COLUMBIA BASIN
FISH & WILDLIFE
COMPENSATION
PROGRAM

SMALL WETLAND LITERATURE REVIEW AND MAPPING

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Executive Summary

Wetland ecosystems are extremely productive and often support high levels of biodiversity and higher numbers of rare species relative to other ecosystems. The progressive loss and conversion of wetlands worldwide has become a key conservation issue and has intensified the need for reliable information on the status and distribution of wetland resources. This is particularly the case with smaller, more isolated wetlands that have received relatively little management or conservation emphasis. This report focuses on the classification, significance, inventory and conservation of wetland habitats in the Columbia Basin Fish & Wildlife Compensation program area, and places special emphasis on small wetlands (<10 ha).

Ten wetland classification systems applicable to the program area were reviewed and a system incorporating 11 site classes is recommended to describe wetland and associated transition and flood ecosystems in the Columbia Basin.

The functional significance of wetlands was reviewed and the Columbia Basin Wildlife-Habitat Relationships Database was used as a tool to further evaluate and quantify the specific habitat values of wetland types and their associated attributes to vertebrate wildlife species. The literature review reinforces the pivotal role played by wetlands in maintaining water quantity and quality and in providing habitat and life support for a diversity of flora and fauna. An estimated 175 vertebrate wildlife species (119 bird, 46 mammal, 7 amphibian and 3 reptile) in the basin are associated with wetlands and 97 of these species are considered wetland obligates. Thirteen of the latter species are listed in British Columbia and many have very localized distributions and/or other specialized habitat requirements in addition to their dependence on wetlands. The literature suggests that small wetlands play an important role in the survival of unique species assemblages because they lack the predatory fish/invertebrates and loons that are capable of depredating amphibian larvae or competitively excluding other waterfowl in larger wetlands, respectively. In addition to wetland size, wetland type, density, distribution, connectivity, complexity and characteristics of adjacent terrestrial areas appear to be important determinants of wetland habitat suitability and species richness.

The provincial 1:20,000 TRIM data set was used to conduct a GIS inventory of wetlands in the program area grouped by wetland type, size class, biogeoclimatic zone, landscape unit, and ownership status. Results are summarized in tables and in a 1:800,000 overview map, and patterns and trends in wetland availability are discussed. GIS analysis of TRIM data indicates that there are 12,203 ha of small (<10 ha) wetlands in the Columbia Basin comprised mainly of marshes (71%) and swamps (28%), with a small area of flooded lands (1%). The 2-5 ha size class is the largest contributor to total wetland area in the basin, followed by the 5-10 ha class, and then progressively smaller size classes. An additional 22,445 ha of small lakes occur within the basin. Biogeoclimatic zones with the highest wetland abundance by area are the IDF (0.77%), SBS (0.70%), PP (0.41%), MS (0.40%), followed by the ICH (0.16%), ESSF (0.06%), and AT (0.02%). All landscape units with a wetland abundance exceeding 0.5% (by area) are located in the East Kootenay. Furthermore, the vast majority of small wetland area in the basin is found on crown (76.9%) land, with the remainder located on private land (22.3%) or in provincial (0.5%) and national parks (0.3%).

For ten areas in the basin, wetland inventories were conducted using both GIS and air photo interpretation. Results were compared to evaluate the adequacy of TRIM wetland coverage and findings indicate that there are a number of problems in identifying, quantifying and interpreting wetland data gathered from TRIM. Air photo interpretation was able to detect more wetlands, and smaller wetlands were more likely to be missed in the GIS analysis, although this pattern was not consistent. There was also a tendency for GIS analysis to overestimate the marsh component, and underestimate the swamp, shallow open water, and total wetland area components. Because fens were not represented in the TRIM classification, they tended to be either missed or classified as marshes. Overall, air photo interpretation was able to provide a much more detailed and fine-grained level of classification than GIS analysis of

TRIM data. Area-based estimates provided in the GIS analysis should therefore be considered a rough first approximation and air photo interpretation is recommended for use in future wetland inventory.

Current provincial and federal legislation, regulations, guidelines and initiatives pertaining to the management and conservation of wetlands were reviewed. The review confirms that although several legal instruments are available to protect wetlands, most are very restrictive, particularly in terms of land jurisdiction. Provincial and federal legislation applying to provincial and national parks, ecological reserves, wildlife management areas (WMAs), wildlife sanctuaries and national wildlife areas offers the best wetland protection, but >99% of small wetlands in the basin are located on crown and private lands not covered by these statutes. Wetlands associated with fish streams have both provincial and federal legislation that could provide protection, however their implementation is often reactive rather than proactive. Several potentially important legislative tools (e.g., *Local Government Act, Environmental and Land Use Act, Growth Strategies Act, Drainage, Ditch and Dike Act Forest Land Reserve Act, Agricultural Land Reserve Act, Land Act, Land Title Act*, etc.) would benefit from the guidance provided through implementation of provincial guidelines or a policy for wetland management.

On crown forest and rangelands representing 77% of the land base where small wetlands are found, the *Forest Practices Code* currently offers protection through the method of wetland classification and establishment of mandatory reserve zones for wetlands >5 ha in size. Wetlands <1 ha in size do not receive protection in any biogeoclimatic zones and those <5 ha are buffered only in a few of the zones represented within the basin. Studies in other jurisdictions have shown that the travel and dispersal distances of wetland-dependent organisms exceed prescribed reserve zone widths by orders of magnitude in virtually all cases, and that larger, biologically relevant buffer zones are needed to conserve wetland species. Current *Forest Practices Code* regulations governing range use activities around small wetlands are weak and recent evaluations have raised concerns for wetland protection in drier zones of the East Kootenay. Under the new *Forest and Range Practices Act*, code requirements become more discretionary, and whether existing wetland protection objectives and standards can be maintained under the new legislation remains unknown.

An estimated 22.3% of small wetlands in the Columbia Basin are located on private land. These “private” wetlands are especially vulnerable due to the lack of applicable legislation. A clearly articulated provincial wetlands policy accompanied by best management practices with strong extension support may be the best opportunity to improve treatment of smal,l privately owned wetlands.

Findings from all project components were synthesized to identify wetland conservation risks and opportunities within the CBFWCP program area. Recommendations include the following:
- protect a diversity of wetland types and sizes in representative areas throughout the CBFWCP area using a combination of strategies (land acquisition and management, wetland landowner incentive programs, promotion of wetland stewardship initiatives, awareness campaigns and training programs, support of wetland habitat/species inventory and research initiatives in the basin, and networking and collaboration with other ENGO and conservation groups);
- use air photo interpretation to evaluate the density, distribution and connectivity of wetlands on a sub-basin or watershed level and field-truth selected areas to further evaluate the reliability of this method in identifying and classifying wetlands;
- lower minimum wetland size thresholds for protection in all BEC zones, increase terrestrial buffer zone widths, and strenghten regulations governing range use in wetland areas;
- conduct additional research on the travel/dispersal distances from wetlands and on home range or breeding territory sizes for wetland species in local ecosystems; and
- provide ministry staff with the mandate and resources to enforce motorised recreational vehicle restrictions, develop recreational access management plans, and undertake associated monitoring and compliance activities in sensitive wetland areas.

Acknowledgments

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1.0 Introduction and Background

Wetlands represent critical breeding, rearing, feeding and staging habitats for many species of fish, wildlife and other biota (Peck 2000). Relative to surrounding areas, wetland habitats often support high levels of biodiversity and a disproportionate number of listed species (Rubec et al. 1988; Mitch and Gosselink 1993; Merritt 1994; Boylan and Maclean 1997). They also perform essential hydrological and biogeochemical functions (see reviews in Rubec et al. 1988; Mitch and Gosselink 1993; Walbridge 1993; Nolan and Jeffries 1996).

Wetland ecosystems are transitional between terrestrial upland and open-water aquatic environments. They are defined as "areas where a water table is at, near, or just above the surface and where soils are saturated for a sufficient length of time such that excess water and resulting low soil oxygen levels are principal determinants of vegetation and soil development"(Banner and MacKenzie 2000). Their most common diagnostic features are hydric soils and an abundance of obligate hydrophytes in the vegetation community. Examples include fens, bogs and swamps to semi-aquatic marshes and shallow open water. Excluded from this definition are deep water and flowing aquatic ecosystems as well as "transitional wetlands" (i.e., those not saturated long enough to be considered true wetland ecosystems), such as shrub-carrs, riparian low benches, and graminoid wet meadows.

Wetlands are dynamic ecosystems, changing both seasonally and with succession, and often clusters of various types are linked together to form a *wetland complex*. The frequency, duration and depth of flooding is the most important determinant of wetland type, and the water regime in turn influences wetland soils, nutrients, and pH. All of these factors, in combination with the surrounding geology, topography and climate determine associated plant and animal communities.

An estimated 70% of Canadian wetlands have been converted from a natural state to other uses associated with agriculture, urban and industrial use, hydroelectric power and gas development, forest harvesting, peat production, etc. (Rubec et al. 1988; Nolan and Jeffries 1996). In the lower 48 states of the U.S., only 47% of the estimated 220 million acres of endemic wetlands still remain (Dahl 1990; Dahl and Johnson 1991). Wetland loss and conversion has become a key conservation issue and has intensified the need for reliable information on the status, distribution and extent of wetland resources. This is particularly the case with smaller, more isolated wetlands that have received relatively little management or conservation emphasis to date (Semlitsch and Bodie 1998; Gibbs 2000; Snodgrass et al. 2000). Small wetlands typically occur in discrete patches in a matrix of upland habitat (Gibbs 2000). They support a high diversity of wetland-dependent organisms living in multiple local populations sustained through occasional migration (Gibbs 1993, 1995, 2000; Snodgrass et al. 2000). Wetland mosaics are critical habitats for relatively sedentary amphibian species, but many highly mobile wetland-inhabiting birds (e.g., shorebirds, waterfowl, wading birds, etc.) also use a spatially dispersed mosaic of sites within particular stages of their life cycle (Haig et al. 1998).

Recent studies focusing on wetland mosaics in the United States indicate that small wetland habitat loss is a serious conservation problem, and that loss of small wetlands causes a direct reduction in the connectivity and viability of residual species populations (Johnson 1994; Semlitsch and Bodie 1998). Significant changes to current legislation and wetland conservation planning will be required in order to achieve adequate protection of small wetlands in most jurisdictions (Semlitsch and Bodie 1998; Gibb 2000; Snodgrass et al. 2000).

Wetland habitat protection in the BC portion of the Columbia Basin, has focused mainly on large, low elevation wetland complexes supporting high concentrations of breeding and migratory birds (e.g., the Creston Valley Wildlife Management Area, the Bummer's Flat Conservation Area, and Columbia River Wetlands Wildlife Management Area). Small wetlands have received little conservation emphasis and information pertaining to their functional significance and pattern of abundance and distribution is required for management and conservation purposes.

In April of 2003, Pandion Ecological Research Ltd., in collaboration with Carver Consulting and Evan McKenzie Ecological Research, was contracted to undertake a literature review and mapping exercise focusing on smaller wetlands (i.e., <10 ha in size) in the Columbia Basin Fish & Wildlife Program (CBFWCP) program area. The study area extends from the U.S. border to McBride and includes the entire area for which TRIM (1:20,000) coverage is available (Figure 1).

2.0 Study Objectives

The objectives of this project were to:

1. summarize wetland classification schemes applicable to the CBFWCP area;
2. identify the functional significance of wetlands and their specific habitat values for vertebrate species;
3. describe wetland habitats in the CBFWCP program area based on a GIS inventory;
4. summarize and compare the results of wetland inventories conducted for selected areas using GIS and air photo interpretation, in order to evaluate the overall adequacy of TRIM wetland coverage; summarize current provincial and federal legislation, regulations and guidelines influencing the management and conservation of wetlands; and
5. synthesize the above wetland information in order to identify conservation risks as well as restoration opportunities within the CBFWCP program area.

3.0 Methods

Methods for this project involved three main components: (1) literature review, (2) GIS and air photo wetland inventory, and (3) information synthesis.

3.1 Literature Review

A review of available wetland classification systems was undertaken to identify systems that could potentially be used to classify wetlands in the CBFWCP study area. Ten systems were reviewed and used as a starting point to identify classification schemes, concepts and ecological criteria that would be useful for classifying wetlands and evaluating their associated wildlife habitat suitability in the Columbia Basin study area.

The functional significance of wetlands and their habitat value to wildlife guilds was described based on a review of readily available literature from local libraries, supplemented by a web-based search/literature review.

The Columbia River Database (Steeger et al. 2001) was used to identify the habitat value and use of wetlands by specific vertebrate species. This comprehensive, state-of-knowledge database describes the wildlife-habitat relationships of 447 wildlife species in the BC Columbia Basin Database (CBD), and it is an extension of the wildlife-habitat classification methodology outlined in "Wildlife-Habitat Relationships in Oregon and Washington" (Johnson and O'Neil 2001). Both the US and BC databases feature lists of vertebrate wildlife species occurring in the respective portions of the Basin and sets of digital matrices that relate these species to *Wildlife Habitat Types*, *Habitat Elements*, *Structural Conditions*, selected *Life History* parameters, and *Key Ecological Functions*.

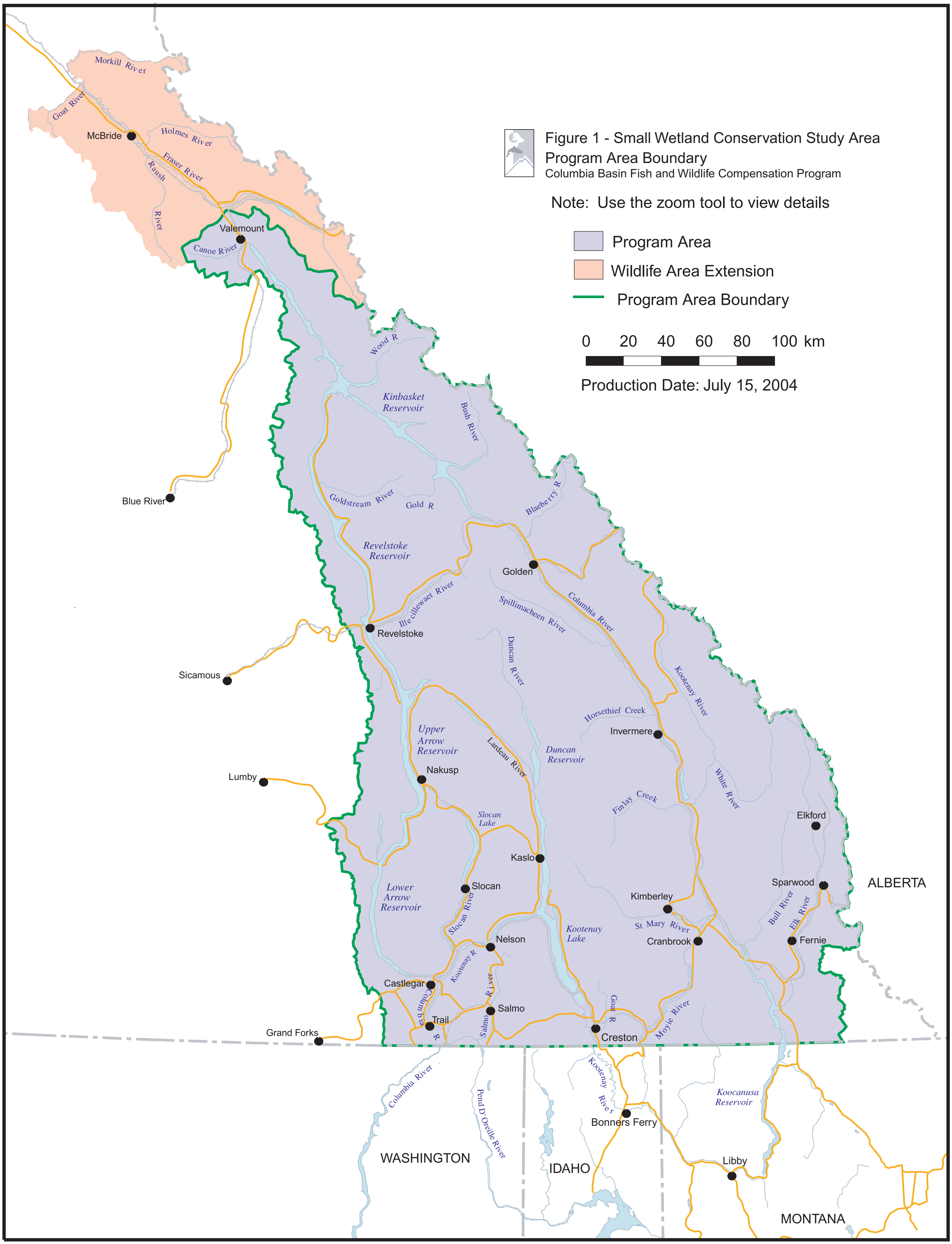

Figure 1 - Small Wetland Conservation Study Area
Program Area Boundary
Columbia Basin Fish and Wildlife Compensation Program

Queries were conducted to determine which species are associated with wetland *habitat elements*[1] in the BC portion of the Columbia Basin. The database was further queried to determine the *nature* (i.e., breeding, foraging, other) and *level of their association*[2] (i.e., closely associated, generally associated, present) with four *wetland habitat types* occurring in the Basin *(*i.e., Herbaceous Wetlands, Montane Coniferous Wetlands, Eastside Riparian Wetlands, and Open Water – Lakes, Rivers and Streams; Ketcheson et al. 2001). For 97 species associated with wetland habitat elements *and* closely associated with wetland habitats, their association with other riparian habitat elements and their key ecological functions[3] were also explored. Results of queries are summarized in tabular format and discussed by wildlife guild.

For listed species closely associated with wetland habitats, additional information was summarized from the Columbia River Database and the literature pertaining to their occurrence and distribution, home range use, life history strategy, seasonal cycle, and habitat requirements. This data is summarized in tabular format and later discussed within the context of wetland conservation and restoration.

Current provincial and federal legislation, regulations and guidelines that influence the management and conservation of wetlands were reviewed. This information was obtained through interviews with wetland specialists in government and the private sector, review of provincial and federal government legislation/policy documents and guidebooks, and through a web-based search/literature review.

3.2 Wetland Inventory

3.2.1 Wetland Inventory Using GIS

Ian Parfitt, Tasha Kirby and Amy Waterhouse conducted a small wetland inventory using the provincial 1:20,000 TRIM data set. This inventory considered wetlands by type (i.e., swamp, marsh, flooded lands and small lakes <10 ha), size class (0.1 – 0.5 ha; 0.5 – 1.0 ha; 1 – 2 ha; 2 – 5 ha; 5 – 10 ha), biogeoclimatic (BEC) zone, landscape unit, and land status (national or provincial park, crown land or private land). Products generated from the inventory included a spreadsheet listing wetland area by wetland type, size class, landscape unit and BEC zone. This information was summarized in tables and patterns and trends in the availability and distribution of wetland types and sizes in BEC zones and landscape units of the basin are discussed. A 1:800,000 overview map was also generated which themes landscape units based on small wetland abundance. The latter was calculated as the percent of wetland area (ha) relative to total landscape unit area. Five wetland abundance classes (<0.01%; 0.01 – ≤0.05%; 0.05 – ≤0.1%; 0.1 – ≤0.5%; >0.5%) were mapped (see Figure 2).

3.2.2 Wetland Inventory Using Air Photo Interpretation

Air photo interpretation was used to delineate, classify (by size and type), and inventory a sample of small wetlands and related terrestrial ecosystems in the Columbia Basin.

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[1] *Habitat elements* are components of the environment believed to most influence wildlife species' distribution, abundance, fitness, and viability. Habitat elements include natural biological and physical attributes. The CBD defines 233 habitat elements, but for or the purpose of this analysis, only 8 habitat elements that directly relate to wetlands and a further 57 habitat elements that relate to riparian habitats were used.

[2] *Level of association*: (a) closely associated - the species has an essential need for this habitat type for its maintenance and viability; (b) generally associated - the habitat type plays a supportive role for the maintenance and viability of the species; (c) present - the habitat provides marginal support to the species for maintenance and viability (Johnson and O'Neil 2001).

[3] *Key ecological functions* are the main roles played by each species in its ecosystem based on the way they use, influence and alter their biotic and abiotic environments.

Sample Selection

CBFWCP staff subjectively chose ten sample areas to include a number of wetland systems and a diversity of wetland types found in the basin. Two sample areas were located in each of five biogeoclimatic (BEC) zones (ESSF, ICH, MS, IDF and PP) represented in the study area. Each sample area corresponded to the area covered by one aerial photograph and stereo air photo pairs (1:16,000 to 1:22,000 in scale) were provided for all sample areas. Sample locations were delineated on 1:20,000 TRIM maps to facilitate comparisons with the wetland inventory conducted for the same areas using GIS techniques. All wetland systems located entirely within the photo areas were included in the inventory. In both of the ESSF sample areas, large fluvial wetland systems spanned several photos, so the wetland systems were split, and the ecosystems classified were confined to only one photo.

Ecosystem Typing

Each photo representing a sample area was overlain with a sheet of transparent film that was labeled with air photo number, scale, location of the sample area, and BEC zone. While viewing the sample area in stereo, entire wetland systems and ecosystem types within systems were delineated using black and red markers, respectively. Inflow and outflow channels that could be recognized were marked with blue arrows indicating the direction of flow. Entire wetlands were labeled with a number or letter-number combination, while wetland and related ecosystem types within each wetland system were identified with a letter following the wetland number (i.e. 10A or G3B).

Size Classification

The scale of each sample area photo was determined and a dot grid was then used to determine the size of entire wetland systems. For relatively simple wetlands, the percentage of the wetland system occupied by each ecosystem component was estimated and then an area for each component was determined. For large and/or complex wetlands where it was difficult to estimate percentages, the areas of all components were determined using the dot grid. Wetland and related ecosystems were grouped into the following six size classes: 1 (0.1 – 0.5 ha); 2 (>0.5 – 1.0 ha); 3 (>1.0 – 2.0 ha); 4 (>2.0 – 5.0 ha); 5 (>5.0 – 10 ha); 6 (>10.0 ha).

Site (Component) Classification

Wetland and related terrestrial ecosystem components were initially classified according to the Wetland and Riparian Ecosystem Classification (WREC) system of BC described by MacKenzie and Banner (2001). The components were classified as to *Ecosystem Realm, Ecosystem Group* and *Ecosystem Class* (see Table 2). The wetland ecosystem classes of the BC system correspond to wetland classes described in the Canadian Wetland Classification System (National Wetlands Working Group 1997). These include *bogs*, *fens*, *swamps*, *marshes*, and *shallow open water* (see class descriptions in Appendix 1). Bogs, fens and swamps are all characterized by an accumulation of peat, but differ based on dominant vegetation and mineral levels. Bogs are sphagnum moss-dominated and receive water exclusively from precipitation, whereas fens and swamps both receive groundwater rich in nutrients, and are dominated by graminoids/bryophytes and trees/shrubs/forbs, respectively. Marshes are nutrient rich mineral wetlands characterized by periodic flooding with standing or slow-moving water and vegetation dominated by graminoids, shrubs, forbs, or emergent plants. For air photo interpretation analysis, marshes were subdivided into *deep marsh* and *shallow marsh*, as the two subclasses could usually be differentiated. Related terrestrial ecosystems described in the BC classification system and delineated during air photo analysis include *low, mid & high bench* ecosystems of the Terrestrial Flood Group, and *shrub-carr* and *meadow* ecosystems of the Terrestrial Transition Group. *Deep water* and *exposed land* ecosystem classes were also identified. Wetland and related ecosystem classes were not further subdivided into site associations and site series of the BEC system, as that level of detail could not be determined using air photo interpretation.

Vegetation Classification

Ecosystem classes were further divided into wetland and related ecosystem components using vegetation features. Vegetation physiognomy (physical form or structure) could be recognized on air photos and was used to subdivide the site classes. General and specific physiognomic vegetation cover types used during the classification process are based on physiognomic terms described in the Canadian Wetland Classification System (see Appendix 1). A *herb* cover type was also used to further classify meadow ecosystems and represents a type dominated by undifferentiated forb and graminoid species. *Low shrub* and *tall shrub* cover was considered ≤2 m and 2-10 m in height, respectively. *Mixed shrub* was considered a mix of low and tall shrub species and *hardwood treed* cover type is synonymous with the *broadleaf treed* physiognomic type.

Other vegetation features used to describe wetland and related ecosystem components include a "component position modifier" as described by Runka and Lewis (1981) and an "interspersion type" for describing the arrangement of ecosystem components within wetland systems (Moon and Selby, 1982; see Appendix 1). Time was not available to photo interpret and record other vegetation features including distribution & density of cover types and surrounding habitat types.

Physical Classification

The hydrogeomorphic classification system presented by MacKenzie and Banner (2001) was used to classify wetland systems according to hydrological processes and physical forms. Wetlands were classified according to *hydrogeomorphic systems, subsystems* and *elements* (see Appendix 1 for lists of the system and subsystems used in the classification). Basin and pond subsystems were further divided into *closed, overflow, linked* or *terminal* elements.

The hydrotopographic character of a wetland (Runka and Lewis 1981) corresponds in part to the hydrogeomorphic classification and was also used during the classification process to classify entire wetland systems with respect to hydrology and topographic location in the landscape.

Physical features recognizable on air photos were also used to differentiate wetland classes into wetland *forms* and *subforms* as described in the Canadian Wetland Classification System (NWWG, 1997; see Appendix 1). Terrestrial Flood and Transition ecosystems were not classified according to wetland form and subform. Other data on physical features that were not collected during the classification exercise include information on wetland juxtaposition and water chemistry.

Wetland System Classification

An attempt was made to classify entire wetland systems by using the concept of vegetation zone sequences (Millar 1976). Millar recognized that vegetation zones form a gradient in response to increasing water depth and duration of flooding in a wetland basin. The central or diagnostic wetland component in the wetland system occupying the lowest portion of the basin corresponds to the greatest depth and duration of flooding and therefore is the key to a wetland's moisture regime. During the air photo inventory, the central (diagnostic) wetland component in each wetland system was identified and the dominance or extent of the central component was recorded as a percentage of the entire wetland. (i.e. Shallow Water (SW) – 15%).

Wetland component zonation patterns or sequences were also identified by listing letter codes for the various components in the order in which they occurred from the center or lowest part of a wetland to its' outer edge. Vegetation cover types were also included in the codes. For example, the code "SWas – dMrt – Fg – Fsl" represents a "Shallow water with submerged aquatics – deep Marsh with tall rushes – Fen with graminoids and Fen with low shrubs" sequence.

Wetland Disturbance

Human use or disturbance to wetlands was identified and recorded using modifiers described by Millar (1976) and Runka and Lewis (1981). Alteration and disturbance modifiers include beaver, cattle grazing, wildlife habitat enhancement, dams, irrigation, and transportation corridors.

Data Collection
Comments about ecosystem components, the classification process and difficulties distinguishing between wetland and related ecosystem classes and vegetation cover types were also recorded. Wetland and related ecosystem classification and inventory data were collected using the form in Appendix 2 (not all fields were completed due to limitations in identifying detailed wetland vegetation and physical features and/or time constraints of the project). More detailed information to further classify wetlands will require additional air photo interpretation and field surveys.

3.3 Information Synthesis

The management and conservation implications for small wetlands in the Columbia Basin are discussed based on (a) current patterns in wetland availability and distribution, (b) wetland habitat element requirements of vertebrate guilds and listed species, and (c) current legislation, regulations and guidelines influencing wetlands. Small wetland conservation risks and restoration opportunities within the basin (emphasis on small wetlands) are discussed in particular landscape units/BEC zones, and in areas with good potential to support wetland-dependent species at risk.

4.0 Results

4.1 Review of Wetland Classification Systems

Appendix 1 provides a general discussion of criteria used to classify wetlands, descriptions of 10 wetland classification systems (Table 1) reviewed, and comments regarding the applicability of each system to wetland inventory in the Columbia Basin. Each classification system is listed in Table 1 with a summary of the classification type, criteria, as well as advantages and disadvantages.

Table 1. Summary of ten wetland classification systems reviewed with their classification levels, criteria, advantages and disadvantages.

Classification Name and Source	Classification Type	Criteria Used in Classification	Advantages & Disadvantages of Classification
Canadian Wetland Classification System (National Wetlands Working Group 1997)	wetland classes, forms, and cover types	- uses broad biological and site level criteria to differentiate classes - uses surface form, pattern, relief and hydrological system to differentiate forms - uses physiognomy to differentiate cover types	- biological, hydrological, and physical criteria are recognizable on remote sensing products & air photos - vegetation cover info is useful for assessing potential wildlife suitability and use of wetland types - this system can easily be linked to other provincial & regional systems
Classification of Wetlands and Deepwater Habitats of the United States (Cowardin et al. 1979)	systems, subsystems, classes, subclasses, and dominance types	- uses hydrologic, geomorphologic, chemical & biological criteria to differentiate systems & subsystems - uses substrate type, flooding regime and vegetation cover to differentiate classes/subclasses - uses water regime & salinity to differentiate dominance types	- classes are designed to be easily recognizable on air photos and remote sensing products - useful as a broad classification at regional levels but is much more limited at the class level - this system is not easily linked to other classification systems - provides the most comprehensive classification of non-vegetated and sparsely vegetated wetland ecosystems
Vegetation of Prairie Potholes, North Dakota	classes, subclasses,	- uses vegetation zones and plant species composition to differentiate classes & subclasses, respectively	- useful for classifying entire wetland systems but wetland classes are not all compatible with other BC and regional systems

Classification Name and Source	Classification Type	Criteria Used in Classification	Advantages & Disadvantages of Classification
(Stewart & Kantrud 1972)	cover types	- uses the spatial relation of emergent cover to open water to differentiate cover types	- cover types and distributions provide information with respect to habitat suitability for wildlife (e.g., for those species requiring dense emergent vegetation or large areas of open water) - vegetation zone and cover information can be identified on remote sensing products & air photos
Classification of Freshwater Wetlands in the Glaciated Northeast U.S. (Golet and Larson 1974)	classes, subclasses, size classes, site types, and cover types	- uses vegetation physiognomy (life forms and subforms) rather than species composition to differentiate wetland classes - the classification includes a list of classes and subclasses and their importance to wildlife species	- classes are compatible to the Canadian, BC, and other regional classification systems - introduces concepts of vegetation interspersion and surrounding habitat types which also influence the overall value of a wetland to wildlife - vegetation cover types can be recognized on air photos and remote sensing products
Wetland Classification in Western Canada (Millar 1976)	types, vegetation zones, and relative salinity categories	- uses vegetation species composition, stability and overall physical appearance to differentiate between types	- uses both vegetation and physical characteristics to classify wetlands which can be identified on air photos and remote sensing products - system developed for prairie wetlands and only some of the types can be correlated with Canadian and BC systems
Classification Framework for Wetlands and Related Ecosystems in BC (Mackenzie & Banner 2001)	classes, systems, and subsystems	- uses hydrology, soils and physiognomy to differentiate wetland classes - uses hydrological processes and geomorphic forms to classify systems	- compatible with the existing BEC system - provides a high level of detail for classifying wetlands based on site associations, however these are not identifiable on remote air photos or sensing products and must be determined in the field - site classes can be identified based on air photos & remote sensing products
Preliminary Wetland Manager's Manual (Runka and Lewis 1981)	classes, subclass, variant, and plant associations	- classes are differentiated based on hydrologic-chemical environments and wetland genesis - subclasses and variants, are based on finer divisions of water chemistry and substrate criteria, as well as differences in vegetation physiognomy	- 5 of 7 classes are comparable to classes in the Canadian Wetland Classification system - divides wetland classes into subclasses/variants based on criteria such as substrate type and water quality that cannot be identified on air photos and must be determined in the field
Wetland Systems of the Cariboo-Chilcotin Region (Moon & Selby 1982)	vegetation components, sequences, and map units	- classifies entire wetland systems (9 in total) based on naturally occurring sequences of vegetation and soil components	- useful for classifying/mapping entire wetlands for broad scale inventories - a loss of information occurs from the component level of classification to the wetland system map label - wetland sequences were defined specifically for the Cariboo Chilcotin and may not be applicable to the CBFWCP area
Classification and Mapping of US Wildlife Habitat Types in the Columbia River Basin of BC (Ketcheson et al. 2001)	wetland habitat types	- classification is based on a compilation of BC forest cover data, TRIM digital data, and GIS techniques	- the four habitat types are extremely general and are of limited use mainly for broad scale regional overview purposes (can be used for trans-boundary mapping) - types are linked to an access database that can be queried and provides information about the habitat elements and structural conditions required by wetland-associated wildlife species
Wetlands and Related Ecosystems of Interior BC (MacKenzie & Shaw 2000)	site associations	- based on the site association unit of the BEC system; wetland sites are described and classified based on similar indicator plant species groups; not all interior associations have been identified	- most useful for describing wetlands in the field since individual plant associations cannot be identified from air photos/remote sensing products - detailed site classification can be linked to higher levels of classification described in Mackenzie & Banner (2001)

Based on all the systems reviewed, Table 2 provides recommended site classes for the classification and inventory of wetland and related ecosystems in the Columbia Basin of BC.

Table 2. Recommended site classes for classification of wetland and related ecosystems in the Columbia Basin.

Wetland Ecosystems		Related Terrestrial Ecosystems	
Peatlands	**Mineral Wetlands**	**Transition Units**	**Flood Units**
Bog	Swamp	Shrub-carr	Active Channel
Fen	Marsh – deep	Meadow	Low Bench
	– shallow		Mid Bench
	Shallow Water		High Bench

4.2 Review of Wetland Significance and Habitat Value for Vertebrates

4.2.1 Wetland Functional Significance and Habitat Value

Wetlands perform a series of essential hydrological and biogeochemical functions (see reviews in Rubec et al. 1988; Mitch and Gosselink 1993; Walbridge 1993; Nolan and Jeffries 1996). By storing precipitation and surface water and then slowly releasing it into associated surface water resources, ground water, and the atmosphere, wetlands play a critical role in regulating the movement of water within watersheds and the global water cycle (Richardson 1994; Mitsch and Gosselink 1993). Wetlands also help maintain water table levels and provide force for ground water recharge and discharge to other waters (O'Brien 1988; Winter 1988). A high perimeter to volume ratio is associated with a greater surface area through which water can infiltrate; for this reason, small wetlands contribute disproportionately to ground water recharge (Weller 1981). By returning over two-thirds of their annual water inputs to the atmosphere through evapotranspiration (Richardson and McCarthy 1994), wetlands play a pivotal role in climate control and help moderate temperature extremes in adjacent uplands (Brinson 1993).

Wetland biogeochemical processes play a role in the global cycles of carbon, nitrogen, and sulfur by transforming them and releasing them into the atmosphere. They can transform nutrients, organic compounds, metals, and components of organic matter and also act as filters of sediments and organic matter. A wetland may be a permanent sink for these substances if the compounds become buried in the substrate. Alternatively, a wetland may retain them only during the growing season, or under flooded conditions, and as such, wetlands play an important role in water purification and filtration of pollutants.

The fluctuating water levels that characterize wetland ecosystems are governed by hydroperiod and control the oxidation-reduction conditions that occur. These conditions play a key role in wetland vegetation composition; nutrient cycling and availability; pH levels; sediment and organic matter accumulation and decomposition; and metal availability and export. Furthermore changes in the frequency, duration, and timing of the hydroperiod may impact spawning/breeding, migration, plant and animal species composition, as well as food chain interactions within wetlands and associated downstream ecosystems (Crance 1988; Snodgrass et al. 2000).

Wetlands are among the most productive ecosystems in the world and impressive numbers of microbe, plant, insect, fish, and vertebrate wildlife species depend in some way on wetland ecosystems (reviews in Weller 1981; Crance 1988; Merritt 1994; Johnson and O’Neil 2001). Many of these species are wetland obligates, and they include a disproportionate number of species listed as endangered or threatened (Wilcove et al. 1993; Boylan and MacLean 1997).

Johnson and O’Neil (2001) provide a thorough review of the function and values of riparian and associated wetland habitats that are summarized in the following points:

(1) they have a high diversity of plant species and vegetation structure, thereby providing niches for numerous fish and wildlife species;
(2) they often contain unique vegetation assemblages, both in composition and structure;
(3) their shape creates high edge to area ratios which increases species richness;
(4) they modify the environment (microclimate) for both terrestrial and aquatic organisms and influence water chemistry, and temperature through shade, sediment retention, and nutrient transformation;
(5) they serve as natural corridors or migration routes;
(6) they provide breeding, nursery, foraging and resting sites for resident and migratory species, as well as cover and refuge from terrestrial predators; decomposed plant matter (detritus) released into wetland water is an important food source for many invertebrates and fish, which in turn forms part of the diet of most other wetland vertebrates; and
(7) they affect aquatic biota through inputs of litter fall and coarse wood, provision of shade, and nutrient sequestration of ground and surface water.

The wildlife habitat value of a wetland is influenced by a host of factors, many of which require further study (reviews in Weller 1978; 1981; Merritt 1994). These factors include wetland type and associated structural diversity and vegetation composition; wetland shape and size; wetland hydroperiod; wetland density, connectivity and degree of isolation; surrounding land use practices and quality of adjacent upland habitat; presence/absence of fish, invertebrate and vertebrate predators, etc.

Wetland type is determined based on physical (e.g., frequency, duration and depth of flooding, geology, topography, climate) and chemical (i.e., inputs of nutrients and sediments) characteristics, which in turn influence rates of plant growth and primary productivity (Weller 1981; Brinson 1993; Mitch and Gosselink 1993; Crance 1988). Wetlands with seasonal hydrologic pulsing, such as marshes and swamps tend to be the most biologically productive. This is because during dry cycles, organic matter is more likely to decompose, aeration improves, and nutrients become more available, thereby promoting greater structural and vegetation diversity (Mitch and Gosselink 1993; Banner and Mackenzie 2000; Ducks Unlimited 2002).

Wetlands are associated with concentric bands corresponding to various vegetation communities or life forms. Many studies focusing on birds have demonstrated a positive relationship between breeding density and vegetation structural diversity, wetland habitat interspersion, and amount of edge habitat found within a wetland (review in Weller 1981). At a broader scale, heterogeneity of wetland types within an overall wetland complex creates greater habitat diversity, interspersion and edge, and results in higher vertebrate species richness (Weller 1978; Frederickson and Reid 1986; Fairbairn and Dinsmore 2001; Porej 2004). Most of these studies suggest that it is the overall structure, rather than the presence of particular plant species that is of greatest importance to wildlife. Nevertheless, particular emergent, submergent or terrestrial plant/tree species and/or their associated invertebrate fauna can be critical food and/or breeding substrates for birds and other vertebrate species (review in Weller 1981; Merritt 1994; Johnson and O'Neil 2001). Many wetland species forage and/or loaf in aquatic habitats but require specific habitat features (e.g., snags, coarse woody debris, floating mats, islands, caves, bluffs, burrows) for successful breeding or roosting. The proximity of these features to a wetland is key to its overall suitability and whether or not it will be used.

Both the shape and size of a wetland affect its associated wildlife community and value as suitable habitat (Harris 1988; Brinson 1993; Kent 1994). The shape of the wetland varies its perimeter to area ratio and has implications for the habitat suitability and reproductive success of wetland edge versus interior species (Kent 1994). Recent investigations of breeding waterfowl densities in small BC wetlands (≤2 ha) indicate an approximate linear relationship between shoreline perimeter and number of breeding waterfowl pairs (D. Kroeker, unpublished data). This relationship breaks down in larger wetlands where loon and fish species are more likely to reside and compete with selected waterfowl species (D. Kroeker, pers. comm.).

A recent study evaluating the effect of wetland area on wetland species richness found significant positive relationships for all taxa examined (Findlay and Houlahan 1997). The relationship was strongest for plants, followed by birds, mammals, and herptiles. Because this study considered a range of wetland types and sizes (wetlands ranging from 13.5–1,500 ha in size), it provides some support for the contention that wetland value increases with size. Many wetland dependent birds select marshes >5 ha in size (Brown and Dinsmore 1986) and both bird species richness and density increase with wetland complex size (Brown and Dinsmore 1986; Porej 2004). The latter studies concluded that a diversity of wetland types in close juxtaposition is important to provide adequate foraging, nesting and overwintering sites for a range of wetland-dependent species.

With the exception of amphibians, our literature search did not uncover strong empirical evidence for specific use or preference for wetlands of small size by vertebrate guilds (see six species listed in section 4.2.3). Studies evaluating amphibian species richness as a function of wetland area indicate lower richness in large, permanent wetlands which are more likely to support predatory fish and invertebrates that can exclude amphibian larvae (Morin 1983; Wilbur 1987; Semlitsch et al. 1996). They suggest that small temporary wetlands support a unique assemblage of amphibian species and are critical to the survival of some invertebrate and vertebrate animal species, particularly amphibians (Moler and Franz 1987; Dodd 1995a, 1997; Gibbs 1993; Semlitsch and Bodie 1998; Snodgrass et al. 2000). Recent investigations in the US indicate that hydroperiod (which is weakly but positively correlated with wetland size) may be a more relevant determinant of amphibian species richness (Snodgrass et al. 2000). This is because juvenile recruitment is dependent on an intermediate hydroperiod that favors the periodic drying characteristics of small wetlands (Pechmann et al. 1989). Therefore, wetlands of small size with an intermediate hydroperiod are of critical importance because they support a unique group of amphibian species that are less mobile and therefore more vulnerable to wetland loss (Semlitsch and Bodie 1998; Snodgrass et al. 2000). These small temporary wetlands are not protected under current legislation in most jurisdictions (Semlitsch and Bodie 1998; Gibbs 2000).

Many recent studies have emphasized the importance of wetland density, distribution, and connectivity (rather than just wetland size) in determining vertebrate species richness and habitat suitability. Wetlands typically occur in discrete patches or mosaics in a matrix of upland habitat (Semlitsch and Bodie 1998; Gibbs 2000). Human activities such as dredging, draining and infilling have altered natural wetland mosaics (i.e., shift from many clustered wetlands to fewer isolated wetlands) and drastically reduced overall wetland area (Gibbs 2000). The implications of these changes are most apparent when considered in the context of the dispersal abilities of small wetland organisms, many of which live in multiple local populations sustained through occasional migration (Hanski and Gilpin 1991; Semlitsch 1998). Average dispersal distances are generally <0.3 km for frogs, salamanders and small mammals (Gibbs 1995; Gibbs 1993; Semlitsch 1998; Semlitsch and Bodie 1998), and <0.5 km for reptiles (Gibbons 1986; Joyal et al. 2001). These organisms are constrained in their ability to disperse across uplands separating wetlands and increasing wetland loss and isolation is expected to further reduce population densities and number of dispersing juveniles, thereby impeding source-sink processes and increasing extinction probabilities at remaining wetlands (Gibbs 1993; Travis 1994; Semlitsch and Bodie 1998).

Reduced wetland availability and connectivity also impacts larger and more wide-ranging animals (e.g., moose, river otter) that depend on wetlands for food and refuge. These animals must travel greater distances within a matrix of disturbed habitat bisected by roads and other developments to access suitable habitat (Weller 1981). The dispersal of aquatic plants is highly dependent on transport by wetland animals (Scultthorpe 1967; Lowcock and Murphy 1990) and will also be impacted by wetland reduction and isolation. Even for highly mobile waterbirds (e.g., shorebirds, wading birds, waterfowl), reduced densities and proximity of wetlands have negative implications. Haig et al. (1998) review a large number of studies that demonstrate the importance of frequent within-season movements among wetlands (for foraging, nest selection, re-nesting, territory switching, and habitat shifts associated with brood rearing, molting, staging, and dispersal, etc.). Waterfowl brood survival is directly related to wetland density because young suffer highest mortality during overland movements (Stoudt 1971; Batt et al. 1989; Rotella and Ratti 1992b). Therefore, in the context of landscape ecology, isolated wetlands tend to support lower waterbird breeding densities and have lower brood survival rates (Rotella and Ratti 1992a,b). Nevertheless, most protection efforts focus on conservation of large single sites along migratory pathways, rather than mosaics of small wetlands that can be critical for successful breeding (Haig et al. 1998).

The characteristics of the terrestrial matrix surrounding a wetland are thought to have a strong influence on the use and species richness of the wetland itself. Recent studies of wetlands in southeastern Ontario confirm that herptile, bird, mammal and plant species richness of wetlands decline with reduced forest cover and increased paved road density peripheral (i.e., up to 2 km) to wetlands (Findlay and Houlahan 1997). These trends suggest that existing wetland policies that focus almost exclusively on land use activities within the wetland itself and/or a narrow buffer zone around its perimeter are unlikely to provide adequate wetland protection for wetland biodiversity. Greater protection must be directed at the terrestrial areas peripheral to wetlands in order to maintain their habitat suitability and connectivity (Joyal et al. 2001; Semlitsch and Bodie 2003).

Many semi-aquatic organisms (e.g., salamanders, frogs, snakes, turtles, insects) depend on both aquatic and terrestrial habitats to complete their life cycle and maintain viable populations. Few studies have empirically addressed biologically relevant terrestrial buffer zones to protect wetland-dependent faunal communities (Brown et al. 1990; Burke and Gibbons 1995; Dodd and Cade 1998; Semlitsch 1998; Joyal et al. 2001; Semlitsch and Bodie 2003). Those that have confirm that both minimum size thresholds and terrestrial buffer zones for wetland protection are inadequate (Semlitsch 1998; Semlitsch and Bodie 1998; Dodd and Cade 1998; Semlitsch and Bodie 2003). This is because the travel and dispersal distances of wetland organisms during various phases of their cycle exceed those prescribed in virtually all cases (Semlitsch 1998; Semlitsch and Bodie 1998; Dodd and Cade 1998; Semlitsch and Bodie 2003).

Wetland regulations typically protect wetlands above a certain size threshold and arbitrarily defined portions of adjacent terrestrial habitat, if any. In BC for example, 10 m reserve zones (i.e., buffers) are prescribed immediately adjacent to the wetland, depending on wetland size and biogeoclimatic zone (see section 4.4). Wetlands <1 ha receive no protection in any BEC zone and those <5 ha are only buffered in selected BEC zones (i.e., PP; BG; IDF xh/xw/xm; CDF; CWH ds/dm/xm). As in other jurisdictions, these reserve and management zone widths are arbitrary and do not reflect the distances that are biologically relevant to wetland fauna.

4.2.2 Wetland Associated Species

Based on queries of the Columbia Basin Database, 175 terrestrial vertebrate species in the CBFWCP area are “associated” with wetland habitat elements (i.e., these elements have a significant influence on their distribution, abundance, fitness, and viability; Appendix 3). They include 7 amphibian, 3 reptile, 119 bird, and 46 mammal species. Twenty-eight of these species (or subspecies) are currently listed (16 blue-listed and 12 red-listed) in BC. Of 175 wetland-associated species, 97, 58 and 14 species are considered “closely associated”, “associated” or “present” respectively in one or more of the four broad wetland habitat types described in the Columbia Basin Database. Table 3 summarizes wetland associations by vertebrate class (amphibians, reptiles, birds and mammals).

Amphibians as a group are highly dependent on wetlands. Six of 7 species found in the CBFWCP area are “closely associated” with wetland habitats and require wetland elements for both breeding and foraging purposes. One of these species (Northern Leopard Frog) is currently red-listed in BC. All amphibians (i.e., frogs, toads and aquatic salamanders) in the basin have a typical biphasic life history pattern (Duellman and Trueb 1986). Adults migrate to aquatic habitats (e.g., wetlands, streams, seasonal pools) and deposit their eggs, and then return to terrestrial habitats. The eggs hatch as aquatic larvae that remain in the water for various amounts of time, depending on hydroperiod, thermal regime, predation, competition, and other related factors (Pechmann et al.1989; Newman 1992; Rowe and Dunson 1995;

Table 3. Summary of the level and type of association with wetland habitats for 175 terrestrial vertebrate (bird, mammal, reptile and amphibian) species in the Columbia Basin requiring wetland habitat elements (Steeger et al. 2001). Numbers of species for each level and type are shown with percentages in parentheses.

Level of Association with Wetland Habitats	Amphibian	Reptile	Bird	Mammal	Total
Closely associated	6 (85.7)	2 (66.7)	68 (57.1)	21 (45.6)	97 (55.4)
Associated	0 (0)	1 (33.3)	37 (31.1)	20 (43.5)	58 (33.1)
Present	0 (0)	0 (0)	10 (8.4)	4 (8.7)	14 (8.0)
No association	1 (14.3)	0 (0)	4 (3.4)	1 (2.2)	6 (3.4)
Type of Association with Wetland Habitats	**Amphibian**	**Reptile**	**Bird**	**Mammal**	**Total**
Breeding and Feeding	6 (88.9)	2 (66.7)	81 (68.1)	42 (91.3)	131 (74.8)
Feeding only	0 (0)	1 (33.3)	34 (28.6)	3 (6.5)	38 (21.7)
Not identified	1 (11.1)	0 (0)	4 (3.4)	1 (2.2)	6 (3.4)
Overall	7	3	119	46	175

Skelly 1996). The larvae eventually metamorphose and emigrate to terrestrial habitats. Breeding seasons can last from a few days to many weeks (Corkran and Thoms 1996). However, irrespective of their specific life history, wetlands satisfy the narrow moisture and temperature requirements of amphibians and provide the food and vegetation cover types used by many members of this guild.

Three reptile species including the blue-listed Painted Turtle are associated with wetlands. Two of these species (Painted Turtle and Common Garter Snake) are considered “closely associated”, requiring wetlands for both breeding and feeding purposes.

Of 119 bird species associated with wetland habitat elements, 81 species use them for both breeding and feeding purposes. Nineteen (16%) of these are listed by the CDC, and 68 (57%) are considered “closely associated” with wetland habitats. Wetland-associated birds can be grouped into a number of functional guilds, based on their life history characteristics and wetland habitat use. Waterfowl (e.g., ducks, geese and swans) as a group are highly dependent on wetlands for both feeding and nesting purposes. All feed on protein-rich aquatic insects, invertebrates, and/or aquatic vegetation during the breeding season and different groups (e.g., dabblers, divers, and sea ducks) have evolved different feeding strategies and associated habitat preferences (e.g., feeding depth in the water column, pond size, degree of open water) to partition these food resources (Ehrlich et al. 1988). A similar partitioning of nesting habitat is evident among waterfowl and other waterbirds, with some species anchoring their floating nests to vegetation, and others nesting on the ground, along banks, in shrubs, trees, and tree cavities surrounding wetlands. Shorebirds comprise another large group of wetland-dependent birds in the Columbia Basin. These species rely to varying extents on aquatic insects and invertebrates for food, and wetlands represent critical feeding areas, both for breeders and migratory species. Grebe, bittern, heron, crane, merganser, rail, coot, gull, tern, and selected raptor, owl and passerine species comprise the remaining wetland-associated bird species in the Columbia Basin. These species have a broad range of feeding and breeding requirements and few generalizations can be made regarding their use of wetlands, other than their preference for protein-rich foods such as fish, aquatic invertebrates, and plants that are more concentrated or found exclusively in wetlands.

At least 41 mammal species are associated with wetlands and all use wetlands for both breeding and feeding purposes. Seven mammal species or subspecies are currently listed by the CDC and 21 are “closely associated” with wetland habitats (Table 3). These include 10 species of bats that feed on hatches of emergent aquatic insects concentrated in wetlands and roost in live defective or dead trees found in abundance adjacent to wetlands (Nagorson and Brigham 1993). They also include 5 species of shrews that prefer moist environments due to their high metabolic rate and requirement for protein rich invertebrates (Nagorson 1996), and at least 12 species of rodents associated with wetlands. Several furbearers, other carnivores and ungulates with diverse requirements comprise the remaining wetland-associated mammals, including listed Caribou, Fisher, Grizzly Bear, and Wolverine (Appendix 3).

4.2.3 Wetland Habitat Elements

Appendix 4 provides a detailed breakdown of the wetland (and other riparian) habitat element requirements of the 97 species closely associated with wetlands. Of these species, 79 and 72 species also show associations with various *river/stream* and *lake/pond/reservoir* habitat elements, respectively. Main trends evident from Appendix 4 include the following:

- 36 species are dependent on the *context* of a wetland (i.e., the setting of the wetland, marsh, wet meadow, bog or swamp is key to the queried species), and in particular,
- 72 species are associated with *marshes* (i.e., frequently or continually inundated wetlands characterized by emergent herbaceous vegetation adapted to saturated soil conditions);
- 59 species are associated with *riverine* wetlands (e.g., 38 species use oxbows in particular);
- 24 species are associated with *forested* wetlands (i.e., swamps);
- 24 species are associated with *non-forested* wetlands (i.e., fens, bog);
- 20 species are associated with *wet meadows* (i.e., grasslands with waterlogged soils near the surface but without standing water for most of the year);
- 43 species depend on ephemeral pools containing water for only part of the year;
- 55 species are associated with various water characteristics, of which *water depth* and to a lesser extent *water velocity* appear to be the most important;
- 60 species are dependent on a particular *zone* of the water column (53 species are associated with the open water zone, 44 with the shoreline zone, and 10 with the submerged/benthic zone);
- 18 species are associated with selected in-water substrates, including sand/mud (18 species), cobble/gravel (4 species), and rock (3 species);
- 45 species are associated with herbaceous plants, including emergent vegetation (36 species), submergent vegetation (26 species), and floating mats (16 species);
- 20 and 35 species are associated with islands and seasonally flooded habitats, respectively; and
- 16 species are differentially associated with wetlands based on the *size* of the water body; only 6 species are specifically associated with small (<2 ha) water bodies (Beaver, Hooded Merganser, Northern Long-eared Myotis, Red-winged and Yellow-headed Blackbird, and Water Shrew).

Based on the results of our databases queries (Appendix 4), the species that require the most habitat elements are Northern River Otter (44 elements), followed by Yellow-headed (37) and Red-winged (36) Blackbirds, Canvasback (35), Spotted Sandpiper (34), Redhead (32), Long-toed Salamander (31), and Greater (31) and Lesser Yellowlegs (31).

4.2.4 Key Ecological Functions (KEFs) of Wetland Species

Appendix 5 lists KEFs performed by the 97 species closely associated with wetland habitats. Key ecological functions performed by a relatively small number of species and relevant to wetland ecology include:

- impoundment of water by creating diversions or dams (Beaver);
- creation of aquatic structures (American Coot, Beaver, Eared Grebe, Horned Grebe, Muskrat, Pied-billed Grebe, Red-necked Grebe); and
- freshwater zooplankton eaters (Long-toed Salamander, Wood Frog).

Other findings most relevant to wetland habitats in the Columbia Basin include the following:

- 89 species are secondary consumers (i.e., primary predator or primary carnivore);
- 86 species are invertebrate eaters (66 terrestrial invertebrate eaters and 54 aquatic macro-invertebrate eaters);
- 70 species are prey for 2° or 3° consumers;
- 51 are herbivores (25 are aquatic herbivores); and
- 36 are vertebrate eaters (26 are piscivorous).

4.2.5 Listed Species

Thirteen listed species (8 blue-listed and 5 red-listed) are closely associated with wetland habitats in the Columbia Basin and information pertaining to their status, occurrence, home range movements, life history, seasonal cycles, and habitat requirements is summarized in Table 4. Many of these species have very localized distributions and are confined to southern and/or drier portions of the basin. For example, confirmed breeding populations of the Northern Leopard Frog and Forster's Tern are known only from the Creston Valley. The Western Grebe breeds in the Creston Valley and Salmon Arm areas whereas the Yellow-breasted Chat breeds only in the Creston Valley, the southernmost portion of the Pend d'Oreille Valley (Machmer, unpublished data), and in the southwest corner of the basin. Short-eared Owls have been observed breeding locally in the basin (Campbell et al. 1990), but overwinter only in the southwest portion.

Based on Appendix 4, 9 of the 13 listed species in Table 4 are associated with marshes, 6 are associated with riverine wetlands, and 3 are associated with wet meadows. The Western Screech-Owl and Northern Long-eared Myotis are the only species associated with forested wetlands, whereas the Short-eared Owl is associated specifically with non-forested wetlands. According to the Columbia Basin Database, the Sandhill Crane is the only listed species in Table 4 sensitive to wetland size (i.e., it defends a large area of wetland habitat around its nest site). In addition to their requirement for specific wetland types and/or sizes, listed species in Table 4 need other habitat elements to be present within a wetland context (e.g., loose friable soil; emergent or floating vegetation; tall grass; dead or dying trees with natural cavities woodpecker holes, loose bark, or crevices; and specific insect, fish or mammal prey species). Availability of these elements will be strongly influenced by wetland and surrounding land use practices.

Table 4. Summary of the status (CDC/COSEWIC), occurrence (by BEC), home range, life history, seasonal cycles, and habitat requirements of 13 listed species closely associated with wetland habitats in the Columbia Basin.

Common Name and Conservation Status (CDC/COSEWIC)	Occurrence (BEC)	Home Range/Movements	Life History/Seasonal Cycle	Wetland Habitat Association	Habitat Elements Used for Breeding	Habitat ElementsUsed for Foraging, Cover, etc.	Diet (A = adult; L = larval)
Northern Leopard Frog (red-listed/ endangered)	year-round resident confirmed only in the Creston Valley (ICH)	marked fidelity to summer home range within and between seasons; uses small (<30 m^2) summer ranges, but occasionally ventures on land during rainy nights; may establish residence as far as 5 km from natal pond (usually less)	eggs hatch in June to August; transform and disperse from breeding ponds at 2-4 months old; may form aggregations on bottom of a water body in winter	marshes, wet meadows, ponds, lake edges and riparian areas	requires dense emergent vegetation that adults attach their egg masses to under the water surface	requires dense emergent vegetation for cover; preyed on by introduced predatory fish	A: insects, invertebrates (beetles, flies, ants, Odonata, grasshoppers, spiders); occasionally small vertebrates L: tadpoles are filter feeders of algae
Painted Turtle (blue-listed/ not evaluated)	irregularly distributed year-round resident in the basin but can be locally abundant in southern interior valleys (ICH, IDF, PP)	home range size variability between males and females is suspected (range from 1 to 50 ha)	adults emerge beginning in late March; local seasonal movements (generally <1 km) occur between hibernacula and oviposition sites; egg-laying in June/July and hatching in late August/September; most hatchlings stay in the nest until May/June of following year; overwinter beginning in October	near shallow permanent water bodies	deposits clutches of eggs (6-18) in nests excavated in friable soil up to hundreds of meters from water (Blood and MacArtney 1998)	basks on boulders and fallen logs in sunny locations; overwinters on top of mud in shallow water near the shore	diet is highly variable, ranging from animal to plant-dominated
Western Grebe (red-listed/ not evaluated)	breeds locally in the Creston Valley and in the Salmon Arm area (ICH, IDF)	breeding home range sizes vary with lake size; highly adapted for swimming and rarely flies except during migration, but may forage several km from nest if water connections exist	migrates to the interior from late March to early May; fall migration in late August to early November; some southern populations are non-migratory; nest-building in May, incubation is 24 days, and age at first flight is 70 days (Blood and Backhouse 1999)	undisturbed lakes with stable water levels, aquatic vegetation for nest-building, abundant small fish, and deep water for feeding	nests in colonies on flooded emergent vegetation; requires stable water levels for nesting	requires emergent vegetation on which to anchor nests but also to protect colonies from wind and waves	mostly fish (80-100%) with aquatic insects, crustaceans and worms comprising the remainder
American Bittern (blue-listed/ not evaluated)	relatively rare localized breeder in marshes of the Creston and east Kootenay Valleys (ICH, IDF, MS, SBS)	densities ranging from 2.6 to 40 birds/100 ha of marsh have been reported	migrates to the interior; 28-29 day incubation period; young leave nest at about 1 to 2 weeks old, but remain near nest and fed until 2 - 4 weeks old; age at fledging unknown; may be at 7 - 8 weeks of age;	freshwater marshes, lakeshores, and wet meadows high quality wetland habitat	requires tall, dense emergent vegetation (cattails and bulrushes) or tall herbaceous cover for nesting	tall, dense emergent vegetation	mainly insects (dragonflies, water bugs, water beetles, and grasshoppers), amphibians, small fish, small mammals (voles, shrews, and pocket gophers), garter snakes, spiders, and crayfish
Great Blue Heron (blue-listed/ not evaluated)	breeds locally and overwinters in southern portions of basin (ICH, IDF, SBS, MS, PP)	mean distance flown from colony to principle foraging sites is 6.5 km in BC; defendss foraging territories of 0.6 ha (freshwater marsh); re-use roost and breeding sites; disperses post- breeding and some animals migrate out of areas without open water	peak breeding is mid March through June; smaller numbers breed from early July to mid August; incubation is 28 days and birds fledge at 70-80 days of age	marshes, swamps, lakes, rivers	colonial nester; builds stick nests in tall dominant hardwood and conifer trees in forests bordering lakes, ponds, riparian woodlands, islands	roosts in large conifers and hardwoods near water and suitable foraging sites; requires calm shallow water for foraging; grassy fields with rodents may be important in some areas	mostly fish, but also amphibians (frogs, tadpoles, and toads), invertebrates, reptiles (turtles, lizards, snakes), small mammals and birds; occasionally carrion; forages alone or in loose flocks
Sandhill Crane (blue-listed/ not at risk)	potential breeder at scattered locations in the basin (ICH, IDF, MS, PP, SBS)	defends a 20-80 ha area the nest; during migration and wintering, may fly significant distances from roosts to feed in grain fields	courtship and nest construction occur in April, and eggs are laid from mid-April through June, with 28 - 32 day incubation; young fledge at 65-70 days and remain with parents for 9 - 10 months; migratory	isolated marshes, swamps, bogs and meadows	nests are a low mound of grasses, sedges, rushes, moss and branches situated on the ground or in shallow water surrounded by shrubs or emergent vegetation	stopover sites during migration include edges of wetlands, swampy fields, dry rangelands, and grain fields	omnivorous species with a broad diet (roots, berries, grasses, lichens, insects, snails, small vertebrates, seeds and grains), depending on site and season

Common Name and Conservation Status (CDC/COSEWIC)	Occurrence (BEC)	Home Range/Movements	Life History/Seasonal Cycle	Wetland Habitat Association	Habitat Elements Used for Breeding	Habitat ElementsUsed for Foraging, Cover, etc.	Diet (A = adult; L = larval)
Forster's Tern (red-listed/ data deficient)	breeds locally only in the Creston Valley (ICH)	migratory species	returns to the interior in mid-May; eggs are laid in late May to June	interior lakes and marshes	nests on floating vegetation or old grebe and muskrat platforms		mainly fish but feeds also on insects, crustaceans, and frogs
Western Screech-Owl (*ssp. macfarlanei*) (red-listed/ species of concern)	resident species and rare breeder in the basin (IDF, ICH)	reported breeding territory and home range sizes are 3 - 9 ha (75% contour interval) 29 - 58 ha (95%; n = 2, Idaho), respectively	may have an altitudinal migration; fledges at 4 - 5 weeks of age; disperses from natal area on average 58 days post-fledging	open deciduous woodlands along lakeshores, streams and rivers	nests in natural cavities and woodpecker holes (Flicker and Pileated) in live and dead deciduous and coniferous trees (rarely nest boxes) near water	roosts in natural cavities and woodpecker holes near water	mammals (voles, deer mice, shrews, harvest mice, kangaroo rats, pocket gophers, and bats), birds, herptiles and insects
Short-eared Owl (blue-listed/ species of concern)	breeds locally; migratory species but overwinters in southwest areas of the basin (ICH, IDF, MS, PP, SBS)	breeds locally in the basin; breeding territory sizes vary depending on prey density but are >20 ha	breeds from late March through June, and occasionally into early September in BC; fledges at 31 - 36 days and independent at approximately 50 days, fall migration occurs from August to early November; forms communal roosts (on the ground) of up to 200 birds in non-breeding season	marshes, swamps, sloughs, lakeshores, grasslands and rangelands	nests built on ground in dry marshes or tall grass meadows and lined with grasses	forage over open fields; overwinter in old fields, pastures or marshes	mostly small mammals (Microtus, Peromyscus, Sorex, Thomomys, Lagurus, Perognathus, Reithrodomys, Dipodomys); occasionally birds, insects, reptiles, and bats
Yellow-breasted Chat (red-listed/ endangered)	rare migratory species that breeds locally in southwest portion of the basin, Creston and Waneta areas (PP, ICH)	average territory patch size estimated at 4.9 ha in the southern Okanagan Valley; ; breeding territory sizes of 1.2 ha reported in 1 study (Indiana)	nesting occurs mid-May to June and young fledge by mid-July; incubation lasts 11 - 15 days; young leave the nest at 8 - 11 days, but the age of independence is unknown; birds gone mid-August	dense low elevation riparian thickets/shrubs in dry, open habitats or along streams and oxbows	nests in damp thickets (shrubs such as rose or willow and/or small trees) that occur along hedgerows, streams, wetlands, lakeshores or gullies	favors dense, tangled shrub growth for both cover and foraging	mostly insects (grasshoppers, beetles, true bugs, ants, bees, wasps, moths, mayflies, caterpillars, spiders); also fruit and berries
Northern Long-eared Bat (blue-listed/ not evaluated)	breeds locally in the ICH wet belt (ICH, SBS)	unknown whether this species hibernates in BC	mating occurs in autumn, females store sperm over winter and ovulate at the time of emergence in spring; 50-60 day gestation; single young born in June/July	wet forests in the ICH	maternity colonies and roosts located in spaces under loose bark or tree cavities of large mature wildlife trees	forages for insects 1-3 m over small ponds and forest openings under tree canopies	caddisflies, moths, beetles, flies, leaf hoppers
Townsend's Big-eared Bat (blue-listed/ not evaluated)	breeds and overwinters locally in the basin (ICH, IDF, PP)	returns year after year to the same maternity colony; sites may be abandoned if disturbed;; will switch among a few nearby sites during winter	mating occurs during fall /winter; young born June – July and weaned at 6 - 8 weeks; relatively short movements between hibernacula and summer roosts	variety of habitats from coniferous forests to grasslands	roost sites include caves, mines, and old buildings; maternity colonies of 12 - 100 are formed; clusters of 2 - several dozen bats may form during hibernation	insects captured in flight or gleaned off plants and other surfaces in insect-rich riparian areas, wetlands, forest edges and open woodlands	mainly moths (also lacewings, beetles, flies, sawflies).
Grizzly Bear (blue-listed/ not evaluated)	resident species (AT, ESSF, ICH, IDF, MS, PP, SBS)	home range size depends on food supply, age, sex, social status, condition, season, and topography	mating occurs in May and June; parturition occurs in January and February; young are weaned in 1.5 - 2.5 years during which time they are defended; males may travel great distances; timing and duration of denning depends on latitude, food supply, and snow depth	coniferous and boreal forests, alpine meadows, usually at higher elevations	dens are excavated on slopes >30%, deep soils, good drainage, and aspects where snow accumulates	require travel corridors around disturbed areas, hiding cover such as tree or shrub canopy, riparian inclusions and rugged terrain (e.g., avalanche chutes)	omnivore (50 - 60% of the diet consists of animal matter); some populations are known to congregate at concentrated sources of food (salmon streams, dumps)

Literature sources: Goossen et al. (1982); Campbell et al. (1990); Butler (1992); Gibbs et al. (1992); Tacha et al. (1992); Holt and Leasure (1993); Cooper (1996); Cannings et al. (1999); Cannings (2000); Cannings and Angell (2001); Johnson and O'Neil (2001); Ohanjanian (1998); Steeger et al. (2001); Waye and Cooper (2001); Bezener and Bishop (2002); Cooper and Beachesne (2003); Machmer and Steeger (2003); Johnston and Rockwell, in prep. (cited in Bezener and Bishop 2002).

4.3 Wetland Inventory Using GIS

Using ARCINFO and the CBFWCP area TRIM data set, all polygons labeled as waterbodies (i.e., glacier, icefield, river/stream, canal, reservoir, tailings pond, marsh, swamp, flooded land, and lake) and measuring ≥1 ha were summed to generate summary statistics for BC portion of the Columbia Basin. A summary of this analysis is presented in Table 5. Water comprises close to half a million ha (474,468) in the basin; 43% of this area consists of glaciers/icefields, another 43% is composed of lakes, and reservoirs, and canals account for only 0.06 and 0.01%, respectively. Wetland habitats in the form of marshes (5.5% or 25,897 ha), swamps (1.7% or 8,100 ha), and flooded lands (0.15% or 699 ha) make up the remainder. Waterbodies measuring <10 ha in size account for 7.8% of all waterbodies in the basin. Small lakes make up the bulk (60.1% and 11,612 lakes total) of this overall area, with marshes (23.5% and 5,122 total) and swamps (9.1% and 1,453 total) comprising the remaining area.

Table 6 provides a breakdown of wetland habitats (by wetland type and size class) for those wetlands measuring <10 ha in size. Marshes (71%) and swamps (28%) make up the bulk of small wetlands in the Columbia Basin and this pattern is consistent within all size categories. The 2-5 ha size class contributes the largest overall area to the total, followed by the 5-10 ha class, and progressively smaller size classes.

Table 5. Waterbody area (ha and %), number, and size (mean, SD) for all waterbodies, and those <10 ha in size.

Waterbody Type	All Waterbodies					Waterbodies <10 ha	
	Total (ha)	Total (%)	Waterbody #	Waterbody size (ha)		Total (ha)	Total (%)
				Mean	SD		
Glacier	105741	22	707	150	363	313	1
Icefield	100675	21	977	103	270	563	2
River/stream	30351	6	1065	28	235	1650	4
Reservoir	298	0	107	3	6	83	0
Canal	53	0	2	26	32	4	0
Tailings pond	16	0	14	1	1	16	0
Lake	202639	43	11653	17	741	22445	60
Marsh	25897	5	5555	5	22	8744	23
Swamp	8100	2	1640	5	12	3385	9
Flooded land	699	0	29	24	49	74	0
Total	474,468	100	21,749	-	-	37,276	100

Table 6. Wetland area (by type and size class) for wetlands <10 ha in the Columbia Basin.

Wetland Type	Wetland Size Class					Total (ha)	Total (%)
	0.1 - 0.5	0.5 - 1.0	1.0 - 2.0	2.0 - 5.0	5.0 -10		
Marsh	428	936	1632	3047	2701	8744	71
Swamp	58	233	540	1312	1241	3385	28
Flooded Land	0	2	9	9	55	74	1
Lake	0	1	8	12	25	46	0
Total	486	1,171	2,188	4,381	4022	12,249	100

Table 7. Wetland area (ha by type and size class) in biogeoclimatic zones occurring in the Columbia Basin.

BEC Zone	Total BEC Area	Wetland Type				Wetland Size Class					Wetland Area
		Marsh	Swamp	Flooded	Lake	0.1 - 0.5	0.5 - 1.0	1.0 - 2.0	2.0 - 5.0	5.0 -10	
AT	1,163,116	189	14	0	0	14	44	50	70	25	202
ESSF	4,261,314	2140	588	4	9	160	352	576	964	689	2742
ICH	2,249,950	2258	1304	16	2	102	274	575	1225	1402	3579
IDF	322,810	1988	462	28	0	96	233	402	885	861	2478
MS	523,478	1409	658	0	18	84	195	393	768	645	2085
PP	94,757	255	94	26	17	17	26	70	122	158	392
SBS	109,396	506	265	0	0	13	46	122	346	243	771
Total	8,724,821	8,744	3,385	74	46	486	1,171	2,188	4,381	4,022	12,249

Table 8. Wetland area (by type and size class) in different land status zones of the Columbia Basin.

Land Status	Wetland Type				Wetland Size Class					Total (ha)
	Marsh	Swamp	Flooded	Lake	0.1 - 0.5	0.5 - 1.0	1.0 - 2.0	2.0 - 5.0	5.0 - 10	
P. park	27	8	0	28	1	1	7	27	27	63
N. park	7	9	0	18	0	1	7	7	18	33
Crown	6842	2567	12	0	412	980	1763	3388	2876	9420
Private	1869	801	62	0	73	189	411	958	1101	2732
Total	8,744	3,385	74	46	486	1,171	2,188	4,381	4,022	12,249

Table 7 shows the distribution of wetland habitats measuring <10 ha in size in BEC zones of the basin (by wetland type and size class). The ICH zone supports the largest area of small wetland habitat (29.2% of the total), followed by the ESSF (22.4%), IDF (20.2%), MS (17.0%), SBS (6.3%), PP (3.2%) and AT (1.6%). However when small wetland area is scaled relative to total BEC zone area, the zones with the highest wetland abundance are the IDF (0.77%), SBS (0.70%), PP (0.41%), MS (0.40%), ICH (0.16%), ESSF (0.06%), and AT (0.02%).

Comparing among size classes within BEC zones, the 2-5 ha size class contributes most to wetland area in most BEC units (with the exception of the ICH and PP zones, where the 5-10 ha size class dominates). Only 0.5% and 0.3% of small wetland habitat is located within provincial and national parks, respectively (wetlands located in provincial Wildlife Management Areas and on non-government organization lands are excluded from Table 8). The bulk of small wetlands (predominantly marshes and swamps) are found on crown (76.9%) lands, with the remainder located on private (22.3%) lands (Table 8).

A breakdown of small (<10 ha) wetland area and frequency by landscape unit is provided in Appendix 6. Total small wetland area in the landscape units evaluated ranged from 0–536.4 ha (mean ± SE = 58.5 ± 5.78 ha), and number of small wetlands per landscape unit ranged from 0–15 (mean ± SE = 6.4 ± 0.19 ha).

Figure 2 (CD in back flap) provides an overview map (1:800,000 scale) of small wetland abundance in landscape units of the CBFWCP area. Percent small wetland abundance per landscape unit was calculated as the area of small wetlands relative to the total area of each landscape unit. Small wetland abundance averaged 0.16 ± 0.02%, with a range of 0–1.5%. The only landscape units with a percent wetland abundance >0.5% are located in the East Kootenay. They include areas (a) bordering the Columbia Wetlands Wildlife Management Area between Fairmont and Golden, (b) near the headwaters of the Kootenay River near Kootenay National Park, (c) between Kimberley and Wasa on the Bummer's Flat Wildlife Management Area and the Cherry-Ta Ta Creek range unit, and (d) from Wardner south to the US border adjacent to Lake Koocanoosa (e.g., Jaffray, Galloway, Pickering Hills, Plumbob and Gold Mountain areas).

Landscape units with very low (i.e., <0.01 % by area) small wetland abundance include (a) RB7, 8 & 9 located west of McBride, (b) R8 north of Revelstoke, (c) N515 east of Slocan City, (d) G15 west of Columbia Reach in the Esplanade Range, (e) G17 & 18 between Banff National Park and Bush Arm in the Valenciennes River drainage, (f) I33 east of the Kootenay River in the Hughes Range, (g) I09 and I06 east of the White and Lussier Rivers in the Quinn Range, (h) C29 east of the Kootenay River, and (j) C25 between Wardner and Fernie (Figure 2).

A GIS-based summary of small wetland (swamp and marsh) and freshwater (lake) area (stratified by type, BEC zone, and size class) for the 10 air photo pairs is provided in Table 9. These results are compared with those from the air photo interpretation evaluation in Table 10 of the next section.

4.4 Wetland Inventory Using Air Photo Interpretation

Table 10 provides a summary overview of the air photo interpretation (API) inventory. The table identifies survey areas by 1:20,000 mapsheet, air photo number and biogeoclimatic zone. The number of wetlands surveyed, as well as areas of wetland and related terrestrial ecosystem components are summarized for each of the ten sample areas and five biogeoclimatic zones. Wetland area is divided into peatlands (bogs and fens), mineral wetlands (swamp, marsh, shallow open water and undifferentiated), while related terrestrial ecosystem area is divided according to transition and flood groups. Freshwater (lake) ecosystem area is quantified as well. Results from the GIS analysis are shown in parentheses on the second line of each row of Table 10 for comparison. In Appendix 7 (a and b), wetland and related

Table 9. GIS-based summary of wetland and related ecosystem area (ha) stratified by sample area, biogeoclimatic zone, wetland type and size class.

Wetland/ Ecosystem Type	**Size Class[1]**	**Vowell Creek**	**Bach-elor Creek**	**ESSF subtotal**	**Marl Creek**	**West Bench**	**ICH subtotal**	**Spillima-cheen**	**Kootenay River**	**MS subtotal**	**Buck Lake**	**Galloway**	**IDF subtotal**	**Wycliffe**	**Jaffary**	**PP subtotal**	**Total**
Peatland/Mineral																	
SWAMP	1	0	0	0	0	0	0	0.05	0	0.05	0.46	0	0.46	0	0.50	0.50	1.01
	2	0	0	0	0	2.26	2.26	0	0	0	1.28	0	1.28	0	0	0	3.54
	3	0	0	0	0	3.03	3.03	0	0	0	2.68	0	2.68	1.55	0	1.55	7.26
	4	0	0	0	0	11.73	11.73	0	3.15	3.15	0	0	0	0	0	0	14.88
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	6	0	0	0	0	22.31	22.31	0	0	0	0	0	0	0	0	0	22.31
	subtotal	0	0	0	0	39.33	39.33	0.05	3.15	3.20	4.42	0	4.42	1.55	0.50	2.05	49.00
MARSH	1	0.28	0	0.28	0.37	0	0.37	2.09	0	2.09	1.37	1.31	1.68	0	0.85	0.85	5.27
	2	0.65	0	0.65	1.30	0	1.30	5.53	0	5.53	0.78	2.19	2.97	0	2.91	2.91	13.36
(DEEP +	3	0	3.47	3.47	7.14	0	7.14	5.28	0	5.28	0	2.51	2.51	0	3.03	3.03	21.43
SHALLOW	4	2.47	0	2.47	9.77	2.41	12.18	8.85	0	8.85	3.33	9.27	12.6	2.64	0	2.64	38.74
MARSH)	5	0	16.81	16.81	5.02	0	5.02	13.93	7.15	21.08	0	5.79	5.79	0	11.63	11.63	60.33
	6	69.77	0	69.77	13.91	0	13.91	28.00	0	28.00	0	0	0	0	19.24	19.24	130.92
	subtotal	73.17	20.28	93.45	37.51	2.41	39.92	63.68	7.15	70.83	5.48	21.07	26.55	2.64	37.66	40.30	271.05
WETLAND TOTALS		73.17	20.28	93.45	37.51	41.74	79.25	63.73	10.30	74.03	9.90	21.07	30.97	4.19	38.16	42.35	320.05
Freshwater Ecosystems																	
LAKE	1	1.20	0.21	1.41	0.30	0	0.30	1.44	0	1.44	0.00	0	0.00	0.90	0	0.90	4.05
	2	3.14	0	3.14	0.50	0	0.50	0	0	0	1.71	0	1.71	1.11	0	1.11	6.46
	3	0	0	0	4.30	0	4.30	3.60	0	3.60	1.42	4.13	5.55	0	0	0	13.45
(DEEP	4	2.76	0	2.76	0	0	0	12.98	3.79	16.77	3.03	3.28	6.31	0	2.06	2.06	27.90
WATER)	5	0	0	0	0	0	0	26.72	9.76	39.48	0	14.66	14.66	17.08	0	17.08	71.22
	6	0	0	0	11.07	0	11.07	82.65	0	82.6	0	15.39	15.39	0	0	0	109.06
	subtotal	7.1	0.21	7.31	16.17	0	16.17	127.39	13.55	143.89	6.16	37.46	43.62	19.09	2.06	21.15	232.14
Total Area Surveyed		80.27	20.49	100.76	57.91	41.74	95.42	191.12	23.85	217.92	16.06	58.53	74.59	23.28	40.22	63.50	552.19

[1]Size Class: 1 (0.1 – 0.5 ha); 2 (0.5 – 1.0 ha); 3 (1 – 2 ha); 4 (2 – 5 ha); 5 (5 – 10 ha); 6 (>10 ha).

Table 10. Summary of the CBFWCP area wetland and related ecosystem inventory stratified by survey area and BEC zone. Wetland areas determined from air photo interpretation and GIS analysis (in parentheses) are shown by site class for comparison.

Survey Area	Map Sheet	Photo No	Photo Scale	BEC Zone	No. Wetland Systems Surveyed [1]	Fresh/ Deep Water Area Classified (ha)	Wetland Area Classified (ha)									Related Terrestrial Ecosystem Area Classified (ha)					Undiff. Wetland/ Terrestrial[7] (ha)	Total (ha)
							Bog	Fen	Peatlands Subtotal[2]	Swamp	Marsh	Shallow Open Water	Mineral Wetlands Subtotal[3]	Peatland/ Mineral Undiff.[4]	Wetland Subtotal	Meadow	Shrub-Carr	Transition Subtotal[5]	Flood[6]	Related Terrestrial Subtotal		
Vowell Cr	82K.086 82K.087	GR597074 #361	1:22 000	ESSF	2 + 2T = 4	0 (7.1)	0	0	0	0.8 (0)	8.4 (73.17)	8.1	17.3 (73.17)	7.1	24.4 (73.17)	64.1	6.7	70.8	3.6	74.4	0	98.8 (80.27)
Bachelor Cr	82N.041 82N.051	BCB91064 #89	1:15 580	ESSF	3	0 (0.21)	0	8.2	8.2	0 (0)	0 (20.28)	0.25	0.25 (20.28)	0	8.45 (20.28)	20.8	11	31.8	0	31.8	30	70.25 (20.49)
ESSF Subtotal					5 + 2T = 7	0 (7.31)	0	8.2	8.2	0.8 (0)	8.4 (93.45)	8.35	17.55 (93.45)	7.1	32.85 (93.45)	84.9	17.7	102.6	3.6	106.2	30	169.05 (100.76)
Marl Creek	82N.054	BCB91187 #266	1:17350	ICH	14 + 1T = 15	0.4 (16.17)	0	23.2	25.1	2.8 (0)	5.0 (37.51)	22.5	30.3 (37.51)	3.6	59 (37.51)	1.3	2.1	3.4	0	3.4	0.5	63.3 (57.91)
West Bench Golden	82N.025 82N.035	BCB96080 #267	1:17500	ICH	28 + 2T = 30	0 0	0	7.8	7.8	45.8 (39.33)	8.0 (2.41)	8.35	62.15 (41.74)	7	76.95 (41.74)	1.9	2.6	4.5	0	4.5	15.85	97.3 (41.74)
ICH Subtotal					42 + 3T = 45	0.4 (16.17)	0	31	32.9	48.6 (39.33)	13.0 (39.92)	30.85	92.45 (79.25)	10.6	135.95 (79.25)	3.2	4.7	7.9	0	7.9	16.35	160.6 (95.42)
Spillimacheen	82K.097 82K.098	BCB91148 #55	1:17 550	MS	29	57.5 (127.39)	0	49.45	49.45	4.75 (0.05)	10.85 (63.38)	59.3	78.6 (63.73)	8.2	136.25 (63.73)	0.2	1.55	1.75	0	1.75	0.7	196.2 (191.12)
Kootenay R. (Palliser)	82J.042 82J.052	BCB91152 #13	1:17 200	MS	5	4.5 (13.55)	0	28.9	28.9	0 (3.15)	8.7 (7.15)	4.6	13.3 (10.30)	0	42.2 (10.30)	5.5	0.6	6.1	0	6.1	0	52.8 (23.85)
MS Subtotal					34	62 (143.89)	0	78.35	78.35	4.75 (3.20)	19.55 (70.83)	63.9	91.9 (74.03)	8.2	178.45 (74.03)	5.7	2.15	7.85	0	7.85	0.7	249 (217.92)
Buck Lake	82G.014 82G.024	BCC00084 #149	1:19 500	IDF	12	1.8 (6.16)	0	2.55	2.55	2.1 (4.42)	2.7 (5.48)	4.15	8.95 (9.90)	0	11.5 (9.90)	3.5	0	3.5	0	3.5	0	16.8 (16.06)
Galloway	82G.034 82G.044	BCC00081 #132	1:19 200	IDF	14 + 5T = 19	11.1 (37.46)	0	5.3	5.3	0 (0)	22.9 (21.07)	21.4	48.15 (21.07)	0	53.45 (21.07)	7.3	0.4	7.7	0	7.7	1.6	73.85 (58.53)
IDF Subtotal					26 + 5T = 31	12.9 (43.62)	0	7.85	7.85	2.1 (4.42)	25.6 (26.55)	25.55	57.1 (30.97)	0	64.95 (30.97)	10.8	0.4	11.2	0	11.2	1.6	90.65 (74.59)
Wycliffe	82G.034	BCC00060 #59	1:19 400	PP	7 + 1T = 8	9.9 (19.09)	0	0	0	0 (1.55)	2.2 (2.64)	8.1	11.1 (4.19)	0	11.1 (4.19)	8.8	0	8.8	0	8.8	0.3	30.1 (23.28)
Jaffary	82G.034	BCC00083 #100	1:19 350	PP	15 + 4T = 19	0 (2.06)	0	0	0	6.8 (0.50)	16.9 (37.66)	8.9	33.7 (38.16)	0.8	34.5 (38.16)	10.95	1.3	12.25	3.1	15.35	1.8	51.65 (40.22)
PP Subtotal					22+ 5T = 27	9.9 (21.15)	0	0	0	6.8 (2.05)	19.1 (40.30)	17.0	44.8 (42.35)	0.8	45.6 (42.35)	19.75	1.3	21.05	3.1	24.15	2.1	81.75 (63.50)
Totals					129 + 15T = 144	85.2 (232.14)	0	125.4	127.3	63.05 (49.00)	85.65 (271.05)	145.65	303.8 (320.05)	26.7	457.8 (320.05)	124.35	26.25	150.6	6.7	157.3	50.75	751.05 (552.19)

[1] Includes wetlands as well as terrestrial transition & flood ecosystems that are symbolized with a “T”.
[3] Mineral wetland components include swamp, marsh & shallow water.
[4] Includes Shallow Marsh-Fen.
[5] Terrestrial transition Components include meadow & shrub-carr.
[6] Terrestrial flood components include low, mid & high bench ecosystems.
[7] Wetland/terrestrial undifferentiated types include fen-(shrub-carr), shallow marsh-meadow, swamp-shrub-carr, swamp-flood bench, and swamp-wet upland forest.

ecosystem areas are further subdivided into six wetland size classes and six vegetation cover types, respectively.

Using API, the number of wetlands/wetland complexes surveyed per photo pair ranged from 3 to 30, and combining all 10 photo pairs, 129 wetlands/wetland complexes and 15 terrestrial transition & flood ecosystems (144 total) could be differentiated (Table 10). GIS analysis of TRIM data detected a total of 100 wetlands/wetland complexes (Table 10). Most of the wetland complexes missed in the GIS analysis were from the West Bench, Spillimacheen and Jaffary photos in particular (compare Appendix 7 with Table 9). In only two cases (Buck Lake and Jaffary) did GIS analysis of the TRIM data identify a wetland that was missed during API. Not only were significantly fewer numbers of wetlands/wetland complexes identified using the GIS method, but the actual areas captured within a wetland complex and their classification differed substantially based on these two methods. For example, a total of 552 ha and 751 ha were surveyed as part of the GIS and API analyses, respectively. The latter method captured terrestrial transition ecosystems (e.g., shrub-carrs and meadows) that were not considered in the GIS analysis and hence are not reflected in the lower area-based totals.

Mineral wetlands accounted for 303.8 ha (63.0 ha of swamp, 85.6 ha of marsh and 145.7 ha of shallow open water) based on API, and 320 ha (47 ha of swamp and 271 ha of marsh) based on GIS analysis of the TRIM data. There was no systematic bias in how a particular method over- or underestimated the total area of mineral wetlands relative to another (i.e., in 5 of 10 photo pairs, the mineral wetland area classified via GIS exceeded that identified via API and vice versa). However, the total area of wetland habitat determined via API exceeded that identified based on GIS analysis of the TRIM data in 7 of 10 cases (Table 10). Looking at the area-based breakdown of wetland types, it is clear that the GIS analysis method overestimated (sometimes by an order of magnitude) the area typed as "marsh" (7 of the 10 photo pairs in Table 10). The GIS output also tended to underestimate the area classified as "swamp" relative to API (5 of the 10 photo pairs in Table 10).

Peatlands (i.e., primarily fens and only one 1.9 ha bog) made up 127.3 ha and represented a substantial portion of total wetland area in the MS and ICH zones (Table 10). In the GIS analysis, these peatlands were either missed or they were classified as marshes and to a lesser extent swamps. Terrestrial transition components (wet meadows and shrub-carrs) comprised 150.6 ha of the area surveyed using API . These were not represented in the TRIM classification and were generally not detected in the GIS analysis. Terrestrial flood ecosystems accounted for only 6.7 ha of the area surveyed via API, and the GIS analysis did not identify "flooded lands" in any of the 10 photo pairs. Table 10 indicates that approximately 51 ha (or 6.8% of the total area surveyed) could not be differentiated between wetland and related terrestrial ecosystems using API methods. Another 26.7 ha (3.6% of the area surveyed) could only be classified to the level of wetlands (i.e., the peatland versus mineral components could not be distinguished).

Pooling all photos, freshwater ecosystems (identified as "definite lakes" in the TRIM) comprised a total of 232.1 ha based on GIS analysis, but only 85.2 ha using API. Furthermore the GIS-based estimate exceeded that generated from API for all photo pairs (Table 10). This is because the shallow open water wetland site class (comprising 145.65 ha) captured much of the area identified as definite lake on the TRIM. These two categories together (85.2 ha of freshwater ecosystem and 145.65 ha of shallow open water totaling 230.85 ha) are roughly equivalent to the 232.1 ha of definite lake identified using GIS. These results indicate that the TRIM data set is likely to underestimate the availability of shallow open water within a wetland context.

Appendix 7a provides area-based summaries for wetland and related ecosystem classes stratified by the six size classes. For each air photo pair, this area-based distribution generated through API was briefly compared to the wetland size distribution produced from the GIS analysis in Table 9. The following generalizations can be made based on these comparisons:

- API was able to detect many more wetlands/wetland complexes than GIS analysis of the TRIM data. Wetland size *per se* did not appear to be a consistent limiting factor because GIS analysis was able to identify very small wetlands (i.e., <0.5 ha) in many cases. Nevertheless, smaller wetlands were more likely to be missed overall.

- There was a tendency for GIS analysis to underestimate total wetland area relative to API methods, but this trend was not consistent (i.e., the opposite tendency was observed in both ESSF photos and the IDF Jaffary photo). In some cases the wetland area estimates generated from the two methods were quite comparable and in other cases, they were out by almost an order of magnitude.

- The GIS analysis consistently overestimated the marsh component and tended to underestimate the swamp component of wetlands on a particular photo. Furthermore because peatlands were not represented in the TRIM classification system, fens were likely to be missed or were often classified as other wetland classes (usually marshes).

- The shallow open water, shallow marsh and deep marsh site classes captured many of the areas classified as "definite lakes" on the TRIM data set. GIS analysis therefore tended to underestimate the availability of shallow open water within a wetland context.

- Overall, API was able to provide a much more detailed and fine-grained level of classification than GIS analysis of TRIM data. For example, several areas classified purely as “marsh” or “marsh and definite lake” in the GIS analysis were partitioned into many site classes including fen, bog, swamp, deep/shallow marsh, shallow open water, as well as terrestrial transition and flood groups. This is not surprising given the greater number of wetland and terrestrial transition ecosystem descriptors to choose from to describe and partition a particular wetland complex.

Appendix 7b provides area-based summaries for wetland and related ecosystem types stratified by vegetation cover types. These cover types cannot be directly compared with the GIS analysis of the TRIM data, but they will be very useful for later ground-truthing of air photo areas and/or linking to wildlife habitat suitability. Site classes with similar vegetation cover types could not always be differentiated using air photo interpretation and the detail observable at the scale of the air photos was a limiting factor.

Few bogs were identified during API. This is likely due to the low level of precipitation and high summer temperatures (which limit peat formation) in many of the sample areas (particularly in the PP, IDF, MS and dry ICH zones of the basin). Also, bogs and fens transitional to bogs may not be distinguishable on the air photos due to a lack of detail. In small wetland basins dominated by emergent vegetation, it was sometimes difficult to interpret the extent (depth) and period of inundation. This made it challenging to distinguish between shallow marsh and meadow wetland classes. The depth of organic soils was difficult to determine in small basins, so shallow marshes on mineral soil and fens on organic soils that are both dominated by graminoid vegetation cover could not always be differentiated. Low shrub-dominated fens and shrub-carrs could also easily be confused during interpretation. Tree shadows occasionally obscured the view of vegetation and physical features in small basins especially, making it difficult to identify graminoid-dominated ecosystems.

Hydrological regime could not always be interpreted with certainty, making it difficult to differentiate between swamps and shrub-carrs dominated by tall shrubs, or swamp and flood bench ecosystems. It was also sometimes difficult to distinguish swamps from wet upland sites, shrub-carrs from upland shrub types, and high bench ecosystems from wet upland forests located adjacent to creeks and rivers. Hydrologic connectivity between wetlands was difficult to determine and this important physical feature that influences water quality, vegetation and therefore wildlife habitat suitability could readily be misinterpreted.

Follow-up field surveys are recommended to verify wetland and related ecosystem classification with respect to site class and vegetation physiognomic types. Additional site and vegetation data could be collected to determine level of site association and site series. Collecting information on hydrologic connectivity and water quality would be useful for further classifying ecosystems in the context of physical features. Evidence of wildlife and human use as well as various forms of wetland disturbance (e.g., livestock grazing, weed invasion, soil compaction, infilling, etc.) should be identified in the field.

4.5 Legislation, Regulations and Guidelines Affecting Wetlands

There exists little legislation providing explicit protection for wetlands in BC. However, many existing instruments can *affect* wetlands, both positively and negatively - from legislation to policies and procedures at the municipal, provincial and federal levels. The tools vary from laws that prescribe allowable activities and designate land-use types (and their associated activities) to requirements for environmental and land-use planning.

Several good reviews of legislative instruments affecting wetlands are available and were incorporated into this review (Nowlan 1996; Dovetail Consulting Inc. 1998; Haddock 2002). Some legislation has recently changed in conjunction with the change of government in BC, and other legislation will change very soon. Given this state of flux, the recent changes are reviewed separately along with inferred implications for wetlands. In most cases, these implications may not be known until the new instruments have been in place for some time. The provincial legislation likely to be most influential to small wetlands in the Columbia Basin (i.e, the new *Forest and Range Regulations*) was released in January of 2004. A separate section addresses these emerging changes through a discussion of the direction that government has indicated it is going. An additional section looks at non-legislative instruments such as a proposed provincial wetland policy. This review excludes instruments of relevance pertaining only to marine wetlands (e.g., the *Oceans Act*, the *Shipping Act*, and the *Navigable Waters Act*).

4.5.1 Review of Legislation

Following Haddock (2002), legislative instruments are reviewed as four types: (a) land-use designation tools, (b) regulation of land-use activities, (c) general environmental protection regulations, and (d) other relevant laws. For each of these instrument classes, municipal, provincial, and federal levels are distinguished, where relevant.

Land-Use Designation Tools

Table 11 describes land-use designation tools in place that protect wetlands (from Haddock 2002). Provincially, the *Wildlife Act*, the *Park Act*, and the *Ecological Reserves Act* are generally effective at protecting wetlands within land applicable to these statutes. Cabinet approval is required to designate these types of lands, and these tools may not be suitable for wetlands that need active management interventions. The *Forest Practices Code* provides for *Wildlife Habitat Areas* on Crown land, but implementation is slow and highly constrained (T. Antifeau, pers. comm.). Also, WHAs apply only to "identified wildlife", so wetlands get protection only if an identified and wetland-dependent species is involved; even then, the protection depends on the strength of the general wildlife measure. A *Wildlife Habitat Features Act* designed to protect small localized features (nests, dens, mineral licks, seeps, springs, etc.) found during forest development on crown land is entering third reading (M. Fenger, pers. comm.). This legislation may have some potential to protect a small wetland, however it would likely only apply to features used by identified wildlife. Furthermore both the applicable features and the associated regulations are still under review (M. Fenger, pers. comm.).

The *Environment and Land Use Act* is good flexible legislation which applies to both private and Crown land and prevails over other legislation. However, this *Act* requires an Order In Council and hence is of very limited use in practice. BC's *Local Government Act* (including the *Local Statutes Amendment Act*) is enabling legislation that empowers local governments to protect any land (public and private) within a municipality through the designation of *Environmentally Sensitive Areas* and *Development Permit Areas*. This avenue for wetland protection depends fully on the discretion of local decision makers and hence would benefit strongly from a *Provincial Wetland Policy* to help guide municipal decision makers. The *Growth Strategies Act* is further enabling legislation that has provided additional planning tools (such as *Regional Growth Management Strategies*) for habitat protection, particularly at the urban margins (Dovetail Consulting 1998). Taken together, these *Acts* empower local governments to undertake greater environmental protection measures, but do not require them to do so.

Federal legislation provides good wetland protection, but because it applies only to wetlands within federal areas under the authority of the legislation (i.e., National Parks, National Wildlife Management Areas, and Migratory Bird Sanctuaries), the extent of protection is quite limited.

Regulation of Land-Use Activities

Table 12 summarises the regulation of specific land-use activities that could impact wetlands (from Haddock 2002). There are four provincial statutes with the potential to regulate land-use activities of relevance to wetland conservation. Through the Riparian Management Area (RMA) Guidebook

Table 11. Land use designation tools affecting wetlands (from Haddock 2002).

Mechanism / (Lead Agency)	Tools	Applies To	Implemented By	Strength[1]	Enforcement	Effectiveness	Limitations (Gaps)	How to Fill Gaps	Who is Impacted?
Provincial									
Wildlife Act (Ministry of Water, Land and Air Protection)	Wildlife Management Areas (WMA) Critical Wildlife Areas Wildlife Sanctuaries	Land under the administration of the Minister responsible for the Wildlife Act (e.g., provincial Crown land, or private land leased to Minister)	Minister, with Cabinet approval	G	G	- Provides reasonably strong protection, enforceability, and flexibility due to regional manager's authority over all activities in a WMA. - Strong degree of decision-making by agency responsible for wildlife habitat. - Good example is the Columbia River Wetlands WMA.	- Requires formal act of designation in order for wetlands to be protected. - Requires high level (Cabinet) consent for minister's designation decisions. - May be difficult for agency to acquire "administration" of land as pre-requisite for WMA designation. - Cannot regulate all activity impacting wetlands (e.g. boating restrictions).	- An overarching provincial wetlands policy; - Amending Wildlife Act to encourage, expand, or require broader application of WMA provisions for certain wetlands (e.g. provincially significant wetlands).	- Expanding WMA designations could affect licensed users of the Crown land gaining WMA status; however, some uses could be accommodated depending on the impact on wetland values.
Park Act (Ministry of Water, Land and Air Protection)	Provincial Parks	Provincial Crown land	Legislature or Cabinet	G	G	- Strongest 'protected area' designation, because many require Act of Legislature to change boundaries.	- Park Act has strong recreation focus; requires high level approval to designate; may not be suitable for wetlands that require active management interventions; not well-suited to small designations of specific wetlands	- Not required. - Could amend section 9(2) to incorporate conservation values, but not vital to do so.	None
Greenbelt Act (Ministry of Water, Land and Air Protection)	Green-belt Land	Provincial Crown land	Cabinet	P	P	- Flexible; authorizes acquisition for greenbelt; some important wetlands were acquired under this Act in the 1970's.	- Weak purpose in Act; - No clear protection requirements; weak enforcement (but available under Park Act); is subject to ALR and Waste Management Act.	- It would be better to focus on other mechanisms for wetland protection.	N/a
Ecological Reserves Act (Ministry of Water, Land and Air Protection)	Ecological Reserves	Provincial Crown land	Cabinet (some require the Legislature to modify boundaries)	G	G	- Good, strong legislation for protection of ecosystems; takes priority over all other legislation.	- Science-based research & education focus; good for many wetlands, but not for those that require active management.	- Not required.	None
Environment and Land Use Act	Ad hoc	All land in BC	Cabinet	V	V	- Good, flexible legislation that can be tailor-made to special circumstances, where other tools are a poor fit. - Prevails over other legislation.	- Protection and enforcement is only as good as the Order that is passed by Cabinet in a given situation. Past enforcement problems were addressed under section 6 of the Park Act, but that might not fit every situation.	- Not required. - However, need to be careful in wording of OIC to ensure adequate protection/enforcement.	- Depends on the Cabinet OIC – potentially anyone.
Forest Practices Code of BC Act (Operational Planning Reg)	Wildlife Habitat Areas	Crown forest land, range land, and private land in a TFL, CFA or WL	Chief Forester & Deputy Minister of Environment (WLAP)	V	G	- WHAs are probably of limited benefit to wetlands, but may provide additional protection (e.g., where general wildlife measures prohibit activity that might otherwise occur in smaller wetlands with no reserve zone). See Table 12 for other Code provisions for wetlands.	- WHAs only apply to identified wildlife, some of which are closely associated with wetlands. Depends on strength of general wildlife measure for the identified wildlife; - Not very flexible; implementation is slow and highly constrained with respect to timber impacts.	- Broader application to wetland-dependent species, not just identified wildlife. - Less constrained implementation.	- Would affect mostly forest licensees carrying out forest practices.
Land Act subsection 15, 16, 17	Reserves, notations and transfers	Crown land; sometimes reserves are referred to as wildlife habitat management areas, natural environment areas, recreation conservation management areas	Land and Water BC Inc.	P	P	- Effective for withdrawing Crown land from disposition; could be an important tool to implement a provincial policy in which important Crown wetlands are not sold. Serves to notify.	- Not necessarily effective in protecting wetlands habitat from land use practices, because there are no enforceable measures to protect habitat *per se*. - Seen more as an interim designation to preserve conservation opportunity until more appropriate designation is made.	- Not necessary to modify this tool, as other more appropriate designations exist. - However, it would be very useful to identify important wetlands on Crown land and place Land Act reserves on them so that they are not inadvertently sold.	- Land and Water BC Inc. - Possibly potential purchasers of Crown land.
Local Government Act	Development permit areas	Private and public land within a municipality	Local governments	P	V	- Not a protective designation *per se*, but invokes procedure that can require measures to preserve, protect, restore or enhance riparian areas, and control drainage	- Depends on willingness of local governments to designate DPAs, and quality of requirements in each development permit.	- Awareness & goodwill re. wetland issues in local government. - Provincial wetlands policy that addresses local government powers & discretion.	Local governments & property owners
Federal									

[1] Rankings: G = good; V = variable (e.g., results are contingent or variable); P = poor. Rankings are based on the security of the designation, the activities prescribed, the availability and quality of sanctions and enforcement mechanisms, etc. (explanatory notes may appear in the "effectiveness" or "limitations" columns.

Mechanism / (Lead Agency)	Tools	Applies To	Implemented By	Strength[1]	Enforcement	Effectiveness	Limitations (Gaps)	How to Fill Gaps	Who is Impacted?
Migratory Birds Convention Act (Canadian Wildlife Service, Environment Canada)	Migratory Bird Sanctuaries	Any land in Canada (in theory) Mostly used where hunting regulation is primary objective	Federal Cabinet	V	G	- Considered archaic legislation and not implemented south of 60° for >50 years. - Potentially useful designation that can provide federal protection for wetlands where there are nationally significant migratory bird populations.	- Primary focus is hunting regulations; poor to no protection for habitat other than nests while active. - Would not protect wetlands outside of nationally significant migratory bird habitat.	- More habitat focus in regulations, or use other federal legislation.	- Depends on whether better regulations applied only in sanctuaries, or in any areas frequented by migratory birds.
Canada Wildlife Act (Canadian Wildlife Service, Environment Canada)	National Wildlife Areas Marine Protected Areas	Land under the "administration" of the Minister of Environment Area of sea in internal waters of Canada	Federal Minister of Environment	G	G	- Flexible, open-ended designations for areas required for wildlife conservation. - Good enforcement provisions for NWAs. - Less difficult to establish, more flexible than National Park designations.	- Regulations do not have habitat focus, but prohibit many activities that harm habitat. - Should be stronger protection for NWAs from outside activity. - Requirement for federal "administration" requires provincial cooperation (purchase, donation or transfer).	- More habitat focus in regulations.	- Depends on areas designated as NWAs.
Canada National Parks Act (Parks Canada)	National Parks	Lands owned by Canada, or agreed to by Province	Federal Cabinet	V	G	- Generally strong protection for wetlands in national parks, but broad exceptions exist. - Good ecological integrity requirements.	- Purpose is not wetland protection; would be ancillary benefit only. - Surprisingly low penalty for environmental damage.	- Better to focus on filling gaps in other, more flexible legislation.	N/a
Oceans Act (Fisheries & Oceans Canada)	Marine Protected Areas	Internal waters of Canada (e.g. tidal wetlands supporting fisheries)	Federal Cabinet	G (but still unknown)	G	- Unproven, but shows promise for marine wetlands of federal and joint jurisdiction.	- Premature to say at this time - Main gap will be the limits on where MPAs apply.	N/A at this time.	N/a
Local Government									
Local Government Act	Environ-mentally Sensitive Areas (ESAs) Development Permit Areas (DPAs)	Potentially applies to any land in a municipality, regional district, or area under Islands Trust jurisdiction	municipal councils, regional district boards, local trust committees of the Islands Trust	V	V	- Local governments have the capacity to declare wetlands as ESAs in official community plans and regional growth strategies, and to restrict use of wetlands through zoning bylaws, development permit areas, etc.	- Enabling only – no provincial direction, policy or model to guide local governments. - Potential for widely discrepant results.	- An overarching provincial policy could apply to local governments. - Introduce wetland provisions directly in the LGA; - Develop model or guidelines for how wetlands should be managed.	- Owners of wetland properties

Table 12. Regulation of specific land-use activities that could impact wetlands (from Haddock 2002).

Mechanism	Focus	Tools	Effectiveness	Limitations (Gaps)	How to Fill Gaps	Lead Agency	Who is Impacted?
Provincial							
Forest Practices Code	"Forest practices" (includes forestry, range, some oil & gas activities) on Crown forest and rangeland, & some private land within tenures	Classification scheme for wetlands, combined with development restrictions; Well-developed discretionary management guidelines.	- Very effective scheme, because it requires classification of all wetlands and, for wetlands >5 hectares, requires restrictive reserve zone. Most wetlands also have a discretionary management zone, accompanied with management guidelines that are clear.	- Classification scheme based on size; wetlands <5 hectares do not get the benefit of any reserve zone; the number and habitat value of these wetlands can be high. Also, Code is weaker regarding range practices around wetlands.	- Amend Operational Planning Regulation to tighten threshold criteria in classification scheme; tighten guidelines for range practices.	Forest Practices Code agencies	Forest and range tenure holders
Forest Land Reserve Act Regulations	Tree farming practices on private land classified as "identified land" aka "managed forest land"	Regulations that specify management requirements for timber harvesting, silviculture, & road-related activities.	- Not effective for wetlands; may be some minor benefit to wetlands associated with fish streams.	- No wetlands protection at all.	- Amend regulations to require protection for wetlands. - Negotiate conservation covenants with land owners. - Create protection incentives through a provincial wetland policy.	Land Reserve Commission	Owners of private forest reserve land
Mineral Exploration (MX) Code	Mineral & coal exploration activities	Regulatory Code of practice with some practices restricted according to size of wetland.	- Discourages road construction and exploratory work in most wetlands (those <1,000 ha and >0.25-0.5 ha in size, depending on biogeoclimatic zone).	- Offers less wetland protection than Forest Practices Code; many discretionary exceptions and some contradictions. - Numerous small and some large wetlands would not be protected.	- Amend to achieve parity with Forest Practices Code. - Close loopholes, tighten discretion that resides with chief inspector.	Ministry of Energy & Mines	Coal and mineral explorationists
Drainage, Ditch and Dike Act	Dike construction and maintenance Part 1 of Act repealed by Bill 8, 2002.	None – but section 63 requires compliance with Water Act.	- Establishes authority for activities that can impact wetlands, but does not impose accountability for impacts. - Under the BC Environmental Assessment Act, new dikes protecting areas > 10 km^2 from flooding are "reviewable".	- This activity may have considerable impact on wetlands, yet does not address wetlands at all. However, most dyking is historic; new dyking undertaken by local government or Ministry of Transportation.	- Overarching provincial wetlands policy should guide all activity that impacts wetlands; or - Amend Act to address wetlands impacts from drainage, ditching and dyking activities	Local governments, Ministry of Transportation	Local governments, Ministry of Transportation

Table 13. General environmental protection legislation relevant to wetlands (from Haddock 2002).

Mechanism	Tools	Effectiveness	Limitations (Gaps)	How to Fill Gaps	Lead Agency	Who is Impacted?
Provincial						
Environmental Assessment Act	Requires environmental assessment of major projects Allows ministerial discretion to require environmental assessment of other projects	Can lead to important protection for wetlands for projects that are not otherwise regulated. Effectiveness depends on: - how many projects affecting wetlands undergo assessment (either by regulation or ministerial discretion); - quality of the assessment undertaken by the project proponent; - ability of the review committee to conduct field and project reviews; - whether review agency input is incorporated into project approval certificates; and - compliance with the terms set out in the project approval certificate.	- Thresholds for requiring assessment are high, therefore many projects that could impact wetlands do not undergo assessment. - Seems *ad hoc*, in that there is no consistent, clear provincial policy for wetlands known to proponents and agencies alike; each situation is "up for negotiation."	- Provincial policy would set a level playing field for all proponents. - Thresholds could be reduced to increase the number of projects that undergo assessment.	Environmental Assessment Office	Major project proponents
Environment Management Act	Environmental protection orders; Declaration of emergencies; Environmental impact assessment	- Provides good authority to order environmental protection for any existing or proposed work, undertaking, product use or resource use that has or potentially has a detrimental environmental impact; - Used to protect wetlands in Cowichan Estuary Environmental Management Plan.	- "Backup" help once there's a problem; - Reactive approach, rather than preventative; - Would not assist most wetlands.	- None required.	Water, Land, Air Protection	N/A
Fish Protection Act	Provincial directives for riparian management (applies to local government decisions regarding residential, commercial & industrial development) Allows for designation of Sensitive Streams	- Directives will help fish-associated wetlands, especially if critical to maintaining MAD and baseflow requirements under a recovery plan. - Wetlands expressly addressed in regulations; - Provides provincial guidance for local governments; - Regulations incorporate no net loss approach; - Restricts licensing under *Water Act;* - Sensitive Stream designation allows for recovery plans that may help associated wetlands.	- Fish-stream focused; - Limited ability to address agricultural impacts to wetlands; - Local governments must establish streamside protection and enhancement areas within 5 years;	- Broaden to address wetlands not associated with fish streams; or - Introduce separate provincial wetland policy that applies to local government decisions.	Water, Land, Air Protection Local governments	Local governments Some water license applicants
Waste Management Act	Permits and prohibitions relating to deposit of waste	- Will provide "backup" help for wetlands impacted by deposit of waste into the environment.	N/A	N/A	Water, Land, Air Protection	Manufacturing industries
Wildlife Act	Regulation of hunting;	- Limited ability to help wetland species through hunting regulations, section 9 (beaver dams) and section 34 (protection for birds, eggs and some nests); - Ability to designate threatened and endangered species, and provide for critical wildlife areas within WMAs (see above).	- Focus on 'take' regulation is a limiting means of managing wildlife; - Habitat provisions are limited, usually requiring formal designation, but available; - Threatened & endangered provisions under-utilized.	- Provincial wetland policy might be better way to address the needs of wetland-associated species.	Water, Land, Air Protection	Depends on approach taken. Presently, affects mainly hunters, some farmers.
Federal						
Fisheries Act	Prohibitions on deposit of deleterious substances & harmful alteration to fish habitat	- Strong federal laws that may help wetlands providing habitat for fish; - Enforcement provides deterrent, and creative sentencing may require remediation.	- After the fact – reactive rather than proactive; - Limited in its ability to help wetlands due to fish focus.	- None required in law, but needs more consistent application (e.g. Act is sometimes enforced to fully protect recharge and base flow to receiving waters, sometimes this connectivity is not even recognized).	Fisheries & Oceans Canada	N/A
Canadian Environmental Assessment Act	Requires environmental assessment for projects where federal government has decision making authority	- Casts a broad net over many of the potential ways that the federal government can affect wetlands; - Is the primary means of implementing the Federal Policy on Wetland Conservation.	- Lack of clear criteria or guidelines for determining the acceptability of projects and mitigation measures.	- First need to assess effectiveness of assessment process against objectives of Federal Policy on Wetlands Conservation.	Canadian Environmental Assessment Agency	Federal agencies, proponents of federally approved projects
Canadian Environmental Protection Act	Regulates toxic substances, pollutants & wastes	- Provides indirect benefits to wetlands by regulating release of toxic substances, pollutants and waste into the environment.	N/A	N/A	Environment Canada	N/A

Table 14. Other laws that may impact wetlands (from Haddock 2002).

Mechanism	Relevance	Effectiveness	Limitations (Gaps)	How to Fill Gaps	Lead Agency	Who is Impacted?
Provincial						
Agriculture Land Reserve Act	Regulates use of agricultural land	- Allows for ecological reserves and wildlife habitat uses of agricultural land if surface is not subject to substantial works;	- Strong priority given to agriculture (i.e., draining wetlands okay); - No consideration of environmental impacts (e.g., loss of wetlands) for most decisions;	- A provincial wetland policy should expressly deal with/ apply to ALR land;	Land Reserve Commission	Property owners in ALR

Mechanism	Relevance	Effectiveness	Limitations (Gaps)	How to Fill Gaps	Lead Agency	Who is Impacted?
(soon to be replaced by the Agriculture Land Commission Act, 2002)		- Very limited allowance for considering environmental values (subsection 43.1,44), but always subordinate to farm use and no net loss principle for agricultural capabilities.	- Assumes agricultural land is scarcer than wetlands; - Could impede ability to implement mitigation measures for wetlands.	- *ALR Act* could be amended to accommodate wetlands, mitigation programs, etc.	(soon to be renamed Agriculture Land Reserve Commission)	
Land Act	Governs the sale and granting of Crown land	Has provisions that could help wetlands by: - withdrawing wetlands from disposition; - requiring reservations and conservation covenants on land sold; - requiring environmental assessment of Crown land before selling it; - regulating activity in designated areas; - enforcing against trespass to Crown wetlands; - allowing for land exchanges (e.g. Crown land for important private wetlands); - allowing any ministry to acquire land and manage it (s.106)	- No provisions or policy addressing sale of important wetlands, reservations, conservation covenants, etc. - No budget for WLAP to acquire important habitat land.	- A provincial wetland policy should expressly deal with disposal of Crown land that contains wetlands.	Land and Water BC Inc. (for dispositions); WLAP (for habitat acquired under section 106)	Applicants for Crown land.
Land Title Act	Allows registration of conservation covenants on land title registry Specifies terms for subdivision approval	- Good tool for protecting wetlands values through encumbrances (rather than outright ownership) on title that survive ownership changes. - Allows approving officers discretion to refuse or impose conditions on subdivision of land.	- Covenant tool is fine; Land Title Office policy requires approval of Land Reserve Commission for ALR land (but not for FLR). This raises issues about weakness of ALR Act regarding wetland values (see above). - Enforcement is problematic. - Cost issues (e.g. survey for LTO, affordability for NGOs) - Discretion regarding subdivision approvals is adequate, so long as wetlands are duly considered by approving officers. Policy guidance on wetland goals and objectives would improve consistency.	- Same as above for *Agriculture Land Reserve Act.* Several options: - have specific provisions for wetlands in s.86, LTA or regulation; - develop provincial policy guidance for approving officers; - education & awareness	Land Title Office; Land Reserve Commission; Approving Officers under LTA (i.e. local government officials, Islands Trust, or Ministry of Transportation officials)	Property owners and wetland & conservation agencies seeking to negotiate and register conservation covenants.
Local Government Act	Zoning and bylaw-making powers governing land use	- In addition to ESA designations mentioned in Table 1, local governments have delegated authority to identify zones and pass bylaws affecting land use that could impact wetlands, for both public and private land. This can have both a positive or negative effect on wetlands.	- Except for Streamside Protection requirements and recovery plans under the *Fish Protection Act* (Table 3), local governments do not have clear mandate to protect wetlands. As more authority is delegated to them (e.g., Community Charter), there needs to be commensurate responsibility or accountability for environmental management, such as wetland protection. Some have developed that through requiring environmental assessment of OCP and zoning changes, but there is no express authority for this initiative in the LGA; - Local governments are constrained by provincial legislation in some respects (e.g. farming practices in section 903(5) *LGA*)	- An overarching provincial wetland policy could apply to local governments, and provide provincial leadership and guidance; - Clarify mandate to protect wetlands (and environment generally) in Community Charter and *Local Government Act*.	Local governments Ministry of Community, Aboriginal and Women's Services	Local governments and constituents
Water Act	Issuance of water licenses	- Diversion of water can be harmful to wetlands, and is regulated under the Water Act; - Unlawful diversion of water (inc. from swamps) is prohibited in section 9. However, exemptions in Part 7 of *Water Regulation* do not appear to have been drafted with wetlands in mind; - Despite section 9, it is quite possible for harm to wetlands to be permitted lawfully.	- Wetlands conservation issues are not effectively addressed in *Water Act* because impact of decision making on wetlands is not a factor – some important wetlands have allegedly been harmed by license approvals. - Lack of clear wetlands mandate for SDMs. - Also, ground water is not presently regulated, yet can have significant impact on wetlands.	- A provincial wetland policy should address Water Act authority; - Introduce wetland impact as a relevant consideration to decision-making; regulate ground water; give Comptroller of Water Rights mandate and authority to make best wetland conservation decision; or, limit authority as done in *Fish Protection Act* (Table 13).	Water, Land and Air Protection (for science-based standards) Land and Water BC Inc. (for dispositions)	Water License applicants
Federal						
Canada Shipping Act	Allows for boating restrictions	- Good tool for regulating boating-related water impacts on wetlands (e.g., no motors, or horsepower limits on access to waters of Canada).	- Implemented by Coast Guard, which doesn't have a wetlands conservation mandate; - Lack of clear role for federal agency with wetland expertise (i.e., CWS)	- MOU between CWS & Coast Guard - MOU between Province and Canada regarding exercise of federal power to protect wetlands.	Coast Guard	Recreational boaters
Income Tax Act	Provides tax incentive for ecological gifts, such as wetlands.	- Foster use of voluntary land donations and conservation easements in return for tax deductions against income (from "Wetlands and Government")	N/A	N/A	Revenue Canada	

Table 15. Non-regulatory programs relevant to wetlands (from Haddock 2002).

Program	Focus	Lead Agency	Effectiveness	Limitations (Gaps)	How to Fill Gaps	Who is Impacted?
Development & Operational Guidelines						
Land Development Guidelines (Vancouver Island and Lower Mainland Regions)	Guidelines for urban land developments, to guide local governments & developers	Water, Land & Air Protection (WLAP)	- Provides measurable standards, environmental objectives, best management practices; - Effective and practical, if implemented by local governments; - Many feel broader development of guidelines would assist local governments in having a more systematic approach to wetlands	- Voluntary, uneven application (depends on 'buy-in' from local government); - Only in use in Regions 1 & 2; - Insufficient direction provided from broader policy perspective; - Not ecosystem-based.	- Should be reviewed and brought up to date with best science & management practices, technologies, wetland conservation policies; - Get provincial agreement on guidelines; or, develop guidelines for more regions (e.g., issues may be different in dry interior, alkaline wetlands); Seek Local Government implementing agreements.	Urban land developers
Operational Guidelines	Various agencies have operational guidelines for either their own activities or those of the private sector	Several provincial agencies	- This analysis did not assess every set of guidelines of every agency that might affect wetlands; the main ones are listed above. However, there are numerous operational guidelines that also could affect wetlands, covering agriculture, urban stormwater and runoff, placer mining, highway construction & maintenance, etc.	- Operational guidelines of this nature are not normally enforceable, but can nevertheless be important standards setting efforts when coupled with education and awareness.	- Agency operational guidelines should be reviewed for potential impacts on wetlands. Such a review would best be done in the context of a provincial wetland policy that established clear wetland conservation objectives. There should be assistance from agency with wetland expertise, e.g. WLAP.	Various agencies and their clients
Land Stewardship & Restoration Programs						
Pacific Salmon Foundation; DFO Habitat Conservation Stewardship & Enhancement Program	Habitat protection, conservation, restoration and education program for urban salmonid habitat	Pacific Salmon Foundation; Federal Department of Fisheries & Oceans	- Supports habitat restoration, capital improvements to small community hatcheries, watershed planning, education/public awareness, various types of resource inventories and assessments and the development of community capacity for salmon restoration.	- Limited ability to deal with wetlands. - Funding is a constraint as not all worthwhile projects can be carried out; - Loss of provincial Urban Salmon Habitat Program.	- Put more $$$ into program to increase delivery effectiveness.	Local government & stewardship groups
Education & Awareness Programs						
ENGO's	Stewardship groups awareness and training	Wetland-keepers (BCWF); "Living by Water" (FBCN); Regional and local groups across BC	- Raises awareness and understanding among public, landowners & ENGOs; - On the ground impact difficult to determine due to lack of follow-up assessment to determine results (per Salasan Report)	- Funding to host more workshops needed; - Needs higher profile	- More funding; - Broader reach throughout province.	Volunteer activity
Provincial	Stewardship Centre web site	WLAP	- Helpful resource for anyone seeking stewardship information on internet	- Provincial government is lacking a broader outreach program to raise wetlands awareness among local governments and the public.	- Develop broader outreach program	Local government, general public
Federal	Contributes to above programs	CWS	N/A	N/A	- Is there a role for greater federal presence in these types of programs?	N/A
Land Acquisition Programs						
ENGOs: Ducks Unlimited Canada; Land Trust Alliance; The Land Conservancy of BC; Nature Trust of BC; Nature Conservancy	Acquiring fee simple or covenants to private land to protect wetlands	(see column 1)	- Highly effective means to protect habitat;	- Limited by available funding; some of the most important wetlands are in areas of expensive real estate; - Conservation covenants can be effective, but require more time to test effectiveness on future landowners.	- Requires extensive fundraising efforts; - Increase landowner awareness and incentives for conservation covenants.	Landowners, conservation NGOs
Federal & Provincial & ENGO Cooperative Programs	Partners in Flight: East Kootenay Conservation Program; Pacific Estuary Conservation Program; South Okanagan-Similkameen Conservation Program; Georgia Basin Ecosystem Initiative, etc.	CWS WLAP ENGOs	- Highly effective means to protect habitat; - Focused on habitat that is provincially, nationally and internationally significant.	- Need acquisition capability outside these areas; - Provincial contribution is weak in terms of funding commitment	- Expand program coverage; - Increase funding.	Landowners, conservation NGOs, federal & provincial agencies
Non-Legal Designations						
Important Bird Areas; Western Hemisphere Shorebird Reserve Network (WHSRN) sites; Ramsar designation, Biosphere Reserves	Non-regulatory designations to raise awareness, moral influence	Multi-agency & NGO: e.g. FBCN, CNF, Bird Studies Canada, CWS, Birdlife International	- Draws attention to international significance of important bird (incl. wetlands) habitats; - Non-threatening approach; - Can help influence decision-making by peer and moral influence.			Landowners; NGOs; local, provincial & federal governments.

(Province of BC 1995), the *Forest Practices Code (FPC)* provides an effective scheme to classify wetlands. It requires a 10-m reserve zone for wetlands >5 ha in area, and for wetlands of 1-5 ha in specific biogeoclimatic zones (see Table 16). A 10-m reserve zone also applies in the case of two or more wetlands that meet specific size and distance thresholds (see Table 16). The reserve and management zone widths from this guidebook are provided in regulation and hence are firm and legal requirements (*FPC Operational Planning Regulations* 61 and 62). A discretionary management zone (20-40 m in width, depending on wetland size and biogeoclimatic zone) and management guidelines are included in the scheme presented in the Guidebook, but not in regulation.

Table 16. Summary of required riparian management area, reserve zone and management zone widths (m) for wetland classes (Forest Practices Code Riparian Management Guidebook, Province of British Columbia 1995).

Wetland Class[1]	Riparian Management Area (m)	Riparian Reserve Zone (m)	Riparian Management Zone (m)
W1	50	10	40
W2	30	10	20
W3	30	0	30
W4	30	0	30
W5	50	10	40

[1] W1 = >5 ha in area; W2 = ≥1 – <5 ha in the PP; BG; IDF xh/xw/xm; CDF; CWH ds/dm/xm BEC zones/subzones; W3 = ≥1 – <5 ha in all other BEC zones/subzones; W4 = ≥0.25 ha and <1 ha; W5 = (i) two or more W1 wetlands located within 100 m of each other; (ii) a W1 wetland and one or more non-W1 wetlands, all of which are within 80 m of each other, or (iii) two or more non-W1 wetlands located within 60 m of each other, and (b) two or more wetlands with a combined size of ≥ 5 ha.

Within the RMA, a *maximum* level of tree retention is specified (Province of BC 1995); overall retention within the wetland RMAs of a given forest development plan should not exceed 25% of the associated stands. This Guidebook provides direction on the management to be followed within the RMA. In the reserve portion of the RMA, harvesting is not permitted. In the management portion, “permitted” activities are given in terms of optional but recommended “best management practices”, hence they are not required. Examples include not operating the tracks and wheels of ground-based equipment within 5 m of any wetland, falling and yarding away from (or parallel) to the wetland, and windthrow assessment and management strategies. It is suggested that the level of wetland protection in the management zone be in proportion to the abundance of wetlands within the associated biogeoclimatic zone. For example, where wetlands are considered uncommon (e.g., PP), it is recommended that 70% of the codominant conifers be retained in the management zone along with all the deciduous trees concentrated near the reserve zone and that important wildlife features should be buffered in order to maintain cover or visual screening. In contrast, where wetlands are considered common, only 10% of codominant conifers should be retained along with only 30% of deciduous trees concentrated near the reserve zone; no action is recommended in this case for buffering wildlife features. Exemptions to wetland protection under the *Code* can be made by the MOF District Manager (e.g., for road-building in a wetland under his jurisdiction – *OPR* Regulation 62).

The *FPC* is weak in regulating range-related activities around small wetlands. Under the *FPC Range Practices Regulation*, only two regulations pertain to wetland riparian areas. Regulation 6(3) prohibits, with some exceptions, refuelling of machinery in a riparian area including a wetland. Regulation 7(3) requires a holder of a Range Use agreement to “not allow livestock use in a riparian area of a community watershed, if the use would result in fecal deposits, trampling of vegetation, deposit of sediments or exposure of mineral soil to an extent that the District Manager determines to be detrimental”. Given that the Forest Service draws up many of the Range Use Plans, this lack of clear limits on riparian disturbance is problematic. Note that Regulation 3 prohibits a variety of activities within 50 m of a stream but does not include reference to wetlands.

The Riparian Management Area Guidebook also provides management direction for range use activities in "riparian areas". The guidelines focus on maintaining "properly functioning condition" of habitat units including the maintenance of a "desired plant community". Range guidelines are applied to general riparian areas rather than the defined Riparian Reserve and Riparian Management Zones. Table 18 in the Guidebook provides semi-quantitative wetland target conditions for four attributes: wetland edge vegetation, nutrient levels, soil trampling, and wildlife. Although general management guidelines are provided to assist in achieving these objectives, it is widely known that many of these objectives are routinely not met on the ground (Peter Davidson, pers. comm.).

Whereas the *Mineral Exploration Code* does discourage exploration in small wetlands >0.5 ha, the number of discretionary exceptions results in a lack of protection for many small wetlands. The *Drainage, Ditch and Dike Act* and the *Forest Land Reserve Act Regulations* provide essentially no protection for wetlands despite the applicability of these activities to wetlands. Again, a provincial wetlands policy would be helpful in this regard.

There are no relevant general local or federal statutes governing specific land-use activities affecting wetlands.

General Environmental Protection Regulations

Table 13 outlines general environmental protection legislation of relevance to wetlands (from Haddock 2002). Of the provincial instruments providing general environmental protection, the *Fish Protection Act* provides perhaps the strongest general protection for wetlands, although these safeguards are limited to wetlands associated with fish streams. Wetlands are explicity addressed in the *Act's* regulations including no-net-loss provisions and the *Act* provides provincial guidance for local governments. Other provincial instruments that give general environmental protection are overly reactive (*Environmental Management Act*), maintain very high thresholds for assessment (*Environmental Assessment Act*), or provide limited habitat provisions and require formal designation (*Wildlife Act*). The *Waste Management Act* merely provides a backup for wetlands impacted by major waste deposits.

The *Fisheries Act* provides strong federal laws that could help wetlands associated with fish habitat. This reactive legislation focuses on prohibitions on the deposit of deleterious substances and harmful alteration of fish habitat, but it is limited by its fish focus. Although the *Canadian Environmental Assessment Act* casts a broad net over many of the potential ways that the federal government can affect wetlands, it lacks clear criteria or guidelines for determining the acceptability of projects and mitigation measures. The *Canadian Environmental Protection Act* regulates the release of toxic substances and wastes into the environment, potentially providing indirect benefits to some wetlands.

Other Laws Relevant to Wetlands

Table 14 highlights other laws that may impact wetlands (from Haddock 2002). Diversion of water can be harmful to wetlands and, in principle, this harm could be regulated by the *Water Act*. The lack of a provincial wetland policy means that wetlands are not a factor in statutory decision making regarding diversions and "works in and about a stream" (i.e., section 9 - application). In addition, groundwater remains unregulated in BC, yet its' removal can severely impact wetlands. As a result, although the Water Act could be beneficial to wetlands, it is probably more often not.

The *Agricultural Land Reserve Act*, the *Land Act*, the *Land Title Act*, and the *Local Government Act* all contain provisions that are potentially useful for wetland protection, however they would all benefit from a provincial wetland policy to provide guidance in decision makers' consideration of wetlands. For example, the Local Government Act allows municipalities to identify zones and pass bylaws affecting land use that could impact wetlands, however there is a need to establish a provincial mandate guiding wetland protection. A provincial wetland policy would help to deal with the disposal, under the *Land Act*, of Crown land containing wetlands. Also, the strong priority given to agriculture in the *Agricultural Land Reserve Act* could be moderated through the creation of a provincial wetland policy.

The federal *Income Tax Act* allows for the use of voluntary land donations and conservation easements in return for tax deductions against income. This may be of use to wetland protection in specific situations. Regulation 8.1 of the *Canada Shipping Act* allows for designated water authorities to request restrictions on navigation for certain waters. Under this regulation, “the authority may submit to the Minister a request for such a restriction together with a report that specifies the location of the waters, the nature of the proposed restriction, information regarding any public consultations held in respect of such a restriction, and particulars regarding the implementation of the proposed restriction.” This regulation has been successfully applied to the Columbia River Wetlands, which had a 10-hp restriction in place that has recently been contested.

Non-Regulatory Instruments Relevant to Wetland Conservation

At the federal level, the *Federal Water Policy* contains wetlands provisions intended to support the government’s philosophy and goals for Canada’s freshwater resources. Specifically, two goals are recognised with respect to water: (1) to protect and enhance the quality of the water resource, and (2) to promote the wise and efficient management and use of water. Within the context of this policy, a policy statement is in place for wetlands encouraging wise use, cooperation, conservation, research, education, etc. (these items are quite similar to those in the Policy on Wetlands Conservation below).

The federal *Policy on Wetlands Conservation* outlines seven strategies to provide for the wise use and management of wetlands (Dovetail Consulting 1998). These include developing public awareness, managing federal wetlands for “no net loss”, promoting wetland conservation in federal protected areas, enhancing provincial-federal cooperation, conserving “wetlands of significance to Canadians”, ensuring a sound scientific basis for policy, and promoting international actions. The policy is not legally enforceable in a court of law, however, it may be used as evidence as proof of the federal governments’ commitment to protecting wetlands.

A long list of non-regulatory programs are in place that can affect wetlands and a review of some of the more influential programs is provided in Table 15 (Haddock 2002). These programs include guidelines, and various stewardship, restoration, education, and land acquisition initiatives. The laws and policies outlined above set the context within which these programs function. Legislation and policy also tend to identify the load to be borne by these alternative instruments due to the gaps in wetland protection that remain and may need addressing.

Land acquisition programs purchase title or covenants to private land containing important wetlands. Although these programs are an effective means to protect habitat, they are limited by available funding. The Nature Trust of BC, the Nature Conservancy of Canada, The Land Conservancy of British Columbia, and Ducks Unlimited Canada are prominent organisations that pursue this conservation strategy.

4.5.2 British Columbia’s Changing Regulatory Environment

When the current BC government came to power in 2001, there began a dramatic shift in governance of BC’s land management. These changes are not yet complete as acts and regulations continue to appear, while ministry downsizing and devolution of powers continue. In this section, we briefly discuss what is known about these changes, focusing on those of direct relevance to the management of small wetlands. General directions in new provincial legislation include providing greater freedom to resource users to pursue practices that they choose, provided that specified objectives set by government are achieved (i.e., a results-based approach). Greater emphasis is being placed on professional reliance, “science-based interpretations”, and effectiveness evaluations to justify the approach and practices selected. Government will inspect activities for compliance and enforcement with regulations and operational plans. There is also a shifting of responsibility for resource management from the province to local governments.

Recent Changes to Specific Legislation and Policy

Changes are currently being phased in, drafted and considered in a variety of areas of policy and legislation that may affect small wetlands. By far the most significant of these are the new regulations for the *Forest and Range Practices Act*, although other items are included in this section.

Forest and Range Practices Act and Regulations

Whereas the *FPC Act of BC* remains in force (though with recent amendments), a new “results based” *Forest and Range Practices Act (FRPA)* has been passed by the Legislature with some provisions to allow for a transition from the existing *FPC*. This *Act* establishes the broad framework for the management of forest and range activities that will replace the existing *FPC* by January 1, 2006, at the latest. New regulations are being phased in gradually over a two year period beginning January 31, 2004 and are intended to maintain environmental objectives and standards achieved under the *FPC*. In terms of wetland and riparian management on land under Ministry of Forests jurisdiction, regulations from the *FPC* are being carried through to *FRPA*, and can be found in sections 47-63 of the *Forest and Range Practices Regulations*. However there are several significant differences under *FRPA*. For instance, licencees may choose to conform to the default regulations (e.g., wetland riparian reserve zone or management zone widths), or they may propose alternative management regimes (“results and strategies” – see section 13 of the *Forest and Range Practices Regulations*) within their *Forest Stewardship Plans* (FSPs). The latter would then be adjudicated by a *Designated Decision Maker* (DDM) to determine if they are consistent with maintaining established environmental objectives (Gerry Fox, pers. comm.). Similarly, range tenure holders now have their own regulation (the *Range Planning and Practices Regulation* found in sections 32-45 of the *Forest and Range Practices Regulations)* and must prepare their own default *Range Use Plans* (RUPs; these plans were previously prepared by Ministry of Forests personnel). The content requirements of RUPs have been significantly reduced and range tenure holders may also apply to prepare more flexible *Range Stewardship Plans* (RSPs), if approved by the Minister. The latter permits the tenure holder to propose alternative management regimes to achieve management objectives. FRPA training is ongoing, and implementation will occur in stages as existing FDPs and RUPs expire. For this reason, the longterm implications of this legioslation are still not clear (Gerry Fox, pers. comm.).

Water Act

Currently, as in the past, where fish habitat concerns or wildlife issues may arise in the application (for a water license or for works in and about a stream), that application may be referred to WLAP for detailed review. It has been suggested that this referral role may be removed to streamline the development process (Mark Haddock pers. comm.). If this referral mechanism were removed, there could be negative impacts on wetlands due to the lack of technical review by a referral biologist.

Mining Act

According to John Errington, the Director Chief of Permits (Mines Branch), the Mineral Exploration Code has been reduced in size to reduce exploration requirements and associated costs. He does not expect the changes already in place to have an impact on how mining exploration will affect small wetlands. However, reduced regulatory requirements could promote a greater rate of mineral exploration and thereby increase the potential for wetland impacts.

A proposal is being considered by Mines Branch to modify how WLAP referrals are managed (John Errington, pers. comm.). Currently, exploration permit applications are routinely referred to WLAP for environmental review, should it be suggested by the nature of the application. The proposal is to continue with referrals only for proposals considered to possess significant environmental implications - for example, a minimum length of new road (e.g., 10 km). Specific thresholds have not been determined, nor has the regulation been written. However, depending on the nature of the thresholds, projected changes could negatively impact small wetlands.

Drinking Water Protection Act

This new piece of legislation focuses on the protection of drinking water for human consumption. If wetland protection were to result from this legislation, it would have to come through a necessary linkage between the wetlands in question and the safety of the water (Mark Haddock, pers. comm.). Establishing such a connection for smaller dispersed wetlands is unlikely, but it may be more likely for larger wetlands that clearly contribute to water quality for human consumption.

Federal Species At Risk Act (SARA)

The Species At Risk Act (SARA) passed by the Canadian Senate on December 12, 2002 assigns the primary role for species protection in Canada to the provinces and territories (Smallwood 2003). The law is largely restricted to federal lands, migratory birds, and aquatic species (defined as fish, marine mammals, and marine plants). Legal (federal) listing is the prerequisite for protection under SARA and once listed, it becomes illegal to destroy the species “residence”. Habitat protection is derived through the prohibition against destruction of critical habitat (s. 58) and the promotion of stewardship and conservation initiatives through conservation agreements (s. 11). Unfortunately, the prohibition does not apply until critical habitat has been identified in a recovery strategy or action plan – generally several years after a species has been legally listed under the Act. Furthermore there are a number of difficulties in clearly defining and identifying critical habitat, which is likely to delay this process.

Recovery of species at risk, central to SARA, is a two-stage process. In the first stage, a recovery strategy outlines the overall strategy for recovery. The second stage involves the preparation of a plan outlining specific measures to be taken to implement the recovery strategy. According to Smallwood (2003), SARA includes two mechanisms – known as safety nets - that allow for discretionary federal action in light of provincial or territorial inaction to protect a species or its critical habitat. The “basic prohibitions safety net” protects a species or its residence. The “critical habitat safety net” protects critical habitat. These are both discretionary and therefore may seldom be used given experience with similar provisions in federal environmental law (Smallwood 2003).

Given its focus on federal lands, and the fact that most federal lands in the Canadian portion of the Columbia Basin reside in National Parks with existing protection, it appears unlikely that SARA will contribute significantly to the increased protection of wetland habitats. The potential is there to improve protection of the few wetlands that may exist on federal lands outside of National Parks where wetlands are designated as critical habitat in a recovery strategy or action plan. Also, if the discretionary provisions were invoked, protection may be increased for provincial wetlands – but only if there is persistent inaction on the part of the province relating directly to a legally-listed (federally) wetland species.

Other Changes Potentially Affecting Wetlands

Changes to Land-Use Planning

In the past decade, strategic land-use planning has been undertaken through multi-stakeholder Land and Resource Management Planning (LRMP) processes in many regions of BC (Dovetail Consulting 1998). This process is changing and it remains unclear how this will affect wetland protection.

Provincial Strategies and Initatives

Several environmental initiatives that may affect wetlands continue to evolve. The Living Rivers Strategy is essentially an accounting of the condition or state of the aquatic environment in BC. To date, its treatment of wetlands has been a determination of the gross area and location of wetlands across the province (Rowena Rae, pers. comm.). The provincial Biodiversity Strategy is in early development and, in theory, could include a wetland component.

Community Charter

On May 8, 2003, the BC government passed the Community Charter with the stated goal of having it come into force on January 1, 2004. According to the BC government's legislation website, (http://www.legis.gov.bc.ca/37th2nd/3rd_read/gov12-3.htm), the Community Charter will establish a new foundation for municipal government in BC. One of the stated objectives is to increase the autonomy given to BC's local governments.

According to Kenward (2003), Section 15 of the Community Charter provides that municipalities may establish a system of licenses, permits, or approvals in the listed "spheres of jurisdiction". The "spheres" where the municipalities have concurrent jurisdiction with the province include "protection of the natural environment" and "wildlife". In such spheres, the municipal bylaw must be approved by the province, either directly, or by agreement, or by regulation. Given that the Charter might necessitate approval from the province for proposed environmental bylaws, it is not clear whether the Charter will increase or decrease the opportunity for regional districts to protect wetlands.

Provincial Wetland Guidelines/Policy

An initiative is underway in BC to define a Provincial Wetland Policy to guide politicians and resource managers in decision-making affecting wetlands. In the spring of 2003, the Wetlands Working Group (WWG) was formed to address the need for better coordination and improvement of management and protection provisions for wetland and estuarine environments in BC. Its mission is "to maintain and restore properly functioning wetland ecosystems throughout BC by (a) influencing and promoting activities affecting wetland protection; (b) encouraging collaborative partnerships among government and non-government organisations; and (c) prioritising, communicating and implementing recommendations for wetland management". Composed of government staff, non-government organisations, and technical specialists, this group is involved in consultation, studies, and discussion about the status and needs of wetlands in BC, particularly to identify important gaps and essential actions. The WWG has identified agriculture/ranching and urban/industrial expansion as the main threats to initially focus on.

A sub-committee of the WWG is preparing the groundwork for drafting a provincial wetlands policy for BC. A draft "action plan" identifying 12 recommendations for wetland stewardship is expected to form the basis for the development of the general provincial goals and objectives. Major issues to be resolved include mapping/data needs, regionalisation of a possible no-net-loss approach, and the form and presentation of the document itself (with respect to Ramsar guidelines). Currently, the absence of clear provincial wetland priorities is resulting in wetlands not being well considered in areas of discretionary provincial and municipal decision making (e.g., considerations in applying the Water Act, municipal permitting and land-use planning, and Crown land dispositions).

4.5.3 Implications for Small Wetlands in the Columbia Basin

The above sections clearly point out that there are legal instruments that can protect wetlands in the Columbia Basin. There are, however, considerable restrictions on those that do, particularly in terms of land jurisdiction. Other important legislation lacks essential guidance – for instance, through implementation of provincial guidelines (or policy) for wetlands management. Wetlands associated with fish streams have both provincial and federal legislation that could be helpful, however staffing shortages often result in implementation being reactive, rather than proactive. The lack of groundwater regulation in BC continues to be a problem for wetland conservation.

Forest and rangelands managed by the Ministry of Forests represent a significant component of the land base where small wetlands are likely of greatest concern. The current *FPC* does offer some protection for small wetlands (see section 4.4.1 – Regulation of Land-Use Activities), partly through the method of classification that is required, and partly through mandatory reserve zones for wetlands >5 ha in size. RUPs require little in the way of environmental protection, particularly toward wetlands, and only one or two regulations govern them (see section 4.4.1). Water sources do not have to be fenced, nor do off-site watering facilities have to be provided to discourage livestock from accessing sensitive wetlands or streams. The quality of RUPs is highly variable, they offer little in the way of enforcable criteria (Sue Crowley, pers. comm.), and where plans are in place, compliance can be a serious problem. Furthermore, some see it a problem that the Ministry of Forests has responsible for both drafting the plans and carrying out compliance and enforcement (Gary Tipper, pers. comm.).

Rules governing range use activities around small wetlands are of particular concern in the East Kootenay. A recent results-based assessment of range practices to maintain riparian values found that in the Cranbrook Forest District, only 49% of the riparian sites examined were deemed healthy, almost half were found found functioning at less than acceptable levels, and that many of the observed impacts could have been avoided through good range management practices (Forest Practices Board 2002). Smyth and Allen (2001) assessed the health of 63 lentic wetlands in the Rocky Mountain Trench as part of a monitoring program to record changes in wetland ecosystem structure and function. They categorized wetlands into five broad wetland classes (Banner and Mackenzie 2001) and described the majority of marsh, shallow open water and fen wetlands they sampled as “non-functional” or “at risk”. This was because wetland plant communities exhibited problematic floristic changes (i.e., a trend away from the desired plant community towards a greater percent cover of increaser and invasive species), and new shrub growth, where present, had been browsed extensively, particularly at the marsh and shallow water sites. Shoreline trampling was extensive at a few of the wetlands and exposed mineral soil was common at many of the wetlands sampled. Livestock impacts (e.g., grazing, vegetation trampling, pugging) were widespread and greatest in the more disturbed sites. Intensive livestock grazing in riparian areas is associated with marked reductions in wildlife species richness and relative abundance (i.e., reduced wildlife suitability and use) across a wide range of sites in western North America (review in Saunders 2001).

Under new *FRPA* legislation, code requirements become more discretionary, and whether existing wetland protection objectives and standards can be maintained or improved under the new legislation remains unknown. New plans (FSPs, RUPs, RSPs) cover a 5-year time window once implemented, so it will be some time before the effects of these new regulations can be established.

Private land often occupies high value riparian and valley bottom environments where small wetlands are frequently located. These “private” wetlands are especially vulnerable due to the lack of applicable regulation. Again, a clearly articulated provincial wetlands policy accompanied by best management practices with strong extension support may improve treatment of small wetlands on private land. Where land is only now being sold by the Crown, a provincial wetland policy would also be useful in informing government staff about steps that should be taken prior to disposition to assure that wetland features are adequately protected, perhaps through covenants or by using the *Land Act* to designate important (small) wetlands. The *Community Charter* (see section 4.4.3) may increase the authority granted to municipal governments over activities on private land. Hence, it may be important for wetland proponents to develop a closer relationship with municipal governments.

The use of back-country motorised recreational vehicles has the potential to be detrimental to small wetlands, particularly in the East Kootenay. On the bulk of Crown land, there is little to stop recreationalists from thoughtlessly damaging important environmental values. Although there has long been the capacity under the *Wildlife Act* and more recently under the *Forest Practices Code* to prevent this from happening in specific areas, these opportunities are seldomly invoked or enforced (Gary Tipper, pers. comm.). Due to the outcry from certain interest groups, Ministry staff are often reluctant to restrict back-country motorised recreation, and it continues to be one of the large gaps in environmental protection, particularly for small wetlands.

5.0 Synthesis and Recommendations

Our literature review explores several wetland classification systems and provides a recommended classification scheme (Table 1) to describe wetlands in the Columbia Basin. The latter incorporates the WREC system of MacKenzie and Banner (2001) and includes selected components from other classification schemes to describe biological, vegetation, and physical features of wetlands, as well as entire wetland systems.

Our review reinforces the pivotal role played by wetlands in maintaining water quantity and quality within the Columbia Basin and in providing habitat and life support for a diversity of flora and fauna. An estimated 175 vertebrate wildlife species (119 bird, 46 mammal, 7 amphibian and 3 reptile) in the basin are associated with wetlands and 97 of these species are considered wetland obligates (i.e., they are critically dependent on various wetland-related habitat elements for breeding, foraging and/or other life requisites). Thirteen of the latter species are currently listed in BC. Many have very localized distributions and/or other specialized habitat requirements in addition to their dependence on wetlands.

The wetland types identified in the Columbia Basin Database (i.e., marsh, riverine wetland, forested and non-forested wetland, wet meadow) correspond only partly with the wetland and transition classes identified in most wetland classification systems (Table 1). Assumptions had to be made to link wetland and transition types in the database with wetland and transition classes in Table 1. To some extent, this limits the usefulness of the database as a tool for evaluating wildlife habitat suitability of standard wetland classes. Recognizing these limitations, our analysis suggests that marshes support the greatest diversity of dependent wildlife species, followed by riverine wetlands (these would most likely correspond to terrestrial flood ecosystems in Table 1), forested wetlands (swamps in Table 1), non-forested wetlands (likely bogs and fens in Table 1), and wet meadows (meadows and shrub-carrs in Table 1). The shallow open water wetland class in Table 1 is not explicitly represented as a wetland type in the database and may correspond to some extent with the shallow lake habitat element in the database.

The Columbia Basin Database does not provide compelling evidence to support the importance of small wetlands for individual species. According to the database, an estimated 16 species are considered sensitive to wetland size (large or small), but only six species are specifically associated with small wetlands (<2 ha). This result likely reflects an information gap and field investigation documenting the wildlife use of small wetlands (stratified by type, size class and BEC zone) is recommended. The literature does however provide more general evidence for small wetlands playing an important role in the survival of unique species assemblages. This is because small wetlands lack the predatory fish/invertebrates and loons that are capable of depredating amphibian larvae or competitively excluding other waterfowl in larger wetlands, respectively. In particular, wetlands of small size and intermediate hydroperiod are thought to be critical to less mobile amphibian species that are vulnerable to wetland loss.

In addition to wetland size, our review indicates that wetland type, density, distribution, connectivity, complexity and characteristics of adjacent terrestrial areas are important determinants of wetland habitat suitability and species richness. Many wetland organisms disperse or use elements within both aquatic and terrestrial habitats to complete various phases of their life cycle. Smaller, less mobile organisms (e.g., frogs, salamanders, small mammals and reptiles) are constrained in their ability to disperse across upland areas that separate wetlands. Reduced availability and connectivity of wetlands would likely have negative implications for all species forced to travel greater distances within a matrix of disturbed habitats.

The Columbia Basin experiences a diversity of climates and has resulted in ecosystems ranging from interior rainforest to semi-arid dry grasslands. Dryer BEC zones of the region (PP, IDF, MS and dry ICH) experience low precipitation and high summer temperatures, which limit peat formation. Marshes and swamps are most common in these areas and some potholes and shallow lakes may experience severe evaporation and drawdown during summer months, resulting in accumulation of salts. Because water is scarce and wetlands are very different from adjacent uplands, they are especially important in the dry interior of the basin. Although the cool, wet climatic conditions of the wet ICH, SBS and ESSF zones are conducive to wetland formation, their primarily mountainous terrain restricts wetland abundance and wetlands are relatively uncommon in these ecosystems (Banner and Mackenzie 2000; MacKenzie and Shaw 2000).

Based on our GIS analysis of the TRIM data, there are an estimated 12,203 ha of small (<10 ha) wetlands in the Columbia Basin comprised mainly of marshes (71%) and swamps (28%), with a small area of flooded lands (1%). The 2-5 ha size class is the largest contributor to total wetland area in the basin, followed by the 5-10 ha class, and then progressively smaller size classes. An additional 22,445 ha of small lakes occur within the Columbia Basin.

As expected, the availability of small wetland habitat within the Columbia Basin varies significantly by BEC zone, landscape unit, and land jurisdiction. The BEC zones with the highest wetland abundance by area are the IDF (0.77%), SBS (0.70%), PP (0.41%), MS (0.40%), followed by the ICH (0.16%), ESSF (0.06%), and AT (0.02%). All of the landscape units with a wetland abundance exceeding >0.5% (by area) are located in the East Kootenay. Furthermore, the vast majority of small wetland area in the basin is found on crown (76.9%) land, with the remainder located on private land (22.3%) or in provincial (0.5%) and national parks (0.3%). Overall, these results provide only a "snapshot" of current wetland abundance and say little about historical wetland distributions and where the majority of small wetland impacts have already occurred.

<u>Recommendations</u>:

1. To accommodate the needs of wetland-dependent species in the Columbia Basin, greater emphasis must be placed on wetland protection. Conservation efforts should focus on protecting a diversity of wetland types and sizes in representative areas throughout the CBFWCP area. Strategies for conservation could include a combination of:

    - land acquisition and management (high priority);

- wetland landowner incentive programs (high priority);
- promotion of wetland stewardship initiatives (medium priority),
- awareness campaigns and training programs (medium priority);
- support of wetland habitat/species inventory and research initiatives in the basin (high priority); and
- networking and collaboration with other ENGO and conservation groups (see list of groups in Table 15) in the basin to achieve conservation goals (high priority).

2. To address the needs of listed species, wetland conservation and management efforts should focus on areas known or likely to support listed species/subspecies (e.g., Creston Valley, East Kootenay Trench, and drier, low elevation wetland habitats found in the West Kootenay and the Robson Valley). These areas currently have a high diversity of wetland-dependent species at risk and, in some cases, they support the only viable populations of a listed species (e.g., Northern Leopard Frog, Forster's Tern and Western Grebe) in the CBFWCP area.

3. Representative small wetlands (i.e., <5 ha) occurring within a matrix of intact terrestrial habitat should be prioritized for future wetland protection efforts, since these habitats receive minimal protection on crown/private lands under current legislation. Conservation priority should also be given to wetland complexes that support several wetland types and sizes in close proximity. The above would be able to accommodate the needs of smaller wetland organisms (salamanders, frogs, reptiles, small mammals) that disperse from natal ponds and/or use both wetland and adjacent terrestrial habitats during their life cycle.

4. Small wetlands in drier, low-elevation zones (e.g., IDF, PP, MS, dry ICH) subject to intensive human settlement, land development, agriculture, range use, flooding, etc. have likely been most heavily impacted by land use activities and should be given priority for future protection, enhancement and restoration activities.

5. Efforts should be made to increase the proportion of small wetlands represented in low-elevation parks and other protected areas.

Our comparative analysis indicates that there are a number of problems in identifying, quantifying and interpreting wetland data gathered from TRIM. API was able to detect many more wetlands and smaller wetlands were more likely to be missed in the GIS analysis, although this pattern was not consistent. There was also a tendency for GIS analysis to overestimate the marsh component, and to underestimate the total wetland area and the area of shallow open water. Overall, API was able to provide a much more detailed and fine-grained level of classification than GIS analysis of TRIM data. Area-based wetland estimates provided in the GIS analysis should therefore be considered a rough first approximation.

<u>Recommendations</u>:

6. It is recommended that API be used as a technique for future wetland inventory in the Columbia Basin. Additional API analysis of wetland availability is necessary to evaluate wetland density, distribution and connectivity on a sub-basin or watershed level (high priority). This would be a valuable first step to delineate potential wetlands worthy of protection through future land designation, acquisition or stewardship programs. Explicit criteria (historical wetland loss, rarity and representation by BEC or LU, species diversity, listed species use, etc.) would need to be developed and applied to candidate wetlands to identify the best overall sites (i.e., those that achieve multiple objectives) for conservation emphasis.

7. Field-truthing of areas classified through API will be required to further evaluate the reliability of this method in identifying and classifying wetlands (high priority). During field-truthing, wetland classes should be determined (as per Table 1), and data on vegetation cover types, presence of specific habitat elements (e.g., emergent/submergent vegetation, floating mats, islands, etc.), wildlife use (i.e., observations/sign) and wetland disturbance (e.g., livestock grazing impacts, irrigation, ATV use, etc.) should be gathered in a standardized format. This information would be used to rank the overall wildlife habitat suitability of particular wetlands for possible protection, enhancement or restoration activities.

Our review of the legislation indicates that there are several legal instruments that protect wetlands. There are however considerable restrictions on those that do, particularly in terms of land jurisdiction. Provincial and federal legislation applying to provincial and national parks, ecological reserves, wildlife management areas (WMAs), wildlife sanctuaries and national wildlife areas offers the best wetland protection. However the majority of small wetlands (>99%) in the basin are located on crown and private lands not covered by these statutes. Furthermore some potentially important legislation (e.g., the *Local Government Act, Environmental and Land Use Act, Growth Strategies Act*, etc.) lacks essential guidance (through implementation of provincial guidelines or policy for wetlands management, for instance). Wetlands associated with fish streams have both provincial and federal legislation that could provide protection, however staffing shortages often result in their implementation being reactive, rather than proactive. The lack of groundwater regulation in BC also continues to be a problem in achieving wetland protection.

On crown forest and rangelands representing 77% of the land base where small wetlands are found, the *FPC* currently offers protection through the method of mandatory wetland classification and establishment of reserve zones (10 m width) for wetlands >5 ha in size. Wetlands <1 ha in size receive no protection in any BEC zone and those <5 ha are buffered only in a few of the zones represented within the basin. As emphasized in our review, these buffer zone widths do not reflect distances that are biologically relevant (e.g., dispersal distance, home range or breeding territory size) to wetland-dependent fauna. Studies in other jurisdictions have clearly shown that prescribed minimum size thresholds and terrestrial buffer zones for wetland protection are inadequate because the travel and dispersal distances of wetland organisms exceed those prescribed by orders of magnitude in virtually all cases.

<u>Recommendations</u>:

8. Adequate small wetland protection on crown lands in the Columbia Basin requires changes to existing legislation (high priority). A lowering (or elimination) of minimum wetland size thresholds for protection in all BEC zones and an increase in terrestrial buffer zone widths will be necessary to reflect the biological requirements of wetland-dependent species.

9. Average travel/dispersal distances from wetlands and/or home range or breeding territory sizes have not been determined for many wetland species (including listed species) and additional research will be required in this topic area (medium priority).

Current *FPC* regulations governing range use activities around small wetlands are weak and recent effectiveness evaluations have raised concerns for wetland protection in drier zones of the East Kootenay.

<u>Recommendations</u>:

10. Regulations governing range use in wetland areas must be “strengthened” rather then “streamlined” to ensure that water sources are fenced and off-site watering facilities are provided to discourage livestock from accessing sensitive wetlands or streams (high priority). These

provisions are critical to ensure that wetland habitat degradation is maintained within acceptable levels.

11. Standards to ensure that RUPs are comprehensive and consistent must be developed and adhered to and efforts focused on monitoring compliance and enforcement need to be expanded (high priority). Once *FRPA* is completely phased in and range tenure holders themselves are preparing five-year RUPs, monitoring and compliance must be stepped up and focus on identifying problems as early as possible during the tenure period.

An estimated 22.3% of small wetlands in the Columbia Basin are located on private land. These “private” wetlands are especially vulnerable due to the lack of applicable legislation.

Recommendations:

12. Pressure must be brought to bear on the provincial government to complete and implement a clearly articulated *provincial wetlands policy* accompanied by best management practices with strong extension support. This action item is considered a very high priority to potentially improve treatment of small wetlands on private land. Where land is only now being sold by the Crown, a provincial wetland policy would also be useful in informing government staff about steps that should be taken prior to disposition to assure that wetland features are adequately protected, perhaps through covenants or by using the *Land Act* to designate important (small) wetlands.

13. It is recommended that all wetland proponents develop a closer relationship with municipal governments, because the *Community Charter* (see section 4.3.2) offers an opportunity to increase the authority granted to municipal governments over activities on private land (medium priority).

The use of back-country motorised recreational vehicles has the potential to be detrimental to small wetlands on Crown land, particularly in the East Kootenay. Although there has long been the capacity under the *Wildlife Act* and more recently under the *FPC* to prevent such impacts in specific areas, these opportunities are seldomly invoked or enforced (Gary Tipper, pers. comm.). Due to pressures from certain interest groups, Ministry staff are often reluctant to restrict back-country motorised recreation, and the latter continues to be one of the large gaps in environmental protection for small wetlands. There are initiatives underway to address this problem. For example, the Ministry of Sustainable Resource Management has recently completed a Recreational Access Management Plan for the eastern portion of the Rocky Mountain Forest District and the Grasslands Council of BC is applying pressure on the provincial government to obtain mandatory licensing for outdoor recreational vehicles. To further address recreational motor vehicle impacts on wetlands,

Recommendations:

14. Ministry staff must be mandated and encouraged to enforce motorised recreational vehicle restrictions in sensitive wetland areas where such protection is warranted (medium priority).

15. Ministry staff must also be provided with the staff and resources to develop recreational access management plans for other parts of the Columbia Basin and to undertake monitoring and compliance to ensure that these plans are being adhered to (high priority).

16. Stewardship groups should be encouraged to take part in "wetland watch" programs in their local area to potentially assist in discouraging destructive practices and/or reporting specific incidents to the appropriate enforcement authority (medium priority).

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APPENDIX 1: Review of Wetland Classification Systems

Overall Findings

There are only a few wetland classification systems regularly used in western Canada and ten systems were reviewed, including national systems for Canada and the U.S., a system developed for the prairies of western Canada, a classification framework for wetlands and related ecosystems in BC, as well as four BC regional and two U.S. regional classification schemes, respectively. Descriptions of all systems and discussions on their applicability to the Columbia Basin are provided. The overall findings of the review are summarized in this section.

The most useful wetland classification systems are hierarchical (i.e., each level in the system provides increasing amounts of detail) and allow the user to select the level of detail required to meet their specific objectives. Furthermore, classification groupings should be based on diagnostic features that are visually discernable in the field and preferably on air photos. Almost all classification systems consider water permanence as a key factor and use vegetation as an index of water permanence.

Wetland vegetation can be stratified by physical appearance corresponding to physiognomy or physical form (structure). Visible differences in plant form are used to divide wetlands into zones or classes that have a characteristic species composition corresponding to a particular water regime. Vegetation zones often occur as a series of concentric rings or bands that reflect the relative depth and duration of flooding at various elevations. Differences in stature and relative coarseness (texture) of dominant species groups are visually distinct and can be recognized on remote sensing products. Therefore vegetation physiognomy can be an important criterion for differentiating wetland components and evaluating those units for wildlife habitat suitability. At a more detailed level, floristic characteristics (i.e., species composition) of wetland vegetation provide the best indicators of water permanence and quality. They can also be directly linked to the species-specific vegetation requirements of wetland-dependent wildlife for various life requisites (e.g., breeding, foraging, cover, etc.).

Physical features (e.g., water source, wetland size, basin depth, hydrological linkages, topographic position in a watershed and surface morphology) can be used as evaluation criteria for classifying wetlands. Many of these physical features can also be identified using remote sensing tools. They are more stable than vegetation characteristics and provide information about the water regime, stability and potential of a wetland over the long-term.

Classification of wetlands can occur at several levels of detail. *Wetland components* can be classified at the *site level* using both *biological* and *physical* criteria, and entire *wetland systems* can be classified at the *landscape level.*

Vegetation Features Used to Classify Wetland Components

Vegetation Physiognomy

Wetland components or classes can be further subdivided using vegetation life-forms. The Canadian System of Wetland Classification (NWWG 1997) recognizes wetland types that are based on the general physiognomy (physical form or structure) of wetland vegetation. Eight main vegetation ***cover types*** used to define wetland types include *Aquatic, Forb, Graminoid, Lichen, Moss, Shrub, Treed and Non-vegetated*. Specific vegetation cover types within some of the main types are also identified, and can be used to provide more detail about wetland types. Classification systems developed by Golet and Larson (1974), Runka and Lewis (1981), and Moon and Selby (1982) also consider vegetation physiognomy.

Vegetation cover types are useful for classifying and inventorying wetlands and can be linked directly to the structural stage requirements of wildlife guilds for various life requisites (i.e., breeding, foraging, other). The cover types recognized by the NWWG (1997) are recommended for use to further classify wetland components in the Columbia Basin study area.

Vegetation Distribution and Density

Other vegetation features which provide more detail about wetland components and are useful for evaluating wetland habitats in the CBFWCP area include (a) the distribution and density of emergent vegetation cover (Steward and Kantrud 1972; Golet and Larson 1974), (b) wetland component position modifiers (Runka and Lewis 1981), (c) vegetation interspersion types (Golet and Larson 1974; Moon and Selby 1982), and (d) surrounding habitat types (Golet and Larson 1974). See Appendix 1 for a discussion of each of these features.

Species Composition

At a more detailed level of wetland classification, wetland components can also be further classified using floristic characteristics or species composition. The U.S. classification system (Cowardin et al. 1979) recognizes "dominance types" based on dominant plant species (or sedentary animal where vegetation is sparse) at the most detailed level of classification. Dominance types are specific to regions and must be identified by the user at the local level. Millar (1976) also notes the importance of identifying dominant species for providing more detailed information about wetland environmental conditions (e.g., water permanence, water quality and recent history of disturbance). Because species composition of wetland components generally cannot be determined using remote sensing products, this level of classification is not useful during the initial stages of wetland classification and inventory in the CBFWCP area.

Plant Associations

The WREC system of BC (Banner and MacKenzie 2001) uses the *site association* as the basic working unit for ecosystem site classification. The *site association* defines all ecologically equivalent sites that are capable of supporting a similar climax plant community or plant association. *Site associations* are also used to define site series within subzones and variants of the BEC system of BC. S*ite associations* and *site series* are used to classify wetland ecosystems based on species composition at the most detailed level of the site component classification.

The draft guide entitled "Wetlands and Related Ecosystems of Interior British Columbia" (MacKenzie and Shaw 2000) describes common wetland, floodplain and transitional ecosystems that have been identified to date in the interior of the province. The guide is based on the broader classification framework described in MacKenzie and Banner (2001) and it groups wetland and related ecosystems within *site classes*. Specific wetland *site associations* and *site series* within broad *site classes* are difficult to identify using remote sensing tools. Therefore, classifying wetland components to the level of *site association* and *site series* is best accomplished in the field.

Plant associations are also recognized as a way to further subdivide wetland components (Runka and Lewis 1981). Millar (1976) describes how plant associations can be used to indicate average salinity conditions in wetlands, and identifies four salinity categories found to be ecologically significant based on species composition of plant communities.

Physical Classification of Wetlands

Physical features are also useful for classifying and evaluating wetlands. MacKenzie and Banner (2001) include a physical or hydrogeomorphic component that describes broad hydrological processes and associated geomorphic forms for entire wetlands. At the broadest level of classification, *systems* group wetlands that have similar dominant water sources and hydrological processes and are characterized by particular physical forms. Six hydrogeomorphic systems include: *Upland*, *Palustrine*, *Lacustrine*, *Fluvial*, *Estuary* and *Marine* and these are further subdivided into *subsystems*, *elements* and *features*. Five of the systems (*Upland* excluded) correspond to the ecological *systems* defined in Cowardin et al. (1979).

The hydrogeomorphic component of the BC WREC system is useful for describing wetlands according to hydrological processes and physical forms. This physical classification provides addition information about environmental conditions that influence wetland water regimes and quality, biological communities, associated wildlife habitats, and ecosystem functioning. The hydrogeomorphic classification corresponds in part to the "hydrotopographyic character" of a wetland described in Runka and Lewis (1981), and to the "site type descriptor" in Golet and Larson (1974). The latter criteria describe the hydrologic and topographic locations of wetlands in the landscape. The hydrogeomorphic element unit in WREC also corresponds to the watershed position categories described by Millar (1976) for palustrine wetland systems.

Wetland *classes* in the Canadian Wetland Classification System (NWWG 1997) are further classified into wetland *forms* and *subforms* based on identification of physical features (e.g., surface relief, form and pattern, hydrological system, basin topography, landforms, and proximity to water bodies and other ecosystems). The Canadian system provides comprehensive keys for classifying the five wetland *classes* to the *form* and subform levels based on physical forms recognized on aerial photographs. These are further subdivided into *vegetation cover types* using vegetation physiognomic features. These types are recognizable on air photos, so the Canadian system provides a relatively simple way to classify and inventory wetland ecosystems over large geographic areas, without the need for detailed field assessments. It is therefore recommended that all three levels of the Canadian Wetland Classification System be used for the initial classification and inventory of wetlands in the CBFWCP area. *Meadow* and *Shrub-carr* site classes (MacKenzie and Banner 2001) not considered in the Canadian system can also be incorporated into the initial classification and inventory.

Other physical features that may be useful for evaluating wetland systems include water chemistry (i.e., salinity, pH) and wetland juxtaposition (Golet and Larson 1974). Field data on species composition of vegetation communities may be useful for indicating the average water salinity of wetlands (Millar 1976), and water quality parameters could also be measured in the field.

Classification of Wetland Systems

Wetlands often consist of mosaics or complexes of wetland components. Several of the classification systems reviewed discuss methods for classifying whole wetland systems, based on the naturally occurring patterns of wetland components. Millar (1976) introduces the concept of vegetation zone sequences, in which the zones form a gradient in response to increasing water depth and duration of flooding in a wetland basin. Since the greatest depth and duration of flooding occurs in the lowest portion of the basin, the vegetation occupying that area is the key to the wetlands' moisture regime. Based on this concept, the author uses vegetation zones occupying the central or lowest part of sampled wetlands to define eight wetland types in the study area. The basic wetland types represent entire wetland systems with repeatable patterns of normal vegetation zonation or sequences. Sequences of vegetation zones could be reduced to a numerical formula, by listing the code numbers of the various zones in the order in which they occur from the center or lowest point of the wetland to its' outer edge. In this way, the concepts of vegetation zone sequences and naming wetland types based on the central vegetation zones can facilitate classifying and mapping entire wetland systems. Abnormal patterns could also be documented using this process. A similar procedure can be used to identify wetland component sequences for wetland systems sampled in the CBFWCP area.

Moon and Selby (1982) developed a system for classifying entire wetland systems in the Cariboo-Chilcotin area based on the sequence in which wetland components occur, rather than on the components themselves. Wetland sequences were determined by evaluating the sequences of vegetation and soil components along a number of transects running from the hydrologic low of wetland basins to the wetland - upland transition boundaries. Diagnostic vegetation and soil sequences (n = 8 and 6, respectively) were used to define nine wetland systems based on the characteristic occurrences of sequences. These systems were given geographic names and all but one of the wetland systems were further subdivided into three map units based on dominance of the most central diagnostic component. Map symbols used to represent wetland systems also include codes to identify deviations in soil sequences, presence and nature of aquic (water) component, the water regime and the degree of interspersion of wetland components.

The system approach to classifying wetlands can be used to classify and map entire wetlands for broad scale inventories (Moon and Selby 1982). It is also useful for recognizing patterns and relationships among multiple components present in a wetland area that can be of importance to wildlife. Another strength of this system is that sequences of vegetation components based on physiognomy alone will classify most systems, without relying on soil components. This facilitates wetland mapping using remote sensing products. The authors concluded that air photo interpretation could provide all information required for the wetland system map symbols, with the exception of soil sequence deviations. The weakness of this classification system is that there is a loss of information about non-diagnostic vegetation and soil components and sequences from the component level of classification to the wetland system map label.

MacKenzie and Banner (2001) also discuss classification of entire wetland systems at the landscape level. The mosaic component of WREC provides a way to classify wetlands as landscape units by combining biological (site) and physical (hydrogeomorphic) components of the classification. The landscape units group mosaics or complexes of wetland ecosystems that occur as repeatable patterns of associated site units reflecting underlying hydrology and geomorphological processes of entire wetlands. Of the two types of landscape units proposed in the classification, the *Ecocomplex* describes repeatable spatial patterns of site units within a hydrogeomorphic unit at a broad level of classification. Therefore, integration of site (ecosystem) and hydrogeomorphic classifications within the *Ecocomplex* unit is useful for classifying and mapping entire wetland systems over large geographic areas. Hydrogeomorphic and mosaic component classifications within WREC are still in preparation.

Wetland systems can also be evaluated with respect to human use or disturbance. Millar (1976) lists a number of man-made alterations to a wetland or its' watershed that can affect water regimes, plant communities, and wildlife values. Runka and Lewis (1981) also include a list of *use modifiers* to describe alterations to wetland ecosystems as a result of land use practices. Wetland *use modifiers* should be identified for sampled wetland systems during the initial classification and inventory of the Columbia Basin area.

Descriptions of Wetland Classification Systems

National Wetland Classification Systems

1. The Canadian Wetland Classification System (2^{nd} edition) - National Wetlands Working Group (1997)

This recently revised classification replaces a report by the same title published in 1987 by the Canadian Wildlife Service, Environment Canada as Report No. 21 in the Ecological Land Classification Series. It is an ecologically based wetland classification system that is hierarchical in nature and recognizes three basic levels of classification including the wetland *class*, wetland *form* and wetland *type*.

Five wetland *classes* are recognized on the basis of properties of wetlands that reflect the overall genetic origin of the wetland ecosystem and the nature of the wetland environment. The five classes include *Bog, Fen, Swamp, Marsh* and *Shallow Water.*

Wetland *forms* are subdivisions of each *class* that are identified on the basis of surface form, surface pattern and surface relief, the hydrological system (source of water and mineral nutrients), basin topography, landforms, and proximity to water bodies, other wetland classes and upland habitats. Many of the wetland *forms* are included in more than one wetland *class.* Examples of wetland *forms* of the *Marsh class* include *Riparian Marsh* (confined to channels or linear drainage ways), *Lacustrine Marsh* (situated on the margins of permanent lakes), and *Basin Marsh* (confined to topographically defined small basins and shallow depressions). The wetland *form* is the basic unit used to inventory and map wetlands. Some wetland *forms* are further subdivided into *subforms* based on the same criteria used for differentiating wetland forms within classes. For example, the *Basin Marsh* wetland can be subdivided into *"Linked"*, *"Isolated"* or *"Discharge" Basin Marsh* on the basis of the hydrogeomorphic setting (hydrology and geomorphology). The classification system currently recognizes 49 wetland *forms* and 72 *subforms* and classification keys and definitions are provided for wetland *classes, forms* and *subforms*.

Wetland *types* are subdivisions of the wetland *forms* and *subforms* based on the general physiognomy (structure) of the vegetation cover. The classification system recognizes eight main vegetation cover types including *Aquatic, Forb, Graminoid, Lichen, Moss, Shrub, Treed* and *Non-vegetated*. Specific *wetland cover types* within some of the main types are also identified (e.g., specific *Graminoid* types *are Grass, Low Rush, Reed, Sedge* and *Tall Rush*). The specific *wetland cover types* when used in conjunction with wetland *forms* and *subforms* constitute the wetland *types*.

Information is also provided on the role of hydrology and water chemistry in the classification system as well as the hydrogeomorphic setting of the various wetland *classes, forms* and *subforms*.

This system could be useful for classifying and inventorying wetland types in the CBFWCP area. It is a relatively simple system that groups wetlands according to hydrological, physical and biotic features that are recognizable on remote sensing products. Using this system, wetland ecosystems can be classified at all three hierarchical levels (*class, form* and *type*) by means of air photo interpretation. In some situations, wetland *subforms* and specific wetland *cover types* may also be recognizable on air photos. In other cases, major vegetation cover types (e.g. "forb" and "graminoid" types) may need to be combined during the classification process. General information provided about vegetation cover is also useful for assessing potential wildlife use of wetland types. This national system can also be linked to more detailed regional and provincial wetland classification systems that are applicable in the CBFWCP study area.

<u>2. Classification of Wetlands and Deepwater Habitats of the United States</u> - Cowardin, L.M., V. Carter and E.T. LaRoe (1979)

This national wetland classification system for the U.S. also uses a hierarchical structure based on five levels of classification: *system, subsystem, class, subclass* and *dominance type.* The highest and most general level of the classification hierarchy is the *ecological system.* Systems group wetlands within a broad level of classification of wetland regimes, in which each regime shares the influence of similar hydrologic, geomorphologic, chemical and biological factors. There are five systems defined at this level including *Marine, Estuarine, Riverine, Lacustrine and Palustrine*. All but the *Palustrine* system are further subdivided into *subsystems* according to traditional ecological concepts. The classification system recognizes eight *subsystems* in the second level of the hierarchy. Examples include the *Tidal, Lower Perennial, Upper Perennial* and *Intermittent Subsystems* of the *Riverine System.*

Within the *subsystems*, eleven *classes* form the third level of the classification system. *Classes* are designed to be easily recognizable on air photos and are identified according to the general appearance of the wetland habitat. There are six *classes* based on substrate type and flooding regime for areas where vegetation cover is not considered dominant (i.e., <30%) and five *classes* based on life-forms of dominant vegetation. The eleven *classes* include *Rock Bottom, Unconsolidated Bottom, Rocky Shore, Unconsolidated Shore, Streambed, Reef, Aquatic Bed, Moss-lichen Wetland, Emergent Wetland, Scrub-shrub Wetland* and *Forest Wetland*. Each *class* may occur in more than one of the *systems* or *subsystems*. Keys to *systems* and *classes* are provided as a guide, and in some cases, *classes* are divided into *subclasses* (28 in total) that reflect finer differences in substrate material or vegetation life-forms. Examples of *subclasses* of the *Forested Wetland class* include *Broad-leaved Deciduous*, *Needle-leaf Deciduous", Broad-leaved Evergreen, Needle-leaved Evergreen,* and *Dead*.

Classes and *subclasses* are the most important levels of the classification system and form the basic units for wetland inventory and mapping. *Modifier terms* must also be applied to *classes* and *subclasses* to complete the classification at those levels. Essential *modifiers* include those for water regime, water chemistry and soils, and special modifiers are used to describe wetland types that are created or highly modified by humans or beavers.

The fifth and most detailed level of classification in the hierarchy is the *dominance type*. The *dominance type* is based on the dominant plant species or sedentary animals on a site and reflects specific environmental conditions including water regime and salinity. The classification is incomplete at this level of detail, as there are an unspecified number of types. *Dominance types* are specific to regions and must be identified by the user of the classification system at the regional level.

The U.S. classification system was designed for use over a wide geographic area with varying degrees of detail and by a variety of users. It is useful as a broad system of classification and is relatively simple and straightforward when used for a specific purpose at a regional level. Compared with the Canadian system, it provides (a) more information about the general hydrogeomorphic setting of wetlands at the *system* and *subsystem* levels, and (b) a more comprehensive classification of non-vegetated and sparsely vegetated wetland ecosystems. At the *class* and lower levels of the hierarchy, the U.S. system has limitations. In an attempt to avoid the use of wetland class terminology, it relies on more general terms for *classes* and *subclasses* in conjunction with *modifiers* to classify wetland ecosystems. In the Canadian system, those same ecosystems are grouped according to well- defined wetland class categories. The latter provide more specific information about genetic origin, water regime, water chemistry and physical appearance of the wetland components without the use of modifiers. For this reason, the Canadian system is simpler to use. Also, the U.S system is not as easily linked to regional and provincial classification systems that incorporate the wetland classes described in the Canadian system. Nevertheless, the general classes described in the U.S. system can be useful for naming wetland components that are sometimes difficult to classify into wetland classes using only the physical appearance of the vegetation on aerial photos.

The Canadian system also provides more detail about the vegetation cover of wetland units within the *wetland type* level of classification. The *class* and *subclass* levels of classification in the U.S. system lack information about vegetation life-forms that can be recognized on aerial photographs and used to facilitate classification, inventory and mapping of wetland units. For example, a *Palustrine Emergent Wetland class* in the U.S. system could correspond to a *Basin Marsh* or a *Basin Fen* in the Canadian system or a *Wet Meadow class* described in Canadian regional and BC wetland classification systems. The *Palustrine Persistent Emergent Wetland subclass* of the U.S. system could be dominated by cattail, bulrush, rush, sedge, reed, grass, or forb plant species. Further differentiation of that *subclass* would require identification of specific *dominance types* based on the dominant wetland plants found within a particular region. Within the Canadian and BC classification systems, the above mentioned *subclass* could be classified as a *Graminoid* or *Forb Basin Marsh, Basin Fen* or *Wet Meadow* wetland *type.* The *Graminoid* wetland *type* could also be further subdivided into *specific Graminoid types* such as *Tall Rush* or *Sedge* wetland *types*. In summary, the Canadian classification system provides more detail about the genesis, natural setting and vegetation cover of wetland ecosystems than the U.S. system at a similar hierarchical level of classification, without the requirement for modifiers or further work to identify dominant plant species within a regional setting.

U.S. Regional Wetland Classification Systems

3. Vegetation of Prairie Potholes, North Dakota, in Relation to Quality of Water and Other Environmental Factors - Stewart, R. E. and H. A. Kantrud (1972)

This system was developed to classify prairie pothole wetlands. It recognizes seven wetland ***classes*** that reflect the water regimes of the wetlands and that are distinguished by the vegetation zone occupying the central or deepest part of the depression and covering ≥5% of the wetland basin. Vegetation zones include *Wetland-low-prairie, Wet Meadow, Shallow Marsh, Deep Marsh, Intermittent-alkali, Permanent Open Water* and *Fen* (alkaline bog). The wetland *classes* are further subdivided into ***subclasses*** based on differences in plant species composition that correspond to ranges in salinity of surface water (i.e., *Saline, Subsaline, Brackish, Moderately Brackish, Slightly Brackish* and *Fresh*). The third component of the classification is the ***cover type***, which reflects differences in the spatial relation of emergent vegetation cover to open water or exposed substrate.

The concept of using the vegetation zone found in the lowest position in a basin to distinguish wetland *classes* is useful for classifying entire wetland systems. This classification also introduces the "wet meadow" *class* that could occur as a component of wetland systems within the CBFWCP study area. The six salinity *subclasses* that subdivide wetland *classes* and provide more detailed information about wetland habitats are based on differences in plant species composition that may be recognizable on remote sensing products (i.e. aerial photographs or satellite imagery). The *cover type* classification component categorizes the density and distribution of emergent vegetation within *classes*. *Cover type* categories provide important information with respect to habitat features and associated wildlife.

4. Classification of Freshwater Wetlands in the Glaciated Northeast U.S. - Golet, F.C. and J.S. Larson (1974)

Wetland features that influence the presence and abundance of many wildlife species are components of this classification system. The system employs vegetation physiognomy (life-forms) rather than species composition to describe wildlife habitat in freshwater wetlands of the region. Five vegetation *life-forms* that differ significantly in wildlife value are recognized. Eighteen life-*subforms* that reflect differences in structure, ecology and density are used to recognize differences in wildlife habitat value among vegetation subgroups belonging to the same *life-form*. The classification includes descriptions of each *life-form* and *subform*, with examples of characteristic wetland genera and species for each description.

Eight *wetland classes* are recognized in this system including *Seasonally Flooded Flats, Fresh Meadow (Fen), Shallow Marsh, Deep Marsh, Open wWater, Shrub Swamp, Wooded Swamp* and *Bog*. On the basis of finer differences in plant *life-forms*, *classes* are divided into twenty-four *subclasses* that differ significantly in their wildlife value, due to differences in dominant *subforms* of vegetation. The classification includes a list of *classes* and *subclasses* and their importance to wildlife species.

Wetlands are also classified according to five *size classes* and six wetland *site types*. The *site type* describes a wetland's hydrologic and topographic location in the landscape. Wetlands are further classified using eight *cover types* (modified after Stewart and Kantrud, 1972) which express the distribution and relative proportions of vegetation cover and water, three *vegetative interspersion types*, and six *surrounding habitat types*. These components of the classification system represent the most important ecological features that determine a wetlands' broad wildlife value. Additional descriptive components include *wetland juxtaposition* and *water chemistry*.

This classification system includes several important concepts that could be applied to classifying and inventorying wetlands in the BC Columbia Basin. It focuses on recognizing unique wildlife habitats of freshwater wetlands based on differences in vegetation *life-forms*. A total of 18 different plant groupings are described using vegetation characteristics that are important for identifying wildlife habitat and use.

Wetland classes in this system are compatible to those used in the Canadian wetland classification system as well as in other Canadian regional and BC classification schemes. The classification also introduces wetland *size classes* and *site types* as criteria for classifying wetlands. The *site type* descriptor is important for providing information about a wetlands' water regime and hence its' attractiveness to wildlife species. The system utilizes vegetation *cover types* and introduces the use *of vegetation interspersion* and *surrounding habitat types*; these three criteria can have a significant influence on the overall value of a wetland for wildlife (Findlay and Houlahan 1997; Munger et al. 1997; Semlitsch 1998; Semlitsch and Bodie 1998; Joyal et al. 2001). In summary, this classification system is one of the most comprehensive for describing wildlife habitat suitability of wetland types using vegetation features that can be recognized on remote sensing products.

Canadian Regional Wetland Classification System

<u>5. Wetland Classification in Western Canada</u> - Millar, J.B. (1976)

This system was developed to classify wetlands of the western Canadian prairies. The classification is based on vegetation and physical features of 103 wetlands at 3 locations in the grassland and aspen parkland regions of Saskatchewan. Many of the criteria used to evaluate wetlands in this system are closely related to those of Stewart and Kantrud (1972).

Wetland vegetation is grouped into seven categories or *vegetation zones* (i.e., *Wet Meadow, Shallow Marsh, Emergent Deep Marsh, Transitional Open Water, Shallow Open Water (SOW), Open Alkali* and *Disturbed*) according to species composition, stability and overall physical appearance. The first five zones form a gradient in response to increasing water depth and duration of flooding. The *Open Alkali* zone reflects extreme salinity while the "disturbed" zone reflects anthropogenic or natural disturbances.

The greatest depth and duration of flooding in a wetland occurs in the lowest portion of the topographic depression and the vegetation occupying that area is the key to interpreting the wetland's moisture regime. Based on this concept, eight basic *wetland types* are defined in terms of the vegetation zone occupying the central or lowest part of the wetland, with one exception. Wetlands with a SOW zone are divided into two types: the "SOW" wetland type has a SOW zone occupying >75% of the wetland's diameter and >56% of its' area, while the "transitional open water" type has a SOW zone occupying less than that diameter and area of the wetland. The *Disturbed* wetland type is further classified according to the type of disturbance (i.e., *Cultivated, Grazed* and *Drawdown).*

As well as identifying *vegetation zones* and *wetland types*, this classification system describes various ways that vegetation can be used to evaluate the water regime, relative stability and wildlife habitat potential of a wetland. Vegetation criteria for evaluation include: (a) the proportion of the wetland occupied by the central vegetation zone, (b) the relative density of emergent vegetation cover in the central vegetation zone and the reason for that density category, (c) the extent of the cover density category, and (d) the pattern or sequence of vegetation zones in the wetland.

Vegetation is also used to interpret a wetlands' *relative salinity* (*Fresh, Moderately Saline, Saline* and *Hypersaline).* As most plant species tolerate a specific range in salinity, plant associations can be used to indicate average salinity conditions in wetlands. The identification of dominant plant species can provide further information about a wetland's current moisture regime and recent history of disturbance.

This system uses physical features such as w*etland size, basin depth* and *position in a watershed* (*Isolated, Overflow, Channel* and *Terminal*) as classification criteria. The final coding for each wetland includes information on central vegetation zone and wetland type, extent and density of central vegetation cover, vegetation sequence, relative salinity, wetland size class, basin depth and watershed position. Information is also provided on wetland and watershed alterations.

The strength of this system of classification is that it utilizes both vegetation and physical characteristics to classify wetlands. Vegetation descriptions based on the type, extent and density of vegetation cover, the sequence of vegetation zones, and dominant plant species provide information about a wetlands' moisture regime, relative stability and salinity, and suitability for wildlife species. Vegetation zones can be identified by physical appearance on remote sensing products and wet meadow, marsh and open water zones can be correlated to wetland (site) classes described in the Canadian and BC classification systems.

The concepts of vegetation zone sequences and naming types of wetlands based on the central vegetation zones within basins are useful for classifying and mapping entire wetlands rather than wetland components (i.e., classes, subclasses, forms, subforms or vegetation types). Describing the topographic position of a wetland within a watershed is also a useful feature of the classification because of the importance of position with respect to water regime and water chemistry that both influence vegetation patterns and associated wildlife habitats. The watershed position of a wetland can be determined using map and air photo interpretation. Wetland and watershed alteration categories described in the report could also be used to evaluate wetland disturbances in the CBFWCP study area.

Provincial (B.C.) Wetland Classification System

6. A Classification Framework for Wetlands and Related Ecosystems in British Columbia: A Third Approximation - MacKenzie, W.H. and A. Banner (2001)

This system being developed by the province of BC is termed the "Wetland and Riparian Ecosystem Classification" project, or WREC. It is an ecologically based classification with a hierarchical framework and incorporates wetland units and concepts from existing classifications and introduces several new concepts. The aim of this system is to provide a wetland site classification that is compatible with the existing biogeoclimatic ecosystem classification (BEC) as well as a landscape unit classification based on hydrological systems and geomorphological patterns. WREC incorporates an ecosystem site component, a hydrogeomorphic component, and a mosaic component into a hierarchical structure.

The site association of BEC is the basic working unit that represents a homogeneous site within a wetland system. Site association units are grouped into ecosystem classes that have broadly similar ecological properties of hydrology, soils and vegetation physiognomy (structure). The five wetland site *classes* (*Bogs, Fens, Marshes, Swamps and Shallow Open Water*) are comparable to those of the Canadian wetland classification system, and are useful for broad scale inventory and mapping. Site *classes* are further grouped into *ecosystem groups* and *ecosystem realms* (Table A1). This classification system also recognizes site associations and site classes that are related to wetland ecosystems and grouped within the *Flood* and *Wetland-terrestrial Transition* ecosystem group of the terrestrial realm. Four ecosystem *classes* in the flood ecosystem group include *High Bench, Mid Bench, Low Bench* and *Active Channel* classes. The *Shrub-carr, Graminoid Meadow* and *Forb Meadow* are the three site *classes* of the transition ecosystem group.

Table 17. (a) Wetlands and related ecosystems in the wetland and terrestrial ecosystem realms and (b) wetland subsystems of selected systems defined in WREC (MacKenzie and Banner 2001).

(a)

Ecosystem Realm	**Ecosystem Group**	**Ecosystem Class**
Wetland	Peatland	Bog Fen
	Mineral	Swamp Marsh Shallow Water
Terrestrial	Flood	High Bench Mid Bench Low Bench Active Channel
	Transition	Shrub-carr Graminoid Meadow Forb Meadow

(b)

System	**SubSystem**
Palustrine	Basin Slope Pond
Fluvial	Alluvial Transport Headwater
Lacustrine	Anthropogenic Littoral Deepwater
Estuary Marine Upland	

The hydrogeomorphic component is the physical component of the classification system. It describes broad hydrological processes and associated geomorphic forms for entire wetlands and is used to group landscape units that consist of complexes of associated wetland ecosystems. The hydrogeomorphic component contains four levels within the hierarchical framework including *system, subsystem, element* and *feature*.

At the broadest level, *systems* group areas that share the influence of similar dominant water source(s) and hydrological processes and are characterized by particular wetland physical forms. Six are recognized in this classification: *Upland, Palustrine, Lacustrine, Fluvial, Estuary* and *Marine*. The *subsystem* specifies broad geomorphic groups within a *system* by combining geomorphic elements with broadly similar hydrological processes. Elements are grouped using features such as river bottom reaches for fluvial systems and basin form, slope, presence of open water, and hydrological linkages for palustrine systems.

Hydrogeomorphic *elements* represent complex geomorphological landscape units that reflect glacial deposition patterns, active hydrological processes or underlying hydrological gradients. The *element* groups repeatable spatial patterns within wetland systems such as zonation, floodplain patterns and landforms. Vegetation characteristics such as zonation patterns provide clues to underlying soils or hydrological gradients and may be used to describe the hydrogeomorphic element. The *element* level of classification is useful for mapping and inventory work. The *feature* is a geomorphological unit that describes a simple landform or position within a larger complex landform (i.e., element). Examples of *elements* of selected *subsystems* and *features* typical of some *elements* are included in the classification framework report.

The Mosaic component of WREC brings together the biological (ecosystem) and physical (hydrogeomorphic) components of the system to produce predictable landscape units. The landscape units represent wetland ecosystem complexes that occur as repeatable patterns of associated site units and reflect underlying hydrological gradients and geomorphological processes.

The landscape units provide an important tool for describing, classifying and mapping wetland ecosystem complexes within a larger landscape framework. Landscape units are named according to the hydrogeomorphic component and the leading or diagnostic site association, site class or site group. To date, landscape units have not been described in the classification.

At present, this classification system is still in draft form. However, it has the potential to provide a high level of detail for classifying wetlands in the BC portion of the Columbia Basin. Site associations, the basic working unit of the classification, are useful for accurately classifying wetland ecosystems in the field, but for the most part, cannot be identified using remote sensing tools. However, the classification system groups site associations into site *classes* that can be recognized on air photos or satellite imagery and that correspond to wetland classes described in other classifications applicable to the CBPWCP study area. This classification also recognizes distinct site associations and classes related to wetland ecosystems. They include units associated with flood sites (i.e. active fluvial terraces and channels) and those on sites transitional between wetland and terrestrial systems (i.e., meadows and shrub-carrs).

The hydrogeomorphic component of the classification is useful for describing wetlands in the context of hydrological processes and geomorphology (physical forms). By profiling the hydrogeomorphic environment of wetland ecosystems, important information is provided about ecosystem structure, composition and functioning, and the influence of environmental conditions on a wetlands' water regime, biological communities and associated wildlife habitats.

The hydrogeomorphic system in this classification corresponds to the ecological system described in Cowardin et al. (1979). The hydrogeomorphic subsystem and element groupings also correspond in part to the hydrotopographic character described in Runka and Lewis (1981), to the wetland site type descriptor in Golet and Larson (1974) and the watershed position categories described by Millar (1976).

The mosaic component provides a means for classifying wetlands as landscape units by combining biological and physical components of the classification. The resulting landscape units are broad, integrative ecological units that group repeating complexes of wetland ecosystems at the landscape level. Integration of site and hydrogeomorphic classifications will facilitate assessment and characterization of landscape units from aerial photos and broad scale inventory and mapping of entire wetland systems over large areas. Potential "eco-complexes" of the WREC system may correspond to some of the wetland form ecosystem units described in the Canadian wetland classification system (NWWG 1997).

B.C. Regional Wetland Classification Systems

<u>7. Preliminary Wetland Manager's Manual: Cariboo Resource Management Region</u> (1st edition). APD Technical Paper 5 - Runka, G.G. and T. Lewis (1981)

This manual is the first attempt at developing a rational, practical, management-oriented approach to classifying, allocating, using, and managing wetlands in the Cariboo-Chilcotin region of BC. The first section of the manual deals with classification of wetlands and the second, with wetland use and management. The wetland classification is intended to be simplistic yet technical enough to accommodate the major integrated management decision-making needs within the region. The classification is hierarchical and comprises four levels: *wetland class, subclass, variant and plant association*. Wetland classes represent specific hydrologic-chemical environments and reflect wetland genesis. Seven wetland *classes* are described in the classification: *Shallow Open Water (SOW), Marshes, Fens, Bogs, Swamps, Shrub-carrs* and *Meadows*. Wetland subclasses are based on finer divisions of water chemistry for the SOW class, water regime (shallow or deep water depth) for marshes, or substrate (mineral, organic or type of organic) for the other classes. Wetland variants reflects differences in vegetation physiognomy (shrub or treed) for the swamp *class*, and further differences in water chemistry and substrate criteria for all other *classes*.

The wetland plant association divides wetland variants on the basis of relatively stable, self-perpetuating wetland plant communities and dominant cover types specific to a biogeoclimatic zone. Dominant cover types identified in the classification include *Graminoid* (mixture of grasses, sedges and/or low rushes), *Sedge, Tule* (bulrushes), *Cattail, Equisetum* (horsetails), *Low Shrub, Tall Shrub, Treed, Sphagnum* (mosses), *Moss* (non-sphagnum mosses), *Floating Aquatic, Submerged Aquatic* and *Non-vegetated*.

Four wetland modifiers, while not part of the taxonomic classification, provide additional information useful for ecosystem analysis and use interpretation. The physical form modifier describes the following wetland form features that are not considered a direct function of wetland genesis or diagnostic of wetland character: *Sloped, Ribbed* (including reticulate), *Hummocky, Channeled and Pond* (interspersed small ponds of water within a wetland class). Wetland position modifiers indicate the relative location of a wetland unit with respect to other wetland components and include *Central, Intermediate, Peripheral, Peripheral/Shore* (surrounding a lake), *Island, Fingered* or *Specified Other*. The wetland hydrotopographic character modifier reflects the local physiographic setting or topographic position and implies the character of the landscape from which the wetland receives surface or ground water. Six hydrotopographic characters are relevant to wetland formation: *Palustrine, Lacustrine, Riverine, Seepage Slope, Estuarine* and *Marine*. *Palustrine* and *lacustrine* categories are further divided into a number of basin types: *Closed Basin, Overflow basin, Linked Basin, Terminal Basin* and *Lowland Palustrine on Extensive Subdued Topography*. The *Riverine* hydrotopographic character is subdivided *into Floodplain Riverine* for wetlands bordering rivers and *Stream Riverine* for wetlands bordering streams. Twelve use modifiers are used to further describe wetland ecosystems that have been altered as a result of past or current land use practices.

This system includes some useful concepts and criteria for classifying wetlands that could by applied to the CBFWCP study area. Five of the seven wetland *classes* described correspond to classes identified in the Canadian wetland classification system and other regional and provincial classifications. The meadow and shrub-carr classes correspond to those in the BC WREC system, although MacKenzie and Banner (2001) consider them transitional terrestrial site classes, rather than wetland classes.

One of the limitations of this classification is that it subdivides wetland *classes* into *subclasses* and *variants* based on criteria such as substrate type and water quality that are not discernable using air photo interpretation. Vegetation is considered a more detailed criterion for classifying wetlands and not utilized until the lowest level of the classification hierarchy to differentiate wetland components. The dominant cover types included in this system correspond closely to those identified in the Canadian wetland classification system.

The classification uses a number of wetland modifiers to provide additional information that is useful for describing and interpreting wetland ecosystems. The form modifiers correspond to wetland form features identified in the form and subform level of classification in the Canadian system. The wetland position modifier describes the juxtaposition of a wetland ecosystem with respect to other wetland components and could be an important criterion when interpreting wildlife habitat use of wetlands.

The *hydrotopographic character modifier* is important for describing the physiographic setting of a wetland that influences the water regime and associated vegetation. The main hydrotopographic character categories correspond to ecological systems in Cowardin et al (1979), and to hydrogeomorphic systems in MacKenzie and Banner (2001). Further subdivisions of hydrotopographic character correspond to hydrogeomorphic *subsystems* and *elements* in MacKenzie and Banner (2001), wetland *form* and *subform* categories in NWWG (1997), wetland *site types* in Golet and Larson (1974), and *wetland position* categories in Millar (1976). The wetland use modifier may be useful for indicating impacts to wildlife habitat due to land use practices.

8. Wetland Systems of the Cariboo-Chilcotin Region, B.C. - Moon, D.E. and C.J. Selby (1982)

This system developed for the Cariboo-Chilcotin area of BC provides a way to classify and inventory entire wetland systems. A wetland system is defined as a diagnostic association and sequence of wetland components or classes. The classification is based on the sequence in which wetland components occur in a wetland system, rather than on the wetland components themselves. Wetland map units are defined using three levels of integration. For Level 1, areas of uniform soil and vegetation characteristics are grouped into soil and vegetation components.

Wetland components (level 1) include both vegetation components and soil components. The vegetation components represent plant communities grouped into eleven physiognomic classes, of which seven are considered diagnostic. Each physiognomic class occupies a distinct position in a hydro-topographic sequence within the wetland system. The eleven vegetation components are listed from wettest to driest sites and include *Aquatic, Non-sphagnum Moss, Cattail, Bulrush, Horsetail, Emergent Grass, Spike-rush, Sedge, Shrub-sedge, Water Tolerant Grasses and Forbs,* and *Shrub – Water Tolerant Grasses and Forbs*. None of the wetland systems surveyed contain all eleven vegetation components. The following soil components are defined on the basis of important soil variables that are strongly correlated to vegetation patterns: *Sedimentary, Floating or Supersaturated, Organic, Peaty-gleysol, Humic-gleysol* and *mineral.*

Wetland sequences (level 2) are defined by the sequence of vegetation and soil components occurring on a transect running from the hydrologic low of the system to the wetland-upland boundary. The characterization of a wetland system requires the description of all sequences found in the system. Eight vegetation sequences and six soil sequences were used to classify nine wetland systems; the nine systems classified 99% of the wetlands sampled in the Cariboo-Chilcotin area. While both vegetation and soil sequences are diagnostic, vegetation sequences alone correctly classified >80%, due to the strong correlation between the two. Therefore reliable mapping of wetland systems based on vegetation patterns alone is possible and facilitates wetland mapping using remote sensing techniques.

Wetland systems identified in the study area were grouped to form wetland map units (level 3). All but one of nine wetland systems were subdivided into three map units based on the relative dominance of the most central diagnostic component (i.e., diagnostic component occupies >50%, 20-50% or <20% of the wetland).

Modifiers were used to describe other wetland characteristics not accounted for in the wetland system and map unit. The latter include presence and nature of aquic components, water regime, and degree of interspersion (from Golet and Larson 1974), which are represented by letters in the wetland map unit symbols.

This classification attempts to characterize whole wetland systems based on naturally occurring sequences of vegetation and soil components, and it is useful for classifying and mapping entire wetlands for broad scale inventories. A wetland system inventory recognizes the patterns of components present in a wetland and their interrelationships; it provides more information than compiling a list of classes/ecological attributes or identifying the dominant class in a wetland complex. Furthermore, sequences of vegetation components based on physiognomy (structure) can classify most wetland systems without relying on soil components. This facilitates mapping of wetlands using remote sensing products. Therefore this system is applicable to the initial classification and inventory of wetlands in the CBFWCP area using air photo interpretation and GIS mapping.

One of the limitations of the system is that there is a loss of information from the component level of classification to the wetland system map label. Since all components in a sequence are not diagnostic and not all sequences in a wetland system are diagnostic, information about non-diagnostic components and sequences is lost in the final map unit symbol (Mayall 1983). Also, some wetland sequences that occur naturally in the Cariboo-Chilcotin area were not identified in the classification system indicating that naturally occurring wetland sequences that are rare or uncommon could be overlooked.

9. Classification and Mapping of U.S. Wildlife Habitat Types in the Columbia River Basin of British Columbia - Ketcheson, M.V., D. Mack and C. Littlewood (2001)

This initiative classified and mapped a number of U.S. wildlife habitat types in the BC portion of the Columbia Basin using BC forest cover, topographic (TRIM) digital data, and GIS techniques to manipulate the data. Four wetland habitat types were defined, including *Open Water (lakes, rivers and streams), Herbaceous Wetlands, Montane Coniferous Wetlands,* and *Eastside Interior Riparian Wetlands*.

The *Open Water* habitat type is identified as all forest cover polygons and TRIM features designated as “lake or river”. This type includes shallow open water (SOW) recognized in many wetland classification systems, as well as deepwater habitats of ponds, lakes and reservoirs.

The *Herbaceous Wetland* habitat type includes any forest cover polygons designated as *Swamp* or *Meadow* in all biogeoclimatic subzones (except the alpine tundra and subalpine ESSF parkland), and any TRIM features designated as *Marsh*. This type represents emergent graminoid plant associations in deep or shallow water that may contain floating or rooted aquatic forbs. The habitat type comprises several wetland classes including graminoid-dominated marshes, fens and wet meadows. Small areas of SOW and patches of low shrub-dominated fen may also be included in this type.

The *Montane Coniferous Wetlands* habitat type includes any forested sites on gentle slopes (<25%) adjacent (within 65 m) to a lake, marsh, river or stream or within 35 m of an intermittent river or stream. It also includes any forest cover polygon designated as NPBr (non-productive brush) using the same adjacency criteria as for forested sites. This type represents forest or woodland dominated by conifers with deciduous trees occasionally dominant. Many of the sites are seasonally or temporarily flooded and following disturbance, tall shrubs may dominate this habitat for some time. The habitat type can include coniferous treed swamp, shrub swamp and possibly open treed bog wetland types recognized in other classification systems. The type would also include high bench and mid bench site classes of the terrestrial flood group identified in the BC wetland classification (MacKenzie and Banner 2001).

The *Eastside Interior Riparian Wetlands* habitat type includes any forested sites in which leading or co-dominant species are black cottonwood, trembling aspen, or other deciduous trees, and with the same slope and adjacency criteria as for the *Montane Coniferous Wetlands*. This type also includes forest cover polygons designated as NPBr within the dry, low elevation Bunchgrass (BG), Ponderosa Pine (PP) and Interior Douglas fir (IDF) biogeoclimatic subzones, with the above mentioned adjacency criteria. All riparian habitats consisting of a mosaic of forest, woodland and shrubland patches along rivers, streams, lakes and ponds are included in this category. This habitat type can include deciduous treed swamp, shrub swamp or shrub meadow (shrub-carr) wetland ecosystems. It can also include Low and *Mid Bench* ecosystem *site classes* of the *Terrestrial Flood group* recognized by MacKenzie and Banner (2001).

The report provides a methodology for classifying and mapping wildlife habitats using existing digital data and GIS techniques. The U.S. habitat types (and in particular the wetland habitat types) are extremely general, but nevertheless of some use for a broad scale inventory of wildlife habitats found in in BC. The strength of this system is that the *habitat types* are linked to a peer-reviewed access database that provides very detailed information pertaining to the *habitat elements* and *structural conditions* required by individual wildlife species. By querying the database by wetland habitat type or habitat element, the wildlife species (as well as their key ecological functions and life histories) and their structural requirements (based on vegetation physiognomy and structural stage) can be determined. However, other wetland classification systems provide much more detail for classifying and inventorying wetland habitats (components or classes) using remote sensing products, and are therefore more useful for identifying the variety of wetland habitats in the study area.

<u>10. Wetlands and Related Ecosystems of Interior British Columbia</u> - MacKenzie, W. and J. Shaw (2000)

This guide is a work in progress that describes common wetland, floodplain and transitional ecosystems of the interior regions of BC. It uses the site association unit of BEC system to describe sites with similar indicator plant species groups. At a more general functional scale, the site is used to define groups of site associations with broadly similar ecological characteristics. The site class classification is adopted from the wetland class concept of the Canadian wetland classification system (NNWG 1997) and expanded to include other ecosystems related to wetlands. The broader classification framework on which this guide is based is described in MacKenzie and Banner (2001).

The bulk of the guide consists of one-page fact sheets describing site associations grouped according to wetland classes. The guide also includes an introductory section and tools to help identify site units such as keys, indicator species lists and comparison tables. Dichotomous keys and vegetation prominence tables are provided for identification of wetland (site) classes as well as site associations.

The guide provides ecological information for recognizing different wetland ecosystems that have been identified to date in the interior of the province. Therefore, it is applicable for classifying and inventorying wetlands in the Columbia Basin of BC and will be most useful for describing wetland ecosystems units in the field. Site associations have been grouped according to wetland classes in the guide, so that detailed site classification can be linked to higher levels of classification described in MacKenzie and Banner (2001) and NWWG (1997).

APPENDIX 2: Data Form Used For Air Photo Interpretation

Area	Air Photo		Wetland System			Wetland Component		Ecosystem Site Classification							Vegetation Features						Physical Features							Wetland System Classification				Wetland Use Modifier[16] (Disturbance)	Comments
	Number	Scale						Realm	Group	Wetland (Site) Class		BEC System			Vegetation Cover Types			Component Position Modifier[5]	Inter-spersion Type[6]	Surrounding Habitat Type(s)[7]	Hydrogeomorphic Classification[8] (Hydrotopographic Character)			Wetland Form /*Subform*[9]	Water Chemistry[10]		Wetland Juxta-position[11]	Central (diagnostic)[12] Wetland Component	Dominance (Extent)[13] of Central Component (% of wetland area)	Wetland Component Zonation Patterns[14] (Sequence(s))	Landscape Unit[15] (Ecocomplex)		
			I.D. No.	Size (ha)	Size Class[1]	I.D. No.	Percent (%) of System			General	Specific	Subzone/ Variant	Site Association	Site Series	Physiognomy[3] General	Physiognomy[3] Specific	Distribution & Density[4]				System	Subsystem	Element		Salinity Class	pH							

APPENDIX 3: Vertebrates Associated with Wetlands in the CBFWCP Area

The CDC status (Red = red-listed; Blue = blue-listed), COSEWIC status (DD = data deficient; E = endangered; NAR = evaluated and not at risk; NE = not evaluated; SC = special concern; T = threatened), level of wetland habitat association (A = associated; C = closely associated; P = present; N = no apparent association), and type of wetland association (B = breeding and feeding; F = feeding only) for 175 terrestrial vertebrate species in the CBFWCP area associated with wetland habitat elements (Steeger et al. 2001).

Vertebrate Species Common Name	CDC Status	COSEWIC Status	Level of Wetland Association	Type of Wetland Association
AMPHIBIANS				
Bullfrog	-	NE	-	-
Columbia Spotted Frog	-	NAR	C	B
Long-toed Salamander	-	-	C	B
Northern Leopard Frog	Red	E	C	B
Pacific Tree Frog	-	-	C	B
Western Toad	-	-	C	B
Wood Frog	-	-	C	B
REPTILES				
Common Garter Snake	-	-	C	B
Painted Turtle	Blue	NE	C	F
Western Terrestrial Garter Snake	-	-	A	B
BIRDS				
Alder Flycatcher	-	-	A	B
American Avocet	Red	NE	A	B
American Bittern	Blue	NE	C	B
American Coot	-	-	C	B
American Crow	-	-	A	B
American Redstart	-	-	C	B
American Tree Sparrow	-	-	A	F
American White Pelican	Red	NAR	A	F
American Wigeon	-	-	C	B
Baird's Sandpiper	-	-	C	F
Bald Eagle	-	-	C	B
Bank Swallow	-	-	C	B
Barn Owl	Blue	SC	A	B
Barrow's Goldeneye	-	-	A	F
Black Tern	-	-	C	B
Black-billed Magpie	-	-	C	B
Black-capped Chickadee	-	-	C	B
Black-crowned Night-heron	-	-	P	B
Blackpoll Warbler	-	-	A	F
Blue Grouse	-	-	C	B
Blue-winged Teal	-	-	C	B
Bobolink	Blue	NE	P	B
Bonaparte's Gull	-	-	C	F
Bufflehead	-	-	C	B
California Gull	Blue	NE	A	B
Calliope Hummingbird	-	-	A	B

Vertebrate Species Common Name	CDC Status	COSEWIC Status	Level of Wetland Association	Type of Wetland Association
Canada Goose	-	-	C	B
Canvasback	-	-	C	B
Caspian Tern	Blue	NAR	A	F
Cinnamon Teal	-	-	C	B
Cliff Swallow	-	-	C	B
Common Goldeneye	-	-	A	B
Common Redpoll	-	-		
Common Snipe	-	-	A	F
Common Yellowthroat	-	-	C	B
Cooper's Hawk	-	-	A	B
Double-crested Cormorant	Red	NAR	P	F
Dunlin	-	-	A	F
Eared Grebe	-	-	C	B
Eastern Kingbird	-	-	C	B
Eurasian Wigeon	-	-	P	F
Forster's Tern	Red	DD	C	B
Fox Sparrow	-	-	P	F
Franklin's Gull	-	-	A	F
Gadwall	-	-	C	B
Great Blue Heron (*ssp. herodias*)	Blue	NE	C	B
Great Gray Owl	-	-	A	B
Great Horned Owl	-	-	A	B
Greater White-fronted Goose	-	-	C	F
Greater Yellowlegs	-	-	C	F
Green-winged Teal	-	-	C	B
Gyrfalcon	Blue	NAR	A	F
Herring Gull	-	-	A	F
Hooded Merganser	-	-	C	B
Horned Grebe	-	-	C	B
Killdeer	-	-	A	B
Least Sandpiper	-	-	C	F
Lesser Scaup	-	-	C	B
Lesser Yellowlegs	-	-	C	F
Lincoln's Sparrow	-	-	C	B
Long-billed Curlew	Blue	SC	-	-
Long-billed Dowitcher	-	-	C	F
Long-tailed Duck	Blue	NE	P	F
Magnolia Warbler	-	-	A	B
Mallard	-	-	C	B
Marsh Wren	-	-	C	B
Merlin	-	-	A	F
Mew Gull	-	-	C	F
Northern Goshawk	-	-	A	B
Northern Harrier	-	-	C	B
Northern Hawk Owl	-	-	A	B
Northern Pintail	-	-	C	B
Northern Rough-winged Swallow	-	-	C	B
Northern Saw-whet Owl	-	-	A	B
Northern Shoveler	-	-	C	B

Vertebrate Species Common Name	**CDC Status**	**COSEWIC Status**	**Level of Wetland Association**	**Type of Wetland Association**
Northern Shrike	-	-	P	F
Northern Waterthrush	-	-	C	B
Olive-sided Flycatcher	-	-	C	B
Pectoral Sandpiper	-	-	C	F
Peregrine Falcon (*ssp. anatum*)	Red	SC	A	B
Pied-billed Grebe	-	-	C	B
Redhead	-	-	C	B
Red-naped Sapsucker	-	-	C	B
Red-necked Grebe	-	-	C	B
Red-tailed Hawk	-	-	A	B
Red-winged Blackbird	-	-	C	B
Ring-billed Gull	-	-	A	F
Ring-necked Duck	-	-	A	B
Ring-necked Pheasant	-	-	C	B
Ross's Goose	-	-	P	F
Rough-legged Hawk	-	-	A	F
Ruddy Duck	-	-	C	B
Ruffed Grouse	-	-	C	B
Rusty Blackbird	-	-	C	B
Sandhill Crane	Blue	NAR	C	B
Semipalmated Sandpiper	-	-	P	F
Sharp-shinned Hawk	-	-	A	B
Short-eared Owl	Blue	SC	C	B
Snow Goose	-	-	A	F
Solitary Sandpiper	-	-	C	B
Song Sparrow	-	-	A	B
Sora	-	-	C	B
Spotted Sandpiper	-	-	C	B
Spruce Grouse	-	-	A	B
Stilt Sandpiper	-	-	P	F
Surf Scoter	-	-		
Tree Swallow	-	-	C	B
Trumpeter Swan	-	-	A	F
Tundra Swan	-	-	C	F
Violet-green Swallow	-	-	A	B
Virginia Rail	-	-	C	B
Western Grebe	Red	NE	C	B
Western Sandpiper	-	-	C	F
Western Screech-owl (*ssp. macfarlanei*)	Red	SC	C	B
White-tailed Ptarmigan	-	-	N	
Wilson's Phalarope	-	-	C	B
Wood Duck	-	-	C	B
Yellow-breasted Chat	Red	E	C	B
Yellow-headed Blackbird	-	-	C	B
MAMMALS				
American Marten	-	-	A	B
Beaver	-	-	C	B
Big Brown Bat	-	-	C	B
Black Bear	-	-	A	B

Vertebrate Species Common Name	**CDC Status**	**COSEWIC Status**	**Level of Wetland Association**	**Type of Wetland Association**
California Myotis	-	-	A	B
Caribou (*southern population*)	Red	T	A	B
Coyote	-	-	A	B
Dusky Shrew	-	-	P	B
Elk	-	-	A	B
Fisher	Red	NE	A	B
Fringed Myotis	Blue	SC	A	B
Gray Wolf	-	-	A	B
Grizzly Bear	Blue	NE	C	F
Heather Vole	-	-	P	B
Hoary Bat	-	-	A	B
Little Brown Myotis	-	-	A	B
Long-legged Myotis	-	-	C	B
Long-tailed Vole	-	-	C	B
Meadow Jumping Mouse	-	-	P	B
Meadow Vole	-	-	C	B
Mink	-	-	C	B
Montane Vole	-	-	C	B
Moose	-	-	C	B
Mule Deer	-	-	A	B
Muskrat	-	-	C	B
Northern Bog Lemming		-	C	B
Northern Long-eared Myotis	Blue	NE	C	B
Northern Pocket Gopher (*ssp. segregatus only*)	Red	NE	P	B
Northern River Otter	-	-	C	B
Pacific Jumping Mouse	-	-	C	B
Pygmy Shrew	-	-	-	-
Raccoon	-	-	C	B
Red Fox	-	-	A	B
Shrew-mole	-	-	A	B
Silver-haired Bat	-	-	A	B
Striped Skunk	-	-	A	B
Townsend's Big-eared Bat	Blue	NE	C	F
Vagrant Shrew	-	-	A	B
Water Shrew	-	-	C	B
Western Harvest Mouse	-	-	C	B
Western Jumping Mouse	-	-	C	B
Western Long-eared Myotis	-	-	A	B
White-tailed Deer	-	-	C	B
Wolverine	Blue	SC	A	F
Yellow-pine Chipmunk	-	-	A	B
Yuma Myotis	-	-	C	B
Total no. species	**-**		**-**	**175**
No. listed species/subspecies	**16 Blue/12 Red**	**1 DD/2 E/6 NAR/ 2 NE/7 SC/1 T**	**97 C / 58 A / 14 P**	**28**

APPENDIX 4: Wetland Habitat Element Requirements of 97 Species Closely Associated With Wetlands

Key to Wetland, Water, River, Stream, Lake, Pond and Reservoir Habitat Elements:

Database Reference	Habitat Elements and Brief Description
4.7	**Wetlands/marshes/wet meadows/bogs and swamps**
4.7.1	Riverine wetlands – wetlands found in association with river
4.7.2	Context – indicates that the setting of the wetland is key to the queried speci
4.7.2.1	Forested wetlands - wetland within a fores
4.7.2.2	Nonforested wetlands – wetland not surrounded by fore
4.7.3	Size – the queried species is differentially associated with a wetland, marsh, wet meadow, bog, or swamp based on the size of the water b
4.7.4	Marsh – frequently or continually inundated wetlands characterized by emergent herbaceous vegetation (grasses, sedges, reeds) adapted to saturated soil condit
4.7.5	Wet meadow – grassland with waterlogged soil near the water surface but without standing water for most of the y
4.1	**Water characteristics – includes various freshwater attributes**
4.1.1	Dissolved oxygen – amount of oxygen passed into solutic
4.1.2	Water depth – distance from the surface of the water to the bottom substra
4.1.3	Dissolved solids – a measure of dissolved minerals in wat
4.1.4	Water pH – a measure of water acidity or alkalinity
4.1.5	Water temperature – water temperature range that is key to the queried species; if known it is in the comments fi
4.1.6	Water velocity – speed or momentum of water flo
4.1.7	Water turbidity – amount of roiled sediment within the wate
4.1.8	Free water – water derived from any sourc
4.1.9	Salinity and alkalinity – the presence of salt
4.2	**Rivers and streams -- various characteristics of rivers and streams**
4.2.1	Oxbows – a pond/wetland created when a river bend is cut off from main chann
4.2.2	Order and class – systems of stream classificatio
4.2.2.1	Intermittent – streams/rivers contain nontidal flowing water for only part of the yea
4.2.2.2	Upper perennial – streams/rivers with high gradient, fast water velocity; substrate consists of rock, cobbles or gravel with occasional patches of sand; little floodplain develop
4.2.2.3	Lower perennial - streams/rivers with low gradient, slow water velocity; substrate consists of sand and mud with well-developed floodp
4.2.3	Zone – system of water body classification based on the horizontal strata of the water colur
4.2.3.1	Open water – open water areas not closely associated with the shoreline or bottom substrat
4.2.3.2	Submerged/benthic – relating to the bottom of a water body, includes the substrate and the overlaying body of water within one meter of the subst
4.2.3.3	Shoreline – continually exposed substrate that is subject to splash, waves and/or periodic flooding; includes gravel bars, islands and immediate nearshore a
4.2.4	In-water substrate – the bottom materials in a body of wate
4.2.4.1	Rock – rocks >256 mm in diamete
4.2.4.2	Cobble/gravel – rocks or pebbles 2.5-256 mm in diamete
4.2.4.3	Sand/mud – fine substrata <2.5 mm in diamete
4.2.5	Vegetation – herbaceous plants
4.2.5.1	Submergent vegetation – rooted aquatic plants that do not emerge above the water surfa
4.2.5.2	Emergent vegetation – rooted aquatic plants that do emerge above the water surfa
4.2.5.3	Floating mats – unrooted plants that form vegetative masses on the surface of the wat
4.2.6	Coarse woody debris in stream and rivers – any piece of woody materia
4.2.7	Pools – portions of streams with reduced current velocity and often with deeper wat
4.2.8	Riffles – shallow rapids where water flows swiftly over partially submerged obstructio
4.2.9	Runs/glides – areas of swiftly flowing water without surface agitation or wave
4.2.10	Overhanging vegetation – herbaceous plants that cascades 1 m over stream and river bank
4.2.11	Waterfalls – steep descent of water within stream or rive

4.2.12	Banks - rising ground that borders a body of water
4.2.13	Seeps or springs – a concentrated flow of ground water issuing from openings in the grour
4.3	Ephemeral pools – pools that contain water for only brief period
4.4	Sand bars – exposed areas of sand or mud substrat
4.5	Gravel bars – exposed areas of gravel substrat
4.6	**Lakes/ponds/reservoirs - various characteristics of lakes, ponds and reservoirs**
4.6.1	Zone – system of water body classification based on the horizontal strata of the water colur
4.6.1.1	Open water – open water areas not closely associated with the shoreline or bottom substrat
4.6.1.2	Submerged/benthic – relating to the bottom of a water body, includes the substrate and the overlaying body of water within one meter of the subst
4.6.1.3	Shoreline – continually exposed substrate that is subject to splash, waves and/or periodic flooding; includes gravel bars, islands and immediate nearshore a
4.6.2	In-water substrate – the bottom materials in a body of wate
4.6.2.1	Rock – rocks >256 mm in diameter
4.6.2.2	Cobble/gravel – rocks or pebbles 2.5-256 mm in diamete
4.6.2.3	Sand/mud – fine substrata <2.5 mm in diamete
4.6.3	Vegetation – herbaceous plants
4.6.3.1	Submergent vegetation – rooted aquatic plants that do not emerge above the water surfa
4.6.3.2	Emergent vegetation – rooted aquatic plants that do emerge above the water surfa
4.6.3.3	Floating mats – unrooted plants that form vegetative masses on the surface of the wat

	Riparian Habitat Elements (Johnson and O'Neill 2001) Related To:																																																																	
	Wetlands								Water Characteristics										Rivers and Streams																													Lakes, Ponds and Reservoirs																		
Closely Associated Species	4.7	4.7.1	4.7.2	4.7.2.1	4.7.2.2	4.7.3	4.7.4	4.7.5	4.1	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6	4.1.7	4.1.8	4.1.9	4.2	4.2.1	4.2.2	4.2.2.1	4.2.2.2	4.2.2.3	4.2.3	4.2.3.1	4.2.3.2	4.2.3.3	4.2.4	4.2.4.1	4.2.4.2	4.2.4.3	4.2.5	4.2.5.1	4.2.5.2	4.2.5.3	4.2.6	4.2.7	4.2.8	4.2.9	4.2.10	4.2.11	4.2.12	4.2.13	4.3	4.4	4.5	4.6	4.6.1	4.6.1.1	4.6.1.2	4.6.1.3	4.6.2	4.6.2.1	4.6.2.2	4.6.2.3	4.6.3	4.6.3.1	4.6.3.2	4.6.3.3	4.6.4	4.6.4.1	4.6.4.2	4.8	4.9	Total
American Bittern	1	1					1		1		1																																					1									1		1						1	9
American Coot	1	1					1		1		1								1	1	1			1	1	1		1					1		1	1												1	1	1		1					1	1	1	1						23
American Redstart	1	1																	1																																															3
American Wigeon	1	1					1		1										1	1	1			1	1	1		1					1	1											1			1	1	1		1					1	1	1						1	22
Baird's Sandpiper	1		1		1				1						1				1		1			1	1			1	1			1												1	1	1	1	1	1			1	1			1								1	1	23
Bald Eagle	1	1					1		1							1			1	1	1		1	1	1	1												1							1	1	1	1	1	1														1	1	21
Bank Swallow	1	1																	1						1	1		1															1					1	1	1		1														11
Beaver	1	1	1	1	1		1		1		1				1		1		1	1	1		1	1	1	1		1										1					1		1			1	1	1		1									1	1				27
Big Brown Bat	1	1					1												1	1					1	1												1		1				1	1			1	1	1																14
Black Tern	1						1																																									1	1	1							1		1						1	8
Black-billed Magpie	1	1																	1																																															3
Black-capped Chickadee	1		1	1																																																														3
Blue Grouse	1		1	1	1														1																									1																						6
Blue-winged Teal	1						1		1		1								1						1	1		1																	1			1	1	1		1					1	1	1						1	17
Bonaparte's Gull	1		1	1					1										1						1	1																				1	1	1	1	1														1		13
Bufflehead	1	1					1		1									1	1	1	1			1	1	1	1		1			1													1			1	1	1	1		1			1										21
Canada Goose	1						1												1	1	1			1	1	1		1					1		1											1	1	1	1	1		1												1		18
Canvasback	1	1	1		1	1	1		1		1							1	1	1	1			1	1	1	1	1	1			1	1	1	1										1			1	1	1	1	1	1			1	1	1	1		1		1			35
Cinnamon Teal	1						1		1		1								1						1	1		1																	1			1	1	1		1					1	1	1						1	17
Cliff Swallow	1	1																	1																										1			1																		5
Columbia Spotted Frog	1	1					1		1		1				1				1	1	1			1	1	1		1					1	1	1								1		1			1	1	1		1	1			1	1	1	1	1					1	29
Common Garter Snake	1	1					1		1		1								1																										1			1									1		1						1	11
Common Yellowthroat	1	1	1	1	1	1	1	1											1														1		1													1									1		1						1	15
Eared Grebe	1					1	1		1		1								1						1	1																						1	1	1	1						1	1	1		1		1			17
Eastern Kingbird	1	1					1																																									1																		4
Forster's Tern	1						1												1	1	1			1	1	1		1																	1	1	1	1	1	1		1					1	1	1	1					1	21
Gadwall	1						1		1		1		1						1						1	1		1					1	1											1			1	1	1		1					1	1								18
Great Blue Heron	1						1		1		1								1	1	1			1	1	1		1																	1			1	1	1		1					1		1					1	1	20
Greater White-fronted Goose	1					1	1		1		1								1						1	1																			1			1	1	1		1					1	1	1		1		1			18
Greater Yellowlegs	1	1	1		1		1		1						1				1	1	1			1	1	1		1	1			1	1			1								1	1	1	1	1	1	1		1	1			1	1			1				1		31
Green-winged Teal	1						1		1		1								1	1	1			1	1	1		1																	1			1	1	1		1					1	1	1						1	20
Grizzly Bear	1																																																																	1
Hooded Merganser	1	1	1	1			1		1		1							1	1	1	1			1	1	1																						1	1	1											1	1				19
Horned Grebe	1						1		1		1								1						1	1							1		1													1	1	1	1						1	1	1		1		1			18
Least Sandpiper	1		1		1		1		1						1				1	1	1			1	1			1	1		1	1												1	1	1	1	1	1			1	1		1	1	1			1				1	1	29
Lesser Scaup	1	1				1	1		1		1							1	1	1	1			1	1	1	1	1	1			1						1										1	1	1	1	1	1			1					1		1	1		28
Lesser Yellowlegs	1	1	1		1		1		1						1				1	1	1			1	1	1		1	1			1	1			1								1	1	1	1	1	1	1		1	1			1	1			1				1		31
Lincoln's Sparrow	1	1	1	1				1																																																									1	6
Long-billed Dowitcher	1						1												1		1			1	1			1	1			1													1	1	1	1	1	1		1	1			1								1		19
Long-legged Myotis	1	1					1												1	1					1	1												1		1				1	1			1	1	1																14
Long-tailed Vole	1	1					1																																																											3
Long-toed Salamander	1	1					1	1	1	1	1				1	1			1	1	1	1			1		1	1																1	1			1	1	1		1	1	1	1	1	1	1	1	1					1	31
Mallard	1	1				1	1		1									1	1	1	1			1	1	1		1																	1	1		1	1	1		1					1	1	1					1	1	24
Marsh Wren	1	1					1												1		1			1									1		1	1												1									1		1	1						13
Meadow Vole	1		1		1														1																																															4
Mew Gull	1	1							1										1						1			1																		1	1	1	1	1		1												1	1	14
Mink	1	1					1		1								1		1						1			1									1											1	1			1														12
Montane Vole	1	1					1	1																																																										4
Moose	1	1	1	1	1		1	1	1								1		1	1	1		1	1	1	1							1	1	1			1						1				1	1	1							1	1	1		1		1			29
Muskrat	1	1	1	1	1		1												1						1	1		1					1	1	1			1			1		1					1	1	1		1					1	1	1							23
Northern Bog Lemming	1		1	1				1																																																										4
Northern Harrier	1	1	1		1	1	1	1																																																										7
Northern Leopard Frog	1	1					1	1	1	1	1				1				1	1	1			1					1			1	1	1	1										1			1					1			1	1	1	1						1	25
Northern Long-eared Myotis	1	1	1	1			1	1											1	1	1	1		1																								1	1	1											1	1			1	17
Northern Pintail	1						1		1		1								1						1	1		1																	1			1	1	1		1					1	1	1		1		1		1	19
Northern River Otter	1	1	1	1	1		1		1	1							1		1	1	1		1	1	1	1		1	1	1	1	1	1	1			1	1	1	1	1		1		1	1	1	1	1	1		1	1	1	1	1	1	1						1	1	44
Northern Rough-winged Swallow	1	1																	1						1	1		1															1					1	1	1		1														11

Riparian Habitat Elements (Johnson and O'Neill 2001) Related To:

	Wetlands								Water Characteristics										Rivers and Streams																													Lakes, Ponds and Reservoirs																		
Closely Associated Species	4.7	4.7.1	4.7.2	4.7.2.1	4.7.2.2	4.7.3	4.7.4	4.7.5	4.1	4.1.1	4.1.2	4.1.3	4.1.4	4.1.5	4.1.6	4.1.7	4.1.8	4.1.9	4.2	4.2.1	4.2.2	4.2.2.1	4.2.2.2	4.2.2.3	4.2.3	4.2.3.1	4.2.3.2	4.2.3.3	4.2.4	4.2.4.1	4.2.4.2	4.2.4.3	4.2.5	4.2.5.1	4.2.5.2	4.2.5.3	4.2.6	4.2.7	4.2.8	4.2.9	4.2.10	4.2.11	4.2.12	4.2.13	4.3	4.4	4.5	4.6	4.6.1	4.6.1.1	4.6.1.2	4.6.1.3	4.6.2	4.6.2.1	4.6.2.2	4.6.2.3	4.6.3	4.6.3.1	4.6.3.2	4.6.3.3	4.6.4	4.6.4.1	4.6.4.2	4.8	4.9	Total
Northern Shoveler	1						1		1										1						1	1		1																	1			1	1	1		1														1	13
Northern Waterthrush	1	1	1	1															1																								1																						1	7
Olive-sided Flycatcher	1																																																																	1
Pacific Tree Frog	1	1	1	1	1		1	1	1						1				1	1	1	1		1	1			1					1	1	1									2	1			1	1			1					1	1	1						1	29
Pacific Jumping Mouse	1	1					1	1																																																										4
Painted Turtle	1	1					1												1	1					1	1		1					1	1	1	1	1											1	1	1		1					1		1	1					1	21
Pectoral Sandpiper	1		1		1		1		1						1				1		1			1	1			1	1			1												1	1			1	1			1	1			1								1	1	22
Pied-billed Grebe	1						1		1		1								1	1					1	1							1		1													1	1	1	1						1	1	1							17
Raccoon	1	1	1	1	1		1		1								1																												1	1	1																			11
Redhead	1	1				1	1		1		1		1					1	1	1	1			1	1	1	1	1	1			1	1	1	1										1			1	1	1	1	1					1	1	1		1		1			32
Red-naped Sapsucker	1			1				1																																																										3
Red-necked Grebe	1						1		1		1								1						1	1																						1	1	1	1						1	1	1		1		1			16
Red-winged Blackbird	1	1	1	1	1	1	1	1	1		1			1				1	1	1	1	1		1									1		1	1					1		1	1	1	1	1	1				1					1		1	1	1	1	1	1	1	36
Ring-necked Pheasant	1	1	1		1														1																									1																						6
Ruddy Duck	1					1	1		1		1							1	1	1	1			1	1	1	1	1					1	1	1													1	1	1	1	1	1			1	1	1	1		1		1			29
Ruffed Grouse	1	1	1	1															1																									1																						6
Rusty Blackbird	1	1	1	1			1												1						1			1																	1			1	1			1														12
Sandhill Crane	1					1		1	1		1								1						1	1		1					1		1													1	1	1		1					1		1		1		1		1	20
Short-eared Owl	1		1		1		1																																																										1	5
Solitary Sandpiper	1	1					1		1						1				1	1	1			1	1			1	1			1													1			1	1	1		1	1			1										20
Sora	1					1	1		1		1								1														1		1									1				1									1		1						1	13
Spotted Sandpiper	1	1	1		1		1												1	1	1		1	1	1	1		1	1	1	1	1	1			1								1	1	1	1	1	1	1		1	1	1	1	1	1			1				1		34
Townsend's Big-eared Bat	1	1					1												1	1					1	1												1		1				1	1			1	1	1																14
Tree Swallow	1						1												1		1			1																								1																		6
Tundra Swan	1					1	1		1		1								1		1			1	1	1							1	1												1		1	1	1							1	1			1		1			20
Virginia Rail	1	1				1	1		1		1								1														1		1									1				1									1		1						1	14
Water Shrew	1						1		1					1		1			1		1		1		1		1	1	1		1							1	1	1	1							1	1		1	1									1	1				23
Western Grebe	1						1		1		1								1		1			1	1	1																						1	1	1							1	1	1	1	1		1			18
Western Harvest Mouse	1	1	1		1		1	1											1		1			1																																										9
Western Jumping Mouse	1						1	1																																																										3
Western Sandpiper	1	1							1		1				1				1		1			1	1	1		1	1			1													1	1	1	1	1	1		1	1			1	1			1				1	1	26
Western Screech-owl	1		1	1																																																														3
Western Toad	1	1					1	1	1		1				1				1	1	1			1	1	1			1			1	1											1	1	1	1	1	1	1							1			1					1	26
White-tailed Deer	1	1	1	1	1			1	1								1		1																									1																				1		11
Wilson's Phalarope	1	1	1		1		1		1						1				1						1	1		1																	1			1	1	1		1	1			1	1		1	1				1		22
Wood Duck	1	1	1	1		1	1		1									1	1	1	1			1	1	1		1													1							1	1	1		1														20
Wood Frog	1		1	1				1	1		1								1	1																									1			1																		10
Yellow-breasted Chat	1	1																																																																2
Yellow-headed Blackbird	1	1	1	1	1	1	1	1	1		1			1				1	1	1	1	1		1				1					1		1	1					1		1	1	1	1	1	1				1					1		1	1	1	1	1	1	1	37
Yuma Myotis	1	1					1												1	1					1	1												1		1				1	1			1	1	1																14
Total Species	97	59	36	24	24	16	72	20	55	3	33	0	2	3	14	3	6	10	79	38	41	5	6	39	58	47	7	42	17	2	4	16	28	13	20	8	3	11	2	6	6	0	9	23	43	19	17	73	60	53	10	44	18	3	4	18	45	26	36	16	19	6	15	20	35	

APPENDIX 5: Key Ecological Functions of 97 Species Closely Associated With Wetlands

Key to Ecological Functions:

Database Reference	Ecological Function and Brief Description
1	**Trophic relationships**
1.1	heterotrophic consumer
1.1.1	primary consumer (herbivore; an organism that feeds primarily on plant materia
1.1.1.1	foliovore (leaf eater)
1.1.1.2	spermivore (seed eater)
1.1.1.3	browser (leaf, stem eater
1.1.1.4.	grazer (grass, forb eater)
1.1.1.5	frugivore (fruit eater)
1.1.1.6	sap feeder
1.1.1.7	root feeder
1.1.1.8.	nectivore (nectar feeder)
1.1.1.9	fungivore (fungus feeder)
1.1.1.10	flower/bud/catkin feeder
1.1.1.11	aquatic herbivore
1.1.1.12	feeds in water on decomposing benthic substrat
1.1.1.13	bark/ cambium/ bole feeder
1.1.2	secondary consumer (primary predator or orimary carnivore; a carnivore that preys on other vertebrate or invertebrate animals, primarily herbivor
1.1.2.1	invertebrate eater
1.1.2.1.1	terrestrial invertebrates
1.1.2.1.2	aquatic macroinvertebrates
1.1.2.1.3	freshwater or marine zooplankton
1.1.2.2	vertebrate feeder (consumer or predator of herbivorous or carnivorous vertbrate
1.1.2.2.1	piscivorous (fish-eating)
1.1.2.3	ovivorous
1.1.3	tertiary consumer
1.1.4	carrion feeder (feeds on dead animals
1.1.5	cannibalisitic (eats members of its own species
1.1.6	coprophagous (feeds on fecal material
1.1.7	feeds on human garbadge/refuse
1.1.7.1	aquatic (e.g., offal and bycatch of fishing boats
1.1.7.2	terrestrial (e.g., garbadge cans, landfills
1.2	prey relationships
1.2.1	prey for secondary or tertiary consumers (primary or secondary predato
2	**Aids in physical transfer of substances for nutrient cycling (C,N,P, etc.)**
3	**Organismal relationships**
3.1	controls or depresses insect population peak
3.2	controls terrestrial vetebrate populations (through predation or displacemen
3.3	pollination vector
3.4	transportation of viable seeds, spores, plants, or animlas (through ingestion, caching, caught in hair or mud on fe
3.4.1	disperses fungi
3.4.2	disperses lichens

3.4.3	disperses bryophytes including mosse
3.4.4	disperses insects and other invertebrates (phoresi:
3.4.5	disperse seeds/fruits (through ingestion or caching
3.4.6	disperses vascular plants
3.5	creates feeding, roosting, denning, or nesting opportunities for other organisı
3.5.1	creates feeding opportunities (other than direct prey relation:
3.5.1.1	creates sap wells in tree:
3.5.2	creates roosting, denning, or nesting opportunitie
3.6	primary creation of structures (possibly used by other organism
3.6.1	aerial structures (typically large raptor or squirrel stick or leaf nests in trees or on platforms, or barn swallow/cliff swallow ne:
3.6.2	ground structures (above-ground, non-aquatic nests and ends and other substrates, such as woodrate middens, nesting mounds of swans, for exam
3.6.3	aquatic structures (muskrat lodges)
3.7	user of structures created by other specie
3.7.1	aerial structures (typically large raptor or squirrel stick or leaf nests in trees or on platforms, or barn swallow/cliff swallow ne:
3.7.2	ground structures (above-ground, non-aquatic nests and ends and other substrates, such as woodrate middens, nesting mounds of swans, for exam
3.7.3	quatic structures
3.8	nest parasite
3.8.1	interspecies parasite (commonly lays eggs in nests of other specie
3.8.2	common interspecific host (parasitized by other specie
3.9	primary cavity excavator in snags or live trees (organisms able to excavate their own cavitie
3.1	secondary cavity user (organisms that do not excavate their own cavities and depend on primary cavity excavators or natural caviti
3.11	primary burrow excavator (fossorial or underground burrows
3.11.1	creates large burrows (rabbit-sized or larger
3.11.2	creates small burrows (less than rabbit-sized
3.12	uses burrows dug bu other species (secondary burrow use
3.13	creates runways (possibly used by other species; runways typically are worn paths in dense vegetatic
3.14	uses runways created by other specie
3.15	pirates food from other dspecie
3.16	interspecific hybridization (speci9es known to regularly interbree
4	**Carrier; transmitter; or reservoir of vertebrate diseases**
4.1	diseases that affect humans
4.2	diseases that affect domestic animal
4.3	diseases that affect other wildlife specie
5	**Soil relationships**
5.1	physically affects (improves) soil structure, aeration, (typically by diggin
5.2	physically affects (degrades) soil structure, aeration, (typically by tramplin
6	**Wood structure relationships (either living or dead wood)**
6.1	physically fragments down woo
6.2	physically fragments standing woo
7	**Water relationships**
7.1	impounds water by creating diversions or dam
7.2	creates ponds or wetlands through wallowin
8	**Vegetation structure and composition relationships**
8.1	creates standing dead trees (snags
8.2	herbivory on trees or shrubs that may alter vegetation structure and composition (browse
8.3	herbivory on trees or shrubs that may alter vegetation structure and composition (grazer

Key Ecological Functions (from Johnson and O'Neill 2001):

Closely Associated Species	1	1.1	1.1.1	1.1.1.1	1.1.1.10	1.1.1.11	1.1.1.12	1.1.1.13	1.1.1.2	1.1.1.3	1.1.1.4	1.1.1.5	1.1.1.6	1.1.1.7	1.1.1.8	1.1.1.9	1.1.2	1.1.2.1	1.1.2.1.1	1.1.2.1.2	1.1.2.1.3	1.1.2.2	1.1.2.2.1	1.1.2.3	1.1.3	1.1.4	1.1.5	1.1.7	1.1.7.1	1.1.7.2	1.2	1.2.1	2	3	3.1	3.1	3.11	3.11.1	3.11.2	3.12	3.13	3.14	3.15	3.16	3.2	3.3
American Bittern	1	1															1	1	1	1		1	1											1												
American Coot	1	1	1	1		1											1	1	1	1		1	1	1							1	1		1												
American Redstart	1	1															1	1	1													1	1		1												
American Tree Sparrow	1	1	1		1				1			1					1	1	1													1	1		1												
Baird's Sandpiper	1	1															1	1	1	1											1	1														
Bald Eagle	1	1															1					1	1	1		1		1		1				1									1		1	
Bank Swallow	1	1															1	1	1													1	1		1	1		1		1								
Beaver	1	1	1	1		1		1		1																					1	1	1	1			1	1				1					
Big Brown Bat	1	1															1	1	1															1	1	1	1										
Black Tern	1	1															1	1	1	1		1	1									1	1		1												
Black-billed Magpie	1	1	1						1			1					1	1	1			1	1			1					1	1		1												
Black-capped Chickadee	1	1	1						1			1					1	1	1													1	1		1	1	1										
Blue Grouse	1	1	1	1	1							1					1	1	1													1	1		1												
Blue-winged Teal	1	1	1	1		1			1							1	1		1											1	1		1												
Bonaparte's Gull	1	1															1	1	1	1		1	1					1		1	1	1		1								1			
Bufflehead	1	1															1	1		1		1	1									1	1		1		1										
Canada Goose	1	1	1	1		1					1						1	1	1	1																										
Canvasback	1	1	1	1		1											1	1		1											1	1		1												
Cinnamon Teal	1	1	1	1		1			1							1	1		1											1	1		1												
Cliff Swallow	1	1															1	1	1													1	1		1	1											
Columbia Spotted Frog	1	1	1			1	1										1	1	1	1											1	1	1														
Common Garter Snake	1	1															1	1	1			1	1									1	1		1						1				1		
Common Yellowthroat	1	1															1	1	1													1	1		1												
Eared Grebe	1	1															1	1		1		1	1												1												
Eastern Kingbird	1	1	1										1					1	1	1													1	1		1												
Forster's Tern	1	1															1	1	1			1	1									1	1		1												
Gadwall	1	1	1	1		1			1							1	1	1	1											1	1		1												
Great Blue Heron	1	1															1	1	1	1		1	1											1	1												
Greater White-fronted Goose	1	1	1	1		1					1						1	1		1											1	1		1												
Greater Yellowlegs	1	1															1	1	1	1		1	1									1	1														
Green-winged Teal	1	1	1	1		1			1							1	1		1											1	1		1												
Grizzly Bear	1	1	1						1			1		1			1					1	1			1	1							1			1	1			1	1			1	
Hooded Merganser	1	1															1	1	1	1		1	1												1		1										
Horned Grebe	1	1															1	1		1		1	1												1												
Least Sandpiper	1	1															1	1	1	1											1	1														
Lesser Scaup	1	1	1			1											1	1		1											1	1		1												
Lesser Yellowlegs	1	1															1	1	1	1		1	1									1	1														
Lincoln's Sparrow	1	1	1						1							1	1	1													1	1		1	1											
Long-billed Dowitcher	1	1															1	1	1	1											1	1														
Long-legged Myotis	1	1															1	1	1															1	1	1	1										
Long-tailed Vole	1	1	1								1																				1	1		1			1		1	1						
Long-toed Salamander	1	1															1	1	1	1	1										1	1	1	1	1					1						
Mallard	1	1	1	1		1			1							1	1	1	1						1					1	1		1										1		
Marsh Wren	1	1															1	1	1	1											1	1														
Meadow Vole	1	1	1					1			1						1	1	1													1	1		1			1		1	1	1					
Mew Gull	1	1	1						1							1	1	1	1		1	1					1	1	1			1	1									1			
Mink	1	1															1	1		1		1	1	1		1							1			1	1		1		1			1	
Montane Vole	1	1	1								1																				1	1		1			1		1	1	1					
Moose	1	1	1	1		1				1	1																				1	1														
Muskrat	1	1	1	1		1											1	1		1		1									1	1		1			1	1			1					
Northern Bog Lemming	1	1	1								1																				1	1														
Northern Harrier	1	1															1	1	1			1												1												1	

Closely Associated Species	3.4	3.4.1	3.4.2	3.4.4	3.4.5	3.4.6	3.5	3.5.1	3.5.1.1	3.5.2	3.6	3.6.1	3.6.2	3.6.3	3.7	3.7.1	3.7.2	3.7.3	3.8	3.8.1	3.8.2	3.9	4	4.1	4.2	4.3	5	5.1	6	6.1	6.2	7	7.1	7.2	8	8.1	8.2	8.3	KEFs
American Bittern											1		1																										11
American Coot	1			1		1					1			1									1	1		1													23
American Redstart																			1		1																			10
American Tree Sparrow	1				1																																		14
Baird's Sandpiper																																							8
Bald Eagle											1	1																											14
Bank Swallow																																							11
Beaver											1			1									1	1			1	1				1	1		1	1			24
Big Brown Bat																							1	1															11
Black Tern	1			1		1							1		1			1																					17
Black-billed Magpie	1				1						1	1			1	1																							20
Black-capped Chickadee	1				1																	1																		16
Blue Grouse	1				1																																		14
Blue-winged Teal	1					1																	1	1		1													17
Bonaparte's Gull																							1	1		1													17
Bufflehead	1			1		1																																	14
Canada Goose															1			1					1	1												1			1	16
Canvasback	1			1		1													1		1		1	1		1													19
Cinnamon Teal	1			1		1																	1	1		1													18
Cliff Swallow											1	1																											11
Columbia Spotted Frog																																							12
Common Garter Snake																																							12
Common Yellowthroat																			1		1																			10
Eared Grebe	1			1		1					1			1																									13
Eastern Kingbird	1				1														1		1																			14
Forster's Tern	1			1		1									1			1																					15
Gadwall	1			1		1																	1	1		1													19
Great Blue Heron	1			1		1	1	1			1	1																											17
Greater White-fronted Goose	1			1		1																	1	1		1													18
Greater Yellowlegs																																							10
Green-winged Teal	1			1		1																	1	1		1													18
Grizzly Bear	1				1		1	1																					1										22
Hooded Merganser	1			1		1													1	1	1		1	1															18
Horned Grebe	1			1		1					1			1																									13
Least Sandpiper																																							8
Lesser Scaup	1			1		1																	1	1		1													16
Lesser Yellowlegs																																							10
Lincoln's Sparrow	1				1														1		1																			15
Long-billed Dowitcher																																							8
Long-legged Myotis																																							9
Long-tailed Vole																																							10
Long-toed Salamander																											1	1											15
Mallard	1			1		1																	1	1		1													21
Marsh Wren																																							8
Meadow Vole																																			1				16
Mew Gull																																							16
Mink															1			1																					17
Montane Vole																																			1			1	13
Moose																																			1		1		11
Muskrat											1			1																									17
Northern Bog Lemming																																							6
Northern Harrier																																							8

	Key Ecological Functions (from Johnson and O'Neill 2001):																													
Closely Associated Species	1	1.1	1.1.1	1.1.1.1	1.1.1.10	1.1.1.11	1.1.1.12	1.1.1.13	1.1.1.2	1.1.1.3	1.1.1.4	1.1.1.5	1.1.1.6	1.1.1.7	1.1.1.8	1.1.1.9	1.1.2	1.1.2.1	1.1.2.1.1	1.1.2.1.2	1.1.2.1.3	1.1.2.2	1.1.2.2.1	1.1.2.3	1.1.3	1.1.4	1.1.5	1.1.7	1.1.7.1	1.1.7.2
Northern Leopard Frog	1	1	1			1	1										1	1	1	1		1								
Northern Long-eared Myotis	1	1															1	1	1											
Northern Pintail	1	1	1	1		1			1								1	1		1										
Northern River Otter	1	1															1	1	1	1		1	1							
Northern Rough-winged Swallow	1	1															1	1	1											
Northern Shoveler	1	1	1	1		1											1	1		1										
Northern Waterthrush	1	1															1	1	1											
Olive-sided Flycatcher	1	1															1	1	1											
Pacific Tree Frog	1	1	1			1	1										1	1	1											
Pacific Jumping Mouse	1	1	1						1		1					1														
Painted Turtle	1	1	1			1											1					1	1			1				
Pectoral Sandpiper	1	1															1	1	1	1										
Pied-billed Grebe	1	1															1	1		1		1	1							
Raccoon	1	1	1						1			1					1	1	1	1		1	1	1				1		1
Redhead	1	1	1	1		1											1	1		1										
Red-naped Sapsucker	1	1	1										1				1	1	1											
Red-necked Grebe	1	1															1	1		1		1	1							
Red-winged Blackbird	1	1	1						1								1	1	1											
Ring-necked Pheasant	1	1	1	1					1			1					1	1	1	1		1								
Ruddy Duck	1	1	1	1		1											1	1		1										
Ruffed Grouse	1	1	1	1	1				1			1					1	1	1			1								
Rusty Blackbird	1	1	1						1			1					1	1	1	1		1	1					1		1
Sandhill Crane	1	1	1			1			1		1	1					1	1	1	1		1		1						
Short-eared Owl	1	1															1	1	1			1								
Solitary Sandpiper	1	1															1	1	1	1		1								
Sora	1	1	1						1								1	1	1	1										
Spotted Sandpiper	1	1															1	1	1	1										
Townsend's Big-eared Bat	1	1															1	1	1											
Tree Swallow	1	1															1	1	1			1								
Tundra Swan	1	1	1	1													1	1		1										
Virginia Rail	1	1															1	1	1	1										
Water Shrew	1	1															1	1		1			1							
Western Grebe	1	1															1	1	1	1		1	1							
Western Harvest Mouse	1	1	1						1			1					1	1	1											
Western Jumping Mouse	1	1	1						1																					
Western Sandpiper	1	1															1	1	1	1										
Western Screech-owl	1	1															1	1	1			1								
Western Toad	1	1	1			1	1										1	1	1	1		1								
White-tailed Deer	1	1	1	1						1	1																			
Wilson's Phalarope	1	1	1						1								1	1	1	1										
Wood Duck	1	1	1	1		1			1								1	1		1										
Wood Frog	1	1	1			1	1										1	1	1	1	1									
Yellow-breasted Chat	1	1															1	1	1											
Yellow-headed Blackbird	1	1	1						1								1	1	1											
Yuma Myotis	1	1															1	1	1											
Total Species	97	97	51	22	3	25	5	2	25	3	10	12	1	1	0	1	89	86	66	54	2	36	26	5	0	6	1	5	1	5

Closely Associated Species	1.2	1.2.1	2	3	3.1	3.1	3.11	3.11.1	3.11.2	3.12	3.13	3.14	3.15	3.16	3.2	3.3	3.4	3.4.1	3.4.2	3.4.4	3.4.5	3.4.6	3.5	3.5.1	3.5.1.1	3.5.2	3.6	3.6.1	3.6.2	3.6.3
Northern Leopard Frog	1	1	1																											
Northern Long-eared Myotis						1																								
Northern Pintail	1	1		1													1			1		1								
Northern River Otter				1						1	1				1															
Northern Rough-winged Swallow	1	1		1	1																									
Northern Shoveler	1	1		1													1			1		1								
Northern Waterthrush	1	1																												
Olive-sided Flycatcher				1																										
Pacific Tree Frog	1	1	1	1						1		1																		
Pacific Jumping Mouse	1	1		1			1		1	1		1																		
Painted Turtle	1	1																												
Pectoral Sandpiper	1	1																												
Pied-billed Grebe				1																							1			1
Raccoon	1	1		1		1				1		1			1		1				1									
Redhead	1	1		1													1			1		1								
Red-naped Sapsucker				1										1									1	1	1					
Red-necked Grebe				1													1			1		1					1			1
Red-winged Blackbird	1	1		1																										
Ring-necked Pheasant	1	1		1													1				1									
Ruddy Duck	1	1		1													1			1		1								
Ruffed Grouse	1	1		1													1				1									
Rusty Blackbird	1	1															1				1		1			1				
Sandhill Crane	1	1		1													1			1		1								
Short-eared Owl				1											1															
Solitary Sandpiper	1	1																												
Sora	1	1		1													1			1		1								
Spotted Sandpiper	1	1		1													1			1		1								
Townsend's Big-eared Bat			1	1	1																									
Tree Swallow	1	1		1	1	1																								
Tundra Swan				1													1			1		1								
Virginia Rail	1	1		1													1			1		1								
Water Shrew				1			1		1	1		1																		
Western Grebe				1													1			1		1					1			1
Western Harvest Mouse	1	1		1			1		1	1																				
Western Jumping Mouse	1	1		1			1		1																					
Western Sandpiper	1	1																												
Western Screech-owl				1		1																								
Western Toad			1	1						1																				
White-tailed Deer	1	1		1							1	1		1																
Wilson's Phalarope	1	1		1													1			1		1								
Wood Duck	1	1		1		1											1			1		1								
Wood Frog	1	1	1	1						1																				
Yellow-breasted Chat	1	1		1													1				1									
Yellow-headed Blackbird	1	1																												
Yuma Myotis			1	1	1	1																								
Total Species	70	70	13	78	11	11	12	4	8	14	7	7	3	4	7	0	41	0	0	28	12	29	4	3	1	1	13	4	2	8

Closely Associated Species	3.7	3.7.1	3.7.2	3.7.3	3.8	3.8.1	3.8.2	3.9	4	4.1	4.2	4.3	5	5.1	6	6.1	6.2	7	7.1	7.2	8	8.1	8.2	8.3	KEFs
Northern Leopard Frog																									13
Northern Long-eared Myotis																									6
Northern Pintail									1	1		1													18
Northern River Otter																									12
Northern Rough-winged Swallow																									9
Northern Shoveler									1	1															16
Northern Waterthrush																									7
Olive-sided Flycatcher					1		1																		8
Pacific Tree Frog																									14
Pacific Jumping Mouse																									13
Painted Turtle																									10
Pectoral Sandpiper																									8
Pied-billed Grebe																									10
Raccoon									1	1	1	1													27
Redhead					1	1			1	1		1													19
Red-naped Sapsucker								1																	13
Red-necked Grebe																									13
Red-winged Blackbird					1		1																		12
Ring-necked Pheasant																									16
Ruddy Duck																									14
Ruffed Grouse																									16
Rusty Blackbird																									19
Sandhill Crane									1	1		1													22
Short-eared Owl																									8
Solitary Sandpiper																									9
Sora									1			1													16
Spotted Sandpiper									1			1													14
Townsend's Big-eared Bat									1	1															10
Tree Swallow																									11
Tundra Swan	1			1																					13
Virginia Rail									1			1													14
Water Shrew																									11
Western Grebe									1	1															11
Western Harvest Mouse	1		1																						11
Western Jumping Mouse																									11
Western Sandpiper																									8
Western Screech-owl																									8
Western Toad													1	1											15
White-tailed Deer															1	1									14
Wilson's Phalarope									1			1													16
Wood Duck																									16
Wood Frog																									15
Yellow-breasted Chat					1		1																		12
Yellow-headed Blackbird																									9
Yuma Myotis																									9
Total Species	7	1	1	5	10	2	9	2	25	21	1	18	3	3	2	1	0	1	1	0	5	1	1	2	

Appendix 6: Summary of Small (<10 ha) Wetland Area (ha) and Frequency by Landscape Unit (LU)

		Number of Wetlands:						
LU	Wetland Area (ha)	Marsh	Swamp	Lake	Flood	Total	LU Area	% Wetland
C01	82.81	5	3	0	0	8	30531	0.271232518
C02	64.48	5	4	0	0	9	53139	0.12134214
C03	18.03	4	2	0	0	6	13002	0.138670974
C04	12.36	2	1	0	0	3	40852	0.030255557
C05	27.66	5	3	0	0	8	38664	0.071539417
C06	27.73	2	4	0	0	6	56311	0.049244375
C07	72.8	5	4	0	0	9	38145	0.190850701
C08	47.63	4	3	0	0	7	34228	0.139155078
C09	74.06	5	5	0	0	10	36059	0.205385618
C10	82.78	5	5	0	0	10	35745	0.231584837
C11	26.97	4	3	0	0	7	29350	0.091890971
C12	41.24	5	2	0	0	7	19251	0.214222638
C13	16.48	4	1	0	0	5	20869	0.078968805
C14	11.99	3	2	0	0	5	30948	0.038742407
C15	30.94	5	2	0	0	7	41495	0.0745632
C19	50.87	5	3	0	0	8	41132	0.123674998
C20	26.05	4	4	0	0	8	33032	0.078862921
C21	88.9	5	3	0	0	8	44206	0.201103923
C22	67.57	5	5	0	0	10	66326	0.101875584
C23	62.15	5	2	0	0	7	64450	0.096431342
C24	63.4	4	4	2	0	10	70631	0.089762286
C26	6.92	3	1	0	0	4	38736	0.017864519
C27	30.62	4	4	0	0	8	61953	0.049424564
C28	9.89	3	1	0	0	4	49132	0.020129447
C29	1.78	2	0	0	0	2	32867	0.005415767
C30	225	5	4	0	0	9	46657	0.48224275
C31	167.13	5	5	0	0	10	20304	0.823138298
C32	185.61	5	5	0	3	13	31780	0.58404657
C33	85	5	4	0	2	11	31801	0.267287192
C34	305.66	5	5	4	1	15	46829	0.652715198
C35	20.75	4	1	0	0	5	20621	0.100625576
C36	98.87	5	5	0	0	10	23942	0.412956311
C37	182.53	5	5	0	0	10	34388	0.530795626
C38	91.9	5	3	0	0	8	31226	0.294306027
G01	7.84	3	0	0	0	3	49309	0.015899734
G02	13.29	4	2	0	0	6	21794	0.060980086
G03	9.91	3	2	0	0	5	24923	0.039762468
G04	2.48	2	1	0	0	3	17172	0.014442115
G06	7.53	3	0	0	0	3	26313	0.028617033
G07	10.05	4	1	0	0	5	64018	0.01569871
G08	15.72	4	2	0	0	6	31246	0.05031044
G09	9.26	4	1	0	0	5	34193	0.027081566
G10	12.07	4	2	0	0	6	59950	0.020133445
G11	1.78	2	0	0	0	2	15619	0.011396376
G12	14.31	5	0	0	0	5	26180	0.054660046
G13	47.02	5	3	0	0	8	56029	0.083920827
G14	49.49	5	1	0	0	6	23815	0.207810204
G14P	64.01	5	0	0	0	5	43661	0.146606812
G15	0.38	1	0	0	0	1	15911	0.002388285
G16	144.56	5	3	0	0	8	34293	0.421543755
G17	0.6	1	0	0	0	1	20172	0.00297442
G18	0.45	1	0	0	0	1	31428	0.001431844
G19	7.31	3	0	0	0	3	51390	0.014224557

		Number of Wetlands:						
LU	Wetland Area (ha)	Marsh	Swamp	Lake	Flood	Total	LU Area	% Wetland
G1P	39.79	2	0	0	0	2	25337	0.15704306
G20	117.8	5	3	0	0	8	37446	0.314586338
G21	14.31	3	4	0	0	7	69273	0.020657399
G22	22.92	5	2	0	0	7	18633	0.123007567
G22P	7.66	3	0	0	0	3	18610	0.041160666
G23	400.78	5	5	0	0	10	44109	0.908612755
G24	2.57	2	0	0	0	2	12931	0.01987472
G25	74.04	5	4	0	1	10	13207	0.560611797
G26	41.33	5	2	0	0	7	34861	0.118556553
G26P	268.74	4	5	4	0	13	121020	0.222062469
G27	26.21	4	2	0	0	6	12075	0.217060041
G27P	5.52	0	1	0	0	1	8060	0.068486352
G28	132.19	5	5	0	0	10	32175	0.410846931
G28P	216.33	5	5	0	0	10	18916	1.143635018
G29	3.86	2	0	0	0	2	23807	0.016213719
G38P	11.28	3	0	0	0	3	25426	0.044364037
G4P	45.35	4	1	0	0	5	21827	0.207770193
I01	82.15	5	5	0	0	10	53822	0.152632752
I02	70.89	5	1	0	0	6	49159	0.144205537
I03	94.16	5	2	0	0	7	35516	0.265119946
I04	101.22	5	2	0	0	7	43268	0.233937321
I05	13.06	4	1	0	0	5	55488	0.023536621
I06	1.68	2	0	0	0	2	24428	0.006877354
I07	20.51	5	0	0	0	5	42731	0.047997941
I08	21.81	4	4	0	0	8	26792	0.081404897
I09	0.27	1	0	0	0	1	32308	0.000835706
I10	12.69	5	0	0	0	5	34978	0.036279947
I11	5.11	1	1	0	0	2	16760	0.03048926
I12	166.33	5	5	1	0	11	45921	0.362209011
I13	3.72	1	0	0	0	1	20423	0.018214758
I14	57.74	5	3	0	0	8	67423	0.085638432
I15	26.67	3	3	0	0	6	45288	0.058889772
I16	1.89	2	0	0	0	2	14550	0.012989691
I17	20.69	5	0	0	0	5	7651	0.270422167
I18	131.13	5	5	0	0	10	26048	0.503416769
I19	19.87	5	0	0	0	5	18541	0.107167898
I20	22.35	4	0	0	0	4	42529	0.052552376
I21	14.46	4	1	0	0	5	19934	0.07253938
I22	3.66	3	1	0	0	4	20792	0.017602924
I23	68.55	5	4	0	0	9	84886	0.080755366
I24	10.27	4	0	0	0	4	21785	0.047142529
I25	42.51	4	2	0	1	7	23249	0.182846574
I26	57.37	4	4	0	0	8	56019	0.102411682
I27	18.72	5	2	0	0	7	16615	0.112669275
I28	3.69	2	0	0	0	2	12266	0.030083157
I29	217.87	5	3	0	1	9	33278	0.654696797
I30	185.99	5	5	0	2	12	23489	0.791817446
I31	40.08	5	1	0	0	6	29682	0.135031332
I32	354.58	5	5	0	0	10	25212	1.406393781
I33	0.34	1	0	0	0	1	9291	0.003659455
I34	132.47	6	5	0	0	11	76814	0.172455542
I35	398.74	5	5	0	0	10	26671	1.495032057
I36	446.8	5	5	0	0	10	32228	1.386372099
I37	81.43	5	5	0	0	10	47613	0.17102472
I38	1.74	4	4	0	0	8	10703	0.016257124
K01	58.56	5	4	0	0	9	71470	0.081936477

		Number of Wetlands:						
LU	Wetland Area (ha)	Marsh	Swamp	Lake	Flood	Total	LU Area	% Wetland
K02	27.54	5	1	0	0	6	26345	0.104535965
K03	53.64	5	3	0	0	8	42461	0.126327689
K04	20.78	4	3	0	0	7	50104	0.041473735
K05	12.96	4	2	0	0	6	34109	0.037995837
K06	34.18	4	4	0	0	8	78276	0.043666002
K07	33.94	3	4	0	0	7	40038	0.084769469
K08	15.63	3	2	0	0	5	43078	0.036283021
K09	9.27	3	2	0	0	5	41671	0.022245686
K10	13.85	3	2	0	0	5	53152	0.026057345
K11	27.1	4	3	0	0	7	23576	0.114947404
K12	83.87	5	4	1	0	10	81989	0.10229421
K13	0	1	0	0	0	1	42454	0
K14	13.02	4	2	0	0	6	42349	0.030744528
K15	19.18	4	2	0	0	6	61793	0.031039114
K16	7.87	3	0	0	0	3	39721	0.019813197
K17	13.58	4	4	0	0	8	69442	0.019555888
K18	22.21	5	2	0	0	7	48015	0.046256378
K20	24.09	3	3	0	0	6	38335	0.062840746
K21	23.1	3	0	0	0	3	51900	0.044508671
K22	10.49	4	0	0	0	4	63182	0.01660283
K23	14.53	3	0	0	0	3	24022	0.060486221
K24	57.96	5	1	0	0	6	53908	0.10751651
K25	62.79	5	4	0	0	9	71547	0.087760493
K26	22.31	4	3	0	0	7	40620	0.054923683
N501	58.83	3	5	0	0	8	36055	0.163167383
N502	39.21	2	5	0	0	7	28646	0.136877749
N503	68.77	5	5	0	0	10	39216	0.175362097
N504	7.1	4	2	0	0	6	19826	0.035811561
N505	36.67	4	3	0	0	7	57284	0.064014384
N506	22.28	4	4	0	0	8	40699	0.05474336
N507	34.2	2	5	0	0	7	21636	0.158069884
N508	24.94	5	3	0	0	8	32825	0.075978675
N509	2.9	1	2	0	0	3	24402	0.011884272
N510	38.69	5	3	0	0	8	39330	0.098372743
N511	7.55	3	1	0	0	4	29743	0.025384124
N512	47.87	5	3	0	0	8	46803	0.102279768
N513	8.73	2	1	0	0	3	19491	0.044789903
N514	46.19	4	3	0	0	7	18014	0.25641168
N515	3.06	3	0	0	0	3	40947	0.007473075
N516	58.9	5	4	0	0	9	55024	0.107044199
N517	36.14	3	4	0	0	7	49936	0.072372637
N518	7.23	3	3	0	0	6	37167	0.01945274
N519	81.53	5	4	0	0	9	48383	0.1685096
N520	109.6	5	5	0	0	10	61103	0.179369262
N521	13.28	3	2	0	0	5	32077	0.04140038
N522	13.75	2	1	0	0	3	40155	0.034242311
N523	67.36	3	4	0	0	7	41659	0.161693752
N524	35.14	5	5	0	0	10	38267	0.091828468
N525	20.39	3	1	0	0	4	58858	0.034642699
N526	33.7	4	5	0	0	9	38794	0.086869103
N527	168.95	5	5	0	0	10	55952	0.301955247
N528	11.24	3	4	0	0	7	45801	0.024540949
N529	69.37	5	3	0	0	8	76321	0.090892415
N530	44.43	5	2	0	0	7	73354	0.060569294
N531	53.18	5	4	0	0	9	8907	0.597058493
R01	58.62	5	3	0	0	8	34736	0.168758637

		Number of Wetlands:						
LU	Wetland Area (ha)	Marsh	Swamp	Lake	Flood	Total	LU Area	% Wetland
R02	35.28	5	2	0	0	7	24349	0.144893014
R03	33.59	4	1	0	1	6	60924	0.055134266
R04	26.88	5	0	0	0	5	19387	0.138649611
R05	107.54	5	3	0	0	8	60804	0.176863364
R06	49.69	5	2	0	0	7	16804	0.295703404
R07	55.36	5	2	0	0	7	40900	0.135354523
R08	0.65	1	0	0	0	1	16852	0.003857109
R09	18.11	5	0	0	0	5	11259	0.160849098
R10	6.42	2	2	0	0	4	46448	0.013821908
R11	11.83	4	1	0	0	5	31424	0.037646385
R12	75.03	5	3	0	0	8	80998	0.092631917
R14	77.39	5	4	0	0	9	44463	0.174054832
R15	65.89	4	3	0	0	7	55619	0.118466711
R16	56.79	5	3	0	0	8	57374	0.098982117
R17	40.45	5	1	0	0	6	39201	0.103186143
R18	48.81	5	1	0	0	6	44653	0.109309565
R19	137.64	5	5	0	0	10	40275	0.341750466
R20	64.11	5	5	0	0	10	99801	0.064237833
RB02	26.81	4	0	0	0	4	52140	0.051419256
RB03	56.53	5	4	0	0	9	43872	0.128852115
RB04	18.7	4	0	0	0	4	44857	0.041688031
RB05	293.45	5	5	0	0	10	71220	0.412033137
RB06	6.19	1	2	0	0	3	30796	0.020100013
RB07	1.19	0	1	0	0	1	34652	0.003434145
RB1	5.31	1	1	0	0	2	35035	0.015156272
RB10	14.37	4	3	0	0	7	41657	0.034496003
RB11	3.5	1	0	0	0	1	14622	0.023936534
RB12	64.63	5	3	0	0	8	90282	0.071586806
RB13	4.9	3	0	0	0	3	44790	0.010939942
RB14	61.59	5	1	0	0	6	43510	0.141553666
RB15	31.19	3	3	0	0	6	50836	0.061354158
RB16	62.33	5	2	0	0	7	56798	0.10973978
RB17	70.81	5	2	0	0	7	40883	0.173201575
RB18	85.98	5	4	0	0	9	69060	0.124500434
RB19	41.92	4	1	0	0	5	52826	0.079354863
RB20	3.67	1	1	0	0	2	9058	0.04051667
RB21	381.52	5	5	0	0	10	92265	0.413504579
RB23	47.95	5	2	0	0	7	81060	0.059153713
RB24	96.34	5	4	0	0	9	12285	0.784208384
RB25	6.29	3	1	0	0	4	17659	0.035619231
RB29	536.36	5	5	0	2	12	221643	0.241992754

APPENDIX 7: Area-based Summary of Wetland Types Based on Air Photo Interpretation

a. Area-based summary of wetland and related ecosystem types surveyed stratified by sample area, biogeoclimatic zone, and size class.

Wetland/ Ecosystem Type	Size Class[1]	Vowell Creek	Bach-elor Creek	ESSF subtotal	Marl Creek	West Bench	ICH subtotal	Spillima-cheen	Kootenay River	MS subtotal	Buck Lake	Galloway	IDF subtotal	Wycliffe	Jaffary	PP subtotal	Total
Peatlands																	
BOG	1 - 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BOG-	1 - 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FEN	3	0	0	0	1.9	0	1.9	0	0	0	0	0	0	0	0	0	1.9
undiff	4 - 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FEN	1	0	0	0	0	0	0	3.05	1.2	4.25	1.25	0.2	1.45	0	0	0	5.7
	2	0	0	0	3.5	3.2	6.7	4.8	1	5.8	0	0.9	0.9	0	0	0	13.4
	3	0	0	0	1.5	2.4	3.9	1.1	1.8	2.9	1.3	1.3	2.6	0	0	0	9.4
	4	0	0	0	7.3	2.2	9.5	9.8	4.7	14.5	0	2.9	2.9	0	0	0	26.9
	5	0	8.2	8.2	0	0	0	8	0	8	0	0	0	0	0	0	16.2
	6	0	0	0	10.9	0	10.9	22.7	20.2	42.9	0	0	0	0	0	0	53.8
	subtotal	0	8.2	8.2	23.2	7.8	31	49.45	28.9	78.35	2.55	5.3	7.85	0	0	0	125.4
subtotal		0	8.2	8.2	25.1	7.8	32.9	49.45	28.9	78.35	2.55	5.3	7.85	0	0	0	127.3
Mineral Wetlands																	
SWAMP	1	0	0	0	0.9	2.1	3	2.85	0	2.85	0.4	0	0.4	0	0.4	0.4	6.65
	2	0.8	0	0.8	0	6.2	6.2	0.6	0	0.6	1.7	0	1.7	0	2	2	11.3
	3	0	0	0	1.9	15	16.9	1.3	0	1.3	0	0	0	0	1.4	1.4	19.6
	4	0	0	0	0	8	8	0	0	0	0	0	0	0	3	3	11
	5	0	0	0	0	14.5	14.5	0	0	0	0	0	0	0	0	0	14.5
	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	subtotal	0.8	0	0.8	2.8	45.8	48.6	4.75	0	4.75	2.1	0	2.1	0	6.8	6.8	63.05
DEEP	1	1	0	1	0	0	0	0.45	0	0.45	0.3	0.5	0.8	0	0.7	0.7	2.95
MARSH	2	2	0	2	1.6	0	1.6	2.5	0	2.5	0	0	0	0	1.6	1.6	7.7
&	3	2.7	0	2.7	0	0	0	5.4	0	5.4	0	2.9	2.9	0	0	0	11
undiff	4	2.7	0	2.7	0	0	0	0	5.9	5.9	0	12	12	0	3.4	3.4	24
(DEEP +	5	0	0	0	0	0	0	0	0	0	0	5.5	5.5	0	0	0	5.5
SHALLOW	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MARSH)	subtotal	8.4	0	8.4	1.6	0	1.6	8.35	5.9	14.25	0.3	20.9	21.2	0	5.7	5.7	51.15
SHALLOW	1	0	0	0	0	0.4	0.4	0.9	0	0.9	0.6	1.1	1.7	0.2	2.3	2.5	5.5
MARSH	2	0	0	0	1.6	0.7	2.3	1.6	0	1.6	0.6	0.9	1.5	0	1.9	1.9	7.3
	3	0	0	0	1.8	3.4	5.2	0	2.8	2.8	1.2	0	1.2	2	0	2	11.2
	4	0	0	0	0	3.5	3.5	0	0	0	0	0	0	0	0	0	3.5
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7	7
	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Wetland/ Ecosystem Type	Size Class[1]	Vowell Creek	Bach-elor Creek	ESSF subtotal	Marl Creek	West Bench	ICH subtotal	Spillima-cheen	Kootenay River	MS subtotal	Buck Lake	Galloway	IDF subtotal	Wycliffe	Jaffary	PP subtotal	Total
	subtotal	0	0	0	3.4	8	11.4	2.5	2.8	5.3	2.4	2	4.4	2.2	11.2	13.4	34.5
SHALLOW WATER	1	0.4	0.25	0.65	0	0.35	0.35	1.3	0	1.3	0.35	1.3	1.65	1.4	1.7	3.1	7.05
	2	2	0	2	0	0	0	0.6	0	0.6	2	1.6	3.6	0.7	0.6	1.3	7.5
	3	2.9	0	2.9	4.8	2.2	7	4.7	0	4.7	1.8	0	1.8	1.2	6.6	7.8	24.2
	4	2.8	0	2.8	9.4	5.8	15.2	10	4.6	14.6	0	0	0	4.8	0	4.8	37.4
	5	0	0	0	8.3	0	8.3	9.5	0	9.5	0	18.5	18.5	0	0	0	36.3
	6	0	0	0	0	0	0	33.2	0	33.2	0	0	0	0	0	0	33.2
	subtotal	8.1	0.25	8.35	22.5	8.35	30.85	59.3	4.6	63.9	4.15	21.4	25.55	8.1	8.9	17	145.65
EXPOSED LAND (mudflats, saltflats, marl deposits)	1	0	0	0	0	0	0	0	0	0	0	0.05	0.05	0.2	0.1	0.3	0.35
	2	0	0	0	0	0	0	0.6	0	0.6	0	0	0	0.6	1	1.6	2.2
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	3.1	0	3.1	0	3.8	3.8	0	0	0	6.9
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	subtotal	0	0	0	0	0	0	3.7	0	3.7	0	3.85	3.85	0.8	1.1	1.9	9.45
Mineral Wetland subtotal		17.3	0.25	17.55	30.3	62.15	92.45	78.6	13.3	91.9	8.95	48.15	57.1	11.1	33.7	44.8	303.8
Peatland/Mineral Undifferentiated																	
Graminoid FEN - SHALLOW MARSH Undiff	1	0	0	0	1.8	0	1.8	0.1	0	0.1	0	0	0	0	0	0	1.9
	2	0	0	0	0	0	0	0.6	0	0.6	0	0	0	0	0.8	0.8	1.4
	3	3	0	3	1.8	4.1	5.9	1.9	0	1.9	0	0	0	0	0	0	10.8
	4	4.1	0	4.1	0	2.9	2.9	5.6	0	5.6	0	0	0	0	0	0	12.6
	5 - 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	subtotal	7.1	0	7.1	3.6	7	10.6	8.2	0	8.2	0	0	0	0	0.8	0.8	26.7
WETLAND TOTALS		24.4	8.45	32.85	59	76.95	135.95	136.25	42.2	178.5	11.5	53.45	64.95	11.1	34.5	45.6	457.8
Mineral Wetlands/Terrestrial Transition Ecosystems Undifferentiated																	
Graminoid SHALLOW MARSH - MEADOW undiff	1	0	0	0	0.5	0.5	1	0.7	0	0.7	0	0	0	0.3	0.2	0.5	2.2
	2	0	0	0	0	0	0	0	0	0	0	1.6	1.6	0	0	0	1.6
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1.6	1.6	1.6
	4 - 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	subtotal	0	0	0	0.5	0.5	1	0.7	0	0.7	0	1.6	1.6	0.3	1.8	2.1	5.4
Tall Shrub SWAMP - [SHRUB-CARR] undiff	1	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0.5
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	2.6	2.6	0	0	0	0	0	0	0	0	0	2.6
	4 - 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	subtotal	0	0	0	0	3.1	3.1	0	0	0	0	0	0	0	0	0	3.1
Mineral / Terr. Trans.																	

Wetland/ Ecosystem Type	Size Class[1]	Vowell Creek	Bach-elor Creek	ESSF subtotal	Marl Creek	West Bench	ICH subtotal	Spillima-cheen	Kootenay River	MS subtotal	Buck Lake	Galloway	IDF subtotal	Wycliffe	Jaffary	PP subtotal	Total
undiff. subtotal		0	0	0	0.5	3.6	4.1	0.7	0	0	0	1.6	1.6	0.3	1.8	2.1	8.5
Mineral Wetlands/Terrestrial Flood/Terrestrial Upland Ecosystems Undifferentiated																	
SWAMP -	1	0	1	1	0	0.85	0.85	0	0	0	0	0	0	0	0	0	1.85
[FLOOD	2	0	0.9	0.9	0	2	2	0	0	0	0	0	0	0	0	0	2.9
BENCH]	3	0	3	3	0	1.7	1.7	0	0	0	0	0	0	0	0	0	4.7
(or wet	4	0	2.1	2.1	0	7.7	7.7	0	0	0	0	0	0	0	0	0	9.8
upland	5	0	[12.7]	[12.7]	0	0	0	0	0	0	0	0	0	0	0	0	[12.7]
site?)	6	0	10.3	10.3	0	0	0	0	0	0	0	0	0	0	0	0	10.3
undiff.	subtotal	0	30	30	0	12.25	12.25	0	0	0	0	0	0	0	0	0	42.25
Terrestrial Transition Ecosystems																	
MEADOW	1	0	0.4	0.4	0.3	0.5	0.8	0.2	0	0.2	0.7	2.4	3.1	1.45	0.95	2.35	6.85
	2	2	0.7	2.7	1	1.4	2.4	0	0.9	0.9	1.3	3.1	4.4	0.7	2.2	2.9	13.3
	3	1.5	5.5	7	0	0	0	0	2	2	1.5	1.8	3.3	2.7	0	2.7	15
	4	0	14.2	14.2	0	0	0	0	2.6	2.6	0	0	0	4	0	4	20.8
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	7.8	7.8	7.8
	6	60.6	0	60.6	0	0	0	0	0	0	0	0	0	0	0	0	60.6
	subtotal	64.1	20.8	84.9	1.3	1.9	3.2	0.2	5.5	5.7	3.5	7.3	10.8	8.8	10.95	19.75	124.35
SHRUB-	1	0	0	0	[0.6]	0	[0.6]	1.55	0	1.55	0	0.4	0.4	0	0.3	0.3	2.85
CARR	2	0	0	0	0	0	0	0	0.6	0.6	0	0	0	0	1	1	1.6
	3	[1.9]	0	[1.9]	[1.5]	2.6	4.1	0	0	0	0	0	0	0	0	0	6
[or upland	4	[4.8]	2.1	6.9	0	0	0	0	0	0	0	0	0	0	0	0	6.9
shrubs?]	5	0	8.9	8.9	0	0	0	0	0	0	0	0	0	0	0	0	8.9
	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	subtotal	[6.7]	11	17.7	[2.1]	2.6	4.7	1.55	0.6	2.15	0	0.4	0.4	0	1.3	1.3	26.25
Terr. Trans. subtotal		70.8	31.8	102.6	3.4	4.5	7.9	1.75	6.1	7.85	3.5	7..7	11.2	8.8	12.25	21.05	150.6
Terrestrial Flood Ecosystems																	
LOW	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0.1
BENCH	2 - 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MID	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.3	0.3
BENCH	2	0.6	0	0.6	0	0	0	0	0	0	0	0	0	0	0.8	0.8	1.4
	3 - 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	subtotal	0.6	0	0.6	0	0	0	0	0	0	0	0	0	0	1.1	1.1	1.7
HIGH	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0.5
BENCH	2	[0.7]	0	[0.7]	0	0	0	0	0	0	0	0	0	0	0	0	[0.7]
[or wet	3	[2.3]	0	[2.3]	0	0	0	0	0	0	0	0	0	0	1.4	1.4	3.7
upland	4 - 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Wetland/ Ecosystem Type	Size Class[1]	Vowell Creek	Bach-elor Creek	ESSF subtotal	Marl Creek	West Bench	ICH subtotal	Spillima-cheen	Kootenay River	MS subtotal	Buck Lake	Galloway	IDF subtotal	Wycliffe	Jaffary	PP subtotal	Total
forest?]	subtotal	[3]	0	[3]	0	0	0	0	0	0	0	0	0	0	1.9	1.9	4.9
Terrestrial Flood Ecosystem subtotal		3.6	0	3.6	0	0	0	0	0	0	0	0	0	0	3.1	3.1	6.7
Wetland & Related Ecosystem Totals		98.8	70.25	169.05	62.9	97.3	160.2	138.7	48.3	187	15	62.75	77.75	20.2	51.65	71.85	665.85
Freshwater Ecosystems																	
DEEP WATER	1	0	0	0	0.4	0	0.4	0	0	0	0.3	0	0.3	0	0	0	0.7
	2	0	0	0	0	0	0	0.9	0	0.9	0	0	0	0	0	0	0.9
	3	0	0	0	0	0	0	1.7	1.5	3.2	1.5	0	1.5	0	0	0	4.7
	4	0	0	0	0	0	0	6.2	3	9.2	0	4	4	0	0	0	13.2
	5	0	0	0	0	0	0	0	0	0	0	7.1	7.7	9.9	0	9.9	17
	6	0	0	0	0	0	0	48.7	0	48.7	0	0	0	0	0	0	48.7
	subtotal	0	0	0	0.4	0	0.4	57.5	4.5	62	1.8	11.1	12.9	9.9	0	9.9	85.2
Total Area Surveyed		98.8	70.25	169.05	63.3	97.3	160.6	196.2	52.8	249	16.8	73.85	90.65	30.1	51.65	81.75	751.05

[1]Size Class: 1 (0.1 – 0.5 ha); 2 (0.5 – 1.0 ha); 3 (1 – 2 ha); 4 (2 – 5 ha); 5 (5 – 10 ha); 6 (>10 ha).

b. Area-based summaries for wetland and related ecosystem types surveyed stratified by sample area, biogeoclimatic zone, and vegetation cover type.

Wetland and Related Terrestrial Ecosystem Components		Vowell Creek	Bach-elor Creek	ESSF subtotal	Marl Creek	West Bench	ICH subtotal	Spillima-cheen	Kootenay River	MS subtotal	Buck Lake	Galloway	IDF subtotal	Wycliffe	Jaffary	PP subtotal	Total
Peatland Types																	
BOG		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BOG – FEN undifferentiated		0	0	0	1.9	0	1.9	0	0	0	0	0	0	0	0	0	1.9
FEN	graminoid	0	8.2	8.2	22.2	2.75	24.95	40.95	20.6	61.55	2.4	5.3	7.7	0	0	0	102.4
	low shrub	0	0	0	0	3.85	3.85	8.5	5.5	14	0	0	0	0	0	0	17.85
	mixed shrub	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	tall shrub	0	0	0	0	0	0	0	0	0	0.15	0	0.15	0	0	0	0.15
	coniferous treed	0	0	0	1	1.2	2.2	0	2.8	2.8	0	0	0	0	0	0	5.0
	subtotal	0	8.2	8.2	23.2	7.8	32.9	49.45	28.9	78.35	2.55	5.3	7.85	0	0	0	125.4
Peatland subtotal		0	8.2	8.2	25.1	7.8	32.9	49.45	28.9	78.35	2.55	5.3	7.85	0	0	0	127.3
Mineral Wetland Types																	
SWAMP	low shrub	0	0	0	0	5.8	5.8	0.3	0	0.3	0	0	0	0	0	0	6.1
	mixed shrub	0	0	0	0	0.4	0.4	0	0	0	0	0	0	0	0	0	0.4
	tall shrub	0.8	0	0.8	0	6.1	6.1	2.25	0	2.25	0.15	0	0.15	0	4.4	4.4	12.9
	coniferous treed	0	0	0	0	3.6	3.6	2	0	2	1.95	0	1.95	0	2.4	2.4	9.95
	broadleaf treed	0	0	0	0	0.9	0.9	0	0	0	0	0	0	0	0	0	0.9
	mixed treed	0	0	0	2.8	29	31.8	0.2	0	0.2	0	0	0	0	0	0	32.0

Wetland and Related Terrestrial Ecosystem Components		Vowell Creek	Bach-elor Creek	ESSF subtotal	Marl Creek	West Bench	ICH subtotal	Spillima-cheen	Kootenay River	MS subtotal	Buck Lake	Galloway	IDF subtotal	Wycliffe	Jaffary	PP subtotal	Total
	subtotal	0.8	0	0.8	2.8	45.8	48.6	4.75	0	4.75	2.1	0	2.1	0	6.8	6.8	63.05
DEEP MARSH & undiff (DEEP + SHALLOW MARSH)	graminoid	8.4	0	8.4	0	0	0	3.3	5.9	9.2	0.3	13.6	13.9	0	0	0	31.5
	tall rush	0	0	0	1.6	0	1.6	5.05	0	5.05	0	7.3	7.3	0	5.7	5.7	19.65
	subtotal	8.4	0	8.4	1.6	0	1.6	8.35	5.9	14.25	0.3	20.9	21.2	0	5.7	5.7	51.15
SHALLOW MARSH	graminoid	0	0	0	3.4	8	11.4	2.5	2.8	5.3	2.4	2	4.4	2.2	11.2	13.4	34.5
SHALLOW WATER	unclassified	8.1	0	8.1	0	8.35	8.35	0.5	0	0.5	0.2	0.3	0.5	0.9	1.55	2.45	19.9
	non-vegetated	0	0.25	0.25	6.5	0	6.5	47.6	0	47.6	0.15	0.1	0.25	1.8	3.45	5.25	59.85
	submerged aq.	0	0	0	0	0	0	9	0	9	1.8	19.7	21.5	0.6	2.1	2.7	33.2
	floating aquatic	0	0	0	0	0	0	0	0	0	2	1.3	3.3	4.8	0.4	5.2	8.5
	undiff aquatic	0	0	0	16	0	16	2.2	4.6	6.8	0	0	0	0	1.4	1.4	24.2
	subtotal	8.1	0.25	8.35	22.5	8.35	30.85	59.3	4.6	63.9	4.15	21.4	25.55	8.1	8.9	17	145.65
EXPOSED LAND	shoreline	0	0	0	0	0	0	0	0	0	0	0.05	0.05	0	0.1	0.1	0.15
	mudflat	0	0	0	0	0	0	0	0	0	0	3.8	3.8	0.2	1	1.2	5.0
	calcareous	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	mudflat (marl)	0	0	0	0	0	0	3.7	0	3.7	0	0	0	0	0	0	3.7
	saltflat	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0.6	.6
subtotal		0	0	0	0	0	0	3.7	0	3.7	0	3.85	3.85	0.8	1.1	1.9	9.45
Mineral Wetland subtotal		17.3	0.25	17.55	30.3	62.15	92.45	78.6	13.3	91.9	8.95	48.15	57.1	11.1	33.7	44.8	303.8
Peatland/Mineral Undifferentiated																	
Graminoid FEN - (SHALLOW MARSH)		7.1	0	7.1	3.6	2.9	6.5	2.5	0	2.5	0	0	0	0	0.8	0.8	16.9
SHALLOW MARSH - (FEN)		0	0	0	0	4.1	4.1	5.7	0	5.7	0	0	0	0	0	0	9.8
Peatland/Mineral subtotal		7.1	0	7.1	3.6	7	10.6	8.2	0	8.2	0	0	0	0	0.8	0.8	26.7
WETLAND TOTALS		24.4	8.45	32.85	59	76.95	135.95	136.25	42.2	178.5	11.5	53.45	64.95	11.1	34.5	45.6	457.8
Mineral Wetlands/Terrestrial Transition Ecosystems Undifferentiated																	
Graminoid SHALLOW MARSH (MEADOW)		0	0	0	0.5	0.25	0.75	0.4	0	0.4	0	0.9	0.9	0.3	1.8	2.1	4.15
MEADOW - (SHALLOW MARSH)		0	0	0	0	0.25	0.25	0.3	0	0.3	0	0.7	0.7	0	0	0	1.25
subtotal		0	0	0	0.5	0.5	1	0.7	0	0.7	0	1.6	1.6	0.3	1.8	2.1	5.4
SWAMP - [SHRUB-CARR]	low shrub	0	0	0	0	1.5	1.5	0	0	0	0	0	0	0	0	0	1.5
	mixed shrub	0	0	0	0	1.1	1.1	0	0	0	0	0	0	0	0	0	1.1
	tall shrub	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0.5
	subtotal	0	0	0	0	3.1	3.1	0	0	0	0	0	0	0	0	0	3.1
Mineral Wetland/ Terrestrial Transtion Undifferentiated subtotal		0	0	0	0.5	3.6	4.1	0.7	0	0	0	1.6	1.6	0.3	1.8	2.1	8.5
Mineral Wetlands/Terrestrial Flood/Terrestrial Upland Ecosystems Undifferentiated																	

Wetland and Related Terrestrial Ecosystem Components		Vowell Creek	Bach-elor Creek	ESSF subtotal	Marl Creek	West Bench	ICH subtotal	Spillima-cheen	Kootenay River	MS subtotal	Buck Lake	Galloway	IDF subtotal	Wycliffe	Jaffary	PP subtotal	Total
SWAMP - (BENCH) (or upland?)	coniferous treed	0	17.3	17.3	0	0	0	0	0	0	0	0	0	0	0	0	17.3
SWAMP - (WET UPLAND SITE]	low shrub	0	0	0	0	0.3	0.3	0	0	0	0	0	0	0	0	0	.3
	coniferous treed	0	0	0	0	5.7	5.7	0	0	0	0	0	0	0	0	0	5.7
	mixed treed	0	0	0	0	6.25	6.25	0	0	0	0	0	0	0	0	0	6.25
	subtotal	0	0	0	0	12.25	12.25	0	0	0	0	0	0	0	0	0	12.25
LOW BENCH - (SWAMP)	tall shrub	0	6.4	6.4	0	0	0	0	0	0	0	0	0	0	0	0	6.4
MID BENCH - (SWAMP)	coniferous treed	0	6.3	6.3	0	0	0	0	0	0	0	0	0	0	0	0	6.3
Mineral Wetland/Terrestrial Flood & Upland Ecosystems Undifferentiated subtotal		0	30	30	0	12.25	12.25	0	0	0	0	0	0	0	0	0	42.25
TERRESTRIAL TRANSITION ECOSYSTEM COMPONENTS																	
MEADOW	graminoid	0	4.2	4.2	0	0	0	0	0	0	0	1.3	1.3	0	0	0	5.7
	herb	64.1	16.6	80.7	1.3	1.9	3.2	0.2	5.5	5.7	3.5	6	9.5	8.8	10.95	19.75	118.85
	subtotal	64.1	20.8	84.9	1.3	1.9	3.2	0.2	5.5	5.7	3.5	7.3	10.8	8.8	10.95	19.75	124.35
SHRUB-CARR [or upland shrubs?]	low shrub	0	2.1	2.1	0	1.4	1.4	0	0.6	0.6	0	0	0	0	0	0	4.1
	tall shrub	[6.7?]	8.9	15.6	[2.1?]	1.2	3.3	0	0	1.55	0	0.4	0.4	0	1.3	1.3	22.15
	subtotal	[6.7?]	11	17.7	[2.1?]	2.6	4.7	1.55	0.6	2.15	0	0.4	0.4	0	1.3	1.3	26.25
TERRESTRIAL TRANSITION ECOSYSTEM TOTALS		70.8	31.8	102.6	3.4	4.5	7.9	1.75	6.1	7.85	3.5	7.7	11.2	8.8	12.25	21.05	150.6
TERRESTRIAL FLOOD ECOSYSTEM COMPONENTS																	
LOW BENCH	tall shrub	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0.1
MID BENCH	broadleaf & mixed treed	0.6	0	0.6	0	0	0	0	0	0	0	0	0	0	1.1	1.1	1.7
	subtotal	0.6	0	0.6	0	0	0	0	0	0	0	0	0	0	1.1	1.1	1.7
HIGH BENCH or wet upland forest?]	coniferous treed	[3?]	0	[3?]	0	0	0	0	0	0	0	0	0	0	1.9	1.9	4.9
	subtotal	[3?]	0	[3?]	0	0	0	0	0	0	0	0	0	0	1.9	1.9	4.9
TERRESTRIAL FLOOD ECOSYSTEM TOTALS		3.6	0	3.6	0	0	0	0	0	0	0	0	0	0	3.1	3.1	6.7
WETLAND & RELATED ECOSYTEM TOTALS		98.8	70.25	169.05	62.9	97.3	160.2	138.7	48.3	187	15	62.75	77.75	20.2	51.65	71.85	665.85
FRESHWATER ECOSYSTEM COMPONENTS																	
DEEP WATER		0	0	0	0.4	0	0.4	57.5	4.5	62	1.8	11.1	12.9	9.9	0	9.9	85.2
TOTAL AREA SURVEYED		98.8	70.25	169.05	63.3	97.3	160.6	196.2	52.8	249	16.8	73.85	90.65	30.1	51.65	81.75	751.05

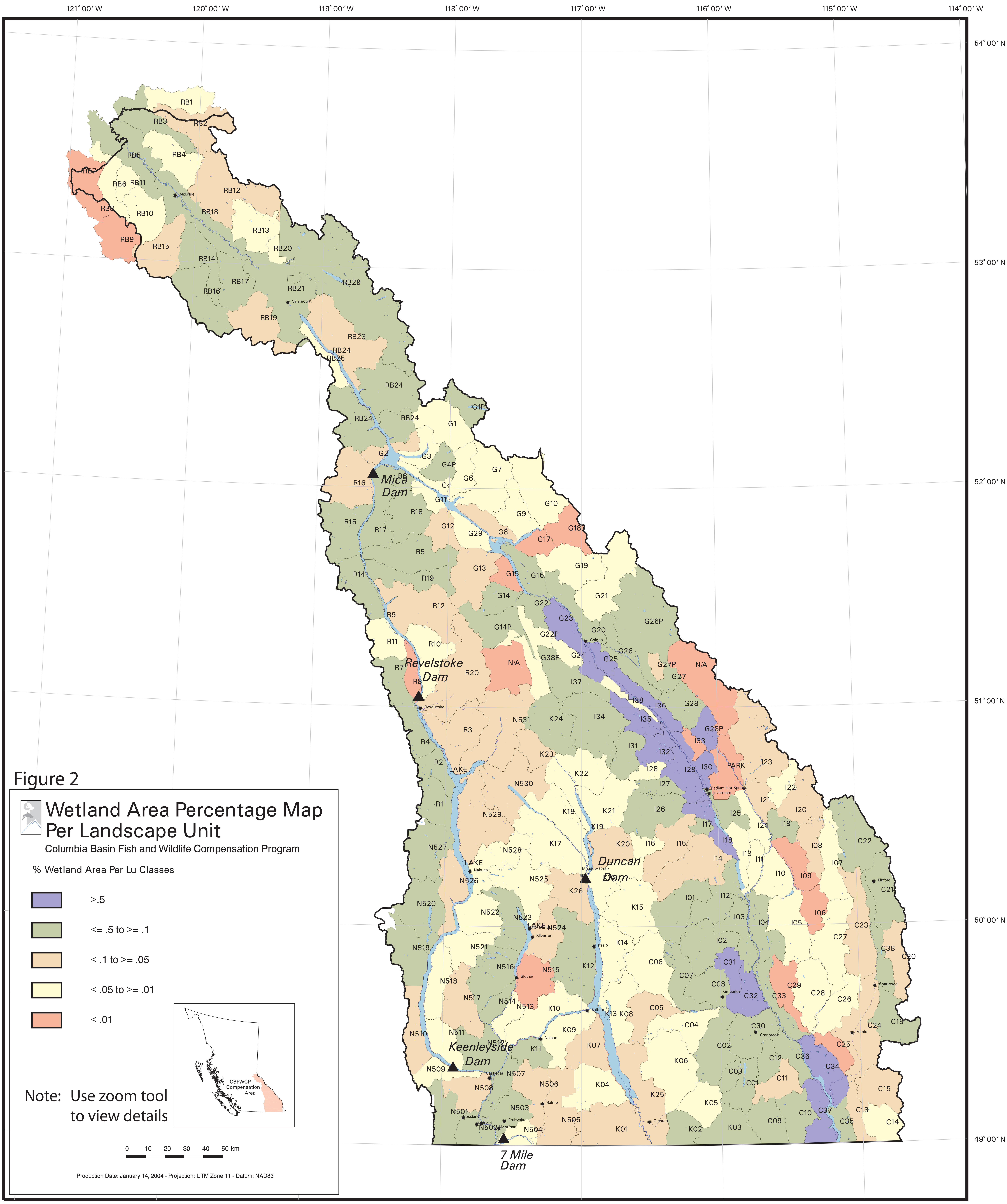
121° 00′ W
120° 00′ W
119° 00′ W
118° 00′ W
117° 00′ W
116° 00′ W
115° 00′ W
114° 00′ W
54° 00′ N
53° 00′ N
52° 00′ N
51° 00′ N
50° 00′ N
49° 00′ N
Mica Dam
Revelstoke Dam
Duncan Dam
Keenleyside Dam
7 Mile Dam
Wetland Area Percentage Map
Per Landscape Unit
Columbia Basin Fish and Wildlife Compensation Program
% Wetland Area Per Lu Classes
>.5
<= .5 to >= .1
< .1 to >= .05
< .05 to >= .01
< .01
CBFWCP Compensation Area
Note: Use zoom tool to view details
0 10 20 30 40 50 km
Production Date: January 14, 2004 - Projection: UTM Zone 11 - Datum: NAD83

Figure 2