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REPORT

Flood Risk Assessment and Inventory Report

Red Deer River Hazard Study

Submitted to:

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Distribution List

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Executive Summary

Alberta Environment and Parks (AEP) commissioned Golder Associates Ltd. (Golder) in August 2017 to conduct the Red Deer River Hazard Study. The primary purpose of the study is to assess and identify river and flood hazards along the Red Deer River reach from Township Road 380 to the Highway 11 Bridge, the Waskasoo Creek reach from the Highway 2A Bridge to its confluence with the Red Deer River, and the Piper Creek reach from Township Road 374 to its confluence with Waskasoo Creek.

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 City of Red Deer, the Town of Penhold, Lacombe County, Red Deer County, and the public.

The Red Deer River Hazard Study includes multiple components and deliverables. This report documents the methodology and results of the flood risk assessment and inventory component. The assessment involved comparison of the flood extents created as part of the open water flood inundation and design flood hazard mapping components of the study, with the collected and interpreted spatial data that contains an inventory of land parcels, buildings, major transportation infrastructure, and population. Flood risk statistics were calculated to quantify flood vulnerabilities for each of the 13 open water flood scenarios and the design flood scenario. The statistics pertain to the number of affected parcels, buildings, and population, as well as the length of affected road and railroad infrastructure, including bridges and culverts.

The main results of the flood risk assessment for the open water floods in the study area are summarized below:

- The total numbers of land parcels, buildings and population, as well as the length of roads and railroads affected in the study area increase steadily from the 2-year flood to the 1,000-year flood. Most affected parcels, buildings and population are located in the City of Red Deer and the Town of Penhold. Most affected roads are located in the City of Red Deer and Red Deer County.
- A large increase in the affected areas occurs between the 100-year flood and the 350-year flood, when parts of Downtown Red Deer south of 47th Street and the areas in Riverside Heavy Industrial Park east of Riverside Drive in the City of Red Deer would be affected by flooding.
- Another large increase occurs between the 500-year flood and 1000-year flood when the neighbourhoods of Waskasoo, Riverside Meadows (east of 54th Avenue), Riverside Light Industrial Park and Riverside Heavy Industrial Park in the City of Red Deer would be affected.
- Between the 75-year flood and the 200-year flood the Red Deer Wastewater Treatment Plant is potentially affected by flood control structure failure inundation. Starting at the 350-year flood, the Red Deer Wastewater Treatment Plant is affected by direct inundation. Starting at the 350-year flood, the Red Deer Water Treatment Plant is affected by direct inundation. At the 1000-year flood one school in the City of Red Deer is affected by direct inundation. No other critical, non-residential buildings (i.e., government buildings, hospitals, schools, or water treatment facilities) in the study area will be affected under any other flood scenario.

- The length of roads affected by direct flood inundation and the total length of affected roads remain low between the 2-year flood and the 20-year flood and increase steadily from the 35-year flood to the 1,000-year floods. Some of the major roads that would be affected by floods in the City of Red Deer include the following:
  - Taylor Drive around the intersection with 32nd Street starting at the 50- year flood and at Capstone at Riverlands starting at the 350-year flood.
  - 51st Avenue Downtown starting at the 100-year flood.
  - 50th Street west of Ross Street Bridges starting at the 350-year flood.
  - 55th Street west of 55th Street Bridge starting at the 200-year flood.
  - 49th Avenue and 50th Avenue north of the Red Deer River crossing starting at the 1000-year flood.
- Some of the major roads that would be affected by floods in Red Deer County include the following:
  - Highway 2 (Red Deer Bypass) north of the Red Deer River crossing starting at the 750-year flood.
  - Highway 2A northeast of Highway 2A Bridge at the 1,000-year flood.
- No railroads would be affected by flood inundation until the 200-year flood. Starting at the 750-year flood, the CN Red Deer Industrial spur in the City of Red Deer and starting at the 350-year flood, the CP mainline (Calgary-Edmonton) in Red Deer County would be affected (around the Waskasoo Creek crossings).

The main results of the flood risk assessment for the design flood in the study area are summarized below:

- There are no buildings located in the floodway.
- There are 6 residential and 8 non-residential buildings located in the flood fringe, all in the City of Red Deer.
- There are 2 non-residential buildings located in the high hazard flood fringe, both in the City of Red Deer.
- There is no population located in floodway areas, and a total of 22 people located in the flood fringe area, all in the City of Red Deer.
- None of the water treatment facilities in the study area are affected by the design flood. The Red Deer Wastewater Treatment Plant would be located in the protected flood fringe.
- Some of the major roads that would be affected are 45th Street, 51st Avenue, 49th Avenue, and 48th Avenue which are located in Downtown, as well as Taylor Drive south of the intersection with 43rd Street and south of the intersection with 32nd Street, all in the City of Red Deer.
- None of the railroads would be affected by the design flood.

Acknowledgements

This component of the Red Deer River Hazard Study was led by Mr. Peter Thiede. Overall project management was provided by Mr. Gaven Tang and Dr. Dejiang Long with support from Mr. Wolf Ploeger. The flood risk inventory and assessment were conducted by Mr. Peter Thiede.

The authors express their special thanks to Mr. Abdullah Mamun & Ms. Jane Eaket, project managers for Alberta Environment and Parks (AEP), who provided overall study management, background data, and technical guidance to Golder's team throughout the hydraulic modelling and flood inundation mapping components.

The authors also express their gratitude to Peter Onyshko of AEP for his support, technical guidance, and for providing background information.

Table of Contents

TABLES

FIGURES

1.0 INTRODUCTION

1.1 Study Background and Objectives

Alberta Environment and Parks (AEP) commissioned Golder Associates Ltd. (Golder) in August 2017 to conduct the Red Deer River Hazard Study. The primary purpose of the study is to assess and identify river and flood hazards along the Red Deer River reach from Township Road 380 to the Highway 11 Bridge, the Waskasoo Creek reach from the Highway 2A Bridge to its confluence with the Red Deer River, and the Piper Creek reach from Township Road 374 to its confluence with Waskasoo Creek.

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 City of Red Deer, the Town of Penhold, Lacombe County, Red Deer County. and the public.

The Red Deer River Hazard Study includes multiple components and deliverables. This report documents the methodology and results of the flood risk assessment and inventory component. The assessment compares the flood extents, which were created as part of the open water flood inundation and design flood hazard mapping components of the study, with the collected and interpreted spatial data that inventory land parcels, buildings, major transportation infrastructure, and population. Flood risk statistics were calculated to quantify flood vulnerabilities for each of the 13 open water flood scenarios and the design flood scenario. The statistics pertain to the number of affected parcels, buildings, and population, as well as the length of affected road and railroad infrastructure, including bridges and culverts.

1.1 Study Area and Reaches

The study area covers approximately 51 km reach of the Red Deer River, 35 km reach of Waskasoo Creek, and 20 km reach of Piper Creek through the City of Red Deer, the Town of Penhold, Lacombe County, and Red Deer County. The study area is shown in Figure 1. The study reaches are summarized in Table 1.

Table 1: River Reaches in the Study Area

River	Reach Description	Length (km)
Red Deer River	From Township Road 380 to the Highway 11 Bridge	51
Waskasoo Creek	From the Highway 2A Bridge to its confluence with the Red Deer River	35
Piper Creek	From Township Road 374 to its confluence with Waskasoo Creek	20

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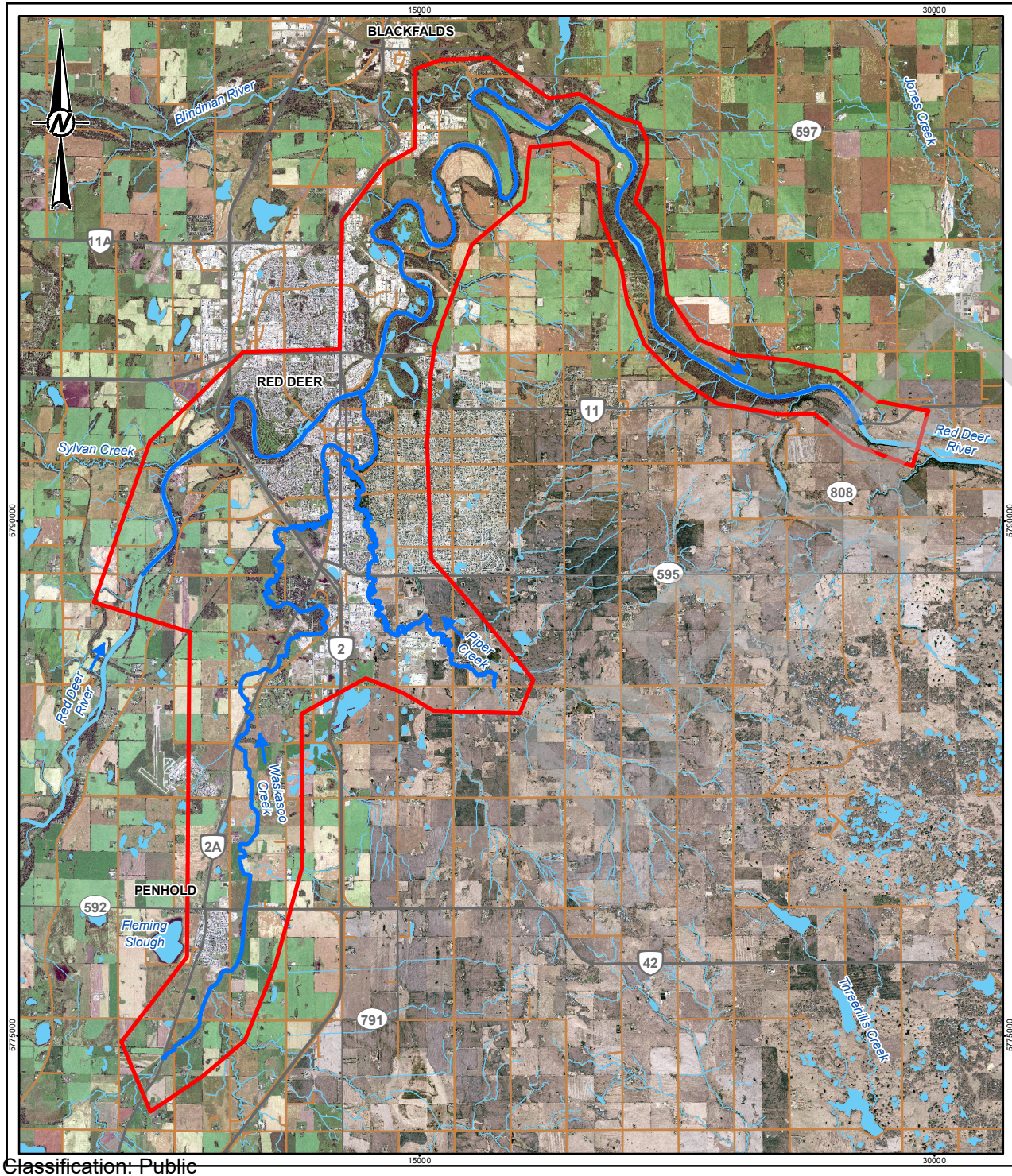

LEGEND

- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- LOCAL ROAD
- FLOW DIRECTION
- WATERCOURSE
- WATERBODY
- SURVEY REACH
- RIVER HAZARD STUDY AREA

0 5 10

1:175,000 KILOMETRES

REFERENCE(S)

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DATUM: NAD 83 CSRS PROJECTION: 3TM 114

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
RED DEER RIVER HAZARD STUDY

TITLE
LOCATION MAP OF THE STUDY AREA

CONSULTANT
GOLDER

YYYY-MM-DD	2019-07-25
DESIGNED	GT
PREPARED	BP
REVIEWED	GT
APPROVED	DL

PROJECT NO.	CONTROL	REV.	FIGURE
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2.0 AVAILABLE SPATIAL DATA

Readily available spatial data for the flood risk inventory included road and railroad data obtained from AltaLIS (the distributor of provincial spatial data) and NRCan. Cadastral data was provided by AEP.

2.1 Cadastral

Cadastral data (i.e., boundaries of registered land parcels) was provided to Golder in November 2017.

2.2 Roads and Railroads

Road and railroad data for the study area was obtained from NRCan (for the City of Red Deer) and AltaLIS (for the remainder of the study area) in May and July 2018.

2.3 Infrastructure

2.3.1 Data Sources

Infrastructure data for the extent of Red Deer was obtained from the City of Red Deer in March 2019. Infrastructure data for the areas outside of the City of Red Deer was provided by AEP in October 2016. The information from these datasets was reclassified and added to the building point datasets as non-residential buildings. The following categories of non-residential buildings were added:

- government buildings;
- hospitals;
- schools; and
- water and wastewater treatment facilities.

Other features from the infrastructure datasets (e.g., emergency services buildings, parks, and recreation infrastructure) were included in the non-residential buildings point dataset and classified as “other non-residential.”

Additional infrastructure features for the areas outside of the City of Red Deer were interpreted from available aerial imagery (see Section 3.1).

Government buildings, hospitals, and water and wastewater treatment facilities included in the flood risk inventory are detailed in the following sections.

2.3.2 Government Buildings

The flood risk inventory includes Red Deer City Hall, Red Deer Courthouse, and Red Deer County Centre which are located within the study area.

2.3.3 Hospitals

The flood risk inventory includes the Red Deer Regional Hospital Centre which is located within the study area.

2.3.4 Water and Wastewater Treatment Facilities

The flood risk inventory includes the Red Deer Water Treatment Plant and Red Deer Wastewater Treatment Plant.

2.4 Census

Population statistics were obtained from the Statistics Canada 2016 census dissemination blocks (Statistics Canada 2017). The census tallies the number of people whose usual place of residence is in the area. Dissemination blocks are the smallest geographic area for which population counts are disseminated in Canada.

3.0 INTERPRETED SPATIAL DATA

3.1 Aerial Photography

The aerial imagery for the study area was collected for AEP by OGL Engineering on July 13, 2018 and provided to Golder. The imagery has a 0.30 m Ground Sampling Distance (GSD) resolution and was provided as 4-band orthophotos.

The imagery was used to derive building points where no other spatial data was provided. It was also used to check and update road information throughout the study area.

3.2 Residential Structures

To more accurately estimate the population affected by each flood scenario, the population count for each dissemination block was evenly distributed between all residential buildings that fall into the block. Where multifamily buildings existed, it was assumed that their average number of residents would be ten times that of the single family homes within the block. Retirement homes were treated as multifamily buildings. Spot checks showed reasonable estimates of residents per building.

Distributing the population numbers to the residential buildings ensures that residents are only counted as affected when their building falls within the inundation extent.

3.3 Non-Residential Structures

All government buildings, hospitals, water treatment facilities and wastewater treatment facilities in the study area were reduced to single points for the flood risk assessment.

Considering the size and importance of these features, manual checks were performed to determine whether they would be affected by flood scenarios, instead of relying on a point-based overlay analysis (see Section 4.1).

4.0 FLOOD RISK ASSESSMENT AND INVENTORY

After the spatial data was compiled, features affected by floods were identified by overlaying flood polygon datasets with the parcel, building, or infrastructure datasets. Features falling within a flood extent were flagged as being affected or potentially affected by the flood scenario.

Flood statistics were then generated by tallying all affected features for the following categories:

- Land parcels;
- Residential buildings;
- Non-residential buildings;
- Major transportation infrastructure; and
- Population (based on residential buildings).

The following sections provide further information on the methodology and the results of the assessment.

4.1 Methodology

Using the inventory datasets developed and described in Sections 2.0 and 3.0, flood statistics were generated for the various flood events and flood scenarios considered in this study.

The method to generate these flood statistics involved the following four steps:

- Flood polygons for the 2-, 5-, 10-, 20-, 35-, 50-, 75-, 100-, 200-, 350-, 500-, 750-, and 1,000-year flood scenarios and the design flood scenario were generated as part of the open water flood inundation and flood hazard mapping work undertaken in this study (Golder 2022a and 2022b).
- For each flood scenarios and scenario, the flood polygons were compared to the inventory dataset in GIS. Land parcels, buildings, and infrastructure were classified as being “affected” if they were located within a mapped flood extent (centroid for parcels). Road and railroad lengths affected by a flooding were also calculated.
- The population affected in each flood scenario was calculated by tallying the number of residents assigned to each affected residential building (see Section 3.2).
- The flood statistics for each category were summarized in a series of Microsoft Excel tables.

A manual check using aerial imagery was performed for non-residential buildings classified as hospital, water treatment facilities and wastewater treatment facilities. As these large facilities are represented by single points in the flood risk inventory dataset, the result of the GIS-based overlay analysis may show the structure as not affected, even though some of the actual building footprint is located within the flood extent. The flood statistics were changed accordingly to include buildings which footprints would be affected.

Flood statistics were calculated separately for two areas of flooding based on flood inundation mapping (Golder 2022a) and two areas of flooding based on design flood hazard mapping (Golder 2022b), as summarized below:

Flood Inundation Mapping:

- Direct flood inundation areas: These are areas expected to be inundated for various flood scenarios and have a direct overland connection to the main river/creek channels.
- Flood control structure failure inundation areas: These are areas that would be flooded if the flood control structure protecting the area would fail.

Flood Hazard Mapping:

- Floodway areas: The floodway generally includes areas where the water is 1 m deep or greater and/or the local velocities are 1 m/s or faster. Typically, the floodway includes the river channel and adjacent overbank areas.
- Flood Fringe areas: The flood fringe is the portion of the design flood hazard area outside the floodway. The flood fringe is divided into three zone:
  - Flood Fringe: Inundated areas outside of the floodway that are shallower and flow velocities are slower.
  - High Hazard Flood Fringe: Areas of deeper or faster-moving water outside of the floodway.

- Protected Flood Fringe: Low lying areas behind dedicated flood control structures that are at risk of flooding if the structures would fail.

All results are reported by local authority and aggregate total. The local authorities include:

- Lacombe County
- Town of Penhold
- City of Red Deer
- Red Deer County

4.2 Open Water Flood Inundation Scenarios

Flood inundation extents were delineated for thirteen (13) open water flood scenarios (Golder 2022a). Flood statistics for direct and flood control structure failure inundation areas were calculated for each flood scenario, and the results are presented in the following sections.

4.2.1 Land Parcels

A summary of land parcels affected by direct inundation is presented in Table 2, including total number, as well as a breakdown of parcels affected in each local authority. A summary of land parcels potentially affected by flood control structure failure is presented in Table 3, including total number, as well as a breakdown of parcels affected in each local authority. Figure 2 shows the affected parcels per flood scenario.

Table 2: Affected Land Parcels – Open Water Flood Inundation Scenarios, Direct Inundation

Scenario	Lacombe County	Town of Penhold	City of Red Deer	Red Deer County	Total
2-Year	0	0	0	1	**1**
5-Year	0	0	3	6	**9**
10-Year	0	1	7	6	**14**
20-Year	0	1	21	8	**30**
35-Year	1	1	57	13	**72**
50-Year	1	2	70	18	**91**
75-Year	1	4	84	21	**110**
100-Year	2	4	102	24	**132**
200-Year	2	4	175	40	**221**
350-Year	2	4	634	55	**695**
500-Year	2	19	728	61	**810**
750-Year	3	31	868	89	**991**
1000-Year	3	40	1,129	95	**1,267**

Table 3: Affected Land Parcels – Open Water Flood Inundation Scenarios, Flood Control Structure Failure

Scenario	Lacombe County	Town of Penhold	City of Red Deer	Red Deer County	Total
20-Year	0	0	1	0	1
100-Year	0	1	0	0	1
200-Year	0	3	0	0	3
350-Year	0	12	0	0	12

The total number of land parcels in the study area affected by direct flood inundation and the total number of affected land parcels remain low between the 2-year flood and the 20-year flood. They increase steadily from the 35-year flood to the 1,000-year flood. The number of land parcels potentially affected by flood control structure failure remains zero for most flood scenarios and reaches its maximum at the 350-year flood (12 parcels in the Town of Penhold affected).

The number of parcels affected in Lacombe County remains low for all flood scenarios.

The number of parcels affected in the Town of Penhold remains low until the 350-year flood and then increases steadily between the 500-year and 1000-year floods.

For the City of Red Deer, the total number of affected land parcels remains low between the 2-year flood and the 20-year flood. A large increase in the affected areas occurs between the 100-year flood and the 350-year flood, when parts of Downtown south of 47th Street and the areas in Riverside Heavy Industrial Park east of Riverside Drive would be affected by flooding from Waskasoo Creek and Red Deer River, respectively. Another large increase occurs between the 500-year flood and 1000-year flood when the neighbourhoods of Waskasoo, Riverside Meadows (east of 54th Avenue), Riverside Light Industrial Park and Riverside Heavy Industrial Park would be affected.

For Red Deer County, the number of affected parcels increases steadily from the 2-year flood to the 1,000-year flood, to a maximum of 95.

For the 100-year flood, a total 132 land parcels would be directly inundated in the study area and 1 would be potentially inundated in the case of flood control structure failure. In comparison, a total of 1,267 land parcels would be directly inundated in the study area for the 1,000-year flood.

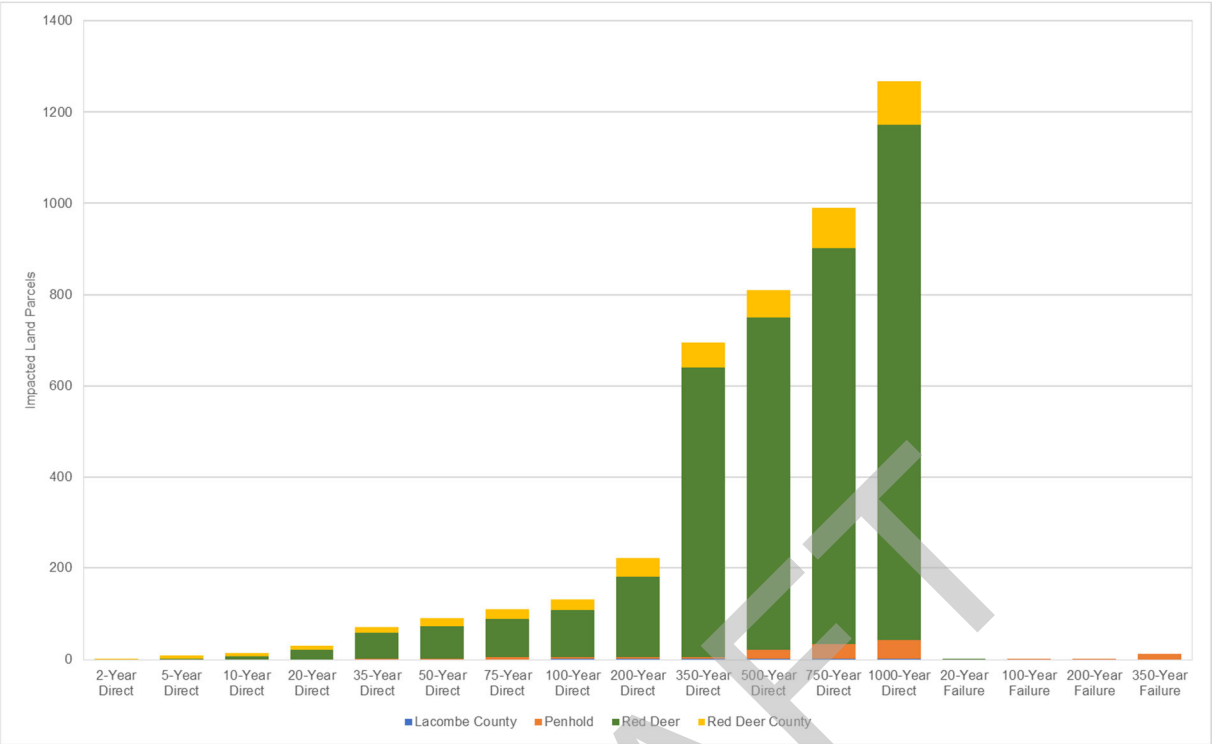

Figure 2: Affected Land Parcels for the Open Water Flood Inundation Scenarios

4.2.2 Buildings and Infrastructure

4.2.2.1 Residential Buildings

A summary of affected residential buildings for each local authority is presented in Tables 4 to 7, including total number, as well as a breakdown of residential buildings affected by direct inundation and potential flood control structure failure inundation. Figures 3 to 6 show affected residential and non-residential buildings per flood scenario (see Section 4.2.2.2 for non-residential buildings).

The total number of residential buildings affected by direct flood inundation in the study area and the total number of residential buildings potentially affected by flood control structure failure remain low between the 2-year flood and the 100-year flood. They increase steadily from the 200-year flood to the 1,000-year flood. The total number of residential buildings potentially affected by flood control structure failure in the study area remains zero for most flood scenarios and reaches its maximum at the 200-year and 350-year floods (10 residential buildings in the Town of Penhold affected during each flood scenario).

No residential buildings would be affected by any flood scenarios in Lacombe County (note that Figure 3 below also shows affected non-residential buildings in Lacombe County, as described in Section 4.2.2.2).

In the Town of Penhold, no residential buildings would be affected between the 2-year flood and the 100-year flood. At the 200-year and 350-year floods some residential buildings would be potentially affected by flood control structure failure. The number of residential buildings affected by direct flood inundation increases steadily between the 200-year and 1000-year flood.

In the City of Red Deer, the number of residential buildings affected by direct flood inundation remains low between the 2-year flood and the 100-year flood. A large increase in the affected areas occurs between the 100-year flood and the 350-year flood, when parts of Downtown south of 47th Street would be affected by flooding

from Waskasoo Creek. Another large increase occurs between the 500-year flood and 1000-year flood when the neighbourhoods of Waskasoo and Riverside Meadows (east of 54th Avenue) would be affected.

For Red Deer County, the number of affected residential buildings increases steadily from the 200-year flood to the 1,000-year flood, to a maximum of 16.

At the 100-year flood, a total of 6 residential buildings would be directly inundated in the study area, and none would be potentially inundated in the case of flood control structure failure. In comparison, a total of 368 residential buildings would be directly inundated in the study area for the 1,000-year flood.

Table 4: Affected Residential Buildings Lacombe County – Open Water Flood Inundation Scenarios

Scenario	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
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Single Family	0	0	0	0	0	0	0	0	0	0	0	0	0
Multifamily	0	0	0	0	0	0	0	0	0	0	0	0	0
Retirement Home	0	0	0	0	0	0	0	0	0	0	0	0	0
Direct Inundation	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Single Family	0	0	0	0	0	0	0	0	0	0	0	0	0
Multifamily	0	0	0	0	0	0	0	0	0	0	0	0	0
Retirement Home	0	0	0	0	0	0	0	0	0	0	0	0	0
Flood Control Structure Failure Inundation	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Single Family	0	0	0	0	0	0	0	0	0	0	0	0	0
Multifamily	0	0	0	0	0	0	0	0	0	0	0	0	0
Retirement Home	0	0	0	0	0	0	0	0	0	0	0	0	0

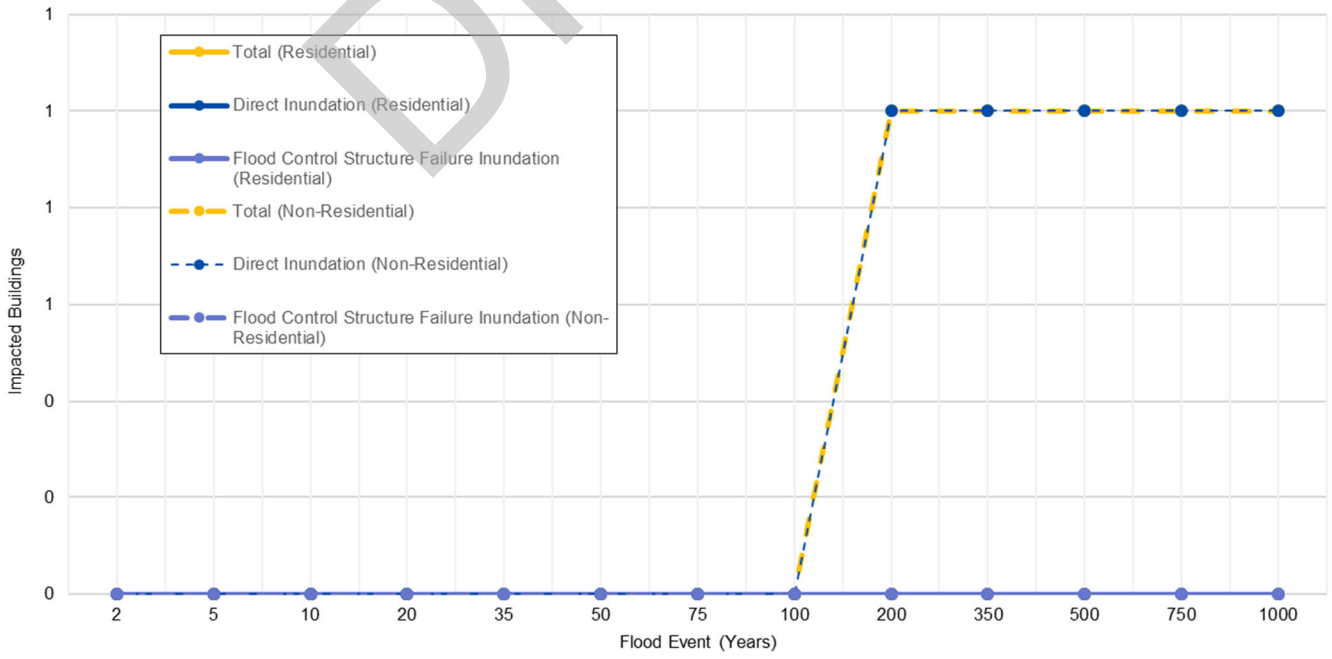

Figure 3: Affected Buildings Lacombe County – Open Water Flood Inundation Scenarios

Table 5: Affected Residential Buildings Town of Penhold – Open Water Flood Inundation Scenarios

Scenario	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
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**10**	**21**	**28**	**44**	**60**
Single Family	0	0	0	0	0	0	0	0	10	21	28	44	60
Multifamily	0	0	0	0	0	0	0	0	0	0	0	0	0
Retirement Home	0	0	0	0	0	0	0	0	0	0	0	0	0
Direct Inundation	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**11**	**28**	**44**	**60**
Single Family	0	0	0	0	0	0	0	0	0	11	28	44	60
Multifamily	0	0	0	0	0	0	0	0	0	0	0	0	0
Retirement Home	0	0	0	0	0	0	0	0	0	0	0	0	0
Flood Control Structure Failure Inundation	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**10**	**10**	**0**	**0**	**0**
Single Family	0	0	0	0	0	0	0	0	10	10	0	0	0
Multifamily	0	0	0	0	0	0	0	0	0	0	0	0	0
Retirement Home	0	0	0	0	0	0	0	0	0	0	0	0	0

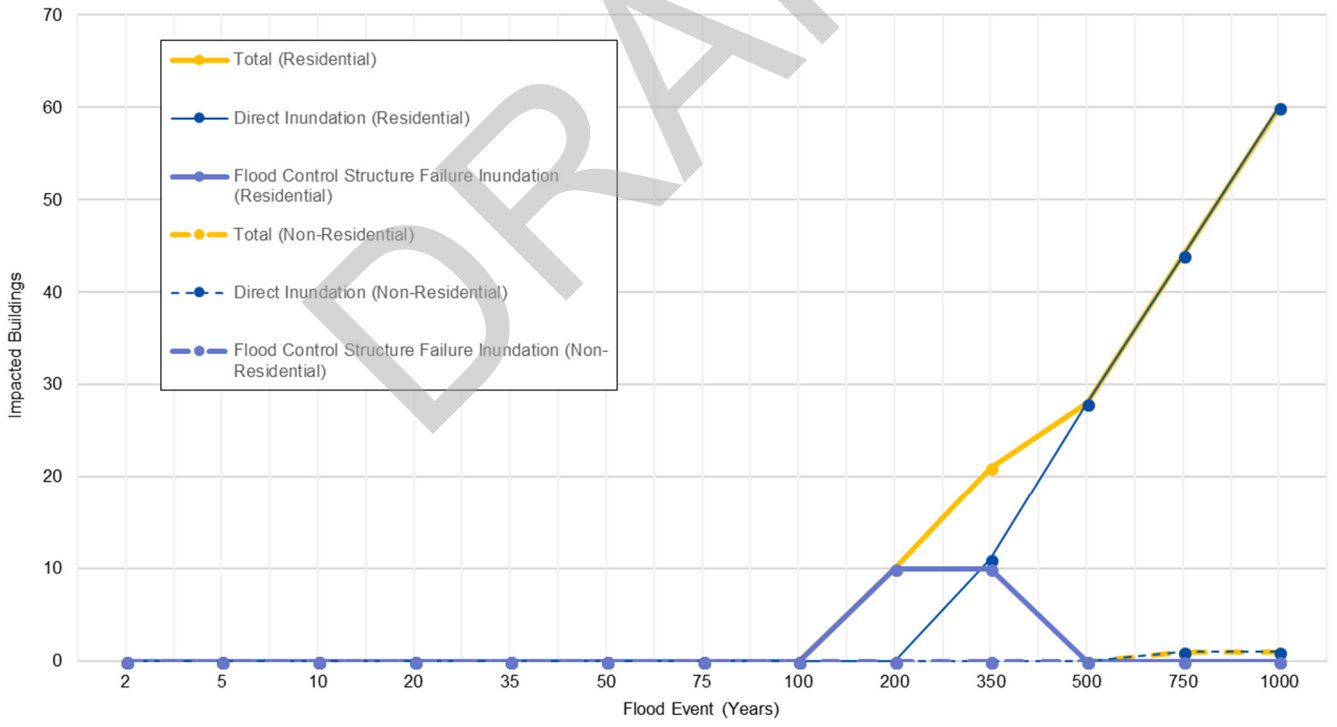

Figure 4: Affected Buildings Town of Penhold – Open Water Flood Inundation Scenarios

Table 6: Affected Residential Buildings City of Red Deer – Open Water Flood Inundation Scenarios

Scenario	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
Total	**0**	**0**	**0**	**0**	**1**	**1**	**2**	**6**	**36**	**73**	**86**	**127**	**292**
Single Family	0	0	0	0	1	1	2	6	34	67	74	114	261
Multifamily	0	0	0	0	0	0	0	0	2	5	11	12	29
Retirement Home	0	0	0	0	0	0	0	0	0	1	1	1	2
Direct Inundation	**0**	**0**	**0**	**0**	**1**	**1**	**2**	**6**	**36**	**73**	**86**	**127**	**292**
Single Family	0	0	0	0	1	1	2	6	34	67	74	114	261
Multifamily	0	0	0	0	0	0	0	0	2	5	11	12	29
Retirement Home	0	0	0	0	0	0	0	0	0	1	1	1	2
Flood Control Structure Failure Inundation	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Single Family	0	0	0	0	0	0	0	0	0	0	0	0	0
Multifamily	0	0	0	0	0	0	0	0	0	0	0	0	0
Retirement Home	0	0	0	0	0	0	0	0	0	0	0	0	0

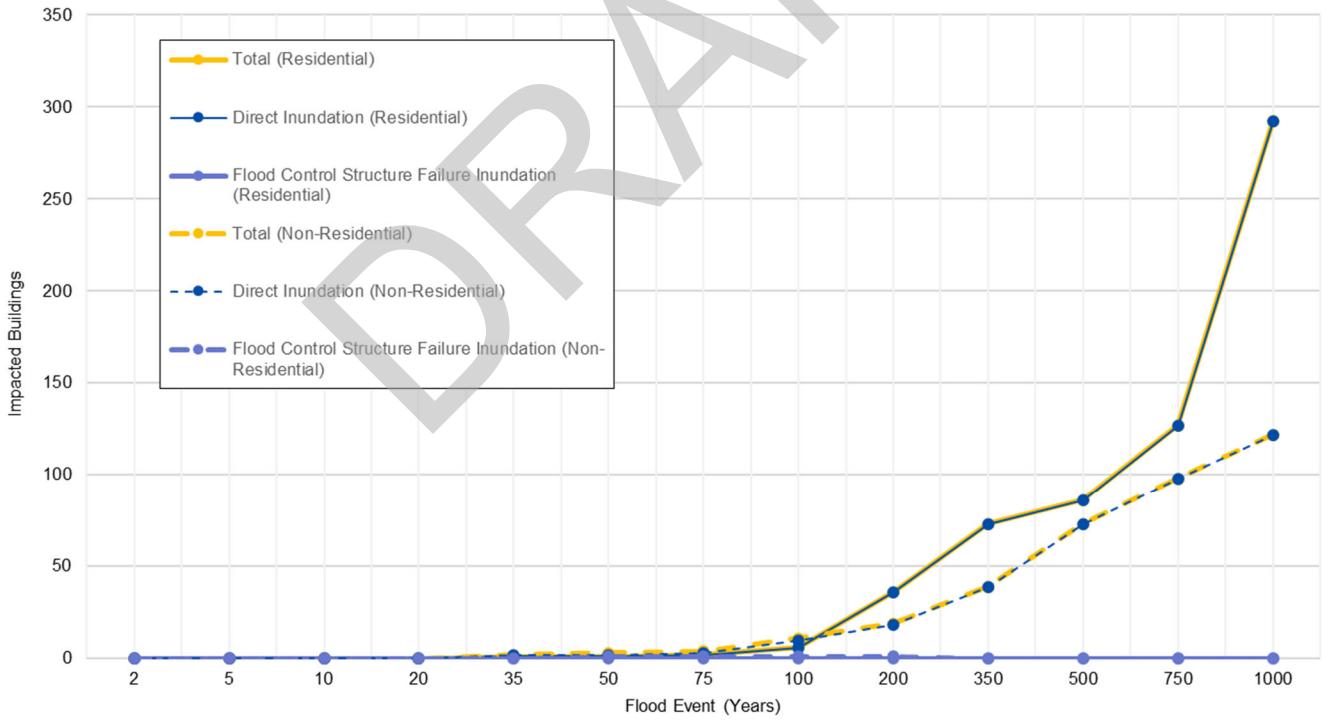

Figure 5: Affected Buildings City of Red Deer – Open Water Flood Inundation Scenarios

Table 7: Affected Residential Buildings Red Deer County– Open Water Flood Inundation Scenarios

Scenario	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
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**4**	**6**	**13**	**16**
Single Family	0	0	0	0	0	0	0	0	1	4	6	13	16
Multifamily	0	0	0	0	0	0	0	0	0	0	0	0	0
Retirement Home	0	0	0	0	0	0	0	0	0	0	0	0	0
Direct Inundation	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**4**	**6**	**13**	**16**
Single Family	0	0	0	0	0	0	0	0	1	4	6	13	16
Multifamily	0	0	0	0	0	0	0	0	0	0	0	0	0
Retirement Home	0	0	0	0	0	0	0	0	0	0	0	0	0
Flood Control Structure Failure Inundation	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Single Family	0	0	0	0	0	0	0	0	0	0	0	0	0
Multifamily	0	0	0	0	0	0	0	0	0	0	0	0	0
Retirement Home	0	0	0	0	0	0	0	0	0	0	0	0	0

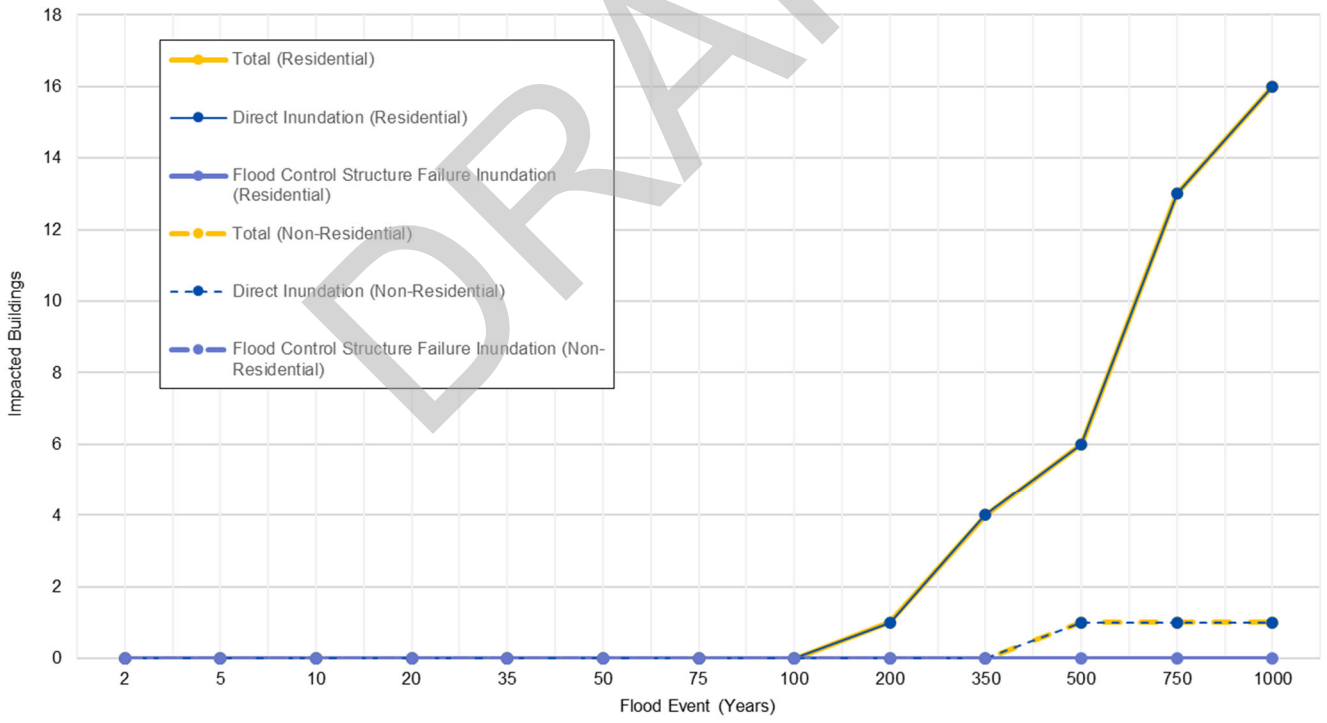

Figure 6: Affected Buildings Red Deer County – Open Water Flood Inundation Scenarios

4.2.2.2 Non-Residential Buildings

4.2.2.2.1 Summary

A summary of affected non-residential buildings for each local authority is presented in Tables 8 to 11, including total number, as well as a breakdown of non-residential buildings affected by direct inundation and potential flood control structure failure inundation. Figures 3 to 6 show affected buildings per flood scenario, including non-residential buildings.

The total number of non-residential buildings affected by direct flood inundation in the study area and the total number of affected non-residential buildings remain low between the 2-year flood and the 100-year flood. They increase steadily from the 200-year flood to the 1,000-year flood. The total number of non-residential buildings potentially affected by flood control structure failure in the study area remains zero for most flood scenarios and reaches its maximum between the 75-year and 200-year floods (one non-residential building, the Red Deer Wastewater Treatment Plant, would be affected).

One non-residential building would be affected between the 200-year and 1,000-year flood in Lacombe County.

One non-residential building would be affected between the 750-year and 1,000-year flood in the Town of Penhold.

In the City of Red Deer, the number of non-residential buildings affected by direct flood inundation remains low between the 2-year flood and the 100-year flood. Between the 200-year flood and the 1,000-year flood, increasingly large parts of Downtown, Riverside Light and Industrial Park Riverside Heavy Industrial Park would be affected by flooding, with a steady increase in the numbers of affected non-residential buildings.

For Red Deer County, the number of affected non-residential buildings increases from one at the 350-year flood to two at the 1,000-year flood.

At the 100-year flood, a total of 11 non-residential buildings would be directly inundated in the study area, and one would be potentially inundated in the case of flood control structure failure. No schools would be directly inundated. In comparison, a total of 125 non-residential buildings, one of which is a school, would be directly inundated in the study area during the 1,000-year flood.

No critical, non-residential buildings (i.e., government buildings, hospitals, schools, water treatment facilities or wastewater treatment facilities) would be affected up to the 50-year flood. No critical, non-residential buildings would be affected by direct inundation up to the 350-year flood. The following sections provide additional information on some of the other more critical non-residential building infrastructure.

Table 8: Affected Non-Residential Buildings Lacombe County – Open Water Flood Inundation Scenarios

Scenario	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
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**
Commercial	0	0	0	0	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0	0	0	0	0
Government Building	0	0	0	0	0	0	0	0	0	0	0	0	0
Hospital	0	0	0	0	0	0	0	0	0	0	0	0	0
School	0	0	0	0	0	0	0	0	0	0	0	0	0
Water Treatment Facility	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Non-Residential	0	0	0	0	0	0	0	0	1	1	1	1	1
Direct Inundation	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**
Commercial	0	0	0	0	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0	0	0	0	0
Government Building	0	0	0	0	0	0	0	0	0	0	0	0	0
Hospital	0	0	0	0	0	0	0	0	0	0	0	0	0
School	0	0	0	0	0	0	0	0	0	0	0	0	0
Water Treatment Facility	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Non-Residential	0	0	0	0	0	0	0	0	1	1	1	1	1
Flood Control Structure Failure Inundation	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Commercial	0	0	0	0	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0	0	0	0	0
Government Building	0	0	0	0	0	0	0	0	0	0	0	0	0
Hospital	0	0	0	0	0	0	0	0	0	0	0	0	0
School	0	0	0	0	0	0	0	0	0	0	0	0	0
Water Treatment Facility	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Non-Residential	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 9: Affected Non-Residential Buildings Town of Penhold – Open Water Flood Inundation Scenarios

Scenario	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
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**
Commercial	0	0	0	0	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0	0	0	0	0
Government Building	0	0	0	0	0	0	0	0	0	0	0	0	0
Hospital	0	0	0	0	0	0	0	0	0	0	0	0	0
School	0	0	0	0	0	0	0	0	0	0	0	0	0
Water Treatment Facility	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Non-Residential	0	0	0	0	0	0	0	0	0	0	0	1	1
Direct Inundation	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**
Commercial	0	0	0	0	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0	0	0	0	0
Government Building	0	0	0	0	0	0	0	0	0	0	0	0	0
Hospital	0	0	0	0	0	0	0	0	0	0	0	0	0
School	0	0	0	0	0	0	0	0	0	0	0	0	0
Water Treatment Facility	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Non-Residential	0	0	0	0	0	0	0	0	0	0	0	1	1
Flood Control Structure Failure Inundation	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Commercial	0	0	0	0	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0	0	0	0	0
Government Building	0	0	0	0	0	0	0	0	0	0	0	0	0
Hospital	0	0	0	0	0	0	0	0	0	0	0	0	0
School	0	0	0	0	0	0	0	0	0	0	0	0	0
Water Treatment Facility	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Non-Residential	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 10: Affected Non-Residential Buildings City of Red Deer – Open Water Flood Inundation Scenarios

Scenario	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
Total	**0**	**0**	**0**	**0**	**2**	**2**	**4**	**11**	**19**	**39**	**73**	**98**	**122**
Commercial	0	0	0	0	2	2	2	7	12	25	48	55	67
Industrial	0	0	0	0	0	0	0	0	2	2	10	21	29
Government Building	0	0	0	0	0	0	0	0	0	0	0	0	0
Hospital	0	0	0	0	0	0	0	0	0	0	0	0	0
School	0	0	0	0	0	0	0	0	0	0	0	0	1
Water Treatment Facility	0	0	0	0	0	0	0	0	0	1	1	1	1
Wastewater Treatment Facility	0	0	0	0	0	0	1	1	1	1	1	1	1
Other Non-Residential	0	0	0	0	0	0	1	3	4	11	14	20	23
Direct Inundation	**0**	**0**	**0**	**0**	**2**	**2**	**3**	**10**	**18**	**39**	**73**	**98**	**122**
Commercial	0	0	0	0	2	2	2	7	12	25	48	55	67
Industrial	0	0	0	0	0	0	0	0	2	2	10	21	29
Government Building	0	0	0	0	0	0	0	0	0	0	0	0	0
Hospital	0	0	0	0	0	0	0	0	0	0	0	0	0
School	0	0	0	0	0	0	0	0	0	0	0	0	1
Water Treatment Facility	0	0	0	0	0	0	0	0	0	1	1	1	1
Wastewater Treatment Facility	0	0	0	0	0	0	0	0	0	1	1	1	1
Other Non-Residential	0	0	0	0	0	0	1	3	4	11	14	20	23
Flood Control Structure Failure Inundation	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**0**	**0**	**0**	**0**
Commercial	0	0	0	0	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0	0	0	0	0
Government Building	0	0	0	0	0	0	0	0	0	0	0	0	0
Hospital	0	0	0	0	0	0	0	0	0	0	0	0	0
School	0	0	0	0	0	0	0	0	0	0	0	0	0
Water Treatment Facility	0	0	0	0	0	0	0	0	0	0	0	0	0
Wastewater Treatment Facility	0	0	0	0	0	0	1	1	1	0	0	0	0
Other Non-Residential	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 11: Affected Non-Residential Buildings Red Deer County– Open Water Flood Inundation Scenarios

Scenario	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
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**
Commercial	0	0	0	0	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0	0	1	1	1
Government Building	0	0	0	0	0	0	0	0	0	0	0	0	0
Hospital	0	0	0	0	0	0	0	0	0	0	0	0	0
School	0	0	0	0	0	0	0	0	0	0	0	0	0
Water Treatment Facility	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Non-Residential	0	0	0	0	0	0	0	0	0	0	0	0	0
Direct Inundation	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**
Commercial	0	0	0	0	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0	0	1	1	1
Government Building	0	0	0	0	0	0	0	0	0	0	0	0	0
Hospital	0	0	0	0	0	0	0	0	0	0	0	0	0
School	0	0	0	0	0	0	0	0	0	0	0	0	0
Water Treatment Facility	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Non-Residential	0	0	0	0	0	0	0	0	0	0	0	0	0
Flood Control Structure Failure Inundation	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Commercial	0	0	0	0	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0	0	0	0	0
Government Building	0	0	0	0	0	0	0	0	0	0	0	0	0
Hospital	0	0	0	0	0	0	0	0	0	0	0	0	0
School	0	0	0	0	0	0	0	0	0	0	0	0	0
Water Treatment Facility	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Non-Residential	0	0	0	0	0	0	0	0	0	0	0	0	0

4.2.2.2.2 Government Buildings

None of the government buildings in the study area would be affected by any of the open water flood scenarios.

4.2.2.2.3 Hospitals

None of the hospitals in the study area would be affected by any of the open water flood scenarios.

4.2.2.2.4 Water and Wastewater Treatment Facilities

The Red Deer Wastewater Treatment Plant would be potentially inundated in the case of flood control structure failure starting at the 75-year flood and impacted by direct inundation starting at the 350-year flood. The Red Deer Water Treatment Plant would be impacted by direct inundation starting at the 350-year flood.

4.2.2.3 Major Transportation Infrastructure

4.2.2.3.1 Roads

A summary of roads affected by direct inundation is presented in Table 12, including total length, as well as a breakdown of roads affected in each local authority. A summary of roads potentially affected by flood control structure failure is presented in Table 13, including total length, as well as a breakdown of roads affected in each local authority. Figure 7 shows the affected roads per flood scenario.

Table 12: Lengths of Affected Roads – Open Water Flood Inundation Scenarios, Direct Inundation

Scenario	Affected Length (km)				Total
	Lacombe County	Town of Penhold	City of Red Deer	Red Deer County	
2-Year	0.0	0.0	0.0	0.1	**0.1**
5-Year	0.0	0.0	0.0	0.3	**0.3**
10-Year	0.0	0.0	0.0	0.5	**0.6**
20-Year	0.0	0.0	0.1	0.6	**0.7**
35-Year	0.0	0.0	1.8	1.0	**2.8**
50-Year	0.0	0.0	2.9	1.3	**4.3**
75-Year	0.0	0.0	4.1	1.7	**5.8**
100-Year	0.0	0.1	6.1	1.9	**8.0**
200-Year	0.1	0.3	10.6	2.6	**13.7**
350-Year	0.2	0.7	20.3	4.3	**25.5**
500-Year	0.2	1.6	24.6	4.8	**31.1**
750-Year	0.3	2.2	31.7	6.8	**41.1**
1000-Year	0.3	2.9	39.9	8.7	**51.8**

Table 13: Lengths of Affected Roads – Open Water Flood Inundation Scenarios, Flood Control Structure Failure

Scenario	Affected Length (km)				Total
	Lacombe County	Town of Penhold	City of Red Deer	Red Deer County	
5-Year	0.0	0.0	0.1	0.0	**0.1**
10-Year	0.0	0.0	0.1	0.0	**0.1**
20-Year	0.0	0.0	0.2	0.0	**0.2**
200-Year	0.0	0.6	0.0	0.0	**0.6**
350-Year	0.0	0.7	0.0	0.0	**0.7**
500-Year	0.0	0.0	0.0	0.0	**0.0**

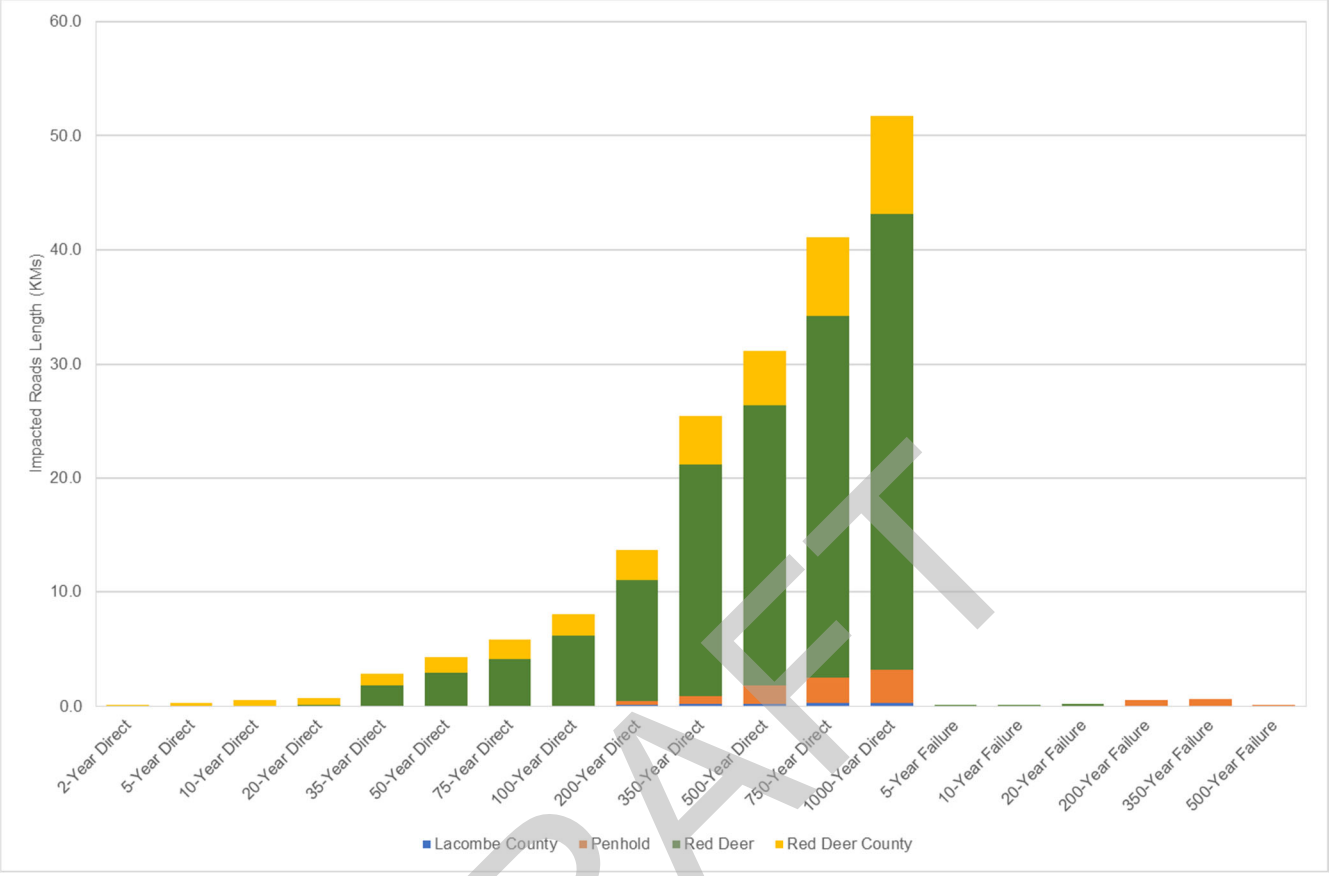

Figure 7: Lengths of Affected Roads – Open Water Flood Inundation Scenarios

The length of roads affected by direct flood inundation and the total length of affected roads remain low between the 2-year flood and the 20-year flood and increase steadily from the 35-year flood to the 1,000-year flood. The length of roads potentially affected by flood control structure failure remains zero for most flood scenarios and reaches its maximum at the 350-year flood (0.7 km of road that would be affected).

The length of roads affected in Lacombe County remains low for all flood scenarios.

The length of roads affected in the Town of Penhold remains low until the 200-year flood and then increases steadily between the 350-year and 1,000-year floods to a maximum of 2.9 km.

For the City of Red Deer, the length of affected roads remains low between the 2-year flood and the 20-year flood. A large increase in the length of affected roads occurs between the 100-year flood and the 350-year flood, when parts of Downtown south of 47th Street and the areas in Riverside Heavy Industrial Park east of Riverside Drive would be affected by flooding from Waskasoo Creek and Red Deer River, respectively. Another large increase occurs between the 500-year flood and 1000-year flood when the neighbourhoods of Waskasoo, Riverside Meadows (east of 54th Avenue), Riverside Light Industrial Park and Riverside Heavy Industrial Park would be affected.

For Red Deer County, the length of affected roads increases steadily from the 2-year flood to the 1,000-year flood to a maximum of 8.7 km.

The following major roads within the City of Red Deer would be affected by direct inundation:

- 43rd Street between 48th Avenue and 49th Avenue starting at the 35-year flood.
- Taylor Drive around the intersection with 32nd Street starting at the 50-year flood.
- Riverside Drive between 67th Street and 49th Avenue starting at the 75-year flood.
- Riverside Drive north of 67th Street starting at the 100-year flood.
- 55th Street east of 55th Street Bridge starting at the 200-year.
- 45th Street between 51st Avenue and 48th Avenue, as well as 51st Avenue and 48th Avenue Downtown south of 49th Street starting at the 100-year flood.
- Taylor Drive around the intersection with 43rd Street starting at the 100-year flood.
- 50th Street west of Ross Street Bridges starting at the 350-year flood.
- 55th Street west of 55th Street Bridge starting at the 200-year flood.
- 77th Street between Riverside Drive and 50th Avenue starting at the 500-year flood.
- 49th and 50th Street Downtown starting at the 350-year flood.
- Taylor Drive in Capstone at Riverlands between 43rd Street and Taylor Drive Bridges starting at the 350-year flood.
- 50th Avenue Downtown between 50th Street and 55th Street starting at the 500-year flood.
- 49th Avenue and 50th Avenue north of the Red Deer River crossing starting at the 1000-year flood.

The following major roads within Red Deer County would be affected by direct inundation:

- Range Road 281 south of Township Road 364 starting at the 5-year flood.
- Township Road 364 around Township Road 364 Bridge starting at the 35-year flood.
- Range Road 275 around Range Road 275 Bridge starting at the 75-year flood.
- Township Road 380 around Township Road 380 Bridge starting at the 200-year flood.
- Waskasoo Avenue south of Township Road 374 starting at the 350-year flood.
- Township Road 374 west of the intersection with Highway 2A starting at the 750-year flood.
- Highway 2 (Red Deer Bypass) north of the Red Deer River crossing starting at the 750-year flood.
- Highway 2A northeast of Highway 2A Bridge at the 1,000-year flood.

In addition, the following major roads within the Town of Penhold would be affected by direct inundation:

- Range Road 280 in the Town of Penhold starting at the 350-year flood.

At the 100-year flood, a total of 8 km of roads would be directly inundated in the study area and no roads would be potentially inundated in the case of flood control structure failure. In comparison, a total of 51.8 km of roads would be directly inundated in the study area at the 1,000-year flood.

4.2.2.3.2 Bridges/Culverts

A summary of bridge/culvert clearances during floods is presented in Table 14.

Table 14: Bridge/Culvert Clearances – Open Water Flood Inundation Scenarios

River	Name	Minimum Low Chord/ Road Surface Elevation (m)	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	
			Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)
Red Deer River	CP Rail Bridge	865.90	858.15	7.75	858.82	7.08	859.24	6.66	859.62	6.28	860.78	5.12	861.19	4.71	861.68	4.22	862.04	3.86	863.04	2.86	863.66	2.24	864.01	1.89	864.50	1.40	864.91	0.99
	Red Deer Bypass (QE II Highway) Northbound and Southbound Bridges	866.70	858.05	8.65	858.73	7.97	859.15	7.55	859.53	7.17	860.70	6.00	861.11	5.59	861.61	5.09	861.97	4.73	862.98	3.72	863.60	3.10	863.96	2.74	864.45	2.25	864.87	1.83
	Heritage Ranch Pedestrian Bridge	863.90	854.75	9.15	855.37	8.53	855.74	8.16	856.09	7.81	857.11	6.79	857.45	6.45	857.86	6.04	858.16	5.74	858.98	4.92	859.50	4.40	859.79	4.11	860.28	3.62	860.62	3.28
	Taylor Drive Northbound and Southbound Bridges	862.40	851.73	10.67	852.30	10.10	852.68	9.72	853.03	9.37	854.13	8.27	854.51	7.89	854.96	7.44	855.30	7.10	856.24	6.16	856.89	5.51	857.17	5.23	857.67	4.73	858.05	4.35
	CP Rail (58 Street) Pedestrian Bridge	856.50	850.78	5.72	851.43	5.07	851.83	4.67	852.20	4.30	853.31	3.19	853.69	2.81	854.13	2.37	854.46	2.04	855.38	1.12	856.02	0.48	856.23	0.27	856.73	-0.23	857.18	-0.68
	50 Avenue (Gaetz Avenue) Bridge	856.60	850.59	6.01	851.22	5.38	851.61	4.99	851.96	4.64	853.03	3.57	853.39	3.21	853.80	2.80	854.10	2.50	854.93	1.67	855.49	1.11	855.60	1.00	856.11	0.49	856.53	0.07
	49 Avenue Bridge	858.50	850.43	8.07	851.04	7.46	851.42	7.08	851.77	6.73	852.81	5.69	853.16	5.34	853.55	4.95	853.85	4.65	854.62	3.88	855.14	3.36	855.18	3.32	855.48	3.02	855.68	2.82
	67 Street (David Thompson Highway) Bridge	858.90	848.56	10.34	849.14	9.76	849.46	9.44	849.74	9.16	850.53	8.37	850.77	8.13	851.05	7.85	851.23	7.67	851.75	7.15	852.12	6.78	852.34	6.56	852.66	6.24	852.92	5.98
	Riverbend (Discovery Canyon) Pedestrian Bridge	849.40	842.87	6.53	843.53	5.87	843.91	5.49	844.26	5.14	845.31	4.09	845.56	3.84	845.85	3.55	846.04	3.36	846.54	2.86	846.86	2.54	847.09	2.31	847.26	2.14	847.35	2.05
Piper Creek	Private Culvert	892.45	892.44	0.01	892.50	-0.05	892.54	-0.09	892.65	-0.20	892.75	-0.30	892.80	-0.35	892.87	-0.42	892.91	-0.46	893.02	-0.57	893.10	-0.65	893.15	-0.70	893.22	-0.77	893.30	-0.85
	Range Road 272 Bridge	892.80	891.71	1.09	891.98	0.82	892.17	0.63	892.33	0.47	892.45	0.35	892.50	0.30	892.57	0.23	892.62	0.18	892.73	0.07	892.82	-0.02	892.88	-0.08	892.96	-0.16	893.07	-0.27
	40 Avenue Culvert	889.30	886.83	2.47	887.04	2.26	887.19	2.11	887.36	1.94	887.53	1.77	887.67	1.63	887.85	1.45	887.99	1.31	888.42	0.88	888.85	0.45	889.17	0.13	889.44	-0.14	889.51	-0.21
	Private Culvert	886.62	886.83	-0.21	886.99	-0.37	887.09	-0.47	887.18	-0.56	887.24	-0.62	887.27	-0.65	887.31	-0.69	887.34	-0.72	887.40	-0.78	887.45	-0.83	887.48	-0.86	887.52	-0.90	887.54	-0.92
	Private Culvert	886.43	884.93	1.50	885.47	0.96	885.90	0.53	886.40	0.03	886.68	-0.25	886.75	-0.32	886.81	-0.38	886.85	-0.42	886.93	-0.50	887.00	-0.57	887.04	-0.61	887.08	-0.65	887.11	-0.68
	Delburne Road (19 Street) Culvert	885.91	881.69	4.22	882.17	3.74	882.47	3.44	882.81	3.10	883.08	2.83	883.26	2.65	883.46	2.45	883.62	2.29	884.09	1.82	884.50	1.41	884.95	0.96	885.41	0.50	885.79	0.12
	Bannerman Close Pedestrian Bridge	880.00	878.00	2.00	878.30	1.70	878.55	1.45	878.72	1.28	878.87	1.13	878.96	1.04	879.05	0.95	879.12	0.88	879.27	0.73	879.39	0.61	879.47	0.53	879.55	0.45	879.61	0.39
	Bower Woods East-West Pedestrian Bridge	875.10	872.48	2.62	872.84	2.26	873.07	2.03	873.31	1.79	873.45	1.65	873.55	1.55	873.64	1.46	873.71	1.39	873.87	1.23	874.01	1.09	874.09	1.01	874.17	0.93	874.23	0.87
	Bower Woods North-South Pedestrian Bridge	873.80	870.63	3.17	870.91	2.89	871.19	2.61	871.35	2.45	871.50	2.30	871.61	2.19	871.72	2.08	871.80	2.00	871.99	1.81	872.14	1.66	872.23	1.57	872.33	1.47	872.41	1.39
	32 Street Bridge	870.20	867.84	2.36	868.06	2.14	868.21	1.99	868.36	1.84	868.49	1.71	868.57	1.63	868.78	1.42	868.95	1.25	868.95	1.25	868.98	1.22	869.06	1.14	869.90	0.30	870.01	0.19
	Kin Canyon South Pedestrian Bridge	867.40	865.48	1.92	865.78	1.62	865.97	1.43	866.16	1.24	866.32	1.08	866.42	0.98	866.51	0.89	866.58	0.82	866.72	0.68	866.85	0.55	866.92	0.48	867.01	0.39	867.08	0.32
	Kin Canyon North Bridge	864.70	863.27	1.43	863.52	1.18	863.70	1.00	863.89	0.81	864.05	0.65	864.14	0.56	864.25	0.45	864.32	0.38	864.51	0.19	864.71	-0.01	864.87	-0.17	865.04	-0.34	865.15	-0.45
	Rotary Picnic Park South Pedestrian Bridge	861.60	859.69	1.91	859.98	1.62	860.20	1.40	860.41	1.19	860.56	1.04	860.66	0.94	860.77	0.83	860.85	0.75	861.04	0.56	861.20	0.40	861.29	0.31	861.39	0.21	861.45	0.15
	Rotary Picnic Park North Pedestrian Bridge	860.20	858.10	2.10	858.42	1.78	858.64	1.56	858.83	1.37	858.98	1.22	859.07	1.13	859.16	1.04	859.22	0.98	859.37	0.83	859.49	0.71	859.57	0.63	859.66	0.54	859.72	0.48
	43 Street Culvert	857.10	855.62	1.48	856.04	1.06	856.43	0.67	856.82	0.28	857.15	-0.05	857.38	-0.28	857.64	-0.54	857.78	-0.68	857.78	-0.68	858.07	-0.97	858.14	-1.04	858.20	-1.10	858.24	-1.14

Table 14: Bridge/Culvert Clearances – Open Water Flood Inundation Scenarios

River	Name	Minimum Low Chord/ Road Surface Elevation (m)	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	
			Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)
Waskasoo Creek	Range Road 281 Culvert	895.28	895.49	-0.21	895.55	-0.27	895.60	-0.32	895.65	-0.37	895.70	-0.42	895.72	-0.44	895.75	-0.47	895.77	-0.49	895.81	-0.53	895.85	-0.57	895.88	-0.60	895.91	-0.63	895.93	-0.65
	Township Road 264 Bridge	895.20	894.36	0.84	894.70	0.50	894.93	0.27	895.14	0.06	895.35	-0.15	895.44	-0.24	895.51	-0.31	895.52	-0.32	895.55	-0.35	895.59	-0.39	895.61	-0.41	895.64	-0.44	895.66	-0.46
	Private Culvert	894.03	894.21	-0.18	894.43	-0.40	894.58	-0.55	894.79	-0.76	894.95	-0.92	895.02	-0.99	895.09	-1.06	895.13	-1.10	895.21	-1.18	895.26	-1.23	895.28	-1.25	895.31	-1.28	895.33	-1.30
	Private Culvert	893.40	893.65	-0.25	893.94	-0.54	894.02	-0.62	894.15	-0.75	894.26	-0.86	894.34	-0.94	894.43	-1.03	894.49	-1.09	894.65	-1.25	894.79	-1.39	894.89	-1.49	894.99	-1.59	895.03	-1.63
	Range Road 280 Bridge	894.90	893.19	1.71	893.66	1.24	893.87	1.03	894.05	0.85	894.19	0.71	894.27	0.63	894.37	0.53	894.43	0.47	894.60	0.30	894.74	0.16	894.84	0.06	894.92	-0.02	894.96	-0.06
	Highway 42 Bridge	893.80	892.41	1.39	892.86	0.94	893.05	0.75	893.23	0.57	893.36	0.44	893.44	0.36	893.53	0.27	893.60	0.20	893.76	0.04	893.94	-0.14	894.05	-0.25	894.26	-0.46	894.53	-0.73
	Private Bridge	892.10	891.58	0.52	892.08	0.02	892.30	-0.20	892.43	-0.33	892.51	-0.41	892.55	-0.45	892.60	-0.50	892.64	-0.54	892.77	-0.67	892.96	-0.86	893.08	-0.98	893.26	-1.16	893.35	-1.25
	Township Road 372 Bridge	892.20	890.51	1.69	891.07	1.13	891.35	0.85	891.61	0.59	891.83	0.37	891.98	0.22	892.11	0.09	892.23	-0.03	892.40	-0.20	892.65	-0.45	892.98	-0.78	893.21	-1.01	893.31	-1.11
	Private Bridge	891.50	890.47	1.03	891.02	0.48	891.28	0.22	891.51	-0.01	891.71	-0.21	891.85	-0.35	891.95	-0.45	892.03	-0.53	892.03	-0.53	892.17	-0.67	892.18	-0.68	892.25	-0.75	892.31	-0.81
	Private Culvert	889.70	889.38	0.32	889.97	-0.27	890.12	-0.42	890.24	-0.54	890.36	-0.66	890.44	-0.74	890.52	-0.82	890.57	-0.87	890.73	-1.03	890.86	-1.16	890.95	-1.25	891.09	-1.39	891.20	-1.50
	Highway 2A Bridge	890.70	888.51	2.19	889.11	1.59	889.46	1.24	889.75	0.95	889.96	0.74	890.08	0.62	890.19	0.51	890.29	0.41	890.52	0.18	890.67	0.03	890.78	-0.08	890.93	-0.23	891.06	-0.36
	CP Rail Bridge	891.20	888.38	2.82	888.98	2.22	889.32	1.88	889.58	1.62	889.75	1.45	889.86	1.34	889.94	1.26	890.02	1.18	890.18	1.02	890.25	0.95	890.30	0.90	890.41	0.79	890.50	0.70
	Township Road 374 Bridge	890.00	887.86	2.14	888.44	1.56	888.78	1.22	889.01	0.99	889.16	0.84	889.26	0.74	889.38	0.62	889.47	0.53	889.63	0.37	889.85	0.15	890.04	-0.04	890.35	-0.35	890.51	-0.51
	CP Rail Bridge	889.30	886.82	2.48	887.43	1.87	887.85	1.45	888.17	1.13	888.42	0.88	888.56	0.74	888.74	0.56	888.87	0.43	889.20	0.10	889.53	-0.23	889.76	-0.46	889.92	-0.62	890.14	-0.84
	Highway 2A Bridge	889.20	886.80	2.40	887.42	1.78	887.84	1.36	888.17	1.03	888.41	0.79	888.56	0.64	888.73	0.47	888.85	0.35	889.18	0.02	889.49	-0.29	889.71	-0.51	889.89	-0.69	890.11	-0.91
	Private Bridge	888.00	886.60	1.40	887.19	0.81	887.57	0.43	887.83	0.17	888.05	-0.05	888.18	-0.18	888.31	-0.31	888.39	-0.39	888.57	-0.57	888.73	-0.73	888.82	-0.82	888.91	-0.91	888.97	-0.97
	Private Bridge	887.80	886.23	1.57	886.80	1.00	887.16	0.64	887.39	0.41	887.55	0.25	887.66	0.14	887.76	0.04	887.84	-0.04	888.08	-0.28	888.33	-0.53	888.43	-0.63	888.54	-0.74	888.61	-0.81
	Lantern Street Bridge	887.30	885.54	1.76	886.06	1.24	886.40	0.90	886.69	0.61	886.90	0.40	887.01	0.29	887.13	0.17	887.20	0.10	887.46	-0.16	887.66	-0.36	887.80	-0.50	887.93	-0.63	888.07	-0.77
	Township Road 375 Bridge	887.30	884.41	2.89	885.05	2.25	885.41	1.89	885.74	1.56	885.98	1.32	886.11	1.19	886.25	1.05	886.35	0.95	886.57	0.73	886.74	0.56	886.84	0.46	886.95	0.35	887.02	0.28
	Highway 2A Bridge	885.70	882.78	2.92	883.43	2.27	883.78	1.92	884.11	1.59	884.38	1.32	884.55	1.15	884.76	0.94	884.92	0.78	885.33	0.37	885.69	0.01	885.83	-0.13	885.96	-0.26	886.05	-0.35
	CP Rail Bridge	886.20	882.63	3.57	883.29	2.91	883.59	2.61	883.83	2.37	884.01	2.19	884.11	2.09	884.23	1.97	884.32	1.88	884.56	1.64	884.79	1.41	884.97	1.23	885.17	1.03	885.30	0.90
	Range Road 275 Bridge	883.60	882.11	1.49	882.73	0.87	883.02	0.58	883.23	0.37	883.37	0.23	883.46	0.14	883.56	0.04	883.62	-0.02	883.77	-0.17	883.89	-0.29	883.97	-0.37	884.05	-0.45	884.13	-0.53
	Private Culvert	881.91	880.91	1.00	881.75	0.16	882.21	-0.30	882.37	-0.46	882.44	-0.53	882.48	-0.57	882.53	-0.62	882.54	-0.63	882.60	-0.69	882.88	-0.97	883.08	-1.17	883.20	-1.29	883.40	-1.49
	Township Road 380 Bridge	880.90	878.73	2.17	879.38	1.52	879.75	1.15	880.03	0.87	880.22	0.68	880.34	0.56	880.50	0.40	880.63	0.27	881.61	-0.71	882.79	-1.89	883.01	-2.11	883.13	-2.23	883.34	-2.44
	Private Bridge	879.50	877.65	1.85	878.43	1.07	878.84	0.66	879.21	0.29	879.49	0.01	879.66	-0.16	879.89	-0.39	880.15	-0.65	881.38	-1.88	882.78	-3.28	883.00	-3.50	883.11	-3.61	883.33	-3.83
	Range Road 275 Bridge	878.00	875.98	2.02	876.71	1.29	877.24	0.76	877.81	0.19	878.37	-0.37	878.80	-0.80	879.37	-1.37	879.89	-1.89	881.33	-3.33	882.76	-4.76	882.98	-4.98	883.09	-5.09	883.31	-5.31
	CP Rail Culvert	882.53	875.81	6.72	876.58	5.95	877.16	5.37	877.76	4.77	878.33	4.20	878.74	3.79	879.30	3.23	879.85	2.68	881.30	1.23	882.75	-0.22	882.98	-0.45	883.09	-0.56	883.31	-0.78
	Highway 2 Bridge	878.40	875.70	2.70	876.44	1.96	876.96	1.44	877.44	0.96	877.86	0.54	878.14	0.26	878.53	-0.13	878.94	-0.54	879.95	-1.55	880.96	-2.56	881.41	-3.01	881.57	-3.17	881.64	-3.24
	Private Bridge	876.50	875.27	1.23	875.93	0.57	876.33	0.17	876.65	-0.15	876.90	-0.40	877.02	-0.52	877.12	-0.62	877.20	-0.70	877.40	-0.90	877.50	-1.00	877.58	-1.08	877.66	-1.16	877.71	-1.21
	Taylor Drive Culvert	874.28	871.54	2.74	872.16	2.12	872.61	1.67	873.06	1.22	873.44	0.84	873.92	0.36	874.86	-0.58	875.06	-0.78	875.34	-1.06	875.52	-1.24	875.62	-1.34	875.74	-1.46	875.82	-1.54
	32 Street Culvert	873.06	868.59	4.47	869.19	3.87	869.73	3.33	870.59	2.47	871.59	1.47	872.75	0.31	873.36	-0.30	873.48	-0.42	873.67	-0.61	873.78	-0.72	873.85	-0.79	873.97	-0.91	874.02	-0.96
	34 Street Culvert	869.87	867.41	2.46	868.12	1.75	868.66	1.21	869.28	0.59	869.95	-0.08	870.67	-0.80	871.43	-1.56	871.68	-1.81	872.00	-2.13	872.18	-2.31	872.29	-2.42	873.04	-3.17	873.22	-3.35
	ACR Trail South Pedestrian Bridge	866.70	864.33	2.37	864.72	1.98	865.03	1.67	865.30	1.40	865.50	1.20	865.64	1.06	865.82	0.88	865.97	0.73	866.26	0.44	866.53	0.17	866.60	0.10	866.68	0.02	866.78	-0.08

Table 14: Bridge/Culvert Clearances – Open Water Flood Inundation Scenarios

River	Name	Minimum Low Chord/ Road Surface Elevation (m)	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	
			Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)	Water Level (m)	Clearance (m)
Waskasoo Creek (continued)	ACR Trail North Pedestrian Bridge	865.10	863.23	1.87	863.62	1.48	863.89	1.21	864.11	0.99	864.26	0.84	864.32	0.78	864.34	0.76	864.35	0.75	864.69	0.41	865.02	0.08	865.07	0.03	865.33	-0.23	865.39	-0.29
	43 Street Culvert	863.11	860.79	2.32	861.47	1.64	862.00	1.11	862.55	0.56	863.25	-0.14	863.28	-0.17	863.41	-0.30	863.47	-0.36	863.52	-0.41	863.59	-0.48	863.59	-0.48	863.62	-0.51	863.65	-0.54
	52 Avenue & 45 Street Loop Culvert	860.31	857.39	2.92	857.68	2.63	858.19	2.12	858.59	1.72	859.00	1.31	859.31	1.00	859.40	0.91	859.71	0.60	860.48	-0.17	861.10	-0.79	861.14	-0.83	861.17	-0.86	861.17	-0.86
	50 Avenue (Gaetz Avenue) Bridge[1]	857.50	855.96	1.54	856.55	0.95	856.93	0.57	857.26	0.24	857.54	-0.04	857.71	-0.21	857.84	-0.34	857.91	-0.41	858.03	-0.53	858.05	-0.55	858.09	-0.59	858.12	-0.62	858.14	-0.64
	49 Avenue Bridge	856.90	855.53	1.37	856.11	0.79	856.47	0.43	856.76	0.14	857.00	-0.10	857.11	-0.21	857.14	-0.24	857.41	-0.51	857.55	-0.65	857.55	-0.65	857.57	-0.67	857.60	-0.70	857.74	-0.84
	48 Avenue Culvert	856.68	854.67	2.01	855.04	1.64	855.67	1.01	856.09	0.59	856.40	0.28	856.59	0.09	856.74	-0.06	856.84	-0.16	857.09	-0.41	857.29	-0.61	857.42	-0.74	857.59	-0.91	857.71	-1.03
	Barett Park South Pedestrian Bridge	855.40	853.30	2.10	854.05	1.35	854.47	0.93	854.82	0.58	855.08	0.32	855.25	0.15	855.42	-0.02	855.54	-0.14	855.94	-0.54	856.28	-0.88	856.42	-1.02	856.60	-1.20	856.73	-1.33
	Barrett Park North Pedestrian Bridge	854.80	852.98	1.82	853.67	1.13	854.08	0.72	854.40	0.40	854.63	0.17	854.79	0.01	854.95	-0.15	855.07	-0.27	855.59	-0.79	856.02	-1.22	856.17	-1.37	856.37	-1.57	856.52	-1.72
	Ross Street Eastbound And Westbound Bridges	854.50	852.57	1.93	853.07	1.43	853.44	1.06	853.76	0.74	854.03	0.47	854.18	0.32	854.34	0.16	854.48	0.02	855.24	-0.74	855.73	-1.23	855.86	-1.36	856.08	-1.58	856.23	-1.73
	Coronation Park South Pedestrian Bridge	855.00	852.25	2.75	852.68	2.32	853.10	1.90	853.46	1.54	853.76	1.24	853.91	1.09	854.07	0.93	854.23	0.77	854.93	0.07	855.34	-0.34	855.41	-0.41	855.70	-0.70	855.94	-0.94
	Coronation Park North Pedestrian Bridge	854.00	851.73	2.27	852.15	1.85	852.50	1.50	852.84	1.16	853.19	0.81	853.34	0.66	853.73	0.27	854.03	-0.03	854.83	-0.83	855.28	-1.28	855.34	-1.34	855.65	-1.65	855.90	-1.90
	53 Street Bridge	854.40	851.36	3.04	851.84	2.56	852.20	2.20	852.55	1.85	853.00	1.40	853.27	1.13	853.62	0.78	853.91	0.49	854.75	-0.35	855.23	-0.83	855.29	-0.89	855.61	-1.21	855.87	-1.47
	55 Street Bridge	853.40	850.74	2.66	851.15	2.25	851.48	1.92	851.79	1.61	852.65	0.75	853.01	0.39	853.45	-0.05	853.79	-0.39	854.66	-1.26	855.16	-1.76	855.21	-1.81	855.56	-2.16	855.83	-2.43
	Gaetz Park Pedestrian Bridge	851.90	850.04	1.86	850.71	1.19	851.11	0.79	851.49	0.41	852.60	-0.70	852.97	-1.07	853.39	-1.49	853.71	-1.81	854.54	-2.64	855.10	-3.20	855.15	-3.25	855.52	-3.62	855.81	-3.91

Note: The clearances are the elevation differences between bridge low chord or culvert road surface elevations and simulated water levels. A negative value indicates the water depth above the low chord for a bridge or above the road surface for a culvert.

1) The 50 Avenue (Gaetz Avenue) Bridge on the Waskasoo Creek was surveyed and modelled as a bridge in the Study. It is acknowledged that the City of Red Deer recognizes this structure as a culvert.

4.2.2.3.3 Railroads

A summary of railroads affected by direct inundation is presented in Table 15, including total length, as well as a breakdown of railroads affected in each local authority. Figure 8 shows the affected railroads per flood scenario.

No railroads would be affected by flood inundation until the 200-year flood. Starting at the 750-year flood, the CN Red Deer Industrial spur in the City of Red Deer would be affected near the intersection with 77th Street.

Starting at the 350-year flood, the CP mainline (Calgary-Edmonton) in the County of Red Deer would be affected around the Waskasoo Creek crossing near the intersection of Highway 2 and 32nd Street, and the Waskasoo Creek crossing near the intersection of Highway 2A and Township Road 374.

No railroads would be potentially affected by flood control structure failure inundation.

At the 100-year flood, no railroads would be inundated in the study area. In comparison, a total of 1.5 km of railroads would be directly inundated in the study area at the 1,000-year flood.

Table 15: Lengths of Affected Railroads – Open Water Flood Inundation Scenarios, Direct Inundation

Scenario	Impacted Railroads Length (km)				Total
	Lacombe County	Town of Penhold	City of Red Deer	Red Deer County	
2-Year	0.0	0.0	0.0	0.0	**0.0**
5-Year	0.0	0.0	0.0	0.0	**0.0**
10-Year	0.0	0.0	0.0	0.0	**0.0**
20-Year	0.0	0.0	0.0	0.0	**0.0**
35-Year	0.0	0.0	0.0	0.0	**0.0**
50-Year	0.0	0.0	0.0	0.0	**0.0**
75-Year	0.0	0.0	0.0	0.0	**0.0**
100-Year	0.0	0.0	0.0	0.0	**0.0**
200-Year	0.0	0.0	0.0	0.0	**0.0**
350-Year	0.0	0.0	0.0	0.4	**0.4**
500-Year	0.0	0.0	0.0	0.5	**0.5**
750-Year	0.0	0.0	0.0	0.5	**0.6**
1000-Year	0.0	0.0	0.6	0.8	**1.5**

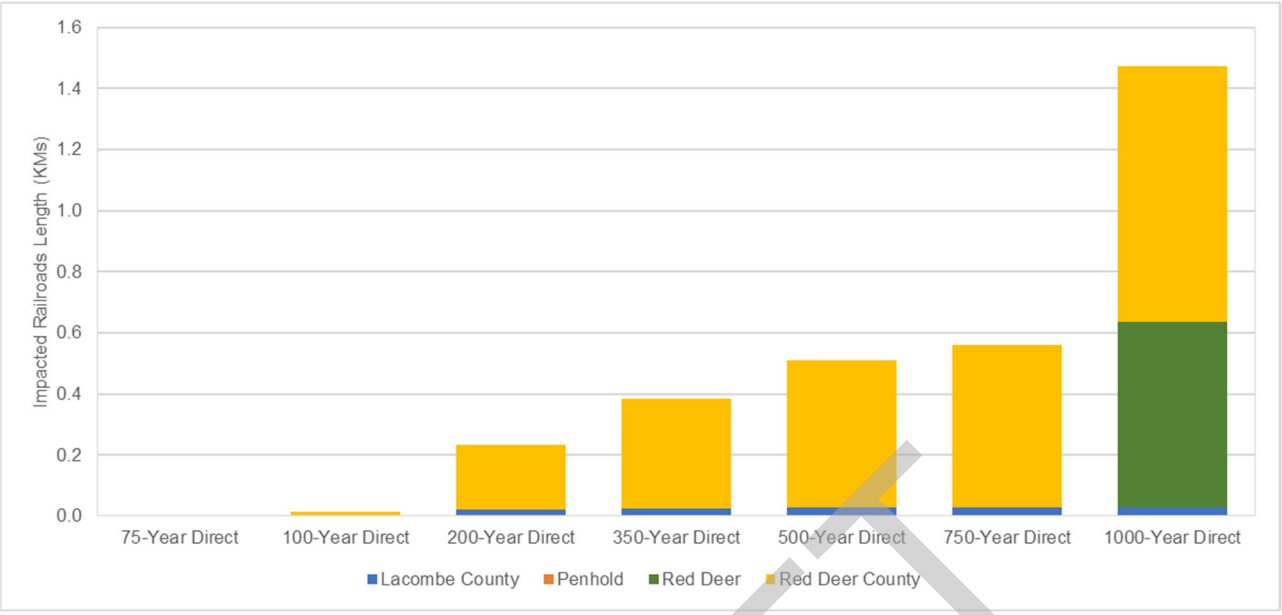

Figure 8: Lengths of Affected Railroads – Open Water Flood Inundation Scenarios

4.2.3 Population

Each residential building in the study area (including single family, multifamily, and retirement homes) was assigned a number of residents based on the population count of the census block they are located in (see Section 2.3). The population affected by a flood scenario was estimated based on a tally of the residents of all affected residential buildings.

A summary of the population affected by direct inundation is presented in Table 16, including total numbers, as well as a breakdown of the population affected in each local authority. A summary of the population potentially affected by flood control structure failure is presented in Table 17, including the total population, as well as a breakdown of the population affected in each local authority. Figure 9 shows the affected population per flood scenario.

Table 16: Affected Population – Open Water Flood Inundation Scenarios, Direct Inundation

Scenario	Impacted Population				Total
	Lacombe County	Town of Penhold	City of Red Deer	Red Deer County	
2-Year	0	0	0	0	**0**
5-Year	0	0	0	0	**0**
10-Year	0	0	0	0	**0**
20-Year	0	0	0	0	**0**
35-Year	0	0	2	0	**2**
50-Year	0	0	2	0	**2**
75-Year	0	0	6	0	**6**
100-Year	0	0	22	0	**22**
200-Year	0	0	116	2	**118**
350-Year	0	23	533	9	**565**
500-Year	0	68	653	15	**736**
750-Year	0	105	758	33	**895**
1000-Year	0	144	1,704	40	**1,888**

Table 17: Affected Population – Open Water Flood Inundation Scenarios, Flood Control Structure Failure

Scenario	Impacted Population				Total
	Lacombe County	Town of Penhold	City of Red Deer	Red Deer County	
200-Year	0	25	0	0	**25**
350-Year	0	30	0	0	**30**

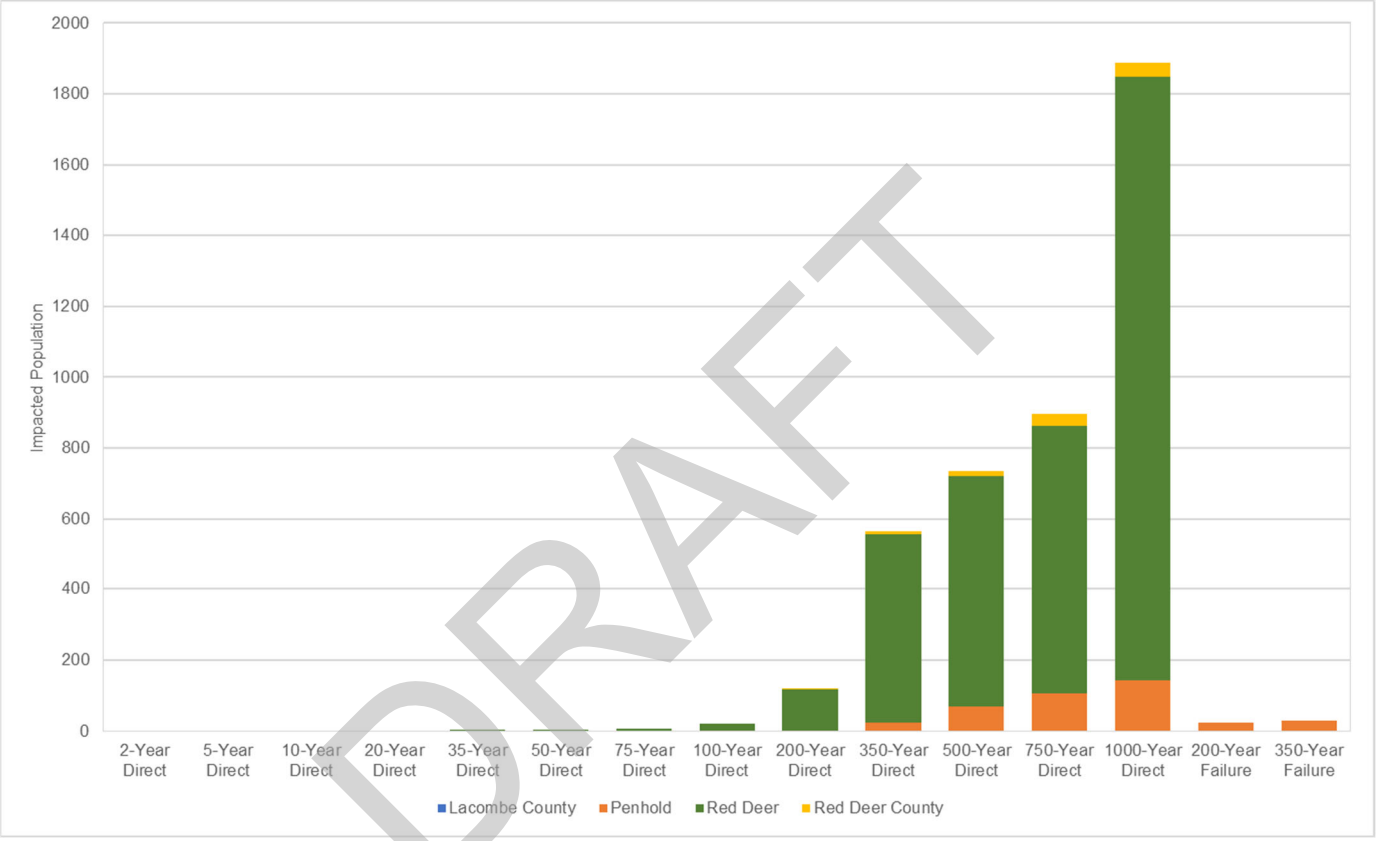

Figure 9: Affected Population – Open Water Flood Inundation Scenarios

The population affected by direct flood inundation and the total affected population remain low between the 2-year flood and the 100-year flood. Large increases occur between the 200-year and 350-year floods, as well as the 750-year and 1,000-year floods. The population potentially affected by flood control structure failure remains zero for most flood scenarios and reaches its maximum at the 350-year flood (a population of 35 in the Town of Penhold affected).

The population affected in Lacombe County remains zero for all flood scenarios.

The population affected in the Town of Penhold remains zero until the 200-year flood and then increases steadily between the 350-year and 1000-year floods.

For the City of Red Deer, the affected population remains low between the 2-year flood and the 100-year flood. A large increase in the affected areas occurs between the 100-year flood and the 350-year flood, when parts of Downtown south of 47th Street and the areas in Riverside Heavy Industrial Park east of Riverside Drive would be affected by flooding from Waskasoo Creek and Red Deer River, respectively. Another large increase occurs between the 750-year flood and 1000-year flood when the neighbourhoods of Waskasoo, Riverside Meadows (east of 54th Avenue), Riverside Light Industrial Park and Riverside Heavy Industrial Park would be increasingly affected.

For Red Deer County, the affected population remains zero between the 2-year flood and the 100-year flood and then increases steadily between the 200-year flood to the 1,000-year flood to a maximum of 40.

At the 100-year flood, a total population of 22 would be affected by direction inundation in the study area and no population would be potentially affected in the case of flood control structure failure. In comparison, a total population of 1,888 would be affected by direct flood inundation in the study area at the 1,000-year flood.

4.3 Design Flood Hazard Scenario

Flood statistics were generated for the design flood scenario using the flood hazard maps prepared as part of this study (Golder 2022b), and the results are presented in the following sections.

Neighbourhoods in the City of Red Deer affected by the design flood would include Riverside Meadows, Riverside Light Industrial Park, Riverside Heavy Industrial Park, Downtown and Capstone at Riverlands. Small parts of the Town of Penhold and some rural properties in Lacombe County and Red Deer County would also be located within the inundation extent of the design flood scenario. The land parcels, residential and non-residential buildings and population located within these areas would be affected by the design flood.

4.3.1 Land Parcels

A summary of affected land parcels is presented in Table 18, including the numbers for each local authority, as well as a breakdown of parcels located in the floodway, flood fringe (neither high hazard nor protected flood fringe), high hazard flood fringe and protected flood fringe.

Table 18: Affected Land Parcels – Design Flood Hazard Scenario

Scenario	Lacombe County	Town of Penhold	City of Red Deer	Red Deer County	Total
Floodway	1	0	33	9	**43**
Flood Fringe	1	4	44	13	**62**
High Hazard Flood Fringe	0	0	25	2	**27**
Protected Flood Fringe	0	1	0	0	**1**

For the design flood, there are 43 land parcels located in the floodway, 62 in the flood fringe, 27 in the high hazard flood fringe and 1 in the protected flood fringe.

4.3.2 Buildings and Infrastructure

4.3.2.1 Residential Buildings

A summary of affected residential buildings for each local authority is presented in Tables 19 to 22, including total number, as well as a breakdown of residential buildings located in the floodway, flood fringe (neither high hazard nor protected flood fringe), high hazard flood fringe and protected flood fringe.

Table 19: Affected Residential Buildings Lacombe County – Design Flood Hazard Scenario

Residential Category	Floodway	Flood Fringe	High Hazard Flood Fringe	Protected Flood Fringe
Multifamily	0	0	0	0
Single Family	0	0	0	0
Retirement Home	0	0	0	0
Total	**0**	**0**	**0**	**0**

Table 20: Affected Residential Buildings Town of Penhold – Design Flood Hazard Scenario

Residential Category	Floodway	Flood Fringe	High Hazard Flood Fringe	Protected Flood Fringe
Multifamily	0	0	0	0
Single Family	0	0	0	0
Retirement Home	0	0	0	0
Total	**0**	**0**	**0**	**0**

Table 21: Affected Residential Buildings City of Red Deer – Design Flood Hazard Scenario

Residential Category	Floodway	Flood Fringe	High Hazard Flood Fringe	Protected Flood Fringe
Multifamily	0	0	0	0
Single Family	0	6	0	0
Retirement Home	0	0	0	0
Total	**0**	**6**	**0**	**0**

Table 22: Affected Residential Buildings Red Deer County – Design Flood Hazard Scenario

Residential Category	Floodway	Flood Fringe	High Hazard Flood Fringe	Protected Flood Fringe
Multifamily	0	0	0	0
Single Family	0	0	0	0
Retirement Home	0	0	0	0
Total	**0**	**0**	**0**	**0**

For the design flood, there are a total 6 residential buildings located in the flood fringe in the study area.

4.3.2.2 Non-Residential Buildings

4.3.2.2.1 Summary

A summary of affected non-residential buildings for each local authority is presented in Tables 23 to 26, including the total number, as well as a breakdown of non-residential buildings located in the floodway, flood fringe (neither high hazard nor protected flood fringe), high hazard flood fringe and protected flood fringe.

Table 23: Affected Non-Residential Buildings Lacombe County – Design Flood Hazard Scenario

Non-Residential Category	Floodway	Flood Fringe	High Hazard Flood Fringe	Protected Flood Fringe
Commercial	0	0	0	0
Industrial	0	0	0	0
Government Building	0	0	0	0
Hospital	0	0	0	0
School	0	0	0	0
Water Treatment Facility	0	0	0	0
Other Non-Residential	0	0	0	0
Total	**0**	**0**	**0**	**0**

Table 24: Affected Non-Residential Buildings Town of Penhold – Design Flood Hazard Scenario

Non-Residential Category	Floodway	Flood Fringe	High Hazard Flood Fringe	Protected Flood Fringe
Commercial	0	0	0	0
Industrial	0	0	0	0
Government Building	0	0	0	0
Hospital	0	0	0	0
School	0	0	0	0
Water Treatment Facility	0	0	0	0
Other Non-Residential	0	0	0	0
Total	**0**	**0**	**0**	**0**

Table 25: Affected Non-Residential Buildings City of Red Deer – Design Flood Hazard Scenario

Non-Residential Category	Floodway	Flood Fringe	High Hazard Flood Fringe	Protected Flood Fringe
Commercial	0	5	2	0
Industrial	0	0	0	0
Government Building	0	0	0	0
Hospital	0	0	0	0
School	0	0	0	0
Water Treatment Facility	0	0	0	0
Wastewater Treatment Facility	0	0	0	1
Other Non-Residential	0	3	0	0
Total	**0**	**8**	**2**	**0**

Table 26: Affected Non-Residential Buildings Red Deer County – Design Flood Hazard Scenario

Non-Residential Category	Floodway	Flood Fringe	High Hazard Flood Fringe	Protected Flood Fringe
Commercial	0	0	0	0
Industrial	0	0	0	0
Government Building	0	0	0	0
Hospital	0	0	0	0
School	0	0	0	0
Water Treatment Facility	0	0	0	0
Other Non-Residential	0	0	0	0
Total	**0**	**0**	**0**	**0**

For the design flood, there are a total of 10 non-residential buildings located in the flood fringe in the study area

No schools would be affected by the design flood.

4.3.2.2.2 Government Buildings

None of the government buildings in the study area would be affected by the design flood.

4.3.2.2.3 Hospitals

None of the hospitals in the study area would be affected by the design flood.

4.3.2.2.4 Water and Wastewater Treatment Facilities

None of the water treatment facilities in the study area would be affected by the design flood. The Red Deer Wastewater Treatment Plant would be located in the protected flood fringe.

4.3.2.3 Major Transportation Infrastructure

4.3.2.3.1 Roads

A summary of affected roads is presented in Table 27, including total length, the length for each local authority, as well as a breakdown of roads located in the floodway, flood fringe (neither high hazard nor protected flood fringe), high hazard flood fringe and protected flood fringe.

Table 27: Lengths of Affected Roads – Design Flood Hazard Scenario

Scenario	Lacombe County	Town of Penhold	City of Red Deer	Red Deer County	Total
Floodway	0.0	0.0	0.9	0.5	**1.4**
Flood Fringe	0.0	0.1	3.6	1.1	**4.7**
High Hazard Flood Fringe	0.0	0.0	1.6	0.4	**2**
Protected Flood Fringe	0.0	0.0	0.0	0.0	**0**

Details on inundation of major roads within the City of Red Deer during the design flood are provided below:

- Riverside Drive between 67th Street and 49th Avenue, Taylor Drive south of the intersection with 43rd Street, as well as 45th Street, 51st Avenue, 49th Avenue, 48th Avenue – all located Downtown, are within in the flood fringe.
- 43rd Street between 48th Avenue and 49th Avenue, and Taylor Drive south of the intersection with 32nd Street are within the floodway.

In Red Deer County, Range Road 275 around the Waskasoo Creek crossing, Range Road 280 south of the Town of Penhold and Township Road 364 east of the Waskasoo Creek crossing are located in the flood fringe. Range Road 281 south of the intersection with Township Road 364 is located in the floodway.

For the design flood, a total length of 1.4 km of roads are located in the floodway, 4.7 km in the flood fringe and 2 km in the high hazard flood fringe in the study area.

4.3.2.3.2 Bridges/Culverts

A summary of bridge/culvert clearances for the design flood hazard scenario is provided in Table 28.

Table 28: Bridge/Culvert Clearances – Design Flood Hazard Scenario

River	Name	Minimum Low Chord / Road Surface Elevation (m)	Water Level (m)	Clearance[(a)] (m)
Red Deer River	CP Rail Bridge	865.90	862.04	3.86
Red Deer River	Red Deer Bypass (QE II Highway) Northbound and Southbound Bridges	866.70	861.97	4.73
Red Deer River	Heritage Ranch Pedestrian Bridge	863.90	858.16	5.74
Red Deer River	Taylor Drive Northbound and Southbound Bridges	862.40	855.30	7.10
Red Deer River	CP Rail (58 Street) Pedestrian Bridge	856.50	854.46	2.04
Red Deer River	50 Avenue (Gaetz Avenue) Bridge	856.60	854.10	2.50
Red Deer River	49 Avenue Bridge	858.50	853.85	4.65
Red Deer River	67 Street (David Thompson Highway) Bridge	858.90	851.23	7.67
Red Deer River	Riverbend (Discovery Canyon) Pedestrian Bridge	849.40	846.04	3.36
Piper Creek	Private Culvert	892.45	892.91	-0.46
Piper Creek	Range Road 272 Bridge	892.80	892.62	0.18
Piper Creek	40 Avenue Culvert	889.30	887.99	1.31
Piper Creek	Private Culvert	886.62	887.34	-0.72
Piper Creek	Private Culvert	886.43	886.85	-0.42

Table 28: Bridge/Culvert Clearances – Design Flood Hazard Scenario

River	Name	Minimum Low Chord / Road Surface Elevation (m)	Water Level (m)	Clearance[(a)] (m)
Piper Creek	Delburne Road (19 Street) Culvert	885.91	883.62	2.29
Piper Creek	Bannerman Close Pedestrian Bridge	880.00	879.12	0.88
Piper Creek	Bower Woods East-West Pedestrian Bridge	875.10	873.71	1.39
Piper Creek	Bower Woods North-South Pedestrian Bridge	873.80	871.80	2.00
Piper Creek	32 Street Bridge	870.20	868.95	1.25
Piper Creek	Kin Canyon South Pedestrian Bridge	867.40	866.58	0.82
Piper Creek	Kin Canyon North Bridge	864.70	864.32	0.38
Piper Creek	Rotary Picnic Park South Pedestrian Bridge	861.60	860.85	0.75
Piper Creek	Rotary Picnic Park North Pedestrian Bridge	860.20	859.22	0.98
Piper Creek	43 Street Culvert	857.10	857.78	-0.68
Waskasoo Creek	Range Road 281 Culvert	895.28	895.77	-0.49
Waskasoo Creek	Township Road 264 Bridge	895.20	895.52	-0.32
Waskasoo Creek	Private Culvert	894.03	895.13	-1.10
Waskasoo Creek	Private Culvert	893.40	894.49	-1.09
Waskasoo Creek	Range Road 280 Bridge	894.90	894.43	0.47
Waskasoo Creek	Highway 42 Bridge	893.80	893.60	0.20
Waskasoo Creek	Private Bridge	892.10	892.64	-0.54
Waskasoo Creek	Township Road 372 Bridge	892.20	892.23	-0.03
Waskasoo Creek	Private Bridge	891.50	892.03	-0.53
Waskasoo Creek	Private Culvert	889.70	890.57	-0.87
Waskasoo Creek	Highway 2A Bridge	890.70	890.29	0.41
Waskasoo Creek	CP Rail Bridge	891.20	890.02	1.18
Waskasoo Creek	Township Road 374 Bridge	890.00	889.47	0.53
Waskasoo Creek	CP Rail Bridge	889.30	888.87	0.43
Waskasoo Creek	Highway 2A Bridge	889.20	888.85	0.35
Waskasoo Creek	Private Bridge	888.00	888.39	-0.39
Waskasoo Creek	Private Bridge	887.80	887.84	-0.04
Waskasoo Creek	Lantern Street Bridge	887.30	887.20	0.10
Waskasoo Creek	Township Road 375 Bridge	887.30	886.35	0.95
Waskasoo Creek	Highway 2A Bridge	885.70	884.92	0.78
Waskasoo Creek	CP Rail Bridge	886.20	884.32	1.88
Waskasoo Creek	Range Road 275 Bridge	883.60	883.62	-0.02
Waskasoo Creek	Private Culvert	881.91	882.54	-0.63
Waskasoo Creek	Township Road 380 Bridge	880.90	880.63	0.27
Waskasoo Creek	Private Bridge	879.50	880.15	-0.65
Waskasoo Creek	Range Road 275 Bridge	878.00	879.89	-1.89
Waskasoo Creek	CP Rail Culvert	882.53	879.85	2.68

Table 28: Bridge/Culvert Clearances – Design Flood Hazard Scenario

River	Name	Minimum Low Chord / Road Surface Elevation (m)	Water Level (m)	Clearance[a] (m)
Waskasoo Creek	Highway 2 Bridge	878.40	878.94	-0.54
Waskasoo Creek	Private Bridge	876.50	877.20	-0.70
Waskasoo Creek	Taylor Drive Culvert	874.28	875.06	-0.78
Waskasoo Creek	32 Street Culvert	873.06	873.48	-0.42
Waskasoo Creek	34 Street Culvert	869.87	871.68	-1.81
Waskasoo Creek	ACR Trail South Pedestrian Bridge	866.70	865.97	0.73
Waskasoo Creek	ACR Trail North Pedestrian Bridge	865.10	864.35	0.75
Waskasoo Creek	43 Street Culvert	863.11	863.47	-0.36
Waskasoo Creek	52 Avenue & 45 Street Loop Culvert	860.31	859.71	0.60
Waskasoo Creek	50 Avenue (Gaetz Avenue) Bridge[b]	857.50	857.91	-0.41
Waskasoo Creek	49 Avenue Bridge	856.90	857.41	-0.51
Waskasoo Creek	48 Avenue Culvert	856.68	856.84	-0.16
Waskasoo Creek	Barett Park South Pedestrian Bridge	855.40	855.54	-0.14
Waskasoo Creek	Barrett Park North Pedestrian Bridge	854.80	855.07	-0.27
Waskasoo Creek	Ross Street Eastbound And Westbound Bridges	854.50	854.48	0.02
Waskasoo Creek	Coronation Park South Pedestrian Bridge	855.00	854.23	0.77
Waskasoo Creek	Coronation Park North Pedestrian Bridge	854.00	854.03	-0.03
Waskasoo Creek	53 Street Bridge	854.40	853.91	0.49
Waskasoo Creek	55 Street Bridge	853.40	853.79	-0.39
Waskasoo Creek	Gaetz Park Pedestrian Bridge	851.90	853.71	-1.81

a) The clearances for the 100-year design flood scenario are the elevation differences between bridge low chord or culvert road surface elevations and simulated water levels. A negative value indicates the water depth above the low chord for a bridge or above the road surface for a culvert.

b) The 50 Avenue (Gaetz Avenue) Bridge on the Waskasoo Creek was surveyed and modelled as a bridge in the Study. It is acknowledged that the City of Red Deer recognizes this structure as a culvert.

4.3.2.3.3 Railroads

None of the railroads in the study area would be affected by the design flood.

4.3.3 Population

A summary of affected population is presented in Table 29, including total number of people, the number for each local authority, as well as a breakdown of population in areas located in the floodway, flood fringe (neither high hazard nor protected flood fringe), high hazard flood fringe and protected flood fringe.

Table 29: Affected Population – Design Flood Hazard Scenario

Scenario	Lacombe County	Town of Penhold	City of Red Deer	Red Deer County	Total
Floodway	0	0	0	0	**0**
Flood Fringe	0	0	22	0	**22**
High Hazard Flood Fringe	0	0	0	0	**0**
Protected Flood Fringe	0	0	0	0	**0**

For the design flood, there are a total of 22 people located in the flood fringe in the study area.

5.0 CONCLUSIONS

The main results of the flood risk assessment for the open water floods in the study area are summarized below:

- The total numbers of land parcels, buildings and population, as well as the length of roads and railroads affected in the study area increase steadily from the 2-year flood to the 1,000-year flood. Most affected parcels, buildings and population are located in the City of Red Deer and the Town of Penhold. Most affected roads are located in the City of Red Deer and Red Deer County.
- A large increase in the affected areas occurs between the 100-year flood and the 350-year flood, when parts of Downtown Red Deer south of 47th Street and the areas in Riverside Heavy Industrial Park east of Riverside Drive in the City of Red Deer would be affected by flooding.
- Another large increase occurs between the 500-year flood and 1000-year flood when the neighbourhoods of Waskasoo, Riverside Meadows (east of 54th Avenue), Riverside Light Industrial Park and Riverside Heavy Industrial Park in the City of Red Deer would be affected.
- Between the 75-year flood and the 200-year flood the Red Deer Wastewater Treatment Plant is potentially affected by flood control structure failure inundation. Starting at the 350-year flood, the Red Deer Wastewater Treatment Plant is affected by direct inundation. Starting at the 350-year flood, the Red Deer Water Treatment Plant is affected by direct inundation. At the 1000-year flood one school in the City of Red Deer is affected by direct inundation. No other critical, non-residential buildings (i.e., government buildings, hospitals, schools, or water treatment facilities) in the study area will be affected under any other flood scenario.
- The length of roads affected by direct flood inundation and the total length of affected roads remain low between the 2-year flood and the 20-year flood and increase steadily from the 35-year flood to the 1,000-year floods. Some of the major roads that would be affected by floods in the City of Red Deer include the following:
  - Taylor Drive around the intersection with 32nd Street starting at the 50- year flood and at Capstone at Riverlands starting at the 350-year flood.
  - 51st Avenue Downtown starting at the 100-year flood.
  - 50th Street west of Ross Street Bridges starting at the 350-year flood.
  - 55th Street west of 55th Street Bridge starting at the 200-year flood.
  - 49th Avenue and 50th Avenue north of the Red Deer River crossing starting at the 1000-year flood.
- Some of the major roads that would be affected by floods in Red Deer County include the following:
  - Highway 2 (Red Deer Bypass) north of the Red Deer River crossing starting at the 750-year flood.
  - Highway 2A northeast of Highway 2A Bridge at the 1,000-year flood.

- No railroads would be affected by flood inundation until the 200-year flood. Starting at the 750-year flood, the CN Red Deer Industrial spur in the City of Red Deer and starting at the 350-year flood, the CP mainline (Calgary-Edmonton) in Red Deer County would be affected (around the Waskasoo Creek crossings).

The main results of the flood risk assessment for the design flood in the study area are summarized below:

- There are no buildings located in the floodway.
- There are 6 residential and 8 non-residential buildings located in the flood fringe, all in the City of Red Deer.
- There are 2 non-residential buildings located in the high hazard flood fringe, all in the City of Red Deer.
- There is no population located in floodway areas, and a total of 22 people located in the flood fringe area, all in the City of Red Deer.
- None of the water treatment facilities in the study area are affected by the design flood. The Red Deer Wastewater Treatment Plant would be located in the protected flood fringe.
- Some of the major roads that would be affected are 45th Street, 51st Avenue, 49th Avenue, and 48th Avenue which are located in Downtown, as well as Taylor Drive south of the intersection with 43rd Street and south of the intersection with 32nd Street, all in the City of Red Deer.
- None of the railroads would be affected by the design flood.

Signature Page

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https://golderassociates.sharepoint.com/sites/140764/project files/5 technical work/04_red deer/05_revision-late 2022/1-report and mapping updates/6-risk/reddeer_flood risk assessment and inventory report_rev2.docx

PERMIT TO PRACTICE
GOLDER ASSOCIATES LTD

RM SIGNATURE: _____

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DATE: _____

PERMIT NUMBER: P005122
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

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