Boundary Hydroelectric Project (FERC No. 2144)

Study No. 16

Inventory of Riparian Trees and Shrubs

Final Report

Prepared for
Seattle City Light

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Correction page to Study 16, Inventory of Riparian Trees and Shrubs, as provided by SCL on February 12, 2009

1) p. 2, third bullet, *The Boundary Wildlife Preserve (BWP) (155 acres) and adjoining SCL-owned property (85 acres).*

Subsequent to completion of the final report, SCL discovered a discrepancy between the description of the study area for the “adjoining SCL-owned parcel” and the area that was surveyed during field studies. The BWP was mapped accurately in the study reports and the entire BWP was surveyed as planned; this discrepancy relates only to the "adjoining SCL-owned property."

Terrestrial field crews were working from an incorrect map of the parcel and thus, detailed field surveys took place on only 42 acres of the parcel. Regardless of this error, SCL believes that the conclusions presented in the final study report are still valid.

Additionally, the size of the “adjoining SCL-owned parcel” is 88 acres, not 85 acres.

Correction page to Study 16, Inventory of Riparian Trees and Shrubs, as provided by SCL on January 23, 2009

1) p. 13, Section 5.1, 3rd line
Replace 97.7 acres with *97.9 acres*

2) p. 40, Table 5.3-1
Replace table with the following updated table:

Table 5.3-1. Potential riparian habitat (by species) that could potentially develop in the fluctuation zone if Boundary reservoir were operated at lower water surface elevations (in 5-foot increments).

Species	Current Acreage	Potential Acreage by Increment				Max. Net Change
		–5 feet	–10 feet	–15 feet	–20 feet	
Sitka alder[1]	7.9	8.1	8.3	8.5	7.9	0.6
Gray alder[1]	0.5	0.5	0.5	0.5	0.5	0.0
Coyote willow[1]	4.0	4.4	4.0	4.0	4.0	0.4
Shining willow[1]	2.2	2.2	2.2	2.2	2.2	0.0
Sitka willow[1]	8.5	7.8	7.8	7.8	7.8	-0.7
MacKenzie's willow[1]	2.3	2.9	3.2	3.2	3.2	0.9
Red-osier dogwood[1]	10.6	16.1	18.5	18.5	18.5	7.9
Black cottonwood[2]	15.7	15.7	15.7	15.7	15.7	0.0
Black hawthorn[2]	2.7	2.7	2.7	2.7	2.7	0.0
Common snowberry[3]	41.2	41.2	41.2	41.2	41.2	0.0
Total[4]	**95.4**	**101.6**	**104.1**	**104.3**	**103.7**	
Net Change in Acres		**6.0**	**8.5**	**8.7**	**8.1**	
Net Percent Change		**6.3**	**8.9**	**9.1**	**8.5**	

Notes:
1 Facultative wetland species—Usually occurs in wetlands (estimated probability 67–99%), but occasionally found in non-wetlands.
2 Facultative species—Equally likely to occur in wetlands or non-wetlands (estimated probability 34–66%).
3 Facultative upland species—Usually occurs in non-wetlands (estimated probability 67–99%), but occasionally found in wetlands (estimated probability 1–33%).
4 Numbers may not total exactly due to rounding error.

3) p. 52, last sentence
Replace sentence with the following sentence: *Overall, the current 95.4 acres of riparian habitat upstream of Boundary Dam could potentially expand an additional 8.7 acres, maximum, an approximate 9 percent increase.*

4) Appendix 1, Table A.1-1, pps. 9 and 11
Replace the tables on page 9 and page 11 with the following updated tables:

Polygon Number	Tree Layer Cover	Tree Layer Height	Shrub Layer No. 1 Cover	Shrub Layer No. 1 Height	Shrub Layer No. 2 Cover	Shrub Layer No. 2 Height	Mature Cottonwood Pre-Damage	Mature Cottonwood Post-Damage	Seedlings % of Cottonwood	Saplings % of Cottonwood	Mature % of Cottonwood	Decadent or Dead % of Cottonwood	Snag % of Cottonwood	Age (from Tree Cores) or estimated age (years)	Substrate[4]	Acres
Rip_Veg	Tree_lay_cov	Tree_lay_hgt	ShrLay1_Cov	ShrLay1_Hgt	ShrLay2_Cov	ShrLay2_Hgt	MatCOT predm	MatCOTpstdm	COT_seed	COT_sap	COT_mature	COT_decad	COT_sng		Substrate	acres
1	10	50	75	10											CGF	2.25
2	30	50	5	3			N	Y	5	10	85	0	0	Less than 45 years – wide size range	SCG	0.25
3	2	2	2	2											SCG	0.73
4	5	30	60	15	50	6									F	0.45
5a			65	15	50	4									CF	0.07
5b			75	18	50	4									F	0.21
6			30	4											F	0.05
7a	1	2	30	4											F	0.02
7b	6	4	50	4											F	0.11
8	5	30	55	6											F	0.17
9			80	10	10	3									CF	0.07
10a			70	10											F	0.02
10b			70	10	15	3									F	0.17
11	2	5	30	5											GF	0.37
12																
13																
14	5	60	30	10	60	4	Y	N							GF	0.56
15a	5	5	60	5			N	N							CGF	1.42
15b	15	5	90	8			N	N							SCGF	0.27
15c	5	3	80	9			N	N							GF	2.54
15d	8	20	80	20	25	7	N	N							GF	0.32
16			75	10											F	4.22
17	30	80	50	12	20	3	Y	Y	0	10	75	10	5	Mature Trees wide size range: 12 - 50 in DBH	GF	0.61
18	60	60	30	4	15	8	N	Y	0	20	80	0	0	20, 22	F	1.38
19	35	70	60	10	35	3	Y	N	25	5	50	0	10	Trees large: 38 - 54 in DBH - 2 saplings and many shrubbed young	F	1.52
20	3	25	80	13	30	3	N	N							CF	0.85
21	20	30	85	10	30	5									F	0.30
22a	5	5	90	10	5	5	N	N							F	4.78
22b	40	70	40	15	50	5	Y	Y	10	50	25	5	10		F	0.50
23a			35	35	30	12	N	N							F	1.53
23b	65	70	25	15	45	5	Y	Y	5	15	80	0	0	53, 35, 65, 19, 26, 22, 28	F	2.55
24a	10	40	50	10	30	5	N	N	0	0	100	0	0		F	1.11
24b	5	10	30	10	35	5	N	N						60, 53, 17	F	0.62
25	60	45	10	6			N	Y	30	40	30	0	0	22, 23	F	0.16
26	5	30	90	20	65	5	N	Y						24	F	0.48
27	8	5	5	10	35	6	N	N							CGF	0.18
28	40	60	50	10	20	4	N	Y	0	50	45	0	5	20,23	F	0.63
29			80	10											F	0.40
30			75	10											F	1.99
31			75	10											F	0.14
32			75	10											F	0.08
33			75	10											F	0.67
34a			100	12											F	1.72
34b			70	10	7	4	N	N							F	0.57
35	35	70	50	25	10	10	Y	Y	5	0	90	5	0	31, 62, 51	F	1.40

Polygon Number	Tree Layer Cover	Tree Layer Height	Shrub Layer No. 1 Cover	Shrub Layer No. 1 Height	Shrub Layer No. 2 Cover	Shrub Layer No. 2 Height	Mature Cottonwood Pre-Damage	Mature Cottonwood Post-Damage	Seedlings % of Cottonwood	Saplings % of Cottonwood	Mature % of Cottonwood	Decadent or Dead % of Cottonwood	Snag % of Cottonwood	Age (from Tree Cores) or estimated age (years)	Substrate[4]	Acres
36	65	8	45	10			N	N	0	100	0	0	0	Dense saplings stand; too young to core	CGF	0.65
37	50	50	25	6			Y	Y	5	35	60	0	0	28,96	F	0.74
38			40	10	30	5	N	Y							F	0.34
39	10	60	75	12	30	5	Y	Y							F	1.20
40	3	5	90	10	10	5	N	N							CGF	2.03
41	30	70	35	5	15	10	Y	N	15	20	50	10	5	35 years at 20 in dbh; Wide size range 5” to 40” dbh	F	0.46
42a	60	70	35	15	65	7	Y	Y	50	25	20	0	5		F	1.68
42b	5	40	60	4	65	25									F	2.03
42c			90	5	80	10									F	0.64
43			65	11	10	4									F	0.31
44a	60	75	70	4	15	8	N	N							F	0.60
44b	5	3	15	12	10	4	N	N							F	0.57
44c	10	3	40	12	25	8	N	N							F	0.78
44d	40	70	70	4	20	10	N	Y	0	30	70	0	0		F	9.22
44e	20	4					N	N	10	90	0	0	0		F	0.28
44f	15	4	10	10	10	4	N	Y							F	0.39
45	10	20	60	5	35	12	N	Y							F	0.74
46	10	70	25	4	15	12	Y	N	0	5	65	0	30		F	5.04
47	45	80	85	5	10	7	Y	N	1	10	80	1	10	67, 66	F	17.63
48			80	12	75	5									F	0.27
50			75	5	60	15									F	0.53
51a			65	10	25	4									F	0.21
51b	40	70	50	12	40	5	Y	N	25	25	50	0	0	78	F	0.28
52			65	10	25	4									F	0.50
53	40	70	50	12	40	5	Y	N	25	25	50	0	0	No access	F	1.08
54	1	3	25	4			N	N							SCF	0.39
55	10	70	25	4	15	12	Y	N	0	5	90	0	5		F	1.25
56a	10	5	5	1			N	N							F	0.24
56b	60	60	70	5	20	10	Y	Y	0	10	75	5	10	43, 60, 92	F	1.21
56c	5	4	25	5			N	N							CGF	1.37
56d	75	8	5	5			N	N	20	80	0	0	0	All saplings; too young to core	F	0.44
58	35	35					Y	Y	50	8	40	1	1	54, 46, 46, 35, 30, 54, 37, 40, 20	CGF	3.46
59			70	6											CF	0.12
60			25	7											SCF	0.71
61a			65	6			N	N							SCF	1.14
61b			30	2											CGF	0.31
62			20	5											CGF	0.55
63			95	13	15	4									F	0.18
64	65	50	35	7	10	5	N	Y	15	5	80	0	0	26, 23, 28, 40,	CF	0.44
65	2	1	5	1			N	N							CGF	0.21

Notes:

Field data collected through September 2007 as described in Section 4 of the report. These data are the source of the summary tables in the report.

1 Vegetation classification abbreviations: RS = Riparian shrub, RDT = Riparian deciduous tree, PSS = Palustrine scrub shrub, PFO = Palustrine forest, US = Upland shrub, REM = Riparian emergent.

2 Tree species abbreviations: POPBAL = *Populus balsamifera* ssp. *trichocarpa*, POPTRE = *Populus tremuloides*, BETPAP = *Betula papifera*, PINPON = *Populus ponderosa*, ABIGRA = *Abies grandis*, THUPLI = *Thuja plicata*.

3 Shrub species abbreviations: ACEDOU = *Acer douglasia*, ALNVIRS = *Alnus viridis* ssp. *sinuata* [was *A. sinuate*], ALNINC = *Alnus incana*, *Berberis aquifolium* [syn. *Mahonia aquifolium]*, CRADOU = *Crataegus douglasii*, CORSER = *Cornus sericea*, *BERAQU*], *PHILEW* = *Philadelphus lewisii*, RUBPAR = *Rubus parviflorus* , SALLUC = *Salix lucida* ssp. *lasiandra*, SALEXI = *Salix exigua* [including *S. melanopsis*], SALSIT = Salix Sitchensis, SALPPRO = *Salix prolixa*, SPIDOU = Spiraea douglasia, SYMALB = *Symphoricarpos albus.*

4 Substrate abbreviations: C = Cobble, G = Gravel, F = Fines, S = Stones.

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Study No. 16: Inventory of Riparian Trees and Shrubs
Final Report
Boundary Hydroelectric Project (FERC No. 2144)

1 INTRODUCTION

Study No. 16, the Inventory of Riparian Trees and Shrubs (Riparian Study), was conducted in support of the relicensing of the Boundary Hydroelectric Project (Project), Federal Energy Regulatory Commission (FERC) No. 2144, as identified in the Revised Study Plan (RSP; SCL 2007) submitted by Seattle City Light (SCL) on February 14, 2007 and approved by the FERC in its Study Plan Determination letter dated March 15, 2007. This is the final report describing the field efforts, analyses, and determination of Project effects and represents the completion of the study.

2 STUDY OBJECTIVES

The goal of the Riparian Study was to provide information needed to determine the extent, types, and structure of riparian tree and shrub species in the Project vicinity, and to assess Project effects on these species. Specific objectives of this study were as follows:

- Identify the current location, extent, and distribution of riparian tree and shrub species.
- Characterize the species composition and structure of riparian tree and shrub stands.
- Document the age structure of cottonwood stands and the number and age class of snags.
- Estimate the distribution and extent of riparian tree and shrub habitat that could potentially occupy the fluctuation zone.
- Identify potential threats to existing riparian tree and shrub stands (e.g., infestations of exotic species, beaver [*Castor canadensis*], erosion, ungulate grazing, trampling, and reservoir level fluctuations).

3 STUDY AREA

The study area for the Riparian Study extended approximately 18 miles along the Pend Oreille River from the Box Canyon tailrace downstream to the U.S.-Canada border (Figure 3.0-1) and encompassed the following:

- Downstream of Metaline Falls—The reservoir, fluctuation zone allowed under the current license (forebay elevation 1,954–1,994 feet NAVD 88 [1,950–1,990 feet NGVD 29])[1, 2], and land within the FERC Project boundary (Project area), which includes most Project facilities, the area 200 horizontal feet (i.e., along the ground surface, perpendicular to the shoreline) beyond the high water level along both reservoir shorelines, and the transmission line right-of-way from the powerhouse to the Bonneville Power Administration interconnection.
- Upstream of Metaline Falls—The reservoir, fluctuation zone (approximately 1,986 – 2,020 feet NAVD 88 [1,982–2,016 feet NGVD 29], as measured at the U.S. Geologic Survey [USGS] gage below Box Canyon Dam), and the land within approximately 200 horizontal feet above the high water level (approximately 2,019 feet NAVD 88 [2,015 feet NGVD 29]) along both reservoir shorelines extending to the FERC project boundary for the Box Canyon Project.[3,4]
- The Boundary Wildlife Preserve (BWP) (155 acres) and adjoining SCL-owned property (85 acres).
- 100 horizontal feet along both sides of the river from Boundary Dam to the U.S.-Canada border (approximately 0.9 mile).

[1] The reservoir fluctuation zone is defined as the area between 1,974 and 1,994 feet NAVD 88 (1,970 and 1,990 feet NGVD 29). Very infrequently, Project maintenance requires that the reservoir be drawn down below this elevation. Between 1987 and 2005 (the period represented by the Project hydrologic record (R2 Resource Consultants, Inc. 2008), drawdowns below 1,974 feet NAVD 88 (1,970 feet NGVD 29) occurred less than 0.25 percent of the time (equivalent to 17.5 days) and drawdowns below 1,964 feet NAVD (1,960 feet NGVD) occurred only 0.02 percent of the time (equivalent to 1.5 days). The only element of this study that is affected by this definition of the study area is Task 3, Mapping of Potential Riparian Tree and Shrub Habitat. This estimate of potential habitat was limited to the upper 20 feet of the fluctuation zone as drawdowns occurring below elevation 1,974 feet NAVD 88 (1,970 feet NGVD) are not of long enough duration to allow for the establishment of vegetation.

[2] SCL is in the process of converting all Project information from an older elevation datum (National Geodetic Vertical Datum of 1929 [NGVD 29]) to a more recent elevation datum (North American Vertical Datum of 1988 [NAVD 88]). As such, elevations are provided relative to both data throughout this document. The conversion factor between the old and new data is approximately 4 feet (e.g., the crest of the dam is 2,000 feet NGVD 29 and 2,004 feet NAVD 88).

[3] As indicated in this and other study reports in the Updated Study Report, SCL agreed that it was appropriate to study the existing fluctuation range of the reservoir; however, for development of the Preliminary Licensing Proposal (PLP) and License Application, SCL will base its assessment of potential protection, mitigation, and enhancement measures on that portion of the fluctuation zone that is determined to be under the influence of Boundary Project operations, versus the effects of inflows and Metaline Falls that are beyond the control of the Project.

[4] Data for the riparian zone downstream of the Box Canyon Dam located within the FERC project boundary for the Box Canyon Project (FERC No. 2042) are included in this report; however, in the development of the PLP and License Application, SCL's assessment of potential protection, mitigation, and enhancement efforts will be limited to those effects that are determined to be under the influence of Boundary Project operations.

The range of water surface elevations recorded during the survey periods for this study is presented below and represents typical operating conditions for the period in which field data were collected. Existing conditions at the time of surveys were considered adequate to acquire all data required for this study:

- From Box Canyon Dam to Metaline Falls—Elevation 1,988–1,991 feet NAVD 88 (1,984–1,987 feet NGVD 29), as measured at the USGS gage 12396500.
- From Metaline Falls to Boundary Dam—Elevation 1,987–1,991 feet NAVD 88 (1,983–1,987 feet NGVD 29), as measured at the SCL gage located in the Boundary forebay.

There were locations in the study area for which access was denied at the time of the survey; these are indicated on Figure 3.0-1.

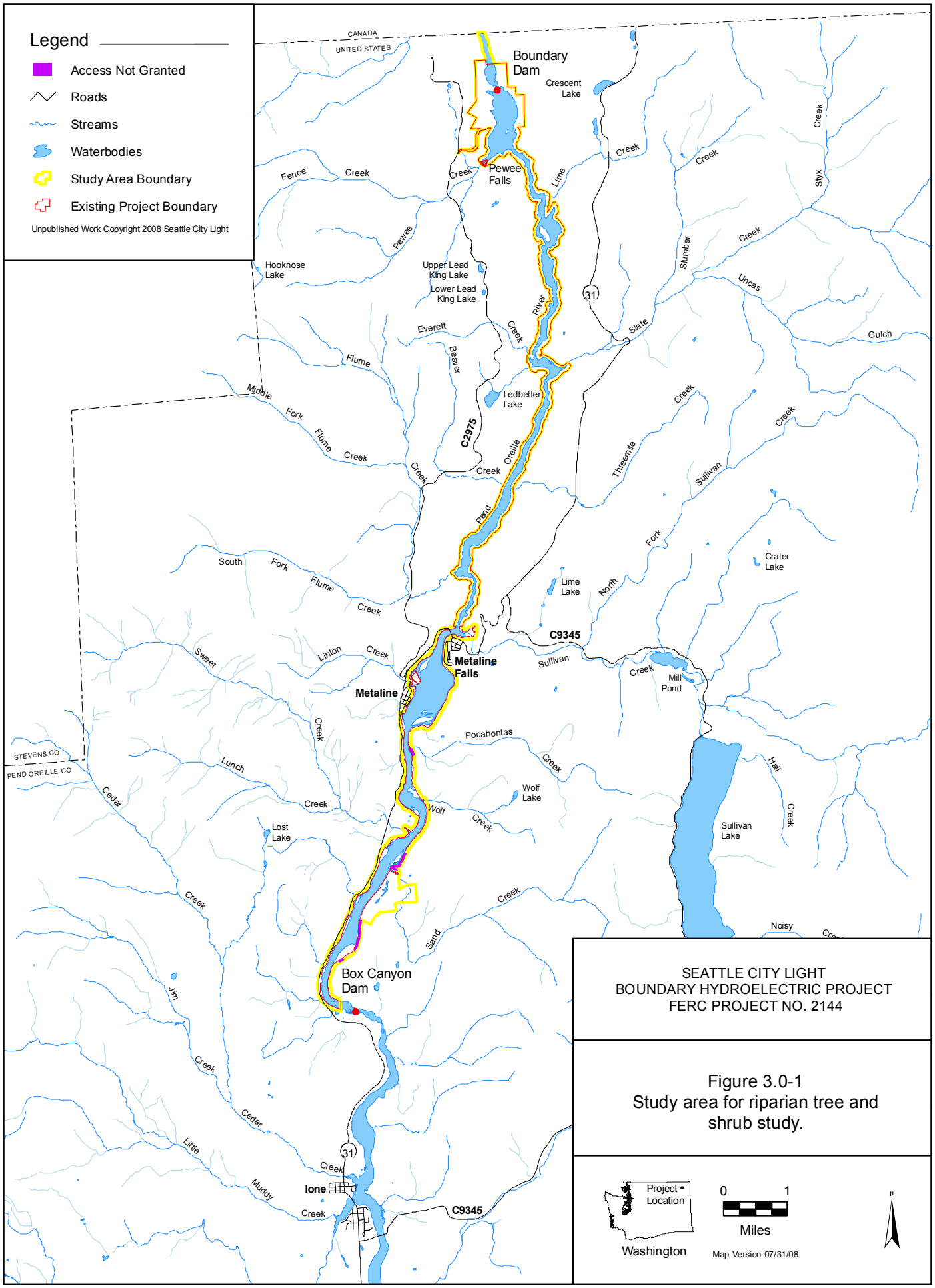


Figure 3.0-1
Study area for riparian tree and shrub study.

4 METHODS

Four tasks were identified for this study:

- Task 1: Map existing riparian tree and shrub stands
- Task 2: Characterize riparian tree and shrub stands
- Task 3: Map potential riparian tree and shrub habitat
- Task 4: Documentation and effects assessment

The methodologies for each task are described in detail below.

4.1. Map Existing Riparian Tree and Shrub Stands

For the purposes of this study, the terms riparian tree/shrub habitat or riparian tree/shrub vegetation are used broadly to include all shrub and forested stands along the reservoir shoreline that are dominated by mesic and hydrophytic deciduous species and that can be classified as either riparian or palustrine wetland. As defined by the vegetation classification system developed for the Pre-Application Document (SCL 2006) and the RSP (SCL 2007), areas were classified as riparian shrub or riparian deciduous tree if the primary hydrologic influence appeared to be a tributary stream or uphill seep. If the primary hydrologic influence was groundwater or the reservoir, then it was classified as palustrine forested or scrub-shrub wetland.

An area was considered forested if it had at least 30 percent coverage of woody vegetation over 19 feet tall based on the Cowardin et al. (1979) classification system (although two stands of dense cottonwood saplings slightly less than 19 feet tall were also classified as forest). Otherwise, the site was classified as shrub.

The RSP designated the following as the focal species for the study:

- Black cottonwood (*Populus balsamifera* ssp. *trichocarpa*)
- Sitka alder (*Alnus viridis* ssp. *sinuata* [was *A. sinuata*])
- Red-osier dogwood (*Cornus sericea*)
- Shining willow (*Salix lucida* ssp. *lasiandra*)
- Coyote willow (*Salix exigua* [including *S. melanopsis*])
- Sitka willow (*Salix sitchensis*)
- Scouler's willow (*Salix scouleriana*)
- Black hawthorn (*Crataegus douglasii*)

Two additional species of willow and an alder species were found in the riparian shrub areas and were added to the focal species list:

- MacKenzie's willow (*Salix prolixa*)
- Bebb's willow (*Salix bebbiana*)
- Gray alder (*Alnus incana*)

The map of tree- and shrub-dominated riparian and wetland habitats in the RSP (Figure 2.4-1 in the RSP [SCL 2007]) served as the starting point for the inventory and mapping of riparian trees and shrubs. The Project's 2005 aerial photographs (1:12,000) were used in the field to refine maps of the distribution of tree- and shrub-dominated riparian and wetland habitats.

Areas previously identified as riparian deciduous tree, riparian shrub, palustrine forested wetland, or palustrine scrub-shrub wetland were surveyed to verify boundaries and categorization. Any errors in the 2005 classification or delineation of existing polygons were noted and corrected. Additional areas that included the focal species were delineated on the field maps or on the aerial photographs. Areas that were difficult to map because of shadows on the aerial photographs or because individual or small patches of riparian species were too small to delineate on a map, were recorded using Global Positioning System (GPS) coordinates.

Data were digitized using ESRI's Geographical Information Systems (GIS) ArcMap software. The spatial data were used to amend the existing cover-type shape files and to create an accurate and comprehensive map depicting the distribution of riparian trees and shrubs in the study area. The data in the shape file table were updated to reflect the newly calculated acreages of riparian habitats.

4.2. Riparian Tree and Shrub Stand Characterization

Riparian tree/shrub habitat characterization data were collected concurrently with the mapping exercise in Task 1. Stand characterization data were entered onto data sheets during the field survey, which occurred between September 2 and 8, 2007. The sheets were reviewed for missing data and scanned onto the Tetra Tech server. The data were later transferred to a Microsoft® Excel spreadsheet and were used to update the GIS shape file. The data are presented in Appendix 1. Data were collected on the following parameters:

- Area (square feet or acres) estimate for each polygon: In general, the vegetation was checked against the existing map or was mapped in the field and the area was calculated later in GIS.

- Species composition: All shrub and tree species, including non-focal species, were recorded for each polygon.

- Canopy cover: Canopy cover was visually estimated for all tree and shrub species in each stand. In larger stands, unique homogenous areas were delineated for separate characterization. For example, in the BWP, Sullivan Creek, and the area close to the Metaline sewage ponds, the stands were subdivided into homogenous units for canopy cover estimate. These subdivided areas were treated as separate units in the data analysis. The estimates of canopy cover of each species were made visually after walking through a stand. Cover was recorded for all shrub and tree species, including those that were not the focal riparian species.

- Average heights: Average height(s) was visually estimated for each woody species in the stand.

- Age class: The RSP provided the following age classification system for willows and other multi-stem focal species (Crowley et al. 2006):
  - Seedlings: 1 stem at surface.
  - Young: 2 to 10 stems at ground surface.
  - Mature: > 10 stems at ground surface and > 50 percent living.
  - Decadent/Dead: > 10 stems at ground surface and < 50 percent living.

  This age classification was designed to be used in long-term monitoring in a limited size plot (2-meter by 1-meter plot) along a 100-meter transect. It was noted in Crowley et al. (2006) that using this age-class indicator is not appropriate for rhizomatous species that often develop thickets, such as coyote willow. Many riparian shrub species can reproduce through layering and all of them develop dense thickets. It is just as difficult to estimate the age class of species that form dense thickets as the rhizomatous shrubs referred to by Crowley et al. (2006). For layering and sprouting shrub species, Crowley et al. (2006) suggested measuring percent cover as was done in this study. Although that can be useful as an indicator of reproduction over time, it does not determine age class distribution in a single survey.

  The age classification system described above was used at each shrub stand where appropriate. This classification system was modified for the following conditions:
  - *Dense shrub thickets where it was difficult to see well enough to estimate age class distribution or to count seedlings:* For these stands, the presence of shoots or sprouts was used to indicate successful vegetative reproduction. The number of seedlings, however, may have been underestimated.
  - *Stands where willow species and Sitka alder adopted a tree form with a single trunk:* Surveyors used judgment in assessing age class of shrub species regardless of the number of stems.

  Where possible, age classes were estimated and it was noted if seedlings were seen. However, this information should be considered more of a recognition that the stands appeared to be regenerating because it is difficult to determine if these are young shrubs or vegetative extensions of the existing shrubs.

  The age classes used for cottonwoods were as follows:
  - Seedlings: Stem is < 4.5 feet tall or < 1 inch diameter at breast height (dbh).
  - Young: Stem is > 4.5 feet tall or < 4.5 feet tall and 1 to < 5 inches dbh.
  - Mature: Stem is ≥ 5 inches dbh.
  - Decadent/Dead: Stem is ≥ 5 inches dbh with < 50 percent live canopy.
  - Snag: Stem is > 5 inches dbh with a completely dead canopy.

  The understory in and adjacent to most cottonwood stands in the study area was dense and difficult to penetrate, thus, seedling numbers may have been underestimated. However, cottonwood seeds typically sprout in open areas with bare substrates rather than regenerating within the shade of an established stand (DeBell 1990; Mahoney and Rood 1998); therefore, areas of dense understory probably supported only a few seedlings.

Beaver cutting (and some deer browsing) also made it difficult to determine age classes in cottonwood stands in some locations. In many cases, the base of the heavily browsed (shrubbed) cottonwood was thick, suggesting that it could be much older than its height would indicate. Although quite short (< 2 feet), a shrubbed cottonwood might be a young tree rather than a seedling as classified by height. Professional judgment was used to classify age of these individuals and the effect of browsing was noted on the data sheet. The presence of flowers or fruit and growing conditions associated with seedling establishment were noted.

Approximately 10 to 20 percent of mature trees in each cottonwood stand were to be selected for coring to determine actual age according to the RSP. The objective of the tree coring was to document the age structure of cottonwood stands. Because coring can lead to decay and other forms of degradation (Maeglin 1979), and 20 percent is a significant portion of a stand, it was decided (during a September 6, 2007 site visit attended by a number of relicensing participants, SCL, and the Tetra Tech riparian study team) that the actual number of trees cored would depend on age diversity within a stand. Only a few trees were selected for coring if most of the mature trees in a stand were relatively uniform in size. In stands that were apparently more diverse, mature trees representing a wide range of sizes were selected for coring. This satisfied the coring objective and minimized harm to trees, particularly in large stands such as the BWP. In many cases, much less than 20 percent of the trees were cored, yet the age classification objectives were still met.

For each tree that was cored, the following data were recorded: dbh, ring count, estimated age (for trees that were hollow and a complete core was not available), estimated height, and whether there was a hollow heart. During coring, many cottonwoods had a strong outflow of a liquid that ranged from fairly clear to red. One of the first cottonwoods to be cored gushed for more than 10 minutes. Due to the potential damage to trees, the surveyors stopped coring when the warning gurgle sound occurred and estimated the age of the tree based on the rings seen on the partial core, the dbh of the tree, and the estimated thickness of the bark.

Black cottonwood tree rings are recognized as being very difficult to interpret. *Populus* spp. trees generally have rings that are diffuse and porous with nearly uniform vessel size and distribution, resulting in indistinct transitions between rings (Maeglin 1979). Several experienced biologists were contacted and the U.S. Forest Service guide (Maeglin 1979) was consulted for techniques to enhance ring boundaries and improve core readability. Several of these techniques were tested during the survey. Rings were counted in the field immediately after coring, and then placed in a straw and labeled for further processing. Several processing techniques were attempted to improve the distinction between rings, including rewetting with glycerin, applying several different strengths of iodine as a wash, and using a binocular microscope. None of these techniques notably improved the visibility of the rings. The most accurate ring counts, as determined by repetition and agreement by both biologists, involved looking at the wet core immediately after coring, increasing core wetness with saliva, using a hand lens, and backlighting the cores in the sun. Each core was counted several times to confirm the ring count; for

particularly troublesome cores, both biologists counted the rings and discussed the outcome.

- Ecotones or transitions to other vegetation layers or habitat types were noted if they were different than shown on the map from the Pre-Application Document. If needed, changes were noted so the vegetation data layer could be corrected.

- Substrates were categorized as follows. In most areas, more than one type of substrate was observed and all were noted.
    - Stones (> 10 inches),
    - Cobble (3 to 10 inches),
    - Gravel (0.08 to 3 inches), and
    - Fines (includes sand and silt) (< 0.08 inch).

- Potential direct and/indirect impacts on riparian trees and shrubs, including Project- and non-Project- related impacts, were recorded. These included the following:
    - Hydrology (stream flow, runoff, flooding),
    - Reservoir water level fluctuations,
    - Invasive species infestations,
    - Human activities (recreation, timber harvest, mining, etc.),
    - Damage or trampling from cattle grazing,
    - Damage from beaver, deer, or other wildlife,
    - Erosion, and
    - Encroachment of conifers.

There were four locations in the study area where access was denied, and there were riparian tree/shrub stands at three of the sites: two palustrine scrub-shrub wetland stands and a palustrine forested wetland. One palustrine scrub-shrub wetland is adjacent to the south end of the BWP (Appendix 1, Figure A.1-1, polygon 55). The second site included both a scrub-shrub stand and a forested wetland and was located across the reservoir from the BWP (Appendix 1, Figure A.1-1, polygons 52 and 53). Viewed from the reservoir, the inaccessible sites appeared similar to adjacent palustrine wetland polygons; data from these surveyed polygons were used to classify the inaccessible sites.

For riparian tree/shrub stands that occurred both inside and outside of the study area boundary (Sullivan Creek, the BWP, and the cottonwood forest near Box Canyon Dam, for example), only the portions within the study area were analyzed.

4.3. Mapping of Potential Riparian Tree and Shrub Habitat

The objective of this task was to estimate the area within the fluctuation zone that could potentially support riparian trees and shrubs if the reservoir were operated at lower water surface elevations, assuming no significant changes in topography or substrate. As described in the RSP,

these estimates were to be calculated for water surface elevations, as measured at the Boundary Dam forebay gage, at increments of –5, –10, –15, and –20 feet below the current summer average water surface elevation (1,990 feet NAVD 88 [1,986 feet NGVD 29]). For purposes of this exercise, the riparian growing season was defined as June 15 to September 15, which encompasses most of the riparian growing season, but occurs after the spring runoff. Based on the 19-year (1987–2005) hydrologic record, the median (50 percent non-exceedance) water surface elevation at Boundary Dam during the summer growing season was approximately 1,990 feet NAVD 88 (1,986 feet NGVD 29), and the median flow into the reservoir measured at the Box Canyon gage (USGS gage 12396500) was 16,355 cubic feet per second (cfs) (the full range was 2,992 to 128,167 cfs). With slight rounding, the water surface increments at the dam were established as 1,985; 1,980; 1,975; and 1,970 feet NAVD 88 (1,981; 1,976; 1,971; and 1,966 feet NGVD 29).

Water surface elevations at Boundary Dam do not equate to water surface elevations further upstream due to the influences of slope, canyon morphology, flow, and the effects of Metaline Falls. The Hydraulic Routing Model (HRM), developed as part of Study 7, the Mainstem Aquatic Habitat Modeling Study (SCL 2009a), was used to estimate median water surface elevations at half-mile intervals along the length of the reservoir under the various operating scenarios. These results showed the following during the summer months:

- There was less than a half-foot difference in water surface elevation between Boundary Dam and just below Metaline Falls for each of the four water surface increments, and the average difference in water surface elevation between half-mile increments was 0.01 feet.

- Differences in water surface elevation immediately above and below Metaline Falls ranged between approximately 1 foot when the water level at Boundary Dam was 1,990 feet NAVD 88 (1,986 feet NGVD 29) and approximately 14 feet when the water surface elevation at Boundary Dam was 1,970 feet NAVD 88 (1,966 NGVD 29).

- There was an approximate 1.5-foot difference in water surface elevation between Box Canyon Dam and Metaline Falls when the water level at Boundary Dam was 1,990 feet NAVD 88 (1,986 feet NGVD 29), and the average difference in water surface elevation between half-mile increments was 0.11 foot. The greatest increment difference occurred at the Box Canyon tailrace (0.44 foot).

- There was an approximate 3.32-foot difference in water surface elevation between Box Canyon Dam and Metaline Falls when the water level at Boundary Dam was 1,985 feet NAVD 88 (1,981 feet NGVD 29), and the average difference in water surface elevation between half-mile increments was 0.24 foot. The greatest increment difference occurred at the Box Canyon tailrace (0.90 foot).

- The influence of the Boundary Project on water surface elevations upstream of Metaline Falls is a function of the inflow into the reservoir and the forebay elevation. In other words, for a given inflow rate into the reservoir, there is a corresponding

forebay elevation below which the Boundary Project has minimal or no influence on water surface elevations upstream of Metaline Falls. At an inflow of 15,000 cfs, the Boundary Project has little to no influence on water surface elevations upstream of Metaline Falls when the forebay elevation is at or below approximately 1,977 feet NAVD 88 (1,973 NGVD 29). For this reason, the 1,975 and 1,970 foot NAVD 88 (1,971 and 1,966 foot NGVD 29) scenarios were not considered above Metaline Falls as those conditions are not expected to be different from current conditions.

Each riparian polygon was assigned a modeled water surface elevation at the nearest half-mile increment, rounded to the nearest 1 foot, for each of the 0, -5, -10, -15, and -20 foot scenarios. (Differences in polygon water surface elevations between half-mile increments were inches, or fractions of inches; the values were rounded to the nearest 1 foot.) The difference between 1,990 feet NAVD 88 (1,986 feet NGVD 29) and the modeled water surface elevation under each operating scenario (1,985, 1,980, 1,975, and 1,970 feet NAVD 88 [1,981, 1,976, 1,971, and 1,966 feet NGVD 29]) represents the predicted extent to which riparian vegetation could expand into the fluctuation zone below its current position. For example, a 5-foot change in water surface elevation at Boundary Dam equates to a 5-foot change at all locations in the lower reservoir under all scenarios. In the upper reservoir, however, the change between 1,990 and 1,985 feet NAVD 88 (1,986 and 1,981 feet NGVD 29) at Boundary Dam equates to a 3- or 4-foot change, depending on the location (with the exception of the Box Canyon tailrace where the change is only 2 feet). For example, a riparian stand in the lower reservoir occurring above the 1,996-foot NAVD 88 (1,991-foot NGVD 29) contour could potentially expand to the 1,991-foot NAVD 88 (1,986-foot NGVD 29) contour, while a stand at the same elevation at the BWP could potentially expand to only 1,992 feet NAVD 88 (1,988 feet NGVD 29).

Not all riparian stands are hydrologically connected to the reservoir or otherwise likely to be influenced by reservoir pool levels during the summer months. These include stands that are primarily influenced by other water sources, such as tributary streams (e.g., Sullivan, Lunch, and Linton creeks), the Metaline Falls sewage outfall, the old Metaline sewage ponds, and stands at higher elevations dominated by a mix of species that can occur in both upland and wetland conditions. The stands that are not hydrologically connected to the reservoir are in the common snowberry (*Symphoricarpos albus)* series, black hawthorn series, and the black cottonwood/red-osier dogwood and black cottonwood/common snowberry plant associations of the black cottonwood series, as defined by Kovalchik and Clausnitzer (2004). For the analysis, it was assumed that these stands would remain unchanged. However, the black cottonwood/alluvial bar plant association does occur along the reservoir edge near Box Canyon Dam and was analyzed for potential change in area resulting from operating at lower reservoir levels.

For stands that are associated with reservoir hydrology, the existing upper and lower elevations were determined, and a prediction was made as to how far the stand might expand into the fluctuation zone of a lowered reservoir. Substrate was an important consideration in this analysis because the ability of riparian stands to extend into the fluctuation zone can be limited by a lack of soil. As demonstrated in Study 1, the Erosion Study Final Report (SCL 2009b), the combination of flow, runoff, wave action, and water surface level fluctuations can mobilize soil from some shoreline areas into the reservoir and leave rock and cobble as the dominant substrates in the fluctuation zone in some locations.

Another step of the analysis involved estimating how much of an existing stand might be lost by an associated lowering of the water table. Reservoir drawdown studies (Lenhart 2000; Shafroth et al. 2002; Stanley and Doyle 2003; Auble et al. 2007) conducted as surrogates to future dam removal, observed or predicted mortality of riparian vegetation that was dependent on water tables associated with the reservoir soon after water levels were lowered. In California, Ferry and Miller (2003) reported a die off of riparian vegetation along the former edge of Clear Creek Reservoir 3 years after Saeltzer Dam was removed. Using the terminology of Nilsson et al. (1997), these reservoirs are "pre-upland," meaning their fluctuation zones were upland communities prior to inundation. There is the expectation that the drawdown zones would quickly revert to upland communities (albeit possibly very different from the pre-inundation communities) after an initial flush of weedy annuals (Auble et al. 2007).

Many of the riparian stands along Boundary Reservoir (particularly Sitka alder and red-osier dogwood stands) occur as narrow bands, especially on steeper slopes, which is indicative of a narrow groundwater-influenced zone relative to plant root depths. Many of these stands occur at "pre-upland" sites, especially in the lower reservoir. It was assumed that the groundwater zone would migrate downslope with the lowering of reservoir water surface elevations, converting former groundwater-affected zones to upland (Lenhart 2000; Shafroth et al. 2002; Auble et al. 2007). This was predicted to occur unless there was evidence of seeps, snowfields, streams, road runoff, or other water sources to maintain stable groundwater levels. Thus, the following were assumed:

- Riparian stands could extend into the fluctuation zone if suitable soil substrate was available to support the dominant species of that stand; soil requirements were determined from both literature and field observations.
- The upper portions of a riparian stand would convert to upland, in concert with expansion into the reservoir fluctuation zone, unless other sources (other than the reservoir) for groundwater were evident. Where there was doubt, it was assumed that the upper elevation of the riparian stand would not convert to upland.

Using these assumptions, it was predicted that some riparian stands might increase multi-fold in size with lowering of operating water levels, while others might convert entirely to upland.

4.4. Documentation and Effects Assessment

Field data were recorded on data sheets during the field survey. The data were later transferred to a Microsoft® Excel spreadsheet that became part of the revised GIS shape file. The data are presented in Appendix 1.

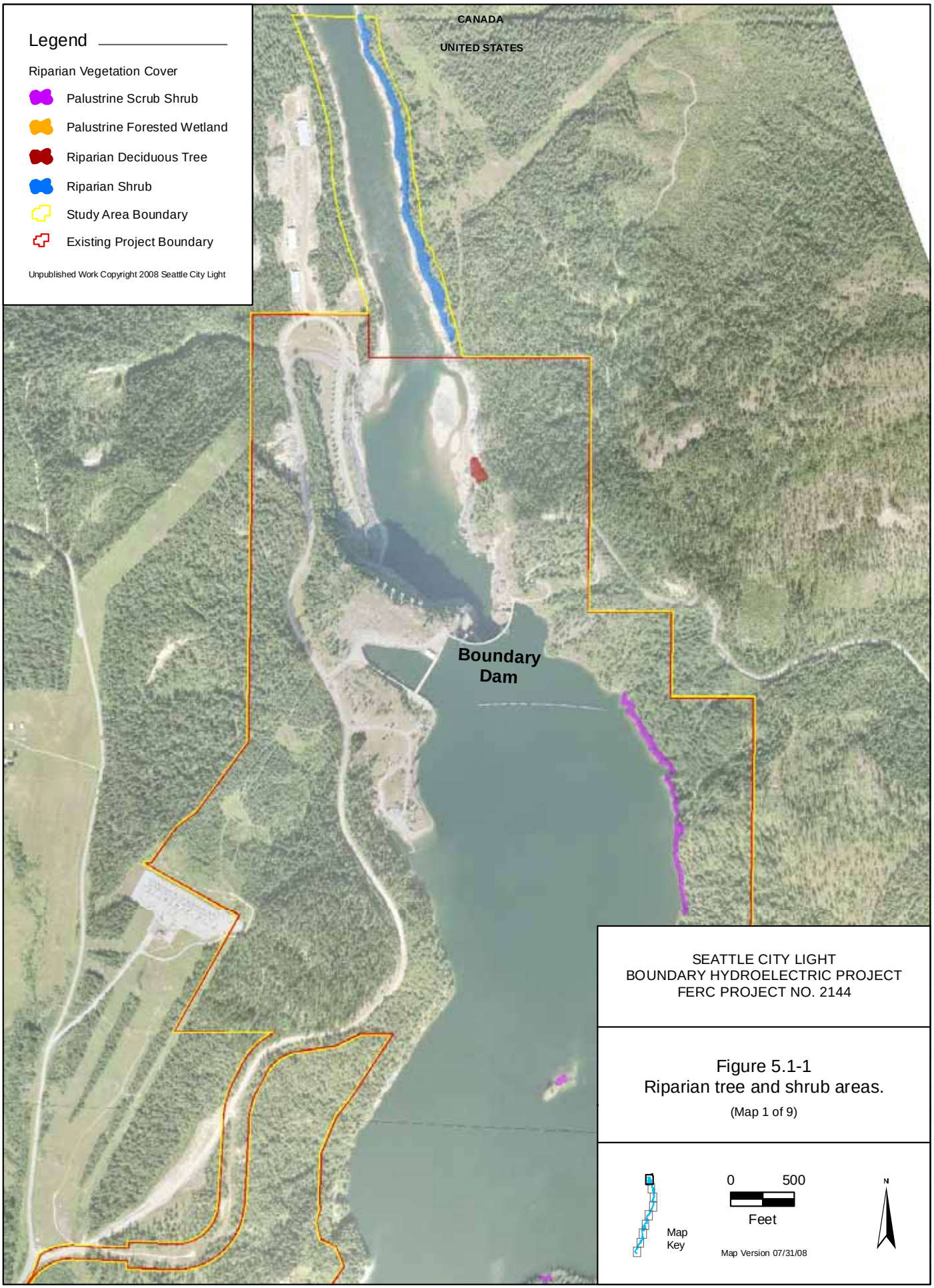
The effects assessment involved describing Project and non-Project effects on the quantity and quality of riparian tree and shrub habitat in the study area using hydrology data, information from the literature and Study 1 (SCL 2009b), and data from Tasks 1 and 2. In particular, this task focused on identifying and describing locations where water surface elevation fluctuations and/or erosion are affecting the maintenance and/or age class distribution of existing stands of cottonwoods or other riparian shrubs. The assessment also considered other threats, including logging, mining, weeds, seasonal high flows, flood inundation, recreation, and herbivory. The

amount of riparian habitat that could potentially develop in the fluctuation zone at lower reservoir water surface elevations was also quantitatively assessed based on the results of Task 3.

5 RESULTS

5.1. Map of Existing Riparian Tree and Shrub Stands

Figure 5.1-1 shows the extent and locations of the existing riparian tree/shrub habitat stands in the study area. Appendix 1 includes a map of all sites surveyed and the detail collected for each polygon. Riparian tree/shrub habitat types occupy 97.7 acres, slightly less than 4 percent of the 2,614-acre study area (Figure 5.1-1). This includes 18.8 acres of riparian shrub, 31.3 acres of palustrine shrub-scrub wetland, 4.3 acres of riparian deciduous trees, and 43.4 acres of palustrine forested wetland. Of the broadly-defined riparian habitat along the reservoir, approximately one-quarter consists of riparian types (influenced by seeps or tributary flow) and three-quarters are palustrine wetlands (influenced by the reservoir). The vast majority of the riparian tree and shrub stands (96 percent) occurs upstream of Metaline Falls, with the remaining split between the reservoir below the falls and the tailrace area (Table 5.1-1).


Legend
Riparian Vegetation Cover
Palustrine Scrub Shrub
Palustrine Forested Wetland
Riparian Deciduous Tree
Riparian Shrub
Study Area Boundary
Existing Project Boundary
Unpublished Work Copyright 2008 Seattle City Light
CANADA
UNITED STATES
Boundary Dam
SEATTLE CITY LIGHT
BOUNDARY HYDROELECTRIC PROJECT
FERC PROJECT NO. 2144
Figure 5.1-1
Riparian tree and shrub areas.
(Map 1 of 9)
Map Key
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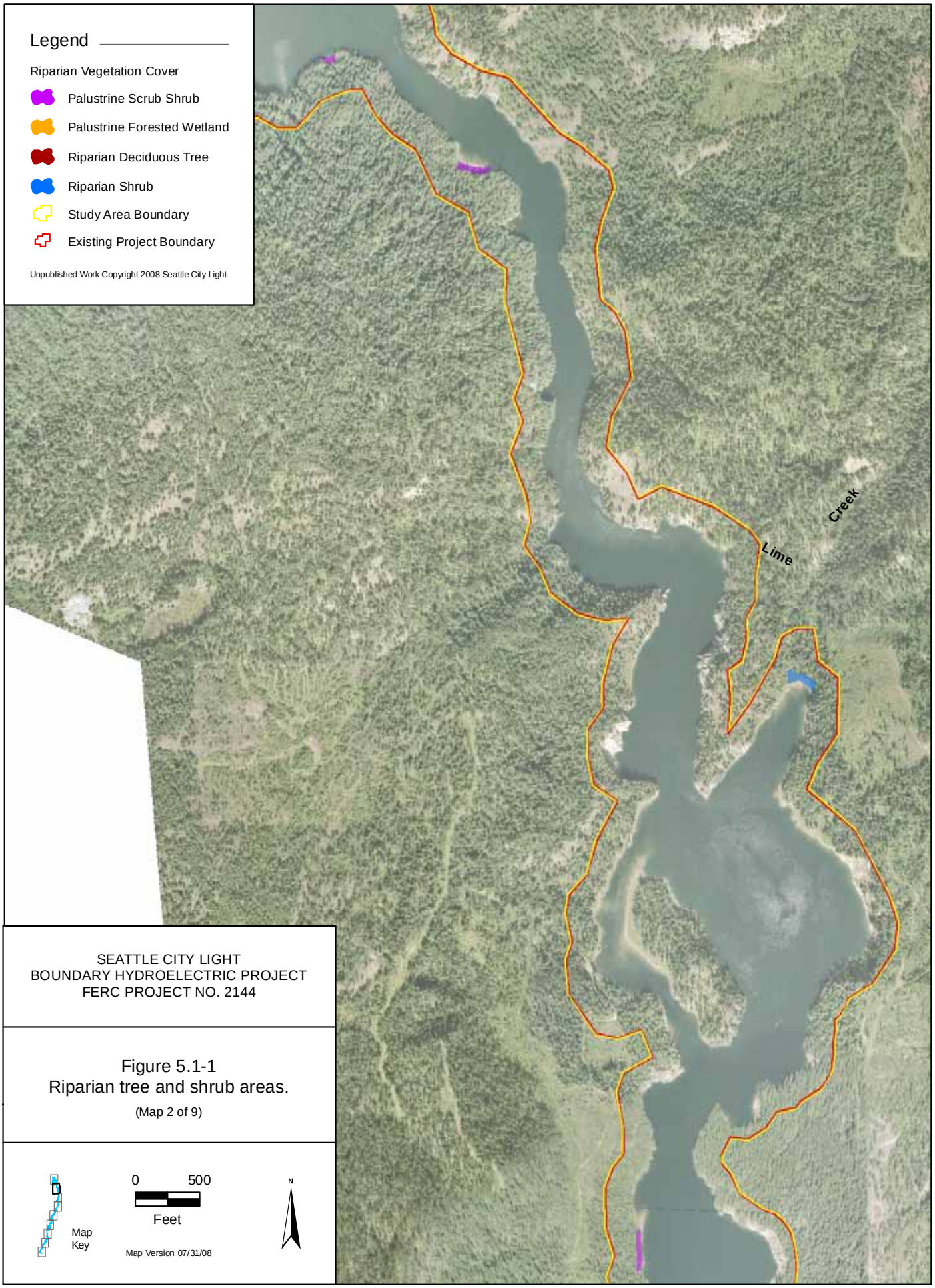
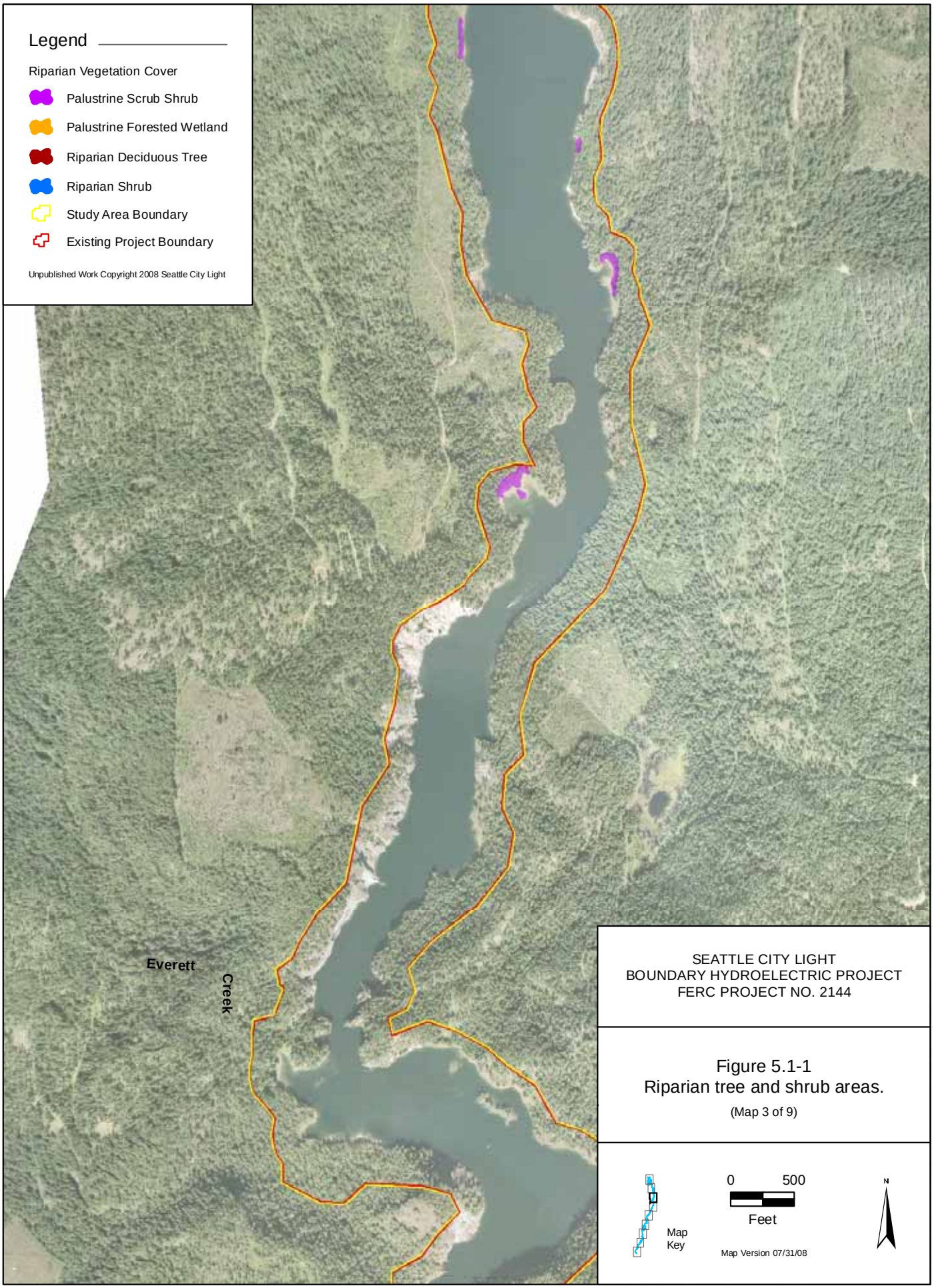
500
Feet
Map Version 07/31/08
N


Legend
Riparian Vegetation Cover
Palustrine Scrub Shrub
Palustrine Forested Wetland
Riparian Deciduous Tree
Riparian Shrub
Study Area Boundary
Existing Project Boundary
Unpublished Work Copyright 2008 Seattle City Light
Lime
Creek
SEATTLE CITY LIGHT
BOUNDARY HYDROELECTRIC PROJECT
FERC PROJECT NO. 2144
Figure 5.1-1
Riparian tree and shrub areas.
(Map 2 of 9)
Map
Key
0
500
Feet
Map Version 07/31/08
N


Legend
Riparian Vegetation Cover
Palustrine Scrub Shrub
Palustrine Forested Wetland
Riparian Deciduous Tree
Riparian Shrub
Study Area Boundary
Existing Project Boundary
Unpublished Work Copyright 2008 Seattle City Light
Everett
Creek
SEATTLE CITY LIGHT
BOUNDARY HYDROELECTRIC PROJECT
FERC PROJECT NO. 2144
Figure 5.1-1
Riparian tree and shrub areas.
(Map 3 of 9)
Map
Key
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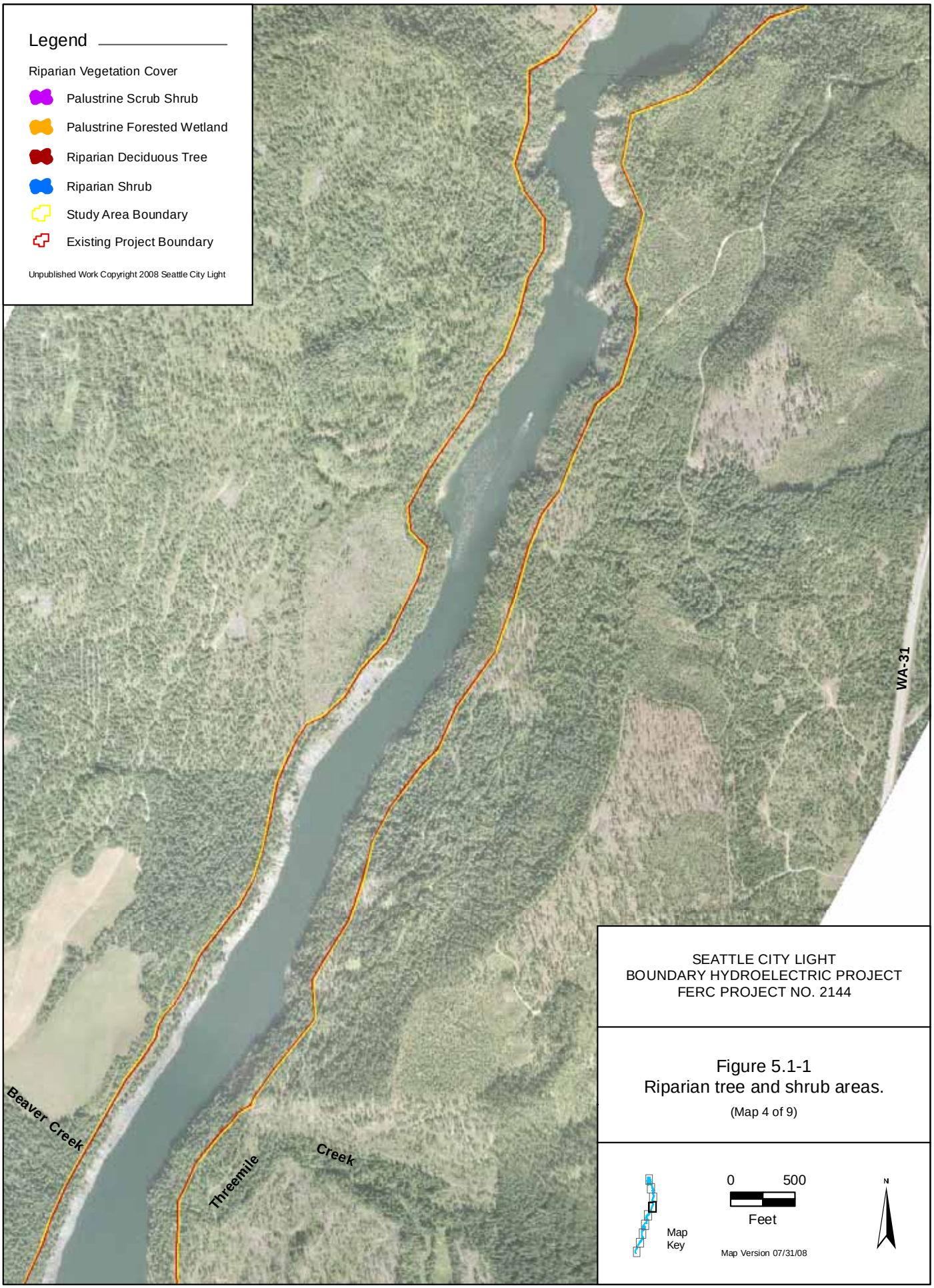
Feet
Map Version 07/31/08
N


Legend
Riparian Vegetation Cover
Palustrine Scrub Shrub
Palustrine Forested Wetland
Riparian Deciduous Tree
Riparian Shrub
Study Area Boundary
Existing Project Boundary
Unpublished Work Copyright 2008 Seattle City Light
WA-31
Beaver Creek
Threemile
Creek
SEATTLE CITY LIGHT
BOUNDARY HYDROELECTRIC PROJECT
FERC PROJECT NO. 2144
Figure 5.1-1
Riparian tree and shrub areas.
(Map 4 of 9)
Map
Key
0
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Feet
Map Version 07/31/08
N

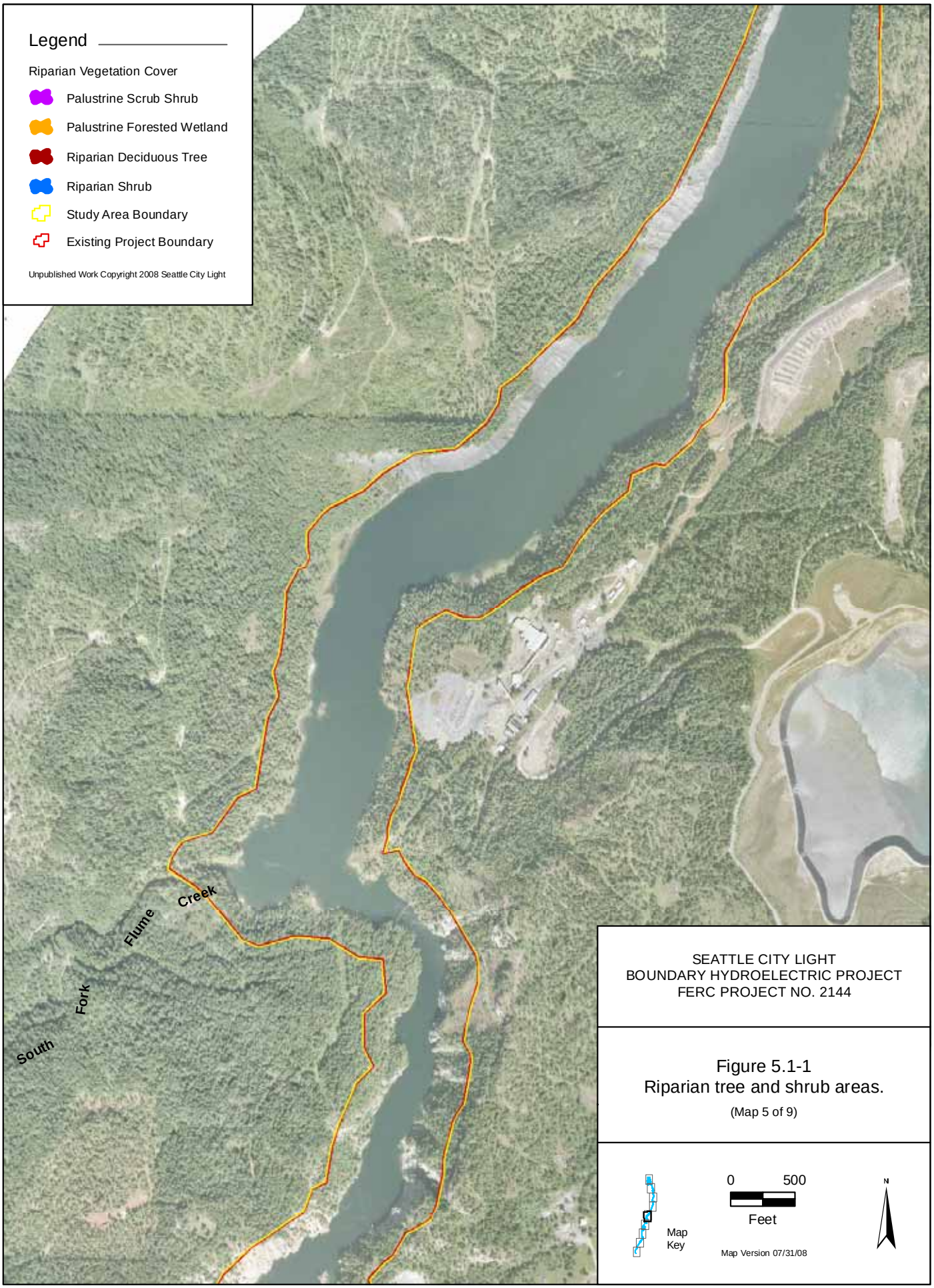


Figure 5.1-1
Riparian tree and shrub areas.
(Map 5 of 9)

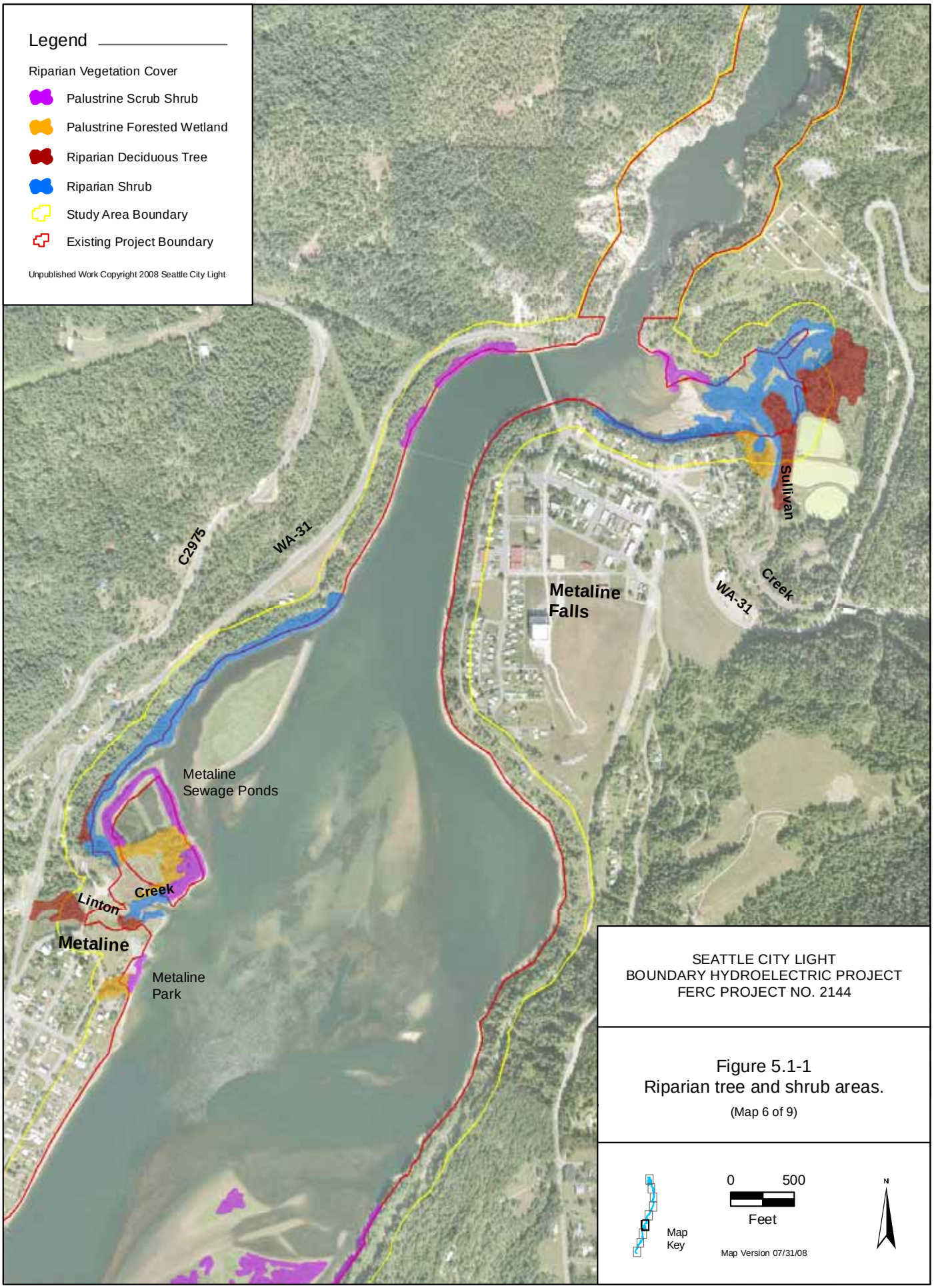
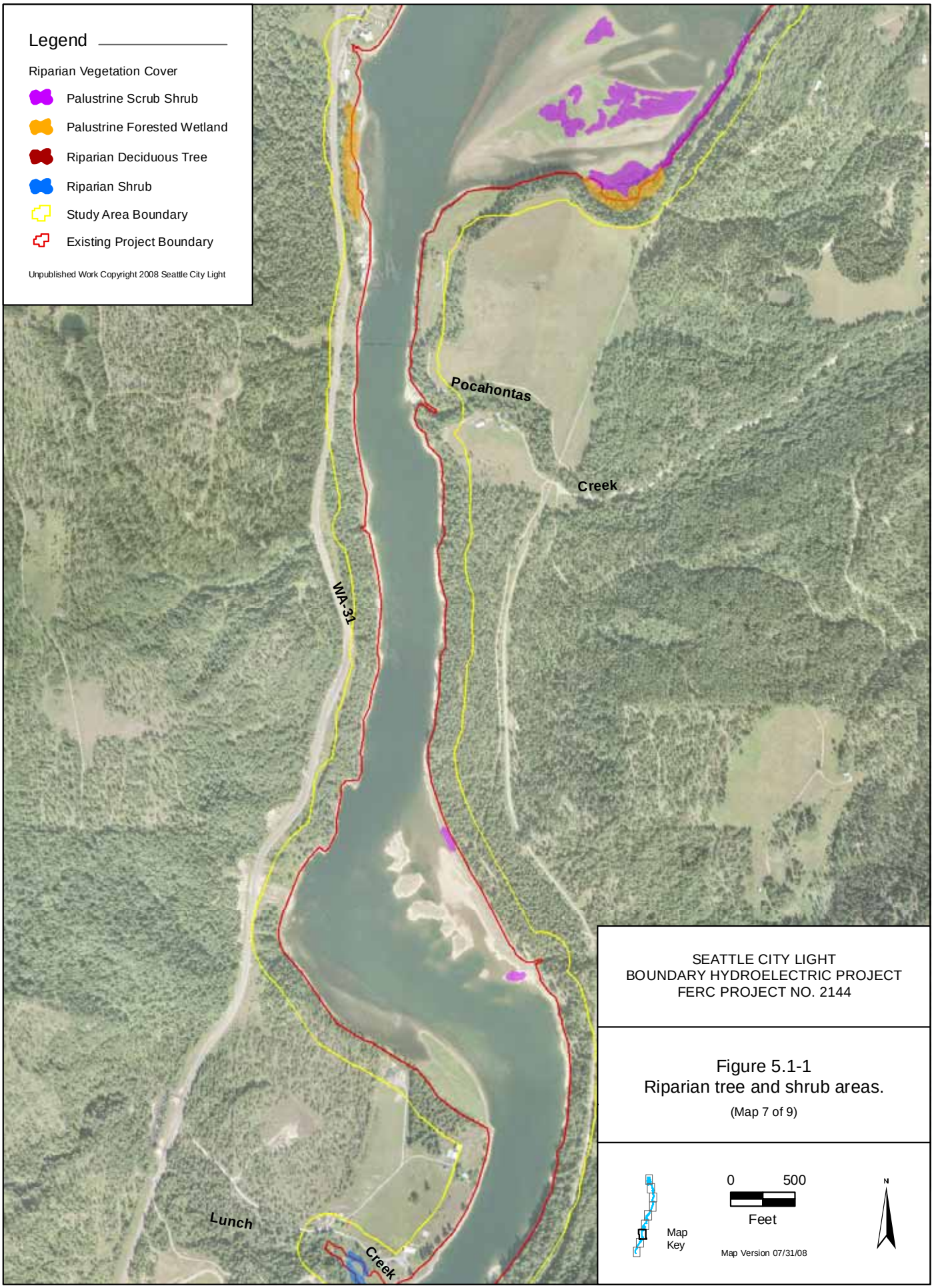


Figure 5.1-1
Riparian tree and shrub areas.
(Map 6 of 9)


Legend
Riparian Vegetation Cover
Palustrine Scrub Shrub
Palustrine Forested Wetland
Riparian Deciduous Tree
Riparian Shrub
Study Area Boundary
Existing Project Boundary
Unpublished Work Copyright 2008 Seattle City Light
Pocahontas
Creek
WA-31
Lunch
Creek
SEATTLE CITY LIGHT
BOUNDARY HYDROELECTRIC PROJECT
FERC PROJECT NO. 2144
Figure 5.1-1
Riparian tree and shrub areas.
(Map 7 of 9)
Map
Key
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Map Version 07/31/08
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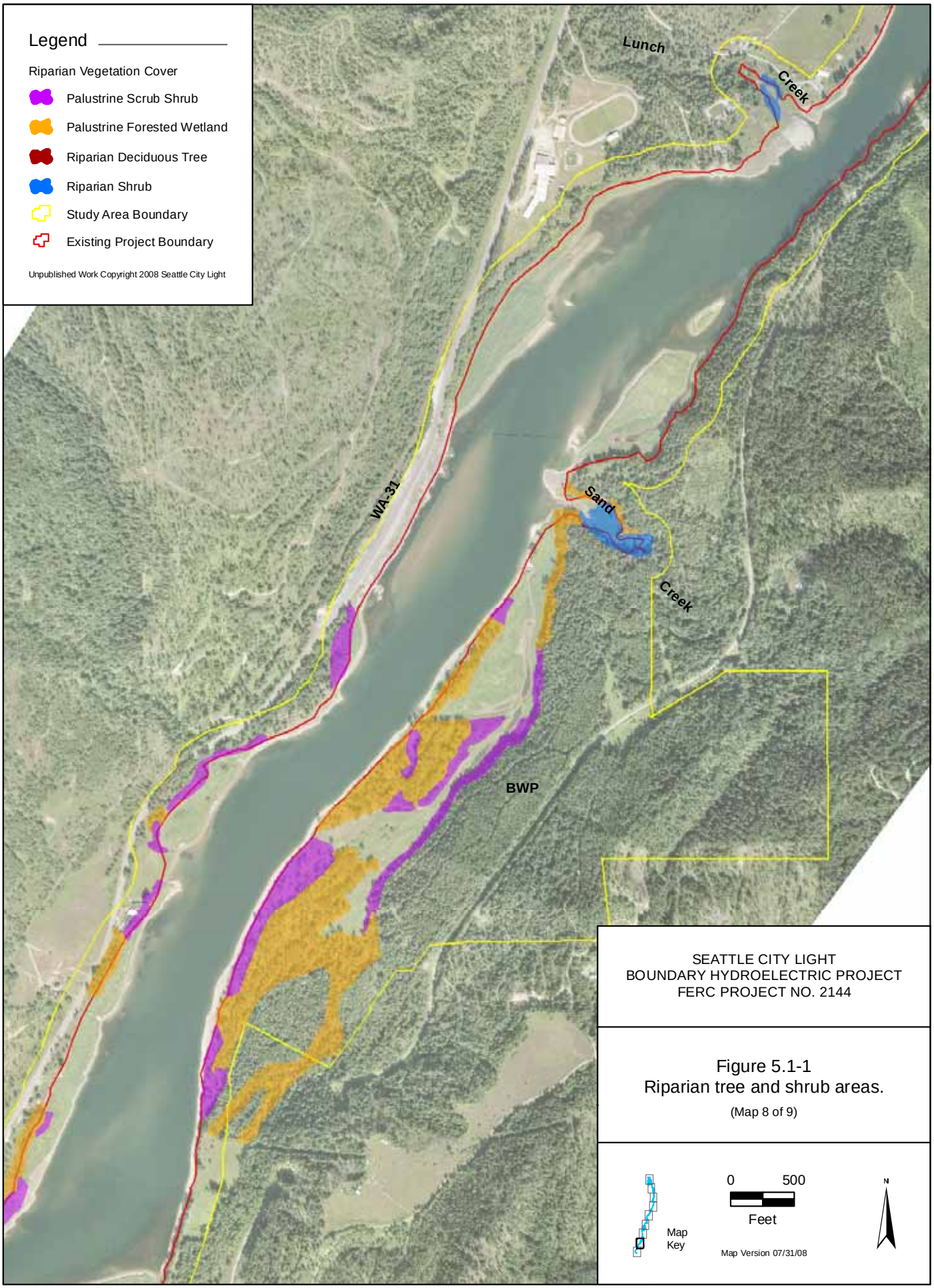

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Figure 5.1-1
Riparian tree and shrub areas.

(Map 8 of 9)

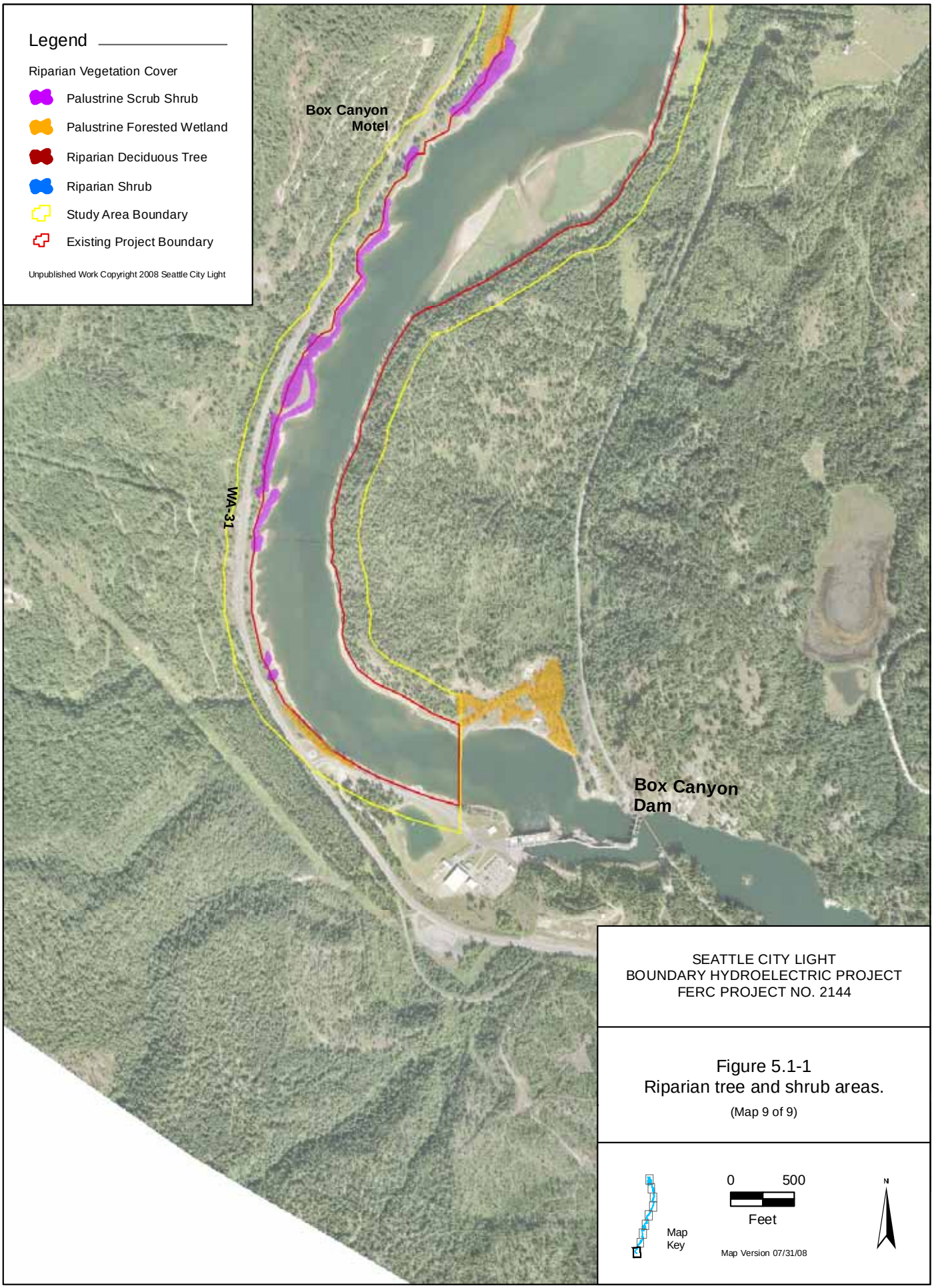
Legend
Riparian Vegetation Cover
Palustrine Scrub Shrub
Palustrine Forested Wetland
Riparian Deciduous Tree
Riparian Shrub
Study Area Boundary
Existing Project Boundary
Unpublished Work Copyright 2008 Seattle City Light
Box Canyon Motel
WA-31
Box Canyon Dam
SEATTLE CITY LIGHT
BOUNDARY HYDROELECTRIC PROJECT
FERC PROJECT NO. 2144
Figure 5.1-1
Riparian tree and shrub areas.
(Map 9 of 9)
Map Key
0
500
Feet
Map Version 07/31/08
N

Table 5.1-1. Acres of riparian tree/shrub vegetation in the study area.

Survey Area	Vegetation Type (ac)				Total Area (ac)
	RDT	RS	PFO	PSS	
Boundary Dam Tailrace	**0.2**	**2.2**	**-**	**-**	**2.5**
Boundary Dam to Metaline Falls	**-**	**0.2**	**-**	**1.5**	**1.7**
Metaline Falls to Box Canyon Dam					
Sullivan Creek	2.9	8.6	0.6	0.6	12.7
Sand Creek	-	2.0	0.5	-	2.5
Lunch Creek	-	0.3	-	-	0.3
NW of Metaline Ponds	0.5	4.8	-	-	5.3
Linton Creek	0.6	0.6	-	-	1.3
BWP	-	-	29.4	10.5	39.9
Adjacent to BWP (south)	-	-	-	1.2	1.2
East side Box Canyon Dam	-	-	3.5	-	3.5
Metaline by Sewage Pond	-	-	2.5	2.6	5.2
PRM 28.9 Islands	-	-	-	3.3	3.3
East of PRM 28.9 Islands	-	-	1.4	2.3	3.7
West Shore - north of Box Canyon Dam	-	-	3.5	7.7	11.2
Other	-	-	2.0	1.5	3.6
Total Metaline Falls to Box Canyon Dam	**4.0**	**16.3**	**43.4**	**29.7**	**93.7**
Grand Total	**4.2**	**18.7**	**43.4**	**31.2**	**97.9**

Notes:
Some stands extended slightly beyond the study area, but acres outside the study area are not included in the analysis.
PFO – palustrine forested wetland
PSS – palustrine scrub-shrub wetland
PRM – Project river mile
RDT – riparian deciduous trees
RS – riparian shrub

5.2. Riparian Tree/Shrub Stand Characterization

Current conditions and characteristics of riparian tree/shrub habitats in the study area and the factors that limit the extent and distribution of these habitats are presented below. The general ecology of the focal riparian species is presented, followed by a characterization of the three unique river reaches in the study area, as there are notable differences in the structure and composition of the same habitat types located in the tailrace, downstream of Metaline Falls, and upstream of the falls.

- ***Sitka alder*** is typically thought of as an early seral shrub found in cool, moist uplands where it colonizes open areas. In eastern Washington, it is also found on well-drained riparian sites and wetland margins. Sitka alder is moderately shade tolerant, which allows it to live in forested habitats; however, it does not tolerate dense overstory

(Kovolchik and Clausnitzer 2004). Its ability to fix nitrogen allows it to invade recently exposed or sterile mineral soil. Dense stands of Sitka alder can develop, remain stable, and retard the establishment of other species. Sitka alder primarily reproduces from abundant winged, lightweight seeds that can travel long distances, but it can also reproduce vegetatively by re-sprouting from the root crown. Seed dispersal normally occurs in fall and germination occurs the following spring. There are many factors that contribute to low seedling survival rates, including summer drought or floods, winter freeze/thaw cycles and scouring by ice or seasonal high flows dense shade, and browse. Seedlings that survive their first year usually develop root systems that remain in contact with a permanent water supply (Uchytil 1989a; Kovalchik and Clausnitzer 2004).

- ***Gray alder*** has habitat requirements and a life history similar to Sitka alder. It can be found in a shrub or tree form and can occur in dense thickets that can be produced through seed or vegetative reproduction. It is generally found in areas with a high water table, often close to streams (Uchytil 1989b).

- ***Red-osier dogwood*** is often found in wetlands and riparian zones, but can also be found in the understory of open forests or in forest openings. Red-osier dogwood requires moderate to full sun, thus, it would not be expected in closed forests. Red-osier dogwood regenerates both from seed and by layering (rooting at branch nodes in contact with moist ground) or by producing new shoots from existing roots. Dense thickets formed through layering are common in eastern Washington. Red-osier dogwood seeds are dormant and need cold stratification to germinate, but they may remain viable in the seed bank for many years. The seeds germinate above the surface of the water, but after several years of growth, the plants can survive with submerged roots for most of a growing season (Crane 1989; Kovalchik and Clausnitzer 2004). Red-osier dogwood is also tolerant of fluctuating water tables (Stevens and Dozier 2006).

- ***Willow*** species are found in a wide range of riparian and wetland habitats. There were six species of willow found in the study area; coyote, Sitka, MacKenzie's, and shining willow were most common, while Bebb's and Scouler's willow were less common and made up a smaller percentage of cover where found. Willow communities tend to be relatively stable once established in wet or moist sites; succession to site conditions more favorable to trees proceeds slowly, if at all. Several willow species can appear either in the shrub or small tree form (Tesky 1992; Anderson 2001, 2006). Most species found in the study area grow best in full sun; however, Sitka and Scouler's willow can tolerate some shade (Moore 2003; Kovalchik and Clausnitzer 2004; Anderson 2006). All eastern Washington willow species appear to be able to propagate by sprouting/suckering as well as by seed. They root by layering or through the rooting of broken stem and root pieces partially buried by flood deposition or beaver activity (Kovalchik and Clausnitzer 2004). Coyote willow also reproduces by sprouting from underground runners and can create dense, clonal thickets (Anderson 2006). Willows produce abundant seeds disseminated by wind and water. Seed viability is generally short-lived, and seeds

more than a few days old may produce abnormal seedlings. The soil where germination occurs must remain moist during the first growing season for the seedling to survive. In the first growing season, seedlings are threatened by summer drought or floods, winter freezing and scouring by ice, seasonal high flows, herbaceous competition, shade from other shrubs or trees, and herbivores—especially beavers (Kovalchik and Clausnitzer 2004). However, most willows are adapted to beaver harvest and generally recover quickly by resprouting from root crowns (Kindschy 1985; Kovalchik and Clausnitzer 2004).

- ***Black hawthorn*** typically forms dense thickets in moist areas but can also be found on mesic sites. It is mostly an understory species associated with *Populus* spp. including cottonwood. Black hawthorn reproduces sexually by producing many fertile seeds. It can also regenerate by sprouting and suckering from the root system following the removal of aboveground stems (Habeck 1991). All black hawthorn stands were found at elevations well above the fluctuation zone, suggesting that their distribution in the study area is influenced by flood and other events, rather than Project-related water fluctuations.

- ***Common snowberry*** is a facultative upland species, meaning it is primarily an upland species occasionally found in wetland situations. It is often in association with black cottonwood or red-osier dogwood, but sometimes is found as the primary plant (Kovalchik and Clausnitzer 2004). Snowberry stands in the study area were found well above the reservoir fluctuation zone suggesting its elevational range along the reservoir is constrained by seasonal flooding. Although not a focal species in this study, snowberry is abundant in the study area and often occurs within riparian stands.

- ***Black cottonwood*** is a pioneer or early seral species and is relatively fast-growing, which gives it an advantage in newly exposed soils (Beals 1966; Crowe and Clausnitzer 1997; Kovalchik and Clausnitzer 2004). Exposed moist, mineral soil in full sunlight creates favorable habitat for black cottonwood seedlings (Crowe and Clausnitzer 1997). Black cottonwood regenerates primarily from seeds, but in existing forests can also regenerate through sprouts, root suckers, or by sprouting from branches fallen in favorable conditions (Crowe and Clausnitzer 1997). Copious seeds are produced in the spring when flows are receding and favorable conditions exist along streams (Crowe and Clausnitzer 1997). Seeds are viable for a short period (1 to 4 weeks) (Braatne et al. 1996; Kovalchik and Clausnitzer 2004). Full sunlight is needed as the seeds have little endosperm (Braatne et al. 1996) and need to photosynthesize early in establishment (Rood and Mahoney 1990). Seedling root growth is relatively fast, up to one-half inch per day, but mortality can be high if the water recedes faster than the roots grow (Kovalchik and Clausnitzer 2004). Rapid root growth and tolerance of inundation and sediment deposition give black cottonwood a competitive advantage over other alluvial bar species (Crowe and Clausnitzer 1997; Kovalchik and Clausnitzer 2004). Because of the need for full sunlight, few seedlings establish in existing cottonwood forests, except where openings and bare soil are found in combination. The specific water and sun

requirements often result in the establishment of even-aged stands in years with favorable conditions. Cottonwood establishment by seedling is generally episodic (5 to 10 years) (Braatne et al. 1996), depending on seed viability in the spring and moisture conditions for the first year, and is usually associated with high water events (Rood et al. 1998).

In general, successful recruitment of cottonwood requires a complex interaction of opposing fluvial processes and seedling/sapling life histories, conditions of which are not met on an annual basis (Braatne et al. 1996), especially if establishment is also confounded by competing vegetation and herbivory by granivore rodents (Anderson and Cooper 2000). Large, erosional flood events, occurring at 30 to 50 year intervals, set up recruitment conditions and establishment of new stands over large areas, referred to as the general-replenishment model (Hughes 1994). Lesser flood events, especially along low-gradient streams, can allow establishment of seedlings either as new stands or as supplements to existing stands on a more frequent (approximately 5 years) basis under what is called the incremental-replenishment model (Hughes 1994). Age-class observations and fluvial geomorphology of the study area suggest the latter model applies best to the Boundary Project study area.

5.2.1. Boundary Dam Tailrace

5.2.1.1. Current Conditions and Characteristics

The 0.9-mile long section of river between Boundary Dam and the Canadian border supports approximately 2.2 acres of riparian shrub habitat and 0.2 acre of riparian deciduous trees, which represents about 2.5 percent of the riparian tree/shrub vegetation in the study area (Table 5.1-1). The largest riparian shrub stand in this reach occurs as a long narrow strip along the eastern shoreline at the base of a mixed conifer forest (Figure 5.1-1). This stand begins approximately 2,000 feet below the dam and extends north to the Canadian border. It is dominated by coyote willow, Sitka alder, and red-osier dogwood. Young willows extend into the emergent vegetation zone on the cobble shore. The area is influenced by numerous upslope seeps, river flows, degradation/aggradation, and periodic flooding. The lack of a significant forb or graminoid cover suggests that the stand is representative of the willow/alluvial bar plant association (Kovalchik and Clausnitzer 2004).

The area close to the dam on the east side of the tailrace does not have upslope seeps and is primarily influenced by the hydrology of the river. In this area, there is a small (0.2 acre) riparian tree (cottonwood) stand located on the cobble/gravel shore (Figure 5.1-1). Cottonwoods in this stand range from saplings to 15-inch dbh and there is very little shrub understory (about 5 percent). The trees were not cored because pre-dam photographs indicate that the stand established after dam construction, allowing researchers to estimate age class based on visual observation of the stand. The stand consists of both tall saplings and young trees that were in shrub form due to beaver activity. The lack of a significant shrub layer suggests this stand is representative of the black cottonwood/alluvial bar plant association (Kovalchik and Clausnitzer 2004).

A few cottonwood seedlings and coyote willow occur on the cobble island in the tailrace (Figure 5.1-1). There are no larger trees or shrubs to indicate that a mature cottonwood stand could establish, and there was evidence of beaver activity.

5.2.1.2. Limiting Factors

The Boundary Dam tailrace is a high-energy environment and is subjected to frequent changes in flow. During the summer season (June 15 to September 15), average hourly flows in the tailrace, as reported in the 19-year hydrologic record (1987–2005), have ranged from 0 to about 137,400 cfs (excluding two high outlier values of 161,435 and 142,741 cfs that occurred on June 15, 1997, and that were likely related to spill tests). Excluding these two outliers, water surface elevations in the tailrace have ranged between approximately 1,716 and 1,756 feet NAVD 88 (1,712 and 1,752 feet NGVD 29) during the summer season.

Flows into the tailrace are a combination of discharge from the Boundary Dam powerhouse and spill, the latter occurring during flood events. The Project-related fluctuation zone is defined as the powerhouse discharge contribution to the tailrace water surface elevations. Water surface elevations in the tailrace are also influenced by the water level of the Seven Mile Reservoir. Powerhouse discharge ranges between 0 and about 55,000 cfs. Seven Mile Reservoir pool elevations have ranged between 1,694 and 1,737 feet NAVD 88 (1,690 and 1,733 feet NGVD 29) according to the 19-year hydrologic record. Using the Boundary Tailrace HRM, the Project-related fluctuation zone in the tailrace was defined between 1,718 and 1,743 feet NAVD 88 (1,714 and 1,739 feet NGVD 29) elevation for this range of hydrologic and operational conditions. Impacts to riparian vegetation above 1,743 feet NAVD 88 (1,739 feet NGVD 29) are considered non-Project-related.

The tailrace fluctuation zone consists primarily of riverine unconsolidated shoreline riparian grass habitat types. Riverine unconsolidated shoreline occurs at the lowest elevations and is characterized by cobble and coarse sediment and a lack of vegetation. There is a gradual increase in fine sediment farther upslope from the low water line and an associated increase in riparian vegetation. For the most part, Sitka alder grows just above the fluctuation zone, while coyote willow is found within the upper 4 feet of the zone (greater than 1,739 feet NAVD 88 [1,735 feet NGVD 29]). The structure of coyote willow—thin, flexible branches; narrow, deciduous leaves; and multiple stems—make it one of the few species adapted to high velocity flood flows (Stevens et al. 2003). However, the magnitude, duration, velocity, and/or frequency of high flows through this area are apparently enough to preclude the establishment of more mature coyote willow stands, since most coyote willow plants occur as seedlings or stunted saplings. In some years, these stands can be completely inundated for weeks at a time.

Study 1 (SCL 2009b) identified three erosion sites (totaling about 0.3 mile of shoreline) in the tailrace with peak flows being the primary factor affecting erosion, underscoring the high energy nature of this area. Based on the number of cut stems observed, beaver probably also play a pivotal role in limiting willow and cottonwood establishment in and near the fluctuation zone.

5.2.2. Boundary Dam to Metaline Falls

5.2.2.1 Current Conditions and Characteristics

Riparian tree/shrub vegetation is very limited along the shoreline of Boundary Reservoir between Boundary Dam and Metaline Falls, representing only 1.7 percent of this habitat in the study area (Table 5.1-1). There are no riparian deciduous tree stands or palustrine forested wetlands in this area, although three black cottonwood trees, of which two are decadent, were recorded at the mouth of Lime Creek. A single, 0.2-acre stand of riparian shrub habitat was documented near Lime Creek. Although Sitka alder dominates, the stand is a mosaic of shrub (approximately 60 percent canopy cover) and emergent wetland species and is classified as riparian habitat because it occurs within the steep, wide Lime Creek outflow. All but the lowest elevations at this site appear to be more influenced by Lime Creek hydrology than by the reservoir.

Palustrine scrub-shrub wetlands occupy just 1.5 acres along the reservoir shoreline and occur as narrow bands in six locations, either in coves or immediately adjacent to the water's edge. These are in the hydrologic gradient between upland, mixed conifer forest and the reservoir, or between the forest and a band of herbaceous vegetation at the reservoir's edge. Sitka alder is the dominant species at all six sites, with canopy cover ranging from 15 to 80 percent (average 58 percent). This species requires moderately well-drained soils to germinate and frequently occurs on well-drained banks at the edges of water or in transitional areas between upland and wetland sites (Kovalchik and Clausnitzer 2004). These characteristics were similarly observed in the study area habitats that supported Sitka alder.

Red-osier dogwood is also common in the palustrine scrub-shrub wetlands between Boundary Dam and Metaline Falls, suggesting that these stands represent the Sitka alder/red-osier dogwood plant association (Kovalchik and Clausnitzer 2004). This plant association is typical in drier riparian areas at lower elevations in the Colville National Forest (Kovalchik and Clausnitzer 2004). The stands in the study area also include several other mesic shrub species including snowberry), hazelnut (*Corylus cornuta*), thimbleberry (*Rubus parviflorus)*, and rose (*Rosa* spp.*)*.

5.2.2.2 Limiting Factors

Riparian tree/shrub vegetation between Boundary Dam and Metaline Falls is likely limited by unsuitable substrate, steep slopes, and geomorphology. Much of the reservoir in this area is bordered by nearly vertical cliffs which only support plant species that can survive in rock crevices. The ability of riparian trees and shrubs to establish and/or expand at many locations with suitable geomorphology is probably limited by a lack of soil in the upper portions or immediately above the fluctuation zone. This is especially evident at stands along the eastern edge of the forebay and other locations along the reservoir edge where cobble and gravel form the emergent substrate. Study 1 (SCL 2009b) identified 43 bank erosion sites, totaling about 5 miles of shoreline, in the lower reservoir where the primary cause was either wave action or reservoir fluctuation. Reservoir fluctuations and wave action work in concert to erode soils from shorelines. While wave amplitudes are generally less than 1 foot when they break at the shoreline, reservoir fluctuations expand the impact several feet by vertically shifting the shoreline elevation. Median daily water level fluctuations in the lower reservoir are about 5 feet in the summer and 10 feet in fall. At many more locations it is apparent that while the terrestrial

banks may not be actively eroding, wave action/reservoir fluctuation has removed fine soils from the nearshore emergent zone leaving cobble, gravel, and bare rock at the surface. These substrates wholly dominate the lower reservoir's emergent shoreline (see Study 1 [SCL 2009b]). Since the primary riparian species in the lower reservoir, Sitka alder, grows in fine soils (Kovalchik and Clausnitzer 2004, Table 5.2-1), a lack of suitable growing substrate is a primary factor in limiting its establishment and/or expansion along the lower reservoir shoreline.

Table 5.2-1. Substrates associated with dominant riparian plant species found in the study area.

Species	Fines or Gravel and Fines		Cobble[1]	
	Acres	%	Acres	%
Black Cottonwood	42.2	90	4.7	10
Sitka/Gray Alder	8.8	99	0.1	1
Red-osier Dogwood	7.4	68	3.5	32
Black Hawthorn	2.7	100	-	-
Coyote Willow	0.2	3	6.2	97
Shining Willow	2.2	100	-	-
MacKenzie's Willow	1.7	74	0.8	26
Sitka Willow	6.9	84	1.4	16
Snowberry	44.1	100	-	-
All acres[2]	**81.0**	**84**	**17.0**	**16**

Notes:
Totals may vary slightly due to rounding.
1 Substrates with cobble; may also include stone and gravel.
2 Acreage by species does not add up to "all acres" because the shrub species acreage includes cottonwood stands where the shrub is dominant.

Inundation from seasonal flooding does not appear to be a limiting factor for establishment or maintenance of riparian vegetation in the lower reservoir. By spilling water during high spring flows, Boundary operations attenuate the effects of spring flooding and maintain water surface elevations in the lower reservoir at about 1,988 feet NAVD 88 (1,984 feet NGVD 29), which is lower than summer median levels (1,990 feet NAVD 88 [1,986 feet NGVD 29]).

Most of the tributary streams to Boundary Reservoir downstream of Metaline Falls are narrow and shaded by adjacent upland, coniferous forest. These streams support little, if any, vegetation that can be classified as distinctly riparian, although the vegetation along the streams is evidently influenced by its proximity to water.

Beaver are common in the lower reservoir and use both Sitka alder and red-osier dogwood for food and building material (Kovalchick and Clausnitzer 2004; observations from this study). Although neither plant is preferred as a food source (Denney 1952; Kovalchik and Clausnitzer 2004), there is little else available to feed on in the lower reservoir (especially in the winter), and heavy beaver use is evident at all stands. Nevertheless, while beaver activity may be altering crown closures, they are probably not a major source of mortality as both Sitka alder and dogwood recover from beaver damage by readily resprouting from root crowns (Kovalchik and

Clausnitzer 2004). The palatability of Sitka alder and red-osier dogwood for ungulates has generally been reported as poor (USDA Forest Service 1988; Uchytil 1989a; Kovalchik and Clausnitzer 2004), with the exception that both species are preferred by moose (Harry 1957; Peek 1974; Pierce 1984; Darris 2005), and mule deer will select red-osier dogwood (Smith 1953; Dusek 1975). No evidence of significant ungulate browsing was recorded.

5.2.3. Metaline Falls to Box Canyon Dam

The riparian tree/shrub vegetation along the reservoir shoreline is more extensive and complex upstream of Metaline Falls. This area supports about 93.5 acres of riparian tree/shrub habitat, much more than the reservoir downstream of the falls. Twenty-five percent of this acreage is classified as riparian because it is influenced by upslope hydrology, tributary streams, or seeps. About 43 percent of the area of riparian tree/shrub habitat upstream of Metaline Falls occurs in or adjacent to the BWP. Another 16 percent occurs in and around the town of Metaline, including the park, the island complex between Project river mile (PRM) 28.5 and 29.0, and on the east shore by these islands. About 15 percent of the acreage borders the west side of the reservoir, within 2 miles of Box Canyon Dam.

5.2.3.1. Riparian Shrub Stands and Palustrine Scrub-Shrub Wetlands

5.2.3.1.1. Current Conditions and Characteristics

Table 5.2-2 summarizes the dominant species in riparian shrub stands and palustrine scrub-shrub wetlands between Metaline Falls and Box Canyon Dam. In general, the species composition of shrub-dominated riparian and wetland habitats in this reach exhibits greater diversity than stands north of Metaline Falls. The only riparian shrub stand where Sitka alder is dominant occurs north and west of the Metaline sewage ponds in an area that has a silt substrate and is fed by numerous seeps. In palustrine scrub-shrub wetlands, willows and dogwood are the dominant species at the lower elevations near the reservoir, where water is readily available and the substrate includes a cobble component. In several of the shrub stands in the BWP and across the reservoir from the BWP, common snowberry, a facultative upland species, is dominant or subdominant, indicating drier conditions. Black hawthorn, a facultative species, is dominant in two stands at the BWP.

Shrub stand height and canopy cover varied considerably between and within stands; however, there are a few generalizations that can be made. The canopy cover ranged from dense thickets with 100 percent shrub cover to open stands with less than 20 percent cover. In general, the stands with high canopy cover were mature, appeared to be regenerating vegetatively, had a substrate dominated by fines, and were at the higher elevations. Many of the stands at lower elevations, mostly on gravel and cobble, were more open and included seedlings that may reestablish each year. Shrub height followed a similar pattern, with the mature, dense stands being taller (8 feet and taller) and at higher elevations relative to the reservoir water surface, and the open, young stands being shorter and occurring at lower elevations.

The majority of the riparian shrub stands and palustrine scrub-shrub wetlands were associated with fines or gravel with fines (Table 5.2-1). The only species not usually found on fines was coyote willow, which was most common at the lowest elevations of stands and associated with

cobble (Table 5.2-1). Dogwood and MacKenzie's willow also grow in substrates with cobble, though to a lesser extent. Dogwood is growing on cobble at the outlet to Sand Creek, and the Mackenzie's willow growing on cobble was largely confined to one long narrow strip on the west shore across from the island at PRM 33.1.

Table 5.2-2. Dominant species in riparian shrub stands and palustrine scrub-shrub wetlands in the Metaline Falls to Box Canyon Dam reach.

Shrub Area Type	Dominant Species and Wetland Indicator Status[1]	Sub-Dominant Species and Wetland Indicator Status[1]	Acres
Riparian shrub	Willow species	Willow, dogwood, alder	9.4
	Sitka alder	Dogwood	4.8
	Red-osier dogwood (FACW)	Sitka willow (FACW)	2.0
	Black hawthorn (FAC)	Sitka willow	0.3
Palustrine scrub-shrub wetland	Snowberry (FACU)	Hawthorn, dogwood	12.4
	Dogwood	Alder, willow, hawthorn	7.2
	Willow species	Dogwood, alder	7.5
	Hawthorn	Dogwood, snowberry	2.6
Total Acres			**46.1**

Notes:

1 Wetland Indicator Status:

OBL	Obligate Wetland	Occurs almost always (estimated probability 99%) under natural conditions in wetlands.
FACW	Facultative Wetland	Usually occurs in wetlands (estimated probability 67-99%), but occasionally found in non-wetlands.
FAC	Facultative	Equally likely to occur in wetlands or non-wetlands (estimated probability 34-66%).
FACU	Facultative Upland	Usually occurs in non-wetlands (estimated probability 67-99%), but occasionally found in wetlands (estimated probability 1-33%).

The riparian deciduous tree and shrub stands at tributary stream outlets are primarily under the influence of riverine processes but also are influenced by the reservoir hydrology at lower elevations. Riparian shrub stands dominated by willow occur at the mouths of Sullivan, Linton, Sand, and Lunch creeks. Another riparian shrub stand north and west of the Metaline sewage pond is dependent on numerous upslope seeps. This stand is dominated by Sitka alder but also has a large component of dogwood and lesser amounts of Douglas spirea (*Spirea douglasii)* and willow. The lowest elevations in all of the riparian shrub stands support willow seedlings where there is cobble substrate.

Detail on the riparian shrub stands by location is provided below (the polygon references refer to the maps in Appendix 1):

- The shrub stands in the **Sullivan Creek** outlet are dominated by willows (polygons 15a, b, c, and d). The lower elevations, closer to the stream's confluence with the reservoir, are almost exclusively willow, but include cottonwood seedlings at the stand edges, as well as a few cottonwood saplings. The cobble bars close to the

reservoir support only coyote willow and cottonwood seedlings. None of these seedlings show evidence of browse and they are likely removed annually by seasonal high flows.

- **Sand Creek** has a wide outlet bordered by a 10- to 12-foot upland bench. The riparian shrub stand in the outlet is dominated by Sitka willow and dogwood (polygon 40). The upslope edges of the outlet support other shrub species (alder, hawthorn, snowberry) and cottonwood saplings.

- The outlet of **Lunch Creek** (polygon 38) supports a small riparian shrub stand bordered by an upland bench and cobble at the creek edges. This shrub stand is dominated by Sitka willow at the lower elevations and along the stream edge, and by hawthorn growing higher on the bench. Dense stands of reed canarygrass (*Phalaris arundinacea*) occur higher on the berm and may inhibit seedling establishment.

- The slough to the north and east of the **Metaline** sewage ponds is primarily bordered by riparian shrubs (polygon 22a), although a narrow band of riparian deciduous trees also occurs (polygon 22b). Both of these stands are influenced primarily by the numerous upslope seeps. Emergent wetland vegetation occurs downslope of the shrub stand. The shrub stand is dominated by Sitka alder but also includes several willow species. There are many young shrubs and cottonwoods visible in the openings. Moderate browse was observed on the young shrubs and cottonwoods. The substrate bordering the slough consists of silt, not cobble as in most of the other riparian areas; therefore, there is dense reed canarygrass competing with seedlings.

- The **Linton Creek** outlet in Metaline Park is bordered by riparian shrubs and a small stand of riparian deciduous trees. The area is dominated by multiple willow species and dogwood, with young shrubs growing on the gradually-sloped bank. Farther from the stream along the reservoir, the shrubs grow on a raised bench and are likely more influenced by the high water table associated with the reservoir than Linton Creek flows.

- The **BWP** supports the largest palustrine shrub/forested wetland complex in the study area. Palustrine scrub-shrub in the BWP covers 10.5 acres, which represents about 34 percent of the palustrine scrub-shrub stands found in the study area. A large portion of the BWP occurs on what appears to be a relict floodplain or terrace that is no longer influenced by overbank flows. However, there is an old channel that is inundated by backwater during high flows and other low points that could be saturated by groundwater or influenced by the reservoir. The shrub stands are dominated by dogwood, hawthorn, and snowberry. Two stands included a small amount (less than 5 percent cover) of Bebb's willow and one stand included a few Sitka alder.

- North of **Box Canyon Dam,** narrow palustrine scrub-shrub and forested wetlands extend for about 2 miles between the west side of the reservoir and the highway. The area south of Box Canyon Resort supports palustrine scrub-shrub wetlands dominated by willow or dogwood shrubs. The wetlands closer to the highway, some growing at least partially on road fill, consist of dense and mature shrubs. The stand closest to Box Canyon Resort, which is largely on road fill, includes dogwood, hawthorn, and snowberry. These stands are probably supported by runoff from the highway that seeps through the fill that compose the steep road embankment.

  The palustrine scrub-shrub wetlands at lower elevations along the reservoir are growing mostly in a cobble substrate and are relatively open. These lower areas are dominated by willow and dogwood shrubs which are likely frequently inundated and periodically removed by seasonal high flows. These stands are also experiencing heavy use by beavers, which is stunting growth. North of Box Canyon Resort, both palustrine forested and scrub-shrub wetlands are sandwiched between the conifer forests bordering the highway and dense reed canarygrass that grows to the edge of the reservoir. Hydrology for these wetlands is primarily runoff from the adjacent upslope road.

- The **Metaline** sewage ponds are a highly altered habitat that include both palustrine scrub-shrub and forested wetlands. The palustrine scrub-shrub wetlands consist of a line of mature, single-stemmed shining willow along the top of the west berm and a mixture of shrubs, primarily dominated on the sides by dogwood, alder, and other willow species. There are many young sprouts, primarily willow, on the sides of the berm; however, they are heavily clipped by beaver to short shrubs. Palustrine scrub-shrub wetlands characterized by dense, mature thickets of red-osier dogwood border the eastern reservoir shoreline across from Metaline. These dogwood stands form a band along the shoreline between the water and the adjacent conifer forest. Expansive dogwood stands occur on the nearby islands.

  A relatively large Sitka alder stand with significant mature cottonwood overstory (polygon 35) also occurs in the Metaline area. Between the alder/cottonwood stand and the reservoir is a dense scrub-shrub wetland dominated by MacKenzie's willow and Sitka alder. The edges of this stand include many willow and alder shoots and sprouts that exhibited evidence of repeated beaver cutting.

5.2.3.1.2. Limiting Factors

Factors present in the Metaline Falls to Box Canyon Dam reach that could potentially limit establishment and maintenance of the riparian shrub species include the effects of seasonal flooding, Project-related reservoir fluctuations, beaver cutting, ungulate grazing, and reed canarygrass. Due to the hydraulic control of Metaline Falls, this reach experiences less pronounced daily operational fluctuations than the lower reservoir and tailrace reaches, yet also experiences higher flood-related water surface elevations and flow velocities. The 1997 flood event resulted in the highest stage recording at USGS gage 12396500 since the completion of the Boundary Project. During this event, the peak water surface elevation at the USGS gage was recorded as approximately 2,020 feet NAVD 88 (2,016 feet NGVD 29) and the coincident Boundary forebay elevation was approximately 1,988 feet NAVD 88 (1,984 feet NGVD 29).

Analysis conducted in support of Study 2, Analysis of Peak Flood Flow Conditions above Metaline Falls Final Report (2009c), estimated that the influence of the Boundary Project on water surface elevations in the Upper Reservoir Reach during this event ranged between 1.6 feet at the downstream end of the reach to 1.1 feet at the upstream end of the reach. Flood-related processes, including high flow velocities and water surface elevations, limit the ability of riparian shrubs to establish along the upper reservoir margins by periodically inundating and/or scouring seedlings.

In many areas, beaver cutting appears to be the most immediate threat to survival of sapling willows and cottonwoods. In some stands there are virtually no young cottonwoods taller than 2 feet (e.g., Sullivan Creek outlet, the stand east of the islands at PRM 28.9, and some areas in the BWP). Locations that support tall saplings, such as parts of the BWP, are further from the river. Breck et al. (2003) found that beavers harvest few trees beyond about 260 feet of protective waters; at greater distances, the risk of predation increases (Jenkins 1980). Willows, especially those closest to the reservoir shoreline edge, are heavily utilized by beaver. Some willow plants, composed of only a few short leaders, are actually over 30 years of age, having been constantly cropped by beavers. White-tailed deer are also feeding on the tips of willows during the winter, contributing to plant deformation and stunting.

In areas with fine sediment that are sheltered from high flow energy, the primary vegetative cover is reed canarygrass (as opposed to Sitka alder in similar situations in the lower reservoir). This weedy grass grows in dense rhizomatous mats that prevent the establishment of other species. With the exception of the island complex between PRM 28.5 and 29.0 where red-osier dogwood dominates, reed canary grass covers all the islands and nearly all the deep, fine-soiled shorelines.

In summary, substantial riparian shrub and tree communities exist higher up within the floodplain, creek tributaries, and places where seeps and other water sources occur. However, riparian development along the edges of the upper reservoir is limited by flood-related processes, beaver cutting, and the presence of reed canarygrass.

5.2.3.2. Riparian Deciduous Tree and Palustrine Forested Wetlands

5.2.3.2.1. Current Conditions and Characteristics

There are 15 riparian deciduous tree and palustrine forested wetlands where black cottonwood is dominant, covering 47.7 acres in the study area (Table 5.1-1). Approximately 90 percent of the area of these stands was found on fines or gravel and fines (Table 5.2-1). The BWP includes 29.4 acres of cottonwoods in three areas (analyzed as six stands), which represents over 60 percent of this forest type (including riparian and palustrine) found in the study area. The next largest single cottonwood areas are at the outlet of Sullivan Creek, with a total of 3.5 acres in three stands, and a stand by Box Canyon Dam, also covering 3.5 acres. Cottonwood forests near Metaline cover 7.0 acres, but occur as more widely separated stands, which are growing in different environments.

Cottonwood stands in the study area include trees with varying age distributions (see Table 5.2-3). There are even-aged stands, which reflect cyclical establishment, and multi-aged stands,

which suggest establishment over a number of years. Three even-aged stands appear to have established about 20 to 25 years ago (center of Sullivan Creek outlet, Linton Creek outlet in Metaline Park, and south of the Metaline boat dock along the road in the park). Two dense stands of 8-foot-tall cottonwood saplings (one at the south end of Metaline across from the islands at PRM 28.9 [polygon 36], one across from the south end of the BWP [polygon 56d]), and the stand with many 4-foot saplings across from the south end of the BWP, are evidence of more recent cyclic establishment. All three of these sapling stands are adjacent to mature stands.

Table 5.2-3. Acres of cottonwood trees in riparian tree/shrub vegetation types by age group between Metaline Falls and Box Canyon Dam.

Vegetation Type	Total Acres	Acres of Mature Trees				Acreage of stands with Seedlings or Saplings	Decadent Tree Acres	Snag Acres
		Only Pre-Dam Constr. (> 40 years)	Only Post-Dam Constr. (< 40 years)	Acreage with Both Pre- and Post-Dam Constr.	Total Mature Trees			
Riparian Deciduous Tree[1]	4.0	1.5	2.0	0.5	4.0	3.1	0.5	4.1
Palustrine Forested Wetland[1]	42.8	19.5	10.3	11.6	41.3	42.8	25.4	26.1
Palustrine Scrub-Shrub Wetland[2]	15.0	6.8	1.1	1.2	9.2	13.3	-	6.3
Riparian Shrub[2]	12.3	-	0.3	-	0.3	12.3	-	-
Total Acres	**74.1**	**27.8**	**13.7**	**13.3**	**48.2**	**71.5**	**25.9**	**36.5**

Notes:
No deciduous tree or palustrine forest habitats were found between Boundary Dam and Metaline Falls.
1 Vegetation was categorized as forested if the total tree cover was > 30% (Cowardin et al. 1979).
2 Cottonwoods were present in shrub stands but with < 15% cover.

There is strong evidence that cottonwoods are reproducing and establishing in the study area. Seedlings or saplings were found in 79 percent of the acreage supporting mature cottonwood trees. Additionally, there were 16.8 acres of forested or shrub stands that included only seedling or sapling cottonwoods. The BWP includes 49 percent (39.0 acres) of the shrub or forested acres with cottonwoods, and all of them included some seedlings or saplings.

Analysis of tree rings suggests that about 41 acres, or over three-quarters of the mature cottonwood acreage in the study area, established before Boundary Dam was built (Table 5.2-3). Of these 41 acres, approximately 30 percent (13 acres) also contains trees that established after the construction of the dam. The mature cottonwoods ranged from approximately 30 to 80 feet tall, with 84 percent over 60 feet. The saplings (defined as 1- to 5-inch dbh) ranged from about 8 feet to 35 feet tall.

In forested palustrine wetland and riparian deciduous tree stands, cottonwood canopy cover ranged from 35 to 75 percent (Table 5.2-4). Approximately 80 percent of those forested acres

had cottonwood canopy cover between 20 and 45 percent. In the shrub stands that included cottonwood, the cottonwood cover ranged from 1 to 15 percent.

Table 5.2-4. Cottonwood canopy cover in riparian tree/shrub vegetation types by acres between Metaline Falls and Box Canyon Dam.

Vegetation Type	Cottonwood Canopy Cover Ranges (%)					Total Acres
	1 to 4	5 to 19	20 to 34	35 to 49	50 to 75	
Riparian Deciduous Tree[1]	–	0.5	-	2.0	1.5	4.0
Palustrine Forested Wetland[1]	–	–	1.4	33.7	7.7	42.8
Palustrine Scrub-Shrub Wetland[2]	2.9	12.3	–	–	–	15.2
Riparian Shrub[2]	2.7	9.4	–	–	–	12.1
Total Acres	**5.6**	**22.2**	**1.4**	**35.7**	**9.2**	**74.1**

Notes:
1 Vegetation was categorized as forested if the total tree cover was > 30% (Cowardin et al. 1979).
2 Cottonwoods were present in shrub stands but with < 15% cover.

Few cottonwood snags or decadent trees were documented in the study area; these habitat features were noted in only 7 of the 23 cottonwood stands. Most were recorded in the stands around Metaline, east of the islands at PRM 28.9, at the outlets of Sand and Sullivan Creeks, and on the east shore in the Box Canyon Dam tailrace; very few were noted in the BWP. Snags near Sand and Sullivan creek provide nesting habitat for woodpeckers, wood ducks (*Aix sponsa*), and tree swallows (*Tachycineta bicolor*).

In a majority of the cottonwood stands in palustrine forested wetlands, snowberry is the dominant shrub species (black cottonwood/common snowberry plant association), but dogwood was common (Table 5.2-5). Snowberry, a facultative upland species, is generally found in upland habitats, so soil moisture conditions must provide a balance between the drier needs of snowberry and the moister needs for cottonwood establishment. In the riparian cottonwood stands, dogwood was the dominant shrub species (black cottonwood/red-osier dogwood plant association), followed by Sitka alder and snowberry.

Table 5.2-5. Acreage of dominant shrub species in palustrine forested wetland and riparian forests.

Dominant Shrub	Tailrace	Upstream of Metaline Falls			Total (ac)
	Riparian Deciduous Trees (ac)	Palustrine Forested Wetland (ac)	Riparian Deciduous Trees (ac)	Total (ac)	
Sitka alder	-	1.4	1.0	2.4	2.4
Red-osier dogwood	-	5.7	1.5	7.2	7.2
Common snowberry	-	32.6	1.4	34.0	34.0
None[1]	0.2	3.7	0.2	3.9	4.1
Total	**0.2**	**43.4**	**4.1**	**47.5**	**47.7**

Note:
1 Open forest. No shrub species with cover > 10%.

Detail on the riparian deciduous tree stands and palustrine forested wetlands by location is provided below:

- **Sullivan Creek** includes three black cottonwood stands, each representing different age distributions. The eastern stand (polygon 19) includes mostly very large cottonwoods (38- to 54-inch dbh), only two tall saplings, and many browsed "shrub" cottonwoods. The two tall saplings were surrounded by dense shrubs, which likely limited access by beaver and deer and associated browsing. Browsing, likely from beaver, appears to be preventing young cottonwoods from growing in this stand. The central cottonwood stand (polygon 18) is on a raised narrow area in the center of a scrub-shrub wetland and includes uniformly-sized trees (9- to 12-inch dbh), 20 to 25 years old, and saplings. The western stand (polygon 17) is on a bench at the south and west sides of the stream and includes a diversity of sizes (12- to 50-inch dbh). The presence of young conifers and the lack of young cottonwoods in this stand may result in succession to a conifer stand over time.

- **Sand Creek** has a wide outlet bordered by a 10- to 12-foot upland bench. The top of the steep, eroded bench above the creek is covered by conifer forest with two narrow stands of mature cottonwood trees at the bench edge (classified as palustrine forested wetland). The cottonwood stands (polygon 41) include several very large cottonwoods and a few snags, but the majority of the trees are a uniform size and approximately 35 years old, based on coring. There were conifer saplings in the cottonwood stands, possibly indicating succession of that area to conifer over time. The only young cottonwoods near Sand Creek were growing on the side of the steep bench, close to the shrub stand.

- The narrow strip of riparian deciduous trees to the north and east of the **Metaline** sewage ponds is dominated by cottonwood and Sitka alder (polygon 22b). This stand is between an upslope conifer forest and a riparian shrub stand adjacent to the slough

separating the island at PRM 27.7 with the mainland. The cottonwoods represent a wide range of ages (cores estimated between 17 and 60 years).

The palustrine forested wetland on the south side of the **Metaline** sewage ponds is dominated by cottonwoods of a wide range of ages (cores estimated to be 19 to 65 years) with a mixture of shrubs (including snowberry, spiraea, hazelnut, dogwood, and shining willow) in the understory. Cottonwood seedlings and saplings occur along the edge of this forested wetland.

- The **Linton Creek** outlet in Metaline Park supports a small stand of riparian deciduous trees. This stand (polygon 25) consists primarily of uniformly aged cottonwoods (approximately 22 years), with seedlings and saplings occurring at the edges. Most of the seedlings are mowed as part of maintenance at the park. Farther upstream on Linton Creek, still in Metaline Park, is a gray alder stand (polygon 26). This stand was classified as riparian deciduous forest because it consists of single-stemmed alder, 20 feet tall, with a shrub understory. Gray alder can be found in a shrub or tree form and is generally found in areas with a high water table, often close to streams (Uchytil 1989b). This stand also includes a few uniformly-sized cottonwoods which were found to be 24 years old.

- Nearly 75 percent of the tree and shrub acreage in the **BWP** consists of palustrine forested wetlands. A wide range of cottonwood sizes (saplings to over 20-inch dbh) occurs, and a few cores confirmed they represent a comparably wide age range (e.g., 35 years for a 10-inch dbh tree and 67 years for an 18-inch dbh tree). The forest understory is dominated by dogwood, hawthorn, and snowberry. There are cottonwood seedlings and saplings along most of the forest edges and in a few openings. This indicates that sunlight and hydrology are appropriate for seedling establishment. Although many of the young cottonwoods have been stunted to shrub size by severe beaver cutting, there are a few areas with saplings tall enough to preclude further stunting by browse. The central forested area (polygons 44d and e) supports a few conifers and includes cottonwood saplings in several forest openings. The dense cottonwood forest in the southern portion of the BWP (polygon 47) does not appear to support any cottonwood saplings but does include young conifers, possibly indicating succession to conifer forest over time. There is also an aspen (*Populus tremuloides*) stand (polygon 44a) in the central forested area, and aspen shoots are interspersed with the cottonwood saplings. These aspen have likely escaped significant mortality from beaver cutting because they are too far from the water. Dense fields of reed canarygrass in the central portion of the BWP also may be preventing cottonwood seedlings from establishing. Other grass species typically form less dense stands and numerous cottonwood seedlings have established in areas where reed canarygrass is not dominant.

- The cottonwood-dominated palustrine forested wetland on the east shore by **Box Canyon Dam** (polygon 58) occurs on a flat, dry bench that slopes to the south and east to a depression at the base of a hill. The depression appears to be inundated or saturated by shallow groundwater. Some of the shoreline has been disturbed, and

there is an old road through the stand. The forest is open with only 35 percent cover and no shrub layer. The mature cottonwoods have a wide range of sizes (saplings to 20-inch dbh) and ages (30 to 65 years) with several dead and decadent trees. The saplings also have a wide range of sizes from 1- to 5-inch dbh. Seedlings and saplings occur throughout this open stand and site hydrology has apparently supported seedling establishment for many of the last 65 years.

- The palustrine forested areas on the west side of the reservoir north of **Box Canyon Resort** are dominated by cottonwood. The mature cottonwoods range in age from 20 to 60 years and seedlings grow at the stand edges. A younger cottonwood stand consists of dense trees that are nearly uniform at 8 feet tall.

5.2.3.2.2. Limiting Factors

In the study area between Metaline Falls and Box Canyon Dam, factors that potentially limit the development of riparian trees and shrubs include 1) regulated flows that may reduce the flood frequency and extent necessary to create suitable seedbed conditions; 2) seasonal flood-related events, which may scour seedlings; 3) fluctuating reservoir water levels, which subject seedlings to daily intervals of inundation and desiccation and limit species richness by creating conditions suitable only to species tolerant of frequently changing water conditions; 4) competing weedy species, especially reed canarygrass; 5) high population densities of seed-eating rodents, especially voles (Anderson and Cooper 2000); 6) beaver, which harvest above-ground stems; and 7) ungulates, which can clip the leaders of saplings, limiting the plants' ability to mature to full trees. Beaver have the ability to suppress black cottonwood recruitment (Lesica and Miles 1999). Although black cottonwood is capable of resprouting after the above-ground stems have been removed (Kovalchik and Clausnitzer 2004), resprouting is dependent on moisture criteria (Hansen et al. 1995) that might not be present at the time of beaver harvest. On the flow-regulated Green River in Colorado, Breck et al. (2003) found the annual loss of cottonwood saplings to beaver foraging to be 25 percent.

5.3. Potential Riparian Tree and Shrub Habitat in the Fluctuation Zone

The amount and type of riparian tree and shrub habitat that could potentially develop in the fluctuation zone if the reservoir were operated at lower water surface elevations is dependent on topography, substrate, and the habitat requirements of the various riparian tree and shrub species that occur in the study area. For purposes of this discussion, the fluctuation zone is the area within which water surface elevations are influenced by normal Boundary Dam operations, outside of the flood season, while the high water zone is the elevational range above the fluctuation zone that is influenced by seasonal flooding. The scour zone is the lower portion of the high water zone where seasonal high-energy flows scour vegetation, thereby limiting seeding establishment.

The estimated acreage changes in each riparian habitat type expected from lower reservoir operating levels are summarized in Table 5.3-1 (see Appendix 2 for details). Overall, it was concluded that lower reservoir water surface elevations would result in little or no net change in available riparian habitat in any of the existing alder, willow, cottonwood, hawthorn, or snowberry stands, or at half of the dogwood stands. The only substantial change predicted

would occur at the dogwood stands associated with the island complex at PRMs 28.5 to 29.0, where existing stands could potentially triple in size. Further information and the rationale for this conclusion are presented below for each riparian habitat type.

Table 5.3-1. Potential riparian habitat (by species) that could potentially develop in the fluctuation zone if Boundary reservoir were operated at lower water surface elevations (in 5-foot increments).

Species	Current Acreage	Potential Acreage by Increment				Max. Net Change
		–5 feet	–10 feet	–15 feet	–20 feet	
Sitka alder[1]	7.9	8.1	8.3	8.5	7.9	0.6
Gray alder[1]	1.0	1.0	1.0	1.0	1.0	0.0
Coyote willow[1]	6.2	6.6	6.2	6.2	6.2	0.4
Shining willow[1]	2.2	2.2	2.2	2.2	2.2	0.0
Sitka willow[1]	8.8	8.1	8.1	8.1	8.1	-0.7
MacKenzie's willow[1]	2.3	2.9	3.2	3.2	3.2	0.9
Red-osier dogwood[1]	10.9	16.4	18.8	18.8	18.8	7.9
Black cottonwood[2]	19.7	19.7	19.7	19.7	19.7	0.0
Black hawthorn[2]	2.7	2.7	2.7	2.7	2.7	0.0
Common snowberry[3]	44.1	44.1	44.1	44.1	44.1	0.0
Total	**105.8**	**111.8**	**114.3**	**114.5**	**113.9**	**9.1**
Net Change in Acres		**6.0**	**8.5**	**8.7**	**8.1**	
Net Percent Change		**5.4**	**7.4**	**7.6**	**7.1**	

Notes:
1 Facultative wetland species—Usually occurs in wetlands (estimated probability 67–99%), but occasionally found in non-wetlands.
2 Facultative specie—Equally likely to occur in wetlands or non-wetlands (estimated probability 34–66%).
3 Facultative upland species—Usually occurs in non-wetlands (estimated probability 67–99%), but occasionally found in wetlands (estimated probability 1–33%).

5.3.1. Sitka Alder Stands

Sitka alder scrub-shrub stands currently occur at 12 locations in the study area. Eleven of these stands occur downstream of Metaline Falls and one above the falls. Seven of the stands (polygons 4, 5a, 5b, 7a, 7b, 9, and 10a; see Appendix 1, Figure A.1-1 for location of stands) occur as narrow bands along the reservoir edge (the lower edge generally following the 1,994-foot NAVD 88 [1,990-foot NGVD 29] contour line). These stands are limited from further expansion by cobble, a substrate that is not a suitable substrate for the establishment of a species that requires soil for germination and establishment (Kovalchik and Clausnitzer 2004; Table 5.2-2). In addition, these stands are dependent on the water table associated with the current reservoir operating levels. The upper 5-foot elevations of these stands would be expected to die back from desiccation due to a lowered water table and eventually convert to upland habitats at each incremental change in operations. Collectively, these stands comprise approximately 1 acre of riparian habitat, 75 percent of which would be lost if the forebay water surface elevation was managed 5 feet lower; over 90 percent would be lost if the water surface elevation was 10 feet lower.

Sitka alder stands also ring the upper ends of three embayments: Monument Bar (polygon 10b), Lime Creek (polygon 8), and a cove at PRM 20.9 (polygon 11). These embayments are shallow, spring or stream-fed, and largely have fine-sediment bottoms. Thus, there is an opportunity for Sitka alder to expand under lower reservoir operating elevations, especially along the newly exposed spring and stream channels. Currently, these embayments support only about 0.71 acre of Sitka alder scrub-shrubs; it is estimated that this acreage could increase to 1.28 acres with a 5-foot decrease in water surface elevations to a maximum of 1.72 acres with a 15-foot decrease (Table 5.3-1).

The one Sitka alder stand that has the greatest potential to increase, on a percentage basis, is on Rat Island. Currently, a 0.05-acre stand (polygon 6) of alder occurs on the mudflats of the northeast end of the island. Dropping the reservoir would expose additional mudflats with nearly an eightfold increase (0.39 acre) in potential habitat with a 5-foot decrease in water surface elevations to over a tenfold increase (to 0.53 acre) with a 15-foot drop. However, the net increase in habitat for all the stands in the lower reservoir combined would be 0.23 acre with a 5-foot elevational change and 0.48 acre with a 10-foot change. At lower water levels, steep slopes would limit the development of new riparian habitat while existing alder at higher elevations would be desiccated. Consequently, a net decrease in riparian habitat of 0.41 and 0.29 acre would be expected with 15-foot and 20-foot changes in water surface elevations, respectively.

In summary, the maximum net increase in Sitka alder riparian habitat that could develop along the lower reservoir as a result of operating the reservoir at lower levels is approximately 0.61 acre (a 27 percent increase over the current water surface elevation; Table 5.3-1), but doing so would also eliminate 6 of the 11 stands currently occurring.

In addition to the 11 existing Sitka alder stands discussed above, 9 locations in the lower reservoir currently devoid of riparian vegetation appear to have the fine, moist soils that favor the establishment of Sitka alder. Nearly all are situated in low-energy coves, small stream mouths, or backwater areas. With lower water surface elevations, these locations could eventually develop riparian stands if the existing sediments are not eroded by fluctuating pool levels. It is not known why these sites do not currently support riparian vegetation.

One stand (polygon 22a) of Sitka alder occurs above Metaline Falls. This 4.78-acre stand begins at Metaline Park and extends north for approximately one-half mile along the west bank of the channel separating the island at PRM 27.7. The southern quarter of the stand is hydrologically connected to both hillside seeps and the reservoir-charged water table (and possibly irrigation water from the park, or even Linton Creek), while the northern three-quarters appears to be connected only to the reservoir water table. A buffer of reed canarygrass grows along the shoreline edge and may currently be limiting expansion of the riparian shrub community to lower elevations. For this analysis, it was assumed that the southern quarter of the stand would not change as a result of lowering reservoir water surface elevations. This part of the stand would remain charged by seeps, while outflow from these seeps into the backwater channel would keep the channel center too saturated for further expansion of the riparian stand into the fluctuation zone. The northern reach of this stand, which approximately follows the 1,996-foot NAVD 88

(1,992-foot NGVD 29) contour line, could potentially expand down to the 1,990-foot NAVD 88 (1,986-foot NGVD 29) contour line (where it would be limited by the saturated flood channel center). Correspondingly, the upper elevations of this stand, which are not associated with hillside seeps, would convert to upland habitat with the lowering of the water table. However, the complexities of multiple water sources (seeps, irrigation, Linton Creek, and the reservoir), expansion limiting factors (reed canarygrass, saturated backwater channel), and the size of this stand, prevent any precise conclusions on whether this portion of the stand would expand or reduce in size. While expansion into the fluctuation zone would probably not be limited by soil type (fine soils are present), it may be limited to a degree by reed canarygrass and a saturated channel. Any expansion, however, would likely be offset by a decline in riparian habitat at higher elevations. Thus, it was concluded that operating the reservoir at lower water surface elevations would result in a shift of portions of this stand into the fluctuation zone, but that there would be no net change in stand acreage.

5.3.2. Willow Stands

Six species of willow were recorded in the study area, with four species (MacKenzie's, shining, Sitka, and coyote) occurring as the dominant species in at least two stands. Their location in the study area reflects the unique ecology of each species. Shining willow was found growing only in the disturbed fine-textured soils forming the berm of the Metaline sewage ponds and along the edges of the nearby Linton Creek outlet. Sitka willow occurred in the wet silt substrates of the wetlands at the mouth of Sullivan Creek. Coyote willow was associated only with cobble bars along the reservoir and at the mouth of Sullivan Creek. MacKenzie's willow was found both at cobble and moist alluvial soil sites, indicative of its ability to tolerate a wider range of substrate conditions compared to Sitka and coyote willows.

- The two stands (polygons 23a, b) of **shining willow** found at Metaline Park collectively comprise 2.15 acres. Neither appears to be dependent on reservoir-influenced water tables because of their association with the fill bank of the Metaline sewage ponds and Linton Creek. The lower elevation of each corresponds to the reservoir fluctuation zone, giving the initial appearance of opportunity for expansion into the fluctuation zone. At closer examination, however, these lines mark a sharp transition (steep banks) between deep fine-textured soils and cobble. Thus, the conclusion was drawn that there would be no change in the acreage of shining willow stands if the reservoir were operated at lower water surface elevations.

- Four stands (polygons 15a, c, d, and 16) of **Sitka willow** occur at or near the mouth of Sullivan Creek, only one (polygon 15a) of which actually approaches the reservoir fluctuation zone. This stand, found along the delta of Sullivan Creek, occurs in fine-textured soils and runs along the southern edge of the large gravel bar. Along the cobble edge, seedling coyote willow and black cottonwoods were observed, and coyote willow is a co-dominant shrub species in the stand. It might appear that the Sitka willow in this 1.42-acre stand could expand onto the gravel bar substrate. The coyote willow, however, tolerates cobble substrate well and is likely to expand, eventually merging with the existing adjacent 0.27-acre coyote willow stand (polygon 15b). Operating the reservoir 5 feet lower would therefore expose an additional 1.75

acres of habitat for coyote willow, but would result in the loss of approximately half of the current Sitka willow, which would desiccate due to a lower water table. Thus, there would be a net loss of about 0.71 acre of Sitka willow habitat if the reservoir were lowered.

- **MacKenzie's willow** occurs along the backwater channel separating the island complex between PRMs 28.5 and 29.0 and the mainland (polygon 34a), and along the edge of the Box Canyon Dam tailrace (polygon 62). Stand 34a is a wet 1.72-acre site charged by seeps, a small stream, snowbanks, and the reservoir. No loss of higher elevation habitat is expected due to lower reservoir water levels because other sources of hydrology exist. Some expansion into the backwater channel would be expected, resulting in a 0.88-acre increase at the -5-foot increment and a 1.28-acre increase at the -10-foot increment.

  Stand 62 is long and narrow, with MacKenzie's willow thinly intermixed with coyote willow and red-osier dogwood. The stand is greatly impacted by seasonal high flows and by beaver. Lowering the reservoir would lower the water table in this area, likely resulting in the loss of nearly all of the current stand due to desiccation. Operating the reservoir at lower water surface elevations would have little influence on seasonal high flows, which can remove seedlings by scouring. Thus, expansion of riparian shrub species into the fluctuation zone at this location is expected to be limited. Overall, there would be a decrease in habitat from the current 0.55 acre to 0.28 acre for the 5-foot increment, and 0.14 acre for the 10-foot increment.

- There are eight riparian shrub stands in the study area dominated by **coyote willow**. Six of these stands occur along the edges of either the reservoir (polygons 54, 59, 61b, 65a, and 65b) or Sullivan Creek (15b), at elevations between 1,994 and 1,999 feet NAVD 88 (1,990 and 1,995 feet NGVD 29). A seventh stand (polygon 27) occurs along the reservoir just north of the Metaline Park boat launch and occurs between 1,994 and 2,006 feet NAVD 88 (1,990 and 2,002 feet NGVD 29). The final stand (polygon 61a) is uniquely located, mostly well upslope of the reservoir (up to 2,020 feet NAVD 88 [2,016 NGVD 29]) in association with a small stream and possibly runoff from the highway. The site includes almost equal amounts of red-osier dogwood and MacKenzie's willow, with coyote willow dominant at lower elevations. All of the coyote willow stands occur adjacent to scour zones and are heavily clipped by beavers.

  The influence of seasonal high flows and of beavers on coyote willow appears to be significant, potentially accounting for the fact that only 2.82 acres of this habitat occurs along more than 12 miles of cobble shoreline, a substrate in which this willow readily establishes. One example is the cobble bars near Wolf Creek. Only two small patches of coyote willow occur in an area that could potentially support ten times that amount. One of these stands (polygon 65b) is over 30 years old, yet the shrubs consist of only thin, 2- to 3-foot leaders which are removed annually by beavers and possibly by seasonal high flow events (the tops are also browsed off by wintering white-tailed deer [*Odocoileus virginianus*]). While this stand is able to persist, the establishment of new coyote willow shrubs close to the scour zone is likely an

infrequent event. Because lower reservoir water surface elevations are likely to have little influence on seasonal high flows (flooding upstream of Metaline Falls is largely controlled by upriver dams, not Boundary Dam), relatively little additional coyote willow habitat is expected to develop in the fluctuation zone under lower operating levels. Consequently, polygons 27, 54, 61b, 65a, and 65b, which occur as narrow bands along the upper edge of the scour zone, would logically experience a net loss due to desiccation of coyote willows at the higher elevations and the inability for shrubs to establish in the scour zone. Collectively, these stands comprise 1.3 acres of coyote willow habitat, of which approximately half would be lost to a 5-foot drop in water surface elevations at the Boundary Dam forebay, and three-quarters would be lost to a 10-foot decrease.

Stand 59 occurs as two small patches of coyote willow, totaling 0.39 acre, that occur above the scour zone. Lowering the reservoir water surface elevation could allow shrubs to expand downslope, but there would be an equal loss of habitat at the higher elevations of the stand due to a lowered water table. Stand 61a (1.14 acres) is maintained by a small stream in addition to the reservoir-associated water table and no change in acreage would be expected by operating the reservoir at lower water surface elevations.

Stand 15b (0.27 acre) consists of two small patches in the gravel bar delta of Sullivan Creek. Much of the Sullivan Creek delta occurs within the reservoir fluctuation zone, thereby limiting the expansion of this gravel bar species under current operating conditions. As much as 1.0 acre of the Sullivan Creek delta gravel bar would be exposed and available for coyote willow expansion (including from stand 15a discussed earlier with Sitka willow) if the reservoir were operated at lower water surface elevations (for a total of 1.27 acres). However, ongoing maintenance of this stand is tenuous due to heavy beaver use and the effects of seasonal high flows from Sullivan Creek. Further, this stand may have been buried by debris deposited during a winter 2007-2008 flood event, and may no longer exist as it was mapped in 2007.

In summary, operating Boundary Reservoir at lower water surface elevations would result in a maximum net increase of only 0.6 acre of all willow habitat (Table 5.3-1). Because seasonal high flows may limit development of the additional 1 acre of habitat in the Sullivan Creek delta, a small net decrease in the acreage of willow habitat may actually be more likely. For willows, lowering the reservoir water surface elevations would force new shrubs to attempt to develop lower in the fluctuation zone where seedling survival would be limited by seasonal high flows. Because Boundary Dam is operated at lower forebay surface elevations during flooding (to ensure reservoir capacity remains in case of a water surge), it has only a small influence on upper reservoir water surface elevations during flood events. Thus, while lowering reservoir water surface elevations correspondingly lowers the water table that willows are dependent on, it does not correspondingly change the scour zone, resulting in a general net decrease in willow habitats.

5.3.3. Red-osier Dogwood Stands

Red-osier dogwood is the most common riparian species in the study area. It is the dominant shrub in 12 stands, and is the second or third most dominant shrub in an additional 38 stands. Most stands occur along the reservoir edge between elevation 1,996 and 2,000 feet NAVD 88

(1,992 and 1,996 feet NGVD 29), suggesting a narrow groundwater tolerance. Two stands (polygons 20 and 21) occur along the western edge of the upper reservoir south of the Metaline Falls bridge. These stands are very narrow and shrubs appear to be growing from soil that has recently crept downslope (evidence includes the small slides and "drunken forests" found in association with these stands). Examination of older photographs suggests that these stands occupy what was once the upper scour zone of the river, since attenuated by upstream dams. These stands cannot expand farther downslope because of a lack of soil. Lower reservoir water surface elevations would lower the associated water table, desiccating the upper elevations of the stands and reducing their combined area from 1.15 acre to 0.72 acre at the -5-foot increment and 0.52 acre at the -10-foot increment. Stand 60, along the Box Canyon Dam tailrace, is similar. Because seasonal high flows would limit further expansion of this stand into the fluctuation zone, it would be expected to be reduced from 0.71 acre to 0.36 acre at the -5-foot increment, and to 0.18 acre at the -10-foot increment.

Polygons 24a and 28 are found at Metaline Park and receive water from a variety of sources, including runoff from the town of Metaline, park irrigation, Linton Creek, and the Metaline sewage ponds. These dogwood stands terminate at the scour line and therefore cannot expand into the fluctuation zone. Because they are maintained by several water sources, they are likely to persist regardless of reservoir water surface elevations; no change in acreage is expected from lower reservoir operating elevations. Polygon 40 is a large (2.03 acre) dogwood thicket running along Sand Creek. It is not dependent on reservoir water surface elevations (it receives water from Sand Creek) but its distribution downstream is probably somewhat limited by the current reservoir fluctuation zone. Consequently, it is estimated that it could expand to 2.08 acres with a 5-foot decline in pool operating elevations, and 2.22 acres with a 10-foot decline.

Polygons 29, 30, 31, 32, and 33 are associated with the island complex between PRMs 28.5 and 29.0, while polygon 34b is a narrow strip occurring across the backwater channel from the island complex. Collectively, these stands cover 3.85 acres and occur between elevation 1,996 and 2,000 feet NAVD 88 (1,992 and 1,996 feet NGVD 29), on relatively flat terrain and on sandy alluvial soil. They are heavily influenced by beaver, but less so than willow (which are a more preferred food source). While there is an abundance of broadleaf weeds, there is no reed canarygrass competing with establishment. Although a substantial amount of the existing dogwood would be expected to desiccate with lowered water surface elevations, the flat topography is conducive to expansion of this habitat into the fluctuation zone. A -5-foot increment change is expected to cause these six stands to expand and merge, nearly tripling the area of dogwood to 10.12 acres. A -10-foot increment change would increase dogwood habitat to 12.77 acres.

Overall, little or no change in 6 of the 12 dogwood stands in the study area is expected under lower reservoir operating levels. However, a significant increase is predicted in the six dogwood stands associated with the island between PRMs 28.5 and 29.0, with a net gain of 5.53 acres with a 5-foot lower forebay water surface, and 7.94 acres with a 10-foot decrease (Table 5.3-1).

5.3.4. Other Riparian Stands

One **black hawthorn** stand (polygon 38), four **snowberry** stands (polygons 14, 39, 42b, and 42c), and six **black cottonwood** stands (polygons 25, 36, 37, 41, 42a, and 64) were included in

this investigation because of their proximity to the upper reservoir fluctuation zone. However, all of these stands occur on higher areas of the floodplain, on terrestrial benches, or on slopes well above the fluctuation zone. None of these stands would markedly change if the upper reservoir were operated at lower water surface elevations. Cottonwoods were a minor component of 30 riparian shrub stands, and cottonwood seedlings were noted in association with willow stands along the reservoir edge. The latter were subject to severe beaver cutting and appeared to be affected by seasonal high flows. One stand of **gray alder** (polygon 26) occurs along Linton Creek and is not influenced by the reservoir.

5.4. Effects Assessment

The following effects assessment considers both Project effects and non-Project effects on riparian tree/shrub habitat. Project effects are related to Project operations and include impacts from reservoir fluctuations and changes in downstream flows and sediment supply, as well as recreation. Non-Project factors that have the ability to affect riparian vegetation include scouring and inundation from seasonal high flows, inundation from flooding, run-off from non-Project roads, herbivory, mining, timber harvest, and grazing.

5.4.1. Project Effects

Hydroelectric projects influence the establishment and maintenance of riparian vegetation both upstream and downstream of dams. They also provide enhanced recreation opportunities, which can also impact riparian vegetation. Each of these is discussed below.

5.4.1.1. Downstream Effects

The type and magnitude of downstream effects from hydroelectric projects depends, to a large extent, on whether the project generates power from a storage reservoir or if it is operated as run-of-river. Many hydroelectric projects, such as SCL's Ross Lake Project, for example (Skagit River Project, FERC No. 553), consist of a reservoir that is drawn down during the winter and filled during spring run-off. Hydroelectric power generation from reservoirs that store water typically dampen annual water surface fluctuations downstream of the dam by reducing winter and spring flood levels and augmenting low summer flows (Toner and Keddy 1997). On many large rivers with storage reservoirs these hydrological changes have been shown to result in downstream channel narrowing and subsequent colonization by trees (Friedman et al. 1998; Collier et al. 1996; Poff et al. 1997). Reducing the frequency and magnitude of spring flood events can also affect the regeneration of high floodplain species, particularly black cottonwood, that germinate in bare substrate and require several weeks of saturated soils in subsequent springs to survive (DeBell 1990; Mahoney and Rood 1998). In addition, augmentation of summer flows may alter the species composition in riparian habitats downstream of storage projects. Toner and Keddy (1997) found that augmenting summer flows led to reductions in native plant biodiversity as aggressive woody species were then able to survive summer desiccation and out-compete native forbs.

Boundary reservoir has very little storage capacity and the Project operates as a run-of-the-river project when flows exceed the hydraulic capacity of the Boundary turbines (i.e., approximately 55,000 cfs). Flood attenuation is controlled by upstream projects such as Albeni Falls and Kerr.

Records from the Z-Canyon gage for 1953–1962, which is prior to construction of the Boundary Project but after completion of the upstream dams, show that daily flows exceeded 100,000 cfs 56 times, with a maximum of 130,000 cfs. Daily flows at the gage in the Boundary tailrace for the 10 years following completion of Boundary Dam (1963–1972) were also >100,000 cfs 56 times with a maximum of 134,000 cfs. Consequently, the Project has had little or no effect on high flow events and does not augment summer flows because of the lack of storage. Unlike river reaches downstream of storage reservoirs, the Boundary tailrace area is periodically scoured by very high flood events and would therefore not be expected to support stands of riparian trees.

Although the Boundary Project does not have a significant influence on flood events or downstream summer flows, it does affect the ability of riparian vegetation to develop in the tailrace reach. Flows in this reach change rapidly as the Boundary Project ramps up or down in response to changing generation needs. Average daily fluctuations in water surface elevations in the tailrace exceeded 8 feet per day 50 percent of the time between 1987 and 2005 (SCL 2008) and exceeded 15 feet per day 10 percent of the time. The frequent changes in water surface elevations make it difficult for riparian development. Maximum water surface elevations due to powerhouse discharge can reach 1,743 feet NAVD 88 (1,739 feet NGVD 29) elevation, completely inundating the willow communities. The tailrace is characterized by a few narrow stands of riparian plants able to withstand the extremely dynamic conditions in this reach.

5.4.1.2. Daily Reservoir Fluctuation

In addition to downstream effects on riparian habitats, hydroelectric project operations also affect the development of these habitats along their associated reservoirs. Daily reservoir water level fluctuations often exceed the wet/dry cycle tolerance of native forbs, favoring the establishment of ruderal non-native weeds and deeper-rooted woody riparian vegetation (Hill et al. 1998). Daily fluctuations, combined with associated erosive actions of powerboat wakes and wind waves can also remove soils from exposed reservoir shorelines (Smith et al. 1997), preventing the establishment of vegetation, and resulting in bare shorelines that are often characteristic of hydroelectric reservoirs (Keddy and Reznick 1986). In contrast, riparian vegetation immediately above the fluctuation zone may benefit from (or even be dependent on) water supplied by periodic waves (Keddy 1983).

The Project reservoir fluctuates daily, generally ranging between 5 and 10 feet in the lower reservoir reach and 2 to 6 feet in the upper reservoir reach. The combined actions of daily fluctuations and waves are evident along the reservoir shoreline where fine sediments have been removed from the fluctuation zone leaving unconsolidated cobble. This is particularly evident in the lower reservoir where soils (originally upland soils) have been washed approximately 10 feet deeper into the reservoir. The lack of fine sediment in the fluctuation zone, and the shoreline immediately above the fluctuation zone, is probably at least partially responsible for the absence of riparian trees and shrubs along much of the reservoir shoreline, and would most likely limit riparian establishment in the current fluctuation zone if the reservoir were operated at lower water surface elevations. However, other factors also likely affect the location, distribution, and extent of riparian habitat. For example, there are nine sheltered sites along the lower reservoir that have substrates of fine sediment but do not support riparian shrubs or trees. This suggests

other processes (e.g., poor seed dispersal, weeds, herbivory) play a role in limiting riparian establishment in the study area.

Although the erosion of soils from the fluctuation zone has influenced the extent and distribution of riparian habitat along the reservoir, there is little evidence to suggest that existing riparian vegetation is being lost. An examination of 25 riparian stands associated with identified erosion sites concluded that only 9 riparian stands were even minimally affected by erosion, generally due to a gradual undercutting of the banks. Only one stand (polygon 15a) was experiencing erosion of management concern, but seasonal flood-related scouring was considered the primary source of the erosion at this site, and daily fluctuation secondary.

Although Boundary Reservoir fluctuates on a daily basis, the current position of riparian vegetation, especially facultative wetland vegetation, along the shoreline is probably a result of water surface elevations during the summer months, and its influence on groundwater levels. Riparian tree/shrub habitat does not occur within the current fluctuation zone, but rather, just above it. Water table levels, especially during the summer growing season, and associated pool levels are likely the major influence in determining the establishment and maintenance of current riparian tree and shrub stands.

Weeds occur along most of the reservoir shoreline, but are especially common in the more sheltered backwaters (protected from annual scouring) of the upper reservoir. Ruderal weedy species dominate the sheltered areas because of their ability to tolerate daily changes in moisture compared to native plants. Weedy annuals (Canadian thistle [*Cirsium arvense*], Dalmatian toadflax [*Linaria dalmatica*], common St. John's wort [*Hypericum perforatum*], common tansy [*Tanacetum vulgare*], white sweetclover [*Melilotus officinalis*]) dominate the island complex between PRMs 28.5 and 29.0, while all the other islands in the upper reservoir are covered in reed canarygrass. Reed canarygrass is also the dominant ground cover in willow stands along Sullivan Creek that are not influenced by the reservoir. Weeds, like all riparian vegetation, are limited to the upper edge of the fluctuation zone, with daily inundation probably preventing establishment farther down into the zone. Lower operating water surface elevations in the upper reservoir would, at least initially, result in a profusion of weeds moving into the newly exposed substrate, which presumably lacks a native seedbank. Whether native shrubs or forbs would ultimately be able to out-compete these weeds is unknown, but evidence from other areas suggests that weeds, particularly reed canarygrass, are persistent. Orr and Stanley (2006), found that at 13 dam removal sites in Wisconsin that were allowed to revegetate on their own, 75 percent of the species that established were non-native, with reed canarygrass dominating many sites. Phillips and Mettler (1994) found reed canarygrass to be the most aggressive colonizer of the drawdown zone of four reservoirs along the lower Snake River in Washington State.

In conclusion, daily reservoir fluctuations appear to have little or no effect on existing woody riparian stands, but may be limiting establishment of new stands at some locations (due to past removal of fine soils). Further, reservoir fluctuations would likely limit establishment of woody riparian vegetation in the fluctuation zone except in sheltered areas such as coves or creek inlets where fine sediment substrates exist.

5.4.1.3. Recreation

The potential effects of recreation activity were evaluated for each riparian stand in the Project area. Potential damage to riparian resources includes trampling of vegetation by campers, anglers, and all-terrain vehicles, as well as the cutting of riparian trees and shrubs for firewood. With the exception of Monument Bar and Metaline Park, no established or dispersed camping/picnicking sites were found associated with riparian tree or shrub stands. A user-made campsite is located at Monument Bar adjacent to a small Sitka alder stand, and some alder trees were cut for stakes, etc., but there is no indication that camping activities have significantly damaged the stand. At Metaline Park, lawns, roadways, and established trails provide easy access to the river without the need for recreationists to traverse riparian resources.

Anglers traverse riparian shrub stands to access the river at some locations, especially along the west side of the river along the Box Canyon tailrace. However, there is no evidence of trampling occurring because the riparian vegetation is relatively sparse here, and denser vegetation stands appear to be avoided due to the presence of western poison ivy (*Toxicodendron rydbergii*).

5.4.2. Non-Project Effects

Non-Project effects, such as seasonal high flows, flooding inundation, road runoff from non-Project roads, herbivory, mining, timber harvest, and grazing have the ability to influence riparian vegetation and are discussed below.

5.4.2.1. Seasonal High Flows

Boundary Reservoir upstream of Metaline Falls has many characteristics of a riverine system, particularly during high flow events. Cobble bars and islands with little or no woody vegetation are evident along the upper reservoir wherever the river thalweg, during flood stage, touches the shoreline. Tree and shrub seedlings can be physically dislodged by high flow velocities. Seedlings can also be damaged or destroyed by shifting gravel and cobble substrates during high flows. Ice can have a similar scouring effect. Seasonal high flows and ice likely play a significant role in preventing the establishment of willow and cottonwood stands along the reservoir edge, particularly upstream of Metaline Falls.

5.4.2.2. Flooding Inundation

Unlike most reservoirs, shoreline vegetation along Boundary Reservoir, particularly upstream of Metaline Falls, can periodically experience prolonged inundation during the spring runoff period. This prolonged inundation in the upper reservoir is due to a combination of several factors, including naturally occurring high flow conditions, the influence of the constriction at Metaline Falls on water surface elevations upstream of Metaline Falls, and the influence of the Boundary Project on water surface elevations upstream of Metaline Falls. Of these factors, naturally occurring high flow events and the constriction at Metaline Falls appear to have the greatest influence on riparian habitat conditions upstream of Metaline Falls. The results of Study 2 (SCL 2009c) showed that Project operations influenced water surface elevations during the peaks of the 1972, 1974, and 1997 flood events by no more than +1.6 feet at the downstream end of the Upper Reservoir Reach to 1.1 feet at the upstream end of the reach.

Using the 1997 flood event as an example, the recorded water surface elevation at USGS gage 12396500 was 2,020 feet NAVD 88 (2,016 feet NGVD 29) and the coincident Boundary forebay elevation was 1,988 feet NAVD 88 (1,984 feet NGVD 29). This peak stage water surface elevation in the Upper Reservoir Reach was high enough to inundate many riparian stands, including portions of the BWP.

These high flood events have some positive effects for riparian deciduous forests in the study area. Many reservoirs support only old and decadent stands of cottonwood trees that established prior to Project construction; the Boundary Project area includes cottonwood stands that represent a variety of age classes. Flood events in 1997 and 2008 demonstrate that flood events, on a decadal timeframe, continue to reach the elevational level of current cottonwood stands upstream of Metaline Falls. As demonstrated by the results of the field research for this study, these stands have responded by continuing to reproduce. Episodic flooding is apparently still sufficient to promote decadal cottonwood reproduction within existing stands and at a few other locations.

5.4.2.3. Road Runoff

Study 1 (SCL 2009b) identified road runoff as a source of erosion that could affect riparian resources. Road runoff concerns were generally associated with over-steep road fills where water runoff has created rills, in some cases leading to slides. Although erosion concerns were evaluated for both Project and non-Project roads, only non-Project road erosion was associated with riparian areas.

Study 1 identified five erosion sites, associated with nine riparian stands, where road runoff was the primary source of erosion. At five of the riparian stands (polygons 60, 61a, 61b, 62, and 63) there was no effect from the erosion because the erosion and riparian stand did not actually coincide. At the remaining four stands (polygons 20, 58, 59, and 64), the effect from erosion was considered moderate and involved both bank erosion and some burial of vegetation by slides.

5.4.2.4. Herbivory

The effect of beaver on the riparian stands in the study area cannot be understated. There are at least 16 beaver lodges or lodge complexes in the study area supporting approximately 80 beavers if all were active (Denney 1952; Breck et al. 2001). The degree to which beavers limit establishment of riparian stands cannot be quantified; however, they likely eat cottonwood seedlings, and there is evidence that they reduce riparian canopy coverage of established stands. Much of the alder, dogwood, and (especially) willow stands found closest to the shoreline are heavily broomed from persistent beaver cutting. One coyote willow stand near Wolf Creek is comprised of individuals with 2- to 3-foot tall leaders, giving the appearance of young shrubs. Examination at the base of the plants revealed that many are over 30 years old. The plants' new growth is harvested annually by beavers, and the tops of those that have survived beaver cutting have been browsed by wintering white-tailed deer.

Evidence of deer browsing was also found at many other riparian stands, but in general, does not appear to pose a significant threat to the establishment or maintenance of riparian vegetation. Voles (*Microtus* spp.) have been identified as having a significant impact on cottonwood populations by harvesting seeds and foraging on seedlings (Anderson and Cooper 2000). Episodic flooding is considered to be necessary for cottonwood reproduction, not only because it establishes seedbeds by clearing existing vegetation, but also because flood events can dramatically reduce vole populations. Significant vole activity was noted in early spring 2008 in all the reed canarygrass stands at the BWP and on the grass islands in the upper reservoir. By late spring, all these areas were entirely inundated by flood waters, possibly resulting in a reduction of the vole population and favoring cottonwood seed survival in 2008 and 2009.

5.4.2.5. Mining

Teck Cominco's Pend Oreille Mine is the only active mine operating in the study area. Activities associated with the operation of the mine do not occur in the vicinity of existing riparian resources. Two black cottonwood stands (polygons 36 and 37) grow from the waste rock associated with the Metaline Mine. Also, two coyote willow stands (polygons 3 and possibly 65b) are growing on gravel bars that have been mined in the past (SCL 2009d). In addition, recreational mining was apparently popular in the Boundary tailrace before security measures limited access (McGregor 2008); there is no evidence of this activity having adverse effects on existing riparian stands.

5.4.2.6. Timber Harvest

There is currently no timber harvesting activity in the Project area. Riparian, aquatic, and visual resource buffer regulations (including the Inland Native Fish Strategy on federal lands and Pend Oreille County Forest Practices regulations on private lands) would limit any future plans to harvest timber within riparian zones. For example, the USFS would not harvest any timber within 300 feet of the Pend Oreille River (a fish-bearing stream) unless a fisheries biologist had determined that the action would actually improve riparian conditions (Borysewicz 2008).

5.4.2.7. Grazing

There is currently no active livestock grazing in the Project area, although trespass cattle occasionally wander into the tailrace area from Canada (e.g., in 2007). No significant cattle damage to riparian resources was noted.

6 CONCLUSIONS

Prior to regulation, the Pend Oreille River was characterized as a system of seasonally moderate to low flows punctuated by high, often destructive flows during peak spring runoff (Pate 2008). Photographs of the river riparian zone within the study area taken prior to Boundary Dam construction show a highly scoured stream corridor of cobbles and boulders devoid of fine sediments and riparian vegetation. Since river regulation, flood peaks have been attenuated by the flood storage and regulated release from upriver dams (especially Kerr and Albeni Falls), and summer water levels are maintained at higher average, albeit fluctuating, water surface

elevations. These two factors, along with beaver herbivory, now dictate the riparian ecology of the study area.

Over 96 percent of the riparian tree and shrub vegetation, and virtually all the black cottonwood stands, occur in the upper reservoir between Metaline Falls and Box Canyon Dam. This is mostly due to the presence of a high floodplain and associated old river channels. Seasonal high flows restrict seedling establishment and appear to be a major limiting factor of riparian development along the upper reservoir although other factors play a role, especially herbivory by beaver.

The tailrace is a high-energy site influenced not only by powerhouse discharge and spill from Boundary Dam during seasonal high flows, but the level of Seven Mile Reservoir as well. Coyote willow occurs in the upper elevations of the fluctuation zone in this reach, but does not develop into mature trees due to inundation from powerhouse discharge and flood waters, and extensive cutting by beavers. Sitka alder are found just above the fluctuation zone where they are only inundated during floods.

The shorelines of the reservoir between Metaline Falls and Boundary Dam are best described as "pre-upland," meaning they were entirely upland communities prior to inundation. Sitka alder, a species found in riparian as well as avalanche chutes and mountain seep areas, is the dominant species, and is only found in sheltered coves and along the exposed margins where residual fine soils remain at the fluctuation zone edge. Most of the lower reservoir shoreline is characterized as bedrock or unconsolidated cobble that has had the fine soils washed away by the combined action of the daily fluctuations and waves from wind and powerboats.

The amount of riparian habitat that could develop in the fluctuation zone at lower reservoir water surface elevations in many locations would be offset by a similar loss of existing habitat due to lowered water tables (Lenhart 2000; Shafroth et al. 2002; Ferry and Miller 2003; Stanley and Doyle 2003; Auble et al. 2007). At these sites, sediment has been washed out of the fluctuation zone by flood-related scouring (upper reservoir and tailrace) or daily fluctuation combined with wind (lower reservoir), thus limiting which riparian species could expand into the current fluctuation zone. An approximately 10 percent net increase in Sitka alder habitat would be expected, but there would be a loss of approximately half the current stands. Only a very slight (1.5 percent) increase in willows is predicted, because expansion into the fluctuation zone would be offset by an associated reduction at the upper elevations. Up to an 86 percent increase in red-osier dogwood cover could occur, but nearly all of this would be at one location near Metaline, with a number of other stands disappearing entirely. Finally, no changes would be expected in the existing black cottonwood, black hawthorn, common snowberry, or gray alder stands because they occur outside of the influence of the fluctuation zone. Overall, the current 94.9 acres of riparian habitat upstream of Boundary Dam could potentially expand an additional 8.8 acres, maximum, an approximate 9 percent increase.

7 VARIANCES FROM FERC-APPROVED STUDY PLAN AND PROPOSED MODIFICATIONS

There was one variance from the FERC-approved study plan. The objective of the tree coring was to document the age structure of cottonwood stands. Because coring can lead to decay and other forms of degradation (Maeglin 1979), it was decided that the actual number of trees to be core sampled would depend on stand diversity (no undue sampling would occur simply to meet protocols). During coring, many cottonwoods had a strong outflow of a liquid that ranged from fairly clear to red. Due to the potential damage to trees, the surveyors would listen for a gurgling sound which preceded this outflow, stop coring a tree when this occurred, and estimate the age of the tree based on the rings seen on the partial core, the dbh of the tree, and the estimated thickness of the bark. Further, it was decided during a September 6, 2007, site visit attended by relicensing participants, SCL, and the Tetra Tech riparian study team that damage to trees should be minimized, and if a site showed a wide distribution of tree sizes or if tree ages were similar, coring would not be necessary.

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Appendix 1: Locations of Riparian Tree and Shrub Stands Surveyed in the Study Area by Polygon

This appendix contains the following figure and table:

Figure A.1-1. Riparian tree and shrub areas.

Table A.1-1. Data in GIS shape file for each polygon.

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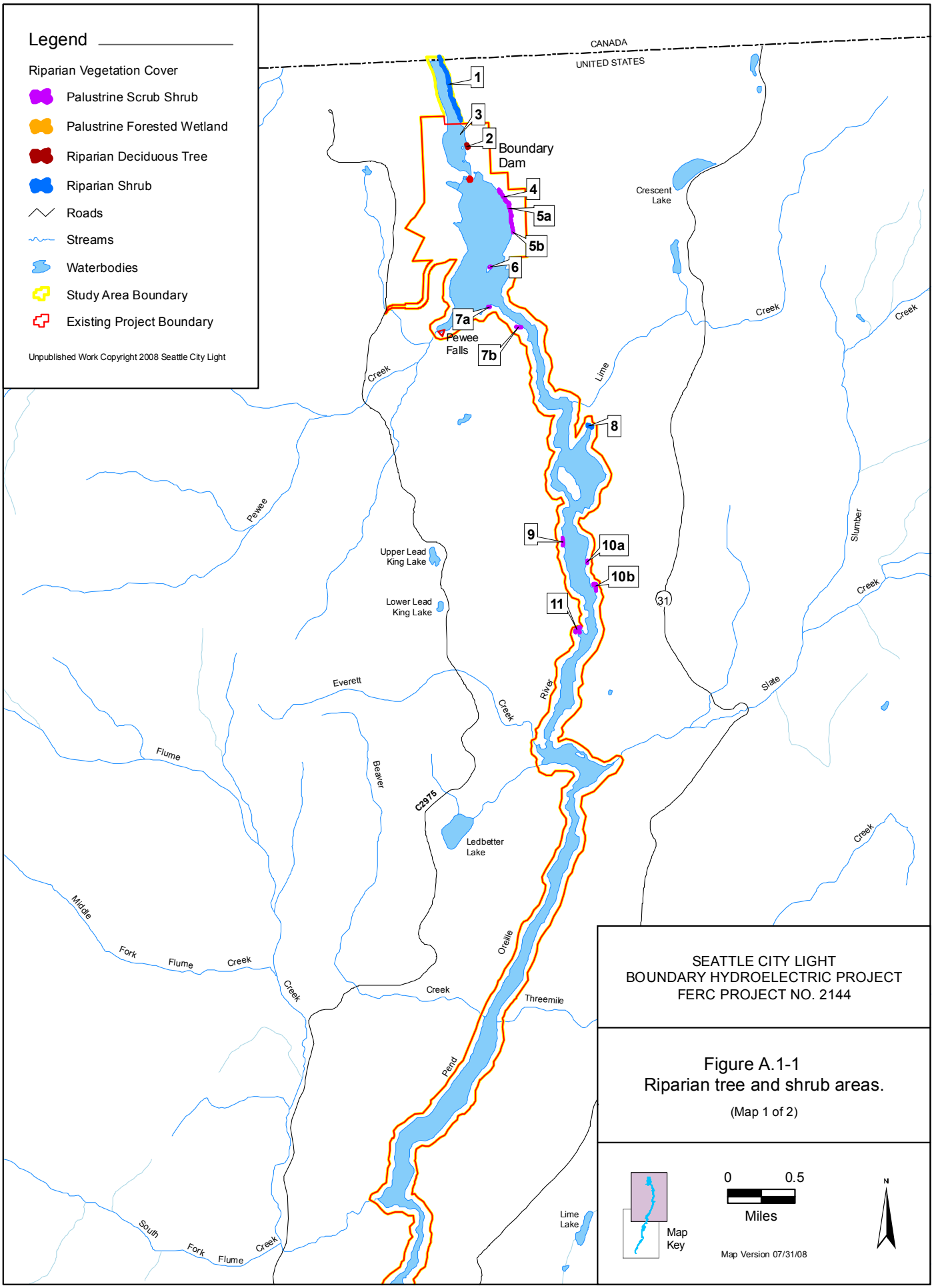
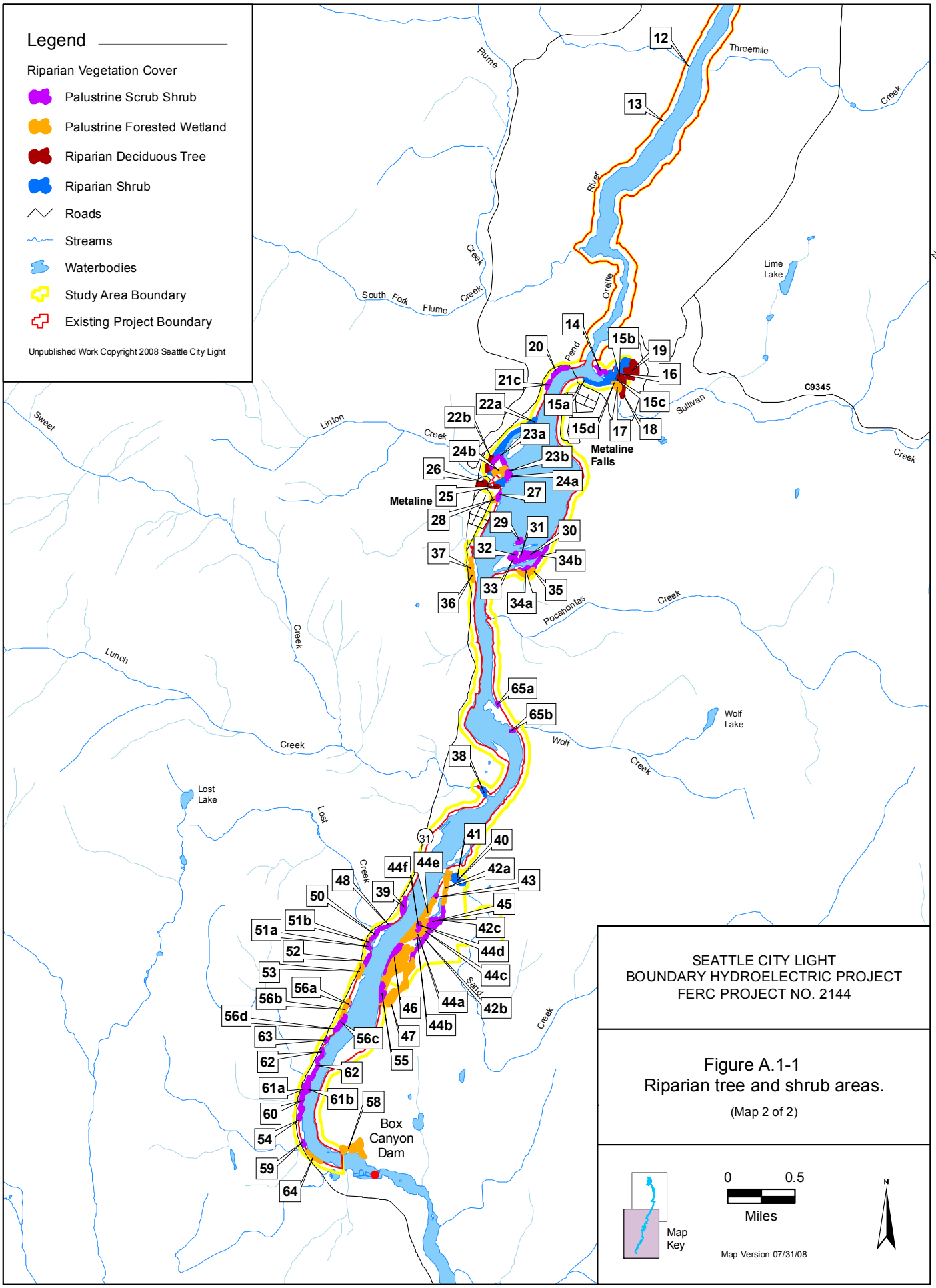

Legend
Riparian Vegetation Cover
Palustrine Scrub Shrub
Palustrine Forested Wetland
Riparian Deciduous Tree
Riparian Shrub
Roads
Streams
Waterbodies
Study Area Boundary
Existing Project Boundary
Unpublished Work Copyright 2008 Seattle City Light
CANADA
UNITED STATES
1
2
3
4
5a
5b
6
7a
7b
8
9
10a
10b
11
Boundary Dam
Pewee Falls
Crescent Lake
Upper Lead King Lake
Lower Lead King Lake
Ledbetter Lake
Lime Lake
Pewee
Creek
Lime
Slumber
Everett
Flume
Beaver
C2975
River
Slate
Middle Fork Flume Creek
South Fork Flume Creek
Threemile
Pend Oreille
31
SEATTLE CITY LIGHT
BOUNDARY HYDROELECTRIC PROJECT
FERC PROJECT NO. 2144
Figure A.1-1
Riparian tree and shrub areas.
(Map 1 of 2)
Map Key
0
0.5
Miles
Map Version 07/31/08
N



SEATTLE CITY LIGHT
BOUNDARY HYDROELECTRIC PROJECT
FERC PROJECT NO. 2144

Figure A.1-1
Riparian tree and shrub areas.

(Map 2 of 2)

Map Key

0 0.5
Miles

Map Version 07/31/08

N

Table A.1-1. Data in GIS shape file for each polygon.

Polygon Number	Vegetation Classification [1]	Dominant Species	Dominant Tree No. 1 [2]	Dominant Tree No. 2	Dominant Tree No. 3	Cover Tree No. 1	Cover Tree No. 2	Cover Tree No. 3	Dominant Shrub No. 1 [3]	Dominant Shrub No. 2	Dominant Shrub No. 3	Cover Shrub No. 1	Cover Shrub No. 2	Cover Shrub No. 3	Potential Threats	Comments
Rip_Veg	ABBREV_	Dom_spec	DomTree1	DomTree2	DomTree3	CoverTree1	CoverTree2	CoverTree3	DomShrub1	DomShrub2	DomShrub3	Cover Shrub1	Cover Shrub2	Cover Shrub3	Threats	Comments
1	RS	SALEXI	THUPLI	BETPAP		5	5		SALEXI	ALNVIRS	CORSER	25	20	20	Upslope hydrology changes; Light to moderate deer/beaver	Upslope hydrology appears most influential. Salix exigua seedlings closer to river than most of the larger shrubs; they may reestablish every year.
2	RDT	POPBAL	POPBAL			30			SALPRO	CORSER	RUBPAR	2	1	1	Beaver; scour	
3	REM		POPBAL			2			SALEXI			2			Beaver; scour	PEM; Few willow and cottonwood seedlings; with less browse or scour and appropriate hydrology could grow to shrub or forested.
4	PSS	ALNVIRS	BETPAP			5			ALNVIRS	SYMALB	SHECAN	60	10	10	Browse along shore; reservoir level fluctuations	
5a	PSS	ALNVIRS							ALNVIRS	CORSER	SYMALB	65	25	20	Browse along shore; reservoir level fluctuations	
5b	PSS	ALNVIRS							ALNVIRS	CORSER	SYMALB	75	25	15	Browse along shore; reservoir level fluctuations	
6	PSS	ALNVIRS							ALNVIRS	SYMALB	PHILEW	30	3	1	Reservoir level fluctuations; recreation	
7a	PSS	ALNVIRS							ALNVIRS	CORCOR	RUBPAR	15	10	5	Reservoir level fluctuations; heavy browse	Browse has kept shrubs short
7b	PSS	ALNVIRS	ABIGRA	PINPON		3	3		ALNVIRS	CORCOR	RUBPAR	20	10	5	Tree encroachment, browse, water level fluctuations	
8	RS	ALNVIRS	THUPLI			5			ALNVIRS	CORSER	ACEDOU	25	10	10	Hydrologic changes in Linton Creek	
9	PSS	ALNVIRS							ALNVIRS	RUBPAR	SPIDOU	80	5	5	Reservoir level fluctuations, recreation	
10a	PSS	ALNVIRS							ALNVIRS			70			Reservoir level fluctuations	On a bench above the reservoir.
10b	PSS	ALNVIRS							ALNVIRS			70			Browse, reservoir level fluctuations	
11	PSS	ALNVIRS							ALNVIRS	SYMALB		25	5		Browse, reservoir level fluctuations, invasive plants	
12	US															
13	US															
14	PSS	SYMALB	POPBAL	BETPAP		3	3		SYMALB	CRADOU	CORSER	30	20	20	Invasives	Shrubs on 12 ft. bench; doesn't appear to be affected by Sullivan Creek or reservoir hydrology
15a	RS	SALSIT	POPBAL			5			SALSIT	SALEXI	SALPRO	35	15	5	Flood and scour of Sullivan Creek, western edges: reservoir level	Many seedlings in gravel areas
15b	RS	SALEXI	POPBAL			15			SALEXI	SALSIT	SALPRO	65	20	5	Flood and scour of Sullivan Creek, western edges: reservoir level	Many seedlings in gravel edges, adolescent POPBAL at cliff edges
15c	RS	SALSIT	POPBAL			5			SALSIT	SALEXI	SALLUC	50	30	15	Reedcanary grass, Sullivan Creek hydrology	Flood debris at 4 ft., reed canary grass dense
15d	RS	SALSIT	POPBAL			3	5		SALSIT	ALNVIRS	CORSER	70	20	20	Beaver, Scour at lowest areas	
16	RS	SALSIT							SALSIT	CORSER	ALNVIRS	30	15	15	Changes in hydrology, Reed canary grass	Dense reed canary grass patches in area and adjacent
17	PFO	CORSER	POPBAL	THUPLI		20	10		CORSER	SYMALB	CRADOU	30	20	10	Bench erosion, succession to conifer	On south terrace above Sullivan creek
18	RDT	POPBAL	POPBAL	BETPAP		60	5		SYMALB	CORSER	CORCOR	20	15	5	Wildlife and beaver browse,	
19	RDT	POPBAL	POPBAL			35			CORSER	SYMALB	ALNVIRS	35	35	20	Beaver and wildlife browse severe, changes in hydrology	Large single stem alder stand in the POPBAL forest
20	PSS	CORSER	BETPAP			3			CORSER	ALNVIRS	SYMALB	50	25	20	Upslope hydrology, bench erosion, human activities (road, garbage)	Steep slope on bench above reservoir, upslope seeps, road prism, garbage
21	PSS	CORSER	BETPAP			20			CORSER	ALNVIRS	SYMALB	30	30	30	Upslope hydrology, bench erosion, invasives	Steep slope on bench above reservoir, upslope seeps, road prism, garbage
22a	RS	ALNVIRS	POPBAL			5			ALNVIRS	CORSER	SPIDOU	50	40	15	Upslope hydrology, reservoir fluctuations (on lower elevations), beaver damage moderate,	
22b	RDT	POPBAL	POPBAL			40			ALNVIRS	SPIDOU	CORSER	40	30	15	Upslope hydrology changes	Narrow line of POPBAL between shrubs and conifer forest, many seeps
23a	PSS	SALLUC							SALLUC	CORSER	ALNVIRS	35	15	15	Invasives, Beaver, water fluctuations	Artificial environment: berm around sewage ponds.
23b	PFO	POPBAL	POPBAL			60			SYMALB	SPIDOU	CRADOU	20	15	10	Human activities (eg., mowed POPBAL saplings)	
24a	PSS	CORSER	POPBAL	PINPON		8	5		CORSER	CRADOU	SYMALB	25	25	20	Reservoir water level, invasives (reed canary grass)	

Table A.1-1, continued…

Polygon Number	Vegetation Classifi-cation	Dominant Species	Dominant Tree No. 1	Dominant Tree No. 2	Dominant Tree No. 3	Cover Tree No. 1	Cover Tree No. 2	Cover Tree No. 3	Dominant Shrub No. 1	Dominant Shrub No. 2	Dominant Shrub No. 3	Cover Shrub No. 1	Cover Shrub No. 2	Cover Shrub No. 3	Threats	Comments
24b	RS	SALLUC	POPBAL			5			SALLUC	SALPRO	SALEXI	20	20	15	Stream fluctuations, reservoir fluctuations, human activities (in park)	Along Linton Creek outlet.
25	RDT	POPBAL	POPBAL			60			SALEXI	SALPRO		5	5		Mowing, recreation	In park, saplings and seedlings at edges are mowed
26	RDT	ALNINC	POPBAL			5			ALNINC	SYMALB		80	60		Human activities, changes in stream hydrology	
27	PSS	SALEXI	POPBAL			8			SALEXI	CORSER	ROSWOO	20	5	5	Recreation, erosion, reservoir fluctuation, browse	On soil bench above gravel rivers edge. SALEXI at edge of bench with exposed roots due to erosion
28	PFO	CORSER	POPBAL			40			CORSER	ROSWOO		50	20		Human activities	
29	PSS	CORSER							CORSER			80			Invasives	
30	PSS	CORSER							CORSER			75			Invasives, beaver, browse	
31	PSS	CORSER							CORSER			75			Invasives, beaver, browse	
32	PSS	CORSER							CORSER			75			Invasives, beaver, browse	
33	PSS	CORSER							CORSER			75			Invasives, beaver, browse	
34a	PSS	SALPRO							SALPRO	ALNVIRS	CORSER	55	35	25	Browse, especially along edges, beaver	portion is ALNSIN forest (single stem), rest is SALIX thicket
34b	PSS	CORSER							CORSER	ALNVIRS		50	10		Browse, reservoir level	
35	PFO	ALNVIRS	POPBAL			35			ALNVIRS			50			Heavy browse, weeds	
36	PFO	POPBAL	POPBAL			65			CORSER			45			Human activity (road in stand)	
37	PFO	POPBAL	POPBAL			50			CORSER			25			Browse moderate, Human activity (road in stand)	
38	RS	CRADOU	POPBAL			2			CRADOU	SALSIT	CORSER	30	25	10	Invasives, changes in stream hydrology	CRADOU at top of bank only
39	PSS	SYMALB	POPBAL			10			SYMALB	CORSER	CRADOU	30	25	25	Dense invasives (reed canary grass and thistle)	
40	RS	CORSER	POPBAL			3			CORSER	SALSIT	SALPRO	60	50	15	Heavy browse, Change in upslope stream hydrology, Reservoir influence on west end	Area closer to river may be influenced by reservoir
41	PFO	POPBAL	POPBAL			30			CORSER	SYMALB	CRADOU	20	15	10	Young conifers encroaching, erosion of bench	Stand at top of bench, young POPBAL on sides of bench. Stream flood may erode bench; succession from above appears to favor conifers.
42a	PFO	POPBAL	POPBAL	BETPAP		60	5		CORSER	CRADOU	SYMALB	50	35	15	Browse, reed canary grass	
42b	PSS	SYMALB	BETPAP	POPTRE		5	3		SYMALB	CRADOU	CORSER	60	40	25	Browse moderate, reed canary grass	
42c	PSS	SYMALB							SYMALB	CRADOU	CORSER	80	55	30	Browse moderate, reed canary grass	
43	PSS	CORSER							CRADOU	CORSER	SYMALB	35	30	10	Invasives, erosion on shore side	
44a	PFO	SYMALB	POPTRE	POPBAL		60	5		SYMALB	CORSER	BERAQU	70	15	10	POPBAL severely browsed, invasives	
44b	PSS	CRADOU	POPBAL	POPTRE		3	3		CRADOU	SYMALB		15	5		POPBAL severely browsed, POPTRE browsed less than POPBAL; invasives	Succession to POPTRE as browse appears to be more severe on POPBAL.
44c	PSS	CRADOU	POPBAL	POPTRE		5	5		CRADOU	CORSER	SYMALB	40	25	10	Browse, invasives	
44d	PFO	SYMALB	POPBAL	POPTRE		40	5		SYMALB	CRADOU	CORSER	70	15	10	Browse, especially young POPBAL, reed canary grass	
44e	PFO	POPBAL	POPBAL			20									Reed canary grass, browse	POPBAL seedlings and saplings in grass; area without the dense reed canary grass nearby; some heavily browsed, others not
44f	PSS	SYMALB	POPBAL	POPTRE		8	8		SYMALB	CRADOU	CORSER	10	5	5	Heavy browse	Heavy browse
45	PSS	SYMALB	POPBAL			10			SYMALB	CRADOU	CORSER	50	35	10	Heavy browse on POPBAL young and CORSER	
46	PSS	SYMALB	POPBAL	POPTRE		8	2		SYMALB	CRADOU	CORSER	20	15	3	Heavy browse	
47	PFO	SYMALB	POPBAL	POPTRE	PINMON	35	10	5	SYMALB	CORSER	SPIDOU	85	5	5	Browse, succession to conifer	POBA young grazed severely; Few become tall saplings; more young conifer
48	PSS	CRADOU							CRADOU	SYMALB	ALNVIRS	80	75	5	Invasives (reed canary grass and knapweed)	
50	PSS	SYMALB							SYMALB	CRADOU	CORSER	70	60	5	Dense reed canary grass	
51a	PSS	CRADOU							CRADOU	SYMALB	CORSER	50	20	15	Dense reed canary grass	On 5-foot bench above river
51b	PFO	SYMALB	POPBAL			40			SYMALB	CRADOU	SORSER	40	30	20	Dense reed canary grass	
52	PSS	CRADOU							CRADOU	SYMALB	CORSER	50	20	15	No access; from water appears similar to 51a so used that data	

Table A.1-1, continued…

Polygon Number	Vegetation Classifi-cation	Dominant Species	Dominant Tree No. 1	Dominant Tree No. 2	Dominant Tree No. 3	Cover Tree No. 1	Cover Tree No. 2	Cover Tree No. 3	Dominant Shrub No. 1	Dominant Shrub No. 2	Dominant Shrub No. 3	Cover Shrub No. 1	Cover Shrub No. 2	Cover Shrub No. 3	Threats	Comments
53	PFO	SYMALB	POPBAL			40			SYMALB	CRADOU	CORSER	40	30	20	No access; from water appears similar to 51b so used that data	
54	PSS	SALEXI	POPBAL			1			SALEXI	CORSER		20	5		Moderate browse, periodic flooding/scouring	
55	PSS	SYMALB	POPBAL	POPTRE		8	2		SYMALB	CRADOU	CORSER	20	15	3		No access: from water appears similar to 46 so that data was used.
56a	PSS	POPBAL	POPBAL			10			CORSER			5				Seedlings and saplings, beginning of new stand in less dense grass area adjacent to mature stand
56b	PFO	POPBAL	POPBAL			60			SYMALB	CRADOU	CORCOR	65	10	10	Human activities (old road bisects stand)	young are along the road and in new stand POPBAL establishing in low area to east - seedlings and saplings'
56c	PSS	SALEXI	POPBAL			5			SALEXI	CORSER	SALLUC	15	10	5	Reservoir water level, flood events, reed canary grass	
56d	PFO	POPBAL	POPBAL			75			CORSER			5			Human activities (south end has dumped cement)	
58	PFO	POPBAL	POPBAL			35									Water level fluctuations, browse, Human activities (road, construction evident)	Wide variety of POPBAL ages
59	PSS	SALEXI							SALEXI	CORSER		50	20		Heavy beaver activity	
60	PSS	CORSER							CORSER	SALPRO		15	10		Flooding, scouring; browse; reed canary grass in areas	
61a	PSS	SALEXI	POPBAL			1			SALEXI	CORSER	SALPRO	25	25	15	Flooding, scouring;	
61b	PSS	SALEXI							SALEXI	CORSER		15	15		Flooding, scouring; beaver	
62	PSS	SALPRO							SALPRO	CORSER	SALEXI	8	5	5	Flooding, scouring; beaver	
63	PSS	CORSER							CORSER	CRADOU	SYMALB	70	25	10	Human activities (on and below highway)	
64	PFO	POPBAL	POPBAL	BETPAP		60	5		CORSER	ALNVIRS	AMAALN	25	5	5	Human activities (on road fill and below), erosion	Very steep area leading up to road to Box Canyon Dam, partially road rip rap
65	PSS	SALEXI	POPBAL			2			SALEXI			5			Flooding, scouring; beaver	Area is cobble beach where Salix and cottonwood established a few plants; beaver activity and hydrology likely prevent further growth and more establishment

Table A.1-1, continued…

Polygon Number	Tree Layer Cover	Tree Layer Height	Shrub Layer No. 1 Cover	Shrub Layer No. 1 Height	Shrub Layer No. 2 Cover	Shrub Layer No. 2 Height	Mature Cottonwood Pre-Damage	Mature Cottonwood Post-Damage	Seedlings % of Cottonwood	Saplings % of Cottonwood	Mature % of Cottonwood	Decadent or Dead % of Cottonwood	Snag % of Cottonwood	Age (from Tree Cores) or estimated age (years)	Substrate[4]	Acres
Rip_Veg	Tree_lay_cov	Tree_lay_hgt	ShrLay1_Cov	ShrLay1_Hgt	ShrLay2_Cov	ShrLay2_Hgt	MatCOT predm	MatCOTpstdm	COT_seed	COT_sap	COT_mature	COT_decad	COT_sng		Substrate	acres
1	10	50	75	10											CGF	2.3
2	30	50	5	3			N	Y	5	10	85	0	0	Less than 45 years – wide size range	SCG	0.2
3	2	2	2	2											SCG	0.7
4	5	30	60	15	50	6									F	0.4
5a			65	15	50	4									CF	0.1
5b			75	18	50	4									F	0.2
6			30	4											F	0.0
7a	1	2	30	4											F	0.0
7b	6	4	50	4											F	0.1
8	5	30	55	6											F	0.2
9			80	10	10	3									CF	0.1
10a			70	10											F	0.0
10b			70	10	15	3									F	0.2
11	2	5	30	5											GF	0.4
12																0.1
13																0.2
14	5	60	30	10	60	4	Y	N							GF	0.6
15a	5	5	60	5			N	N							CGF	1.4
15b	15	5	90	8			N	N							SCGF	0.3
15c	5	3	80	9			N	N							GF	2.5
15d	8	20	80	20	25	7	N	N							GF	0.3
16			75	10											F	4.6
17	30	80	50	12	20	3	Y	Y	0	10	75	10	5	Mature Trees wide size range: 12 - 50 in DBH	GF	0.9
18	60	60	30	4	15	8	N	Y	0	20	80	0	0	20, 22	F	1.9
19	35	70	60	10	35	3	Y	N	25	5	50	0	10	Trees large: 38 - 54 in DBH - 2 saplings and many shrubbed young	F	4.4
20	3	25	80	13	30	3	N	N							CF	0.8
21	20	30	85	10	30	5									F	0.3
22a	5	5	90	10	5	5	N	N							F	4.8
22b	40	70	40	15	50	5	Y	Y	10	50	25	5	10		F	0.5
23a			35	35	30	12	N	N							F	1.5
23b	65	70	25	15	45	5	Y	Y	5	15	80	0	0	53, 35, 65, 19, 26, 22, 28	F	2.5
24a	10	40	50	10	30	5	N	N	0	0	100	0	0		F	1.1
24b	5	10	30	10	35	5	N	N						60, 53, 17	F	0.6
25	60	45	10	6			N	Y	30	40	30	0	0	22, 23	F	0.2
26	5	30	90	20	65	5	N	Y						24	F	1.0
27	8	5	5	10	35	6	N	N							CGF	0.2
28	40	60	50	10	20	4	N	Y	0	50	45	0	5	20,23	F	0.6
29			80	10											F	0.4
30			75	10											F	2.0
31			75	10											F	0.1
32			75	10											F	0.1
33			75	10											F	0.7
34a			100	12											F	1.7
34b			70	10	7	4	N	N							F	0.6
35	35	70	50	25	10	10	Y	Y	5	0	90	5	0	31, 62, 51	F	1.4

Table A.1-1, continued…

Polygon Number	Tree Layer Cover	Tree Layer Height	Shrub Layer No. 1 Cover	Shrub Layer No. 1 Height	Shrub Layer No. 2 Cover	Shrub Layer No. 2 Height	Mature Cottonwood Pre-Damage	Mature Cottonwood Post-Damage	Seedlings % of Cottonwood	Saplings % of Cottonwood	Mature % of Cottonwood	Decadent or Dead % of Cottonwood	Snag % of Cottonwood	Age (from Tree Cores) or estimated age (years)	Substrate[4]	Acres
36	65	8	45	10			N	N	0	100	0	0	0	Dense saplings stand; too young to core	CGF	0.6
37	50	50	25	6			Y	Y	5	35	60	0	0	28,96	F	0.7
38			40	10	30	5	N	Y							F	0.3
39	10	60	75	12	30	5	Y	Y							F	1.2
40	3	5	90	10	10	5	N	N							CGF	2.0
41	30	70	35	5	15	10	Y	N	15	20	50	10	5	35 years at 20 in dbh; Wide size range 5" to 40" dbh	F	0.5
42a	60	70	35	15	65	7	Y	Y	50	25	20	0	5		F	1.7
42b	5	40	60	4	65	25									F	2.0
42c			90	5	80	10									F	0.6
43			65	11	10	4									F	0.3
44a	60	75	70	4	15	8	N	N							F	0.6
44b	5	3	15	12	10	4	N	N							F	0.6
44c	10	3	40	12	25	8	N	N							F	0.8
44d	40	70	70	4	20	10	N	Y	0	30	70	0	0		F	9.2
44e	20	4					N	N	10	90	0	0	0		F	0.3
44f	15	4	10	10	10	4	N	Y							F	0.4
45	10	20	60	5	35	12	N	Y							F	0.7
46	10	70	25	4	15	12	Y	N	0	5	65	0	30		F	5.0
47	45	80	85	5	10	7	Y	N	1	10	80	1	10	67, 66	F	20.6
48			80	12	75	5									F	0.3
50			75	5	60	15									F	0.5
51a			65	10	25	4									F	0.2
51b	40	70	50	12	40	5	Y	N	25	25	50	0	0	78	F	0.3
52			65	10	25	4									F	0.5
53	40	70	50	12	40	5	Y	N	25	25	50	0	0	No access	F	1.1
54	1	3	25	4			N	N							SCF	0.4
55	10	70	25	4	15	12	Y	N	0	5	90	0	5		F	1.3
56a	10	5	5	1			N	N							F	0.2
56b	60	60	70	5	20	10	Y	Y	0	10	75	5	10	43, 60, 92	F	1.2
56c	5	4	25	5			N	N							CGF	1.4
56d	75	8	5	5			N	N	20	80	0	0	0	All saplings; too young to core	F	0.4
58	35	35					Y	Y	50	8	40	1	1	54, 46, 46, 35, 30, 54, 37, 40, 20	CGF	3.7
59			70	6											CF	0.1
60			25	7											SCF	0.7
61a			65	6			N	N							SCF	1.1
61b			30	2											CGF	0.3
62			20	5											CGF	0.6
63			95	13	15	4									F	0.2
64	65	50	35	7	10	5	N	Y	15	5	80	0	0	26, 23, 28, 40,	CF	0.4
65	2	1	5	1			N	N							CGF	0.2

Notes:

Field data collected through September 2007 as described in Section 4 of the report. These data are the source of the summary tables in the report.

1 Vegetation classification abbreviations: RS = Riparian shrub, RDT = Riparian deciduous tree, PSS = Palustrine scrub shrub, PFO = Palustrine forest, US = Upland shrub, REM = Riparian emergent.

2 Tree species abbreviations: POPBAL = *Populus balsamifera* ssp. *trichocarpa*, POPTRE = *Populus tremuloides*, BETPAP = *Betula papifera*, PINPON = *Populus ponderosa*, ABIGRA = *Abies grandis*, THUPLI = *Thuja plicata.*

3 Shrub species abbreviations: ACEDOU = *Acer douglasia*, ALNVIRS = *Alnus viridis* ssp. *sinuata* [was *A. sinuate*], ALNINC = *Alnus incana*, *Berberis aquifolium* [syn. *Mahonia aquifolium]*, CRADOU = *Crataegus douglasii*, CORSER = *Cornus sericea*, *BERAQU*], *PHILEW* = *Philadelphus lewisii*, RUBPAR = *Rubus parviflorus* , SALLUC = *Salix lucida* ssp. *lasiandra*, SALEXI = *Salix exigua* [including *S. melanopsis*], SALSIT = Salix Sitchensis, SALPPRO = *Salix prolixa*, SPIDOU = Spiraea douglasia, SYMALB = *Symphoricarpos albus.*

4 Substrate abbreviations: C = Cobble, G = Gravel, F = Fines, S = Stones.

Appendix 2: Potential Riparian Habitat

Table A.2-1. Potential riparian habitat that could develop in the Boundary Reservoir fluctuation zone if Boundary Dam were operated at lower water surface levels as measured at the Boundary Dam forebay.

Polygon	River Mile	Dominant Species	Acreage				
			Current	-5 ft	-10 ft	-15 ft	-20 ft
4	17.2	ALNVIRS	0.45	0.16	0.00	0.00	0.00
5a	17.3	ALNVIRS	0.07	0.00	0.00	0.00	0.00
5b	17.4	ALNVIRS	0.21	0.08	0.07	0.05	0.03
6	17.7	ALNVIRS	0.05	0.39	0.47	0.53	0.53
7a	18.0	ALNVIRS	0.02	0.00	0.00	0.00	0.00
7b	18.3	ALNVIRS	0.11	0.00	0.00	0.00	0.00
8	19.2	ALNVIRS	0.17	0.27	0.47	0.62	0.83
9	20.2	ALNVIRS	0.07	0.00	0.00	0.00	0.00
10a	20.3	ALNVIRS	0.02	0.00	0.00	0.00	0.00
10b	20.5	ALNVIRS	0.17	0.24	0.14	0.07	0.00
11	20.9	ALNVIRS	0.37	0.77	1.01	1.03	0.30
12	24.3	US	0.11	0.11	0.11	0.11	0.11
13	24.7	US	0.20	0.20	0.20	0.20	0.20
14	27.0	SYMALB	0.56	0.56	0.56		
15a	27.0	SALSIT	1.42	0.71	0.71		
15b	27.0	SALEXI	0.27	1.27	1.27		
15c	27.0	SALSIT	2.54	2.54	2.54		
15d	27.0	SALSIT	0.32	0.32	0.32		
16	26.9	SALSIT	4.22	4.22	4.22		
17	27.0	CORSER	0.61	0.61	0.61		
18	27.0	POPBAL	1.38	1.38	1.38		
19	26.9	POPBAL	1.52	1.52	1.52		
20	27.1	CORSER	0.85	0.46	0.32		
21	27.2	CORSER	0.30	0.26	0.20		
22a	27.7	ALNVIRS	4.78	4.78	4.78		
22b	27.8	POPBAL	0.50	0.50	0.50		
23a	27.8	SALLUC	1.53	1.53	1.53		
23b	27.9	POPBAL	2.55	2.55	2.55		
24a	27.9	CORSER	1.11	1.11	1.11		
24b	27.9	SALLUC	0.62	0.62	0.62		
25	28.0	POPBAL	0.16	0.16	0.16		
26	28.1	ALNINC	0.48	0.48	0.48		
27	28.0	SALEXI	0.18	0.07	0.03		
28	28.0	CORSER	0.63	0.63	0.63		
29	28.8	CORSER	0.40	2.01	0.00		
30	28.9	CORSER	1.99	0.00	0.00		
31	28.9	CORSER	0.14	0.00	0.00		
32	28.9	CORSER	0.08	0.00	0.00		
33	28.9	CORSER	0.67	7.16	11.68		
34a	29.0	SALPRO	1.72	2.60	3.00		
34b	28.9	CORSER	0.57	0.95	1.09		
35	29.0	ALNVIRS	1.40	1.40	1.40		
36	29.1	POPBAL	0.65	0.65	0.65		

Table A.2-1, continued…

Polygon	River Mile	Dominant Species	Acreage				
			Current	-5 ft	-10 ft	-15 ft	-20 ft
37	29.0	POPBAL	0.74	0.74	0.74		
38	30.9	CRADOU	0.34	0.34	0.34		
39	32.0	SYMALB	1.20	1.20	1.20		
40	31.7	CORSER	2.03	2.08	2.22		
41	31.7	POPBAL	0.46	0.46	0.46		
42a	31.8	POPBAL	1.68	1.68	1.68		
42b	32.3	SYMALB	2.03	2.03	2.03		
42c	32.0	SYMALB	0.64	0.64	0.64		
43	31.8	CORSER	0.31	0.31	0.31		
44a	32.0	SYMALB	0.60	0.60	0.60		
44b	32.0	CRADOU	0.57	0.57	0.57		
44c	32.0	CRADOU	0.78	0.78	0.78		
44d	32.0	SYMALB	9.22	9.22	9.22		
44e	32.0	POPBAL	0.28	0.28	0.28		
44f	32.1	SYMALB	0.39	0.39	0.39		
45	32.0	SYMALB	0.74	0.74	0.74		
46	32.3	SYMALB	5.04	5.04	5.04		
47	32.8	SYMALB	17.63	17.63	17.63		
48	32.2	CRADOU	0.27	0.27	0.27		
50	32.3	SYMALB	0.53	0.53	0.53		
51a	32.4	CRADOU	0.21	0.21	0.21		
51b	32.4	SYMALB	0.28	0.28	0.28		
52	32.3	CRADOU	0.50	0.50	0.50		
53	32.4	SYMALB	1.08	1.08	1.08		
54	33.9	SALEXI	0.39	0.39	0.39		
55	32.5	SYMALB	1.25	1.25	1.25		
56a	32.6	POPBAL	0.24	0.24	0.24		
56b	32.6	POPBAL	1.21	1.21	1.21		
56c	32.9	SALEXI	1.37	1.37	1.37		
56d	32.9	POPBAL	0.44	0.44	0.44		
58	34.3	POPBAL	3.46	3.46	3.46		
59	34.0	SALEXI	0.12	0.12	0.12		
60	33.8	CORSER	0.71	0.36	0.18		
61a	33.7	SALEXI	1.14	1.31	1.31		
61b	33.7	SALEXI	0.31	0.29	0.43		
62	33.5	SALPRO	0.55	0.28	0.14		
63	33.2	CORSER	0.18	0.18	0.18		
64	34.1	POPBAL	0.44	0.44	0.44		
65a	30.3	SALEXI	0.21	0.25	0.25		
65b	30.3	SALEXI	0.21	0.30	0.30		

Note:
The change in riparian habitat, by polygon, was evaluated at 5, 10, 15, and 20 feet below normal Boundary operations in the lower reservoir, and at 5 and 10 feet below normal Boundary operations in the upper reservoir.