Peace Project Water Use Plan

Peace River Wildlife Stranding Survey

Final Report

Reference: GMSMON-12

Study Period: 2010-2012

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March 20, 2013

BC Hydro Peace River Wildlife Standing Survey, GMSMON 12 2010 Pre-spill and 2012 Post-spill Survey Results

Final Report submitted to:

BC Hydro Water Licence Requirements

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Cover photo: Peace River below the Peace Canyon Dam. Photo © K. Bachmann, Cooper Beauchesne and Associates Ltd.

EXECUTIVE SUMMARY

Spill events which exceed the normal operating discharge levels (2,000 m^3/s) at the Peace Canyon Dam on the Peace River near Hudson's Hope, BC, are known, or suspected, to impact four groups of wildlife downstream from the dam: ungulates, beaver (*Castor canadensis*), riparian birds, and western toad (*Bufo boreas*). To address these impacts, BC Hydro's Peace Spill Protocol contains monitoring protocols for wildlife to be activated once a spill crosses the 2000 m^3/s threshold.

This project, GMSMON 12, was conducted to assess the effects of a spill on the four target taxa in the period 2009-2013, should a spill occur. It was conducted in the riparian area of the Peace River valley from Hudson's Hope downstream to Ft. St. John. Using a per-spill/post-spill study design, four management questions were addressed:

1) What are the impacts on ungulates and their habitat as a result of a spill event?

2) What are the impacts on beavers and their habitat as a result of a spill event?

3) What are the impacts on riparian birds and their habitat as a result of a spill event?

4) What are the impacts on the western toad and their habitat as a result of a spill event?

To answer these management questions, the following hypotheses were tested by the monitoring program:

H_1: Ungulate mortality/habitat loss resulting from a spill significantly impacts the ungulate population in the Peace River floodplain downstream of Peace Canyon Dam.

H_2: Beaver mortality/habitat loss resulting from a spill significantly impacts the beaver population in the Peace River floodplain downstream of Peace Canyon Dam.

H_3: Riparian bird mortality/habitat loss resulting from a spill significantly impacts the riparian bird population in the Peace River floodplain downstream of Peace Canyon Dam.

H_4: Western toad mortality/habitat loss resulting from a spill does not significantly impact the western toad population in the Peace River floodplain downstream of Peace Canyon Dam.

In anticipation of a spill occurring, pre-spill monitoring was completed in 2010. A spill reaching a maximum of 2879 m^3/s occurred in late June of 2012 and continued through to the middle of July. Post-spill monitoring was completed in late July of 2012. Aerial surveys were used to survey ungulates and beaver structures, while ground-based surveys were conducted for riparian birds (point count surveys) and western toad (systematic searches). The same surveys were completed both pre- and post-spill. Riparian habitat classification and mapping from another project (GMSWORKS 7) was used to assess the impacts on habitat for each of the target taxa.

We identified short-term impacts to riparian habitat in general, although concluded that long-term effects were negligible, and may even be beneficial in the maintenance of riparian habitat. Ungulate populations and habitat were likely not impacted, or only minimally so as a result of the spill. We did, however, document what we considered negative, albeit short-term impacts on

some species of riparian associated birds, all ground- or low shrub-nesting species. Similarly, we noted negative short-term impacts on beaver habitat, mainly through the destruction of lodge and food cache structures. Because of a small sample size, we were not able to assess the impact of the spill on western toad populations or habitat in the study area.

Based on the data we collected and assessment of the method used in this study, we offered three main recommendations to improve the study design and, ultimately, the confidence with which the management questions can be answered:

1. Focus monitoring activities on riparian habitat, riparian birds and western toad using an indicator species approach
2. Re-work project sampling design (size and spatial extent) and sample methods to better answer management questions
3. Ensure that aerial survey methods, if used in the future, are properly designed and able to provide the level of resolution required.

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CBA staff Karl Bachmann, James Bradley, Allan Carson, and Vicki Prigmore completed the fieldwork for the project.

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This report was written by Karl Bachmann, Vicki Prigmore, and Ryan Gill. Harry van Oort and John Cooper provided an internal review of the draft manuscript.

1 INTRODUCTION

In 1996 a controlled release of water (spill) from the WAC Bennett and Peace Canyon (PCN) dams raised concerns about downstream impacts to wildlife (BC Hydro 1997). As a result of some of the observed impacts on wildlife (e.g., drowning ungulates) of the 1996 spill event, monitoring studies were recommended to assess impacts on a variety of resources for future spill events. Spill events which exceed the normal operating discharge levels at PCN (2,000cms) are known, or suspected, to impact four groups of wildlife downstream from the dam: ungulates, beaver (*Castor canadensis*), riparian birds, and western toad (*Bufo boreas*). These impacts include mortality of individuals and loss of habitat for that species or species group.

The Peace Spill Protocol (PSP) contains monitoring plans detailing environmental information to be collected surrounding a spill event (BC Hydro 2007). Some of these surveys are required for any spill and some are conditional on discharge volume; wildlife surveys are triggered by total discharges (turbine discharge + additional discharge) of >2,000 m^3/s for 2 days at the PCN (BC Hydro 2007). Minimum discharge for the PCN dam is 283 m^3/s; maximum turbine discharge is 1,982 m^3/s. Peak spill conditions will depend on the magnitude of the spill. Post spill conditions in the study area (see below) are defined as beginning after the discharge from the dam returns to a pre-spill state (i.e., turbine discharge alone, between 283 m^3/s and 1,982 m^3/s), and constitute the normal operating levels for the Peace River below the PCN dam.

Since 1996, several wildlife surveys have been conducted that provide information on the vulnerability of floodplain-dwelling wildlife to spill events along the Peace River. In 1996 (Diversified Environmental Services 1996) Diversified Environmental Services conducted an assessment of ungulate use of islands with the Peace River. Two years later, Wiacek (1998) prepared a summary of the wildlife resources in the area and the potential impacts of fluctuating water levels on them. Robertson (1999) conducted aerial surveys for aquatic birds (focus on shorebirds and waterfowl) in 1996 and again in 1999. Fraker and Hawkes (2000) conducted wildlife surveys in 1999 on the floodplain of the Peace River from the Peace Canyon Dam to the Alberta border that focused on water-associated birds, amphibians and reptiles, and aquatic mammals. In 2005 and 2006, Keystone (Keystone Wildlife Research Ltd. 2009, Simpson et al. 2009) completed baseline wildlife surveys in the Peace River corridor to update previous baseline work that had been completed in the early 1990s (Simpson 1991, 1993). None of these studies, however, provide recent or specific data to allow a pre-spill/post-spill assessment of impacts to affected wildlife species.

Similarly, although terrestrial ecosystem mapping had been completed for the study area (Keystone Wildlife Research Ltd. 2007), no information was available specific to riparian habitat types in the Peace River valley. Riparian habitat mapping, however, was recently completed for the entire study area as part of the GMSWORKS 7 project (MacInnis et al. 2011), which classified the entire study area into 24 riparian habitat classes.

As a result of high water levels in the Williston Reservoir from the above average snowpack that accumulated in the winter of 2011/2012, the first spill in a decade began on 26 June, 2012 from the WAC Bennett and PCN dams. The spill reached a maximum of 2,879 m^3/s on July 9th, and continued until the middle of July.

2 OBJECTIVES AND MANAGEMENT HYPOTHESIS

To address data requirements for assessing spill impacts, this project (GMSMON-12) consists of wildlife surveys and assessment of potential impacts of habitat loss and direct mortality on wildlife as the result of a spill. To address the impact of spill events on selected wildlife several management questions have been developed (BC Hydro 2007):

1) What are the impacts on ungulates and their habitat as a result of a spill event?
2) What are the impacts on beavers and their habitat as a result of a spill event?
3) What are the impacts on riparian birds and their habitat as a result of a spill event?
4) What are the impacts on the western toad and their habitat as a result of a spill event?

To address these management questions, the following hypotheses will be tested by the monitoring program:

H_1: Ungulate mortality/habitat loss resulting from a spill significantly impacts the ungulate population in the Peace River floodplain downstream of Peace Canyon Dam.

H_2: Beaver mortality/habitat loss resulting from a spill significantly impacts the beaver population in the Peace River floodplain downstream of Peace Canyon Dam.

H_3: Riparian bird mortality/habitat loss resulting from a spill significantly impacts the riparian bird population in the Peace River floodplain downstream of Peace Canyon Dam.

H_4: Western toad mortality/habitat loss resulting from a spill does not significantly impact the western toad population in the Peace River floodplain downstream of Peace Canyon Dam.

This report provides the final results of the pre-spill monitoring completed in 2010 and post-spill monitoring completed after the mid-summer spill that occurred in 2012. Based on these results, an assessment of the findings as they apply to the management question is presented, and recommendations for future spill monitoring are offered.

3 STUDY AREA

The study area consists of the floodplain of the Peace River from the PCN to the confluence of the Peace and Pine Rivers (Figure 1). Impacts of flow regulation by the PCN are reduced downstream of the Pine River due to tributary influence (BC Hydro 2007). Approximately 40 islands of varying sizes occur within this stretch of river, the largest of which are in the 100 ha range. The linear distance of the mainstem Peace River in the study area is 102 km.

Because this project used habitat classification information from the GMWORKS-7 project (MacInnis et al. 2011), we used the same boundaries for our study area, riparian habitat between minimum and maximum flows of 283 m^3/s and 3398 m^3/s, respectively. All of the study area is contained by the Boreal White and Black Spruce (BWBS) biogeoclimatic zone (Meidinger and Pojar 1991).

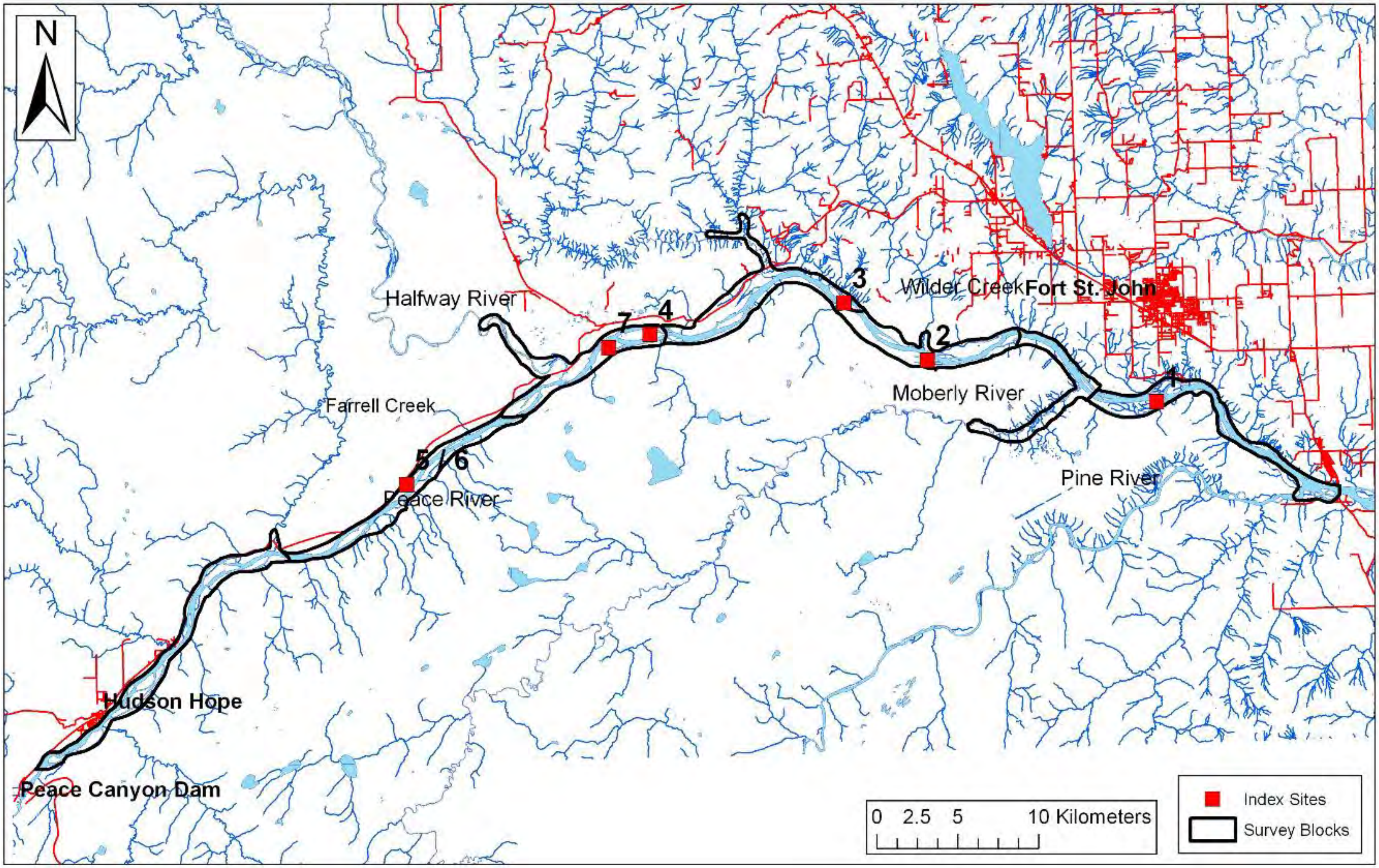


Figure 1. GMSMON 12 study area, index sites, and aerial survey blocks in the Peace River valley downstream from the Peace Canyon Dam, B.C.

4 METHODS

The survey design used a pre- and post-spill approach to address the study objectives. Pre-spill surveys established a baseline for species richness and abundance. Post-spill surveys were compared against this baseline to estimate mortality and/or habitat loss. A peak-spill aerial survey specifically to detect stranded and/or swimming ungulates was suggested, but was contingent on the magnitude of the spill. Surveys were either conducted over the entire study area (e.g., aerial ungulate surveys) or at index sites (e.g., point count surveys).

A broad outline of survey methods to be used was laid out in the project terms of reference (BC Hydro 2008), and formed the basis for the project methods. Due to sample size limitations, we did not use statistical tests to compare pre/post spill difference for the four target taxa. Where sufficient data was available, quantitative assessments of habitat loss and mortality were made; otherwise, available information was used to make a qualitative assessment of spill impacts.

Reports and data from previous surveys conducted in the study area were consulted to provide guidance on index site selection based on recorded locations of target species. Kim Hawkins and Anre MacIntosh (BC Hydro) provided copies of relevant reports, some of which were downloaded from the BC Hydro ‘Site C’ website. Literature searches were also conducted in Ministry of Environment and Ministry of Forests databases. A set of 0.5 m contour lines extracted from a digital elevation model (DEM) provided by BC Hydro was overlaid on an orthophoto background to identify areas likely to flood during a spill event (characterized by low gradients and elevations close to operational levels of the river). With large areas of the riverbank characterized by steep cutbanks or rendered inaccessible by private land considerations, most candidate sites were associated with near-shore and mid-channel islands.

Two days of helicopter-based site reconnaissance were conducted to evaluate and select index sites for this project and the GMSMON 3 project (monitoring fish stranding). Because ground-based bird and amphibian surveys are labour intensive and time consuming, we chose to restrict these surveys to index sites representative of the study area. We selected 6 index sites based on their habitat type (entirely or predominantly riparian), likelihood of flooding, and absence of privately-owned land. Index sites were distributed along the length of the study area to sample the maximum diversity of river configurations and habitat classes (Figure 1). The number of index sites selected was determined by budgetary constraints. Index sites varied in shape and size (Appendix 7), but each contained a mosaic of riparian/lotic habitats. Aerial surveys for ungulate and beaver were completed across the entire study area; point count and nest searching surveys were completed at index sites 1, 2, 3, 4, 5/6, and amphibian surveys were completed at index sites 5/6 and 7.

An additional two days of ground reconnaissance was conducted to evaluate the feasibility of accessing some candidate shoreline sites by vehicle and on foot. The relative scarcity of access roads and amount of private land bordering the river channel, however, rendered aerial or boat-based access the only feasible methods for the majority of sites. Only index site 5/6 was accessible by vehicle and on foot.

To assess spill effects, maximum inundation extent data was provided by BC Hydro in 2 different formats. Inundation extent for the PCN to Halfway River reach was provided as a model of a 3,000 m^3/s flow, while data for the Halfway River to Pine River reach was based on digitization of inundation extent based on air photos taken on July 9th at 2879 m^3/s. To determine whether the discrepancy between the two data sets would influence our results, we performed a QC/QA process that involved comparing sites in the PCN to Halfway River reach using 2,750 m^3/s and

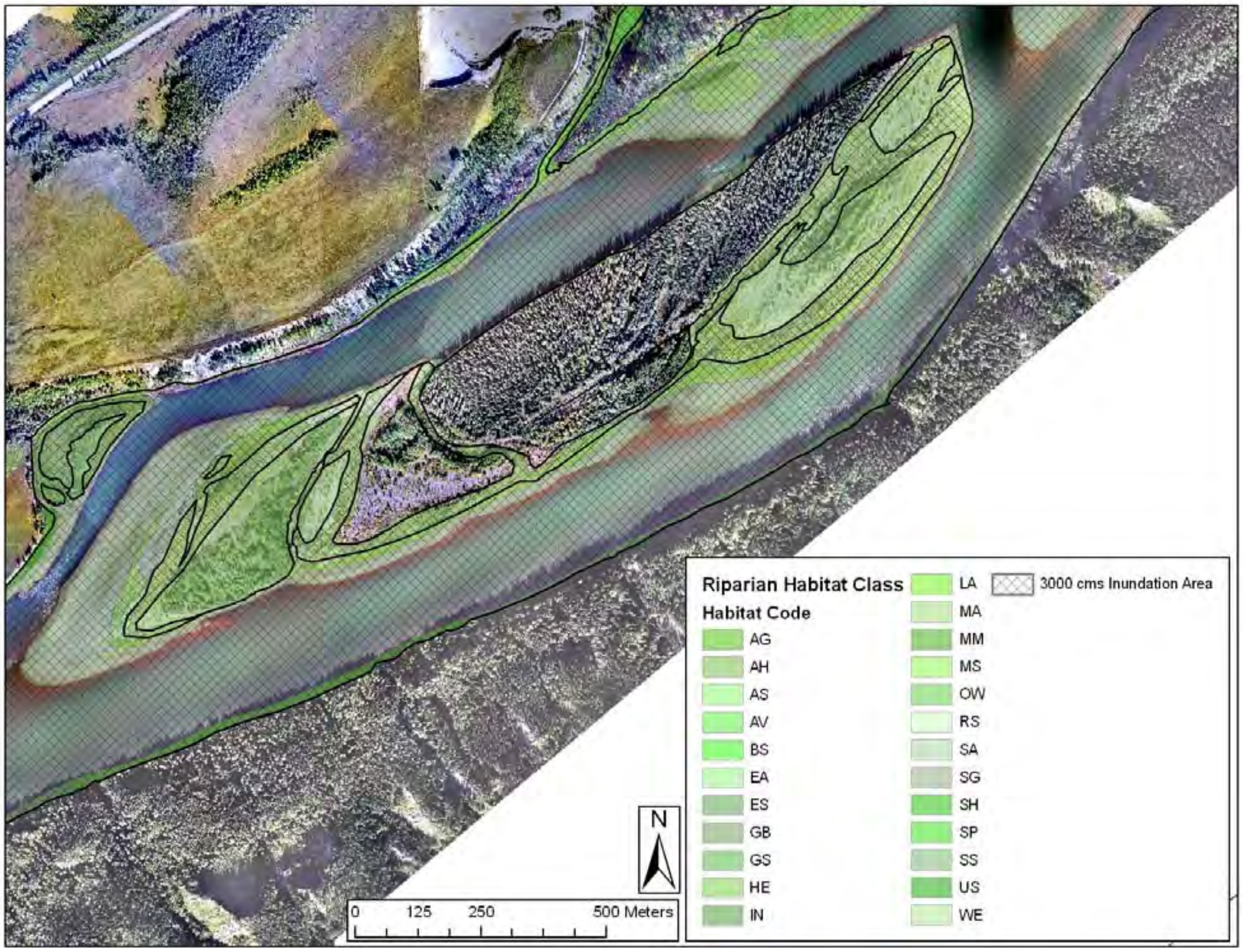
3,000 m^3/s models. We concluded that the difference in inundation extent between the two layers was relatively minor at the majority of sites along the study area, and thus the 121 m^3/s difference between our two inundation extent data sets was also likely to be insignificant. Using ArcMap 10.1 (*ArcMap* 2011), we merged the two files into a single inundation layer.

4.1 Riparian Habitat

Riparian habitat mapping and classification information from the BC Hydro GMSWORKS 7 project (MacInnis et al. 2011) was used to assess the extent of habitat loss for the four target taxa. The baseline used for maximum area of riparian habitat was riparian areas between minimum and maximum flows of 283 m^3/s and 3398 m^3/s, respectively. Our study did not test species – habitat associations, so we did not make a rigorous assessment of relative importance of habitat classes to each species or group of species. Similarly, although we did make qualitative observations of the flood tolerance and sensitivity to inundation effects for different habitat classes, we did not conduct a rigorous assessment of these impacts.

Pre-spill riparian habitat areas are reported directly from the GMSWORKS 7 results. Using ArcMap, we used the 3000 m^3/s inundation polygon to clip the habitat class polygons from the GMSWORKS 7 project (Figure 2). From this subset, we summarized the number of habitat polygons, percentage of each habitat class, and total area inundated using MS Excel.

Figure 2. Example of riparian habitat classes and 3000 cms inundation area in the Peace River valley, BC.



4.2 Ungulates

Aerial ungulate surveys were conducted throughout the entire survey area to estimate the number of ungulates on islands pre- and post-spill, and to potentially detect swimming ungulates at peak-spill. Encounter transects were used to conduct presence/not detected surveys for ungulates (Resources Inventory Committee 2002). Although sightability of ungulates was probably low due to leafed-out deciduous trees, it was similar for both pre- and post-spill surveys. Aerial surveys allowed a relatively rapid survey of the entire study area and the possibility of a peak-spill survey for drowning ungulates. This would not be possible with ground-based ungulate surveys.

As per the project terms of reference, we began an assessment of the need for a peak spill survey once the spill began. The purpose of the peak spill survey was to detect any ungulates that attempted to swim from a mid-stream island or previously connected area separated from the river bank by the spill (BC Hydro 2008). The peak spill polygon provided a rough estimation of how many islands were likely to be submerged at peak spill. This analysis, in conjunction with consultation with BC Hydro personnel, indicated that the estimated peak spill level would not flood many islands completely, and so a peak spill survey was not required.

For the aerial ungulate survey, the survey area was subdivided into the same survey block boundaries previously used by Keystone (Simpson 1993):

- Reach 1 – Peace Canyon Dam to Farrell Creek (23 km)
- Reach 2 – Farrell Creek to Halfway River (22 km)
- Reach 3 – Halfway River to Cache Creek (16 km)
- Reach 4 – Cache Creek to Moberly River (23 km)
- Reach 5 – Moberly River to Pine River (18 km)

For pre-spill surveys, a total of seven survey blocks (Figure 1, Table 1) totalling 117.6 km^2 were surveyed on the 2nd and 3rd of June 2010 starting at 06:30 in the morning and finishing before noon to capture times of increased ungulate activity. Pre-spill survey time for all blocks (excluding ferry and re-fueling time) totalled 7.28 hours. The same seven survey blocks were surveyed post-spill on the 24th of July (Table 1). Surveys began at 8:30 in the morning due to fog in the river valley, and were completed in a single day. Post-spill survey time for all blocks (excluding ferrying and re-fueling time) was 2.95 hours.

Table 1. Pre- and post-spill ungulate survey blocks and effort in the Peace River valley, B.C.

Block	Geographic location	Km^2	Pre-spill			Post-spill		
			Survey date	Survey time (hrs.)	Survey effort (min./ km^2)	Survey date	Survey time (hrs.)	Survey effort (min./ km^2)
Peace Canyon	Peace Canyon dam to Farrell Creek	19.9	2-Jun-2010	1.52	4.6	24-July-2012	0.50	1.5
Farrell Creek	Farrell Creek to Halfway River	15.1	2-Jun-2010	1.13	4.5	24-July-2012	0.33	1.3
Halfway River	Either side of the Peace – Halfway River	18.4	2-Jun-2010	1.35	4.4	24-July-2012	0.48	1.6

	confluence and up the first section of the Halfway River							
Cache Creek[1]	Either side of the Peace – Cache Creek Confluence and up the first section of Cache Creek	20.8	3-Jun-2010	0.90	3.2	24-July-2012	0.48	1.7
Wilder Creek	Centred on Wilder Creek	15.4	3-Jun-2010	0.85	3.3	24-July-2012	0.40	1.6
Moberly River	From Tea Creek to the Peace – Moberly confluence	10.7	3-Jun-2010	0.73	4.1	24-July-2012	0.28	1.6
Pine River[2]	From the Peace – Moberly confluence to the Peace – Pine confluence	17.3	3-Jun-2010	0.80	2.8	24-July-2012	0.48	1.7

[1] The Bear Flats area was not surveyed due to private land considerations so 3.78 km^2 were subtracted from the survey block area for survey effort calculations.

[2] The Pine River survey block encompassed large recreational areas (e.g., parks) and private land areas. The lower survey effort reflects an increased helicopter speed to minimize disturbance over these areas.

The same survey blocks were surveyed pre- and post-spill using a Bell 206 Jet Ranger with rear bubble windows and a Eurocopter A-Star. The survey crew consisted of 3 people, including the pilot. The navigator sat in the front seat to the left of the pilot and was responsible for navigating, tracking survey block boundaries, marking observation waypoints with a GPS, and spotting. The observer in the rear of the helicopter recorded observation details on data sheets and spotted and classified animals. All observers and the pilot communicated with each other using headsets. Upon spotting an animal, the observer called out the species and other details to be recorded on the data sheet. The navigator also recorded the waypoint location and provided a waypoint number.

A Garmin (Olathe, KS) GPS 76CSx was used to take waypoints for each animal observation. All location data were recorded in UTM coordinates (NAD 83 datum). To ensure complete coverage of each survey block, we used a GPS – GIS interface to generate real-time flight tracks on a laptop computer linked to the GPS. DNR Garmin (*DNRGarmin* 2007) was used to overlay the flight path and waypoint locations on an ArcMap coverage consisting of contours, streams, and survey block boundaries. These flight paths were automatically saved to a .shp file for each survey block.

Due to the linear nature of the survey blocks, survey coverage consisted of flying parallel flight lines at a constant height and speed. The pilot was guided by the navigator to maintain flight at 80 – 100 km/hr and a height of 50 – 80 m above the ground. Where the width of the area being surveyed exceeded 200 m on either side of the flight line down the centre (400 m wide transects), additional parallel transects were flown to ensure complete coverage of the survey block and its margins. The target for survey effort was 4.0 minutes/km^2.

We adapted RISC standard data sheets (Animal Observation Form - Ungulate (Aerial) Encounter/Fixed-width Transect, Appendix 2) to record location and classification data for all observations. A Level II age and sex classification scheme (adult male, adult female, juvenile) was used to classify ungulate observations (Resources Inventory Committee 2002). Although this survey was focused on ungulates (and beaver, see below), all mammal observations were recorded during the course of the surveys.

All ungulate observations were entered into an MS Excel spreadsheet and summarized, then exported into ArcMap 10.1. MS Excel was used to calculate survey effort by dividing total survey time for each block by the area of the block in km^2.

4.3 Riparian Birds

Pre- and post-spill breeding bird surveys were conducted at the six index sites to estimate the impact of a spill on low-nesting bird species. Based on the previously conducted literature review and knowledge of the nesting ecology of bird species documented in the area, we focused on ground- and low shrub-nesting bird species (see Appendix 8) for our estimations of nest mortality. A total of 93 point count stations were established (minimum 200 m from centre to centre) and surveyed at index sites 1, 2, 3, 4, and 5/6 (Appendix 6, Appendix 7).

Pre-spill point count surveys and nest searching was conducted from 13-16 June and on 18 June, 2010 by a crew of two people; this timing coincided with the peak of the breeding season for the majority of species. Post-spill point count surveys were completed between 21st-23rd and 24th-25th of July, 2012. This was after the peak of the breeding season for most species, but the timing of the end of the spill was the over-riding consideration. Due to time and logistical constraints, only 52 of the 93 point count stations were surveyed at index sites 1, 2, 3, 4, and 5/6 (Appendix 6, Appendix 7).

Point count surveys 5 minutes in length and recording all species heard or seen (Resources Inventory Committee 1999) were completed between sunrise and 4 hours after sunrise. Upon arriving at a point count station, the observer waited 1 minute to allow any disturbance effects on resident birds to dissipate. During point counts, each bird detection within 100 m was spatially mapped on a data sheet with concentric radii of 25, 50, 75, and 100 m from the point count station (Appendix 3). Birds beyond 100 m were noted but not spatially located, as distance estimation at further distances is problematic (Alldredge et al. 2007). Time was broken down into 0-3 minutes and 3-5 minutes intervals, and detections associated to whichever time interval they were initially detected in. Environmental variables (e.g., wind speed, Appendix 5) and time of day were also recorded. Birds detected flying over the point count station were recorded but were noted as “fly-overs” rather than detections associated with habitat sampled by the point count survey.

Pre-spill nest searches targeting focal species were conducted opportunistically after morning point count surveys. Observations of breeding behaviour (e.g., carrying nest-building material) for focal species were noted during point counts as areas to conduct subsequent nest searches. Nests of other species (e.g., raptor stick nests, cavity nests unlikely to be flooded) were also recorded but were not considered during the analysis. The UTM coordinates, nest type, height off the ground, and species using the nest were recorded for each nest. Nests sites found during pre-spill surveys were checked during post-spill surveys for evidence of flooding or other disturbance. Any nests found during post-spill surveys were also recorded.

Bird detections were transferred from hard copy data sheets to a .shp file layer using ArcMap 9.3.1 (Figure 3). All bird detections were also entered into an MS Access database, then exported into MS Excel for summary analysis.

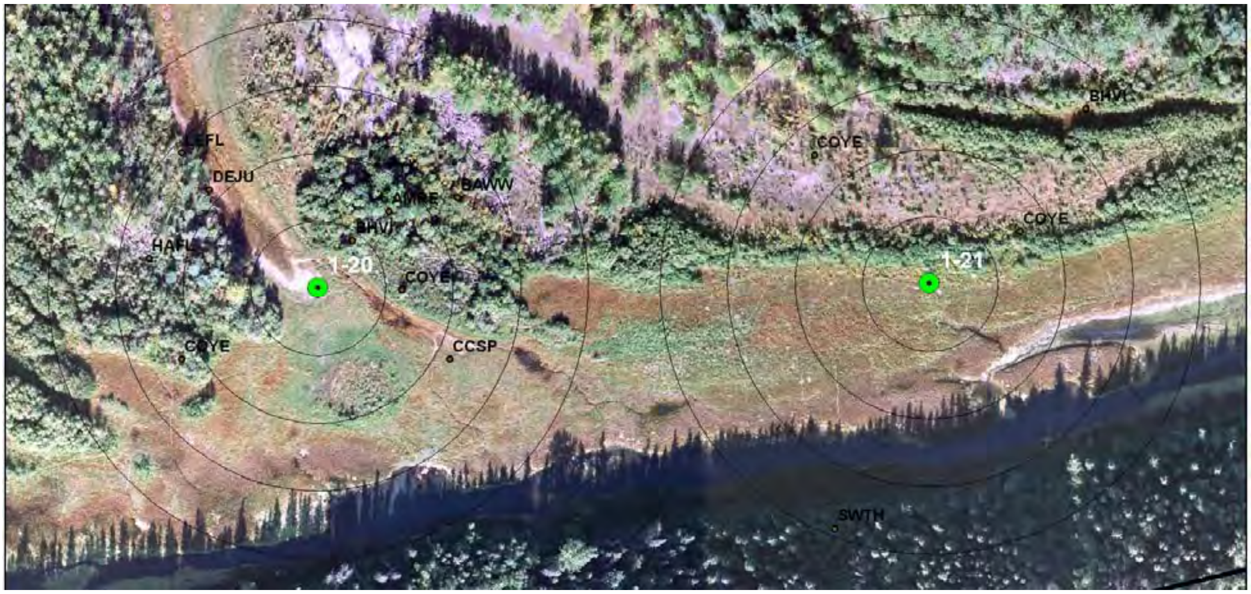


Figure 3. Bird detections mapped from point count surveys in the Peace River Valley, BC. Green circles are point count stations, 4-letter bird codes follow RISC (1999), parallel circles are concentric radii of 25, 50, 75, and 100 m.

We compared bird species richness and abundance qualitatively comparing point count data from pre- and post-spill point count surveys.

To estimate nest mortality (referred to as ‘bird mortality’ in the terms of reference), we selected focal bird species for which we had found three or more nests during pre- and post-spill nest surveys. These species were: Killdeer, Spotted Sandpiper, Savannah Sparrow, Lincoln’s Sparrow, Song Sparrow, and American. Assuming that each singing male represented 1 breeding territory and nest, we combined the nest records and singing male observations into a single ‘nest’ record file for each species.

Using ArcMap 10.1, the nest record file for each selected species was overlaid on the riparian habitat data, and each nest site assigned to a habitat class polygon. The nest density (nests/ha.) for each polygon containing a nest(s) was calculated, and then the average nest density across all polygons of that habitat class containing nests of that species was calculated. Then for each species, the average nest density for each habitat class was applied to all habitat class polygons in the study area to get an estimate of total nest numbers for the study area. To estimate nest mortality by species, we overlaid the 3000 m^3/s on the riparian habitat class layer and clipped the inundated areas out. We then re-calculated the number of nests by species in the non-inundated areas and compared the result to the pre-spill numbers.

To confirm our assumptions about the susceptibility of our selected species to nest mortality, we checked a sub-set of pre-spill nest sites during post-spill point count surveys and recorded the status: not flooded, flooded or unknown.

4.4 Beaver

Pre- and post-spill aerial surveys for beaver were done throughout the study area concurrently with aerial surveys for ungulates (see section 3.1, above) to asses the impact of a spill on beavers using beaver structures (see below) as an indicator. These surveys were consistent with RISC standards (Resource Inventory Committee 1998), although the timing is outside the optimum window (fall season after deciduous leaves have come off the trees and food caching activity is at its peak intensity). Given possible spill timing of June onwards, however, it was decided that surveys must be completed prior to a potential spill in 2010.

Observers recorded all beaver structures observed, including lodges, bank burrows, dams, food caches, and recent feeding activity. Structures immediately adjacent to each other (e.g., a food cache beside a bank lodge) we not counted as independant observations, but we marked as a single detection. Signs of recent activity such as mud-piling, green vegetation on structures and/or in food caches were also noted. Any observations of individual animals were also recorded. We estimated the total number of individuals in our study area by using an average of five individuals per active colony (Denny 1952), as evidenced by recent activity around lodges and food caches.

4.5 Western Toad

Pre- and post-spill surveys to assess the impact of a spill on western toad were done at two of the six index sites in the same field session as point count surveys for riparian birds (see section 3.2, above). A crew of two people conducted 2 days of pre-spill amphibian surveys at index sites 5/6 and 7 on the 12th and 17th of June, respectively. The same survey was completed post-spill at index sites 5/6 and 7 on the 19th and 20th of July, respectively. Methods followed provincial standards for determining presence/absence of pond-breeding amphibians in Resource Inventory Committee (1998). Fraker and Hawkes (2000) recommended conducting amphibian surveys during the breeding season (March – June) to increase the likelihood of detecting species occurring in the Peace River floodplain. Although the focus was on western toad, all reptiles and amphibians encountered during the surveys were recorded.

Amphibian surveys consisted of systematic shoreline searches for juveniles and adults (Resources Inventory Committee 1998). Any individuals found were identified and photographed where possible. At locations with large numbers of tadpoles (>100) the observation was recorded as ‘tadpoles’ if it was not possible to count an exact number. Species identifications were confirmed using Matsuda et al. (2006) for adults, and an unpublished tadpole key from the Ministry of Environment in Fort St. John, BC. Shoreline searches were conducted around larger open water bodies within index sites. These surveys involved one searcher walking in a zigzag pattern parallel to the shoreline of pools, disturbing vegetation and overturning coarse woody debris and other physical features within 4-5 m of the water’s edge. Due to the relatively small and well defined area of the index sites, all habitat judged suitable for western toad was surveyed at each site.

5 RESULTS

5.1 Riparian Habitat

5.1.1 Pre-spill

A total of 2441.91 ha. of riparian habitat classified into 24 habitat classes occurred within the study area (Table 2, Appendix 1). The largest group by area was the non-vegetated habitat classes, followed by balsam poplar dominated classes.

Table 2. Pre-spill riparian habitat classes and areas in the Peace River Valley between the PCN dam and Pine River, from MacInnis et al. (2011).

Habitat Code	Habitat Name	Habitat Class	Area (ha.)		
			Number of polygons	Total area	Percent of total area
Non-vegetated					
SA	Sandstone	Non-vegetated – gentle slope – sandstone	13	6.27	0.26
GB	Gravel bars	Non-vegetated – gentle slope – sand/gravel	222	742.25	30.40
GS	Gravel slope	Non-vegetated – moderate to steep slope – sand/gravel	11	4.65	0.19
IN	Industrial	Industrial/ residential/ recreational/ agricultural land	9	1.17	0.05
BS	Boulder slope	Non-vegetated – gravel/ cobble/ boulder	46	18.26	0.75
SH	Shale slope	Non-vegetated – shale – steep slope	4	0.44	0.02
SS	Sandstone slope	Non vegetated-steep slope – sandstone.	53	18.11	0.74
OW	Open Water	Water*	24	25.51	1.04
			Totals 816.65		**33.44**
Wetland and Aquatic					
AV	Aquatic vegetation	Aquatic to semi-aquatic vegetation – depressions and side channels	39	96.68	3.96
WE	Wetland	Wetland complex	19	116.15	4.76
			Totals 212.83		**8.72**
Shrub / graminoid / forb					
HE	Herbaceous	Herb – gentle slopes – sand/ gravel.	138	231.27	9.47
RS	Riparian shrub	Riparian shrub – graminoid/ forb	165	246.96	10.11
US	Upland shrub	Upland low shrub – graminoid.	5	4.05	0.17
			Totals 482.29		**19.75**
Balsam poplar dominated					

LA	Late Ac	Mature Ac stand	87	99.90	4.09
MA	Mid Ac	Mid Ac Sw-stand	187	330.28	13.53
AG	Ac – Sw - gravel	Early Ac Sw – shrub – sand/ gravel	52	109.88	4.50
AH	Ac – Sw - herb	Early Ac Sw – shrub and/or pole sapling	14	17.75	0.73
AS	Ac sapling	Mid Ac pole sapling and/or shrub	35	42.79	1.75
			Totals 600.60		**24.60**
White spruce, paper birch, or trembling aspen dominated					
MM	Mature mixed	Mature Sw Ep Ac stand	63	73.58	3.01
MS	Mature spruce	Mature Sw Ac Ep stand	170	170.00	6.96
SG	Sw – Ac - gravel	Early Sw Ac shrub – sand/ gravel	24	40.34	1.65
SP	Pioneer Sw	Early Sw Ac shrub – grass/ herb	13	11.70	0.48
ES	Birch – Spruce slope	Steep slope – Ep Sw stand	66	22.13	0.91
EA	Birch – aspen slope	Steep slope – Ep At	26	11.79	0.48
			Totals 329.54		**13.50**

*Note: this class does not include the area of the Peace River itself, only water that occurred within terrestrial polygons such as small ponds.

5.1.2 Post-spill

A total of 60.2% of the riparian habitat area was inundated at the peak of the spill (Table 3). The highest average percent inundated during the spill was in the balsam poplar dominated group (*x*=85.41%, *se*=3.32), followed by wetland and aquatic (*x*=81.56%, *se*=2.55), shrub/graminoid/forb (*x*=72.10%, *se*=9.30), white spruce, paper birch or trembling aspen dominated (*x*=49.55%, *se*=13.40), and finally non-vegetated (*x*=13.86%, *se*=4.71).

Table 3. Area (ha.) of riparian habitat inundated during the 2012 spill from the PCN dam, Peace River Valley, BC.

Habitat code	Number of polygons inundated	Average polygon area pre-spill (ha.)	Average polygon area peak-spill (ha.)[1]	Total area pre-spill (ha.)	Total area peak-spill (ha.)	% of area inundated
SA	13	0.48	0.48	6.27	6.25	0.35
GB	187	3.34	2.72	742.25	509.25	31.39
GS	11	0.42	0.40	4.65	4.40	5.28
IN	8	0.13	0.12	1.17	0.95	18.69
BS	47	0.39	0.38	18.26	17.92	1.88
SH	4	0.11	0.08	0.44	0.31	29.71

SS	52	0.34	0.27	18.11	13.94	22.99
OW	23	1.06	1.10	25.51	25.35	0.60
AV	30	2.48	0.51	96.68	15.36	84.11
WE	10	6.11	2.44	116.15	24.38	79.01
HE	97	1.68	1.10	231.27	107.14	53.67
RS	93	1.50	0.55	246.96	51.49	79.15
US	4	0.81	0.17	4.05	0.67	83.48
LA	61	1.15	0.07	99.90	4.22	95.78
MA	132	1.77	0.47	330.28	62.50	81.08
AG	30	2.11	0.87	109.88	26.25	76.11
AH	10	1.27	0.21	17.75	2.11	88.13
AS	20	1.22	0.30	42.79	6.00	85.97
MM	53	1.17	0.13	73.58	7.09	90.37
MS	145	1.00	0.19	170.00	27.78	83.66
SG	20	1.68	1.26	40.34	25.11	37.76
SP	11	0.90	0.48	11.70	5.24	55.19
ES	62	0.34	0.31	22.13	19.42	12.27
EA	23	0.45	0.42	11.79	9.66	18.06
Totals 1146		**-**	**-**	**2442**	**973**	**60.16**

[1] Area not inundated at the peak or maximum extent of the spill.

5.2 Ungulates

5.2.1 Pre-spill

A total of 42 detections comprising 81 individual ungulates were made (Table 4, Appendix 3). Three of these detections were juveniles or included juveniles in the group (moose: 2, elk: 1, Figure 4). Detections are defined as sightings made during the survey (i.e., a single detection can include multiple individuals). Detections by survey block ranged from a low of 2 (Pine River) to a high of 9 (Peace Canyon, Cache Creek, Wilder Creek) with the remaining blocks all having 3 detections (Farrell Creek, Halfway River, Moberly River). The majority of individuals were detected on the banks of the main channel for all species with the exception of mule deer, which were observed equally on in-stream islands (Table 4).

Table 4. Numbers and locations of individuals made during pre-spill aerial ungulate surveys in the Peace River valley, BC.

BLOCK	MOOSE		ELK		MULE DEER		WHITE-TAILED DEER		UNIDENTIFIED DEER	
	BANK	ISLAND	BANK	ISLAND	BANK	ISLAND	BANK	ISLAND	BANK	ISLAND
Peace Canyon	-	-	-	1	1	1	5	2	2	-
Farrell Creek	2	-	3	-	-	1	-	-	-	-
Halfway River	1	1	-	-	-	-	-	-	1	-
Cache Creek	2	1	19	-	6	3	-	-	-	-
Wilder Creek	1	-	1	1	5	3	-	-	-	2
Moberly River	-	-	-	-	5	3	-	-	-	-
Pine River	-	-	-	-	-	6	-	-	-	-
TOTAL	**6 2**		**23**	**2**	**17**	**17**	**5 2 3 2**			

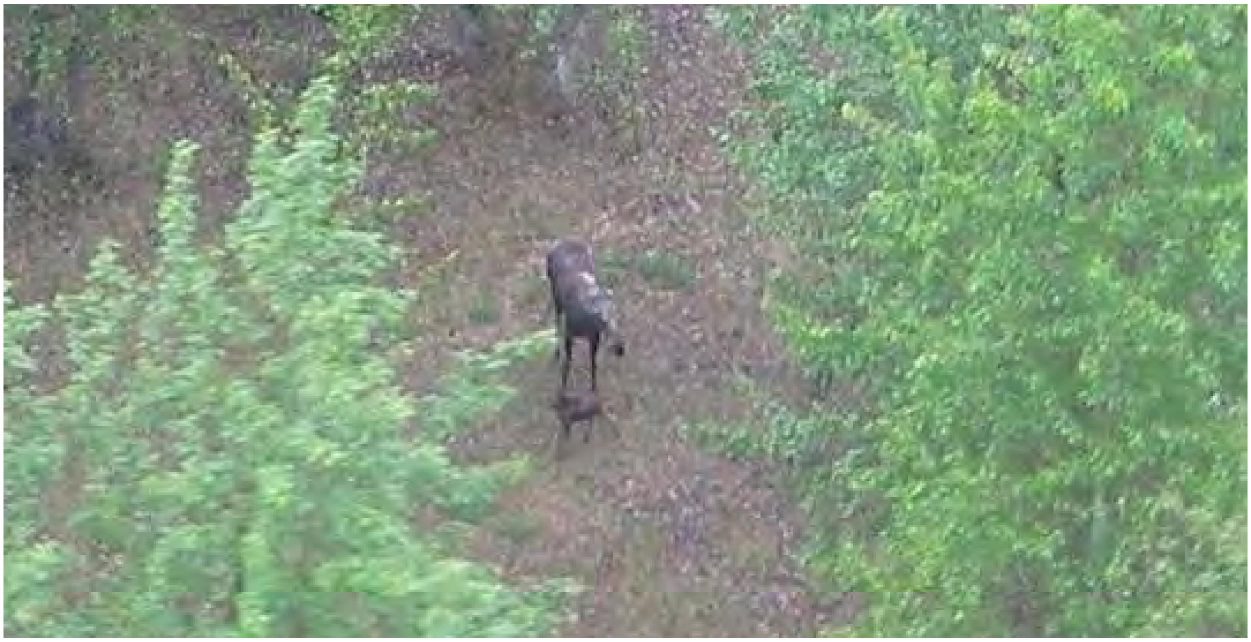


Figure 4. Moose cow with new (< 5 days old) calf on a mid-channel island, 3-Jun-2010, Peace River valley, B.C.

5.2.2 Post-spill

A total of 16 detections comprising 23 individual ungulates were made (Table 5, Appendix 5). Only 1 juvenile ungulate was detected, an unidentified deer on an island in the Peace Canyon block. Detections were low in all survey blocks, although detections were distributed through all seven survey blocks.

Table 5. Numbers and locations of individuals made during post-spill aerial ungulate surveys in the Peace River valley, BC.

BLOCK	MULE DEER		UNIDENTIFIED DEER	
	BANK	ISLAND	BANK	ISLAND
Peace Canyon	-	-	-	4
Farrell Creek	-	-	-	1
Halfway River	-	-	1	-
Cache Creek	1	-	1	3
Wilder Creek	-	4	3	-
Moberly River	-	-	1	-
Pine River	3	1	-	-
TOTAL 4		**5**	**6**	**8**

5.3 Riparian Birds

5.3.1 Pre-spill

Surveys recorded a total of 676 detections of 70 species (Appendix 8). Four threatened or endangered species were detected during the surveys: Black-throated green warbler, Canada warbler, LeConte’s sparrow, and Rusty blackbird (Appendix 8).

Seventy-seven nests were found during nest searching activities, including 31 unoccupied nests (Appendix 9). Some unoccupied nests had signs indicating they had obviously been constructed in a previous nesting season (e.g. nest cup full of dead leaves and spider webs), but others were likely built during the survey year and became unoccupied (e.g., predation, Figure 6). Nest searching focused on areas likely to be inundated (less likely to be treed), so the majority of nests found were cup nest in shrubs and small trees (61.5%, n = 48) and ground nests (26.9%, n = 21). Other nest types found were bank (n = 3), cavity (n = 3), and stick (n = 3). Of the occupied cup nests found, the average height above the ground was 2.83 m (SE = ± 0.56).

Figure 5. American Robin nest with 4 eggs built in the crook of an alder shrub ~ 1 m off of the ground, Peace River valley, BC.

Figure 6. Common garter snake predating a chipping sparrow nest in the Peace River valley, BC.

5.3.2 Post-spill

Surveys recorded a total of 265 detections of 49 species (Appendix 8). Of the four threatened or endangered species detected in pre-spill surveys, only Canada Warbler was detected again during post-spill surveys (Appendix 8).

Some differences were noted in species composition and abundance between pre- and post-spill surveys (Appendix 8). No detections of black-and-white warbler, a ground nester, were made during post-spill surveys, although they were detected relatively often during pre-spill (*n*=15) surveys. A similar pattern was evident for species associated with ground or low-shrub habitats such as Clay-coloured Sparrow (pre *n* = 14; post *n* = 1), Killdeer (pre *n* = 8; post *n* = 0), Lincoln's Sparrow (pre *n* = 31; post *n* = 4), Magnolia warbler (pre *n* = 10; post *n* = 0), Ovenbird (pre *n* = 5; post *n* = 0), Savannah Sparrow (pre *n* = 6; post *n* = 0), and Tennessee Warbler (pre *n* = 19; post *n* = 0). Some ground- or low shrub-nesting species such as Song Sparrow (pre *n* = 45; post *n* = 46), Spotted sandpiper (pre *n* = 16; post *n* = 10), and Yellow warbler (pre *n* = 49; post *n* = 49) however, were roughly equal in abundance between pre- and post-spill surveys.

Average density by habitat class for which nests occurred in was generally low, with the exception of spotted sandpiper in the riparian shrub habitat class (Table 6).

Table 6. Nest density by habitat class for riparian bird species in the Peace River valley, BC.

HABITAT CODE	AVERAGE DENSITY (NESTS/HA.)					
	Killdeer	Savannah Sparrow	Spotted Sandpiper	Song Sparrow	Lincoln's Sparrow	American Redstart
AG	-	-	-	-	0.114	6.590
AS	-	-	-	-	0.235	0.644
AV	-	-	-	0.154	0.085	0.170
GB	0.073	0.266	0.205	0.315	-	0.423
LA	-	-	-	0.291	0.291	1.689
MA	-	0.119	-	0.736	0.196	0.237
RS	-	0.494	2.368	0.476	0.580	0.421
WE	-	0.096	-	0.192	0.294	0.096
HE	-	0.204	-	0.384	0.256	-
SG	-	-	-	0.289	0.289	-
SP	-	-	-	0.747	-	-

Highest estimated nest mortality for the entire study area was for killdeer, and lowest was for American redstart (Table 7).

Table 7. Estimated nest mortality by species for the study area, Peace River valley, BC.[1]

SPECIES	ESTIMATED TOTAL NUMBER OF NESTS	ESTIMATED NUMBER OF NESTS NOT FLOODED	% NEST MORTALITY
Killdeer	54	38	29.63
Savannah Sparrow	416	324	22.12
Spotted Sandpiper	736	587	20.24
Song Sparrow	769	624	18.86
Lincoln's Sparrow	373	324	13.14
American Redstart	1445	1310	9.34

[1] This does not take into account males that did not breed, failed nests, predated nests or any other cause of nest failure.

Of the 77 nest sites found during pre-spill nest searches (in 2010), 29 were checked to confirm the flood status (in 2012). Nests were only counted as flooded if there was obvious evidence of flood damage or debris to the nest structure (Figure 7) or nest site in general. Of these 29 nests, 14 were unoccupied and not assigned to a species. Of the 15 nests where the nesting species was identified, only 3 ground nests were confirmed as flooded: a Spotted Sandpiper nest, a Tennessee Warbler nest, and an unidentified (probably Savannah) sparrow nest.

Figure 7. Flooded American Robin nest low in alder shrub, Peace River valley, BC. Note heavy layer of sediment coating nest structure.

5.4 Beaver

5.4.1 Pre-spill

In total, 99 observations were made of beaver structures (Table 8, Figure 8, Appendix 10). Three individual animals were observed, 2 on lodge structures and one swimming mid-stream. By using an assumption of 5 individuals per active lodge/bank lodge, the population estimate for the study area is 100 animals (Table 8).

Table 8. Summary of beaver structures and individuals observed during pre-spill aerial surveys, Peace River Valley, B.C.

Survey Block	Active?	Bank lodge	Dam	Feeding	Food cache	Lodge	Grand Total	Block pop. estimate[1]
Cache Creek	N	3	2	-	-	2	7	35
	Y	6	-	-	-	1	7	
Farrell	N	3	-	-	-	3	6	15

Creek	Y	1	-	-	-	2	3	
Halfway River	N	7	2	-	-	3	12	5
	Y	-	-	1	-	1	2	
Moberley River	N	3	2	-	-	4	9	15
	Y	3	-	-	-	-	3	
Peace Canyon	N	2	2	1	-	5	10	5
	Y	-	-	2	-	1	3	
Pine River	N	11	6	-	-	1	18	-
Wilder Creek	N	7	2	-	1	1	11	25
	Y	3	1	-	-	2	6	
Total		**49**	**17**	**4**	**1**	**26**	**99**	**100**

[1] Population estimates for each block derived by assuming 5 individuals per active lodge.

Figure 8. Beaver food cache on main stem of the Peace River, B.C. Note fresh green material added to edge of cache.

5.4.2 Post-spill

A total of 23 observations were made of beaver structures across the study area (Table 9). Three individual animals were observed, all 3 swimming in mid-channel. No active structures were confirmed, so no post-spill population estimate is available.

Table 9. Summary of beaver structures and individuals observed during post-spill aerial surveys, Peace River valley, BC.

Survey Block	Active?	Bank lodge	Dam	Feeding	Food cache	Lodge	Grand Total	Block pop. estimate[1]
Cache Creek	N	1	3	-	-	-	4	-
Farrell Creek	N	1	-	-	-	-	1	-
Halfway River	N	1	2	-	-	1	4	-
Moberley	N	1	-	-	-	-	1	-

River								
Peace Canyon	N	1	1	-	-	2	4	-
Pine River	N	2	-	-	-	3	5	-
Wilder Creek	N	1	2	-	-	1	4	-
Total		**8**	**8**			**7**	**23**	**-**

5.5 Western Toad

5.5.1 Pre-spill

Two species of amphibian, western toad (Table 10, Figure 9) and wood frog) were detected across both sites. Other amphibian and reptile observations were recorded opportunistically during point count surveys and nest searching for birds at all index sites (Appendix 12).

Table 10. Number of amphibians by age class detected during pre-spill surveys in the Peace River valley, BC.

SITE	**DATE**	**WESTERN TOAD**			**WOOD FROG**			**SITE TOTAL**
		Adult	Juv.	Total	Adult	Juv.	Total	
5/6	Jun-12	1	1	2	10	-	10	12
7	Jun-17	3	-	3	4	4	8	11
Species Total		**4**	**1**	**5**	**14**	**4**	**18**	**23**

Figure 9. Western toad pair in pectoral amplexus in shallow side-channel pool on the shore of the Peace River, B.C. Note string of eggs.

5.5.2 Post-spill

Post-spill surveys for western toad recorded two species of amphibian, western toad and wood frog at both sites, but only in the adult stage of their life-cycle (Table 11). Anecdotal observations of western toad at all stages of their life-cycle, however, were detected at other index sites (Figure 10; Appendix 12).

Table 11. Number of amphibians by age class detected during post-spill surveys in the Peace River valley, BC.

SITE	DATE	WESTERN TOAD			WOOD FROG			SITE TOTAL
		Adult	Juv.	Total	Adult	Juv.	Total	
5/6	Jul-19	1	-	1	4	-	4	5
7	Jul-20	1	-	1	-	3	3	4
Species Total		**2**	**-**	**2**	**4**	**3**	**7**	**9**

Figure 10. Western toad tadpoles in margin of shallow pool, post-spill, Peace River valley.

6 DISCUSSION

The spill that occurred in 1996 was significantly larger than the spill that occurred in 2012, with a total volume of 4,236 m^3/s, more than double the PCN maximum normal discharge of 1,982 m^3/s (BC Hydro 1997). Some of the survey design components laid out in the terms of reference (BC Hydro 2008) were designed to address wildlife impacts from a flood of this magnitude (e.g., drowning ungulates). Because the 2012 spill reached a peak of only 2,879 m^3/s, the majority

(~97%) of the in-channel islands were not flooded during the spill, and less riparian habitat was inundated across the entire study area. Thus it is reasonable to assume that the overall effects on the 4 target taxa of the 2012 spill were of lower magnitude.

Even at this lower spill volume, however, we did detect impacts on some of the four target taxa (see individual sections below). This suggests that even at the lower end of the range of spill volumes, there are measurable impacts to wildlife in the study area. The 2,000 m^3/s threshold in the PSP (BC Hydro 2008) is thus probably an appropriate trigger for the wildlife monitoring program. Spill timing will also influence the effect of a spill on wildlife given that with the exception of beaver, the impacts on the target taxa are mostly associated with the spring/summer breeding season (i.e., when reproductive structures such as eggs or relatively non-mobile young are present in the area). With western toad beginning breeding relatively early in the year (April/May) and the young of some songbird species fledging as late as the middle to end of July, the combined breeding period of all four target taxa is relatively broad. It is unlikely that a spill would occur during a time period when none of the target taxa are vulnerable to the resulting impacts.

Our field observations suggested that the maximum water height reached roughly 2.0 – 2.5 metres above the normal level of the river (Figure 11). In some places (large low lying islands), flood water had extended inland over 100 m from the wetted line at normal flows. Sediment deposition is possibly the most pervasive of the physical effects, with a layer of fine silt deposited (≤ 50 cm deep) in nearly all flooded riparian areas, in places extending into older cottonwood groves. The ground surface in these areas consisted of a hard drying mud, sometimes with a thin grass cover; few forbs and very little ground cover vegetation or litter remained. Areas exposed to stronger currents during the spill have less sediment deposition.

Figure 11. Sediment on willow shrubs indicating maximum inundation depth on an in-channel island, Peace River valley, BC.

Riparian habitat

Based on our data on extent of inundation on all riparian habitat classes and ground observations of inundated area, there are likely not major long-term impacts to riparian habitat. Short-term negative impacts to riparian habitat for the four target taxa are evident (see below), however, particularly for riparian birds.

Some riparian vegetation shows evidence of flooding over 1.0 m deep, but most of it less than 1.0 m. In areas exposed to strong current, frequently shingle beaches, some vegetation (mostly young cottonwood) had been bent over by the force of the water. Erosion of steep banks adjacent to swift current areas appears to have been heavy in some places, with two point count stations now 12 m and 20 m away from their previous respective locations, which are now part of the river.

In the GMSWORKS 7 report, MacInnis et al. (2011) noted that the balsam poplar dominated group, wetland and aquatic group, and riparian shrub/ graminoid/ forb group were the most likely to be affected by flood events due to their proximity to the river edge. Together these classes cover >43% of the study area, and so are a significant component of the riparian vegetation. This pattern was confirmed by our observations assessment of riparian habitat inundated under the 3000m m^3/s spill, with the balsam poplar habitat class having the highest area inundated (85%), followed by wetland and aquatic (81%), riparian shrub/graminoid (72%), white spruce/paper birch/aspen dominated (49%), and finally non-vegetated (13%).

Although the spill lasted for approximately 20 days, not all areas that were inundated at peak spill were inundated for the full duration of the spill. Logically, areas immediately adjacent to the river edge were flooded first and drained last. Because, however, the only flow data available was for the maximum spill volume of 3,000m m^3/s, we were unable to assess differences in extent and duration of flooding for different areas at intermediate spill volumes, or severity of effects on different habitat classes. There are considerable differences in the duration, frequency and timing of flooding on regulated rivers when compared to natural flood events on free-flowing river systems. Several studies have concluded that mimicking natural hydrological regimes reduces the negative ecological impacts associated with changes in flow and water-level regimes (Poff and Zimmerman 2010). Erosion and deposition resulting from rapid changes in flow rates will inherently change the isolated pools and wetlands (Johansson and Nilsson 2002).

Although the phrase ‘riparian habitat loss’ reflects the terminology of the project terms of reference, riparian habitat is not actually ‘lost’ as the result of a spill. It is rendered unavailable for a period of time (during inundation) for some groups of species such as nesting birds. Given that some riparian habitat types (e.g., cottonwood dominated stands) associated with river floodplains are created and maintained by periodic flood events (Burns and Honkala 1990), it is likely that the short-term impacts (e.g., during and immediately after a spill) on wildlife populations from flood mortality and habitat loss are out-weighed by the long-term value of spill events in creating and maintaining riparian habitat (Braatne et al. 2008). It should be noted that the PSP includes plans to complete a project (GMSMON 6) that will examine the persistence of flood-maintained vegetation communities under a regulated flow regime.

Ungulates

In addressing the first management question and associated hypothesis:

1) What are the impacts on ungulates and their habitat as a result of a spill event?

H_1: Ungulate mortality/habitat loss resulting from a spill significantly impacts the ungulate population in the Peace River floodplain downstream of Peace Canyon Dam, we suggest that the impacts to the ungulate population downstream of the PCN dam are relatively minor.

The four ungulate species (elk, moose, mule deer and white-tailed deer) that occur in the study area are relatively synchronous in timing of calving. Calving takes places in late May to early June (Shackleton 1999). With the 2012 spill occurring in late June, the calving period would have been over for several weeks.

Of the four target taxa, ungulates were probably the least affected group. The majority of pre-spill detections were on bank areas rather than islands, however, some observations were made on islands, especially for mule deer. These detections included juvenile (estimated < 2 weeks old) moose, elk, and mule deer, and other studies have confirmed ungulate birthing sites on these in-channel islands (Simpson 1993). Islands that were totally or almost totally submerged, however, tended to be sparsely vegetated, low-lying shingle bars, not suitable ungulate foraging or birthing habitat. Given that the magnitude of the 2012 spill was relatively small, very few of the islands in the study area were fully inundated, and none of the higher elevation islands with well developed conifer habitat were impacted significantly. Precocial ungulate young are mobile shortly after birth, and would have little difficultly moving away from flood prone birthing areas on islands above the inundation level. We expect that few, if any, ungulates drowned as a direct result of the spill.

Pre- and post-spill survey data were not directly comparable with the most recently available ungulate aerial survey data collected in 2006 by Keystone (2009), as they completed their surveys in the winter under completely different sightability conditions. Ungulate sightability during our survey was greatly reduced due to the heavy deciduous canopy that dominated much of the study area.

Survey effort was less than half in the post-spill as composed to pre-spill survey effort. Between 2010 (pre-spill survey) and 2012 (post-spill survey), internal BC Hydro helicopter operation regulations that were in flux solidified and prohibited low and slow flying to enable helicopter auto-rotation in case of engine failure. These new guidelines do not allow single-engine helicopter speed or height above the ground to conform to RISC standards for aerial ungulate surveys. Due to the lack of twin-engine helicopter availability during the period during and immediately post-spill, a single engine helicopter was used in 2012. The increased speed reduces survey effort, and the increased height above the ground decreases efficacy of observers in detected ungulates. This reduced survey effort is likely the main reason that relatively few ungulates were detected across the entire study area during post-spill surveys as compared to pre-spill surveys.

The majority of the temporary 'habitat loss' occurred in the habitat classes immediately adjacent to the river channel (e.g. non-vegetated types) or low-lying ephemeral wetland areas. The effects on ungulates from these habitats becoming temporarily inundated are probably minimal. While riparian habitat classes do contain foraging habitat such as shrub or grass/sedge dominated areas, the low magnitude and short duration of the spill would not render these unavailable for long. Adult ungulates are also strong swimmers, and would be capable of relatively strong currents to access alternate foraging areas. We did observe an instance of a female elk on the bank while her calf was hidden on an island separated from each other by a relatively deep and fast river channel. Ungulates often select birthing sites based on vegetation characteristics, including the dense cover often typical of riparian areas (e.g., Poole et al. 2007). Thus, if spills promote maintenance and/or development of riparian habitat over the long term (see riparian habitat section, above), the long-term benefits of maintaining riparian floodplain habitat utilized as birthing sites by ungulates may outweigh short-term impacts of habitat unavailability due to a spill.

Riparian Birds

In regards to the management question and associated hypothesis:

3) What are the impacts on riparian birds and their habitat as a result of a spill event?

H_3: Riparian bird mortality/habitat loss resulting from a spill significantly impacts the riparian bird population in the Peace River floodplain downstream of Peace Canyon Dam,

we concluded there were significant short term impacts on local populations of riparian birds due to nest mortality of ground- and low shrub-nesting species.

The majority of bird species in the study area begin courtship and nest building activities starting in mid-May and extending through until early June, lay eggs in early to mid-June, and have fledged young by the middle of July (*The birds of North America online* 2012). Timing of breeding varies annually, mainly due to weather conditions along migration routes and at breeding locations. The late June start of the 2012 spill would have overlapped with the fledging period for most of the bird species we detected in the study area. Sensitivity to spill impacts varied by species according to nesting ecology (i.e., both timing of nesting and location of nest).

Extrapolating our nest mortality results to other species, we suspect that many ground and low-shrub nesting species of the flooded parts of the riparian zone lost nests due to the flooding associated with the 2012 spill. Further to this, the ground surface in riparian zones was altered by the sediment deposition, to the extent that it would not be suitable for post-flood nesting attempts. In combination, these habitat impacts likely explain the absence or near absence in the 2012 post-spill period of species like Killdeer, Tennessee Warbler, Black and White Warbler, Magnolia Warbler, Lincoln's, Savannah and Clay-coloured Sparrow, all abundant and breeding in 2010. It is possible that by conducting the 2012 post-spill point count surveys at the very end of the breeding season (late July), we may have not detected species that had already bred and fledged young. This, however, is unlikely to explain the complete absence of the species noted above, as several other species with similar breeding phenology (e.g., Yellow Warbler) were still present in the study area.

It should be noted, however, that it is possible (if unlikely) that some other annual effect could potentially explain these differences. For example, the Halfway River experienced a natural flood event in July 2012 that was nearly the volume of the spill itself. There was likely some natural nest mortality associated with this event. Of note, many Spotted Sandpipers and Song Sparrow were seen with fledged young post-spill. These ground nesters, perhaps choosing higher settings and breeding earlier in the season, were clearly not so negatively affected by the flood. Several tall-shrub nesting species (Yellow Warbler, Red-eyed Vireo) were also observed with fledged young and appear to have been minimally affected. For other riparian shrub nesting species, active and inactive nests of Cedar Waxwing and American Robin found in 2012, were nearly all above flood height and these species appeared minimally affected.

The nest mortality figures we present are based on relatively few actual nests, and the assumption that each singing male represented an active nest. This does not take into account males that did not breed, failed nests, predated nests or any other cause of nest failure. These nest mortality estimates should be used as a rough relative index only. For example, spotted sandpiper nest density in the RS habitat class is very high. This is as a result of two separate nest records falling within an RS habitat polygon with a very small area, thus inflating the nest density estimate for that habitat type. Also, we only estimated mortality for those species where we had sufficient data to do so. A ground-nesting species like LeConte's sparrow, which is blue-listed in BC, may have suffered nest mortality due to the spill, but we were not able to assess this even anecdotally.

Breeding habitat for several of the ground- and low shrub-nesting bird species in our study area was widely inundated. For example, Killdeer nest on a gravel/cobble substrate free of vegetation, habitat commonly found in low-gradient areas along the edge of the river susceptible to flooding. Similarly, Savannah Sparrows nest in short and/or sparse grass habitat, often adjacent to low-gradient areas prone to flooding. Based on the results of the point count surveys and their nesting ecology, we consider the following riparian bird species occurring in our study area to be most vulnerable to spill related nest mortality:

- Savannah Sparrow
- LeConte's Sparrow
- Lincoln's Sparrow
- Clay-coloured Sparrow
- Song Sparrow
- Magnolia Warbler
- Black-and-white Warbler
- Tennessee Warbler
- Killdeer
- Spotted Sandpiper
- Solitary Sandpiper

While there was likely widespread nest failure in 2012 for ground and low-shrub nesting species in the inundated portion of the riparian zone, the habitat damage that occurred was relatively minimal, and the long-term effects on riparian bird populations in the area should be minimal. Furthermore, it should be noted that the spill of 2012 coincided with a very wet spring and summer, and many rivers in BC overflowed their normal spring freshet levels causing widespread flooding, and damage to private properties and public infrastructures (e.g., bridges and roads) throughout the province. It is certain that nest mortality would have been high in unregulated rivers and creeks. When this is considered, the relative impact of the spill may be negligible, and even preferable to unregulated systems.

Beaver

In regards to the management question and associated hypothesis:

2) What are the impacts on beavers and their habitat as a result of a spill event?

H_2: Beaver mortality/habitat loss resulting from a spill significantly impacts the beaver population in the Peace River floodplain downstream of Peace Canyon Dam,

we concluded that there were likely significant short term impacts to the beaver population in the study area due to habitat loss, specifically losses of lodges and food caches.

Unlike the other three target taxa, potential impacts to beaver from a spill are not focused on the breeding season. While beaver in the study area probably give birth to young from mid-May to mid-June (Nagorsen 2005), lodge and food cache structures are used year round to meet life history requisites. A spill occurring at any point of the year that affects these structures would have potential impacts to the beaver population in the study area.

Despite lower survey effort in post-spill aerial surveys, lodges and food caches are obvious structures in relatively open areas, and so structures detected in pre-spill surveys would be unlikely to be missed in post-spill surveys. Lower survey effort alone would not account for the large drop in number of beaver structures recorded. Anecdotal observations on the ground of destroyed lodges and collapsed bank lodges confirm that some percentage of beaver structures were destroyed by the spill.

These losses, however, are unlikely to have a long-term impact on the local beaver population. Beaver will readily re-colonize an area and can quickly repair/re-build structures and food caches. The magnitude of the spill was not high enough to physically remove riparian vegetation (e.g., balsam poplar stems adjacent to water). During riparian bird and western toad surveys, we noted areas of fresh vegetation harvesting in areas still covered in moist flood-deposited sediment.

During ground surveys, it was noted that a layer of fine fluvial sediment had accumulated on vegetation, driftwood, and structures like beaver dams and lodges (Figure 12). This layer of fine sediment likely made it difficult to identify the fresh green vegetative material added to active lodges and dams during aerial surveys, unless it was added immediately post-spill. We suspect this is the reason that we did not identify any active structures during out post-spill survey. Although we could not positively confirm the active status of beaver structures during the survey, the observation of swimming individuals indicated that obviously some percentage of colonies were still active.

Figure 12. Heavy layer of flood deposited sediment on beaver lodge in the Peace River valley, BC.

Previous beaver surveys between the PNC dam and Moberly River estimated higher number of individuals than the results of this study. Surveys completed in 1976 (Blood 1979) estimated 150-200 individuals, while surveys completed 14 year later (Simpson 1993) estimated 380 individuals. Fraker and Hawkes (2000) conducted surveys for beaver in the Peace floodplain and found them to be common downstream of Farrell Creek, but uncommon upstream. They recorded observations of lodges, dams, and food caches; most of the food caches were situated on the mainstem of the river. This is consistent with what was observed during this study (Appendix 11). Upstream of Farrell Creek, we noted that the river channel substrate is composed of significant sections of bedrock, with steep river banks fewer slow-moving eddies and back channels. Downstream of Farrell Creek, there were more back channels and other suitable habitat for beaver colonies to be established. Prior to our survey, the most recent survey (completed in 2005) estimated 335 individuals (Keystone Wildlife Research Ltd. 2009).

Blood (1979) noted that beaver colonies on the Peace River largely use bank lodges, which are harder to detect from the air. Additionally, previous surveys were focused on exclusively on beaver with higher survey effort, as well as a boat-based component that allowed greater detection of bank lodges. In combining ungulate and beaver surveys into a single aerial survey, we most likely decreased the detection rate for beaver structures, resulting in the lower population estimate resulting from our survey.

Western Toad

Regarding the final management question and associated hypothesis:

> 4) What are the impacts on the western toad and their habitat as a result of a spill event?
>
> H_4: Western toad mortality/habitat loss resulting from a spill does not significantly impact the western toad population in the Peace River floodplain downstream of Peace Canyon Dam,

we were unable to assess the degree of impact, if any, to western toad populations and habitat in the study area.

Western toad begin breeding activities in the spring, probably in early- to mid-April in the study area, and continue through until June. While it is likely that a spill occurring during the breeding season would have a greater effect on western toad populations due to the presence of egg masses and tadpoles, any spill within the active (non-hibernation) period would probably have some effect. Relative to the spatial scale that a spill occurs at, western toad have relatively low mobility and are dependant on small pool and back-channel habitats, habitats that are rendered temporarily unavailable by a spill.

Due to a limited number of survey sites, it is difficult to say what the impacts to the western toad population in the study area are. While our data set is not sufficiently robust to draw firm conclusions regarding the impact of a spill on the western toad populations, we can confirm that the species occurred both pre- and post-spill at both survey sites. Undoubtedly there was some mortality of adults and/or juveniles, however, our anecdotal observation suggest that the mortality rate was not high enough to be noticeable.

In order to maximize detectability, western toad surveys should be conducted during the breeding season (approximately March through June) and when possible, immediately after rain or during a wet period of weather to maximize the likelihood of detecting amphibians (Resources Inventory Committee 1998, Fraker and Hawkes 2000). The pre-spill effort was completed towards the end of the optimal survey window. However the timing of the 2012 effort was dictated by the spill and surveys were conducted once water conditions dropped to a safe level, several weeks later than the expected peak breeding season. Where studies are conducted at different times during the western toad life cycle, the results may not be comparable (Resources Inventory Committee 1998). This may partially explain why higher numbers of western toad were detected at all sites where they were observed during the pre-spill surveys. Weather conditions were good during both pre- and post-spill surveys and we observed abundant back channel and ephemeral pool habitat, however, so the difference in numbers may reflect a real effect of the spill.

During flood events, water levels increase rapidly allowing the main river channels to connect with usually isolated pools which under normal conditions provide secure breeding and nursing habitat for amphibians (Matsuda et al. 2006). Water levels then recede, once again isolating the pools and creating many shallow ephemeral pools. Depending on the timing of a spill, the creation of additional off-channel aquatic habitat may positively affect toad abundance (Bateman et al. 2008). Conversely however, changes in water temperature, debris loads, turbidity and flow volume may result in negative impacts on the survival, growth and development of western toads (Hecnar and M'Closkey 1996, Matsuda et al. 2006). Increased volume and flow rate will likely result in eggs, larvae, juvenile and adult amphibians being flushed out of their habitat and washed into the flooded main channel resulting in displacement, increased stress and potentially mortality (Eskew et al. 2012). Increased flow rates with high debris loads also have the potential to scour the substrate and surrounding riparian vegetation reducing vital thermal and security cover for surviving toads. Within the study area, increased flow rates can occur without exceeding the 2,000 m^3/s threshold that triggers the wildlife monitoring. Based on the data from this study, we cannot make an assessment of whether the 2,000 m^3/s spill volume is above or below the threshold of where significant impacts to western toad habitat begin to occur.

6.1 Recommendations

During the course of this study, several issues and deficiencies in study design components were noted that decreased the certainty with which we could address the management questions. Issues specific to the four target taxa included:

- Ungulates – aerial surveys conducted after leaf-out are not ideal due to low sightability, and aerial surveys alone do no provide a direct measure of habitat impacts. Using aerial surveys to detect drowning ungulates is a labour-intensive way to measure what is probably a negligible effect at the population level.
- Beaver – it is difficult to identify active lodges and food caches using aerial surveys completed after a spill event has covered signs of recent activity with layers of fluvial sediment
- Riparian birds – our limited number of sample sites (5 across the 100 km length of the study area) meant that we only had sufficient data to estimate nest mortality for six species. This did not include any of the rare or endangered bird species known to occur in the study area.
- Western toad – our limited number of sample sites (2 across the 100 km length of the study area) did not provide sufficient data to detect an affect, if any, on western toad populations.

Overall, to address the uncertainty in answering the management questions and associated hypothesis, we suggest a two-part approach:

1) Focus spill effects monitoring on taxa that experience or likely experience significant impacts, or where impacts may have a large effect relative to population size (i.e., rare or endangered species)
2) Based on this narrowed focus, redesign study methods and sampling effort to ensure the monitoring program will be able to answer the management questions with the required degree of certainty

Based on our experience in conducting pre- and post-spill monitoring for the 2012 spill, we offer the following recommendations:

1. Focus monitoring efforts on riparian habitat, riparian birds and western toad.

- Monitoring changes in riparian habitat amount and distribution concurrently will allow the linkage of population level changes in the indicator species with changes in habitat.
- Consider adopting an indicator species approach to monitoring future spill effects. Songbirds are ideally suited to this role, and western toad can be relatively efficiently monitored at the same time.
    - Several songbird species in the study area are listed as threatened or endangered (e.g., Canada Warbler), as is Western Toad. Even relatively small effects from nest mortality and habitat loss due to a spill may have a larger affect on populations in the study area. Expanding the riparian bird sampling across the study area would also give a nest mortality estimate for more riparian bird species with a greater degree of certainty.
    - While the study design to quantify impacts on western toad (i.e., systematic searches) is able to provide data to answer the management questions, the sample size (2 sites) was too small. In conjunction with expanding the songbird surveys as per above, surveys for western toad should be completed at the same sampling locations as the songbird surveys.
- Neither beaver nor any of the ungulate species occurring within the study area are classified by any jurisdiction as threatened or endangered, so limited mortality of individuals from periodic flood events is unlikely to have long-lasting population level impacts.
    - Dropping the ungulate and beaver surveys will also negate having to use an expensive twin-engined helicopter to conduct aerial surveys, allowing more resources to be allocated to better answering management questions for riparian birds and western toad.
    - The impacts of a spill likely mimic naturally occurring flood events that took place prior to WAC Bennett and PNC dam construction. Ungulates using Peace River riparian areas as birthing sites would likely have experienced periodic mortality from natural food events, as would beaver in the riparian area. Population level impacts are more likely to occur from region-wide stochastic events (e.g., the severe winter of 2006/2007 in the Peace which severely decreased ungulate numbers across the Peace region).

2. Ensure that study design components (e.g., using aerial surveys) laid out in future terms of references for monitoring spill impacts on wildlife lend themselves to answering management questions in a rigorous fashion.
    - In conjunction with recommendation one (above), methods mandated in the monitoring terms of reference should be compatible with study design considerations such as sample size, rigorous statistical tests, and broad applicability of results. By narrowing the monitoring focus, resources can be focused on providing rigorous tests of fewer management hypotheses.
    - For example, a model incorporating factors such as spill magnitude, duration and timing and bird species breeding phenology could be used to evaluate relative mortality risk by bird species.

3. If aerial surveys are used in the future, reconcile RISC standard ungulate aerial survey methods with BC Hydro guidelines on low-speed, low-altitude flight operations.
    - Although following RISC ungulate aerial survey methods is required in the terms of reference, current BC Hydro guidelines on single-engined helicopter use do not allow conformance to these guidelines. Twin-engined machines are permissible, but due to their relative scarcity, are not available on short notice.

- If a twin-engined helicopter is not available, ungulate surveys should not be conducted due to the low sightability that results from constraints on flying slowly at a low height above the ground.

LITERATURE CITED

Alldredge, M. W., T. R. Simons, and K. H. Pollock. 2007. A field evaluation of distance measurement error in auditory avian point count surveys. The Journal of Wildlife Management 71:2759–66 pp.

ArcMap. 2011. Environmental Systems Research Incorporated (ESRI), Redlands, California. Retrieved from http://www.esri.com/.

Bateman, H. L., M. Harner, and A. Chung-MacCoubrey. 2008. Abundance and reproduction of toads (Bufo) along a regulated river in the southwestern United States: importance of flooding in riparian ecosystems. Journal of Arid Environments 72:1613–1619 pp.

BC Hydro. 1997. 1996 spillway discharge environmental monitoring overview. Peace River generating facilities. Strategic Fisheries Report, BC Hydro.

BC Hydro. 2007. Peace project water use plan. Revised for acceptance for the comptroller of water rights. BC Hydro.

BC Hydro. 2008. Peace project water use plan, monitoring program terms of reference, Peace spill protocol: GMSMON 12 - Peace River wildlife stranding survey.

Blood, D. A. 1979. Peace River site C hydroelectric development environmental and socioeconomic assessment: wildlife sub-report. BC Hydro and Power Authority.

Braatne, J. H., S. B. Rood, L. A. Goater, and C. L. Blair. 2008. Analyzing the impacts of dams on riparian ecosystems: a reivew of research strategies and their relevance to the Snake River through Hells Canyon. Environmental Management 41:267–281 pp.

Burns, R. M., and B. H. Honkala. 1990. Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook, US Department of Agriculture, Forest Service, Washington, DC.

Denny, R. N. 1952. A summary of north american beaver management, 1946-1948. 64 pp. Colorado Game and Fish Department.

Diversified Environmental Services. 1996. Assessment of ungulate use and forage availability on islands in the Peace River. BC Hydro and Power Authority, Burnaby, B.C.

DNRGarmin. 2007. Minnesota Department of Natural Resources. Retrieved from http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmin/DNRGarmin.html.

Eskew, E. A., S. J. Price, and M. E. Dorcas. 2012. Effects of river-flow regulation on anuran occupance and abundance in riparian zones. Conservation Biology 26:504–512 pp.

Fraker, M. A., and V. C. Hawkes. 2000. Peace River wildlife surveys: 1999. BC Hydro.

Hecnar, S. J., and R. T. M'Closkey. 1996. Amphibian species richness and distribution in relation to pond water chemistry in south-western Ontario, Cananda. Freshwater Biology 36:7–15 pp.

Johansson, M. E., and C. Nilsson. 2002. Responses of riparian plants to flooding in free-flowing and regulated boreal rivers: an experimental study. Journal of Applied Ecology 39:971–986 pp.

Keystone Wildlife Research Ltd. 2007. Terrestrial ecosystem mapping of the Peace River study area report. Baseline inventory surveys 2007. BC Hydro.

Keystone Wildlife Research Ltd. 2009. Peace River wildlife surveys - summary report. Winter baseline inventory surveys. BC Hydro, Burnaby, B.C.

MacInnis, A. M., K. Bachmann, and R. Gill. 2011. GMSWORKS-7: Peace River riparian habitat assessment final report. BC Hydro Generation, Water, Hudson’s Hope, BC.

Matsuda, B. M., D. M. Green, and P. T. Gregory. 2006. Amphibians and reptiles of British Columbia. Royal British Columbia Museum, Victoria, BC.

Meidinger, D., and J. Pojar. 1991. Ecosystems of British Columbia. BC Ministry of Forests, Victoria, BC.

Nagorsen, D. W. 2005. Rodents and lagomorphs of British Columbia. Royal British Columbia Museum, Victoria, BC.

Poff, N. L., and J. K. H. Zimmerman. 2010. Ecological responses to altered flow regimes: a literature review to inform the science and management of environmental flows. Freshwater Biology 55:194–205 pp.

Poole, K. G., R. Serrouya, and K. Stuart-Smith. 2007. Moose calving strategies in interior montane ecosystems. Journal Information 88:139–50 pp.

Resource Inventory Committee. 1998. Inventory methods for beaver and muskrat. Ministry of Environment, Lands and Parks, Victoria, B.C.

Resources Inventory Committee. 1998. Inventory methods for pond-breeding amphibians and painted turtle. Ministry of Environment, Lands and Parks, Victoria, B.C.

Resources Inventory Committee. 1999. Inventory methods for forest and grassland songbirds. Ministry of Environment, Lands and Parks, Victoria, BC.

Resources Inventory Committee. 2002. Aerial-based inventory methods for selected ungulates: bison, mountain goat, mountain sheep, moose, elk, deer and caribou. Ministry of Sustainable Resource Management, Victoria, BC.

Resources Inventory Standards Committee. 2008. The vertebrates and invertebrates of British Columbia: Scientific and English names. Ministry of Environment, 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 pp.

Shackleton, D. 1999. Hoofed mammals of British Columbia. UBC Press, Vancouver, BC.

Simpson, K. 1991. Peace River Site C hydroelectric development. Environmental Assessment. Consumptive Wildlife Resrouces. Keystone Bio-Research, White Rock, B.C.

Simpson, K. 1993. Peace River Site C hydroelectric development. Environmental Assessment. Consumptive Wildlife Resources. Keystone Bio-Research, White Rock, B.C.

Simpson, L., L. Andrusiak, K. Simpson, W. Blashill, C. Guppy, and M. Kellner. 2009. Peace River wildlife surveys - baseline inventory surveys - 2006. BC Hydro, Burnaby, B.C.

The birds of North America online. 2012. Cornell Lab of Ornithology, Ithaca. Retrieved March 8, 2012, from http://bna.birds.cornell.edu/bna.

Wiacek, R. 1998. Peace River fluctuating flows wildlife impact study. BC Hydro.

Appendix 1. Final habitat codes, names, classes, and descriptions of riparian habitats identified during photo interpretation in the Peace River valley, BC.

Habitat Code	Habitat Name	Habitat Class	Habitat Description
Non-vegetated			
SA	Sandstone	Non-vegetated – gentle slope – sandstone	Non-vegetated sandstone flats occurring at the lower end of the Peace River canyon.
GB	Gravel bars	Non-vegetated – gentle slope – sand/gravel	Mostly non-vegetated sand/gravel bars along the river edge and surrounding islands.
GS	Gravel slope	Non-vegetated – moderate to steep slope – sand/gravel	Non-vegetated sand/gravel slopes along the river edge.
IN	Industrial	Industrial/ residential/ recreational/ agricultural land	Any land utilized for industrial, residential, recreational or agricultural activity.
BS	Boulder slope	Non-vegetated – gravel/ cobble/ boulder	Channel edges, often steep and cliff-like, consisting of various-sized rock substrate (i.e., gravels, cobbles and boulders); non-vegetated or sparsely vegetated/treed.
SH	Shale slope	Non-vegetated – shale – steep slope	Exposed shale bedrock or monoliths below the inundation line.
SS	Sandstone slope	Non vegetated-steep slope – sandstone.	Steep eroding bluffs, cliffs, or slopes; sand-dune like in appearance. Non- to sparsely vegetated.
OW	Open Water	Water*	Standing or pooled water occurring between the elevations of the inundation/high water mark and the low water mark.
Wetland and aquatic			
AV	Aquatic vegetation	Aquatic to semi-aquatic vegetation – depressions and side channels	Periodically inundated depressions and side channels along the river bank and between islands and the river bank; may be partially submerged in shallow water. Containing aquatic and semi-aquatic vegetation (e.g., sedges and rushes). Pioneer seral.
WE	Wetland	Wetland complex	Isolated depression or wet area that has developed wetland characteristics (e.g., standing water, wetland vegetation). Dis-climax.
Shrub/ graminoid/ forb			
HE	Herbaceous	Herb – gentle slopes – sand/ gravel.	Herbaceous-dominant vegetation cover on sand/gravel beds along the riverside and islands. Pioneer seral.
RS	Riparian shrub	Riparian shrub – graminoid/ forb	Shrubby vegetation composed of willow, alder, and poplar with some degree of grasses and forbs coverage. Pioneer seral.
US	Upland shrub	Upland low shrub – graminoid.	Plant community occurring on low relief/ floodplain/upland areas above riparian zone, as a matrix throughout disturbed areas such as agricultural fields, roads, right-of-ways, etc. (Can be interspersed with pockets of At and sometimes Ac.) Pioneer seral.

Balsam poplar dominated			
LA	Late Ac	Mature Ac stand	Mature balsam poplar-dominant stand with other intermittent tree species (e.g., white spruce). Mature to over-mature seral.
MA	Mid Ac	Mid Ac Sw-stand	Mid-seral balsam poplar -dominant stand with other intermittent species (e.g., white spruce). Ranges from pioneer seral to mid seral.
AG	Ac – Sw - gravel	Early Ac Sw – shrub – sand/ gravel	Young-seral balsam poplar and white spruce stand growing in on sand/gravel substrate. Pioneer seral to young seral.
AH	Ac – Sw - herb	Early Ac Sw – shrub and/or pole sapling	Balsam poplar-dominated with some white spruce, early successional stage. Ranges from pioneer to mid seral.
AS	Ac sapling	Mid Ac pole sapling and/or shrub	Balsam poplar stand. Pioneer to young seral.
White spruce, paper birch or trembling aspen dominated			
MM	Mature mixed	Mature Sw Ep Ac stand	Mixed stand of mature white spruce, paper birch, and balsam poplar; often on islands. Ranges from mid-seral to maturing climax stands.
MS	Mature spruce	Mature Sw Ac Ep stand	Mature white spruce-dominant with poplar and paper birch subdominant; stands along riparian zone and islands. Ranges from young climatic climax to maturing climatic climax.
SG	Sw – Ac - gravel	Early Sw Ac shrub – sand/ gravel	Mixed tree cover of white spruce and balsam poplar with well-developed shrub understory on sand/gravel substrate. Pioneer to young seral.
SP	Pioneer Sw	Early Sw Ac shrub – grass/ herb	White spruce dominated shrub cover mixed with balsam poplar; moderate to high grass/herb cover. Pioneer seral.
ES	Birch – Spruce slope	Steep slope – Ep Sw stand	Steep sloped riverbank or streambank with moderate to high cover of mature paper birch and white spruce, some balsam poplar may also be present; narrow sand/gravel bar at the base of the hillside may be present. Ranges from maturing seral to maturing climax.
EA	Birch – aspen slope	Steep slope – Ep At	Steep sloped riverbank or streambank with low to moderate cover of paper birch and trembling aspen, some white spruce may also be present; understory of grasses/forbs/shrubs; narrow sand/gravel bar at the base of the hillside may be present. Pioneer to mid seral.

Appendix 2. Resource Inventory Standards Committee Animal Observation Form - Ungulate (Aerial) Encounter / Fixed-width Transect.

Animal Observation Form - Ungulate (Aerial) Encounter / Fixed-width Transect **Page ___/___**

Project ________________________________ **Survey** _______________________________ **Study Area** _____________________________

Transect Label _____________ Stratum _____________ Trans Comment ____________________

Trans: Lgth _______ Width _______ Bearing _______ UTM: Start ____/________/_________End ____/________/_________

Obs Date ______/______/________ User Stats: 1) ________ 2) ________ 3) ________ 4) ________

Obs Day	**Time**	**CC**	**Wind**	**Temp**	**Precip**	**Snow Depth**	**Snow Cover**
Start							
End						**Days since 5 cm Snow ____**	

Navigator __________________________________ Surveyors ____

Wpt #	**Species**	**Grp Tot**	**Ungulate Classification BEU**									**User Stats**			
			Distance	**Direction**	**u j**		**a f**		**m**			**Snow Cover**	**Veg Cover**		
	M-														
	M-														
	M-														
	M-														
	M-														
	M-														
	M-														
	M-														
	M-														
	M-														
	M-														

Wpt #	**Comments**

[Use the back side of this form if additional lines are needed for observations associated with the transect labelled at the top of this form]

Appendix 3. Species detections and UTM coordinates for ungulates detected during 2010 pre- and 2012 post-spill aerial surveys of the Peace River valley, B.C. (CEEL = elk, ALAL = moose, ODHE = mule deer, ODVI = white-tailed deer, ODSP = unidentified deer species).

Species[1]	Easting	Northing	Date	Survey Block	Count	Bank/Island[2]	Comment
Pre-spill							
ODHE	567699	6208734	2/6/2010	Peace Canyon	1	I	mule deer
CEEL	567225	6208435	2/6/2010	Peace Canyon	1	I	female elk
ODVI	571529	6212736	2/6/2010	Peace Canyon	2	I	2 white-tailed deer
ODSP	575844	6218527	2/6/2010	Peace Canyon	1	B	deer spp.
ODSP	574099	6217210	2/6/2010	Peace Canyon	1	B	deer spp.
ODHE	574558	6218526	2/6/2010	Peace Canyon	1	I	mule deer
ODVI	578711	6221087	2/6/2010	Peace Canyon	2	B	2 white-tailed deer, 1 male, 1 female
ODVI	573072	6214686	2/6/2010	Peace Canyon	3	B	3 white-tailed deer
ODHE	565460	6207539	2/6/2010	Peace Canyon	1	B	1 mule deer
ALAL	582211	6219909	2/6/2010	Farrell Creek	2	B	female moose with calf
ODHE	583784	6221173	2/6/2010	Farrell Creek	1	I	mule deer
CEEL	590743	6227317	2/6/2010	Farrell Creek	3	B	3 female adult elk
ALAL	595575	6229645	2/6/2010	Halfway River	1	B	female moose
ODSP	599538	6232865	2/6/2010	Halfway River	1	B	deer spp.
ALAL	601139	6233413	2/6/2010	Halfway River	1	I	female adult moose, standing still, possible calf present
ODHE	610887	6237044	3/6/2010	Cache Creek	1	B	mule deer
ODHE	612636	6236084	3/6/2010	Cache Creek	2	B	2 mule deer
ODHE	613089	6236234	3/6/2010	Cache Creek	3	I	3 mule deer
ALAL	614029	6235411	3/6/2010	Cache Creek	2	I	female moose and very young calf
ALAL	612443	6237070	3/6/2010	Cache Creek	1	B	female moose
CEEL	609650	6236915	3/6/2010	Cache Creek	3	B	3 elk at mouth of Red Creek
CEEL	608762	6236437	3/6/2010	Cache Creek	5	B	4 adult elk and 1 calf
CEEL	608575	6236537	3/6/2010	Cache Creek	1	B	1 elk
CEEL	608974	6236855	3/6/2010	Cache Creek	8	B	8 elk
ODHE	608028	6236681	3/6/2010	Cache Creek	2	B	2 mule deer
CEEL	608654	6237041	3/6/2010	Cache Creek	2	B	2 female elk
ODHE	607104	6239605	3/6/2010	Cache Creek	1	B	mule deer
ALAL	608094	6236574	3/6/2010	Cache Creek	1	B	adult male moose
CEEL	615274	6233279	3/6/2010	Wilder Creek	1	B	female elk, calf possible present based on behaviour

ODHE	624457	6233144	3/6/2010	Wilder Creek	1	I	female mule deer
ODSP	624004	6232944	3/6/2010	Wilder Creek	2	I	2 deer and 1 black bear, confrontational stance, calf present?
ODHE	623959	6233610	3/6/2010	Wilder Creek	2	B	2 mule deer
ODHE	622539	6233148	3/6/2010	Wilder Creek	1	B	female mule deer
ODHE	623561	6233060	3/6/2010	Wilder Creek	2	I	2 female mule deer
CEEL	619994	6232254	3/6/2010	Wilder Creek	1	I	female elk
ALAL	618805	6232989	3/6/2010	Wilder Creek	1	B	adult moose
ODHE	615494	6234382	3/6/2010	Wilder Creek	2	B	2 mule deer
ODHE	628768	6230511	3/6/2010	Moberley River	3	I	3 mule deer
ODHE	627151	6232960	3/6/2010	Moberley River	4	B	2 male and 2 female mule deer
ODHE	626733	6228863	3/6/2010	Moberley River	1	B	mule deer with white radio collar
ODHE	632125	6229340	3/6/2010	Pine River	2	I	2 female mule deer
ODHE	634774	6230265	3/6/2010	Pine River	4	I	4 mule deer
Post-spill							
ODSP	642221	6224379	7/24/2012	Pine River	3	B	
ODSP	633298	6229538	7/24/2012	Pine River	1	I	
ODSP	628662	6230919	7/24/2012	Moberley River	1	B	adult on bank
ODHE	623523	6232976	7/24/2012	Wilder Creek	3	I	
ODHE	619805	6232021	7/24/2012	Wilder Creek	1	I	
ODSP	621633	6232961	7/24/2012	Wilder Creek	2	B	in river near bank
ODSP	614545	6234088	7/24/2012	Wilder Creek	1	B	running along dry channel
ODSP	613346	6236351	7/24/2012	Cache Creek	3	I	
ODSP	608280	6239204	7/24/2012	Cache Creek	1	B	
ODHE	609131	6236615	7/24/2012	Cache Creek	1	B	
ODSP	597730	6231563	7/24/2012	Halfway River	1	B	right along forest edge
ODSP	580862	6219746	7/24/2012	Farrell Creek	1	I	in low shrubby area
ODSP	574663	6219098	7/24/2012	Peace Canyon	1	I	running into forested area
ODSP	568705	6210118	7/24/2012	Peace Canyon	2	I	1 adult and 1 juvenile
ODSP	569635	6211342	7/24/2012	Peace Canyon	1	I	near waters edge

[1] Mammal species codes follow Resource Inventory Committee (2008).

[2] Bank/Island refers to location of observation – on the main channel bank or an in-stream island

Appendix 4. Point count data sheet.

Date: **Observer:** **Time:** **Visit:** **Ceiling:** **Cloud:** **Wind:** **Temp:** **Precip.:**

BIRD
= heard singing

BIRD - V
= seen singing

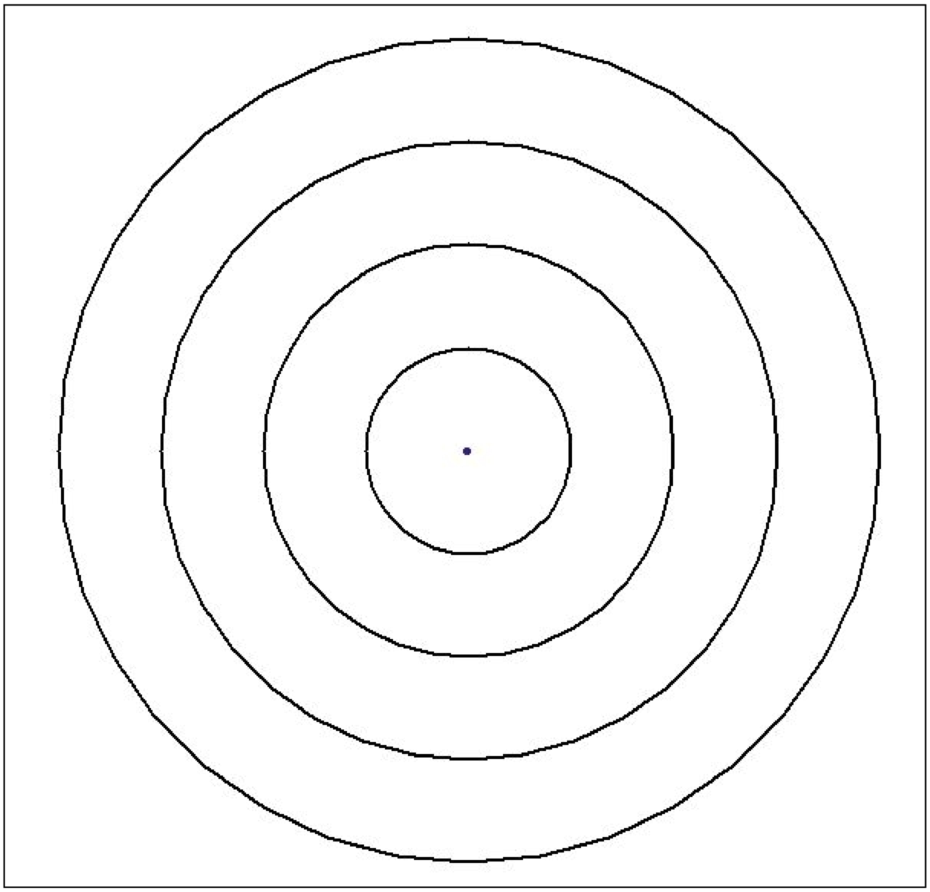
BIRD - V
= seen

BIRD
= detected (i.e. calling)

BIRD
= flyover (not landing within radius)

 # - BIRD
= more than one individual in association (e.g. flock)

BIRD^2
= bird detected in second time interval (min. 3-5)



25 m ring increments from 0 (plot centre) to 100 m.

Appendix 5. Environmental variable codes for point count surveys.

Ceiling:

The height of cloud cover. Record the average height of clouds during the survey.

ATT = Above Tree-tops
BTT = Below Tree-tops
AR = Above Ridge
BR = Below Ridge
H = High
VH = Very High

Cloud Cover (CC):

The extent of cloud cover during the survey period.

1 = clear, 0% cloud cover
2 = scattered clouds, <50% cloud cover
3 = scattered clouds, >50% cloud cover
4 = unbroken clouds, 100% cloud cover

Wind:

The strength of the dominant wind over the survey period using the Beaufort Scale. If wind strength split evenly between 1 or more classes, choose that which best characterized the conditions and detectability of birds. Acceptable conditions are Winds 0-3. >3 is considered unacceptable for conducting point counts (RISC 1999a).

0 = calm (<2 km/h)
1 = light air (2-5 km/h)
2 = light breeze, leaves rustle (6-12 km/h)
3 = gentle breeze, leaves and twigs constantly move (13-19 km/h)
4 = moderate breeze, small branches move, dust rises (20-29 km/h)
5 = fresh breeze, small trees sway (30-39 km/h)
6 = strong breeze, large branches moving, wind whistling (40-49 km/h)
7 = moderate gale+, whole trees in motion (≥50 km/h)

Precipitation:

The type of precipitation (if any) during the survey period. Acceptable conditions are no rain through very light drizzle.

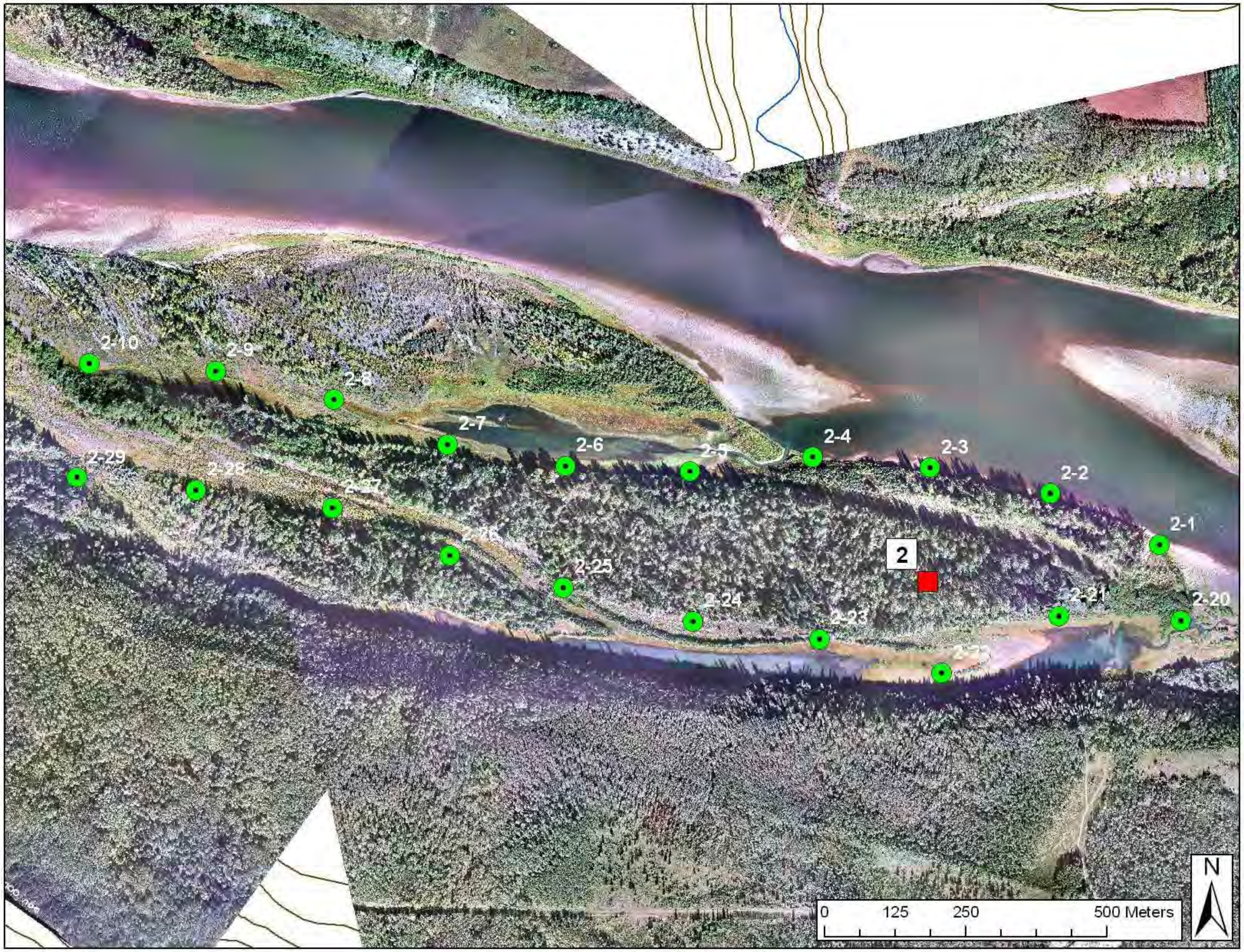
N = None
F = Fog
M = Misty Drizzle
D = Drizzle
LR = Light Rain
HR = Hard Rain
LS = Light Snow/Flurries
HS = Heavy Snow

Appendix 6. UTM coordinates of point count stations established at GMSMON 12 index sites in the Peace River Valley, BC.

PCS[1]	EASTING	NORTHING
1-1	631953	6229313
1-2	632174	6229325
1-3	632206	6229107
1-4	632393	6229348
1-5	632615	6229372
1-6	632903	6229411
1-7	633114	6229487
1-8	633332	6229585
1-9	633461	6229425
1-10	633542	6229576
1-11	633755	6229613
1-20	632233	6228589
1-21	632459	6228590
1-22	632719	6228762
1-23	632954	6228832
1-24	633155	6229000
1-25	633327	6229137
1-26	633420	6229332
1-27	633622	6229314
1-28	633805	6229430
2-1	619550	6231976
2-2	619358	6232066
2-3	619146	6232113
2-4	618938	6232132
2-5	618721	6232106
2-6	618501	6232116
2-7	618292	6232154
2-8	618091	6232233
2-9	617882	6232284
2-10	617660	6232297
2-20	619589	6231842
2-21	619374	6231850
2-22	619166	6231749
2-23	618950	6231810
2-24	618727	6231841
2-25	618498	6231900
2-26	618297	6231957
2-27	618090	6232041
2-28	617848	6232072
2-29	617637	6232095
3-1	613875	6235781
3-2	614000	6235611
3-3	614190	6235496
3-4	614344	6235362
3-5	614551	6235316
3-6	614679	6235164
3-7	614392	6235172
3-8	614176	6235212
3-9	613970	6235286
3-10	613791	6235397
3-20	613736	6235865
3-21	613623	6236064
3-22	613461	6236216
3-23	613256	6236344
3-24	613058	6236430
3-25	613087	6236190
3-26	613234	6236030
3-27	613406	6235872
3-28	613551	6235696
3-29	613706	6235557
4-1	601753	6233830
4-2	601962	6233872
4-3	602165	6233905
4-4	602379	6233887
4-5	602589	6233817
4-6	602798	6233785
4-7	602951	6233659
4-8	602791	6233518
4-9	602607	6233420
4-10	602409	6233320
4-20	601782	6233643
4-21	601579	6233593
4-22	601377	6233637
4-23	601177	6233628
4-24	600964	6233661
4-25	600765	6233701
4-26	600558	6233675
4-27	600336	6233605
4-28	600123	6233551
4-29	600012	6233324
6-1	586874	6224197
6-2	587045	6224323
6-3	587118	6224524
6-4	587260	6224679
6-5	587416	6224818
6-6	587585	6224963
6-7	587291	6224473
6-20	586678	6224082
6-21	586518	6223926
6-22	586363	6223787
6-23	586247	6223599
6-24	586168	6223397
6-25	586249	6223428

[1] Point Count Station; the first number indicates the index site, the second the individual point count station.

Appendix 7. Maps of point count station locations at index sites in the Peace River valley, B.C. Green circles are point count stations; red squares are index site labels.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2-9
2-8
2-7
2-6
2-5
2-4
2-3
2-2
2-1
2-29
2-28
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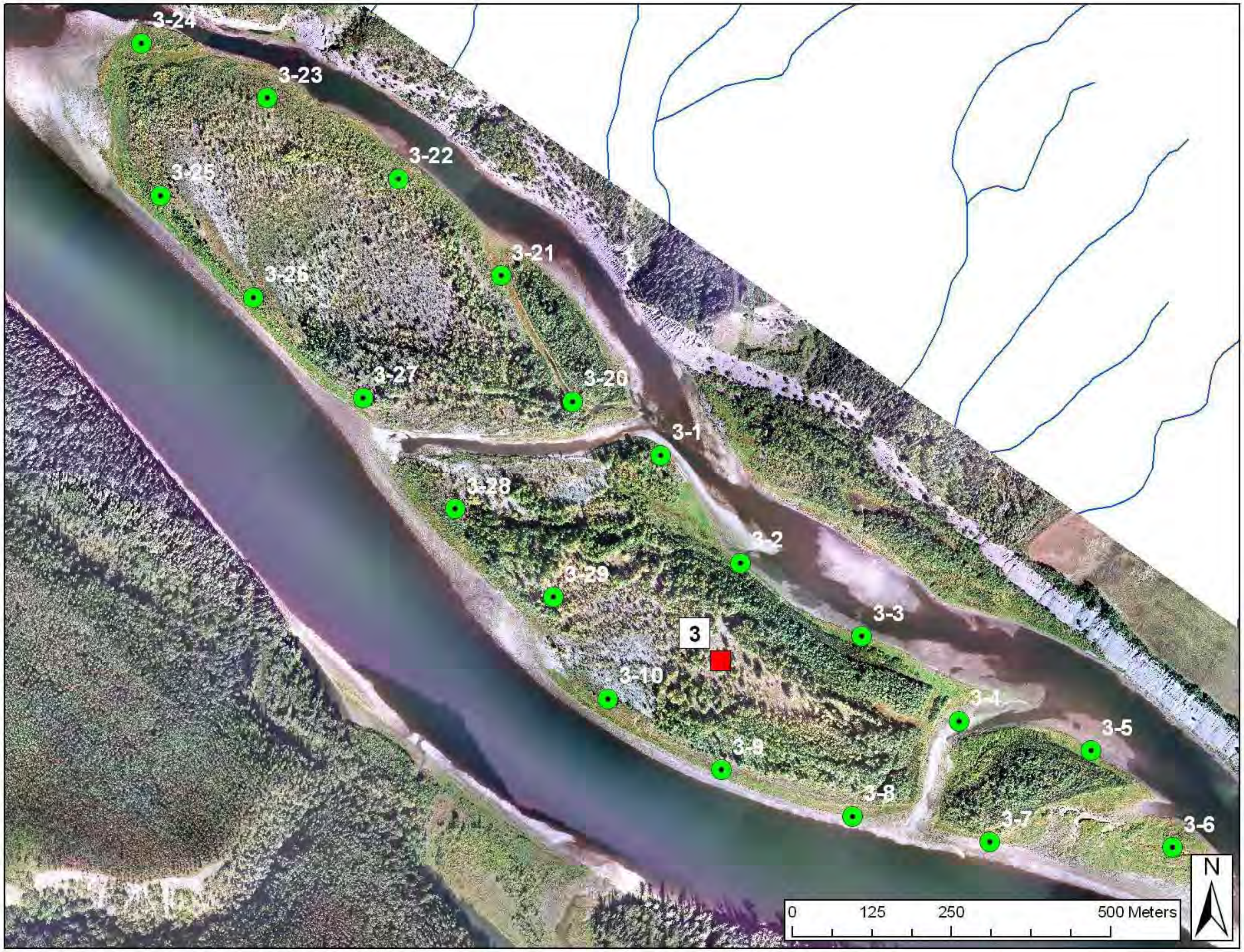
2-23
2-22
2-21
2-20
2
0
125
250
500 Meters
N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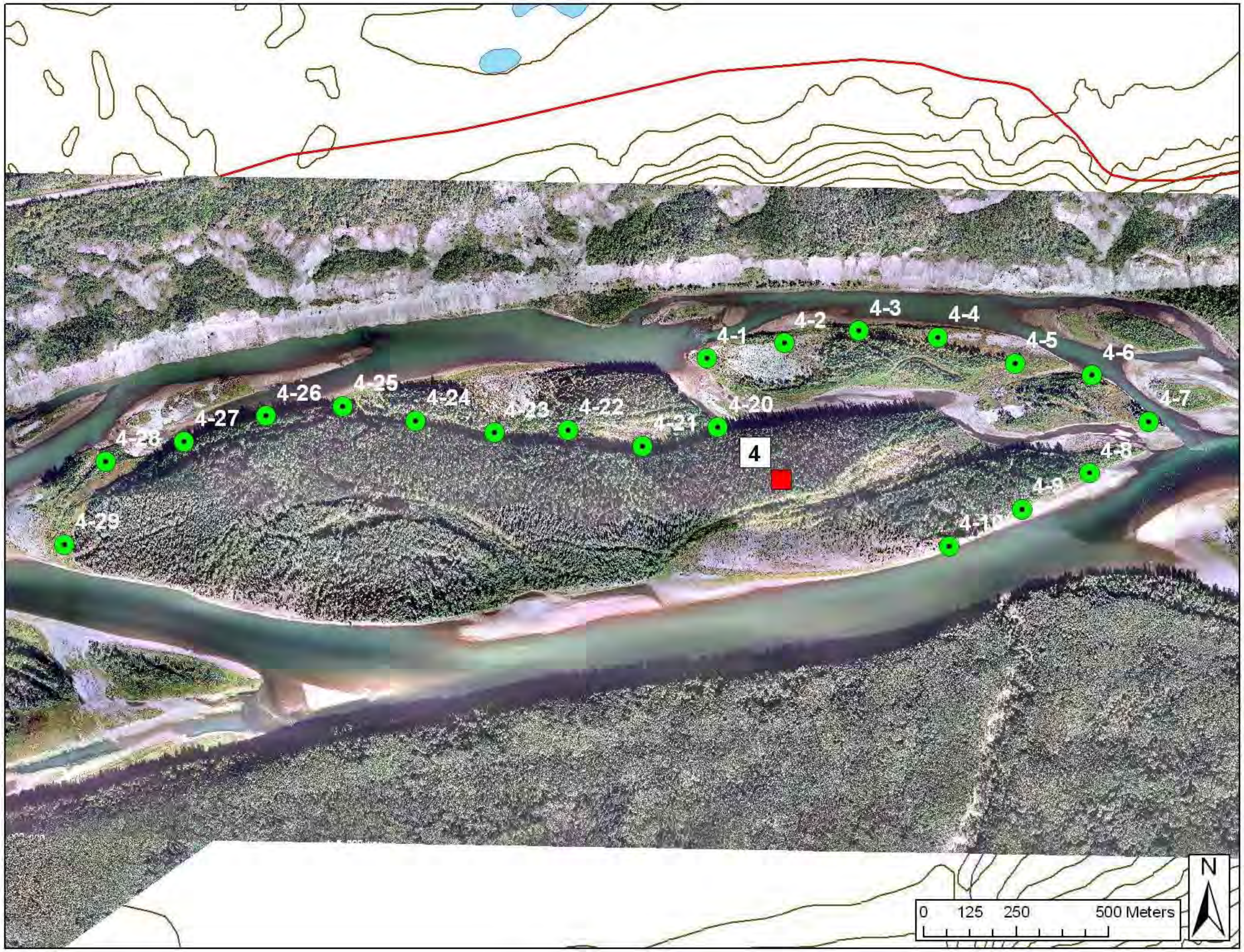
125
250
500 Meters
N


4-1
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4-26
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4-29
4
0 125 250 500 Meters
N


6-6
6-5
6-4
6-3
6-
6-2
5 / 6
6-1
6-20
6-21
6-22
6-23
6-25
0
125
250
500 Meters
N

Appendix 8. Bird species detected during 2010 pre- and 2012 post-spill point count surveys at index sites in the Peace River valley, BC. Focal species are in bold.

Species	Number of Detections												
	2010					2010 Total	2012					2012 Total	Grand Total
	IS-1	IS-2	IS-3	IS-4	IS-5/6		IS-1	IS-2	IS-3	IS-4	IS-5/6		
ALFL	4	8	7	9		**28**	3	2	1		2	8	**36**
AMCR		4				**4**							**4**
AMKE		1				**1**							**1**
AMRE	7	16	3	6	3	**35**	2	4	3		1	10	**45**
AMRO	17	9	7	8	3	**44**	3	1	5	1	2	12	**56**
AMWI		1			1	**2**							**2**
BAEA								2			1	3	**3**
BAGO				2		**2**							**2**
BAWW	9	1	2	1	2	**15**							**15**
BBMA	2	4				**6**	1			1		2	**8**
BCCH	1		1	1		**3**	1	1		1	1	4	**7**
BEKI	1					**1**		2				2	**3**
BGWA		2				**2**							**2**
BHCO	1		3	1	2	**7**							**7**
BHVI	5	3	3	4		**15**							**15**
BKSW	1	6	3			**10**							**10**
BOGU		1				**1**		2	3			5	**6**
BRBL				1		**1**							**1**
BRCR				1		**1**							**1**
BWWA											1	1	**1**
CAGO		1				**1**							**1**
CAWA				1	1	**2**					1	1	**3**
CCSP	6	2	6			**14**			1			1	**15**
CEWA	3	1	7	4	4	**19**	3	3	2		1	9	**28**
CHSP	4	4	3	11	6	**28**	1				1	2	**30**
COGO		1			2	**3**					1	1	**4**
COME					1	**1**							**1**
CORA	5			1		**6**							**6**

COYE	7	3	12	4	3	**29**		1			1	**30**
DEJU	2			2	1	**5**		2	2		4	**9**
DOWO								1	2		3	**3**
EUST				1		**1**						**1**
FOSP	2					**2**						**2**
FRGU	1	1				**2**						**2**
GRJA					1	**1**				1		1	**2**
GRSC											1	1	**1**
GWTE								1				1	**1**
HAFL	1					**1**							**1**
HAWO	1	1				**2**			1		1	2	**4**
HETH	1	5		1		**7**	1					1	**8**
KILL			4	3	1	**8**							**8**
LCSP					1	**1**							**1**
LEFL	7	2	3	2	1	**15**	2	2	2		6	12	**27**
LISP	4	5	12	7	3	**31**		1		1	2	4	**35**
MACW								1				1	**1**
MALL					1	**1**		1				1	**2**
MERL		3	1			**4**							**4**
MGNW	1	2		4	3	**10**							**10**
NOFL		2	1	1	1	**5**	1	1		1	1	4	**9**
NOWA		1				**1**					1	1	**2**
NRSW		1				**1**	1		1			2	**3**
OCWA	1		1		3	**5**	1	1				2	**7**
OVEN		2	2	1		**5**							**5**
PISI		1				**1**		5	2		1	8	**9**
PIWO							1					1	**1**
PSFL					4	**4**					1	1	**5**
PUFI				1		**1**					1	1	**2**
RBGR	3	1			1	**5**		2				2	**7**
RBNU	1		1	6	3	**11**	1					1	**12**
REVI	10	14	18	10	13	**65**	3	10	4	2	8	27	**92**
RNDU											1	1	**1**
RUBL			1			**1**							**1**

RUGR							1					1	**1**
RWBL		6	2		3	**11**					4	4	**15**
SAVS	3		2	1		**6**							**6**
SOSA			1			**1**							**1**
SOSP	7	5	12	12	9	**45**	1	5	21	16	3	46	**91**
SPSA	5	1	6	4		**16**	2	1	5	2		10	**26**
SWSP		1				**1**							**1**
SWTH	2	1		2	1	**6**	1		1			2	**8**
TEWA	5	6	1	2	5	**19**							**19**
TUSW		2				**2**							**2**
WAVI	1	1				**2**							**2**
WBNU							1					1	**1**
WETA	1	1		3		**5**		2			1	3	**8**
WEWP							1			1	1	3	**3**
WTSP	2	4		3	2	**11**				1		1	**12**
YBSA		1			1	**2**				1		1	**3**
YEWA	12	9	11	7	10	**49**	10	15	17		7	49	**98**
YRWA	4	6		6	3	**19**							**19**
Grand Total	**150**	**153**	**136**	**134**	**99**	**672**	**42 69**	**73 29**			**52**	**265**	**937**

[1] Bird species codes follow Resource Inventory Committee (2008).

Appendix 9. UTM coordinates of nests found in the Peace River valley by species, May/June 2010 and July 2012.

SPECIES[1]	EASTING	NORTHING	DATE AND TIME	TYPE	COMMENTS
NEST	628708	6230677	28-May-10	CAVITY	stick nest and possible bufflehead cavity in Ac
Savannah Sparrow	616084	6233530	28-May-10	GROUND	SAVS nest with 4 eggs, pic # 001
Spotted Sandpiper	608274	6235500	29-May-10	GROUND	SPSA nest with 3 eggs, pic # 002
Killdeer	608195	6235549	29-May-10	GROUND	KILL chick and parents
Savannah Sparrow	599184	6232519	29-May-10	GROUND	SAVS nest, no eggs
Killdeer	593980	6228842	29-May-10	GROUND	KILL nest site, multiple scrapes
NEST	614530	6235286	15-Jun-10	STICK	unoccupied stick nest
NEST	602663	6233718	16-Jun-10	STICK	unoccupied stick nest
American Kestrel	619504	6232008	14-Jun-10	CAVITY	AMKE nest in Ac cavity, 15 m above ground
American Robin	613604	6235607	15-Jun-10	CUP	AMRO nest, 2 eggs, 1.5 m above ground
American Robin	600414	6232968	17-Jun-10	CUP	AMRO nest, 4 eggs, 3 m above ground
American Robin	600371	6232975	17-Jun-10	CUP	AMRO nest in construction, 4 m above ground
American Robin	599375	6232925	17-Jun-10	CUP	AMRO nest, 4 eggs, 3 m above ground
Clay-coloured Sparrow	614433	6235334	15-Jun-10	CUP	CCSP nest, 3 chicks, 0.25 m above ground
Chipping Sparrow	586994	6224265	18-Jun-10	CUP	CHSP nest, 4 chicks, 0.5 m above ground
Eastern Phoebe	619468	6232026	14-Jun-10	BANK	EAPH nest under over-hanging root mass on steep bank, 3 m above ground
Hermit Thrush	602327	6233339	16-Jun-10	GROUND	HETH nest on ground, 3 eggs
Belted Kingfisher	619450	6232037	14-Jun-10	BANK	KING nest in side of bank
Lincoln’s Sparrow	618486	6232253	14-Jun-10	GROUND	LISP nest on ground, 5 eggs
Lincoln’s Sparrow	602664	6233772	16-Jun-10	GROUND	LISP nest on ground, 3 chicks
Lincoln’s Sparrow	600370	6232961	17-Jun-10	GROUND	LISP nest on ground
Lincoln’s Sparrow	586982	6224168	18-Jun-10	GROUND	LISP nest on ground
Mallard	633191	6229499	13-Jun-10	GROUND	MALL nest on ground, 7 eggs, 3 m above waterline
NEST	602328	6233334	16-Jun-10	CUP	unoccupied cup nest
NEST	602610	6233440	16-Jun-10	CUP	unoccupied cup nest
NEST	600415	6232955	17-Jun-10	CUP	unoccupied cup nest
NEST	600395	6232959	17-Jun-10	CUP	unoccupied cup nest
NEST	600119	6232995	17-Jun-10	CUP	unoccupied cup nest
NEST	587559	6224962	18-Jun-10	CUP	unoccupied cup nest
NEST	587124	6224509	18-Jun-10	CUP	unoccupied cup nest
NEST	587102	6224481	18-Jun-10	CUP	unoccupied cup nest
NEST	587018	6224274	18-Jun-10	CUP	unoccupied cup nest
Song Sparrow	617714	6232468	14-Jun-10	GROUND	SOSP nest on ground, 3 chicks, 2 eggs
Song Sparrow	602968	6233658	16-Jun-10	GROUND	SOSP nest on ground, 1 egg
Swamp Sparrow	586850	6224183	18-Jun-10	GROUND	SWSP nest on ground, 4 chicks, pic #369
Tennessee Warbler	617572	6232479	14-Jun-10	GROUND	TEWA nest on ground, 3 chicks 1 egg
Cedar Waxwing	600392	6232959	17-Jun-10	CUP	CEWA nest, 1.5 m above ground
UNSP	599842	6232774	17-Jun-10	CUP	unknown sparrow nest, 4 chicks, 0.25 m above ground
White-throated Sparrow	586992	6224207	18-Jun-10	GROUND	WTSP nest on ground, in construction
Savannah Sparrow	587017	6224261	6-Dec-10	GROUND	SAVS nest with 5 eggs, pic #316

American Robin	633757	6229389	13-Jun-10	CUP	AMRO nest, 4 eggs, 1.3 m above ground, picture #320
American Robin	633471	6229158	13-Jun-10	CUP	AMRO nest, 5 m above ground
American Redstart	633434	6229138	13-Jun-10	CUP	AMRE nest, 2.5 m above ground, pic #321
Rose-breasted Grosbeak	633433	6229135	13-Jun-10	CUP	RBGR nest, 6 m above ground
UNSP	633277	6229031	13-Jun-10	GROUND	unidentified sparrow nest on ground, 4 chicks, pic #322
American Redstart	618497	6231894	14-Jun-10	CUP	AMRE nest, 2.5 m above ground, pic #323
American Redstart	617643	6232083	14-Jun-10	CUP	AMRE nest, 2.5 m above ground, pic #333
Yellow-belied Sapsucker	617991	6231971	14-Jun-10	CAVITY	YBSA nest in Ep, 9 m above ground
Cedar Waxwing	613109	6236159	15-Jun-10	CUP	CEWA nest, 2 m above ground
Common Nighthawk	613606	6235707	15-Jun-10	GROUND	CONI nest site, flushed female from scrape in ground
Merlin	613426	6235938	15-Jun-10	STICK	MERL nest, 8 m above ground
NEST	613326	6235946	15-Jun-10	CUP	unoccupied cup nest with mud construction, 1 m above ground
NEST	613332	6235923	15-Jun-10	CUP	unoccupied small cup nest, 0.5 m above ground, possible COYE
NEST	613227	6236031	15-Jun-10	CUP	unoccupied grass cup nest, 0.75 m above ground
NEST	613146	6236113	15-Jun-10	CUP	unoccupied grass cup nest, 3 m above ground
NEST	613131	6236128	15-Jun-10	CUP	unoccupied grass cup nest, 0.25 m above ground
NEST	613093	6236255	15-Jun-10	CUP	unoccupied grass cup nest, 1 m above ground
NEST	613131	6236360	15-Jun-10	CUP	unoccupied grass cup nest, 1.5 m above ground
NEST	613664	6236057	15-Jun-10	CUP	unoccupied grass cup nest, 0.75 m above ground
Yellow Warbler	613661	6236043	15-Jun-10	CUP	YEWA nest, small grass and hair cup, 5 m off ground
NEST	613661	6236014	15-Jun-10	CUP	unoccupied cup nest, 0.5 above ground
Eastern Phoebe	601673	6233743	16-Jun-10	BANK	EAPH nest under lip of undercut bank, chicks present, 3 m above flood channel
Yellow-rumped Warbler	600479	6233638	16-Jun-10	CUP	YRWA nest in mature Sx, 10 m above ground
NEST	600830	6233685	16-Jun-10	CUP	unoccupied cup nest, 2.5 m above ground
NEST	600938	6233679	16-Jun-10	CUP	2 unoccupied cup nests, 2 m and 3 m above ground
NEST	601102	6233646	16-Jun-10	CUP	unoccupied cup nest, 2 m above ground
NEST	599080	6232493	17-Jun-10	STICK	unoccupied stick nest, 3 m above ground
Song Sparrow	598776	6232134	17-Jun-10	GROUND	SOSP nest on ground, 5 eggs, pic #337
NEST	598756	6232061	17-Jun-10	CUP	unoccupied nest, 2 m above ground
Spotted Sandpiper	598874	6232234	17-Jun-10	GROUND	adult SPSA and downy chick
Chipping Sparrow	586215	6223421	18-Jun-10	CUP	0.25 m above ground, 2 chicks being predated by common garter snake, pic #341-367
NEST	586198	6223429	18-Jun-10	CUP	unoccupied cup nest, 2 m above ground
NEST	586207	6223428	18-Jun-10	CUP	unoccupied cup nest, 2 m above ground
NEST	586227	6223448	18-Jun-10	CUP	unoccupied cup nest, 0.5 m above ground
NEST	586225	6223453	18-Jun-10	CUP	unoccupied cup nest, 1.5 m above ground
NEST	586244	6223465	18-Jun-10	CUP	unoccupied small twig nest, 1.5 m above ground
NEST	586251	6223485	18-Jun-10	CUP	unoccupied grass/twig nest, 2 m above ground
Red-winged Blackbird	586391	6223690	18-Jun-10	CUP	RWBB in cattail clump on side of pond, 0.25 m above ground

White-throated Sparrow	598569	6231796	19-Jul-12		High water mark at base of nest
NEST	602682	6233475	20-Jul-12		Evidence of flooding to ~0.90m - nest height above high water mark (small cup nest)
NEST	602674	6233468	21-Jul-12		Evidence of flooding to ~0.95m - Bottom of nest 15cm above high water mark (medium cup nest)
Cedar Waxwing	602581	6233411	21-Jul-12		Evidence of flooding to ~0.95m - active nest 4 eggs
NEST	613415	6236275	21-Jul-12		Evidence of flooding to ~0.4m above ground
American Robin	613423	6236265	22-Jul-12		Evidence of flooding to ~0.8m - active nest 1 nestling and 1 egg
NEST	613653	6236055	22-Jul-12		Evidnce of flooding to ~0.45m
NEST	613760	6235842	22-Jul-12		Evidence of flooding to ~0.9m above ground
NEST	619111	6231794	22-Jul-12		Evidence of flooding to ~1.45m above ground
NEST	618841	6231797	23-Jul-12		Evidence of flooding to ~1.35m above ground
Cedar Waxwing	618528	6231866	23-Jul-12		Evidence of flooding to ~1.6m above ground - active nest 5 eggs
NEST	632044	6229112	23-Jul-12		Evidence of flooding to ~0.4m above ground
NEST	632044	6229104	25-Jul-12		Evidence of flooding to ~0.45m
NEST	632556	6228746	25-Jul-12		Evidence of flooding to ~0.4m above ground
NEST	633446	6229159	25-Jul-12		Evidence of flooding to 1.55m above ground right to bottom of nest
Cedar Waxwind	633541	6229234	25-Jul-12		Evidence of flooding to ~1.6m above ground - active nest 4 eggs
American Robin	587144	6224420	25-Jul-12		in alder, empty above flood level by 20cm.
NEST	599724	6233104	19-Jul-12		used and empty, possibly a flycatcher, above max water height by 2m.
Cedar Waxwing	600384	6232972	20-Jul-12		adult sitting on 5 eggs. In small poplar about 1m above ground and above max flood level.
Northern Rough-winged Swallow	601698	6233717	20-Jul-12		
American Robin	614149	6235255	21-Jul-12		used and empty. 2.5m high in Cottonwood. Flood level 1.25m here.
Cedar Waxwing	614327	6235208	22-Jul-12		In alder 1.25 off ground, 4 eggs. Flood height to 2 feet here so nest ok. Photo.
Cedar Waxwing	614359	6235192	22-Jul-12		used and empty, 2.5m high. Flood height 2.5 feet
Cedar Waxwing	614386	6235188	22-Jul-12		In alder, 1.5m high. Flood height 2 feet and would have remained active during flood. Photo
Cedar Waxwing	614574	6235285	22-Jul-12		In alder , 3m high, well above flood height of 2 feet.
Yellow Warbler	614207	6235472	22-Jul-12		used and empty, 2.25m high. Flood height 3 feet here.
Cedar Waxwing	618133	6232185	22-Jul-12		possibly CEDW nest. flooded with nest muddy. Water level to 1.25m. photo
American Robin	618123	6232213	23-Jul-12		3.5m high in willow with flood height 4.5feet.
American Robin	633342	6229472	23-Jul-12		used and empty, 1.5m up in cottonwood. Flood height 1ft, nest probably ok.
American Robin	632923	6229380	25-Jul-12		used and empty, 2,25m up in cottonwood. Flood height <1ft, nest probably ok.

[1] The code ‘NEST’ denotes an unoccupied nest; the code ‘UNSP’ denotes an unidentified sparrow nest.

Appendix 10. Beaver (*Castor canadensis*) detections and UTM coordinates for detections made during 2010 pre- and 2012 post-spill aerial surveys of the Peace River valley, B.C.

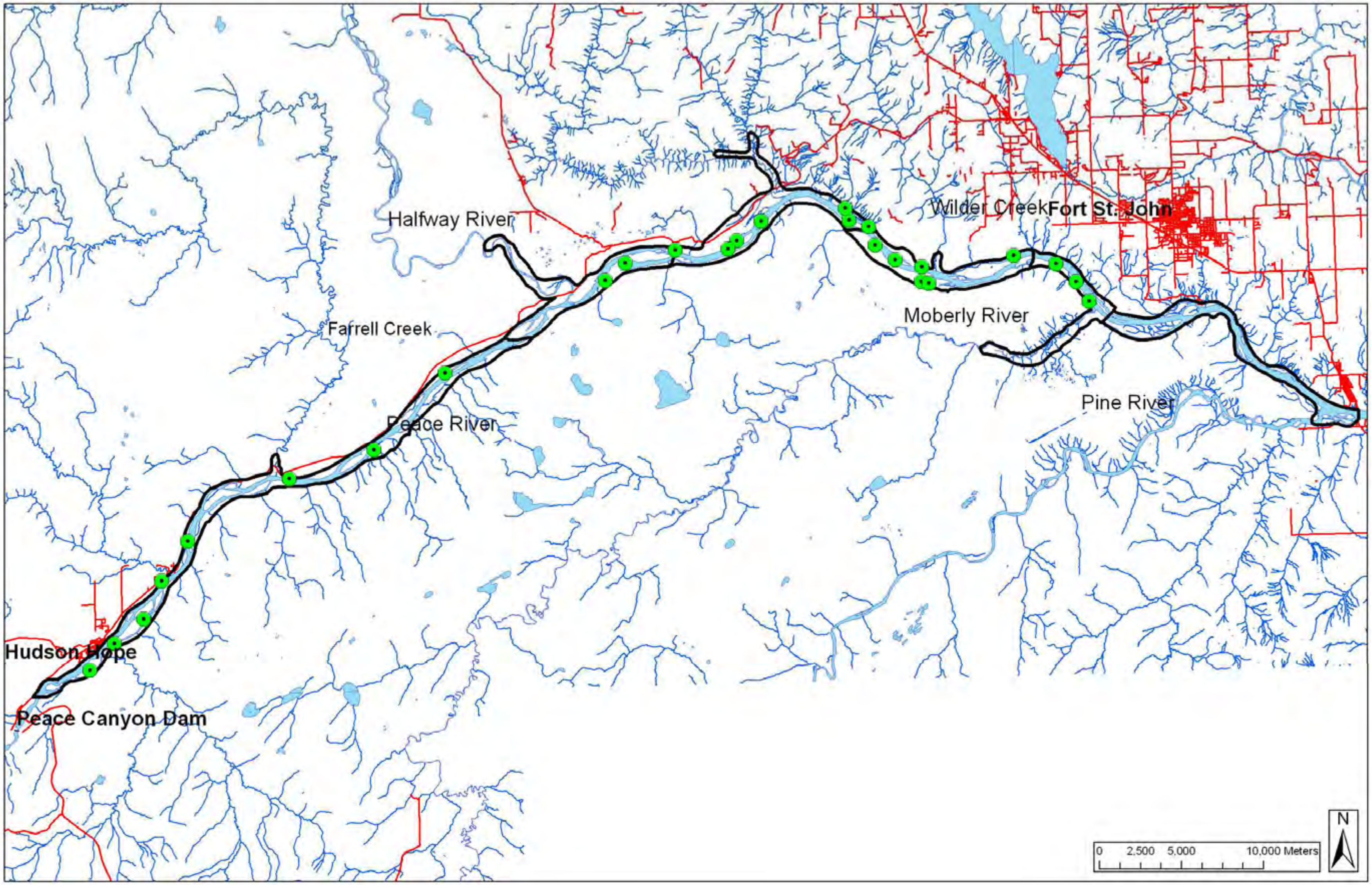
EASTING	NORTHING	DATE AND TIME	SURVEY BLOCK	STRUCTURE	ACTIVE?	COUNT	COMMENTS
565550	6207094	2-Jun-10	Peace Canyon	Dam	N	1	old beaver dam
567316	6208178	2-Jun-10	Peace Canyon	Feeding	Y	1	beaver feeding activities
570583	6211310	2-Jun-10	Peace Canyon	Feeding	Y	1	fresh beaver feeding
568811	6209820	2-Jun-10	Peace Canyon	Feeding	Y	1	beaver in water towing freshly cut Ac branch
570884	6211416	2-Jun-10	Peace Canyon	Feeding	N	1	old beaver feeding
573746	6216365	2-Jun-10	Peace Canyon	Bank lodge	N	1	old beaver bank lodge
577236	6219065	2-Jun-10	Peace Canyon	Lodge	N	1	old beaver lodge
577989	6219415	2-Jun-10	Peace Canyon	Lodge	N	1	old beaver lodge
576307	6219355	2-Jun-10	Peace Canyon	Lodge	N	1	old beaver lodge
574250	6218742	2-Jun-10	Peace Canyon	Lodge	N	1	old beaver lodge
573692	6217508	2-Jun-10	Peace Canyon	Lodge	N	1	old beaver lodge
573489	6217200	2-Jun-10	Peace Canyon	Dam	N	1	old beaver dam
573267	6216069	2-Jun-10	Peace Canyon		Y	1	beaver in river
573152	6215628	2-Jun-10	Peace Canyon	Bank lodge	N	1	old beaver bank lodge
571683	6213635	2-Jun-10	Peace Canyon	Lodge	Y	1	old beaver lodge, some signs of feeding acitivity
581336	6219662	2-Jun-10	Farrell Creek	Bank lodge	N	1	bank lodge
584640	6221623	2-Jun-10	Farrell Creek	Lodge	Y	1	beaver lodge, possible active
591096	6227494	2-Jun-10	Farrell Creek	Lodge	N	1	very old beaver lodge
589587	6226760	2-Jun-10	Farrell Creek	Lodge	N	1	old beaver lodge
588982	6226327	2-Jun-10	Farrell Creek	Bank lodge	Y	1	beaver bank lodge and recent feeding
587963	6225439	2-Jun-10	Farrell Creek	Bank lodge	N	1	beaver bank lodge
587714	6225170	2-Jun-10	Farrell Creek	Lodge	N	1	beaver dam and lodge complex
585023	6222477	2-Jun-10	Farrell Creek	Bank lodge	N	1	beaver bank lodge
579487	6219877	2-Jun-10	Farrell Creek	Lodge	Y	1	beaver lodge, recent beaver feeding activity
595006	6230178	2-Jun-10	Halfway River	Lodge	N	1	beaver lodge
595575	6229645	2-Jun-10	Halfway River	Dam	N	1	old beaver dam
596165	6230276	2-Jun-10	Halfway River	Lodge	N	1	beaver lodge
595686	6230321	2-Jun-10	Halfway River	Bank lodge	N	1	old beaver bank lodge
600544	6232752	2-Jun-10	Halfway River	Bank lodge	N	1	old beaver bank lodge
598753	6231953	2-Jun-10	Halfway River	Lodge	Y	1	beaver lodge, fresh green visible

599569	6232585	2-Jun-10	Halfway River	Lodge	N	1	old beaver lodge
599990	6233006	2-Jun-10	Halfway River	Feeding	Y	1	fresh beaver feeding activity
601508	6233997	2-Jun-10	Halfway River	Bank lodge	N	1	beaver bank lodge
599864	6233661	2-Jun-10	Halfway River	Bank lodge	N	1	old beaver bank lodge
599705	6233634	2-Jun-10	Halfway River	Dam	N	1	2 beaver dams on back channel
599429	6233504	2-Jun-10	Halfway River	Bank lodge	N	1	old beaver bank lodge
597720	6231343	2-Jun-10	Halfway River	Bank lodge	N	1	old beaver bank lodge
594992	6230275	2-Jun-10	Halfway River	Bank lodge	N	1	old beaver bank lodge
606760	6234384	3-Jun-10	Cache Creek	Bank lodge	Y	1	active beaver bank lodge
606257	6233867	3-Jun-10	Cache Creek	Bank lodge	Y	1	active beaver lodge
608281	6235563	3-Jun-10	Cache Creek	Bank lodge	Y	1	2 beaver bank lodges, possible active
614437	6235364	3-Jun-10	Cache Creek	Bank lodge	N	1	2 inactive beaver bank lodges
613632	6235628	3-Jun-10	Cache Creek	Bank lodge	Y	1	active beaver bank lodge
614817	6235226	3-Jun-10	Cache Creek	Lodge	Y	1	beaver lodge and 1 beaver
613416	6236379	3-Jun-10	Cache Creek	Bank lodge	Y	1	beaver bank lodge and 1 beaver
608606	6236189	3-Jun-10	Cache Creek	Bank lodge	N	1	old beaver bank lodge
609059	6237263	3-Jun-10	Cache Creek	Bank lodge	N	1	2 old beaver bank lodges
607407	6240898	3-Jun-10	Cache Creek	Dam	N	1	old beaver dam
607079	6235200	3-Jun-10	Cache Creek	Lodge	N	1	old beaver lodge
607463	6235524	3-Jun-10	Cache Creek	Dam	N	1	old beaver dam
607736	6235812	3-Jun-10	Cache Creek	Lodge	N	1	old beaver dam and lodge complex
603028	6233808	3-Jun-10	Cache Creek	Bank lodge	Y	1	beaver bank lodge with food cache
614140	6234533	3-Jun-10	Wilder Creek	Bank lodge	N	1	old beaver bank lodge
614519	6234095	3-Jun-10	Wilder Creek	Dam	N	1	old beaver dam
618027	6231896	3-Jun-10	Wilder Creek	Dam	Y	1	beaver dam with fresh beaver feeding
618505	6231787	3-Jun-10	Wilder Creek	Lodge	Y	1	beaver lodge with fresh beaver feeding
618422	6232135	3-Jun-10	Wilder Creek	Lodge	N	1	old beaver lodge
615237	6234102	3-Jun-10	Wilder Creek	Bank lodge	Y	1	bank lodge with food cache
617207	6232959	3-Jun-10	Wilder Creek	Bank lodge	N	1	old beaver bank lodge
616436	6233217	3-Jun-10	Wilder Creek	Bank lodge	Y	1	beaver bank lodge with recent/green feeding
624831	6233253	3-Jun-10	Wilder Creek	Food cache	N	1	old beaver food cache
623676	6233159	3-Jun-10	Wilder Creek	Bank lodge	N	1	old beaver bank lodge
623662	6233490	3-Jun-10	Wilder Creek	Lodge	Y	1	beaver and old beaver lodge
622845	6233181	3-Jun-10	Wilder Creek	Bank lodge	N	1	beaver bank lodge

622539	6233148	3-Jun-10	Wilder Creek	Bank lodge	N	1	beaver bank lodge
620995	6232858	3-Jun-10	Wilder Creek	Dam	N	1	2 old beaver dams
622442	6232437	3-Jun-10	Wilder Creek	Bank lodge	N	1	old beaver bank lodge
618078	6232805	3-Jun-10	Wilder Creek	Bank lodge	Y	1	beaver bank lodge with fresh green
616238	6233722	3-Jun-10	Wilder Creek	Bank lodge	N	1	beaver bank lodge
629725	6229827	3-Jun-10	Moberley River	Bank lodge	N	1	old beaver bank lodge
628698	6230766	3-Jun-10	Moberley River	Lodge	N	1	2 old beaver lodges
627885	6231901	3-Jun-10	Moberley River	Lodge	N	1	old beaver lodge
625762	6233554	3-Jun-10	Moberley River	Lodge	N	1	old beaver lodge
625368	6233583	3-Jun-10	Moberley River	Bank lodge	N	1	old beaver bank lodge
628613	6230313	3-Jun-10	Moberley River	Bank lodge	N	1	old beaver bank lodge
628293	6230694	3-Jun-10	Moberley River	Bank lodge	Y	1	beaver bank lodge with fresh green
627493	6231910	3-Jun-10	Moberley River	Bank lodge	Y	1	beaver bank lodge with fresh green
626260	6232972	3-Jun-10	Moberley River	Bank lodge	Y	1	beaver bank lodge with fresh green
622576	6227800	3-Jun-10	Moberley River	Dam	N	1	2 beaver dams in side channel of river
625944	6228069	3-Jun-10	Moberley River	Dam	N	1	beaver dam
628856	6230019	3-Jun-10	Moberley River	Lodge	N	1	beaver lodge
629661	6229197	3-Jun-10	Pine River	Bank lodge	N	1	beaver dam and bank lodge
630382	6228800	3-Jun-10	Pine River	Dam	N	1	beaver dam
630779	6228675	3-Jun-10	Pine River	Dam	N	1	beaver dam
631188	6228557	3-Jun-10	Pine River	Dam	N	1	beaver dam
631452	6228536	3-Jun-10	Pine River	Dam	N	1	beaver dam
631725	6228545	3-Jun-10	Pine River	Dam	N	1	beaver dam
633666	6229132	3-Jun-10	Pine River	Bank lodge	N	1	beaver bank lodge
636372	6230050	3-Jun-10	Pine River	Bank lodge	N	1	beaver bank lodge
636934	6229227	3-Jun-10	Pine River	Lodge	N	1	2 old beaver lodges
637514	6227293	3-Jun-10	Pine River	Dam	N	1	beaver dam
638003	6227055	3-Jun-10	Pine River	Bank lodge	N	1	beaver bank lodge
641083	6225360	3-Jun-10	Pine River	Bank lodge	N	1	beaver bank lodge
642505	6224734	3-Jun-10	Pine River	Bank lodge	N	1	beaver bank lodge
642290	6224876	3-Jun-10	Pine River	Bank lodge	N	1	beaver bank lodge
642009	6225062	3-Jun-10	Pine River	Bank lodge	N	1	beaver bank lodge
637814	6228045	3-Jun-10	Pine River	Bank lodge	N	1	2 beaver bank lodges
636390	6230393	3-Jun-10	Pine River	Bank lodge	N	1	beaver bank lodge

633013	6229829	3-Jun-10	Pine River	Bank lodge	N	1	old beaver bank lodge
643035	6223386	24-Jul-12	Pine River	Lodge	N	1	
638237	6227410	24-Jul-12	Pine River	Bank Lodge	N	1	
634936	6230108	24-Jul-12	Pine River	Bank Lodge	N	1	
632264	6228575	24-Jul-12	Pine River	Lodge	N	1	
631207	6228556	24-Jul-12	Pine River	Lodge	N	1	
625991	6228282	24-Jul-12	Moberley River	Dam	N	1	
624813	6233372	24-Jul-12	Moberley River	Bank Lodge	N	1	
622912	6233155	24-Jul-12	Wilder Creek	Bank Lodge	N	1	
618413	6231879	24-Jul-12	Wilder Creek			1	Swimming in side channel with stick in mouth
618073	6231929	24-Jul-12	Wilder Creek	Dam	N	1	
613794	6234869	24-Jul-12	Wilder Creek	Dam	N	1	
618292	6232205	24-Jul-12	Wilder Creek	Lodge	N	1	
607824	6236295	24-Jul-12	Cache Creek	Dam	N	1	
605577	6233525	24-Jul-12	Cache Creek	Bank Lodge	N	1	
608819	6236549	24-Jul-12	Cache Creek	Dam	N	1	
607921	6235880	24-Jul-12	Cache Creek	Dam	N	1	
604354	6233149	24-Jul-12	Cache Creek			1	Swimming in main channel
599785	6233553	24-Jul-12	Halfway River	Dam	N	2	
598806	6232123	24-Jul-12	Halfway River	Bank Lodge	N	1	
594724	6230122	24-Jul-12	Halfway River	Lodge	N	1	
597545	6230922	24-Jul-12	Halfway River			1	Swimming in main channel
589583	6226494	24-Jul-12	Farrell Creek	Bank Lodge	N	1	
579151	6219735	24-Jul-12	Peace Canyon	Bank Lodge	N	1	
578248	6219298	24-Jul-12	Peace Canyon	Lodge	N	1	
573661	6217135	24-Jul-12	Peace Canyon	Dam	N	1	
576386	6219562	24-Jul-12	Peace Canyon	Lodge	N	1	

Appendix 11. Map of active beaver lodges and food caches detected during pre-spill aerial surveys, June 2-3, 2010 in the Peace River valley, B.C.



Appendix 12. Reptile and amphibian detections for 2010 pre- and 2012 post-spill surveys in the Peace River valley (BUBO = western toad, RASY = wood frog, THIS = common garter snake).

SPECIES[1]	EASTING	NORTHING	DATE	COUNT	COMMENTS
Pre-spill					
RASY	632024	6229099	28-May-10	1	wood frog
BUBO	599192	6232518	28-May-10	1	juvenile Western Toad
BUBO	567180	6208350	28-May-10	1	wetland pond with tadpoles
RASY	586711	6224157	12-Jun-10	1	wood frog in pool
RASY	587050	6224243	12-Jun-10	1	wood frog
RASY	586996	6224179	12-Jun-10	1	wood frog
RASY	586996	6224171	12-Jun-10	1	wood frog
RASY	586959	6224136	12-Jun-10	1	wood frog
RASY	586744	6224124	12-Jun-10	2	wood frog
THIS	586568	6223956	12-Jun-10	1	common garter snake
RASY	586538	6223930	12-Jun-10	1	
THIS	586501	6223890	12-Jun-10	1	
BUBO	586347	6223721	12-Jun-10	1	juvenile western toad
BUBO	586250	6223562	12-Jun-10	1	
RASY	586239	6223539	12-Jun-10	1	
RASY	586329	6223700	12-Jun-10	1	
BUBO	601755	6233645	16-Jun-10	2	juvenile western toad
RASY	601743	6233638	16-Jun-10	1	wood frog
RASY	601676	6233610	16-Jun-10	1	juvenile wood frog
RASY	599135	6232486	17-Jun-10	1	juvenile wood frog
RASY	599108	6232357	17-Jun-10	1	juvenile wood frog
RASY	599093	6232342	17-Jun-10	1	juvenile wood frog
RASY	599089	6232333	17-Jun-10	2	adult and juvenile wood frog
RASY	598585	6231789	17-Jun-10	2	wood frog
RASY	602536	6233374	16-Jun-10	1	wood frog
RASY	599203	6232521	17-Jun-10	1	wood frog
BUBO	600136	6232934	17-Jun-10	1	western toad
BUBO	599199	6232515	17-Jun-10	2	mating pair of western toad in pond, eggs coming out behind pair in string
BUBO	6258447	990841	9-Sep-10	2	adult western toad and toadlet
BUBO	6258689	990350	9-Sep-10	1	western toad toadlet
Post-spill					
ANBO	587450	6224965	19-Jul-12	1	
ANBO	587013	6224230	19-Jul-12		
RASY	587037	6224235	19-Jul-12	1	
RASY	586933	6224133	19-Jul-12	1	
RASY	587346	6224800	19-Jul-12	1	
RASY	587472	6224948	19-Jul-12	1	
THIS	587065	6224322	19-Jul-12	1	
THEL	587202	6224586	19-Jul-12	1	
THEL	587167	6224653	19-Jul-12	1	
THEL	586913	6224170	19-Jul-12	1	
THEL	586864	6224195	19-Jul-12	1	

ANBO	598788	6232107	20-Jul-12	1	
RASY	599013	6232219	20-Jul-12	1	
RASY	599049	6232267	20-Jul-12	1	
RASY	599157	6232443	20-Jul-12	1	
THIS	599467	6232646	20-Jul-12	1	

[1] Amphibian and reptile species codes follow Resource Inventory Committee (2008); UNID denotes unidentified species.