



August 2018

FORT MCMURRAY RIVER HAZARD STUDY

Open Water Flood Inundation Mapping Report

Submitted to:
Alberta Environment and Parks
11th Floor, Oxbridge Place
9820 - 106 Street NW
Edmonton, AB T5K 2J6

RAFT



REPORT

Report Number: 1662603_R0004_0

Distribution:

5 Paper Copies: Alberta Environment and Parks
1 E-Copy: Alberta Environment and Parks





Executive Summary

Alberta Environment and Parks (AEP) retained Golder Associates Ltd. (Golder), in collaboration with SG1 Water Consulting Ltd. (SG1) and Hatch Ltd. (Hatch), in September 2016 to conduct the Fort McMurray River Hazard Study. The primary purpose of the study is to assess and identify river and flood hazards along the Athabasca River, the Clearwater River (including the Snye), and the Hangingstone River through Fort McMurray, Alberta in the Regional Municipality of Wood Buffalo (RMWB).

The study is conducted under the provincial Flood Hazard Identification Program (FHIP), the goals of which include enhancement of public safety and reduction of future flood damages through the identification of river and flood hazards. Project stakeholders include the Government of Alberta, the RMWB, and the public.

The study includes multiple components and deliverables. This report documents the methodology and results of the open water flood inundation mapping component, including the inundation maps for the 2-, 5-, 10-, 20-, 35-, 50-, 75-, 100-, 200-, 350-, 500-, 750-, and 1,000-year open water floods.

The flood inundation maps were prepared using ArcGIS. The simulated flood water levels at the cross sections were used to create a continuous water surface. The edge of inundation was delineated by subtracting the LiDAR DTM from the water surface. The following types of flood inundation were mapped:

- Direct inundation where there is a direct overland connection between the main river channels and inundated areas on the floodplains. This includes special areas where inundation is caused by single or multiple overtopping points.
- Indirect inundation areas (isolated areas) that are potentially inundated but have no direct overland connection to the main river channels.
- Flooding behind flood control structures.

Flood inundation mapping for the Lower Townsite was prepared using an interpolation technique and assumptions regarding the pool water level on the inside of the Prairie Loop Boulevard flood control structure.

Based on the simulation results, the main areas to be affected by open water flooding have been identified as follows:

- Low lying floodplain area between the Clearwater River meander bends upstream of Waterways (Draper area).
- Grayling Terrace on the Hangingstone River for the open water floods with return periods of 350 years and higher.
- Lower Townsite due to a flow spill from the Hangingstone River near Heritage Park due to the open water floods with return periods of 200 years and higher.

The flood inundation maps are provided in a separate document.



Acknowledgements

This component of the Fort McMurray River Hazard Study was led by Dr. Wolf Ploeger. Overall project management was provided by Dr. Wolf Ploeger and direction by Dr. Dejiang Long. The flood inundation mapping was prepared by Peter Thiede, Gaven Tang, Brian Pendergast and Wolf Ploeger.

The authors express their special thanks to Abdullah Mamun, Patricia Stevenson and Jim Choles, Project Managers for Alberta Environment and Parks, who provided overall study management, background data, and technical guidance.

DRAFT



Table of Contents

1.0 INTRODUCTION.....	1
1.1 Study Objectives.....	1
1.2 Study Area and Reaches.....	1
2.0 AVAILABLE DATA.....	3
2.1 Flood Frequencies.....	3
2.2 Digital Terrain Model and Aerial Imagery.....	3
2.3 HEC-RAS Model.....	3
2.4 Flood Control Structures.....	4
3.0 FLOOD INUNDATION MAPS.....	5
3.1 Methodology.....	5
3.2 Direct Flood Inundation Areas.....	6
3.2.1 General Procedure.....	6
3.2.2 Summary of Manual Edits.....	7
3.3 Indirect Flood Inundation Areas.....	12
3.3.1 Inundation of Isolated Areas.....	12
3.3.2 Inundation Due to Potential Flood Control Structure Failure.....	12
3.4 Inundation Mapping of the Lower Townsite.....	13
3.5 Areas Affected by Flooding.....	15
3.5.1 Flooding of Residential Areas.....	15
3.5.2 Flooding of Commercial and Industrial Areas.....	15
3.5.3 Flooding of Bridges and Culverts.....	16
4.0 FLOOD WATER LEVEL AND DEPTH DATA.....	18
4.1 GIS Data Specifications.....	18
4.2 General Comments.....	18
5.0 CONCLUSIONS.....	18



TABLES

Table 1: River Reaches within the Study Area 1

Table 2: Summary of Flood Frequency Estimates 3

Table 3: Flood Control Structures within the Study Area..... 4

Table 4: Special Areas for the 5-Year Flood Event 8

Table 5: Special Areas for the 10-Year Flood Event 8

Table 6: Special Areas for the 20-Year Flood Event 8

Table 7: Special Areas for the 35-Year Flood Event 9

Table 8: Special Areas for the 50-Year Flood Event 9

Table 9: Special Areas for the 75-Year Flood Event 9

Table 10: Special Areas for the 100-Year Flood Event 10

Table 11: Special Areas for the 200-Year Flood Event 10

Table 12: Special Areas for the 350-Year Flood Event 11

Table 13: Special Areas for the 500-Year Flood Event 11

Table 14: Special Areas for the 750-Year Flood Event 11

Table 15: Special Areas for the 1,000-Year Flood Event 12

Table 16: Effects on Bridges along the Athabasca River 17

Table 17: Effects on Bridges along the Hangingstone River 17

FIGURES

Figure 1: Study Area 2

Figure 2: Example of Manual Edits to Water Level Surface TIN in Special Areas along the Clearwater River
(Scenario 2) 7

Figure 3: Illustration of Flood Control Structure Failure Inundation and Isolated Area Inundation..... 12

Figure 4: Breaklines to Support Inundation Mapping for the Lower Townsite 14

APPENDICES

APPENDIX A

Computed Open Water Flood Levels



1.0 INTRODUCTION

1.1 Study Objectives

Alberta Environment and Parks (AEP) retained Golder Associates Ltd. (Golder), in collaboration with SG1 Water Consulting Ltd. (SG1) and Hatch Ltd. (Hatch), in September 2016 to conduct the Fort McMurray River Hazard Study. The primary purpose of the study is to assess and identify river and flood hazards along the Athabasca River, the Clearwater River (including the Snye), and the Hangingstone River through Fort McMurray, Alberta in the Regional Municipality of Wood Buffalo (RMWB).

The study is conducted under the provincial Flood Hazard Identification Program (FHIP), the goals of which include enhancement of public safety and reduction of future flood damages through the identification of river and flood hazards. Project stakeholders include the Government of Alberta, the RMWB, and the public.

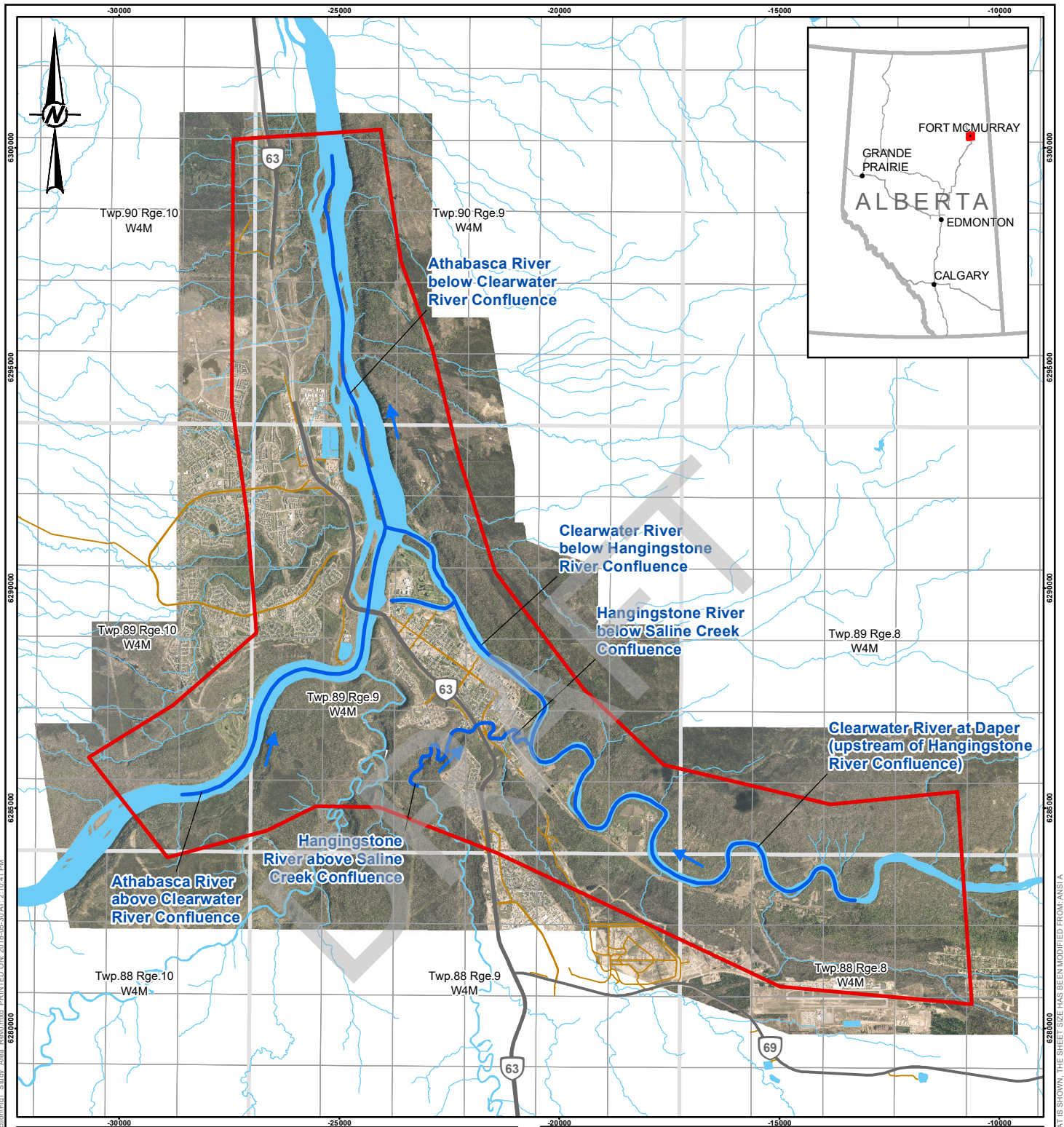
The study includes multiple components and deliverables. This report documents the methodology and results of the component of flood inundation mapping for the 2-, 5-, 10-, 20-, 35-, 50-, 75-, 100-, 200-, 350-, 500-, 750-, and 1,000-year open water floods.

1.2 Study Area and Reaches

The study area includes about 15 km of the Athabasca River, about 20 km of the Clearwater River (including 1.5 km of the Snye), and approximately 5 km of Hangingstone River through Fort McMurray (see Figure 1). The study area is within the RMWB. The study reaches are summarized in Table 1.

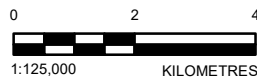
Table 1: River Reaches within the Study Area

River	Reach Description	Length
Athabasca River	From a location 6 km upstream of Highway 63 bridges to a location 8 km downstream of the Clearwater River confluence	15 km
Clearwater River	From the confluence with Athabasca River to a location 20 km upstream of the confluence	20 km
Hangingstone River	From a location 3 km upstream of Memorial Drive (Highway 63) Bridges to the confluence with Clearwater River	5 km
The Snye	Full length from Snye Dyke to the confluence with Clearwater River	1.5 km



LEGEND

- STUDY REACH
- STUDY AREA
- ➔ FLOW DIRECTION
- WATERCOURSE
- WATERBODY
- TRANSPORTATION FEATURES**
- PRIMARY HIGHWAY
- LOCAL ROAD



REFERENCE(S)

IMAGERY CAPTURED MAY 2017 BY GEODESY GROUP INC. FOR THE GOVERNMENT OF ALBERTA. DIGITAL BASE DATA OBTAINED FROM ALTALIS LTD. © GOVERNMENT OF ALBERTA 2014. ALL RIGHTS RESERVED. CANVEC, GEOGRATIS, IHS ENERGY INC. REGIONAL MUNICIPALITY OF WOOD BUFFALO.
 PROJECTION: 3TM 111° DATUM: NAD 83 CSRS

CLIENT



PROJECT

FORT MCMURRAY RIVER HAZARD STUDY

TITLE

STUDY AREA

CONSULTANT



YYYY-MM-DD 2018-05-30

DESIGNED WP

PREPARED PT

REVIEWED WP

APPROVED DL

PROJECT NO.

1662603

CONTROL

4000

REV.

0

FIGURE

1



2.0 AVAILABLE DATA

2.1 Flood Frequencies

The flood frequency estimates for the Athabasca, Clearwater and Hangingstone Rivers are documented in the Open Water Hydrology Assessment Report (Golder 2017). The relevant flood frequency estimates at key locations within the study area as shown in Figure 1 are summarized in Table 2.

Table 2: Summary of Flood Frequency Estimates

Location	Flood Peak Discharges for the Various Return Periods (m ³ /s)												
	2-Year	5-Year	10-Year	20-Year	35-Year	50-Year	75-Year	100-Year	200-Year	350-Year	500-Year	750-Year	1,000-Year
Athabasca River above Clearwater River Confluence	2,030	2,800	3,360	3,950	4,460	4,790	5,190	5,480	6,230	6,870	7,310	7,820	8,200
Athabasca River below Clearwater River Confluence	2,290	3,110	3,710	4,330	4,860	5,210	5,620	5,920	6,680	7,340	7,780	8,300	8,680
Clearwater River at Draper (upstream of Hangingstone River Confluence)	366	513	609	699	770	814	864	900	983	1,050	1,090	1,140	1,170
Clearwater River below Hangingstone River Confluence	385	540	641	737	812	859	911	949	1,040	1,110	1,150	1,200	1,240
Hangingstone River above Saline Creek Confluence	35.8	63.5	87.4	116	143	162	187	206	260	312	349	397	434
Hangingstone River below Saline Creek Confluence	35.8	63.5	87.4	116	143	162	187	206	260	312	349	397	434

2.2 Digital Terrain Model and Aerial Imagery

A detailed Digital Terrain Model (DTM) for the study area was provided by AEP. It was developed from a 2016 LiDAR survey. The DTM is available as gridded raster with 0.5 m resolution, ESRI Terrain and Triangulated Irregular Network (TIN). The DTM was delivered in the local study coordinate system and datum (3TM 111°, NAD83 CSRS).

An aerial imagery for the study area was collected by GeodesyGroup Inc. (GeodesyGroup) on May 18, 2017. The imagery has a 0.30 m Ground Sampling Distance (GSD) resolution and was delivered as 4-band orthophotos and stereo images. Details regarding the aerial imagery collection and specifications are provided in the Survey and Base Data Collection Report (Golder 2018).

The orthophoto imagery was used as a base image for production of the open water flood inundation map library.

2.3 HEC-RAS Model

A one-dimensional hydraulic model was created for the study area using HEC-RAS (Version 5.0.3). A detailed description of the HEC-RAS model is provided in the Hydraulic Model Creation and Calibration Report (Golder 2018). The model was calibrated using the following data:

- The measured water levels and discharges during the low flow conditions surveyed in September 2016.



- The high water marks and high water levels collected by AEP and RMWB during and after the June 2013 flood (the high flow conditions).
- The flow-stage rating curve data for the WSC gauging stations 07DA001 (Athabasca River below McMurray), 07CD001 (Clearwater River at Draper) and 07CD004 (Hangingstone River at Fort McMurray).

The calibrated model parameter values based on the high flow conditions were used in the production model to create flood profiles for the 2-, 5-, 10-, 20-, 35-, 50-, 75-, 100-, 200-, 350-, 500-, 750-, and 1,000-year open water floods.

2.4 Flood Control Structures

A summary of flood control structures within the study area is provided in Table 4. Details regarding the flood control structures are provided in the Survey and Base Data Collection Report (Golder 2018).

Table 3: Flood Control Structures within the Study Area

Waterbody	Description	Name / Identifier	Approximate Length (m)	Side of River ⁽¹⁾	Type
The Snye	Elevated pathway between MacDonald Drive and Borealis Park	Reach 1 (Snye Dyke)	635	Right	Pathway
Clearwater River	Prairie Loop Boulevard between McLeod Street and Riedel Street (Riverwalk Villas)	Reach 5 (Lower Townsite)	210	Left	Road
Clearwater River	Prairie Loop Boulevard between Riedel Street and Franklin Avenue	Reach 6 (Lower Townsite)	1945	Left	Road
Clearwater River	Prairie Loop Boulevard between Franklin Avenue and Saline Creek Drive intersection	Augment to Reach 7 (Lower Townsite)	465	Left	Road
Clearwater and Hangingstone Rivers	Saline Creek Drive between Saline Creek Drive Bridge and Park Street	Reach 10 (Waterways)	1450	Right (Hangingstone); Left (Clearwater)	Road
Clearwater and Hangingstone Rivers	Saline Creek Drive between Saline Creek turnaround and Prairie Loop Boulevard	Reach 10 (Waterways)	95	Left (Hangingstone); Left (Clearwater)	Road
Clearwater River	Saline Creek Drive between Park Street and junction with Draper Road	Reach 11 (Waterways)	1125	Left	Road
Saline Creek	Retaining structure – gabion basket	Reach 10 (Waterways)	210	Left	Retaining Structure

Notes:

1) Left side or right side as seen by an observer looking downstream.



3.0 FLOOD INUNDATION MAPS

3.1 Methodology

The flood inundation maps were prepared based on the following information:

- Simulated water levels at individual cross sections for the 5-, 10-, 20-, 35-, 50-, 75-, 100-, 200-, 350-, 500-, 750- and 1,000-year flood events.
- Locations and extents of individual cross sections.
- LiDAR DTM.
- Information about permanent flood control structures.

The purpose of the flood inundation mapping is to show the areas that are inundated by direct and indirect inundation. Direct inundation is the flood inundation where there is a direct overland connection between the main river channels and flooded areas on the floodplains. In addition, the following special inundation areas are identified for each flood event:

- Scenario 1 – Isolated Areas: Isolated areas are potentially inundated areas that have no direct overland connection to the main river channels. These areas may be potentially inundated due to unidentified culverts, groundwater connection, permeable embankments, or backup from storm sewer systems.
- Scenario 2 – Single Overtopping Point: At locations where inundated areas are connected to the main channel at a single overtopping point (spill point), the inundation extent was re-evaluated using a constant water level which is equal to that at the spill point.
- Scenario 3 – Multiple Overtopping Points: If there are multiple overtopping points related to a single overflow area, the inundation extent was based on the hydraulic gradient in the main channel between the overtopping points. The inundation extent upstream of the most upstream overtopping point and downstream of the most downstream overtopping point, were evaluated using the estimated water level at these bounding spill points.
- Scenario 4 – Single Overtopping Point Causing Overtopping Downstream: Under Scenario 2, if the area behind the single overtopping location would be (after some time) completely inundated and pooled with a constant surface water elevation similar to the water level at the spill point, this may cause a second overtopping further downstream and flow back into the main channel, because at that point the water level behind the embankment may be higher than that in the main channel. In this case, the inundation extent was re-evaluated using a linear interpolation between the water level at the upstream spill point and the ground elevation at the downstream re-entry point.
- Scenario 5 – Potential Flood Inundation due to Flood Control Structure Failure: In areas where permanent flood control structures have been identified and are not overtopped, the protected areas are shown as potentially flooded. The inundation extent is determined by assuming that the flood control structure is ineffective.



3.2 Direct Flood Inundation Areas

3.2.1 General Procedure

The following general procedure was used in ArcGIS to develop the inundation extent for the 13 open water flood events:

- 1) Assign water levels at each section for all flood events to the cross section polyline features as attributes. The result is one polyline feature that includes the simulated water levels for all flood events.
- 2) Create a continuous water level surface using a Triangulated Irregular Network (TIN) between cross sections.
- 3) Manually adjust the water level surface TIN in special areas (see Scenarios 2, 3 and 4 and Section 3.2.2). This adjustment is made by using 3D break lines to separate the manually adjusted areas from the original water surface areas. Between the 3D break line and the next upstream/downstream cross sections, the water surface was interpolated (see Figure 2).
- 4) Convert the adjusted TIN into a water level raster with the same resolution and cell alignment as the DTM raster.
- 5) Subtract the DTM from the water level raster.
- 6) Assign "NoData" to dry cells (with water depths smaller than 0.01 m).
- 7) Convert the wet area into a polygon dataset. Features not directly connected to the main river channels are flagged (Scenario 1).

In addition to this general procedure, the following guidelines were applied:

- Backwater inundation for relatively large tributaries was included and based on the simulated water levels at the main channel at the confluences of those tributaries. This applies to Little Fishery Creek (tributary to the Athabasca River at the Fort McMurray Golf Club), Horse River (tributary to the Athabasca River), Conn Creek (tributary to the Athabasca River opposite of the Clearwater River confluence), Saprea Creek (tributary to the Clearwater River), and Saline Creek (tributary to the Hangingstone River).
- Areas expected to be inundated during a flood event but not delineated automatically using ArcGIS were added to the inundation areas. This applies to some areas at the Upper Hangingstone River where there were gaps in the inundation of the main channel for the 2-year flood. In these areas, the inundation extent for the next larger flood event (i.e. 5-year flood) with a continuous inundation without gaps was used.

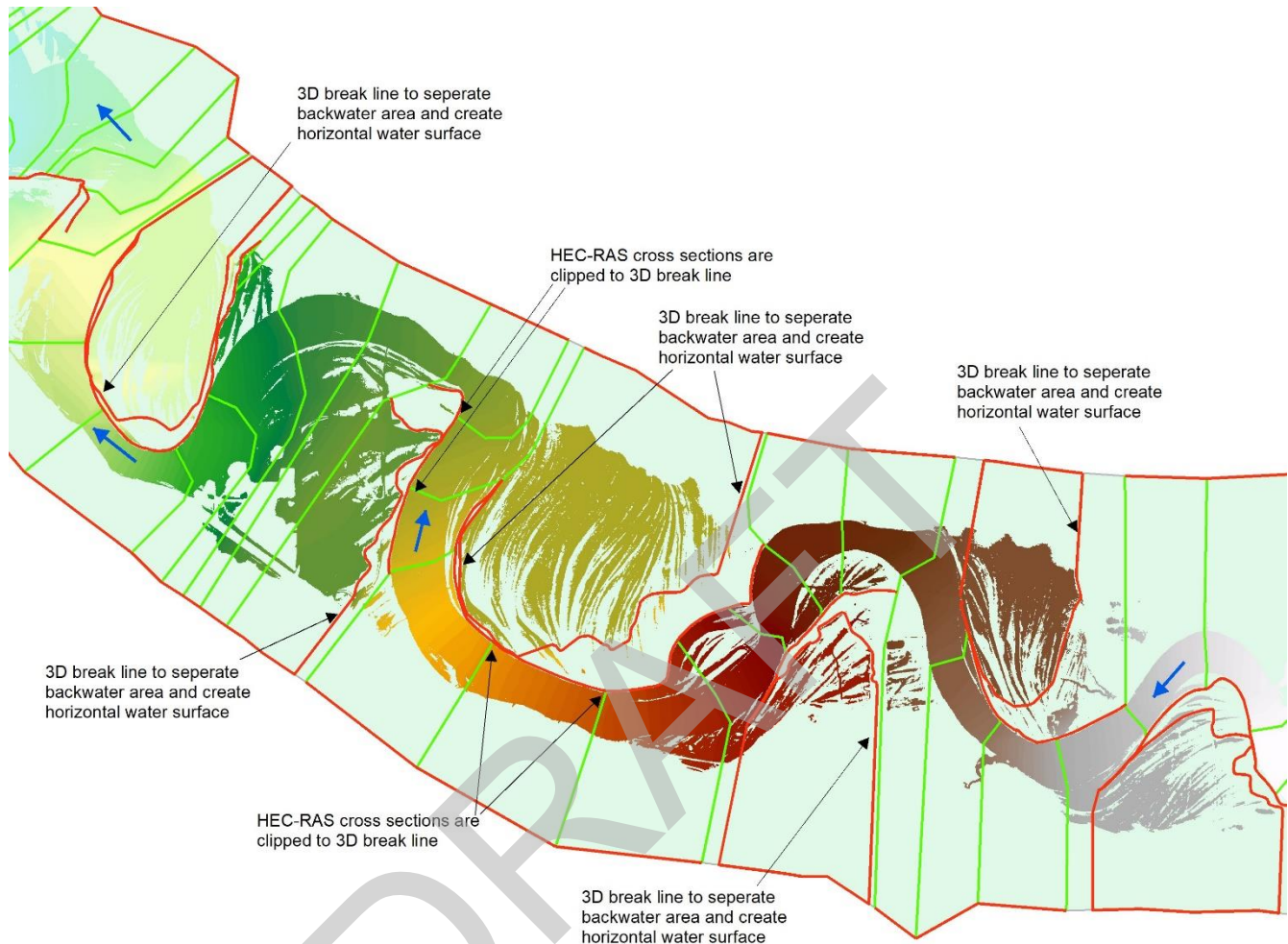


Figure 2: Example of Manual Edits to Water Level Surface TIN in Special Areas along the Clearwater River (Scenario 2)

3.2.2 Summary of Manual Edits

A special approach was used for inundation mapping of the Lower Townsite (see Section 3.4). Details of the manual edits are discussed below.

2-Year Flood

There is no special inundation area for the 2-year flood event.



5-Year Flood

A summary of manual edits applied to the inundation extent for the 5-year flood event is provided in Table 4.

Table 4: Special Areas for the 5-Year Flood Event

No	River	Location	Scenario	Elevation	Comment
1	Clearwater River	between Cross Sections 63 and 64, right bank	2	242.95 m	Backwater from single spill point
2	Hangingstone River	upstream of Cross Section 158, left bank	2	243.22 m	Backwater from single spill point

Note: Right bank is the bank on the right side when looking downstream, left bank is the bank on the left when looking downstream.

10-Year Flood

A summary of manual edits applied to the inundation extent for the 10-year flood event is provided in Table 5.

Table 5: Special Areas for the 10-Year Flood Event

No	River	Location	Scenario	Elevation	Comment
1	Athabasca River	between Cross Sections 25 and 26, left bank	2	239.93 m	Backwater from single spill point
2	Clearwater River	between Cross Sections 39 and 40, right bank	2	245.05 m	Backwater from single spill point
3	Clearwater River	between Cross Sections 43 and 44, right bank	2	244.74 m	Backwater from single spill point
4	Clearwater River	between Cross Sections 44 and 45, right bank	2	244.69 m	Backwater from single spill point
5	Clearwater River	between Cross Sections 57 and 58, left bank	2	243.72 m	Backwater from single spill point
6	Clearwater River	between Cross Sections 62 and 63, right bank	2	243.45 m	Backwater from single spill point
7	Hangingstone River	between Cross Sections 158 and 159, left bank	2	243.68 m	Backwater from single spill point

Note: Right bank is the bank on the right side when looking downstream, left bank is the bank on the left when looking downstream.

20-Year Flood

A summary of manual edits applied to the inundation extent for the 20-year flood event is provided in Table 6.

Table 6: Special Areas for the 20-Year Flood Event

No	River	Location	Scenario	Elevation	Comment
1	Athabasca River	between Cross Sections 21 and 22, left bank	2	241.56 m	Backwater from single spill point
2	Athabasca River	between Cross Sections 25 and 26, left bank	2	240.44 m	Backwater from single spill point
3	Clearwater River	between Cross Sections 39 and 40, right bank	2	245.37 m	Backwater from single spill point
4	Clearwater River	between Cross Sections 43 and 44, right bank	2	245.02 m	Backwater from single spill point
5	Clearwater River	upstream and downstream of Cross Sections 45, left bank	2	244.97 m	Backwater from single spill point
6	Clearwater River	between Cross Sections 48 and 49, right bank	2	244.75 m	Backwater from single spill point
7	Clearwater River	between Cross Sections 53 and 54, left bank	2	244.39 m	Backwater from single spill point
8	Clearwater River	between Cross Sections 57 and 58, right bank	2	244.08 m	Backwater from single spill point
9	Clearwater River	between Cross Sections 61 and 62, left bank	2	243.86 m	Backwater from single spill point
10	Clearwater River	between Cross Sections 62 and 63, left bank	2	243.84 m	Backwater from single spill point
11	Clearwater River	between Cross Sections 62 and 63, left bank	2	243.82 m	Backwater from single spill point
12	Hangingstone River	between Cross Sections 129 and 130, right bank	2	247.89 m	Backwater from single spill point

Note: Right bank is the bank on the right side when looking downstream, left bank is the bank on the left when looking downstream.



FORT McMURRAY RIVER HAZARD STUDY - OPEN WATER FLOOD INUNDATION MAPPING REPORT

35-Year Flood

A summary of manual edits applied to the inundation extent for the 35-year flood event is provided in Table 7.

Table 7: Special Areas for the 35-Year Flood Event

No	River	Location	Scenario	Elevation	Comment
1	Athabasca River	between Cross Sections 17 and 18, left bank	2	242.83 m	Backwater from single spill point
2	Athabasca River	between Cross Sections 21 and 22, left bank	2	241.94 m	Backwater from single spill point
3	Clearwater River	between Cross Sections 39 and 40, left bank	2	245.68 m	Backwater from single spill point
4	Clearwater River	between Cross Sections 39 and 40, right bank	2	245.60 m	Backwater from single spill point
5	Clearwater River	between Cross Sections 44 and 45, right bank	2	245.27 m	Backwater from single spill point
6	Clearwater River	upstream of Cross Sections 45, left bank	2	245.21 m	Backwater from single spill point
7	Clearwater River	between Cross Sections 52 and 53, right bank	2	244.68 m	Backwater from single spill point
8	Clearwater River	downstream of Cross Sections 52, left bank	4	244.73 m	Extending pool downstream to overtopping point of 75-year flood.
9	Clearwater River	between Cross Sections 60 and 61, right bank	2	244.17 m	Backwater from single spill point

Note: Right bank is the bank on the right side when looking downstream, left bank is the bank on the left when looking downstream.

50-Year Flood

A summary of manual edits applied to the inundation extent for the 50-year flood event is provided in Table 8

Table 8: Special Areas for the 50-Year Flood Event

No	River	Location	Scenario	Elevation	Comment
1	Athabasca River	between Cross Sections 17 and 18, left bank	2	243.06 m	Backwater from single spill point
2	Clearwater River	between Cross Sections 31 and 33, left bank	2	246.53 m	Backwater from single spill point
3	Clearwater River	between Cross Sections 38 and 39, left bank	2	245.84 m	Backwater from single spill point
4	Clearwater River	between Cross Sections 39 and 40, right bank	2	245.74 m	Backwater from single spill point
5	Clearwater River	between Cross Sections 43 and 44, right bank	2	245.44 m	Backwater from single spill point
6	Clearwater River	upstream of Cross Sections 45, left bank	2	245.36 m	Backwater from single spill point
7	Clearwater River	between Cross Sections 52 and 53, right bank	2	244.83 m	Backwater from single spill point
8	Clearwater River	downstream of Cross Sections 52, left bank	4	244.89 m	Extending pool downstream to overtopping point of 75-year flood.

Note: Right bank is the bank on the right side when looking downstream, left bank is the bank on the left when looking downstream.

75-Year Flood

A summary of manual edits applied to the inundation extent for the 75-year flood event is provided in **Error! Reference source not found.**

Table 9: Special Areas for the 75-Year Flood Event

No	River	Location	Scenario	Elevation	Comment
1	Athabasca River	between Cross Sections 17 and 18, left bank	2	243.30 m	Backwater from single spill point
2	Clearwater River	between Cross Sections 31 and 33, left bank	2	246.69 m	Backwater from single spill point
3	Clearwater River	between Cross Sections 34 and 35, right bank	2	246.46 m	Backwater from single spill point
4	Clearwater River	between Cross Sections 38 and 39, left bank	2	245.99 m	Backwater from single spill point
5	Clearwater River	between Cross Sections 39 and 40, right bank	2	245.89 m	Backwater from single spill point
6	Clearwater River	between Cross Sections 43 and 44, right bank	2	245.59 m	Backwater from single spill point
7	Clearwater River	upstream of Cross Sections 45, left bank	2	245.52 m	Backwater from single spill point



FORT MCMURRAY RIVER HAZARD STUDY - OPEN WATER FLOOD INUNDATION MAPPING REPORT

Table 9: Special Areas for the 75-Year Flood Event

No	River	Location	Scenario	Elevation	Comment
8	Clearwater River	between Cross Sections 51 and 52, right bank	2	245.03 m	Backwater from single spill point
9	Clearwater River	downstream of Cross Sections 52, and overtopping point, left bank	4	245.06 m upstream, 245.00 m at overtopping point	Extending pool downstream to overtopping point.
10	Clearwater River	between Cross Sections 65 and 66, left bank	2	244.32 m	Backwater from single spill point

Note: Right bank is the bank on the right side when looking downstream, left bank is the bank on the left when looking downstream.

100-Year Flood

A summary of manual edits applied to the inundation extent for the 100-year flood event is provided in Table 10.

Table 10: Special Areas for the 100-Year Flood Event

No	River	Location	Scenario	Elevation	Comment
1	Clearwater River	between Cross Sections 31 and 33, left bank	2	246.81 m	Backwater from single spill point
2	Clearwater River	between Cross Sections 34 and 35, right bank	2	246.57 m	Backwater from single spill point
3	Clearwater River	between Cross Sections 38 and 39, left bank	2	246.20 m	Backwater from single spill point
4	Clearwater River	upstream of Cross Sections 43, right bank	2	245.73 m	Backwater from single spill point
5	Clearwater River	upstream of Cross Sections 45, left bank	2	245.61 m	Backwater from single spill point
6	Clearwater River	between Cross Sections 51 and 52, right bank	2	245.16 m	Backwater from single spill point
7	Clearwater River	downstream of Cross Sections 52, and overtopping point, left bank	4	245.19 m upstream, 245.00 m at overtopping point	Extending pool downstream to overtopping point.
8	Hangingstone River	between Cross Sections 147 and 148, left bank	2	245.44 m	Backwater from single spill point

Note: Right bank is the bank on the right side when looking downstream, left bank is the bank on the left when looking downstream.

200-Year Flood

A summary of manual edits applied to the inundation extent for the 200-year flood event is provided in Table 11.

Table 11: Special Areas for the 200-Year Flood Event

No	River	Location	Scenario	Elevation	Comment
1	Clearwater River	between Cross Sections 31 and 32, left bank	2	247.07 m	Backwater from single spill point
2	Clearwater River	between Cross Sections 34 and 35, right bank	2	246.81 m	Backwater from single spill point
3	Clearwater River	upstream of Cross Sections 37, left bank	2	246.56 m	Backwater from single spill point
4	Clearwater River	between Cross Sections 38 and 39, left bank	2	246.34 m	Backwater from single spill point
5	Clearwater River	upstream of Cross Sections 43, right bank	2	245.99 m	Backwater from single spill point
6	Hangingstone River	between Cross Sections 147 and CS 148, left bank	2	245.69 m	Backwater from single spill point

Note: Right bank is the bank on the right side when looking downstream, left bank is the bank on the left when looking downstream.



FORT MCMURRAY RIVER HAZARD STUDY - OPEN WATER FLOOD INUNDATION MAPPING REPORT

350-Year Flood

A summary of manual edits applied to the inundation extent for the 350-year flood event is provided in Table 12.

Table 12: Special Areas for the 350-Year Flood Event

No	River	Location	Scenario	Elevation	Comment
1	Clearwater River	between Cross Sections 30 and 31, left bank	2	247.28 m	Backwater from single spill point
2	Clearwater River	upstream of Cross Sections 37, left bank	2	246.74 m	Backwater from single spill point
3	Clearwater River	between Cross Sections 42 and 43, right bank	2	246.22 m	Backwater from single spill point
4	Hangingstone River	between Cross Sections 150 and 151, left bank	2	245.86 m	Backwater from single spill point

Note: Right bank is the bank on the right side when looking downstream, left bank is the bank on the left when looking downstream.

500-Year Flood

A summary of manual edits applied to the inundation extent for the 500-year flood event is provided in Table 13.

Table 13: Special Areas for the 500-Year Flood Event

No	River	Location	Scenario	Elevation	Comment
1	Clearwater River	between Cross Sections 30 and 31, left bank	2	247.43 m	Backwater from single spill point
2	Clearwater River	upstream of Cross Sections 37, left bank	2	246.85 m	Backwater from single spill point
3	Clearwater River	between Cross Sections 42 and 43, right bank	2	246.35 m	Backwater from single spill point
4	Hangingstone River	between Cross Sections 115 and 116, left bank	2	252.06 m	Backwater from single spill point
5	Hangingstone River	between Cross Sections 150 and 151, left bank	2	246.04 m	Backwater from single spill point

Note: Right bank is the bank on the right side when looking downstream, left bank is the bank on the left when looking downstream.

750-Year Flood

A summary of manual edits applied to the inundation extent for the 750-year flood event is provided in Table 14.

Table 14: Special Areas for the 750-Year Flood Event

No	River	Location	Scenario	Elevation	Comment
1	Clearwater River	between Cross Sections 30 and 31, left bank	2	247.55 m	Backwater from single spill point
2	Clearwater River	upstream of Cross Sections 37, left bank	2	246.99 m	Backwater from single spill point
3	Clearwater River	between Cross Sections 41 and 42, right bank	2	246.54 m	Backwater from single spill point
4	Hangingstone River	upstream of Cross Sections 115, left bank	2	252.35 m	Extent of pool upstream was drawn to extent of pool in the 1,000-year event to avoid larger inundation polygons in smaller return period
5	Hangingstone River	between Cross Sections 150 and 151, left bank	4	246.27 m upstream, 246.20 m at overtopping point	Single overtopping point causing overtopping downstream

Note: Right bank is the bank on the right side when looking downstream, left bank is the bank on the left when looking downstream.



1,000-Year Flood

A summary of manual edits applied to the inundation extent for the 1,000-year flood event is provided in Table 15.

Table 15: Special Areas for the 1,000-Year Flood Event

No	River	Location	Scenario	Elevation	Comment
2	Clearwater River	upstream of Cross Sections 37, left bank	2	247.08 m	Backwater from single spill point
4	Hangingstone River	between CS 114 and 115, left bank	2	252.69 m	Backwater from single spill point
5	Hangingstone River	between Cross Sections 150 and 151, left bank	4	246.43 m upstream, 246.20 m at overtopping point	Single overtopping point causing overtopping downstream

Note: Right bank is the bank on the right side when looking downstream, left bank is the bank on the left when looking downstream.

3.3 Indirect Flood Inundation Areas

3.3.1 Inundation of Isolated Areas

Isolated areas are potentially inundated areas that have no direct overland connection to the main river channels. These areas may be potentially inundated due to unidentified culverts, groundwater connection, permeable embankments, or backup from storm sewer systems. The extents of isolated areas are identified based on the river main channel water levels.

3.3.2 Inundation Due to Potential Flood Control Structure Failure

Inundation due to potential flood control structure failure is mapped based on main channel water levels. Isolated areas behind flood control structures are only mapped as flood control structure failure if the flood water level in the main river channel is higher than the natural ground or the toe of the control structure as shown in Figure 3.

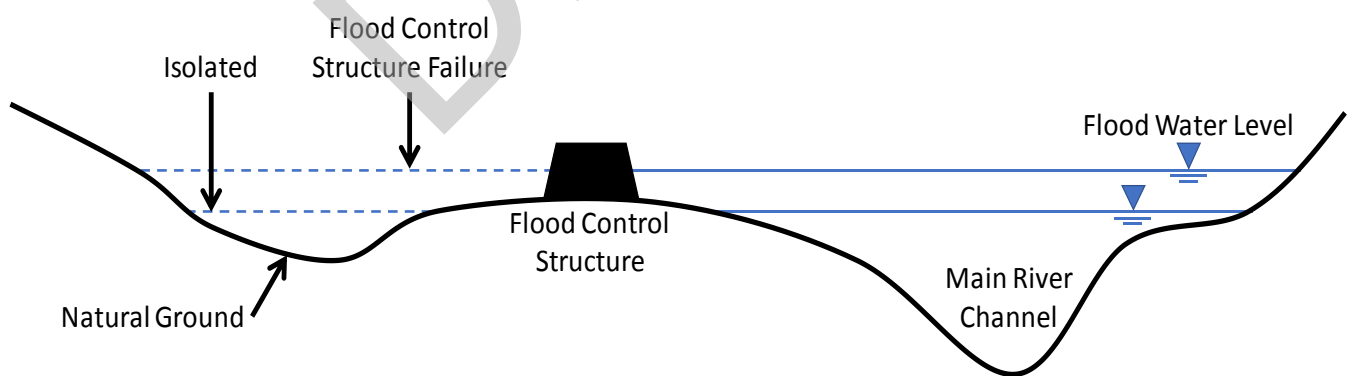


Figure 3: Illustration of Flood Control Structure Failure Inundation and Isolated Area Inundation



3.4 Inundation Mapping of the Lower Townsite

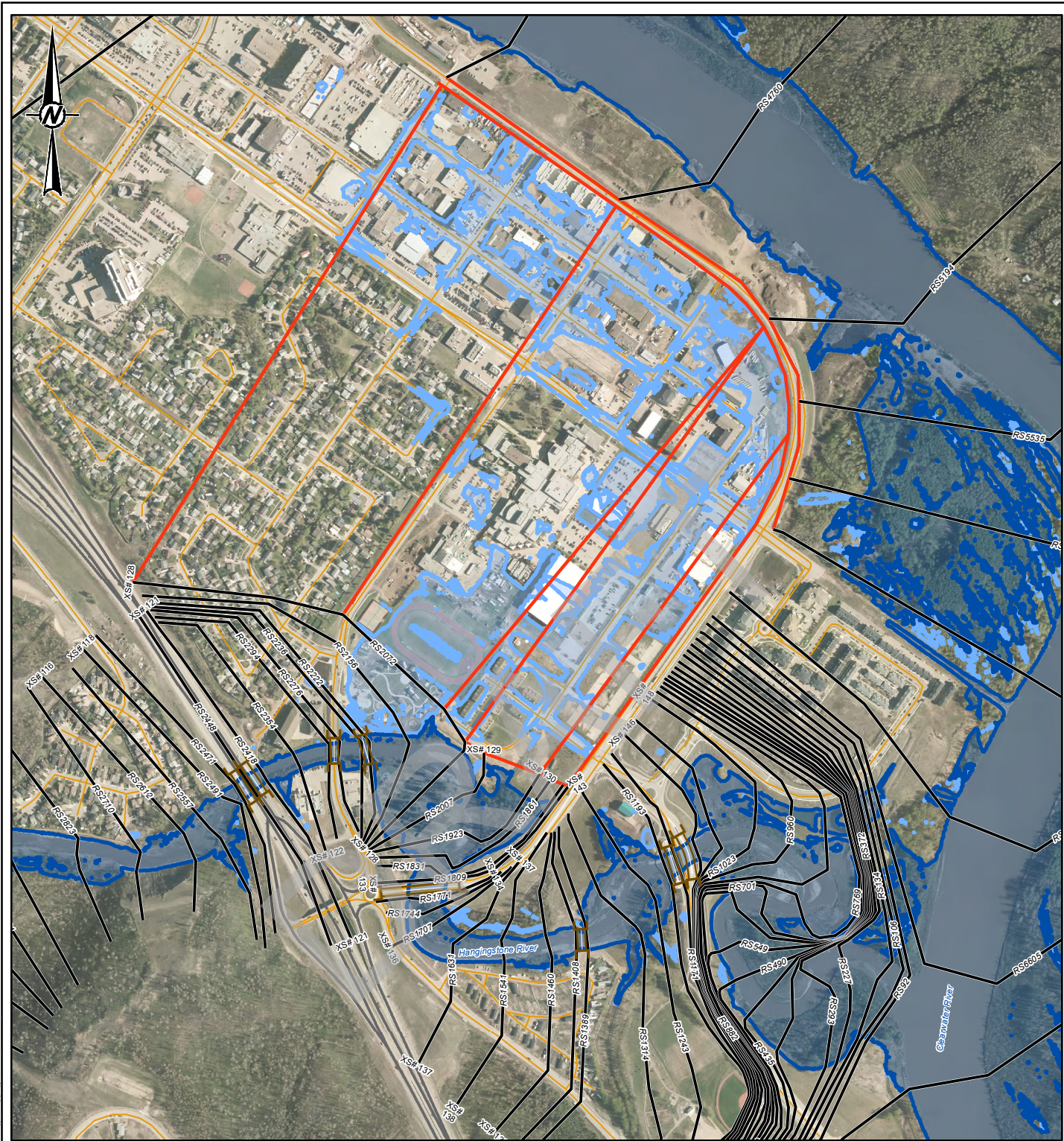
All simulated open water flood levels of the Clearwater River, up to the 1,000-year flood event, are lower than the toe of the flood control structures.

For the floods with return periods of 200 years and higher, the simulated water levels of the Hangingstone River near the Heritage Park are higher than its left bank. These floods are expected to inundate parts of the Lower Townsite north and west of Prairie Loop Boulevard.

The flood inundation extents between the Hangingstone River at Cross Section 128 and the Clearwater River were estimated by linear interpolation of the simulated Hangingstone River water levels and the assumed water level (i.e. 247.5 m) at the breaklines (i.e. linear features to maintain the known elevation values in a surface) along the inside (i.e. north and west) toe of Prairie Loop Boulevard (i.e. Flood Control Structure Reaches 5 and 6). This approach was used for all return periods. However for return periods 100 years and lower, the flood inundation in the Lower Townsite remains isolated (Scenario 1).

The water level interpolation for the Lower Townsite was also supported by the information along the breaklines from Cross Section 128 following Queen Street, King Street and approximately parallel to Penhorwood Street across Franklin Avenue to the toe of Prairie Loop Boulevard. Another breakline was defined along the Clearwater River side of Prairie Boulevard. All breaklines are 3D polylines that have fixed water levels at both ends. The water levels along the breaklines are linearly interpolated. The breaklines are shown in Figure 4.

DRAFT



- LEGEND**
- BREAKLINE
 - CROSS SECTION
 - 100-YEAR FLOOD INUNDATION EXTENT**
 - INUNDATED
 - ISOLATED
 - LOCAL ROAD
 - PRIMARY HIGHWAY



REFERENCE(S)
 ALBERTA DIGITAL BASE DATA OBTAINED FROM ALTALIS LTD. © GOVERNMENT OF ALBERTA 2014. ALL RIGHTS RESERVED. IMAGERY CAPTURED MAY 2017 BY GEODESY GROUP INC. FOR THE GOVERNMENT OF ALBERTA
 PROJECTION: 3TM 111° DATUM: NAD 83 CSRS



PROJECT
 FORT MCMURRAY RIVER HAZARD STUDY

TITLE
BREAKLINES TO SUPPORT INUNDATION MAPPING OF THE LOWER TOWNSHIP FOR OPEN-WATER FLOODS

CONSULTANT	YYYY-MM-DD	2018-05-30
	DESIGNED	WP
	PREPARED	SK
	REVIEWED	WP
	APPROVED	DL



PROJECT NO.	CONTROL	REV.	FIGURE
1662603	4000	0	4



3.5 Areas Affected by Flooding

3.5.1 Flooding of Residential Areas

Athabasca River

- There would be no residential area affected by flooding along the Athabasca River due to open water floods up to the 1,000-year flood event.

Upper Clearwater River (Draper Area, Upstream of Park Street)

- There would be limited flooding of low lying Clearwater River floodplains for open water floods up to the 75-year flood event.
- There would be large portions of the Clearwater River floodplain which are flooded by the open water floods with return periods of 100 years and higher.
- Residential properties generally appear to be located above the low-lying floodplain area, but access to the properties especially along Garden Lane would be limited during the open water floods with return periods of 20 years and higher.

Upper Hangingstone River (above Highway 63 Bridges)

- The community of Grayling Terrace upstream of Highway 63 would be inundated during the open water floods with return periods of 350 years and higher. The spill point would be at the river-facing ends of Gilbert Place and Graham Place.

Lower Townsite

- Open water floods could spill over the left bank of the Hangingstone River near Heritage Park to cause flooding of the Lower Townsite.
- Overtopping of the Hangingstone River bank would occur during the open water floods with return periods of 200 years and higher.
- The residential properties on Mills Avenue, along Penhorwood Street and low-lying areas of Rae Crescent and Bennett Crescent, would be flooded during the open water floods with return periods of 200 years and higher.

Ptarmigan Court

- The 1,000-year open water flood would inundate Parkview Drive.

Waterways

- No direct flooding of the Waterways community would occur due to the open water floods with return periods up to 1,000 years.

3.5.2 Flooding of Commercial and Industrial Areas

Athabasca River

- No direct flooding of commercial and industrial areas would occur due to the open water floods with return periods up to 1,000 years.



- Properties in the TaigaNova Eco-Industrial Park may be flooded by indirect inundation during the open water floods with return periods of 500 years and higher.

Clearwater River

- The main building of Dunvegan Gardens on Garden Lane would not be inundated during the open water floods with return periods up to 1,000 years, but the access to the Garden Centre would be limited during the open water floods with return periods of 20 years and higher.

Lower Townsite

- The Hangingstone River water would overtop its left bank near Heritage Park during the open water floods with return periods of 200 years and higher. The flood waters from that spill would inundate the commercial and industrial areas between Prairie Loop Boulevard and King Street, and between Prairie Loop Boulevard and Franklin Avenue east of Queen Street.

3.5.3 Flooding of Bridges and Culverts

A bridge is considered to be affected by flooding when water reaches its low chord.

The three bridges across the Athabasca River, which are included in the HEC-RAS model as one hydraulic structure, have a freeboard of several meters above the flood levels for all open water flood events.

None of the eight bridges on the Hangingstone River would be affected during the 100-year flood event. The Ptarmigan Court Footbridge would be affected by the 500-year open water flood event. Flooding of the Ptarmigan Court Footbridge approaches and the floodplains would occur during the 200-year open water flood event. Flooding of the Heritage Park Footbridge approaches and the floodplains would occur during the 50-year open water flood event.

Tables 4 and 5 present summaries of the simulated open water flood levels, 100-year flow velocities and clearances for the 100-year flood at the Athabasca River and Hangingstone River bridges. There is no bridge on the Clearwater River or the Snye.



FORT MCMURRAY RIVER HAZARD STUDY - OPEN WATER FLOOD INUNDATION MAPPING REPORT

Table 16: Effects on Bridges along the Athabasca River

Bridge Station (m)	Name	Minimum Deck Elevation (m)	Minimum Low Chord Elevation (m)	Simulated Water Levels for Various Flood Events (m), Rounded to the Nearest Decimetre													Average Flow Velocity for the 100-year Flood Event (m/s)	Clearance for the 100-year Flood Event (m)	Flood Event Causing Pressure Flow (Return Period)
				2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1,000-year			
10675	Three Athabasca River Bridges	256.6	253.0	242.49	243.04	243.46	243.82	244.11	244.29	244.49	244.64	245.00	245.30	245.49	245.72	245.87	2.9	8.0	> 1,000 years

Table 17: Effects on Bridges along the Hangingstone River

Bridge Station (m)	Name	Minimum Deck Elevation (m)	Minimum Low Chord Elevation (m)	Simulated Water Levels for Various Flood Events (m), Rounded to the Nearest Decimetre													Average Flow Velocity for the 100-year Flood Event (m/s)	Clearance for the 100-year Flood Event (m)	Flood Event Causing Pressure Flow (Return Period)
				2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1,000-year			
2,459	Highway 63 (Southbound)	255.3	253.4	248.35	248.89	249.24	249.59	249.88	250.06	250.28	250.43	250.86	251.21	251.42	251.66	251.86	2.8	2.9	> 1,000 years
2,435	Highway 63 (Northbound)	255.4	253.8	248.33	248.84	249.19	249.53	249.8	249.97	250.19	250.34	250.76	251.1	251.29	251.53	251.72	2.9	3.5	> 1,000 years
2,284	Tolen Drive Bridge	251.9	250.6	247.89	248.31	248.59	248.87	249.07	249.19	249.33	249.42	249.65	249.88	250.01	250.15	250.41	3.3	1.2	> 1,000 years
2,227	Heritage Park Footbridge	252.3	250.3	247.71	248.12	248.42	248.69	248.88	248.98	249.08	249.15	249.33	249.6	249.87	250.27	250.53	3.3	1.2	> 1,000 years
1,791	Prairie Loop Boulevard Bridge	259.8	255.7	246.27	246.86	247.18	247.49	247.74	247.88	248.06	248.18	248.49	248.76	248.94	249.15	249.31	1.9	7.5	> 1,000 years
1,399	Ptarmigan Court Footbridge	247.6	247.0	244.41	244.79	245.08	245.38	245.63	245.79	245.97	246.11	246.45	246.74	246.95	247.19	247.37	2.4	0.9	> 1,000 years
1,181	Saline Creek Drive Footbridge	250.0	249.0	243.85	244.35	244.69	245.00	245.27	245.42	245.61	245.74	246.07	246.34	246.52	246.72	246.87	2.1	3.2	> 1,000 years
1,149	Saline Creek Drive Bridge	251.2	247.5	243.80	244.28	244.62	244.92	245.17	245.32	245.49	245.62	245.93	246.2	246.38	246.58	246.73	2.4	1.9	> 1,000 years



4.0 FLOOD WATER LEVEL AND DEPTH DATA

4.1 GIS Data Specifications

For each of the 13 flood events the following GIS data is provided:

- Inundation polygons;
- Flood water level triangulated irregular network;
- Flood water level raster; and
- Flood water depths raster.

All GIS data is created in ArcGIS 10.3 compatible format in the native study coordinate system [Canadian Spatial Reference System, North American Datum of 1983 (CSRS NAD83), Epoch 2002 and 3-Degree Transverse Mercator projection with the Central Meridian of 111° (3TM 111)]. All raster files have a spatial resolution of 0.5 m.

The inundation polygons and raster files are stored in ArcGIS file geodatabases, Version 10.3. The flood water level TINs are stored as ArcGIS Terrain datasets in file geodatabases, Version 10.3.

4.2 General Comments

The flood water level data provided as TINs cover all areas between cross section lines and in special inundation areas within the study area including dry areas. The flood water level and depths rasters are clipped to the inundation extents for each of the 13 flood events.

The open water flood inundation maps are provided in a separate document.

5.0 CONCLUSIONS

The calibrated HEC-RAS model and the LiDAR DTM provided a good basis for simulating the flood levels and preparing the inundation maps for the 13 open water flood events (i.e. 2-, 5-, 10-, 20-, 35-, 50-, 75-, 100-, 200-, 350-, 500-, 750-, and 1,000-year open water floods), including direct flood inundation areas and other indirect flood inundation areas.

Based on the simulation results, the main areas to be affected by open water flooding have been identified as follows:

- Low lying floodplain area between the Clearwater River meander bends upstream of Waterways (Draper area).
- Grayling Terrace on the Hangingstone River for the open water floods with return periods of 350 years and higher.
- Lower Townsite due to a flow spill from the Hangingstone River near Heritage Park due to the open water floods with return periods of 200 years and higher.



Report Signature Page

This report was prepared and reviewed by the undersigned.

GOLDER ASSOCIATES LTD.

Prepared by:

Reviewed by:

ORIGINAL SIGNED

Peter Thiede, Dipl.-Ing.
GIS Specialist

ORIGINAL SIGNED

Dejiang Long, Ph.D., P.-Eng
Principal, Senior River Engineer

ORIGINAL SIGNED

Wolf Ploeger, Dr.-Ing.
Associate, Senior River Specialist

PT/DL/WP

DRAFT

Golder and the G logo are trademarks of Golder Associates Corporation

[https://golderassociates.sharepoint.com/sites/10170g/shared documents/04 open water inundation maps/report/final rev0/1662603_r0004_0_open water inundation mapping_20180913.docx](https://golderassociates.sharepoint.com/sites/10170g/shared%20documents/04%20open%20water%20inundation%20maps/report/final%20rev0/1662603_r0004_0_open%20water%20inundation%20mapping_20180913.docx)



THIRD PARTY DISCLAIMER

This report has been prepared by Golder Associates Ltd. (Golder) for the benefit of the client to whom it is addressed. The information and data contained herein represent Golder's best professional judgment in light of the knowledge and information available to Golder at the time of preparation. Except as required by law, this report and the information and data contained herein are to be treated as confidential and may be used and relied upon only by the client, its officers and employees. Golder denies any liability whatsoever to other parties who may obtain access to this report for any injury, loss or damage suffered by such parties arising from their use of, or reliance upon, this report or any of its contents without the express written consent of Golder and the client.

REFERENCES

- AENV (Alberta Environment). 1983. *City of Calgary Floodplain Study*. April 1983
- AGRA (AGRA Earth & Environmental). 1996. *Elbow River – M.D. of Rockyview Flood Risk Mapping Study*. February 1996
- City of Calgary. 2014. *Calgary's Flood Resilient Future*, Report from the Expert Management Panel on River Flood Mitigation. June 2014
- City of Calgary. 2014. *Calgary Flood Story*, www.floodstory.com.
- Golder (Golder Associates Ltd.). 2010. *Hydrology Study, Bow and Elbow River Updated Hydraulic Model Project, Rev. A*. Prepared for Alberta Environment. March 2010
- Golder. 2015a. *Bow River and Elbow River Basins – Hydrology of the 2013 Flood Event*. Prepared for The City of Calgary. January 2014
- Golder. 2015b. *Bow and Elbow River Updated Hydraulic Model Project – Survey Data Collection and Digital Elevation Model Creation*. Prepared for The City of Calgary. February 2015
- Golder. 2015c. *Bow and Elbow River – Hydraulic Model and Flood Inundation Mapping Update*. Prepared for The City of Calgary and Alberta Environment and Parks. July 2015.
- Golder. 2016. *DRAFT Bow, Elbow, Highwood and Sheep River Hydrology Assessment*. Prepared for Alberta Environment and Parks. June 2016
- UMA (UMA Engineering Ltd.). 1992. *Elbow River at Bragg Creek Hydraulic Study*. March 1992
- Vroegop, Ruben. 2014. *Forewarned and Forearmed: The Calgary Emergency Management Agency and the 2013 Flood*. The conference board of Canada. July 2, 2014



APPENDIX A

Computed Open Water Flood Levels

DRAFT



FORT MCMURRAY RIVER HAZARD STUDY - OPEN WATER FLOOD INUNDATION MAPPING REPORT

Table A.1: Athabasca River Flood Profile

River	Reach	River Sta.	Min Ch. El	2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
Athabasca	Upper Reach	17518.78	241.62	246.46	247.14	247.59	248.03	248.38	248.60	248.85	249.03	249.47	249.83	250.07	250.34	250.53
Athabasca	Upper Reach	16534.76	241.38	245.83	246.53	246.99	247.44	247.80	248.02	248.28	248.46	248.90	249.26	249.50	249.77	249.97
Athabasca	Upper Reach	15715.68	240.92	245.35	246.01	246.46	246.89	247.24	247.45	247.69	247.86	248.29	248.63	248.85	249.11	249.29
Athabasca	Upper Reach	15048.28	240.26	244.98	245.61	246.04	246.46	246.79	247.00	247.24	247.41	247.83	248.17	248.40	248.66	248.84
Athabasca	Upper Reach	14345.85	240.75	244.53	245.18	245.63	246.05	246.39	246.61	246.86	247.03	247.46	247.82	248.05	248.32	248.51
Athabasca	Upper Reach	13706.22	239.47	244.14	244.82	245.28	245.71	246.06	246.27	246.52	246.70	247.14	247.49	247.73	247.99	248.19
Athabasca	Upper Reach	13070.66	240.11	243.70	244.40	244.87	245.30	245.65	245.87	246.11	246.29	246.72	247.07	247.30	247.56	247.75
Athabasca	Upper Reach	12236.63	235.8	243.40	244.07	244.53	244.95	245.29	245.51	245.75	245.92	246.35	246.69	246.92	247.18	247.36
Athabasca	Upper Reach	11791.47	237.85	243.22	243.87	244.31	244.72	245.05	245.25	245.48	245.65	246.06	246.39	246.61	246.86	247.04
Athabasca	Upper Reach	11308.5	238.23	242.88	243.47	243.89	244.27	244.57	244.76	244.98	245.13	245.51	245.82	246.03	246.26	246.43
Athabasca	Upper Reach	10746.91	238.01	242.58	243.15	243.59	243.97	244.27	244.46	244.67	244.83	245.21	245.53	245.74	245.97	246.14
Athabasca	Upper Reach	10564.41	238.35	242.45 ^(a)	243.02 ^(a)	243.47 ^(a)	243.85 ^(a)	244.15 ^(a)	244.34 ^(a)	244.56 ^(a)	244.71 ^(a)	245.10 ^(a)	245.42 ^(a)	245.63 ^(a)	245.86 ^(a)	246.03 ^(a)
Athabasca	Upper Reach	10305.52	238.92	242.26	242.84	243.30	243.68	243.99	244.18	244.40	244.55	244.94	245.26	245.47	245.71	245.88
Athabasca	Upper Reach	9779.201	238.3	241.87	242.45	242.94	243.32	243.62	243.81	244.03	244.18	244.57	244.89	245.09	245.33	245.50
Athabasca	Upper Reach	9174.223	237.57	241.48	242.10	242.65	243.04	243.35	243.54	243.76	243.92	244.31	244.63	244.84	245.08	245.25
Athabasca	Lower Reach	8558.773	237.24	241.27	241.92	242.51	242.92	243.23	243.43	243.65	243.81	244.20	244.53	244.74	244.98	245.16
Athabasca	Lower Reach	7895.353	235.72	241.07	241.73	242.27	242.68	242.99	243.20	243.42	243.59	243.98	244.31	244.53	244.77	244.95
Athabasca	Lower Reach	7143.78	236.46	240.80	241.45	241.88	242.29	242.62	242.82	243.06	243.23	243.64	243.98	244.20	244.45	244.63
Athabasca	Lower Reach	6437.807	235.36	240.57	241.23	241.66	242.08	242.41	242.62	242.86	243.03	243.44	243.79	244.01	244.26	244.44
Athabasca	Lower Reach	5675.062	235.09	240.42	241.09	241.53	241.95	242.28	242.49	242.73	242.90	243.32	243.66	243.88	244.14	244.32
Athabasca	Lower Reach	4899.097	233.02	240.13	240.79	241.22	241.63	241.96	242.17	242.40	242.57	242.97	243.30	243.51	243.76	243.93
Athabasca	Lower Reach	4246.117	235.44	239.87	240.53	240.95	241.36	241.68	241.88	242.11	242.27	242.67	242.99	243.20	243.44	243.61
Athabasca	Lower Reach	3082.808	235.16	239.52	240.17	240.58	240.98	241.30	241.50	241.73	241.88	242.28	242.60	242.80	243.04	243.21
Athabasca	Lower Reach	2347.389	234.3	239.35	240.00	240.42	240.81	241.13	241.33	241.55	241.71	242.10	242.42	242.62	242.86	243.03
Athabasca	Lower Reach	1419.641	233.4	239.11	239.76	240.17	240.56	240.87	241.07	241.30	241.45	241.84	242.16	242.37	242.60	242.77
Athabasca	Lower Reach	128.5046	233.12	238.71	239.35	239.75	240.13	240.43	240.63	240.85	241.00	241.38	241.70	241.90	242.13	242.29

(a) Linear Interpolation between upstream and downstream water levels to remove dip at bridge.



FORT MCMURRAY RIVER HAZARD STUDY - OPEN WATER FLOOD INUNDATION MAPPING REPORT

Table A.2: Clearwater River Flood Profile

River	Reach	River Sta.	Min Ch. El	2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
Clearwater	Upper Reach	20359.02	241.31	245.28	245.91	246.28	246.60	246.83	246.97	247.12	247.22	247.45	247.62	247.72	247.85	247.92
Clearwater	Upper Reach	19986.3	241.67	245.20	245.83	246.21	246.53	246.77	246.91	247.06	247.16	247.39	247.57	247.67	247.79	247.87
Clearwater	Upper Reach	19705.16	242.18	245.11	245.74	246.12	246.44	246.68	246.82	246.98	247.08	247.31	247.48	247.59	247.72	247.80
Clearwater	Upper Reach	19181.71	241.03	244.99	245.63	246.02	246.35	246.59	246.73	246.88	246.99	247.22	247.40	247.50	247.63	247.71
Clearwater	Upper Reach	18685.47	240.85	244.87	245.51	245.91	246.23	246.47	246.61	246.77	246.87	247.10	247.28	247.38	247.51	247.59
Clearwater	Upper Reach	18261.58	240.87	244.78	245.42	245.81	246.14	246.38	246.53	246.68	246.79	247.02	247.21	247.32	247.45	247.54
Clearwater	Upper Reach	17882.61	240.31	244.69	245.32	245.70	246.03	246.26	246.40	246.55	246.66	246.89	247.07	247.18	247.32	247.40
Clearwater	Upper Reach	17460.42	237.64	244.62	245.26	245.64	245.96	246.20	246.34	246.49	246.60	246.83	247.02	247.13	247.26	247.35
Clearwater	Upper Reach	16972.25	241.28	244.54	245.18	245.56	245.89	246.12	246.26	246.42	246.52	246.76	246.94	247.05	247.18	247.27
Clearwater	Upper Reach	16560.32	240.18	244.43	245.06	245.44	245.76	246.00	246.14	246.29	246.39	246.62	246.81	246.92	247.06	247.15
Clearwater	Upper Reach	16222.89	240.91	244.36	245.00	245.38	245.71	245.94	246.08	246.23	246.34	246.57	246.76	246.87	247.01	247.10
Clearwater	Upper Reach	15826.04	238.81	244.24	244.85	245.23	245.54	245.77	245.91	246.05	246.16	246.38	246.57	246.68	246.82	246.92
Clearwater	Upper Reach	15382.2	238.75	244.15	244.76	245.14	245.46	245.70	245.83	245.98	246.09	246.32	246.51	246.63	246.77	246.87
Clearwater	Upper Reach	14757.45	240.54	244.03	244.65	245.04	245.37	245.60	245.74	245.89	245.99	246.23	246.42	246.54	246.69	246.79
Clearwater	Upper Reach	14127.07	241.05	243.91	244.55	244.94	245.27	245.50	245.64	245.79	245.90	246.14	246.34	246.46	246.61	246.72
Clearwater	Upper Reach	13537.46	239.82	243.81	244.45	244.85	245.18	245.41	245.55	245.71	245.81	246.06	246.26	246.38	246.54	246.65
Clearwater	Upper Reach	13178.92	240.31	243.74	244.38	244.78	245.11	245.35	245.49	245.64	245.75	246.01	246.21	246.34	246.50	246.62
Clearwater	Upper Reach	12785.95	240.44	243.67	244.32	244.72	245.05	245.30	245.44	245.60	245.72	245.98	246.19	246.32	246.48	246.59
Clearwater	Upper Reach	12424.12	236.37	243.63	244.27	244.66	244.99	245.24	245.38	245.55	245.66	245.93	246.14	246.28	246.44	246.56
Clearwater	Upper Reach	11984.9	239.96	243.57	244.21	244.60	244.94	245.18	245.33	245.50	245.61	245.88	246.10	246.24	246.41	246.53
Clearwater	Upper Reach	11537.24	238.96	243.50	244.14	244.54	244.88	245.13	245.28	245.45	245.57	245.84	246.06	246.21	246.38	246.50
Clearwater	Upper Reach	11033.47	239.56	243.41	244.05	244.45	244.78	245.03	245.19	245.36	245.48	245.77	245.99	246.14	246.31	246.44
Clearwater	Upper Reach	10662.83	239.81	243.36	243.99	244.40	244.74	244.99	245.15	245.32	245.44	245.73	245.96	246.10	246.28	246.41
Clearwater	Upper Reach	10095.14	239.03	243.24	243.87	244.27	244.61	244.86	245.02	245.19	245.31	245.60	245.84	245.99	246.17	246.30
Clearwater	Upper Reach	9673.802	239.46	243.19	243.82	244.24	244.57	244.83	244.99	245.16	245.29	245.58	245.82	245.98	246.16	246.30
Clearwater	Upper Reach	9209.617	239.27	243.12	243.75	244.17	244.51	244.76	244.92	245.10	245.23	245.53	245.77	245.92	246.11	246.25
Clearwater	Upper Reach	8934.315	239.56	243.03	243.66	244.08	244.43	244.69	244.85	245.03	245.16	245.47	245.72	245.88	246.07	246.21
Clearwater	Upper Reach	8679.208	239.19	242.94	243.58	244.01	244.36	244.62	244.79	244.97	245.10	245.42	245.67	245.83	246.03	246.17
Clearwater	Upper Reach	8439.882	238.76	242.85	243.49	243.93	244.28	244.55	244.71	244.90	245.04	245.36	245.62	245.79	245.99	246.13
Clearwater	Upper Reach	8120.876	239.63	242.74	243.41	243.86	244.22	244.49	244.66	244.86	244.99	245.32	245.59	245.76	245.96	246.10
Clearwater	Upper Reach	7779.764	237.66	242.64	243.31	243.77	244.13	244.40	244.58	244.77	244.91	245.24	245.51	245.68	245.89	246.04
Clearwater	Upper Reach	7396.448	238.07	242.57	243.25	243.71	244.08	244.35	244.53	244.72	244.86	245.20	245.47	245.65	245.86	246.01
Clearwater	Upper Reach	7080.891	235.03	242.51	243.19	243.66	244.02	244.30	244.47	244.67	244.81	245.15	245.43	245.61	245.82	245.97
Clearwater	Upper Reach	6802.133	238.39	242.46	243.14	243.61	243.97	244.25	244.43	244.62	244.77	245.11	245.40	245.58	245.79	245.95
Clearwater	Mid Reach	6604.857	237.84	242.41	243.09	243.57	243.93	244.22	244.39	244.59	244.74	245.09	245.38	245.56	245.77	245.93
Clearwater	Mid Reach	6350.496	238.45	242.37	243.05	243.53	243.90	244.18	244.36	244.56	244.70	245.05	245.34	245.52	245.74	245.90
Clearwater	Mid Reach	6078.455	238.61	242.32	243.00	243.48	243.85	244.14	244.32	244.52	244.66	245.02	245.31	245.49	245.71	245.87
Clearwater	Mid Reach	5805.896	238.84	242.28	242.96	243.45	243.82	244.10	244.28	244.49	244.63	244.99	245.28	245.46	245.68	245.84
Clearwater	Mid Reach	5535.46	236.06	242.20	242.87	243.35	243.71	243.99	244.17	244.37	244.51	244.87	245.16	245.35	245.57	245.74
Clearwater	Mid Reach	5194.108	237.74	242.14	242.81	243.29	243.66	243.94	244.12	244.32	244.47	244.82	245.12	245.31	245.53	245.70
Clearwater	Mid Reach	4759.934	238.27	242.07	242.74	243.23	243.60	243.88	244.07	244.27	244.42	244.78	245.08	245.27	245.50	245.67
Clearwater	Mid Reach	4324.203	238.45	242.00	242.66	243.16	243.53	243.81	243.99	244.20	244.35	244.72	245.02	245.22	245.45	245.61



FORT MCMURRAY RIVER HAZARD STUDY - OPEN WATER FLOOD INUNDATION MAPPING REPORT

Table A.2: Clearwater River Flood Profile

River	Reach	River Sta.	Min Ch. El	2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
Clearwater	Mid Reach	3906.219	238.76	241.94	242.61	243.12	243.49	243.78	243.97	244.18	244.33	244.70	245.00	245.20	245.43	245.60
Clearwater	Mid Reach	3541.042	238.27	241.88	242.53	243.04	243.42	243.71	243.90	244.11	244.27	244.64	244.95	245.15	245.39	245.56
Clearwater	Mid Reach	3182.93	238.76	241.84	242.47	242.98	243.36	243.66	243.85	244.07	244.22	244.60	244.92	245.12	245.36	245.53
Clearwater	Mid Reach	2815.173	238.10	241.79	242.42	242.93	243.32	243.62	243.81	244.03	244.18	244.56	244.88	245.08	245.32	245.49
Clearwater	Lower Reach	2250.473	238.07	241.70	242.33	242.85	243.24	243.54	243.74	243.96	244.11	244.50	244.82	245.02	245.26	245.44
Clearwater	Lower Reach	1847.547	237.92	241.64	242.27	242.81	243.20	243.51	243.70	243.92	244.08	244.47	244.79	245.00	245.24	245.42
Clearwater	Lower Reach	1470.964	238.15	241.59	242.23	242.77	243.17	243.48	243.68	243.90	244.06	244.45	244.78	244.99	245.23	245.40
Clearwater	Lower Reach	1043.023	237.96	241.48	242.11	242.67	243.07	243.38	243.58	243.81	243.97	244.36	244.69	244.90	245.15	245.33
Clearwater	Lower Reach	479.8225	237.78	241.42	242.07	242.64	243.05	243.36	243.56	243.79	243.95	244.35	244.68	244.90	245.15	245.32

DRAFT



FORT MCMURRAY RIVER HAZARD STUDY - OPEN WATER FLOOD INUNDATION MAPPING REPORT

Table A.3: Hangingstone River Flood Profile

River	Reach	River Sta.	Min Ch. El	2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
Hangingstone	Hangingstone	5585.592	263.83	265.08	265.49	265.83	266.12	266.35	266.50	266.69	266.83	267.21	267.50	267.71	267.94	268.12
Hangingstone	Hangingstone	5506.659	263.40	264.75	265.20	265.54	265.82	266.04	266.20	266.39	266.54	266.93	267.21	267.41	267.59	267.73
Hangingstone	Hangingstone	5376.601	261.90	263.56	264.02	264.31	264.61	264.83	264.96	265.10	265.19	265.46	265.82	266.00	266.33	266.49
Hangingstone	Hangingstone	5277.659	261.59	263.24	263.59	263.84	264.09	264.32	264.45	264.62	264.73	265.04	265.30	265.47	265.68	265.83
Hangingstone	Hangingstone	5161.992	261.10	262.51	262.86	263.12	263.41	263.66	263.82	264.01	264.15	264.52	264.80	264.98	265.20	265.35
Hangingstone	Hangingstone	5048.179	260.47	261.67	262.05	262.30	262.56	262.78	262.93	263.10	263.22	263.54	263.81	264.00	264.20	264.36
Hangingstone	Hangingstone	4975.215	260.09	261.26	261.66	261.93	262.21	262.45	262.62	262.81	262.94	263.31	263.63	263.86	264.13	264.33
Hangingstone	Hangingstone	4941.598	259.42	261.13	261.55	261.83	262.11	262.35	262.52	262.72	262.86	263.25	263.59	263.82	264.10	264.30
Hangingstone	Hangingstone	4874.372	259.41	260.89	261.29	261.53	261.77	261.96	262.10	262.27	262.38	262.66	262.88	263.02	263.18	263.29
Hangingstone	Hangingstone	4787.698	259.19	260.44	260.81	261.02	261.26	261.47	261.61	261.80	261.92	262.22	262.46	262.62	262.82	262.97
Hangingstone	Hangingstone	4693.74	258.87	259.91	260.29	260.56	260.83	261.08	261.24	261.43	261.57	261.92	262.26	262.48	262.76	262.95
Hangingstone	Hangingstone	4600.277	258.28	259.44	259.87	260.18	260.48	260.75	260.91	261.12	261.26	261.62	261.91	262.10	262.33	262.49
Hangingstone	Hangingstone	4524.798	257.26	259.12	259.59	259.89	260.20	260.47	260.64	260.86	261.01	261.37	261.66	261.85	262.06	262.21
Hangingstone	Hangingstone	4505.953	257.21	258.97	259.41	259.70	260.01	260.27	260.44	260.65	260.79	261.16	261.45	261.63	261.83	261.98
Hangingstone	Hangingstone	4449.333	256.96	258.72	259.14	259.45	259.76	260.03	260.21	260.42	260.57	260.93	261.21	261.39	261.58	261.71
Hangingstone	Hangingstone	4408.838	257.03	258.50	258.95	259.29	259.63	259.92	260.10	260.32	260.47	260.84	261.12	261.31	261.50	261.64
Hangingstone	Hangingstone	4313.529	256.15	257.87	258.42	258.77	259.14	259.42	259.60	259.81	259.96	260.37	260.70	260.94	261.16	261.32
Hangingstone	Hangingstone	4172.101	255.28	257.24	257.67	257.97	258.29	258.56	258.73	258.95	259.10	259.51	259.88	260.11	260.40	260.62
Hangingstone	Hangingstone	4122.038	255.77	256.93	257.32	257.61	257.92	258.18	258.35	258.57	258.72	259.10	259.45	259.66	259.91	260.12
Hangingstone	Hangingstone	4051.339	255.25	256.57	256.93	257.19	257.47	257.71	257.87	258.07	258.21	258.57	258.88	259.07	259.29	259.47
Hangingstone	Hangingstone	3971.188	255.01	256.08	256.43	256.72	257.02	257.28	257.46	257.68	257.85	258.27	258.63	258.84	259.09	259.28
Hangingstone	Hangingstone	3906.399	254.55	255.63	256.09	256.45	256.80	257.09	257.29	257.53	257.71	258.16	258.54	258.76	259.03	259.26
Hangingstone	Hangingstone	3803.124	253.36	255.11	255.58	255.90	256.24	256.52	256.70	256.93	257.09	257.52	257.88	258.12	258.42	258.64
Hangingstone	Hangingstone	3759.014	253.25	254.92	255.36	255.67	255.99	256.26	256.43	256.65	256.81	257.22	257.56	257.79	258.09	258.31
Hangingstone	Hangingstone	3667.133	252.66	254.45	254.80	255.04	255.29	255.50	255.63	255.80	255.93	256.29	256.58	256.77	257.00	257.17
Hangingstone	Hangingstone	3543.804	252.55	253.87	254.25	254.53	254.84	255.10	255.27	255.48	255.65	256.09	256.44	256.66	256.94	257.15
Hangingstone	Hangingstone	3410.358	251.82	253.01	253.34	253.58	253.84	254.05	254.19	254.36	254.48	254.79	255.08	255.28	255.53	255.70
Hangingstone	Hangingstone	3297.98	251.00	252.29	252.66	252.94	253.23	253.48	253.63	253.82	253.95	254.28	254.56	254.75	254.97	255.14
Hangingstone	Hangingstone	3204.177	250.21	251.82	252.23	252.53	252.84	253.09	253.24	253.43	253.56	253.89	254.17	254.36	254.60	254.77
Hangingstone	Hangingstone	3112.05	250.00	251.40	251.83	252.12	252.41	252.65	252.80	252.98	253.11	253.43	253.71	253.89	254.12	254.27
Hangingstone	Hangingstone	3031.108	249.41	251.20	251.60	251.88	252.15	252.38	252.53	252.70	252.83	253.13	253.39	253.57	253.77	253.92
Hangingstone	Hangingstone	2952.679	249.63	250.69	251.10	251.39	251.67	251.92	252.07	252.28	252.41	252.76	253.05	253.24	253.47	253.62
Hangingstone	Hangingstone	2822.849	248.43	250.09	250.57	250.82	251.07	251.29	251.44	251.62	251.75	252.08	252.36	252.54	252.75	252.87
Hangingstone	Hangingstone	2710.264	248.47	249.73	250.24	250.40	250.58	250.76	250.89	251.07	251.19	251.55	251.86	252.07	252.35	252.59
Hangingstone	Hangingstone	2611.931	247.97	249.10	249.45	249.72	250.06	250.35	250.55	250.79	250.96	251.41	251.80	252.05	252.35	252.59
Hangingstone	Hangingstone	2557.02	247.46	248.78	249.25	249.61	249.98	250.29	250.49	250.74	250.91	251.38	251.77	252.03	252.34	252.57
Hangingstone	Hangingstone	2490.552	247.05	248.43	248.97	249.33	249.70	249.99	250.18	250.41	250.57	251.00	251.34	251.55	251.82	252.02
Hangingstone	Hangingstone	2471.188	246.14	248.37	248.91	249.26	249.62	249.91	250.10	250.32	250.48	250.92	251.29	251.51	251.78	251.99
Hangingstone	Hangingstone	2448.198	245.93	248.34	248.87	249.22	249.57	249.85	250.03	250.25	250.40	250.83	251.19	251.40	251.64	251.84
Hangingstone	Hangingstone	2417.885	246.43	248.23	248.70	249.01	249.31	249.55	249.71	249.89	250.02	250.36	250.69	250.92	251.25	251.52
Hangingstone	Hangingstone	2353.985	246.14	248.07	248.54	248.84	249.14	249.38	249.52	249.70	249.83	250.16	250.47	250.67	250.91	251.09
Hangingstone	Hangingstone	2293.532	246.30	247.91	248.33	248.62	248.89	249.10	249.23	249.37	249.47	249.72	249.98	250.14	250.37	250.63



FORT MCMURRAY RIVER HAZARD STUDY - OPEN WATER FLOOD INUNDATION MAPPING REPORT

Table A.3: Hangingstone River Flood Profile

River	Reach	River Sta.	Min Ch. El	2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
Hangingstone	Hangingstone	2276.289	246.60	247.84	248.28	248.58	248.87	249.09	249.22	249.37	249.47	249.74	250.02	250.18	250.38	250.59
Hangingstone	Hangingstone	2235.721	246.06	247.72	248.14	248.44	248.71	248.9	249.01	249.12	249.20	249.40	249.91 ^(a)	250.06 ^(a)	250.21 ^(a)	250.47 ^(a)
Hangingstone	Hangingstone	2221.769	246.14	247.70	248.11	248.40	248.67	248.86	248.97	249.06	249.13	249.27	249.87 ^(a)	250.02 ^(a)	250.15 ^(a)	250.43 ^(a)
Hangingstone	Hangingstone	2156.103	246.45	247.46	247.91	248.22	248.48	248.68	248.79	248.90	249.07 ^(a)	249.25 ^(a)	249.68 ^(a)	249.83 ^(a)	249.88	250.23 ^(a)
Hangingstone	Hangingstone	2071.505	245.66	247.18	247.73	248.10	248.39	248.63	248.77	248.90	248.99	249.22	249.44	249.59	249.78	249.98
Hangingstone	Hangingstone	2007.202	244.91	246.92	247.45	247.81	248.04	248.25	248.36	248.51	248.62	248.93	249.22	249.41	249.64	249.81
Hangingstone	Hangingstone	1923.395	244.79	246.58	247.16	247.53	247.8	248.05	248.21	248.39	248.52	248.86	249.15	249.35	249.57	249.74
Hangingstone	Hangingstone	1860.687	245.00	246.38	246.95	247.31	247.64	247.9	248.06	248.24	248.37	248.7	248.99	249.18	249.41	249.58
Hangingstone	Hangingstone	1831.466	244.92	246.30	246.88	247.20	247.51	247.81 ^(a)	247.97 ^(a)	248.14 ^(a)	248.27 ^(a)	248.59 ^(a)	248.87 ^(a)	249.05 ^(a)	249.27 ^(a)	249.43 ^(a)
Hangingstone	Hangingstone	1809.216	244.15	246.28	246.86	247.19	247.5	247.75	247.9	248.07	248.19	248.5	248.77	248.95	249.16	249.32
Hangingstone	Hangingstone	1771.252	243.80	246.18	246.73	247	247.27	247.47	247.6	247.75	247.87	248.25	248.56	248.76	248.99	249.16
Hangingstone	Hangingstone	1744.084	244.07	246.09	246.63	246.9	247.16	247.36	247.47	247.61	247.71	247.98	248.21	248.38	248.54	248.65
Hangingstone	Hangingstone	1706.852	244.41	245.88	246.4	246.65	246.9	247.11	247.26	247.41	247.53	247.84	248.11	248.3	248.49	248.61
Hangingstone	Hangingstone	1630.86	244.15	245.46	245.85	246.09	246.33	246.53	246.67	246.85	246.97	247.24	247.48	247.62	247.81	247.95
Hangingstone	Hangingstone	1541.086	243.74	245.09	245.5	245.73	245.98	246.19	246.33	246.52	246.66	246.97	247.24	247.42	247.64	247.81
Hangingstone	Hangingstone	1459.563	243.38	244.61	245.03	245.3	245.59	245.82	245.98	246.16	246.3	246.64	246.94	247.15	247.41	247.61
Hangingstone	Hangingstone	1408.073	242.89	244.45	244.84	245.12	245.42	245.67	245.83	246.02	246.16	246.51	246.81	247.02	247.28	247.48
Hangingstone	Hangingstone	1389.484	242.51	244.33	244.67	244.95	245.26	245.65 ^(a)	245.81 ^(a)	246.00 ^(a)	246.14 ^(a)	246.50 ^(a)	246.80 ^(a)	247.02 ^(a)	247.28 ^(a)	247.47 ^(a)
Hangingstone	Hangingstone	1313.773	242.89	244.1	244.57	244.92	245.26	245.55	245.72	245.93	246.08	246.46	246.78	247	247.26	247.45
Hangingstone	Hangingstone	1242.932	242.36	243.94	244.45	244.8	245.14	245.41	245.58	245.78	245.92	246.28	246.59	246.79	247.04	247.21
Hangingstone	Hangingstone	1193.156	241.37	243.86	244.36	244.7	245.02	245.29	245.44	245.63	245.76	246.09	246.37	246.55	246.76	246.91
Hangingstone	Hangingstone	1171.259	241.88	243.82	244.31	244.64	244.95	245.2	245.35	245.53	245.66	245.98	246.25	246.43	246.64	246.79
Hangingstone	Hangingstone	1129.931	241.74	243.74	244.22	244.55	244.85	245.08	245.23	245.39	245.51	245.90 ^(a)	246.18 ^(a)	246.36 ^(a)	246.58 ^(a)	246.73 ^(a)
Hangingstone	Hangingstone	1087.974	241.71	243.69	244.17	244.5	244.8	245.04	245.19	245.37	245.49	245.82	246.11	246.29	246.51	246.67
Hangingstone	Hangingstone	1022.868	241.52	243.58	244.06	244.39	244.69	244.93	245.08	245.26	245.39	245.73	246.02	246.21	246.43	246.59
Hangingstone	Hangingstone	960.0525	241.96	243.36	243.9	244.27	244.57	244.81	244.97	245.15	245.29	245.62	245.91	246.09	246.31	246.48
Hangingstone	Hangingstone	882.2751	240.80	243.25	243.85	244.23	244.54	244.79	244.94	245.13	245.27	245.61	245.9	246.08	246.31	246.47
Hangingstone	Hangingstone	768.9972	240.77	243.09	243.72	244.13	244.46	244.73	244.9	245.09	245.23	245.58	245.88	246.07	246.29	246.46
Hangingstone	Hangingstone	700.7451	241.01	242.98	243.62	244.06	244.43	244.7	244.87	245.06	245.21	245.56	245.85	246.04	246.27	246.44
Hangingstone	Hangingstone	648.1558	240.74	242.94	243.58	244.03	244.38	244.65	244.81	245.01	245.15	245.49	245.77	245.96	246.17	246.33
Hangingstone	Hangingstone	548.9328	240.88	242.83	243.45	243.89	244.23	244.49	244.66	244.85	244.99	245.33	245.61	245.78	245.99	246.15
Hangingstone	Hangingstone	489.7931	241.24	242.78	243.42	243.85	244.2	244.46	244.63	244.83	244.96	245.3	245.58	245.75	245.96	246.11
Hangingstone	Hangingstone	434.9363	240.54	242.73	243.38	243.82	244.17	244.44	244.61	244.8	244.94	245.28	245.55	245.73	245.94	246.09
Hangingstone	Hangingstone	372.1107	240.61	242.68	243.33	243.77	244.12	244.4	244.57	244.77	244.91	245.25	245.53	245.7	245.91	246.07
Hangingstone	Hangingstone	292.7723	240.69	242.61	243.27	243.73	244.08	244.35	244.53	244.73	244.87	245.21	245.48	245.66	245.87	246.02
Hangingstone	Hangingstone	226.8436	240.37	242.56	243.22	243.68	244.04	244.32	244.49	244.69	244.83	245.17	245.44	245.62	245.82	245.98
Hangingstone	Hangingstone	133.8605	240.06	242.49	243.17	243.63	244	244.27	244.45	244.64	244.78	245.12	245.39	245.57	245.77	245.92
Hangingstone	Hangingstone	106.2144	240.37	242.48	243.17	243.64	244	244.28	244.45	244.65	244.79	245.13	245.4	245.57	245.78	245.93
Hangingstone	Hangingstone	92.31356	240.21	242.47	243.17	243.64	244.01	244.29	244.46	244.66	244.8	245.14	245.42	245.59	245.8	245.95

(a) Linear Interpolation between upstream and downstream water levels to remove dip at bridge.



FORT MCMURRAY RIVER HAZARD STUDY - OPEN WATER FLOOD INUNDATION MAPPING REPORT

Table A.4: Snye River Flood Profile

River	Reach	River Sta.	Min Ch. El	2-year	5-year	10-year	20-year	35-year	50-year	75-year	100-year	200-year	350-year	500-year	750-year	1000-year
Snye	Snye	1332.108	239.34	241.75	242.38	242.91	243.3	243.6	243.8	244.02	244.17	244.56	244.88	245.09	245.33	245.5
Snye	Snye	931.9456	238.31	241.75	242.38	242.91	243.3	243.6	243.8	244.02	244.17	244.56	244.88	245.09	245.33	245.5
Snye	Snye	455.9648	238.63	241.75	242.38	242.91	243.3	243.6	243.8	244.02	244.17	244.56	244.88	245.09	245.33	245.5
Snye	Snye	171.6331	238.11	241.75	242.38	242.91	243.3	243.6	243.8	244.02	244.17	244.56	244.88	245.09	245.33	245.5

DRAFT

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

For more information, visit golder.com

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 44 1628 851851
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

DRAFT

Golder Associates Ltd.
102, 2535 - 3rd Avenue S.E.
Calgary, Alberta, T2A 7W5
Canada
T: +1 403 299 5600

