

MEMORANDUM

To: Steve Hemstrom, Senior Fish Biologist,
Chelan County Public Utility District #1

From: Sarah Montgomery and Charles Kiblinger,
Anchor QEA, LLC

Re: Lamprey Geospatial Modeling

To assist Chelan County Public Utility District #1 (Chelan PUD) in understanding the distribution of Pacific lamprey in the Columbia River Basin, we developed a geospatial analytical framework to estimate the potential spawning and rearing habitat accessible to anadromous fishes. Our approach included mapping habitats in the basin using known salmonid habitat data to infer lamprey habitat suitability. The GIS model estimates total potential lamprey habitat in the mainstem and tributaries between hydroelectric projects, allowing biologists to infer how passage might influence access to upstream habitat or spatial structure within the basin. See Figure 1 in Attachment 1 for the relevant waterbodies and inter-dam watersheds. This memorandum provides a brief description of methods, followed by results in a table format to accompany the spreadsheet output from the GIS modeling efforts.

We emphasize that this is a large-scale assessment of habitat areas that have the potential to contain suitable spawning and rearing areas for lamprey. That is, the potential for habitat suitability is inferred from anadromous salmonid StreamNet data rather than juvenile and adult lamprey surveys. The resulting dataset reflects three types of potential lamprey habitat in the Columbia Basin:

1. Potential spawning habitat. Lamprey and anadromous salmonids share similar requirements for spawning habitat; therefore, anadromous salmonid spawning/rearing areas recorded in StreamNet are considered potential lamprey spawning areas.
2. Potential rearing habitat. Lampreys prefer soft sediments in slow-moving waterbodies for rearing. Because spawning habitat is generally composed of gravelly or rocky substrate, it is unsuitable for lamprey rearing. Thus, any non-spawning habitat areas

downstream of a spawning area are considered potential rearing habitat in this analysis.

3. **Accessible habitat.** Accessible habitat areas are those where anadromous salmonids have a recorded presence upstream of the last potential spawning area on any waterbody. We infer lamprey are not present in these areas because ammocoetes are unlikely to swim upstream after emerging from redds. Thus, the rearing and spawning areas in a specific reach do not add up to the total areas of that reach, because there is accessible habitat that is unlikely used as spawning or rearing habitat.

METHODOLOGY

Methods for geospatial analysis were based on StreamNet and U.S. Geological Survey's National Hydrography dataset (NHD), and included the following steps:

- Group NHD Level 12 Hydrologic Unit Codes (HUCs) to delineate "dam watersheds" from one dam to the next using a looping python script (based on the "HUC12" and "ToHUC" fields) and manual inspection.
 - Clip StreamNet data to area of interest (AOI) (dam watersheds) and query for anadromous/salmon/spawning/rearing.
 - Prep NHDArea polygons (correct topological overlap areas).
 - Intersect NHDArea polygons with AOI.
 - Intersect each minimum bounding geometry (using RECTANGLE_BY_WIDTH) of each StreamNet line segment with the NHD polygon(s) that line intersects; iterate on StreamNet's RecordID (unique identifier for each segment).
 - Append all individual results of the step above into one polygon dataset (has topological overlap).
 - Dissolve the results of the step above on NHD permanent identifier field to remove overlap. This represents all spawning areas.
 - Combine the results of the step above with remaining NHD polygons that were not captured when generating the above; those remainders are classified as "not spawning."
 - Manually search and flag polygons upstream of the last "spawning" polygon on a stream as "not rearing"; the rest are "rearing."
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RESULTS

Table 1 presents the distribution of the three types of potential lamprey habitat (accessible habitat, potential rearing habitat, and potential spawning habitat) for each reach in the basin.

Table 2 presents the availability and proportion of each type of potential lamprey habitat upstream of mainstem landmarks.

Table 1. Total Accessible Area and Potential Rearing and Spawning Habitat Area for Pacific Lamprey in the Columbia River Basin.

Columbia River Reach	Accessible Habitat (No Spawn/Rearing)	Potential Rearing Habitat	Potential Spawning Habitat	Total Potential Habitat
Columbia Mouth to Bonneville Dam (RKM 235.1)	11,853,007	779,092,698	160,874,567	951,820,273
Bonneville Dam to the Dalles (RKM 308.1.5)	837,752	79,447,507	7,475,533	87,760,793
The Dalles Dam to John Day Dam (RM 347.0)	977,147	55,631,416	21,398,688	78,007,251
John Day Dam to McNary Dam (RKM 469.8)	-	230,833,726	9,855,561	240,719,287
McNary to Columbia-Snake Confluence (RKM 522.6)	-	109,083,561	706,208	109,789,769
Columbia-Snake Confluence to Ice Harbor Dam (RKM 15.6)	-	7,980,049	-	7,980,049
Ice Harbor Dam to Lower Monumental Dam (RKM 66.9)	-	32,980,127	-	32,980,127
Lower Monumental Dam to Little Goose Dam (RKM 113.1)	4,090,038	24,357,221	2,822,117	31,269,377
Little Goose Dam to Lower Granite Dam (RKM 173.0.5)	-	38,487,526	874,251	39,361,777
Lower Granite Dam to Snake-Clearwater Confluence (RKM 235.7)	-	23,585,016	134,283	23,719,299
Snake-Clearwater Confluence to Dworshak Dam (RKM 66.6)	478,386	1,058,331	17,320,194	18,856,911
Snake-Clearwater Confluence to Hell's Canyon Dam (RKM 397.4)	63,390	23,857,776	93,173,063	117,094,229
Columbia-Snake Confluence to Priest Rapids Dam (RKM 638.9)	26,352,960	30,500,477	82,782,015	139,635,452
Priest Rapids Dam to Wanapum Dam (RM 669.0)	7,541,568	30,725,823	-	38,267,391
Wanapum Dam to Rock Island Dam (RKM 729.5)	-	58,130,370	18,597	58,149,327
Rock Island Dam to Rocky Reach Dam (RKM 762.2)	-	23,537,899	7,548,842	31,086,741
Rocky Reach Dam to Wells Dam (RKM 829.9)	-	37,383,526	1,174,052	38,557,578
Wells Dam to Chief Joseph Dam (RKM 877.1)	236,435	35,256,144	25,142,986	60,635,565
TOTAL	52,430,683	1,621,929,194	431,331,320	2,105,691,197

*All area values are shown in square meters

Table 2. Availability of Potential Pacific Lamprey Rearing, Spawning, and Accessible Habitat Area in the Columbia River Basin.

Mainstem Landmark	Potential Rearing Habitat Upstream of Landmark		Potential Spawning Habitat Upstream of Landmark		Accessible Habitat Upstream of Landmark	
	Area (square meters)	Percent of Total Area	Area (square meters)	Percent of Total Area	Area (square meters)	Percent of Total Area
Columbia River Mouth	1,621,929,194	100.0%	431,331,320	100.0%	2,105,691,197	100.0%
Bonneville Dam	842,836,496	52.0%	270,456,753	62.7%	1,153,870,924	54.8%
The Dalles Dam	763,388,988	47.1%	262,981,219	61.0%	1,066,110,131	50.6%
John Day Dam	707,757,573	43.6%	241,582,531	56.0%	988,102,880	46.9%
McNary Dam	476,923,847	29.4%	231,696,970	53.7%	747,383,593	35.5%
Priest Rapids Dam	185,033,762	11.4%	33,884,838	7.9%	226,696,602	10.8%
Wanapum Dam	154,307,939	9.5%	33,884,838	7.9%	188,429,212	8.9%
Rock Island Dam	96,177,569	5.9%	33,865,880	7.9%	130,279,884	6.2%
Rocky Reach Dam	72,639,670	4.5%	26,317,038	6.1%	99,193,143	4.7%
Wells Dam	35,256,144	2.2%	25,142,986	5.8%	60,635,565	2.9%
Chief Joseph Dam	-	0.0%	-	0.0%	-	0.0%

Note: Snake River totals are included between the McNary and Priest Rapids projects.

Note: Estimates of spawning and rearing habitat above each Project include the Okanogan River Basin which is not known to produce lamprey currently.

ATTACHMENT 1
FIGURE SHOWING NHD WATERBODIES AND
INTER-DAM WATERSHEDS

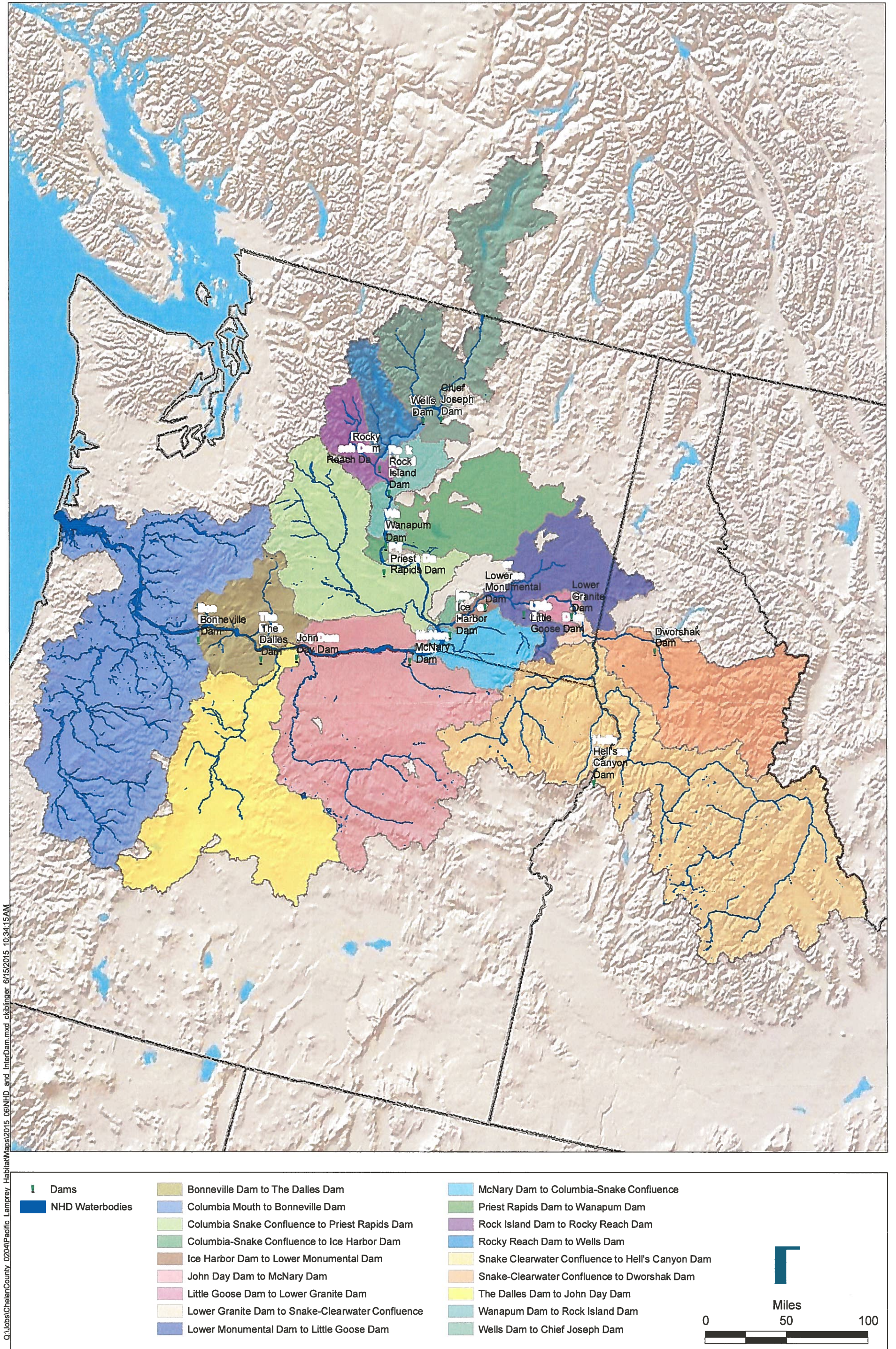


Figure 1
NHD Waterbodies and Inter-Dam Watersheds
Lamprey Habitat GIS