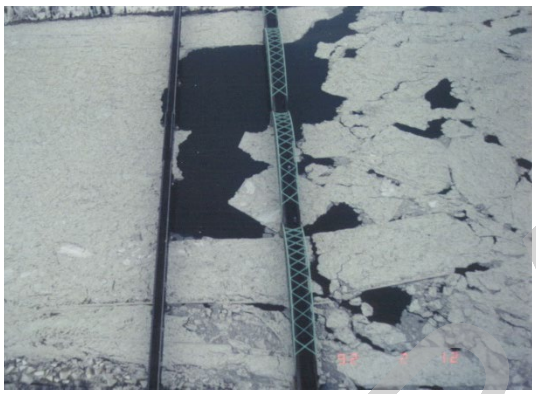
PEACE RIVER HAZARD STUDY

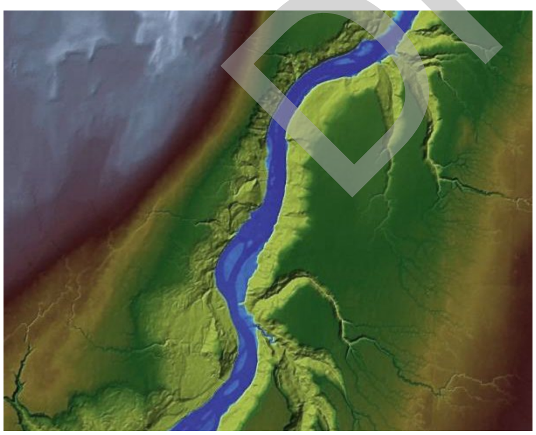
OPEN WATER FLOOD INUNDATION MAPPING

FINAL REPORT



Prepared for:

Alberta Environment and Parks



3 November 2017

(Revised 22 June 2020)

NHC Ref. No. 1001119

nhc
northwest hydraulic consultants
water resource specialists

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Prepared for:

Alberta Environment and Parks
Edmonton, Alberta

Prepared by:

Northwest Hydraulic Consultants Ltd.
Edmonton, Alberta

3 November 2017
(Revised 22 June 2020)

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APEGA Permit to Practice - P654

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DISCLAIMER

EXECUTIVE SUMMARY

Northwest Hydraulic Consultants Ltd. was retained in September 2015 by Alberta Environment and Parks to conduct a River Hazard Study for the Peace River through the Town of Peace River. The objectives of this River Hazard Study are to identify and assess river and flood-related hazards along 54 km of the Peace River, from about 6 km upstream of Shaftesbury Ferry to about 5 km downstream of the Highway 986 bridge, and along 1.2 km of the Heart River upstream of its confluence with the Peace River.

The Peace River Hazard Study has been structured into nine major project components. This report summarizes the work of the fourth component, *Open Water Flood Inundation Mapping*. The open water flood inundation map library is the key deliverable for this project component, provided as an appendix to this report.

This report summarizes the available data and methodology used to prepare the flood inundation maps. A total of 13 flood scenarios based on the calibrated open water flood frequency profiles were mapped individually for the 2-, 5-, 10-, 20-, 35-, 50-, 75-, 100-, 200-, 350-, 500-, 750-, and 1000-year events.

The open water flood inundation maps provide information that can be used by provincial and local authorities to assist in emergency preparedness planning for future flood events. Both direct and indirect inundation areas are indicated on the maps. Directly inundated areas are those that have overland connectivity to the actively flowing channel, including areas behind flood control structures that are overtopped. Indirectly inundated areas are those that may become inundated due to groundwater seepage, flooding of subsurface connections such as pipes and culverts, or potential failure of flood control structures prior to overtopping.

The flood control structures at the Town of Peace River are not expected to overtop for a 100-year return period flood; however, larger floods (i.e. the 200-year and greater) would be expected to cause overtopping. For such events, the Lower West Peace area would be inundated up to the base of the Shaftesbury Trail embankment. On the east side of the river, much of the townsite would be impacted, with the most extensive flooding occurring downstream of the Highway 2 bridges. The Lower West Peace area is shown as potentially flooded due to flood control structure failure for the 10- through 100-year flood scenarios and, likewise, the townsite on the east side of the river is potentially impacted for the 20- through 100-year flood scenarios. For the 200-year and larger flood scenarios, low-lying portions of Highway 684 show inundation from the Peace River above the Smoky River confluence. Also, low-lying portions of the rail line to the Daishowa (DMI) pulp mill site fall within the inundation extents for the 200-year and larger flood scenarios from approximately XS #14 to XS #11, upstream of the Highway 986 bridge.

CREDITS AND ACKNOWLEDGEMENTS

Northwest Hydraulic Consultants Ltd. would like to express appreciation to Alberta Environment and Parks (AEP) for initiating this project and making extensive background information available. The ongoing support and technical feedback from the AEP River Engineering and Technical Services Section team has been greatly appreciated throughout the project.

Project Managers for AEP were Nadia Kovachis Watson and Adam Minke. The following NHC personnel were part of the study team and participated in the open water flood inundation mapping component of the study:

- Dan Healy (Project Manager) – responsible for the overall direction of the project.
- Robyn Andrishak (Hydraulic Modelling and Inundation Mapping Lead) – author of this report and responsible for development of the open water flood inundation maps.
- Sarah North (GIS Specialist) – responsible for data management and documentation, conversion of hydraulic model results to flood extents, creation of base maps, and map production.
- Gary Van Der Vinne (Senior Technical Reviewer) – provided senior review input and advice.

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1 INTRODUCTION

1.1 Study Objectives

The overall objectives of the Peace River Hazard Study are to identify and assess river and flood hazards along the Peace and Heart rivers through the Town of Peace River (TPR). The study is being completed 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. The intent is to reduce potential future flood damage and disaster assistance costs to the federal, provincial, and local governments, including First Nations. New floodplain maps will inform land use planning decisions, assist with developing flood mitigation options and facilitate emergency response planning.

The Peace River Hazard Study has been structured into the following major project components.

1) Survey and Base Data Collection
2) Open Water Hydrology Assessment
3) Hydraulic Model Creation and Calibration
4) Open Water Flood Inundation Map Production
5) Open Water Flood Hazard Identification
6) Ice Jam Modelling Assessment and Flood Hazard Identification
7) Governing Design Flood Hazard Map Production
8) Flood Risk Assessment and Inventory
9) Channel Stability Investigation

This report summarizes the work of the fourth component – ***Open Water Flood Inundation Map Production***. The primary tasks, services, and deliverables associated with this report are:

- Open water flood inundation map production;
- Flood water surface TIN development; and
- Flood depth grid creation.

The open water flood inundation maps are a key component of the overall study and support the flood risk assessment and inventory.

1.2 Study Area and Reach

The Peace River flows into northwestern Alberta from British Columbia, passing through TPR, which is located about 380 km northwest of Edmonton. The extent of the contributing basin for the study reach is shown in **Figure 1**. Peace River flows are regulated by BC Hydro for hydropower production at Bennett Dam and Peace Canyon (PCN) Dam. The primary storage unit that enables regulation is Williston Lake, the reservoir created by Bennett Dam, which has sufficient capacity to provide multi-year storage of inflows.

The study reach consists of a 54 km segment of the Peace River beginning at the west boundary of 1-82-24-W5M about 6 km upstream of the Shaftesbury Ferry crossing (Highway 740) to the north boundary of 24-85-21-W5M about 5 km downstream of the Highway 986 bridge. The location of the study reach is shown in **Figure 1.** TPR is the most developed and populated area along this reach of the Peace River. Also included in the study area is a 1.2 km reach of the Heart River upstream of its confluence with the Peace River and a limited reach of the Smoky River near its confluence with the Peace River. Study limits are shown in **Figure 2**.

2 AVAILABLE DATA

The open water flood inundation maps were prepared using information compiled for previous components of the Peace River Hazard Study. Descriptions of the data used for this flood inundation mapping study component are provided below.

2.1 Flood Frequencies

An open water hydrology assessment of the Peace River was conducted as part the Peace River Hazard Study (refer to the ***Open Water Hydrology Assessment*** report provided under separate cover), which included estimates for both regulated and naturalized flows on the Peace River. The study reach was divided into three sub-reaches of interest:

- Peace River above the Smoky River confluence.
- Peace River below the Smoky River confluence.
- Heart River at the mouth.

Table 1 summarizes the naturalized flood frequency discharges from the 2- to 1000-year floods, with associated probabilities of exceedance in any given year indicated.

Table 1 Naturalized flood frequency discharge estimates for the Peace and Heart rivers

Return Period (Years)	Probability of Exceedance in Any Given Year (%)	Naturalized Flood Frequency Discharge (m^3/s)		
		Peace River above Smoky River Confluence	Peace River below Smoky River Confluence	Heart River at the Mouth
1,000	0.10	19,600	31,600	317
750	0.13	19,000	30,100	305
500	0.20	18,200	28,100	289
350	0.29	17,500	26,400	274
200	0.50	16,500	23,900	252
100	1.0	15,200	21,100	224
75	1.3	14,700	20,100	212
50	2.0	13,900	18,600	195
35	2.9	13,300	17,400	180
20	5.0	12,300	15,600	157
10	10	11,100	13,500	127
5	20	9,770	11,600	96
2	50	7,850	9,050	49

Regulated flood peaks were not used when generating open water flood inundation maps for the study in accordance with the terms of reference and FHIP guidelines. The Log-Pearson III distribution was used to define the flood frequencies on the Peace River and the Pearson III distribution was used on the Heart River.

2.2 DTM and Aerial Imagery

2.2.1 LiDAR-Derived DTM

A 0.5 m resolution, bare earth, digital terrain model (DTM) based on airborne LiDAR data was supplied by AEP for this study. The DTM was based on data collected by Airborne Imaging on 7 October 2015 (Airborne Imaging, 2016). A complete description of the digital terrain model data and its comparison to the ground survey data can be found in Section 4.1 of the ***Survey and Base Data Collection*** report, provided under separate cover.

The DTM, supplied in GeoTIF format tiles, was used to derive flood depth grids as described in Sections 3 and 4 of this report. LiDAR sensors have limited penetration of water, so the LiDAR-derived DTM does not represent bathymetric elevations for submerged portions of river beds or other water features.

2.2.2 Aerial Imagery

ORTHOSHOP Geomatics Ltd. (OGL) completed acquisition of new aerial imagery on 3 May 2016 and used this imagery to generate colour-balanced orthorectified mosaics. Details of the aerial imagery acquisition and data processing procedures can be found in Appendix G of the ***Survey and Base Data Collection*** report, provided under separate cover.

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 calibrated HEC-RAS model was developed for the 54.1 km study reach of the Peace River and 1.1 km study reach of the Heart River. In total, 54 cross sections along the Peace River and 27 cross sections along the Heart River were specified. For details see the ***Hydraulic Model Creation and Calibration*** report, provided under separate cover.

The calibrated hydraulic model was used to generate flood frequency profiles for the thirteen naturalized open water floods of varying magnitude listed in **Table 1**. The computed flood frequency water levels at each surveyed cross section on the Peace River are provided in **Table 2**. Computed flood frequency water levels for the Heart River are provided in **Table 3**.

Table 2 Computed flood frequency water levels – Peace River

Cross Section	Flood Return Period						
	2-year	5-year	10-year	20-year	35-year	50-year	75-year
	Water Surface Elevation (m)						
XS #54	325.29	326.14	326.69	327.14	327.54	327.78	328.10
XS #53	324.60	325.44	326.02	326.49	326.90	327.15	327.48
XS #52	324.14	324.98	325.54	326.01	326.41	326.66	326.98
XS #51	323.84	324.68	325.23	325.70	326.10	326.35	326.66
XS #50	323.42	324.20	324.71	325.16	325.55	325.79	326.09
XS #49	323.13	323.91	324.42	324.88	325.28	325.53	325.84
XS #48	322.68	323.50	324.05	324.54	324.97	325.23	325.57
XS #47	322.29	323.13	323.69	324.20	324.65	324.92	325.26
XS #46	322.05	322.90	323.47	324.00	324.44	324.73	325.07
XS #45	321.51	322.40	323.02	323.59	324.07	324.37	324.74
XS #44	321.12	321.94	322.51	323.07	323.54	323.83	324.19
XS #43	320.67	321.51	322.10	322.69	323.19	323.50	323.87
XS #42	320.25	321.09	321.68	322.30	322.81	323.14	323.51
XS #41	319.69	320.52	321.14	321.82	322.37	322.71	323.11
XS #40	319.25	320.07	320.68	321.40	321.96	322.32	322.72
XS #39	318.98	319.80	320.43	321.18	321.77	322.14	322.55
XS #38	318.55	319.44	320.11	320.94	321.56	321.96	322.39
XS #37	317.57	318.56	319.30	320.28	320.99	321.42	321.88
XS #36	317.49	318.50	319.24	320.21	320.90	321.33	321.78
XS #35	317.10	318.11	318.84	319.85	320.58	321.02	321.48
XS #34	316.88	317.94	318.72	319.79	320.52	320.97	321.44
XS #33	316.54	317.60	318.35	319.34	320.08	320.54	321.03
XS #32	316.23	317.25	317.96	318.77	319.44	319.86	320.33
XS #31	316.03	317.03	317.72	318.52	319.17	319.60	320.06
XS #30	315.88	316.86	317.55	318.35	318.99	319.42	319.87
XS #29	315.65	316.60	317.26	318.04	318.66	319.07	319.51
XS #28	315.59	316.54	317.21	317.99	318.62	319.03	319.47
XS #27	315.36	316.30	316.97	317.74	318.36	318.77	319.20
XS #26	315.35	316.29	316.96	317.73	318.35	318.76	319.20
XS #25	315.35	316.29	316.95	317.72	318.35	318.75	319.19
XS #24	315.32	316.25	316.90	317.66	318.28	318.68	319.12
XS #23	315.29	316.23	316.89	317.67	318.30	318.70	319.15

Table 2 Computed flood frequency water levels – Peace River (continued)

Cross Section	Flood Return Period					
	100-year	200-year	350-year	500-year	750-year	1000-year
	Water Surface Elevation (m)					
XS #54	328.30	328.83	329.24	329.53	329.85	330.09
XS #53	327.69	328.23	328.65	328.95	329.29	329.54
XS #52	327.18	327.72	328.14	328.44	328.78	329.04
XS #51	326.87	327.41	327.83	328.14	328.48	328.74
XS #50	326.29	326.83	327.25	327.55	327.90	328.16
XS #49	326.04	326.61	327.04	327.36	327.72	328.00
XS #48	325.78	326.40	326.87	327.21	327.60	327.91
XS #47	325.49	326.13	326.61	326.96	327.36	327.66
XS #46	325.31	325.95	326.45	326.80	327.21	327.52
XS #45	324.99	325.67	326.19	326.56	326.99	327.31
XS #44	324.44	325.13	325.66	326.05	326.50	326.83
XS #43	324.12	324.86	325.42	325.82	326.29	326.64
XS #42	323.78	324.54	325.12	325.53	326.01	326.37
XS #41	323.38	324.19	324.80	325.24	325.74	326.12
XS #40	323.00	323.84	324.45	324.90	325.41	325.80
XS #39	322.84	323.71	324.34	324.80	325.33	325.72
XS #38	322.69	323.59	324.25	324.72	325.27	325.67
XS #37	322.20	323.15	323.83	324.31	324.86	325.26
XS #36	322.10	323.04	323.70	324.17	324.71	325.11
XS #35	321.81	322.78	323.45	323.92	324.47	324.87
XS #34	321.77	322.75	323.43	323.91	324.45	324.86
XS #33	321.38	322.40	323.08	323.57	324.13	324.54
XS #32	320.66	321.65	322.29	322.74	323.27	323.66
XS #31	320.38	321.37	321.99	322.45	322.97	323.35
XS #30	320.20	321.20	321.82	322.27	322.80	323.19
XS #29	319.82	320.78	321.37	321.79	322.28	322.64
XS #28	319.79	320.76	321.35	321.77	322.26	322.63
XS #27	319.52	320.48	321.06	321.48	321.96	322.32
XS #26	319.51	320.48	321.06	321.48	321.96	322.32
XS #25	319.51	320.48	321.06	321.48	321.96	322.32
XS #24	319.43	320.38	320.95	321.36	321.83	322.18
XS #23	319.46	320.43	321.02	321.44	321.93	322.29

Table 2 Computed flood frequency water levels – Peace River (continued)

Cross Section	Flood Return Period						
	2-year	5-year	10-year	20-year	35-year	50-year	75-year
	Water Surface Elevation (m)						
XS #22	315.25	316.21	316.90	317.69	318.34	318.76	319.22
XS #21	315.08	316.09	316.79	317.61	318.27	318.71	319.18
XS #20	314.90	315.90	316.61	317.45	318.14	318.58	319.07
XS #19	314.60	315.61	316.32	317.12	317.76	318.17	318.62
XS #18	314.29	315.40	316.15	316.97	317.63	318.04	318.50
XS #17	313.79	314.96	315.74	316.59	317.25	317.68	318.14
XS #16	313.46	314.65	315.44	316.29	316.96	317.39	317.85
XS #15	313.13	314.31	315.09	315.94	316.61	317.04	317.51
XS #14	312.62	313.82	314.62	315.46	316.13	316.55	317.01
XS #13	312.42	313.62	314.41	315.25	315.92	316.34	316.80
XS #12	311.99	313.19	313.97	314.80	315.46	315.88	316.33
XS #11	311.67	312.88	313.67	314.50	315.17	315.58	316.04
XS #10	311.42	312.67	313.49	314.34	315.02	315.45	315.92
XS #9	311.05	312.26	313.05	313.87	314.51	314.92	315.35
XS #8	310.81	312.04	312.85	313.68	314.33	314.74	315.19
XS #7	310.76	311.99	312.78	313.60	314.25	314.66	315.10
XS #6	310.53	311.75	312.54	313.35	314.00	314.40	314.84
XS #5	310.39	311.60	312.37	313.17	313.80	314.20	314.63
XS #4	310.17	311.36	312.12	312.91	313.53	313.92	314.34
XS #3	309.86	311.06	311.83	312.63	313.26	313.66	314.08
XS #2	309.54	310.77	311.56	312.38	313.02	313.43	313.87
XS #1	309.10	310.31	311.09	311.90	312.54	312.95	313.38

Table 2 Computed flood frequency water levels – Peace River (continued)

Cross Section	Flood Return Period					
	100-year	200-year	350-year	500-year	750-year	1000-year
	Water Surface Elevation (m)					
XS #22	319.54	320.54	321.15	321.59	322.09	322.47
XS #21	319.51	320.52	321.14	321.59	322.11	322.49
XS #20	319.41	320.45	321.08	321.54	322.06	322.45
XS #19	318.95	319.93	320.60	321.10	321.66	322.08
XS #18	318.84	319.72	320.41	320.91	321.48	321.90
XS #17	318.47	319.36	320.05	320.55	321.12	321.53
XS #16	318.18	319.07	319.76	320.25	320.82	321.24
XS #15	317.85	318.73	319.43	319.92	320.49	320.91
XS #14	317.35	318.25	318.93	319.43	320.00	320.41
XS #13	317.14	318.02	318.71	319.20	319.77	320.18
XS #12	316.66	317.53	318.21	318.69	319.25	319.65
XS #11	316.37	317.25	317.92	318.41	318.97	319.37
XS #10	316.26	317.16	317.87	318.37	318.95	319.37
XS #9	315.67	316.53	317.19	317.67	318.21	318.61
XS #8	315.51	316.37	317.04	317.53	318.08	318.48
XS #7	315.42	316.27	316.92	317.39	317.93	318.32
XS #6	315.16	316.01	316.66	317.13	317.66	318.05
XS #5	314.94	315.77	316.40	316.86	317.38	317.76
XS #4	314.64	315.46	316.08	316.53	317.04	317.42
XS #3	314.39	315.22	315.85	316.31	316.84	317.22
XS #2	314.18	315.03	315.69	316.16	316.70	317.09
XS #1	313.69	314.53	315.18	315.64	316.17	316.56

Table 3 Computed flood frequency water levels – Heart River

Cross Section	Flood Return Period						
	2-year	5-year	10-year	20-year	35-year	50-year	75-year
	Water Surface Elevation (m)						
XS #81	319.33	319.92	320.26	320.48	320.63	320.76	320.97
XS #80	318.86	319.46	319.78	320.01	320.24	320.45	320.73
XS #79	318.52	319.06	319.38	319.74	320.10	320.36	320.68
XS #78	318.14	318.67	319.05	319.53	319.95	320.24	320.56
XS #77	317.70	318.33	318.80	319.36	319.82	320.13	320.49
XS #76	317.42	318.12	318.64	319.25	319.74	320.07	320.44
XS #75	317.19	317.92	318.48	319.13	319.66	320.02	320.41
XS #74	317.10	317.83	318.40	319.06	319.61	319.98	320.38
XS #73	317.02	317.72	318.29	318.96	319.53	319.92	320.34
XS #72	316.73	317.55	318.18	318.89	319.48	319.89	320.32
XS #71	316.54	317.48	318.13	318.86	319.46	319.86	320.29
XS #70	316.45	317.44	318.09	318.83	319.44	319.84	320.28
XS #69	316.30	317.30	317.96	318.71	319.34	319.75	320.21
XS #68	316.25	317.27	317.94	318.70	319.32	319.74	320.20
XS #67	316.21	317.23	317.90	318.67	319.30	319.72	320.18
XS #66	316.19	317.21	317.89	318.66	319.29	319.72	320.18
XS #65	316.06	317.06	317.73	318.52	319.16	319.60	320.06
XS #64	316.05	317.05	317.73	318.52	319.16	319.60	320.06
XS #63	316.03	317.05	317.74	318.53	319.18	319.62	320.09
XS #62	316.02	317.03	317.72	318.52	319.17	319.60	320.07
XS #61	315.99	317.00	317.69	318.50	319.15	319.59	320.06
XS #60	315.99	316.99	317.69	318.49	319.15	319.59	320.06
XS #59	315.98	316.99	317.68	318.48	319.11	319.54	320.00
XS #58	315.97	316.96	317.65	318.45	319.09	319.52	319.98
XS #57	315.96	316.96	317.65	318.44	319.08	319.51	319.97
XS #56	315.96	316.95	317.64	318.44	319.08	319.51	319.97
XS #55	315.96	316.95	317.64	318.44	319.08	319.51	319.97

Table 3 Computed flood frequency water levels – Heart River (continued)

Cross Section	Flood Return Period					
	100-year	200-year	350-year	500-year	750-year	1000-year
	Water Surface Elevation (m)					
XS #81	321.14	321.79	322.28	322.65	323.12	323.47
XS #80	320.95	321.70	322.22	322.61	323.08	323.43
XS #79	320.91	321.70	322.22	322.61	323.08	323.43
XS #78	320.82	321.65	322.19	322.58	323.06	323.42
XS #77	320.77	321.62	322.17	322.57	323.05	323.41
XS #76	320.72	321.59	322.14	322.54	323.03	323.39
XS #75	320.70	321.58	322.14	322.54	323.03	323.39
XS #74	320.68	321.57	322.13	322.53	323.03	323.39
XS #73	320.64	321.55	322.11	322.52	323.01	323.37
XS #72	320.62	321.54	322.11	322.51	323.01	323.37
XS #71	320.60	321.52	322.09	322.50	323.00	323.36
XS #70	320.58	321.52	322.09	322.50	323.00	323.36
XS #69	320.53	321.49	322.07	322.49	322.99	323.35
XS #68	320.52	321.49	322.07	322.48	322.98	323.35
XS #67	320.51	321.47	322.06	322.47	322.98	323.34
XS #66	320.50	321.46	322.04	322.46	322.96	323.33
XS #65	320.39	321.35	321.92	322.36	322.88	323.26
XS #64	320.39	321.36	321.93	322.37	322.89	323.27
XS #63	320.41	321.38	321.95	322.39	322.91	323.28
XS #62	320.40	321.37	321.95	322.38	322.90	323.28
XS #61	320.39	321.36	321.94	322.38	322.90	323.28
XS #60	320.39	321.36	321.94	322.38	322.90	323.28
XS #59	320.32	321.31	321.92	322.37	322.90	323.27
XS #58	320.29	321.29	321.91	322.36	322.89	323.27
XS #57	320.29	321.29	321.91	322.36	322.89	323.27
XS #56	320.29	321.29	321.91	322.36	322.89	323.27
XS #55	320.29	321.29	321.91	322.36	322.89	323.27

2.4 Flood Control Structures

A system of flood control dykes was constructed at TPR after the open water flood of 1972. The extents of the flood control dykes are shown on **Figure 3**. The flood control dyke on the right (east) bank of the river protects a large portion of downtown TPR extending both upstream and downstream of the Highway 2 bridge, from the water treatment plant to 109 Avenue. Following the 1990 flood, the open guardrail on the Heart River Bridge in downtown Peace River was replaced with a solid concrete wall and integrated into the surrounding flood control dyke system that ties into high ground near the valley wall on both sides of the Heart River. The Lower West Peace neighbourhood is also enclosed by a flood control dyke along the left (west) bank of the Peace River.

A small earthen berm extends along the right bank of the Heart River through Twelve Foot Davis Park. Detailed records are not available for this structure, although it was likely constructed to provide some measure of flood protection for the park site.

3 FLOOD INUNDATION MAPS

Flood inundation mapping shows areas of ground that could be covered by water under one or more flood scenarios for existing conditions. For this study, one flood inundation map series was created for each of the flood frequency return period scenarios described in Section 2.1. Additional information concerning the flood inundation map production is provided below.

3.1 Methodology

The existing, calibrated HEC-RAS model was used to generate water surface elevations for each flood scenario to be mapped, and the supplied DTM was used to determine the inundated areas for each flood scenario. Cross section lines were prepared in ArcGIS as follows to support the flood inundation mapping:

- An attribute field containing the water surface elevation for each of the flood scenarios was populated using the values from **Table 2** and **Table 3**.
- Left and right endpoints were extended outward, as needed, so that straight lines connecting the endpoints of adjacent cross sections remained outside the 1000-year flood extents.

A boundary polygon was generated that enclosed all of the cross sections; this polygon defined the clipping extents for inundated areas. Automated routines were then used to complete the following tasks in ArcGIS for each of the flood scenarios:

- A triangular irregular network (TIN) representing a continuous water surface elevation (WSE) profile along the study reach was generated for each flood scenario, based on the computed WSE at each cross section; between cross sections, WSE was linearly interpolated.
- The WSE TIN was converted to a tiled set of preliminary WSE grids. The WSE grid tiles matched the alignment and horizontal resolution of the LiDAR-derived bare earth DTM tiles supplied by AEP.
- Each bare earth DTM grid tile was subtracted from the corresponding WSE grid tile to generate a tiled set of flood depth grids. Grid cells with depth values less than 0 m, which represent dry areas, were assigned a value of *NoData*.
- Based on the depth grids, all areas with depths greater than 0 m were converted to inundation polygons. A simplification was applied in the raster to polygon conversion, so that the polygon boundaries do not exactly follow the edge of each raster cell.
- Filtering was used to remove isolated inundation areas smaller than 100 m^2. Holes less than 100 m^2 in area were also removed from the inundation extents.

The resulting inundation polygons were then reviewed to identify direct overtopping in overbank areas, as described in the Section 3.2. An adjusted version of the WSE TIN was created to reflect any edits made, and the above steps were repeated to produce adjusted WSE grids, depth grids, and inundation polygons.

The adjusted inundation polygons were smoothed in ArcGIS. A *PAEK* smoothing algorithm was applied with a 20 m tolerance. This allowed for an inundation boundary that is smoothed, but remains very similar to the original inundation polygon output. The smoothed inundation polygons were further reviewed in ArcGIS and classified to identify inundation of isolated areas and areas of potential flood control structure failure.

The final smoothed inundation extent polygons were used to clip the WSE grid tiles. The resulting WSE grids have *NoData* values for all dry areas, but retain WSE values wherever inundation is shown.

GIS deliverables include (for each flood scenario):

- Model cross sections with computed open water flood frequency levels attached as attributes (polyline layer in Esri file geodatabase format).
- Preliminary WSE TIN, based directly on calibrated HEC-RAS model results (Esri TIN format).
- Adjusted WSE TIN, including adjustments to account for direct overtopping in overbank areas (Esri TIN format).
- Tiled flood depth grids (Esri file geodatabase grid feature class format).
- Smoothed flood inundation extent polygons, with polygons classified as inundation extents, isolated areas, or potential flood control structure failure areas (polygon layer in Esri file geodatabase format).
- Tiled WSE grids, clipped to the inundation extent polygons (Esri file geodatabase grid feature class format).

3.2 Direct Flood Inundation Areas

Direct flood inundation areas were identified as either being part of the actively-flowing river channel or flooded overbank areas connected to the actively-flowing river channel. Areas showing extensive overbank flooding directly connected to the channel at one distinct location (overtopping point) were adjusted such that the water surface elevation across that area was set equal to the water surface elevation at the overtopping point. This generally reduced the size of the inundated area extending upstream of an overtopping point and increased the size of the inundated area extending downstream of the overtopping point. In a few instances, these adjustments resulted in a new overtopping point forming downstream. In these cases, the water surface elevations in the overbank area were re-adjusted such that they were interpolated linearly between the upstream overtopping point and the ground elevation at the new downstream overtopping point.

All adjustments were made to the water surface TINs so that inundation polygons could be re-generated from the data using the procedure described in Section 3.1 above.

3.3 Indirect Flood Inundation Areas

Indirect flood inundation areas were identified as having ground elevations below the water surface but no direct overland connection to the actively flowing river channel based on the surrounding topography. Two types of indirect flood inundation areas were identified for mapping purposes: isolated areas and areas of potential flooding due to flood control structure failure.

3.3.1 Inundation of Isolated Areas

Isolated areas, mapped using water surface elevations interpolated between cross sections, could potentially become inundated during a flood due to subsurface flow through porous media or flooding of buried pipes and culverts. Inundated areas behind embankments not identified as dedicated flood control structures, such as roads, railways, and berms, were considered isolated areas.

3.3.2 Inundation Due to Potential Flood Control Structure Failure

The identified flood control structures provide protection for the Town of Peace River. For a given flood scenario, the area behind the flood control structure was shown as inundated due to potential failure of the structure when the water surface elevation was higher than the ground elevation behind the flood control structure and water surface elevations did not indicate overtopping of a flood control structure. This does not imply failure of flood protection structures is expected to occur.

For conditions where water surface elevations overtopped portions of a flood control structure, the areas behind the flood control structures were mapped as direct flood inundation areas.

In either case, the inundation extent of the protected area was determined by extending the water surface elevation from the main channel into the area behind the flood control structure.

3.4 Areas Affected by Flooding

3.4.1 Flooding of Residential Areas

The majority of residential buildings fall outside the direct flood inundation extents up to the 100-year flood scenario; however, many buildings at the Peace River townsite on the east and west sides of the river are protected by the existing flood control structures. Potential failure of those structures would result in flooding of numerous structures on the west side of the river for the 10-year and larger flood scenarios and along the east side for the 20-year and larger flood scenarios.

Further details regarding impacted structures are provided with the ***Flood Risk Assessment and Inventory*** report provided under separate cover.

3.4.2 Flooding of Commercial and Industrial Areas

Existing commercial and light industrial buildings on the east side of the Peace River within the main Peace River townsite are outside the direct flood inundation extents up to the 100-year flood scenario due to the system of flood control dykes. For 20-year and larger events, a number of these buildings would be potentially impacted by failure of the flood control structures. Also, low-lying portions of the rail line to the Daishowa (DMI) pulp mill site fall within the inundation extents for the 200-year and larger flood scenarios from approximately XS #14 to XS #11, upstream of the Highway 986 bridge. For the 200-year and larger flood scenarios, low-lying portions of Highway 684 show inundation from the Peace River above the Smoky River confluence, which may impact access to the Correctional Centre and Shaftesbury Ferry crossing site.

Further details regarding impacted structures are provided with the ***Flood Risk Assessment and Inventory*** report provided under separate cover.

3.4.3 Flooding of Bridges and Culverts

Bridges crossing the Peace River in the study area are each above the 1000-year flood level and are not expected to be impacted. Along the Heart River, the low chord of the 101 Street bridge is just above the 10-year flood level but due to modifications that integrated the structure into the existing system of flood control dykes, the bridge deck would only be subject to direct inundation for events larger than the 100-year flood scenario. The two pedestrian bridges crossing the Heart River are also expected to become flooded for events larger than the 100-year flood scenario. The rail bridge crossing the Heart River is situated well above the 1000-year flood level.

4 WATER SURFACE ELEVATION GRIDS

Water surface elevation grids were prepared for each flood scenario and provided with the GIS deliverables for this study component, along with the WSE TINs, flood depth grids, and inundation extent polygons. A description of the water surface elevation grids is provided below.

4.1 Water Surface Elevation Grid Specifications

For each of the flood scenarios, the adjusted WSE TINs described in Section 3.1 were converted to a tiled set of WSE grids matching the alignment, horizontal resolution, and tiling boundaries of the LiDAR-derived DTM supplied by AEP. Water surface elevations in metres are provided as 32-bit floating point grid cell values. The WSE grids at this stage were used to compute the flood depth grids, as described in Section 5.1.

As a final step, the inundation extent polygons generated from the flood depth grids were used to clip the WSE grids such that a value of *NoData* is provided for all dry areas and the water surface elevation values are indicated only where inundation is shown.

4.2 General Comments

WSE grids are provided for information only. Grid cell values are based on linear interpolation between cross sections in the hydraulic model, and as such, discrete cell values should be considered approximate. Since the adjusted WSE grids have been clipped using the smoothed inundation extent polygons, water's edge boundaries implied by the raster WSE grids correspond to the inundation extent boundaries presented on the inundation maps.

5 FLOOD DEPTH GRIDS

Flood depth grids were prepared for each flood scenario and provided with the GIS deliverables for this study component, along with the WSE TINs, WSE grids, and inundation extent polygons. A description of the flood depth grids is provided below.

5.1 Flood Depth Grid Specifications

For each of the flood scenarios, each bare earth DTM grid tile was subtracted from the corresponding adjusted WSE grid tile (prior to clipping) to generate a set of flood depth grid tiles representing water depth in metres as 32-bit floating point values. All flood depth grids maintained the same alignment, horizontal resolution, and tiling boundaries as the LiDAR-derived bare earth DTM supplied by AEP. Grid cells with depth values less than 0 m, which represent dry areas, were assigned a value of *NoData*.

5.2 General Comments

The flood depth grids are provided for information only. Grid values are based on linear interpolation of water surface elevations between cross sections in the hydraulic model, and as such, discrete cell values should be considered approximate. Water's edge boundaries implied by the raster depth grids may deviate slightly from the inundation extent boundaries presented on the inundation maps. This is because the depth grids are computed by subtracting the bare earth DTM grids from the adjusted water surface grids, whereas the mapped inundation extent boundaries, which were derived from the depth grids, have been further filtered and smoothed as discussed in Section 3.1.

Also, since the LiDAR-derived DTM indicates the approximate water surface elevation at the time of the LiDAR survey for submerged portions of river beds and other ground covered by water, depth values in those areas should not be considered accurate. Elsewhere, the depth grids may be used for many purposes, such as to identify areas in the floodplain that exceed a specified depth criteria. For example, these data were used to delineate the non-encroached 1 m depth contour to support flood hazard identification for this study.

6 CONCLUSIONS

The objectives of this study were to assess river and flood-related hazards along a 54 km reach of the Peace river and a 1.1 km reach of the Heart River that includes the Town of Peace River. The Peace River Hazard Study was divided into nine major project components. This report summarizes the work of the ***Open Water Flood Inundation Map Production*** component, for which flood frequency water levels have been superimposed on the digital terrain model of the study area as described throughout this report. The reports for the three previous work components mentioned above should also be read in conjunction with this report, as they provide additional pertinent background information.

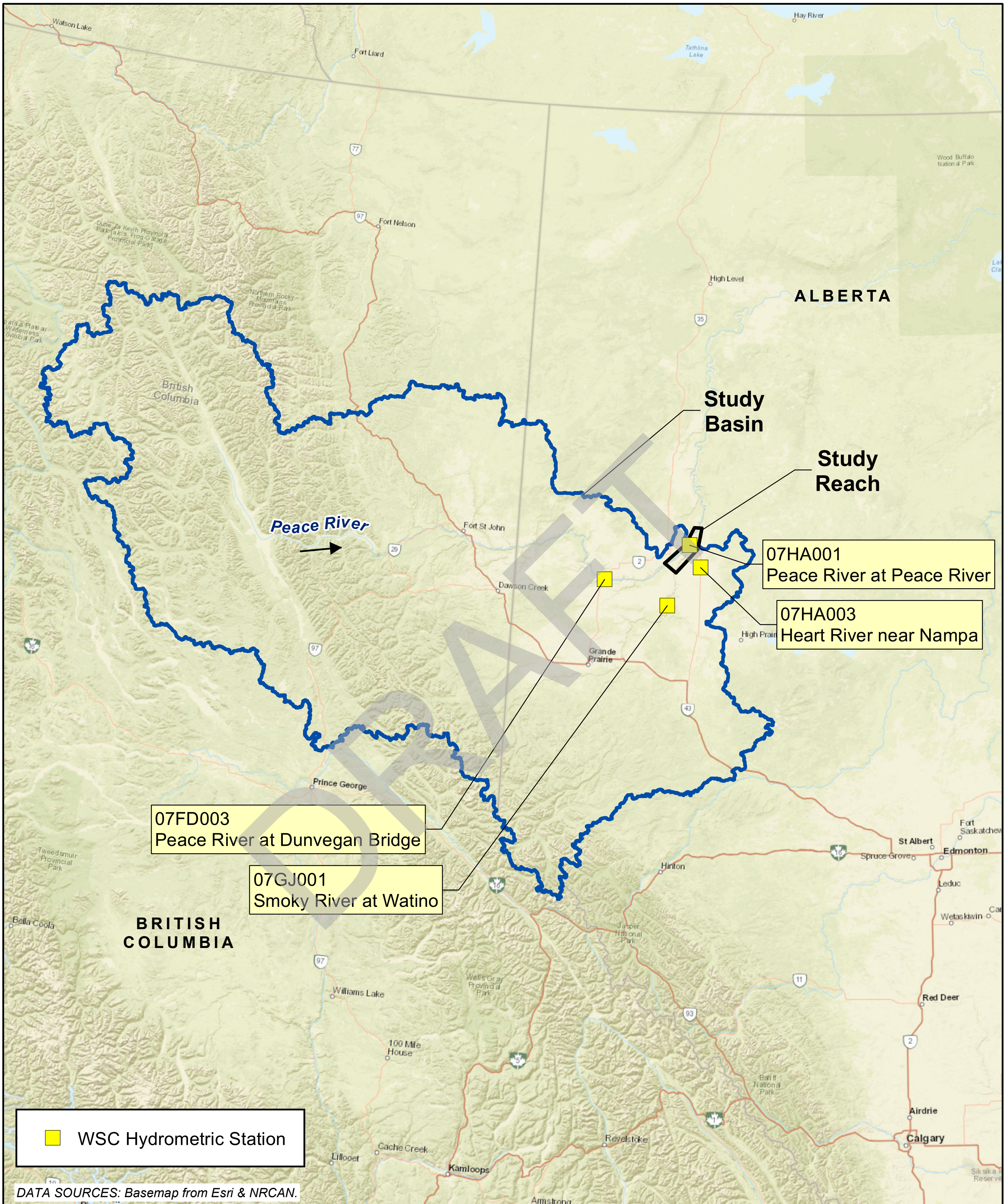
The majority of residential, commercial, and industrial buildings fall outside the direct flood inundation extents up to the 100-year flood scenario; however, many buildings at the Peace River townsite on the east and west sides of the river are protected by the existing flood control structures. Potential failure of those structures would result in flooding of numerous structures on the west side of the river for the 10-year and larger flood scenarios and along the east side for the 20-year and larger flood scenarios.

Bridges crossing the Peace River in the study area are each above the 1000-year flood level and are not expected to be impacted. Along the Heart River, bridge decks should only be subject to direct inundation for events larger than the 100-year flood scenario, except for the rail bridge which is situated well above the 1000-year flood level. For the 200-year and larger flood scenarios, low-lying portions of Highway 684 show inundation from the Peace River above the Smoky River confluence. Also, low-lying portions of the rail line to the Daishowa (DMI) pulp mill site fall within the inundation extents for the 200-year and larger flood scenarios from approximately XS #14 to XS #11, upstream of the Highway 986 bridge.

7 REFERENCES

Airborne Imaging. 2016. 13215_BowPeace 2015 DTM Creation Report, dated March 24, 2016.

Figures



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SCALE - 1:5,000,000

0 100 200 KM

N

Coordinate System: NAD 1983 CSRS 10TM AEP FOREST
Units: METRES

Job: 1001119 | Date: 19-OCT-2017

PEACE RIVER HAZARD STUDY

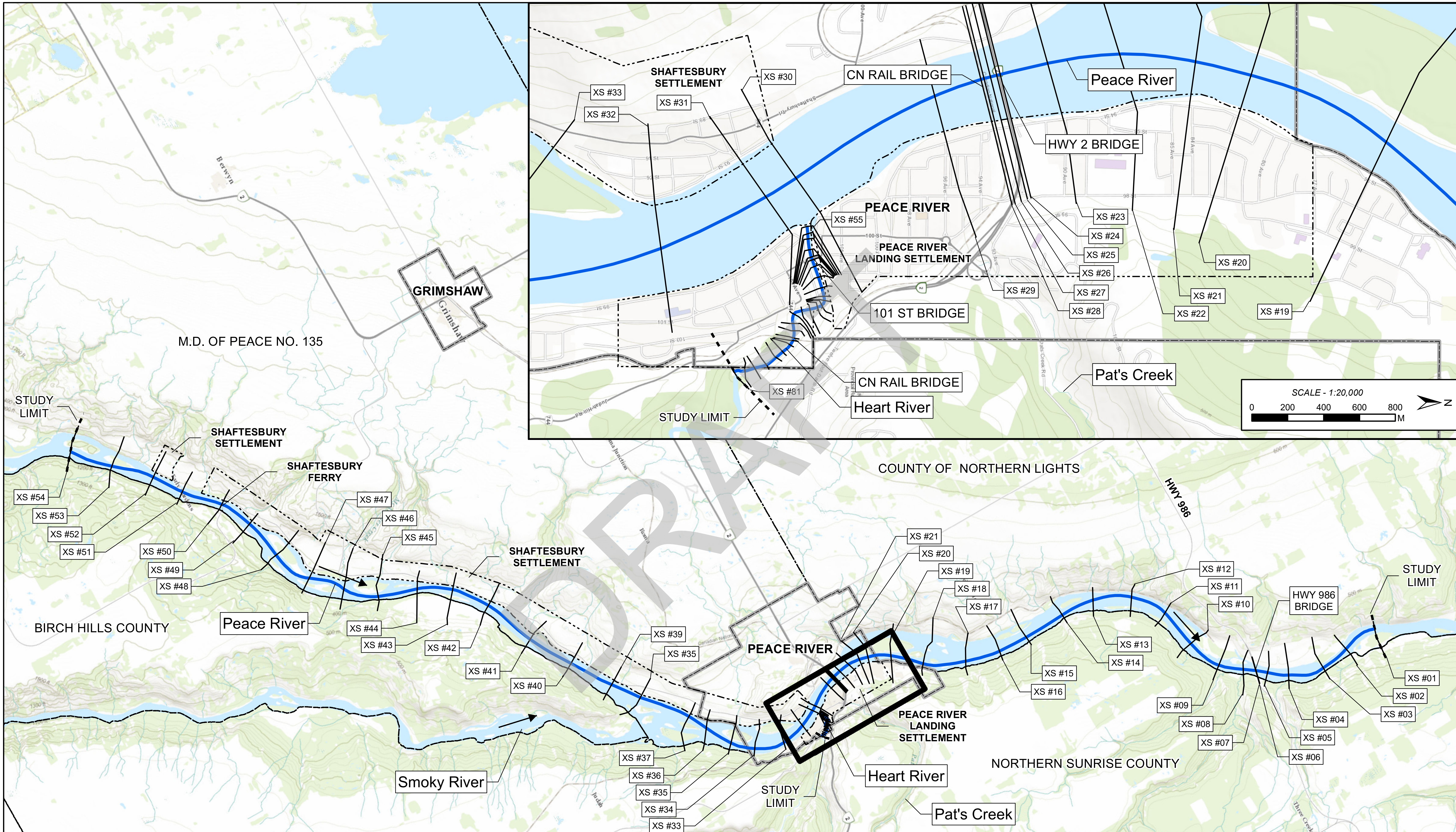
OPEN WATER FLOOD INUNDATION MAPPING

LOCATION MAP

FIGURE 1

MSN, \\mainfile-van\Projects\Active\1001119 Peace River Flood Hazard Study\GIS\1001119_MSN_Fig_T400_LocnMap1.mxd

Classification: Public



Model Stream Network
Model Cross Section
Settlement
Town
County or Municipal District

DATA SOURCES: Basemap from Esri & NRCAN.

SCALE - 1:130,000

0 1 2 3 4 5 KM

Coordinate System: NAD 1983 CSRS 3TM 117
Units: METRES

Job: 1001119 Date: 19-OCT-2017

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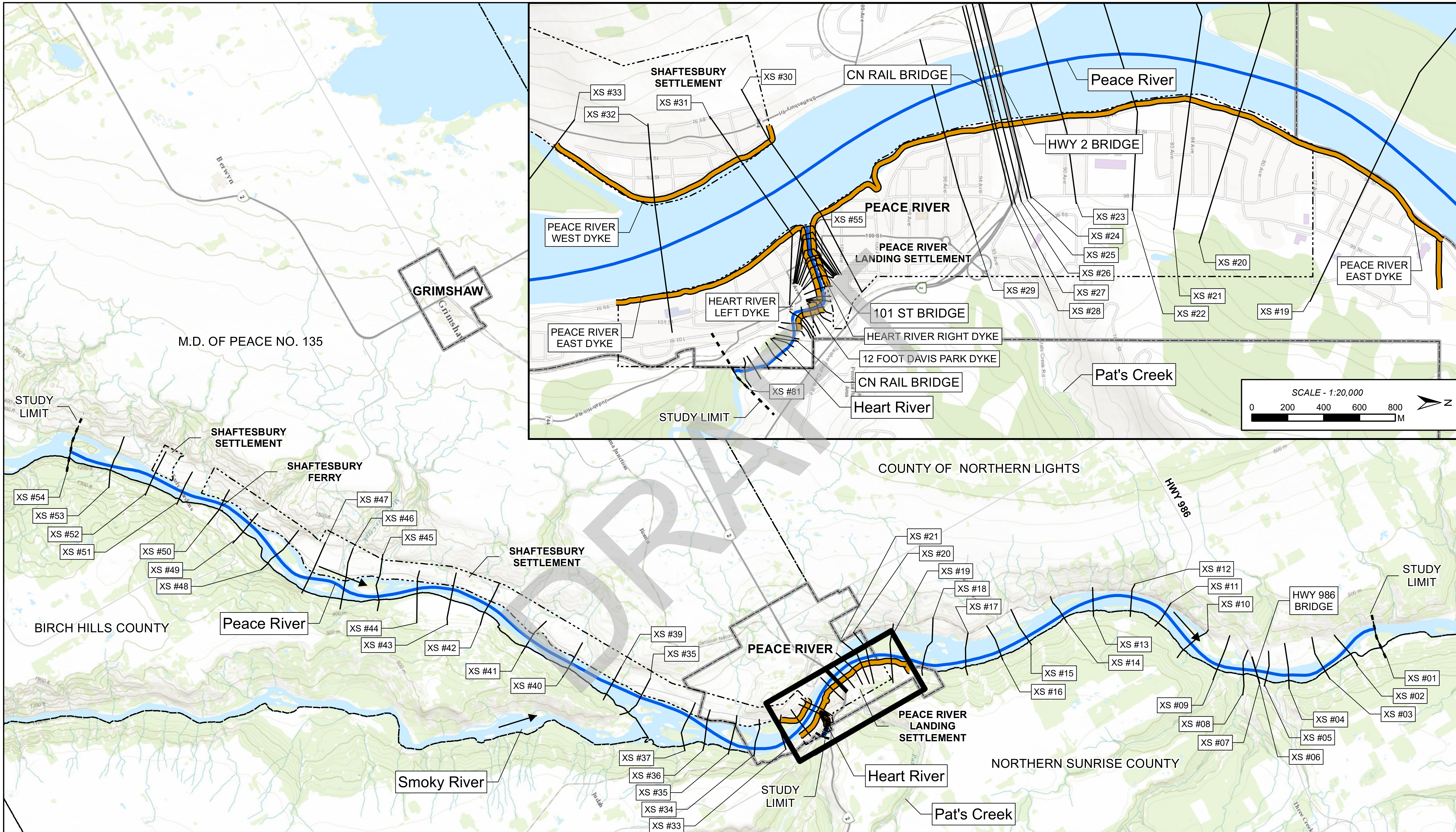
PEACE RIVER HAZARD STUDY
OPEN WATER FLOOD INUNDATION MAPPING
STUDY AREA

FIGURE 2



Model Stream Network
Model Cross Section
Flood Control Structure
Settlement
Town
County or Municipal District

DATA SOURCES: Basemap from Esri & NRCAN.

SCALE - 1:130,000

0 1 2 3 4 5 KM

Coordinate System: NAD 1983 CSRS 3TM 117
Units: METRES

Job: 1001119 *Date: 19-OCT-2017*

PEACE RIVER HAZARD STUDY

OPEN WATER FLOOD INUNDATION MAPPING

FLOOD CONTROL STRUCTURE LOCATIONS AND EXTENTS

FIGURE 3

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Classification: Public

Appendix A
Open Water Flood Inundation Map Library