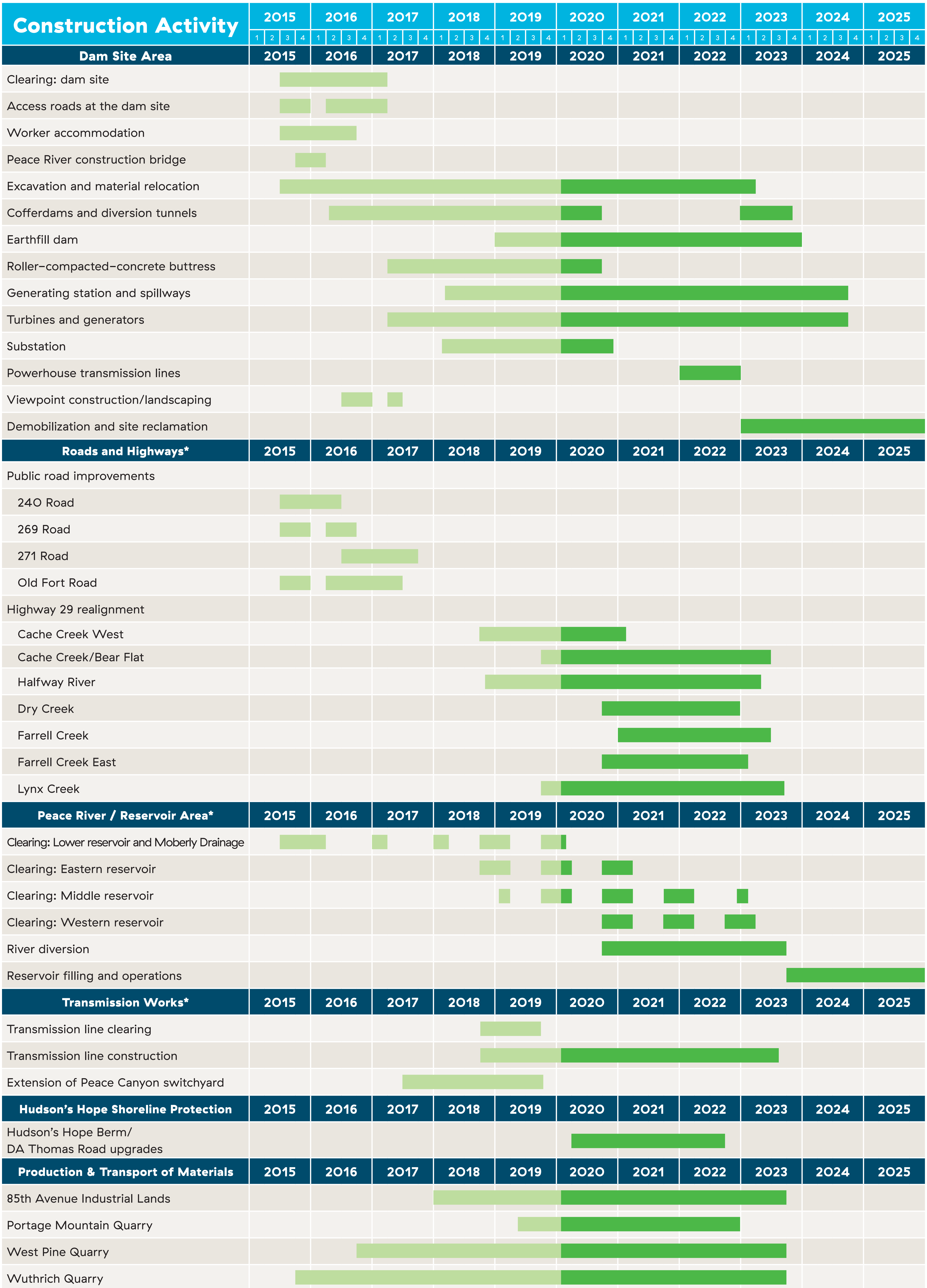
Appendix 1. Site C Clean Energy Project Construction Schedule

Site C Construction Schedule

February 2020
BCH20-176



The construction schedule is indicative only and subject to change. The purpose of the schedule is to illustrate the general sequence of construction activities, but the dates and schedule may change.

* Timelines do not include site preparation or wood disposal.

BC Hydro
Power smart

Appendix 2. Breeding Bird Follow-up Monitoring – Songbirds 2020 Annual Report

Site C Clean Energy Project
Breeding Bird Follow-up Monitoring – Songbirds
2020 Annual Report



PRESENTED TO

BC Hydro and Power Authority

MARCH 22, 2021
ISSUED FOR USE
FILE: 704-ENV.VENV03095-01.SONG-2020
REVISION 1

Saulteau EBA Environmental Services Joint Venture
Suite 1000 – 10th Floor, 885 Dunsmuir Street
Vancouver, BC V6C 1N5 CANADA
Tel 604.685.0275 Fax 604.684.6241

Site C Clean Energy Project Breeding Bird Follow-Up Monitoring - Songbirds 2020 Annual Report

FILE: 704-ENV.VENV03095-01.SONG-2020
March 22, 2021

PRESENTED TO

Site C Clean Energy Project
BC Hydro and Power Authority
P.O. Box 49260
Vancouver, BC V7X 1V5

PRESENTED BY

Saulteau EBA Environmental Services Joint Venture
1000-885 Dunsmuir Street
Vancouver, BC V6E 3X2
P +1-604-685-0275

Prepared by:

FILE: 704-ENV.VENV03095-01.SONG-2020
FILE: 704-ENV.VENV03095-01.SONG-2020

Jeff Matheson, M.Sc., R.P.Bio. **2021-03-22**
Senior Biologist

Prepared by:

FILE: 704-ENV.VENV03095-01.SONG-2020
FILE: 704-ENV.VENV03095-01.SONG-2020

Elyse Hofs, B.Sc., Dipl.T **2021-03-22**
Junior Biologist

EXECUTIVE SUMMARY

Saulteau EBA Environmental Services Joint Venture (SEES JV) completed breeding bird point count surveys in the area of BC Hydro and Power Authority's (BC Hydro) Site C Clean Energy Project ("Site C", the Project) in spring and summer 2020. The surveys were part of BC Hydro's Breeding Bird Follow-up Monitoring Program for songbirds[1]. Songbirds are passerines, hummingbirds, swifts, doves, kingfisher, and pigeons (i.e., all members of the orders *Passeriformes*, *Apodiformes*, *Columbiformes*, and *Coraciiformes*). Songbird baseline surveys were conducted in 2006, 2008, 2011 and 2012. Surveys were again conducted in 2016, 2017, 2018, 2019 and 2020 as part of the follow-up monitoring program. This report describes the methods used to conduct the 2020 surveys and a summary of the results.

Surveys were conducted June 4-26, 2020 at 97 stations in the Peace River valley and around the Project footprint. Each station was surveyed two times to maximize the detection of early and late breeders. Birds were surveyed using unlimited radius point counts.

A total of 87 bird species were detected, of which 71 were songbirds. Six species listed under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), the *Species at Risk Act* (SARA) and/or British Columbia's Red and Blue lists were observed during the surveys. The median number of songbird species detected per point count survey was 8 (range 3 to 18).

Surveys conducted in 2020 represent an initial establishment of semi-permanent monitoring stations that will be monitored through to 10 years post-construction.

[1] Woodpecker and Common Nighthawk surveys are also included under BC Hydro's Breeding Bird Follow-up Monitoring Program.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

1.0 INTRODUCTION

Saulteau EBA Environmental Services Joint Venture (SEES JV) completed breeding bird point count surveys in the area of BC Hydro and Power Authority's (BC Hydro) Site C Clean Energy Project ("Site C", the Project) in spring and summer 2020. The surveys were part of BC Hydro's Breeding Bird Follow-up Monitoring Program for songbirds[2]. Songbirds are passerines, hummingbirds, swifts, doves, kingfisher, and pigeons (i.e., all members of the orders *Passeriformes*, *Apodiformes*, *Columbiformes*, and *Coraciiformes*). Songbird baseline surveys were conducted in 2006, 2008, 2011 and 2012. Surveys were again conducted in 2016, 2017, 2018, 2019 and 2020 as part of the follow-up monitoring program.

The objectives of the Breeding Bird Follow-up Monitoring Program for songbirds are to:

1. Determine the distribution and abundance of songbirds within habitat lost or otherwise affected by the Project to verify the predictions made in the Environmental Impact statement (EIS).
2. Identify species-habitat relationships to help identify areas for offsetting impacts.
3. Conduct effectiveness monitoring to determine the degree to which mitigation areas offset impacts to songbirds and their habitat and determine further songbird mitigation requirements.
4. Determine changes to the songbird community in the Peace River valley (to 10 years post-construction).

The annual report prepared in 2019 (SEES JV 2019) provided an analysis of the data collected 2006-2019 in support of objectives 1 and 2. Mitigation areas (currently the Marl Fen, Rutledge and Wilder Creek properties) were comprehensively surveyed in 2016 and 2017. BC Hydro intends to conduct the next comprehensive surveys of the mitigation properties when the reservoir has been inundated or when there are land use changes or habitat modification in the mitigation properties, whichever occur first. The point count data obtained from surveys in 2020 were primarily in support of objective 4 and will form part of the long-term monitoring data to assess changes in the songbird community over time (baseline to 10 years post-construction).

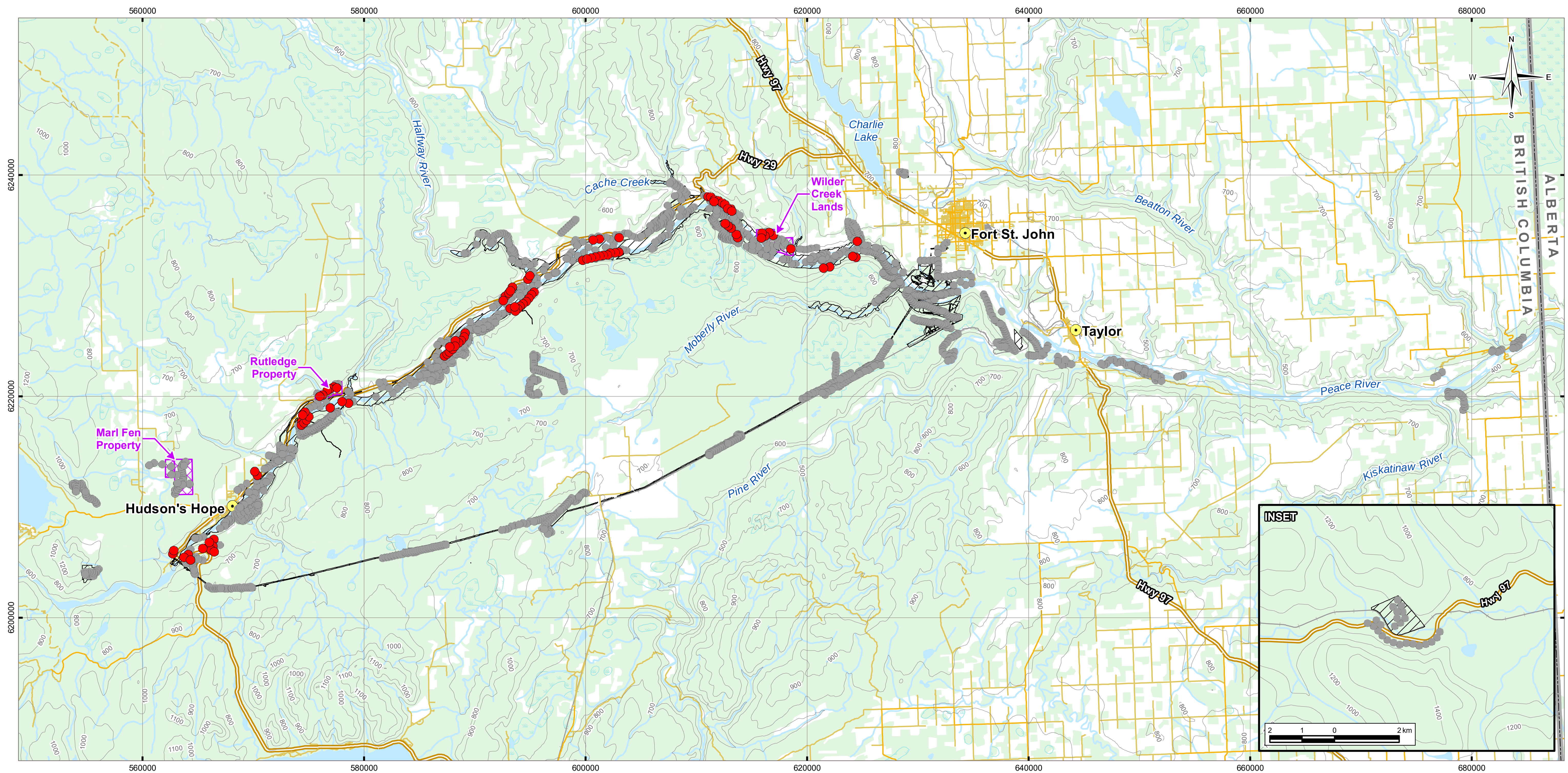
2.0 METHODS

2.1 Survey Locations

Point counts for baseline and the follow-up monitoring program have been conducted throughout the Peace River valley (and its tributaries) and in the adjacent plateau areas, both inside and outside the Project footprint (Figure 1). Clearing of the dam site area was completed in 2016. Clearing of the reservoir commenced in 2017 and has incrementally progressed westward from the dam site in each year. By May 2020, most portions of the reservoir footprint along the Peace River from the dam site to the mouth of the Halfway River including the Moberly River and Cache Creek reservoir footprints had been cleared [3]. Point counts in 2020 were predominantly located outside the reservoir footprint, while still remaining within the Peace River valley (or its major tributaries).

[2] Woodpecker and Common Nighthawk surveys are also included under BC Hydro's Breeding Bird Follow-up Monitoring Program.

[3] The Watson Slough area along Highway 29 remains largely uncleared, with clearing planned the winter of 2022/2023.

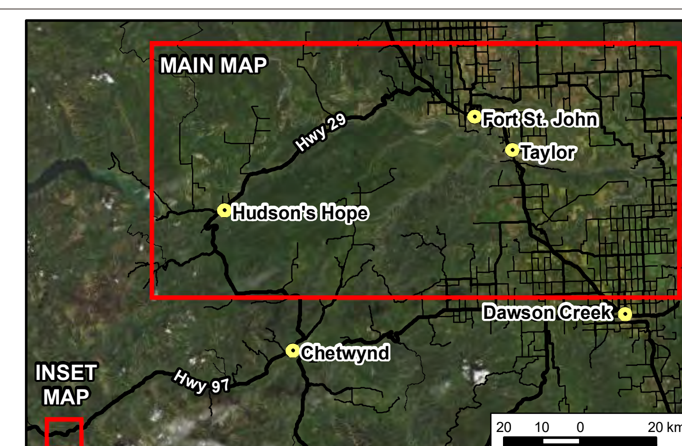


LEGEND

Songbird Survey Locations

Survey Year

- 2020
- 2006 to 2019
- Project Footprint
- Potential Mitigation Property
- Populated Place
- Highway
- Main Road
- Local Road
- Resource/Recreational Road
- Railway
- Residential Area
- Contour (100 m)
- Watercourse
- Waterbody
- Wetland
- Wooded Area
- Provincial Boundary



NOTES

Base data source: CanVec 1:250,000.

STATUS

ISSUED FOR USE

SITE C SONGBIRD 2020 ANNUAL REPORT

Songbird Survey Locations

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	BC hydro

Scale: 1:350,000

5 2.5 0 5

Kilometres

FILE NO.
PENW03042-01_Fig01_SONG_Overview.mxd

TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	YL	JM	0

DATE December 16, 2020

PROJECT NO. ENW.PENW03042-01

Figure 1

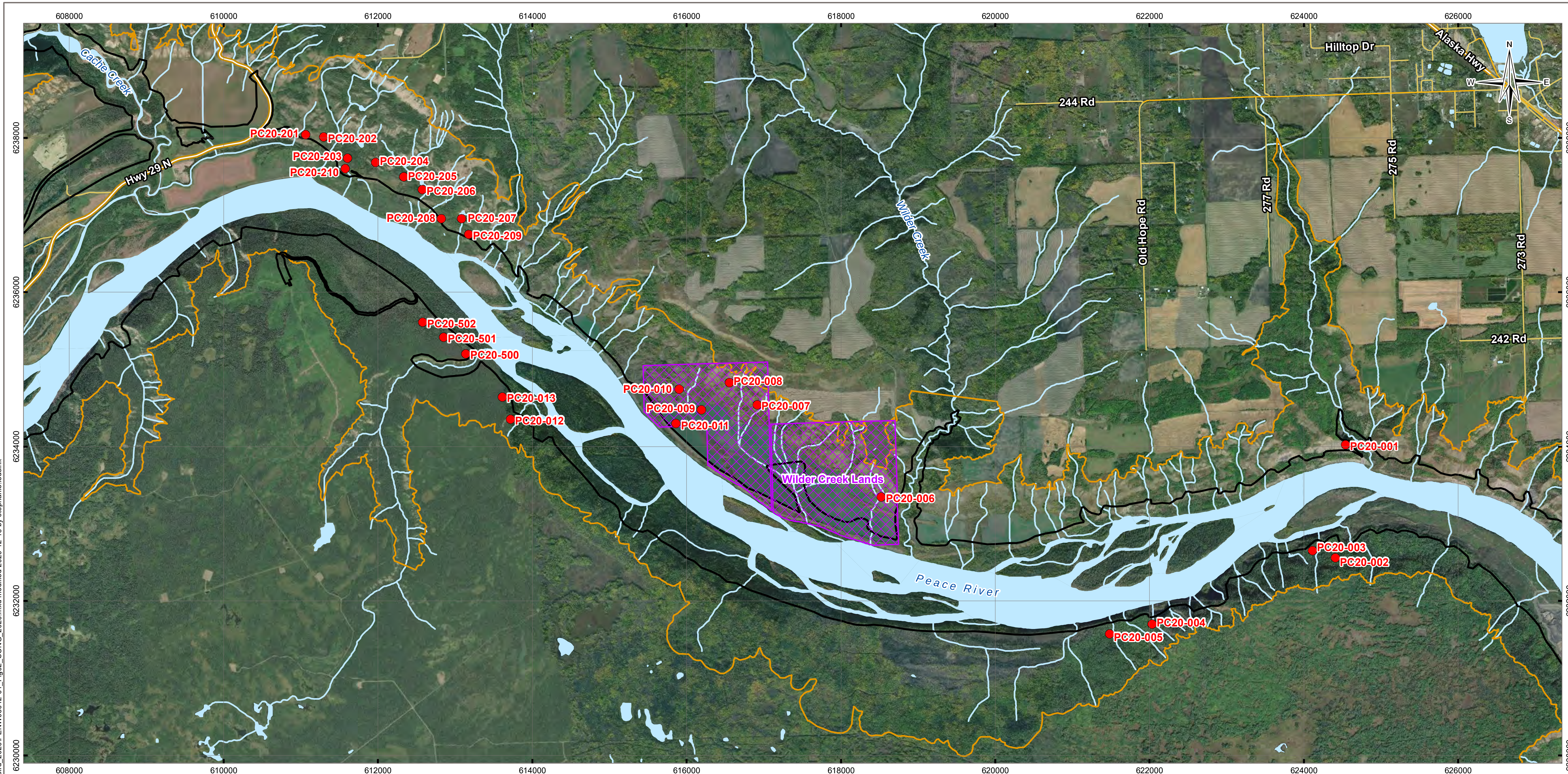
Q:\Vancouver\GIS\ENVIRONMENTAL\PENW\PENW03042-01\Maps\Songbird_2020\PENW03042-01_Fig01_SONG_Overview.mxd modified 2020-12-16 by stephanie.leusink

An initial list of 90 candidate survey stations were randomly located within the Peace River valley outside the reservoir footprint in accessible areas (slopes that can be traversed on foot) and stratified by bird habitat class in proportion to mapped area of each class in the Peace River valley (see Section 3.0 for classes). Some survey stations were located within the Rutledge and Wilder Creek mitigation properties as these two properties are within the Peace River valley (the Marl Fen property is located outside the Peace River valley). Candidate locations were then manually adjusted to be 100 m from a habitat edge (e.g. forest-wetland transition) where possible and some locations were linked to form a sequence of survey locations that can be visited on foot. To allow for sampling of all bird habitat classes, some stations were located within uncleared portions of the footprint west of the Halfway River for bird habitat classes that do not exist outside the footprint (e.g., riparian forest that currently only exists in the valley bottom footprint). Some pre-selected survey stations could not be surveyed or could be surveyed only once due to accessibility issues or disturbance. New survey stations were selected as replacements. In 2020, 194 point count surveys were conducted at 97 stations (Figures 2a to 2d).

2.2 Point Count Surveys

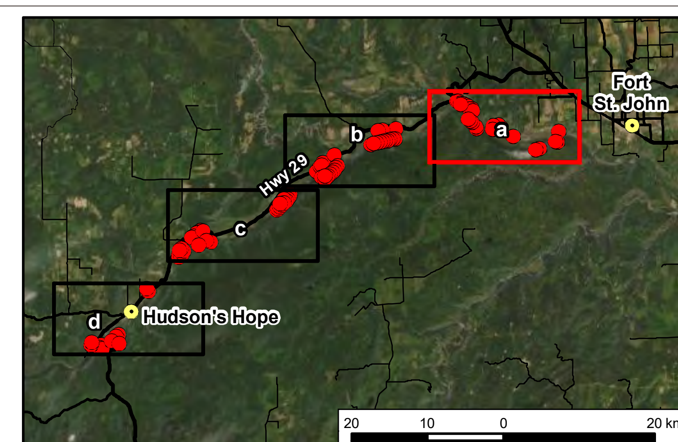
Point count surveys were conducted as unlimited radius point counts with distance-to-detection intervals set at 0-50 m, 51-100 m and >100 m. Each point count survey was conducted over ten minutes and bird detections were recorded in three intervals: 0-3 minutes, 3-5 minutes and 5-10 minutes. Point counts were conducted June 4-26, 2020. Point counts took place from sunrise to approximately four hours after sunrise. After arriving at each station, the surveyor waited one minute, then commenced the 10-minute survey period and recorded all birds seen and/or heard. Data were recorded on a standardized data form. Each station was surveyed (visited) two times, with at least two weeks between visits, to maximize the detection of early and late breeders.

Incidental observations were recorded when non-songbird species were observed during surveys, or when any bird species listed under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) or *Species at Risk Act* (SARA) were observed outside of survey stations (e.g., when surveyors were traveling between stations) or survey periods (e.g. before or after daily observations have started/finished). For each incidental observation, date, time, GPS location, gender, behavior and habitat were recorded.



LEGEND

- 2020 Songbird Survey Location
- Project Footprint
- Potential Mitigation Property
- Peace River Valley
- Highway
- Main Road
- Local Road
- Watercourse
- Waterbody



NOTES
Base data source:
CanVec 1:50,000 (2019)
Imagery from ESRI; Maxar

STATUS
ISSUED FOR USE

SITE C SONGBIRD 2020 ANNUAL REPORT

2020 Songbird Survey Locations

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	BC hydro

Scale: 1:50,000
1 0.5 0 1
Kilometres

FILE NO.
PENW03042-01_Fig02_SONG_2020.mxd

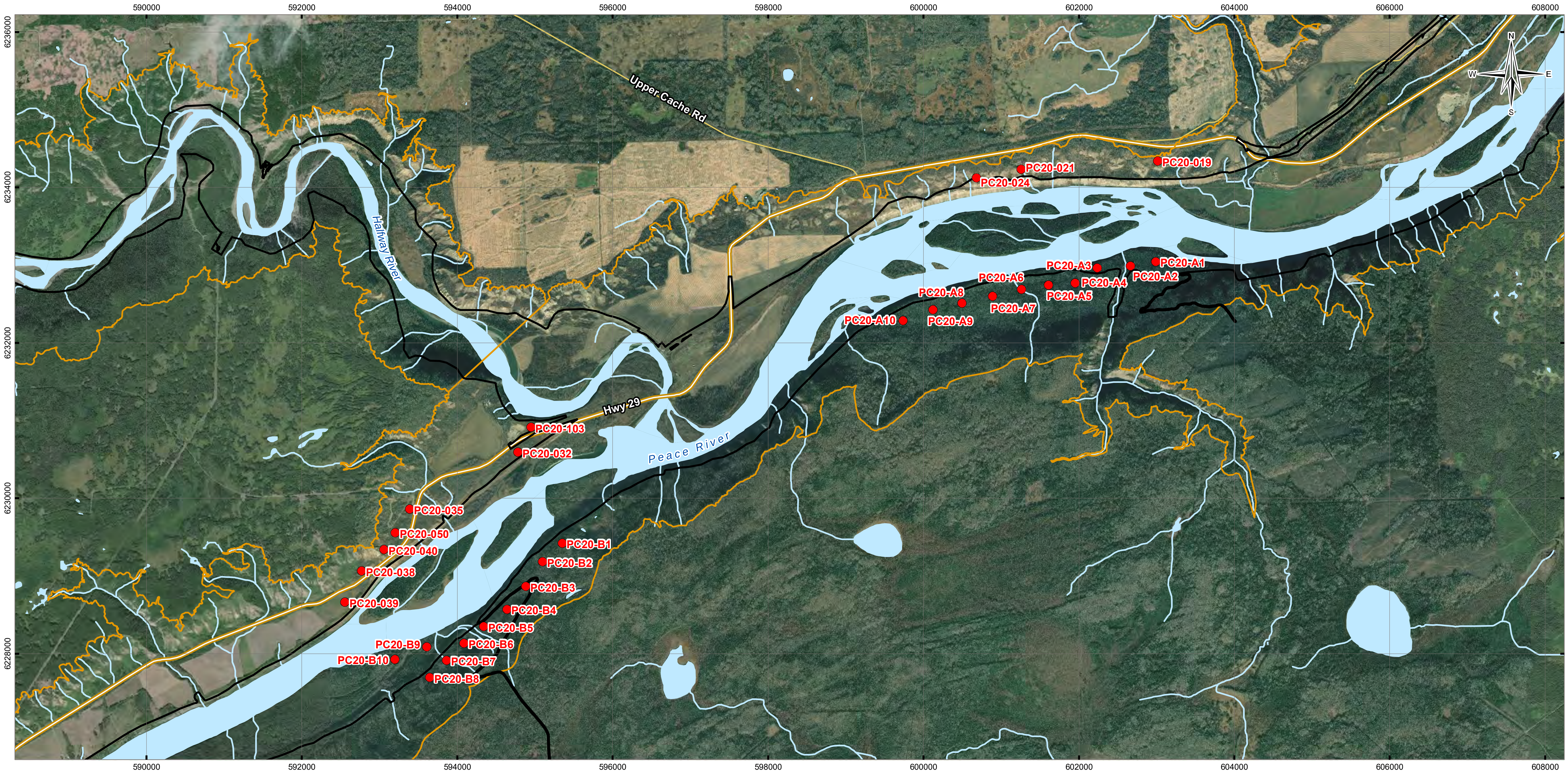
TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	YL	JM	0

DATE	PROJECT NO.
December 16, 2020	ENW.PENW03042-01

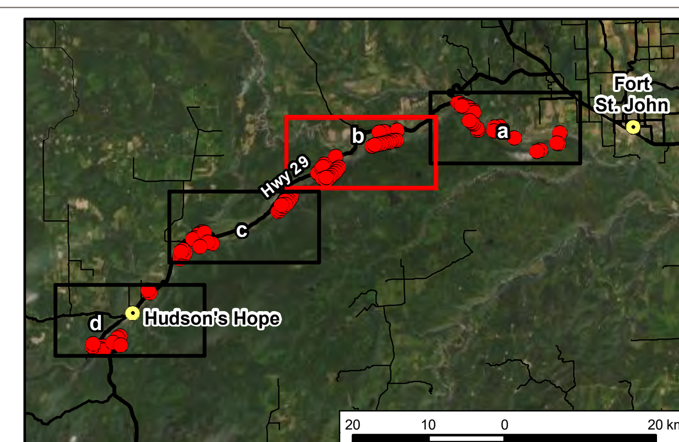
Figure 2a

Q:\Vancouver\GIS\ENVIRONMENTAL\PENW\PENW03042-01\Maps\Songbird_2020\PENW03042-01_Fig02_SONG_2020.mxd modified 2020-12-16 by stephanie.leusink



LEGEND

- 2020 Songbird Survey Location
- Project Footprint
- Potential Mitigation Property
- Peace River Valley
- Highway
- Local Road
- Watercourse
- Waterbody



NOTES
Base data source:
CanVec 1:50,000 (2019)
Imagery from ESRI; Maxar

STATUS
ISSUED FOR USE

SITE C SONGBIRD 2020 ANNUAL REPORT

2020 Songbird Survey Locations

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	BC hydro

Scale: 1:50,000
1 0.5 0 1
Kilometres

TETRA TECH

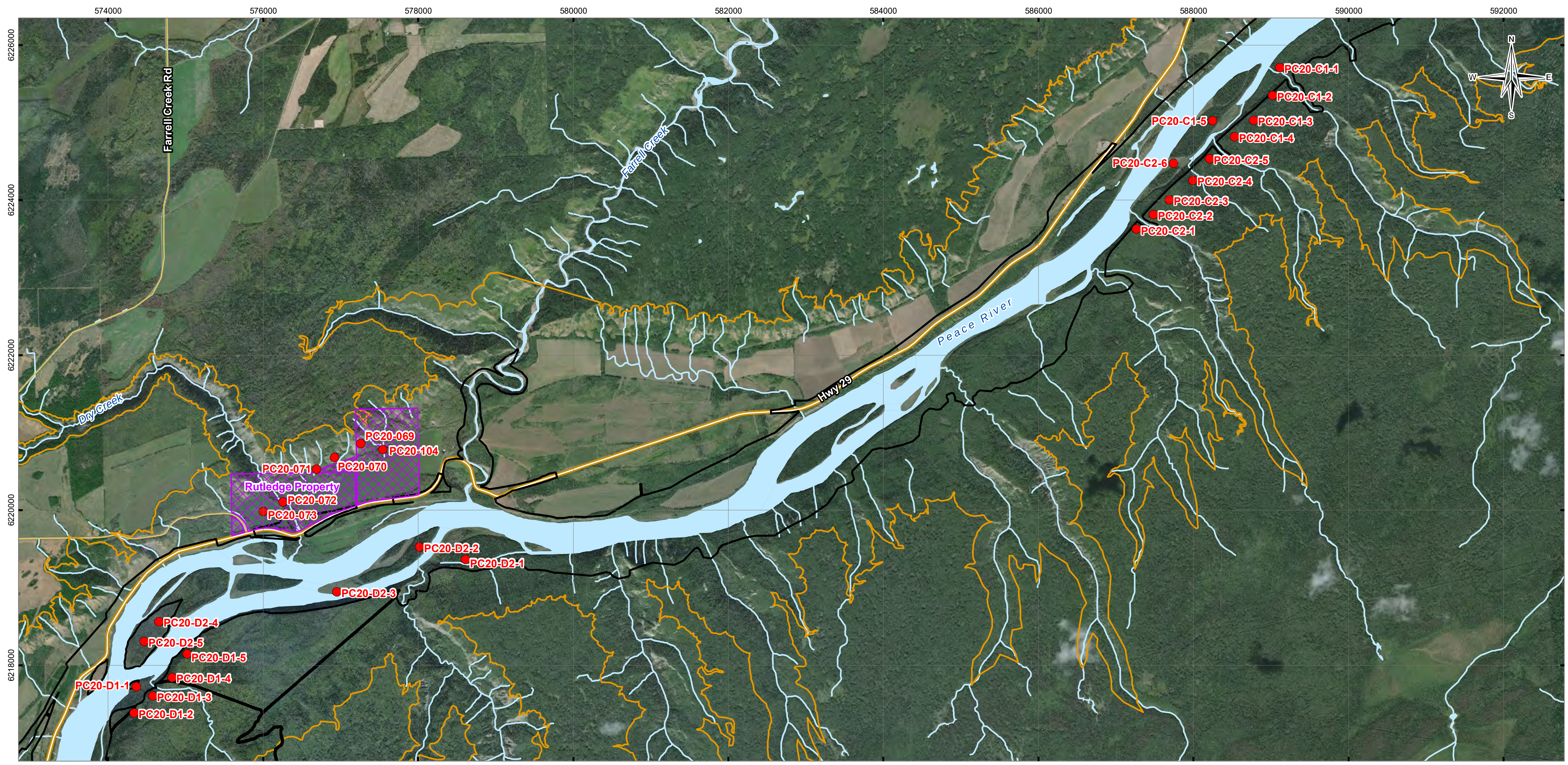
FILE NO.
PENW03042-01_Fig02_SONG_2020.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	YL	JM	0

DATE	PROJECT NO.
December 16, 2020	ENW.PENW03042-01

Figure 2b

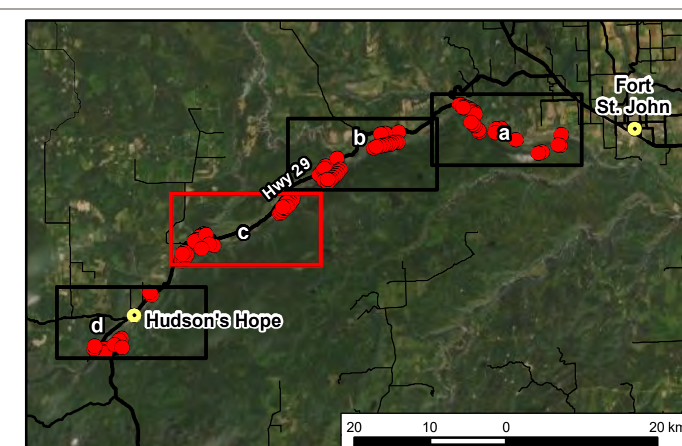
Q:\Vancouver\GIS\ENVIRONMENTAL\PENW\PENW03042-01\Maps\Songbird_2020\PENW03042-01_Fig02_SONG_2020.mxd modified 2020-12-16 by stephanie.leusink



Q:\Vancouver\GIS\ENVIRONMENTAL\PENW\PENW03042-01\Maps\Songbird_2020\PENW03042-01_Fig02_SONG_2020.mxd modified 2020-12-16 by stephanie.leusink

LEGEND

- 2020 Songbird Survey Location
- Project Footprint
- Potential Mitigation Property
- Peace River Valley
- Highway
- Local Road
- Watercourse
- Waterbody



NOTES
Base data source:
CanVec 1:50,000 (2019)
Imagery from ESRI; Maxar

STATUS
ISSUED FOR USE

SITE C SONGBIRD
2020 ANNUAL REPORT

2020 Songbird Survey Locations

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	BC hydro

Scale: 1:50,000
1 0.5 0 1
Kilometres

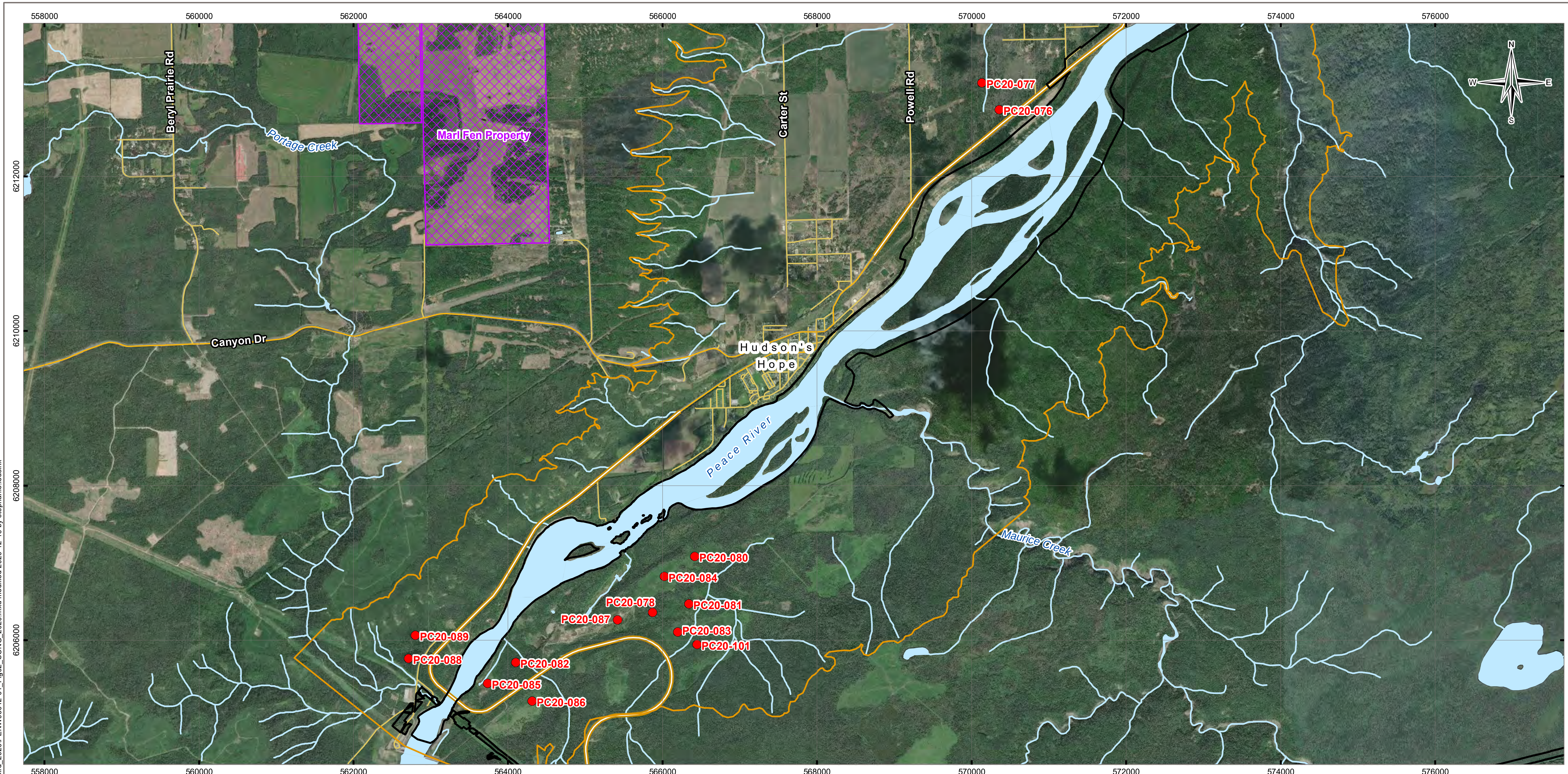
FILE NO.
PENW03042-01_Fig02_SONG_2020.mxd

TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	YL	JM	0

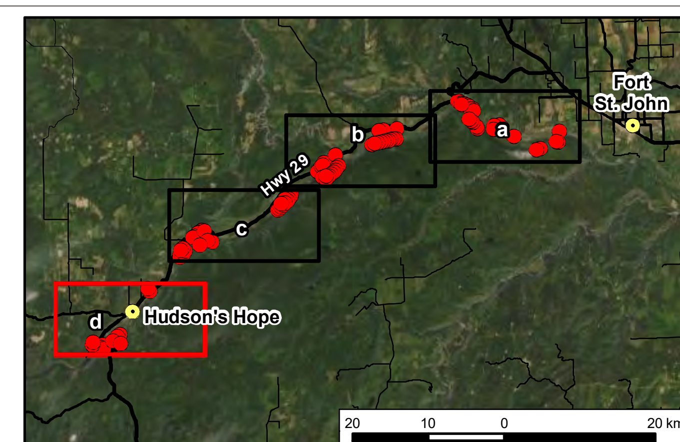
DATE	PROJECT NO.
December 16, 2020	ENW.PENW03042-01

Figure 2c



LEGEND

- 2020 Songbird Survey Location
- Project Footprint
- Potential Mitigation Property
- Peace River Valley
- Highway
- Main Road
- Local Road
- Watercourse
- Waterbody



NOTES
Base data source:
CanVec 1:50,000 (2019)
Imagery from ESRI; Maxar

STATUS
ISSUED FOR USE

SITE C SONGBIRD 2020 ANNUAL REPORT

2020 Songbird Survey Locations

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	BC hydro

Scale: 1:50,000
1 0.5 0 1
Kilometres

TETRA TECH

FILE NO.
PENW03042-01_Fig02_SONG_2020.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	YL	JM	0

DATE	PROJECT NO.
December 16, 2020	ENW.PENW03042-01

Figure 2d

3.0 RESULTS AND DISCUSSION

Surveys were conducted in 15 bird habitat classes (Table 1). Six of the 97 point count stations were surveyed only one time due to accessibility issues or safety concerns. Two stations surveyed in the first survey round were not visited a second time due to distance from an access point and difficult topography. Three replacement stations were selected in similar habitat and surveyed once during the second survey round. One additional station could not be surveyed on the second survey round because of bear activity.

Table 1. Number of songbird point count stations and surveys conducted in 2020 by bird habitat class.

Bird Habitat Class	Stations	Surveys
Coniferous-shrub	1	2
Coniferous-young forest	9	18
Coniferous-mature forest	20	38
Deciduous-shrub	13	25
Deciduous-young forest	13	25
Deciduous-mature forest	15	28
Riparian-mixed shrub	2	4
Riparian-mixed young forest	2	4
Riparian-mixed mature forest	1	2
Fen/bog-shrub	1	2
Wetland-shrub	4	8
Dry slopes-grassland	2	4
Dry slopes-shrubland	9	18
Cultivated	4	8
Non-vegetated	1	2
Total	**97**	**188**

A total of 87 bird species were detected, of which 71 were songbirds (Table 2). Six species listed under COSEWIC, SARA and/or British Columbia's Red and Blue lists were observed during the surveys. The median number of songbird species detected per point count survey was 8 (ranging from 3 to 18). Other bird species were recorded as incidental observations and are listed in Appendix C.

Table 2: Songbird species observed during the 2020 point count surveys.

English Name	Scientific Name	BC List	COSEWIC	SARA	Total Detections
Northern Flicker *	*Colaptes auratus*	Yellow	-	-	5
Downy Woodpecker *	*Dryobates pubescens*	Yellow	-	-	1
Hairy Woodpecker *	*Dryobates villosus*	Yellow	-	-	3
Pileated Woodpecker *	*Dryocopus pileatus*	Yellow	-	-	1
American Three-toed Woodpecker *	*Picoides dorsalis*	Yellow	-	-	2
Yellow-bellied Sapsucker *	*Sphyrapicus varius*	Yellow	-	-	27
Olive-sided Flycatcher	*Contopus cooperi*	Blue	Special Concern	Threatened	5
Western Wood-Pewee	*Contopus sordidulus*	Yellow	-	-	25
Alder Flycatcher	*Empidonax alnorum*	Yellow	-	-	39
Pacific-slope Flycatcher	*Empidonax difficilis*	Yellow	-	-	8
Least Flycatcher	*Empidonax minimus*	Yellow	-	-	88
Dusky Flycatcher	*Empidonax oberholseri*	Yellow	-	-	2
Warbling Vireo	*Vireo gilvus*	Yellow	-	-	33
Red-eyed Vireo	*Vireo olivaceus*	Yellow	-	-	137
Philadelphia Vireo	*Vireo philadelphicus*	Yellow	-	-	2
Blue-headed Vireo	*Vireo solitarius*	Yellow	-	-	7
American Crow	*Corvus brachyrhynchos*	Yellow	-	-	22
Common Raven	*Corvus corax*	Yellow	-	-	15
Blue Jay	*Cyanocitta cristata*	Yellow	-	-	2
Canada Jay	*Perisoreus canadensis*	Yellow	-	-	16
Black-billed Magpie	*Pica hudsonia*	Yellow	-	-	5
Cedar Waxwing	*Bombycilla cedrorum*	Yellow	-	-	43
Black-capped Chickadee	*Poecile atricapillus*	Yellow	-	-	3
Boreal Chickadee	*Poecile hudsonicus*	Yellow	-	-	3
Cliff Swallow	*Petrochelidon pyrrhonota*	Yellow			2
Bank Swallow	*Riparia riparia*	Yellow	Threatened	Threatened	13
Tree Swallow	*Tachycineta bicolor*	Yellow	-	-	3
Violet-green Swallow	*Tachycineta thalassina*	Yellow			5

English Name	Scientific Name	BC List	COSEWIC	SARA	Total Detections
Ruby-crowned Kinglet	*Regulus calendula*	Yellow	-	-	10
Golden-crowned Kinglet	*Regulus satrapa*	Yellow	-	-	18
Marsh Wren	*Cistothorus palustris*	Yellow	-	-	2
Red-breasted Nuthatch	*Sitta canadensis*	Yellow	-	-	30
House Wren	*Troglodytes aedon*	Yellow	-	-	9
Pacific Wren	*Troglodytes pacificus*	Yellow			1
Brown Creeper	*Certhia americana*	Yellow			1
Gray Catbird	*Dumetella carolinensis*	Yellow	-	-	7
Hermit Thrush	*Catharus guttatus*	Yellow	-	-	33
Swainson's Thrush	*Catharus ustulatus*	Yellow	-	-	99
Townsend's Solitaire	*Myadestes townsendi*	Yellow	-	-	1
American Robin	*Turdus migratorius*	Yellow	-	-	83
LeConte's Sparrow	*Ammospiza leconteii*	Yellow			5
Purple Finch	*Haemorhous purpureus*	Yellow	-	-	7
White-winged Crossbill	*Loxia leucoptera*	Yellow	-	-	1
Pine Siskin	*Spinus pinus*	Yellow	-	-	59
Canada Warbler	*Cardellina canadensis*	Blue	Threatened	Threatened	14
Wilson's Warbler	*Cardellina pusilla*	Yellow	-	-	6
MacGillivray's Warbler	*Geothlypis tolmiei*	Yellow			7
Common Yellowthroat	*Geothlypis trichas*	Yellow	-	-	13
Orange-crowned Warbler	*Leiothlypis celata*	Yellow	-	-	36
Tennessee Warbler	*Leiothlypis peregrina*	Yellow	-	-	25
Black-and-white Warbler	*Mniotilta varia*	Yellow	-	-	23
Northern Waterthrush	*Parkesia noveboracensis*	Yellow	-	-	8
Ovenbird	*Seiurus aurocapilla*	Yellow	-	-	118
Yellow-rumped Warbler	*Setophaga coronata*	Yellow	-	-	84
Magnolia Warbler	*Setophaga magnolia*	Yellow	-	-	14
Yellow Warbler	*Setophaga petechia*	Yellow	-	-	101
American Redstart	*Setophaga ruticilla*	Yellow	-	-	31
Blackpoll Warbler	*Setophaga striata*	Yellow	-	-	1

English Name	Scientific Name	BC List	COSEWIC	SARA	Total Detections
Cape May Warbler	*Setophaga tigrina*	Blue	-	-	1
Black-throated Green Warbler	*Setophaga virens*	Blue	-	-	13
Red-winged Blackbird	*Agelaius phoeniceus*	Yellow	-	-	50
Brewer's Blackbird	*Euphagus cyanocephalus*	Yellow	-	-	2
Baltimore Oriole	*Icterus galbula*	Blue	-	-	18
Brown-headed Cowbird	*Molothrus ater*	Yellow	-	-	2
Dark-eyed Junco	*Junco hyemalis*	Yellow	-	-	27
Swamp Sparrow	*Melospiza georgiana*	Yellow	-	-	3
Lincoln's Sparrow	*Melospiza lincolnii*	Yellow	-	-	21
Song Sparrow	*Melospiza melodia*	Yellow	-	-	23
Savannah Sparrow	*Passerculus sandwichensis*	Yellow	-	-	7
Vesper Sparrow	*Pooecetes gramineus*	Yellow	-	-	14
Clay-colored Sparrow	*Spizella pallida*	Yellow	-	-	55
Chipping Sparrow	*Spizella passerina*	Yellow	-	-	26
White-throated Sparrow	*Zonotrichia albicollis*	Yellow	-	-	257
Golden-crowned Sparrow	*Zonotrichia atricapilla*	Yellow			1
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Yellow	-	-	36
Western Tanager	*Piranga ludoviciana*	Yellow	-	-	64

* Includes woodpeckers. Though not songbirds, woodpeckers are also part of the Breeding Bird Follow-up Monitoring Program (surveyed separately from songbirds) and are regularly detected during points counts.

Surveys conducted in 2020 represent an initial establishment of semi-permanent monitoring stations that will be monitored through to 10 years post-construction. In each future year, some stations may be lost to land use changes or access, and others will be added as needed to best address the objective to characterize changes in the bird community of the Peace River valley over time.

4.0 REFERENCES

Saulteau EBA Environmental Services Joint Venture (SEEJ JV) 2019. Site C Clean Energy Project Breeding Bird Follow-up Monitoring – Songbirds. 2020 Annual Report. Prepared by Tetra Tech Canada Inc. for BC Hydro and Power Authority.

APPENDIX A
2020 POINT COUNT STATIONS

Table A1: Songbird point count stations surveyed in 2020 *

Station	UTM Zone	UTM Easting	UTM Northing	Survey 1 Date	Survey 1 Time	Survey 2 Date	Survey 2 Time	Bird Habitat Class
PC20-001	10	624540	6234024	2020-06-04	04:39	2020-06-22	04:29	Non-vegetated
PC20-002	10	624407	6232558	2020-06-04	05:47	2020-06-22	05:33	Deciduous-mature forest
PC20-003	10	624110	6232653	2020-06-04	05:09	2020-06-22	05:00	Deciduous-mature forest
PC20-004	10	622034	6231701	2020-06-04	05:45	2020-06-22	05:33	Deciduous-mature forest
PC20-005	10	621480	6231575	2020-06-04	06:21	2020-06-22	06:01	Deciduous-young forest
PC20-006	10	618522	6233347	2020-06-04	07:28	2020-06-22	06:50	Dry slopes-shrubland
PC20-007	10	616913	6234543	2020-06-04	08:58	2020-06-22	08:29	Dry slopes-grassland
PC20-008	10	616553	6234827	2020-06-04	08:26	2020-06-22	07:57	Dry slopes-shrubland
PC20-009	10	616192	6234479	2020-06-04	09:29	2020-06-22	08:58	Cultivated
PC20-010	10	615902	6234745	2020-06-04	07:51	2020-06-22	07:15	Dry slopes-shrubland
PC20-011	10	615862	6234301	2020-06-04	07:26	2020-06-22	06:53	Cultivated
PC20-012	10	613720	6234356	2020-06-04	10:10	-	-	Coniferous-mature forest
PC20-013	10	613614	6234644	2020-06-04	09:19	-	-	Coniferous-mature forest
PC20-019	10	603014	6234339	2020-06-09	04:19	2020-06-26	04:23	Dry slopes-grassland
PC20-021	10	601258	6234232	2020-06-09	04:51	2020-06-26	04:49	Deciduous-shrub
PC20-024	10	600679	6234123	2020-06-09	05:24	2020-06-26	05:13	Deciduous-shrub
PC20-032	10	594779	6230591	2020-06-09	06:22	2020-06-26	06:06	Coniferous-shrub
PC20-035	10	593385	6229860	2020-06-09	06:51	2020-06-26	06:31	Deciduous-shrub
PC20-038	10	592767	6229065	2020-06-09	07:58	2020-06-26	07:30	Dry slopes-shrubland
PC20-039	10	592553	6228662	2020-06-09	08:23	2020-06-26	07:51	Cultivated
PC20-040	10	593058	6229341	2020-06-09	07:34	2020-06-26	07:13	Dry slopes-shrubland

Station	UTM Zone	UTM Easting	UTM Northing	Survey 1 Date	Survey 1 Time	Survey 2 Date	Survey 2 Time	Bird Habitat Class
PC20-050	10	593202	6229554	2020-06-09	07:13	2020-06-26	06:54	Dry slopes-shrubland
PC20-069	10	577259	6220860	2020-06-08	09:16	2020-06-25	05:56	Dry slopes-shrubland
PC20-070	10	576921	6220683	2020-06-08	08:50	2020-06-25	05:32	Dry slopes-shrubland
PC20-071	10	576686	6220531	2020-06-08	08:30	2020-06-25	05:11	Deciduous-shrub
PC20-072	10	576256	6220108	2020-06-08	07:26	2020-06-25	04:40	Riparian-mixed young forest
PC20-073	10	576001	6219985	2020-06-08	07:05	2020-06-25	04:20	Cultivated
PC20-076	10	570355	6212864	2020-06-08	05:48	2020-06-25	07:25	Coniferous-young forest
PC20-077	10	570134	6213209	2020-06-08	06:09	2020-06-25	07:50	Coniferous-young forest
PC20-078	10	565870	6206360	2020-06-08	08:30	2020-06-25	06:00	Deciduous-mature forest
PC20-080	10	566416	6207084	2020-06-08	06:10	2020-06-25	06:30	Deciduous-shrub
PC20-081	10	566341	6206470	2020-06-08	06:58	2020-06-25	07:20	Wetland-shrub
PC20-082	10	564101	6205711	2020-06-08	05:11	2020-06-25	05:08	Deciduous-mature forest
PC20-083	10	566196	6206107	2020-06-08	07:21	-	-	Deciduous-shrub
PC20-084	10	566021	6206826	2020-06-08	06:38	2020-06-25	07:00	Deciduous-shrub
PC20-085	10	563734	6205440	2020-06-08	04:32	2020-06-25	04:32	Fen/bog-shrub
PC20-086	10	564312	6205213	2020-06-08	09:11	2020-06-25	08:50	Deciduous-shrub
PC20-087	10	565416	6206263	2020-06-08	05:42	2020-06-25	05:36	Deciduous-shrub
PC20-088	10	562713	6205763	2020-06-08	04:34	2020-06-25	08:44	Deciduous-mature forest
PC20-089	10	562800	6206063	2020-06-08	05:07	2020-06-25	09:17	Deciduous-mature forest
PC20-101	10	566447	6205946	2020-06-08	07:44	2020-06-25	07:56	Coniferous-young forest
PC20-103	10	594948	6230914	2020-06-09	05:58	2020-06-26	05:47	Deciduous-shrub
PC20-104	10	577541	6220783	2020-06-08	09:40	2020-06-25	06:20	Deciduous-young forest

Station	UTM Zone	UTM Easting	UTM Northing	Survey 1 Date	Survey 1 Time	Survey 2 Date	Survey 2 Time	Bird Habitat Class
PC20-201	10	611065	6238042	2020-06-09	04:20	2020-06-26	04:19	Dry slopes-shrubland
PC20-202	10	611295	6238013	2020-06-09	04:41	2020-06-26	04:39	Deciduous-young forest
PC20-203	10	611606	6237736	2020-06-09	05:19	2020-06-26	05:33	Deciduous-mature forest
PC20-204	10	611968	6237681	2020-06-09	06:27	2020-06-26	06:13	Deciduous-young forest
PC20-205	10	612332	6237495	2020-06-09	07:02	2020-06-26	06:50	Deciduous-mature forest
PC20-206	10	612573	6237329	2020-06-09	07:40	2020-06-26	07:19	Wetland-shrub
PC20-207	10	613084	6236953	2020-06-09	09:10	2020-06-26	08:38	Wetland-shrub
PC20-208	10	612820	6236955	2020-06-09	08:10	2020-06-26	07:48	Deciduous-shrub
PC20-209	10	613174	6236752	2020-06-09	08:35	2020-06-26	08:07	Deciduous-young forest
PC20-210	10	611575	6237602	2020-06-09	05:49	2020-06-26	05:04	Wetland-shrub
PC20-500	10	613140	6235203	-	-	2020-06-22	08:00	Deciduous-young forest
PC20-501	10	612849	6235419	-	-	2020-06-22	08:35	Deciduous-mature forest
PC20-502	10	612581	6235611	-	-	2020-06-22	09:03	Deciduous-mature forest
PC20-A1	10	602990	6233046	2020-06-05	05:07	2020-06-23	05:35	Deciduous-mature forest
PC20-A10	10	599738	6232286	2020-06-05	09:01	2020-06-23	08:56	Coniferous-mature forest
PC20-A2	10	602661	6232990	2020-06-05	04:44	2020-06-23	05:17	Deciduous-shrub
PC20-A3	10	602233	6232962	2020-06-05	05:30	2020-06-23	06:10	Deciduous-shrub
PC20-A4	10	601952	6232770	2020-06-05	06:07	2020-06-23	06:28	Coniferous-mature forest
PC20-A5	10	601607	6232742	2020-06-05	06:35	2020-06-23	06:51	Coniferous-mature forest
PC20-A6	10	601260	6232688	2020-06-05	07:06	2020-06-23	07:14	Coniferous-mature forest
PC20-A7	10	600890	6232601	2020-06-05	07:33	2020-06-23	07:38	Coniferous-mature forest
PC20-A8	10	600496	6232512	2020-06-05	08:03	2020-06-23	08:02	Coniferous-mature forest

Station	UTM Zone	UTM Easting	UTM Northing	Survey 1 Date	Survey 1 Time	Survey 2 Date	Survey 2 Time	Bird Habitat Class
PC20-A9	10	600121	6232427	2020-06-05	08:31	2020-06-23	08:32	Coniferous-mature forest
PC20-B1	10	595350	6229422	2020-06-05	05:17	2020-06-23	05:50	Coniferous-young forest
PC20-B10	10	593197	6227928	2020-06-05	09:31	2020-06-23	09:07	Coniferous-young forest
PC20-B2	10	595098	6229182	2020-06-05	05:40	2020-06-23	06:13	Coniferous-mature forest
PC20-B3	10	594882	6228865	2020-06-05	06:04	2020-06-23	06:34	Coniferous-young forest
PC20-B4	10	594639	6228571	2020-06-05	06:32	2020-06-23	06:55	Coniferous-young forest
PC20-B5	10	594340	6228348	2020-06-05	07:05	2020-06-23	07:17	Deciduous-young forest
PC20-B6	10	594087	6228135	2020-06-05	07:34	2020-06-23	07:39	Deciduous-young forest
PC20-B7	10	593863	6227915	2020-06-05	08:02	2020-06-23	07:58	Deciduous-young forest
PC20-B8	10	593646	6227692	2020-06-05	08:32	2020-06-23	08:18	Coniferous-young forest
PC20-B9	10	593609	6228086	2020-06-05	09:00	2020-06-23	08:41	Coniferous-mature forest
PC20-C1-1	10	589114	6225713	2020-06-07	04:28	2020-06-24	04:35	Deciduous-young forest
PC20-C1-2	10	589021	6225353	2020-06-07	05:02	2020-06-24	05:08	Coniferous-mature forest
PC20-C1-3	10	588775	6225032	2020-06-07	05:30	2020-06-24	05:36	Coniferous-mature forest
PC20-C1-4	10	588528	6224817	2020-06-07	05:58	2020-06-24	06:04	Coniferous-mature forest
PC20-C1-5	10	588244	6225026	2020-06-07	06:45	2020-06-24	06:37	Riparian-mixed mature forest
PC20-C2-1	10	587264	6223631	2020-06-07	04:28	2020-06-24	04:39	Deciduous-young forest
PC20-C2-2	10	587483	6223815	2020-06-07	05:51	2020-06-24	05:01	Deciduous-young forest
PC20-C2-3	10	587687	6224007	2020-06-07	05:13	2020-06-24	05:20	Deciduous-young forest
PC20-C2-4	10	587990	6224257	2020-06-07	05:46	2020-06-24	05:42	Coniferous-young forest
PC20-C2-5	10	588205	6224535	2020-06-07	06:09	2020-06-24	06:07	Coniferous-mature forest
PC20-C2-6	10	587739	6224475	2020-06-07	06:38	2020-06-24	06:41	Riparian-mixed shrub

Station	UTM Zone	UTM Easting	UTM Northing	Survey 1 Date	Survey 1 Time	Survey 2 Date	Survey 2 Time	Bird Habitat Class
PC20-D1-1	10	574364	6217723	2020-06-07	07:46	2020-06-24	07:43	Riparian-mixed young forest
PC20-D1-2	10	574335	6217385	2020-06-07	08:11	2020-06-24	08:11	Coniferous-mature forest
PC20-D1-3	10	574574	6217605	2020-06-07	08:34	2020-06-24	08:31	Coniferous-mature forest
PC20-D1-4	10	574823	6217844	2020-06-07	09:08	2020-06-24	09:00	Deciduous-mature forest
PC20-D1-5	10	575018	6218149	2020-06-07	09:30	2020-06-24	09:21	Coniferous-mature forest
PC20-D2-1	10	578611	6219365	2020-06-07	07:38	2020-06-24	07:40	Coniferous-mature forest
PC20-D2-2	10	578018	6219525	2020-06-07	08:11	2020-06-24	08:15	Coniferous-mature forest
PC20-D2-3	10	576950	6218948	2020-06-07	08:40	2020-06-24	08:39	Riparian-mixed shrub
PC20-D2-4	10	574657	6218563	2020-06-07	09:18	2020-06-24	09:12	Deciduous-mature forest
PC20-D2-5	10	574463	6218308	2020-06-07	09:38	2020-06-24	09:36	Deciduous-mature forest

* Six of the 97 point-count stations were surveyed only one time due to accessibility issues or disturbance (see Sexton 3.1).

APPENDIX B

INCIDENTAL BIRD OBSERVATIONS

Table B.1. Incidental observations of birds recorded outside of point count surveys and birds recorded during point counts that are not songbirds.

English Name	Scientific Name	BC List	COSEWIC	SARA	Total Detections
Green-winged Teal	*Anas crecca*	Yellow	-	-	3
Bufflehead	*Bucephala albeola*	Yellow	-	-	3
Ruffed Grouse	*Bonasa umbellus*	Yellow	-	-	1
Sora	*Porzana carolina*	Yellow	-	-	3
Killdeer	*Charadrius vociferus*	Yellow	-	-	1
Wilson's Snipe	*Gallinago delicata*	Yellow	-	-	5
Common Loon	*Gavia immer*	Yellow	-	-	1
Sharp-shinned Hawk	*Accipiter striatus*	Yellow	-	-	1
Merlin	*Falco columbarius*	Yellow	-	-	1
Bald Eagle	*Haliaeetus leucocephalus*	Yellow	-	-	3
Northern Flicker	*Colaptes auratus*	Yellow	-	-	5
Downy Woodpecker	*Dryobates pubescens*	Yellow	-	-	1
Hairy Woodpecker	*Dryobates villosus*	Yellow	-	-	3
Pileated Woodpecker	*Dryocopus pileatus*	Yellow	-	-	1
American Three-toed Woodpecker	*Picoides dorsalis*	Yellow	-	-	2
Yellow-bellied Sapsucker	*Sphyrapicus varius*	Yellow	-	-	27
Canada Warbler	*Cardellina canadensis*	Blue	Threatened	Threatened	3
Yellow-rumped Warbler	*Setophaga coronata*	Yellow	-	-	1
Yellow Warbler	*Setophaga petechia*	Yellow	-	-	1

APPENDIX C
PROJECT QUALIFIED ENVIRONMENTAL PROFESSIONALS

Name and Affiliation	Project Role
Jeff Matheson, M.Sc., R.P.Bio. Tetra Tech Canada Inc.	Project manager, report author
Elyse Hofs, B.Sc., Dipl.T. Tetra Tech Canada Inc.	Data entry, report author
Claudio Bianchini, R.P.Bio. Bianchini Biological Services	Field data collection

APPENDIX D
LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

NATURAL SCIENCES

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

The Professional Document is intended for the sole use of Saulteau EBA Environmental Services Joint Venture's (SEES JV) Client (the "Client") as specifically identified in the SEES JV Services Agreement or other Contractual Agreement entered into with the Client (either of which is termed the "Contract" herein). SEES JV does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the Client, unless authorized in writing by SEES JV.

Any unauthorized use of the Professional Document is at the sole risk of the user. SEES JV accepts no responsibility whatsoever for any loss or damage where such loss or damage is alleged to be or, is in fact, caused by the unauthorized use of the Professional Document.

Where SEES JV has expressly authorized the use of the Professional Document by a third party (an "Authorized Party"), consideration for such authorization is the Authorized Party's acceptance of these Limitations on Use of this Document as well as any limitations on liability contained in the Contract with the Client (all of which is collectively termed the "Limitations on Liability"). The Authorized Party should carefully review both these Limitations on Use of this Document and the Contract prior to making any use of the Professional Document. Any use made of the Professional Document by an Authorized Party constitutes the Authorized Party's express acceptance of, and agreement to, the Limitations on Liability.

The Professional Document and any other form or type of data or documents generated by SEES JV during the performance of the work are SEES JV's professional work product and shall remain the copyright property of SEES JV.

The Professional Document is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of SEES JV. Additional copies of the Document, if required, may be obtained upon request.

1.2 ALTERNATIVE DOCUMENT FORMAT

Where SEES JV submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed SEES JV's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by SEES JV shall be deemed to be the original. SEES JV will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Both electronic file and/or hard copy versions of SEES JV's Instruments of Professional Service shall not, under any circumstances, be altered by any party except SEES JV. SEES JV's Instruments of Professional Service will be used only and exactly as submitted by SEES JV.

Electronic files submitted by SEES JV have been prepared and submitted using specific software and hardware systems. SEES JV makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by SEES JV for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of SEES JV.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with SEES JV with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for SEES JV to properly provide the services contracted for in the Contract, SEES JV has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO SEES JV BY OTHERS

During the performance of the work and the preparation of this Professional Document, SEES JV may have relied on information provided by third parties other than the Client.

While SEES JV endeavours to verify the accuracy of such information, SEES JV accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to SEES JV at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

SEES JV is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 ENVIRONMENTAL ISSUES

The ability to rely upon and generalize from environmental baseline data is dependent on data collection activities occurring within biologically relevant survey windows.

It is incumbent upon the Client and any Authorized Party, to be knowledgeable of the level of risk that has been incorporated into the project design or scope, in consideration of the level of the environmental baseline information that was reasonably acquired to facilitate completion of the scope.

1.8 NOTIFICATION OF AUTHORITIES

SEES JV professionals are bound by their ethical commitments to act within the bounds of all pertinent regulations. In certain instances, observations by SEES JV of regulatory contravention may require that regulatory agencies and other persons be informed. The client agrees that notification to such bodies or persons as required may be done by SEES JV in its reasonably exercised discretion.

Appendix 3. Waterbird Migration Follow-up Monitoring Program – 2020

DRAFT REPORT

Site C Vegetation and Wildlife Waterbird Migration Follow-up Monitoring Program – 2020 Annual Report

Photo Credit: C.T.St.Clair

Prepared for:

BC Hydro
Site C Clean Energy Project
1055 Dunsmuir Street
PO Box 49260, BC V7X 1V5

Project No. 989619-07

Prepared by:

Hemmera Envirochem Inc.
18th Floor, 4730 Kingsway
Burnaby, BC V5H 0C6
T: 604.669.0424
F: 604.669.0430
hemmera.com

March 26, 2021

EXECUTIVE SUMMARY

Annual waterbird surveys were conducted on the Peace River and transmission line right of way (ROW) portions of the Site C Clean Energy Project study area in 2017 through 2020. Standwatch and transect surveys conducted on foot, river boat surveys, and passive bioacoustics monitoring surveys using autonomous recording units (ARUs) were applied to obtain records of waterbird abundance, distribution, and habitat associations. Survey results will be used to assess Project-related changes in waterbird abundance, density, and diversity, as per the objectives of the Waterbird Migration Follow-up Monitoring Program.

This report details the results of surveys conducted in 2017 through 2020. Descriptive statistics present the results relative to monitoring objectives. Results presented herein describe survey effort, variation in waterbird abundance, density, and diversity within and between the spring migration (April 1 to May 30) and fall migration (August 1 to October 30) as well as across habitat types and study areas. Results are summarized for cumulative counts of all waterbird species and for 7 foraging guilds comprised of species with similar morphology and prey: large dabblers, dabbling ducks, benthic feeding divers, piscivorous divers, shorebirds, gulls and surface feeding terns, and marsh birds.

Surveys of the Peace River in 2017 through 2020 provide 4 years of baseline data to assess potential impacts of the Project on waterbirds within a before-after control-impact (BACI) study design framework. Baseline data collection will continue through the Site C construction phase. Surveys in 2020 were conducted between Hudson's Hope and the Alberta Border (i.e., the Peace River study area), with a total of 2 and 3 completed survey rounds during waterbird migrations in spring and fall, respectively. A total of 63,111 waterbirds of 60 species were recorded during boat-based surveys conducted during the spring and fall of 2017 through 2020. From these results, summary statistics were calculated using pooled data from 36 surveys that covered the entire length of the study area. During spring, overall waterbird densities (i.e., densities summed across foraging guilds) were higher in the area with anticipated impacts from reservoir inundation (i.e., the Inundation Impact area [40.6 birds/km^2/survey]) compared to areas with potential impacts from changes in flow regime (i.e., the Flow Impact area [44.4 birds/km^2/survey]), and areas downstream of the Pine River where changes to the Peace River will be moderated by natural flows (i.e., the Control area [40.7 birds/km^2/survey]). In contrast, overall waterbird densities in fall were higher within the Flow Impact area (94.0 birds/km^2/survey) than in the Control area (13.2 birds/km^2/survey) or Inundation Impact area (19.8 birds/km^2). As reported in previous years, all foraging guilds occurring within areas of anticipated Project-related effects were also recorded in the Control area. These results confirm that areas of the Peace River downstream of the Pine River provide an appropriate control for assessing background variation for waterbirds, a key assumption of BACI studies.

The highest abundances of waterbirds were recorded during the early spring migration on surveys from April 1 to 14, with an estimated 3,569 birds across the Peace River study area on average across years. Mean waterbird abundances recorded in early spring were higher than in any other period of spring or fall migration. Estimated waterbird abundances were lower in fall surveys relative to spring, with mean abundances of approximately 1,500 birds between August and mid-October and were lowest in late fall (approximately 800 in late October). The most abundant species guild was large dabblers (27,353 individuals across years), followed by gulls (13,643 individuals) and dabbling ducks (12,355 individuals).

To describe variation in waterbird abundance across habitat types, sections of the river with similar habitat features (e.g., water flow volumes and depth, substrate type, and aquatic vegetation) were categorized into habitat types associated with flow rates and connectivity to the Peace River. The 3 habitat types assessed in this study were as follows: Mainstem of the river, Moderate Flow (consistently connected to the river and with moderate flows), and Limited Connectivity to the river (e.g., backchannels consistently connected and open to the river on the downstream end). In spring, the greatest densities of waterbirds were recorded in sections of the river with Limited Connectivity (225.6 birds/km^2/survey), followed by high connectivity and Moderate Flow (61.5 birds/km^2/survey), and were lowest within the river's Mainstem (23.7 birds/km^2/survey). The greatest densities observed during fall were also observed in Limited Connectivity river habitat (114.0 birds/km^2/survey), but higher densities were reported from Mainstem (20.8 birds/km^2/survey) relative to Moderate Flow (11.2 birds/km^2/survey) habitat types.

Regarding diversity, 11 to 15 waterbird species were typically observed across Mainstem and Moderate Flow habitat types the Peace River study area, with the exception of lower species richness in the late fall (October 15 to October 30) when 8 to 9 species were observed on average, and the late spring (May 7 to May 30) when 19 species were observed on average across years. Species evenness was similar across survey periods ranging from 0.5 to 0.7 in all periods of spring and fall migration apart from late fall (0.4).

Wetlands along and adjacent to the Project transmission line ROW on the Moberly Plateau were surveyed during 2 and 3 survey rounds over the spring (May 4 to May 27, 2020) and fall (August 7 to October 2, 2020), respectively. A total of 22 wetland stations were surveyed in 2020. Wetland survey stations contained varying combinations of open water, sedge, and willow-sedge habitat types. Wetland surveys conducted annually from 2017 through 2020 (100 meter transects, and 20 minute stationary standwatch surveys) detected a total of 6,714 waterbirds of 46 species, providing season-specific estimates of density and diversity within habitats with demonstrated use by waterbirds. Standwatch surveys of open water habitat detected 6,400 individuals across 44 waterbird species in 2017 through 2020. Fewer individuals and species (314 individuals of 19 species) were observed within sedge and willow-sedge habitat with low water depth (i.e., less than 50 cm) surveyed by walking transects. However, these surveys were only conducted over the past 3 years as compared to 4 years for standwatch and river surveys and provide data for habitat types with greater detection constraints (e.g., tall and thick vegetation) and cryptic species such as marsh birds.

The greatest densities of waterbirds within open water and flooded wetlands surveyed via standwatch methods were observed during early fall (August 1 to August 14). In contrast, the highest densities of waterbirds observed during transect surveys within vegetated habitat were documented during the late spring. Dabbling ducks were the most abundant waterbirds across all wetland types, with the exception of sedge and willow-sedge habitats with shallow water (less than 50 cm), where marsh birds were detected in higher densities on average than any other foraging guild during the fall. Relatively low waterbird densities and diversity within weltands during the late fall (October) were associated with freezing conditions that likely restrict waterbirds access to forage.

Bioacoustic monitoring using ARUs provides additional data on marsh bird species, which can be detected more effectively using audio rather than visual survey methods. ARU surveys in 2017 through 2020 were conducted at a total of 22 sites during May, June and July, when marsh bird species' vocalizations are most frequent. ARUs were deployed to record bird vocalizations within sedge and willow-sedge habitat in addition to the edge of open water and upland forested areas. Sora (*Porzana carolina*) was detected at all sites and yellow rail (*Coturnicops noveboracensis*) was detected at 8 sites, while American bittern (*Botaurus lentiginosus*) was not detected. These surveys provide data on sora complimentary to those from transect surveys, demonstrating the species' ubiquity within vegetated wetlands. ARU survey results also confirm the rarity of American bittern in the region and the continued presence of yellow rail within wetlands along and adjacent to the transmission line ROW, particularly within sedge-dominated habitat with low water levels. Virginia rail (*Rallus limicola*), a species only recently known to occur in the region and not reported from baseline studies, was detected at 2 of 6 sites where ARUs were deployed in 2020.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOS (WITHIN TEXT)

LIST OF APPENDICES

1.0 INTRODUCTION

This report describes the combined results of the 2017, 2018, 2019, and 2020 Waterbird Migration Follow-up Monitoring Program surveys for shorebirds, marsh birds, waterfowl, and other birds associated with aquatic and wetland habitats (collectively known as 'waterbirds'). This program is being conducted to fulfill, in part, the requirements and conditions set forth in the Site C Clean Energy Project's Provincial Environmental Assessment Certificate (EAC) (Condition 21) and the Federal Decision Statement (FDS) (Conditions 10.2 10.3, 11.3 and 11.4) (BC Hydro 2013).

1.1 Background

In the Site C Environmental Impact Statement (EIS), BC Hydro assessed the potential effects of the Site C Clean Energy Project (the Project) on Wildlife Resources using key species groups, including shorebirds, marsh birds, and waterfowl (BC Hydro 2013). Effects of the Project on these waterbirds were assessed in terms of habitat alteration and fragmentation, disturbance and displacement, and mortality (BC Hydro 2013).

The EIS assessed the residual effects of the Project on waterfowl and shorebirds as high magnitude because of the anticipated extent of river and back channel habitat loss (i.e., habitat alteration and fragmentation). The duration and geographic extent of the effect is dependent on future waterbird use of the reservoir and wetlands created through habitat compensation. There was low confidence in the characterization of this expected use, because use will depend on the success of vegetation establishment along the boundaries of the reservoir, the extent of ice formation in the reservoir, the use of nest boxes, and the use of nesting habitat in artificial and created wetlands (BC Hydro 2013).

BC Hydro coordinated baseline studies of waterbirds in the Peace River and adjacent wetlands in 2006, 2008 and 2012 through 2014. Baseline waterbird studies employed fixed-wing aircraft and twin-engine helicopter surveys and, to a lesser extent, ground and boat surveys (Simpson and Andrusiak 2009; BC Hydro 2013; Churchland et al. 2015). The Vegetation and Wildlife Technical Committee (VWTC) reviewed the summary of baseline studies for waterbirds and noted that no shorebirds were documented during helicopter and fixed-wing aircraft surveys between 2012 and 2014. The lack of shorebird observations during aerial surveys, as well as challenges in species identification from a helicopter, prompted the VWTC to request that a follow-up monitoring program better suited to detecting and identifying a wide range of bird species be developed to provide a more complete assessment of waterbird use of the Peace River during spring and fall migration periods. Such a program was developed in conjunction with the VWTC, and this report provides a summary of results from 2017 through 2020.

1.2 Monitoring Objectives

The objective of the follow-up monitoring program is to address uncertainties regarding the effects of the Project (i.e., change from river valley to reservoir and changes in flow regime) on waterbirds that use habitat along and surrounding the Peace River (including wetland and non-wetland areas). Data collected helps to satisfy the monitoring requirements of the FDS and EAC, by evaluating the effectiveness of mitigation and compensation measures for waterbirds, and by verifying the accuracy of the predictions made in the EIS regarding waterbirds and their habitat.

The specific objectives of the waterbird monitoring program are as follows:

- Assess changes in waterbird wetland and non-wetland habitat on the Peace River and the transmission line right-of-way (ROW) from Project construction through to the first 10 years of Project operations to assess Project-related impacts relative to those predicted in the EIS (EIS Volume 2; Appendix R- Section 4.1).
- Document changes in waterbird relative abundance and diversity across habitats (Peace River and wetlands) during the first 10 years of Project operations relative to pre-reservoir and transmission line conditions to assess Project-related impacts relative to those predicted in the EIS (EIS Volume 2; Appendix R- Section 4.1).
- Monitor waterbird use of natural and created compensatory wetland features from Project construction through to the first 10 years of Project operations to evaluate the effectiveness of mitigation and compensation measures.

The monitoring program will improve understanding of baseline conditions for waterbirds, and allow a robust assessment of Project-related changes in habitat and habitat use by waterbirds. This report contains data from 2017, 2018, 2019, and 2020 using methods designed to provide improved species identification of shorebirds and other small waterbirds. As such, more recent data cannot be readily pooled with, or directly compared to, data collected in prior years using aerial survey methods. Comparisons to data from boat surveys conducted in 2006 and 2008 were not conducted due to inconsistencies in the timing of historical surveys and discrepancies between historic methods and those used in the updated survey protocols.

1.3 Study Area and Temporal Scope

The study area for the Waterbird Migration Follow-up Monitoring Program comprises the Peace River between Hudson's Hope and the Alberta border, and wetland habitat on the Moberly Plateau within 3 kilometres (km) of the Project transmission line local assessment area (**Figure 1**). Additional wetland habitat within the Moberly Plateau that was surveyed from fixed-wing aircraft during 2017 was not surveyed in subsequent years because species identification was seldom possible from the elevations required for safe flight, and access from the ground is limited. Sites with newly enhanced and created compensation wetlands with waterbird habitat will be included in the study as they are identified.

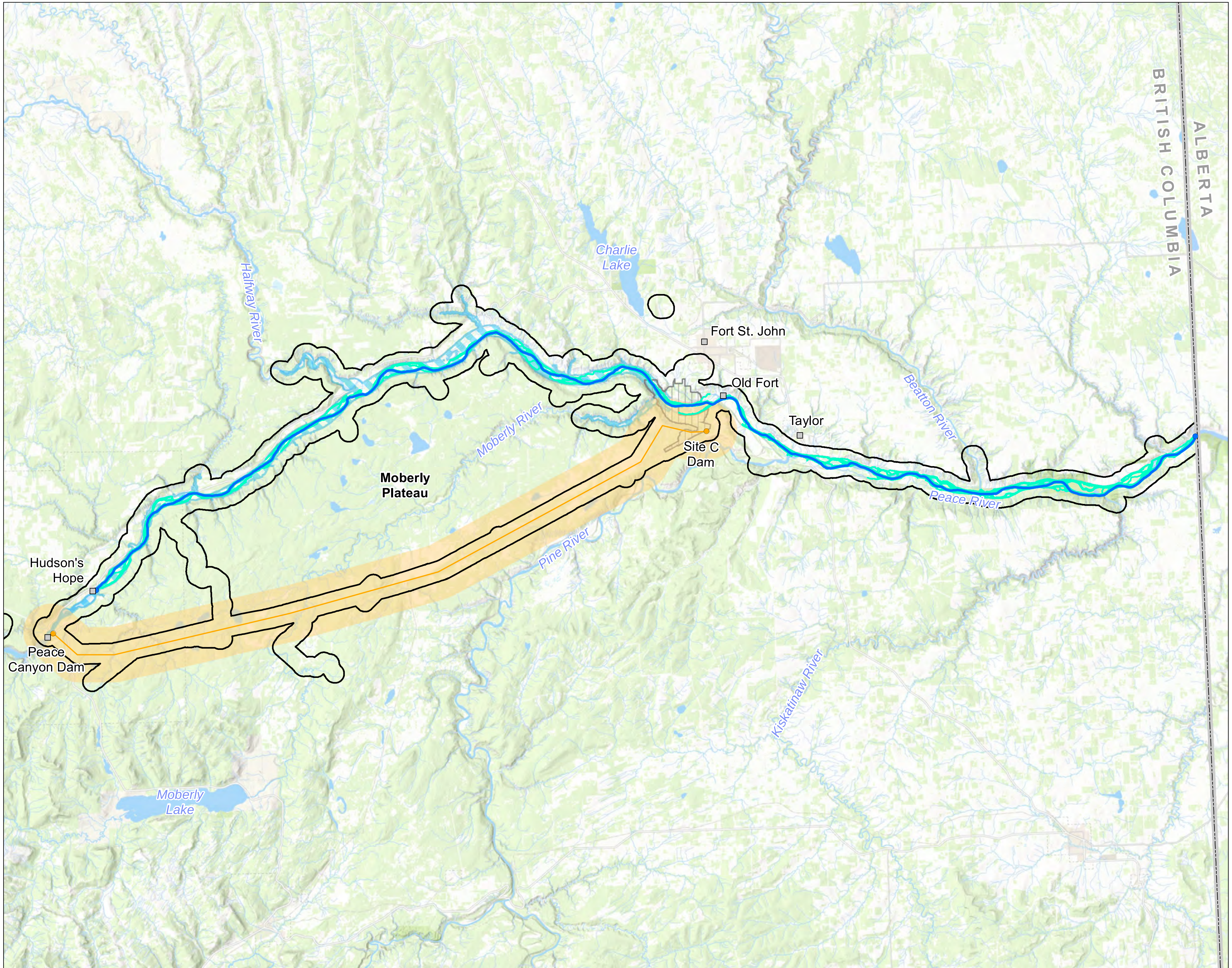
Waterbird survey data will be collected each year through Project construction and for the first 10 years of Project operations, as per EAC Condition 21. The monitoring program has been focused on spring and fall migration periods because the greatest numbers and diversity of waterbirds are present in the study area during those periods (Simpson and Andrusiak 2009; Hilton et al. 2013). In 2017, surveys of the Peace River, and wetland habitats adjacent to the Project transmission line were conducted during 3 survey periods within each of the spring (April/May) and fall (August/September) migrations to document early, middle, and late migrants in each season. In 2018 and 2019, fall surveys of the Peace River were extended into October with a fourth survey period included to obtain additional data on late migrating waterbird species (e.g., merganser [*Mergus*] and goldeneye [*Bucephala*] species).

To inform the timing and number of surveys conducted in 2020, a power analysis was conducted using the Peace River waterbird survey data collected by boat in 2017, 2018, and 2019 (**Appendix A**). The results of the analysis indicated that 2 surveys during the early spring migration (April 1 to 15) and one survey during each of the first 3 fall migration survey periods (encompassing August 1 to October 14) would be sufficient to meet the study objectives (i.e., allow for detection, with 80% certainty, of a 50% change in abundance of each foraging group in the impact area). Thus, surveys in 2020 excluded the fourth fall migration survey period in late October, and were suspended in the spring following the partial completion of a third survey in the middle period of spring migration (April 16 to May 7).

During the spring, Peace River surveys have been initiated earlier than wetland surveys along the transmission line to document waterbirds using the river before upland wetlands thawed. Prior to thawing, wetlands along the transmission line are unavailable for waterbird foraging use and waterbirds primarily use habitat along the Peace River. During the fall, river and wetland surveys along the transmission line ROW are conducted concurrently.

Migratory Waterbird Follow-up Monitoring Program
2020 Report
Site C, Peace River, BC

Figure 1 - Study Areas of the Waterbird Monitoring Program on the Peace River and Moberly Plateau



Legend

- Site C LAA
- Proposed Dam Site
- Proposed Reservoir
- Peace River
- Wetlands Survey
- Transmission Line
- Extent of Peace River Waterbird Surveys
- Provincial Border

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Base

N

1:400,000

0 5 10 15 20 25

Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-07	Production Date: Feb 25, 2021	Figure 1

Hemmera
An Ausenco Company

BC hydro

Path: S:\Geomatics\Projects\989619\07_waterfowl\mxd\MonitoringProgram2020\Fig1_989619_07_Waterbirds_Wildlife_Survey_Transects_210225.mxd

2.0 MONITORING METHODS

Survey methods to meet the objectives of the waterbird monitoring program were developed using guidance from Resource Inventory Standards Committee (RISC) protocols, with review from the VWTC and subsequent input from Environment and Climate Change Canada and Native Plant Solutions of Ducks Unlimited Canada. The survey methods employed during the 2020 field program are described in the following sections. Additional rationale for the methods is presented in the Site C Vegetation and Wildlife Waterbird Migration Follow-up Monitoring Program (BC Hydro 2018).

Baseline surveys conducted for waterfowl between 2006 and 2014 were designed to assess species within the orders Anseriformes (i.e., ducks, geese, and swans), Procellariiformes (i.e., loons), and Podicipediformes (i.e., grebes). Surveys in 2015 and 2016 (Mushanski et al. 2015), using the same methods, expanded the focus to include Charadriiformes (e.g., snipe, sandpipers, phalaropes, plovers, gulls, terns, avocets), Gruiformes (e.g., rails), and Pelecaniformes (e.g., bitterns). The Waterbird Migration Follow-up Monitoring Program is designed to survey the full range of waterbird species present in the study area.

Differences in site accessibility and detection constraints across habitat types and waterbird species required multiple survey methods for the Peace River and wetlands adjacent to the Project transmission line ROW. The Peace River was surveyed by boat along the mainstem of the river and within any channels accessible by boat. Wetlands along the Project transmission line were surveyed using fixed-length transects in all vegetated habitat with less than 50 cm of standing water that were safely traversable on foot, and standwatch stationary surveys of open water habitat included flooded wetlands. Finally, autonomous recording units (ARUs) were used within wetland habitats along the Project transmission line ROW to monitor vocalizations of marsh bird species more readily detected using audio as compared to visual survey methods.

All waterbirds and provincially or federally-listed species observed were recorded during waterbird surveys. The time and precise (Universal Transverse Mercator [UTM]) location of waterbird observations were recorded using time-referenced waypoints along with species, number of individuals, habitat characteristics, and distance measures from observation locations. The distribution of habitat types across the study area was primarily derived from available terrestrial ecosystem mapping (TEM) data developed for the Peace River Terrestrial Ecosystem Mapping Project (Keystone Wildlife Research Ltd. 2012). The TEM data was complimented with satellite imagery and observations from the field to refine wetland and river habitat type designations within study areas. Data will be analyzed to assess potential changes to waterbird relative abundance and diversity across these habitat types (BC Hydro 2018).

Within subsequent sections of this report, the following terminology is used to define the temporal scope of survey efforts:

- **Survey day** – Survey effort in a given day, which covers only a portion of the transmission line ROW wetlands or Peace River study areas.
- **Survey round** – A group of survey days, which together encompass the entire Peace River study area or all wetland survey stations within transmission line ROW study area
- **Survey period** – A period of time which encompasses a defined period of spring or fall migration, including the peak migration of one or more species groups (i.e., foraging guilds).

2.1 Habitat Assessment

Prior to the initiation of boat and ground-based field surveys in 2017, the area of wetland habitat types within the Peace River Valley and Moberly Plateau study areas were summarized from existing TEM data using ArcGIS Desktop (v.10.5.1) software (Hemmera 2018). Wetland habitat area has not changed appreciably since 2017, such that the proportional extent of habitat types is expected to have remained unchanged through 2020. According to the TEM data, the most widespread wetland habitat types in the study area are Labrador tea-sedge and tamarack-sedge (**Table 1**, **Figure 5**). Sedge and open water are less widespread, and willow-sedge is the least common wetland habitat type. Habitat data collected with waterbird observations are described for each survey method in **Sections 2.2** and **2.3**.

Table 1 Area of Wetland Habitat Types in the Peace River Valley and Moberly Plateau Study Area

Wetland Habitat Type	Area (ha)
Labrador tea-sedge	7,243
Tamarack-sedge	4,749
Cultivated field	3,845
Sedge	1,782
Open water	1,535
Willow-sedge	720
Non-forested floodplain wetlands	440

Note: Habitat areas presented here are derived from TEM data developed for the Peace River Terrestrial Ecosystem Mapping Project (Keystone Wildlife Research Ltd. 2012).

Water flow and depth are known to influence the abundance, distribution, and species composition of waterbirds within wetland systems (Colwell and O. W. Taft 2000; Baschuk et al. 2012). These are particularly important factors to consider on the Peace River given the pronounced fluctuations in flow associated with hydroelectric dams and the presence of the Peace Canyon dam immediately upstream of the study area. Hydrological monitoring stations that were active during spring and fall waterbird migration periods in 2017 through 2020 were identified to obtain hourly water flow data. Flow data were obtained from monitoring stations within each treatment area (Inundation Impact, Flow Impact, Control), since flows in each of these areas are uniquely influenced by inputs from tributaries along the course of the Peace River. Hourly flow data were summarized using SigmaPlot (v.12.5) to illustrate the frequency of flow rates within each treatment area. To determine if surveys were conducted under representative flow conditions, frequency distributions of hourly river flow rates throughout the spring and fall of 2017 through 2020 were compared to frequency distributions from hours during which surveys were conducted in those years. Following subsequent years of data collection, flow rate data can also be used as a habitat variable in models describing waterbird distribution within the Inundation Impact area prior to inundation and within the Flow Impact and Control areas before and after inundation. After inundation, reservoir water level changes within the Inundation Impact area are expected to be minimal, with the exception of short duration changes due to relatively rare, extreme events.

2.2 Peace River Waterbird Surveys – Boat Surveys

2.2.1 Study Design

Surveys of the Peace River were conducted to assess the relative abundance and diversity of waterbirds using riverine and backchannel habitat. In 2017 through 2019, 5 surveys were conducted during spring and 6 surveys were conducted during fall, with greater survey frequency (i.e., shorter gaps between surveys) in spring compared to fall to account for a more condensed migration window. As described in **Section 1.3**, survey effort in 2020 was reduced to 2 spring and 3 fall surveys in accordance with the conclusions of a power analysis conducted on the previous 3 years of survey data (Native Plant Solutions 2020).

A before-after, control-impact (BACI) study design has been applied to allow Project-related changes in waterbird relative abundance and diversity to be detected and distinguished from background (e.g., natural) variation within waterbird communities in the Peace River valley. Within the BACI study design framework, the areas surveyed to assess impacts are as follows: (i) the Site C reservoir from Hudson's Hope to the Project site (impact from inundation; **Figure 2**), (ii) the Peace River from the Site C dam to the Pine River confluence with the Peace River (impact from change in flow regime; **Figure 3**), and (iii) the Peace River from the Pine River confluence to the Alberta border (control; **Figure 4**). Below the confluence of the Peace and Pine rivers, Project-related changes in flow regime will be moderated by inputs from the Pine River. Control and impact areas within the Peace River study area are, hereafter, referred to as 'treatment areas'.

The before condition for the BACI design will be that which exists prior to reservoir filling, which is planned to occur in fall 2023. Impacts are expected once reservoir filling begins. The river diversion period (planned to occur fall 2020 to fall 2023) will be part of the before condition because water volumes and flow rates are expected to be mostly un-changed outside of the immediate construction area and small headpond during this period.

The total length of river within the study area is 142.5 km; 78.1 km in the Inundation Impact area (**Figure 2**), 18.0 km in the Flow Impact area (**Figure 3**), and 46.5 km in the Control area (**Figure 4**). The total river area assessed in this study, including side-channels and wetted backchannels, varies depending on water levels associated with discharge rates from the Peace Canyon dam and tributaries to the Peace River. The total mapped area of the Peace River as defined within TEM data is 5,662.9 hectares (ha), with 2,797.6 ha in the Inundation Impact area, 588.1 ha in the Flow Impact area, and 2,277.2 ha in the Control area. While actual wetted areas will vary in accordance with water levels, they are anticipated to vary proportionally across treatment areas such that estimates of waterbird densities determined from the study would be affected evenly across Impact and Control areas.

Four (4) habitat types based on connectivity to the Peace River and associated water flow rates, depths, substrate and vegetative cover were delineated with polygons across the study area using satellite imagery, and notes regarding water depth collected during surveys conducted in 2017 through 2020: Mainstem, Moderate Flow, Limited Connectivity, and Minimal Connectivity. Specific characteristics for each of these habitat types are detailed in **Table 2**. Habitat characteristics associated with connectivity to the Peace River were considered relevant to waterbirds because flow volumes correspond with sediment grain size and, consequently, the extent of aquatic vegetation that is a key foraging resource for dabbling ducks and large dabblers. Additionally, water depth is an important driver of waterbird abundances for a variety of species and is known to influence habitat selection and species composition, with dabbling ducks selecting habitat along a depth gradient relevant to their morphology, and piscivorous as well as benthic feeding divers typically preferring deeper water (Baschuk et al. 2012; Colwell and O. W. Taft 2000).

Portions of the river with Minimal connectivity to the river were not accessible by boat and therefore were not surveyed in 2020. Limited Connectivity habitat was inaccessible by boat when river levels and flow rates were low. Despite these constraints on river boat survey methods, the power analysis conducted using data collected from 2017 through 2019 specified that surveys of areas accessible by boat would provide sufficient power to detect changes in waterbird abundance for all foraging guilds (Native Plant Solutions 2020; **Appendix A**).

Photographs showing examples of Peace River habitat types surveyed by boat are presented in **Photo 1**.

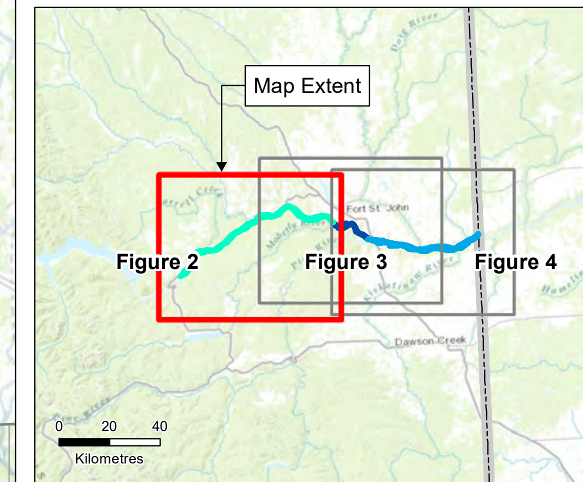
Table 2 Characteristics of River Habitat Types Used to Delineate Polygons Along the Peace River

River Habitat Type	Characteristics
Minimal Connectivity	Minimal or no connectivity to the river (e.g., lentic water features) except during extreme high water or flooding events with minimal or no flow and silty or otherwise fine-grained substrates and mostly shallow, including ephemeral ponds. Both emergent and submergent aquatic vegetation proliferates in these habitats.
Limited Connectivity	Limited connectivity to the river (e.g., backchannels primarily connected to the river at the downstream end) with relatively low flow rate and volumes, fine substrates (e.g., silts and sands) and many shallow areas only inundated when river levels are high. Submergent aquatic vegetation occurs along the shoreline in these habitats.
Moderate Flow	Consistently connected to the river (e.g., side channels connected on up- and downstream ends) with relatively moderate flows, moderately sized substrates (e.g., sand, gravel) and shallow waters typically inundatating most of the river bed. Aquatic vegetation is sparse.
Mainstem	Main channel of the river where water flow rates, depths, and substrate size (e.g., gravel, cobble) are greatest. Permananently inundated with aquatic vegetation sparse or absent.

Photo 1 Examples of habitat types defined for the Peace River including a Mainstem portion of the river (upper photo) and a Moderate Flow side channel (lower photo, in the center/right) also showing a small area with Limited Connectivity to the Peace River (lower photo, on the left).

Migratory Waterbird Follow-up Monitoring Program
2020 Report
Site C, Peace River, BC

Figure 2 - Inundation Impact Area on the Peace River



Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Base

N

1:220,000

0 2 4 6 8 10
Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

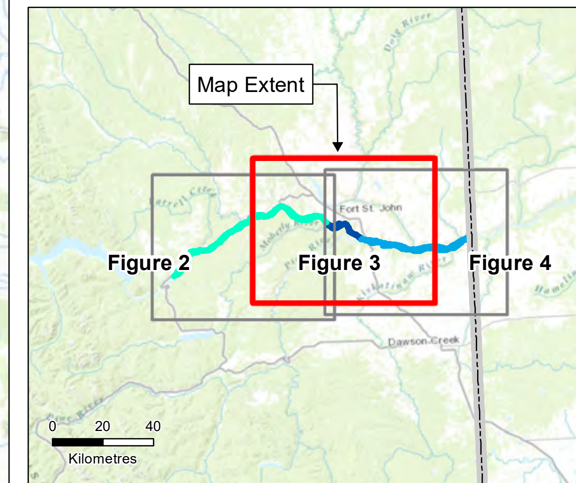
989619-07	Production Date: Feb 25, 2021	Figure 2

Hemmera An Ausenco Company

BC hydro

Migratory Waterbird Follow-up Monitoring Program
2020 Report
Site C, Peace River, BC

Figure 3 - Flow Regime Change Impact Area on the Peace River



Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Base

N

1:220,000

0 2 4 6 8 10
Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-07	Production Date: Feb 25, 2021	Figure 3

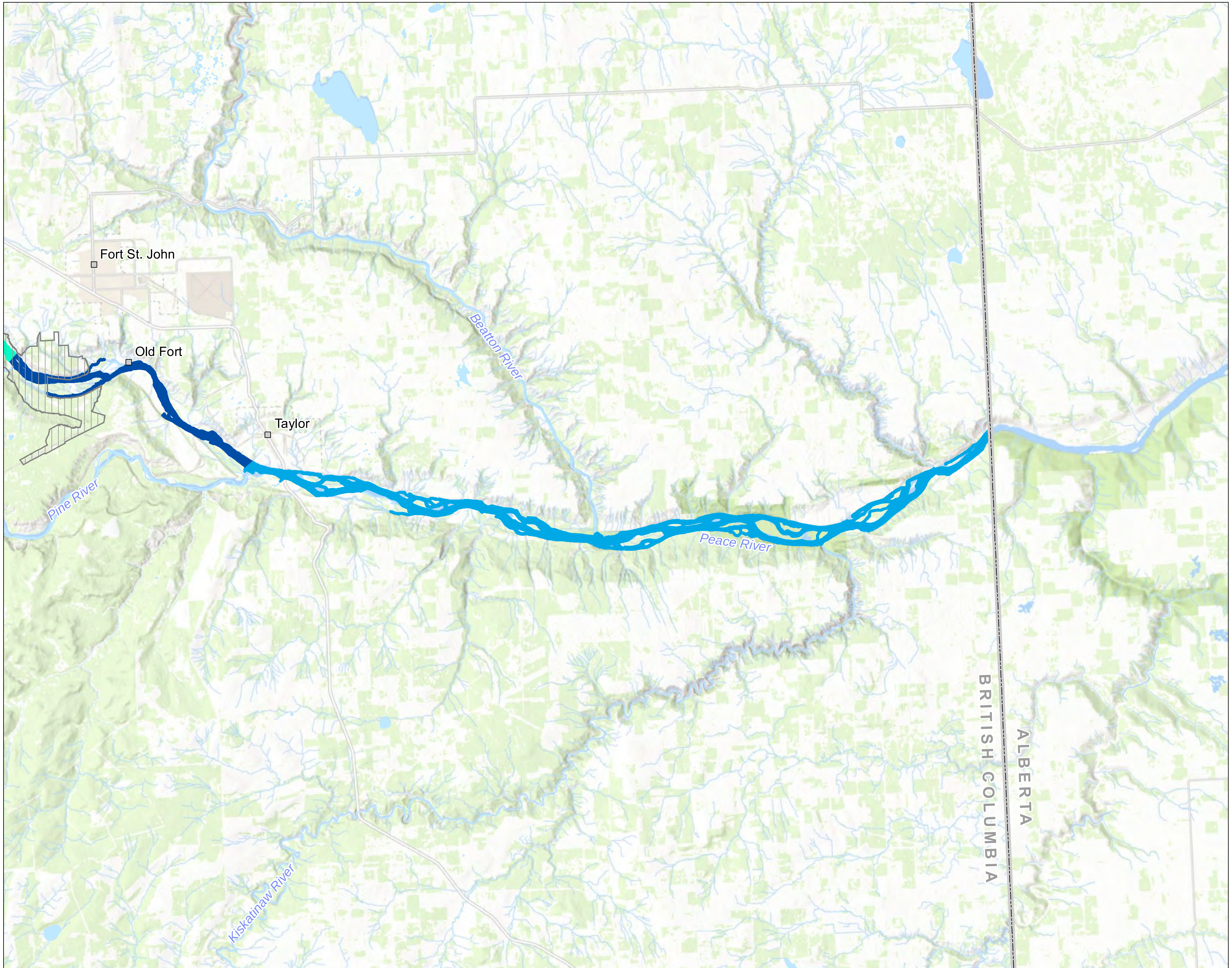
Hemmera An Ausenco Company

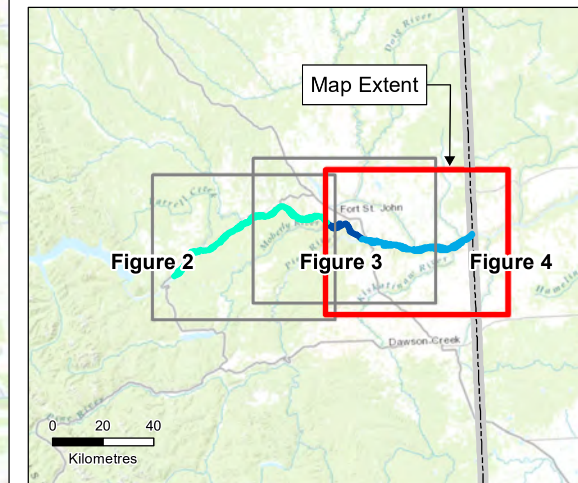
BC hydro

Path: S:\Geomatics\Projects\989619\07_waterfowl\mxd\MonitoringProgram2020\Fig3_989619_07_Waterbirds_FlowRegimeChangeImpactArea_210225.mxd

Migratory Waterbird Follow-up Monitoring Program
2020 Report
Site C, Peace River, BC

Figure 4 - Control Area on the Peace River





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Base

N

1:220,000

0 2 4 6 8 10
Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-07	Production Date: Feb 25, 2021	Figure 4

Hemmera
An Ausenco Company

BC hydro

2.2.2 Survey Methods

Boat surveys, following a modified version of the “Floating Rivers in Rafts or Kayaks” methods described in Inventory Methods for Riverine Birds (RIC 1998) and Inventory Methods for Waterfowl and Allied Species (RIC 1999), provided visual coverage throughout most of the Peace River study area from Hudson’s Hope to the Alberta border (**Figure 1**). Surveys usually required 2 days to provide coverage of the complete length of river from Hudson’s Hope to the Alberta border. Surveys took place in daylight hours between 07:00 and 18:00. During a typical survey round, the upstream portion of the river was surveyed on the first day and the downstream portion of the river was surveyed the second day. Occasionally, a third day was required to complete the survey round due to mechanical issues, inclement weather, or otherwise inappropriate conditions (e.g., ice break-up and release into river).

The jet boats used for surveys are well suited to accessing and passing through shallow waters and provided efficient coverage of a broad range of habitat types. Boat surveys provided clear lines of sight of open water habitat as well as shoreline, nearshore areas, exposed sandbanks, gravel bars, and mudbanks/flats along the mainstem of the river, side channels, and many backchannels. Survey routes circled around islands and side-channels and extended up backchannels wherever water levels allowed. Areas where water levels were too low for boat access or the entrance to back/side-channels was obstructed by debris were not surveyed. Boat surveys were conducted at speeds of 30 to 40 km/hour, except where shallow waters required faster speeds to prevent the boat from grounding on the riverbed. Also, speeds were slowed briefly for no more than one to 2 minutes to improve the accuracy of species identification and abundance estimates when large or multiple flocks of waterbirds were observed.

Surveys were conducted by biologists trained in waterbird identification and survey protocols. During boat surveys, 2 observers focused their respective survey efforts on opposite shores to the center of the river and communicated bird movements to prevent double counting birds. The observers scanned the river from the front of the boat using the naked eye to detect birds and used binoculars for species identification. Data were recorded using electronic data forms immediately following each observation using map-based spatial software. Only one surveyor entered data at any given time so at least one observer was available to search. Surveys were not conducted during sustained inclement weather conditions that would result in a reduced ability to detect waterbirds (i.e., wind speeds greater than 3 on the Beaufort scale [≥20 km/h, frequent whitecaps], rain or fog that resulting in poor visibility [less than 1 km]; as per provincial standards (RIC 1999).

Field crews recorded the following information during each survey day:

- Survey date
- Start and end time
- Proportion of backchannels surveyed and visible
- GPS track of the survey transect line
- Weather conditions at the start of surveys and any notable changes in weather
- Survey crew (including 3rd observer if present).

Field crews recorded the following information for each individual or flock of waterbirds observed:

- UTM coordinates
- Date and time (hour and minute)
- Species
- Number of Individuals
- Habitat type (gravel bar, open river, riverbank, terrestrial)
- Distance to disturbance (Not disturbed, <50 m, 50-<100 m, 100-<200 m, 200-400 m, >400 m).

To provide estimates of absolute abundance, 2 methods were employed to account for birds that were present during surveys but not detected by observers. Distance sampling using line transect methods (Buckland et al. 2015) was applied starting in the fall of 2018 (and continuing throughout 2019 and 2020 surveys) by recording a track of each survey using a handheld GPS, from which distance can be calculated between the transect and each georeferenced waterbird record. Through data analysis, abundance and density estimates can be adjusted to account for birds not detected due to their distance from the survey transect based on the relationship between distance to birds from the path of the survey vessel (i.e., transect line) and the number of birds detected within various distance categories. Additionally, a subset of surveys have included a third observer to check for consistency in data collected between observers and to test assumptions of distance sampling. During river surveys in the fall of 2018 and in the spring and fall of 2019 and 2020, surveyors recorded GPS tracks of the boat survey route as part of broader efforts to assess waterbird detectability across the monitoring program.

2.3 Transmission Line Wetland Surveys ‑ Transect, Standwatch, and ARU

2.3.1 Study Design

Wetland surveys on the Moberly Plateau are designed to assess impacts to waterbirds associated with the Site C transmission line. To assess these impacts (e.g., expanding the area of cleared vegetation along the transmission line ROW), the study provides estimates of waterbird abundances and diversity within impacted habitat types used by waterbirds. Habitat-specific densities of waterbirds provided by the study can be compared to the area of impacted habitat to estimate the number and species of birds impacted by the transmission line. To assess potential changes to wetland habitat use due to other impacts of the Project (e.g., potential displacement of waterbirds from inundated river valley habitat into adjacent wetlands), the study provides data to compare abundances within habitat types before relative to after reservoir inundation.

To assess the abundance and diversity of waterbirds using wetland habitats adjacent to the Project transmission line ROW on the Moberly Plateau, surveys were conducted using the following methods:

- Fixed-length transects of vegetated habitat traversed on foot with water depths less than 50 cm
- Stationary standwatch surveys of open water and flooded wetland habitat
- Passive bioacoustics monitoring using ARUs of vegetated wetlands as well as transition zones between vegetated wetlands other habitat types (e.g., open water, upland forests).

Unique survey methods were applied across these habitat types due to distinct access and detection constraints. The specific methods applied to each habitat type were selected to minimize detection constraints and maximize the amount of information obtained on waterbirds. Survey methods and protocols also included measures of detection rate to further account for habitat-specific differences in waterbird detectability.

Wetland waterbird surveys in 2020 were conducted at 22 survey stations encompassing open water, sedge, and willow-sedge habitats. Surveys in 2020 covered all but 3 of the 25 stations surveyed in 2019. Three stations were excluded from 2020 surveys because they could not be effectively surveyed on foot or were replaced with more safely accessible habitat near existing stations. Wetland surveys within other habitats (e.g., Labrador tea-sedge and Tamarack-sedge) were discontinued as of 2019 due to a lack of observed use by waterbirds (**Table 3**). The only waterbird recorded outside of open water, sedge and willow-sedge habitats during 7 to 10 surveys conducted at each station in 2018 was a Wilson's snipe (*Gallinago delicata*) within Labrador tea-sedge habitat (Hemmera 2019). Wilson's snipe is regularly observed within sedge and willow-sedge habitats (**Appendix B**), so it is not unique to Labrador tea-sedge habitat.

Wetland habitats at each station were surveyed once over a 2 to 3-day period (i.e., survey round). In 2017, 2018 and 2019, surveys at each station were conducted over 4 rounds following thaw in the spring, and 6 rounds in the fall. Survey frequency along the transmission line in 2020 was the same as that applied to the river, resulting in 2 sets of wetland surveys in the spring and 3 in the fall.

Wetland survey effort was standardized either by length (100 m transects) or time (20-minute standwatch surveys). Transects could not always be completed in a consistent time due to differences in conditions between sites and seasons such as variable terrain, vegetation, and water depth. However, transect surveys were targeted for completion within 10 minutes and the time taken was recorded to allow for differences in waterbird detections due to survey time to be assessed and accounted for if required.

Photographs showing examples of standwatch and transect surveys and habitats surveyed by the respective methods are provided in **Photo 2**, **Photo 3**, and **Photo 4**.

Table 3 Wetland Habitat Types Adjacent to the Project Transmission Line ROW and Observed Presence

Wetland Habitat Type	Characteristics	Consistent Waterbird Observations in 2017 and 2018?
Open water (OW)	Open water with no (or limited) emergent vegetation, including shallow open water (less than 2 m depth), as well as ponds, and lakes transitioning or connected to wetlands.	Yes
Tamarack-sedge (TS)	Fen with tamarack-dominated overstorey	No
Sedge (SE)	Uniform sedge (*Carex* sp) flat low area with less than 10% willow – birch. Typically wetted and often with standing water.	Yes
Labrador tea-sedge (BT)	Labrador tea-dominated peat bogs, often with black spruce overstory	No
Willow-sedge (WS)	Sedge (*Carex* sp.) meadow with scattered (>10%) willows/scrub birch. Often bordering sedge habitat in slightly elevated and areas with less standing water than sedge habitat.	Yes
Cultivated field (CF)	Only considered if wetted and/or water source or wetland occurs within 100 m	No

Photo 2 Example of a standwatch survey of open water habitat.

Photo 3 Example of a transect survey within a sedge-dominated wetland.

Photo 4 Example of a transect survey within a willow-sedge and scrub birch-dominated wetland.

Marsh bird species that can easily go undetected during standwatch and transect surveys (e.g., yellow rail [*Coturnicops noveboracensis*], American bittern [*Botaurus lentiginosus*]) were assessed with passive acoustic monitoring using Autonomous Recording Units (ARU) (Song Meter 3 and Song Meter 4, Wildlife Acoustics Inc. Maynard, Massachusetts, USA). Passive acoustic monitoring using ARUs is particularly useful for detecting rail and bittern species as they have known call signatures but are rarely observed during time-constrained, daytime surveys due to scarcity on the landscape, cryptic appearance and behavior, and limited diurnal activity. Acoustic data from ARU deployments provide comparable and potentially greater detection rates for yellow rail as compared to call playback methods (Bayne et al. 2014), and reduce safety hazards associated with accessing and working in remote areas at night. ARUs are designed to record acoustic data, (e.g., calls and songs of birds), at specified time intervals over a period of days, weeks, or months. ARUs were programmed to record acoustic data between dusk and dawn, during the peak vocalization period for rails and American bittern (i.e., from May through July [Conway 2011]).

In 2020, bioacoustics monitoring with ARUs was primarily focused on habitat types in which yellow rail had been recorded most consistently because this was the only species recorded with ARUs and not by other survey methods in the previous 3 years of monitoring. Consequently, bioacoustic monitoring in 2020 primarily targeted sedge-dominated habitats, the habitat type in which yellow rail was most often observed in prior years (**Figure 5**). Bioacoustic monitoring in 2020 also targeted sedge-dominated habitat adjacent to open water sites, as this habitat type was only present at to monitoring locations in prior years.

2.3.2 Survey Methods

The objective of waterbird surveys at wetland stations was to assess waterbird abundance within each focal habitat type in which waterbirds were regularly observed in prior years (open water, sedge, willow-sedge; (**Table 3**). Thus, survey efforts were focused on collecting independent samples of abundance data from each wetland type rather than for the station as a whole. Wetland survey stations assessed during surveys in 2020 and prior years contain one or more focal wetland type. Consequently, each wetland habitat type within a station was surveyed separately such that multiple surveys were often conducted at a single wetland station in a single survey day or survey round. Furthermore, distinct survey methods were applied to some habitat types to maximise efficiency of data collection and minimize detection constraints to the extent possible. Wetland survey methods, and the habitats to which they were applied, are described below.

2.3.2.1 Transect and Standwatch Surveys

Two (2) crews, each consisting of a biologist and a field assistant, completed wetland surveys during daylight hours between 07:00 and 18:00. Biologists were experienced in visual and vocalization identification of wetland bird species and were trained in survey protocols as well as wetland habitat characterization (i.e., identification of habitat types described in **Table 3**). Surveys were not conducted during sustained inclement weather such as high winds (i.e., >3 on the Beaufort scale) or moderate to heavy precipitation that would impede visibility within one kilometre.

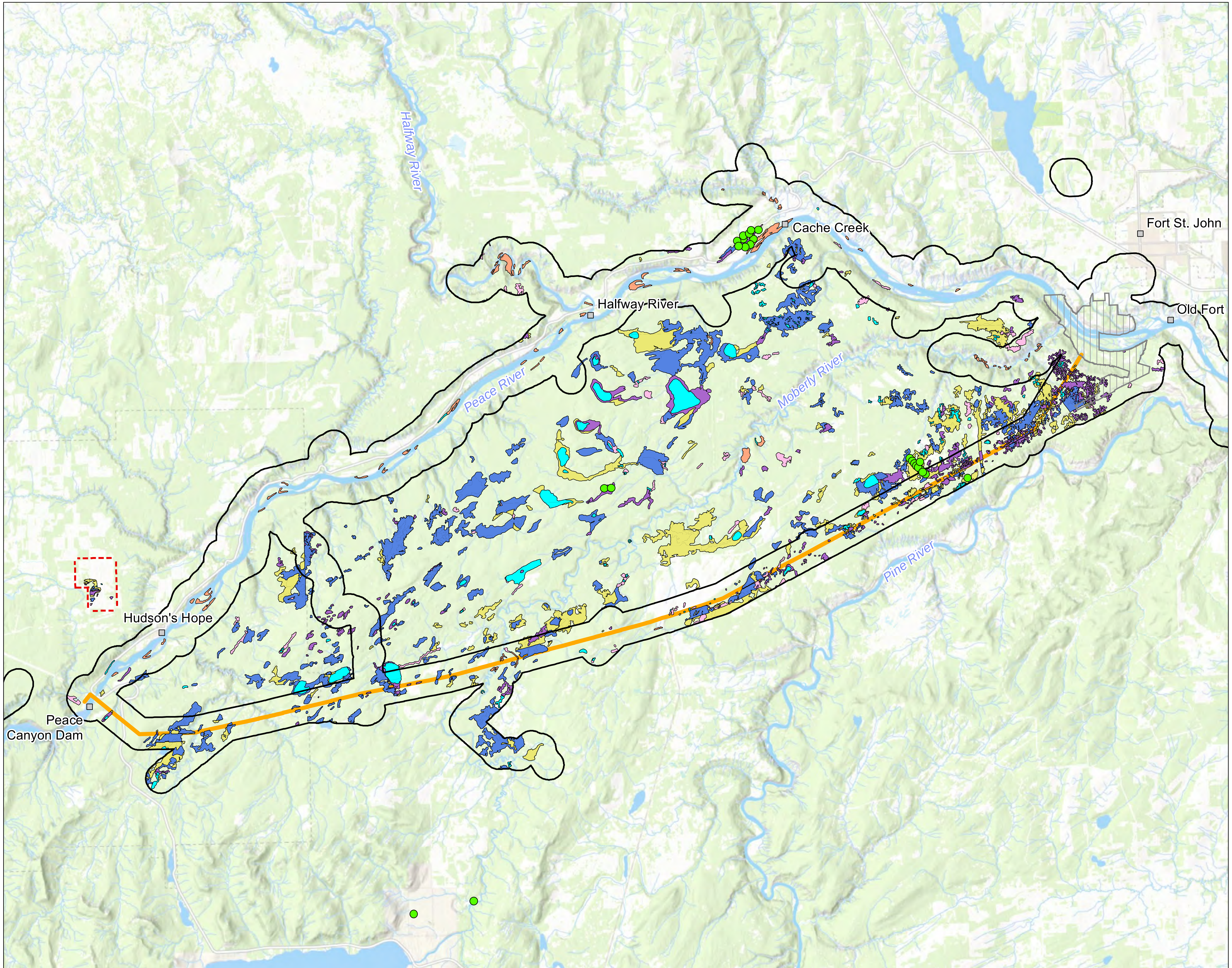
As in 2018 and 2019, fixed length transect surveys of 100 m were conducted in 2020 in sedge and willow-sedge habitats along the transmission line ROW. This method is considered appropriate given the lack of unobstructed lines of sight within these wetland types. Sedge and willow-sedge wetlands with water levels less than 50 cm were surveyed with at least one, and a maximum of 3 transects. Where multiple wetland types were present within wetland stations, transects were conducted within distinct habitat types to provide data specific to each type. Transects were generally straight but followed meandering routes where necessary to stay within target habitat types or safe terrain.

Stationary standwatch surveys of 20-minute duration were conducted in 2017, 2018, 2019, and 2020 at wetlands with open water habitat and flooded wetlands. Standwatch surveys are the most appropriate method for these habitats because visual lines of sight from ground-level, or from a slightly elevated perspective, provide efficient visual detection of waterbirds on the water's surface across large areas. Wetlands with areas of open-water interspersed with vegetation, surveyed by RPAS in 2018 and 2019, were also surveyed with 20-minute standwatch surveys in 2020. Where necessary, the 20-minute survey was divided into two 10-minute segments at 2 vantage points, while being cautious to avoid double-counting birds. The same vantage points were used to survey open-water wetland stations during each survey round.

Wetland surveys were repeated within a subset of open water and flooded areas surveyed by standwatch methods to obtain a measure of the number of birds not detected during a typical survey (i.e., to inform detection rates). Transect surveys typically disturbed waterbirds causing them to flush and leave the area, thereby altering abundances and leading to reduced numbers during repeated surveys. Consequently, repeated transect surveys were not informative of detection rates. Instead, distance to disturbance and from the transect was recorded to allow incomplete detection to be accounted for with distance sampling.

Migratory Waterbird Follow-up Monitoring Program
2020 Report
Site C, Peace River, BC

Figure 5 - Wetland Habitat Types and Historic Yellow Rail Detections in and Adjacent to the Peace River Valley and Transmission Line Route



Legend

- Site C LAA
- Proposed Dam Site
- Marl Fen Property - BC Hydro Wetland Compensation Site
- Transmission Line Right-of-Way
- Historic YERA records (prior to 2017) from eBird and Baseline Studies

Wetland Types

- Labrador-tea – sedge (BT)
- Non-forested floodplain wetland (WH)
- Sedge (SE)
- Open water (OW)
- Tamarack-sedge (TS)
- Willow sedge (WS)

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
3. OW has been used as the idientfier for Shallow Open Water wetland field locations; however, please note that the wetland classification also includes LA and PD habitat codes.

Sources

- Basemap: ESRI World Topographic Base

N

1:250,000

0 2 4 6 8 10

Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-07	Production Date: Feb 25, 2021	Figure 5

Hemmera An Ausenco Company

BC hydro

Path: S:\Geomatics\Projects\989619\07_waterfowl\mxd\MonitoringProgram2020\Fig5_989619_07_Waterbirds_Wetlands_210225.mxd

The following information was recorded at each wetland survey station:

- Wetland Station ID
- Date and time
- Survey lead and field assistant names
- Weather data (temp, cloud cover, wind, precipitation) recorded within the hour
- Proportion of each habitat type within the wetland or survey station (e.g., extent [%] of open water).

The following information was recorded for each survey:

- Start and end time of survey
- Start and end UTM coordinates
- Survey method (transect, standwatch) and ID (transect 1, transect 2)
- Area of habitat surveyed (area of open water, width of contiguous habitat along transect)
- Proportion of each habitat type present within the surveyed area
- Estimated water depth within each habitat type in survey area
- Estimate of average vegetation height (measure of detection constraint)
- Extent (%) of vegetation present within open water areas (for standwatch surveys).

The following information was recorded for each waterbird or flock observed during surveys:

- UTM coordinates
- Date and time (hour and minute)
- Species
- Number of individuals
- Habitat type in which the bird was observed
- Estimated water depth (dry, >0 to 10 cm, 10 to 50 cm, >50 cm) where flock was observed
- Primary behavior
- Detection type (detected while flushing, flying, not disturbed)
- Distance from the observer and transect (for transect surveys).

As detailed above, habitat data were collected at 3 scales (waterbird records, survey, wetland station) for each bird or flock observed and at 2 scales for each survey (survey, and station). This approach was taken to provide habitat association data for each waterbird record and to ensure that the size of wetland habitat patches and the habitat present within surrounding areas could be accounted for if either are found to be a factor affecting the abundance and/or diversity of waterbirds.

2.3.2.2 Autonomous Recording Units

All ARUs were fitted with omnidirectional SMM-A1 microphones recording at a sample rate of 16 kHz and gain of 0 dB. The microphones were installed approximately 2 m above ground and were set up to record acoustic data from 30 minutes before dusk to 30 minutes after dawn. Dusk and dawn recording times are recognized automatically by the internal GPS and clock of the ARU, which accurately detects the time zone where the ARU is recording. ARUs were deployed and recorded data for a minimum of one week (i.e., 7 nights) at each site.

3.0 DATA MANAGEMENT AND ANALYSIS

Waterbird records from 2020 surveys were compiled into the existing database from 2017, 2018, and 2019 using Microsoft Access software for data management. Once data were compiled, quality assurance measures were applied to identify anomalous species or count data. Any outlying records (e.g., high counts, rare species) were verified by confirming with field staff and, where possible, by reviewing data sources (e.g. hardcopy data forms, survey notes, ARU files).

As in previous years, the scope of this annual report is limited to descriptive statistics (primarily ranges and means) to demonstrate that survey methods are capturing the targeted species guilds across all study areas within relevant time periods and habitat types, and to highlight broad patterns in abundance and distribution. Metrics of waterbird diversity and abundance are reported for each study area, season and survey periods within seasons, as well as across habitat types. Abundance and diversity data are also summarised by species guilds defined by diet: dabbling ducks (i.e., small waterfowl that feed primarily on aquatic vegetation), large dabblers (i.e., large waterfowl [e.g., geese and swans] that feed primarily on vegetation), piscivorous divers (i.e., diving birds that forage on fish), benthic feeding divers (i.e., small waterfowl and sea ducks that feed primarily on benthic invertebrates), gulls and surface-feeding terns (i.e., small to large size birds that forage on fish and insects near the water's surface, and occasionally garbage - hereafter referred to simply as 'gulls'), shorebirds (i.e., plovers and sandpipers that feed primarily on or near the shoreline), and unidentified waterbirds. Birds that were not identified to species were recorded to the most specific taxonomic level possible. A full list of species observed and the guilds to which they are assigned is presented in **Appendix B**.

Abundances are described in terms of relative abundance because they represent the number of waterbirds detected, rather than true (i.e., absolute) abundances, which require estimates of the proportion of birds not detected. Distance and repeated survey data were collected (as described in **Section 2.2.2** and **2.3.2**) to provide measures of detectability and allow for estimates of absolute abundance in future analyses to assess the magnitude and significance of Project-related change. Throughout this report, the terms abundance and density refer to relative abundance and relative density, as summary statistics are not corrected for detection rate via distance sampling or other means. Measures of abundance are reported in terms of density per unit of survey area or transect length except in cases where abundances are reported for an entire study area (e.g., the Peace River study area) in which case the relevant area (i.e., the study area) is known and is specified within the results (see **Section 4.1.2**).

Waterbird diversity is presented in terms of species richness (i.e., the number of species) and species evenness (i.e., the degree of similarity in abundance of each species) using Pielou's evenness index. The equation for calculating Pielou's evenness index is reported by MacDonald et al. (2017):

$$Species\ evenness = \frac{(-\sum_{i=1}^{S}(p_i \times \ln p_i))}{(\ln S)}$$

Where *S* is the number of species (i.e., species richness), p_i is the proportion of all sampled waterbirds represented by species *i,* and *ln* is the natural logarithm. MacDonald et al. (2017) generally recommend against using indices that combine measures of species richness and evenness, such as the Shannon-Wiener index, for measuring changes in biodiversity because of output that is difficult to meaningfully interpret.

3.1 Peace River Waterbird Surveys – Boat Surveys

Waterbird data were summarized to provide mean abundance or density, and diversity statistics across sections of the Peace River that will be differentially affected by the Project (i.e., treatment areas), habitat types, seasons, and survey periods. To provide estimates of densities within habitat types and treatment areas, density estimates were averaged first across survey rounds within survey periods, then across survey periods, then across years to provide mean densities that were equally weighted across the 3 temporal scales at which survey data were collected.

To assess differences in abundance and diversity related to habitat, survey data were initially summarized in terms of the number of birds/ha within each habitat type (i.e., density by area of habitat) by assigning each waterbird detection to the habitat polygon in which the bird was recorded in or closest to (e.g., birds on the shoreline or within 100 m of the river) and dividing total counts in polygons and habitat types (**Table 2**) by the area surveyed. Abundance data were summarized by multiplying these densities (birds/ha) by the total area within each treatment area. Determining densities based on assigning waterbird records to habitat polygons is a method that has been applied to other monitoring studies of wetland and riverine systems in British Columbia (Hemmera 2020a). This method provides improved resolution for density determinations compared to estimates based on river length (e.g., birds/km), as it allows for separate estimates of density in unique habitats that occur within each of the treatment areas. Additionally, the use of density by area estimates is aligned with the statistical power analyses that informed the level and timing of survey effort in 2020, in which measures of survey effort used to generate estimates of statistical power were adjusted based on the area covered during each round of surveys (**Appendix A**).

To provide estimates of abundance across the study area during the spring and fall migration periods, estimates of density derived for each habitat type from each survey round were averaged first across surveys within periods and then across years to derive mean densities for each survey period. These habitat-specific densities were then multiplied by the areas of the respective habitats in the study area and summed to provide a total estimate of abundance for all habitats surveyed within the study area.

To provide comparable measures of diversity, estimates of richness and evenness were determined using data from a restricted area to provide standardized (i.e., equal) survey effort across surveys. To accomplish this, diversity statistics were derived from data collected in areas that were consistently surveyed in all years and seasons. Consequently, diversity estimates were primarily derived from survey data collected within areas of the Peace River comprised of Mainstem and Moderate connectivity habitat types, as these areas were accessible by boat during both low and high flow conditions. These habitat types comprise the vast majority (approximately 90%) of the study area (**Table 5**). While some species that forage predominantly in shallow and low flow habitat may be missed by these limited summaries of diversity, subsequent analyses of Project-related effects, more sophisticated analytical methods (e.g., species rarefaction / accumulation curves) can be used to account for variable survey effort and incorporate diversity data from areas of Limited river connectivity. A complete list of the species and numbers of individual waterbirds observed is presented within **Appendix B** of the report.

Data from surveys that did not cover the entire study area due to logistical constraints or inappropriate survey conditions were excluded from calculations of abundance and diversity. Similar to the limitations of diversity data statistics described above and methods applied to account for incomplete detection below, these data will be maintained within the monitoring program database and can be incorporated into more sophisticated analyses of Project-related effects in future years, but such analyses were considered beyond the scope of annual baseline monitoring reporting.

3.2 Transmission Line Wetland Surveys – Transect, Standwatch, and ARU

Data from surveys conducted annually from 2017 through 2020 were summarized to provide estimates of abundance and diversity for each survey. These estimates were compared across survey periods, seasons, and years. The number of birds observed within each habitat type was presented per unit of survey effort. For transect surveys, the number of birds observed within sedge and willow-sedge during each survey were determined per 100 m transect conducted in each habitat type. The mean number of birds within each foraging guild observed per transect was calculated for each wetland type and multiplied by 10 to provide an estimate of the number of birds per kilometre of transect. Data collected from standwatch surveys were used to provide estimates of density at stations with permanent open water, and an average estimate of density was calculated across all these stations for each foraging guild based on the area of open water. Summarization of diversity statistics from wetland waterbird surveys was complicated by uneven sampling effort across years, seasons, and survey periods. However, survey effort was applied evenly to all foraging guilds as all guilds were targeted during each survey. Consequently, survey data were pooled across all time periods to provide measures of species richness for foraging guilds for each survey method allowing for comparisons of diversity across these guilds. Additionally, although differences in survey effort and detection constraints prevent direct comparison across methods, the total number of species observed was summarized by foraging guild for each survey method applied within wetlands.

Acoustic data were downloaded and analyzed using a cluster analysis method in Kaleidoscope Pro (Wildlife Acoustics, Inc.), followed by manual verification. Cluster analysis groups bird songs with similar parameters such as minimum and maximum frequency range of the song, duration of the song and inter-syllable gap. Reference songs of sora, yellow rail, and American bittern were obtained from the Cornell Laboratory of Ornithology (Macauley Library), and Xeno-canto (www.xeno-canto.org) and characteristics for several songs from each of these species were matched to the groups of songs from the cluster analysis. Recorded songs suspected to be of sora, yellow rail or American bittern were aurally verified and checked against the reference calls from the Macaulay Library. Although the Peace Region is outside of the recognized range of Virginia rail (*Rallus limicola*) (Conway 2020), an incidental observation of this species at Watson Slough in 2019 prompted a review of recent species records in the region, which revealed multiple records in 2019 and 2020 (eBird 2020). Consequently, bioacoustics data recorded from ARU deployments in 2020 were also analyzed to identify vocalizations of Virginia rail.

The number of nights that ARUs were deployed was recorded at each site and the results of acoustic data analyses were assessed as present or not detected for American bittern, sora, Virginia rail, and yellow rail at each monitoring station. Bioacoustics data cannot easily distinguish between individual birds to provide estimates of abundance at ARU monitoring sites. However, estimates of density for sora are provided from standwatch and transect surveys and all audio data has been archived for more detailed analyses if they are deemed necessary at a later date.

4.0 RESULTS

Results for the monitoring program from 2017, 2018, 2019, and 2020 provide an overview of habitat data as well as waterbird abundance and diversity indices within habitat types, seasons, and, where possible, survey periods.

4.1 Peace River Waterbird Surveys – Boat Survey

4.1.1 Timing

In 2017, 2018, and 2019 the Peace River study area was surveyed during 5 survey rounds in the spring and 6 survey rounds in the fall (**Table 4**). Survey effort and timing in 2020 was adjusted in accordance with a power analysis of the previous 3 years of data (**Appendix A**), resulting in 2 surveys in spring and 3 surveys in fall (**Table 4**). Over the course of these first 4 years of the monitoring program, 40 survey rounds were attempted and a total of 36 surveys of the full length of the Peace River study area were completed (**Table 4**). Details are provided below regarding issues preventing completion of the other 4 surveys and a required third day for completion of 2 survey rounds.

Table 4 Peace River Survey Timing During 2017 Through 2020 Annual Waterbird Migration Monitoring

Survey Period	2017 Survey Dates	2018 Survey Dates	2019 Survey Dates	2020 Survey Dates
Spring				
Early (Apr 1 to Apr 14)	Apr 5, 6 Apr 12[2]	Apr 13, 14	Apr 3, 4, 8[1] Apr 11, 12	Apr 7, 8 Apr 13, 14
Middle (Apr 15 to May 6)	Apr 26, 27 May 3, 4	Apr 25, 26, May 1[1] May 5, 6	Apr 19, 24[2] May 1, 2	Apr 23, 24[2]
Late (May 7 to May 30)	May 10, 11 May 14, 15	May 10, 11 May 18, 19	May 9, 10	No surveys
Fall				
Early (Aug 1 to Aug 14)	Aug 8, 9 Aug 14, 15	Aug 4, 5	Aug 7, 9	Aug 5, 6
Early-Middle (Aug 15 to Sep 14)	Aug 22, 23 Aug 28, 29	Aug 20, 21 Sep 4, 5	Aug 19, 20 Sept 4, 5[2]	Aug 31, Sep 1
Late-Middle (Sep 15 to Oct 14)	Sep 21, 22 Sep 27, 28	Sep 20, 21 Oct 4, 5	Sep 16, 17 Sep 30, Oct 1	Sep 29, Sep 30
Late (Oct 15 to Oct 30)	No surveys	Oct 15, 16	Oct 16, 17	No surveys

Note: When multiple survey rounds were completed within a survey period, survey dates from each round are presented on separate lines. [1]Two (2) days were typically required to complete surveys; however, inclement weather (e.g., heavy rain, snow, high winds), unsafe river conditions (e.g., release of ice-break up from tributaries into the Peace River), or logistical constraints (e.g., mechanical issues with boat) occasionally required a third day for surveys. [2]In other cases, survey conditions and logistical constraints did not allow for complete coverage of the study area within a week and resulted in an incomplete survey.

Incomplete surveys and surveys requiring a third day were typically the result of poor survey conditions or mechanical issues with the boat. Due to rain and wind speeds that exceeded survey standards (**Section 2.2.2**), the Control area was not surveyed during the second survey round of the early spring period in 2017. The first survey of middle spring 2018 and early spring 2019 were not completed within the usual 2 days because ice from the Pine River entered the Peace River and a third survey day was required to complete these survey rounds. In 2019, the first round of middle spring surveys was not completed due to mechanical issues with the river boat and a lack of alternative options within the survey window (**Table 4**). Finally, a partially completed survey round was also conducted in the middle spring period of 2020, prior to finalization of the power analysis. This survey was cut short at the confluence with the Beatton River, from which an ice break-up had released into downstream areas of the Peace River.

4.1.2 Peace River Habitat Types and Study Areas

All 4 habitat types based on flow, water depth, and connectivity to the river are present in the Inundation Impact, Flow Impact, and Control areas in **Table 5**. Mainstem habitat comprises the vast majority (77%) of the area of the Peace River, followed by areas of Moderate Flow habitat (13%). Areas of Minimal and Limited Connectivity habitat comprise 4% and 6% of the total study area, respectively. With the exception of the relatively small proportion of Moderate Flow habitat within the Flow Impact area (3% of total), the habitat types are found in similar proportions in all treatment areas.

Table 5 Area of River Habitat Types, as Defined by Flow Volume and Connectivity, within Peace River Treatment Areas

Treatment Area	River Habitat Type				Total (ha)
	Minimal Connectivity (ha)	Limited Connectivity (ha)	Moderate Flow (ha)	Mainstem (ha)	
Control	92.7	114.5	422.9	1,647.1	2,277.2
Flow Impact	4.9	35.1	16.9	531.2	588.1
Inundation Impact	142.5	189.3	292.7	2,173.1	2,797.6
Total	240.1	338.9	732.5	4,351.4	5,662.9

4.1.3 Peace River Water Flow Regime

Locations with active hydrological monitoring gauges from which water flow data were obtained were as follows: Inundation Impact area - Hudson's Hope (2017, 2018)[1] and Peace Canyon Dam (2019, 2020); Flow Impact area - Old Fort (all years); Control area – Taylor (all years). The hydrological gauges are located within or adjacent to the towns they are named after in **Figure 1**. Water flow data from these monitoring stations during the spring and fall migrations of 2017 through 2020 are summarized across years, seasons, and treatment areas in **Table 6** and frequency distributions illustrating the flow regime throughout the spring and fall migration within each treatment area relative to flows during surveys are presented in **Figure 6**. Flow rates in the Inundation and Flow Impact areas were highest in 2020 and 2017 and lowest in 2019 and were typically higher in the fall compared to spring (**Table 6**). Flow rates in the

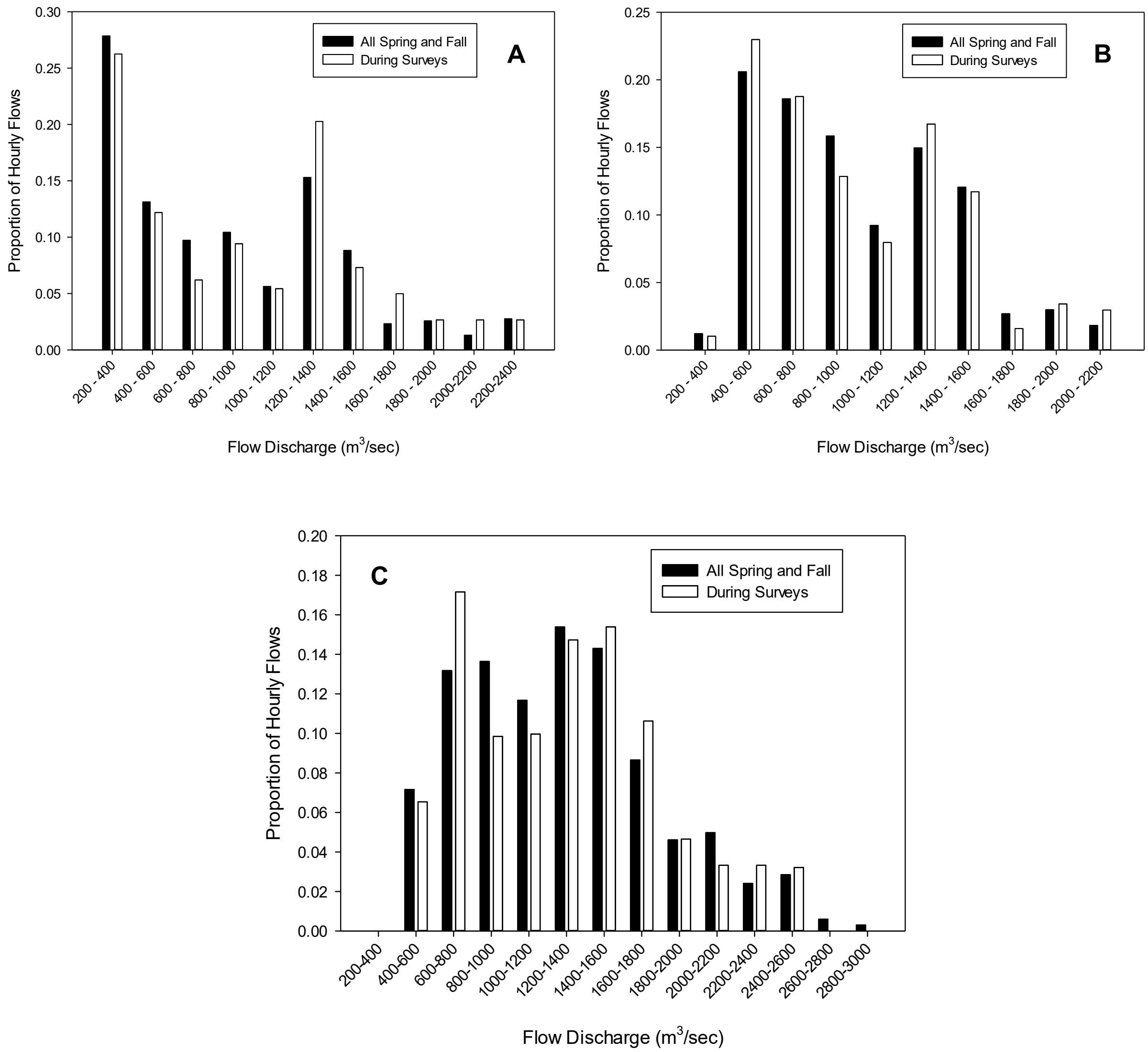
[1] The Hudsons' Hope gauge was discontinued in 2019 to facilitate the placement of rip-rap for Site C reservoir shoreline erosion protection. Thus, in 2019 and 2020, flow data for the Inundation Impact area was collected from a gauge at Peace Canyon Dam.

Control area were also relatively low in 2019 and high in 2017 and 2020, but, unlike the impact areas were highest in the spring of 2018. Flow data frequency distributions illustrated in **Figure 6** provide evidence that, across the 4 survey years, flow discharge rates were similarly distributed and, thus,representative of discharge rates throughout the spring and fall migration periods in all treatment areas.

Table 6 Mean Hourly Water Flow Rates on the Peace River During Waterbird Surveys Across Years, Seasons, and Treatment Areas in 2017 Through 2020

Season	Year	Water Flow (m^3/sec) within Treatment Areas			
		Inundation Impact	Flow Impact	Control	Mean
Spring	2017	650	909	1,412	**991**
	2018	594	862	1,626	**1,027**
	2019	520	559	725	**602**
	2020	1,383	1,364	1,492	**1,413**
Fall	2017	1,409	1,363	1,445	**1,406**
	2018	1,086	1,129	1,232	**1,149**
	2019	847	787	982	**872**
	2020	1,565	1,687	1,869	**1,707**

Note: Flow discharge data in the Inundation Area were collected from Hudson’s Hope in 2017 and 2018 and from Peace Canyon Dam in 2019 and 2020, from daydates within the spring and fall migration when Peace River waterbird surveys were condcuted. Data for the Flow Impact and Control area were collected from Old Fort and Taylor (downstream of the Pine River confluence), respectively, during the same dates.



Note: Flow discharge data in the Inundation Area were collected from Hudson's Hope in 2017 and 2018 and from Peace Canyon Dam in 2019 and 2020, during April 1 to May 31 (spring migration) and August 1 to October 31 (fall migration). Data for the Flow Impact and Control area were collected from Old Fort and Taylor (downstream of the Pine River confluence), respectively, during the same dates.

Figure 6 Distribution of hourly flow rates (shown as proportion of total) in the Inundation Impact (A), Flow Impact (B), and Control (C) areas during surveys relative to across spring and fall migrations in 2017, 2018, 2019, and 2020.

4.1.4 Relative Abundance and Density

As in previous years, waterbirds were observed along the entirety of the Peace River study area in spring and fall of 2020 (see location figures in **Appendix C – Figures C-1 to C-4**). There were a total of 63,111 individual waterbirds observed during Peace River boat surveys in 2017 through 2020 of which 89% were identified to species (**Appendix C-1**). In 2020, a total of 13,040 waterbirds were observed during Peace River boat surveys, of which 95% were identified to species (**Appendix C-2**).

Mean abundances were highest during the early survey period during spring and the late-middle fall migration periods (**Table 7**). Large dabblers, primarily Canada goose (*Branta canadensis*), were the most abundant waterbirds overall, with the highest abundances observed during the early spring, and in fall during late-middle and late survey periods. Dabbling ducks and gulls were the next most adundant guilds.

Table 7 Mean Abundance Estimates (birds/survey round) of Waterbird Foraging Guilds within the Peace River During Spring and Fall of 2017 Through 2020

Foraging Guild	Spring Survey Periods			Fall Survey Periods				Average of Survey Period Means
	Early	Middle	Late	Early	Early-Middle	Late-Middle	Late	
Benthic Feeding Divers	167	214	24	3	18	11	5	63
Dabbling Ducks	537	743	479	109	189	470	51	368
Gulls	3	46	32	851	799	400	102	319
Large Dabblers	2,461	524	533	189	338	803	623	782
Piscivorous Divers	314	109	47	47	37	22	12	84
Shorebirds	2	5	121	191	101	4	0	61
Unknown Waterbirds	85	144	70	17	6	28	13	52
Total Mean Abundance	**3,569**	**1,785**	**1,306**	**1,407**	**1,490**	**1,739**	**805**	

Note: Mean abundances reflect relative rather than absolute abundances as they do not account for incomplete detection. Abundances within each survey round were calculated by extrapolating density estimates observed within each habitat across the entire study area to account for the areas not accessible by boat, which varied across survey rounds depending on water levels and boat access. Mean abundances were then calculated within each habitat type across survey rounds first within periods of each year, and then across years so that differences in sampling effort did not bias means towards abundances observed in years with more survey rounds.

Totals of mean densities of waterbird foraging guilds varied across river habitat types, primarily reflecting the distribution of the most abundant guilds (i.e., large dabblers and dabbling ducks in spring, gulls and large dabblers in fall; **Table 8, Table 9**). The highest mean densities observed across seasons and habitat types were in the spring within Moderate Flow habitat and within the Inundation Impact treatment area. During spring, mean densities summed across foraging guilds were more than 10 times higher within Limited Connectivity and Moderate Flow habitat types than those in Mainstem habitats (**Table 8, Figure 7, Figure 8, Figure 9**). Mean densities during fall were higher in the Flow Impact area compared to other treatment areas (**Table 9, Figure 10, Figure 11, Figure 12**). During fall, total waterbird densities were greatest within Limited Connectivity habitat, where densities were more than 2 and 4 times those reported from Moderate Flow and Mainstem habitats, respectively (**Table 9**).

Table 8 Mean Spring Densities (birds/km^2/survey round) of Migrant Waterbirds by River Habitat Type and Treatment Area During 2017 Through 2020

Foraging Guild	Density by River Habitat Type			Density by Treatment Area		
	Limited Connectivity	Moderate Flow	Mainstem	Inundation Impact	Flow Impact	Control
Benthic Feeding Divers	16.0	2.6	1.5	3.3	4.3	1.0
Dabbling Ducks	59.3	17.0	6.2	8.6	17.1	11.9
Gulls	0.0	0.1	0.6	0.4	2.1	0.2
Large Dabblers	126.0	32.4	12.0	20.3	16.8	24.7
Piscivorous Divers	13.2	4.3	1.9	4.7	2.1	1.0
Shorebirds	4.9	1.9	0.3	0.9	0.8	0.7
Unknown Waterbirds	6.2	3.4	1.3	2.4	1.1	1.4
Total Mean Density	**225.6**	**61.5**	**23.7**	**40.6**	**44.4**	**40.7**
Estimated Abundance	**737**	**451**	**1,032**	**1,074**	**259**	**887**

Note: Mean densities reflect relative rather than absolute densities as they do not account for incomplete detection. Means were calculated by averaging density estimates (birds/km^2/survey) within each habitat type across survey rounds first within periods of each year, and then across years so that differences in sampling effort did not bias means towards abundances observed in years with more survey rounds. Total mean density is the sum of all foraging guild and unknown waterbird densities.

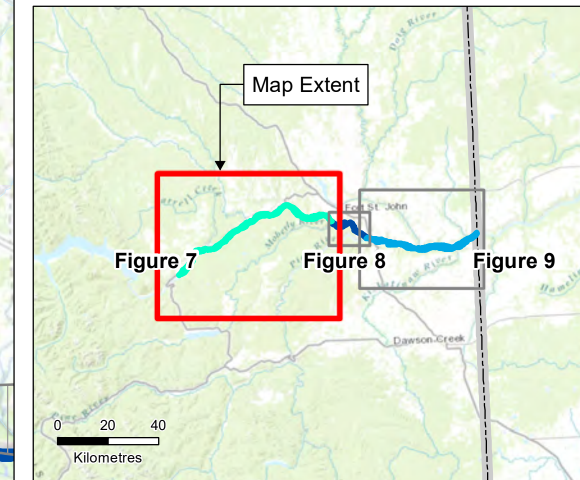
Table 9 Mean Fall Densities (birds/km^2/survey round) of Migrant Waterbirds by River Habitat Type and Treatment Area During 2017 Through 2020

Foraging Guild	Density by River Habitat Type			Density by Treatment Area		
	Limited Connectivity	Moderate Flow	Mainstem	Inundation Impact	Flow Impact	Control
Benthic Feeding Divers	0.6	<0.1	0.2	0.2	0.4	0.1
Dabbling Ducks	46.5	0.5	1.1	3.8	13.1	1.2
Gulls	2.9	0.4	12.1	6.7	60.7	0.2
Large Dabblers	50.7	6.5	6.3	6.9	17.9	9.3
Piscivorous Divers	3.8	0.9	0.2	0.6	0.4	0.5
Shorebirds	6.1	2.7	0.8	1.1	0.7	1.8
Unknown Waterbirds	3.5	0.1	0.1	0.4	0.8	<0.1
Total Mean Density	**114.0**	**11.2**	**20.8**	**19.8**	**94.0**	**13.2**
Estimated Abundance	**373**	**82**	**906**	**525**	**548**	**287**

Note: Mean densities reflect relative rather than absolute densities as they do not account for incomplete detection. Means were calculated by averaging density estimates (birds/km^2/survey) within each habitat type across survey rounds first within periods of each year, and then across years so that differences in sampling effort did not bias means towards abundances observed in years with more survey rounds. Total mean density is the sum of all foraging guild and uknown waterbird densities.

Migratory Waterbird Follow-up Monitoring Program
2020 Report
Site C, Peace River, BC

Fig. 7- Mean Relative Density (birds/km^2/survey) of Spring Migrant Waterbirds in Reaches of the Inundation Impact Treatment Area based on Annual Means from 2017, 2018, 2019, and 2020



Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Waterbird densities (birds/km^2/survey round) by quartile [3]

- 8.8 - 45.1
- 45.2 - 83.3
- 83.4 - 166.3
- 166.4 - 971.7

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
3. Waterbird density values were classified using approximate Quantile Breaks.

Sources

- Basemap: ESRI World Topographic Base

N

1:220,000

0 2 4 6 8 10
Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-07	Production Date: Feb 25, 2021	Figure 7

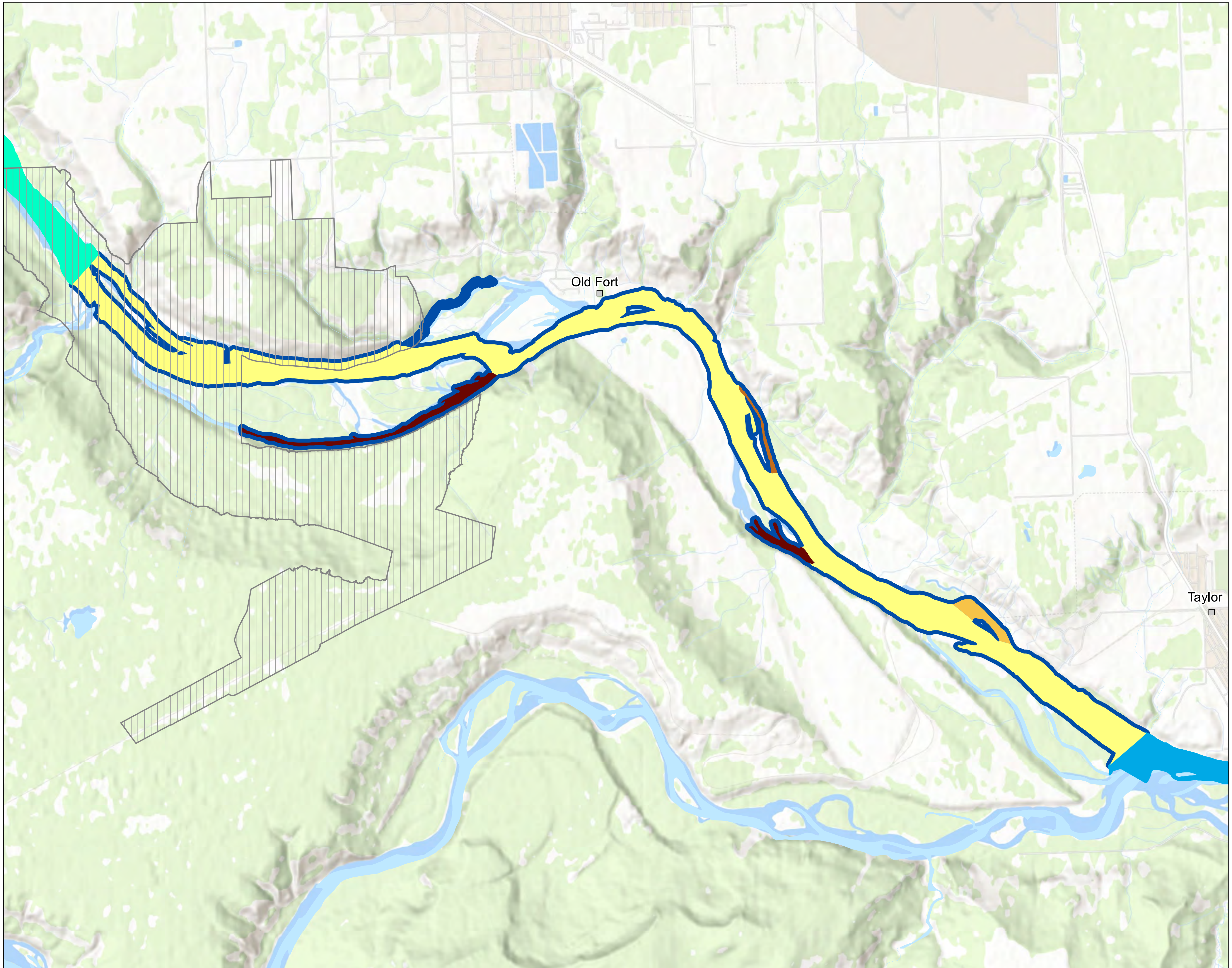
Hemmera
An Ausenco Company

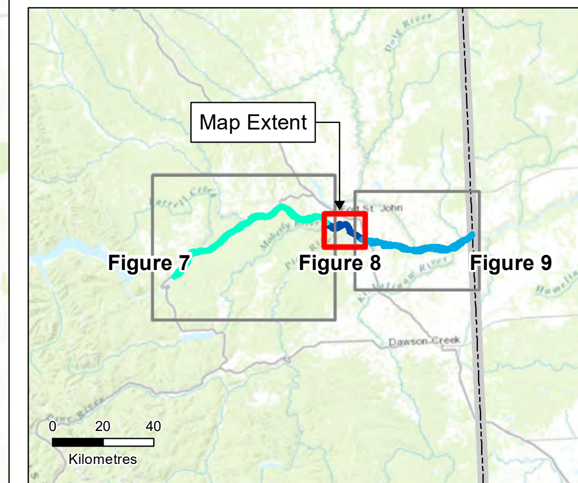
BC hydro

Path: S:\Geomatics\Projects\989619\07_waterfowl\mxd\MonitoringProgram2020\Fig7_989619_07_Waterbirds_SpringDensity_InundationImpactArea_210225.mxd

Migratory Waterbird Follow-up Monitoring Program
2020 Report
Site C, Peace River, BC

Fig. 8 - Mean Relative Density (birds/km²/survey) of Spring Migrant Waterbirds in Reaches of the Flow Regime Impact Treatment Area based on Annual Means from 2017, 2018, 2019, and 2020





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Waterbird densities (birds/km²/survey round) by quartile [3]

- 8.8 - 45.1
- 45.2 - 83.3
- 83.4 - 166.3
- 166.4 - 971.7

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
3. Waterbird density values were classified using approximate Quantile Breaks.

Sources

- Basemap: ESRI World Topographic Base

N

1:50,000

0 500 1,000 1,500 2,000 2,500

Metres

NAD 1983 UTM Zone 10N

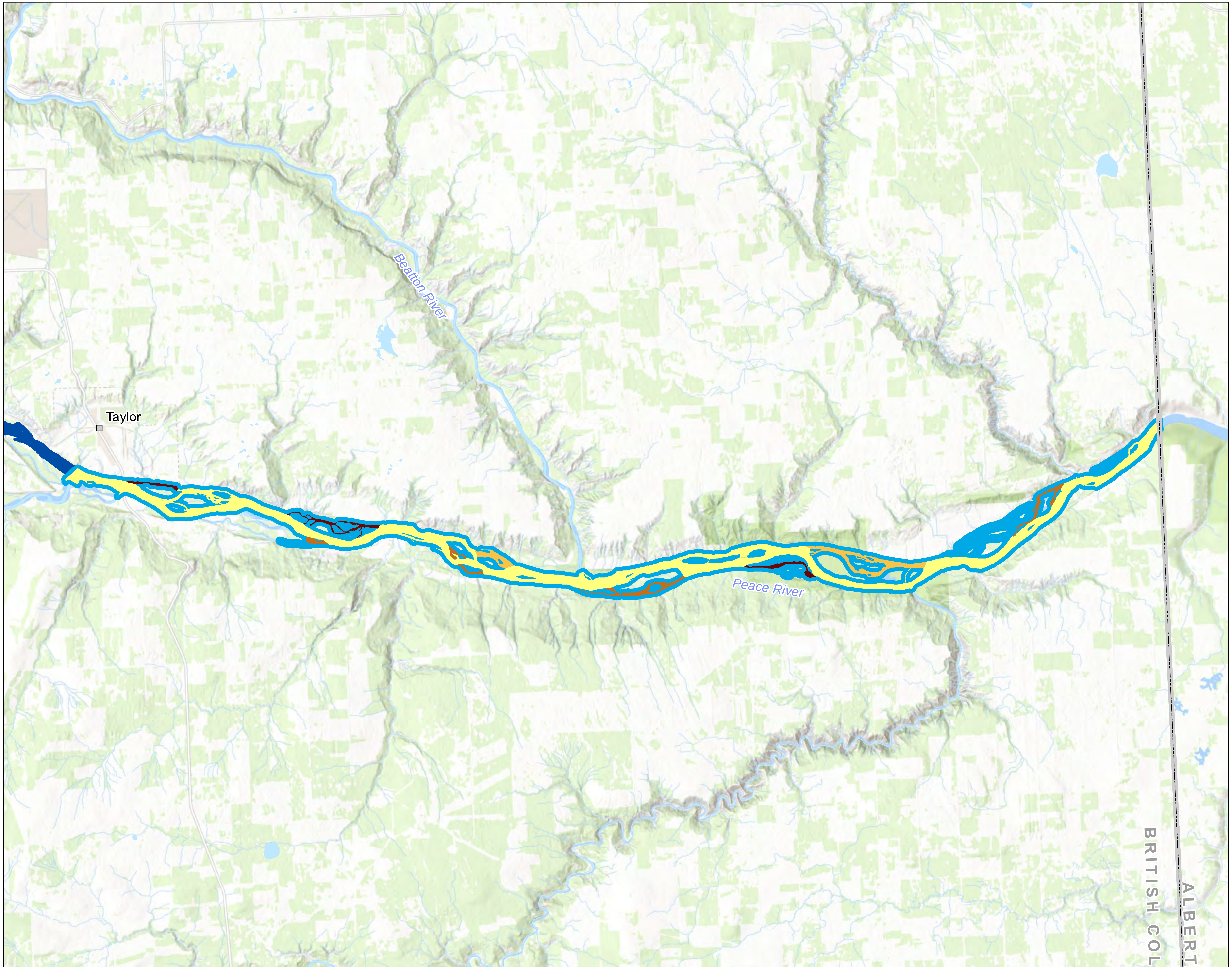
Page Size: 11" x 17"

989619-07	Production Date: Feb 25, 2021	Figure 8

Hemmera An Ausenco Company

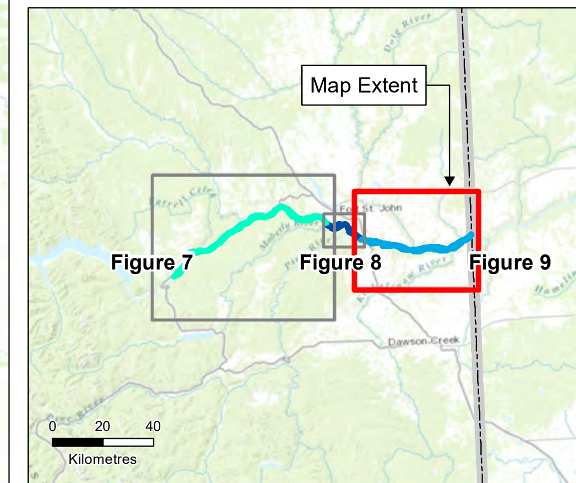
BC hydro

Path: S:\Geomatics\Projects\989619\07_waterfowl\mxd\MonitoringProgram2020\Fig8_989619_07_Waterbirds_SpringDensity_FlowRegimeChangeImpactArea_210225.mxd



Migratory Waterbird Follow-up Monitoring Program
2020 Report
Site C, Peace River, BC

Fig 9 - Mean Relative Density (birds/km²/survey) of Spring Migrant Waterbirds in Reaches of the Control Treatment Area based on Annual Means from 2017, 2018, 2019, and 2020



Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area

Waterbird densities (birds/km²/survey round) by quartile [3]

- 8.8 - 45.1
- 45.2 - 83.3
- 83.4 - 166.3
- 166.4 - 971.7

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a “stand-alone” document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
3. Waterbird density values were classified using approximate Quantile Breaks.

Sources

- Basemap: ESRI World Topographic Base

N

1:150,000

0 2 4 6 8 10

Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

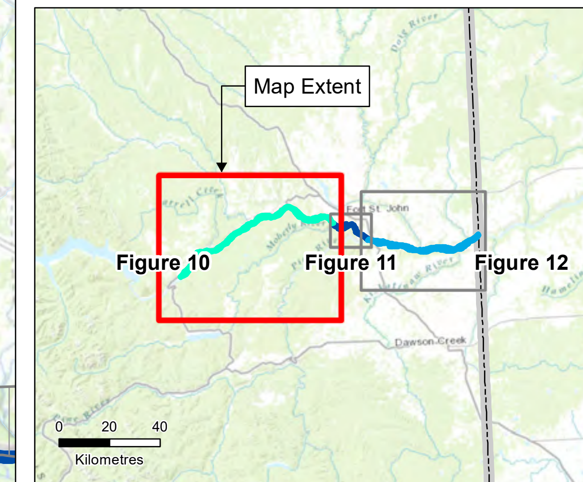
989619-07	Production Date: Feb 25, 2021	Figure 9

Hemmera An Ausenco Company

BC hydro

Migratory Waterbird Follow-up Monitoring Program
2020 Report
Site C, Peace River, BC

Fig. 10 - Mean Relative Density (birds/km²/survey) of Fall Migrant Waterbirds in Reaches of the Inundation Impact Treatment Area based on Annual Means from 2017, 2018, 2019, and 2020



Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Waterbird densities (birds/km²/survey round) by quartile [3]

- 2.2 - 8.3
- 8.4 - 17.2
- 17.3 - 63.1
- 63.2 - 346.5

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
3. Waterbird density values were classified using approximate Quantile Breaks.

Sources

- Basemap: ESRI World Topographic Base

N

1:220,000

0 2 4 6 8 10
Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-07	Production Date: Feb 25, 2021	Figure 10

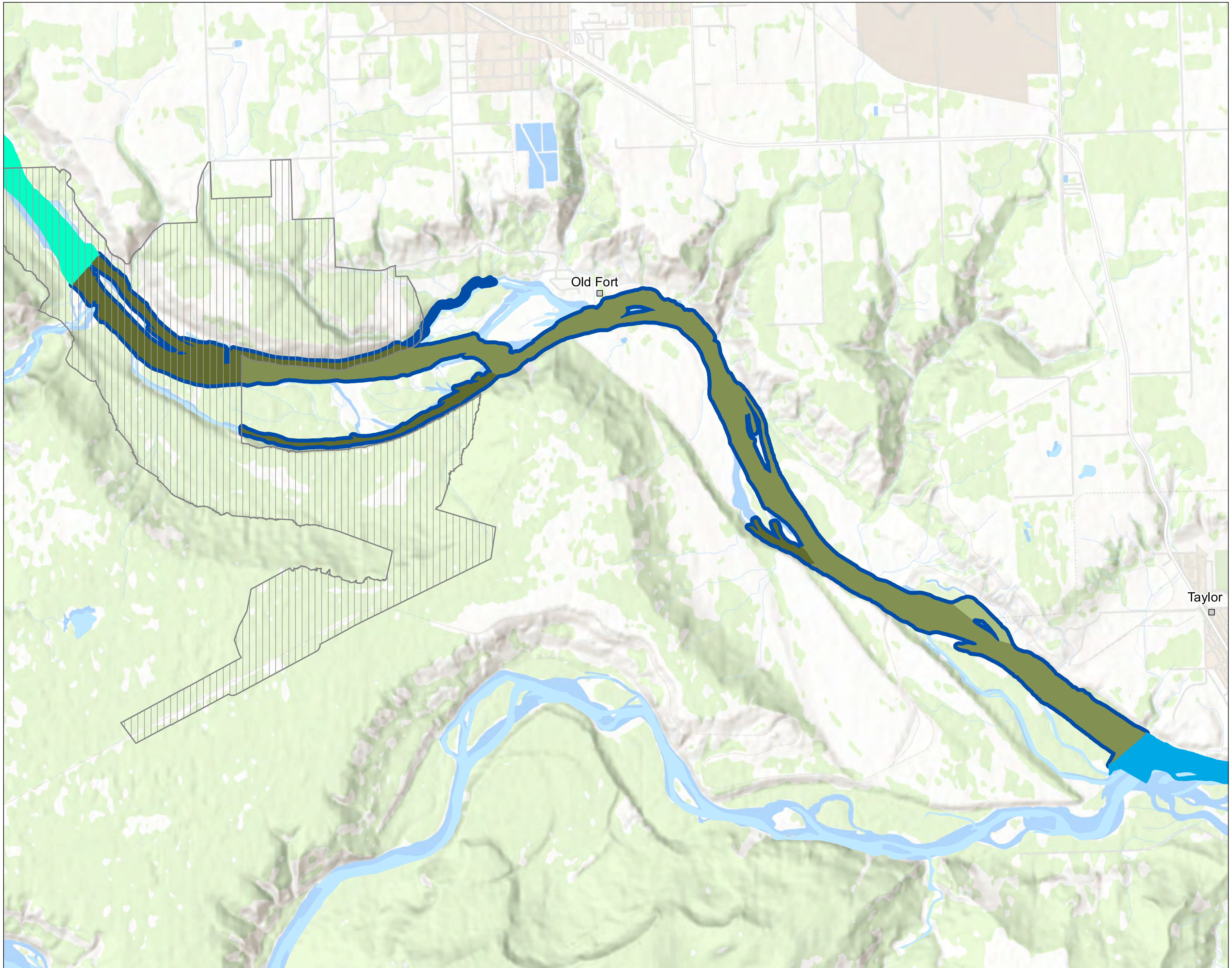
Hemmera An Ausenco Company

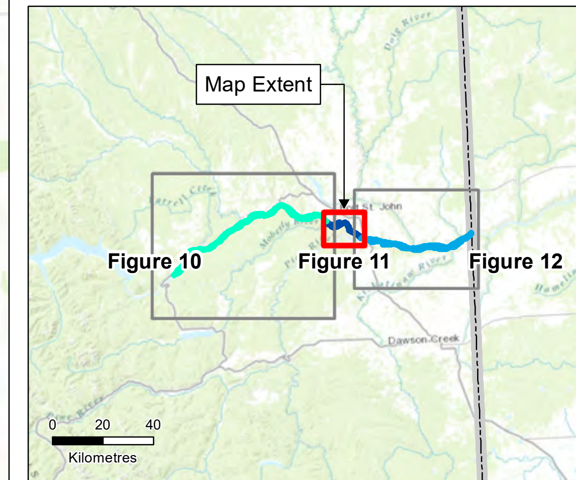
BC hydro

Path: S:\Geomatics\Projects\989619\07_waterfowl\mxd\MonitoringProgram2020\Fig10_989619_07_Waterbirds_FallDensity_InundationImpactArea_210225.mxd

Migratory Waterbird Follow-up Monitoring Program
2020 Report
Site C, Peace River, BC

Fig. 11 - Mean Relative Density (birds/km^2/survey) of Fall Migrant Waterbirds in Reaches of the Flow Regime Impact Treatment Area based on Annual Means from 2017, 2018, 2019, and 2020





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Waterbird densities (birds/km^2/survey round) by quartile [3]

- 2.2 - 8.3
- 8.4 - 17.2
- 17.3 - 63.1
- 63.2 - 346.5

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a “stand-alone” document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
3. Waterbird density values were classified using approximate Quantile Breaks.

Sources

- Basemap: ESRI World Topographic Base

N

1:50,000

0 500 1,000 1,500 2,000 2,500
Metres

NAD 1983 UTM Zone 10N

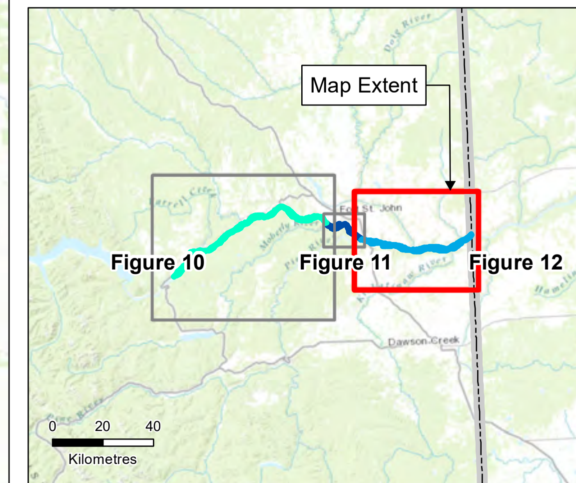
Page Size: 11" x 17"

989619-07	Production Date: Feb 25, 2021	Figure 11

Hemmera An Ausenco Company BC hydro

Migratory Waterbird Follow-up Monitoring Program
2020 Report
Site C, Peace River, BC

Fig. 12 - Mean Relative Density (birds/km^2/survey) of Fall Migrant Waterbirds in Reaches of the Control Treatment Area based on Annual Means from 2017, 2018, 2019, and 2020



Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area

Waterbird densities (birds/km^2/survey round) by quartile [3]

- 2.2 - 8.3
- 8.4 - 17.2
- 17.3 - 63.1
- 63.2 - 346.5

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
3. Waterbird density values were classified using approximate Quantile Breaks.

Sources

- Basemap: ESRI World Topographic Base

N

1:150,000

0 2 4 6 8 10
Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-07	Production Date: Feb 25, 2021	Figure 12

Hemmera An Ausenco Company
BC hydro

4.1.5 Diversity

A total of 60 waterbird species were detected across the 2017, 2018, 2019, and 2020 boat surveys of the Peace River (**Appendix B-1**). Dabbling ducks (14 species) were the most species rich foraging guild observed, followed by piscivorous divers (11 species) and shorebirds (10 species) over the 4 years of monitoring that has been conducted (**Appendix B-1**). Average species richness across spring survey periods was generally higher for dabbling ducks than other species, particularly in the middle and late spring (**Table 10**). Benthic feeding divers were most diverse in the middle and late spring as well. In contrast, species richness for gulls and shorebirds was greater in the fall, particularly during the early fall for shorebirds. Species richness was similar between the spring and fall for large dabblers and piscivorous divers, with the exception of higher diversity for piscivorous divers in the late spring compared to other periods (**Table 10**).

Table 10 Mean Diversity Metrics for Waterbird Foraging Guilds on the Peace River Across Seasons and Survey Periods During 2017 Through 2020

Foraging Guild	Spring Species Richness			Spring Mean	Fall Species Richness				Fall Mean
	Early	Middle	Late		Early	Early-Middle	Late-Middle	Late	
Benthic Feeding Divers	2.1	2.7	3.5	**2.7**	0.5	0.4	0.9	0.0	**0.5**
Dabbling Ducks	4.3	5.3	6.5	**5.1**	2.0	2.5	2.4	1.5	**2.2**
Gulls	0.4	1.8	3.3	**1.7**	4.1	3.3	3.1	3.5	**3.4**
Large Dabblers	2.1	2.0	1.3	**1.8**	1.1	1.5	1.6	2.0	**1.4**
Piscivorous Divers	1.3	2.2	3.0	**2.0**	1.9	2.1	2.5	1.5	**2.0**
Shorebirds	0.5	0.5	1.2	**0.6**	2.5	1.3	0.8	0.0	**1.3**
Total Species Richness	**10.6**	**14.5**	**18.8**	**13.9**	**12.0**	**10.8**	**11.4**	**8.5**	**10.8**
Species Evenness	**0.5**	**0.7**	**0.7**	**0.5**	**0.5**	**0.5**	**0.6**	**0.4**	**0.5**

Note: Mean species richness was calculated by averaging species richness across survey rounds first within periods each year, and then across years so that differences in sampling effort did not bias means towards diversity observed in years with more survey rounds. Data from Minimal and Limited Connectivity habitat are excluded due to variable access to these habitats due to water level changes. Individual birds not identified to species are excluded from species richness totals and diversity calculations.

Due to unequal areas of the river habitat types and treatment areas (i.e., unequal survey effort and sample sizes; see **Table 5**), diversity statistics are not directly compared across habitat types or treatment areas.

4.1.6 Waterbird Species at Risk

The following species designated as at risk as per provincial, *Species at Risk Act* (SARA), or Committee on the Status of Endangered Wildlife in Canada (COSEWIC) rankings, were observed during the 2017, 2018, 2019, and 2020 Peace River surveys:

- California gull (*Larus californicus),* BC listing (Blue)
- Eared grebe (*Podiceps nigricollis*), BC listing (Blue)
- Great blue heron (*Ardea herodias herodias*), BC listing (Blue)[2]
- Horned grebe (*Podiceps auratus*), COSEWIC (special concern [SC]), SARA (SC)
- Long-tailed duck (*Clangula hyemalis*), BC listing (Blue)

2 Great blue heron was not a target species and is not included in estimates of abundance or diversity due to its rarity in the region and unique foraging strategy relative to the species guilds assessed in this study.

- Red-necked phalarope (*Phalaropus lobatus*), BC listing (Blue)
- Surf scoter (*Melanitta perspicillata*), BC listing (Blue)
- Tundra swan (*Cygnus columbianus*), BC listing (Blue)
- Western grebe (*Aechmophorus occidentalis*), BC listing (Red), COSEWIC (SC), SARA (SC).

Records of waterbird species at risk were generally few (i.e., 6 or less in total across years), with the exception of surf scoter (194 individuals), California gull (29 individuals), and Red-necked phalarope (11) (**Appendix B-1**).

4.2 Transmission Line Wetland Surveys

4.2.1 Timing

In 2020, transect and standwatch surveys were conducted on the Moberly Plateau and adjacent to the Site C transmission line ROW during spring (May 4 to May 27, 2020) and fall (August 7 to October 2, 2020) waterbird migrations (**Table 11**). Surveys in 2020 were conducted during 2 survey periods in spring and 3 survey periods in fall over a total of 16 days (7 days in spring and 9 days in fall). Survey effort was evenly spaced over time within both spring and fall to sample waterbirds throughout their northward and southward migrations. No wetland surveys were conducted in the early spring survey because wetlands were frozen and unavailable for waterbird foraging during that time (**Table 11**). Bioacoustic monitoring for marsh birds was conducted from May 19 through June 27 of 2017, from July 4 through July 23 of 2018, from May 17 through August 1 of 2019, and from May 6 through June 26 of 2020 (**Table 14**).

Table 11 Wetland Survey Timing During 2017 Through 2020 Annual Waterbird Migration Monitoring

Survey Period	2017 Survey Dates	2018 Survey Dates	2019 Survey Dates	2020 Survey Dates
Spring				
Early (Apr 1 to Apr 14)	Wetlands Frozen	Wetlands Frozen	Wetlands Frozen	Wetlands Frozen
Middle (Apr 15 to May 6)	Apr 29, 30; May 1, 2	Apr 27, 28, 29 May 2, 3, 4	Apr 21, 22, 23 May 3, 4, 5	May 4, 5, 6
Late (May 7 to May 30)	May 16, 17; May 18, 19, May 25, 26; May 27, 28	May 7, 8, 9 May 15, 16, 17	May 11, 12, 13 May 22, 23, 24	May 24, 25, 26, 27
Fall				
Early (Aug 1 to Aug 14)	Aug 10, 11; 12, 13	Aug 6, 7, 8	Aug 10, 11, 12	Aug 7, 8, 9
Early-Middle (Aug 15 to Sep 14)	Aug 24, 25; 26, 27	Aug 22, 23, 24, Sep 6, 7, 10	Aug 21, 22, 23 Sep 10, 11	Sep 2, 3, 4
Late-Middle (Sep 15 to Oct 14)	Sep 23, 24; 25, 26	Sep 17, 18, 19 Oct 1, 2, 3	Sep 18, 19, 20 Oct 2, 3	Sep 28, Oct 1, 2
Late (Oct 15 to Oct 30)	No surveys	Oct 17, 18, 19	Oct 18, 19	No surveys

4.2.2 Habitats

In 2020, 22 wetland stations were surveyed for waterbirds (**Figure 13**, **Figure 14**, **Figure 15, Table 12**). Within these stations, 16 wetlands with open water habitat were surveyed by standwatch methods, 11 areas with willow-sedge habitat were surveyed by transect methods, and 12 wetlands with sedge habitat were also surveyed by transect methods. Standwatch surveys were conducted at 4 open water wetlands clear of vegetation (i.e., lakes), which provided unobstructed lines of sight, and 12 areas of open water interspersed with emergent or flooded vegetation. Transect surveys targeting waterbirds within vegetated wetlands contained a minimum of 3 meters of sedge and/or willow-sedge habitat on either side of the transect line. ARU surveys were conducted at 6 stations in 2020; 3 stations where marsh bird surveys using ARUs were conducted in previous years and at 3 stations not surveyed previously. Photos of stations showing aerial views or representative habitat are provided in **Appendix D**.

Table 12 Survey Methods and Wetland Habitat Types Survey within Stations

	Bioacoustics (ARU) Surveys	Transect Surveys[1]	Standwatch Surveys[2]
Station ID	Sedge, Open Water, Willow-Sedge	Sedge, Willow-Sedge	Open Water
OW-01	-	2020	2017, 2018, 2019, 2020
OW-02	-	-	2017, 2018, 2019, 2020
OW-04	-	-	2017, 2018, 2019, 2020
OW-06	2020	2020	2017, 2018, 2019, 2020
OW-07	-	-	2020
OW-09	-	-	2017, 2018, 2019, 2020
OW-10	-	-	2017, 2018, 2019, 2020
OW-11	-	-	2017, 2018, 2019, 2020
SE-01	-	2018, 2019	-
SE-02	-	2018, 2019, 2020	2020
SE-03	-	2018, 2019, 2020	2020
SE-04	2018, 2019, 2020	2018, 2019, 2020	2020
SE-05	2017, 2019, 2020	2018, 2019, 2020	-
SE-06	2017, 2019, 2020	2018, 2019	2020
SE-07	-	2018, 2019, 2020	2020
SE-09	2020	2018, 2019, 2020	2020
SE-10	2017, 2019	2018, 2019, 2020	-
SE-11	2020	2018, 2019, 2020	-
SE-12	-	2018, 2019	2020
SE-14	-	2018, 2019, 2020	2020
WS-01	2019	2018, 2019, 2020	-
WS-02	-	2018, 2019, 2020	-
WS-03	-	2018, 2019, 2020	-

[1] Surveys conducted with water depths of 0.5 m or less

[2] Surveys conducted in areas of 0.25 ha or more of open water. Stations only surveyed in 2020 were surveyed using remotely piloted aircraft systems (RPAS) in 2018 and 2019

Within the wetland survey stations listed above, a total of 200 standwatch surveys of open water and 425 transect surveys of sedge, and willow-sedge habitat were conducted under appropriate survey conditions during the spring and fall of 2017 through 2020 (**Table 13**). Of the total 625 surveys, 324 were conducted during spring and 301 were conducted during fall.

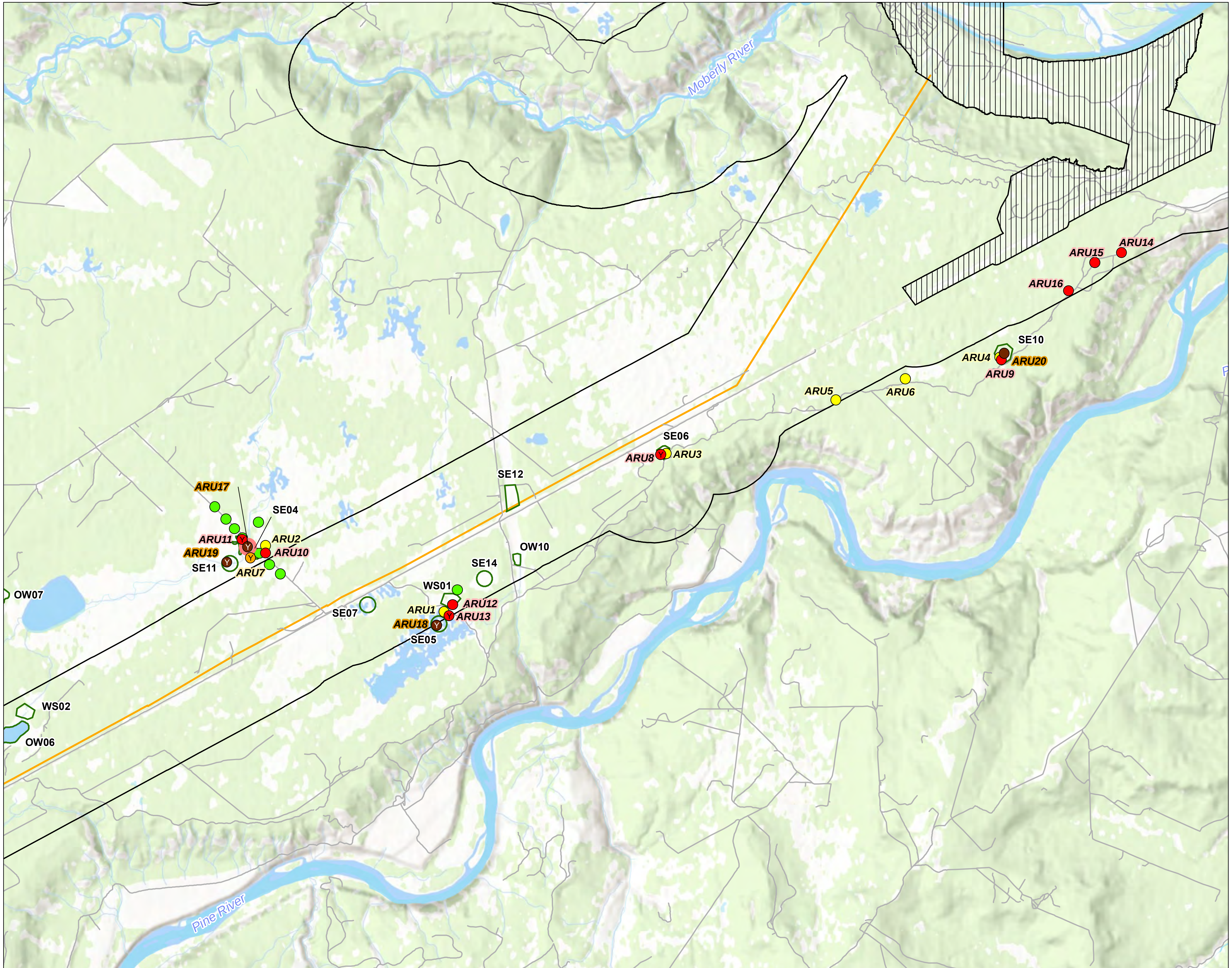
Table 13 Number of Unique Wetland Surveys for Migrating Waterbirds Conducted by Standwatch and Transect Methods by Survey Period During 2017 Through 2020

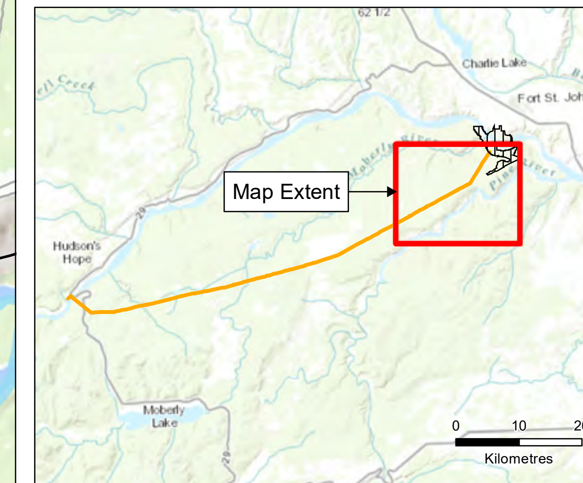
Survey Method	Year	Spring			Fall				Total
		Early[1]	Middle	Late	Early	Middle-Early	Middle-Late	Late[1]	
Standwatch (OW)	2017	0	2	8	6	5	6	0	27
	2018	0	9	15	6	11	12	6	59
	2019	0	11	13	6	13	12	3	58
	2020	0	11	12	11	12	10	0	56
Total		**0**	**33**	**48**	**29**	**41**	**40**	**9**	**200**
Transect (WS,SE)	2017	0	0	0	0	0	0	0	0
	2018	0	11	32	20	27	37	21	148
	2019	0	28	38	22	38	41	6	173
	2020	0	20	22	21	21	20	0	104
Total		**0**	**59**	**92**	**63**	**86**	**98**	**27**	**425**
Grand Total		**0**	**92**	**140**	**92**	**127**	**138**	**36**	**625**

Note: Multiple transects conducted within the same habitat type counted as a single unique survey. [1]No surveys were conducted during early spring and few surveys were conducted during late fall due to snow and ice cover of wetlands.

Migratory Waterbird Follow-up Monitoring Program
2020 Report
Site C, Peace River, BC

Figure 13 - Wetland Survey Stations and ARU Monitoring Locations on the Transmission Line Route (East)





Legend

- Site C LAA
- Proposed Dam Site
- Wetland Survey Station
- Access / Service Road
- Transmission Line Right-of-Way
- 2020 Bioacoustic Monitoring Station
- 2019 Bioacoustic Monitoring Station
- 2018 Bioacoustic Monitoring Station
- 2017 Bioacoustic Monitoring Station
- Bioacoustic Monitoring Station with YERA Detected
- Bioacoustic Monitoring Station with VIRA Detected
- Historic YERA records (prior to 2017) from eBird and Baseline Studies

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
3. OW has been used as the identfier for Shallow Open Water wetland field locations; however, please note that the wetland classification also includes LA and PD habitat codes.

Sources

- Basemap: ESRI World Topographic Base

N

1:60,000

0 0.5 1 1.5 2 2.5
Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

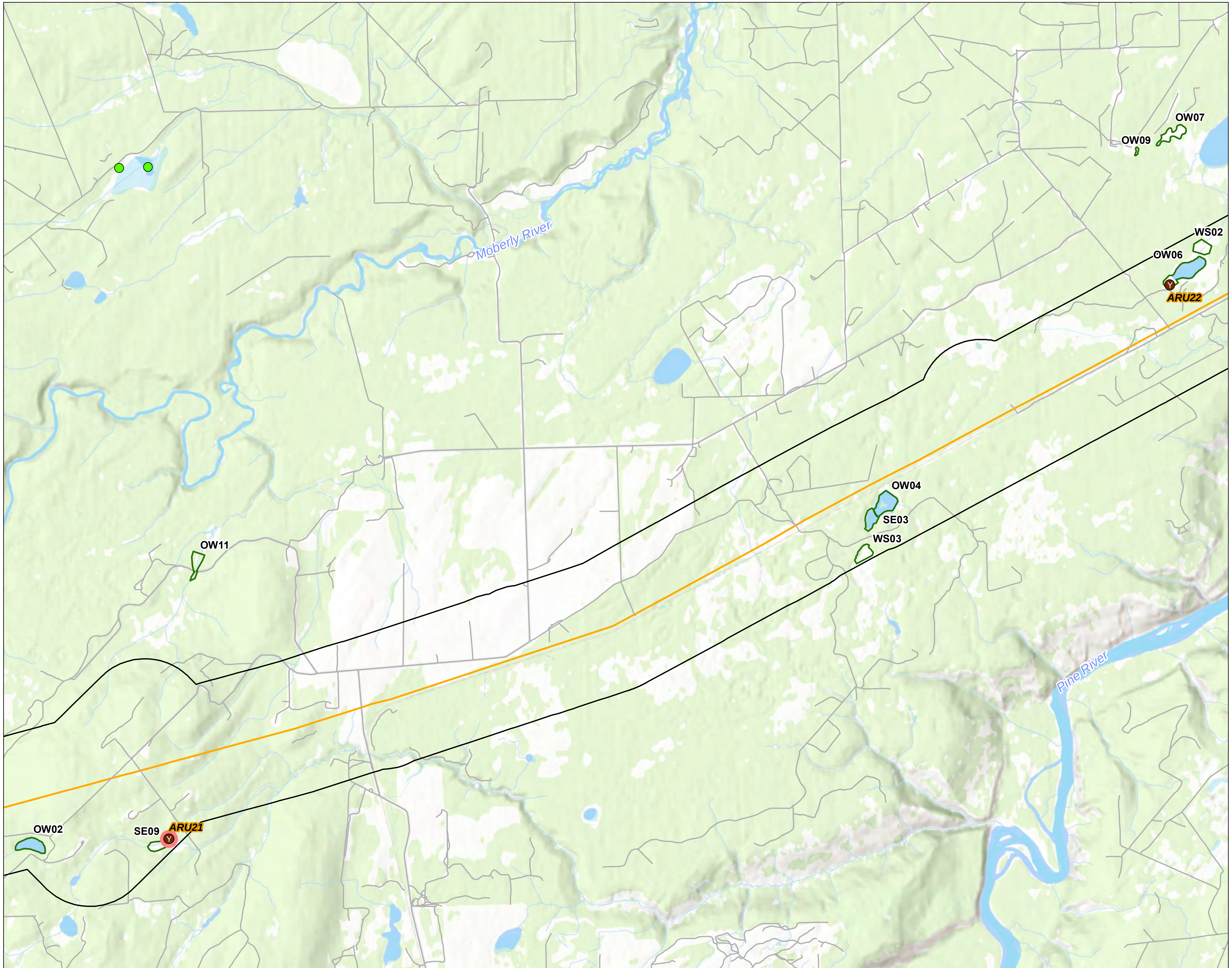
989619-07	Production Date: Feb 25, 2021	Figure 13

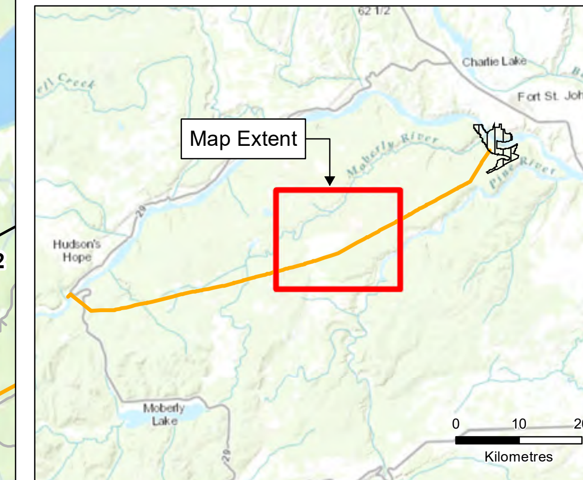
Hemmera An Ausenco Company

BC hydro

Migratory Waterbird Follow-up Monitoring Program
2020 Report
Site C, Peace River, BC

Figure 14 - Wetland Survey Stations Locations on the Transmission Line Route (Central)





Legend

- Site C LAA
- Wetland Survey Station
- Access / Service Road
- Transmission Line Right-of-Way
- 2020 Bioacoustic Monitoring Station
- Bioacoustic Monitoring Station with YERA Detected
- Bioacoustic Monitoring Station with VIRA Detected
- Historic YERA observations from eBird and Baseline Studies

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
3. OW has been used as the identfier for Shallow Open Water wetland field locations; however, please note that the wetland classification also includes LA and PD habitat codes.

Sources

- Basemap: ESRI World Topographic Base

N

1:60,000

0 0.5 1 1.5 2 2.5
Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-07	Production Date: Feb 25, 2021	Figure 14

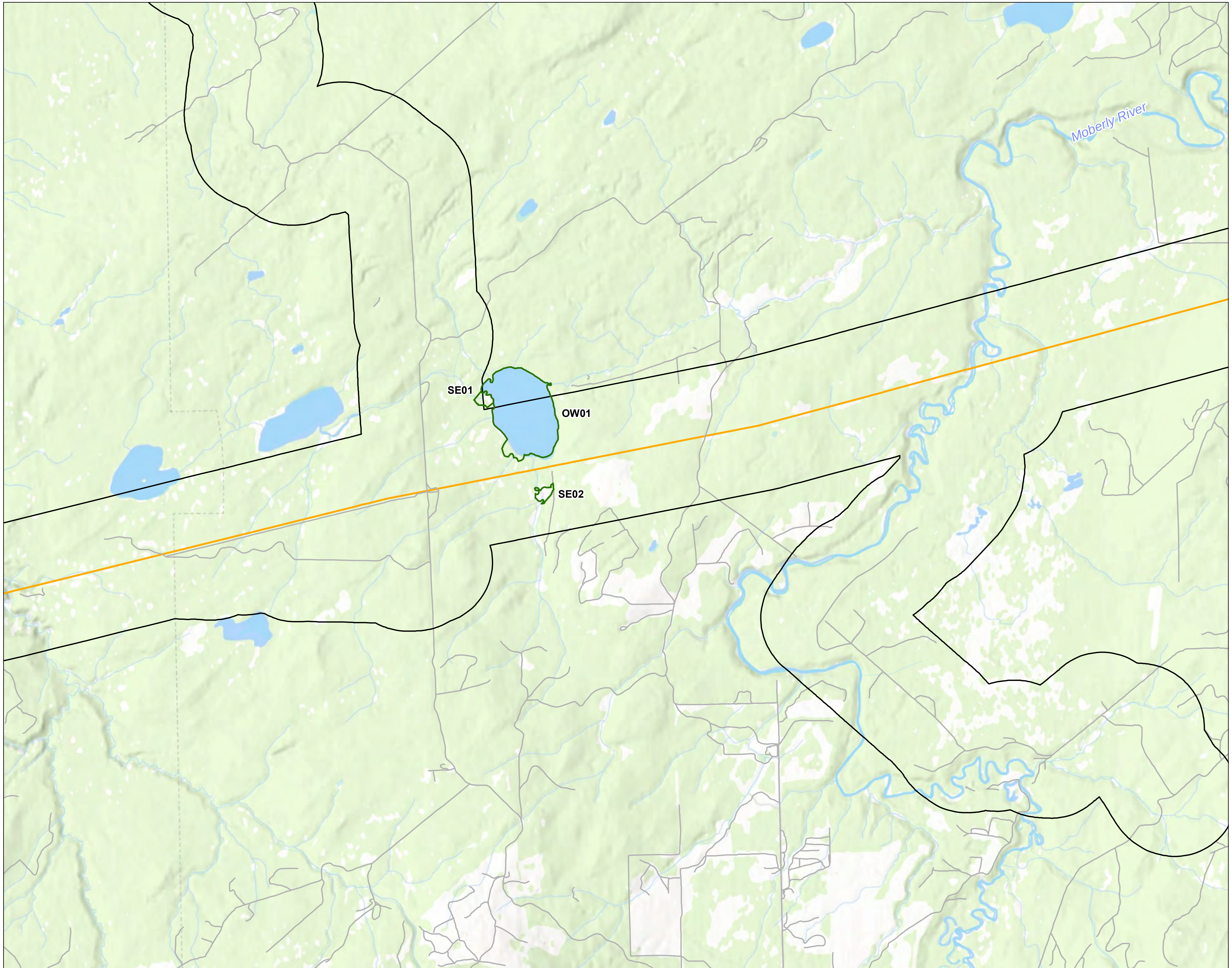
Hemmera
An Ausenco Company

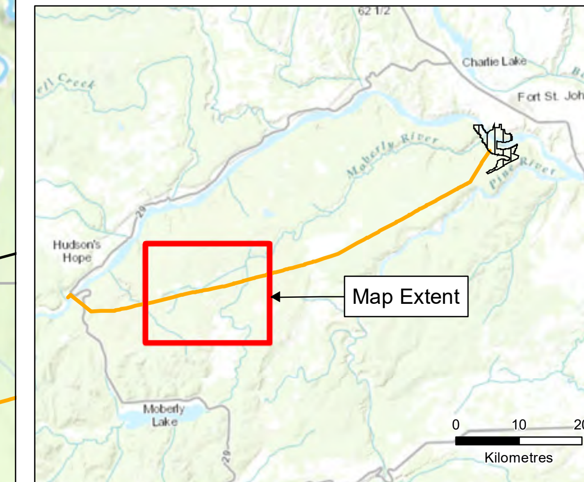
BC hydro

Path: S:\Geomatics\Projects\989619\07_waterfowl\mxd\MonitoringProgram2020\Fig14_989619_07_Waterbirds_Wetland_Survey_Stations_Central_210225.mxd

Migratory Waterbird Follow-up Monitoring Program
2020 Report
Site C, Peace River, BC

Figure 15 - Wetland Survey Stations Locations on the Transmission Line Route (West)





Legend

- Site C LAA
- Wetland Survey Station
- Access / Service Road
- Transmission Line Right-of-Way

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.
3. OW has been used as the idientfier for Shallow Open Water wetland field locations; however, please note that the wetland classification also includes LA and PD habitat codes.

Sources

- Basemap: ESRI World Topographic Base

N

1:60,000

0 0.5 1 1.5 2 2.5

Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-07	Production Date: Feb 25, 2021	Figure 15

Hemmera An Ausenco Company

BC hydro

4.2.3 Autonomous Recording Units (ARU)

Bioacoustic monitoring with ARU devices was conducted at 22 sites and recorded acoustic data over a total of 279 survey nights during the 2017 through 2020 monitoring programs (**Figure 13**). These included a total of 87 nights from 6 locations in 2017, 20 nights from one location in 2018, 112 nights from 9 locations in 2019, and 60 nights from 6 locations in 2020 (**Table 14**). As in previous years, sora were detected at all locations in 2020 and no American bittern vocalizations were recorded. Yellow rail was not detected in 2017, but was detected at the one site surveyed in 2018, at 3 sites in 2019, and at 4 of the 6 locations in 2020 (**Table 14**). Analysis of bioacoustics data for Virginia rail identified the species at 2 of the 6 sites where ARUs were deployed in 2020 (**Table 14**). All species, when detected, were detected within the first 2 nights of ARU deployments. Yellow rail and Virginia rail were not detected in the sedge-dominated area adjacent to the large open water area at OW-06, nor were they recorded within habitat with interspersed sedge, willow-sedge, and upland forest, around an area flooded by a beaver dam at SE-06.

Table 14 ARU Location, Habitat Description, Survey Effort, and Detections of Target Species During 2017, 2018, 2019, and 2020

ARU Survey ID	Latitude	Longitude	Habitat type	Wetland Survey Station	Dates of Acoustic Monitoring	Number of nights	SORA	YERA	AMBI	VIRA[3]
ARU-01	56.104658	-121.044231	Sedge and willow-sedge	SE-05[2]	May 16 to May 28, 2017	13	Yes	No	No	N/A
ARU-02	56.115311	-121.090337	Sedge and upland forested	N/A	May 16 to May 28, 2017	13	Yes	No	No	N/A
ARU-03	56.126825	-120.985543	Sedge and edge of open water	SE-10	May 28 to Jun 12, 2017	16	Yes	No	No	N/A
ARU-04	56.139182	-120.898154	Sedge and upland forested	SE-06	May 28 to Jun 12, 2017	16	Yes	No	No	N/A
ARU-05	56.134144	-120.941172	Sedge	N/A	Jun 12 to Jun 27, 2017	16	Yes	No	No	N/A
ARU-06	56.136775	-120.923437	Sedge	N/A	Jun 12 to Jun 24, 2017	13	Yes	No	No	N/A
ARU-07	56.113610	-121.094496	Sedge	SE-04	Jul 4 to Jul 23, 2018	20	Yes	Yes	No	N/A
ARU-08	56.126888	-120.986697	Sedge, willow-sedge, upland forested	SE-06	May 17 to May 24, 2019	8	Yes	Yes	No	N/A
ARU-09	56.139104	-120.897989	Open water, upland forested	SE-10	May 17 to May 24, 2019	8	Yes	No	No	N/A
ARU-10	56.114216	-121.08986	Open water, sedge, upland forested	SE-04[2]	May 17 to May 24, 2019	8	Yes	No	No	N/A
ARU-11	56.116424	-121.096006	Sedge, willow-sedge, upland forested	SE-04	May 24 to Jun 14, 2019	22	Yes	Yes	No	N/A
ARU-12	56.105986	-121.042059	Sedge, willow-sedge, upland forested	WS-01	May 24 to Jun 14, 2019	22	Yes	No	No	N/A
ARU-13	56.104382	-121.042940	Sedge, willow-sedge, upland forested	SE-05[2]	May 24 to Jun 14, 2019	22	Yes	Yes	No	N/A
ARU-14	56.154077	-120.866156	Sedge, willow-sedge, upland forested	N/A	Jul 22 to Aug 1, 2019	11	Yes	No	No	N/A

ARU Survey ID	Latitude	Longitude	Habitat type	Wetland Survey Station	Dates of Acoustic Monitoring	Number of nights	SORA	YERA	AMBI	VIRA[3]
ARU-15	56.152748	-120.872644	Sedge	N/A	Jul 22 to Aug 1, 2019	11	Yes	No	No	N/A
ARU-16	56.148765	-120.880178	Sedge	N/A	Jul 22 to Aug 1, 2019	11	Yes	No	No	N/A
ARU-17	56.11519	-121.09466	Sedge, willow-sedge, upland forested	SE-04	May 6 to May 15, 2020	10	Yes	Yes	No	Yes
ARU-18	56.10309	-121.04630	Sedge, upland forested, willow-sedge, open water	SE-05	May 6 to May 16, 2020	11	Yes	Yes	No	No
ARU-19	56.11307	-121.10017	Sedge and willow-sedge	SE-11	May 26 to June 5, 2020	10	Yes	Yes	No	No
ARU-20	56.14001	-120.89719	Sedge, upland forested, open water	SE-06	May 26 to June 4, 2020	9	Yes	No	No	No
ARU-21	56.01027	-121.42445	Sedge, upland forested, open water, willow-sedge	SE-09	June 16 to June 26, 2020	10	Yes	Yes	No	Yes
ARU-22	56.08691	-121.16201	Sedge, upland forested, willow-sedge, open water	OW-06	June 16 to June 26, 2020	10	Yes	No	No	No
					Totals	**279**	**22/22**	**8/22**	**0/22**	**2/6**

[1] Days ARU recorded acoustic data.

[2] Adjacent to wetland station.

[3] ARU data only reviewed for VIRA in 2020 as it was considered outside of the species' range in prior years

4.2.4 Relative Abundance and Density

Summaries of abundance are provided below by survey method and habitat type (**Table 15**, **Table 16**). Waterbird abundances are summarized as mean density by area of open water for standwatch surveys of open water habitat including permanent water features (e.g., lakes), as well as inundated sedge and willow-sedge habitats (**Table 15**), and as mean density per km of transect survey within sedge and willow-sedge habitats with water levels less than 50 cm (**Table 16**).

Standwatch surveys detected 6,400 waterbirds from 2017 through 2020 (**Appendix B-1**), including 1,660 individuals in 2020, of which 98% were identified to foraging guild (**Appendix B-2**). Across years, mean densities of waterbirds recorded during the late fall period were less than one quarter of any other period during spring or fall. Waterbirds observed during standwatch surveys were primarily comprised of dabbling ducks and benthic feeding divers (**Table 15**).

Transect surveys of vegetated wetlands with low water levels detected 314 waterbirds within sedge and willow-sedge habitat during 2018, 2019, and 2020 (**Appendix B-1**), including 95 individuals during surveys conducted in 2020 (**Appendix B-2**). Due to the close proximity of observations, 100% were identified to foraging guild and 98% were identified to species in 2020. Mean abundances observed within vegetated habitats were higher during the late spring and early fall compared to other survey periods due to high numbers of dabbling ducks, marsh birds, and shorebirds observed during that time. No waterbirds were detected during transect surveys on the Moberly Plateau and adjacent to the Site C transmission line ROW during the late fall **(Table 16**). In spring, dabbling ducks, were the most abundant foraging guild within vegetated wetlands followed by marsh birds. In fall, marsh birds and dabbling ducks were again the most commonly detected foraging guilds observed on transect surveys, and were the only foraging guilds observed after the early fall, when smaller numbers of shorebirds and large dabblers were observed (**Table 16**).

As mentioned previously, no surveys were conducted in the early spring because wetlands largely covered in ice and snow during that time and are, therefore, unavailable to waterbirds as foraging habitat.

Table 15 Mean Waterbird Densities (birds/ha/survey) within Open Water Habitat Reported by Foraging Guild From 2017 Through 2020 Standwatch Surveys

Foraging Guild	Spring		Fall			
	Middle	Late	Early	Early-Middle	Late-Middle	Late
Benthic Feeding Divers	1.7	1.3	2.7	2.1	1.7	0.4
Dabbling Ducks	6.4	4.9	5.9	4.9	4.8	1.0
Gulls	<0.1	0.1	<0.1	0.0	0.0	0.0
Large Dabblers	0.8	0.5	0.1	0.1	0.1	<0.1
Marsh Birds	<0.1	0.3	<0.1	0.2	0.0	0.0
Piscivorous Divers	0.1	0.2	0.2	0.2	0.3	0.2
Shorebirds	0.2	0.9	1.1	0.1	0.0	0.0
Unknown Waterbirds	<0.1	0.2	0.3	0.1	0.5	0.3
Total	**9.2**	**8.3**	**10.4**	**7.7**	**7.3**	**1.9**

Note: Mean densities reflect relative rather than absolute densities as they do not account for incomplete detection. Mean relative densities were calculated by averaging relative density across survey rounds first within each period per year, and then across years to avoid bias associated with uneven sampling effort in some periods and years. Results include survey data from open water habitat with flooded vegetated wetlands and interspersed with areas vegetated with rushes and sedge.

Table 16 Mean Waterbird Densities (birds/km/survey) within Vegetated Wetland (sedge, willow-sedge) Habitat Reported by Foraging Guild from 2018, 2019, and 2020 Transect Surveys

Foraging Guild	Spring		Fall			
	Middle	Late	Early	Early-Middle	Late-Middle	Late
Benthic Feeding Divers	0.0	0.0	0.0	0.0	0.0	0.0
Dabbling Ducks	1.4	5.5	3.5	0.1	0.7	0.0
Gulls	0.0	0.0	0.0	0.0	0.0	0.0
Large Dabblers	0.3	0.1	0.2	0.0	0.0	0.0
Marsh Birds	1.0	4.3	2.7	1.3	1.6	0.0
Piscivorous Divers	0.0	0.0	0.0	0.0	0.0	0.0
Shorebirds	0.2	1.8	1.0	0.0	0.0	0.0
Unknown Waterbirds	0.0	0.0	0.0	0.0	0.0	0.0
Total	**3.0**	**11.7**	**7.4**	**1.4**	**2.3**	**0.0**

Note: Mean densities reflect relative rather than absolute densities as they do not account for incomplete detection. Mean relative densities were calculated by averaging relative density across survey rounds first within each period per year, and then across years to avoid bias associated with variable survey effort across survey periods and years.

4.2.5 Diversity

Standwatch surveys detected 44 waterbird species during the spring and fall of 2017 through 2020 (**Appendix B-1**), including 31 species in 2020 (**Appendix B-2**). Transect surveys detected 19 species during 2018, 2019, and 2020, 13 of which were observed in 2020.

Weather related changes to access constraints resulted in variable survey effort across years and survey periods (**Table 13**). Comparisons of diversity across survey periods and years, and determination of inter-annual means as presented elsewhere in this report, would require further analyses (e.g., species rarefaction/ accumulation curves) to account for variation in survey effort. However, survey effort was applied evenly to all foraging guilds as all guilds were targeted during each survey. Thus, wetland survey data pooled across years provide comparable measures of species richness for foraging guilds as observed by each survey method (**Table 17**).

The most diverse foraging guilds observed during standwatch surveys of open water and flooded wetlands were dabbling ducks followed by piscivorous divers with 13 and 10 species observed, respectively, from 2017 through 2020 (**Table 17**). During transect surveys of vegetated wetlands, dabbling ducks were the most species rich guilds observed, with 8 species. No more than 4 species of any other guild were observed during transect surveys and gulls were entirely absent from survey records.

Table 17 Species Richness of Waterbird Foraging Guilds Observed During Transect and Standwatch Surveys of Wetland Habitats in 2017 Through 2020

Foraging Guild	Transect Surveys 2018 to 2020		Standwatch Surveys 2017 to 2020	
	Number of Species	Proportion of Species	Number of Species	Proportion of Species
Benthic Feeding Divers	1	0.05	7	0.16
Dabbling Ducks	8	0.42	13	0.30
Gulls	0	0.00	4	0.09
Large Dabblers	2	0.11	2	0.05
Marsh Birds	3	0.16	2	0.05
Piscivorous Divers	1	0.05	10	0.23
Shorebirds	4	0.21	6	0.14
Total	**19**	**-**	**44**	**-**

4.2.6 Waterbird Species at Risk

The following species designated as at risk, as per provincial, *Species at Risk Act* (SARA), or Committee on the Status of Endangered Wildlife in Canada (COSEWIC) rankings, were observed during 2017 through 2020 transmission line wetland surveys:

- Eared grebe (*Podiceps nigricollis*), BC listing (Blue)
- Horned grebe (*Podiceps auratus*), COSEWIC (SC), SARA (SC)
- Long-tailed duck (*Clangula hyemalis*), BC listing (Blue)
- Surf scoter (*Melanitta perspicillata*), BC listing (Blue)
- Western grebe (*Aechmophorus occidentalis*), BC listing (Red), COSEWIC (SC), SARA (SC)
- Yellow rail (*Coturnicops noveboracensis*), BC listing (Red), COSEWIC (SC), SARA (SC).

Across years, the most commonly observed waterbird species at risk within wetlands was surf scoter (86 individuals). Horned grebes (54 individuals) and eared grebes (77 individuals) were also regularly recorded. Fewer than 30 individuals of other species at risk were recorded within wetalnds across the 3 survey years. Yellow-rail were also detected during transect surveys for the first time in 2020 (**Appendix B-1**).

5.0 DISCUSSION AND RECOMMENDATIONS

As per the objectives described in **Section 1.2**, the monitoring program has improved understanding of baseline conditions for waterbirds, including assessment of habitat and documentation of habitat-specific abundance, density, and diversity for waterbird species groups. The results obtained are discussed below within the context of these monitoring objectives and prior understanding regarding baseline conditions for waterbirds and their habitat within the Peace River Valley and wetlands on the Moberly Plateau.

5.1 Habitat Assessments

Waterbird habitat associations (e.g., river reach and wetland types) and habitat characteristic data (e.g., TEM mapping and Peace River flow rates) collected during 2017 through 2020 improve understanding of baseline conditions and factors influencing the distribution and abundance of waterbirds. Waterbird location and habitat association data collected during this monitoring program improve on the data available prior to 2017, in which bird observations were recorded within 5 km segments without habitat characteristics. While TEM-based mapping provides informative wetland habitat data, it does not include landform information pertinent to waterbird presence on the Peace River, where river dynamics can change habitat from year to year. However, re-characterization of habitat types along the Peace River following Project commissioning will provide comparisons of habitat availability relative to Project-related changes to Impact treatment areas. LIDAR data of the Peace River Valley may also be considered in future analyses (e.g., BACI models) to assess the influence of topographic features on waterbirds. Similarly, river levels may influence waterbird abundances and / or diversity and can be considered in models assessing the magnitude and significance of Project-related changes to the abundance and diversity of waterbirds. Consideration of flow rate as a co-variate within future BACI models should account for the influence of river levels on waterbird abundance or density, including potential bias from surveys conducted under atypical conditions. For example, high river levels could result in a re-distribution of dabbling waterbirds from Mainstem and Moderate Flow habitats to more shallow areas such as Minimal and Limited Connectivity habitat types where suitable foraging depths persist. Inclusion of flow rate as a co-variate in analyses could account for such variation and increase power to detect change.

Once the Site C reservoir begins to fill, the Inundation Impact area will be buffered from the effects of river flow rates, at which point waterbird abundance and diversity metrics in that area will no longer be influenced by this factor. Reservoir levels can be recorded during this period and may also help to explain variations in the abundance and diversity of waterbirds, although such fluctuations in water levels are expected to be rare.

5.2 Peace River Waterbird Surveys

Boat surveys of the Peace River in 2017 through 2020 have provided estimates of abundance and diversity throughout the spring and fall migrations to meet the waterbird monitoring program objectives (**Section 4.1**). All target taxa, including shorebirds, were observed during boat surveys. Results from Peace River observations in 2017 through 2020 identified 89% of birds at the species level and 97% of records to the foraging guild level at which Project-related effects are to be assessed (**Appendix B-1**). This represents a substantial improvement over survey methods applied prior to 2017, which were unable to detect shorebirds and had species identification rates under 80% (Hemmera 2017). Results of Peace River surveys are discussed below, first summarizing the most abundant species, then discussing patterns of abundance and diversity across foraging guilds, across habitat types, and, finally, treatment areas.

The most common waterbird species observed on the Peace River across all years was Canada goose, followed by mallard, Bonaparte's gull (*Chroicocephalus philadelphia*), and Franklin's gull (*Leucophaeus pipixcan*) (**Appendix B-1**). While Canada goose was the most abundant species in all years, 2020 was the first year in which mallard (865 individuals) was not the second most abundant, as both Franklin's gull (1,699 individuals) and common merganser (*Mergus merganser* – 1,150 individuals) were recorded in greater numbers (**Appendix B-1; Appendix B-2;** Hemmera 2018, 2019, 2020b). Surveys in 1996 and 1999 resulted in similarly high abundances of Canada goose relative to other speices, which made up over 50% of the observed waterbirds (Robertson 1999; Robertson and Hawkes 2000; Hawkes et al. 2006).

Regarding foraging guilds, large dabblers were observed in the greatest abundances overall, dabbling ducks and gulls were observed in moderate abundances, while benthic feeding divers, piscivorous divers, and shorebirds were the least-abundant waterbird guilds observed on the Peace River. Timing of peak abundance for each waterbird foraging guild was variable. In spring, with the exception of shorebirds, most guilds arrived in the early to middle survey periods (i.e., during April) and were less numerous during the late survey period in May. In fall, variability in peak abundances across guilds was greater, with shorebird and gull abundances peaking in the earlier half of the season (i.e., August through mid-September), large dabbler abundance peaking in the latter half (i.e., later September through October), dabbling ducks and benthic feeding diver abundance peaking in the middle, and piscivorous divers maintaining fairly consistent abundances throughout. Patterns of abundance for each foraging guild are described in detail below.

Large dabblers, made up primarily of Canada geese (98% of all records for this guild), were observed in abundances more than twice those of any other guild across survey periods (**Table 7**). The Peace River is functioning as a stopover site during spring and fall migration and as a breeding site for Canada geese. Large dabblers were found in the greatest abundances in the early spring (i.e., early April) and the latter survey periods in fall (i.e., late September and October). Their migration timing highlights the importance of the Peace River as an ice-free stop over that is available when other habitats are not (i.e., in early spring and often in late fall as well). The greatest densities of large dabblers were observed within portions of the study area with Limited Connectivity to the river and Moderate Flow (**Table 8**). These are shallower habitats as compared to the Mainstem of the river, typically with more fine-grained sediments associated with aquatic vegetation that offer forage for this herbivorous waterbird. In terms of the total number of birds using each habitat type, lower densities within Mainstem river habitat are offset by the larger area, resulting in a similar total number of birds within each habitat type.

Gulls were the second most abundant waterbird guild overall, and the most abundant waterbird guild observed during fall in all survey years (**Table 7**), indicating that they were primarily using the survey area as a fall migration stopover site. The most abundant gulls in 2020 were Franklin's gulls (1,699 individuals), while California gull comprised only one detection (**Appendix B-2**). As in past years, the greatest concentrations of these and other gulls were observed on gravel bars (when river flows are low) and gravel shorelines (when river flows are high and the gravel bar is submerged) at the confluence of the Moberly River between 500 m and 1.5 km upstream of the Site C construction bridge. Behavioral observations during surveys suggest that gulls are using these areas as a roost, rather than as a foraging site. Roost sites for gulls are typically selected to provide a resting place that is safe from predators within close proximity to foraging areas (Clark et al. 2016). The gravel bar roost provides safety from land-based predators as it is cut off from land on both sides by the Peace River and is the closest such feature to the North Peace Regional Landfill (distance of 2.5 km), a high-use foraging location for gulls. These observations, among other observations of gulls foraging within Mainstem habitats, led to high gull densities within this habitat as compared to more sheltered and shallow Limited Connectivity and Moderate Flow habitat types.

Dabbling ducks, primarily mallards (60% of all dabbling duck records), were the third most abundant guild recorded from 2017 through 2020, while redhead (*Aythya americana*), American coot (*Fulica americana*), and lesser scaup (*Aythya affinis*) were the least abundant, with less than 60 individuals of each species observed overall across years (**Table 7**; **Appendix B-1**). Mallards are known to be early spring migrants (Drilling et al. 2020). Similar to large dabblers, dabbling ducks were observed in the highest densities within Limited Connectivity and Moderate Flow habitat where forage is available for primarily herbivorous species. These habitat associations align with results from prior annual reports. However, in previous years, dabbling ducks were reported in greater abundances than gulls. Lower dabbling duck numbers relative to gulls reported for 2020 are likely due to reduced coverage of Limited and Minimal Connectivity habitat types in which these ducks occur in higher densities than Moderate Flow and Mainstem habitats.

Piscivorous divers, primarily common merganser (94% of all piscivorous diver records: **Appendix B-1**), were most abundant in the early spring (i.e., early April), with declining abundances through the later spring survey periods and stable abundances through all fall survey periods. A total of 3,195 common merganser were detected by boat in 2017 through 2020, while only one red-breasted merganser was detected (**Appendix B-1**). These results indicate that most piscivorous divers observed in the Peace River are using the site as a migratory stopover during the northward migration, and smaller numbers may use the area for breeding and/or as a stopover site duing southward migration. The density of piscivorous divers observed within Moderate Flow and Limited Connectivity habitat types was more than double and more than 7 times, respectively, than observed within Mainstem habitats. Contrary to results reported in prior years using lower resolution habitat classifications, these results indicate that features used to classify habitat (e.g., water depth, and flow rate) have an important influence on the distribution of piscivorous divers. This may also indicate that their prey (primarily fish) may be not be evenly distributed across river habitat types as previously suggested.

Benthic feeding divers, primarily goldeneye (*Bucephala spp.*) (82% of benthic feeding divers; **Appendix B-1**), were observed in the highest abundances during early and middle spring survey periods (i.e., April through early May). Common goldeneye were the most abundant goldeneye species, with 1,522 individuals detected in 2017 through 2020, while only 128 Barrow's goldeneye were detected (**Appendix B-1**). Similar to piscivorous divers, abundances of benthic feeding divers declined later in the spring and remained low throughout the fall indicating their primary use of the Peace River occurs during northward migration. Densities of benthic feeding divers during spring were highest within habitat types with the lowest flow rates and connectivity to the Peace River. Sparse records from the fall provide no indication of habitat preferences for these birds during southward migration. These results are consistent with those reported in previous years.

Shorebirds arrive in late spring (i.e., May) as they migrate through the region, and their peak abundances occur in the early fall (i.e., the first half of August). This timing for peak abundance, and the relatively low diversity, was consistent with survey results from previous years (Hemmera 2018, 2019, 2020b). Mean shorebird densities were greatest within Limited Connectivity followed by Moderate Flow habitat types in both spring and fall, and within these were more than 2-fold higher in Limited as compared to Moderate Flow habitat. The vast majority (83%) of shorebirds observed across survey years were spotted sandpiper (*Actitis macularia*), followed by semipalmated sandpiper (*Calidris pusilla*), for which a single flock of 115 individuals in 2019 accounts for all but 2 individuals and 6% of all shorebird records (**Appendix B-1**). In 2020, only 3 shorebird species were observed, as compared to 10 in 2019 and 6 in both 2017 and 2018. The smaller number of species observed in 2020 is likely due, at least in part, to the reduced frequency of surveys, which was about half of that applied in prior years, in accordance with the results of the power analysis presented in **Appendix A**. Results for shorebirds in 2020 add to a growing body of evidence that, with the exception of spotted sandpiper, the Peace River is not heavily used by migratory shorebirds. These results do not support theories presented by Blood (1979) who hypothesized that large numbers of shorebirds were likely to use the Peace River valley during migration.

Peace River waterbird surveys from the spring of 2017 through 2020 found the highest mean abundance and densities in the early spring. Higher waterbird numbers in the early spring are likely driven by the lack of available wetland habitat on the plateau, which is typically frozen during this time, leaving few open water habitat alternatives other than the Peace River. Wetlands on the plateau typically thaw by late April, allowing waterbirds to disperse more broadly across open water habitat during the later survey periods. During the middle spring period, early and late migrant waterbirds use the river for mate selection, as a migratory stopover, and for breeding. Consistent with results reported in previous years, which found greater diversity in reaches of the Peace River that included backchannels compated to mainstem reaches, 2020 analyses of diversity within Mainstem and Moderate Flow habitats found lower species diversity in the early spring (April 1 to April 14) relative to middle and late spring periods (April 15 through May 30). These results remain consistent with the findings of other researchers who found mid-May to be the peak of the spring migration (Siddle 2010).

Peace River surveys in the fall found that diversity, as measured by species richness and evenness, did not decline until the late survey period (i.e., after October 15). Declines in diversity during the late-middle fall survey period (September 15 to October 15) noted in the previous annual monitoring report (Hemmera 2020b), were not apparent within data from 2017 through 2020 reported here. This could be a result of the inclusion of a fourth year of survey data or the exclusion of shallow habitats from the calculation of diversity statistics in 2020. As reported in previous years, the diversity of waterbirds reported in late fall was the lowest observed in any survey period. At this time in the year, waterbirds have mostly migrated through the region, and only late migrants and year-round resident species are present (Siddle 2010). Despite the relatively low abundances of other species guilds, large dabblers (primarily Canada goose) are found in some of their highest numbers during late fall and late-middle fall (i.e., after September 15). The only other survey period in which Canada goose was observed in similarly high abundances was early spring (i.e., early April).

Abundances of waterbirds varied across the habitat types defined for this study, indicating that waterbirds within the Peace River distributed themselves across gradients of water depth and other habitat features associated with flow rates and connectivity to the river. Higher abundances of dabbling ducks and large dabblers within more shallow habitats (e.g., Limited Connectivity and Moderate Flow habitats) align with findings from other studies assessing waterbirds associations with wetlands of various water depths (Colwell and O. W. Taft 2000; Baschuk et al. 2012). However, this was not the case for abundances of benthic feeding and piscivorous divers which other studies have found to prefer deeper waters, but which were also observed in higher densities within more shallow habitat types in this study. While overall densities of waterbirds observed across Peace River habitat types were highest in Limited Connectivity habitat regardless of season, densities varied between Mainstem and Moderate Flow habitats between seasons. In spring, waterbirds used Moderate Flow habitat more than Mainstem, whereas that pattern was reversed in fall. This finding appears to be driven by relatively low densities of dabbling ducks and large dabblers (e.g., Canada goose) within Moderate Flow habitat in spring, and higher abundances of gulls in the fall, which were primarily recorded in Mainstem habitat in both seasons. Differences in detection rates across habitat types may contribute to higher abundances of some species within Limited Connectivity and Moderate Flow relative to Mainstem habitats given that the distance to detection is typically smaller within shallower habitats and birds are more readily flushed and detected in these circumstances.

Thus, it is likely that detection rates of small birds (e.g., benthic feeding divers, shorebirds, dabbling ducks) was greater within Limited Connectivity and Moderate Flow as compared to Mainstem habitats. Such potential biases related to distance to detection can be accounted for in analyses of Project-related effects through the application of distance sampling (Buckland et al. 2015), for which distance to detection measures have been recorded during surveys.

Waterbird records are not tied to the river habitat categories applied in the summary statistics of this report. Thus, habitat types and assignments can be refined or re-classifed to account for other factors if they are found to explain variation in waterbird abundance better than the habitat types proposed here.

Surf scoter was the only species at risk regularly observed during Peace River surveys, with a total of 24 separate observations across years during boat surveys compared to 7 or fewer for all other species at risk. California gull and tundra swan are similar in appearance to other species, so their numbers may have been underestimated. Some California gull individuals may have been recorded as unknown gull species. Similarly, some tundra swan individuals may have been recorded as unknown swan species or pooled with records of trumpeter swan (*Cygnus buccinator*).

Peace River Summary

Data collected in 2017 through 2020 show that all habitats in the Peace River are used by waterbirds, with variations in timing, distribution and abundance for each of the guilds. Large dabbling ducks (Canada goose), gulls and dabbling ducks are the most commonly seen waterbirds, and shorebirds are only present in low numbers, mostly during the late spring and early fall. The greatest densities of waterbids were consistently observed within Limited Connectivity habitat, such as backchannels with little to no flow rates, silty sediments, and relatively abundant aquatic vegatation. While these areas comprised only 6% of the Peace River study area (**Table 5**), they were estimated to support 33% and 27% of the abundances of waterbirds in the spring (**Table 8**) and fall (**Table 9**), respectively. Despite lower densities, more birds were observed within the Mainstem of the Peace River (46% in spring, 67% in fall) than in any other habitat because this habitat comprised 77% of the study area.

The summary of data within treatment areas found that waterbird densities were similar within the Control and impact areas. All foraging guilds occurring within the impact areas were also found to be present within the Control area in both spring and fall, therefore meeting a standard assumption for BACI study design and data analysis. However, the numbers and densities of benthic feeding divers and gulls observed within the control area are low relative to the impact areas. The high numbers of gulls in the Flow Impact area and within Confluence river reaches, particularly during fall, explains some of the divergence in gull densities across treatment areas. As described above, most gulls are concentrated around disturbed habitat at the Project construction site and close to the local landfill. While benthic feeding divers are found in low densities within the Control relative to other treatment areas, they are present and will still provide some indication of background variations in density under baseline and post-construction conditions.

5.3 Transmission Line Wetland Surveys

Wetland surveys along the transmission line successfully provided estimates of spring and fall abundance and diversity of waterbirds in suitable wetland habitat types. Survey results provide the data required to meet the study's monitoring objectives (**Section 4.2**). A representative suite of sampling stations has been established, and consistent monitoring of these has been conducted in 2018, 2019, and 2020. Additionally, 4 consecutive years of monitoring have been conducted at stations surveyed by standwatch methods since 2017. Taken together, these methods provide density and abundance data for all wetland habitats where waterbirds have been found to regularly occur.

A total of 46 species were detected during wetland surveys across habitat types in 2017 through 2020, including the 24 species that were detected during transmission line surveys in 2008, prior to the initiation of the current follow-up monitoring program (EIS, appendix R, part 4). The increased diversity recorded under the current monitoring efforts likely reflects increased survey effort relative to 2008 surveys, as well as the more focused effort applied in 2019 and 2020 to wetland habitats with regular waterbird occurrence.

The dabbling duck foraging guild, encompassing small species of duck that primarily forage on aquatic vegetation, were the most commonly recorded foraging guild in open water and flooded sedge and willow-sedge wetlands surveyed by standwatch. Ring-necked duck (*Aythya collaris*), American wigeon (*Mareca americana*), scaup species (*Aythya* spp.), green-winged teal (*Anas crecca*) and mallards were among the most-numerous species observed. Vegetated wetland surveys conducted by walking transects found dabbling ducks (e.g., mallards, green- and blue-winged teal [*Spatula discors*], and northern shoveler [*Spatula clypeata*]) and marsh birds (e.g., Wilson's snipe [*Gallinago delicata*], and sora [*Porzana carolina*]) were most abundant with 145 and 112 records across years, respectively (**Appendix B-1**). Shorebirds (e.g., spotted sandpiper) were the next most abundant with 50 records. Results from wetland transect and standwatch surveys were similar to findings from 2006 and 2008, when mallards and American wigeons accounted for 69% of the observations in wetlands (EIS, appendix R, part 4) and are aligned with prior reports from this monitoring program (Hemmera 2018, 2019, 2020b). Open water wetlands such as lakes and ponds had the greatest number of waterbird observations, and the highest diversity, mostly of dabbling ducks. Again, this is consistent with the 2006 through 2008 studies in the transmission line ROW area (EIS, appendix R, part 4) and 2017 (Hemmera 2018). While fewer waterbirds were observed within sedge and willow-sedge habitats surveyed by transect methods, these surveys documented abundances of sora and wilson's snipe (*Gallinago gallinago*), which seldom use flooded habitat and, consequently, are not observed as frequently during standwatch survey methods.

The timing of peak waterbird abundance and diversity is likely linked to spring thaw and the open water habitats on the Moberly Plateau becoming available. This coincides with reduced numbers of waterbirds on the Peace River, as waterbirds appear to relocate from river to upland wetlands in middle to late spring. Across survey periods, mean densities of waterbird foraging guilds were lowest in the late fall (i.e., after October 15). This likely reflects the increasingly cold conditions in mid-October, such as the snowfall (~10 cm) observed on October 19, 2019 and earlier southward migration of some species. The absence of waterbirds observed from transect surveys of vegetated sedge and willow-sedge wetlands during the late fall survey periods suggests reduced vocalizations and/or presence of marsh birds and re-distribution of dabbling ducks into other habitat types during October. The lack of waterbird observations from transect surveys during late fall of 2017 through 2019 supports the discontinuation of transect surveys during this period in 2020 and as planned in subsequent years.

Bioacoustics monitoring surveys conducted with ARU deployments satisfy monitoring objectives to document trends in the presence of yellow rail, American bittern, and sora. In 2020 ARUs were also used to document the presence of Virginia rail, and this is planned to continue through future monitoring years. Observations of crepuscular marsh birds have been consistent across the wetlands during the 4 study years, indicating that sora are common, yellow rail are uncommon but regularly occur within relatively large areas of non-flooded sedge habitat, and American bittern are rare. Wetland transect surveys provide ample and more easily quantifiable data on sora as compared to ARU deployments. Regarding American bittern, since no records of this species were confirmed during 4 years of monitoring or as part of any other Site C wildlife studies, it is unlikely that additional bioacoustics monitoring would yield meaningful estimates of density beyond what is already known (i.e., the species is rare and typically absent or undetected within suitable habitat in the region). Thus, while bioacoustics data will continue to be collected and analyzed for these species, sora and American bittern are no longer considered priorities in the allocation of acoustic monitoring efforts (i.e., ARU deployment locations). ARU bioacoustics monitoring confirms previous reports of yellow rail from call-playback and point-count surveys (Hilton et al. 2013) EIS, appendix R, part 4). Furthermore, ARU deployments in 2020 re-detected yellow rail at 2 sites in which it was detected in prior years (ARU deployments within sedge habitat at wetland stations SE-04 and SE-05) indicating that the species can persist across years within sedge-dominated wetlands.

6.0 CLOSING

This Report has been prepared by Hemmera, based on fieldwork conducted by Hemmera, for sole benefit and use by BC Hydro. In performing this Work, Hemmera has relied in good faith on information provided by others, and has assumed that the information provided by those individuals is both complete and accurate. This Work was performed to current industry standard practice for similar environmental work, within the relevant jurisdiction and same locale. The findings presented herein should be considered within the context of the scope of work and Project terms of reference; further, the findings are time sensitive and are considered valid only at the time the Report was produced. The conclusions and recommendations contained in this Report are based upon the applicable guidelines, regulations, and legislation existing at the time the Report was produced; any changes in the regulatory regime may alter the conclusions and/or recommendations.

We sincerely appreciate the opportunity to have assisted BC Hydro with this project and if there are any questions, please do not hesitate to contact the undersigned by phone or email.

Report prepared by:
Hemmera Envirochem Inc.

DRAFT

C. Toby St Clair, M.Sc., P.Biol., R.P.Bio.
604.669.0424 (124)
tstclair@hemmera.com

Report reviewed by:
Hemmera Envirochem Inc.

DRAFT

Ryan Gill, R.P.Bio.
250.837.1870
ryan.gill@hemmera.com

7.0 REFERENCES

Baschuk, M.S., N. Koper, D.A. Wrubleski, and G. Goldsborough. 2012. Effects of water depth, cover and food resources on habitat use of marsh birds and waterfowl in boreal wetlands of Manitoba, Canada. Waterbirds 35(1):44–55.

BC Hydro. 2013. Site C Clean Energy Project environmental impact statement. Volume 2: assessment methodology and environmental effects assessment. Section 14: wildlife resources. Report prepared for BC Hydro. Keystone Wildlife Research Ltd.

BC Hydro. 2018. Site C waterbird migration follow-up monitoring program.

Blood, D.A. 1979. Peace River Site C Hydroelectric Development: environmental and socioeconomic assessment: wildlife sub-report.

Buckland, S.T., E.A. Rexstad, T.A. Marques, and C.S. Oedekoven. 2015. Distance Sampling: Methods and Applications. Springer International Publishing, Cham, Switzerland.

Churchland, C., K. Routledge, T. Jones, and T.K. Simpson. 2015. Site C Clean Energy Project spring waterfowl use of the Peace River. Keystone Wildlife Research Ltd, Vancouver, BC.

Clark, D.E., S. DeStefano, K.G. MacKenzie, K.K.G. Koenen, and J.J. Whitney. 2016. Roost site selection by ring-billed and herring gulls. Journal of Wildlife Management 80(4):708–719.

Colwell, M.A., and O. W. Taft. 2000. Waterbird communities in managed wetlands of varying water depth. Waterbirds: The International Journal of Waterbird Biology 23(1):45–55.

Conway, C.J. 2020. Virginia Rail (Rallus limicola). In A.F. Poole, F.B. Gill and S.M. Billerman and B.K. Keeney and P.G. Rodewald, and T.S. Schulenberg, Editors. Birds of the World. Cornell Laboratory of Ornithology.

Drilling, N., R.D. Titman, and F. McKinney. 2020. Mallard (Anas platyrhynchos). In A.F. Poole, F.B. Gill and S.M. Billerman and B.K. Keeney and P.G. Rodewald, and T.S. Schulenberg, Editors. Birds of the World. Cornell Laboratory of Ornithology.

Hawkes, V., G.F. Searing, M. Todd, M. Bentley, M.W. Demarchi, J. Muir, and M.K. McNicholl. 2006. Peace River wildlife surveys: 2005 habitat suitability modeling and wildlife inventory. Report to BC Hydro, Burnaby, BC.

Hemmera Envirochem (Hemmera). 2017. Site C Clean Energy Project - 2016 waterfowl surveys. Report prepared for BC Hydro, Burnaby, BC.

Hemmera Envirochem (Hemmera). 2018. Site C vegetation and wildlife waterbird migration follow-up monitoring program - 2017. Report prepared for BC Hydo, Burnaby, BC.

Hemmera Envirochem (Hemmera). 2019. Site C vegetation and wildlife waterbird migration follow-up monitoring program - 2018. Report prepared for BC Hydro, Burnaby, BC.

Hemmera Envirochem (Hemmera). 2020a. CLBMON-40: Arrow Lakes Reservoir shorebird and waterbird monitoring program: 10 year final report, 2008-2017, Burnaby B.C.

Hemmera Envirochem (Hemmera). 2020b. Site C vegetation and wildlife waterbird migration follow-up monitoring program - 2019. Report Prepared for BC Hydro, Burnaby, BC.

Hilton, S., L. Simpson, L. Andrusiak, and C. Albrecht. 2013. Part 4 migratory birds. Terrestrial vegetation and wildlife report. Site C Clean Energy Project. Report prepared for BC Hydro. Keystone Wildlife Research Ltd, Vancouver, BC.

Keystone Wildlife Research Ltd. 2012. Expanded legend for the Peace River terrestrial ecosystem mapping project. Prepared for BC Hydro and Power Authority.

MacDonald, Z.G., S.E. Nielsen, and J.H. Acorn. 2017. Negative relationships between species richness and evenness render common diversity indices inadequate for assessing long-term trends in butterfly diversity. Biodiversity and Conservation 26(3):617–629.

Mushanski, M., J. Vitt, and L. Ross. 2015. Fall migration waterfowl surveys for the Site C Clean Energy Project. Report prepared for BC Hydro.

Native Plant Solutions. 2020. Waterbird program analysis: statistical analysis of survey effort and timing, combined 2017, 2018, and 2019 Peace River waterbird data.

RIC. 1998. Inventory methods for riverine birds: harlequin duck, belted kingfisher and American dipper: Standards for Components of British Columbia's Biodiversity No. 12. Report prepared for the Terrestrial Ecosystems Task Force Resources Inventory Committee. Version 2.0. Ministry of Environment, Lands and Parks Resources Inventory Branch, Victoria, BC.

RIC. 1999. Inventory methods for waterfowl and allied species: loons, grebes, swans, geese, ducks, American coot, and sandhill crane: Standards for Components of British Columbia's Biodiversity No. 18. Report prepared for the Terrestrial Ecosystems Task Force Resources Inventory Committee. Version 2.0. The Committee, Victoria, BC.

Robertson, I. 1999. Surveys of water-associated birds on the peace river downstream of the W. A. C. Bennett Dam. British Columbia Birds 9:3–10.

Robertson, I., and V.C. Hawkes. 2000. Water-associated birds. In M.A. Fraker, and V.C. Hawkes, Editors. Peace River wildlife surveys: 1999. Report to BC Hydro, Burnaby, BC.

Siddle, C. 2010. Birds of North Peace River (Fort St. John and Vicinity) British Columbia, 1975-1999. Wildlife Afield 7(2):143–280.

Simpson, L., and L. Andrusiak. 2009. Baseline vegetation and wildlife report. Report prepared for BC Hydro. Keystone Wildlife Research Ltd, Vancouver, BC.

APPENDIX A

Ducks Unlimited / Native Plant Solutions Technical Memo: Waterbird Program Analysis: Statistical Analysis of Survey Effort and Timing, Combined 2017, 2018 and 2019 Peace River Waterbird Data

Unit A, 1238 Chevrier Blvd.
Winnipeg, MB R3T 1Y3
Phone: 204-953-8200
www.nativeplantsolutions.com

April 16, 2020

BC Hydro
333 Dunsmuir St, 6th floor
Vancouver, BC V6B 5R3

ATTENTION: Brock Simons

RE: Waterbird Program Analysis:
Statistical Analysis of Survey Effort and Timing,
Combined 2017, 2018 and 2019 Peace River Waterbird Data

Overview

BC Hydro has requested Native Plant Solutions (NPS)/Ducks Unlimited Canada (DUC) to repeat statistical analyses performed in December 2019 on the Peace River Waterbird data, now with combined 2017, 2018 and 2019 data. The intent of this technical memo is to outline the results of the analysis, as part of preparation for the 2020 waterbird monitoring field season. Specifically, DUC reviewed survey effort and survey timing in 2017, 2018 and 2019, based on the data provided by Hemmera on November 19th, 2019 and December 18th, 2019. The review focused on the 2017-2019 River Transect Waterbird data, including statistical analyses of the difference in density observed during survey periods (Statistical Analysis #1) and the sampling effort required to detect change (Statistical Analysis #2). The analysis also determines what effect dropping the UAV portion of the survey program will have on the overall survey effort required.

Background to monitoring methodology

Statistical analysis was conducted on the combined 2017-2019 unmanned aerial vehicle (UAV) and river boat survey data. During each season of migration, the season was split into several periods (spring: early, mid, late; and fall: early, early-mid, late-mid and late). Survey effort in 2019 was kept the same as in 2018 with the goal of better capturing and defining optimal survey periods for each foraging group and determining if the late fall survey period added in 2018 improved detection of Benthic Divers. Table 1 lists the survey periods and dates for each field season.

Within most survey periods, two replicate surveys were conducted, with each survey taking two days to complete. There was an exception in 2018 where three days were required due to ice washing down the Peace River on April 26 in the middle of the survey. There was also an exception in 2019 where three days were required to complete the first survey of the season (April 3, 4, 8). Note that in spring 2017, one survey day was dropped from statistical analysis (April 12), due to poor weather and therefore low bird counts. Survey dates in 2017-2019 were as described in Table 1.

Table 1. Survey periods and dates in 2017, 2018 and 2019.

Period	2017 Dates	2018 Dates	2019 Dates
Spring_Early	Apr. 5, 6	Apr. 13, 14	Apr. 3, 4, 8; Apr. 11, 12
Spring_Mid	Apr. 26, 27; May 3, 4	Apr. 25, 26 & May 1; May 5, 6	Apr. 19, 24; May 1, 2
Spring_Late	May 10, 11; May 14, 15	May 10, 11; May 18, 19	May 9, 10
Fall_Early	Aug. 8, 9; Aug. 14, 15	Aug. 4, 5	Aug. 7, 9
Fall_Early-Mid	Aug. 22, 23; Aug. 28, 29	Aug. 20, 21; Sep. 4, 5	Aug. 19, 20; Sep. 4, 5
Fall_Late-Mid	Sep. 21, 22; Sep. 27, 28	Sep. 20, 21; Oct. 4, 5	Sep. 16, 17; Sep. 30, Oct. 1
Fall_Late	none	Oct. 15, 16	Oct. 16, 17

In this technical memo, the following terminology is used when referring to the waterbird monitoring program:

- **Survey period:** A survey period is the timing of when a survey happens within a season (i.e., spring or fall) to document migrants, including early, early-mid, mid, late-mid and late. The original study design of the Waterbird Migration Follow-up Monitoring Program (BC Hydro 2018) was structured to have two surveys within each period acting as replicates to provide measures of uncertainty around estimates of relative abundance and diversity. For example, late spring is a survey period, containing two surveys.
- **Survey:** A survey is the census of waterbirds over the length of the Peace River, from the Peace Canyon Dam (Hudson's Hope) to the Alberta border (BC Hydro 2018). A survey typically takes two survey days to complete. For example, April 5 and 6 in spring 2017 is an early survey. Survey effort is quantified as the total length (km) of the river impact and control areas surveyed over the course of a survey.
- **Survey day:** A survey takes two survey days (noting the above-mentioned exceptions) to complete, with half of the river study area being surveyed each day and, in most cases, the whole river being surveyed in consecutive days. Each day is referred to in this technical memo as a survey day. For example, 12 survey days were conducted in fall of 2017 (e.g., August 8, 9, 14, 15, 22, 23, 28 and 29, and September 21, 22, 27 and 28).
- **Survey Area:** A survey area is a portion of the river labelled as one of control, flow impact, and inundation impact. For the remainder of this technical memo, flow and inundation impacts will be treated together as the "impact" area.

Statistical Analysis #1 - Statistical analysis of differences in density observed during survey periods (i.e., early, mid and late) in spring and fall

Statistical Analysis #1 tests for differences among early, mid and late periods in both spring and fall survey periods. Based on the results of Statistical Analysis #1, the biological inference that can be made from this is to assess if the timing and number of survey periods in spring and fall of 2017, 2018 and 2019 were capturing peaks in abundance during migration and the specific survey timing recommended for capturing any peaks.

The spring and fall survey periods were analysed separately, fit with foraging group-specific negative binomial regression models, with total bird counts per complete river survey (normally completed over two consecutive days) as the response and survey period (Spring: early vs. mid vs. late; and Fall: early vs. early-mid vs. late-mid vs. late), study area (control vs flow and inundation impact) and year as predictors. The natural log of surveyed river length by study area (km) was used as an offset variable to scale total bird counts for differing effort across surveys. Survey period and study area were treated as additive predictors in the foraging group model since preliminary analyses suggested similar patterns in waterbird abundance peaks across the control and impact areas.

A complete list of species observed during spring and fall surveys in 2017, 2018 and 2019 is provided in Appendix A. Some species and foraging groups (e.g., bald eagles) were not included in the combined analysis due to the low densities observed. Differences in density among survey periods were also analyzed at a foraging group level. The allocation of species to each foraging group is also listed in Appendix A. Discussion of the 2017-2019 data is focused at the foraging group level because of the greater strength of inference analysis at the foraging group level allows (see NPS 2018 technical memo).

During spring migration surveys (Table 2), at a foraging group level, the early period yielded the highest counts for Large Dabblers and Piscivorous Divers and lowest counts for Surface Feeding Terns/Gulls. Late spring surveys yielded the highest counts for Shorebirds, Surface Feeding Terns/Gulls, with lowest counts for Benthic-Feeding Divers and Piscivorous Divers.

During fall migration surveys (Table 3), at a foraging group level, the early survey period yielded the highest counts for Shorebirds and lowest counts for Large Dabblers. Late-mid and late fall surveys yielded the highest counts for Large Dabblers.

Table 2. Spring survey periods results.

Forage Group	Differences in densities observed among Early, Mid, and Late Periods	Estimated number of birds seen per 100 km of river surveyed (standard error)[1]
	Foraging Group Level[2]	
Benthic Feeding Divers	Early and Mid > Late	Control: E: 32.8 (12.1); M: 32.1 (12.2); L: 9.2 (3.2) Impact: E: 98.1 (36.8); M: 95.9 (29.5); L: 27.5 (10.1)
Dabbling Ducks	No	Control: 413.2 (49.2) Impact: 289.5 (33.3)
Surface Feeding Terns/Gulls	Mid and Late > Early	Control: E: 0.3 (0.3); M: 10.7 (5.4); L: 14.2 (7.5) Impact: E: 0.9 (0.6); M: 30.4 (14.8); L: 40.1 (21.2)
Large Dabblers (Geese and Swans)	Early > Mid and Late	Control: E: 1,154.0 (136.7); M: 444.3 (48.7); L: 365.8 (40.2) Impact: E: 1,151.3 (136.2); M: 443.3 (44.7); L: 365.0 (40.4)
Piscivorous Divers	Early > Mid > Late	Control: E: 79.6 (16.9); M: 33.5 (6.3); L: 19.2 (3.7) Impact: E: 183.7 (33.8); M: 77.4 (13.3); L: 44.2 (8.5)
Shorebirds	Late > Early and Mid	Control: E: 1.1 (0.6); M: 1.9 (0.9); L: 52.9 (15.7) Impact: E: 1.3 (0.6); M: 2.2 (0.8); L: 63.2 (22.6)

[1] – E: early; M: mid; L: late.

[2] – Highest survey counts for Foraging Groups are indicated in red.

Table 3. Fall survey periods results.

Species or Forage Group	Differences in densities observed among Early, Early-Mid, Late-Mid, and Late Periods	Estimated number of birds seen per 100 km of river surveyed (standard error)[1]
Foraging Group Level[2]		
Benthic-Feeding Divers	No	Control: 1.0 (0.6) Impact: 7.6 (2.9)
Dabbling Ducks	Early-Middle and Late-Middle > Late	Control: E: 16.2 (7.5); E-M: 30.2 (11.3); L-M: 35.9 (12.1); L: 4.4 (2.7) Impact: E: 185.0 (78.2); E-M: 344.2 (117.8); L-M: 409.9 (163.1); L: 50.2 (25.8)
Surface Feeding Terns/Gulls	Early, Early-Middle and Late-Middle > Late	Control: E: 12.3 (6.1); E-M: 24.8 (8.8); L-M: 9.5 (3.6); L: 1.7 (1.1) Impact: E: 591.3 (220.3); E-M: 1,190.9 (480.2); L-M: 458.1 (175.1); L: 82.5 (49.8)
Large Dabblers (Geese and Swans)	Late and Late-Middle > Early; Late-Middle > Early-Middle	Control: E: 255.0 (63.4); E-M: 469.9 (110.9); L-M: 939.5 (193.5); L: 780.6 (263.7) Impact: E: 145.1 (37.1); E-M: 267.3 (55.6); L-M: 534.5 (115.2); L: 444.1 (152.0)
Piscivorous Divers	No	Control: 16.6 (3.9) Impact: 20.7 (4.0)
Shorebirds	Early > Early-Mid > Late-Mid	Control: E: 228.5 (40.4); E-M: 96.7 (15.4); L-M: 3.5 (0.9); L: 0 (--) Impact: E: 112.2 (19.0); E-M: 47.5 (7.6); L-M: 1.7 (0.5); L: 0 (--)

[1] – E: early; E-M: early-mid; L-M: late-mid; L: late.

[2] – Highest survey counts for Foraging Groups are indicated in red.

Statistical Analysis #2 - Statistical power analysis to estimate sampling efforts required to detect change in impact area relative to control

The second objective of the statistical analysis was to conduct a power analysis, based on the available 2017, 2018 and 2019 survey data, to estimate the sampling effort required to detect change of a specific magnitude in the impact area relative to the control area. Based on the results of the statistical analysis, this provides guidance on determining the magnitude and possibilities for allocating effort to detect, with 80% statistical power, a 50% change in foraging group abundance in the impact area contrasted with no change in the control area over time.

For Statistical Analysis #2 a baseline average of relative abundances for the impact and control areas were calculated from the 2017, 2018 and 2019 survey data. Within the 2017-2019 survey data, some foraging groups exhibited differences in counts among survey periods in a season, whereas other foraging groups did not. For the foraging groups for which there were statistically detectable differences in counts across survey periods, relative abundance estimates from particular survey periods are informative baselines as identifiable 'optimal' survey periods, such that averaging across survey periods would conceal important within-season differences in relative abundances. Therefore, for foraging groups exhibiting statistically detectable differences in counts across survey periods, baseline bird densities were estimated using the survey periods that yielded the highest densities. For foraging groups without statistically detectable differences in counts across survey periods (i.e., either due to counts that did not vary much across survey periods over a season, or where counts varied greatly among surveys within a survey period), relative abundance estimates from particular survey periods are not informative baselines. Rather, pooled baseline estimates of abundance across a season are best and will mitigate the impacts of survey-specific variation. Therefore, for foraging groups where there were not statistically detectable differences in counts among survey periods, baseline bird densities were estimated using averages across all surveys.

Relative abundance is the average number of birds that were counted during a survey in a study area (control vs flow and inundation impact), per 100 km length of river surveyed. Given the best estimates of foraging group relative abundances (and their standard errors) from the 2017-2019 survey data, the statistical power analyses estimated the sampling efforts required to detect changes of a specified magnitude in the impact area as contrasted with no change in the control area. For the purposes of this analysis, a 50% change in relative abundance in the impact area was seen as a reasonable target (i.e., both statistical and biological; Hatch 2003). Tables 4 and 5 give the survey effort required to detect 50% change in relative abundance in the impact area versus no change in the control area given 2017-2019 spring (Table 4) and fall (Table 5) survey baselines. Note that survey effort is given in the number of surveys and the estimated number of years to detect change (i.e., should the current survey effort be maintained over time).

In spring (Table 4), the survey effort required to detect a 50% change in relative abundance (i.e., based on the 2017-2019 spring survey data) in the impact area versus no change in the control area was the least for Large Dabblers (Geese and Swans), with increasing survey effort to detect change in Piscivorous Divers, Dabbling Ducks, Benthic-Feeding Divers, and Surface Feeding Terns/Gulls. Note that early and mid surveys are not informative for estimating relative abundance of Shorebirds. In fall (Table 5), the survey effort required to detect a 50% change in relative abundance (i.e., based on the 2017-2019 fall survey data) in the impact area versus no change in the control area was the least for Shorebirds, with increasing survey effort to detect change in Large Dabblers, Dabbling Ducks, Piscivorous Divers, Surface Feeding Terns/Gulls, and Benthic-Feeding Divers.

Table 4. Survey effort required to detect a 50% change in relative abundance in the impact area contrasted with no change in the control area given a 2017-2019 Spring Survey baseline. [1]

Forage Group	Survey Periods Used for Estimating Baseline Abundance (number of complete river surveys in 2017-2019)	2017-2019 Baseline Average Relative Abundance per 100 km (Standard Error)	Estimated survey effort required beyond 2017-2020 baseline period
Benthic-Feeding Divers	Early & Mid (n = 10 surveys)	Control: 32.4 (9.7) Impact: 97.0 (24.8)	12 (3 years; assuming 2 early and 2 mid surveys each year)
Dabbling Ducks	Early, Mid, Late (n = 15 surveys)	Control: 413.2 (49.2) Impact: 289.5 (33.3)	9 (~3 years; assuming 4 complete river surveys per year)
Surface Feeding Terns/Gulls	Mid & Late (n = 11 surveys)	Control: 12.3 (4.9) Impact: 34.9 (13.5)	18 (~9 years; assuming 2 mid surveys per year)
Large Dabblers (Geese and Swans)	Early (n = 4 surveys)	Control: 1154.0 (136.7) Impact: 1151.3 (136.2)	1 (1 year; assuming 2 early surveys per year)
Piscivorous Divers	Early (n = 4 surveys)	Control: 79.6 (16.9) Impact: 183.7 (33.8)	3 (2 years; assuming 2 early surveys per year)
Shorebirds	Late (n = 5 surveys)	Control: 52.9 (15.7) Impact: 63.2 (22.6)	10 (n/a; no additional late surveys planned)

[1] – Red indicates foraging groups that should not be the focus of surveys within this season.

Table 5. Survey effort required to detect a 50% change in relative abundance in the impact area contrasted with no change in the control area given a 2017-2019 Fall Survey baseline. [1]

Forage Group	Survey Periods Used for Estimating Baseline Abundance (number of complete river surveys in 2017-2019)	2017-2019 Baseline Average Relative Abundance per 100 km (Standard Error)	Estimated survey effort required beyond 2017-2020 baseline period
Benthic-Feeding Divers	Early, Early-Mid, Late-Mid, Late (n = 18 surveys)	Control: 1.0 (0.6) Impact: 7.6 (2.9)	> 210 (> 70 years; assuming 3 complete river surveys per year)
Dabbling Ducks	Early, Early-Mid, Late-Mid, (n = 16 surveys)	Control: 26.0 (6.9) Impact: 296.7 (76.3)	9 (3 years; assuming 1 early, 1 early-mid and 1 late-mid survey per year)
Surface Feeding Terns/Gulls	Early, Early-Mid, Late-Mid (n = 16 surveys)	Control: 14.3 (4.2) Impact: 685.8 (173.2)	24 (~8 years; assuming 1 early, 1 early-mid and 1 late-mid survey per year)
Large Dabblers (Geese and Swans)	Early-Mid, Late-Mid, Late (n = 14 surveys)	Control: 701.1 (124.8) Impact: 398.8 (69.0)	2 (1 year; assuming 1 early-mid and 1 late-mid survey per year)
Piscivorous Divers	Early, Early-Mid, Late-Mid, Late (n = 18 surveys)	Control: 16.6 (3.9) Impact: 20.7 (4.0)	15 (5 years; assuming 1 early, 1 early-mid and 1 late-mid survey per year)
Shorebirds	Early (n = 4 surveys)	Control: 228.5 (40.4) Impact: 112.2 (19.0)	2 (2 years; assuming 1 early survey per year)

[1] – Red indicates foraging groups that should not be the focus of surveys within this season.

The sensitivity of these results to exclusion of the survey data collected on back channels via unmanned aerial vehicles (UAVs) was also examined. For each survey and survey area, the proportion of the area surveyed by UAV was excluded from the measure of survey effort (i.e., surveyed river length) and all birds observed during UAV surveys were excluded from total bird counts. A summary of the proportions of area surveyed by UAV and total birds counted by UAV is provided in Table 6. In the fall, UAV surveys accounted for a large proportion of the Large Dabblers counted overall and for Dabbling Ducks counted in the impact area.

Table 6. Average proportion of River Survey Area and Total Birds counted by UAV.

Study Area	River Area	Benthic-Feeding Divers	Dabbling Ducks	Surface-Feeding Terns/Gulls	Large Dabblers	Piscivorous Divers	Shorebirds
Spring Surveys							
Control	0.038	0.082	0.050	0.172	0.120	0.112	0.000
Impact	0.063	0.073	0.165	0.050	0.141	0.060	0.030
Fall Surveys							
Control	0.026	0.000	0.128	0.000	0.476	0.032	0.005
Impact	0.033	0.208	0.459	0.001	0.286	0.128	0.032

Adjusted baseline average relative abundances were calculated, omitting the UAV data, and power analyses re-run to estimate sampling effort required to detect, with 80% statistical power, 50% changes in relative abundance in the impact area versus no change in the control area given 2017-2019 spring (Table 7) and fall (Table 8) survey baselines.

Table 7. Survey effort required to detect a 50% change in relative abundance in the impact area contrasted with no change in the control area given a 2017-2019 Spring Survey baseline (UAV data omitted). [1]

Forage Group	**Survey Periods Used for Estimating Baseline Abundance (number of complete river surveys in 2017-2019)**	**2017-2019 Baseline Average Relative Abundance per 100 km (Standard Error)**	**Estimated survey effort required beyond 2017-2020 baseline period**
Benthic-Feeding Divers	Early & Mid (n = 10 surveys)	Control: 31.3 (9.6) Impact: 95.9 (24.7)	11 (~3 years; assuming 2 early and 2 mid surveys each year)
Dabbling Ducks	Early, Mid, Late (n = 15 surveys)	Control: 392.6 (44.8) Impact: 246.9 (27.3)	8 (2 years; assuming 4 complete river surveys per year)
Surface Feeding Terns/Gulls	Mid & Late (n = 11 surveys)	Control: 7.9 (3.3) Impact: 41.2 (16.9)	80 (40 years; assuming 2 mid surveys per year)
Large Dabblers (Geese and Swans)	Early (n = 4 surveys)	Control: 1121.6 (138.4) Impact: 1096.7 (134.5)	1 (~1 year; assuming 2 early surveys per year)
Piscivorous Divers	Early (n = 4 surveys)	Control: 79.0 (18.9) Impact: 197.3 (41.9)	2 (~2 years; assuming 2 early surveys per year)

Forage Group	Survey Periods Used for Estimating Baseline Abundance (number of complete river surveys in 2017-2019)	2017-2019 Baseline Average Relative Abundance per 100 km (Standard Error)	Estimated survey effort required beyond 2017-2020 baseline period
Shorebirds	Late (n = 5 surveys)	Control: 54.1 (13.1) Impact: 54.5 (15.2)	10 (n/a; no additional late surveys planned)

[1] – Red indicates foraging groups that should not be the focus of surveys within this season.

Table 8. Survey effort required to detect a 50% change in relative abundance in the impact area contrasted with no change in the control area given a 2017-2019 Fall Survey baseline (UAV data omitted). [1]

Forage Group	Survey Periods Used for Estimating Baseline Abundance (number of complete river surveys in 2017-2019)	2017-2019 Baseline Average Relative Abundance per 100 km (Standard Error)	Estimated survey effort required beyond 2017-2020 baseline period
Benthic-Feeding Divers	Early, Early-Mid, Late-Mid, Late (n = 18 surveys)	Control: 0.9 (0.6) Impact: 6.5 (3.2)	> 210 (> 70 years; assuming 3 complete river surveys per year)
Dabbling Ducks	Early, Early-Mid, Late-Mid, (n = 16 surveys)	Control: 24.8 (7.2) Impact: 198.9 (56.0)	12 (4 years; assuming 1 early, 1 early-mid and 1 late-mid survey per year)
Surface Feeding Terns/Gulls	Early, Early-Mid, Late-Mid (n = 16 surveys)	Control: 14.8 (4.4) Impact: 720.8 (184.5)	12 (4 years; assuming 1 early, 1 early-mid and 1 late-mid survey per year)
Large Dabblers (Geese and Swans)	Early-Mid, Late-Mid, Late (n = 14 surveys)	Control: 505.0 (89.2) Impact: 323.9 (57.6)	2 (1 year; assuming 1 early-mid and 1 late-mid survey per year)
Piscivorous Divers	Early, Early-Mid, Late-Mid, Late (n = 18 surveys)	Control: 15.6 (3.9) Impact: 17.8 (3.7)	13 (~4 years; assuming 1 early, 1 early-mid and 1 late-mid survey per year)
Shorebirds	Early (n = 4 surveys)	Control: 230.7 (40.4) Impact: 113.0 (19.0)	2 (2 years; assuming 1 early survey per year)

[1] – Red indicates foraging groups that should not be the focus of surveys within this season.

Given the estimates of survey effort required beyond 2019 and survey periods suited to characterizing relative abundance or use by each foraging group, we can consider different scenarios for survey plans in future years. Factors to consider for future efforts include the following:

- If a foraging group is observed in lower abundances or with greater variability across survey periods, the ability to detect a 50% change in relative abundance in the impact area contrasted with no change in the control area may not be achievable within a reasonable time period, which is defined as ≤ 10 years, or the post-construction monitoring period. The foraging groups shaded in grey tone in Tables 9 and 10 fall into this category. BC Hydro may want to consider tailoring their spring and fall survey plans to exclude certain foraging groups, for which detecting statistically significant differences over time is unlikely during the period of the waterbird monitoring program (e.g., Surface Feeding Terns/Gulls and shorebirds in spring; Benthic-Feeding Divers in fall).
- If peak abundances for a foraging group are observed uniquely in a survey period, the region should be surveyed during that time period. For example, the early survey period is important to characterize relative abundances of Large Dabblers and Piscivorous Divers in spring, compared to the early survey time for Shorebirds in fall.
- For species whose relative abundances or use are well captured during any survey within a survey period (e.g., Dabbling Ducks in spring and fall; Benthic-Feeding Divers and Piscivorous Divers in fall), the particular timing of surveys does not play much of a role. It is simply the overall survey effort that helps to moderate the variability observed across survey occasions.

Tables 9 and 10 consider the impacts of survey timing scenarios given that an early survey is necessary in the spring and late-mid or late surveys may be necessary in the fall. In general, a 50% change in relative abundance in the impact area contrasted with no change in the control area would be detected within 10 years for five of the foraging groups in spring. It will take 8 years of effort of 3 or more fall surveys/year to detect a 50% change in relative abundance in the impact area contrasted with no change in the control area for five of the foraging groups.

Table 9. Impacts of modified Spring Waterbird Survey plans beyond 2020. [1]

Foraging Group	Periods useful for Characterizing Foraging Group Use	Estimated survey effort (number of surveys) required beyond 2017-2020 baseline period	Number of years required if 1 Early Survey is conducted per year *(n= 2 survey days required/spring season)*	Number of years required if 2 Early Surveys is conducted per year *(n= 4 survey days required/spring season)*	Number of years required if 2 Early Surveys, 1 Mid Survey are conducted per year *(n= 6 survey days required/spring season)*	Number of years required if 2 Early Surveys, 2 Mid Surveys conducted are per year *(n= 8 survey days required/spring season)*
Dabbling Ducks	Any	9	9	5	3	3
Large Dabblers	Early	1	1	1	1	1
Piscivorous Divers	Early	3	3	2	2	2
Benthic Feeding Divers	Early, Mid	12	12	6	4	3
Surface Feeding Terns/Gulls	Mid, Late	18	-	-	18	9
Shorebirds	Late	10	-	-	-	-

[1] – Grey indicates foraging groups where 50% change cannot be detected within 10 years, with 80% statistical power, with the survey scenarios described.

Table 10. Impacts of modified Fall Waterbird Survey plans beyond 2020. [1]

Foraging Group	Periods useful for Characterizing Foraging Group Use	Estimated survey effort (number of surveys) required beyond 2017-2020 baseline period	Number of years required if 1 Early Survey, 1 Late-Mid Survey is conducted per year (*n= 4 survey days required/fall season)*	Number of years required if 1 Early Survey, 1 Late-Mid, 1 Late Survey are conducted per year (*n= 6 survey days required/fall season)*	Number of years required if 1 Early Survey, 1 Early-Mid, 1 Late-Mid Survey are conducted per year (*n= 6 survey days required/fall season)*	Number of years required if 1 Early Survey, 1 Early-Mid, 1 Late-Mid, 1 Late Survey are conducted per year (*n= 8 survey days required/fall season)*
Piscivorous Divers	Any	15	8	5	5	4
Large Dabblers	Early-Middle, Late-Middle, Late	2	2	1	1	1
Surface Feeding Terns/Gulls	Early, Early-Middle, Late-Middle	24	12	12	8	8
Dabbling Ducks	Early-Middle, Late-Middle, Late	9	9	5	5	3
Shorebirds	Early	2	2	2	2	2
Benthic-Feeding Divers	Any	> 210	> 105	> 70	> 70	> 53

[1] – Grey indicates foraging groups where 50% change cannot be detected within 10 years, with 80% statistical power, with the survey scenarios described.

Discussion

For the spring 2017-2019 survey data, optimal survey periods were identified for most foraging groups, except for Dabbling Ducks. The early and mid-surveys in spring yielded the highest counts for Benthic-Feeding Divers, Large Dabblers and Piscivorous Divers, while the late survey yielded the highest survey counts for Gulls/Surface Feeding Terns and Shorebirds. As presented in the statistical analyses of the 2017-2019 waterbird data, Dabbling Duck density was variable among surveys, but peak counts did not align with particular survey periods; it is overall survey effort rather than a particular allocation across survey periods that is useful for moderating the effects of survey-to-survey variability in Dabbling Duck counts.

For the fall 2017-2019 survey data, no optimal survey periods were clear for Piscivorous Divers or Benthic-Feeding Divers, due to high survey-to-survey variation in counts that did not align with particular survey periods. Low counts coupled with high variation, as seen with the Benthic-Feeding Divers, results in a high survey effort required to detect change in the fall (Table 5).

In order to efficiently detect, with 80% statistical power, 50% changes in relative abundance in the impact area versus no change in the control area, survey effort should be focused on the survey period(s) that best characterize the relative abundance of each foraging group. Tables 9 and 10 demonstrated various scenarios of survey effort and the subsequent number of years it will take to detect a 50% change in relative abundance in the impact area versus no change in the control for each foraging group.

Based on the results of the power analysis of survey effort scenarios in spring, conducting two early surveys per year will allow for the detection of 50% change in relative abundance in the impact area versus no change in the control within 1-6 years for Dabbling Ducks (n=18 field surveys days required), Large Dabblers (n=2 early field survey days required), Piscivorous Divers (n=6 early field survey days required) and Benthic-Feeding Divers (n=24 early or mid field survey days required) (Table 9). We recommend that Surface Feeding Terns/Gulls or Shorebirds not be the focus in spring surveys, because of the low likelihood of being able to detect statistically significant changes in these foraging groups within the waterbird monitoring program (i.e., during construction and the first 10 years of operations).

Based on the results of power analysis of survey effort scenarios in fall, conducting 1 early and 1 late-mid survey per year will allow for the detection of 50% change in relative abundance in the impact area versus no change in the control within 2-9 years for Piscivorous Divers (n=30 survey days), Large Dabblers (n=4 late-mid survey days), Dabbling Ducks (n=18 late-mid survey days) and Shorebird (n=4 early survey days). Changes in the impact areas (relative to no change in the control areas) for Surface Feeding Terns/Gulls can be detected within 12 years (n=48 survey days) with 1 early and 1 late-mid survey. Adding one more early, early-mid or late-mid survey per fall season does improve the power to detect changes in Surface Feeding Terns/Gulls in a shorter period (n=8 years; 48 survey days; Table 10).

For fall surveys we recommend that the focus is not on Benthic-feeding Divers because of the greater survey effort required to detect this foraging group within the fall season as compared to the spring season. Under the scenarios presented in Table 10 a 50% change in the impact area versus no change in the control for Benthic-Feeding Divers cannot be detected within 10 years.

Each foraging group varies from one another on life characteristics such as nesting and foraging behaviors, diet preferences and habitat preferences. Variation can also be seen within a foraging group as well. For example, Piscivorous Divers have similar food preferences, but vary in nesting behaviors. This makes it difficult to use one foraging group as an indicator for another. Statistically, Shorebirds and Surface Feeding Terns/Gulls have similar peaks in abundance, however they differ from all other foraging groups in this regard, which also makes the use of other foraging groups as an indicator difficult.

Overall, this suggests that to create more efficiency within the Waterbird survey program the early and mid surveys should be the focus during the spring survey period. Reduction in fall survey effort could include eliminating the early-mid and late-mid replicates, and the late period to detect of Surface Feeding Terns/Gulls within 8 years (n=48 survey days), with the caveat that focus of detecting Benthic Feeding Divers will be in the spring season.

The removal of the UAV data had little impact on the required survey effort (Tables 7 and 8) with exception to the Surface Feeding Terns/Gulls in the Spring survey period. Survey effort for this foraging group increased from 9 years to 40 years (given 2 mid surveys) with the exclusion of UAV data. If it is determined to be in the best interest of the survey program to eliminate the UAV portion of the waterbird surveys the detection of Surface Feeding Terns/Gulls should be focused on in the fall season.

References

BC Hydro. 2018. Site C Vegetation and Wildlife Waterbird Migration Follow-up Monitoring Program (v4 January 2018). 30 pp.

Hatch, S. A. 2003. Statistical power for detecting trends with applications to seabird monitoring. Biological Conservation 111:317-329.

Native Plant Solutions (NPS). 2018. Waterbird monitoring 2018 program technical memo: review of survey effort and timing. 12 pp.

Appendix A – Complete list of species and foraging groups observed during 2017/2018/2019 surveys, along the Peace River.

Species Code	Common Name	Latin Name	Foraging Mode Species Group
CONI	Common Nighthawk	*Chordeiles minor*	Aerial Insectivores
AMDI	American Dipper	*Cinclus mexicanus*	Benthic-Feeding Divers
BAGO	Barrow's Goldeneye	*Bucephala islandica*	Benthic-Feeding Divers
BUFF	Bufflehead	*Bucephala albeola*	Benthic-Feeding Divers
COGO	Common Goldeneye	*Bucephala clangula*	Benthic-Feeding Divers
HADU	Harlequin Duck	*Histrionicus histrionicus*	Benthic-Feeding Divers
LTDU	Long-tailed Duck	*Clangula hyemalis*	Benthic-Feeding Divers
RUDU	Ruddy Duck	*Oxyura jamaicensis*	Benthic-Feeding Divers
SUSC	Surf Scoter	*Melanitta perspicillata*	Benthic-Feeding Divers
UNGO	Unknown Goldeneye	-	Benthic-Feeding Divers
UNKN SCOTER	Unknown Scoter	*Mellanita sp.*	Benthic-Feeding Divers
WWSC	White-winged Scoter	*Melanitta fusca*	Benthic-Feeding Divers
GBHE	Great blue heron	*Ardea herodias*	Cranes and Herons
SACR	Sandhill Crane	*Grus canadensis*	Cranes and Herons
AMCO	American Coot	*Fulica americana*	Dabbling Ducks
AMWI	American Wigeon	*Anas americana*	Dabbling Ducks
BWTE	Blue-winged Teal	*Anas discors*	Dabbling Ducks
CANV	Canvasback	*Aythya valisineria*	Dabbling Ducks
CITE	Cinnamon Teal	*Anas cyanoptera*	Dabbling Ducks
GADW	Gadwall	*Anas strepera*	Dabbling Ducks
GRSC	Greater Scaup	*Aythya marila*	Dabbling Ducks
GWTE	Green-winged Teal	*Anas crecca*	Dabbling Ducks
LESC	Lesser Scaup	*Aythya affinis*	Dabbling Ducks
MALL	Mallard	*Anas platyrhynchos*	Dabbling Ducks
NOPI	Northern Pintail	*Anas acuta*	Dabbling Ducks
NSHO	Northern Shoveler	*Anas clypeata*	Dabbling Ducks
REDH	Redhead	*Aythya americana*	Dabbling Ducks
RNDU	Ring-necked Duck	*Aythya collaris*	Dabbling Ducks
UNDA	Unknown Dabbling Duck	-	Dabbling Ducks
UNSC	Unknown Scaup	-	Dabbling Ducks
UNTE	Unknown Teal	-	Dabbling Ducks
BLTE	Black Tern	*Chlidonias niger*	Surface Feeding Terns/Gulls
BHGU	Black-headed Gull	*Chroicocephalus ridibundus*	Surface Feeding Terns/Gulls
BOGU	Bonaparte's Gull	*Chroicocephalus philadelphia*	Surface Feeding Terns/Gulls

Species Code	Common Name	Latin Name	Foraging Mode Species Group
CAGU	California Gull	*Larus californicus*	Surface Feeding Terns/Gulls
FRGU	Franklin's Gull	*Leucophaeus pipixcan*	Surface Feeding Terns/Gulls
HEGU	Herring Gull	*Larus argentatus*	Surface Feeding Terns/Gulls
MEGU	Mew Gull	*Larus canus*	Surface Feeding Terns/Gulls
RBGU	Ring-billed Gull	*Larus delawarensis*	Surface Feeding Terns/Gulls
SAGU	Sabine's Gull	*Xema sabini*	Surface Feeding Terns/Gulls
ICGU	Thayer's Gull	*Larus glaucoides*	Surface Feeding Terns/Gulls
UNGU	Unknown Gull	-	Surface Feeding Terns/Gulls
CACG	Cackling Goose	*Branta hutchinsii*	Large Dabblers
CAGO	Canada Goose	*Branta canadensis*	Large Dabblers
GWFG	Greater White-fronted Goose	*Anser albifrons*	Large Dabblers
SNGO	Snow Goose	*Chen caerulescens*	Large Dabblers
TRUS	Trumpeter Swan	*Cygnus buccinator*	Large Dabblers
TUSW	Tundra Swan	*Cygnus columbianus*	Large Dabblers
UNSW	Unknown Swan	-	Large Dabblers
SORA	Sora	*Porzana carolina*	Marsh Birds
WISN	Wilson's Snipe	*Gallinago delicata*	Marsh Birds
YERA	Yellow Rail	*Coturnicops noveboracensis*	Marsh Birds
ARTE	Arctic Tern	*Sterna paradisaea*	Piscivorous Divers
BEKI	Belted Kingfisher	*Megaceryle alcyon*	Piscivorous Divers
COLO	Common Loon	*Gavia immer*	Piscivorous Divers
COME	Common Merganser	*Mergus merganser*	Piscivorous Divers
COTE	Common Tern	*Sterna hirundo*	Piscivorous Divers
EAGR	Eared Grebe	*Podiceps nigricollis*	Piscivorous Divers
HOME	Hooded Merganser	*Lophodytes cucullatus*	Piscivorous Divers
HOGR	Horned Grebe	*Podiceps auritus*	Piscivorous Divers
PBGR	Pied-billed Grebe	*Podilymbus podiceps*	Piscivorous Divers
RBME	Red-breasted Merganser	*Mergus serrator*	Piscivorous Divers
RNGR	Red-necked Grebe	*Podiceps grisegena*	Piscivorous Divers
UNGR	Unknown Grebe	-	Piscivorous Divers
UNLO	Unknown Loon	-	Piscivorous Divers
UNME	Unknown Merganser	-	Piscivorous Divers

Species Code	Common Name	Latin Name	Foraging Mode Species Group
UNKN TERN	Unknown Tern	-	Piscivorous Divers
WEGR	Western Grebe	*Aechmophorus occidentalis*	Piscivorous Divers
AMKE	American Kestrel	*Falco sparverius*	Raptors
BAEA	Bald Eagle	*Haliaeetus leucocephalus*	Raptors
COHA	Cooper's Hawk	*Accipiter cooperii*	Raptors
GOEA	Golden Eagle	*Aquila chrysaetos*	Raptors
MERL	Merlin	*Falco columbarius*	Raptors
NOHA	Northern Harrier	*Circus cyaneus*	Raptors
OSPR	Osprey	*Pandion haliaetus*	Raptors
RTHA	Red-tailed Hawk	*Buteo jamaicensis*	Raptors
RLHA	Rough-legged Hawk	*Buteo lagopus*	Raptors
SSHA	Sharp-shinned Hawk	*Accipiter striatus*	Raptors
UNAC	Unknown Accipiter	-	Raptors
UNHA	Unknown Hawk	-	Raptors
UNRA	Unknown Raptor	-	Raptors
GRYE	Greater Yellowlegs	*Tringa melanoleuca*	Shorebirds
KILL	Killdeer	*Charadrius vociferus*	Shorebirds
LESA	Least Sandpiper	*Calidris minutilla*	Shorebirds
LEYE	Lesser Yellowlegs	*Tringa flavipes*	Shorebirds
LBDO	Long-billed Dowitcher	*Limnodromus scolopaceus*	Shorebirds
RNPH	Red-necked Phalarope	*Phalaropus lobatus*	Shorebirds
SEPL	Semi-palmated Plover	*Charadrius semipalmatus*	Shorebirds
SESA	Semi-palmated Sandpiper	*Calidris pusilla*	Shorebirds
SOSA	Solitary Sandpiper	*Tringa solitaria*	Shorebirds
SPSA	Spotted Sandpiper	*Actitis macularius*	Shorebirds
UNSA	Unknown Sandpiper	-	Shorebirds
UNSH	Unknown Shorebird	-	Shorebirds
PEEP	Unknown small calidrid	*Calidris sp.*	Shorebirds
UNYE	Unknown Yellowlegs	-	Shorebirds
UNDI	Unknown Diving Bird	-	Unknown Waterbirds
UNDU	Unknown Duck	-	Unknown Waterbirds
UNKN	Unkown spp	-	Unknown Waterbirds

APPENDIX B

Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances from 2017 through 2020 (Table B-1 [2017, 2018, 2019, 2020] and B-2 [2020])

Table B-2: Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances in 2020

Foraging Guild	English Name	Scientific Name	River Boat Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland Transect Abundance [c]
Benthic Feeding Divers			**472**	**191**	**0**
	Common Goldeneye	*Bucephala clangula*	348	36	0
	Surf Scoter	*Melanitta perspicillata*	37	21	0
	Goldeneye sp.	*Bucephala sp.*	57	5	0
	Bufflehead	*Bucephala albeola*	25	107	0
	Barrow's Goldeneye	*Bucephala islandica*	4	12	0
	White-winged Scoter	*Melanitta fusca*	0	7	0
	Benthic Feeding Diver sp.	*n/a*	1	3	0
Dabbling Ducks			**1,416**	**1,195**	**23**
	Mallard	*Anas platyrhynchos*	865	138	1
	Green-winged Teal	*Anas crecca*	47	64	0
	Dabbling Duck sp.	*n/a*	124	453	5
	American Wigeon	*Mareca americana*	200	52	7
	Scaup sp.	*n/a*	2	148	0
	Ring-necked Duck	*Aythya collaris*	22	118	0
	Northern Shoveler	*Spatula clypeata*	16	72	5
	Northern Pintail	*Anas acuta*	126	17	0
	Teal sp.	*n/a*	10	0	0
	Blue-winged Teal	*Spatula discors*	0	49	1
	Lesser Scaup	*Aythya affinis*	2	77	0
	Gadwall	*Mareca strepera*	0	2	0
	Redhead	*Aythya americana*	1	0	0
	Cinnamon Teal	*Spatula cyanoptera*	0	0	2
	American Coot	*Fulica americana*	1	5	2
Gulls			**2,234**	**44**	**0**
	Franklin's Gull	*Leucophaeus pipixcan*	1,699	0	0
	Ring-billed Gull	*Larus delawarensis*	274	0	0
	Bonaparte's Gull	*Chroicocephalus philadelphia*	46	18	0
	Gull sp.	*n/a*	194	6	0
	Herring Gull	*Larus argentatus*	20	0	0
	California Gull	*Larus californicus*	1	0	0
	Black Tern	*Chlidonias niger*	0	20	0
Large Dabblers			**7,462**	**46**	**1**
	Canada Goose [d]	*Branta canadensis*	7,305	17	1
	Trumpeter Swan [d]	*Cygnus buccinator*	102	29	0
	Large Dabbler sp.	*n/a*	55	0	0
Marsh Birds			**0**	**13**	**58**
	Sora	*Porzana carolina*	0	10	18
	Wilson's Snipe	*Gallinago delicata*	0	3	37
	Yellow Rail	*Coturnicops noveboracensis*	0	0	3

Table B-2: Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances in 2020

Foraging Guild	English Name	Scientific Name	River Boat Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland Transect Abundance [c]
Piscivorous Divers			**1,177**	**117**	**2**
	Common Merganser	*Mergus merganser*	1,150	0	0
	Belted Kingfisher	*Megaceryle alcyon*	4	0	0
	Merganser sp.	*n/a*	2	0	0
	Red-necked Grebe	*Podiceps grisegena*	0	9	0
	Common Loon	*Gavia immer*	3	25	0
	Red-breasted Merganser	*Mergus serrator*	1	0	0
	Pied-billed Grebe	*Podilymbus podiceps*	0	3	2
	Horned Grebe	*Podiceps auritus*	0	26	0
	Hooded Merganser	*Lophodytes cucullatus*	13	0	0
	Loon sp.	*n/a*	1	0	0
	Grebe sp.	*n/a*	0	1	0
	Eared Grebe	*Podiceps nigricollis*	0	53	0
	Piscivorous Diver sp.	*n/a*	3	0	0
Shorebirds			**117**	**22**	**11**
	Spotted Sandpiper	*Actitis macularius*	114	1	0
	Greater Yellowlegs	*Tringa melanoleuca*	0	1	0
	Lesser Yellowlegs	*Tringa flavipes*	0	8	7
	Killdeer	*Charadrius vociferus*	1	0	0
	Shorebird sp.	*n/a*	1	2	0
	Solitary Sandpiper	*Tringa solitaria*	1	10	4
Unknown Waterbirds			**162**	**32**	**0**
	Duck sp.	*n/a*	151	32	0
	Unknown sp.	*n/a*	10	0	0
	Diving Bird sp.	*n/a*	1	0	0
Grand Total			**13,040**	**1,660**	**95**

Notes:

[a] - Includes flying records as birds were often flushed to flight in front of boat. Includes all habitat types, all treatment areas, and data from incomplete surveys.

[b] - Excludes flying records. Includes records of birds observed in open water and sedge habitat.

[c] - Excludes flying records. Includes records on waterbirds observed in sedge, and willow sedge habitat.

[d] - Trumpeter swans and Canada geese, include a small proportion (<5%) of tundra swans and cackling geese, respectively.

Table B-1: Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances from 2017, 2018, 2019, and 2020

Foraging Guild	English Name	Scientific Name	River Boat Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland Transect Abundance [c]
Benthic Feeding Divers			**2,263**	**1,039**	**1**
	American Dipper	*Cinclus mexicanus*	1	0	0
	Barrow's Goldeneye	*Bucephala islandica*	128	24	0
	Benthic Feeding Diver sp.	*n/a*	1	3	0
	Bufflehead	*Bucephala albeola*	182	663	1
	Common Goldeneye	*Bucephala clangula*	1,522	175	0
	Goldeneye sp.	*Bucephala sp.*	214	30	0
	Harlequin Duck	*Histrionicus histrionicus*	3	0	0
	Long-tailed Duck	*Clangula hyemalis*	1	22	0
	Ruddy Duck	*Oxyura jamaicensis*	5	28	0
	Scoter sp.	*Melanita sp.*	2	0	0
	Surf Scoter	*Melanitta perspicillata*	194	86	0
	White-winged Scoter	*Melanitta fusca*	10	8	0
Cranes and Herons			**56**	**0**	**0**
	Great Blue Heron	*Ardea herodias*	1	0	0
	Sandhill Crane	*Antigone canadensis*	55	0	0
Dabbling Ducks			**12,355**	**3,436**	**145**
	American Coot	*Fulica americana*	58	57	7
	American Wigeon	*Mareca americana*	1,267	294	7
	Blue-winged Teal	*Spatula discors*	439	244	17
	Canvasback	*Aythya valisineria*	15	106	0
	Cinnamon Teal	*Spatula cyanoptera*	2	0	2
	Dabbling Duck sp.	*n/a*	124	453	5
	Gadwall	*Mareca strepera*	30	12	0
	Greater Scaup	*Aythya marila*	28	41	0
	Green-winged Teal	*Anas crecca*	1,512	354	19
	Lesser Scaup	*Aythya affinis*	42	186	0
	Mallard	*Anas platyrhynchos*	7,447	437	27
	Northern Pintail	*Anas acuta*	883	60	4
	Northern Shoveler	*Spatula clypeata*	171	192	57
	Redhead	*Aythya americana*	7	4	0
	Ring-necked Duck	*Aythya collaris*	37	522	0
	Scaup sp.	*Aythya sp.*	137	458	0
	Teal sp.	*n/a*	156	16	0

Table B-1: Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances from 2017, 2018, 2019, and 2020

Foraging Guild	English Name	Scientific Name	River Boat Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland Transect Abundance [c]
Gulls and Surface Feeding Terns			**13,643**	**191**	**0**
	Black Tern	*Chlidonias niger*	0	20	0
	Bonaparte's Gull	*Chroicocephalus philadelphia*	5,161	158	0
	California Gull	*Larus californicus*	29	0	0
	Franklin's Gull	*Leucophaeus pipixcan*	4,891	1	0
	Gull sp.	*n/a*	947	6	0
	Herring Gull	*Larus argentatus*	187	0	0
	Mew Gull	*Larus canus*	324	6	0
	Ring-billed Gull	*Larus delawarensis*	2,097	0	0
	Sabine's Gull	*Xema sabini*	1	0	0
	Thayer's Gull	*Larus glaucoides*	6	0	0
Large Dabblers			**27,353**	**217**	**4**
	Cackling Goose	*Branta hutchinsii*	24	0	0
	Canada Goose [d]	*Branta canadensis*	26,851	74	2
	Greater White-fronted Goose	*Anser albifrons*	11	0	0
	Snow Goose	*Anser caerulescens*	1	0	0
	Swan sp.	*Cygnus sp.*	119	6	0
	Trumpeter Swan [d]	*Cygnus buccinator*	289	137	2
	Tundra Swan	*Cygnus columbianus*	3	0	0
	Large Dabbler sp.	*n/a*	55	0	0
Marsh Birds			**0**	**51**	**112**
	Sora	*Porzana carolina*	0	39	52
	Wilson's Snipe	*Gallinago delicata*	0	12	57
	Yellow Rail	*Coturnicops noveboracensis*	0	0	3
Piscivorous Divers			**3,414**	**390**	**2**
	Arctic Tern	*Sterna paradisaea*	2	0	0
	Belted Kingfisher	*Megaceryle alcyon*	88	5	0
	Common Loon	*Gavia immer*	24	105	0
	Common Merganser	*Mergus merganser*	3,195	26	0
	Common Tern	*Sterna hirundo*	3	0	0
	Eared Grebe	*Podiceps nigricollis*	6	77	0
	Grebe sp.	*n/a*	2	7	0
	Hooded Merganser	*Lophodytes cucullatus*	23	16	0
	Horned Grebe	*Podiceps auritus*	2	54	0
	Loon sp.	*n/a*	5	0	0
	Merganser sp.	*n/a*	18	0	0
	Pied-billed Grebe	*Podilymbus podiceps*	0	17	2
	Red-breasted Merganser	*Mergus serrator*	9	6	0
	Red-necked Grebe	*Podiceps grisegena*	32	71	0
	Tern sp.	*n/a*	1	0	0
	Western Grebe	*Aechmophorus occidentalis*	1	6	0
	Piscivorous Diver sp.	*n/a*	3	0	0

Table B-1: Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances from 2017, 2018, 2019, and 2020

Foraging Guild	English Name	Scientific Name	River Boat Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland Transect Abundance [c]
Shorebirds			**1,928**	**189**	**50**
	Greater Yellowlegs	*Tringa melanoleuca*	3	12	3
	Killdeer	*Charadrius vociferus*	24	1	0
	Least Sandpiper	*Calidris minutilla*	15	0	0
	Lesser Yellowlegs	*Tringa flavipes*	17	36	11
	Long-billed Dowitcher	*Limnodromus scolopaceus*	2	0	0
	Pectoral Sandpiper	*Calidris melanotos*	0	65	0
	Peep Sp.	*Calidris sp.*	34	0	0
	Red-necked Phalarope	*Phalaropus lobatus*	11	0	0
	Sandpiper sp.	*n/a*	20	6	0
	Semi-palmated Plover	*Charadrius semipalmatus*	11	0	0
	Semi-palmated Sandpiper	*Calidris pusilla*	117	0	0
	Shorebird sp.	*n/a*	59	1	0
	Solitary Sandpiper	*Tringa solitaria*	14	30	8
	Spotted Sandpiper	*Actitis macularius*	1,600	38	28
	Yellowlegs sp.	*Tringa sp.*	1	0	0
Unknown Waterbirds			**2,099**	**887**	**0**
	Diving Bird sp.	*n/a*	14	0	0
	Duck sp.	*n/a*	1,801	844	0
	Unknown sp.	*n/a*	284	43	0
Grand Total			**63,111**	**6,400**	**314**

Notes:

[a] - Includes flying records as birds were often flushed to flight in front of boat. Includes all habitat types, all treatment areas, and data from incomplete surveys.

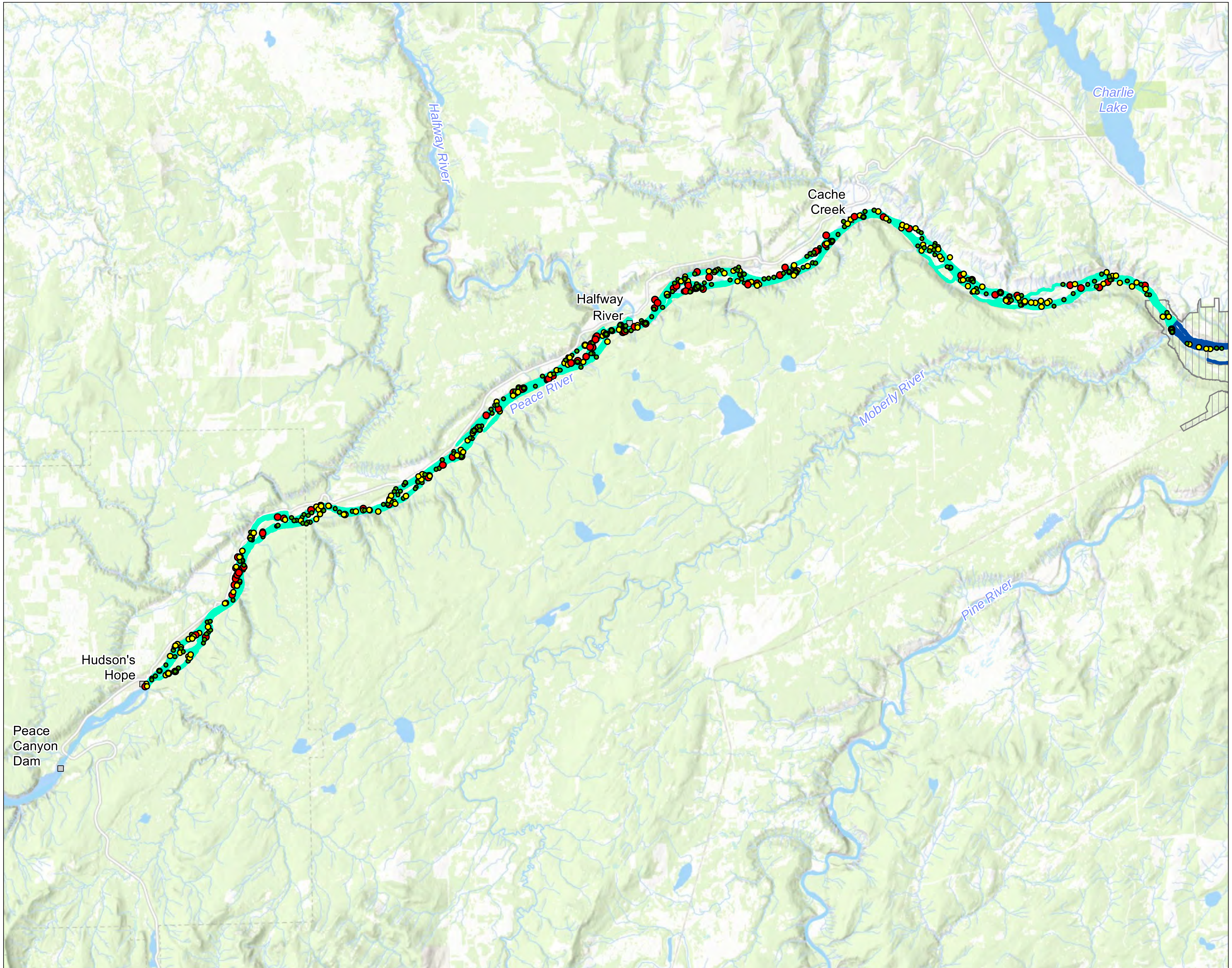
[b] - Excludes flying records. Includes records of birds observed in open water and sedge habitat.

[c] - Excludes flying records. Includes records of waterbirds observed in sedge, and willow sedge habitat.

[d] - Trumpeter swans and Canada geese, include a small proportion (<5%) of tundra swans and cackling geese, respectively.

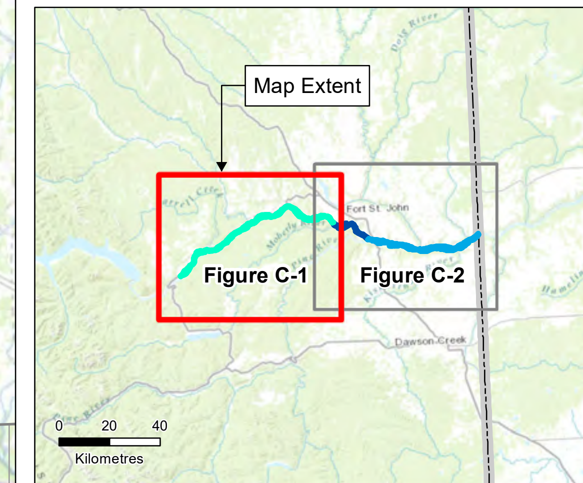
APPENDIX C

Spatial Representation of Waterbird Observations within the Peace River Study Area in Spring and Fall 2020 (Figures C-1 to C-4)



Migratory Waterbird Follow-up Monitoring Program
2020 Report
Site C, Peace River, BC

Waterbirds Recorded within Inundation Impact Area Spring 2020



Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Number of Bird Observations

- 1 - 2 birds
- 3 - 9 birds
- 10 or more birds

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Base

N

1:220,000

0 2 4 6 8 10
Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

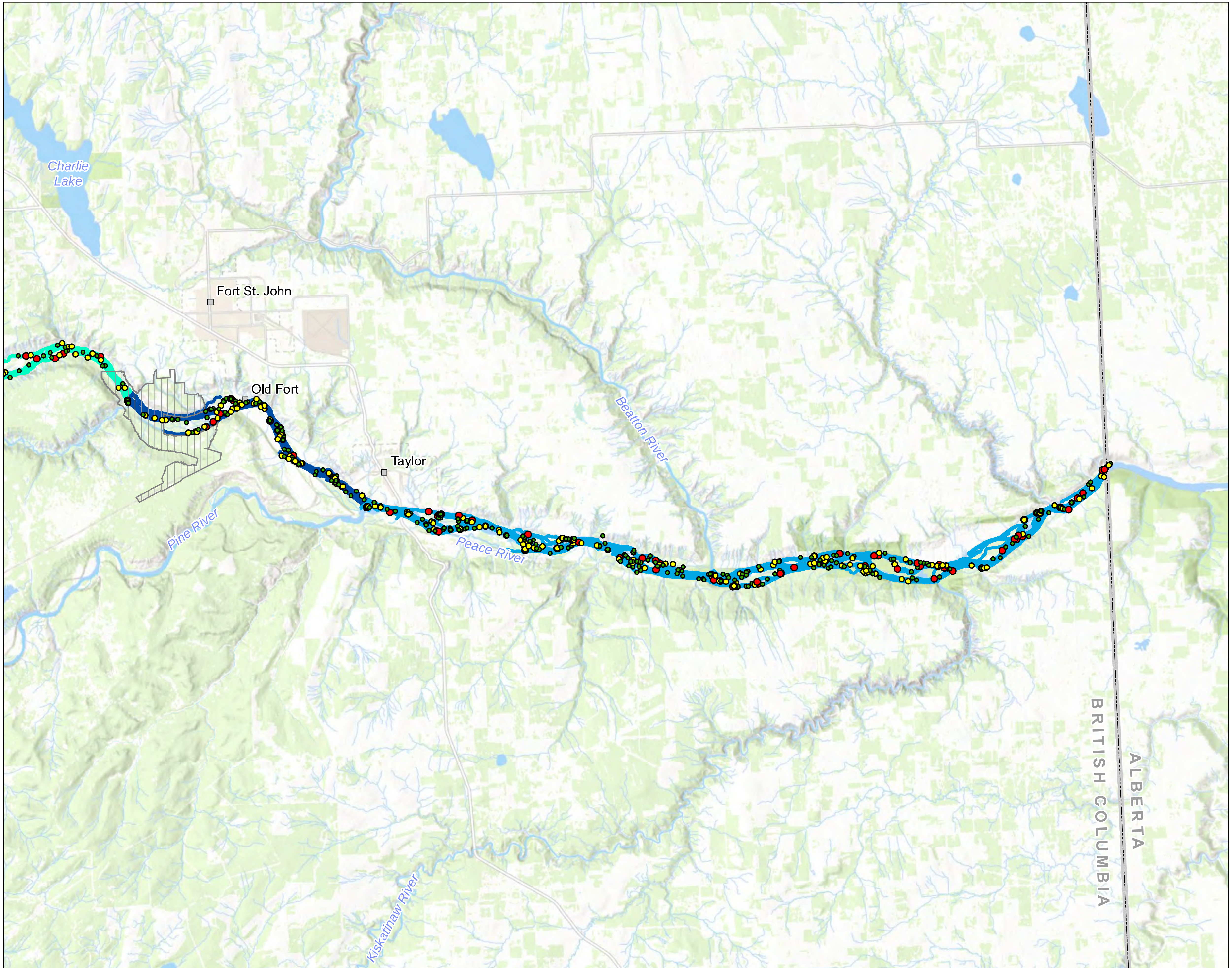
989619-07	Production Date: Dec 18, 2020	Figure C-1

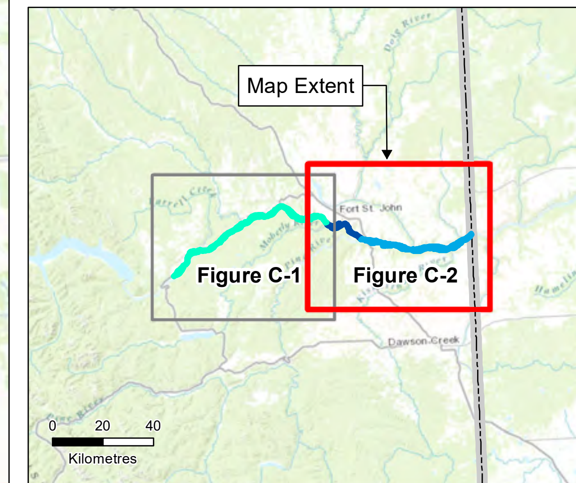
Hemmera An Ausenco Company

BC hydro

Migratory Waterbird Follow-up Monitoring Program
2020 Report
Site C, Peace River, BC

Waterbirds Recorded within Flow Regime Impact Area and Control Area Spring 2020





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Number of Bird Observations

- 1 - 2 birds
- 3 - 9 birds
- 10 or more birds

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Base

N

1:220,000

0 2 4 6 8 10
Kilometres

NAD 1983 UTM Zone 10N

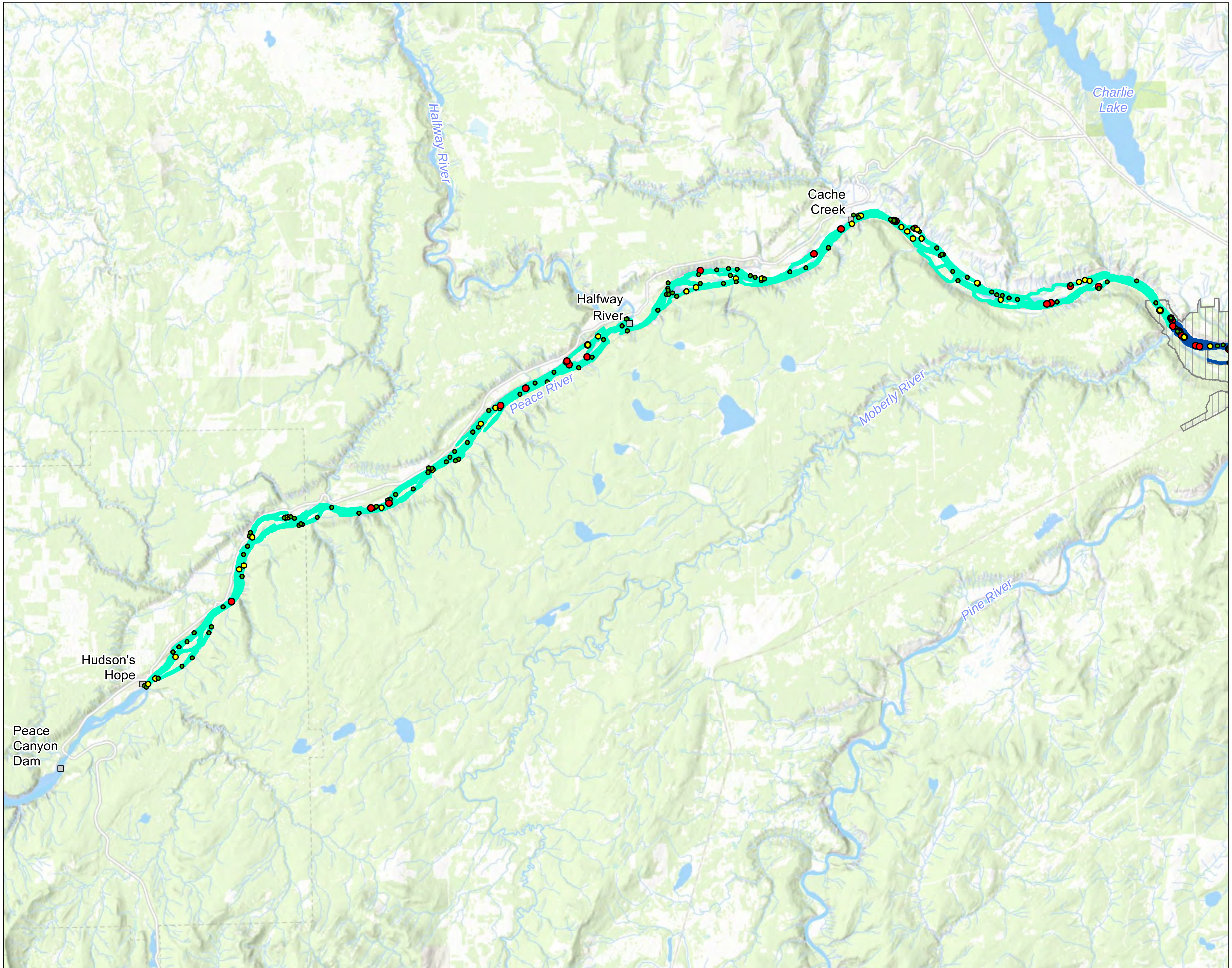
Page Size: 11" x 17"

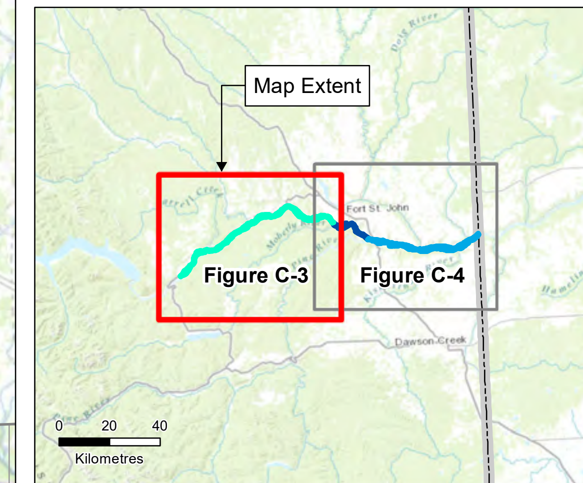
989619-07	Production Date: Dec 18, 2020	Figure C-2

Hemmera
An Ausenco Company
BC hydro

Migratory Waterbird Follow-up Monitoring Program
2020 Report
Site C, Peace River, BC

Waterbirds Recorded within Inundation Impact Area Fall 2020





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Number of Bird Observations

- 1 - 2 birds
- 3 - 9 birds
- 10 or more birds

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a “stand-alone” document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Base

N

1:220,000

0 2 4 6 8 10

Kilometres

NAD 1983 UTM Zone 10N

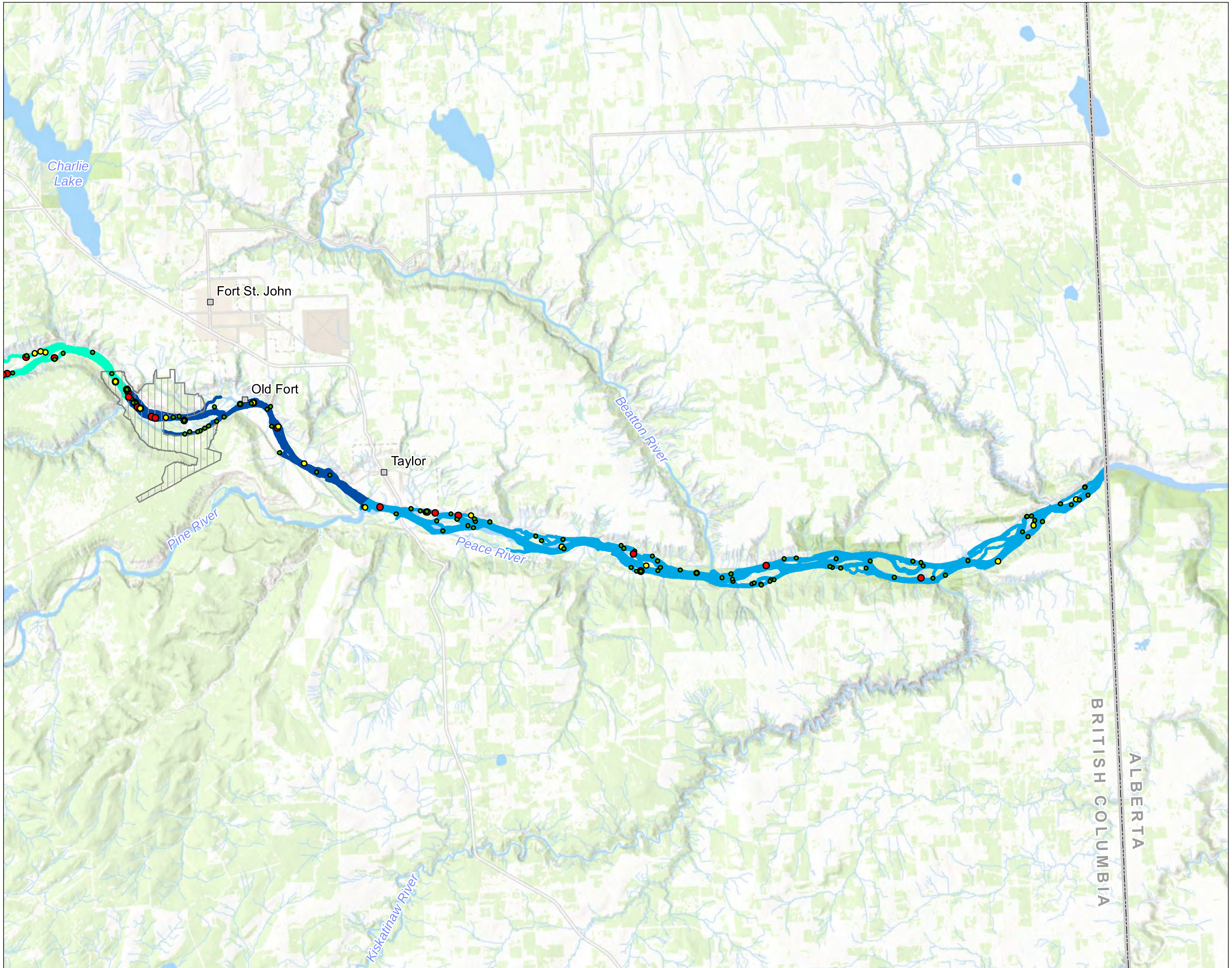
Page Size: 11" x 17"

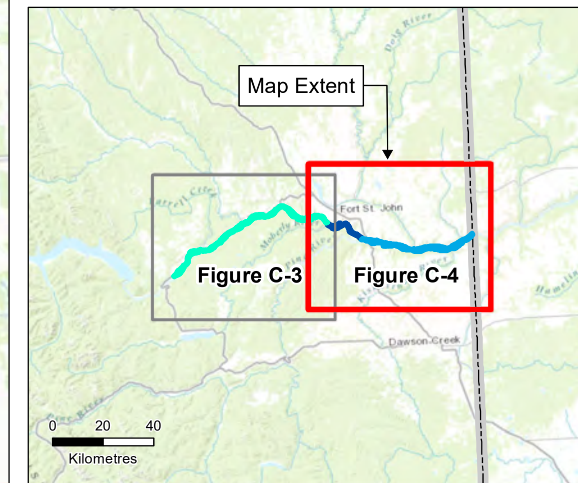
989619-07	Production Date: Dec 18, 2020	Figure C-3

Hemmera An Ausenco Company
BC hydro

Migratory Waterbird Follow-up Monitoring Program
2020 Report
Site C, Peace River, BC

Waterbirds Recorded within Flow Regime Impact Area and Control Area Fall 2020





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Number of Bird Observations

- 1 - 2 birds
- 3 - 9 birds
- 10 or more birds

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Base

N

1:220,000

0 2 4 6 8 10
Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-07	Production Date: Dec 18, 2020	Figure C-4

Hemmera An Ausenco Company

BC hydro

APPENDIX D
Wetland Survey Station Photos

Photo 1 Aerial Photograph of Wetland Survey Station OW01 (September 9, 2018)

Photo 2 Aerial Photograph of Wetland Survey Station OW02 (September 18, 2018)

Photo 3 Aerial Photograph of Wetland Survey Station SE03 (lower left) and OW04 (upper right; August 22, 2019)

Photo 4 Aerial Photograph of Wetland Survey Station OW06 (October 17, 2018)

Photo 5 Aerial Photograph of Wetland Survey Station OW07 (August 22, 2019)

Photo 6 Photograph of Wetland Survey Station OW09 (October 17, 2018) Showing Habitat Representative of the Wetland Area Surveyed

Photo 7 Aerial Photograph of Wetland Survey Station OW10 (August 22, 2019)

Photo 8 Aerial Photograph of Wetland Survey Station OW11 (August 22, 2019)

Photo 9 Aerial Photograph of Wetland Survey Station SE02 (August 22, 2019)

Photo 10 Aerial Photograph of Wetland Survey Station SE04 (August 22, 2019)

Photo 11 Aerial Photograph of Wetland Survey Station SE05 (August 6, 2018)

Photo 12 Aerial Photograph of Wetland Survey Station SE06 (August 12, 2019)

Photo 13 Aerial Photograph of Wetland Survey Station SE07 (August 22, 2019)

Photo 14 Aerial Photograph of Wetland Survey Station SE08 (August 22, 2019)

Photo 15 Aerial Photograph of Wetland Survey Station SE09 (August 7, 2018)

Photo 16 Aerial Photograph of Wetland Survey Station SE10 (August 22, 2019)

Photo 17 Aerial Photograph of Wetland Survey Station SE11 (August 6, 2018)

Photo 18 Aerial Photograph of Wetland Survey Station SE12 (August 12, 2019)

Photo 19 Aerial Photograph of Wetland Survey Station SE14 (August 6, 2018)

Photo 20 Aerial Photograph of Wetland Survey Station WS01 (August 6, 2018)

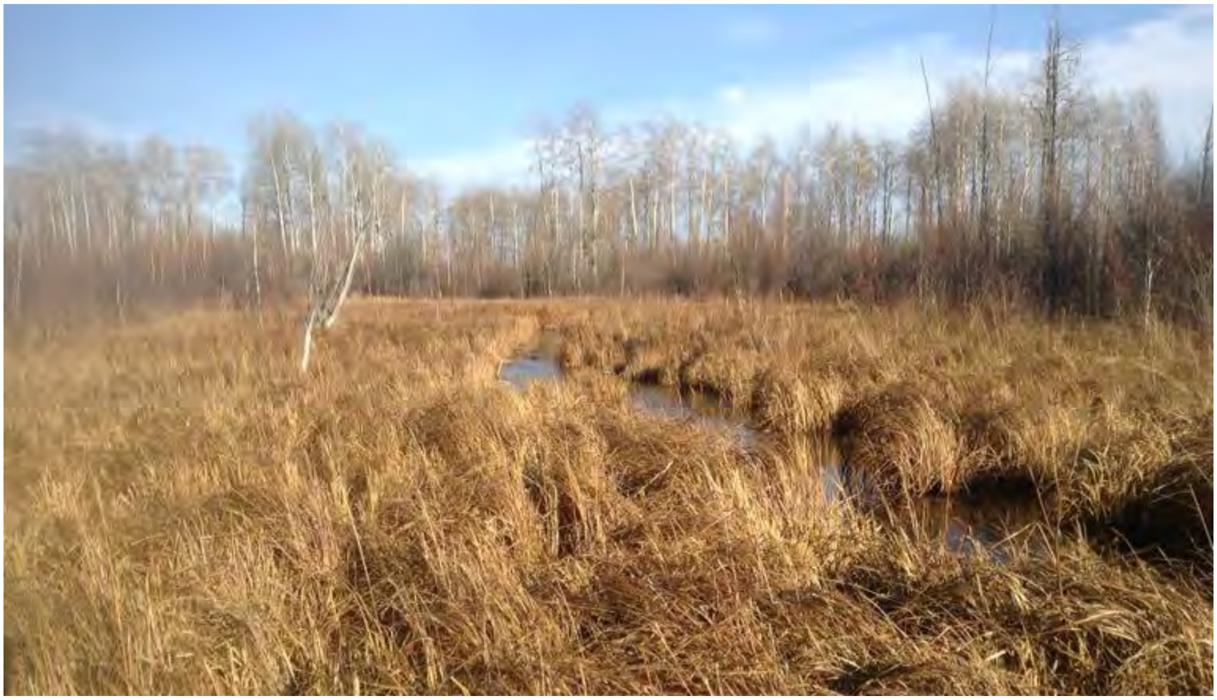


Photo 21 Photograph of Wetland Survey Station WS02 (October 17, 2018) Showing Habitat Representative of the Wetland Area Surveyed

Photo 22 Aerial Photograph of Wetland Survey Station WS03 (August 7, 2018)

Appendix 4. Wetland Monitoring 2020 Field Summary Report

Site C Clean Energy Project
Wetland Monitoring Program
2020 Annual Report

DATE: MARCH 2, 2021

PRESENTED TO:

BC Hydro
1111 West Georgia Street, 9^{th} floor
Vancouver, BC V6E 4G2

PRESENTED BY:

EcoLogic Consultants Ltd.
Unit 4 - 252 East 1st Street
North Vancouver, BC V7L 1B3
Phone: 604 803-7146

and

Tetra Tech Canada Incorporated
on behalf of Saulteau EBA Environmental
Services Joint Venture (SEES JV)
885 Dunsmuir Street, Suite 1000
Vancouver, BC V6C 1N5
Phone: 604 685-0275

EXECUTIVE SUMMARY

BC Hydro developed a Wetland Monitoring Program (the Program) for the Site C Clean Energy Project to address, in part, requirements outlined in the Federal Decision Statement (FDS) condition 11 and Environmental Assessment Certificate (EAC) condition 12:

- ***FDS condition 11.4.1****. Baseline data on the biogeochemical, hydrological and ecological functioning of the wetlands and associated riparian habitat in the area affected by the Designated Project, including: ground and surface water quality and quantity; vegetation cover; biotic structure and diversity; migratory bird abundance, density, diversity and use; species at risk abundance, density, diversity and use; and current use of the wetlands for traditional purposes by Aboriginal people, including the plant and wildlife species that support that use.*

- ***FDS condition 11.4.3****. An approach to monitor and evaluate any changes to baseline conditions, as defined in condition 11.4.1 and identify improvements based on monitoring data.*

- ***EAC condition 12****. The EAC Holder must monitor construction and operation activities that could cause changes in wetland functions.*

The Program consists of two components: baseline wetland monitoring, which is focused on gathering information on the physical, ecological, biogeochemical and hydrological conditions of wetlands prior to construction activities; and wetland monitoring during construction and operations, which is focused on gathering information to evaluate changes from baseline conditions due to Site C Project activities.

The 2020 field program included the first year of construction monitoring for wetlands that were initially sampled between 2016 and 2018. A total of 47 construction-phase wetlands were selected for 2020 based on the program sampling design of re-assessing (construction phase wetland monitoring) wetlands two years after the baseline data collection, and then every five years after that (Native Plant Solutions 2020). With the exception of two wetlands that could not be accessed in 2020, all wetlands assessed in 2021 and beyond will fall under construction-phase monitoring. By 2027, all wetlands in the monitoring program will have a two- and five-year monitoring assessment completed, which should allow for an analysis of change in wetland parameters.

A total of 40 wetlands were assessed in 2020, bringing the total number of wetlands in the monitoring program to 128. Data on the physical, ecological, biogeochemical and hydrological conditions collected at each of the 2020 wetlands are presented in this report.

TABLE OF CONTENTS

List of Figures

List of Tables

List of Plates

List of Appendices

1. INTRODUCTION

1.1 PROJECT CONDITIONS

BC Hydro developed a Baseline and Construction Phase Wetland Monitoring Program (Native Plant Solutions 2020) for the Site C Clean Energy Project (the Project) to address, in part, requirements outlined in the Federal Decision Statement (FDS) condition 11 and Environmental Assessment Certificate (EAC condition 12.

> ***FDS condition 11.4.1**. Baseline data on the biogeochemical, hydrological and ecological functioning of the wetlands and associated riparian habitat in the area affected by the Designated Project, including: ground and surface water quality and quantity; vegetation cover; biotic structure and diversity; migratory bird abundance, density, diversity and use; species at risk abundance, density, diversity and use; and current use of the wetlands for traditional purposes by Aboriginal people, including the plant and wildlife species that support that use.*
>
> ***FDS condition 11.4.3**. An approach to monitor and evaluate any changes to baseline conditions, as defined in condition 11.4.1 and identify improvements based on monitoring data.*
>
> ***EAC condition 12**. The EAC Holder must monitor construction and operation activities that could cause changes in wetland functions.*

1.2 PROJECT OVERVIEW

The Wetland Monitoring Program (the Program; Native Plant Solutions 2018) consists of two components:

1. Baseline wetland monitoring – gathers information (i.e., biogeochemical, hydrological and ecological) on wetlands prior to construction activities, including verification of ecosystem mapping and wetland condition.
2. Construction and operations wetland monitoring – gathers information at two- and five-year intervals after initiation of construction to evaluate changes from baseline conditions due to Project activities.

The Program is designed to allow for the following:

- collection of baseline data on the biogeochemical, hydrological, and ecological functioning of the wetlands and associated riparian habitat in the area affected by the Project;
- an evaluation of the change to baseline wetland conditions due to the Project;
- selection of mitigation measures for loss of wetland areas and functions, including reclamation, improvement, creation and protection (BC Hydro 2015); and

- flexibility in the monitoring program to allow for further refinement in the characterization of baseline and affected wetlands, as data become available.

This 2020 annual report focuses on the start of the construction monitoring phase of the Project, with all of the wetlands originally sampled under baseline conditions between 2016 and 2018. In 2016 and 2017, wetlands were sampled before the BC Hydro Site C Vegetation and Wildlife Wetland Monitoring Program: Baseline and Construction Phase Wetland Monitoring (Native Plant Solutions 2020) methodology was completed. To ensure a consistent dataset for future analyses, those wetlands were re-assessed during the 2020 field surveys using the full baseline methodology described by Native Plant Solutions (2020) applied to the existing data, instead of the construction phase monitoring methodology.

1.3 Study Area

The study area includes three distinct areas within the project activity zone (PAZ) and the downstream area of the dam site:

1. the reservoir footprint (the future inundation zone), which is composed of the Western Reservoir, Middle Reservoir, Eastern Reservoir, Lower Reservoir and the Dam Site Area;
2. the transmission line, separated into Phase A and Phase B; and
3. the downstream area.

2. METHODS

2.1 Site Selection

The 2020 field program included the first year of construction monitoring for wetlands that were initially sampled between 2016 and 2018. A total of 47 construction phase wetlands were selected for 2020 based on the program sampling design of re-assessing (construction phase wetland monitoring) wetlands two years after the baseline data collection, and then every five years after that (Native Plant Solutions 2020). The wetlands selected for 2020 consisted of five wetland types (Table 2.1-1), with 26 wetlands from 2016 and 2017, and 21 from 2018. All of the wetlands on the 2020 target list were located along the transmission line, primarily within the cleared corridor.

Table 2.1-1. Target Number and Type of Construction Phase Wetlands for 2020

Wetland Type	Code	2020 Target
Black spruce-Labrador tea-sphagnum	BT	4
Shallow open water	OW	4
Sedge wetland	SE	25
Tamarack sedge	TS	4
Willow sedge wetland	WS	10

2.2 Field Methodology

Field surveys were conducted to collect site-level information for site-level data categories (Table 2.2-1). The surveys use standardized methodologies to collect a wide range of physical and ecological characteristics of each wetland. Any observed changes or disturbances (such as vegetation removal, soil disturbance, dust deposition, and alterations to hydrology) were also described for each wetland using the condition assessment forms created by Native Plant Solutions (2020).

The following field data were collected through the 2020 field program:

- field plot data;
- spatial data of plot locations and wetland delineation;
- plot photographs;
- vegetation floristic quality index data;
- analytical data (laboratory analysis of water quality); and
- wetland condition assessments.

Comprehensive and detailed methods are provided in the BC Hydro Site C Wetland Monitoring Program Field Manual; Baseline and Construction Phase (Appendix D of Native Plant Solutions 2020). As wetlands sampled in 2016 and 2017 were completed before the development of the full baseline monitoring program, data were collected for them as per the Baseline Monitoring Phase (Native Plant Solutions 2020).

Table 2.2-1. Baseline and Construction Phase Wetland Monitoring Program: Data Categories and Parameters

Category	Parameter	Monitoring Phase [a]	Federal Condition 11.4.1
Site Information	Photo stations	B/C	–
	Site diagram	B/C	–
	Wetland ecosystem classification	B/C	–
Physical Parameters	Wetland delineation	B/C *	–
	Adjacent ecosystems	B/C *	–
	Slope position	B	–
Ecological Parameters	Cover type and percent open water	B/C	Biotic structure, biotic diversity
	Vegetation cover and communities present	B/C	Vegetation cover, biotic structure, biotic diversity
	Successional stage and structural stage	B/C	Biotic structure, biotic diversity
	Incidental wildlife observations	B/C	Biotic structure, biotic diversity
Biogeochemical Parameters	Water quality sampling	B/C *	Groundwater quality, surface water quality
	Soil profiles	B	–
Hydrological Parameters	*Hydrology*	B/C	–
	Water depth	B/C	Surface water quantity
	Inlets/outlets	B/C	–

[a] B = baseline field monitoring; C = construction phase monitoring;
* - reduced construction phase monitoring.
Italicized parameters indicate key parameters that will be used to define wetland types.
Source: Native Plant Solutions (NPS) 2020.

2.3 Ecosystem Classification and Mapping

The existing Site C ecosystem mapping for the PAZ includes three distinct but related products: Terrestrial Ecosystem Mapping (TEM); broad habitat mapping; and Detailed Wetland Mapping (DWM). The existing ecosystem classification and mapping is based on *A Field Guide for Identification and Interpretation of Ecosystems of the Northeast Portion of the Prince George Forest Region* (DeLong et al. 1990), *Wetlands of British Columbia* (MacKenzie and Moran 2004), and units created for the Project (2006 to 2012) by regional forest ecologists (Andrusiak and Simpson 2012).

In order to achieve the stated goals of the monitoring program and to satisfy the federal and provincial approval conditions for the Project, it is important that the wetland classification used is structured to accommodate the current (i.e., DeLong et al. 2011 and Mackenzie and Moran 2004) provincial classification. Therefore, Table 2.3-1 presents a crosswalk table that uses a “best fit” process to correlate existing PAZ ecosystem classification and current provincial classification system units. The crosswalk table was created by Tetra Tech and refined by EcoLogic for the 2018 wetland field program (Native Plant Solutions 2018). All DWM wetlands that contain 2020 sample plots were classified using the current Site Association descriptions to ensure a consistent mapping product.

Table 2.3-1. Crosswalk of Existing PAZ Ecosystem Classification and Current Provincial Ecosystem Mapping Codes

	Existing PAZ Ecosystem Units		Current Provincial Ecosystem Units	
Wetland Class	Wetland Type (Map Code)	Vegetation Community Description	Site Association	Vegetation Community Description
Bog	BT	Sb - Labrador tea – Sphagnum	Wb03	Black spruce - Lingonberry - Peat-moss
	BT	Assumed Wb05 included in BT	Wb05	Black spruce - Water sedge - Peat-moss
	TS	Tamarack - Sedge	Wb06	Tamarack - Water sedge - Fen moss
	BT	-	Wb08	Black spruce – Soft-leaved sedge – Peatmoss bog
	BT	-	Wb09	Black spruce – Common horsetail – Peat-moss
Fen	SE	Sedge Wetland	Wf00	Fen (unclassified)
	SE	Sedge Wetland	Wf01	Water sedge - Beaked sedge
	-	-	Wf02	Scrub birch- water sedge
Marsh	SE	Sedge Wetland	Wm00	Marsh (unclassified)
	SE	Sedge Wetland	Wm01	Beaked sedge - Water sedge
	SE	Sedge Wetland	Wm02	Swamp horsetail - Beaked Sedge
	SE	Sedge Wetland	Wm03	Awned sedge
	SE	Sedge Wetland	Wm04	Common spike-rush
	SE	Sedge Wetland	Wm05	Cattail
	SE	Sedge Wetland	Wm06	Great bulrush
	SE	Sedge Wetland	Wm15	Bluejoint – Beaked sedge
Swamp	-	-	Ws00	Swamp (unclassified)
	WS	Willow Sedge Wetland	Ws02	Mountain alder – Pink spirea – Sitka sedge
	WS	Willow Sedge Wetland	Ws03 (Ws14)	Bebb’s willow - Bluejoint
	WS	Willow Sedge Wetland	Ws04	Drummond's willow - Beaked sedge
	WS	Willow Sedge Wetland	Ws05	MacCalla's willow - Beaker sedge

Wetland Class	Existing PAZ Ecosystem Units		Current Provincial Ecosystem Units	
	Wetland Type (Map Code)	Vegetation Community Description	Site Association	Vegetation Community Description
	WS	Willow Sedge Wetland	Ws06	Sitka willow - Sitka sedge
	-	-	Ws07	Spruce - Common horsetail - Leafy moss
	-	-	Ws15	SwSb - Labrador tea - Glow moss
Open Water	OW	Shallow open water	OW	Shallow Open Water (unclassified)
Floodplain	WH	Willow – Horsetail – Sedge – Riparian Wetland	Fl00	Low bench floodplain (unclassified)
	WH	Willow – Horsetail – Sedge – Riparian Wetland	Fl03	Pacific willow – Red-osier dogwood – Horsetail
	WH	Willow – Horsetail – Sedge – Riparian Wetland	Fl06	Sandbar willow
	-	-	Fm00	Mid bench floodplain (unclassified)
	Fm02 (09)[1]	ActSw - Red-osier dogwood	Fm02 (112)	Cottonwood - Spruce - Red-osier dogwood

2.4 Floristic Quality Index

2.4.1 Introduction

To supplement the vegetation sampling methods outlined in Section 4.0 of the BC Hydro Site C Wetland Monitoring Program Field Manual, a vegetation monitoring technique was implemented that uses random sample plots to facilitate the calculation of the Floristic Quality Index (FQI) of wetlands. The FQI is a measurement of the quality of wetland vegetation communities and has been found to be a good indicator of plant conditions, habitat quality, and wetland health. The FQI was developed from a 2013 University of Alberta study titled the "Floristic Quality Assessment for Marshes in Alberta's Northern Prairie and Boreal Regions" (Wilson et al. 2013). Iterations of the FQI have been used as part of wetland monitoring protocols across Canada and the United States. FQI has been intensely researched and is now being used as an indicator across North America because it can be adapted to a region's unique vegetation assemblages (Washington 1984, Rooney and Rogers 2002, Bourdaghs et al. 2006).

Each wetland vegetation species identified within a wetland is assigned a coefficient of conservatism (CC) value; the CC value for each species is based on an average value between 0 and 10, and assigned by a group of expert botanists. The CC value is an indicator of a species' tolerance to disturbance and specificity to a particular habitat type (e.g.., species adapted to disturbed areas have a low CC values, whereas species with specific habitat requirements and not tolerant of disturbance have higher CC values). The CC

[1] Map codes do not exist for the floodplain site associations. The site series associated with the Fm02 changed from 09 to 112 in the updated field guide (DeLong et al. 2011).

values used to analyze the 2018 and 2020 wetland data were obtained from a list of CC values that had been compiled by the BC Wildlife Federation (2018). These CC values are wetland specific and were based on plant communities found in British Columbia east of the Cascade Mountains.

In general, the following categories and definitions are used for the CC values:

0 – non-native species and ruderal species growing on waste ground;

1–3 – species commonly found in a wide variety of conditions with a high tolerance to disturbance;

4–6 – species usually found within a specific plant community, but tolerant of moderate disturbance;

7–8 – species found in advanced stages of succession that tolerate minor disturbance; and

9–10 – species with very low tolerance to disturbance.

The following FQI equation was used to calculate an FQI score. The equation is unbiased by species richness and provides a measurement of wetland health:

$$\mathbf{FQI = Mean\ CC_N / 10\ (\sqrt{N} / \sqrt{S}) * 100}$$

Where:
CC_N = Coefficient of Conservation for all species
N = Number of native species
S = Total number of species

The FQI results for each wetland can then be compared across monitoring years to highlight consistencies or differences, and ultimately to identify trends in wetland health over time.

2.4.2 FQI Standards and Field Protocols

The following standards and field protocols were used for vegetation FQI sampling:

- The standard seven-letter code naming system established for British Columbia (BC MOE and MOF 2010) was used for recording observed species. Naming conventions used for vegetation species were from the British Columbia Species and Ecosystem Explorer (B.C. CDC 2020).
- Floristic Quality Index plots were established and surveyed within each monitoring wetland. Three pairs of quadrats (six quadrats in total) were deployed randomly throughout each wetland. A power analysis conducted as part of the study by Wilson et al. (2013) showed that six quadrats were sufficient to detect differences in species richness between monitored wetlands within the same type or class.
- Each wetland is broadly divided into thirds and one pair of quadrats is established within each of the three sampling areas. The quadrats are tossed in a randomly selected cardinal direction to add randomness to the location;
- Quadrat pairs were positioned directly beside each other.

- Each quadrat measures one square metre. Quadrats were measured in the field with a square PVC tube quadrat measuring 1 meter in length and width.
- Quadrat data were recorded on standard FQI field sheets using the standard naming convention established for the Wetland Monitoring Program.
- Within each of the quadrats, all herbaceous, shrub, and tree species and their percent cover were recorded. Percent cover estimations included overlapping vegetation and therefore the total percent cover could be greater than 100%. For example, if an overhead shrub species covered 100% of the quadrat, the percent cover of herbaceous species present in the understory would still be recorded.
- Percent cover of live vegetation was estimated for each species present using the recording increment vegetation cover method shown in Table 2.3-2 and from the comparison charts for estimation of foliage cover from the 2010 Field Manual for Describing Terrestrial Ecosystems (BC MOE and MOF 2010).
- Photos of each quadrat were taken as part of sampling to further document the wetland vegetation community being monitored. Photos were taken using the Solocator Application for iPhones, which records the cardinal direction and the UTM location of the photo.

Table 2.3-2. Increments used for Recording Vegetation Cover for the Wetland FQI Quadrats as Adapted from the Ecological Land Survey Site Description Manual (ASRD 2003)

Cover Range	Recording Increment (%)	Examples (%)
A single plant	Exactly 0.1	0.1
Several plants	Exactly 0.5	0.5
1 – 10 %	To the nearest 1	1, 2, 3, 5, 8
10 – 30%	To the nearest 5	10, 15, 25
30 – 100%	To the nearest 10	30, 40, 50, 60, 70, 80, 90

The wetland indicator status for each species was obtained from the United States Department of Agriculture (USDA 2020) Natural Resource Conservation Service Plants Database and is described below in Table 2.3-3. When available, the Alaska wetland region was used. In the event that the Alaska status was not provided, the wetland status for the Great Plains region was used as a substitute.

Table 2.3-3. Wetland Indicator Status Codes and Descriptions[1]

Indicator Code	Indicator Status	Description
OBL	Obligate Wetland	Almost always occur in wetlands
FACW	Facultative Wetland	Usually occur in wetlands, but may occur in non-wetlands
FAC	Facultative	Occur in wetlands and non-wetlands
FACU	Facultative Upland	Usually occur in non-wetlands, but may occur in wetlands
UPL	Obligate Upland	Almost never occur in wetlands

[1] Adapted from USDA Natural Resource Conservation Service Plants Database (USDA NRCS 2020).

3. RESULTS

3.1 Summary of 2020 Field Survey Effort

Field surveys were completed from July 21 to August 1, 2020, along the transmission line. A total of 40 of the 47 targeted wetlands were sampled (Tables 3.1-1 and 3.1-2; Figure 3.1-1).

Table 3.1-1. Wetlands Targeted and Actual Wetlands Assessed in 2020

Wetland Type	Code	2020 Target	Sampled in 2020
Black spruce-Labrador tea-sphagnum	BT	4	4
Shallow open water	OW	4	2
Sedge wetland*	SE	25	20
Tamarack sedge	TS	4	4
Willow sedge wetland	WS	10	10
Total		**47**	**40**

*Includes marsh and fen site associations.

Table 3.1-2. Summary of Wetlands Sampled in 2020

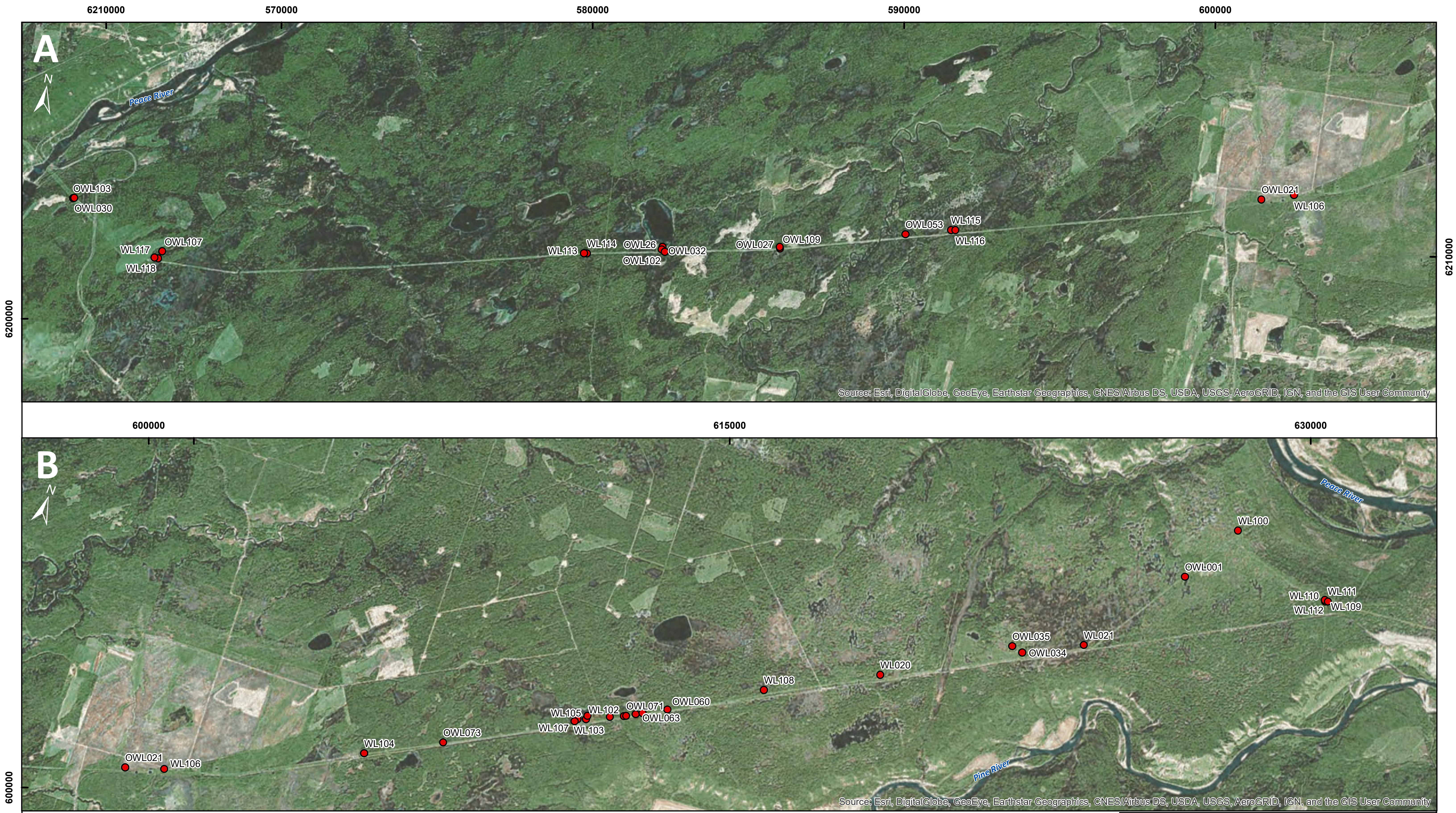
Plot ID	Wetland Class	Site Association	Wetland Type	Previous Sample Date(s)	Sampled in 2020
OWL001	Shallow Open Water	OW	OW	2016	y
OWL011	*	*	SE	2016	n
OWL021	Marsh	Wm00	SE	2016	y
OWL026	Marsh	Wm03	SE	2016	y
OWL027	Marsh	Wm01	SE	2016	y
OWL030	Swamp	Ws00	WS	2016	y
OWL031	*	*	OW	2016	n
OWL032	Swamp	Ws05	WS	2016	y
OWL034	Fen	Wf01	SE	2016	y
OWL035	Bog	Wb09	BT	2016	y
OWL053	Swamp	Ws00	WS	2016	y
OWL060	Marsh	Wm03	SE	2016	y
OWL061	*	*	SE	2016	n
OWL063	Marsh	Wm03	SE	2016	y
OWL066	*	*	SE	2016	n
OWL067	Marsh	Wm03	SE	2016	y

Plot ID	Wetland Class	Site Association	Wetland Type	Previous Sample Date(s)	Sampled in 2020
OWL068	*	*	SE	2016	n
OWL070	Marsh	Wm03	SE	2016	y
OWL071	Marsh	Wm03	SE	2016	y
OWL073	Marsh	Wm01	SE	2016	y
OWL102	Swamp	Ws05	WS	2017	y
OWL103	Shallow Open Water	OW	OW	2017	y
OWL104	*	*	WS	2017	n
OWL107	Swamp	Ws07	WS	2017	y
OWL109	Bog	Wb05	BT	2017	y
OWL110	Shallow Open Water	OW	OW	2017	n
WL020	Bog	Wb06	TS	2016, 2018	y
WL021	Fen	Wf02	SE	2016, 2018	y
WL100	Swamp	Ws03	WS	2018	y
WL101	Marsh	Wm01	SE	2016, 2018	y
WL102	Fen	Wf02	SE	2016, 2018	y
WL103	Marsh	Wm01	SE	2016, 2018	y
WL104	Marsh	Wm01	SE	2016, 2018	y
WL105	Marsh	Wm02	SE	2016, 2018	y
WL106	Swamp	Ws14	WS	2016, 2018	y
WL107	Swamp	Ws04	WS	2018	y
WL108	Swamp	Ws14	WS	2016, 2018	y
WL109	Marsh	Wm05	SE	2018	y
WL110	Marsh	Wm03	SE	2018	y
WL111	Marsh	Wm01	SE	2018	y
WL112	Marsh	Wm05	SE	2018	y
WL113	Bog	Wb06	TS	2018	y
WL114	Bog	Wb05	BT	2018	y
WL115	Bog	Wb06	TS	2016, 2018	y
WL116	Bog	Wb06	TS	2016, 2018	y
WL117	Swamp	Ws07	WS	2017, 2018	y
WL118	Bog	Wb03	BT	2016, 2018	y

*As these wetlands were not surveyed in 2020, the wetland class and site association classification for them is unknown.

Seven targeted wetlands were not assessed in 2020:

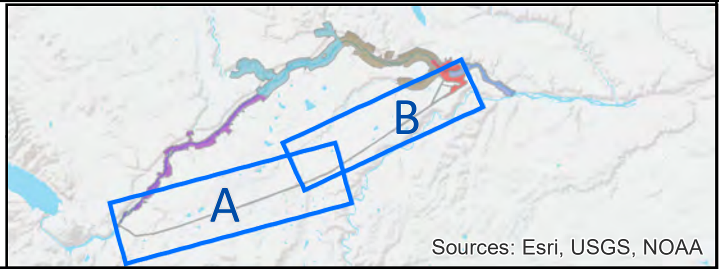
- OWL011 and OWL061 were not accessible at the time of the survey. These two sites will be added to the 2021 sample plan.
- OWL031 and OWL103 were combined by beavers into one wetland since the baseline assessment. The two sites were assessed as a single wetland (OWL103) in 2020 and are expected to be a single wetland for future sampling.
- OWL066 is contained within the newer 2019 MWL69 wetland boundary. It will be assessed as MWL69 in the future.
- OWL068 was determined to be not a wetland and will be removed from the monitoring program. This site was originally sampled in 2016 and mapped as an SE wetland. An assessment of soils and vegetation during the 2020 field survey indicated that OWL068 was incorrectly classified as a wetland in 2016.
- OWL104 is contained within the newer 2018 WL117. It will be assessed as WL117 in the future.
- OWL110 could not be safely accessed across the floating bog. It was previously sampled during the winter of 2017 when the bog was frozen, allowing access to the site. This site will be removed from the monitoring program.



Site C Project
Location of 2020 Sample Sites
Figure 3.1-1

Legend
● 2020 Wetland Sample Sites

0 2 4 6 8
km
1:110,000



Date: 2021-01-13
Map Number: BCHWL-27
Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983

ECOLOGIC
environmental consulting

3.2 Ecosystem Classification and Mapping

Based on the results of the 2020 field season, 22 wetlands were determined to belong to a different classification than identified in the DWM (Table 3.2-1). The 2020 field season resulted in numerous changes to wetland type classifications because many of the DWM polygons had not been ground-truthed. DWM wetlands mapped as Field Truthing Required (FTR) have not previously been classified. Several sample locations are located in wetlands that were not captured in the DWM (indicated as Not Mapped in Table 3.2-1). The data collected is being used to refine the TEM wetland classification and delineation throughout the PAZ.

Table 3.2-1. Summary of Ecosystem Classification and Mapping Changes

Plot ID	DWM Wetland Type(s)	2020 Site Association	2020 Wetland Type	2020 Wetland Type Change
OWL001	OW	OW	OW	No
OWL021	SE	Wm00	SE	No
OWL026	SE	Wm03	SE	No
OWL027	SE	Wm01	SE	No
OWL030	TS	Ws00	WS	Yes
OWL032	TS	Ws05	WS	Yes
OWL034	TS	Wf01	SE	Yes
OWL035	Not Mapped	Wb09	BT	NA
OWL053	FTR	Ws00	WS	Yes
OWL060	Not Mapped	Wm03	SE	NA
OWL063	FTR	Wm03	SE	Yes
OWL067	Not Mapped	Wm03	SE	NA
OWL070	FTR	Wm03	SE	Yes
OWL071	FTR	Wm03	SE	Yes
OWL073	FTR	Wm01	SE	Yes
OWL102	FTR	Ws05	WS	Yes
OWL103	TS	OW	OW	Yes
OWL107	WS	Ws07	WS	No
OWL109	TS	Wb05	BT	Yes
OWL110	OW	OW	OW*	No
WL020	TS	Wb06	TS	No
WL021	SE	Wf02	SE	No
WL100	TS	Ws03	WS	Yes

Plot ID	DWM Wetland Type(s)	2020 Site Association	2020 Wetland Type	2020 Wetland Type Change
WL101	SE	Wm01	SE	No
WL102	SE	Wf02	SE	No
WL103	FTR	Wm01	SE	Yes
WL104	SE	Wm01	SE	No
WL105	SE	Wm02	SE	No
WL106	Not Mapped	Ws14	WS	NA
WL107	Not Mapped	Ws04	WS	NA
WL108	FTR	Ws14	WS	Yes
WL109	FTR	Wm05	SE	Yes
WL110	FTR	Wm03	SE	Yes
WL111	FTR	Wm01	SE	Yes
WL112	FTR	Wm05	SE	Yes
WL113	WS	Wb06	TS	Yes
WL114	BT	Wb05	BT	No
WL115	TS	Wb06	TS	No
WL116	BT	Wb06	TS	Yes
WL117	TS	Ws07	WS	Yes
WL118	TS/SE	Wb03	BT	Yes

**Visual assessment only. Not sampled due to unsafe access.*

3.3 Wetland Summaries

3.3.1 Bog Overview

Eight bogs were sampled in 2020, comprising two wetlands types (BT and TS) and four site associations (Table 3.3-1). All but one of the bogs have been modified by one or more of the transmission lines (existing transmission line or the new Project transmission lines), with conditions including recent clearing of all tall shrubs and trees (Plate 3.3-1), regenerating conifer shrubs (Plate 3.3-2), or a mix of herbaceous vegetation and seral shrub species after clearing and grubbing (Plate 3.3-3 and Plate 3.3-4). Appendix A contains descriptions of the structural stage and successional status used in Table 3.3-1.

Table 3.3-1. Summary of Bogs Sampled in 2020

Wetland Class	Site Association	Wetland Type	Description	No. Sampled	Structural Stage(s)	Successional Status(es)	Hydrology
Bog	Wb03	BT	Black spruce - Lingonberry - Peat-moss	1	Low Shrub	Young Climax	Permanently to Semi-permanently Flooded
	Wb05	BT	Black spruce - Water sedge - Peat-moss	2	Tall Shrub, Old Conifer Forest	Young Climax, Old Climax	Permanently to Semi-permanently Flooded
	Wb06	TS	Tamarack - Water sedge - Fen moss	4	Low Shrub, Tall Shrub	Young Seral	Permanently to Semi-permanently Flooded
	Wb09	BT	Black spruce – Common horsetail – Peat-moss	1	Tall Shrub	Young Seral	Permanently to Semi-permanently Flooded
Total				**8**			

Plate 3.3-1. Wb03 Black spruce - Lingonberry - Peat-moss bog at wetland WL118 in 2020 showing the cleared portion within the transmission line right-of-way.

Plate 3.3-2. Regenerating Wb05 Black spruce - Water sedge - Peat-moss bog at wetland OWL109 in 2020 in the old transmission line right-of-way.

Plate 3.3-3. Wb06 Tamarack - Water sedge - Fen moss bog at wetland WL115 in 2020 showing the cleared and grubbed portion within the transmission line right-of-way.

Plate 3.3-4. Wb09 Black spruce – Common horsetail – Peat-moss bog at wetland OWL035 in 2020 showing the cleared and grubbed portion within the transmission line right-of-way.

3.3.2 Fen Overview

Three fens were sampled in 2020, comprising one wetland type (SE) and two site associations (Table 3.3-2). The fens ranged from largely undisturbed pocket wetlands in the old transmission line corridor (Plate 3.3-5) to highly disturbed (cleared and grubbed) and modified (hydrological alterations from construction road) sites within the new transmission line corridor. Appendix A contains descriptions of the structural stage and successional status used in Table 3.3-2.

Table 3.3-2. Summary of Fens Sampled in 2020

Wetland Class	Site Association	Wetland Type	Description	No. Sampled	Structural Stage(s)	Successional Status(es)	Hydrology
Fen	Wf01	SE	Water sedge - Beaked sedge	1	Graminoid	Disclimax	Permanently to Semi-permanently Flooded
	Wf02	SE	Scrub birch-water sedge	2	Low Shrub	Young Seral	Permanently to Semi-permanently Flooded
Total				**3**			

Plate 3.3-5. Wf01 Water sedge - Beaked sedge fen at wetland OWL034 in a depression outside of the recently cleared transmission corridor.

Plate 3.3-6. Wf02 Scrub birch- water sedge fen at wetland WL021, which was cleared and modified by the transmission line construction.

3.3.3 Marsh Overview

Fifteen marshes were sampled in 2020 (Table 3.3-3), comprising one wetland type (SE) and four site associations. One unclassified wetland (Plate 3.3-7) was sampled in a highly modified (clearing, soil disturbance, and non-native species) at the base of a new transmission line tower. The majority of the other marsh site associations (Plates 3.3-8 to 3.3-10) had little evidence of clearing; however, physical changes such as soil disturbance, changes to hydrology and non-native vegetation were evident. Appendix A contains descriptions of the structural stage and successional status used in Table 3.3-3.

Table 3.3-3. Summary of Marshes Sampled in 2020

Wetland Class	Site Association	Wetland Type	Description	No. Sampled	Structural Stage(s)	Successional Status(es)	Hydrology
Marsh	Wm00	SE	Marsh (unclassified)	1	Graminoid	Young Seral	Permanently to Semi-permanently Flooded
	Wm01	SE	Beaked sedge - Water sedge	5	Graminoid	Disclimax	Permanently to Semi-permanently Flooded
	Wm03	SE	Awned sedge	8	Graminoid	Disclimax	Permanently to Semi-permanently Flooded
	Wm05	SE	Cattail	2	Graminoid	Disclimax	Permanently to Semi-permanently Flooded
Total				**16**			

Plate 3.3-7. Wm00 Unclassified marsh at OWL021 in a modified area at the base of a new transmission line tower.

Plate 3.3-8. Wm01 Beaked sedge - Water sedge marsh at OWL027 between the new and old transmission lines.

Plate 3.3-9. Wm03 Awned sedge marsh at OWL060 under the old transmission line.

Plate 3.3-10. Wm05 Cattail marsh at WL112 in a modified wetland complex.

3.3.4 Shallow Open Water Overview

Two shallow open water (OW) wetlands were assessed in 2020 (Table 3.3-4). Both of the OW wetlands (Plates 3.3-11 and 3.3-12) were strongly modified due to recent beaver activity, which included construction of dams and lodges and alteration of water levels. Appendix A contains descriptions of the structural stage and successional status used in Table 3.3-4.

Table 3.3-4. Summary of Shallow Open Water Sampled in 2020

Wetland Class	Site Association	Wetland Type	Description	No. Sampled	Structural Stage(s)	Successional Status(es)	Hydrology
Open Water	OW	OW	Shallow Open Water (unclassified)	2	Aquatic	NA	Permanently Flooded
Total				**2**			

Plate 3.3-11. Beaver modified OW at wetland OW001 outside of the transmission line corridor

Plate 3.3-12. Beaver modified OW at wetland OWL103 under the old transmission line.

3.3.5 Swamp Overview

A total of 10 swamps were sampled in 2020, comprising two unclassified swamps and five site associations (Table 3.3-5). Many of the swamps are in various stages of post-disturbance recovery, including the presence of secondary successional species such as grey alder (*Alnus incana*) instead of the typical willow (*Salix* spp.) species (Plate 3.3-13). Shrub-dominated swamps (Plates 3.3-14 and 3.3-15) were often largely intact (not cleared or grubbed) with cutting limited to the wetland perimeter. Forested swamps typically had no trees remaining due to clearing and grubbing within the transmission line (Plates 3.3-16 and 3.3-17). Appendix A contains descriptions of the structural stage and successional status used in Table 3.3-5.

Table 3.3-5. Summary of Swamps Sampled in 2019

Wetland Class	Site Association	Wetland Type	Description	No. Sampled	Structural Stage(s)	Successional Status(es)	Hydrology
Swamp	Ws00	WS	Swamp (unclassified)	2	Low Shrub, Tall Shrub	Young Seral, Secondary Seral	Seasonally to Intermittently Flooded
	Ws03	WS	Bebb's willow - Bluejoint	1	Tall Shrub	Young Seral	Seasonally to Intermittently Flooded

Wetland Class	Site Association	Wetland Type	Description	No. Sampled	Structural Stage(s)	Successional Status(es)	Hydrology
	Ws05	WS	MacCalla's willow - Beaked sedge	3	Tall Shrub	Young Seral	Seasonally to Intermittently Flooded
	Ws07	WS	Spruce - Common horsetail - Leafy moss	2	Sparse, Old Mixed Forest	Pioneer Seral, Old Climax	Permanently to Semi-permanently Flooded
	Ws14	WS	SwSb - Labrador tea - Glow moss	2	Graminoid, Tall Shrub	Secondary Seral, Young Climax	Semi-permanently Flooded
Total				**10**			

Plate 3.3-13. Highly modified Ws00 unclassified swamp at OWL030 in a cleared area between the new and existing transmission lines.

Plate 3.3-14. Ws03 Bebb's willow - Bluejoint swamp at WL100 in the new transmission line with minimal shrub cutting around the wetland perimeter.

Plate 3.3-15. Ws05 MacCalla's willow - Beaked sedge swamp at OWL102 in the new transmission line with minimal shrub cutting around the wetland perimeter.

Plate 3.3-16. Regenerating Ws07 Spruce - Common horsetail - Leafy moss swamp at WL117 in the new transmission line that was cleared and grubbed.

Plate 3.3-17. Regenerating Ws14 SwSb - Labrador tea - Glow moss swamp at WL106 in the new transmission line that was cleared and grubbed.

3.4 Floristic Quality Index

Each of the 2020 wetlands was assessed for species richness, distribution of CC values, proportion of wetland indicator species, proportion of non-native species, and FQI score.

3.4.1 Species Richness and CC-Values

Species richness was calculated for each wetland assessed in 2018 and 2020 individually (Figure 3.4-1) and then the data were combined and richness calculated for each wetland type (Figure 3.4-2).

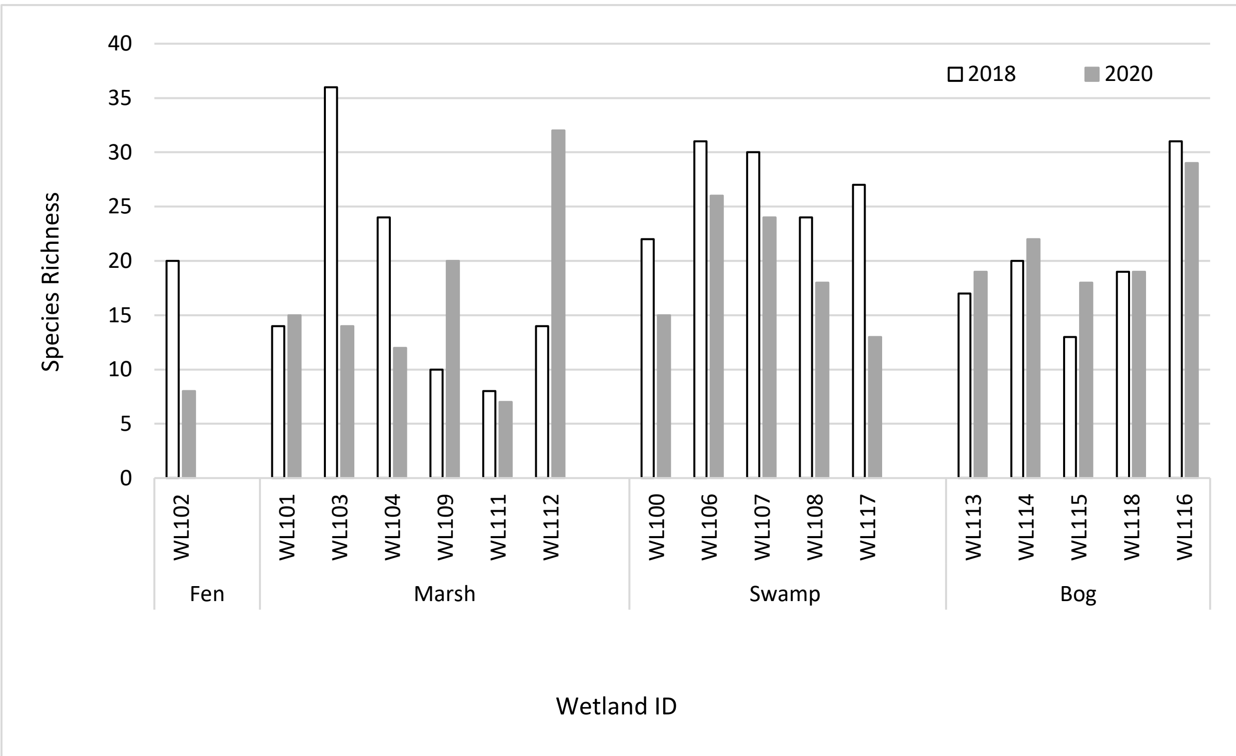


Figure 3.4-1. Individual Species Richness for Each Wetland Assessed in 2018 and 2020

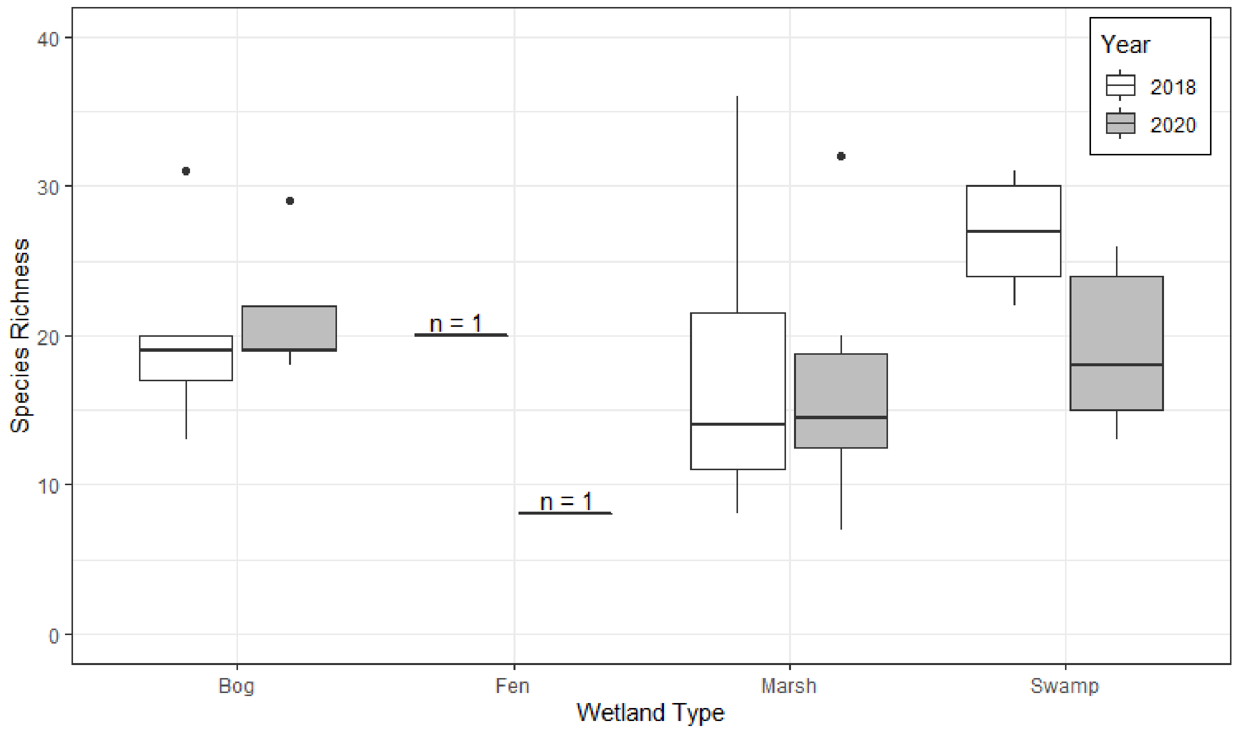


Figure 3.4-2. Comparison of Species Richness by Wetland (2018 and 2020)

Species richness varied among individual wetlands and between monitoring years (Figure 3.4-1). Higher species richness was documented in 2018 across most wetland types with the exception of bogs and a few marshes. Bogs appeared to have the most consistent species richness between the two years (i.e., less variability). Median species richness was similar across the two years for the marshes and bogs (Figure 3.4-2). It appears that species richness is higher in bogs and swamps than in fens and marshes based on median values; however, species richness is highly variable in marshes (i.e., some marshes have high species richness), and less so in swamps and bogs. The distribution of CC values assigned to the vegetation species in each wetland type was also plotted (Figures 3.4-3 to 3.4-6).

The distribution of CC values for each wetland type remained similar across both years (Figures 3.4-3 to 3.4-6). Marsh and swamp wetlands had a higher frequency of species with CC values between 0 and 3, whereas bog wetlands had a higher frequency of species with CC values between 4 and 7. None of the wetlands contained species with CC values above 7.

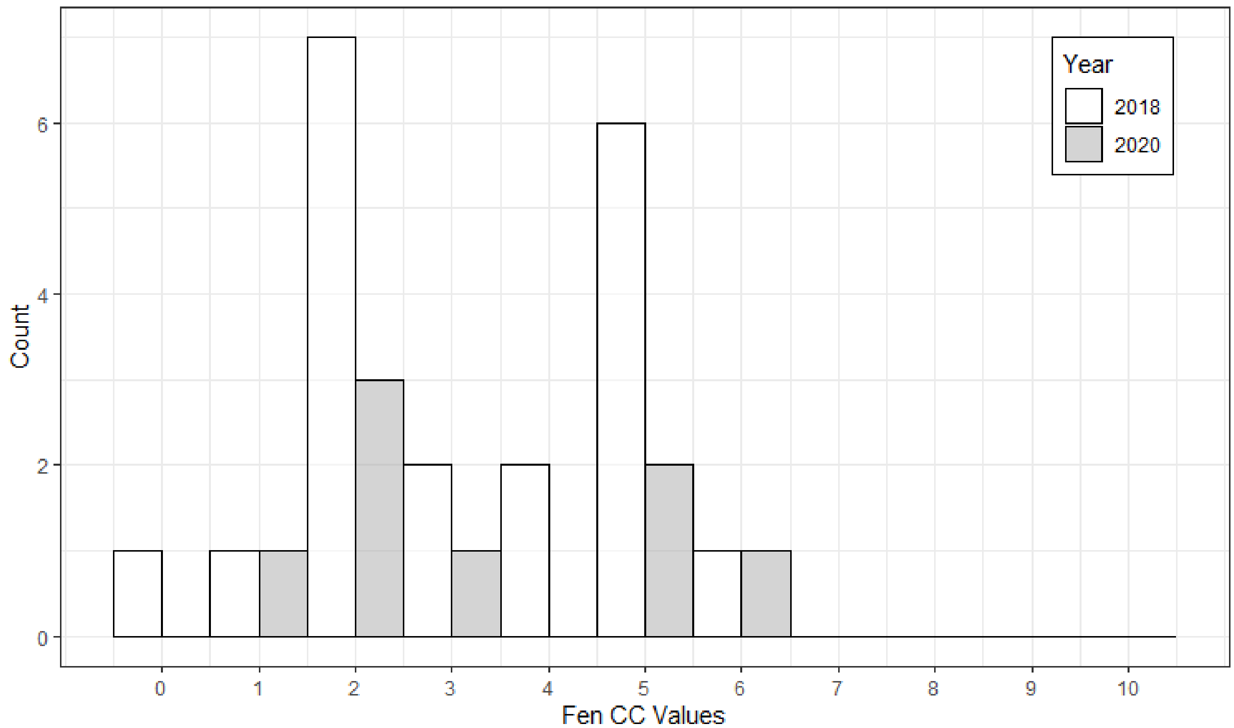


Figure 3.4-3. Coefficient of Conservatism Value Distribution for Fens Assessed in 2018 and 2020

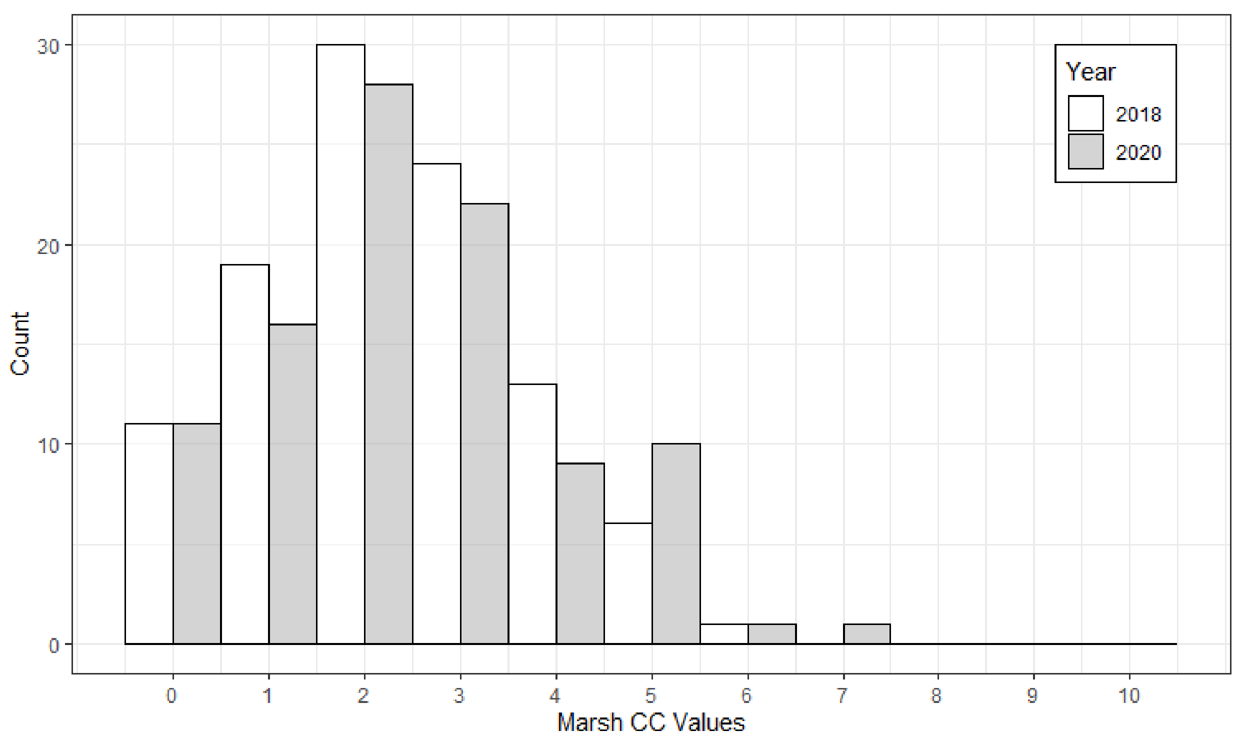


Figure 3.4-4. Coefficient of Conservatism Value Distribution for Marshes Assessed in 2018 and 2020

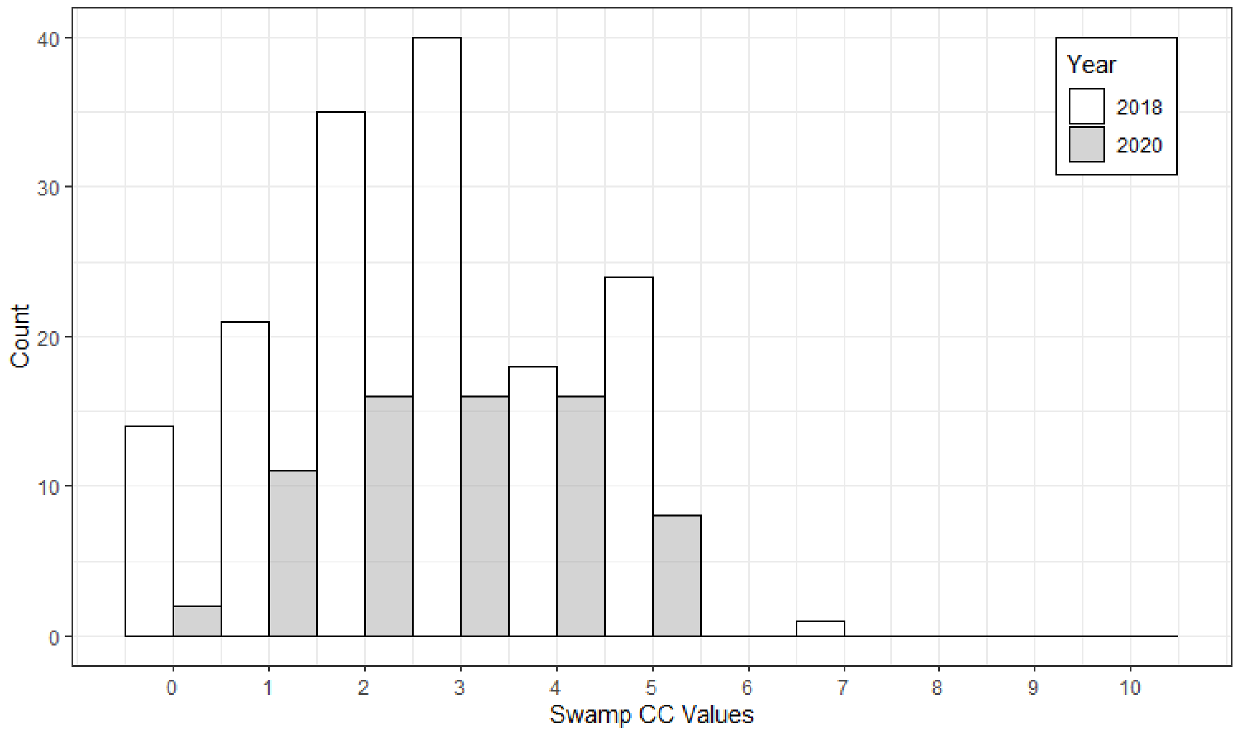


Figure 3.4-5. Coefficient of Conservatism Value Distribution for Swamps Assessed in 2018 and 2020

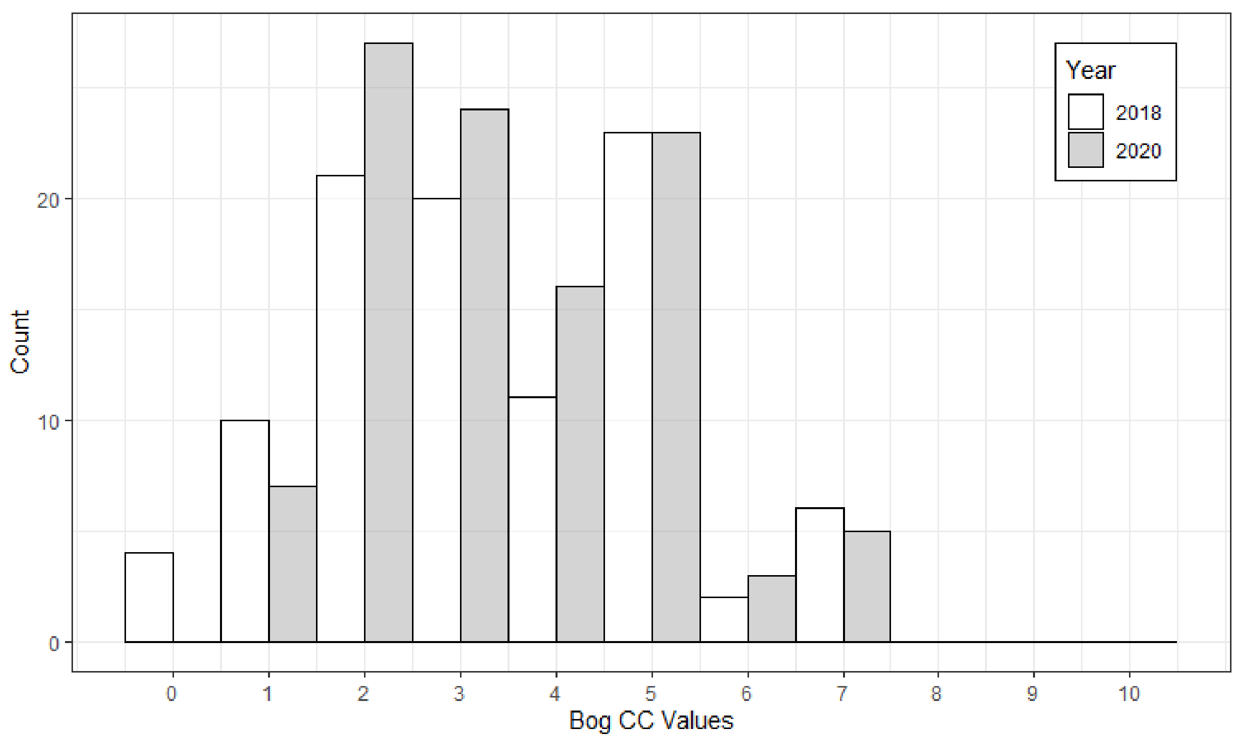


Figure 3.4-6. Coefficient of Conservatism Value Distribution for Bogs Assessed in 2018 and 2020

3.4.2 Wetland Indicator Species

The proportion of wetland indicator species identified during the 2018 and 2020 assessments were calculated for each wetland individually (Figure 3.4-7) and was then combined and compared by wetland type (Figure 3.4-8).

An equal or increased number of wetland indicator species were documented in 2020 across most wetlands, with the exception of the single fen and a few marshes and bogs (Figure 3.4-7). Bogs had increased percentages of wetland indicators when compared to swamps and marshes (Figure 3.4-8). Marshes appear to have the greatest variability of percentage of wetland indicator species. Bogs and marshes had similar median percentage of wetland indicator species between years, and swamps and the fen wetland had a higher percentage of wetland indicator species in 2020.

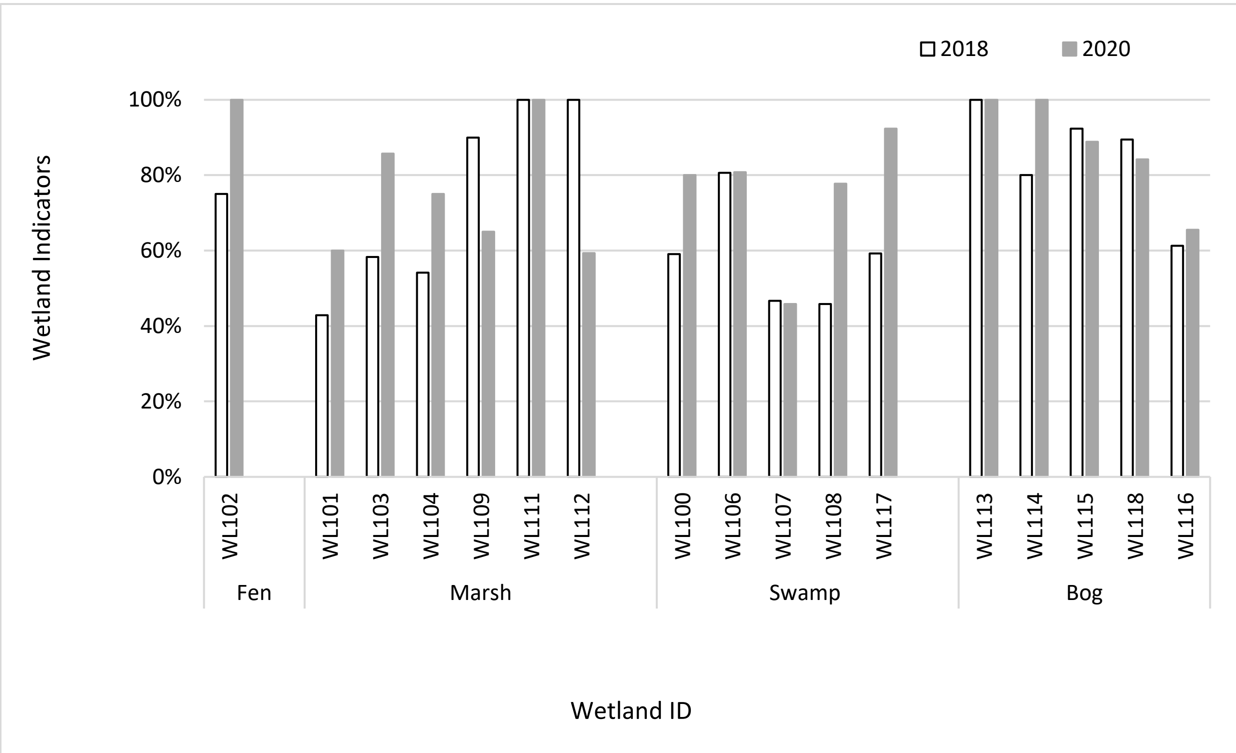


Figure 3.4-7. Percentage of Wetland Indicator Species Identified for Each Wetland Assessed in 2018 and 2020

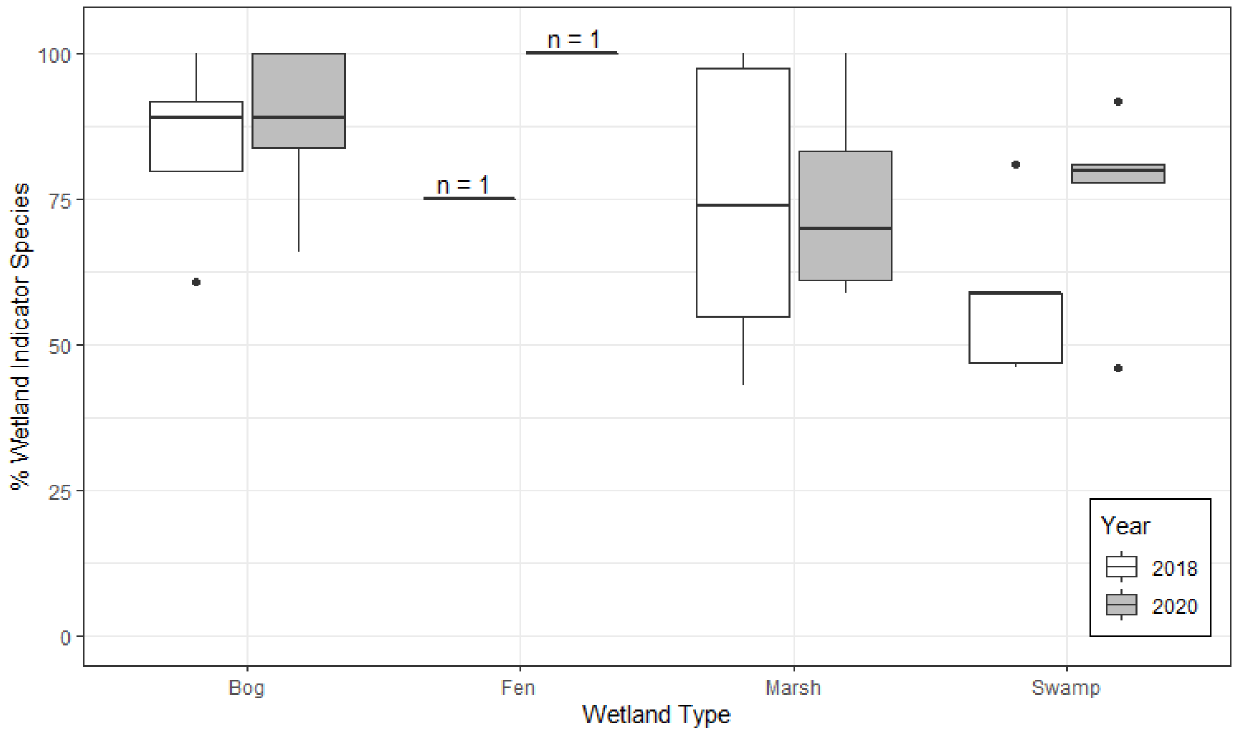


Figure 3.4-8. Comparison of Wetland Indicator Species by Wetland (2018 and 2020)

3.4.3 Non-Native Species

The proportion of non-native species identified during the 2018 and 2020 assessments was calculated for each wetland individually (Figure 3.4-9) and was then combined and compared by wetland type (Figure 3.4-10). Non-native species were detected in 12 of the 18 wetlands, and the proportion of these non-native species varied widely between wetland types and monitoring years (Figure 3.4-9). Marshes had the largest range of percentage of non-native species and the highest median percentage of non-native species (Figure 3.4-10). In 2018 more non-native species were detected in bogs. Overall, the median percentage of non-native species in each wetland type remains low (less or equal to 10%) in 2018 and 2020.

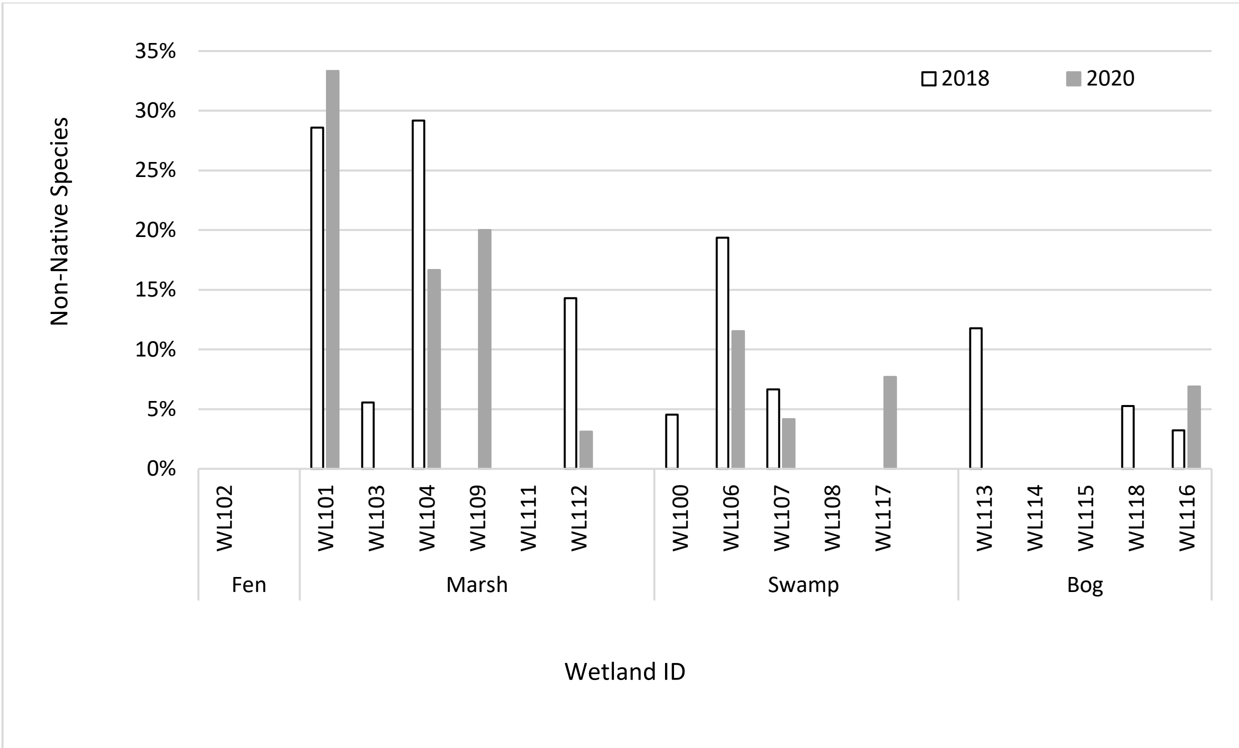


Figure 3.4-9. Percentage of Non-native Species Identified for Each Wetland Assessed in 2018 and 2020

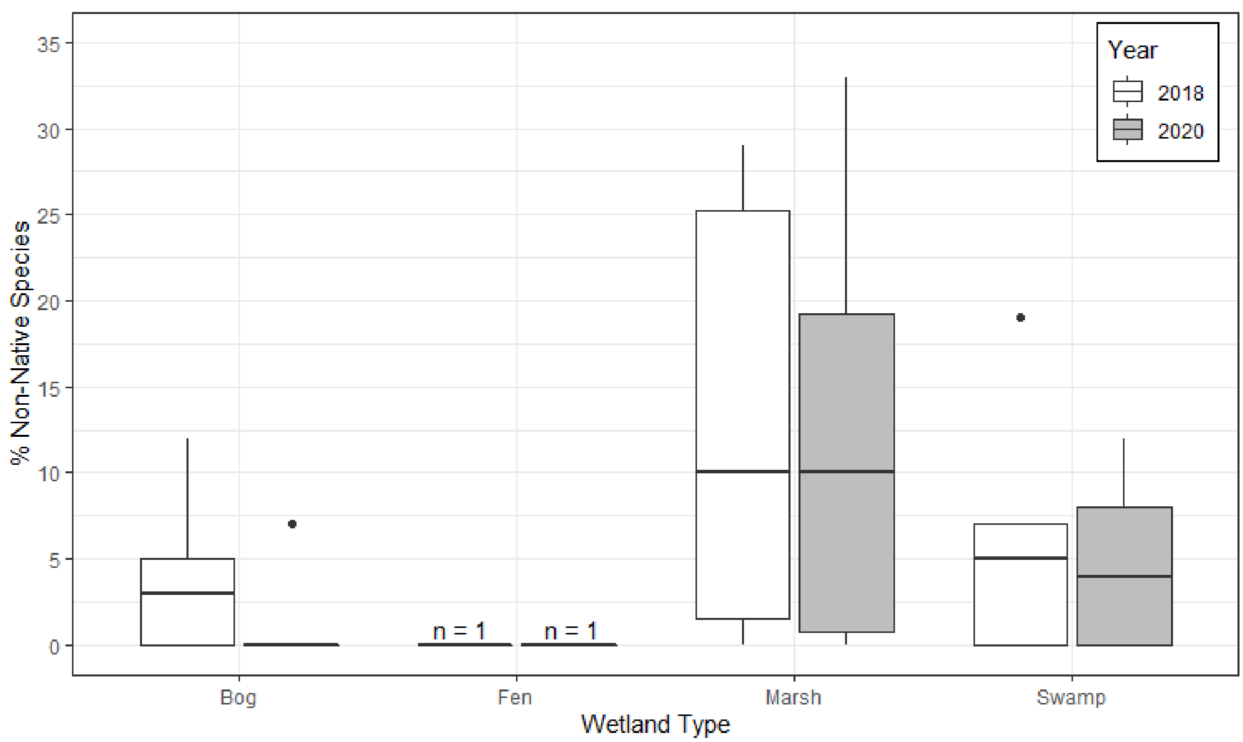


Figure 3.4-10. Comparison of Non-native Species by Wetland (2020 and 2018)

3.4.4 FQI Score

The FQI score was calculated for each wetland assessed in 2018 and 2020 individually (Figure 3.4-11) and was then combined and compared by wetland type (Figure 3.4-12). Individual FQI scores varied slightly between 2018 and 2020 (Figure 3.4-11). The median FQI scores for fens and marshes were very consistent between the two years, and swamp and bog wetlands had higher median FQI scores in 2020 (Figure 3.4-12). Bogs had the highest median FQI score, and marshes had the lowest median FQI score.

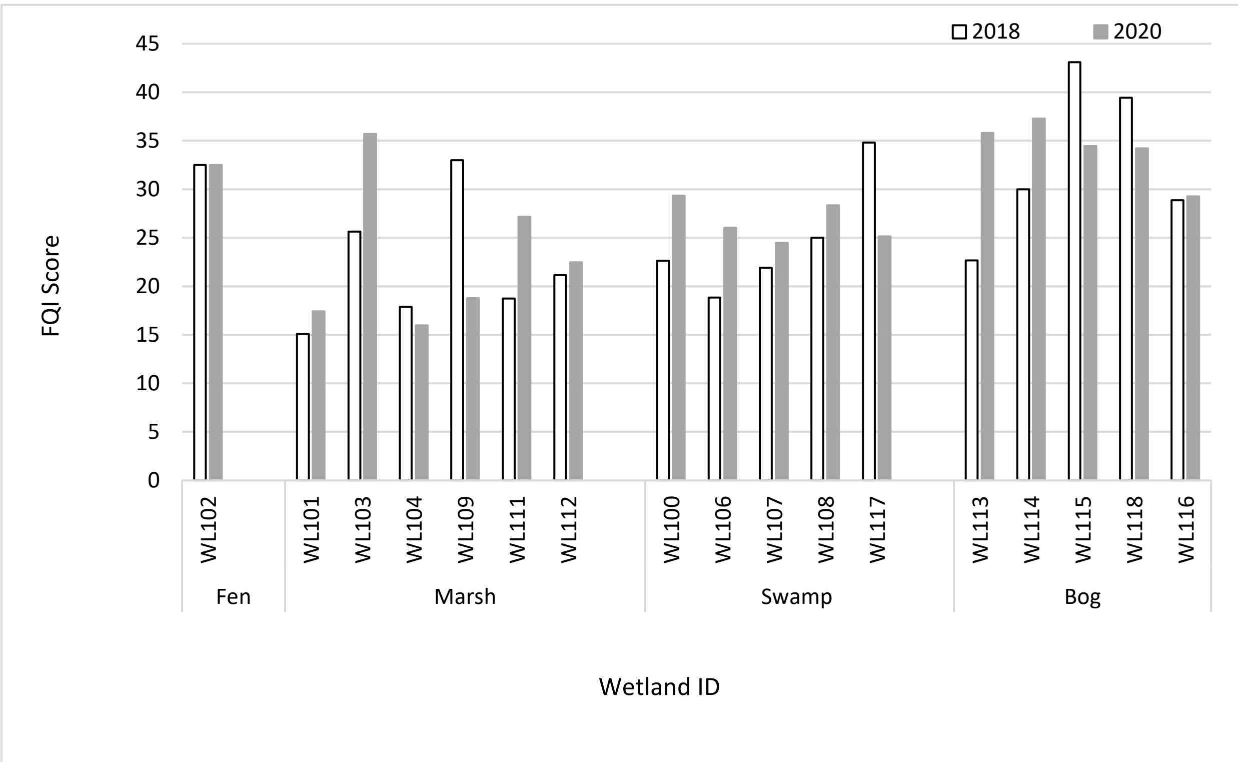


Figure 3.4-11. Individual FQI Scores for Each Wetland Assessed in 2018 and 2020

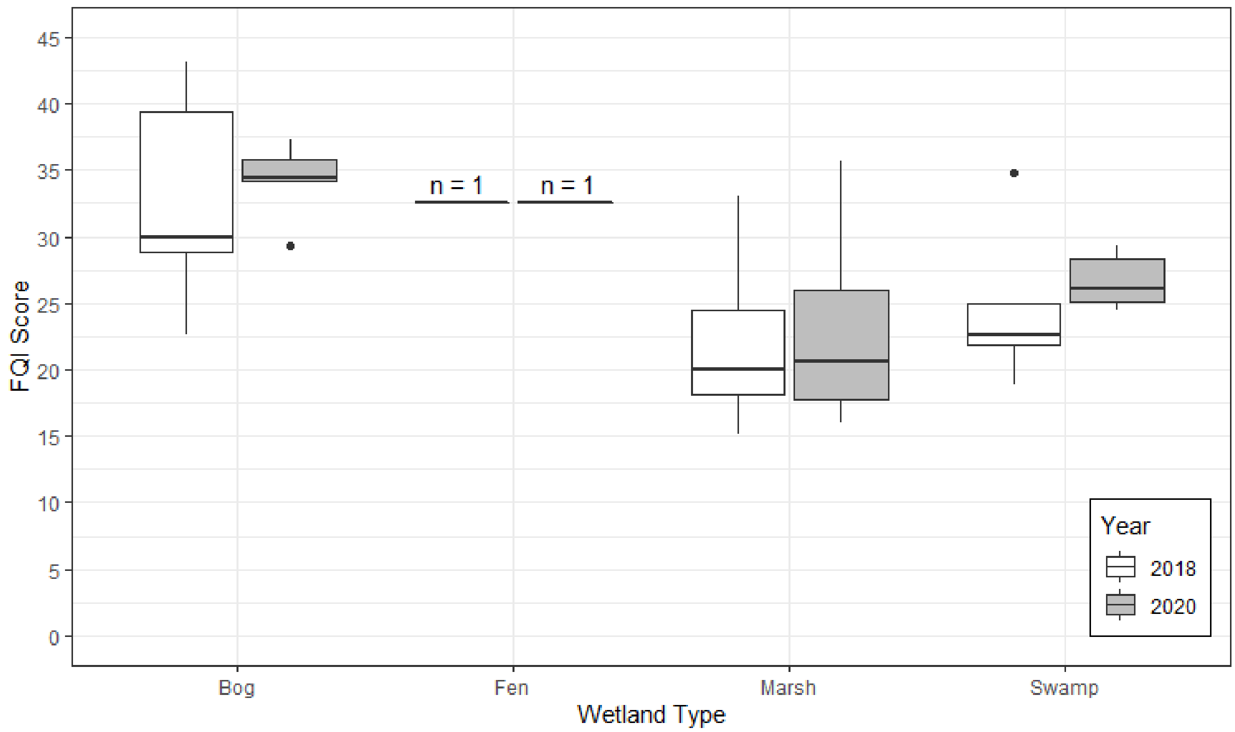


Figure 3.4-12. Comparison of FQI Scores by Wetland Type (2018 and 2020)

3.4.5 FQI Discussion

Species richness showed variation between the two monitoring years (Figure 3.4-2). The variation in individual species richness between 2018 and 2020 is expected and could be due to a number of factors including differing quadrat locations, wetland water levels, survey timing, or surveyor experience.

Species richness can be easily influenced by non-native or weedy species, and therefore is not always the best indicator of a healthy wetland. In addition, there are a number of naturally occurring vegetation communities that have characteristically lower species richness but would still be considered healthy. To adjust for the nuances that come with species richness, we compared the distribution of CC values assigned to the vegetation species identified within wetland type (Figures 3.4-3 to 3.4-6). Based on the two years of data available, bogs appear have more species that don't tolerate disturbance (higher CC values) compared to marshes and swamps.

FQI was found to be the highest in bogs, and lowest in marshes. These FQI scores are not unexpected as often bogs contain a unique combination of plant species (e.g., a number of *Vaccinium* and *Drosera* species) that are adapted to the acidic and nutrient-poor conditions typical of bog wetlands (Mackenzie and Moran 2004). In addition, bog vegetation is very slow growing, not tolerant of disturbances and can be easily out-competed if conditions change (Mackenzie and Moran 2004). Marshes, on the other hand, often contain fewer species, and those species tend to be less specialized and can be found in other environments as well (e.g., a sedge marsh that is 80% beaked sedge).

This year (2020) was the first year that a BC-specific list of CC values were available. The 2019 wetland data will be updated with the BC-specific CC values in 2021, when those wetlands have two years of data that can be analyzed.

4. SUMMARY OF WETLAND SAMPLING: 2016–2020

A total of 128 wetlands within the PAZ have been assessed since the beginning of the Program in 2016. Starting in 2018, with the development of a standard methodology (Native Plant Solutions 2020), the 2016 and 2017 were re-sampled to ensure that all data were consistent. With the exception of the two wetlands mentioned in Section 3.1, all wetlands assessed in 2021 and beyond will fall under the Construction Phase Monitoring portion of the project (Table 4-1).

Table 4-1. Summary of Wetland Sampling; 2016-2020.

General Location	Pre-NPS Methodology		Baseline and/or Construction Monitoring		
	2016	2017	2018	2019	2020
Downstream	-	-	-	5	-
Transmission Line	53	-	21	37	40
Reservoir	3	6	36	7	-
Total	56	6	57	49	40

Since 2018, all wetland sampling has been completed as per the *BC Hydro Site C Vegetation and Wildlife Wetland Monitoring Program: Baseline and Construction Phase Wetland Monitoring* (Appendix D of Native Plant Solutions 2020). The use if a current and standardized methodology allows for detailed classification of each wetland to the provincial Site Association level (Table 4-2).

Table 4-2. Baseline and Construction Monitoring Wetlands Sampled from 2018 to 2020

Wetland Class	Site Association	Vegetation Community	No. Sampled 2018	No. Sampled 2019	No. Sampled 2020
Reservoir Footprint					
Bog	Wb06	Tamarack - Water sedge - Fen moss	1		
Fen	Wf00	Fen (unclassified)	1		
Swamp	Ws00	Swamp (unclassified)	4		
	Ws02	Mountain alder – Pink spirea – Sitka sedge		2	
	Ws05	MacCalla's willow - Beaked sedge	1		
	Ws15	SwSb - Labrador tea - Glow moss	1		
Marsh	Wm00	Marsh (unclassified)	1		
	Wm02	Swamp horsetail - Beaked sedge	1		
	Wm03	Awned sedge	2		
	Wm04	Common spike-rush	1		
	Wm05	Cattail	1		
	Wm06	Great bulrush	1		

Wetland Class	Site Association	Vegetation Community	No. Sampled 2018	No. Sampled 2019	No. Sampled 2020
Open Water	OW	Shallow Open Water (unclassified)	1		
Floodplain	Fl00	Low bench floodplain (unclassified)	8	3	
	Fl03	Pacific willow – Red-osier dogwood – Horsetail	1	1	
	Fl06	Sandbar willow	4	6	
	Fm00	Mid bench floodplain (unclassified)	2		
	Fm02	Cottonwood - Spruce - Red-osier dogwood	5		
Total			***36***	***12***	***0***
Transmission Line					
Bog	Wb03	Black spruce - Lingonberry - Peat-moss	1	6	1
	Wb05	Black spruce - Water sedge - Peat-moss	1		2
	Wb06	Tamarack - Water sedge - Fen moss	3	7	4
	Wb08	Black spruce - Soft-leaved sedge - Peat-moss		7	
	Wb09	Black spruce – Common horsetail – Peat-moss			1
Fen	Wf01	Water sedge - Beaked sedge		3	1
	Wf02	Scrub birch – Water sedge	2	1	2
Swamp	Ws00	Swamp (unclassified)	1		2
	Ws03	Bebb's willow - Bluejoint		1	2
	Ws04	Drummond's willow - Beaked sedge	1		
	Ws05	MacCalla's willow - Beaked sedge			3
	Ws06	Sitka willow - Sitka sedge	1		
	Ws07	Spruce - Common horsetail - Leafy moss	1		2
	Ws14	Mountain Alder – Bebb's Willow – Bluejoint	2		2
Marsh	Wm00	Marsh (unclassified)		1	1
	Wm01	Beaked sedge - Water sedge	4	3	5
	Wm02	Swamp horsetail - Beaked sedge	1	1	
	Wm03	Awned sedge	1	4	8
	Wm05	Cattail	2		2
	Wm15	Bluejoint - Beaked sedge		2	
Open Water	OW	Shallow Open Water (unclassified)		1	2
Total			***21***	***37***	***40***

5. WETLAND SAMPLING PLAN: 2021–2027

As per *BC Hydro Site C Vegetation and Wildlife Wetland Monitoring Program: Baseline and Construction Phase Wetland Monitoring* (Native Plant Solutions 2020), wetlands are sampled two years after the initial baseline assessment, then every five years after that. A summary of the total number (including wetlands that have been re-assessed after the baseline visit) of wetlands that have been sampled to date, and the expected number of wetlands to be sampled from 2021 to 2027 (2027 is the first year when the two- and five-year construction monitoring assessments will be completed for all wetlands in the study) is presented in Table 5-1. The specific wetland sites that were sampled from 2016 to 2020, and those that will be sampled from 2021 to 2027, are presented in Table 5-2. Wetlands located within the reservoir area are not included in the construction monitoring, as they will be inundated as the reservoir is filled.

Table 5-1. Summary of Wetlands Sampled from 2016 to 2020 and the Planned Construction Monitoring Plan for 2021 to 2027

General Location	Pre-NPS Methodology		Baseline and/or Construction Monitoring			Construction Monitoring						
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Downstream	-	-	-	5	-	5	-	-	-	-	5	-
Transmission Line	53	-	21	37	40	40	22	-	-	20	38	22
Reservoir	3	6	36	7	-	-	-	-	-	-	-	-
Total	56	6	57	49	40	45	22	0	0	20	43	22

Table 5-2. Wetlands Sampled from 2016 to 2020 and the Planned Construction Monitoring Plan for 2021 to 2027

General Location	Site	Pre-NPS Methodology				Baseline and/or Construction Monitoring				Construction Monitoring			
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Downstream	WL203				x		x					x	
	WL204				x		x					x	
	WL205				x		x					x	
	WL206				x		x					x	
	WL207				x		x					x	
Reservoir	WL001			x									
	WL002	x		x									
	WL003			x									
	WL004	x		x									
	WL005			x									
	WL006	x		x									

General Location	Site	Pre-NPS Methodology				Baseline and/or Construction Monitoring				Construction Monitoring			
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Reservoir (cont'd)	WL007			x									
	WL008			x									
	WL009			x									
	WL010			x									
	WL011			x									
	WL012			x									
	WL013			x									
	WL014			x									
	WL015			x									
	WL016			x									
	WL017			x									
	WL018			x									
	WL019			x									
	WL022			x									
	WL023			x									
	WL024			x									
	WL025			x									
	WL026			x									
	WL027			x									
	WL028			x									
	WL029			x									
	WL030			x									
	WL031			x									
	WL032			x									
	WL033			x									
	WL034			x									
	WL035			x									
	WL036			x									
	WL037			x									
	WL038			x									
	WL208				x								
	WL209				x								
	WL210				x								

General Location	Site	Pre-NPS Methodology				Baseline and/or Construction Monitoring				Construction Monitoring			
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Reservoir (cont'd)	WL211				x								
	WL212				x								
	WL213				x								
	WL214				x								
Transmission Line	BR2				x		x					x	
	MWL02	x			x		x					x	
	MWL08	x			x		x					x	
	MWL09	x			x		x					x	
	MWL10	x			x		x					x	
	MWL12	x			x		x					x	
	MWL13	x			x		x					x	
	MWL14	x			x		x					x	
	MWL18	x			x		x					x	
	MWL19	x			x		x					x	
	MWL33	x			x		x					x	
	MWL58	x			x		x					x	
	MWL59	x			x		x					x	
	MWL62	x			x		x					x	
	MWL69	x			x		x					x	
	MWL72	x			x		x					x	
	OWL001	x				x		x					x
	OWL011	x					x	x					x
	OWL021	x				x		x					x
	OWL026	x				x		x					x
	OWL027	x				x		x					x
	OWL030	x				x		x					x
	OWL032	x				x		x					x
	OWL034	x				x		x					x
	OWL035	x				x		x					x
	OWL053	x				x		x					x
	OWL060	x				x		x					x
	OWL061	x					x	x					x
	OWL063	x				x		x					x

General Location	Site	Pre-NPS Methodology				Baseline and/or Construction Monitoring				Construction Monitoring			
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Transmission Line (cont'd)	OWL067	x				x		x					x
	OWL070	x				x		x					x
	OWL071	x				x		x					x
	OWL073	x				x		x					x
	OWL102		x			x		x					x
	OWL103		x			x		x					x
	OWL107		x			x		x					x
	OWL109		x			x		x					x
	OWL110		x			x		x					x
	PI1				x		x					x	
	PI2				x		x					x	
	PI4				x		x					x	
	PR				x		x					x	
	WL020	x		x		x					x		
	WL021	x		x		x					x		
	WL100			x		x					x		
	WL101	x		x		x					x		
	WL102	x		x		x					x		
	WL103	x		x		x					x		
	WL104	x		x			x					x	
	WL105	x		x		x					x		
	WL106	x		x		x					x		
	WL107			x		x					x		
	WL108	x		x		x					x		
	WL109			x		x					x		
	WL110			x		x					x		
	WL111			x		x					x		
	WL112			x		x					x		
	WL113			x		x					x		
	WL114			x		x					x		
	WL115	x		x		x					x		
	WL116	x		x		x					x		
	WL117		x	x		x					x		

General Location	Site	Pre-NPS Methodology				Baseline and/or Construction Monitoring				Construction Monitoring			
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Transmission Line (cont'd)	WL118	x		x		x					x		
	WL200				x		x					x	
	WL201				x		x					x	
	WL202	x			x		x					x	
	WL215	x			x		x					x	
	WL216				x		x					x	
	WL217				x		x					x	
	WL218	x			x		x					x	
	WL219	x			x		x					x	
	WL220	x			x		x					x	
	WL221	x			x		x					x	
	WL222				x		x					x	
	WL223				x		x					x	
	WL224	x			x		x					x	
	WL225	x			x		x					x	
	WL226				x		x					x	
	WL228	x			x		x					x	
	WL229				x		x					x	

REFERENCES

ASRD. 2003. *Ecological Land Survey Site Description Manual* (2nd edition). Alberta Sustainable Resource Development: Edmonton, AB.

Andrusiak, L., and Simpson, L. 2012. *Expanded Legend for the Peace River Terrestrial Ecosystem Mapping Project*. Prepared for BC Hydro by Keystone Wildlife Research Ltd.

B.C. Conservation Data Centre. 2020. BC Species and Ecosystems Explorer. B.C. Ministry of Environment, Victoria B.C. Available: http://a100.gov.bc.ca/pub/eswp

BC Hydro. 2015. *Vegetation and wildlife mitigation and monitoring plan, Site C Clean Energy Project*. Version 1, June 5, 2015. 629pp.

BC MOE and BC MOF. 2010. *Field Manual for Describing Terrestrial Ecosystems* (2nd Edition). B.C. Ministry of Environment, Lands and Parks and B.C. Ministry of Forests: Victoria, B.C.

BC Wildlife Federation. 2018. Floristic Quality Index for Eastern British Columbia, Canada – East of Cascade Mountains.

Bourdaghs, M., Johnston, C.A., and Regal, R.R. 2006. Properties and performance of the floristic quality index in Great Lakes coastal wetlands. *Wetlands* 26:718-725.

Cretini, K.F., and Steyer, G.D. 2011. Floristic Quality Index: An Assessment Tool for Restoration Projects and Monitoring Sites in Coastal Louisiana. U.S. Department of the Interior and U.S. Geological Survey.

DeLong, C., A. Banner, W. H. MacKenzie, B. J. Rogers, and B. Kaytor. 2011. *A field guide to ecosystem identification for the Boreal White and Black Spruce Zone of British Columbia*. Land Management Handbook 65. BC Ministry of Forests.

DeLong, C., MacKinnonn, A., and Jang., L. 1990. A Fi*eld Guide for Identification and Interpretation of Ecosystems of the Northeast Portion of the Prince George Forest Region*. Land Management Handbook 22. BC Ministry of Forests.

MacKenzie, W.H., and Moran, J.R. 2004. *Wetlands of British Columbia: A Guide to Identification.* Victoria, BC: BC Ministry of Forests.

Native Plant Solutions (NPS). 2018. *Assessment of wetland function for the Site C Clean Energy Project*. Prepared for BC Hydro: April 2018. 207pp.

Native Plant Solutions (NPS). 2020. BC *Hydro Site C Vegetation and Wildlife Wetland Monitoring Program: Baseline and Construction Phase Wetland Monitoring*. Prepared for BC Hydro: February 2020. 115pp.

Rooney, T.P. and Rogers, D.A. 2002. The modified floristic quality index. *Natural Areas Journal* 22:340–344.

United States Department of Agriculture. 2020. Natural Resource Conservation Service Plants Database. Available at: https://plants.sc.egov.usda.gov/java.

Washington, H.G. 1984. Diversity, biotic, and similarity indices: a review with special relevance to aquatic ecosystems. *Water Resources* 18:653–694.

Wilson, M.J., Forest, A.S., and Bayley, S.E. 2013. Floristic Quality Assessment for Marshes in Alberta's Northern Prairie and Boreal Regions. Aquatic Ecosystems Health and Management. 16:3. 288-299.

APPENDIX A. DEFINITION OF STRUCTURAL STAGES AND SUCCESSIONAL STATUS CODES

Structural stage codes and structural stage modifiers are used to describe the vegetation structure and appearance in each ecosystem unit. Structural stage codes describe the relative age of a given ecosystem (i.e., shrub-dominated vs. old-growth forest) while the modifiers are used to provide additional descriptions of structural stages (BC MOE and MOF 2010). Note that while the successional status has been included in the summary tables for each wetland class, it has been loosely applied as the codes used to describe successional status in British Columbia were developed for forested communities and are not directly applicable to non-forested wetlands.

Structural Stage

Structural Stage	Description
Post-disturbance stages or environmentally induced structural development	
1 Sparse/bryoid	Initial stages of primary and secondary succession; bryophytes and lichens often dominant, can be up to 100%; time since disturbance less than 20 years for normal forest succession, may be prolonged (50–100+ years) where there is little or no soil development (bedrock, boulder fields); total shrub and herb cover less than 20%; total tree layer cover less than 10%.
1a Sparse	Less than 10% vegetation cover.
Stand initiation stages or environmentally induced structural development	
2 Herb	Early successional stage or herbaceous communities maintained by environmental conditions or disturbance (e.g., snow fields, avalanche tracks, wetlands, grasslands, flooding, intensive grazing, intense fire damage); dominated by herbs (forbs, graminoids, ferns); some invading or residual shrubs and trees may be present; tree layer cover less than 10%, shrub layer cover less than or equal to 20% or less than 1/3 of total cover, herb-layer cover greater than 20%, or greater than or equal to 1/3 of total cover; time since disturbance less than 20 years for normal forest succession; many herbaceous communities are perpetually maintained in this stage.
2a Forb-dominated	Herbaceous communities dominated (greater than 1/2 of the total herb cover) by non-graminoid herbs, including ferns.
2b Graminoid-dominated	Herbaceous communities dominated (greater than 1/2 of the total herb cover) by grasses, sedges, reeds, and rushes.
2c Aquatic	Herbaceous communities dominated (greater than 1/2 of the total herb cover) by floating or submerged aquatic plants; does not include sedges growing in marshes with standing water (which are classed as 2b).
3 Shrub/Herb	Early successional stage or shrub communities maintained by environmental conditions or disturbance (e.g., snow fields, avalanche tracks, wetlands, grasslands, flooding, intensive grazing, intense fire damage); dominated by shrubby vegetation; seedlings and advance regeneration may be abundant;

Structural Stage	Description
	tree layer cover less than 10%, shrub layer cover greater than 20% or greater than or equal to 1/3 of total cover.
3a Low shrub	Communities dominated by shrub layer vegetation less than 2 m tall; may be perpetuated indefinitely by environmental conditions or repeated disturbance; seedlings and advance regeneration may be abundant; time since disturbance less than 20 years for normal forest succession.
3b Tall shrub	Communities dominated by shrub layer vegetation that are 2–10 m tall; may be perpetuated indefinitely by environmental conditions or repeated disturbance; seedlings and advance regeneration may be abundant; time since disturbance less than 40 years for normal forest succession.
Stem exclusion stages	
4 Pole/Sapling	Trees greater than 10 m tall, typically densely stocked, have overtopped shrub and herb layers; younger stands are vigorous (usually greater than 10–15 years old); older stagnated stands (up to 100 years old) are also included; self-thinning and vertical structure not yet evident in the canopy - this often occurs by age 30 in vigorous broadleaf stands, which are generally younger than coniferous stands at the same structural stage; time since disturbance is usually less than 40 years for normal forest succession; up to 100+ years for dense (5,000–15,000+ stems per hectare), stagnant stands.
5 Young Forest	Self-thinning has become evident and the forest canopy has begun differentiation into distinct layers (dominant, main canopy, and overtopped); vigorous growth and a more open stand than in the pole/sapling stage; time since disturbance is generally 40–80 years but may begin as early as age 30, depending on tree species and ecological conditions.
Understory reinitiation stage	
6 Mature Forest	Trees established after the last disturbance have matured; a second cycle of shade tolerant trees may have become established; understories become well developed as the canopy opens up; time since disturbance is generally 80−140 years for biogeoclimatic group A and 80−250 years for group B.
Old-growth stage	
7 Old Forest	Old, structurally complex stands composed mainly of shade-tolerant and regenerating tree species, although older seral and long-lived trees from a disturbance such as fire may still dominate the upper canopy; snags and coarse woody debris in all stages of decomposition typical, as are patchy understories; understories may include tree species uncommon in the canopy, due to inherent limitations of these species under the given conditions; time since disturbance generally greater than 140 years for biogeoclimatic group A and greater than 250 years for group B.

Structural Stage Modifiers are used to describe the overstorey structure of a forested stand, often related to disturbance history or edaphic conditions (BC MOE and MOF 2010).

Structural Stage Modifiers

Modifier	Description
s single storied	Closed forest stand dominated by the overstory crown class (dominant and co-dominant trees); intermediate and suppressed trees account for less than 20% of all crown classes combined, advance regeneration in the understory is generally sparse.
t two storied	Closed forest stand co-dominated by distinct overstory and intermediate crown classes; the suppressed crown class is lacking or accounts for less than 20% of all crown classes combined' advance regeneration is variable.
m multistoried	Closed forest stand with all crown classes well represented; each of the intermediate and suppressed classes account for greater than 20% of all crown classes combined, advance regeneration is variable.
o open	Forest stand with very open main and intermediate crown classes (totaling less than 25% cover); substantial understorey light levels commonly result in well-developed shrub and/or herb understorey.

Stand composition modifiers are used to provide additional descriptions of structural stages 3 to 7 and indicate the dominance of the stand by broadleaf, conifers or a mixed forest (BC MOE and MOF 2010).

Stand Composition Modifiers

Modifier	Description
C - coniferous	Greater than 3/4 of total tree layer cover is coniferous.
B - broadleaf	Greater than 3/4 of total tree layer cover is broadleaf.
M - mixed	Neither coniferous or broadleaf account for greater than 3/4 of total tree layer cover.

Successional status describes a temporal stage of a given ecosystem type in relation to its expected stable state for a given environment (BC MOE and MOF 2010). It is generally used to describe the development of a community after a large scale disturbance (natural or human). The successional system was developed for forested ecosystems, but can be generally applied to other communities to reflect the current status of the community relative to what is expected to occur on the site (BC MOE and MOF 2010).

Successional Status

Successional Status	Description
NV – Non-vegetated	Due to substrate or disturbance, vegetation cover is absent or less than five percent.
PS – Pioneer Seral	Initial stages of re-vegetation after disturbance.

Successional Status	Description
YS – Young Seral	Early successional community where competition has not created structural complexity. Often a mix of pioneer and early successional species. Forested stands are even aged, and less than 60 years old.
MS – Maturing Seral	Early successional tree species that have gone through natural self-thinning. Overstorey and understory of trees present, with understory species including shade tolerant trees. Trees of mature age, generally 60–140 years old.
OS – Overmature Seral	Overstorey seral tree species are dying, usually older than 140 years.
YC – Young Climax	Young stand with trees species typical of climax expected for site. Composition and structure are underdeveloped.
MC – Maturing Climax	Mature (80–120 years old) stand of climax species that has undergone natural thinning, with few seral species remaining. Vertical structure is developed.
OC – Old Climax	Old (greater than 250 years) and composed of expected climax species. Vertical structure is well developed, including canopy gaps, and large woody debris is common on forest floor.
DC - Disclimax	Persistent community that does not reflect the expected species composition due to disturbance (historic or repeated). Used for species conditions where processes or events are holding natural succession from moving forward.

Appendix 5. 2020 Preconstruction Rare Plant Surveys

EAGLE CAP CONSULTING
environmental consulting services

2020 Annual Report
Pre-construction Rare Plant Surveys
Site C Clean Energy Project

Prepared by:

Eagle Cap Consulting Ltd.
1103-240 70 Shawville Blvd. SE
Calgary, Alberta T2Y 2Z3

Prepared for:

BC Hydro and Power Authority
Suite 600, 4 Bentall Centre
1055 Dunsmuir Street
PO Box 49260
Vancouver, British Columbia

January 27, 2021

Contents

1. Introduction

1.1. Background

The Environmental Assessment Certificate (EAC #E14-02) for the Site C Clean Energy Project (the Project) sets out the conditions that BC Hydro must comply with during construction and operation of the Project (BC Environmental Assessment Office 2014). Condition 9 states in part:

- *The EAC Holder must, with the use of a QEP, complete an inventory in areas not already surveyed and use rare plant location information as inputs to final design of access roads and transmission lines. These preconstruction surveys must target rare plants as defined in Section 13.2.2 of the EIS —including vascular plants, mosses, and lichens.*
- *The EAC Holder must create and maintain a spatial database of known rare plant occurrences in the vicinity of Project components that must be searched to avoid effects to rare plants during construction activities. The database must be updated as new information becomes available and any findings of new rare plant species occurrences must be submitted to Environment Canada and MOE using provincial data collection standards.*

In addition, the Federal Decision Statement (FDS) issued under the Canadian Environmental Assessment Act sets out conditions relating to rare plants (Canadian Environmental Assessment Agency 2014). Condition 16 states in part:

- *16.1 The Proponent shall ensure that potential effects of the Designated Project on species at risk, at-risk and sensitive ecological communities and rare plants are addressed and monitored.*
- *16.2. The Proponent shall develop, in consultation with Environment Canada, a plan setting out measures to address potential effects of the Designated Project on species at risk, at-risk and sensitive ecological communities and rare plants.*
- *16.3. The plan shall include:*
    - *16.3.3. measures to mitigate environmental effects on species at risk and at-risk and sensitive ecological communities and rare plants;*
    - *16.3.4. conservation measures to ensure the viability of rare plants, such as seed recovery and plant relocation;*
    - *16.3.6. an approach to monitor and evaluate the effectiveness of mitigation measures and to verify the accuracy of the predictions made during the environmental assessment on species at risk, at-risk and sensitive ecological communities and rare plants; and*

- *16.3.7. an approach for tracking updates to the status of listed species identified by the Government of British Columbia, Committee on the Status of Endangered Wildlife in Canada, and the Species at Risk Act, and implementation of additional measures, in accordance with species recovery plans, to mitigate effects of the Designated Project on the affected species should the status of a listed species change during the life of the Designated Project.*

To partially fulfill EAC condition 9 and FDS conditions 16.1, 16.2, 16.3.3, 16.3.4, 16.3.6 and 16.3.7, BC Hydro is conducting preconstruction rare plant surveys in previously unsurveyed areas of the proposed transmission line, access roads, and other construction corridors. By documenting additional occurrences of rare plants within the Project footprint, measures to mitigate effects to these occurrences—including seed recovery and translocation—can be identified.

Data collected during these pre-construction rare plant surveys are added to the Project's spatial environmental features database. These spatial data are used during detailed design and construction to identify opportunities for avoidance, areas where extra care is needed, and areas where losses will occur. The first season of pre-construction surveys was completed in the summer and fall of 2015, and the work has been proceeding every year since. This interim report documents the methods and results of the surveys completed from 2015 through the end of the 2020 field season.

1.2. Scope

The goals of the study are:

- to develop, maintain, and update a spatial database of rare plant occurrences in the vicinity of Project facilities;
- to determine the location of rare plant occurrences in previously unsurveyed areas that are proposed for ground or vegetation disturbance during construction and operation of the Project;
- to determine the location of rare plant occurrences within two mitigation parcels that will be used to compensate for project effects;
- to record detailed occurrence data in the master rare plant spatial database for all rare plant populations found, and submit these data to the B.C. Ministry of Environment and Climate Change Strategy (MOECCS) and—for taxa of federal concern—to Environment and Climate Change Canada (ECCC);
- to develop occurrence-specific mitigation measures to eliminate or reduce adverse effects to rare plant populations resulting from the Project; and
- to assist construction teams in implementing the ongoing rare plant mitigation measures.

1.3. Study Area

Pre-construction rare plant surveys are being conducted in:

- the Highway 29 realignment corridors;
- the proposed transmission line corridor;
- the proposed new or upgraded transmission line access road corridors;
- the proposed new or upgraded access road corridors into the reservoir clearing zone—excluding the reservoir footprint;
- the proposed aggregate extraction areas;
- the proposed Project Access Road corridor running from Jackfish Road to the Dam Site;
- the proposed access road extension at the Portage Mountain site;
- the 85th Avenue industrial site;
- the proposed conveyor corridor from the 85th Avenue industrial site to the dam site;
- the 204 hectare Rutledge mitigation parcel along Highway 29 at Dry Creek; and
- the 423 hectare Wilder Creek mitigation parcel located along the Peace River approximately six kilometres downstream from Bear Flat.

Pre-construction rare plant surveys were completed for some of these areas during the 2015 through 2019 field seasons. The 2020 work focussed on access roads on both sides of the Halfway River, and on the remaining segments of Highway 29 realignment corridors on the north side of the Peace River.

2. Methods

2.1. Pre-field Review

Each year in the spring the investigation begins with a pre-field review designed to collect and analyze existing data. This information is used to create a field study plan and to identify data gaps in order to direct further research.

For the purpose of the investigation, “rare plants” are defined as the following vascular plants, mosses, and lichens:

- species listed on Schedule 1 of the Canadian Species at Risk Act (SARA) as amended (Government of Canada 2002);
- species assigned a status of Extinct, Extirpated, Endangered, Threatened, or Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2020); and
- species on the B.C. MOECCS’ provincial Red or Blue lists (BCCDC 2020).

Since 2005, BC Hydro has been conducting rare plant surveys in the Project's Regional Assessment Area (RAA)—as defined in the Site C Environmental Impact Statement (Hilton et al. 2013). As such, much is known about the rare flora of the area, and the pre-field review is based heavily on rare plant occurrence data collected over the last 15 years. Currently, 26 different rare plant taxa are reported to occur in the Project area. Consequently, these 19 vascular plants, four lichens, and three mosses form the basis of the target species list for the work, comprising the rare species with the highest likelihood of occurrence.

Since 2011 all rare plant data for the Project are managed in a master rare plant spatial database. This database contains occurrence information for all known rare plant sites in the RAA, as well as rare plant survey tracks, field notes, species information, and other collected data relevant to the rare plant work. Periodically, the master rare plant spatial database is queried to update the Project's spatial environmental features database (separately maintained by BC Hydro). This environmental features database is made available to Project engineers for use in mitigation planning.

In order to identify additional rare plant species that could potentially occur in the Project area, each year the dataset of all B.C. vascular plants, mosses, and lichens is downloaded from the MOECCS' Species and Ecosystem Explorer (BCCDC 2020). Queries are run on the dataset to extract a list of the rare plant species that MOECCS associates with the Peace River Regional District and the Boreal Black and White Spruce Biogeoclimatic Zone. Each species on this list is further reviewed to determine its potential for occurrence within the areas targeted for survey.

In addition, the Conservation Data Centre's (CDC) occurrence dataset of all species and ecosystems at risk (MOECCS 2019) is downloaded from the B.C. Data Catalogue and added to the master rare plant spatial database. The dataset is queried to investigate historic and verified extant rare plant occurrences within the Project area.

All the above information is compiled to produce a list of target rare plant species potentially occurring within the Project area. This target list includes the 26 taxa currently reported to occur in the Project area, as well as numerous other possible Peace Region species uncovered during the pre-field review of data and literature. The target list is used as a working guideline and can never be an exhaustive list of all potential rare plants for a given area. For this reason, the botanists consider all described plant taxa while conducting surveys.

Aerial imagery, contour information, and project maps are reviewed to predict the habitat types present in the survey corridors. General plant communities are determined, and the locations of possible high-suitability rare plant habitat are noted.

To refine their search images for the target taxa, the surveyors study photographs, herbarium specimens, and species descriptions in various published references (Hitchcock et al. 1955; Flora of North America Editorial Committee 1993; Goward et al. 1994; McCune et al. 1995; Douglas et al. 1998; Goward 1999; Brodo et al. 2001; Cronquist et al. 2013; Brodo 2016) and online databases (Klinkenberg 2020; NatureServe 2020; CNALH 2020). In addition, they review similar data for species that might be confused with the target taxa. Tables of summary identification characteristics are prepared for field use. The goals are to maximize detectability of the target species and to reduce surveyor bias during the field work.

The final field plan each year is designed to guide the methods, coverage, and timing of the rare plant surveys. Seasonal timing is based on the predicted phenologies of the target species.

2.2. Field Survey

The pre-construction surveys began in June of 2015 and have taken place every year since. Over the six field seasons, 253 surveyor-days have been spent surveying a total transect distance of 1,435.6 kilometres (Table 1 and Figure 1).

Table 1: Rare Plant Survey Effort

Year	Start Date	End Date	Surveyor-Days	Total Survey Km
2015	June 30	September 7	42	209.8
2016	June 20	August 23	41	191.8
2017	June 23	August 12	12	51.7
2018	June 13	August 29	56	409.3
2019	May 31	August 15	46	250.7
2020	June 4	October 9	56	322.3
Totals			**253**	**1,435.6**

Table notes:

- *Surveyor-Days = days spent surveying x number of botanists*
- *Total Survey Km = total survey transect distance*

For all six years, the surveys were performed by two senior-level rare plant botanists, both of whom have been working with the rare flora of the Project area for the past 10 years. The surveyors primarily use a habitat-directed meander search protocol to cover the areas surveyed. This survey technique is based on floristic, intuitive-controlled meander search types outlined in various rare plant survey guidelines (Whiteaker et al. 1998; ANPC 2000; ANPC 2012; Penny & Klinkenberg 2012; MOECCS Ecosystems Branch 2018). The surveyors, working together or separately, walk the length of the linear corridors, zig-zagging back and forth from one edge of the proposed disturbance area to the other. For non-linear survey areas such as the Industrial 85th Avenue or Portage Mountain sites, the surveyors conduct meander transects to cover the entire area.

When using the habitat-directed meander search protocol:

- surveyors walk variable-width transects that are spaced relatively close together (typically so that the edge of the transect just surveyed is still visible to the surveyor or their partner—this distance varies based on the habitat surveyed and the detectability of the target species);
- surveyors attempt to locate all rare plant occurrences and high-suitability rare plant habitat within a defined unit in a systematic way (e.g., by walking in a zig-zag pattern along linear features, or in a contour pattern when surveying non-linear features); and

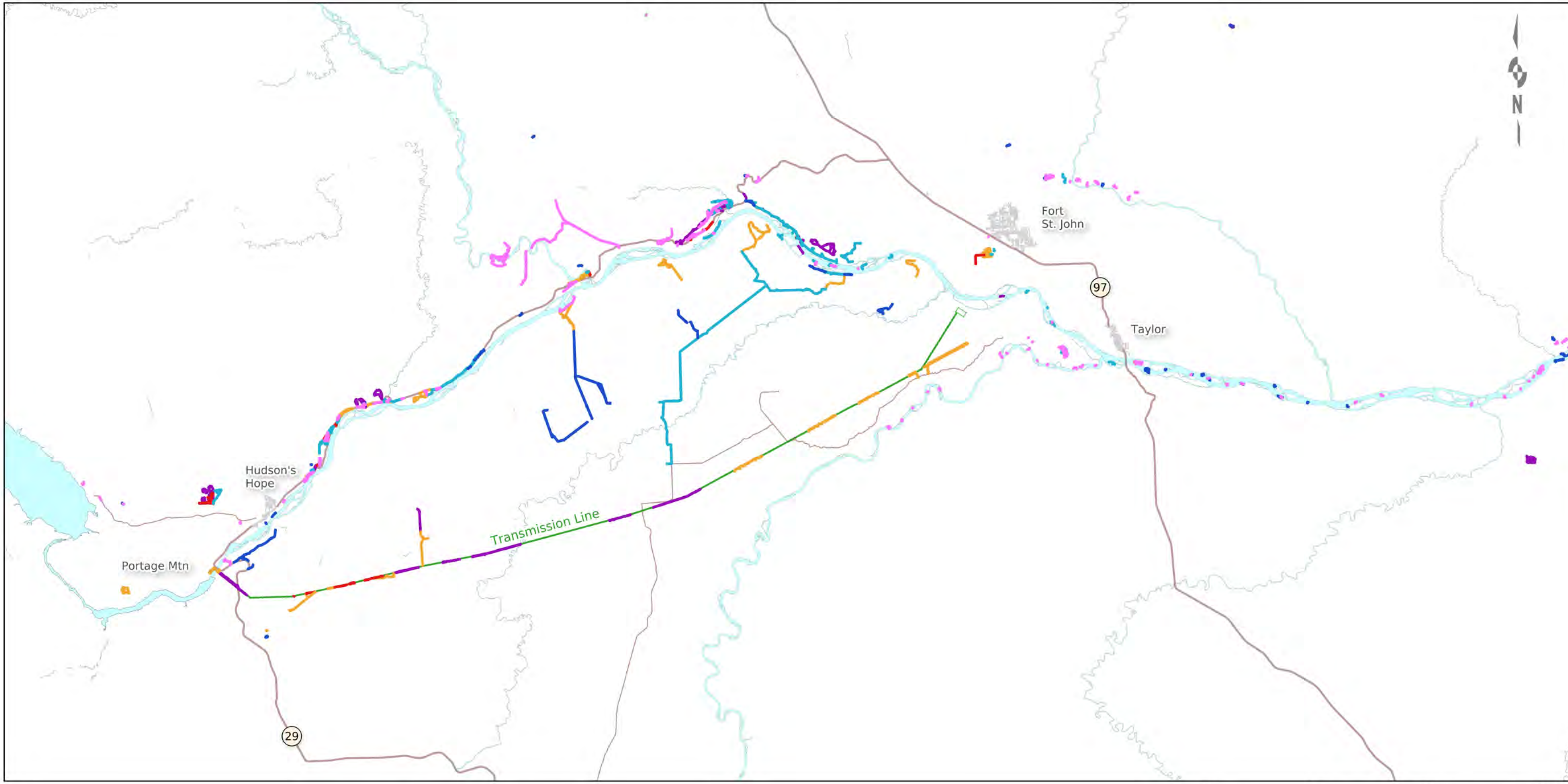
- surveyors attempt to traverse a representative cross-section of all low-suitability rare plant habitat within the unit.

The habitat-directed meander search preferentially covers high-suitability ecosystems over the more common low-suitability habitats (MacDougall & Loo 2002). The survey method is floristic in nature, meaning that all plant taxa encountered are recorded and identified to a level necessary to determine their rarity (ANPC 2012). Furthermore, the habitat-directed meander search pattern is variable-intensity, such that when a rare plant occurrence or high-suitability rare plant habitat is located, the surveyors increase the intensity of their survey by narrowing the spacing of the transect pattern they are walking. Depending on the kind of habitat being surveyed and the detectability of the target rare species, this can require very close, hands-and-knees survey work in some areas.

For certain linear corridors that traverse habitat with a low potential for rare plant occurrence, the botanists drive slowly along the corridor in a Utility Terrain Vehicle (UTV) or truck, scanning both sides for rare plants and pockets of high-suitability rare plant habitat. This procedure is only conducted in corridors where the majority of habitat is low-probability, and at a speed of approximately 5 kilometres per hour. If high-potential rare plant habitat is encountered—such as wetlands or rock outcrops—the surveyors exit the vehicle and survey the habitat on foot. In 2015, 5.1% of the total 209.8 kilometres traversed was surveyed from UTV and the rest was walked. In 2016 only 0.9% of the total 191.8 kilometres survey distance was covered by UTV. In 2017, none of the transects were surveyed by UTV. In 2018, 14.6% of the total 409.3 kilometres was covered by UTV or truck, and in 2019, 2.3% of the total 250.7 kilometers was covered by UTV. Likewise in 2020, 2.3% of the total 322.3 transect kilometres were surveyed in this way.

In 2016, surveys were conducted within the Rutledge and Wilder Creek mitigation parcels. These surveys were designed to provide a general overview of the rare plant populations present within the parcels, in order to inform mitigation planning. As such, these areas were surveyed at a lower intensity level, covering a smaller percentage of the suitable habitats than in the areas proposed for disturbance. Although the habitat-directed meander survey technique described above was used in the mitigation parcels, certain areas of suitable habitat were not covered.

During the fieldwork, the surveyors constantly monitor all areas traversed for changes in habitat and plant association, as well as for previously unrecorded plant species (common and rare). Lists are kept of all plants and plant communities observed; unknown species are collected for later identification in the lab; Global Positioning System (GPS) units are used to mark location points as appropriate; and notes and photographs are taken to record plants of interest, landforms and unique features, habitat quality and disturbance, and areas requiring further survey.



Map Location

Map Notes:

1. Based on surveys completed through October 2020.
2. Map Datum: NAD83
3. Map Projection: UTM Zone 10 N
4. Water Features Base Data from BC FreshwaterAtlas.
5. Road Base Data from the BC Digital Roads Atlas project.
6. Project-specific spatial data supplied by BC Hydro.

Legend

Roads
- Highway
- Secondary Roads
- Urban

Survey Transects
- 2015
- 2016
- 2017
- 2018
- 2019
- 2020

Map Scale 1:350000

0 10 20 30 km

SITE C CLEAN ENERGY PROJECT

BC hydro

EAGLE CAP CONSULTING environmental consulting services

Figure 1
Rare Plant Survey Routes
2015 to 2020

Date	January 15, 2021	DWG NO	2021-01-05-0001	Revision 1

When target rare plants are found during the fieldwork, occurrence information is entered into custom-built digital forms or recorded on printed CDC rare plant survey forms (BCCDC 2012). Where paper forms are used, the information is later transcribed into digital format to facilitate analysis of the sites. Photographs are taken of both the individual plants and the surrounding habitat. Consistent with the B.C. Resource Information Standards Committee guidelines and the rare plant survey guidelines on the B.C. E-Flora website a voucher specimen is collected where permitted by the landowner, and when doing so would not compromise the viability of the population (RIC 1999; Penny & Klinkenberg 2012; MOECCS Ecosystems Branch 2018). At each vascular rare plant site, GPS units are used to record the boundary of the occurrence to facilitate mitigation planning.

Delimitation of occurrences is based on *A Habitat-Based Strategy for Delimiting Plant Element Occurrences* (NatureServe 2004). The Element Occurrence (EO) is a fundamental unit of information in the CDC system, and is defined as "an area of land and/or water in which a species or natural community is, or was present." (NatureServe 2002). Based on the NatureServe guidance, rare plants are typically grouped into a single occurrence when they are located closer than one kilometre from another individual of the same species. In some cases, occurrences are composed of two or more discrete patches—also referred to as "sites" in this report—spread out over a large area. These patches are mapped separately to facilitate mitigation planning, but are recorded as a single occurrence when the patches are closer than one kilometre to each other.

The botanists conducting the 2019 and 2020 preconstruction surveys were also working on the Site C Experimental Rare Plant Translocation program at the time, selecting and documenting potential recipient sites for translocation outplanting. When new rare plant sites were found during potential recipient site selection work, they were documented using the same methods as described above. All of the new rare plant sites found during the survey work for either program are reported here to provide a single document that contains all the new rare plant sites.

2.3. Mitigation Planning and Implementation Assistance

In certain priority cases, where rare plant occurrences are situated in or near Project construction zones, the botanists work with BC Hydro planning teams and contractors to develop mitigation measures designed to reduce or eliminate impacts to the occurrences. This takes place on an as-needed basis in situations where a species is particularly difficult to identify in the field, or the layout of the occurrence is complex and difficult to map on the ground. The mitigation measures developed are focussed on avoidance or impact reduction, and include flagging occurrences in the field, coordinating with on-site construction personnel, and rare plant salvage operations.

In addition, for one Red-listed species confirmed for the project area in 2018—*Selaginella rupestris* (rock selaginella)—a set of mitigation options were developed for all known occurrences in the RAA.

2.4. Analysis

As field data are collected, they are imported into the master rare plant spatial database on a daily basis. This includes rare plant occurrence information, survey transect routes, and field notes. Collected data are encrypted and secured with multi-factor authentication protocols. The information and field photos are backed up nightly to secure off-site servers.

Following the field season, the collected rare plant information is compiled and analyzed in the Project rare plant Geographic Information System (GIS). Voucher specimens are examined and sent to outside experts when additional verification is required. New rare plant locations are compared with CDC data to determine if the newly discovered sites can be combined as extensions of previously recorded occurrences.

Every year, once the data have been compiled, verified, and cleaned, a submission package is prepared for the CDC. This dataset contains all the new rare plant occurrences found during the previous field season, as well as any updates and extensions to previously reported occurrences. The data are provided in a spatial format compatible with CDC submission requirements. Voucher specimens are prepared based on MOECCS guidelines (MOECCS 2018) and submitted to the appropriate herbarium.

The following quality assurance and quality control measures are applied to promote accurate data collection and analysis:

- The master rare plant spatial database, which contains all rare plant data for the project, is a custom-built spatial database (PostgreSQL 11.10 spatially enabled with PostGIS 2.5). The database server software is regularly updated to the latest stable versions and all security patches are applied soon after issue.
- The tables in the database have been normalized to reduce data redundancy and improve integrity.
- Primary key constraints are enforced for all relational tables to improve database integrity and allow complex queries to be run.
- Data fields are constrained at the database level to ensure type-consistency. Electronic input forms also constrain entered data to provide front-end validation and user guidance.
- Regular updates are pulled from the MOECCS' Ecosystem Explorer and are added to the master database to ensure that analyses are performed using the latest CDC rare plant statuses and nomenclature.
- The data fields *UTM northing*, *UTM easting*, and *occurrence area* are calculated programmatically from the rare plant polygons, for accuracy of the derived fields. Point data are also derived programmatically from the rare plant polygons for locational consistency between the spatial fields.

- Multipolygons—a GIS feature class that allows one or more closed plane figures to be recorded for each occurrence—are used as the basic spatial descriptor for the rare plant occurrences recorded after 2008. This allows for more precise avoidance mitigation than would be possible using single polygons or points.
- Custom-built electronic forms are used by the botanists to enter rare plant data in the field while at the occurrence. Paper versions of the forms are also used in cases where there are difficulties with the electronic entry devices. In these cases, the paper forms are transcribed onto the electronic forms as soon as possible to allow for data validation.
- Every record is reviewed for typographical and transcription errors at the end of the field season.
- Associated species lists are reviewed by a second botanist to ensure identification accuracy.
- Rare plant polygons are reviewed on aerial imagery and ecosystem layers in the GIS to check boundary accuracy by the botanist(s) who recorded the occurrence.
- Voucher specimens are collected where appropriate and verified in the lab and herbarium, or are sent to species experts for further verification when taxonomic questions still exist.

3. Results

3.1. Pre-field Review

The 2020 pre-field review identified 106 rare plant taxa with potential for occurrence in the overall Project area (Appendix 1). The list comprises 38 vascular plant species, 50 bryophytes, and 18 lichens. As noted previously, this list was used for planning purposes and was not considered to be an exhaustive listing of all possible rare plant taxa in the project area. The surveyors considered all rare taxa during the surveys, whether they were on the target list or not.

It should also be noted that the CDC regularly reviews the statuses of the plant taxa in the province to determine if new information warrants a change in the rarity rankings. As the Site C rare plant work proceeds, the numerous new occurrences that have been found during the surveys have allowed the CDC to reassess many of the plant taxa in the RAA. These reassessments are typically published by the CDC in May of the year, allowing Project botanists to incorporate the updates into the field plan for the upcoming season.

However, in 2019 the CDC status update was not published until July 5, after several weeks of field work had been completed. The update removed 10 RAA plant taxa from the Red or Blue lists, meaning that they no longer meet the definition of “rare plants” for the Project (see Section 2.1). This reduced the number of rare plant sites within the RAA by more than half, from 261 occurrences before the update, to 124 after the update.

In 2020, the CDC status updates were published in May, allowing ample time to incorporate the results into the 2020 field plan. However, the 2020 status changes were more limited than in 2019, resulting in only a few modifications to the target species list, and no changes to the statuses of species that have been observed during rare plant surveys for the Project.

3.2. Field Survey

The 2015 field surveys found 34 new sites of 14 different rare plant species—11 vascular plants and three lichens. Some of these new sites were within 1 kilometre of other occurrences of the same species found in previous years, and so were considered to be extensions of these previously reported occurrences. Of the 14 rare species, five were on the MOE's Red list, with the remaining nine being on the Blue list. None of the taxa were listed on Schedule 1 of the Species at Risk Act, or were considered to be Extinct, Extirpated, Endangered, Threatened, or Special Concern by COSEWIC (Government of Canada 2002; COSEWIC 2020). Some of the rare taxa found in 2015 have since had their statuses revised and are no longer Red- or Blue-listed by MOECCS.

In 2016, 88 new sites of 13 different rare plant species were found—10 vascular plants and three lichens. As in 2015, some of the new sites were considered to be extensions of occurrences found in previous years. Of the 13 rare species found in 2016, five were on the B.C. Red list, while the remaining eight were on the Blue list. None of the 2016 taxa were listed on Schedule 1 of the Species at Risk Act, or were considered to be Extinct, Extirpated, Endangered, Threatened, or Special Concern by COSEWIC (Government of Canada 2002; COSEWIC 2020). As with the 2015 rare plant taxa, some of the 13 rare plant species found in 2016 are no longer Red- or Blue-listed by the MOECCS.

In 2017, three new sites of two different lichen species were found. One of the sites was considered to be an extension of a previously reported occurrence, and two were new occurrences. Both taxa found in 2017 were on the B.C. Blue list, however they have both since been removed. Neither was listed on Schedule 1 of the Species at Risk Act, or was considered to be Extinct, Extirpated, Endangered, Threatened, or Special Concern by COSEWIC (Government of Canada 2002; COSEWIC 2020).

For the 2018 field season, 46 rare plant sites were found. Several of these were extensions of previously known occurrences. Fourteen different rare plant taxa were found: four B.C. Red list, and 10 Blue list. None of the 14 were listed on Schedule 1 of the Species at Risk Act, or were considered to be Extinct, Extirpated, Endangered, Threatened, or Special Concern by COSEWIC (Government of Canada 2002; COSEWIC 2020). Several of the taxa documented in 2018 have since been removed from the B.C. Red/Blue lists.

In 2019, 21 occurrences of nine rare or formerly rare taxa were found or expanded. These 21 occurrences contained 47 separate patches. One of the taxa was on the B.C. Red list, six were on the Blue list, and two were on the Yellow list (*i.e.*, apparently secure) after being revised in July 2019 when the CDC status changes were published (BCCDC 2020). None of the nine taxa was listed on Schedule 1 of the Species at Risk Act, or was considered to be Extinct, Extirpated, Endangered, Threatened, or Special Concern by COSEWIC (Government of Canada 2002; COSEWIC 2020).

During the 2020 field season, 22 rare plant occurrences (comprising 47 separate patches) were discovered or expanded. Nine rare plant species were documented: three Red-listed taxa and six

Blue-listed taxa. None of the nine species are listed on Schedule 1 of the Species at Risk Act or are considered to be Extinct, Extirpated, Endangered, Threatened, or Special Concern by COSEWIC (Government of Canada 2002; COSEWIC 2020).

In total, 159 occurrences containing 329 patches of 27 currently or formerly listed rare plant taxa were discovered or expanded during the preconstruction surveys (Table 2 and Figure 2). Over the course of the six survey years, the investigators recorded 644 vascular plant, bryophyte, and lichen taxa (Appendix 2).

Table 2: Rare plants found during the Site C Preconstruction surveys

Taxon	Common Name	Current BC List	Occurrences	Patches
Vascular Plants				
Artemisia herriotii	Herriot's Sage	Yellow	7	24
Atriplex gardneri var. gardneri	Gardner's Sagebrush	Red	2	3
Avenula hookeri	Spike-oat	Yellow	1	1
Calamagrostis montanensis	Plains Reedgrass	Yellow	5	14
Carex backii	Back's Sedge	Yellow	4	11
Carex sprengelii	Sprengel's Sedge	Blue	4	7
Carex torreyi	Torrey's Sedge	Blue	6	11
Carex xerantica	Dry-land Sedge	Blue	9	17
Castilleja miniata var. fulva	Tawny Paintbrush	Yellow	1	1
Cirsium drummondii	Drummond's Thistle	Yellow	4	13
Geum triflorum var. triflorum	Old Man's Whiskers	Yellow	7	28
Juncus stygius var. americanus	Bog Rush	Yellow	1	1
Oxytropis campestris var. davisii	Davis' Locoweed	Blue	20	30
Pedicularis parviflora	Small-flowered Lousewort	Yellow	1	2
Penstemon gracilis	Slender Penstemon	Blue	8	20
Piptatheropsis canadensis	Canada Ricegrass	Red	4	13
Polypodium sibiricum	Siberian Polypody	Yellow	1	12
Potentilla pulcherrima	Pretty Cinquefoil	Yellow	4	9
Ranunculus rhomboideus	Prairie Buttercup	Blue	7	11
Selaginella rupestris	Rock Selaginella	Red	7	10
Silene drummondii var. drummondii	Drummond's Campion	Yellow	3	3
Sphenopholis intermedia	Slender Wedgegrass	Yellow	7	13

Symphyotrichum puniceum var. puniceum	Purple-stemmed Aster	Yellow	7	7
Lichens				
Physcia biziana	Frosted rosette	Yellow	16	28
Physcia stellaris	Immaculate rosette	Yellow	8	11
Ramalina sinensis	Threadbare ribbon	Yellow	14	25
Usnea cavernosa	Pitted beard	Yellow	1	4
TOTAL			**159**	**329**

Table notes:

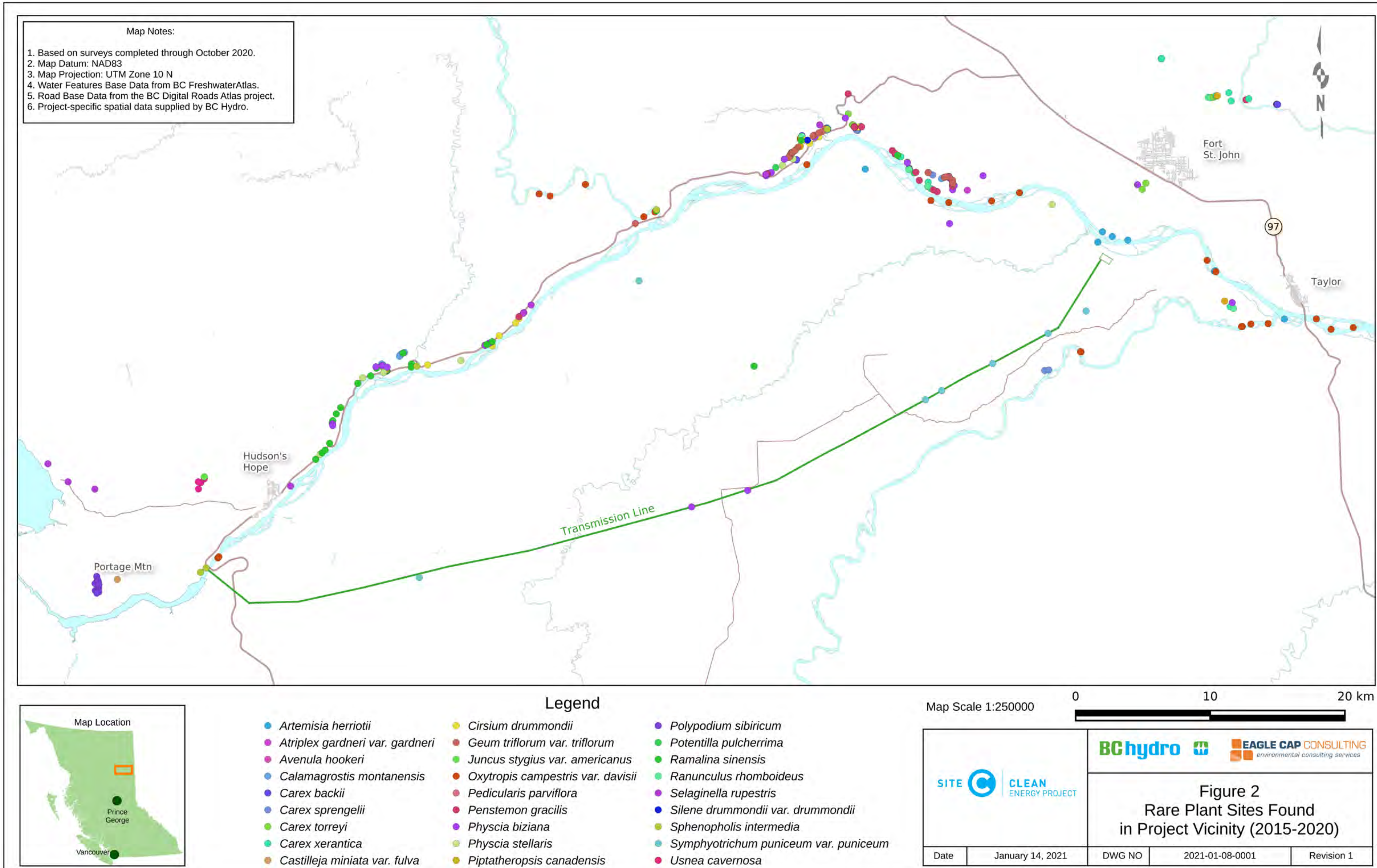
- *BC List (B.C. MOECCS): Red = Endangered, Threatened, or Extirpated; Blue = Special Concern; Yellow = Apparently Secure*
- *Occurrences: Includes newly discovered occurrences as well as occurrences expanded during the preconstruction surveys*

Many of the rare plant taxa found during the pre-construction surveys had been documented previously in other occurrences during the baseline surveys performed for the Project environmental impact assessment. Species descriptions for the nine currently rare-listed taxa recorded during the 2015–2020 preconstruction surveys are presented in Appendix 3. Each section also contains an overview of the new sites documented in 2020, and to-date summary information on all reported occurrences for each of these taxa in the RAA.

In this report all of the rare plant taxa discussed in Appendix 3 are currently Red- or Blue-listed by the CDC. For clarity, rare species found in previous years that have subsequently been removed from the Red or Blue lists are not included. Although not currently of conservation concern, the occurrence data for these taxa have been retained in the master rare plant spatial database for future reference if needed.

Information on additional taxa and occurrences documented in the RAA prior to 2015 can be found in the following references:

- Site C Project Environmental Impact Statement, Volume 2, Appendix R, Part 1 (Hilton et al. 2013);
- Report: Site C Clean Energy Project: Pre-disturbance Rare Plant Assessment #1: Rolling Work Plan 10 (Eagle Cap Consulting Ltd 2014);
- Report: Site C Clean Energy Project: Wildlife, Vegetation and Mapping Inventory for the Marl Fen Property (Simpson et al. 2014); and
- B.C. Ecosystem Explorer website (BCCDC 2020).


Map Notes:
1. Based on surveys completed through October 2020.
2. Map Datum: NAD83
3. Map Projection: UTM Zone 10 N
4. Water Features Base Data from BC FreshwaterAtlas.
5. Road Base Data from the BC Digital Roads Atlas project.
6. Project-specific spatial data supplied by BC Hydro.
Fort St. John
Taylor
97
Hudson's Hope
Portage Mtn
Transmission Line
N
Map Location
Prince George
Vancouver
Legend
Artemisia herriotii
Atriplex gardneri var. gardneri
Avenula hookeri
Calamagrostis montanensis
Carex backii
Carex sprengelii
Carex torreyi
Carex xerantica
Castilleja miniata var. fulva
Cirsium drummondii
Geum triflorum var. triflorum
Juncus stygius var. americanus
Oxytropis campestris var. davisii
Pedicularis parviflora
Penstemon gracilis
Physcia biziana
Physcia stellaris
Piptatheropsis canadensis
Polypodium sibiricum
Potentilla pulcherrima
Ramalina sinensis
Ranunculus rhomboideus
Selaginella rupestris
Silene drummondii var. drummondii
Sphenopholis intermedia
Symphyotrichum puniceum var. puniceum
Usnea cavernosa
Map Scale 1:250000
0
10
20 km
SITE C CLEAN ENERGY PROJECT
BC hydro
EAGLE CAP CONSULTING
environmental consulting services
Figure 2
Rare Plant Sites Found in Project Vicinity (2015-2020)
Date
January 14, 2021
DWG NO
2021-01-08-0001
Revision 1

3.3. Mitigation Planning and Implementation

To-date, eight priority rare plant occurrences have required specific mitigation assistance from the pre-construction rare plant survey team. In 2018, two occurrences of Red-listed species—*Piptatheropsis canadensis* (Canada ricegrass) and *Atriplex gardneri* var. *gardneri* (Gardner's sagebrush)—adjacent to access roads in the Wilder Creek area were flagged, mapped, and photographed to assist the road crews in avoiding these occurrences. The forestry contractor responsible for the area was contacted so that crews understood how the sites were flagged and the importance of avoiding them in the field. Monitoring surveys conducted in 2019 found that both sites had been substantially avoided during the road work and the viability of the occurrences had not been threatened by the activity. The Canada ricegrass occurrence had been completely avoided, and the Gardner's sagebrush occurrence had only a few individuals impacted, leaving the majority untouched.

In 2019, a priority rare plant site in the Farrell Creek East Highway 29 realignment clearing zone was identified that required additional mitigation assistance. The site contained two priority rare plant occurrences—*Selaginella rupestris* (rock selaginella) and *Penstemon gracilis* (slender penstemon)—that could be reduced or extirpated by clearing activities. Due to access restrictions, propagule salvage operations could not occur at this site until BC Hydro acquired rights to the land. In cooperation with the BC Hydro off-dam environmental planning team, a mitigation plan was developed delaying clearing activities until 2021, allowing for propagule salvage after land acquisition.

In 2020, preconstruction rare plant surveys discovered an occurrence of *Carex sprengelii* (Sprengel's sedge) in an area at Dry Creek that had been recently cleared. The overstory trees and shrubs had been cut and removed, and some ground disturbance had taken place. In the opening, four Sprengel's sedge plants were found, all of which were in late fruit. The remaining undispersed Sprengel's sedge achenes were collected and sent to NATS Nursery in Langley, B.C. to be incorporated into the Project's Experimental Rare Plant Translocation program. The four plants were left in place and will be monitored in future years.

Also in 2020, late season field work within the Cache Creek Highway Realignment construction corridor discovered another new occurrence of Canada ricegrass. Nine separate patches were found in and adjacent to the LTC (Leave to Construct) corridor. Several detailed options were developed to mitigate impacts to the patches. Because clearing in this area was scheduled for the Fall of 2020, the rare plant botanists returned to the site in early October to implement and facilitate mitigation measures for the occurrence.

One of the nine patches was in an area that had been cleared. Twelve Canada ricegrass plants were still present along the edges of the former patch—some stems were broken but the remaining base and root portions of the plants were intact. Several of the stem heads contained undispersed fruit and 27 seeds were collected. After microscope examination, nine of the seeds were found to be apparently viable, and these were sent to NATS Nursery for storage and propagation as part of the Project's Experimental Rare Plant Translocation program. The 12 plants were salvaged and directly replanted at two suitable recipient sites outside of the LTC zone. The replanting work was fully documented and these two plantings will be monitored in future years.

The remaining eight patches had not been affected by project activities. Two of these patches are well away from the LTC zone and are not expected to be affected by the Project. The other six are in areas of the LTC zone where construction activities may be able to avoid disturbing the patches. These six were clearly flagged and staked in the field to facilitate avoidance. Personnel from the construction firms were contacted so that they were aware of the rare plant sites and understood how the patches are flagged in the field. In addition, the botanists met with a representative from the Site C off-dam environmental team and visited each of the flagged patches. This occurrence will be monitored in subsequent years to determine the success of these measures and implement additional mitigation (such as salvage) if needed.

4. Discussion

4.1. Coverage

Survey coverage of the areas proposed for construction disturbance—both the linear corridors and non-linear areas—was considered sufficient to locate the majority of identifiable target rare plant species. The field crew used a habitat-directed search protocol, employing a variable-intensity survey pattern that focussed time and effort on the habitats most likely to contain rare plant occurrences. Transects were spaced so that the majority of rare plant occurrences and high-suitability rare plant habitat would have been visible during the surveys. See Section 2.2 above for a complete description of the survey methods.

For the mitigation parcels—where the goal was to provide only a general overview of the rare plant populations present—the lower intensity meander surveys sampled most of the important habitats at both parcels. Although there are likely additional rare plant occurrences to be found at the mitigation parcels, the surveys provided a general picture of the rare plant resources present.

The logistics of performing rare plant surveys in the project area present certain challenges for coverage and timing. Several of the target rare plant species have extremely limited seasonal identification periods—some can only be optimally found during a four-week-long window that may change slightly from year to year depending on the weather. In addition, access is often unsafe or impossible during substantial periods of the growing season due to severe weather events, flooding, road wash-outs, and impassible wetland conditions. These physical access limitations are particularly constraining on the plateau south of the Peace River, but can also be challenging on the north side of the river. Furthermore, landowner restrictions prevent surveyors' access to certain areas until BC Hydro is able to acquire access rights to the specific survey parcels (and often the roads that lead up to them).

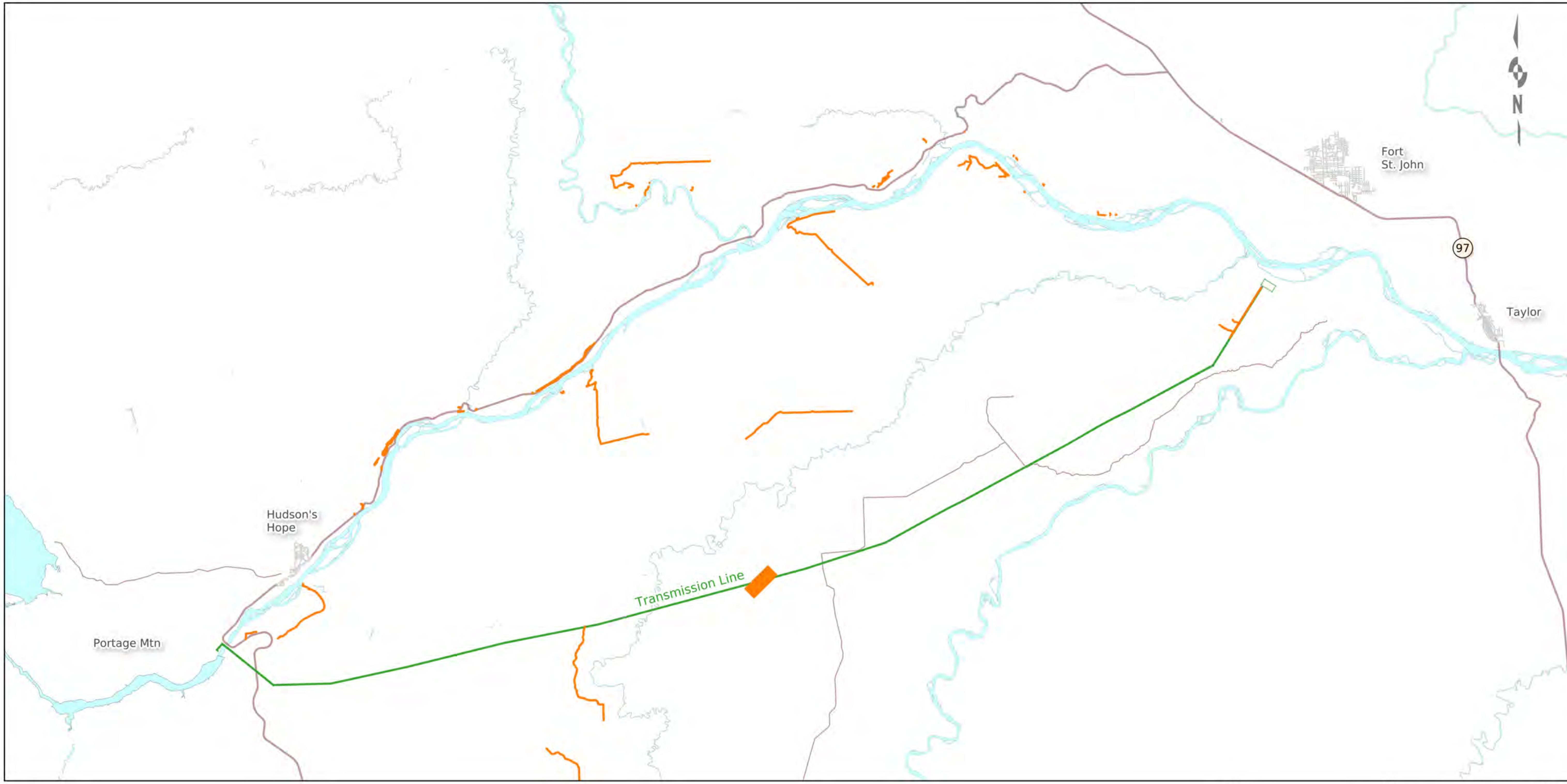
All these factors—target species identification periods, favourable weather and road conditions, legally granted access permission—must coincide for a successful survey visit. Often, repeated attempts are necessary. In a limited number of cases, it was not possible to access certain planned construction corridors at the appropriate time of year prior to clearing. Over the six years of pre-construction surveys, an estimated 695 hectares of corridor have been surveyed. Of that total, the surveyors found approximately 31.8 hectares (4.6% of the total) were cleared before they arrived. Nevertheless, these areas were surveyed using the standard methods described in Section 2.2 when rare plant habitat persisted following the clearing.

4.2. Seasonal Timing

Based on the observed phenology of the plants in the areas surveyed and data gathered during previous years' survey work, the seasonal timing of the surveys was sufficient to identify most of the target rare plants. The June and early July work typically focussed on sites north of the Peace River, where floodplain and grassland habitats make up the majority of the high-potential rare plant habitats present. Target species in these habitats often bloom early in the season, and then wither by later in the summer (although some notable exceptions have been observed, such as Canada ricegrass, which is not clearly identifiable until later in the season). The late summer and early fall surveys mainly focussed on areas south of the Peace River, where wetlands are the primary high-potential rare plant habitats. Many of these wetland-associated target rare plants bloom later in the season, and persist longer into the fall than those found in the upland areas.

4.3. Remaining Areas to Survey

At the beginning of the 2020 field season, 172.2 hectares of preconstruction corridor remained to be surveyed. Field work began on those 172.2 hectares in early June and progressed well. Over the course of the summer, BC Hydro provided updates to the project facilities spatial layers, increasing the amount of required survey corridor. This increase was primarily a result of continuing refinements to the proposed access routes, additional layout changes to the Highway 29 realignment routes, and the need to survey several aggregate extraction areas. By the end of the 2020 field season, 365.1 hectares of planned corridor and extraction areas remained to be surveyed (Figure 3). Rare plant surveys of these areas are scheduled to take place during the 2021 field season.



Map Location

Prince George

Vancouver

Map Notes:

1. Based on surveys completed through October 2020.
2. Map Datum: NAD83
3. Map Projection: UTM Zone 10 N
4. Water Features Base Data from BC FreshwaterAtlas.
5. Road Base Data from the BC Digital Roads Atlas project.
6. Project-specific spatial data supplied by BC Hydro.

Legend

Roads
- Highway
- Secondary A
- Urban

Preconstruction Corridors
- To Be Surveyed

Map Scale 1:250000

0 10 20 km

SITE C CLEAN ENERGY PROJECT

BC hydro

EAGLE CAP CONSULTING environmental consulting services

Figure 3
Remaining Preconstruction Survey Areas

Date	January 8, 2021	DWG NO	2021-01-08-0003	Revision 0

5. CLOSURE

Reviewed and approved:

<Original signed and sealed January 27, 2021 at Calgary, Alberta>

Randy Krichbaum M.Sc., R.P. Bio., P. Biol.
Senior Ecologist
Eagle Cap Consulting Ltd.

6. References

Alberta Native Plant Council (ANPC). 2000. Guidelines For Rare Plant Surveys. Edmonton, Alberta: Alberta Native Plant Council.

Alberta Native Plant Council (ANPC). 2012. ANPC Guidelines for Rare Vascular Plant Surveys in Alberta – 2012 Update. Edmonton, Alberta: Alberta Native Plant Council.

Ball PW, Reznicek AA. 2002. *Carex*. In: Flora of North America Editorial Committee, editor. Flora of North America North of Mexico. Vol. 23. New York, New York: Oxford University Press; p. 252–333.

Barkworth ME. 2007. *Piptatherum*. In: Flora of North America Editorial Committee, editor. Flora of North America North of Mexico. Vol. 24. New York, New York: Oxford University Press.

BC Conservation Data Centre (BCCDC). 2012. Field survey form (plants) [Internet]. [cited 2017 Jan 1]. Available from: http://www.env.gov.bc.ca/cdc/contribute.html

BC Conservation Data Centre (BCCDC). 2020. BC Species and Ecosystems Explorer [Internet]. [cited 2020 Jun 1]. Available from: http://a100.gov.bc.ca/pub/eswp

BC Environmental Assessment Office. 2014. Environmental Assessment Certificate #E14-02: Site C Clean Energy Project. Victoria, BC: BC Environmental Assessment Office.

Brodo IM. 2016. Keys to Lichens of North America: Revised and Expanded. New Haven, Connecticut, USA: Yale University Press.

Brodo IM, Sharnoff SD, Sharnoff S. 2001. Lichens of North America. New Haven, Connecticut, USA: Yale University Press.

Canadian Environmental Assessment Agency. 2014. Decision Statement Issued under Section 54 of the Canadian Environmental Assessment Act, 2012, for the Site C Clean Energy Project. Ottawa, Ontario: Canadian Environmental Assessment Agency.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2020. Species at Risk Public Registry [Internet]. [cited 2020 May 31]. Available from: http://www.registrelep-sararegistry.gc.ca/sar/index/default_e.cfm

Consortium of North American Lichen Herbaria (CNALH). 2020. CNALH Data Portal [Internet]. [cited 2020 Sep 23]. Available from: http://lichenportal.org/portal/index.php

Cronquist A, Holmgren AH, Holmgren NH, Reveal JL, Holmgren PK. 2013. Intermountain flora: vascular plants of the Intermountain West, USA: Volumes One through Seven. New York, New York: NYBG Press.

Douglas GW, Straley GB, Meidinger DV, Pojar J, editors. 1998. Illustrated flora of British Columbia: 8 volume set. Victoria, BC: British Columbia, Ministry of Environment, Lands and Parks.

Eagle Cap Consulting Ltd. 2014. Site C Clean Energy Project: Pre-disturbance Rare Plant Assessment #1: Rolling Work Plan 10. Vancouver, BC: BC Hydro.

Elisens WJ, Packer JG. 1980. A contribution to the taxonomy of the *Oxytropis campestris* complex in northwestern North America. Can J Bot. 58:1820–1831.

Flora of North America Editorial Committee, editor. 1993. Flora of North America North of Mexico. New York, New York: Oxford University Press.

Freeman CC, Rabeler RK. 2016. *Plantaginaceae*. Flora of North America North of Mexico [Internet]. [cited 2016 Nov 30]. Available from: http://floranorthamerica.org/Review/under-prod-17

Government of Canada. 2002. Species at Risk Act [as amended through May 14, 2012]. SC 2002, c 29. Ottawa, Ontario, Canada: Government of Canada.

Goward T. 1999. The Lichens of British Columbia: Part 2: Fruticose Species. Victoria, British Columbia: BC Ministry of Forests, Research Branch.

Goward T, McCune B, Meidinger D. 1994. The Lichens of British Columbia: Part 1: Foliose and Squamulose Species. Victoria, British Columbia: BC Ministry of Forests, Research Branch.

Gray A, Fernald ML. 1950. Gray's manual of botany: a handbook of the flowering plants and ferns of the central and northeastern United States and adjacent Canada. 8th ed. Portland, Oregon: Dioscorides Press.

Hilton S, Andrusiak L, Krichbaum RS, Björk CR. 2013. Site C Clean Energy Project: Environmental Impact Statement: Volume 2: Appendix R: Terrestrial Vegetation and Wildlife Report, Part 1: Vegetation and Ecological Communities (amended). Vancouver, BC: BC Hydro.

Hitchcock CL, Cronquist A, Ownbey M, Thompson JW. 1955. Vascular plants of the Pacific Northwest. Seattle, Washington: University of Washington Press.

Hitchcock CL, Cronquist A, Ownbey M, Thompson JW. 1959. Vascular plants of the Pacific Northwest: Part 4: Ericaceae through Campanulaceae. Seattle, Washington: University of Washington Press.

Klinkenberg B. 2020. E-Flora BC: Electronic Atlas of the Plants of British Columbia [Internet]. [cited 2020 Nov 10]. Available from: http://eflora.bc.ca

Lapin M. 2004. *Piptatherum canadense* (Poiret) Dorn (Canada Ricegrass) Conservation and Research Plan for New England. Framingham, Massachusetts, USA: New England Wild Flower Society.

MacDougall AS, Loo JA. 2002. Predicting occurrences of geographically restricted rare floral elements with qualitative habitat data. Canadian Forest Service Environmental Reviews. 10:167–190.

McCune B, Goward T, Mikulin AG, Stone DF, Taylor L. 1995. Macrolichens of the northern Rocky Mountains. Eureka, California: Mad River Press.

Ministry of Environment and Climate Change Strategy (MOECCS). 2019. Dataset of Species and Ecosystems at Risk - Publicly Available Occurrences - CDC. Victoria, BC: Government of British Columbia.

Ministry of Environment and Climate Change Strategy (MOECCS) Ecosystems Branch. 2018. Inventory and Survey Methods for Rare Plants and Lichens. Victoria, BC: Resources Information Standards Committee.

Moss EH, Packer JG. 1983. Flora of Alberta: a manual of flowering plants, conifers, ferns and fern allies found growing without cultivation in the province of Alberta, Canada. Toronto, Ontario: University of Toronto Press.

NatureServe. 2002. Element Occurrence Data Standard. Arlington, Virginia.

NatureServe. 2004. A Habitat-Based Strategy for Delimiting Plant Element Occurrences: Guidance from the 2004 Working Group. Arlington, Virginia: Natureserve.

NatureServe. 2020. NatureServe Explorer: An online encyclopedia of life: Version 7.1 [Internet]. [cited 2020 Nov 10]. Available from: http://explorer.natureserve.org/

Penny J, Klinkenberg R. 2012. Rare plant inventory methods [Internet]. [cited 2017 Dec 26]. Available from: http://www.geog.ubc.ca/biodiversity/eflora/ProtocolsforRarePlantSurveys.html

Resources Inventory Committee (RIC). 1999. Voucher Specimen Collection, Preparation, Identification and Storage Protocol: Plants & Fungi: Standards for components of British Columbia's biodiversity No. 4b. Victoria, British Columbia: Government of British Columbia.

Romaschenko K, Peterson PM, Soreng RJ, Futorna O, Susanna A. 2011. Phylogenetics of *Piptatherum* s.l. (Poaceae: Stipeae): Evidence for a new genus, *Piptatheropsis*, and resurrection of *Patis*. Taxon. 60:1703–1716.

Simpson L, Churchland C, Jones T, Simpson TK. 2014. Site C Clean Energy Project: Wildlife, Vegetation and Mapping Inventory for the Marl Fen Property. Vancouver, BC: BC Hydro.

Valdespino IA. 1993. *Selaginella*. In: Flora of North America Editorial Committee, editor. Flora of North America North of Mexico. Vol. 2. New York, New York: Oxford University Press.

Welsh SL. 1991. *Oxytropis* DC. - Names, basionyms, types, and synonyms - Flora North America Project. Great Basin Naturalist. 51:377–396.

Welsh SL. 2003. *Atriplex*. In: Flora of North America Editorial Committee, editor. Flora of North America North of Mexico. Vol. 4. New York, New York: Oxford University Press.

Whiteaker L, Henderson J, Holmes R, Hoover L, Lesher R, Lippert J, Olson E, Potash L, Seevers J, Stein M, Wogen N. 1998. Survey Protocols for Survey & Manage Strategy 2 Vascular Plants: V 2.0. Oregon: US Bureau of Land Management.

Whittemore AT, Parfitt BD. 1997. *Ranunculus*. In: Flora of North America Editorial Committee, editor. Flora of North America North of Mexico. Vol. 3. New York and Oxford.

7. APPENDICES

7.1. Appendix 1: Rare plant taxa with potential for occurrence in the Site C Project area

Scientific Name	Common Name	BC List	COSEWIC	SARA
VASCULAR PLANTS				
Acorus americanus	American Sweet-flag	Blue		
Alopecurus magellanicus	Alpine Meadow-foxtail	Red		
Arctophila fulva	Pendantgrass	Blue		
Artemisia alaskana	Alaskan Sagebrush	Blue		
Atriplex gardneri var. gardneri	Gardner's Sagebrush	Red		
Botrychium montanum	Mountain Moonwort	Blue		
Botrychium paradoxum	Two-spiked Moonwort	Blue		
Carex bicolor	Two-coloured Sedge	Blue		
Carex lapponica	Lapland Sedge	Blue		
Carex sprengelii	Sprengel's Sedge	Blue		
Carex torreyi	Torrey's Sedge	Blue		
Carex xerantica	Dry-land Sedge	Blue		
Drosera linearis	Slender-leaf Sundew	Blue		
Epilobium saximontanum	Rocky Mountain Willowherb	Blue		
Lomatium foeniculaceum var. foeniculaceum	Fennel-leaved Desert-parsley	Blue		
Oxytropis campestris var. davisii	Davis' Locoweed	Blue		
Packera ogotorukensis	Ogotoruk Creek Butterweed	Red		
Penstemon gormanii	Gorman's Penstemon	Blue		
Penstemon gracilis	Slender Penstemon	Blue		
Piptatheropsis canadensis	Canada Ricegrass	Red		
Polemonium boreale	Northern Jacob's-ladder	Blue		
Polygala senega	Seneca-snakeroot	Red		
Polygonum ramosissimum ssp. prolificum	Proliferous Knotweed	Red		
Potentilla furcata	Forked Cinquefoil	Red		
Prenanthes racemosa	Purple Rattlesnake-root	Red		
Ranunculus cardiophyllus	Heart-leaved Buttercup	Red		
Ranunculus rhomboideus	Prairie Buttercup	Blue		
Rosa arkansana	Arkansas Rose	Blue		
Salix petiolaris	Meadow Willow	Blue		
Salix raupii	Raup's Willow	Red		

Sarracenia purpurea ssp. purpurea	Common Pitcher-plant	Red		
Saussurea angustifolia var. angustifolia	Northern Sawwort	Red		
Selaginella rupestris	Rock Selaginella	Red		
Silene repens	Pink Campion	Blue		
Symphyotrichum falcatum var. commutatum	White Prairie Aster	Red		
Tephroseris palustris	Marsh Fleabane	Blue		
Thalictrum dasycarpum	Purple Meadowrue	Blue		
Utricularia ochroleuca	Ochroleucous Bladderwort	Blue		
BRYOPHYTES				
Acaulon muticum var. rufescens	[no common name]	Red		
Amblyodon dealbatus	[no common name]	Blue		
Atrichum tenellum	[no common name]	Red		
Aulacomnium acuminatum	[no common name]	Blue		
Barbula convoluta var. gallinula	[no common name]	Red		
Bartramia halleriana	Haller's Apple Moss	Red	T (Nov 2011)	1-T (Jun 2003)
Brachythecium trachypodium	[no common name]	Blue		
Bryobrittonia longipes	[no common name]	Blue		
Bryum uliginosum	[no common name]	Blue		
Cynodontium glaucescens	[no common name]	Blue		
Dicranum majus var. orthophyllum	[no common name]	Red		
Didymodon rigidulus var. icmadophilus	[no common name]	Blue		
Didymodon subandreaeoides	[no common name]	Red		
Encalypta brevicollis	[no common name]	Blue		
Encalypta intermedia	[no common name]	Blue		
Encalypta longicolla	[no common name]	Blue		
Encalypta mutica	[no common name]	Blue		
Encalypta spathulata	[no common name]	Blue		
Grimmia teretinervis	[no common name]	Red		
Haplodontium macrocarpum	Porsild's Bryum	Red	T (Dec 2017)	1-T (Feb 2011)
Hygrohypnum alpestre	[no common name]	Blue		
Hygrohypnum alpinum	[no common name]	Blue		
Lescuraea saxicola	[no common name]	Blue		
Meesia longiseta	[no common name]	Blue		
Myurella sibirica	[no common name]	Red		
Orthothecium strictum	[no common name]	Blue		

Philonotis yezoana	[no common name]	Blue		
Plagiobryum demissum	[no common name]	Red		
Pohlia bulbifera	[no common name]	Blue		
Pseudocalliergon turgescens	[no common name]	Blue		
Schistidium boreale	[no common name]	Blue		
Schistidium confertum	[no common name]	Red		
Schistidium pulchrum	[no common name]	Blue		
Schistidium robustum	[no common name]	Blue		
Schistidium trichodon	[no common name]	Blue		
Seligeria subimmersa	[no common name]	Red		
Seligeria tristichoides	[no common name]	Blue		
Sphagnum balticum	[no common name]	Blue		
Sphagnum contortum	[no common name]	Blue		
Sphagnum wulfianum	[no common name]	Blue		
Splachnum vasculosum	[no common name]	Blue		
Tayloria froelichiana	[no common name]	Blue		
Tayloria splachnoides	[no common name]	Red		
Tetraplodon urceolatus	[no common name]	Red		
Timmia norvegica	[no common name]	Blue		
Timmia sibirica	[no common name]	Red		
Tortella humilis	[no common name]	Red		
Trichostomum crispulum	[no common name]	Blue		
Warnstorfia pseudostraminea	[no common name]	Blue		
Weissia brachycarpa	[no common name]	Blue		
LICHENS				
Anaptychia crinalis	Electrified millepede	Red		
Anaptychia ulotrichoides	Amputated millepede	Blue		
Cladonia parasitica	Fence-rail pixie	Red		
Collema bachmanianum	Caesar's tarpaper	Blue		
Collema coniophilum	Crumpled tarpaper	Red	T (Nov 2010)	1-T (Feb 2017)
Fulgensia desertorum	Desert sulphur	Blue		
Fulgensia subbracteata	Creeping Sulphur	Blue		
Heterodermia speciosa	Smiling centipede	Red		
Leptogium schraderi	Collapsing vinyl	Red		
Phaeophyscia adiastola	Granulating shadow	Blue		
Phaeophyscia hispidula	Whiskered shadow	Red		

Physcia dimidiata	Exuberant rosette	Blue		
Physcia tribacia	Beaded rosette	Red		
Physciella chloantha	Downside shade	Blue		
Squamarina cartilaginea	Pea-green dimple	Red		
Squamarina lentigera	Snow-white dimple	Red		
Thyrea confusa	Candied gummybear	Blue		
Xanthoparmelia camtschadalis	Rockfrog	Red		

Table notes:

- *B.C. List (B.C. Ministry of Environment): Red = Endangered, Threatened, or Extirpated; Blue = Special Concern*
- *COSEWIC (Committee on the Status of Endangered Wildlife in Canada): E = Endangered; T = Threatened; SC = Special Concern; DD = Data Deficient*
- *SARA (Species at Risk Act): 1-E = Schedule 1 Endangered; 1-T = Schedule 1 Threatened; 1-SC = Schedule 1 Special Concern*

7.2. Appendix 2: Plant and lichen species recorded during the 2015–2020 surveys

Vascular Plants

Acer glabrum var. douglasii
Acer negundo
Achillea alpina
Achillea borealis
Achillea millefolium var. lanulosa
Achnatherum nelsonii ssp. dorei
Achnatherum richardsonii
Aconitum delphiniifolium
Actaea rubra
Agropyron cristatum ssp. pectinatum
Agrostis capillaris
Agrostis exarata
Agrostis gigantea
Agrostis scabra
Alisma triviale
Allium cernuum
Allium cernuum var. cernuum
Allium schoenoprasum var. sibiricum
Alnus incana ssp. tenuifolia
Alnus viridis ssp. crispa
Alnus viridis ssp. sinuata
Alopecurus aequalis
Alopecurus pratensis
Amelanchier alnifolia
Amerorchis rotundifolia
Anaphalis margaritacea
Androsace septentrionalis
Anemone cylindrica
Anemone multifida var. multifida
Anemone patens ssp. multifida
Anemone virginiana var. cylindroidea
Angelica genuflexa
Antennaria howellii ssp. canadensis
Antennaria howellii ssp. petaloidea
Antennaria microphylla
Antennaria neglecta
Antennaria parvifolia
Antennaria pulcherrima ssp. pulcherrima
Antennaria racemosa
Antennaria rosea
Anthoxanthum hirtum
Apocynum androsaemifolium
Apocynum androsaemifolium var. androsaemifolium
Aquilegia brevistyla
Aralia nudicaulis
Arctium minus
Arctium sp.
Arctostaphylos uva-ursi
Arnica chamissonis
Arnica cordifolia
Artemisia biennis
Artemisia campestris ssp. pacifica
Artemisia dracunculus
Artemisia frigida
Artemisia herriotii
Askellia elegans
Asparagus officinalis
Astragalus agrestis
Astragalus alpinus var. alpinus
Astragalus americanus
Astragalus australis
Astragalus canadensis
Astragalus cicer
Astragalus eucosmus
Astragalus laxmannii var. robustior
Astragalus tenellus
Athyrium filix-femina ssp. cyclosorum
Atriplex gardneri var. gardneri
Avena sativa
Avenula hookeri
Axyris amaranthoides
Beckmannia syzigachne
Betula neoalaskana
Betula papyrifera
Betula pumila
Betula pumila var. glandulifera
Bidens cernua
Blitum capitatum
Boechera divaricarpa
Boechera grahamii
Boechera pendulocarpa
Boechera retrofracta
Boechera stricta
Botrypus virginianus
Brassica rapa var. rapa
Bromus ciliatus
Bromus inermis
Bromus pumpellianus ssp. pumpellianus
Calamagrostis canadensis
Calamagrostis canadensis var. langsdorfii
Calamagrostis montanensis
Calamagrostis purpurascens var. purpurascens

Calamagrostis stricta ssp. inexpansa
Calla palustris
Callitriche palustris
Caltha natans
Campanula rotundifolia
Capsella bursa-pastoris
Caragana arborescens
Cardamine oligosperma var. oligosperma
Carex aquatilis
Carex aquatilis var. aquatilis
Carex arcta
Carex atherodes
Carex atratiformis
Carex aurea
Carex backii
Carex bebbii
Carex brunnescens
Carex brunnescens ssp. brunnescens
Carex canescens ssp. canescens
Carex capillaris
Carex chordorrhiza
Carex concinna
Carex crawfordii
Carex cusickii
Carex deweyana var. deweyana
Carex diandra
Carex disperma
Carex duriuscula
Carex eburnea
Carex filifolia
Carex foenea
Carex gynocrates
Carex inops ssp. heliophila
Carex interior
Carex lasiocarpa
Carex limosa
Carex livida var. radicaulis
Carex magellanica ssp. irrigua
Carex microptera
Carex obtusata
Carex peckii
Carex pellita
Carex praticola
Carex retrorsa
Carex richardsonii
Carex rossii
Carex sartwellii
Carex siccata
Carex sprengelii
Carex tenera
Carex tenuiflora
Carex torreyi
Carex utriculata
Carex vaginata
Carex viridula ssp. viridula
Carex xerantica
Castilleja miniata
Castilleja miniata var. fulva
Centaurea stoebe ssp. micranthos
Cerastium arvense
Cerastium fontanum
Cerastium nutans
Chamerion angustifolium
Chenopodiastrum simplex
Chenopodium album
Chenopodium album ssp. album
Chenopodium album ssp. striatum
Chenopodium desiccatum
Chenopodium pratericola
Chrysosplenium tetrandrum
Cicuta bulbifera
Cicuta douglasii
Cicuta virosa
Cinna latifolia
Circaea alpina ssp. alpina
Cirsium arvense
Cirsium drummondii
Cirsium foliosum
Cirsium vulgare
Clematis occidentalis ssp. grosseserrata
Coeloglossum viride var. virescens
Collomia linearis
Comandra umbellata
Comandra umbellata var. umbellata
Comarum palustre
Conyza canadensis
Corallorhiza maculata
Corallorhiza striata var. striata
Corallorhiza trifida
Cornus canadensis
Cornus stolonifera
Corydalis aurea ssp. aurea
Corylus cornuta
Crepis tectorum

Cypripedium passerinum
Cystopteris fragilis
Dactylis glomerata
Dactylorhiza viridis
Danthonia intermedia ssp. intermedia
Danthonia spicata
Dasiphora fruticosa
Delphinium glaucum
Deschampsia cespitosa ssp. cespitosa
Descurainia sophia
Diphasiastrum complanatum
Dracocephalum parviflorum
Drosera linearis
Drosera rotundifolia
Drosera rotundifolia var. rotundifolia
Dryas drummondii
Drymocallis convallaria
Dryopteris carthusiana
Dryopteris expansa
Elaeagnus commutata
Eleocharis mamillata ssp. mamillata
Eleocharis palustris
Elymus canadensis
Elymus glaucus
Elymus glaucus ssp. glaucus
Elymus lanceolatus ssp. lanceolatus
Elymus repens
Elymus trachycaulus
Elymus trachycaulus ssp. subsecundus
Elymus trachycaulus ssp. trachycaulus
Epilobium angustifolium
Epilobium ciliatum
Epilobium ciliatum ssp. ciliatum
Epilobium ciliatum ssp. glandulosum
Epilobium halleanum
Epilobium hornemannii ssp. hornemannii
Epilobium palustre
Equisetum arvense
Equisetum fluviatile
Equisetum hyemale
Equisetum hyemale ssp. affine
Equisetum laevigatum
Equisetum palustre
Equisetum pratense
Equisetum scirpoides
Equisetum sylvaticum
Equisetum variegatum ssp. variegatum
Erigeron caespitosus
Erigeron glabellus var. pubescens
Erigeron philadelphicus
Erigeron philadelphicus var. philadelphicus
Eriophorum angustifolium
Eriophorum chamissonis
Eriophorum gracile
Eriophorum sp.
Eriophorum viridicarinatum
Erysimum cheiranthoides
Euphrasia nemorosa
Euphrasia subarctica
Eurybia conspicua
Eurybia sibirica
Fallopia convolvulus
Festuca rubra ssp. rubra
Festuca saximontana
Festuca trachyphylla
Fragaria vesca var. bracteata
Fragaria virginiana
Fragaria virginiana var. platypetala
Galearis rotundifolia
Galeopsis bifida
Galium boreale
Galium labradoricum
Galium trifidum
Galium trifidum ssp. trifidum
Galium triflorum
Gentianella amarella ssp. acuta
Geocaulon lividum
Geranium bicknellii
Geum aleppicum
Geum macrophyllum
Geum macrophyllum ssp. macrophyllum
Geum macrophyllum var. perincisum
Geum triflorum
Geum triflorum var. triflorum
Glyceria borealis
Glyceria grandis var. grandis
Glyceria striata
Gnaphalium uliginosum
Goodyera repens
Grindelia squarrosa var. quasiperennis
Gymnocarpium dryopteris
Halenia deflexa ssp. deflexa
Halerpestes cymbalaria
Hedysarum alpinum

Hedysarum boreale
Heracleum maximum
Hesperostipa comata ssp. comata
Hesperostipa curtiseta
Heuchera richardsonii
Hieracium aurantiacum
Hieracium canadense
Hieracium umbellatum ssp. umbellatum
Hierochloë hirta ssp. arctica
Hippuris vulgaris
Hordeum jubatum ssp. jubatum
Hypopitys monotropa
Impatiens noli-tangere
Juncus alpinoarticulatus ssp. americanus
Juncus balticus ssp. ater
Juncus bufonius
Juncus dudleyi
Juncus nodosus
Juncus stygius ssp. americanus
Juncus vaseyi
Juniperus communis
Koeleria macrantha
Lactuca serriola
Lappula occidentalis var. occidentalis
Lappula squarrosa
Larix laricina
Lathyrus ochroleucus
Lemna minor
Lepidium densiflorum
Leucanthemum vulgare
Leymus cinereus
Leymus innovatus ssp. innovatus
Limosella aquatica
Linaria genistifolia ssp. dalmatica
Linaria vulgaris
Linnaea borealis
Linum lewisii ssp. lewisii
Listera borealis
Listera cordata
Lithospermum incisum
Lonicera dioica var. glaucescens
Lonicera involucrata
Lotus corniculatus
Lycopodium dendroideum
Madia glomerata
Maianthemum canadense
Maianthemum racemosum ssp. amplexicaule
Maianthemum stellatum
Maianthemum trifolium
Matricaria discoidea
Medicago lupulina
Medicago sativa
Medicago sativa ssp. falcata
Melampyrum lineare var. lineare
Melica smithii
Melilotus albus
Melilotus officinalis
Mentha arvensis
Menyanthes trifoliata
Mertensia paniculata var. paniculata
Mitella nuda
Moehringia lateriflora
Monarda fistulosa var. menthaefolia
Moneses uniflora
Monotropa uniflora
Muhlenbergia glomerata
Mulgedium pulchellum
Myriophyllum sibiricum
Nassella viridula
Neslia paniculata
Nuphar sp.
Oplopanax horridus
Opuntia fragilis
Orobanche fasciculata
Orthilia secunda
Orthilia secunda var. secunda
Orthocarpus luteus
Oryzopsis asperifolia
Osmorhiza berteroi
Osmorhiza sp.
Oxybasis glauca
Oxytropis campestris var. davisii
Oxytropis deflexa var. sericea
Oxytropis sericea var. speciosa
Oxytropis splendens
Packera paupercula
Packera plattensis
Packera streptanthifolia
Parnassia palustris
Pascopyrum smithii
Pedicularis groenlandica
Pedicularis labradorica
Pedicularis parviflora
Penstemon gracilis

Penstemon procerus var. procerus
Persicaria amphibia
Persicaria amphibia var. emersa
Persicaria amphibia var. stipulacea
Persicaria hydropiper
Persicaria lapathifolia
Persicaria sp.
Petasites frigidus var. palmatus
Petasites frigidus var. sagittatus
Phalaris arundinacea var. arundinacea
Phleum pratense ssp. pratense
Picea glauca
Picea mariana
Pinus contorta var. latifolia
Piptatheropsis canadensis
Piptatheropsis pungens
Piptatherum pungens
Plantago major
Platanthera aquilonis
Platanthera huronensis
Platanthera obtusata ssp. obtusata
Platanthera orbiculata
Platanthera sp.
Poa alpina ssp. alpina
Poa compressa
Poa glauca
Poa glauca ssp. glauca
Poa nemoralis ssp. interior
Poa palustris
Poa pratensis
Poa pratensis ssp. pratensis
Poa secunda
Polygonum achoreum
Polygonum aviculare
Polygonum douglasii
Polygonum fowleri
Polygonum ramosissimum
Polypodium sibiricum
Populus balsamifera
Populus tremuloides
Potamogeton alpinus
Potamogeton gramineus
Potamogeton pusillus ssp. tenuissimus
Potentilla anserina
Potentilla gracilis var. fastigiata
Potentilla hippiana
Potentilla norvegica
Potentilla pensylvanica
Potentilla pensylvanica var. pensylvanica
Potentilla pulcherrima
Prosartes trachycarpa
Prunus pensylvanica
Prunus virginiana ssp. melanocarpa
Prunus virginiana var. demissa
Pseudoroegneria spicata
Puccinellia distans
Puccinellia nuttalliana
Pulsatilla nuttalliana
Pyrola asarifolia
Pyrola chlorantha
Pyrola minor
Ranunculus acris
Ranunculus aquatilis var. aquatilis
Ranunculus aquatilis var. diffusus
Ranunculus cymbalaria
Ranunculus gmelinii
Ranunculus macounii
Ranunculus rhomboideus
Ranunculus sceleratus
Ranunculus sceleratus var. multifidus
Rhinanthus minor
Rhododendron groenlandicum
Ribes hudsonianum var. hudsonianum
Ribes lacustre
Ribes oxyacanthoides ssp. oxyacanthoides
Rorippa palustris
Rorippa palustris ssp. palustris
Rosa acicularis ssp. sayi
Rosa woodsii ssp. woodsii
Rubus arcticus ssp. acaulis
Rubus chamaemorus
Rubus idaeus ssp. strigosus
Rubus parviflorus var. parviflorus
Rubus pedatus
Rubus pubescens
Rumex britannica
Rumex crispus
Rumex fueginus
Rumex occidentalis
Rumex triangulivalvis
Salix arbusculoides
Salix bebbiana
Salix candida
Salix discolor

Salix drummondiana
Salix interior
Salix lasiandra var. lasiandra
Salix maccalliana
Salix myrtillifolia
Salix pedicellaris
Salix planifolia
Salix prolixa
Salix pseudomonticola
Salix pseudomyrsinites
Salix pyrifolia
Salix scouleriana
Salix serissima
Salsola tragus
Sanicula marilandica
Saxifraga tricuspidata
Schizachne purpurascens
Schoenoplectus tabernaemontani
Scirpus microcarpus
Scutellaria galericulata
Selaginella rupestris
Senecio eremophilus var. eremophilus
Senecio vulgaris
Shepherdia canadensis
Silene drummondii var. drummondii
Silene latifolia
Sisymbrium altissimum
Sisyrinchium montanum var. montanum
Sium suave
Solidago altissima ssp. gilvocanescens
Solidago bellidifolia
Solidago glutinosa
Solidago lepida var. lepida
Solidago lepida var. salebrosa
Solidago multiradiata
Solidago simplex var. simplex
Sonchus arvensis
Sonchus arvensis ssp. uliginosus
Sorbus scopulina var. scopulina
Sparganium emersum
Sparganium natans
Sparganium sp.
Sphenopholis intermedia
Spiraea betulifolia ssp. lucida
Spiraea lucida
Spiranthes romanzoffiana
Stachys palustris ssp. pilosa
Stellaria borealis
Stellaria borealis ssp. borealis
Stellaria longifolia
Stellaria longipes var. longipes
Stellaria media
Stuckenia pectinata
Symphoricarpos albus
Symphoricarpos occidentalis
Symphyotrichum boreale
Symphyotrichum ciliolatum
Symphyotrichum ericoides var. pansum
Symphyotrichum laeve var. geyeri
Symphyotrichum lanceolatum var. hesperium
Symphyotrichum puniceum var. puniceum
Tanacetum vulgare
Taraxacum officinale
Thalictrum venulosum
Thinopyrum intermedium
Thlaspi arvense
Tofieldia pusilla
Tragopogon dubius
Triantha glutinosa
Trifolium hybridum
Trifolium pratense
Trifolium repens
Triglochin maritima
Triglochin palustris
Tripleurospermum inodorum
Triticum aestivum
Turritis glabra
Typha latifolia
Urtica dioica ssp. gracilis
Utricularia intermedia
Vaccinium caespitosum
Vaccinium membranaceum
Vaccinium myrtilloides
Vaccinium oxycoccos
Vaccinium vitis-idaea ssp. minus
Valeriana dioica ssp. sylvatica
Verbascum thapsus
Veronica beccabunga ssp. americana
Veronica peregrina var. xalapensis
Veronica scutellata
Viburnum edule
Vicia americana
Viola adunca var. adunca
Viola canadensis var. rugulosa

Woodsia scopulina
Zizia aptera
Bryophytes
Aulacomnium palustre
Ceratodon purpureus
Funaria hygrometrica
Hylocomium splendens
Marchantia polymorpha
Pleurozium schreberi
Polytrichum commune
Preissia quadrata
Ptilium crista-castrensis
Sphagnum magellanicum
Sphagnum sp.
Lichens
Bryoria capillaris
Bryoria fuscescens
Bryoria lanestris
Bryoria sp.
Caloplaca cerina
Caloplaca holocarpa
Cetraria ericetorum
Cladina rangiferina
Cladina sp.
Cladonia carneola
Cladonia pocillum
Cladonia sp.
Collema furfuraceum
Diploschistes muscorum
Enchylium tenax
Endocarpon pusillum
Evernia mesomorpha
Flavocetraria cucullata
Hypogymnia occidentalis
Hypogymnia physodes
Icmadophila ericetorum
Lathagrium undulatum var. granulosum
Lecanora impudens
Leptogium saturninum
Leptogium teretiusculum
Lobaria pulmonaria
Melanelixia subaurifera
Melanohalea exasperatula
Melanohalea septentrionalis
Melanohalea subolivacea
Nephroma resupinatum
Parmelia fraudans
Parmelia sulcata
Parmeliopsis ambigua
Parmeliopsis hyperopta
Peltigera aphthosa
Peltigera britannica
Peltigera didactyla
Peltigera elisabethae
Peltigera extenuata
Peltigera lepidophora
Peltigera leucophlebia
Peltigera malacea
Peltigera neckeri
Peltigera sp.
Phaeophyscia orbicularis
Phaeophyscia sciastra
Phaeophyscia sp.
Physcia adscendens
Physcia aipolia
Physcia alnophila
Physcia biziana
Physcia caesia
Physcia phaea
Physcia stellaris
Physcia tenella
Physconia muscigena
Physconia perisidiosa
Platismatia glauca
Ramalina dilacerata
Ramalina obtusata
Ramalina sinensis
Rinodina sp.
Stereocaulon tomentosum
Tuckermannopsis americana
Tuckermannopsis sp.
Umbilicaria americana
Usnea cavernosa
Usnea filipendula
Usnea lapponica
Usnea scabrata
Usnea sp.
Usnea substerilis
Vulpicida pinastri
Xanthomendoza fallax
Xanthoparmelia wyomingica
Xanthoria candelaria

7.3. Appendix 3: Species Accounts for Rare Plant Taxa Found During Preconstruction Surveys

7.3.1. Atriplex gardneri var. gardneri (Gardner's sagebrush)

Gardner's sagebrush (Figure 4), a small perennial sub-shrub with a woody base, is a member of the Chenopodiaceae (goosefoot family). Variety *gardneri* is found on fine-textured saline soils and dry grassy slopes in the Great Plains and Intermountain regions of central North America (Douglas et al. 1998; Welsh 2003). In B.C., Gardner's sagebrush is known only from the Peace River region (BCCDC 2020). Variety *gardneri* can be found as far east in Canada as southern Manitoba, and as far south as Utah and Colorado in the United States (Welsh 2003; NatureServe 2020).

Gardner's sagebrush has a rank of S2 (Imperilled) in B.C. and is on the province's Red list (BCCDC 2020). The taxon has a global classification of G5TNR (*Atriplex gardneri* as a species is ranked globally Secure, but variety *gardneri* has not yet been given a global rank). Several other sub-national jurisdictions provide a rank for Gardner's sagebrush: Saskatchewan, Montana, and Wyoming S5 (Secure), Alberta S4 (Apparently Secure), Manitoba S2 (Imperilled), and Utah and Nebraska S1 (Critically Imperilled) (NatureServe 2020).

Figure 4: *Atriplex gardneri* var. *gardneri* (Gardner's sagebrush)

One new site of Gardner's sagebrush was found in the study area in 2020. An estimated 50 male and female plants in bloom were observed in an approximate area of 50 square metres on a dry grassland slope at Clayhurst Ecological Reserve, above the Peace River at the Alberta border. This patch was determined to be an extension of an occurrence first reported in 1981, from a hillside approximately 730 metres to the southwest. The grassland habitat at the 2020 site was noted to be in good condition with a diverse cryptogamic crust and few non-native species present.

There are a total of four known occurrences (in five patches) of Gardner’s sagebrush in the RAA. Three of these occurrences (four patches) are situated north of the Peace River near the Alberta border, and, excluding the newly-located patch described above, are older records without information on the number of individuals or areal coverage. The fourth occurrence of Gardner’s sagebrush, discovered in 2018 during Site C survey work, is some 60 kilometres to the west near Wilder Creek. Here, an estimated 150 male plants were found scattered over an area of 618 square metres; no female plants were observed at this site.

All four of the Gardner’s sagebrush occurrences are situated on open, dry, south-facing grassland slopes. The dominant associated species include native grasses such as various wildryes (*Elymus* spp.), junegrass (*Koeleria macrantha*), and green needlegrass (*Nassella viridula*), and native forbs such as prairie sagewort (*Artemisia frigida*) and asters (*Symphyotrichum* spp.).

7.3.2. Carex sprengelii (Sprengel's sedge)

Sprengel's sedge (Figure 5) is a perennial herb belonging to the Cyperaceae (sedge family); plants have tall stems with fibrous bases and bear achenes in drooping heads. The species forms loose clumps in a variety of dry to wet habitats, including openings, slopes, and alluvial woodlands, often on calcareous substrates (Douglas et al. 1998; Ball & Reznicek 2002). Sprengel's sedge was only known from three locations in B.C. prior to the Site C rare plant survey work: two near Williams Lake, and one in the Peace River region (BCCDC 2020). The taxon ranges across North America as far east as New Brunswick, and as far south as Colorado, Missouri, and New Jersey. It is also reported from Alaska (Ball & Reznicek 2002; NatureServe 2020).

Figure 5: *Carex sprengelii* (Sprengel's sedge)

Sprengel's sedge has a rank of S3 (Vulnerable) in B.C., and is on the provincial Blue list (BCCDC 2020). Globally, the taxon is classed G5 (Secure). Across much of North America the taxon is classed as Secure (S5) or Apparently Secure (S4), but is considered rare on the western, southern, and eastern edges of its range: S3 (Vulnerable) in Québec, Pennsylvania, Illinois, Montana and Wyoming; S2 (Imperilled) in New Brunswick, Maine, Ohio, Missouri, and Colorado; S1 (Critically Imperilled) in Alaska, and SH (Possibly Extirpated) in Delaware (NatureServe 2020).

One new occurrence of Sprengel's sedge was found in the study area in 2020, on the east edge of Dry Creek canyon north of Highway 29. Four fruiting plants were documented in three clusters in an overall area of 95 square metres. The habitat consisted of shrubby aspen woodland that had been recently cleared. (It is unclear whether the occurrence will be fully extirpated by the clearing: if the Sprengel's sedge plants are not disturbed further, they may survive if the surrounding vegetation is allowed to regrow). In total, there are six known occurrences (in ten patches) of Sprengel's sedge in the RAA. Four of these occurrences (seven patches)—found during survey work for the Site C project—are situated between Dry Creek and Wilder Creek, on flat to south-facing slopes north of the Peace River. An estimated 37 plants have been observed growing in a total approximate area of 17 square metres, in various shrub and woodland habitats. All of these sites are moist to mesic, and the Sprengel's sedge plants are generally found in relatively shaded microhabitats. Associated species are similar, including prairie saskatoon (*Amelanchier alnifolia*), prickly rose (*Rosa acicularis*), chokecherry (*Prunus virginiana*), aspen (*Populus tremuloides*), and native and weedy herbs such as smooth brome (*Bromus inermis*), northern bedstraw (*Galium boreale*), and American vetch (*Vicia americana*).

The remaining two sites of Sprengel's sedge in the RAA are derived from CDC records that lack certain population data. An occurrence of 20 plants in two patches was discovered between a hay field and a shrubby south-facing escarpment above the Pine River in 2016; areal extent, associated species, and other details of this occurrence were not documented. Additionally, a sixth occurrence of Sprengel's sedge, first observed in 2010, is reported from over 80 kilometres southwest, in moist balsam poplar (*Populus balsamifera*) woods north of the Moberly River. No clear information is available on the number of individuals or areal coverage (BCCDC 2020).

7.3.3. Carex torreyi (Torrey's sedge)

Torrey's sedge (Figure 6) is a soft-hairy perennial in the Cyperaceae (sedge family) found growing in montane meadows, shrublands, and moist woods (Douglas et al. 1998; Ball & Reznicek 2002). In B.C. the species is found only in the Peace River region (BCCDC 2020). Globally, Torrey's sedge is distributed east across Canada to Ontario, and south in the U.S. as far as Colorado, South Dakota, Minnesota, and Wisconsin (NatureServe 2020).

Figure 6: *Carex torreyi* (Torrey's sedge)

Torrey's sedge is ranked S3? (Vulnerable?) in B.C. and is on the province's Blue list (BCCDC 2020). The species is ranked G4G5 (Apparently Secure or Secure) globally. Sub-national ranks vary—Torrey's sedge is classed as S4 (Apparently Secure) in Alberta and Saskatchewan, S3 (Vulnerable) in Manitoba and Montana, S2 (Imperilled) in Ontario and Wyoming, and S1 (Critically Imperilled) in Colorado and Wisconsin (NatureServe 2020).

One new site of Torrey's sedge was discovered in the study area in 2020. An estimated 15 plants in bloom were recorded in a small area of low shrub on a south-facing grassland slope above Fish Creek, approximately four kilometres northeast of Fort St. John. This patch was determined to be an extension of an occurrence first reported in 2019, from a hillcrest approximately 300 metres to the east.

There are a total of 11 occurrences (in 18 patches) of Torrey's sedge reported in the RAA. An estimated 550 plants have been observed growing in a total area of approximately 425 square metres. Ten of the occurrences are situated north of the Peace River; the 11th occurrence (not reconfirmed since the 1960 report) is located more than 45 kilometres south, near Dawson Creek, B.C. All of the occurrences were found on mesic to xeric south-facing slopes in open shrub grassland complexes. Associated species are similar at the sites and include native shrubs such as prickly rose, prairie saskatoon, and snowberry (*Symphoricarpos* spp.); native and non-native graminoids such as smooth brome, bluegrasses (*Poa* spp.), and sedges (*Carex* spp.); and a diverse mix of native and weedy forbs.

7.3.5. Carex xerantica (dry-land sedge)

Dry-land sedge (Figure 7), a perennial herb with silvery-gold heads of the Cyperaceae (sedge family), is found in xeric steppe and montane habitats such as dry grasslands and hillsides, open forests, and rock outcrops (Douglas et al. 1998; Ball & Reznicek 2002). In B.C., dry-land sedge has been collected in the Peace River area as well as scattered locations in the central interior and central Rocky Mountains (BCCDC 2020; Klinkenberg 2020). There is some disagreement on the taxon's global range. Douglas et al. (1998) note that dry-land sedge extends east from B.C. to Manitoba, and south to Minnesota and Nebraska; Ball & Reznicek (2002) show the species occurring as far east as Ontario and also in Wyoming; and Natureserve (2020) reports the sedge from as far north as Yukon and Alaska, and as far south as Arizona and New Mexico.

Figure 7: *Carex xerantica* (dry-land sedge)

Dry-land sedge is classed as S3 (Vulnerable) in B.C., and is on the provincial Blue list (BCCDC 2020). Although globally the taxon is considered Secure (G5), most jurisdictions that provide a rank for the species indicate some degree of rarity: S1 (Critically Imperilled) in Alaska, Yukon and Wyoming; S2 (Imperilled) in Manitoba, Ontario, Nebraska, Colorado, and New Mexico; and S3 (Vulnerable) in Minnesota. Alberta and Saskatchewan rank the species S4 (Apparently Secure) (NatureServe 2020).

Three new sites of dry-land sedge were documented in the study area in 2020. A small occurrence was recorded on a steep, south-facing grassland slope east of the Beatton River, above Cecil Lake Road. Here, an estimated 15 flowering plants were found growing in clusters along a small trail over an area of approximately five square metres. The second new site was determined to be an extension of an occurrence first reported in 2005, west of the Beatton River at Cecil Lake Road. A patch of approximately 10 flowering plants was discovered on both sides of a small trail, on a very steep southeast-facing grassland hillside above Fish Creek.

The third new dry-land sedge site of 2020 consisted of the substantial expansion of a previously-known occurrence, on a grassland bench west of the confluence of the Peace and Pine Rivers. This site was first observed in 2012, when only a portion of the very large bench was surveyed; during the 2020 revisit, the estimated number of dry-land sedge plants was increased to 2,000 and the areal coverage was nearly doubled, to over 20 hectares (however, the full extent of the grassland bench remains unsurveyed). The diverse native plant community at this site is in very good condition and few non-native species were observed.

In total, there are 16 known occurrences of dry-land sedge (in 34 patches) in the RAA. An estimated 9,165 plants have been observed growing in an approximate total area of 12.6 hectares. Fourteen of the occurrences were found on south-facing slopes north of the Peace River from Bear Flat east to the Alberta border, and one on a bench above the south bank of the Peace at the Pine River. Dry-land sedge has also been collected on a slope above the Pouce Coupe River, over 25 kilometres to the south. The dry-land sedge sites are invariably located in xeric grassland habitat, generally in the vicinity of low shrub thickets. The dominant associated species include native shrubs such as prairie saskatoon, prickly rose, and snowberry; native sedges; and native grasses such as junegrass, needlegrasses (*Achnatherum* spp. and *Nassella viridula*), needle-and-thread grass (*Hesperostipa comata*), and short-awned porcupinegrass (*Hesperostipa curtiseta*). A diverse mix of native and non-native forbs are also present at dry-land sedge occurrences.

7.3.6. Oxytropis campestris var. davisii (Davis' locoweed)

Davis' locoweed (Figure 8) is a small perennial in the Fabaceae (pea family) that grows on stream gravels and in mesic to dry meadows and forest openings in the montane zone (Elisens & Packer 1980; Welsh 1991; Douglas et al. 1998). Variety *davisii* is found in northeast B.C. where it can be locally abundant, and is also reported from Alberta (Welsh 1991; BCCDC 2020; NatureServe 2020). Davis' locoweed is classed S3? (Vulnerable?) by the BCCDC, and is on the provincial Blue list (BCCDC 2020). Globally, the variety is also ranked as Vulnerable (T3), due to its limited range. Alberta lists Davis' locoweed as S2? (Imperilled?) (NatureServe 2020).

Figure 8: *Oxytropis campestris* var. *davisii* (Davis' locoweed)

Eight new occurrences (in 15 patches) of Davis' locoweed were documented in the study area in 2020. Half of these sites consisted of just a few scattered plants on tributary rivers unregulated by the existing system of dams on the Peace River. One occurrence, of three plants in two patches, was found on the lower Halfway River in floodplain woodlands: the single isolated plant was vegetative and the clump of two plants were in late fruit. Three occurrences (comprising a total of eight blooming plants in seven patches) were located on silt-cobble floodplain along an approximately 18 kilometre stretch of the lower Pine River. Habitats at these sites varied from willow (*Salix* sp.) thickets to open stands of early seral balsam poplar.

The remaining four new occurrences of Davis' locoweed (comprising six relatively large patches) were discovered on islands and shoreline in diverse locations along the Peace River, from near the Peace

Canyon Dam downstream to the confluence of the Kiskatinaw River. The smallest new occurrence, of an estimated 50 plants in bloom and early fruit, covered 192 square metres on an island downstream of the confluence of the Beatton River. On Raspberry Island, near the mouth of the Kiskatinaw River, approximately 150 plants in bloom were observed in two patches with a total areal coverage of some 95 square metres. A third new occurrence, on an island just downstream of Taylor, B.C., consisted of an estimated 1,750 blooming plants across an area of approximately 1.3 hectares. Habitats were similar at these three occurrences: open cobble floodplain with young balsam poplar and scattered native and weedy herbs.

The final new occurrence of Davis' locoweed (two patches) was found on the south shore of the Peace River 1.8 kilometres downstream of the Peace Canyon Dam. Here, thousands of fruiting plants were observed growing densely in an area of 703 square metres. The habitat was somewhat unusual at this site, consisting of thin, rocky soil over bedrock with the Davis' locoweed plants occupying a narrow band between the river shore and the edge of a white spruce (*Picea glauca*) and paper birch (*Betula papyrifera*) forest. A diverse mix of native and weedy herbs were also present, including a substantial patch of spotted knapweed (*Centaurea stoebe* ssp. *micranthos*) (Provincial Noxious).

There are a total of 28 occurrences of Davis' locoweed (in 38 patches) reported in the RAA. An estimated 70,000 plants have been recorded in an approximate total area of 13 hectares. Twenty of the occurrences have been documented from along the Peace River, and many of these sites contain hundreds or thousands of individuals and cover relatively large areas of ground. Four occurrences have been observed along the Halfway River, and three on the Pine River near its confluence with the Peace River. There is also one historical record of Davis' locoweed on the Pine River at Highway 97, over 50 kilometres to the south (not reconfirmed since the 1954 report).

Except for the historical record on the Pine River, all Davis' locoweed occurrences in the RAA have been mapped within 400 metres of current river shorelines, on non-active cobble bars, floodplains or river benches which have begun to revegetate. Habitat at the majority of sites is similar, consisting of open, often bare cobble-silt substrates and young to medium-aged balsam poplar. Other associated species include a relatively sparse cover of native and weedy herbs such as yellow mountain-avens (*Dryas drummondii*) and sweet-clover (*Melilotus* spp.) as well as quackgrass, slender wheatgrass and Canada wildrye (*Elymus* spp.). The notable exception is the forested bedrock habitat at the new occurrence below the Peace Canyon Dam, as described above.

7.3.7. Penstemon gracilis (slender penstemon)

Slender penstemon (Figure 9) is a perennial herb of the Plantaginaceae (plantain family)—formerly of the Scrophulariaceae (figwort family)—that inhabits mesic to dry plains and grasslands (Hitchcock et al. 1959; Douglas et al. 1998; Freeman & Rabeler 2016). The species is commonly found throughout much of the Great Plains and Midwestern regions of Canada and the U.S., but in B.C. is restricted to the Peace River area (Hitchcock et al. 1959; BCCDC 2020; NatureServe 2020).

Figure 9: *Penstemon gracilis* (slender penstemon)

Slender penstemon is ranked S3 (Vulnerable) in B.C., and is on the province's Blue list (BCCDC 2020). The species' global status is G5 (Secure) (NatureServe 2020). Of the remaining 17 jurisdictions where it is known to occur, only four rank slender penstemon with any degree of rarity—Manitoba and Wyoming as S3 (Vulnerable), and Iowa and Michigan as S1 (Critically Imperilled) (NatureServe 2020).

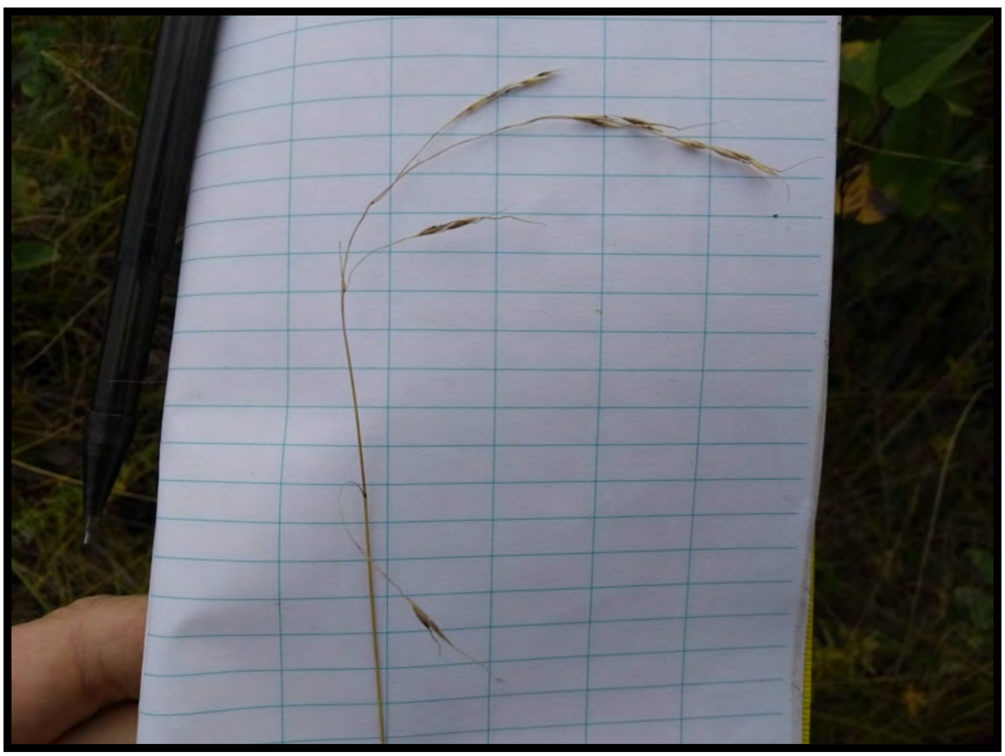
Two new sites of slender penstemon were discovered in the study area in 2020. A small occurrence was recorded on a south-facing slope above Cecil Lake Road east of the Beatton River, in a grassland and woodland mosaic. Here, 19 slender penstemon plants were found growing in two patches over a combined area of approximately 90 square meters. The second new site was determined to be an extension of an occurrence first reported in 1995, north of the Peace River near the Alberta border. Two small patches of slender penstemon were observed in dry native grassland openings within upland woodlands, on both sides of Clayhurst Road.

In total, there are 25 occurrences of slender penstemon (in 54 patches) reported in the RAA. All of the occurrences are situated north of the Peace River, from the Farrell Creek area east to the Alberta border. An estimated 3,940 plants have been documented in an approximate total area of 3.9 hectares. All of the occurrences were found on south-facing slopes and invariably located in xeric grassland habitat, generally in the vicinity of low shrub thickets. Dominant associated species include the native shrubs prairie saskatoon, prickly rose, and common snowberry (*Symphoricarpos albus*), native graminoids such as junegrass, wildryes, and sedges, and a diverse mix of native and non-native forbs.

7.3.8. Piptatheropsis canadensis (Canada ricegrass)

Canada ricegrass (Figure 10) is a delicate perennial bunchgrass of the Poaceae (grass family). The species grows in grasslands and open woods and on hillsides and dry slopes; additionally, in eastern North American sites, the taxon is specifically reported from dry, sparsely-vegetated soils which are usually sandy or rocky, as well as moist peaty barrens. Canada ricegrass ranges from Alberta east across Canada to Newfoundland, and south into the U.S. Northeast and Great Lakes regions (Gray & Fernald 1950; Moss & Packer 1983; Lapin 2004; Barkworth 2007; BCCDC 2020). Prior to the 2018 Site C rare plant survey work, no verified extant occurrences of Canada ricegrass were known from B.C. (BCCDC 2020). Of note: the genus *Piptatheropsis* was only recently described (Romaschenko et al. 2011), therefore Canada ricegrass is still referred to by the name *Piptatherum canadense* in some important literature (Lapin 2004; Barkworth 2007; NatureServe 2020).

Figure 10: *Piptatheropsis canadensis* (Canada ricegrass)



Canada ricegrass is ranked S1 (Critically Imperilled) in B.C., and is on the province's Red list (BCCDC 2020). The taxon's global classification is G4G5 (Apparently Secure or Secure) (NatureServe 2020). However, although Canada ricegrass is widely distributed across North America, the species has few reported occurrences and most of these are small (frequently less than 100 individuals at a site) (Lapin 2004). Accordingly, Canada ricegrass is generally classed as rare sub-nationally: SH (Possibly Extirpated) in Prince Edward Island; S1 (Critically Imperilled) in Manitoba, Wisconsin, West Virginia, and New Hampshire; S2 (Imperilled) in Alberta, Saskatchewan, New Brunswick, Nova Scotia, Newfoundland, Minnesota, Michigan, New York, and Maine; and S4 (Apparently Secure) in Ontario and Québec (NatureServe 2020).

Three new occurrences (in twelve patches) of Canada ricegrass were found in the study area in 2020. A small site was discovered on a slope above Fish Creek, approximately four kilometres northeast of Fort St. John. Here, an estimated 30 Canada ricegrass plants were found in two patches totalling approximately 74 square metres. A large site consisting of nine patches was documented north of Highway 29 west of Cache Creek: approximately 150 plants over a total area of 306 square metres. Finally, an occurrence of about 50 Canada ricegrass plants in a 188-square-metre area was recorded on a native grassland bench near the confluence of the Peace and Pine Rivers.

There are a total of four known occurrences of Canada ricegrass (in 13 patches) in the RAA, all found during Site C survey work. The occurrences are located from the Cache Creek area east to the Pine and Beatton Rivers. An estimated total of 230 plants have been documented in an approximate total area of 608 square metres. All of the Canada ricegrass sites occur on level to gently sloped, open, good quality native shrub-grassland or remnants of such, usually in close proximity to aspen woodlands. Soils at the sites can be moist to dry. The Canada ricegrass plants grow scattered in dense vegetation consisting of a diverse assemblage of low shrubs and herbs. Dominant associated species are native plants and include the shrubs prairie saskatoon, prickly rose, and chokecherry; grasses such as spreading needlegrass (*Achnatherum richardsonii*), slender wheatgrass (*Elymus trachycaulus ssp. subsecundus*), and false melic (*Schizachne purpurascens*), and forbs such as northern bedstraw and anemones (*Anemone* spp.). A few non-native species are also present at the sites, particularly Kentucky bluegrass (*Poa pratensis*).

7.3.9. Ranunculus rhomboideus (prairie buttercup)

Prairie buttercup (Figure 11) is a soft-hairy perennial of the Ranunculaceae (buttercup family). The species grows in grasslands, prairies, open woods and thickets across north-central North America (Whittemore & Parfitt 1997; Douglas et al. 1998). In B.C., prairie buttercup is only known from the Peace River region (BCCDC 2020). The taxon's range extends north to Northwest Territories and southeast through the Canadian prairie provinces and the northern U.S. Great Plains into Nebraska, Iowa, Illinois, Michigan, and southern Ontario (Whittemore & Parfitt 1997; NatureServe 2020).

Figure 11: Ranunculus rhomboideus (prairie buttercup)

Prairie buttercup has a ranking of S2S3 (Imperilled and Vulnerable) in B.C., and is on the province's Blue list (BCCDC 2020). Globally, the taxon is ranked G5 (Secure). Only sporadic sub-national ranks are provided for prairie buttercup: Alberta, Saskatchewan, Manitoba, and Ontario class the species as S4 (Apparently Secure); Iowa as S3 (Vulnerable); Illinois and Michigan as S2 (Imperilled); Nebraska as S1 (Critically Imperilled); and Québec as SX (Presumed Extirpated) (NatureServe 2020).

Two new sites of prairie buttercup were documented in the study area in 2020. Both new patches, of just two flowering plants each, were discovered on open shrub-grassland slopes above Fish Creek, approximately four kilometres northeast of Fort St. John. These patches were determined to be extensions of an occurrence first reported in 2019.

In total, 11 occurrences of prairie buttercup (in sixteen patches) have been reported in the RAA. Eight of the occurrences (thirteen patches)—discovered during the Site C rare plant survey work—are situated north of the Peace River from the Cache Creek area east to the Pine River, and contain an estimated 206 plants in an approximate total area of 416 square metres. The remaining three occurrences are historical records not recently verified and with no information available on precise location, number of individuals or areal coverage. The habitat for prairie buttercup is somewhat variable: soils can range from moist to dry, shrub cover can be dense to sparse, and occurrence microsite can be flat to sloped. Dominant associated species include a wide variety of native forbs such as northern bedstraw and American vetch as well as weedy grasses such as smooth brome and Kentucky bluegrass. Native shrub species are also present, the most commonly reported being rose (*Rosa* spp.) and prairie saskatoon.

7.3.10. Selaginella rupestris (rock selaginella)

Rock selaginella (Figure 12) is a small, mat-forming evergreen perennial in the Selaginellaceae (spike-moss family). The taxon is found in a variety of open, dry, rocky or gravelly habitats in eastern and central North America (Valdespino 1993; Douglas et al. 1998). In B.C., rock selaginella is known only from the Peace River region (BCCDC 2020; Klinkenberg 2020). The taxon ranges east across Canada to Nova Scotia and southeast in the U.S. to southern Georgia (Valdespino 1993; NatureServe 2020).

Figure 12: *Selaginella rupestris* (rock selaginella)

Rock selaginella is ranked S2 (Imperilled) in B.C., and is on the Red list for the province (BCCDC 2020). The taxon is classed as G5 (Secure) globally, but sub-national rankings vary. Of the jurisdictions providing a rank, rock selaginella is listed as S5 (Secure) in Ontario, Québec, Arkansas, Georgia, and Virginia; as S4 (Apparently Secure) in Saskatchewan, Manitoba, and New York; as S3 (Vulnerable) in Alberta, Illinois, North Carolina, West Virginia, Vermont, and Massachusetts; as S2 (Imperilled) in Iowa, Alabama, and New Jersey; as S1 (Critically Imperilled) in New Brunswick, Nova Scotia, Ohio, Indiana, North Dakota, and Wyoming; and SX (Presumed Extirpated) in Delaware (NatureServe 2020).

Four new sites of rock selaginella were found in the study area in 2020 as part of the Site C work. A large occurrence was discovered in a shrub-grassland opening in upland woodlands, between Highway 29 and the Peace River just east of Hudson’s Hope, B.C. Here, hundreds of clumps were growing in an area of 295 square metres. A small occurrence of an estimated 50 clumps of rock selaginella in an approximate area of 50 square metres was documented in a rocky opening on a steep forested slope above the east end of Williston Reservoir. Similarly, another occurrence with many clumps over roughly 30 square metres was observed farther east on the same slope, at the base of a short cliff in open, shrubby woods.

In addition, one previously-reported occurrence from 2000 was resurveyed in 2020, and both the areal coverage and the estimated number of rock selaginella plants were substantially increased. This occurrence is situated at Clayhurst Ecological Reserve, on a grassland slope north of the Peace River just west of the Alberta border. Hundreds of rock selaginella clumps were found growing in an area of approximately 56 square metres.

In total, there are nine known occurrences of rock selaginella (in twelve patches) in the RAA. Eight of the occurrences—discovered or resurveyed as part of the Site C rare plant work—are located north of the Peace River, from Williston Reservoir east to the Alberta border, and contain an estimated 4,700 individuals in an approximate total area of 7,631 square metres.

The ninth occurrence of rock selaginella in the RAA, newly reported for 2020 but not part of the Site C work, consists of a collection from over 45 kilometres south of the Peace River. A few clumps were found on a dry grassland hillcrest north of Highway 97, sixteen kilometres southwest of Chetwynd, B.C.; areal extent, associated species, and other details were not documented.

The rock selaginella sites are dry and usually rocky; most of the occurrences are in open shrub-grassland habitat on south-facing hillsides or hillcrests, and slopes are often quite steep. The sole exception is one of the new occurrences outlined above that was found in open woods at the base of a cliff. Dominant associated species include the shrubs prairie saskatoon, kinnikinnick (*Arctostaphylos uva-ursi*), and common juniper (*Juniperus communis*); graminoids such as junegrass, thickspike wildrye (*Elymus lanceolatus* ssp. *lanceolatus*), and various dryland sedge species; and forbs such as prairie sagewort, northern bedstraw, and woolly yarrow (*Achillea borealis*).