0.0318	48504	46.992	47.800	50.323	0.0322
83437	33.922	41.300	45.462	0.0318	48345	47.312	48.000	50.112	0.0322
83310	44.229	47.800	51.713	0.0318	48185	47.324	47.900	50.035	0.0322
83148	44.010	47.200	51.131	0.0318	48025	48.097	50.100	53.381	0.0322
82985	34.719	37.200	39.744	0.0318	47865	46.926	47.200	48.536	0.0322
82865	34.930	37.200	39.791	0.0318	47706	47.376	48.500	50.445	0.0322
82744	34.928	37.400	39.845	0.0318	47546	47.482	48.800	50.455	0.0322
82624	49.623	47.800	45.567	0.0318	47386	47.470	48.800	50.274	0.0322
82466	49.802	47.800	46.037	0.0318	47226	45.580	46.300	47.879	0.0322
82307	44.456	38.100	32.137	0.0318	47067	47.470	48.300	51.482	0.0322
82177	45.450	39.600	32.658	0.0318	46907	51.468	50.900	50.289	0.0322
82048	47.105	39.900	32.290	0.0318	46747	53.315	48.200	43.476	0.0322
81918	45.982	43.600	41.929	0.0318	46587	42.641	49.400	58.080	0.0322
81775	46.110	43.600	41.687	0.0318	46428	45.963	53.600	61.935	0.0322
81631	46.096	43.600	41.940	0.0318	46268	41.333	39.300	39.006	0.0322
81488	46.216	44.600	43.295	0.0318	46200	97A / Young Street Bridge			
81342	46.367	44.600	43.358	0.0318	46112	48.367	44.600	37.664	0.0322
81195	46.360	44.700	43.620	0.0318	45983	39.754	39.100	37.128	0.0322
81049	36.965	37.900	38.434	0.0318	45854	43.688	40.700	38.308	0.0322
80925	36.674	37.800	38.354	0.0318	45724	36.661	37.100	37.316	1.0322

Frequency Analysis Solution for daily maximum streamflows at Deep Creek at Adair Street:

Table AI-4: Calculated maximum daily design flow by return period for Shuswap River (includes climate factors)

Return Period	Probability	Design Flood Flow (m^3/s)
1.01	0.99	228.0
2	0.50	385.7
5	0.20	472.8
10	0.10	527.3
20	0.05	578.1
50	0.02	642.0
100	0.01	689.2
200	0.05	735.8

APPENDIX II: FLOOD MAPS

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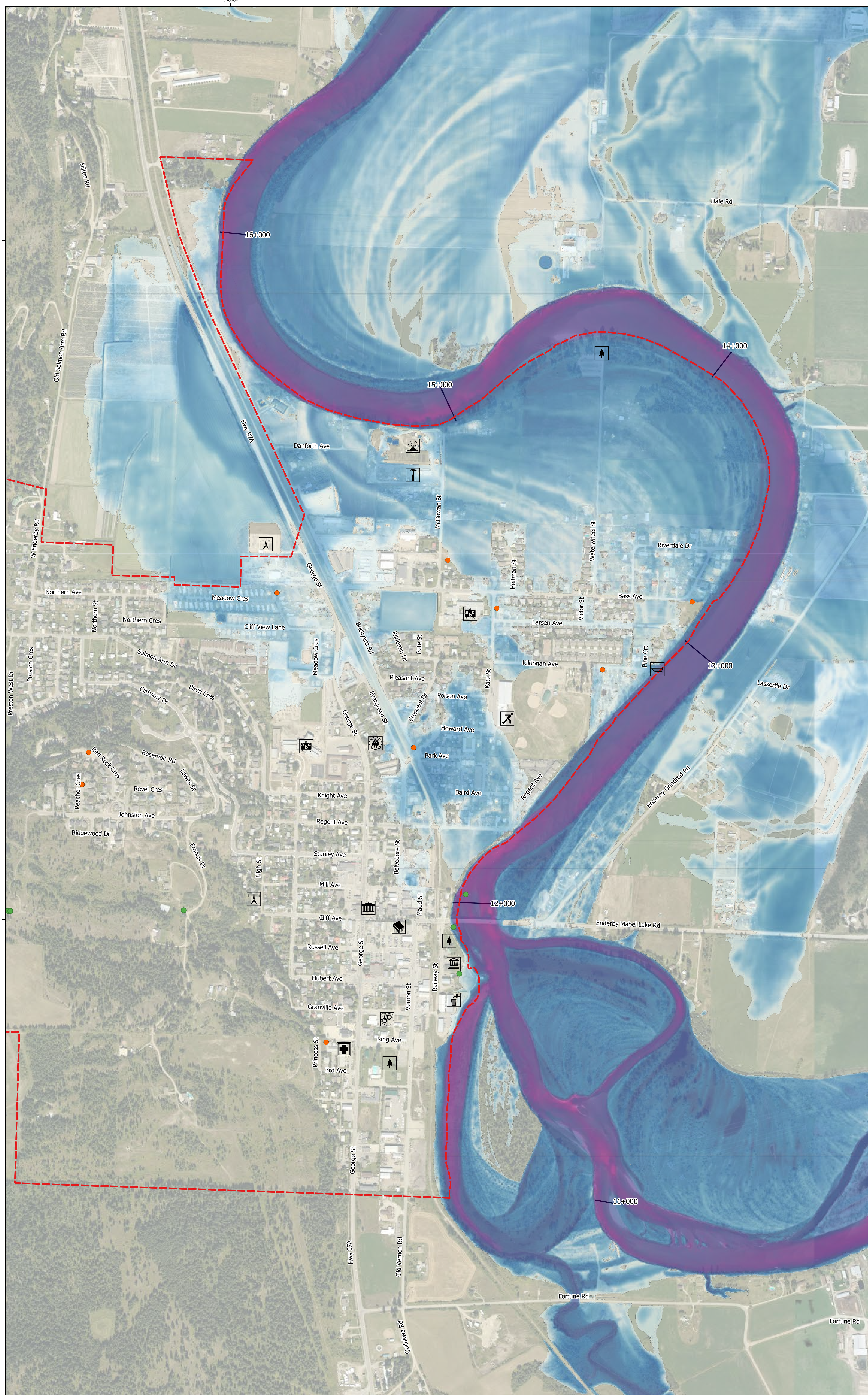

Legend

Maximum Flood Depth

- 0.00 - 0.24 m
- 0.25 - 0.49 m
- 0.50 - 0.99 m
- 1.00 - 1.99 m
- 2.00 - 3.99 m
- 4.00 - 9.99 m
- Stationing Line
- Municipal_Boundary
- Municiapl Water Booster Station
- Sanitary Lift Station
- Cadastre
- Boat Launch
- Park
- Arena
- School
- Sub Station
- Fire Departmant
- Community Health Centre
- Museum and City Hall
- Public Library
- Visitor Centre
- Police Station
- Public Works Yard
- Wastewater Trearment Plant
- Water Treatment Plant

Notes:

The City of Enderby does not assume any liability by reason of the failure to delineate flood areas on this map.

This map assumes the vertical datum of 2013 (CVGD2013). River stationing references are in metres and measure from the Ashton Creek hydrometric station (0+000).

Flooding shown is an estimate only and is to be read and interpreted with the City of Enderby Flood Mapping and Risk Assessment Report. Flooding shown may still occur outside of the delineated floodplain boundary, and irregularities or local blockages caused by existing or future fences, walls, hedges, vehicles, boats, flood defences or other barriers may alter the flooding shown. Flooding shown is from source water conveyed by Fortune Creek and the Shuswap River only. Therefore, this map does not show flooding caused by local watershed runoff (i.e. local creeks, drainage and stormwater systems, etcetera) or other sources. For site-specific applications, check the estimated flooding shown by comparing existing or future ground elevations (established by benchmarks) to the elevations shown on the Water Surface Elevation drawing.

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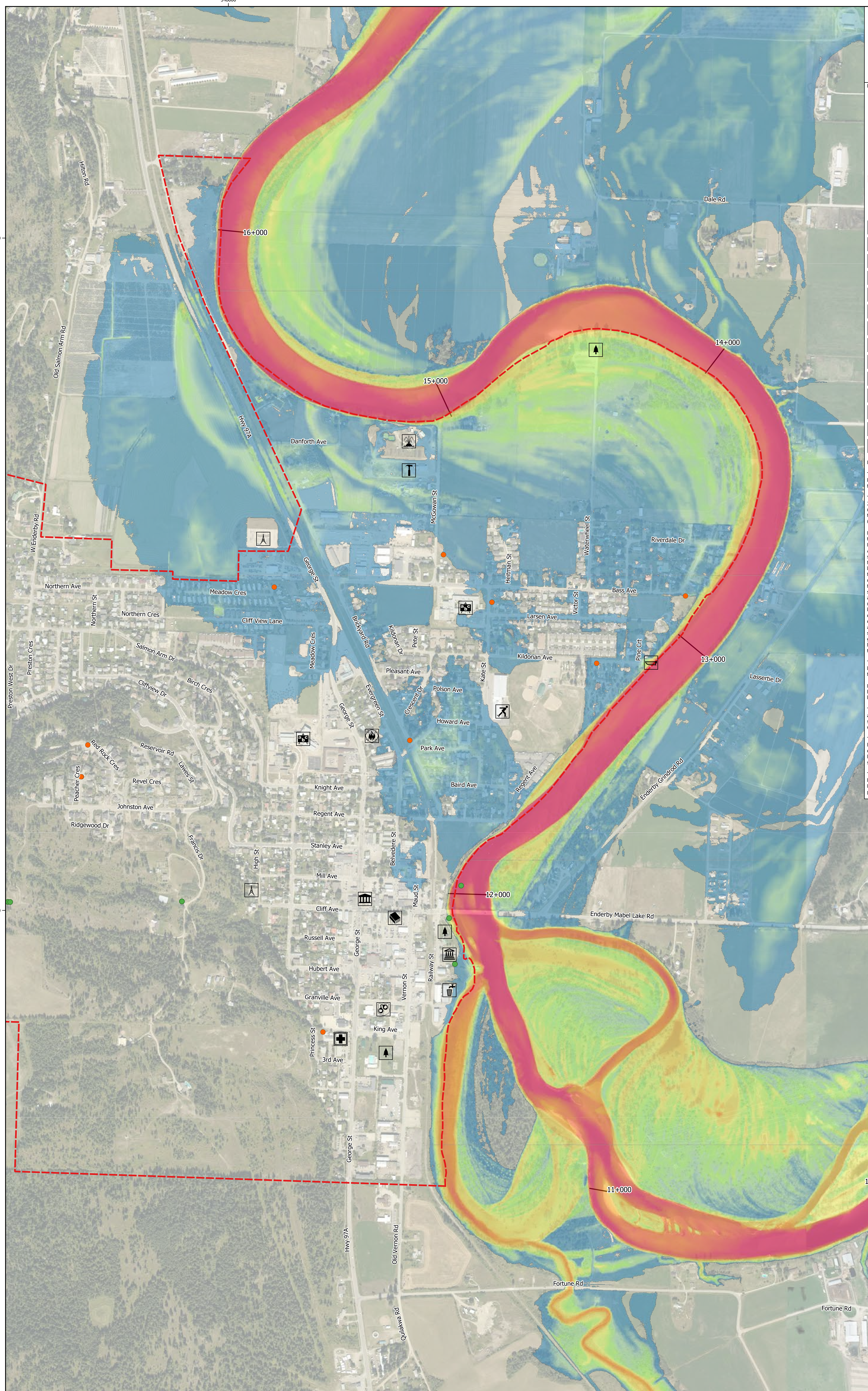
Building and floodplain elevations should be based on field surveys and established bench marks.

The model geometry was kept constant at all flows although variations (erosion, subsidence, or future constructions) may occur before and during a flood.

The accuracy of simulated flood levels is limited by the reliability of the water level data used for calibrating the model. Only limited calibration data was available at select locations.

The accuracy of the location of a floodplain boundary is limited by the accuracy of the DEM, model boundary conditions and model parameters.

CONSULTANT	CLIENT	DATE	SEAL	TITLE	MAP NO.
Interior Dams	City Of ENDERBY	JAN 12 2021 PROJ.NO. 0023.01 GIS CRD / ENG ABH 0 50 100 150 200 m SCALE 1:5000 NAD 1983 UTM 11N	PROFESSIONAL PROVINCE OF BRITISH COLUMBIA A. B. N. HAHN # 40045 ENGINEER 2021-11-09	Maximum Water Depth Shuswap River at Enderby 200-Year Flood Innundation Area	D200



Legend

Maximum Flood Hazard

- 0.00 - 0.49 m2/s
- 0.50 - 0.99 m2/s
- 1.00 - 1.49 m2/s
- 1.50 - 1.99 m2/s
- 2.00 - 4.99 m2/s
- 5.00 - 9.99 m2/s
- Stationing Line
- Municipal_Boundary
- Municipal Water Booster Station
- Sanitary Lift Station
- Cadastre
- Boat Launch
- Park
- Arena
- School
- Sub Station
- Fire Department
- Community Health Centre
- Museum and City Hall
- Public Library
- Visitor Centre
- Police Station
- Public Works Yard
- Wastewater Trearment Plant
- Water Treatment Plant

Notes:

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CONSULTANT	CLIENT	DATE JAN 12 2021 PROJ.NO. 0023.01 GIS CRD / ENG ABH 0 50 100 150 200 m SCALE 1:5000 NAD 1983 UTM 11N	SEAL	TITLE	MAP NO.
Interior Dams	City of Enderby		PROFESSIONAL ENGINEER, PROVINCE OF BRITISH COLUMBIA, A. B. N. HAHN # 40045, 2021-11-09	Maximum Water Hazard Shuswap River at Enderby 200-Year Flood Innundation Area	H200


Maximum Water Elevation
Shuswap River at Enderby
200-Year Flood Innundation Area
MAP NO. W200
CONSULTANT
Interior Dams
CLIENT
City Of ENDERBY
DATE JAN 12 2021
PROJ.NO. 0023.01
GIS CRD
ENG ABH
0 50 100 150 200 m
SCALE 1:5000 NAD 1983 UTM 11N
SEAL
PROFESSIONAL
PROVINCE OF BRITISH COLUMBIA
A. B. N. HAHN
40045
ENGINEER
2021-11-09
Legend
Maximum Water Elevation
352.75 m
353.00 m
353.25 m
353.50 m
353.75 m
354.00 m
Water Elevation Contours
Stationing Line
Municipal_Boundary
Municipal Water Booster Station
Sanitary Lift Station
Cadastre
Boat Launch
Park
Arena
School
Sub Station
Fire Department
Community Health Centre
Museum and City Hall
Public Library
Visitor Centre
Police Station
Public Works Yard
Wastewater Trearment Plant
Water Treatment Plant
Notes:
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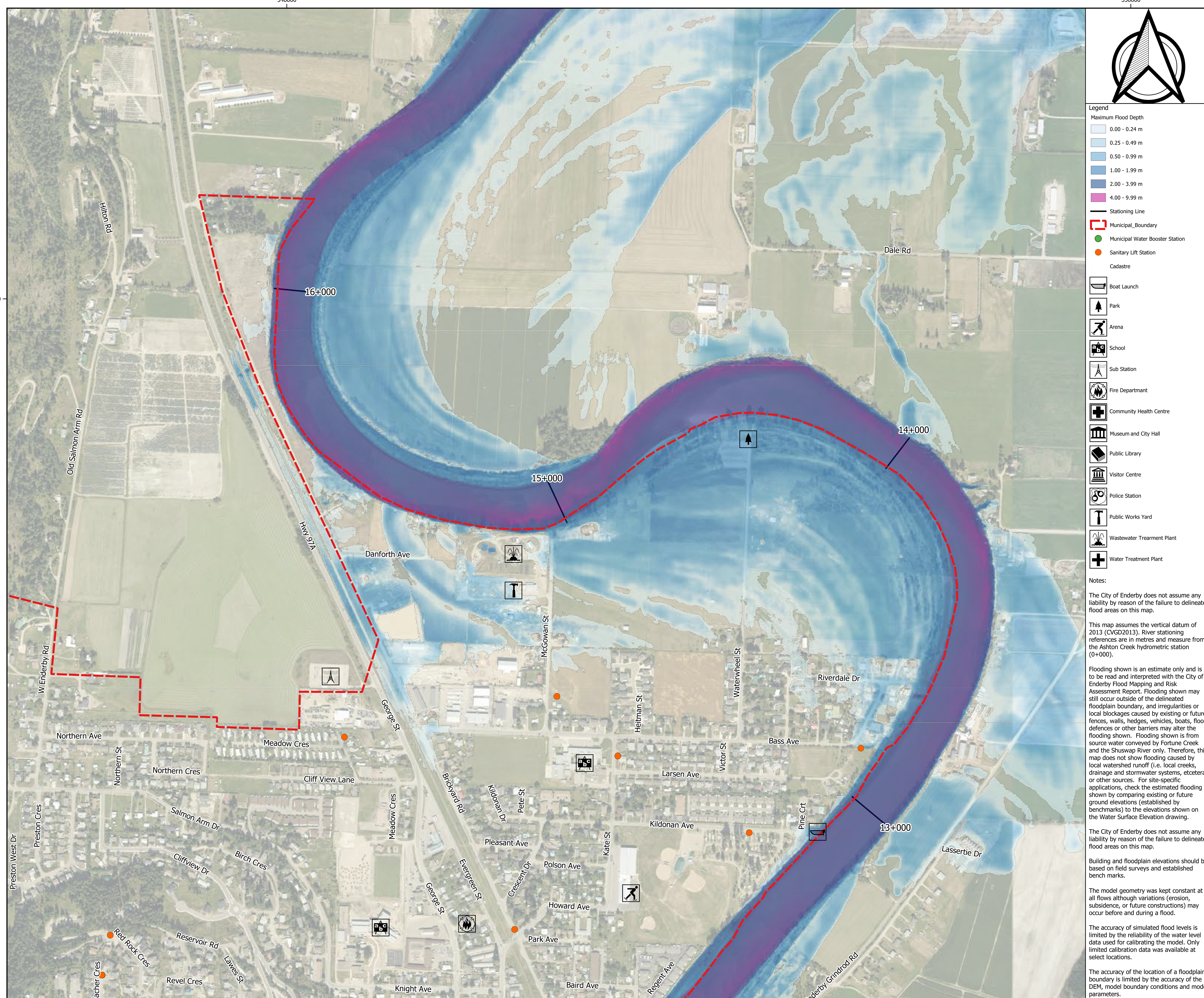
348000
350000
5604000
5602000
16+000
15+000
14+000
13+000
12+000
11+000
10+000
353.20
353.30
353.40
353.50
353.60
353.70
353.80
353.90
Dale Rd
Hilton Rd
Old Salmon Arm Rd
Hwy 97A
Danforth Ave
McGowan St
Waterwheel St
Riverdale Dr
Heitman St
Bass Ave
Victor St
Larsen Ave
Pine Crt
Kildonan Ave
Lassertie Dr
W Enderby Rd
Northern Ave
Meadow Cres
Northern St
Northern Cres
Cliff View Lane
George St
Brickyard Rd
Kildonan Dr
Pete St
Meadow Cres
Salmon Arm Dr
Birch Cres
Cliffview Dr
Preston Cres
Preston West Dr
Pleasant Ave
Polson Ave
Kate St
Crescent Dr
Evergreen St
Howard Ave
Park Ave
Baird Ave
Regent Ave
Enderby Grindrod Rd
Reservoir Rd
Red Rock Cres
Lawes St
Revel Cres
Peacher Cres
Johnston Ave
Ridgewood Dr
Francis Dr
Knight Ave
Regent Ave
Stanley Ave
Belvedere St
High St
Mill Ave
Maud St
Cliff Ave
Enderby Mabel Lake Rd
Russell Ave
Hubert Ave
Railway St
Granville Ave
Vernon St
King Ave
Princess St
3rd Ave
Hwy 97A
Old Vernon Rd
Graham Rd
Fortune Rd
Fortune Rd
Quilakwa Rd



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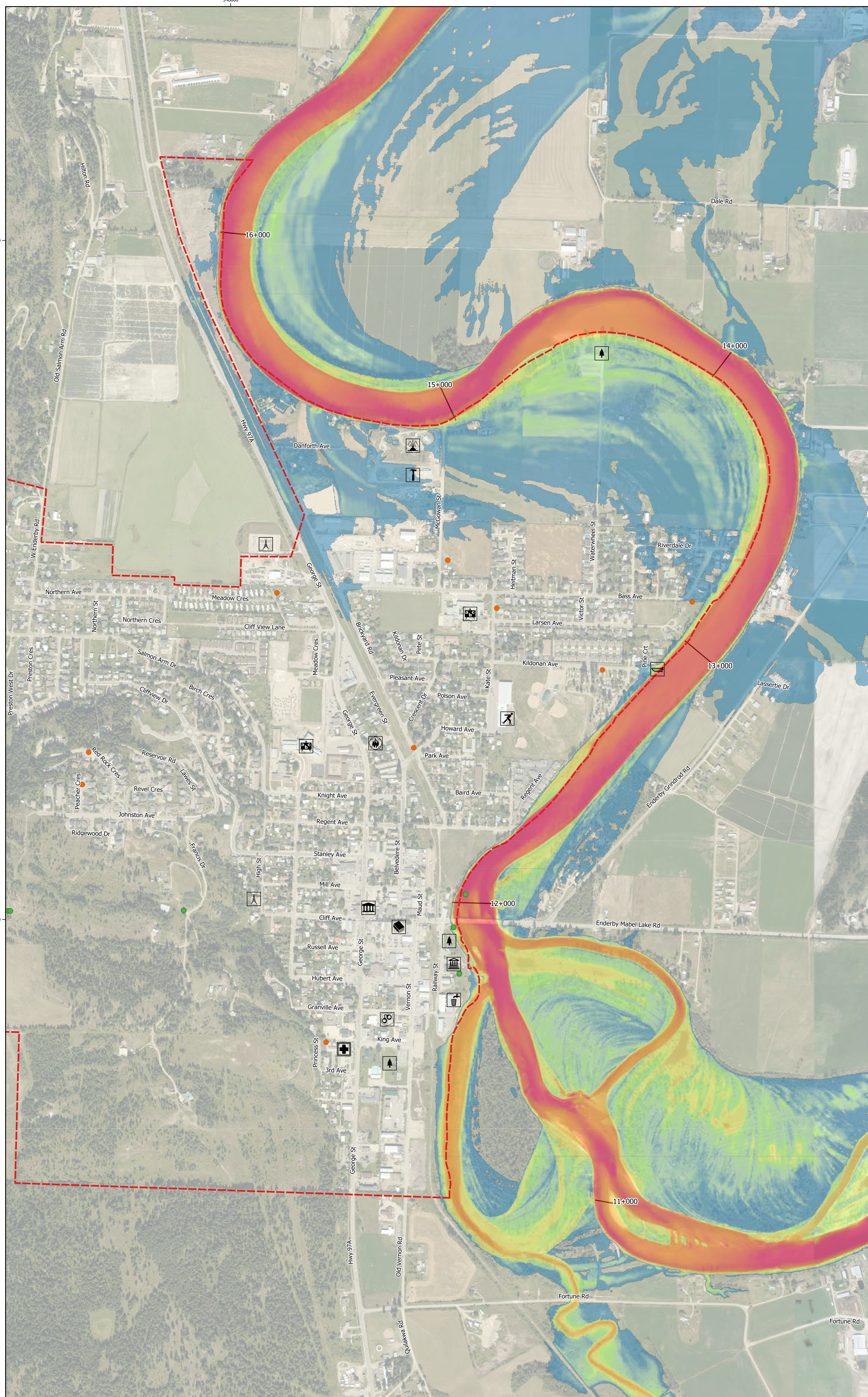
Interior Dams	City Of ENDERBY	JAN 12 2021 PROJ.NO. 0023.01 GIS CRD / ENG ABH 0 50 100 150 200 m SCALE 1:5000 NAD 1983 UTM 11N	PROFESSIONAL ENGINEER, PROVINCE OF BRITISH COLUMBIA, A. B. N. HAHN # 40045, 2021-11-09	Maximum Water Depth Shuswap River at Enderby 20-Year Flood Innundation Area	D20

348000 350000



Legend

Maximum Flood Hazard

- 0.00 - 0.49 m2/s
- 0.50 - 0.99 m2/s
- 1.00 - 1.49 m2/s
- 1.50 - 1.99 m2/s
- 2.00 - 4.99 m2/s
- 5.00 - 9.99 m2/s
- Stationing Line
- Municipal_Boundary
- Municipal Water Booster Station
- Sanitry Lift Station
- Cadastre
- Boat Launch
- Park
- Arena
- School
- Sub Station
- Fire Departmant
- Community Health Centre
- Museum and City Hall
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- Visitor Centre
- Police Station
- Public Works Yard
- Wastewater Trearment Plant
- Water Treatment Plant

Notes:

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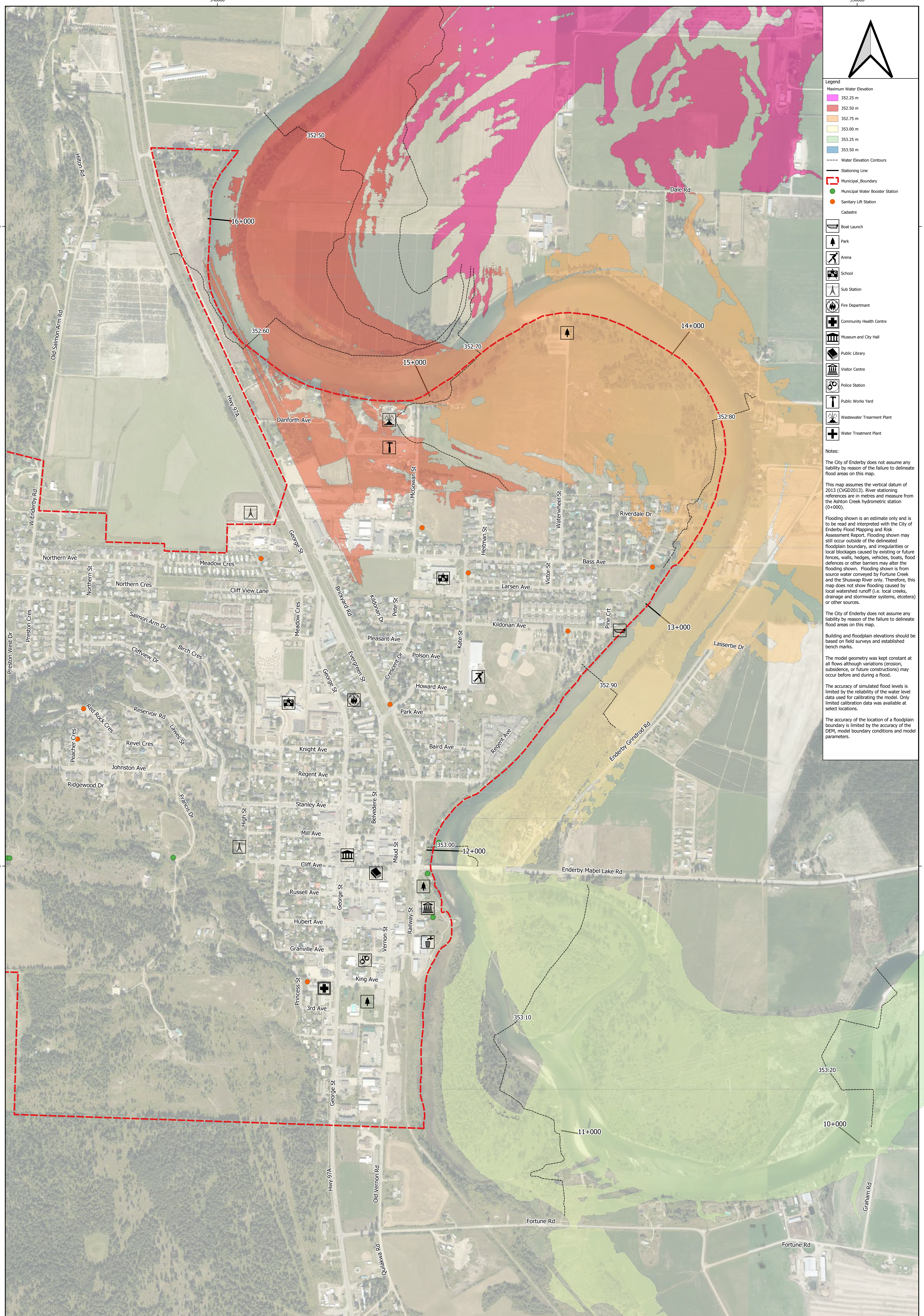
CONSULTANT	CLIENT	DATE	SEAL	TITLE	MAP NO.
Interior Dams	City Of ENDERBY	DATE JAN 12 2021 PROJ.NO. 0023.01 GIS CRD / ENG ABH 0 50 100 150 200 m SCALE 1:5000 NAD 1983 UTM 11N	PROFESSIONAL ENGINEER, PROVINCE OF BRITISH COLUMBIA, A. B. N. HAHN # 40045, 2021-11-09	Maximum Water Hazard Shuswap River at Enderby 20-Year Flood Innundation Area	H20

348000 350000



CONSULTANT	CLIENT	DATE JAN 12 2021	SEAL	TITLE	MAP NO.
Interior Dams	City Of ENDERBY	PROJ.NO. 0023.01	PROFESSIONAL PROVINCE OF BRITISH COLUMBIA A. B. N. HAHN # 40045 ENGINEER 2021-11-09	Maximum Water Elevation Shuswap River at Enderby	W20
		GIS CRD / ENG ABH		20-Year Flood Innundation Area	
		0 50 100 150 200 m SCALE 1:5000 NAD 1983 UTM 11N			

348000 350000

APPENDIX III: FLOOD MAPPING ASSURANCE STATEMENT

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To: The Client

Date: November 10, 2021

City of Enderby

Name (print)

P.O. Box 400, Enderby, BC, V0E 1V0

Address (print)

Flood Mapping Project:

City of Enderby - Flood Mapping and Risk Assessment Report

The undersigned hereby gives assurance that he/she is an APEGBC registered professional and the Qualified Professional for the project identified above.

I have signed, sealed and dated the attached report in accordance with the *APEGBC Professional Practice Guidelines – Flood Mapping in BC*. The report supports and accurately reflects the assurances made in this Assurance Statement.

I have completed the following activities:

(Check the applicable items)

	Activity
x	Reviewed the relevant provincial legislation and local government regulations, policies, and floodplain bylaws
x	Reviewed available and relevant background information, documentation and data
x	Visited the site and reviewed the conditions in the field that may be relevant
x	Considered the need for, and scale of, investigations that address future land use changes and climate change
x	Developed and executed the flood mapping in accordance with the criteria established by the client
x	Addressed any significant comments arising from internal or peer reviews
x	Prepared a flood mapping report along with the accompanying digital information

I hereby give assurance that the attached flood mapping report and supporting digital documentation have been produced in accordance with the *APEGBC Professional Practice Guidelines – Flood Mapping in BC*.

Aaron Hahn
Name (print)

Signature

November 10, 2021
Date

13890 Forest Hills Drive, Lake Country, BC, V4V 1A5
Address (print)

(Affix Professional Seal here)

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
A. B. N. HAHN
40045
2021-11-10

(778) 480-6063
Telephone

ahahn@interiordams.com
(email)

If the APEGBC Qualified Professional is a member of a firm, complete the following:

I am a member of the firm Interior Dams Incorporated (Permit to Practice No. 1001013) (Print name of firm), and I sign this letter on behalf of the firm.

APPENDIX IV: SUPPORTING RISK ASSESSMENT DATA

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Table AIV-1: Loss of life (LoL) estimation

Building Type	Area/Creek	PAR[1]	DV[2]	FR[3]	LoL[4]
RESIDENTIAL					
Single Family Dwelling	Baird Ave	3	0.00768	0.0002	0.0006
Single Family Dwelling	Baird Ave	3	0.00387	0.0002	0.0006
Single Family Dwelling	Baird Ave	3	0.01112	0.0002	0.0006
Single Family Dwelling	Baird Ave	3	0.00576	0.0002	0.0006
Single Family Dwelling	Baird Ave	3	0.01625	0.0002	0.0006
Single Family Dwelling	Baird Ave	3	0.11229	0.0002	0.0006
Multiple Family Dwelling	Baird Ave	72	0.06114	0.0002	0.0144
Single Family Dwelling	Baird Ave	3	0.04953	0.0002	0.0006
Single Family Dwelling	Baird Ave	3	0.00033	0.0002	0.0006
Single Family Dwelling	Baird Ave	3	0.04903	0.0002	0.0006
Single Family Dwelling	Baird Ave	3	0.00559	0.0002	0.0006
Single Family Dwelling	Baird Ave	3	0.08295	0.0002	0.0006
Single Family Dwelling	Baird Ave	3	0.00049	0.0002	0.0006
Single Family Dwelling	Baird Ave	3	0.01787	0.0002	0.0006
Single Family Dwelling	Baird Ave	3	0.00455	0.0002	0.0006
Single Family Dwelling	Baird Ave	3	0.00084	0.0002	0.0006
Single Family Dwelling	Baird Ave	3	0.08268	0.0002	0.0006
Single Family Dwelling	Baird Ave	3	0.04890	0.0002	0.0006
Single Family Dwelling	Bass Ave	3	0.00034	0.0002	0.0006
Single Family Dwelling	Bass Ave	3	0.01126	0.0002	0.0006
Single Family Dwelling	Bass Ave	3	0.00005	0.0002	0.0006
Single Family Dwelling	Bass Ave	3	0.00714	0.0002	0.0006
Single Family Dwelling	Bass Ave	3	0.00194	0.0002	0.0006
Single Family Dwelling	Bass Ave	3	0.00404	0.0002	0.0006
Single Family Dwelling	Bass Ave	3	0.00021	0.0002	0.0006
Single Family Dwelling	Bass Ave	3	0.00578	0.0002	0.0006
Single Family Dwelling	Belvedere St	3	0.02624	0.0002	0.0006
Single Family Dwelling	Belvedere St	3	0.00729	0.0002	0.0006
Multiple Family Dwelling	Belvedere St	24	0.00023	0.0002	0.0048
Single Family Dwelling	Belvedere St	3	0.03686	0.0002	0.0006
Single Family Dwelling	Belvedere St	3	0.04260	0.0002	0.0006
Multiple Family Dwelling	Belvedere St	15	0.00333	0.0002	0.003
Single Family Dwelling	Belvedere St	3	0.00159	0.0002	0.0006
Single Family Dwelling	Belvedere St	3	0.04768	0.0002	0.0006
Single Family Dwelling	Brickyard Rd	3	0.01286	0.0002	0.0006
Single Family Dwelling	Brickyard Rd	3	0.00176	0.0002	0.0006
Single Family Dwelling	Brickyard Rd	3	0.01148	0.0002	0.0006
Single Family Dwelling	Brickyard Rd	3	0.00247	0.0002	0.0006
Single Family Dwelling	Brickyard Rd	3	0.00016	0.0002	0.0006
Single Family Dwelling	Brickyard Rd	3	0.00030	0.0002	0.0006
Single Family Dwelling	Brickyard Rd	3	0.02173	0.0002	0.0006
Single Family Dwelling	Brickyard Rd	3	0.00134	0.0002	0.0006
Single Family Dwelling	Brickyard Rd	3	0.06430	0.0002	0.0006
Single Family Dwelling	Brickyard Rd	3	0.02803	0.0002	0.0006
Single Family Dwelling	Brickyard Rd	3	0.00244	0.0002	0.0006
Single Family Dwelling	Brickyard Rd	3	0.00122	0.0002	0.0006
Single Family Dwelling	Brickyard Rd	3	0.00081	0.0002	0.0006
Single Family Dwelling	Brickyard Rd	3	0.02418	0.0002	0.0006
Single Family Dwelling	Cliff View Lane	3	0.00236	0.0002	0.0006
Single Family Dwelling	Cliff View Lane	3	0.00891	0.0002	0.0006
Single Family Dwelling	Cliff View Lane	3	0.00878	0.0002	0.0006

Table AIV-1: Loss of life (LoL) estimation

Building Type	Area/Creek	PAR[1]	DV[2]	FR[3]	LoL[4]
RESIDENTIAL					
Single Family Dwelling	Cliff View Lane	3	0.00032	0.0002	0.0006
Single Family Dwelling	Cliff View Lane	3	0.00072	0.0002	0.0006
Single Family Dwelling	Cliff View Lane	3	0.01368	0.0002	0.0006
Single Family Dwelling	Cliff View Lane	3	0.00233	0.0002	0.0006
Single Family Dwelling	Cliff View Lane	3	0.00177	0.0002	0.0006
Single Family Dwelling	Cliff View Lane	3	0.00072	0.0002	0.0006
Single Family Dwelling	Cliff View Lane	3	0.00022	0.0002	0.0006
Single Family Dwelling	Cliff View Lane	3	0.00340	0.0002	0.0006
Single Family Dwelling	Cliff View Lane	3	0.00112	0.0002	0.0006
Single Family Dwelling	Cliff View Lane	3	0.00129	0.0002	0.0006
Single Family Dwelling	Cliff View Lane	3	0.02304	0.0002	0.0006
Single Family Dwelling	Cliff View Lane	3	0.00049	0.0002	0.0006
Single Family Dwelling	Cliff View Lane	3	0.00780	0.0002	0.0006
Single Family Dwelling	Cliff View Lane	3	0.00355	0.0002	0.0006
Single Family Dwelling	Cliff View Lane	3	0.00599	0.0002	0.0006
Single Family Dwelling	Cliff View Lane	3	0.00013	0.0002	0.0006
Single Family Dwelling	Cliff View Lane	3	0.01833	0.0002	0.0006
Single Family Dwelling	Cliff View Lane	3	0.02245	0.0002	0.0006
Single Family Dwelling	Cliff View Lane	3	0.01776	0.0002	0.0006
Single Family Dwelling	Cliff View Lane	3	0.00016	0.0002	0.0006
Single Family Dwelling	Crescent Dr	3	0.02444	0.0002	0.0006
Single Family Dwelling	Crescent Dr	3	0.08754	0.0002	0.0006
Single Family Dwelling	Crescent Dr	3	0.00355	0.0002	0.0006
Single Family Dwelling	Crescent Dr	3	0.00016	0.0002	0.0006
Single Family Dwelling	Crescent Dr	3	0.00841	0.0002	0.0006
Single Family Dwelling	Crescent Dr	3	0.00035	0.0002	0.0006
Single Family Dwelling	Crescent Dr	3	0.00021	0.0002	0.0006
Single Family Dwelling	Danforth Ave	3	0.02921	0.0002	0.0006
Single Family Dwelling	Evergreen St	3	0.02523	0.0002	0.0006
Single Family Dwelling	George St	3	0.01264	0.0002	0.0006
Single Family Dwelling	George St	3	0.00704	0.0002	0.0006
Single Family Dwelling	George St	3	0.00168	0.0002	0.0006
Single Family Dwelling	George St	3	0.03682	0.0002	0.0006
Single Family Dwelling	George St	3	0.00725	0.0002	0.0006
Single Family Dwelling	George St	3	0.00011	0.0002	0.0006
Single Family Dwelling	Heitman St	3	0.00061	0.0002	0.0006
Single Family Dwelling	Heitman St	3	0.00145	0.0002	0.0006
Single Family Dwelling	Heitman St	3	0.00011	0.0002	0.0006
Single Family Dwelling	Howard Ave	3	0.00036	0.0002	0.0006
Multiple Family Dwelling	Howard Ave	36	0.00429	0.0002	0.0072
Single Family Dwelling	Howard Ave	3	0.02853	0.0002	0.0006
Single Family Dwelling	Howard Ave	3	0.10469	0.0002	0.0006
Single Family Dwelling	Howard Ave	3	0.01727	0.0002	0.0006
Single Family Dwelling	Howard Ave	3	0.00282	0.0002	0.0006
Single Family Dwelling	Howard Ave	3	0.00043	0.0002	0.0006
Single Family Dwelling	Howard Ave	3	0.01712	0.0002	0.0006
Single Family Dwelling	Howard Ave	3	0.06533	0.0002	0.0006
Single Family Dwelling	Howard Ave	3	0.00930	0.0002	0.0006
Single Family Dwelling	Howard Ave	3	0.00955	0.0002	0.0006
Single Family Dwelling	Howard Ave	3	0.00024	0.0002	0.0006
Single Family Dwelling	Howard Ave	3	0.00175	0.0002	0.0006
Single Family Dwelling	Howard Ave	3	0.00775	0.0002	0.0006

Table AIV-1: Loss of life (LoL) estimation

Building Type	Area/Creek	PAR[1]	DV[2]	FR[3]	LoL[4]
RESIDENTIAL					
Single Family Dwelling	Howard Ave	3	0.02318	0.0002	0.0006
Single Family Dwelling	Howard Ave	3	0.05120	0.0002	0.0006
Single Family Dwelling	Howard Ave	3	0.00513	0.0002	0.0006
Single Family Dwelling	Howard Ave	3	0.00405	0.0002	0.0006
Single Family Dwelling	Howard Ave	3	0.00111	0.0002	0.0006
Single Family Dwelling	Howard Ave	3	0.00234	0.0002	0.0006
Single Family Dwelling	Kate St	3	0.05377	0.0002	0.0006
Single Family Dwelling	Kate St	3	0.00318	0.0002	0.0006
Single Family Dwelling	Kate St	3	0.00093	0.0002	0.0006
Multiple Family Dwelling	Kate St	6	0.00028	0.0002	0.0012
Single Family Dwelling	Kate St	3	0.00366	0.0002	0.0006
Single Family Dwelling	Kate St	3	0.00058	0.0002	0.0006
Single Family Dwelling	Kildonan Ave	3	0.00014	0.0002	0.0006
Single Family Dwelling	Kildonan Ave	3	0.01966	0.0002	0.0006
Single Family Dwelling	Kildonan Ave	3	0.00047	0.0002	0.0006
Single Family Dwelling	Kildonan Ave	3	0.00962	0.0002	0.0006
Single Family Dwelling	Kildonan Ave	3	0.04702	0.0002	0.0006
Single Family Dwelling	Kildonan Ave	3	0.01027	0.0002	0.0006
Single Family Dwelling	Kildonan Ave	3	0.02468	0.0002	0.0006
Single Family Dwelling	Kildonan Ave	3	0.00157	0.0002	0.0006
Single Family Dwelling	Knight Ave	3	0.00024	0.0002	0.0006
Single Family Dwelling	Knight Ave	3	0.00892	0.0002	0.0006
Single Family Dwelling	Knight Ave	3	0.00386	0.0002	0.0006
Single Family Dwelling	Larsen Ave	3	0.00892	0.0002	0.0006
Single Family Dwelling	Larsen Ave	3	0.00036	0.0002	0.0006
Single Family Dwelling	Larsen Ave	3	0.00004	0.0002	0.0006
Single Family Dwelling	Larsen Ave	3	0.00073	0.0002	0.0006
Single Family Dwelling	Larsen Ave	3	0.00026	0.0002	0.0006
Single Family Dwelling	Larsen Ave	3	0.00147	0.0002	0.0006
Single Family Dwelling	Larsen Ave	3	0.01208	0.0002	0.0006
Single Family Dwelling	Larsen Ave	3	0.00513	0.0002	0.0006
Single Family Dwelling	Larsen Ave	3	0.00115	0.0002	0.0006
Single Family Dwelling	Larsen Ave	3	0.00078	0.0002	0.0006
Single Family Dwelling	Larsen Ave	3	0.00131	0.0002	0.0006
Single Family Dwelling	Larsen Ave	3	0.00089	0.0002	0.0006
Single Family Dwelling	McGowan St	3	0.08977	0.0002	0.0006
Single Family Dwelling	McGowan St	3	0.06118	0.0002	0.0006
Single Family Dwelling	McGowan St	3	0.06391	0.0002	0.0006
Single Family Dwelling	McGowan St	3	0.04203	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.16396	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.12117	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.05570	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.03101	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.10135	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.05661	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.01928	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.06626	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.05788	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.06209	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.05290	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.10577	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.06080	0.0002	0.0006

Table AIV-1: Loss of life (LoL) estimation

Building Type	Area/Creek	PAR[1]	DV[2]	FR[3]	LoL[4]
RESIDENTIAL					
Single Family Dwelling	Meadow Cres	3	0.03898	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.06099	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.00730	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.04899	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.03204	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.01730	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.14171	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.07000	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.11690	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.10766	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.01118	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.01934	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.09665	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.05359	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.09889	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.00901	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.04379	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.01899	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.01037	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.01319	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.13150	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.01772	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.01131	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.07558	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.03452	0.0002	0.0006
Single Family Dwelling	Meadow Cres	3	0.00229	0.0002	0.0006
Single Family Dwelling	Park Ave	3	0.04959	0.0002	0.0006
Single Family Dwelling	Park Ave	3	0.04668	0.0002	0.0006
Single Family Dwelling	Park Ave	3	0.01176	0.0002	0.0006
Single Family Dwelling	Park Ave	3	0.00367	0.0002	0.0006
Single Family Dwelling	Park Ave	3	0.00896	0.0002	0.0006
Single Family Dwelling	Park Ave	3	0.00839	0.0002	0.0006
Single Family Dwelling	Park Ave	3	0.00729	0.0002	0.0006
Single Family Dwelling	Park Ave	3	0.00766	0.0002	0.0006
Single Family Dwelling	Park Ave	3	0.09753	0.0002	0.0006
Single Family Dwelling	Park Ave	3	0.01521	0.0002	0.0006
Single Family Dwelling	Park Ave	3	0.01777	0.0002	0.0006
Single Family Dwelling	Park Ave	3	0.06301	0.0002	0.0006
Single Family Dwelling	Park Ave	3	0.05882	0.0002	0.0006
Single Family Dwelling	Park Ave	3	0.03192	0.0002	0.0006
Single Family Dwelling	Park Ave	3	0.00935	0.0002	0.0006
Single Family Dwelling	Park Ave	3	0.08406	0.0002	0.0006
Single Family Dwelling	Park Ave	3	0.01526	0.0002	0.0006
Single Family Dwelling	Park Ave	3	0.01033	0.0002	0.0006
Single Family Dwelling	Park Ave	3	0.01765	0.0002	0.0006
Single Family Dwelling	Park Ave	3	0.00330	0.0002	0.0006
Single Family Dwelling	Pine Crt	3	0.01472	0.0002	0.0006
Single Family Dwelling	Pleasant Ave	3	0.00337	0.0002	0.0006
Single Family Dwelling	Polson Ave	3	0.00112	0.0002	0.0006
Single Family Dwelling	Polson Ave	3	0.00164	0.0002	0.0006
Single Family Dwelling	Polson Ave	3	0.10028	0.0002	0.0006
Single Family Dwelling	Polson Ave	3	0.01052	0.0002	0.0006

Table AIV-1: Loss of life (LoL) estimation

Building Type	Area/Creek	PAR[1]	DV[2]	FR[3]	LoL[4]
RESIDENTIAL					
Single Family Dwelling	Polson Ave	3	0.00244	0.0002	0.0006
Single Family Dwelling	Polson Ave	3	0.09265	0.0002	0.0006
Single Family Dwelling	Polson Ave	3	0.00304	0.0002	0.0006
Single Family Dwelling	Regent Ave	3	0.00012	0.0002	0.0006
Single Family Dwelling	Regent Ave	3	0.02570	0.0002	0.0006
Single Family Dwelling	Regent Ave	3	0.00214	0.0002	0.0006
Single Family Dwelling	Regent Ave	3	0.01378	0.0002	0.0006
Single Family Dwelling	Regent Ave	3	0.03709	0.0002	0.0006
Single Family Dwelling	Regent Ave	3	0.00595	0.0002	0.0006
Single Family Dwelling	Regent Ave	3	0.00816	0.0002	0.0006
Single Family Dwelling	Regent Ave	3	0.01754	0.0002	0.0006
Single Family Dwelling	Regent Ave	3	0.00092	0.0002	0.0006
Single Family Dwelling	Regent Ave	3	0.00047	0.0002	0.0006
Single Family Dwelling	Regent Ave	3	0.00115	0.0002	0.0006
Single Family Dwelling	Regent Ave	3	0.00770	0.0002	0.0006
Single Family Dwelling	Regent Ave	3	0.00023	0.0002	0.0006
Single Family Dwelling	Regent Ave	3	0.00017	0.0002	0.0006
Single Family Dwelling	Regent Ave	3	0.00337	0.0002	0.0006
Single Family Dwelling	Regent Ave	3	0.00028	0.0002	0.0006
Single Family Dwelling	Regent Ave	3	0.00005	0.0002	0.0006
Single Family Dwelling	Regent Ave	3	0.00010	0.0002	0.0006
Single Family Dwelling	Regent Ave	3	0.00790	0.0002	0.0006
Single Family Dwelling	Regent Ave	3	0.00110	0.0002	0.0006
Single Family Dwelling	Regent Ave	3	0.00443	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.01538	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.01190	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.04905	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.00774	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.04805	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.05323	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.00196	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.00862	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.01565	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.04125	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.07702	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.01872	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.00808	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.07111	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.03156	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.00269	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.02973	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.01357	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.04732	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.00584	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.00309	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.00469	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.09947	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.04826	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.07754	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.00070	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.02262	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.03840	0.0002	0.0006

Table AIV-1: Loss of life (LoL) estimation

Building Type	Area/Creek	PAR[1]	DV[2]	FR[3]	LoL[4]
RESIDENTIAL					
Single Family Dwelling	Riverdale Dr	3	0.01453	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.09425	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.05326	0.0002	0.0006
Single Family Dwelling	Riverdale Dr	3	0.06300	0.0002	0.0006
Single Family Dwelling	Salmon Arm Dr	3	0.00012	0.0002	0.0006
Single Family Dwelling	Salmon Arm Dr	3	0.00003	0.0002	0.0006
Single Family Dwelling	Salmon Arm Dr	3	0.00018	0.0002	0.0006
Single Family Dwelling	Salmon Arm Dr	3	0.00007	0.0002	0.0006
Single Family Dwelling	Salmon Arm Dr	3	0.00006	0.0002	0.0006
Single Family Dwelling	Victor St	3	0.00186	0.0002	0.0006
Single Family Dwelling	Victor St	3	0.00030	0.0002	0.0006
Single Family Dwelling	Victor St	3	0.00024	0.0002	0.0006
Single Family Dwelling	Waterwheel St	3	0.01238	0.0002	0.0006
Single Family Dwelling	Waterwheel St	3	0.00019	0.0002	0.0006
Single Family Dwelling	Waterwheel St	3	0.00929	0.0002	0.0006
Single Family Dwelling	Waterwheel St	3	0.01450	0.0002	0.0006
Single Family Dwelling	Waterwheel St	3	0.00271	0.0002	0.0006
Single Family Dwelling	Waterwheel St	3	0.00883	0.0002	0.0006
Single Family Dwelling	Waterwheel St	3	0.01097	0.0002	0.0006
NON-RESIDENTIAL					
High School	Bass Ave	75	0.01091	0.0002	0.0150
Community Centre	Belvedere St	10	0.00027	0.0002	0.0020
Liquor Store	Belvedere St	9	0.00838	0.0002	0.0018
Automotive Retailer	Brickyard Rd	12	0.03042	0.0002	0.0024
Car Wash Facility	George St	21	0.00142	0.0002	0.0042
Flower Shop	George St	9	0.00036	0.0002	0.0018
Gas Station	George St	6	0.01034	0.0002	0.0012
Automotive Garage	Highway 97A	9	0.00057	0.0002	0.0018
Construction Merchandiser	Highway 97A	33	0.00058	0.0002	0.0066
Campground	Kildonan Ave	40	0.00309	0.0002	0.0080
Church	Knight Ave	20	0.00056	0.0002	0.0040
Upholstery Repair	Maud St	9	0.00164	0.0002	0.0018
Public Works Facility	McGowan St	6	0.01785	0.0002	0.0012
Dentist*	Mill Ave	12	0.01362	0.0002	0.0024
Massage Therapist*	Mill Ave	6	0.03655	0.0002	0.0012
Clothing Retailer	Mill Ave	6	0.00019	0.0002	0.0012
				Calculated Value	0.251
				LoL ESTIMATE	**0**

*These are considered vital to sustaining a community according to NDMP guidelines: communications technology, finance, healthcare, food, water, transportation, safety, government and manufacturing (Government of Canada, 2018)

NOTE1 The population at risk (PAR) was assumed based on 3 people per home as per BC dam break inundation guidelines. PAR at places of businesses was assumed to be equal to the number of employees (from Section 3.3.4). The PAR at places of businesses with customers was assumed to be 2 times the number of employees.

NOTE2 DV is the product of depth (D) and velocity (V).

NOTE3 FR is the fatality rate as per the RCEM graphical method.

NOTE4 Loss of life (LoL) is the product of PAR and DV.

Residential Damage Function for Class A One-Storey (NRC, 2017):

Table AIV-2: Residential damage function for Class A one-storey

Class A - Residential One-Storey					
Depth relative to main floor	Main Floor Contents	Main Floor Structure	Basement Contents	Basement Structure	Total
-2.7	$0	$0	$0	$0	$0
-2.6	$0	$0	$400	$231	$632
-2.4	$0	$0	$554	$271	$825
-2.1	$0	$0	$715	$299	$1,015
-1.8	$0	$0	$778	$299	$1,077
-1.5	$0	$0	$784	$305	$1,090
-1.2	$0	$0	$786	$335	$1,122
-0.9	$0	$0	$788	$335	$1,123
-0.6	$0	$0	$810	$356	$1,167
-0.3	$0	$0	$836	$357	$1,193
0	$0	$0	$836	$365	$1,201
0.1	$373	$588	$836	$365	$2,162
0.3	$624	$594	$836	$365	$2,420
0.6	$758	$674	$836	$365	$2,633
0.9	$809	$848	$836	$365	$2,858
1.2	$816	$848	$836	$365	$2,865
1.5	$816	$848	$836	$365	$2,865
1.8	$839	$848	$836	$365	$2,888
2.1	$839	$848	$836	$365	$2,888
2.4	$839	$848	$836	$365	$2,888
2.7	$839	$848	$836	$365	$2,888

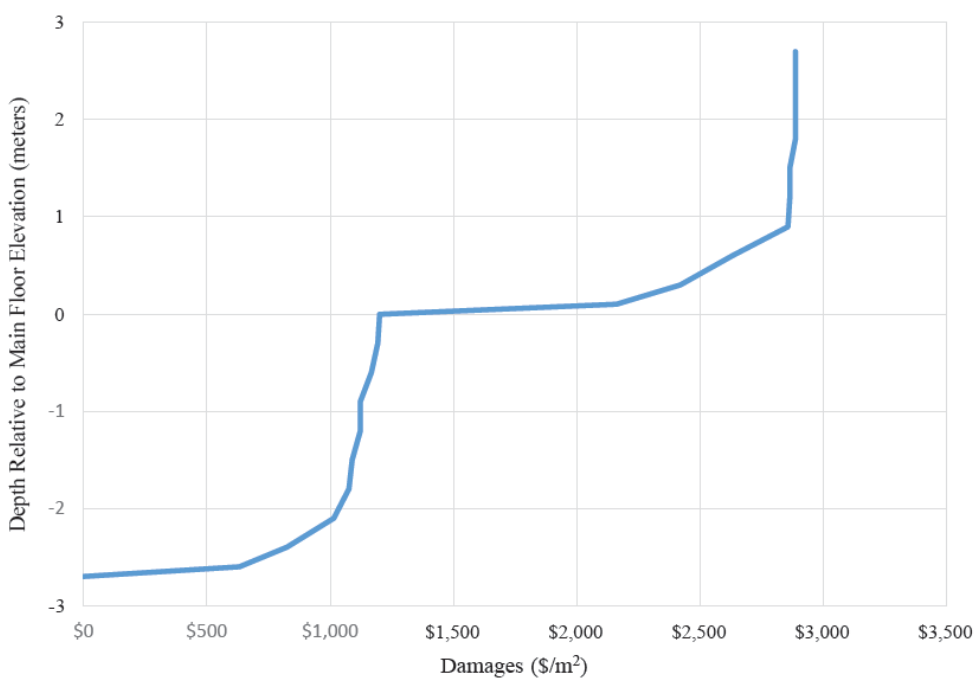

Figure AIV-1: Residential damage function for Class A one-storey

Residential Damage Function for Class A Two-Storey (NRC, 2017):

Table AIV-3: Residential damage function for Class A two-storey

Class A -Residential Two-Storey					
Depth relative to main floor	Main Floor Contents	Main Floor Structure	Basement Contents	Basement Structure	Total
-2.7	$0	$0	$0	$0	$0
-2.6	$0	$0	$226	$241	$467
-2.4	$0	$0	$354	$354	$708
-2.1	$0	$0	$395	$406	$802
-1.8	$0	$0	$437	$406	$843
-1.5	$0	$0	$440	$429	$869
-1.2	$0	$0	$442	$466	$908
-0.9	$0	$0	$444	$466	$910
-0.6	$0	$0	$475	$506	$980
-0.3	$0	$0	$523	$507	$1,030
0	$0	$0	$523	$522	$1,045
0.1	$343	$665	$523	$522	$2,053
0.3	$545	$676	$523	$522	$2,266
0.6	$663	$826	$523	$522	$2,534
0.9	$748	$1,051	$523	$522	$2,845
1.2	$766	$1,051	$523	$522	$2,862
1.5	$767	$1,051	$523	$522	$2,863
1.8	$767	$1,051	$523	$522	$2,863
2.1	$767	$1,051	$523	$522	$2,863
2.4	$767	$1,051	$523	$522	$2,863
2.7	$767	$1,051	$523	$522	$2,863

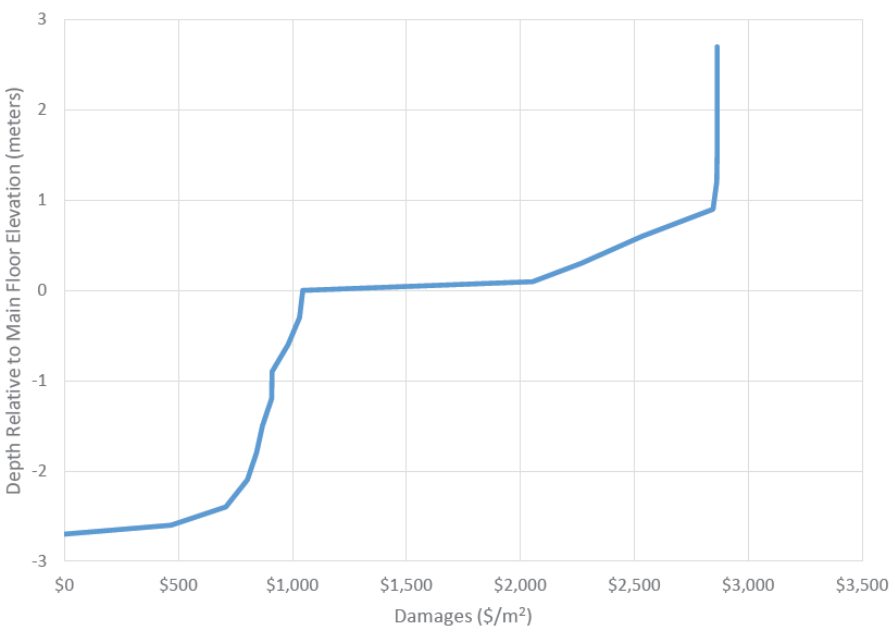

Figure AIV-2: Residential damage function for Class A two-storey

Residential Damage Function for Class B One-Storey (NRC, 2017):

Table AIV-4: Residential damage function for Class B one-storey

Class B - Residential One-Storey					
Depth relative to main floor[1]	Main Floor Contents	Main Floor Structure	Basement Contents[2]	Basement Structure[2]	Total
-2.7	$0	$0	$0	$0	$0
-2.6	$0	$0	$226	$232	$458
-2.4	$0	$0	$339	$282	$621
-2.1	$0	$0	$375	$312	$687
-1.8	$0	$0	$401	$312	$713
-1.5	$0	$0	$410	$322	$732
-1.2	$0	$0	$411	$334	$745
-0.9	$0	$0	$412	$334	$746
-0.6	$0	$0	$426	$362	$788
-0.3	$0	$0	$504	$363	$867
0	$0	$0	$504	$374	$877
0.1	$221	$400	$504	$374	$1,498
0.3	$384	$407	$504	$374	$1,668
0.6	$431	$457	$504	$374	$1,765
0.9	$492	$578	$504	$374	$1,947
1.2	$494	$578	$504	$374	$1,949
1.5	$494	$578	$504	$374	$1,949
1.8	$495	$578	$504	$374	$1,950
2.1	$495	$578	$504	$374	$1,950
2.4	$495	$578	$504	$374	$1,950
2.7	$495	$578	$504	$374	$1,950

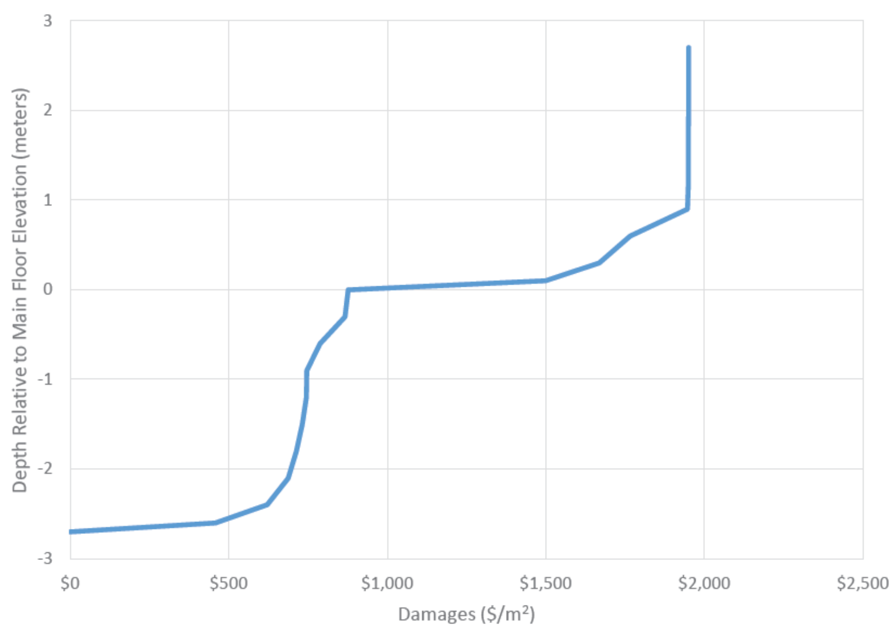

Figure AIV-3: Residential damage function for Class B one-storey

Residential Damage Function for Class B Two-Storey (NRC, 2017):

Table AIV-5: Residential damage function for Class B two-storey

Class B - Residential Two-Storey					
Depth relative to main floor	Main Floor Contents	Main Floor Structure	Basement Contents	Basement Structure	Total
-2.7	$0	$0	$0	$0	$0
-2.6	$0	$0	$163	$242	$405
-2.4	$0	$0	$255	$331	$586
-2.1	$0	$0	$294	$385	$678
-1.8	$0	$0	$324	$385	$709
-1.5	$0	$0	$332	$402	$735
-1.2	$0	$0	$336	$420	$756
-0.9	$0	$0	$336	$420	$756
-0.6	$0	$0	$364	$470	$833
-0.3	$0	$0	$427	$473	$900
0	$0	$0	$427	$490	$917
0.1	$235	$524	$427	$490	$1,676
0.3	$342	$536	$427	$490	$1,795
0.6	$422	$625	$427	$490	$1,964
0.9	$481	$792	$427	$490	$2,190
1.2	$507	$792	$427	$490	$2,216
1.5	$508	$792	$427	$490	$2,217
1.8	$511	$792	$427	$490	$2,220
2.1	$511	$792	$427	$490	$2,220
2.4	$512	$792	$427	$490	$2,221
2.7	$512	$792	$427	$490	$2,221

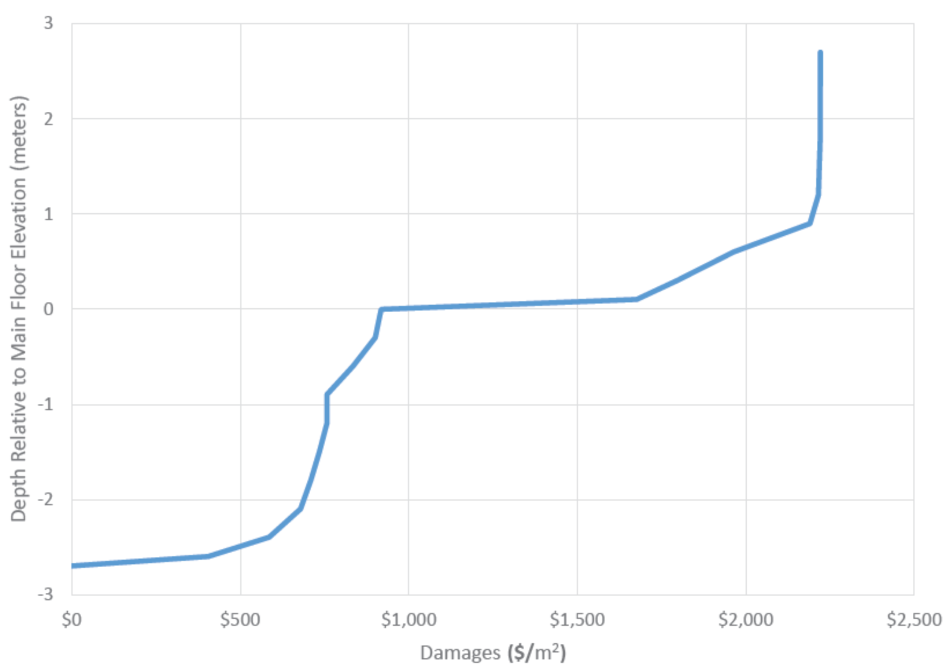

Figure AIV-4: Residential damage function for Class B two-storey

Residential Damage Function for Class C One-Storey (NRC, 2017):

Table AIV-6: Residential damage function for Class C one-storey

Class C - Residential One-Storey					
Depth relative to main floor	Main Floor Contents	Main Floor Structure	Basement Contents	Basement Structure	Total
-2.7	$0	$0	$0	$0	$0
-2.6	$0	$0	$294	$237	$530
-2.4	$0	$0	$350	$309	$659
-2.1	$0	$0	$385	$356	$741
-1.8	$0	$0	$418	$356	$774
-1.5	$0	$0	$422	$374	$796
-1.2	$0	$0	$422	$383	$806
-0.9	$0	$0	$423	$383	$806
-0.6	$0	$0	$439	$424	$863
-0.3	$0	$0	$511	$427	$938
0	$0	$0	$511	$439	$950
0.1	$240	$467	$511	$439	$1,657
0.3	$360	$479	$511	$439	$1,789
0.6	$420	$557	$511	$439	$1,927
0.9	$468	$672	$511	$439	$2,090
1.2	$479	$672	$511	$439	$2,100
1.5	$479	$672	$511	$439	$2,101
1.8	$479	$672	$511	$439	$2,101
2.1	$479	$672	$511	$439	$2,101
2.4	$479	$672	$511	$439	$2,101
2.7	$479	$672	$511	$439	$2,101

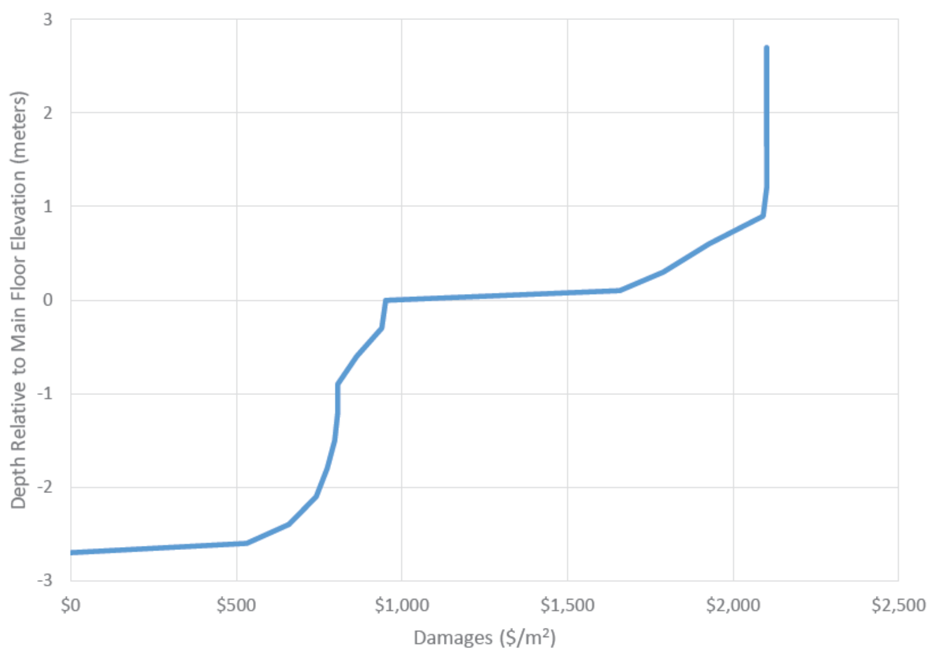

Figure AIV-5: Residential damage function for Class C one-storey

Residential Damage Function for Class C Two-Storey (NRC, 2017):

Table AIV-7: Residential damage function for Class C two-storey

Class C - Residential Two-Storey					
Depth relative to main floor	Main Floor Contents	Main Floor Structure	Basement Contents	Basement Structure	Total
-2.7	$0	$0	$0	$0	$0
-2.6	$0	$0	$191	$207	$398
-2.4	$0	$0	$232	$322	$554
-2.1	$0	$0	$257	$399	$656
-1.8	$0	$0	$264	$399	$663
-1.5	$0	$0	$264	$428	$692
-1.2	$0	$0	$264	$442	$706
-0.9	$0	$0	$264	$442	$706
-0.6	$0	$0	$287	$508	$794
-0.3	$0	$0	$346	$512	$858
0	$0	$0	$346	$532	$878
0.1	$204	$599	$346	$532	$1,681
0.3	$271	$619	$346	$532	$1,767
0.6	$301	$744	$346	$532	$1,923
0.9	$376	$897	$346	$532	$2,152
1.2	$383	$897	$346	$532	$2,158
1.5	$384	$897	$346	$532	$2,159
1.8	$386	$897	$346	$532	$2,161
2.1	$386	$897	$346	$532	$2,161
2.4	$386	$897	$346	$532	$2,161
2.7	$386	$897	$346	$532	$2,161

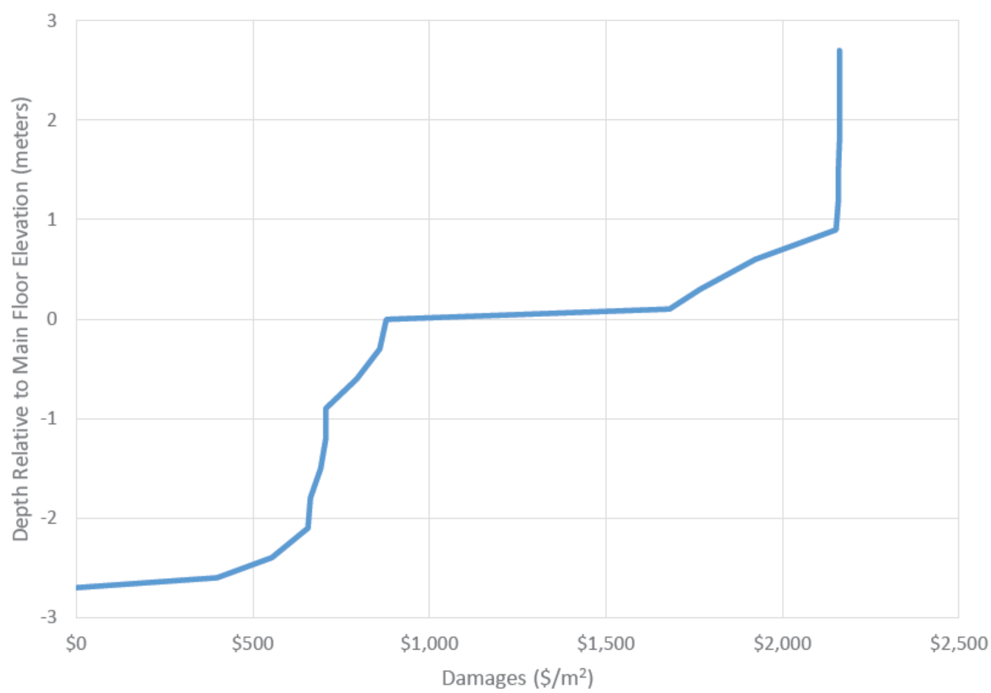

Figure AIV-6: Residential damage function for Class C two-storey

Residential Damage Function for One-Storey Mobile Homes (NRC, 2017):

Table AIV-8: Residential damage function for one-storey mobile homes

One Storey Mobile Home (No Basement)					
Depth relative to main floor	Main Floor Contents	Main Floor Structure	Basement Contents	Basement Structure	Total
-2.7	$0	$0	$0	$0	$0
-2.6	$0	$0	$0	$0	$0
-2.4	$0	$0	$0	$0	$0
-2.1	$0	$0	$0	$0	$0
-1.8	$0	$0	$0	$0	$0
-1.5	$0	$0	$0	$0	$0
-1.2	$0	$0	$0	$0	$0
-0.9	$0	$0	$0	$0	$0
-0.6	$0	$0	$0	$0	$0
-0.3	$0	$0	$0	$0	$0
0	$0	$0	$0	$0	$0
0.1	$243	$362	$0	$0	$605
0.3	$379	$405	$0	$0	$785
0.6	$426	$405	$0	$0	$831
0.9	$481	$470	$0	$0	$951
1.2	$483	$470	$0	$0	$953
1.5	$483	$470	$0	$0	$953
1.8	$483	$470	$0	$0	$953
2.1	$483	$470	$0	$0	$953
2.4	$483	$470	$0	$0	$953
2.7	$483	$470	$0	$0	$953

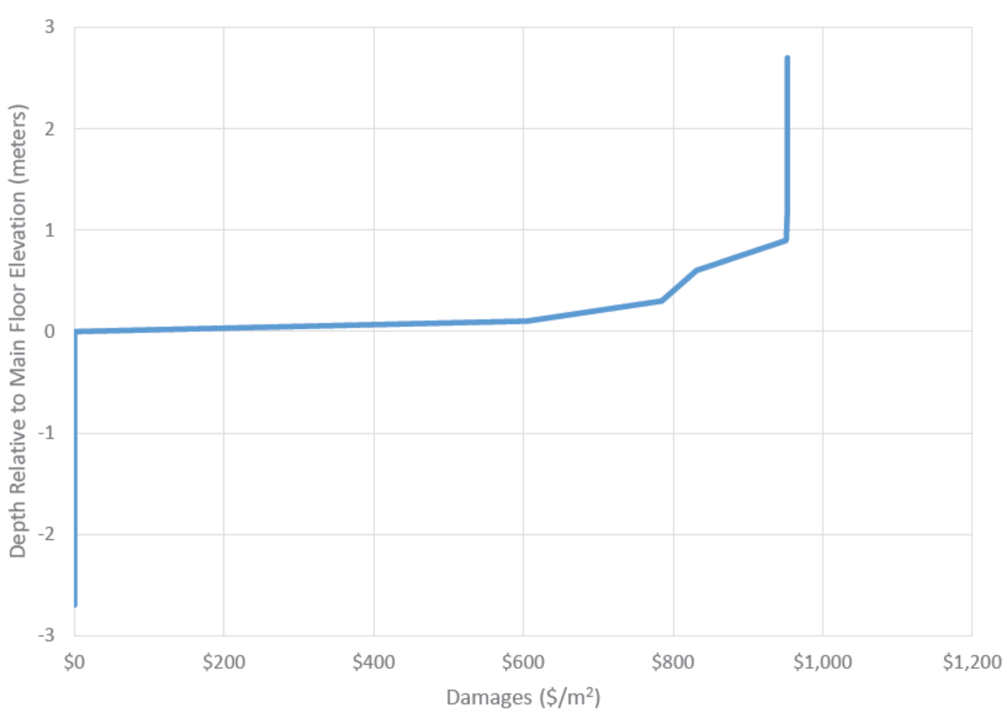

Figure AIV-7: Residential damage function for one-storey mobile homes

Residential Damage Function for Apartments with Four Floors or Less (NRC, 2017):

Table AIV-9: Residential damage function for apartments with four floors or less

Apartment Building with Four Floors or Less			
Depth relative to main floor	Main Floor Contents	Main Floor Structure	Total
0	$0	$0	$0
0.1	$260	$822	$1,082
0.3	$394	$914	$1,307
0.6	$494	$1,105	$1,599
0.9	$565	$1,203	$1,768
1.2	$571	$1,203	$1,774
1.5	$571	$1,203	$1,774
1.8	$571	$1,203	$1,774
2.1	$571	$1,203	$1,774
2.4	$571	$1,203	$1,774
2.7	$571	$1,203	$1,774

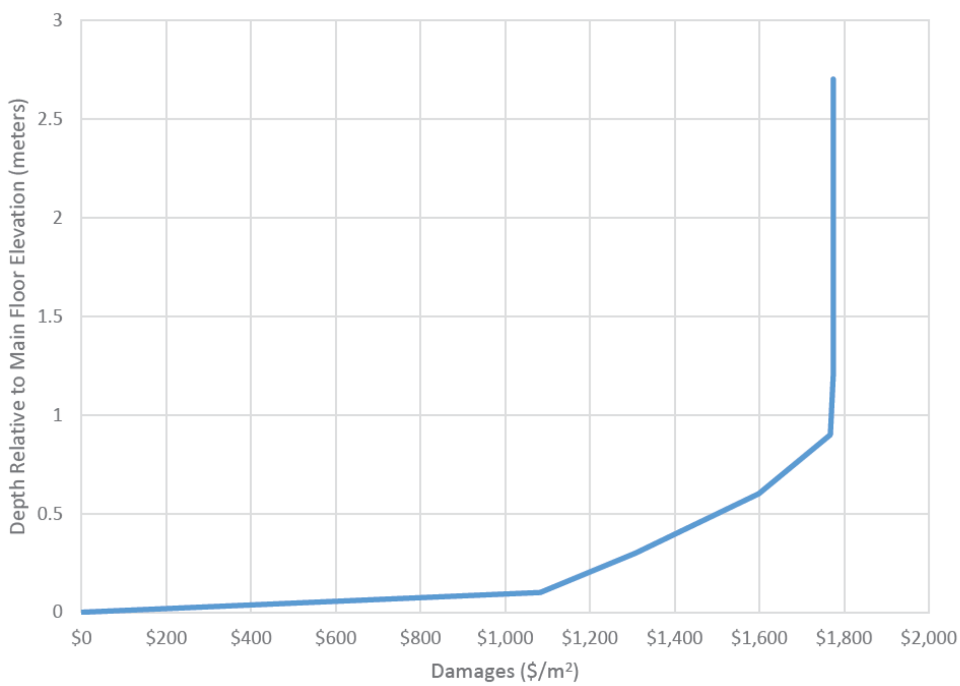

Figure AIV-8: Residential damage function for apartments with four floors or less

Table AIV-10: Impact to automobiles loss estimation

Residence Type	Area	D[1] (m)	NV[2]	DF[3] (%)	Total Loss[4] ($)
AUTOMOBILES AT RESIDENCES					
Single Family Dwelling	Baird Ave	1.45	1.43	100%	29,117
Single Family Dwelling	Baird Ave	0.60	1.43	60%	17,470
Single Family Dwelling	Baird Ave	1.13	1.43	100%	29,117
Single Family Dwelling	Baird Ave	0.45	1.43	15%	4,368
Single Family Dwelling	Baird Ave	1.07	1.43	100%	29,117
Single Family Dwelling	Baird Ave	1.36	1.43	100%	29,117
Single Family Dwelling	Baird Ave	0.94	1.43	100%	29,117
Single Family Dwelling	Baird Ave	0.23	1.43	15%	4,368
Single Family Dwelling	Baird Ave	0.98	1.43	100%	29,117
Single Family Dwelling	Baird Ave	0.87	1.43	100%	29,117
Single Family Dwelling	Baird Ave	0.85	1.43	100%	29,117
Single Family Dwelling	Baird Ave	0.16	1.43	15%	4,368
Single Family Dwelling	Baird Ave	0.65	1.43	60%	17,470
Single Family Dwelling	Baird Ave	1.33	1.43	100%	29,117
Single Family Dwelling	Baird Ave	0.27	1.43	15%	4,368
Single Family Dwelling	Baird Ave	0.96	1.43	100%	29,117
Single Family Dwelling	Baird Ave	0.81	1.43	100%	29,117
Single Family Dwelling	Bass Ave	0.36	1.43	15%	4,368
Single Family Dwelling	Bass Ave	0.26	1.43	15%	4,368
Single Family Dwelling	Bass Ave	0.35	1.43	15%	4,368
Single Family Dwelling	Bass Ave	0.30	1.43	15%	4,368
Single Family Dwelling	Bass Ave	0.32	1.43	15%	4,368
Single Family Dwelling	Belvedere St	1.12	1.43	100%	29,117
Single Family Dwelling	Belvedere St	0.73	1.43	60%	17,470
Single Family Dwelling	Belvedere St	0.87	1.43	100%	29,117
Single Family Dwelling	Belvedere St	1.19	1.43	100%	29,117
Single Family Dwelling	Belvedere St	0.45	1.43	15%	4,368
Single Family Dwelling	Belvedere St	0.98	1.43	100%	29,117
Single Family Dwelling	Brickyard Rd	1.27	1.43	100%	29,117
Single Family Dwelling	Brickyard Rd	0.38	1.43	15%	4,368
Single Family Dwelling	Brickyard Rd	0.23	1.43	15%	4,368
Single Family Dwelling	Brickyard Rd	0.45	1.43	15%	4,368
Single Family Dwelling	Brickyard Rd	0.37	1.43	15%	4,368
Single Family Dwelling	Brickyard Rd	0.37	1.43	15%	4,368
Single Family Dwelling	Brickyard Rd	0.16	1.43	15%	4,368
Single Family Dwelling	Brickyard Rd	0.61	1.43	60%	17,470
Single Family Dwelling	Brickyard Rd	1.87	1.43	100%	29,117
Single Family Dwelling	Brickyard Rd	0.32	1.43	15%	4,368
Single Family Dwelling	Brickyard Rd	0.21	1.43	15%	4,368
Single Family Dwelling	Brickyard Rd	0.65	1.43	60%	17,470
Single Family Dwelling	Cliff View Lane	0.32	1.43	15%	4,368
Single Family Dwelling	Cliff View Lane	0.37	1.43	15%	4,368
Single Family Dwelling	Cliff View Lane	0.36	1.43	15%	4,368
Single Family Dwelling	Cliff View Lane	0.23	1.43	15%	4,368
Single Family Dwelling	Cliff View Lane	0.32	1.43	15%	4,368
Single Family Dwelling	Cliff View Lane	0.43	1.43	15%	4,368
Single Family Dwelling	Cliff View Lane	0.25	1.43	15%	4,368
Single Family Dwelling	Cliff View Lane	0.21	1.43	15%	4,368
Single Family Dwelling	Cliff View Lane	0.16	1.43	15%	4,368
Single Family Dwelling	Cliff View Lane	0.16	1.43	15%	4,368
Single Family Dwelling	Cliff View Lane	0.35	1.43	15%	4,368

Table AIV-10: Impact to automobiles loss estimation

Residence Type	Area	D[1] (m)	NV[2]	DF[3] (%)	Total Loss[4] ($)
AUTOMOBILES AT RESIDENCES					
Single Family Dwelling	Cliff View Lane	0.25	1.43	15%	4,368
Single Family Dwelling	Cliff View Lane	0.54	1.43	60%	17,470
Single Family Dwelling	Cliff View Lane	0.22	1.43	15%	4,368
Single Family Dwelling	Cliff View Lane	0.32	1.43	15%	4,368
Single Family Dwelling	Cliff View Lane	0.25	1.43	15%	4,368
Single Family Dwelling	Cliff View Lane	0.48	1.43	60%	17,470
Single Family Dwelling	Cliff View Lane	0.48	1.43	60%	17,470
Single Family Dwelling	Crescent Dr	0.55	1.43	60%	17,470
Single Family Dwelling	Crescent Dr	1.62	1.43	100%	29,117
Single Family Dwelling	Crescent Dr	0.34	1.43	15%	4,368
Single Family Dwelling	Crescent Dr	0.63	1.43	60%	17,470
Single Family Dwelling	Danforth Ave	0.64	1.43	60%	17,470
Single Family Dwelling	Evergreen St	0.94	1.43	100%	29,117
Single Family Dwelling	George St	0.34	1.43	15%	4,368
Single Family Dwelling	George St	0.31	1.43	15%	4,368
Single Family Dwelling	George St	0.29	1.43	15%	4,368
Single Family Dwelling	George St	0.47	1.43	60%	17,470
Single Family Dwelling	George St	0.21	1.43	15%	4,368
Single Family Dwelling	Heiman St	0.16	1.43	15%	4,368
Single Family Dwelling	Howard Ave	1.49	1.43	100%	29,117
Single Family Dwelling	Howard Ave	1.26	1.43	100%	29,117
Single Family Dwelling	Howard Ave	1.17	1.43	100%	29,117
Single Family Dwelling	Howard Ave	0.75	1.43	100%	29,117
Single Family Dwelling	Howard Ave	0.23	1.43	15%	4,368
Single Family Dwelling	Howard Ave	1.15	1.43	100%	29,117
Single Family Dwelling	Howard Ave	1.57	1.43	100%	29,117
Single Family Dwelling	Howard Ave	0.95	1.43	100%	29,117
Single Family Dwelling	Howard Ave	0.81	1.43	100%	29,117
Single Family Dwelling	Howard Ave	0.23	1.43	15%	4,368
Single Family Dwelling	Howard Ave	1.45	1.43	100%	29,117
Single Family Dwelling	Howard Ave	1.22	1.43	100%	29,117
Single Family Dwelling	Howard Ave	1.52	1.43	100%	29,117
Single Family Dwelling	Howard Ave	0.99	1.43	100%	29,117
Single Family Dwelling	Howard Ave	0.71	1.43	60%	17,470
Single Family Dwelling	Howard Ave	0.36	1.43	15%	4,368
Single Family Dwelling	Howard Ave	0.75	1.43	100%	29,117
Single Family Dwelling	Kate St	0.98	1.43	100%	29,117
Single Family Dwelling	Kate St	0.50	1.43	60%	17,470
Single Family Dwelling	Kate St	0.94	1.43	100%	29,117
Single Family Dwelling	Kate St	0.41	1.43	15%	4,368
Single Family Dwelling	Kildonan Ave	0.36	1.43	15%	4,368
Single Family Dwelling	Kildonan Ave	0.22	1.43	15%	4,368
Single Family Dwelling	Kildonan Ave	0.27	1.43	15%	4,368
Single Family Dwelling	Kildonan Ave	0.87	1.43	100%	29,117
Single Family Dwelling	Kildonan Ave	0.79	1.43	100%	29,117
Single Family Dwelling	Kildonan Ave	0.81	1.43	100%	29,117
Single Family Dwelling	Kildonan Ave	0.30	1.43	15%	4,368
Single Family Dwelling	Knight Ave	0.75	1.43	100%	29,117
Single Family Dwelling	Knight Ave	0.61	1.43	60%	17,470
Single Family Dwelling	Larsen Ave	0.27	1.43	15%	4,368
Single Family Dwelling	Larsen Ave	0.35	1.43	15%	4,368
Single Family Dwelling	Larsen Ave	0.38	1.43	15%	4,368

Table AIV-10: Impact to automobiles loss estimation

Residence Type	Area	D[1] (m)	NV[2]	DF[3] (%)	Total Loss[4] ($)
AUTOMOBILES AT RESIDENCES					
Single Family Dwelling	Larsen Ave	0.25	1.43	15%	4,368
Single Family Dwelling	Larsen Ave	0.21	1.43	15%	4,368
Single Family Dwelling	Larsen Ave	0.22	1.43	15%	4,368
Single Family Dwelling	Larsen Ave	0.19	1.43	15%	4,368
Single Family Dwelling	McGowan St	0.46	1.43	60%	17,470
Single Family Dwelling	McGowan St	0.49	1.43	60%	17,470
Single Family Dwelling	McGowan St	0.52	1.43	60%	17,470
Single Family Dwelling	McGowan St	0.33	1.43	15%	4,368
Single Family Dwelling	Meadow Cres	0.97	1.43	100%	29,117
Single Family Dwelling	Meadow Cres	0.84	1.43	100%	29,117
Single Family Dwelling	Meadow Cres	0.78	1.43	100%	29,117
Single Family Dwelling	Meadow Cres	0.68	1.43	60%	17,470
Single Family Dwelling	Meadow Cres	0.69	1.43	60%	17,470
Single Family Dwelling	Meadow Cres	0.60	1.43	60%	17,470
Single Family Dwelling	Meadow Cres	0.53	1.43	60%	17,470
Single Family Dwelling	Meadow Cres	0.80	1.43	100%	29,117
Single Family Dwelling	Meadow Cres	0.63	1.43	60%	17,470
Single Family Dwelling	Meadow Cres	0.85	1.43	100%	29,117
Single Family Dwelling	Meadow Cres	0.89	1.43	100%	29,117
Single Family Dwelling	Meadow Cres	0.91	1.43	100%	29,117
Single Family Dwelling	Meadow Cres	0.91	1.43	100%	29,117
Single Family Dwelling	Meadow Cres	0.76	1.43	100%	29,117
Single Family Dwelling	Meadow Cres	0.68	1.43	60%	17,470
Single Family Dwelling	Meadow Cres	0.47	1.43	60%	17,470
Single Family Dwelling	Meadow Cres	0.83	1.43	100%	29,117
Single Family Dwelling	Meadow Cres	0.75	1.43	100%	29,117
Single Family Dwelling	Meadow Cres	0.80	1.43	100%	29,117
Single Family Dwelling	Meadow Cres	0.90	1.43	100%	29,117
Single Family Dwelling	Meadow Cres	0.87	1.43	100%	29,117
Single Family Dwelling	Meadow Cres	0.80	1.43	100%	29,117
Single Family Dwelling	Meadow Cres	0.75	1.43	100%	29,117
Single Family Dwelling	Meadow Cres	0.58	1.43	60%	17,470
Single Family Dwelling	Meadow Cres	0.65	1.43	60%	17,470
Single Family Dwelling	Meadow Cres	0.77	1.43	100%	29,117
Single Family Dwelling	Meadow Cres	0.85	1.43	100%	29,117
Single Family Dwelling	Meadow Cres	0.81	1.43	100%	29,117
Single Family Dwelling	Meadow Cres	0.49	1.43	60%	17,470
Single Family Dwelling	Meadow Cres	0.63	1.43	60%	17,470
Single Family Dwelling	Meadow Cres	0.57	1.43	60%	17,470
Single Family Dwelling	Meadow Cres	0.43	1.43	15%	4,368
Single Family Dwelling	Meadow Cres	0.46	1.43	60%	17,470
Single Family Dwelling	Meadow Cres	0.80	1.43	100%	29,117
Single Family Dwelling	Meadow Cres	0.54	1.43	60%	17,470
Single Family Dwelling	Meadow Cres	0.47	1.43	60%	17,470
Single Family Dwelling	Meadow Cres	0.70	1.43	60%	17,470
Single Family Dwelling	Meadow Cres	0.81	1.43	100%	29,117
Single Family Dwelling	Meadow Cres	0.25	1.43	15%	4,368
Single Family Dwelling	Park Ave	1.34	1.43	100%	29,117
Single Family Dwelling	Park Ave	1.20	1.43	100%	29,117
Single Family Dwelling	Park Ave	1.47	1.43	100%	29,117
Single Family Dwelling	Park Ave	0.79	1.43	100%	29,117
Single Family Dwelling	Park Ave	1.09	1.43	100%	29,117

Table AIV-10: Impact to automobiles loss estimation

Residence Type	Area	D[1] (m)	NV[2]	DF[3] (%)	Total Loss[4] ($)
AUTOMOBILES AT RESIDENCES					
Single Family Dwelling	Park Ave	1.37	1.43	100%	29,117
Single Family Dwelling	Park Ave	0.83	1.43	100%	29,117
Single Family Dwelling	Park Ave	1.25	1.43	100%	29,117
Single Family Dwelling	Park Ave	1.29	1.43	100%	29,117
Single Family Dwelling	Park Ave	1.59	1.43	100%	29,117
Single Family Dwelling	Park Ave	0.94	1.43	100%	29,117
Single Family Dwelling	Park Ave	1.73	1.43	100%	29,117
Single Family Dwelling	Park Ave	2.02	1.43	100%	29,117
Single Family Dwelling	Park Ave	1.64	1.43	100%	29,117
Single Family Dwelling	Park Ave	1.42	1.43	100%	29,117
Single Family Dwelling	Park Ave	1.31	1.43	100%	29,117
Single Family Dwelling	Park Ave	1.22	1.43	100%	29,117
Single Family Dwelling	Park Ave	1.01	1.43	100%	29,117
Single Family Dwelling	Park Ave	1.72	1.43	100%	29,117
Single Family Dwelling	Park Ave	0.68	1.43	60%	17,470
Single Family Dwelling	Pine Crt	0.22	1.43	15%	4,368
Single Family Dwelling	Pleasant Ave	0.21	1.43	15%	4,368
Single Family Dwelling	Polson Ave	0.91	1.43	100%	29,117
Single Family Dwelling	Polson Ave	0.50	1.43	60%	17,470
Single Family Dwelling	Polson Ave	1.30	1.43	100%	29,117
Single Family Dwelling	Polson Ave	1.05	1.43	100%	29,117
Single Family Dwelling	Polson Ave	0.95	1.43	100%	29,117
Single Family Dwelling	Polson Ave	1.11	1.43	100%	29,117
Single Family Dwelling	Polson Ave	0.79	1.43	100%	29,117
Single Family Dwelling	Regent Ave	0.66	1.43	60%	17,470
Single Family Dwelling	Regent Ave	1.09	1.43	100%	29,117
Single Family Dwelling	Regent Ave	0.76	1.43	100%	29,117
Single Family Dwelling	Regent Ave	0.72	1.43	60%	17,470
Single Family Dwelling	Regent Ave	0.21	1.43	15%	4,368
Single Family Dwelling	Regent Ave	0.37	1.43	15%	4,368
Single Family Dwelling	Regent Ave	0.80	1.43	100%	29,117
Single Family Dwelling	Regent Ave	0.26	1.43	15%	4,368
Single Family Dwelling	Regent Ave	0.20	1.43	15%	4,368
Single Family Dwelling	Regent Ave	0.15	1.43	15%	4,368
Single Family Dwelling	Riverdale Dr	0.44	1.43	15%	4,368
Single Family Dwelling	Riverdale Dr	0.40	1.43	15%	4,368
Single Family Dwelling	Riverdale Dr	0.82	1.43	100%	29,117
Single Family Dwelling	Riverdale Dr	0.44	1.43	15%	4,368
Single Family Dwelling	Riverdale Dr	0.57	1.43	60%	17,470
Single Family Dwelling	Riverdale Dr	0.79	1.43	100%	29,117
Single Family Dwelling	Riverdale Dr	0.30	1.43	15%	4,368
Single Family Dwelling	Riverdale Dr	0.34	1.43	15%	4,368
Single Family Dwelling	Riverdale Dr	0.64	1.43	60%	17,470
Single Family Dwelling	Riverdale Dr	0.73	1.43	60%	17,470
Single Family Dwelling	Riverdale Dr	0.44	1.43	15%	4,368
Single Family Dwelling	Riverdale Dr	0.61	1.43	60%	17,470
Single Family Dwelling	Riverdale Dr	0.66	1.43	60%	17,470
Single Family Dwelling	Riverdale Dr	0.68	1.43	60%	17,470
Single Family Dwelling	Riverdale Dr	0.40	1.43	15%	4,368
Single Family Dwelling	Riverdale Dr	0.79	1.43	100%	29,117
Single Family Dwelling	Riverdale Dr	0.37	1.43	15%	4,368
Single Family Dwelling	Riverdale Dr	0.28	1.43	15%	4,368

Table AIV-10: Impact to automobiles loss estimation

Residence Type	Area	D[1] (m)	NV[2]	DF[3] (%)	Total Loss[4] ($)
AUTOMOBILES AT RESIDENCES					
Single Family Dwelling	Riverdale Dr	1.13	1.43	100%	29,117
Single Family Dwelling	Riverdale Dr	0.62	1.43	60%	17,470
Single Family Dwelling	Riverdale Dr	0.98	1.43	100%	29,117
Single Family Dwelling	Riverdale Dr	0.76	1.43	100%	29,117
Single Family Dwelling	Riverdale Dr	0.84	1.43	100%	29,117
Single Family Dwelling	Riverdale Dr	0.35	1.43	15%	4,368
Single Family Dwelling	Riverdale Dr	0.69	1.43	60%	17,470
Single Family Dwelling	Riverdale Dr	0.74	1.43	100%	29,117
Single Family Dwelling	Riverdale Dr	0.54	1.43	60%	17,470
Single Family Dwelling	Victor St	0.31	1.43	15%	4,368
Single Family Dwelling	Victor St	0.15	1.43	15%	4,368
Single Family Dwelling	Victor St	0.16	1.43	15%	4,368
Single Family Dwelling	Waterwheel St	0.24	1.43	15%	4,368
Single Family Dwelling	Waterwheel St	0.25	1.43	15%	4,368
Single Family Dwelling	Waterwheel St	0.29	1.43	15%	4,368
Single Family Dwelling	Waterwheel St	0.18	1.43	15%	4,368
Single Family Dwelling	Waterwheel St	0.19	1.43	15%	4,368
Single Family Dwelling	Waterwheel St	0.24	1.43	15%	4,368
Multiple Family Dwelling	Baird Ave	1.05	34.32	100%	698,816
Multiple Family Dwelling	Belvedere St	0.55	7.15	60%	87,352
Multiple Family Dwelling	Howard Ave	0.92	17.16	100%	349,408
Multiple Family Dwelling	Kate St	0.18	2.86	15%	8,735
AUTOMOBILES IN PUBLIC AREAS[NOTE5]					
Campground	Kildonan Ave	0.35	13.00	0.28	75,339
Curling Rink	Kate St	0.24	5.00	0.15	15,271
School	Bass Ave	0.58	30.00	0.62	379,747
Industrial	Cliff View Lane	0.41	28.00	0.29	167,985
Food Services	George St	0.33	8.00	0.15	24,434
Retail	Belvedere St	0.33	7.00	0.21	30,543
Commercial	Railway St	0.17	1.00	0.15	3,054
			TOTAL		**$5,790,454**

[NOTE1] D represents the depth of flood at a particular GIS node location.
[NOTE2] NV represents the number of vehicles at that GIS node.
[NOTE3] DF is the damage function in percent.
[NOTE4] Values are in 2020 dollars.
[NOTE5] Average of SPFD nodes

Table AIV-11: Residential structural and content damage loss estimation

Building Classification	Area	D[1] (m)	SD[2] ($/m²)	CD[3] ($/m²)	Total Loss[4] ($)
Single Family Dwelling	Baird Ave	1.45	53,335	45,583	98,918
Single Family Dwelling	Baird Ave	0.60	66,383	65,956	132,338
Single Family Dwelling	Baird Ave	1.13	56,890	48,570	105,460
Single Family Dwelling	Baird Ave	0.45	48,224	45,490	93,714
Single Family Dwelling	Baird Ave	1.07	50,075	42,717	92,792
Single Family Dwelling	Baird Ave	1.36	41,423	35,403	76,826
Single Family Dwelling	Baird Ave	0.94	59,219	54,987	114,206
Single Family Dwelling	Baird Ave	0.23	67,764	66,305	134,068
Single Family Dwelling	Baird Ave	0.98	116,266	112,373	228,639
Single Family Dwelling	Baird Ave	0.87	61,869	53,280	115,150
Single Family Dwelling	Baird Ave	0.85	48,376	41,912	90,288
Single Family Dwelling	Baird Ave	0.16	33,582	21,217	54,799

Table AIV-11: Residential structural and content damage loss estimation

Building Classification	Area	D[1] (m)	SD[2] ($/m^2)	CD[3] ($/m^2)	Total Loss[4] ($)
Single Family Dwelling	Baird Ave	0.65	40,020	37,144	77,164
Single Family Dwelling	Baird Ave	1.33	36,979	31,605	68,583
Single Family Dwelling	Baird Ave	0.27	39,423	34,155	73,577
Single Family Dwelling	Baird Ave	0.96	88,096	87,404	175,500
Single Family Dwelling	Baird Ave	0.81	66,702	58,514	125,215
Single Family Dwelling	Bass Ave	0.10	29,528	16,314	45,842
Single Family Dwelling	Bass Ave	0.36	69,513	65,581	135,094
Single Family Dwelling	Bass Ave	0.09	54,503	33,772	88,275
Single Family Dwelling	Bass Ave	0.26	73,437	60,777	134,214
Single Family Dwelling	Bass Ave	0.35	25,871	24,408	50,279
Single Family Dwelling	Bass Ave	0.30	76,199	83,216	159,415
Single Family Dwelling	Bass Ave	0.14	81,133	78,432	159,564
Single Family Dwelling	Bass Ave	0.32	76,636	85,320	161,956
Single Family Dwelling	Belvedere St	1.12	76,342	76,526	152,868
Single Family Dwelling	Belvedere St	0.73	49,371	46,542	95,913
Single Family Dwelling	Belvedere St	0.87	54,373	49,063	103,437
Single Family Dwelling	Belvedere St	1.19	99,976	104,334	204,310
Single Family Dwelling	Belvedere St	0.45	46,327	43,700	90,027
Single Family Dwelling	Belvedere St	0.98	78,768	81,483	160,251
Single Family Dwelling	Brickyard Rd	1.27	53,335	45,583	98,918
Single Family Dwelling	Brickyard Rd	0.38	46,328	43,705	90,032
Single Family Dwelling	Brickyard Rd	0.23	49,357	38,929	88,285
Single Family Dwelling	Brickyard Rd	0.45	79,213	85,573	164,786
Single Family Dwelling	Brickyard Rd	0.09	38,845	21,462	60,307
Single Family Dwelling	Brickyard Rd	0.37	42,497	40,092	82,589
Single Family Dwelling	Brickyard Rd	0.37	82,421	88,606	171,027
Single Family Dwelling	Brickyard Rd	0.16	87,158	84,801	171,959
Single Family Dwelling	Brickyard Rd	0.61	72,799	81,065	153,863
Single Family Dwelling	Brickyard Rd	1.87	53,335	45,676	99,010
Single Family Dwelling	Brickyard Rd	0.32	74,255	80,904	155,159
Single Family Dwelling	Brickyard Rd	0.12	73,983	65,266	139,250
Single Family Dwelling	Brickyard Rd	0.21	50,181	37,620	87,802
Single Family Dwelling	Brickyard Rd	0.65	106,574	98,916	205,490
Single Family Dwelling	Cliff View Lane	0.32	50,074	47,244	97,319
Single Family Dwelling	Cliff View Lane	0.37	51,304	48,401	99,705
Single Family Dwelling	Cliff View Lane	0.36	51,304	48,401	99,705
Single Family Dwelling	Cliff View Lane	0.23	49,730	39,223	88,952
Single Family Dwelling	Cliff View Lane	0.32	50,484	47,630	98,114
Single Family Dwelling	Cliff View Lane	0.43	52,535	49,557	102,092
Single Family Dwelling	Cliff View Lane	0.25	49,816	41,228	91,044
Single Family Dwelling	Cliff View Lane	0.14	49,385	31,201	80,586
Single Family Dwelling	Cliff View Lane	0.21	49,644	37,217	86,861
Single Family Dwelling	Cliff View Lane	0.16	49,385	31,201	80,586
Single Family Dwelling	Cliff View Lane	0.16	49,385	31,201	80,586
Single Family Dwelling	Cliff View Lane	0.35	50,894	48,015	98,910
Single Family Dwelling	Cliff View Lane	0.25	49,816	41,228	91,044
Single Family Dwelling	Cliff View Lane	0.54	54,995	51,870	106,866
Single Family Dwelling	Cliff View Lane	0.14	49,385	31,201	80,586
Single Family Dwelling	Cliff View Lane	0.22	49,730	39,223	88,952
Single Family Dwelling	Cliff View Lane	0.14	49,299	29,196	78,495
Single Family Dwelling	Cliff View Lane	0.32	50,074	47,244	97,319
Single Family Dwelling	Cliff View Lane	0.10	49,213	27,190	76,403
Single Family Dwelling	Cliff View Lane	0.25	49,816	41,228	91,044

Table AIV-11: Residential structural and content damage loss estimation

Building Classification	Area	D[1] (m)	SD[2] ($/m^2)	CD[3] ($/m^2)	Total Loss[4] ($)
Single Family Dwelling	Cliff View Lane	0.48	53,355	50,328	103,683
Single Family Dwelling	Cliff View Lane	0.48	53,355	50,328	103,683
Single Family Dwelling	Cliff View Lane	0.12	49,299	29,196	78,495
Single Family Dwelling	Crescent Dr	0.55	74,183	76,171	150,354
Single Family Dwelling	Crescent Dr	1.62	93,168	92,678	185,846
Single Family Dwelling	Crescent Dr	0.34	79,226	74,744	153,970
Single Family Dwelling	Crescent Dr	0.09	34,908	19,287	54,195
Single Family Dwelling	Crescent Dr	0.63	34,951	32,696	67,647
Single Family Dwelling	Crescent Dr	0.13	45,725	27,079	72,804
Single Family Dwelling	Crescent Dr	0.08	89,244	88,941	178,185
Single Family Dwelling	Danforth Ave	0.64	52,150	52,199	104,349
Single Family Dwelling	Evergreen St	0.94	77,039	65,594	142,633
Single Family Dwelling	George St	0.34	56,627	53,425	110,051
Single Family Dwelling	George St	0.31	58,420	55,118	113,538
Single Family Dwelling	George St	0.29	41,990	38,001	79,991
Single Family Dwelling	George St	0.47	38,416	36,236	74,652
Single Family Dwelling	George St	0.21	35,743	26,796	62,540
Single Family Dwelling	George St	0.10	98,426	54,380	152,806
Single Family Dwelling	Heitman St	0.15	88,998	81,342	170,340
Single Family Dwelling	Heitman St	0.16	56,052	35,413	91,465
Single Family Dwelling	Heitman St	0.05	58,600	61,035	119,636
Single Family Dwelling	Howard Ave	0.12	65,794	60,132	125,925
Single Family Dwelling	Howard Ave	1.49	86,283	73,744	160,027
Single Family Dwelling	Howard Ave	1.26	51,201	43,760	94,961
Single Family Dwelling	Howard Ave	1.17	52,386	44,749	97,135
Single Family Dwelling	Howard Ave	0.75	56,908	50,923	107,832
Single Family Dwelling	Howard Ave	0.23	43,762	34,516	78,278
Single Family Dwelling	Howard Ave	1.15	71,374	69,564	140,938
Single Family Dwelling	Howard Ave	1.57	46,342	39,623	85,965
Single Family Dwelling	Howard Ave	0.95	45,512	38,761	84,274
Single Family Dwelling	Howard Ave	0.81	52,896	48,206	101,103
Single Family Dwelling	Howard Ave	0.08	23,229	12,834	36,062
Single Family Dwelling	Howard Ave	0.23	62,411	49,224	111,635
Single Family Dwelling	Howard Ave	1.45	53,335	45,583	98,918
Single Family Dwelling	Howard Ave	1.22	88,424	87,670	176,094
Single Family Dwelling	Howard Ave	1.52	51,675	44,165	95,841
Single Family Dwelling	Howard Ave	0.99	65,256	64,156	129,413
Single Family Dwelling	Howard Ave	0.71	58,333	52,937	111,270
Single Family Dwelling	Howard Ave	0.36	44,193	41,693	85,887
Single Family Dwelling	Howard Ave	0.75	26,427	23,648	50,075
Single Family Dwelling	Kate St	0.98	125,660	129,859	255,519
Single Family Dwelling	Kate St	0.50	100,439	112,568	213,007
Single Family Dwelling	Kate St	0.13	81,323	76,199	157,522
Single Family Dwelling	Kate St	0.94	49,409	46,825	96,235
Single Family Dwelling	Kate St	0.41	61,753	67,555	129,308
Single Family Dwelling	Kildonan Ave	0.11	78,167	67,577	145,744
Single Family Dwelling	Kildonan Ave	0.36	74,581	78,110	152,691
Single Family Dwelling	Kildonan Ave	0.22	65,888	59,850	125,738
Single Family Dwelling	Kildonan Ave	0.27	65,333	69,612	134,945
Single Family Dwelling	Kildonan Ave	0.87	62,215	53,578	115,793
Single Family Dwelling	Kildonan Ave	0.79	89,854	93,233	183,087
Single Family Dwelling	Kildonan Ave	0.81	77,971	81,350	159,321
Single Family Dwelling	Kildonan Ave	0.30	83,854	92,968	176,822

Table AIV-11: Residential structural and content damage loss estimation

Building Classification	Area	D[1] (m)	SD[2] ($/m²)	CD[3] ($/m²)	Total Loss[4] ($)
Single Family Dwelling	Knight Ave	0.14	41,977	26,521	68,498
Single Family Dwelling	Knight Ave	0.75	49,275	44,093	93,368
Single Family Dwelling	Knight Ave	0.61	43,575	41,096	84,671
Single Family Dwelling	Larsen Ave	0.27	68,742	68,782	137,524
Single Family Dwelling	Larsen Ave	0.10	81,319	67,977	149,296
Single Family Dwelling	Larsen Ave	0.05	21,572	11,918	33,490
Single Family Dwelling	Larsen Ave	0.10	34,318	18,961	53,278
Single Family Dwelling	Larsen Ave	0.08	65,029	66,111	131,140
Single Family Dwelling	Larsen Ave	0.35	75,185	77,441	152,626
Single Family Dwelling	Larsen Ave	0.38	73,618	82,842	156,460
Single Family Dwelling	Larsen Ave	0.25	75,344	78,307	153,651
Single Family Dwelling	Larsen Ave	0.21	79,224	79,454	158,678
Single Family Dwelling	Larsen Ave	0.22	60,762	54,723	115,485
Single Family Dwelling	Larsen Ave	0.13	39,850	27,076	66,926
Single Family Dwelling	Larsen Ave	0.19	90,228	83,652	173,879
Single Family Dwelling	McGowan St	0.46	82,313	92,374	174,687
Single Family Dwelling	McGowan St	0.49	52,242	49,277	101,519
Single Family Dwelling	McGowan St	0.52	30,338	28,616	58,954
Single Family Dwelling	McGowan St	0.33	89,694	84,622	174,316
Single Family Dwelling	Meadow Cres	0.97	50,371	42,912	93,283
Single Family Dwelling	Meadow Cres	0.84	47,560	41,459	89,019
Single Family Dwelling	Meadow Cres	0.78	45,451	40,396	85,846
Single Family Dwelling	Meadow Cres	0.68	42,639	38,978	81,617
Single Family Dwelling	Meadow Cres	0.69	42,639	38,978	81,617
Single Family Dwelling	Meadow Cres	0.60	39,827	37,561	77,387
Single Family Dwelling	Meadow Cres	0.53	38,665	36,468	75,133
Single Family Dwelling	Meadow Cres	0.80	46,857	41,105	87,961
Single Family Dwelling	Meadow Cres	0.63	40,530	37,915	78,445
Single Family Dwelling	Meadow Cres	0.85	48,263	41,814	90,076
Single Family Dwelling	Meadow Cres	0.89	49,668	42,522	92,191
Single Family Dwelling	Meadow Cres	0.91	50,371	42,877	93,248
Single Family Dwelling	Meadow Cres	0.91	50,371	42,877	93,248
Single Family Dwelling	Meadow Cres	0.76	45,451	40,396	85,846
Single Family Dwelling	Meadow Cres	0.68	41,936	38,624	80,560
Single Family Dwelling	Meadow Cres	0.47	37,793	35,649	73,442
Single Family Dwelling	Meadow Cres	0.83	47,560	41,459	89,019
Single Family Dwelling	Meadow Cres	0.75	44,748	40,042	84,789
Single Family Dwelling	Meadow Cres	0.80	46,857	41,105	87,961
Single Family Dwelling	Meadow Cres	0.90	50,371	42,877	93,248
Single Family Dwelling	Meadow Cres	0.87	48,966	42,168	91,133
Single Family Dwelling	Meadow Cres	0.80	46,857	41,105	87,961
Single Family Dwelling	Meadow Cres	0.75	44,748	40,042	84,789
Single Family Dwelling	Meadow Cres	0.58	39,536	37,288	76,824
Single Family Dwelling	Meadow Cres	0.65	41,233	38,270	79,502
Single Family Dwelling	Meadow Cres	0.77	45,451	40,396	85,846
Single Family Dwelling	Meadow Cres	0.85	48,263	41,814	90,076
Single Family Dwelling	Meadow Cres	0.81	46,857	41,105	87,961
Single Family Dwelling	Meadow Cres	0.49	38,084	35,922	74,006
Single Family Dwelling	Meadow Cres	0.63	40,530	37,915	78,445
Single Family Dwelling	Meadow Cres	0.57	39,246	37,015	76,260
Single Family Dwelling	Meadow Cres	0.43	37,212	35,103	72,315
Single Family Dwelling	Meadow Cres	0.46	37,793	35,649	73,442
Single Family Dwelling	Meadow Cres	0.80	46,857	41,105	87,961

Table AIV-11: Residential structural and content damage loss estimation

Building Classification	Area	D[1] (m)	SD[2] ($/m²)	CD[3] ($/m²)	Total Loss[4] ($)
Single Family Dwelling	Meadow Cres	0.54	38,955	36,742	75,697
Single Family Dwelling	Meadow Cres	0.47	37,793	35,649	73,442
Single Family Dwelling	Meadow Cres	0.70	42,639	38,978	81,617
Single Family Dwelling	Meadow Cres	0.81	46,857	41,105	87,961
Single Family Dwelling	Meadow Cres	0.25	35,286	29,203	64,489
Single Family Dwelling	Meadow Cres	0.70	42,639	38,978	81,617
Single Family Dwelling	Park Ave	1.34	90,913	83,371	174,283
Single Family Dwelling	Park Ave	1.20	91,631	89,639	181,270
Single Family Dwelling	Park Ave	1.47	92,544	94,216	186,760
Single Family Dwelling	Park Ave	0.79	105,186	110,690	215,876
Single Family Dwelling	Park Ave	1.09	57,643	52,370	110,014
Single Family Dwelling	Park Ave	1.37	81,877	85,099	166,976
Single Family Dwelling	Park Ave	0.83	107,222	111,716	218,939
Single Family Dwelling	Park Ave	1.25	82,843	84,034	166,877
Single Family Dwelling	Park Ave	1.29	82,836	86,391	169,227
Single Family Dwelling	Park Ave	1.59	80,608	80,261	160,869
Single Family Dwelling	Park Ave	0.94	97,975	97,689	195,664
Single Family Dwelling	Park Ave	1.73	80,608	80,307	160,916
Single Family Dwelling	Park Ave	2.02	80,608	80,334	160,942
Single Family Dwelling	Park Ave	1.64	73,602	62,965	136,566
Single Family Dwelling	Park Ave	1.42	112,525	116,585	229,111
Single Family Dwelling	Park Ave	1.31	83,655	86,618	170,273
Single Family Dwelling	Park Ave	1.22	85,942	84,793	170,734
Single Family Dwelling	Park Ave	1.01	147,343	152,042	299,385
Single Family Dwelling	Park Ave	1.72	80,608	80,301	160,909
Single Family Dwelling	Park Ave	0.68	96,969	104,768	201,737
Single Family Dwelling	Pine Crt	0.22	43,762	34,516	78,278
Single Family Dwelling	Pleasant Ave	0.21	81,217	81,521	162,738
Single Family Dwelling	Polson Ave	0.91	84,830	82,106	166,935
Single Family Dwelling	Polson Ave	0.50	65,107	69,785	134,892
Single Family Dwelling	Polson Ave	1.30	22,756	19,449	42,205
Single Family Dwelling	Polson Ave	1.05	91,321	77,881	169,201
Single Family Dwelling	Polson Ave	0.95	41,719	35,531	77,251
Single Family Dwelling	Polson Ave	1.11	39,823	33,990	73,813
Single Family Dwelling	Polson Ave	0.79	36,651	32,361	69,012
Single Family Dwelling	Regent Ave	0.07	34,990	19,332	54,323
Single Family Dwelling	Regent Ave	0.66	79,924	73,613	153,537
Single Family Dwelling	Regent Ave	1.09	74,965	63,966	138,931
Single Family Dwelling	Regent Ave	0.76	43,800	39,194	82,994
Single Family Dwelling	Regent Ave	0.72	37,121	33,687	70,808
Single Family Dwelling	Regent Ave	0.21	30,862	23,137	53,998
Single Family Dwelling	Regent Ave	0.37	42,241	39,850	82,091
Single Family Dwelling	Regent Ave	0.80	48,868	43,147	92,016
Single Family Dwelling	Regent Ave	0.08	30,758	16,994	47,752
Single Family Dwelling	Regent Ave	0.06	30,758	16,994	47,752
Single Family Dwelling	Regent Ave	0.14	51,443	32,501	83,944
Single Family Dwelling	Regent Ave	0.26	51,891	42,946	94,837
Single Family Dwelling	Regent Ave	0.09	41,011	22,658	63,669
Single Family Dwelling	Regent Ave	0.06	30,758	16,994	47,752
Single Family Dwelling	Regent Ave	0.15	51,443	32,501	83,944
Single Family Dwelling	Regent Ave	0.08	30,758	16,994	47,752
Single Family Dwelling	Regent Ave	0.05	20,505	11,329	31,835
Single Family Dwelling	Regent Ave	0.06	30,758	16,994	47,752

Table AIV-11: Residential structural and content damage loss estimation

Building Classification	Area	D[1] (m)	SD[2] ($/m²)	CD[3] ($/m²)	Total Loss[4] ($)
Single Family Dwelling	Regent Ave	0.20	51,622	36,679	88,301
Single Family Dwelling	Regent Ave	0.09	41,011	22,658	63,669
Single Family Dwelling	Regent Ave	0.15	51,443	32,501	83,944
Single Family Dwelling	Riverdale Dr	0.44	81,636	90,711	172,347
Single Family Dwelling	Riverdale Dr	0.40	56,240	53,055	109,295
Single Family Dwelling	Riverdale Dr	0.82	63,170	55,068	118,238
Single Family Dwelling	Riverdale Dr	0.44	68,032	70,220	138,252
Single Family Dwelling	Riverdale Dr	0.57	92,666	87,398	180,064
Single Family Dwelling	Riverdale Dr	0.79	57,556	50,818	108,374
Single Family Dwelling	Riverdale Dr	0.07	50,148	27,707	77,855
Single Family Dwelling	Riverdale Dr	0.30	67,480	72,830	140,310
Single Family Dwelling	Riverdale Dr	0.34	76,489	81,460	157,949
Single Family Dwelling	Riverdale Dr	0.64	48,540	45,409	93,949
Single Family Dwelling	Riverdale Dr	0.73	35,650	32,123	67,773
Single Family Dwelling	Riverdale Dr	0.44	59,411	61,780	121,191
Single Family Dwelling	Riverdale Dr	0.09	67,258	37,160	104,418
Single Family Dwelling	Riverdale Dr	0.61	65,626	67,988	133,614
Single Family Dwelling	Riverdale Dr	0.66	49,479	45,923	95,403
Single Family Dwelling	Riverdale Dr	0.09	70,342	38,864	109,205
Single Family Dwelling	Riverdale Dr	0.68	65,312	59,706	125,018
Single Family Dwelling	Riverdale Dr	0.40	68,436	64,561	132,996
Single Family Dwelling	Riverdale Dr	0.79	44,633	39,408	84,041
Single Family Dwelling	Riverdale Dr	0.37	53,357	50,337	103,694
Single Family Dwelling	Riverdale Dr	0.12	69,387	65,017	134,404
Single Family Dwelling	Riverdale Dr	0.28	43,323	39,207	82,530
Single Family Dwelling	Riverdale Dr	1.13	79,646	67,998	147,644
Single Family Dwelling	Riverdale Dr	0.62	56,408	52,769	109,177
Single Family Dwelling	Riverdale Dr	0.98	61,868	52,706	114,574
Single Family Dwelling	Riverdale Dr	0.05	26,492	21,497	47,989
Single Family Dwelling	Riverdale Dr	0.76	45,485	40,701	86,186
Single Family Dwelling	Riverdale Dr	0.84	73,189	63,409	136,598
Single Family Dwelling	Riverdale Dr	0.35	45,975	43,374	89,349
Single Family Dwelling	Riverdale Dr	0.69	80,566	85,284	165,850
Single Family Dwelling	Riverdale Dr	0.74	78,124	69,908	148,032
Single Family Dwelling	Riverdale Dr	0.54	74,702	70,457	145,159
Single Family Dwelling	Salmon Arm Dr	0.06	18,061	9,979	28,040
Single Family Dwelling	Salmon Arm Dr	0.06	18,061	9,979	28,040
Single Family Dwelling	Salmon Arm Dr	0.12	45,232	26,787	72,019
Single Family Dwelling	Salmon Arm Dr	0.06	18,061	9,979	28,040
Single Family Dwelling	Salmon Arm Dr	0.10	36,122	19,958	56,080
Single Family Dwelling	Victor St	0.31	55,898	58,937	114,836
Single Family Dwelling	Victor St	0.15	90,514	79,144	169,659
Single Family Dwelling	Victor St	0.16	62,673	53,320	115,992
Single Family Dwelling	Waterwheel St	0.24	113,232	115,024	228,256
Single Family Dwelling	Waterwheel St	0.05	18,406	10,169	28,575
Single Family Dwelling	Waterwheel St	0.25	106,089	113,262	219,351
Single Family Dwelling	Waterwheel St	0.29	47,614	43,090	90,704
Single Family Dwelling	Waterwheel St	0.18	61,947	44,015	105,962
Single Family Dwelling	Waterwheel St	0.19	82,765	73,464	156,229
Single Family Dwelling	Waterwheel St	0.24	77,684	82,237	159,922
Multiple Family Dwelling	Baird Ave	1.05	619,392	528,233	1,147,625
Multiple Family Dwelling	Belvedere St	0.09	147,540	81,516	229,056
Multiple Family Dwelling	Belvedere St	0.55	940,285	886,855	1,827,139

Table AIV-11: Residential structural and content damage loss estimation

Building Classification	Area	D[1] (m)	SD[2] ($/m^2)	CD[3] ($/m^2)	Total Loss[4] ($)
Multiple Family Dwelling	Howard Ave	0.92	508,456	432,920	941,376
Multiple Family Dwelling	Kate St	0.18	129,949	127,269	257,218
				TOTAL	**$35,093,138**

NOTE1 D represents the depth of flood at a particular GIS node location.
NOTE2 SD represents the structural damage.
NOTE3 CD represents the contents damage.
NOTE4 Values are in 2020 dollars.

Table AIV-12: Residential property cleanup damages

Building Class	Area	NRC Class	D[1] (m)	Total Loss ($)
Single Family Dwelling	Bass Ave	B	0.356	5,518
Single Family Dwelling	Riverdale Dr	B	0.573	5,518
Single Family Dwelling	Riverdale Dr	B	0.067	5,518
Single Family Dwelling	Riverdale Dr	B	0.093	5,518
Single Family Dwelling	Baird Ave	C	1.453	2,759
Single Family Dwelling	Baird Ave	C	0.602	2,759
Single Family Dwelling	Baird Ave	C	1.133	2,759
Single Family Dwelling	Baird Ave	C	0.453	2,759
Single Family Dwelling	Baird Ave	C	1.070	2,759
Single Family Dwelling	Baird Ave	C	1.359	2,759
Single Family Dwelling	Baird Ave	C	0.937	2,759
Single Family Dwelling	Baird Ave	C	0.226	2,759
Single Family Dwelling	Baird Ave	C	0.984	2,759
Single Family Dwelling	Baird Ave	C	0.867	2,759
Single Family Dwelling	Baird Ave	C	0.851	2,759
Single Family Dwelling	Baird Ave	C	0.156	2,759
Single Family Dwelling	Baird Ave	C	0.648	2,759
Single Family Dwelling	Baird Ave	C	1.328	2,759
Single Family Dwelling	Baird Ave	C	0.266	2,759
Single Family Dwelling	Baird Ave	C	0.961	2,759
Single Family Dwelling	Baird Ave	C	0.812	2,759
Single Family Dwelling	Bass Ave	C	0.103	2,759
Single Family Dwelling	Bass Ave	C	0.088	2,759
Single Family Dwelling	Bass Ave	C	0.258	2,759
Single Family Dwelling	Bass Ave	C	0.345	2,759
Single Family Dwelling	Bass Ave	C	0.297	2,759
Single Family Dwelling	Bass Ave	C	0.141	2,759
Single Family Dwelling	Bass Ave	C	0.320	2,759
Single Family Dwelling	Belvedere St	C	1.117	2,759
Single Family Dwelling	Belvedere St	C	0.726	2,759
Single Family Dwelling	Belvedere St	C	0.867	2,759
Single Family Dwelling	Belvedere St	C	1.187	2,759
Single Family Dwelling	Belvedere St	C	0.445	2,759
Single Family Dwelling	Belvedere St	C	0.984	2,759
Single Family Dwelling	Brickyard Rd	C	1.273	2,759
Single Family Dwelling	Brickyard Rd	C	0.383	2,759
Single Family Dwelling	Brickyard Rd	C	0.225	2,759
Single Family Dwelling	Brickyard Rd	C	0.454	2,759
Single Family Dwelling	Brickyard Rd	C	0.086	2,759
Single Family Dwelling	Brickyard Rd	C	0.375	2,759
Single Family Dwelling	Brickyard Rd	C	0.367	2,759
Single Family Dwelling	Brickyard Rd	C	0.164	2,759

Table AIV-12: Residential property cleanup damages

Building Class	Area	NRC Class	D[1] (m)	Total Loss ($)
Single Family Dwelling	Brickyard Rd	C	0.610	2,759
Single Family Dwelling	Brickyard Rd	C	1.875	2,759
Single Family Dwelling	Brickyard Rd	C	0.321	2,759
Single Family Dwelling	Brickyard Rd	C	0.117	2,759
Single Family Dwelling	Brickyard Rd	C	0.211	2,759
Single Family Dwelling	Brickyard Rd	C	0.646	2,759
Single Family Dwelling	Crescent Dr	C	0.554	2,759
Single Family Dwelling	Crescent Dr	C	1.625	2,759
Single Family Dwelling	Crescent Dr	C	0.342	2,759
Single Family Dwelling	Crescent Dr	C	0.094	2,759
Single Family Dwelling	Crescent Dr	C	0.631	2,759
Single Family Dwelling	Crescent Dr	C	0.131	2,759
Single Family Dwelling	Crescent Dr	C	0.077	2,759
Single Family Dwelling	Danforth Ave	C	0.637	2,759
Single Family Dwelling	Evergreen St	C	0.937	2,759
Single Family Dwelling	George St	C	0.340	2,759
Single Family Dwelling	George St	C	0.308	2,759
Single Family Dwelling	George St	C	0.285	2,759
Single Family Dwelling	George St	C	0.473	2,759
Single Family Dwelling	George St	C	0.215	2,759
Single Family Dwelling	George St	C	0.105	2,759
Single Family Dwelling	Heitman St	C	0.149	2,759
Single Family Dwelling	Heitman St	C	0.156	2,759
Single Family Dwelling	Heitman St	C	0.055	2,759
Single Family Dwelling	Howard Ave	C	0.117	2,759
Single Family Dwelling	Howard Ave	C	1.492	2,759
Single Family Dwelling	Howard Ave	C	1.258	2,759
Single Family Dwelling	Howard Ave	C	1.172	2,759
Single Family Dwelling	Howard Ave	C	0.750	2,759
Single Family Dwelling	Howard Ave	C	0.234	2,759
Single Family Dwelling	Howard Ave	C	1.148	2,759
Single Family Dwelling	Howard Ave	C	1.570	2,759
Single Family Dwelling	Howard Ave	C	0.945	2,759
Single Family Dwelling	Howard Ave	C	0.812	2,759
Single Family Dwelling	Howard Ave	C	0.078	2,759
Single Family Dwelling	Howard Ave	C	0.234	2,759
Single Family Dwelling	Howard Ave	C	1.445	2,759
Single Family Dwelling	Howard Ave	C	1.219	2,759
Single Family Dwelling	Howard Ave	C	1.516	2,759
Single Family Dwelling	Howard Ave	C	0.992	2,759
Single Family Dwelling	Howard Ave	C	0.711	2,759
Single Family Dwelling	Howard Ave	C	0.359	2,759
Single Family Dwelling	Howard Ave	C	0.750	2,759
Single Family Dwelling	Kate St	C	0.977	2,759
Single Family Dwelling	Kate St	C	0.500	2,759
Single Family Dwelling	Kate St	C	0.125	2,759
Single Family Dwelling	Kate St	C	0.937	2,759
Single Family Dwelling	Kate St	C	0.406	2,759
Single Family Dwelling	Kildonan Ave	C	0.109	2,759
Single Family Dwelling	Kildonan Ave	C	0.360	2,759
Single Family Dwelling	Kildonan Ave	C	0.219	2,759
Single Family Dwelling	Kildonan Ave	C	0.266	2,759
Single Family Dwelling	Kildonan Ave	C	0.867	2,759

Table AIV-12: Residential property cleanup damages

Building Class	Area	NRC Class	D[1] (m)	Total Loss ($)
Single Family Dwelling	Kildonan Ave	C	0.789	2,759
Single Family Dwelling	Kildonan Ave	C	0.813	2,759
Single Family Dwelling	Kildonan Ave	C	0.305	2,759
Single Family Dwelling	Knight Ave	C	0.141	2,759
Single Family Dwelling	Knight Ave	C	0.750	2,759
Single Family Dwelling	Knight Ave	C	0.609	2,759
Single Family Dwelling	Larsen Ave	C	0.266	2,759
Single Family Dwelling	Larsen Ave	C	0.101	2,759
Single Family Dwelling	Larsen Ave	C	0.053	2,759
Single Family Dwelling	Larsen Ave	C	0.096	2,759
Single Family Dwelling	Larsen Ave	C	0.078	2,759
Single Family Dwelling	Larsen Ave	C	0.345	2,759
Single Family Dwelling	Larsen Ave	C	0.375	2,759
Single Family Dwelling	Larsen Ave	C	0.250	2,759
Single Family Dwelling	Larsen Ave	C	0.212	2,759
Single Family Dwelling	Larsen Ave	C	0.218	2,759
Single Family Dwelling	Larsen Ave	C	0.133	2,759
Single Family Dwelling	Larsen Ave	C	0.191	2,759
Single Family Dwelling	McGowan St	C	0.459	2,759
Single Family Dwelling	McGowan St	C	0.486	2,759
Single Family Dwelling	McGowan St	C	0.334	2,759
Single Family Dwelling	Park Ave	C	1.336	2,759
Single Family Dwelling	Park Ave	C	1.195	2,759
Single Family Dwelling	Park Ave	C	1.469	2,759
Single Family Dwelling	Park Ave	C	0.789	2,759
Single Family Dwelling	Park Ave	C	1.086	2,759
Single Family Dwelling	Park Ave	C	1.367	2,759
Single Family Dwelling	Park Ave	C	0.828	2,759
Single Family Dwelling	Park Ave	C	1.250	2,759
Single Family Dwelling	Park Ave	C	1.289	2,759
Single Family Dwelling	Park Ave	C	1.594	2,759
Single Family Dwelling	Park Ave	C	0.937	2,759
Single Family Dwelling	Park Ave	C	1.734	2,759
Single Family Dwelling	Park Ave	C	2.016	2,759
Single Family Dwelling	Park Ave	C	1.641	2,759
Single Family Dwelling	Park Ave	C	1.422	2,759
Single Family Dwelling	Park Ave	C	1.312	2,759
Single Family Dwelling	Park Ave	C	1.219	2,759
Single Family Dwelling	Park Ave	C	1.008	2,759
Single Family Dwelling	Park Ave	C	1.719	2,759
Single Family Dwelling	Park Ave	C	0.680	2,759
Single Family Dwelling	Pine Crt	C	0.221	2,759
Single Family Dwelling	Pleasant Ave	C	0.210	2,759
Single Family Dwelling	Polson Ave	C	0.914	2,759
Single Family Dwelling	Polson Ave	C	0.500	2,759
Single Family Dwelling	Polson Ave	C	1.305	2,759
Single Family Dwelling	Polson Ave	C	1.047	2,759
Single Family Dwelling	Polson Ave	C	0.945	2,759
Single Family Dwelling	Polson Ave	C	1.109	2,759
Single Family Dwelling	Polson Ave	C	0.789	2,759
Single Family Dwelling	Regent Ave	C	0.070	2,759
Single Family Dwelling	Regent Ave	C	1.086	2,759
Single Family Dwelling	Regent Ave	C	0.758	2,759

Table AIV-12: Residential property cleanup damages

Building Class	Area	NRC Class	D[1] (m)	Total Loss ($)
Single Family Dwelling	Regent Ave	C	0.719	2,759
Single Family Dwelling	Regent Ave	C	0.211	2,759
Single Family Dwelling	Regent Ave	C	0.367	2,759
Single Family Dwelling	Regent Ave	C	0.797	2,759
Single Family Dwelling	Regent Ave	C	0.080	2,759
Single Family Dwelling	Regent Ave	C	0.063	2,759
Single Family Dwelling	Regent Ave	C	0.141	2,759
Single Family Dwelling	Regent Ave	C	0.258	2,759
Single Family Dwelling	Regent Ave	C	0.086	2,759
Single Family Dwelling	Regent Ave	C	0.063	2,759
Single Family Dwelling	Regent Ave	C	0.148	2,759
Single Family Dwelling	Regent Ave	C	0.078	2,759
Single Family Dwelling	Regent Ave	C	0.055	2,759
Single Family Dwelling	Regent Ave	C	0.062	2,759
Single Family Dwelling	Regent Ave	C	0.195	2,759
Single Family Dwelling	Regent Ave	C	0.088	2,759
Single Family Dwelling	Regent Ave	C	0.150	2,759
Single Family Dwelling	Riverdale Dr	C	0.445	2,759
Single Family Dwelling	Riverdale Dr	C	0.397	2,759
Single Family Dwelling	Riverdale Dr	C	0.824	2,759
Single Family Dwelling	Riverdale Dr	C	0.441	2,759
Single Family Dwelling	Riverdale Dr	C	0.795	2,759
Single Family Dwelling	Riverdale Dr	C	0.300	2,759
Single Family Dwelling	Riverdale Dr	C	0.341	2,759
Single Family Dwelling	Riverdale Dr	C	0.640	2,759
Single Family Dwelling	Riverdale Dr	C	0.728	2,759
Single Family Dwelling	Riverdale Dr	C	0.436	2,759
Single Family Dwelling	Riverdale Dr	C	0.611	2,759
Single Family Dwelling	Riverdale Dr	C	0.656	2,759
Single Family Dwelling	Riverdale Dr	C	0.094	2,759
Single Family Dwelling	Riverdale Dr	C	0.682	2,759
Single Family Dwelling	Riverdale Dr	C	0.400	2,759
Single Family Dwelling	Riverdale Dr	C	0.788	2,759
Single Family Dwelling	Riverdale Dr	C	0.367	2,759
Single Family Dwelling	Riverdale Dr	C	0.124	2,759
Single Family Dwelling	Riverdale Dr	C	0.284	2,759
Single Family Dwelling	Riverdale Dr	C	1.133	2,759
Single Family Dwelling	Riverdale Dr	C	0.622	2,759
Single Family Dwelling	Riverdale Dr	C	0.978	2,759
Single Family Dwelling	Riverdale Dr	C	0.054	2,759
Single Family Dwelling	Riverdale Dr	C	0.757	2,759
Single Family Dwelling	Riverdale Dr	C	0.842	2,759
Single Family Dwelling	Riverdale Dr	C	0.354	2,759
Single Family Dwelling	Riverdale Dr	C	0.690	2,759
Single Family Dwelling	Riverdale Dr	C	0.744	2,759
Single Family Dwelling	Riverdale Dr	C	0.541	2,759
Single Family Dwelling	Salmon Arm Dr	C	0.058	2,759
Single Family Dwelling	Salmon Arm Dr	C	0.058	2,759
Single Family Dwelling	Salmon Arm Dr	C	0.121	2,759
Single Family Dwelling	Salmon Arm Dr	C	0.058	2,759
Single Family Dwelling	Salmon Arm Dr	C	0.097	2,759
Single Family Dwelling	Victor St	C	0.307	2,759
Single Family Dwelling	Victor St	C	0.151	2,759

Table AIV-12: Residential property cleanup damages

Building Class	Area	NRC Class	D[1] (m)	Total Loss ($)
Single Family Dwelling	Victor St	C	0.158	2,759
Single Family Dwelling	Waterwheel St	C	0.237	2,759
Single Family Dwelling	Waterwheel St	C	0.051	2,759
Single Family Dwelling	Waterwheel St	C	0.252	2,759
Single Family Dwelling	Waterwheel St	C	0.286	2,759
Single Family Dwelling	Waterwheel St	C	0.185	2,759
Single Family Dwelling	Waterwheel St	C	0.190	2,759
Single Family Dwelling	Waterwheel St	C	0.242	2,759
Multiple Family Dwelling	Kate St	C	0.180	2,759
Multiple Family Dwelling	Baird Ave	MA	1.047	16,554
Multiple Family Dwelling	Belvedere St	MA	0.086	16,554
Multiple Family Dwelling	Belvedere St	MA	0.547	16,554
Multiple Family Dwelling	Howard Ave	MA	0.922	16,554
			TOTAL	**$656,642**

NOTE1 D represents the depth of flood at a particular GIS node location.
NOTE2 Values are in 2020 dollars.

Table AIV-13: Loss due to displacement of residents estimation

Building Class	Area	D[1] (m)	DT[2] (days)	Loss ($) 0-14 days	14+ days	Sum losses x 0.6
Single Family Dwelling	Baird Ave	1.45300	218	2,100	6,497	5,158
Single Family Dwelling	Baird Ave	0.60153	91	2,100	2,577	2,806
Single Family Dwelling	Baird Ave	1.13278	170	2,100	5,015	4,269
Single Family Dwelling	Baird Ave	0.45309	68	2,100	1,867	2,380
Single Family Dwelling	Baird Ave	1.07022	161	2,100	4,737	4,102
Single Family Dwelling	Baird Ave	1.35931	204	2,100	6,065	4,899
Single Family Dwelling	Baird Ave	0.93738	141	2,100	4,120	3,732
Single Family Dwelling	Baird Ave	0.22647	34	2,100	817	1,750
Single Family Dwelling	Baird Ave	0.98434	148	2,100	4,336	3,862
Single Family Dwelling	Baird Ave	0.86710	131	2,100	3,811	3,547
Single Family Dwelling	Baird Ave	0.85147	128	2,100	3,719	3,491
Single Family Dwelling	Baird Ave	0.15616	24	2,100	509	1,565
Single Family Dwelling	Baird Ave	0.64841	98	2,100	2,793	2,936
Single Family Dwelling	Baird Ave	1.32800	200	2,100	5,941	4,825
Single Family Dwelling	Baird Ave	0.26553	40	2,100	1,003	1,862
Single Family Dwelling	Baird Ave	0.96091	145	2,100	4,244	3,806
Single Family Dwelling	Baird Ave	0.81241	122	2,100	3,534	3,380
Single Family Dwelling	Bass Ave	0.10309	16	2,100	262	1,417
Single Family Dwelling	Bass Ave	0.35645	54	2,100	1,435	2,121
Single Family Dwelling	Bass Ave	0.08752	14	3,500	-	2,100
Single Family Dwelling	Bass Ave	0.25797	39	2,100	972	1,843
Single Family Dwelling	Bass Ave	0.34509	52	2,100	1,373	2,084
Single Family Dwelling	Bass Ave	0.29703	45	2,100	1,157	1,954
Single Family Dwelling	Bass Ave	0.14081	22	2,100	447	1,528
Single Family Dwelling	Bass Ave	0.32043	49	2,100	1,280	2,028
Single Family Dwelling	Belvedere St	1.11713	168	2,100	4,953	4,232
Single Family Dwelling	Belvedere St	0.72647	109	2,100	3,132	3,139
Single Family Dwelling	Belvedere St	0.8671	131	2,100	3,811	3,547
Single Family Dwelling	Belvedere St	1.18741	179	2,100	5,293	4,436
Single Family Dwelling	Belvedere St	0.44522	67	2,100	1,836	2,362
Single Family Dwelling	Belvedere St	0.98431	148	2,100	4,336	3,862

Table AIV-13: Loss due to displacement of residents estimation

Building Class	Area	D[1] (m)	DT[2] (days)	Loss ($) 0-14 days	14+ days	Sum losses x 0.6
Single Family Dwelling	Brickyard Rd	1.27335	192	2,100	5,694	4,677
Single Family Dwelling	Brickyard Rd	0.38266	58	2,100	1,558	2,195
Single Family Dwelling	Brickyard Rd	0.22516	34	2,100	817	1,750
Single Family Dwelling	Brickyard Rd	0.45383	69	2,100	1,898	2,399
Single Family Dwelling	Brickyard Rd	0.08621	13	3,250	-	1,950
Single Family Dwelling	Brickyard Rd	0.37491	57	2,100	1,527	2,176
Single Family Dwelling	Brickyard Rd	0.36734	56	2,100	1,496	2,158
Single Family Dwelling	Brickyard Rd	0.16385	25	2,100	540	1,584
Single Family Dwelling	Brickyard Rd	0.60956	92	2,100	2,608	2,825
Single Family Dwelling	Brickyard Rd	1.87491	282	2,100	8,472	6,343
Single Family Dwelling	Brickyard Rd	0.32111	49	2,100	1,280	2,028
Single Family Dwelling	Brickyard Rd	0.11740	18	2,100	323	1,454
Single Family Dwelling	Brickyard Rd	0.21078	32	2,100	756	1,713
Single Family Dwelling	Brickyard Rd	0.6456	97	2,100	2,762	2,917
Single Family Dwelling	Cliff View Lane	0.31586	48	2,100	1,249	2,010
Single Family Dwelling	Cliff View Lane	0.37045	56	2,100	1,496	2,158
Single Family Dwelling	Cliff View Lane	0.36267	55	2,100	1,466	2,139
Single Family Dwelling	Cliff View Lane	0.22986	35	2,100	848	1,769
Single Family Dwelling	Cliff View Lane	0.32361	49	2,100	1,280	2,028
Single Family Dwelling	Cliff View Lane	0.42523	64	2,100	1,743	2,306
Single Family Dwelling	Cliff View Lane	0.25330	38	2,100	941	1,824
Single Family Dwelling	Cliff View Lane	0.14398	22	2,100	447	1,528
Single Family Dwelling	Cliff View Lane	0.20642	31	2,100	725	1,695
Single Family Dwelling	Cliff View Lane	0.15955	24	2,100	509	1,565
Single Family Dwelling	Cliff View Lane	0.15955	24	2,100	509	1,565
Single Family Dwelling	Cliff View Lane	0.34705	53	2,100	1,404	2,102
Single Family Dwelling	Cliff View Lane	0.24548	37	2,100	910	1,806
Single Family Dwelling	Cliff View Lane	0.54242	82	2,100	2,299	2,639
Single Family Dwelling	Cliff View Lane	0.14392	22	2,100	447	1,528
Single Family Dwelling	Cliff View Lane	0.22211	34	2,100	817	1,750
Single Family Dwelling	Cliff View Lane	0.13617	21	2,100	416	1,510
Single Family Dwelling	Cliff View Lane	0.31583	48	2,100	1,249	2,010
Single Family Dwelling	Cliff View Lane	0.10486	16	2,100	262	1,417
Single Family Dwelling	Cliff View Lane	0.25336	39	2,100	972	1,843
Single Family Dwelling	Cliff View Lane	0.47992	72	2,100	1,990	2,454
Single Family Dwelling	Cliff View Lane	0.47992	72	2,100	1,990	2,454
Single Family Dwelling	Cliff View Lane	0.12048	19	2,100	354	1,473
Single Family Dwelling	Crescent Dr	0.55441	84	2,100	2,361	2,676
Single Family Dwelling	Crescent Dr	1.62479	244	2,100	7,299	5,640
Single Family Dwelling	Crescent Dr	0.34238	52	2,100	1,373	2,084
Single Family Dwelling	Crescent Dr	0.09363	15	2,100	231	1,399
Single Family Dwelling	Crescent Dr	0.63141	95	2,100	2,700	2,880
Single Family Dwelling	Crescent Dr	0.13141	20	2,100	385	1,491
Single Family Dwelling	Crescent Dr	0.07675	12	3,000	-	1,800
Single Family Dwelling	Danforth Ave	0.63739	96	2,100	2,731	2,899
Single Family Dwelling	Evergreen St	0.93695	141	2,100	4,120	3,732
Single Family Dwelling	George St	0.33966	51	2,100	1,342	2,065
Single Family Dwelling	George St	0.30847	47	2,100	1,219	1,991
Single Family Dwelling	George St	0.28506	43	2,100	1,095	1,917
Single Family Dwelling	George St	0.47256	71	2,100	1,959	2,436
Single Family Dwelling	George St	0.21475	33	2,100	786	1,732

Table AIV-13: Loss due to displacement of residents estimation

Building Class	Area	D[1] (m)	DT[2] (days)	Loss ($)		
				0-14 days	14+ days	Sum losses x 0.6
Single Family Dwelling	George St	0.10492	16	2,100	262	1,417
Single Family Dwelling	Heitman St	0.14859	23	2,100	478	1,547
Single Family Dwelling	Heitman St	0.15601	24	2,100	509	1,565
Single Family Dwelling	Heitman St	0.05487	9	2,250	-	1,350
Single Family Dwelling	Howard Ave	0.11700	18	2,100	323	1,454
Single Family Dwelling	Howard Ave	1.49210	224	2,100	6,682	5,269
Single Family Dwelling	Howard Ave	1.25769	189	2,100	5,602	4,621
Single Family Dwelling	Howard Ave	1.17178	176	2,100	5,200	4,380
Single Family Dwelling	Howard Ave	0.74991	113	2,100	3,256	3,213
Single Family Dwelling	Howard Ave	0.23431	36	2,100	879	1,787
Single Family Dwelling	Howard Ave	1.14835	173	2,100	5,108	4,325
Single Family Dwelling	Howard Ave	1.57022	236	2,100	7,052	5,491
Single Family Dwelling	Howard Ave	0.94522	142	2,100	4,151	3,751
Single Family Dwelling	Howard Ave	0.81244	122	2,100	3,534	3,380
Single Family Dwelling	Howard Ave	0.07803	12	3,000	-	1,800
Single Family Dwelling	Howard Ave	0.23419	36	2,100	879	1,787
Single Family Dwelling	Howard Ave	1.44525	217	2,100	6,466	5,140
Single Family Dwelling	Howard Ave	1.21863	183	2,100	5,416	4,510
Single Family Dwelling	Howard Ave	1.51550	228	2,100	6,805	5,343
Single Family Dwelling	Howard Ave	0.99210	149	2,100	4,367	3,880
Single Family Dwelling	Howard Ave	0.71088	107	2,100	3,071	3,102
Single Family Dwelling	Howard Ave	0.35928	54	2,100	1,435	2,121
Single Family Dwelling	Howard Ave	0.74991	113	2,100	3,256	3,213
Single Family Dwelling	Kate St	0.97681	147	2,100	4,305	3,843
Single Family Dwelling	Kate St	0.50024	76	2,100	2,114	2,528
Single Family Dwelling	Kate St	0.12524	19	2,100	354	1,473
Single Family Dwelling	Kate St	0.93741	141	2,100	4,120	3,732
Single Family Dwelling	Kate St	0.40619	61	2,100	1,651	2,250
Single Family Dwelling	Kildonan Ave	0.10931	17	2,100	293	1,436
Single Family Dwelling	Kildonan Ave	0.36008	55	2,100	1,466	2,139
Single Family Dwelling	Kildonan Ave	0.21866	33	2,100	786	1,732
Single Family Dwelling	Kildonan Ave	0.26587	40	2,100	1,003	1,862
Single Family Dwelling	Kildonan Ave	0.86740	131	2,100	3,811	3,547
Single Family Dwelling	Kildonan Ave	0.78931	119	2,100	3,441	3,325
Single Family Dwelling	Kildonan Ave	0.81274	122	2,100	3,534	3,380
Single Family Dwelling	Kildonan Ave	0.30484	46	2,100	1,188	1,973
Single Family Dwelling	Knight Ave	0.14056	22	2,100	447	1,528
Single Family Dwelling	Knight Ave	0.74991	113	2,100	3,256	3,213
Single Family Dwelling	Knight Ave	0.60928	92	2,100	2,608	2,825
Single Family Dwelling	Larsen Ave	0.26587	40	2,100	1,003	1,862
Single Family Dwelling	Larsen Ave	0.10068	16	2,100	262	1,417
Single Family Dwelling	Larsen Ave	0.05280	8	2,000	-	1,200
Single Family Dwelling	Larsen Ave	0.09598	15	2,100	231	1,399
Single Family Dwelling	Larsen Ave	0.07843	12	3,000	-	1,800
Single Family Dwelling	Larsen Ave	0.34515	52	2,100	1,373	2,084
Single Family Dwelling	Larsen Ave	0.37524	57	2,100	1,527	2,176
Single Family Dwelling	Larsen Ave	0.25024	38	2,100	941	1,824
Single Family Dwelling	Larsen Ave	0.21222	32	2,100	756	1,713
Single Family Dwelling	Larsen Ave	0.21826	33	2,100	786	1,732
Single Family Dwelling	Larsen Ave	0.13306	20	2,100	385	1,491
Single Family Dwelling	Larsen Ave	0.19064	29	2,100	663	1,658

Table AIV-13: Loss due to displacement of residents estimation

Building Class	Area	D[1] (m)	DT[2] (days)	Loss ($)		
				0-14 days	14+ days	Sum losses x 0.6
Single Family Dwelling	McGowan St	0.45877	69	2,100	1,898	2,399
Single Family Dwelling	McGowan St	0.48621	73	2,100	2,021	2,473
Single Family Dwelling	McGowan St	0.51804	78	2,100	2,175	2,565
Single Family Dwelling	McGowan St	0.33371	51	2,100	1,342	2,065
Single Family Dwelling	Meadow Cres	0.97205	146	2,100	4,274	3,825
Single Family Dwelling	Meadow Cres	0.83920	126	2,100	3,657	3,454
Single Family Dwelling	Meadow Cres	0.77673	117	2,100	3,379	3,288
Single Family Dwelling	Meadow Cres	0.68298	103	2,100	2,947	3,028
Single Family Dwelling	Meadow Cres	0.69080	104	2,100	2,978	3,047
Single Family Dwelling	Meadow Cres	0.60486	91	2,100	2,577	2,806
Single Family Dwelling	Meadow Cres	0.52679	80	2,100	2,237	2,602
Single Family Dwelling	Meadow Cres	0.80017	121	2,100	3,503	3,362
Single Family Dwelling	Meadow Cres	0.62830	95	2,100	2,700	2,880
Single Family Dwelling	Meadow Cres	0.84705	128	2,100	3,719	3,491
Single Family Dwelling	Meadow Cres	0.89392	135	2,100	3,935	3,621
Single Family Dwelling	Meadow Cres	0.90955	137	2,100	3,997	3,658
Single Family Dwelling	Meadow Cres	0.90955	137	2,100	3,997	3,658
Single Family Dwelling	Meadow Cres	0.76111	115	2,100	3,318	3,251
Single Family Dwelling	Meadow Cres	0.67517	102	2,100	2,916	3,010
Single Family Dwelling	Meadow Cres	0.47202	71	2,100	1,959	2,436
Single Family Dwelling	Meadow Cres	0.83145	125	2,100	3,626	3,436
Single Family Dwelling	Meadow Cres	0.74548	112	2,100	3,225	3,195
Single Family Dwelling	Meadow Cres	0.80017	121	2,100	3,503	3,362
Single Family Dwelling	Meadow Cres	0.90173	136	2,100	3,966	3,639
Single Family Dwelling	Meadow Cres	0.87048	131	2,100	3,811	3,547
Single Family Dwelling	Meadow Cres	0.80017	121	2,100	3,503	3,362
Single Family Dwelling	Meadow Cres	0.74551	112	2,100	3,225	3,195
Single Family Dwelling	Meadow Cres	0.58142	88	2,100	2,484	2,750
Single Family Dwelling	Meadow Cres	0.65170	98	2,100	2,793	2,936
Single Family Dwelling	Meadow Cres	0.76889	116	2,100	3,348	3,269
Single Family Dwelling	Meadow Cres	0.84702	128	2,100	3,719	3,491
Single Family Dwelling	Meadow Cres	0.80798	122	2,100	3,534	3,380
Single Family Dwelling	Meadow Cres	0.48773	74	2,100	2,052	2,491
Single Family Dwelling	Meadow Cres	0.62830	95	2,100	2,700	2,880
Single Family Dwelling	Meadow Cres	0.57367	87	2,100	2,453	2,732
Single Family Dwelling	Meadow Cres	0.42520	64	2,100	1,743	2,306
Single Family Dwelling	Meadow Cres	0.46426	70	2,100	1,929	2,417
Single Family Dwelling	Meadow Cres	0.80017	121	2,100	3,503	3,362
Single Family Dwelling	Meadow Cres	0.54242	82	2,100	2,299	2,639
Single Family Dwelling	Meadow Cres	0.47211	71	2,100	1,959	2,436
Single Family Dwelling	Meadow Cres	0.69858	105	2,100	3,009	3,065
Single Family Dwelling	Meadow Cres	0.80798	122	2,100	3,534	3,380
Single Family Dwelling	Meadow Cres	0.24554	37	2,100	910	1,806
Single Family Dwelling	Park Ave	1.33585	201	2,100	5,972	4,843
Single Family Dwelling	Park Ave	1.19522	180	2,100	5,324	4,454
Single Family Dwelling	Park Ave	1.46866	221	2,100	6,589	5,214
Single Family Dwelling	Park Ave	0.78897	119	2,100	3,441	3,325
Single Family Dwelling	Park Ave	1.08585	163	2,100	4,799	4,139
Single Family Dwelling	Park Ave	1.36710	206	2,100	6,126	4,936
Single Family Dwelling	Park Ave	0.82803	125	2,100	3,626	3,436
Single Family Dwelling	Park Ave	1.24994	188	2,100	5,571	4,602

Table AIV-13: Loss due to displacement of residents estimation

Building Class	Area	D[1] (m)	DT[2] (days)	Loss ($)		
				0-14 days	14+ days	Sum losses x 0.6
Single Family Dwelling	Park Ave	1.28897	194	2,100	5,756	4,714
Single Family Dwelling	Park Ave	1.59366	240	2,100	7,176	5,566
Single Family Dwelling	Park Ave	0.93738	141	2,100	4,120	3,732
Single Family Dwelling	Park Ave	1.73425	261	2,100	7,824	5,954
Single Family Dwelling	Park Ave	2.01553	303	2,100	9,120	6,732
Single Family Dwelling	Park Ave	1.64053	247	2,100	7,392	5,695
Single Family Dwelling	Park Ave	1.42178	214	2,100	6,373	5,084
Single Family Dwelling	Park Ave	1.31241	197	2,100	5,849	4,769
Single Family Dwelling	Park Ave	1.21866	183	2,100	5,416	4,510
Single Family Dwelling	Park Ave	1.00772	152	2,100	4,460	3,936
Single Family Dwelling	Park Ave	1.71866	258	2,100	7,731	5,899
Single Family Dwelling	Park Ave	0.67957	102	2,100	2,916	3,010
Single Family Dwelling	Pine Crt	0.22131	34	2,100	817	1,750
Single Family Dwelling	Pleasant Ave	0.20956	32	2,100	756	1,713
Single Family Dwelling	Polson Ave	0.91400	138	2,100	4,027	3,676
Single Family Dwelling	Polson Ave	0.49991	75	2,100	2,083	2,510
Single Family Dwelling	Polson Ave	1.30460	196	2,100	5,818	4,751
Single Family Dwelling	Polson Ave	1.04678	158	2,100	4,645	4,047
Single Family Dwelling	Polson Ave	0.94525	142	2,100	4,151	3,751
Single Family Dwelling	Polson Ave	1.10928	167	2,100	4,923	4,214
Single Family Dwelling	Polson Ave	0.78897	119	2,100	3,441	3,325
Single Family Dwelling	Regent Ave	0.07022	11	2,750	-	1,650
Single Family Dwelling	Regent Ave	0.66403	100	2,100	2,855	2,973
Single Family Dwelling	Regent Ave	1.08591	163	2,100	4,799	4,139
Single Family Dwelling	Regent Ave	0.75781	114	2,100	3,287	3,232
Single Family Dwelling	Regent Ave	0.71875	108	2,100	3,101	3,121
Single Family Dwelling	Regent Ave	0.21094	32	2,100	756	1,713
Single Family Dwelling	Regent Ave	0.36710	56	2,100	1,496	2,158
Single Family Dwelling	Regent Ave	0.79688	120	2,100	3,472	3,343
Single Family Dwelling	Regent Ave	0.07950	12	3,000	-	1,800
Single Family Dwelling	Regent Ave	0.06253	10	2,500	-	1,500
Single Family Dwelling	Regent Ave	0.14056	22	2,100	447	1,528
Single Family Dwelling	Regent Ave	0.25778	39	2,100	972	1,843
Single Family Dwelling	Regent Ave	0.08594	13	3,250	-	1,950
Single Family Dwelling	Regent Ave	0.0625	10	2,500	-	1,500
Single Family Dwelling	Regent Ave	0.14847	23	2,100	478	1,547
Single Family Dwelling	Regent Ave	0.07813	12	3,000	-	1,800
Single Family Dwelling	Regent Ave	0.05481	9	2,250	-	1,350
Single Family Dwelling	Regent Ave	0.06247	10	2,500	-	1,500
Single Family Dwelling	Regent Ave	0.19537	30	2,100	694	1,676
Single Family Dwelling	Regent Ave	0.08817	14	3,500	-	2,100
Single Family Dwelling	Regent Ave	0.15021	23	2,100	478	1,547
Single Family Dwelling	Riverdale Dr	0.44458	67	2,100	1,836	2,362
Single Family Dwelling	Riverdale Dr	0.39740	60	2,100	1,620	2,232
Single Family Dwelling	Riverdale Dr	0.82428	124	2,100	3,595	3,417
Single Family Dwelling	Riverdale Dr	0.440700	67	2,100	1,836	2,362
Single Family Dwelling	Riverdale Dr	0.57330	86	2,100	2,422	2,713
Single Family Dwelling	Riverdale Dr	0.79489	120	2,100	3,472	3,343
Single Family Dwelling	Riverdale Dr	0.06659	10	2,500	-	1,500
Single Family Dwelling	Riverdale Dr	0.29965	45	2,100	1,157	1,954
Single Family Dwelling	Riverdale Dr	0.34067	52	2,100	1,373	2,084

Table AIV-13: Loss due to displacement of residents estimation

Building Class	Area	D[1] (m)	DT[2] (days)	Loss ($) 0-14 days	14+ days	Sum losses x 0.6
Single Family Dwelling	Riverdale Dr	0.63950	96	2,100	2,731	2,899
Single Family Dwelling	Riverdale Dr	0.72849	110	2,100	3,163	3,158
Single Family Dwelling	Riverdale Dr	0.43610	66	2,100	1,805	2,343
Single Family Dwelling	Riverdale Dr	0.09283	14	3,500	-	2,100
Single Family Dwelling	Riverdale Dr	0.61050	92	2,100	2,608	2,825
Single Family Dwelling	Riverdale Dr	0.65576	99	2,100	2,824	2,954
Single Family Dwelling	Riverdale Dr	0.09436	15	2,100	231	1,399
Single Family Dwelling	Riverdale Dr	0.68152	103	2,100	2,947	3,028
Single Family Dwelling	Riverdale Dr	0.39966	60	2,100	1,620	2,232
Single Family Dwelling	Riverdale Dr	0.78754	119	2,100	3,441	3,325
Single Family Dwelling	Riverdale Dr	0.36676	56	2,100	1,496	2,158
Single Family Dwelling	Riverdale Dr	0.12405	19	2,100	354	1,473
Single Family Dwelling	Riverdale Dr	0.28412	43	2,100	1,095	1,917
Single Family Dwelling	Riverdale Dr	1.13300	170	2,100	5,015	4,269
Single Family Dwelling	Riverdale Dr	0.62189	94	2,100	2,669	2,862
Single Family Dwelling	Riverdale Dr	0.97757	147	2,100	4,305	3,843
Single Family Dwelling	Riverdale Dr	0.05402	9	2,250	-	1,350
Single Family Dwelling	Riverdale Dr	0.75745	114	2,100	3,287	3,232
Single Family Dwelling	Riverdale Dr	0.84241	127	2,100	3,688	3,473
Single Family Dwelling	Riverdale Dr	0.35400	54	2,100	1,435	2,121
Single Family Dwelling	Riverdale Dr	0.68954	104	2,100	2,978	3,047
Single Family Dwelling	Riverdale Dr	0.74423	112	2,100	3,225	3,195
Single Family Dwelling	Riverdale Dr	0.54068	82	2,100	2,299	2,639
Single Family Dwelling	Salmon Arm Dr	0.05814	9	2,250	-	1,350
Single Family Dwelling	Salmon Arm Dr	0.05804	9	2,250	-	1,350
Single Family Dwelling	Salmon Arm Dr	0.12054	19	2,100	354	1,473
Single Family Dwelling	Salmon Arm Dr	0.05804	9	2,250	-	1,350
Single Family Dwelling	Salmon Arm Dr	0.09711	15	2,100	231	1,399
Single Family Dwelling	Victor St	0.30688	47	2,100	1,219	1,991
Single Family Dwelling	Victor St	0.15060	23	2,100	478	1,547
Single Family Dwelling	Victor St	0.15842	24	2,100	509	1,565
Single Family Dwelling	Waterwheel St	0.23676	36	2,100	879	1,787
Single Family Dwelling	Waterwheel St	0.05072	8	2,000	-	1,200
Single Family Dwelling	Waterwheel St	0.25180	38	2,100	941	1,824
Single Family Dwelling	Waterwheel St	0.28625	43	2,100	1,095	1,917
Single Family Dwelling	Waterwheel St	0.18454	28	2,100	632	1,639
Single Family Dwelling	Waterwheel St	0.18973	29	2,100	663	1,658
Single Family Dwelling	Waterwheel St	0.24185	37	2,100	910	1,806
Multi Family Dwelling	Baird Ave	1.04678	158	2,100	4,645	97,125
Multi Family Dwelling	Belvedere St	0.08588	13	3,250	-	15,600
Multi Family Dwelling	Belvedere St	0.54681	83	2,100	2,330	13,289
Multi Family Dwelling	Howard Ave	0.92178	139	2,100	4,058	44,340
Multi Family Dwelling	Kate St	0.17987	27	2,100	601	3,242
					TOTAL	**$924,605**

NOTE1 D represents the depth of flood at a particular GIS node location.
NOTE2 DT represents the calculated displacement time in days.

Table AIV-14: Loss of rental income (LoRI) estimation

Building Class	Area	Displacement Time (Months)	Rental Rate ($/month)	LoRI ($)
RESIDENTIAL				
Single Family Dwelling	Baird Ave	7.27	926	1,317
Single Family Dwelling	Baird Ave	3.03	926	550
Single Family Dwelling	Baird Ave	5.67	926	1,027
Single Family Dwelling	Baird Ave	2.27	926	411
Single Family Dwelling	Baird Ave	5.37	926	973
Single Family Dwelling	Baird Ave	6.80	926	1,233
Single Family Dwelling	Baird Ave	4.70	926	852
Single Family Dwelling	Baird Ave	1.13	926	205
Single Family Dwelling	Baird Ave	4.93	926	894
Single Family Dwelling	Baird Ave	4.37	926	791
Single Family Dwelling	Baird Ave	4.27	926	773
Single Family Dwelling	Baird Ave	0.80	926	145
Single Family Dwelling	Baird Ave	3.27	926	592
Single Family Dwelling	Baird Ave	6.67	926	1,208
Single Family Dwelling	Baird Ave	1.33	926	242
Single Family Dwelling	Baird Ave	4.83	926	876
Single Family Dwelling	Baird Ave	4.07	926	737
Single Family Dwelling	Bass Ave	0.53	926	97
Single Family Dwelling	Bass Ave	1.80	926	326
Single Family Dwelling	Bass Ave	0.47	926	85
Single Family Dwelling	Bass Ave	1.30	926	236
Single Family Dwelling	Bass Ave	1.73	926	314
Single Family Dwelling	Bass Ave	1.50	926	272
Single Family Dwelling	Bass Ave	0.73	926	133
Single Family Dwelling	Bass Ave	1.63	926	296
Single Family Dwelling	Belvedere St	5.60	926	1,015
Single Family Dwelling	Belvedere St	3.63	926	659
Single Family Dwelling	Belvedere St	4.37	926	791
Single Family Dwelling	Belvedere St	5.97	926	1,081
Single Family Dwelling	Belvedere St	2.23	926	405
Single Family Dwelling	Belvedere St	4.93	926	894
Single Family Dwelling	Brickyard Rd	6.40	926	1,160
Single Family Dwelling	Brickyard Rd	1.93	926	350
Single Family Dwelling	Brickyard Rd	1.13	926	205
Single Family Dwelling	Brickyard Rd	2.30	926	417
Single Family Dwelling	Brickyard Rd	0.43	926	79
Single Family Dwelling	Brickyard Rd	1.90	926	344
Single Family Dwelling	Brickyard Rd	1.87	926	338
Single Family Dwelling	Brickyard Rd	0.83	926	151
Single Family Dwelling	Brickyard Rd	3.07	926	556
Single Family Dwelling	Brickyard Rd	9.40	926	1,704
Single Family Dwelling	Brickyard Rd	1.63	926	296
Single Family Dwelling	Brickyard Rd	0.60	926	109
Single Family Dwelling	Brickyard Rd	1.07	926	193
Single Family Dwelling	Brickyard Rd	3.23	926	586
Single Family Dwelling	Cliff View Lane	1.60	926	290
Single Family Dwelling	Cliff View Lane	1.87	926	338
Single Family Dwelling	Cliff View Lane	1.83	926	332
Single Family Dwelling	Cliff View Lane	1.17	926	211

Table AIV-14: Loss of rental income (LoRI) estimation

Building Class	Area	Displacement Time (Months)	Rental Rate ($/month)	LoRI ($)
Single Family Dwelling	Cliff View Lane	1.63	926	296
Single Family Dwelling	Cliff View Lane	2.13	926	387
Single Family Dwelling	Cliff View Lane	1.27	926	230
Single Family Dwelling	Cliff View Lane	0.73	926	133
Single Family Dwelling	Cliff View Lane	1.03	926	187
Single Family Dwelling	Cliff View Lane	0.80	926	145
Single Family Dwelling	Cliff View Lane	0.80	926	145
Single Family Dwelling	Cliff View Lane	1.77	926	320
Single Family Dwelling	Cliff View Lane	1.23	926	224
Single Family Dwelling	Cliff View Lane	2.73	926	495
Single Family Dwelling	Cliff View Lane	0.73	926	133
Single Family Dwelling	Cliff View Lane	1.13	926	205
Single Family Dwelling	Cliff View Lane	0.70	926	127
Single Family Dwelling	Cliff View Lane	1.60	926	290
Single Family Dwelling	Cliff View Lane	0.53	926	97
Single Family Dwelling	Cliff View Lane	1.30	926	236
Single Family Dwelling	Cliff View Lane	2.40	926	435
Single Family Dwelling	Cliff View Lane	2.40	926	435
Single Family Dwelling	Cliff View Lane	0.63	926	115
Single Family Dwelling	Crescent Dr	2.80	926	508
Single Family Dwelling	Crescent Dr	8.13	926	1,474
Single Family Dwelling	Crescent Dr	1.73	926	314
Single Family Dwelling	Crescent Dr	0.50	926	91
Single Family Dwelling	Crescent Dr	3.17	926	574
Single Family Dwelling	Crescent Dr	0.67	926	121
Single Family Dwelling	Crescent Dr	0.40	926	73
Single Family Dwelling	Danforth Ave	3.20	926	580
Single Family Dwelling	Evergreen St	4.70	926	852
Single Family Dwelling	George St	1.70	926	308
Single Family Dwelling	George St	1.57	926	284
Single Family Dwelling	George St	1.43	926	260
Single Family Dwelling	George St	2.37	926	429
Single Family Dwelling	George St	1.10	926	199
Single Family Dwelling	George St	0.53	926	97
Single Family Dwelling	Heitman St	0.77	926	139
Single Family Dwelling	Heitman St	0.80	926	145
Single Family Dwelling	Heitman St	0.30	926	54
Single Family Dwelling	Howard Ave	0.60	926	109
Single Family Dwelling	Howard Ave	7.47	926	1,353
Single Family Dwelling	Howard Ave	6.30	926	1,142
Single Family Dwelling	Howard Ave	5.87	926	1,063
Single Family Dwelling	Howard Ave	3.77	926	683
Single Family Dwelling	Howard Ave	1.20	926	218
Single Family Dwelling	Howard Ave	5.77	926	1,045
Single Family Dwelling	Howard Ave	7.87	926	1,426
Single Family Dwelling	Howard Ave	4.73	926	858
Single Family Dwelling	Howard Ave	4.07	926	737
Single Family Dwelling	Howard Ave	0.40	926	73
Single Family Dwelling	Howard Ave	1.20	926	218
Single Family Dwelling	Howard Ave	7.23	926	1,311
Single Family Dwelling	Howard Ave	6.10	926	1,106

Table AIV-14: Loss of rental income (LoRI) estimation

Building Class	Area	Displacement Time (Months)	Rental Rate ($/month)	LoRI ($)
Single Family Dwelling	Howard Ave	7.60	926	1,378
Single Family Dwelling	Howard Ave	4.97	926	900
Single Family Dwelling	Howard Ave	3.57	926	646
Single Family Dwelling	Howard Ave	1.80	926	326
Single Family Dwelling	Howard Ave	3.77	926	683
Single Family Dwelling	Kate St	4.90	926	888
Single Family Dwelling	Kate St	2.53	926	459
Single Family Dwelling	Kate St	0.63	926	115
Single Family Dwelling	Kate St	4.70	926	852
Single Family Dwelling	Kate St	2.03	926	369
Single Family Dwelling	Kildonan Ave	0.57	926	103
Single Family Dwelling	Kildonan Ave	1.83	926	332
Single Family Dwelling	Kildonan Ave	1.10	926	199
Single Family Dwelling	Kildonan Ave	1.33	926	242
Single Family Dwelling	Kildonan Ave	4.37	926	791
Single Family Dwelling	Kildonan Ave	3.97	926	719
Single Family Dwelling	Kildonan Ave	4.07	926	737
Single Family Dwelling	Kildonan Ave	1.53	926	278
Single Family Dwelling	Knight Ave	0.73	926	133
Single Family Dwelling	Knight Ave	3.77	926	683
Single Family Dwelling	Knight Ave	3.07	926	556
Single Family Dwelling	Larsen Ave	1.33	926	242
Single Family Dwelling	Larsen Ave	0.53	926	97
Single Family Dwelling	Larsen Ave	0.27	926	48
Single Family Dwelling	Larsen Ave	0.50	926	91
Single Family Dwelling	Larsen Ave	0.40	926	73
Single Family Dwelling	Larsen Ave	1.73	926	314
Single Family Dwelling	Larsen Ave	1.90	926	344
Single Family Dwelling	Larsen Ave	1.27	926	230
Single Family Dwelling	Larsen Ave	1.07	926	193
Single Family Dwelling	Larsen Ave	1.10	926	199
Single Family Dwelling	Larsen Ave	0.67	926	121
Single Family Dwelling	Larsen Ave	0.97	926	175
Single Family Dwelling	McGowan St	2.30	926	417
Single Family Dwelling	McGowan St	2.43	926	441
Single Family Dwelling	McGowan St	2.60	926	471
Single Family Dwelling	McGowan St	1.70	926	308
Single Family Dwelling	Meadow Cres	4.87	926	882
Single Family Dwelling	Meadow Cres	4.20	926	761
Single Family Dwelling	Meadow Cres	3.90	926	707
Single Family Dwelling	Meadow Cres	3.43	926	622
Single Family Dwelling	Meadow Cres	3.47	926	628
Single Family Dwelling	Meadow Cres	3.03	926	550
Single Family Dwelling	Meadow Cres	2.67	926	483
Single Family Dwelling	Meadow Cres	4.03	926	731
Single Family Dwelling	Meadow Cres	3.17	926	574
Single Family Dwelling	Meadow Cres	4.27	926	773
Single Family Dwelling	Meadow Cres	4.50	926	816
Single Family Dwelling	Meadow Cres	4.57	926	828
Single Family Dwelling	Meadow Cres	4.57	926	828
Single Family Dwelling	Meadow Cres	3.83	926	695

Table AIV-14: Loss of rental income (LoRI) estimation

Building Class	Area	Displacement Time (Months)	Rental Rate ($/month)	LoRI ($)
Single Family Dwelling	Meadow Cres	3.40	926	616
Single Family Dwelling	Meadow Cres	2.37	926	429
Single Family Dwelling	Meadow Cres	4.17	926	755
Single Family Dwelling	Meadow Cres	3.73	926	677
Single Family Dwelling	Meadow Cres	4.03	926	731
Single Family Dwelling	Meadow Cres	4.53	926	822
Single Family Dwelling	Meadow Cres	4.37	926	791
Single Family Dwelling	Meadow Cres	4.03	926	731
Single Family Dwelling	Meadow Cres	3.73	926	677
Single Family Dwelling	Meadow Cres	2.93	926	532
Single Family Dwelling	Meadow Cres	3.27	926	592
Single Family Dwelling	Meadow Cres	3.87	926	701
Single Family Dwelling	Meadow Cres	4.27	926	773
Single Family Dwelling	Meadow Cres	4.07	926	737
Single Family Dwelling	Meadow Cres	2.47	926	447
Single Family Dwelling	Meadow Cres	3.17	926	574
Single Family Dwelling	Meadow Cres	2.90	926	526
Single Family Dwelling	Meadow Cres	2.13	926	387
Single Family Dwelling	Meadow Cres	2.33	926	423
Single Family Dwelling	Meadow Cres	4.03	926	731
Single Family Dwelling	Meadow Cres	2.73	926	495
Single Family Dwelling	Meadow Cres	2.37	926	429
Single Family Dwelling	Meadow Cres	3.50	926	634
Single Family Dwelling	Meadow Cres	4.07	926	737
Single Family Dwelling	Meadow Cres	1.23	926	224
Single Family Dwelling	Park Ave	6.70	926	1,214
Single Family Dwelling	Park Ave	6.00	926	1,088
Single Family Dwelling	Park Ave	7.37	926	1,335
Single Family Dwelling	Park Ave	3.97	926	719
Single Family Dwelling	Park Ave	5.43	926	985
Single Family Dwelling	Park Ave	6.87	926	1,245
Single Family Dwelling	Park Ave	4.17	926	755
Single Family Dwelling	Park Ave	6.27	926	1,136
Single Family Dwelling	Park Ave	6.47	926	1,172
Single Family Dwelling	Park Ave	8.00	926	1,450
Single Family Dwelling	Park Ave	4.70	926	852
Single Family Dwelling	Park Ave	8.70	926	1,577
Single Family Dwelling	Park Ave	10.10	926	1,831
Single Family Dwelling	Park Ave	8.23	926	1,492
Single Family Dwelling	Park Ave	7.13	926	1,293
Single Family Dwelling	Park Ave	6.57	926	1,190
Single Family Dwelling	Park Ave	6.10	926	1,106
Single Family Dwelling	Park Ave	5.07	926	918
Single Family Dwelling	Park Ave	8.60	926	1,559
Single Family Dwelling	Park Ave	3.40	926	616
Single Family Dwelling	Pine Crt	1.13	926	205
Single Family Dwelling	Pleasant Ave	1.07	926	193
Single Family Dwelling	Polson Ave	4.60	926	834
Single Family Dwelling	Polson Ave	2.50	926	453
Single Family Dwelling	Polson Ave	6.53	926	1,184
Single Family Dwelling	Polson Ave	5.27	926	955

Table AIV-14: Loss of rental income (LoRI) estimation

Building Class	Area	Displacement Time (Months)	Rental Rate ($/month)	LoRI ($)
Single Family Dwelling	Polson Ave	4.73	926	858
Single Family Dwelling	Polson Ave	5.57	926	1,009
Single Family Dwelling	Polson Ave	3.97	926	719
Single Family Dwelling	Regent Ave	0.37	926	66
Single Family Dwelling	Regent Ave	3.33	926	604
Single Family Dwelling	Regent Ave	5.43	926	985
Single Family Dwelling	Regent Ave	3.80	926	689
Single Family Dwelling	Regent Ave	3.60	926	653
Single Family Dwelling	Regent Ave	1.07	926	193
Single Family Dwelling	Regent Ave	1.87	926	338
Single Family Dwelling	Regent Ave	4.00	926	725
Single Family Dwelling	Regent Ave	0.40	926	73
Single Family Dwelling	Regent Ave	0.33	926	60
Single Family Dwelling	Regent Ave	0.73	926	133
Single Family Dwelling	Regent Ave	1.30	926	236
Single Family Dwelling	Regent Ave	0.43	926	79
Single Family Dwelling	Regent Ave	0.33	926	60
Single Family Dwelling	Regent Ave	0.77	926	139
Single Family Dwelling	Regent Ave	0.40	926	73
Single Family Dwelling	Regent Ave	0.30	926	54
Single Family Dwelling	Regent Ave	0.33	926	60
Single Family Dwelling	Regent Ave	1.00	926	181
Single Family Dwelling	Regent Ave	0.47	926	85
Single Family Dwelling	Regent Ave	0.77	926	139
Single Family Dwelling	Riverdale Dr	2.23	926	405
Single Family Dwelling	Riverdale Dr	2.00	926	363
Single Family Dwelling	Riverdale Dr	4.13	926	749
Single Family Dwelling	Riverdale Dr	2.23	926	405
Single Family Dwelling	Riverdale Dr	2.87	926	520
Single Family Dwelling	Riverdale Dr	4.00	926	725
Single Family Dwelling	Riverdale Dr	0.33	926	60
Single Family Dwelling	Riverdale Dr	1.50	926	272
Single Family Dwelling	Riverdale Dr	1.73	926	314
Single Family Dwelling	Riverdale Dr	3.20	926	580
Single Family Dwelling	Riverdale Dr	3.67	926	665
Single Family Dwelling	Riverdale Dr	2.20	926	399
Single Family Dwelling	Riverdale Dr	0.47	926	85
Single Family Dwelling	Riverdale Dr	3.07	926	556
Single Family Dwelling	Riverdale Dr	3.30	926	598
Single Family Dwelling	Riverdale Dr	0.50	926	91
Single Family Dwelling	Riverdale Dr	3.43	926	622
Single Family Dwelling	Riverdale Dr	2.00	926	363
Single Family Dwelling	Riverdale Dr	3.97	926	719
Single Family Dwelling	Riverdale Dr	1.87	926	338
Single Family Dwelling	Riverdale Dr	0.63	926	115
Single Family Dwelling	Riverdale Dr	1.43	926	260
Single Family Dwelling	Riverdale Dr	5.67	926	1,027
Single Family Dwelling	Riverdale Dr	3.13	926	568
Single Family Dwelling	Riverdale Dr	4.90	926	888
Single Family Dwelling	Riverdale Dr	0.30	926	54
Single Family Dwelling	Riverdale Dr	3.80	926	689

Table AIV-14: Loss of rental income (LoRI) estimation

Building Class	Area	Displacement Time (Months)	Rental Rate ($/month)	LoRI ($)
Single Family Dwelling	Riverdale Dr	4.23	926	767
Single Family Dwelling	Riverdale Dr	1.80	926	326
Single Family Dwelling	Riverdale Dr	3.47	926	628
Single Family Dwelling	Riverdale Dr	3.73	926	677
Single Family Dwelling	Riverdale Dr	2.73	926	495
Single Family Dwelling	Salmon Arm Dr	0.30	926	54
Single Family Dwelling	Salmon Arm Dr	0.30	926	54
Single Family Dwelling	Salmon Arm Dr	0.63	926	115
Single Family Dwelling	Salmon Arm Dr	0.30	926	54
Single Family Dwelling	Salmon Arm Dr	0.50	926	91
Single Family Dwelling	Victor St	1.57	926	284
Single Family Dwelling	Victor St	0.77	926	139
Single Family Dwelling	Victor St	0.80	926	145
Single Family Dwelling	Waterwheel St	1.20	926	218
Single Family Dwelling	Waterwheel St	0.27	926	48
Single Family Dwelling	Waterwheel St	1.27	926	230
Single Family Dwelling	Waterwheel St	1.43	926	260
Single Family Dwelling	Waterwheel St	0.93	926	169
Single Family Dwelling	Waterwheel St	0.97	926	175
Single Family Dwelling	Waterwheel St	1.23	926	224
Multi Family Dwelling	Baird Ave	5.27	926	22,910
Multi Family Dwelling	Belvedere St	0.43	926	628
Multi Family Dwelling	Belvedere St	2.77	926	2,507
Multi Family Dwelling	Howard Ave	4.63	926	10,078
Multi Family Dwelling	Kate St	0.90	926	3,915
			TOTAL	**$182,954**

Table AIV-15: Impact to non-residential properties loss estimation

Building Classification	Area	Flood Depth (m)	Structural Damage ($/m^2)	Total Damage
Institution	Bass Ave	0.610	504	708,023
Institution	Belvedere St	0.123	442	209,192
Office/Retail	Belvedere St	0.100	353	44,488
Industrial/Warehouse	Brickyard Rd	0.727	558	447,700
Industrial/Warehouse	George St	0.339	453	160,414
Industrial/Warehouse	George St	0.152	443	177,375
Industrial/Warehouse	George St	0.422	471	35,155
Industrial/Warehouse	Highway 97A	0.152	443	148,156
Industrial/Warehouse	Highway 97A	0.222	446	302,522
Hotel/Motel	Kildonan Ave	0.096	353	46,326
Institution	Knight Ave	0.234	446	74,595
Industrial/Warehouse	Maud St	0.22467	446.075	45585
Industrial/Warehouse	Maud St	0.225	446	45,586
Office/Retail	Mill Ave	0.975	638	254,228
Office/Retail	Mill Ave	0.912	638	37,453
TOTAL STRUCTURAL				$2,867,516
Building Classification	Area	Flood Depth (m)	Content Damage ($/m^2)	Total Damage

Institution	Bass Ave	0.610	476	667,742
Institution	Belvedere St	0.123	262	123,887
Groceries	Belvedere St	0.100	195	24,580
Warehouse/Industrial	Brickyard Rd	0.727	503	403,408
Warehouse/Industrial	George St	0.339	427	151,344
Warehouse/Industrial	George St	0.152	280	112,064
Warehouse/Industrial	George St	0.422	445	33,162
Warehouse/Industrial	Highway 97A	0.152	280	93,603
Warehouse/Industrial	Highway 97A	0.222	352	238,605
Hotels	Kildonan Ave	0.096	195	25,595
Institution	Knight Ave	0.234	352	58,834
Furniture/Appliances	Maud St	0.225	352	35,954
Medical	Mill Ave	0.975	543	216,578
Medical	Mill Ave	0.912	543	31,880
Medical	Mill Ave	0.147	280	111,388
			TOTAL CONTENT	$2,328,623
			TOTAL STRUCTURAL & CONTENT	**$5,196,139**

Calculation table for Figure 3-15, Figure 3-16, and Figure 3-17:

Table AIV-15: Example annual risk curve calculations

Flood Hazard Severity (Return Period)	Probability of Occurrence	Impact of Hazard ($, 2020)	Annual Risk ($, 2020)	Cumulative Risk ($, 2020)
1	1.0000	0	0	0
2	0.5000	0	0	0
3	0.3333	0	0	0
4	0.2500	0	0	0
6	0.1667	0	0	0
8	0.1250	0	0	0
10	0.1000	0	0	0
15	0.0667	0	0	0
20	0.0500	0	0	0
30	0.0333	2,990,397	99,680	99,680
40	0.0250	5,980,795	149,520	249,200
50	0.0200	8,971,192	179,424	428,624
60	0.0167	11,961,590	199,360	627,983
70	0.0143	14,951,987	213,600	841,583
80	0.0125	17,942,384	224,280	1,065,863
90	0.0111	20,932,782	232,586	1,298,450
100	0.0100	23,923,179	239,232	1,537,681
110	0.0091	26,913,577	244,669	1,782,350
120	0.0083	29,903,974	249,200	2,031,550
130	0.0077	32,894,371	253,034	2,284,584
140	0.0071	35,884,769	256,320	2,540,903
150	0.0067	38,875,166	259,168	2,800,071
160	0.0063	41,865,563	261,660	3,061,731
170	0.0059	44,855,961	263,859	3,325,590
180	0.0056	47,846,358	265,813	3,591,403
190	0.0053	50,836,756	267,562	3,858,964
200	0.0050	53,827,153	269,136	4,128,100

APPENDIX V: REGULATIONS

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Excerpt from Section 39 of the WSA Water Sustainability Regulation (Province of BC, 2018a):

NOTE: Sections that do not apply have been removed.

Authorized changes

39 (1)The following changes in and about a stream are authorized changes:

(a) the installation, maintenance or removal of a culvert for crossing a stream for the purposes of a road, trail or footpath, if all the following conditions are met:

(i) the equipment used for site preparation, or for installation, construction, maintenance or removal of the culvert, is situated in a dry stream channel or operated from the top of the bank;
(ii) if the stream is fish-bearing, the culvert allows fish in the stream to pass up or down stream under all flow conditions;
(iii) the culvert inlet and outlet incorporate measures to protect the structure and the stream channel against erosion;
(iv) debris can pass through the culvert;
(v) the installation, maintenance or removal of the culvert does not destabilize the stream channel;
(vi) the culvert and its approach roads do not produce a backwater effect or increase the head of the stream;
(vii) the culvert capacity is equivalent to the hydraulic capacity of the stream channel or is capable of passing the 1 in 200 year maximum daily flow without the water level at the culvert inlet exceeding the top of the culvert;
(viii) the culvert has a minimum equivalent diameter of 600 mm;
(ix) if the culvert has an equivalent diameter of 2 m or greater, or has a design capacity to pass a flow of more than 6 m^3 per second, the culvert is designed by an engineering professional and constructed in conformance with that design;
(x) the culvert is installed in a manner that permits the removal of obstacles and debris within the culvert and at the culvert ends;
(xi) if the changes in and about the stream are related to a right of way, the stream channel, except the portion within the right of way, is not altered;
(xii) embankment fill materials do not, and are unlikely to, encroach on culvert inlets and outlets;
(xiii) the culvert has a depth of fill cover that is at least 300 mm or as required by the culvert manufacturer's specifications;
(xiv) the maximum fill heights above the top of the culvert do not exceed 2 m;
(xv) the culvert is made of materials that meet the applicable standards of the Canadian Standards Association;

(e) the construction, maintenance or removal by the Crown in right of either Canada or British Columbia of a flow or water level measuring device in a stream;
(h)the restoration or maintenance of a stream channel by a municipality or regional district;
(i) the mechanical or manual cutting of annual vegetation within a stream channel;
(j) the restoration or maintenance of fish habitat by the Crown in right of either Canada or British Columbia;

(k) the repair or maintenance of existing dikes or existing erosion protection works to their original state, if the dikes or works were functional during the previous year;
(o) the construction or placement, under the direction of the Crown in right of British Columbia, a municipality or a regional district, or an agent of any of them, of erosion protection works or flood protection works during an emergency declared under the *Emergency Program Act* that involves flooding;
(p)the clearing of an obstruction from a bridge or culvert by the Crown in right of British Columbia, a municipality or a regional district during a flood, if the obstruction is causing or has the potential to cause a significant risk of harm to public safety, the environment, land or other property;
(q) the installation or cleaning of drainage outlets;
(u) the removal of a beaver dam under section 9 of the *Wildlife Act*, if the removal is carried out in such a manner that downstream flooding and erosion do not occur;
(v)the construction of a temporary ford for vehicular traffic across a stream, if

> (i) the construction occurs at a time in the year during which the construction can occur without causing a risk of significant harm to fish, wildlife or the aquatic ecosystem of the stream,
> (ii) the 1 in 10 year maximum daily flow over the ford is accommodated without the loss of the ford and without eroding the stream channel,
> (iii) any culvert is designed and installed to pass the average low flow for the period of use,
> (iv) the stream channel is protected against any anticipated erosion
>> (A)for the period of construction and use of the ford, and
>> (B)after the ford is removed,
>
> (v) sediment from approach ditches does not enter the stream,
> (vi) the driveable running surface is erosion-free,
> (vii) the stream remains in its channel,
> (viii) channel debris will pass over the ford, and
> (ix) the ford is removed at the end of the period of use at a time when the removal can proceed without causing a risk of significant harm to fish, wildlife or the aquatic ecosystem of the stream;

(w) the construction of a temporary diversion around or through a worksite for the purposes of constructing or maintaining bridge abutments, constructing or maintaining piers other than bridge piers, maintaining bridge piers or constructing works authorized under this section, if

> (i) the size of the worksite is minimized,
> (ii) any pumps, pipes or conduits used to divert water around or through the worksite are sized to divert the 1 in 10 year maximum daily flow for the period of construction,
> (iii) any pump or intake withdrawing water from a fish-bearing stream is screened to prevent potential loss of fish due to entrainment or impingement,
> (iv) any cofferdams used to isolate successive parts of the construction occurring at the worksite are designed by an engineering professional and constructed in accordance with that design,
> (v) the natural channel remaining outside of any cofferdams is adequate to pass the 1 in 10 year maximum daily flow for the period of construction,

(vi) the flow of water diverted around the worksite using ditches remains within the stream channel,
(vii) any ditches used to divert the flow of water around the worksite are designed and constructed to divert the 1 in 10 year maximum daily flow around or through the worksite and are protected from any anticipated erosion for the period of construction and use of the ditch, and
(viii) any ditches are completely backfilled and the area returned as closely as possible to the state that existed before the changes in and about the stream were made;

Excerpt from Section 524 of the Local Government Act (Province of BC, 2015):

Requirements in relation to flood plain areas

524 (1) In this section:

"environment minister" means the minister charged with the administration of the *Environmental Management Act*;

"Provincial guidelines" means the policies, strategies, objectives, standards, guidelines and environmental management plans, in relation to flood control, flood hazard management and development of land that is subject to flooding, prepared and published by the environment minister under section 5 of the *Environmental Management Act*;

"Provincial regulations" means, in relation to a local government, any applicable regulations enacted under section 138 (3) (e) *[general authority to make regulations — flood hazard management]* of the *Environmental Management Act*.

(2) If a local government considers that flooding may occur on land, the local government may, by bylaw, designate the land as a flood plain.

(3) If land is designated as a flood plain under subsection (2), the local government may, by bylaw, specify

(a) the flood level for the flood plain, and
(b) the setback from a watercourse, body of water or dike of any landfill or structural support required to elevate a floor system or pad above the flood level.

(4) In making bylaws under this section, a local government must

(a) consider the Provincial guidelines, and
(b) comply with the Provincial regulations and a plan or program the local government has developed under those regulations.

(5) A bylaw under subsection (3) may make different provisions for one or more of the following:

(a) different areas of a flood plain;
(b) different zones;
(c) different uses within a zone or an area of a flood plain;
(d) different types of geological or hydrological features;
(e) different standards of works and services;
(f) different siting circumstances;
(g) different types of buildings or other structures and different types of machinery, equipment or goods within them;
(h) different uses within a building or other structure.

(6) If a bylaw under subsection (3) applies,

(a) the underside of any floor system, or the top of any pad supporting any space or room, including a manufactured home, that is used for

(i) dwelling purposes,
(ii) business, or

(iii) the storage of goods that are susceptible to damage by floodwater

must be above the applicable flood level specified by the bylaw, and

(b) any landfill required to support a floor system or pad must not extend within any applicable setback specified by the bylaw.

(7) Subject to the Provincial regulations and a plan or program a local government has developed under those regulations, the local government may exempt a person from the application of subsection (6), or a bylaw under subsection (3), in relation to a specific parcel of land or a use, building or other structure on the parcel of land, if the local government considers it advisable and either

(a) considers that the exemption is consistent with the Provincial guidelines, or

(b) has received a report that the land may be used safely for the use intended, which report is certified by a person who is

(i) a professional engineer or geoscientist and experienced in geotechnical engineering, or

(ii) a person in a class prescribed by the environment minister under subsection (9).

(8) The granting of an exemption, and the exemption, under subsection (7) may be made subject to the terms and conditions the local government considers necessary or advisable, including, without limitation,

(a) imposing any term or condition contemplated by the Provincial guidelines in relation to an exemption,

(b) requiring that a person submit a report described in subsection (7) (b), and

(c) requiring that a person enter into a covenant under section 219 of the *Land Title Act*.

(9) The environment minister may make regulations prescribing a class of persons the minister considers qualified, for the purposes of this section, to certify reports referred to in subsection (7) (b).

APPENDIX VI: LIDAR SPECIFICATIONS & TERMS OF USE

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LiDAR Metadata Summary		
Owner:	Forests, Lands, and Natural Resource Operations and Rural Development, GeoBC	
Project Name:	Thompson Watershed 2019	
Date of Data Submission:	May 2020	
Project Location:	Thompson Watershed: See Appendix A	
Sign-off:	Brett Edwards; Brett.1.Edwards@gov.bc.ca	
License:	GeoBC (FLNRORD) – Signed Data Use Agreement with GeoBC Required	
Acquisition Parameters	**Parameter**	**Value**
	Specifications:	-
	Sensor Model:	Riegl LMS-Q780
	Max Returns:	-
	Max Scan Angle:	±25°
	Pulse Rate:	100-400 khz
	Beam Divergence:	0.25mrad @ $1/e^2$
	Flying Height (AGL):	800-900m
	Swath Overlap:	30%
	Target Density:	16 pts/m^2
	Project Units:	meters
	Range of Acquisition Dates:	2019/09/16 – 2019/11/08
Format	**Parameter**	**Value**
	LAS Version:	1.4
	LAS Point Record Format:	6
	Global Encoding:	16
Accuracy	**Parameter**	**Value**
	*Non-Vegetated Vertical Accuracy (95% [1.96*RMSE$_Z$]):*	0.14m
	Number of Check Points:	137
Class	**Parameter**	**Value**
	Classified (Yes/No):	Yes
	Class Codes Used:	1,2,7,9,17,18
Reference System	**Parameter**	**Value**
	Horizontal Datum:	NAD83 (CSRS)
	Projection System:	UTM Z10/11
	Vertical Datum:	CGVD2013
	Geoid Model:	CGG2013
Notes:	This data was not collected to GeoBC specifications. The data meets accuracy requirements but the GPS time is recorded as GPS Week Time, not Adjusted Standard GPS Time.	