ANADROMOUS REINTRODUCTION POTENTIAL FOR THE SPOKANE BASIN AND SELECT TRIBUTARIES TO LAKE ROOSEVELT USING THE ECOSYSTEM DIAGNOSIS AND TREATMENT MODEL

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Acronyms and Abbreviations

BOA	Bonneville Dam, adult fish ladder
BON	Bonneville Dam
CCT	Colville Confederated Tribes
CJD	Chief Joseph Dam
ECY	Washington Department of Ecology
EDT	Ecosystem Diagnosis and Treatment Model
EDT3	The current (third generation) version of the EDT Model
FCRPS	Federal Columbia River Power System (now the Columbia River System Operations)
FDRL	Franklin Delano Roosevelt Lake, "Lake Roosevelt"
GCD	Grand Coulee Dam
HUC 10	USGS 10th field hydrologic unit (watershed
HUC 12	USGS 12th field hydrologic unit (subwatershed)
km	Kilometer
LCM	EDT life cycle model (represents an individual age class and behavioral form)
LOP	Level of Proof
MCN	McNary Dam
NMFS	National Marine Fisheries Service
NPCC	Northwest Power and Conservation Council
PRD	Priest Rapids Dam
RIS TLRC	Rock Island Dam tailrace
RIS	Rock Island Dam
RRE TLRC	Rocky Reach Dam tailrace
RRE	Rocky Reach Dam
SAR	Smolt-to-adult return rate
STFAP	Spokane Tribal Fisheries Anadromous Program
STOI	Spokane Tribe of Indians
UCUT	Upper Columbia United Tribes
USGS	United States Geological Survey
WLS RES	Wells Reservoir pool
WLS	Wells Dam

Executive Summary

The Spokane Tribe of Indians (STOI) have developed an assessment of habitat suitability for summer steelhead, summer/fall Chinook salmon and spring Chinook salmon in the Intermountain Province. This assessment evaluated the Spokane River subbasin and several select tributary watersheds to Franklin Delano Roosevelt Lake in the Upper Columbia Subbasin, referred to hereafter as the FDRL Tributaries. The purpose of this effort is twofold:

1) Produce an analysis of current habitat suitability for anadromous species consistent with components of Phase I of the Upper Columbia United Tribes anadromous reintroduction plan (UCUT 2015) and Northwest Power and Conservation Council's phased approach (NPCC 2014), and;
2) Provide an assessment of habitat limiting factor performance and habitat critical data gaps useful for guiding the development of a habitat monitoring and restoration program

The results presented herein are intended to support both of these objectives, with the latter providing a basis for the future development of the Spokane Tribal Fisheries Anadromous Program (STFAP).

This assessment was conducted using new Ecosystem Diagnosis and Treatment (EDT) models developed for the historically accessible portion of the Spokane River subbasin and select tributaries to Lake Roosevelt. The EDT model analyses relied on a current conditions habitat scenario constructed using the best available data for these subbasins. This habitat scenario is considered preliminary and only partially complete due to a lack of suitable data and information for parameterizing several important habitat attributes. Future STFAP EDT model projects will focus on improving the current conditions scenario by filling critical data gaps, and constructing a template conditions scenario as a basis for identifying and prioritizing habitat protection and restoration opportunities.

ICF and STFAP developed hypothetical populations of steelhead, summer/fall Chinook and spring Chinook based on population parameters defined for a similar EDT modeling exercise conducted for the Confederated Tribes of the Colville Reservation (CCT; ICF 2017). ICF and the CCT hosted a life history model workshop with regional fisheries experts to define probable age composition, and life stage timing, distribution and behavioral characteristics based on knowledge of remaining extant populations in the Upper Columbia region. The information gained from this workshop was used to parameterize EDT model populations used in both of these reintroduction analyses. Together the CCT and STFAP analyses provide a systematic assessment of habitat suitability in the US portion of the blocked area based on consistent methods and assumptions and the best available data.

ICF relied on the consensus opinion of workshop attendees and National Marine Fisheries Service intrinsic potential model criteria to define the extent of probable habitat for steelhead, spring Chinook salmon and summer/fall Chinook salmon in each subbasin. A summary of total habitat length and area in each subbasin, by species, is provided in Table E-1.

ICF applied three different sets of assumptions about Grand Coulee Dam and Chief Joseph Dam passage survival to evaluate reintroduction potential. These scenarios use the following passage survival rates for juvenile migrants moving downstream and adult migrants moving upstream:

- Biological opinion (BiOp) survival: 95% juvenile downstream, 98% adult upstream survival at each dam
- Moderate survival: 90% juvenile downstream, 97% adult upstream survival at each dam
- Low survival: 85% juvenile downstream, 95% adult upstream survival at each dam

The BiOP survival assumption is consistent with Federal Columbia River Power System biological opinion survival standards for other federally-operated dams on the Columbia River mainstem (NMFS 2008). The moderate and low survival assumptions are provided to evaluate habitat suitability at survival rates below BiOP standards. ICF calibrated juvenile and adult migrant survival in the remainder of the Columbia River migration corridor and Pacific Ocean to match recent observations for extant species, emphasizing data collected after 2008 when significant changes in federal hydropower system operations and other system improvements were implemented to increase juvenile migrant survival.

These alternative passage survival scenarios apply only to Grand Coulee Dam and Chief Joseph Dam. A consistent set of passage survival assumptions was applied to all the remaining Columbia River mainstem dams, and to the Spokane River mainstem dams. Columbia River dam survival rates were calibrated consistent with recent observations as detailed in Appendix A.[1] Potential passage survival at Nine Mile Dam, Long Lake Dam, and Little Falls Dam on the Spokane River is theoretical at this time. For the purpose of this analysis, ICF and STFAP assumed that these structures will remain in place but will be retrofitted with fish passage that meets BiOp passage criteria applied to dams on the mainstem Columbia River. This BiOp survival assumption is applied to the Spokane River dams throughout this analysis, regardless of the Chief Joseph and Grand Coulee survival scenario.

A summary of EDT-estimated habitat suitability for summer steelhead, summer/fall Chinook and spring Chinook in the Spokane River and FDRL Tributaries is presented in Tables E-2, E-3 and E-4. The take home messages from these results are as follows:

- There is moderate potential for summer steelhead reintroduction in these watersheds:
    - The Spokane River and its tributaries could theoretically support a population of approximately 1200 adult steelhead under current habitat conditions and the BiOp passage scenario at Chief Joseph, Grand Coulee, and Spokane River dams, assuming that all other manmade passage barriers within potential anadromous habitat are addressed
    - The FDRL Tributaries could support a population of approximately 80 steelhead under the same scenario assumptions
    - Steelhead life stage survival metrics are consistent with observed survival rates in other currently populated and functional watersheds in the Upper Columbia downstream of Chief Joseph Dam
    - Egg-to-parr survival in the Spokane subbasin ranges from 3.8% to 7.9% under current conditions across all subpopulations and life history strategies[2]

1 Observed survival rates at the mainstem dams meet or exceed BiOP criteria.

2 Egg-to-parr survival in this study means survival from the beginning of incubation through the end of the first summer of active rearing. Incubation survival estimates are likely to be high because ICF was unable to locate sufficient data to parameterize the EDT bed scour attribute.

- There is substantial potential for summer/fall Chinook reintroduction in the Spokane River system:
  - The Spokane River and its tributaries could potentially support an equilibrium abundance of over 6700 adult summer/fall Chinook with a productivity of 3.4 under current conditions, using the BiOp passage survival scenario
  - Even under the most conservative (lowest) hydrosystem passage survival assumption, the model predicted an equilibrium abundance of over 4600 adult spawners with a productivity of 2.7 under current conditions
  - The FDRL Tributaries could support an equilibrium abundance of approximately 275 adult summer/fall Chinook under the BiOP passage survival scenario, and 185 adults under the low passage survival scenario
  - Under current conditions, egg-to-parr survival is 7.3% for 0-age migrants and 11.6% to 8.0% for stream and reservoir-type 1-age migrants, respectively[3]
- Spring Chinook habitat suitability is relatively modest:
  - The Spokane River could support an equilibrium abundance of approximately 250 adult spring Chinook with a productivity of 1.8 under the BiOp passage survival scenario
  - The FDRL tributaries could produce less than 20 spring Chinook, suggesting that these watersheds cannot support a viable spawning population under current conditions
  - EDT-estimated spring Chinook egg-to-parr survival in the Spokane subbasin ranges from 11.6% to 14.8% under current conditions across all subpopulations and life history strategies
  - Life history diversity is limited; less than 2% of spring Chinook life history trajectories are successful (i.e. have a cumulative productivity greater than 1 from spawning through adult escapement), indicating this life history strategy is supported by a small set of successful spatial and temporal pathways through the environment

This preliminary analysis was limited by a lack of data and spatially extensive data gaps for several key habitat attributes used in the EDT model. In some cases key attributes could not be parameterized due to a lack of suitable data and information. In other cases, attributes were parameterized using a combination of methods to compensate for a lack of site-specific empirical data. These methods include watershed modeling and spatial analysis, aerial imagery interpolation, and extrapolation of data between reaches with similar watershed conditions. Each of these approaches have associated uncertainty. ICF assigned a Level of Proof (LOP) rating to each of the input attributes used in the EDT model. The LOP rating is an ordinal score from 1 to 5 that describes our confidence in the representativeness of the data and information source used to parameterize each attribute.[4] Inputs that could not be parameterized due to a lack of data are assigned the lowest rating. This report summarizes LOP ratings by input attribute and reporting area. An overview of LOP ratings for EDT model habitat attributes in the study area is provided in Table E-5. STFAP will use this information to identify critical data gaps for future habitat assessment and monitoring

3 Does not reflect bed scour effects due to lack of sufficient data.

4 An LOP score of 1 reflects high confidence in the underlying data source and its representativeness at the EDT reach scale. A score of 5 identifies attributes that could not be parameterized due to a lack of available data, or have hypothetical ratings based on extrapolation from similar watersheds. Intermediate scores represent an increasing level of confidence in the data source in descending order.

efforts. The EDT model platform is flexible and can incorporate new data and information as it becomes available.

Future STFAP EDT model projects will include the development of template and degraded habitat scenarios for the Spokane Basin and FDRL tributaries. Template scenarios in EDT are intended to represent a restoration ideal for their target systems. They typically combine the estimates of pre-development conditions in target watersheds with existing habitat conditions associated with development and critical infrastructure, such as cities, dams, and transportation features. EDT uses the template conditions scenario to identify and prioritize habitat restoration opportunities. Degraded habitat scenarios are typically generic representations of a complete loss of habitat function. More recently, EDT practitioners are using the degraded scenario to evaluate watershed conditions under climate change. This provides a systematic method for identifying habitat protection and restoration priorities to support strategic watershed planning.

Table E-1. Summary of potentially suitable anadromous habitat extent by stream environment type in the Spokane River and FDRL Tributaries in the Upper Columbia subbasin.

Species	Subbasin/ Watershed	Environment Type	Habitat Length (kilometers/miles)	Habitat Area (hectares/acres)
Steelhead	**Spokane River**	Small tributary	200.0/124.0	91.2/225.2
		Headwater	364.8/226.2	353.2/872.9
		Low Stream Order	79.3/49.2	173.3/428.3
		Mid-stream Order	17.4/10.8	110.6/273.3
		Total	*661.4/410.1*	*728.3/1799.8*
	FDRL Tributaries	Small tributary	21.3/13.2	9.3/22.9
		Headwater	18/11.1	14.1/34.8
		Low Stream Order	6/3.7	10.8/26.8
		Mid-stream Order	--	--
		Total	*45.3/28.1*	*34.2/84.5*
	All Habitat	**Grand Total**	**706.7/438.1**	**762.5/1884.2**
Chinook Salmon	**Spokane River**	Small tributary	6.6/4.1	4.8/11.9
		Low Stream Order	290.9/180.3	310.2/766.5
		Mid-stream Order	79.3/49.2	173.3/428.3
		High Stream Order	17.4/10.8	110.6/273.3
		Total	*394.2/244.4*	*598.9/1480.0*
	FDRL Tributaries	Small tributary	1.8/1.1	1.3/3.1
		Headwater	12.7/7.9	11.4/28.1
		Low Stream Order	6/3.7	10.8/26.8
		Mid-stream Order	--	--
		Total	*20.5/12.7*	*23.5/58.0*
	All Habitat	**Grand Total**	**414.7/257.1**	**622.4/1538.0**

Environment type descriptions:

Small tributary: Lower elevation tributary streams, Shreve Order 1 to 2

Headwater: High-elevation headwater tributaries, Shreve Order 1 to 4

Low stream order: Tributary and mainstem reaches, Shreve Order 5 to 50

Mid-stream order: Tributary and mainstem reaches, Shreve Order >50

Note: Habitat area summary does not include potential reservoir rearing habitats. Reservoir rearing habitat area used in EDT focused on inundated arms of spawning tributaries. While this habitat assumption does not place a capacity limitation on rearing potential, it is not representative the full extent of potential reservoir rearing habitat in Lake Roosevelt.

Table E-2. Theoretical Spokane River and FDRL Tributaries summer steelhead population performance under current conditions based on three hypothetical passage survival scenarios at Chief Joseph and Grand Coulee Dams.

Passage Scenario	Subbasin Population	EDT Performance Metric by Watershed Habitat Scenario			
		Diversity	Productivity	Capacity	Equilibrium Abundance
BiOp	Spokane River	18.4%	2.4	2064	1213
	FDRL Tributaries	25.8%	2.3	145	81
Moderate	Spokane	15.6%	2.3	1816	1019
	FDRL Tributaries	21.2%	2.1	128	68
Low	Spokane	12.6%	2.1	1555	824
	FDRL Tributaries	15.6%	2.0	109	54

Passage Scenario: Grand Coulee Dam and Chief Joseph Dam passage assumptions.
BiOp = 95% juvenile downstream/98% adult upstream survival at each dam
Moderate = 90%/97% juvenile/adult survival at each dam
Low = 85%/95% juvenile/adult survival at each dam

Table E-3. Theoretical Spokane River summer/fall Chinook population performance under current conditions based on three hypothetical passage survival scenarios at Chief Joseph and Grand Coulee Dams.

Passage Scenario	Subbasin Population	EDT Performance Metric by Watershed Habitat Scenario			
		Diversity	Productivity	Capacity	Equilibrium Abundance
BiOp	Spokane River	60.6%	3.4	9535	6729
	FDRL Tributaries	70.2%	3.3	397	275
Moderate	Spokane	57.0%	3.1	8451	5707
	FDRL Tributaries	67.5%	2.9	351	231
Low	Spokane	52.4%	2.7	7291	4634
	FDRL Tributaries	64.8%	2.6	303	185

Passage Scenario: Grand Coulee Dam and Chief Joseph Dam passage assumptions.
BiOp = 95% juvenile downstream/98% adult upstream survival at each dam
Moderate = 90%/97% juvenile/adult survival at each dam
Low = 85%/95% juvenile/adult survival at each dam

Table E-4. Theoretical Spokane River and FDRL Tributaries spring Chinook population performance under current conditions based on three hypothetical passage survival scenarios at Chief Joseph and Grand Coulee Dams.

Passage Scenario	Subbasin Population	EDT Performance Metric by Watershed Habitat Scenario			
		Diversity	Productivity	Capacity	Equilibrium Abundance
BiOp	Spokane River	1.4%	1.8	543	246
	FDRL Tributaries	0.7%	2.2	32	17
Moderate	Spokane	1.0%	1.7	476	198
	FDRL Tributaries	0.5%	2.0	28	14
Low	Spokane	0.6%	1.6	407	148
	FDRL Tributaries	0.4%	1.8	24	11

Passage Scenario: Grand Coulee Dam and Chief Joseph Dam passage assumptions.
BiOp = 95% juvenile downstream/98% adult upstream survival at each dam
Moderate = 90%/97% juvenile/adult survival at each dam
Low = 85%/95% juvenile/adult survival at each dam

Table E-5. Level of Proof rating summary for habitat attributes used in the Spokane River and FDRL Tributaries EDT models.

Analysis Area	Environment Type	Reporting Watershed	Level of Proof				
			1	2	3	4	5
Spokane River	Reservoir	Spokane Arm/Lake Roosevelt	19%	28%	54%	0%	0%
	Riverine	Spokane Mainstem & Tributaries	1%	6%	44%	13%	35%
	Riverine	Little Spokane Lower	1%	20%	40%	6%	33%
		Little Spokane Dragoon	1%	16%	42%	7%	34%
		Little Spokane Upper	0%	19%	40%	7%	34%
		Hangman Lower	2%	12%	43%	13%	30%
		Hangman Middle	0%	8%	49%	12%	30%
		Hangman Upper	1%	11%	47%	11%	30%
FDRL Tributaries	Reservoir	Lake Roosevelt	17%	50%	33%	0%	0%
	Riverine	FDRL - Harvey	4%	6%	20%	8%	63%
		FDRL - Stranger	3%	6%	20%	9%	63%
		FDRL - Cheweka	3%	6%	20%	9%	63%
		FDRL - Lodgepole	3%	6%	20%	9%	63%
		FDRL - Colville	15%	11%	34%	7%	31%
		FDRL - Magee	3%	6%	20%	9%	63%
		FDRL - Onion	3%	6%	20%	9%	63%
		FDRL - Quillisacut	3%	6%	20%	9%	63%
		FDRL - Deep	3%	6%	20%	9%	63%

FDRL - Harvey	4%	6%	20%	8%	63%
FDRL - Stranger	3%	6%	20%	9%	63%
FDRL - Cheweka	3%	6%	20%	9%	63%
FDRL - Lodgepole	3%	6%	20%	9%	63%
FDRL - Colville	15%	11%	34%	7%	31%
FDRL - Magee	3%	6%	20%	9%	63%
FDRL - Onion	3%	6%	20%	9%	63%
FDRL - Quillisacut	3%	6%	20%	9%	63%
FDRL - Deep	3%	6%	20%	9%	63%

Section 1

Introduction

1.1 Purpose and Scope

This technical report presents the results of Ecosystem Diagnosis and Treatment (EDT) model analyses of anadromous reintroduction potential for summer steelhead, spring Chinook and summer/fall Chinook salmon in the historically accessible section of the Spokane River basin and select tributaries to the east shore of the Columbia River in the "blocked area" upstream of Grand Coulee Dam. The analysis was conducted by ICF on behalf of the Spokane Tribal Fisheries Anadromous Program (STFAP) and is intended to be consistent with Phase I anadromous reintroduction plans developed by the Columbia Basin Tribes and First Nations (2015) and the Northwest Power and Conservation Council's phased research approach (NPCC 2014).

STFAP contracted with ICF to develop an EDT model platform for potential anadromous habitat in the Spokane River basin and FDRL Tributaries. The objectives of this modeling effort are threefold:

1) Develop a base EDT modeling platform to quantify anadromous habitat suitability consistent with Columbia Basin Tribes and First Nations (2015) and NPCC (2014) research objectives;
2) Identify critical habitat data gaps useful for guiding the development of STFAP habitat monitoring efforts;
3) Provide a data synthesis platform for future limiting factor status and trends reporting and habitat protection and restoration planning.

The current scope of work presented in this report addresses objectives 1 and 2. The EDT model platforms developed for this effort support objective 3 and will be fully developed under future funded projects.

The STFAP analysis was developed in conjunction with a similar EDT-based anadromous reintroduction potential analysis for the Confederated Tribes of the Colville Reservation (CCT). The CCT analysis evaluated reintroduction potential for the same species in the Sanpoil River and four independent tributaries to Lake Roosevelt on the Colville Reservation (Barnaby, Hall, Stranger and Nez Perce creeks). The STFAP and CCT analyses apply the same out-of-basin survival assumptions to allow for direct comparison of EDT model results between study areas. When considered together, the STFAP and CCT analyses provide a systematic assessment of the habitat availability, suitability, and salmon survival potential in most tributary habitats upstream of Grand Coulee Dam.

1.2 Study Area

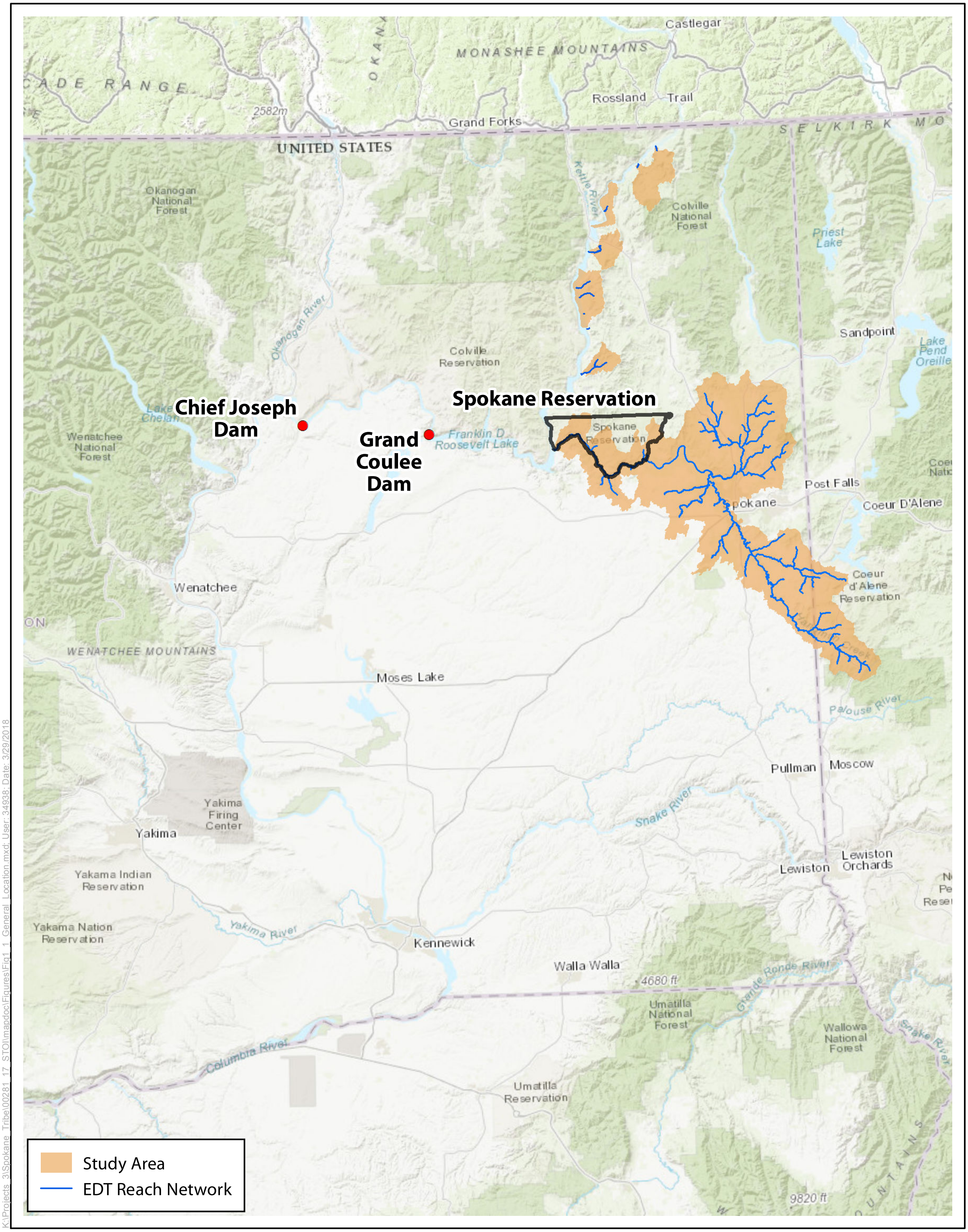
The study area for the STFAP reintroduction analysis encompasses the historically accessible portions of the Spokane River basin downstream of Spokane Falls, including Hangman Creek and the Little Spokane River, and selected independent tributaries draining to the east side of Lake Roosevelt between the Spokane River and the Canadian border (Figure 1-1). STFAP identified potential anadromous stream reaches in the study area using an intrinsic potential (IP) analysis based on outputs provided by and methods developed by the National Marine Fisheries Service's Northwest Fishery Science Center (ICTRT 2007; Cooney and Holzer 2006). ICF subsequently screened the initial set of IP reaches to eliminate areas above natural barriers. This screened list of reaches was used to develop the EDT model platform for the study area.

ICF divided the study area into a set of USGS HUC10 watershed and HUC12 subwatershed-scale reporting units for the purpose of this analysis. There are seven HUC10-scale reporting watersheds in the Spokane Basin, including the Spokane Mainstem & Tributaries, Little Spokane Lower, Little Spokane Dragoon, Little Spokane Upper, Hangman Lower, Hangman Middle, and Hangman Upper (Figure 1-2). These seven analysis watersheds encompass 43 assessment units, or HUC12-scale subwatersheds. This report summarizes EDT results for the Spokane Basin at the reporting watershed scale for simplicity. There are eight HUC12-scale assessment units in the Lake Roosevelt portion of the study area, referred to hereafter as the FDRL Tributaries. These include accessible segments of Deep Creek, Onion Creek, China Creek, the lower Colville River, Quillisascut Creek, Magee Creek, Stranger Creek, and Harvey Creek (Figure 1-3). The reporting watersheds for the FDRL Tributaries portion of the study area are the HUC12 assessment units.

While not presented in this report, the anadromous reintroduction analysis results can be summarized and reported from reach to basin scales if desired.

1.3 Species Considered

This reintroduction analysis evaluates habitat suitability for three anadromous species, summer steelhead (*Oncorhynchus mykiss*), and spring and summer/fall Chinook salmon (*O. tshawytscha*).



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ICF

Figure 1-1
Location of the Spokane River and Select FDRL Tributaries in relation to Lake Roosevelt, Grand Coulee Dam and the Spokane Indian Reservation

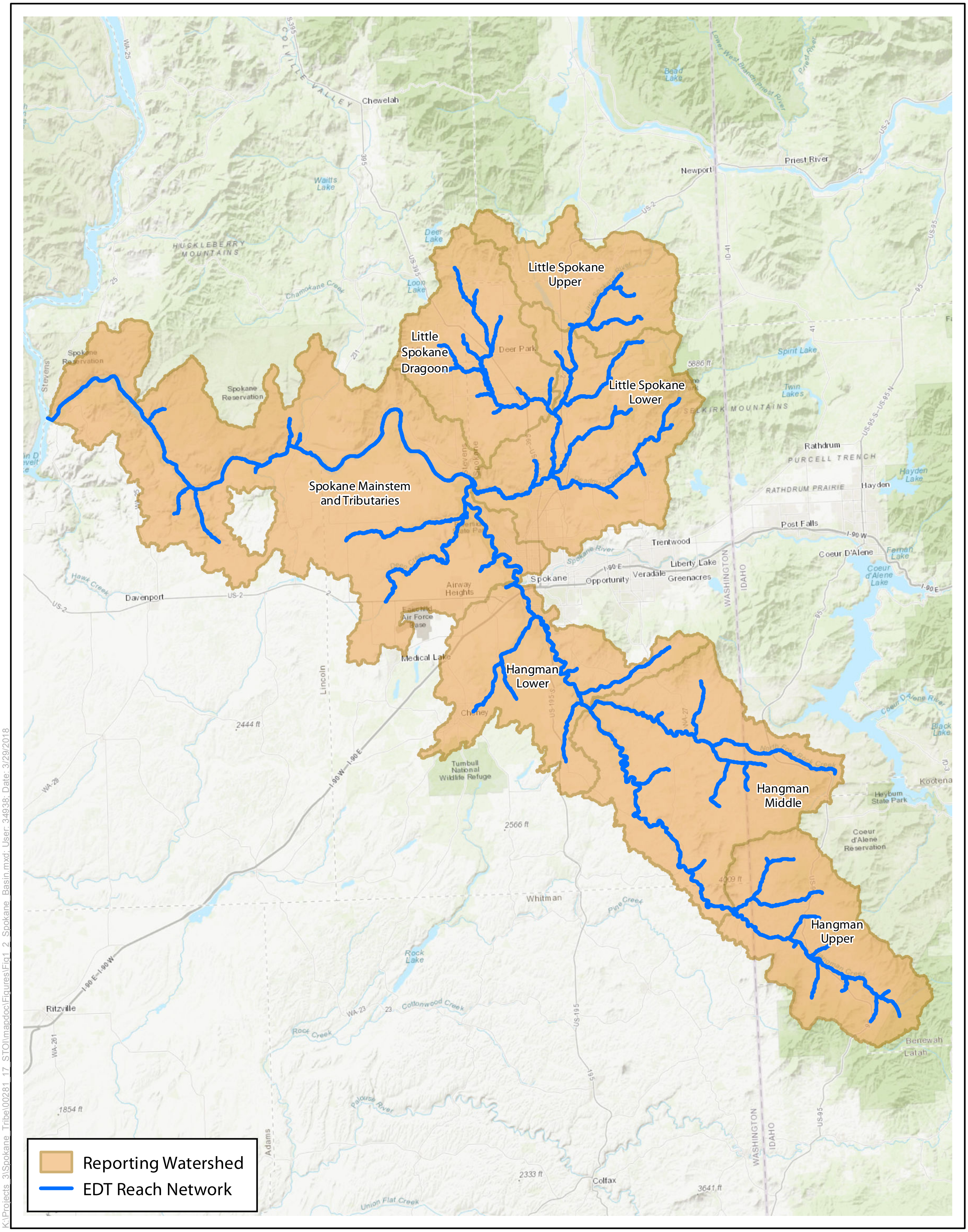

Figure 1-2
Spokane River Basin HUC 10 Analysis Watersheds

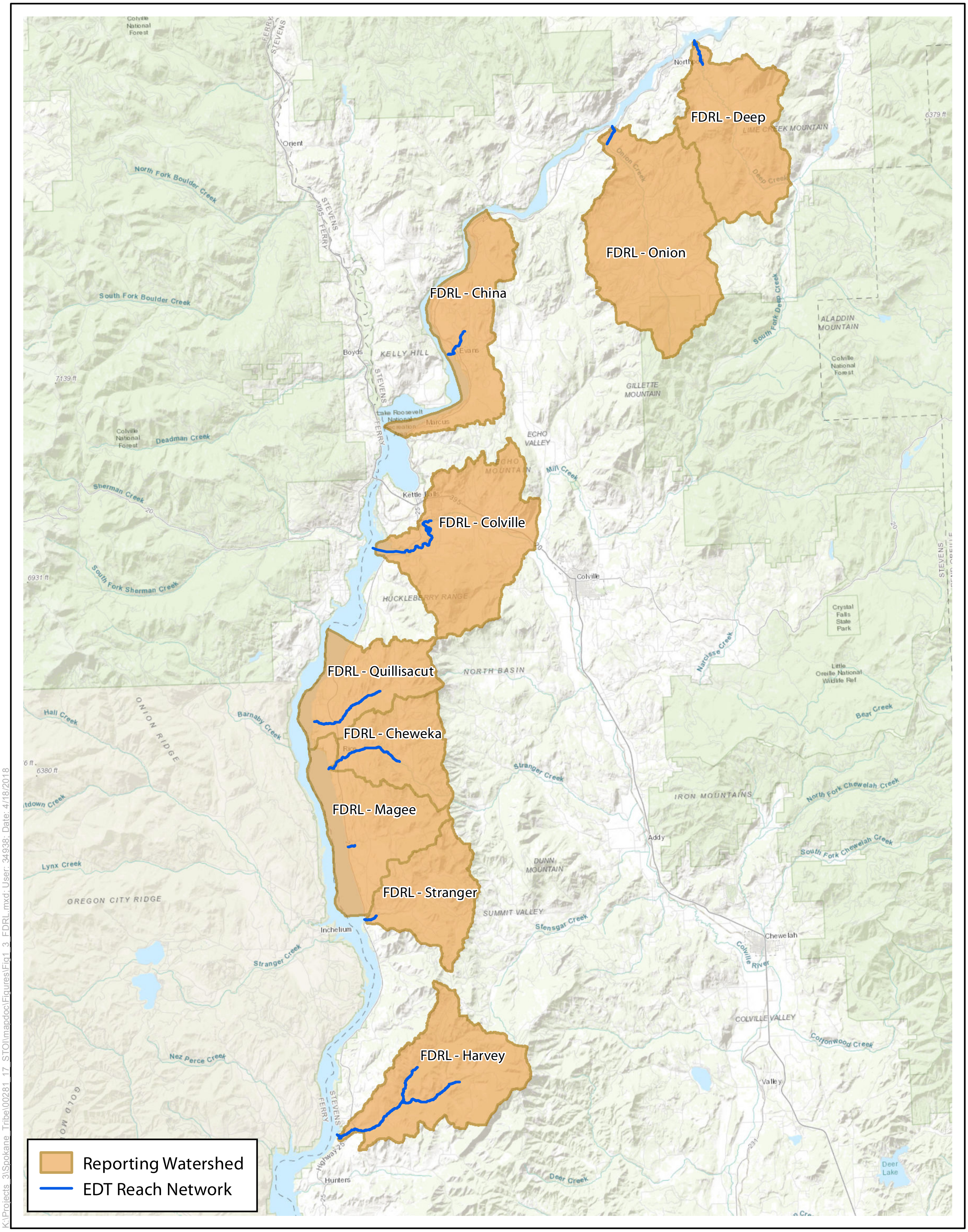

Figure 1-3
Select FDRL Tributaries HUC 12 Analysis Subwatersheds

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Section 2
Methods and Assumptions

This section describes the methods and key assumptions used in the anadromous reintroduction analysis. This analysis relied on the development of new EDT models for the Spokane River and the FDRL Tributaries.

2.1 Analysis Methods

2.1.1 Development of the Spokane and FDRL Tributaries EDT Models

ICF used the STFAP intrinsic potential analysis as the basis for the development of the Spokane and FDRL Tributaries EDT models. The reaches STFAP identified as potential anadromous habitat were used as a starting point for defining the extent of the model reach network. ICF refined the intrinsic potential analysis by recalculating the gradient parameter using the NetMap hydrogeomorphic model and bankfull width parameter using a regression formula developed for Columbia Basin streams by Beechie and Imaki (2014).[5] These refined results were used to delineate the extent of the EDT reach network.

The EDT reach network was constructed following the 'common spatial currency' concept developed by the CCT's Okanogan Basin Monitoring and Evaluation Program. This approach has been implemented in the Okanogan, Methow, Entiat, and Wenatchee subbasins and provides the geospatial backbone for existing and planned EDT models in these systems.

The common spatial currency concept consists of two key elements:

- Assessment units based on USGS 12th field HUCs (subwatersheds)
- A routed stream reach network with the following characteristics:
  - Optimized reach lengths ranging from 1-5 kilometers
  - Integration of reach naming conventions used in existing conservation and restoration planning and management efforts
  - Passage obstructions incorporated as attributable reaches in the network
  - Reach break points positioned to emphasize uniformity of gradient and valley confinement characteristics to the extent practicable

5 $w = 0.177*(A^{0.397})*(P^{0.453})$ where A = upstream drainage area and P = average annual precipitation ($R^2 = 0.844$, $P<0.001$)

This approach emphasizes geomorphic uniformity within reaches by placing reach break points at environmental discontinuities.[6] Channel segments with geomorphically uniform conditions over long distances were split to avoid reaches greater than 5 kilometers in length.[7]

The geographic separation between the Spokane River and the FDRL Tributaries required the development of separate EDT reach geometries and EDT models for each area. The Spokane River model is composed of 264 habitat reaches covering 762 stream kilometers and 18 distinct obstruction reaches, representing major known manmade barriers. The FDRL Tributaries model is composed of 20 habitat reaches covering 43 kilometers of stream and eight identified obstruction reaches. There are numerous additional manmade fish passage obstructions within the study area. ICF and STFAP reviewed available information sources but ultimately determined that insufficient information was available to identify and parameterize all features under the current scope of work. These features can be added to the EDT model in future project phases. This EDT analysis assumes 100% passage survival at all in-basin manmade obstructions other than the mainstem Spokane River dams. The same assumption was applied in the CCT anadromous habitat suitability analysis. Consistency of approach allows for direct comparison of the two analyses.

The Spokane EDT model is composed of 35 habitat attributes, describing channel dimensions, habitat composition, and habitat quality.[8] These attributes are parameterized at the reach level by month. ICF used the following sources of data and information to parameterize the Spokane and FDRL Tributaries EDT models:

- Aerial imagery interpretation: Various habitat attribute ratings interpolated from features visible in aerial imagery
- Avista Corporation: Limnological data in Lake Spokane (also known as “Long Lake”)
- Coeur d’Alene Tribe of Indians (CDAT): Habitat survey and water quality monitoring data at discrete locations in the upper Hangman Creek subbasin
- ICF-interpolated: Attributes parameterized by ICF using a variety of methods, including logistic regression models, interpolation from attribute data patterns in adjacent reaches and/or months, and best professional judgment[9]
- NetMap – LEMMA: Riparian vegetation composition data used to characterize riparian habitat conditions obtained from the Landscape Ecology, Modeling, Methods & Analysis (LEMMA) project (LEMMA 2017)
- NetMap: Watershed modeling software used to estimate channel gradient, confinement, thermal refugia, and sediment characteristics (TerrainWorks 2015)

6 These included changes in gradient class (0-1%, 1-2%, 2-4%, 4-6%, >6%) and changes in valley confinement ratio (floodplain width/bankfull width <4, >4).

7 ‘Length optimization’ splits were placed at useful landmark locations, like stream gages, bridge crossings, and changes in land use (e.g. from forested to plowed agriculture).

8 The EDT model can contain up to 46 environmental attributes. Several low-confidence attributes were removed from the Spokane and FDRL Tributaries EDT models because they were not used in the CCT anadromous reintroduction analysis, are reliant on professional judgment, and/or the model rule structure has not been updated to reflect current science. Examples include Poaching/Harrassment, Metals in Water, Metals in Sediment, and Miscellaneous Toxins.

9 Includes extrapolation of selected attribute ratings for the FDRL Tributaries from the CCT EDT model, based on geomorphic and land use similarity to select tributaries to Lake Roosevelt on the Colville Reservation.

- NorWeST: Regional water temperature model used to estimate August average water temperatures, developed by the US Forest Service - Rocky Mountain Research Station
- Spokane County Conservation District (SCCD): Water quality monitoring data at discrete locations within the Hangman Creek subbasin
- Spokane Riverkeeper: Water quality monitoring data at discrete locations in the Hangman Creek and Little Spokane subbasins
- Spokane Tribe of Indians (STOI): Limnological and stream water quality monitoring data at discrete locations, primarily in Spokane Arm of Lake Roosevelt
- US Forest Service – Rocky Mountain Research Station (USFS – RMRS): Variable Infiltration Capacity hydrologic model outputs for the study area
- US Geological Survey (USGS): Flow and temperature data at discrete USGS gage locations in the study area
- Washington Department of Ecology (ECY): Water quality and physical habitat monitoring data at discrete locations around the basin
- Washington Department of Fish and Wildlife (WDFW): Habitat survey data at discrete locations in the study area, concentrated primarily in the Little Spokane subbasin

A summary of data sources used to parameterize the Spokane and FDRL Tributaries EDT models is provided by reporting area and attribute class in Tables 2-1 and 2-2, respectively.

Table 2-1. Summary of data sources used to parameterize the Spokane EDT model by reporting watershed and attribute class.

Reporting Watershed	Data Source	Habitat Quality Attributes	Habitat Composition Attributes	All Attributes
Spokane Mainstem & Tributaries	Aerial imagery	4.4%	97.7%	29.2%
	Avista Corporation	1.7%	0.0%	1.2%
	ECY	0.4%	0.0%	0.3%
	ICF-interpolated	56.9%	2.3%	42.4%
	NetMap	15.8%	0.0%	11.6%
	NetMap - LEMMA	7.9%	0.0%	5.8%
	NorWeST	0.3%	0.0%	0.2%
	SCCD	0.1%	0.0%	0.1%
	STOI	1.0%	0.0%	0.8%
	USFS - RMRS	10.6%	0.0%	7.8%
	USGS	1.0%	0.0%	0.8%
Little Spokane Lower	Aerial imagery	0.0%	12.8%	4.4%
	ECY	0.1%	0.0%	0.1%
	ICF-interpolated	43.5%	7.8%	31.2%
	NetMap	13.3%	0.0%	8.8%
	NetMap - LEMMA	8.5%	0.0%	5.6%
	NorWeST	0.5%	0.0%	0.3%
	SCCD	4.7%	0.0%	3.1%
	USFS - RMRS	17.6%	0.0%	11.6%
	USGS	2.4%	0.0%	1.5%
	WDFW	9.4%	79.5%	33.5%
Little Spokane Dragoon	Aerial imagery	0.0%	13.0%	4.4%
	ECY	0.4%	0.0%	0.3%
	ICF-interpolated	45.2%	26.1%	38.7%
	NetMap	13.3%	0.0%	8.8%
	NetMap - LEMMA	8.9%	0.0%	5.9%
	NorWeST	0.5%	0.0%	0.4%
	SCCD	2.7%	0.0%	1.8%
	USFS - RMRS	20.0%	0.0%	13.2%
	WDFW	8.0%	60.9%	25.9%
	WDFW & ECY	0.9%	0.0%	0.6%
Little Spokane Upper	Aerial imagery	0.0%	19.8%	6.5%
	ICF-interpolated	43.2%	0.0%	28.9%
	NetMap	13.3%	0.0%	8.9%
	NetMap - LEMMA	10.8%	0.0%	7.2%
	NorWeST	0.5%	0.0%	0.3%
	Riverkeeper	0.2%	0.0%	0.1%
	SCCD	6.9%	0.0%	4.6%
	USFS - RMRS	20.0%	0.0%	13.4%
	WDFW	5.1%	80.2%	29.9%

Reporting Watershed	Data Source	Habitat Quality Attributes	Habitat Composition Attributes	All Attributes
Hangman Lower	Aerial imagery	0.0%	46.9%	16.3%
	ECY	0.5%	0.0%	0.3%
	ICF-interpolated	50.2%	21.9%	40.4%
	NetMap	13.3%	0.0%	8.7%
	NetMap - LEMMA	11.7%	0.0%	7.6%
	NorWeST	0.2%	0.0%	0.1%
	Riverkeeper	0.3%	0.0%	0.2%
	SCCD	0.5%	0.0%	0.3%
	STOI	0.2%	0.0%	0.2%
	USFS - RMRS	16.4%	0.0%	10.7%
	USGS	3.6%	0.0%	2.3%
	WDFW	2.9%	31.3%	12.7%
	WDFW & ECY	0.2%	0.0%	0.2%
Hangman Middle	Aerial imagery	0.0%	40.1%	14.0%
	CDAT	0.2%	0.0%	0.1%
	ECY	0.5%	0.0%	0.3%
	ICF-interpolated	51.8%	53.0%	52.2%
	NetMap	13.3%	0.0%	8.7%
	NetMap - LEMMA	12.8%	0.0%	8.4%
	NorWeST	0.3%	0.0%	0.2%
	Riverkeeper	0.2%	0.0%	0.1%
	SCCD	0.2%	0.0%	0.1%
	USFS - RMRS	20.0%	0.0%	13.0%
	WDFW	0.7%	6.9%	2.9%
Hangman Upper	Aerial imagery	0.0%	16.7%	5.8%
	CDAT	5.9%	8.3%	6.7%
	ICF-interpolated	48.4%	75.0%	57.7%
	NetMap	13.3%	0.0%	8.7%
	NetMap - LEMMA	12.1%	0.0%	7.9%
	NorWeST	0.1%	0.0%	0.1%
	Riverkeeper	0.2%	0.0%	0.1%
	USFS - RMRS	20.0%	0.0%	13.0%

Table 2-2. Summary of data sources used to parameterize the FDRL Tributaries EDT model by reporting watershed and attribute class.

Reporting Subwatershed	Data Source	Habitat Quality Attributes	Habitat Composition Attributes	All Attributes
FDRL - Harvey	ICF - interpolated	56.2%	72.0%	72.0%
	ECY	5.6%	28.0%	0.5%
	NetMap	19.2%	0.0%	13.9%
	NetMap - LEMMA	7.1%	0.0%	5.1%
	USFS - RMRS	11.5%	0.0%	8.3%
	NorWeST	0.3%	0.0%	0.2%
FDRL - Stranger	ICF - interpolated	61.2%	100.0%	72.0%
	NetMap	19.2%	0.0%	13.9%
	NetMap - LEMMA	7.7%	0.0%	5.6%
	USFS - RMRS	11.5%	0.0%	8.3%
	NorWeST	0.3%	0.0%	0.2%
FDRL - Magee	ICF - interpolated	61.2%	100.0%	72.0%
	NetMap	19.2%	0.0%	13.9%
	NetMap - LEMMA	7.7%	0.0%	5.6%
	USFS - RMRS	11.5%	0.0%	8.3%
	NorWeST	0.3%	0.0%	0.2%
FDRL - Cheweka	ICF - interpolated	59.9%	100.0%	71.1%
	ECY	1.3%	0.0%	0.9%
	NetMap	19.2%	0.0%	13.9%
	NetMap - LEMMA	7.7%	0.0%	5.6%
	USFS - RMRS	11.5%	0.0%	8.3%
	NorWeST	0.3%	0.0%	0.2%
FDRL - Quillisacut	ICF - interpolated	61.2%	100.0%	72.0%
	NetMap	19.2%	0.0%	13.9%
	NetMap - LEMMA	7.7%	0.0%	5.6%
	USFS - RMRS	11.5%	0.0%	8.3%
	NorWeST	0.3%	0.0%	0.2%
FDRL - Colville	Aerial imagery	15.0%	100.0%	41.4%
	ICF - interpolated	44.6%	0.0%	30.7%
	ECY	5.0%	0.0%	3.4%
	NetMap	20.0%	0.0%	13.8%
	USGS	15.0%	0.0%	10.3%
	NorWeST	0.4%	0.0%	0.3%
FDRL - China	ICF - interpolated	61.2%	100.0%	72.0%
	NetMap	19.2%	0.0%	13.9%
	NetMap - LEMMA	7.7%	0.0%	5.6%
	USFS - RMRS	11.5%	0.0%	8.3%
	NorWeST	0.3%	0.0%	0.2%

Reporting Subwatershed	Data Source	Habitat Quality Attributes	Habitat Composition Attributes	All Attributes
FDRL - Onion	ICF - interpolated	61.2%	100.0%	72.0%
	NetMap	19.2%	0.0%	13.9%
	NetMap - LEMMA	7.7%	0.0%	5.6%
	USFS - RMRS	11.5%	0.0%	8.3%
	NorWeST	0.3%	0.0%	0.2%
FDRL - Deep	ICF - interpolated	61.2%	100.0%	72.0%
	NetMap	19.2%	0.0%	13.9%
	NetMap - LEMMA	7.7%	0.0%	5.6%
	USFS - RMRS	11.5%	0.0%	8.3%
	NorWeST	0.3%	0.0%	0.2%

2.1.2 Data Quality Summary

ICF assigned a Level of Proof (LOP) rating to every habitat attribute entered into the Spokane and FDRL Tributaries EDT models. The LOP rating is an ordinal score describing the level of confidence in the underlying data source. Rating definitions are provided in Table 2-3. ICF developed a preliminary assessment of data gaps across the study area by summarizing LOP ratings by attribute class, reporting watershed, and assessment unit. Data quality summary results are presented in Section 4.

STFAP will use this information to assess information needs and create a framework for habitat assessment and monitoring program development. This framework will be refined in future projects using the EDT model to identify critical data gaps associated with priority habitat limiting factors. The EDT model generates a reporting metric called the weighted LOP score that considers the effect of each EDT habitat attribute to limiting factor performance.[10] Weighted LOP scores are generated for each EDT survival factor at the reach and assessment unit scale, providing a powerful tool for spatially explicit identification of data gaps associated with critical limiting factors.

10 Based on the proportional effect of each EDT survival factor on habitat productivity at reach and assessment unit scales.

Table 2-3. EDT Level of Proof rating definitions.

Rating	Definition	Example
1	Thoroughly established, generally accepted, supported by peer-reviewed empirical evidence and/or data with representative geographic coverage	Current, high-quality empirical data that is representative of reach-level habitat conditions
2	Strong weight of evidence in support but not fully conclusive	Empirical data more than 10 years old Aerial imagery interpretation High-certainty model-derived attributes (e.g. gradient, valley confinement)
3	Theoretical support with some evidence from experiments or direct observations	Current professional knowledge Extrapolation from empirical data in similar reaches
4	Speculative, little empirical support or limited observation	Low-certainty model-derived attributes Extrapolation from general regional monitoring (e.g. EMAP)
5	Presumptive, not based on empirical data or direct observation	Hypothetical rating based on general watershed characteristics No attribute rating

2.1.3 Configuring Hypothetical Anadromous Populations

ICF and STFAP elected to use the hypothetical populations of summer steelhead, summer/fall Chinook, and spring Chinook previously developed for the CCT reintroduction analysis (ICF 2017). ICF and the CCT hosted a life history model workshop on June 28th, 2016 to define parameters necessary to construct theoretical anadromous populations in EDT.[11] This approach necessarily relied on expert opinion and extrapolation from existing populations in other Upper Columbia subbasins because the target species were extirpated from the study area nearly a century ago and information about historical population structure is scarce.

Based on the findings of this meeting, ICF and the CCT used the following approach to parameterize anadromous populations in the EDT model:

- Summer steelhead
  - Adapt the existing Okanogan summer steelhead population from the Okanogan EDT model
  - Incorporate additional reservoir rearing life cycle models based on observed redband trout population structure within the study area
- Summer/fall Chinook
  - Adapt the existing Okanogan summer/fall Chinook population from the Okanogan EDT model

11 The meeting included representatives from the CCT, STFAP, the Washington Department of Fish and Wildlife, the US Geological Survey, and the Upper Columbia United Tribes.

- Spring Chinook
  - Construct a new population in the EDT model platform based on observed population structure in the Methow, Entiat and Wenatchee rivers
  - Incorporate reservoir rearing and holding life history model elements to reflect observed behavior in these populations

These model populations where successfully used in the CCT reintroduction analysis on the Sanpoil River and Colville Reservation tributaries to Lake Roosevelt. These population parameters were subsequently imported into and modified for use in the Spokane Tribe EDT model.

Each EDT population is composed of a set of EDT Life Cycle Models (LCM) and designated spawning reaches. Each LCM is composed of a set of constraints used to define spawning, rearing, and migratory timing and behavior of individual age classes. Each EDT population is composed of a proportional distribution of LCMs configured to be representative of the age structure and range of life history expression of the modeled species. The LCMs and population configuration for each species are described in the following sections.

Steelhead

Theoretical EDT population structure for Spokane River and FDRL Tributaries summer steelhead is summarized in Table 2-4 and outlined in detail in Table 2-5. This structure is based on the existing steelhead population parameters used in the Okanogan EDT model, with modifications to represent the broader range of life history diversity expressed by Upper Columbia DPS steelhead. The model populations are based on extensive monitoring and characterization of extant populations, modified to consider the probable range of historical life history expression. In addition, a reservoir-rearing life history form was added to reflect probable use of reservoir habitats by juvenile steelhead. The rationale for the reservoir component is based on the observed behavior of adfluvial redband trout originating in the study area (ICF 2013). The workshop participants anticipated that up to 10% of steelhead reintroduced to the US portion of the blocked area would use the reservoir as primary rearing habitat prior to emigration. The remaining steelhead LCMs are evenly divided between transient, or “mover,” and resident rearing, or “stayer” juvenile life history strategies. Mover-type LCMs are allowed to redistribute in the spring and fall to reflect use of different habitats during winter and summer rearing. Stayer-type LCMs are assumed to remain in essentially the same habitat throughout the entire juvenile rearing period ranging from one to three years. Adult age at migration, or the number of years spent in the ocean, was derived from a cross-section of observed population structure in the Upper Columbia DPS. The proportion of 3-ocean year-adults was increased relative to observed population to ensure that this life history form is well represented in the model.

Table 2-4. Summary of EDT summer steelhead age structure and rearing strategy composition used in the Spokane and FDRL Tributaries EDT models.

Parameter	Age or Rearing Strategy	Proportion of Population
Juvenile age at smolting	Age-1	42.25%
	Age-2	35.50%
	Age-3	22.25%
Adult age at migration	1 ocean year	34.75%
	2 ocean years	54.25%
	3 ocean years	11.00%
Rearing strategy	Mover (transient)	45.0%
	Stayer (resident)	45.0%
	Reservoir	10.0%

Juvenile age at smolting: Age when migrant juveniles enter the Lake Roosevelt component of the migratory corridor exhibiting migratory behavior

Adult age at migration: Number of years spent rearing in the ocean before re-entering the Columbia River as migrant adults

Mover: Transient rearing behavioral type, demonstrating substantial movement between summer and winter rearing habitats

Stayer: Resident rearing behavioral type, remains in close proximity to incubation habitat until outmigration

Reservoir: Transient rearing juveniles that emigrate to reservoir habitats, overwinter, and migrate to the ocean at age 1

Table 2-5. EDT summer steelhead Life Cycle Models and population composition used in the Spokane and FDRL Tributaries EDT models.

Life Cycle Model	Juvenile Rearing Strategy	Juvenile Age at Migration	Ocean Age	Percent of Population
Age 1/1 Transient - Reservoir Rearing	Reservoir	1	1	4.5%
Age 1/2 Transient - Reservoir Rearing	Reservoir	1	2	5.0%
Age 1/3 Transient - Reservoir Rearing	Reservoir	1	3	0.5%
Age 1/1 Transient	Mover	1	1	4.8%
Age 1/2 Transient	Mover	1	2	8.5%
Age 1/3 Transient	Mover	1	3	1.8%
Age 2/1 Transient	Mover	2	1	7.0%
Age 2/2 Transient	Mover	2	2	11.0%
Age 2/3 Transient	Mover	2	3	2.0%
Age 3/1 Transient	Mover	3	1	3.5%
Age 3/2 Transient	Mover	3	2	5.0%
Age 3/3 Transient	Mover	3	3	1.5%
Age 1/1 Resident	Stayer	1	1	6.5%
Age 1/2 Resident	Stayer	1	2	9.0%
Age 1/3 Resident	Stayer	1	3	1.8%
Age 2/1 Resident	Stayer	2	1	4.5%
Age 2/2 Resident	Stayer	2	2	9.0%
Age 2/3 Resident	Stayer	2	3	2.0%
Age 3/1 Resident	Stayer	3	1	4.0%
Age 3/2 Resident	Stayer	3	2	6.8%
Age 3/3 Resident	Stayer	3	3	1.5%

Probable spawning reaches for steelhead were identified using the analysis of steelhead intrinsic potential habitats conducted by the STFAP. For the purpose of this modeling analysis, steelhead are assumed to spawn in every historical anadromous reach with suitable riverine (versus currently inundated) habitat. Because this same analysis was used to define the reach geometry used in the EDT model, steelhead are assumed to spawn in the portions of every accessible reach that provide suitable habitat conditions.

EDT spawning reaches for summer steelhead in the Spokane River and FDRL Tributaries are shown Figures 2-1 and 2-2, respectively. The extent of potential steelhead spawning habitat in the Spokane River and FDRL Tributaries is summarized in Table 2-6.

Table 2-6. Summary statistics for reaches identified as potential steelhead spawning habitat by stream environment type in the Spokane River and FDRL Tributaries.

Species	Subbasin/ Watershed	Environment Type	Habitat Length (kilometers/miles)	Habitat Area (hectares/acres)
Steelhead	**Spokane River**	Small tributary	200.0/124.0	91.2/225.2
		Low Stream Order	364.8/226.2	353.2/872.9
		Mid-stream Order	79.3/49.2	173.3/428.3
		High Stream Order	17.4/10.8	110.6/273.3
		Total	*661.4/410.1*	*728.3/1799.8*
	FDRL Tributaries	Small tributary	21.3/13.2	9.3/22.9
		Low Stream Order	18/11.1	14.1/34.8
		Mid-stream Order	6/3.7	10.8/26.8
		High Stream Order	--	--
		Total	*45.3/28.1*	*34.2/84.5*
	All Habitat	**Grand Total**	**706.7/438.1**	**762.5/1884.2**

Environment type descriptions:

Small tributary: Small tributary and headwater streams, Shreve Order 1 to 4

Low stream order: Tributary and mainstem reaches, Shreve Order 5 to 50

Mid-stream order: Tributary and mainstem reaches, Shreve Order >50

High stream order: Mainstem Spokane River between Nine Mile Reservoir and Hangman Creek

Note: Habitat area summary is based on bankfull width in identified spawning reaches.

Summer/Fall Chinook

Theoretical EDT population structure for Spokane River summer/fall Chinook is summarized in Table 2-7 and outlined in detail in Table 2-8. This structure is based on the existing population parameters for Okanogan River summer/fall Chinook. The Okanogan population parameters were imported into the Sanpoil EDT model for the CCT anadromous reintroduction analysis. The Spokane summer/fall Chinook population is based on the same parameters used in the Sanpoil model. It includes a diverse range of life history strategies, including ocean-type, stream-type, and reservoir rearing behavior, and use of mainstem reservoir habitats as thermal refugia during adult holding. Ocean-type LCMs emigrate in their first summer (age-0). Reservoir-type LCMs migrate to reservoir habitats in their first summer, overwinter in the reservoir and emigrate in their second summer (age-1). Stream-type LCMs rear in watershed habitats and emigrate in their second summer at age-1.

ICF used the STFAP intrinsic potential analysis to identify potential spawning reaches for Chinook salmon in the study area. All identified stream reaches having a gradient of less than 7% and a bankfull width greater than 3.8 meters were considered potential spawning habitat for both spring and summer/fall Chinook for the purpose of this analysis (Cooney and Holzer 2006). EDT spawning reaches in the Spokane River and FDRL Tributaries are shown Figures 2-3 and 2-4, respectively. The extent of potential Chinook spawning habitat in the Spokane River and FDRL Tributaries is summarized in Table 2-9.

Table 2-7. Summary of EDT summer/fall Chinook age structure and behavioral-type composition used in the Spokane and FDRL Tributaries EDT models.

Parameter	Age or Behavioral Type	Proportion of Population
Juvenile rearing/ migration behavior type	Ocean-type	86.4%
	Stream-type	4.4%
	Reservoir	9.2%
Adult age at migration	1 ocean year (jacks)	5.0%
	2 ocean years	10.1%
	3 ocean years	49.9%
	4 ocean years	35.0%
Adult holding behavior	Watershed	54.4%
	Reservoir	45.6%

Juvenile rearing/migration behavior type:

Ocean-type: Migrate at age-0 from emergence through summer

Stream-type: Migrate at age-1

Reservoir-type: Emigrate to reservoir habitats, overwinter, and migrate at age 1

Adult age at migration: Number of years spent rearing in the ocean before re-entering the Columbia River as migrant adults

Adult holding behavior type:

Watershed: Migrate to pre-spawn holding habitats in Spokane and FDRL Tributaries

Reservoir: Hold in Spokane Arm or Lake Roosevelt prior to migrating to spawning habitat

Table 2-8. EDT summer/fall Chinook Life Cycle Models and population composition used in the Spokane and FDRL Tributaries EDT models.

Life Cycle Model	Adult Holding	Juvenile Rearing	Ocean Age	Percent of Population
Summer Direct/Direct migrant age 0/1	Watershed	Ocean-type	1 (jack)	1.9%
Summer Direct/Direct migrant age 0/2	Watershed	Ocean-type	2	3.9%
Summer Direct/Direct migrant age 0/3	Watershed	Ocean-type	3	19.4%
Summer Direct/Direct migrant age 0/4	Watershed	Ocean-type	4	13.6%
Summer Direct/Delayed migrant age 1/1	Watershed	Reservoir	1 (jack)	0.2%
Summer Direct/Delayed migrant age 1/2	Watershed	Reservoir	2	0.5%
Summer Direct/Delayed migrant age 1/3	Watershed	Reservoir	3	2.3%
Summer Direct/Delayed migrant age 1/4	Watershed	Reservoir	4	1.6%
Summer Direct/Stream-type age 1/1	Watershed	Stream-type	1 (jack)	0.1%
Summer Direct/Stream-type age 1/2	Watershed	Stream-type	2	0.2%
Summer Direct/Stream-type age 1/3	Watershed	Stream-type	3	1.1%
Summer Direct/Stream-type age 1/4	Watershed	Stream-type	4	0.8%
Summer Delayed/Direct migrant age 0/1	Reservoir	Ocean-type	1 (jack)	1.9%
Summer Delayed/Direct migrant age 0/2	Reservoir	Ocean-type	2	3.9%
Summer Delayed/Direct migrant age 0/3	Reservoir	Ocean-type	3	19.4%
Summer Delayed/Direct migrant age 0/4	Reservoir	Ocean-type	4	13.6%
Summer Delayed/Delayed migrant age 1/1	Reservoir	Reservoir	1 (jack)	0.2%
Summer Delayed/Delayed migrant age 1/2	Reservoir	Reservoir	2	0.5%
Summer Delayed/Delayed migrant age 1/3	Reservoir	Reservoir	3	2.3%
Summer Delayed/Delayed migrant age 1/4	Reservoir	Reservoir	4	1.6%
Summer Delayed/stream-type age 1/1	Reservoir	Stream-type	1 (jack)	0.1%
Summer Delayed/stream-type age 1/2	Reservoir	Stream-type	2	0.2%
Summer Delayed/stream-type age 1/3	Reservoir	Stream-type	3	1.1%
Summer Delayed/stream-type age 1/4	Reservoir	Stream-type	4	0.8%
Fall Direct/Direct migrant age 0/1	Watershed	Ocean-type	1 (jack)	0.6%
Fall Direct/Direct migrant age 0/2	Watershed	Ocean-type	2	0.9%
Fall Direct/Direct migrant age 0/3	Watershed	Ocean-type	3	4.3%
Fall Direct/Direct migrant age 0/4	Watershed	Ocean-type	4	3.0%

Table 2-9. Summary statistics for reaches identified as potential Chinook salmon spawning habitat by stream environment type in the Spokane River and FDRL Tributaries.

Species	Subbasin/ Watershed	Environment Type	Habitat Length (kilometers/miles)	Habitat Area (hectares/acres)
Chinook Salmon	**Spokane River**	Small tributary	6.6/4.1	4.8/11.9
		Low Stream Order	290.9/180.3	310.2/766.5
		Mid-stream Order	79.3/49.2	173.3/428.3
		High Stream Order	17.4/10.8	110.6/273.3
		Total	*394.2/244.4*	*598.9/1480.0*
	FDRL Tributaries	Small tributary	14.5/9.0	12.7/31.2
		Low Stream Order	6.0/3.7	10.8/26.8
		Mid-stream Order	--	--
		Total	*20.5/12.7*	*23.5/58.0*
	All Habitat	**Grand Total**	**414.7/257.1**	**622.4/1538.0**

Environment type descriptions:

Small tributary: Small tributary and headwater streams, Shreve Order 1 to 4
Low stream order: Tributary and mainstem reaches, Shreve Order 5 to 50
Mid-stream order: Tributary and mainstem reaches, Shreve Order >50
High-stream order: Mainstem Spokane River between Nine Mile Reservoir and Hangman Creek

Note: Habitat area summary is based on bankfull width in identified spawning reaches.

Spring Chinook

Theoretical EDT population structure for Spokane River and FDRL Tributaries spring Chinook is summarized in Table 2-10 and outlined in detail in Table 2-11. This structure is based on observed population composition in Methow, Wenatchee, and Entiat Rivers, with additional modifications to reflect the assumed use of reservoir habitats in Lake Roosevelt for adult holding and juvenile rearing. The adult age distribution spring Chinook assumes approximately 4%, 70%, 21% and 5% of the 6,000 EDT life history trajectories used to model each population that will be composed of spawners that spent 1, 2, 3, and 4 years in the ocean, respectively. Each subbasin population is configured to allow for 50% to hold through the summer in reservoir habitats in Lake Roosevelt as prespawn adults. The EDT population configuration also assumes that 26% of juveniles will spend their first winter rearing in reservoir habitats.

As stated in the previous section, probable spawning reaches for Chinook salmon were selected using the STFAP intrinsic potential analysis. Spring Chinook spawning reaches in the Spokane River and FDRL Tributaries EDT models are shown in Figures 2-3 and 2-4, respectively. The extent of potential Chinook spawning and rearing habitat in the Spokane River and FDRL Tributaries is summarized in Table 2-9.

Table 2-10. Summary of EDT spring Chinook age structure and behavioral-type composition used in the Spokane and FDRL Tributaries EDT models.

Parameter	Age or Behavioral Type	Proportion of Population
Juvenile rearing/ migration behavior type	Stream-type	74.0%
	Reservoir	26.0%
Adult age at migration	1 ocean year (jacks)	4.0%
	2 ocean years	70.0%
	3 ocean years	21.0%
	4 ocean years	5.0%
Adult holding behavior	Watershed	50%
	Reservoir	50%

Juvenile rearing/migration behavior type:

Stream-type: Migrate at age-1

Reservoir-type: Emigrate to reservoir habitats, overwinter, and migrate at age 1

Adult age at migration: Number of years spent rearing in the ocean before re-entering the Columbia River as migrant adults

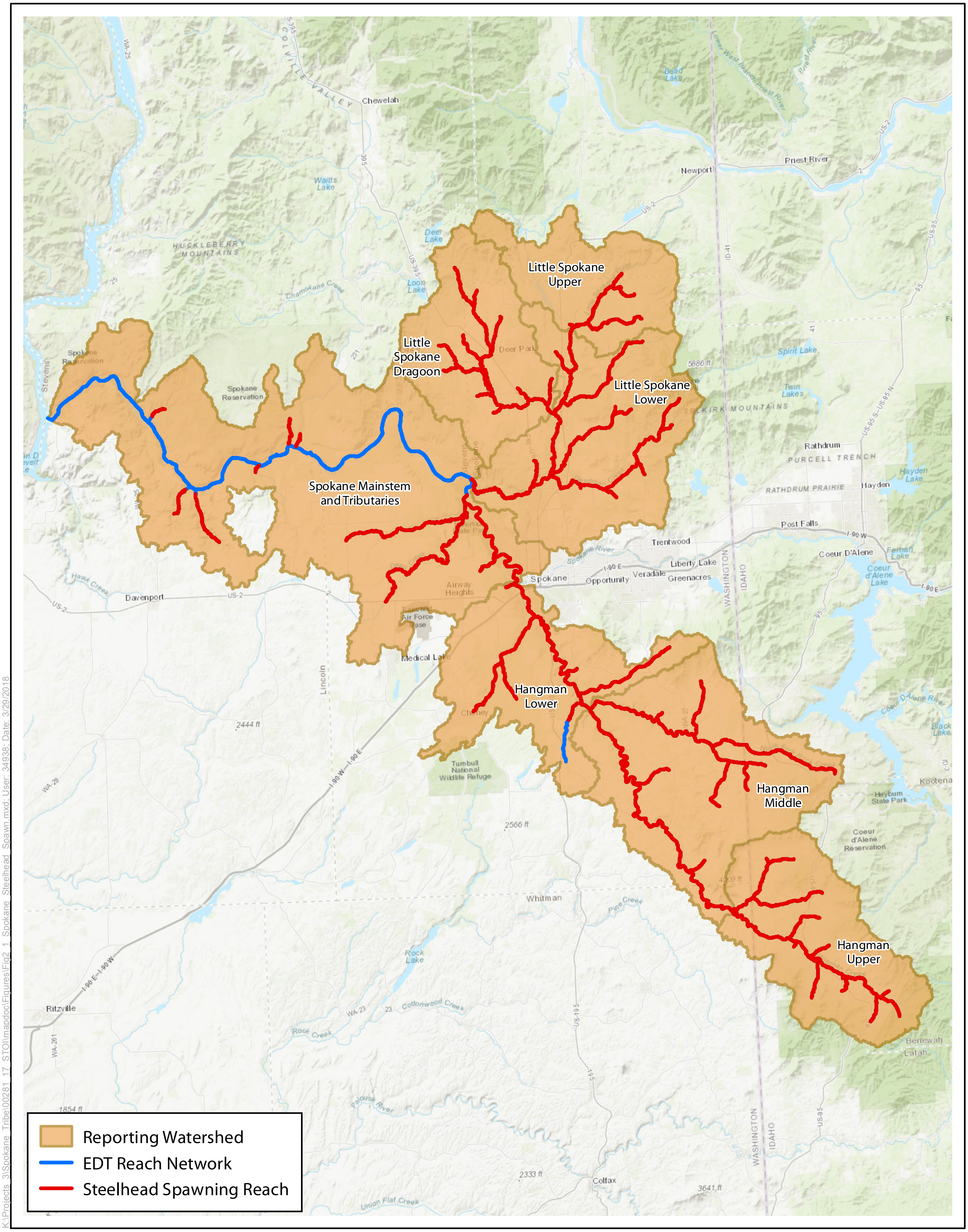
Adult holding behavior type:

Watershed: Migrate to pre-spawn holding habitats

Reservoir: Hold in Spokane Arm or Lake Roosevelt prior to migrating to spawning habitat

Table 2-11. EDT Spring Chinook Life Cycle Models and population composition used in the Spokane and FDRL Tributaries EDT models.

Life Cycle Model	Adult Holding	Juvenile Rearing	Ocean Age	Percent of Population
Age 1/1 - Reservoir Rearing	Watershed	Reservoir	1 (jack)	0.5%
Age 1/2 - Reservoir Rearing	Watershed	Reservoir	2	9.0%
Age 1/3 - Reservoir Rearing	Watershed	Reservoir	3	2.5%
Age 1/4 - Reservoir Rearing	Watershed	Reservoir	4	1.0%
Age 1/1 - Local Rearing	Watershed	Stream-type	1 (jack)	1.5%
Age 1/2 - Local Rearing	Watershed	Stream-type	2	26.0%
Age 1/3 - Local Rearing	Watershed	Stream-type	3	8.0%
Age 1/4 - Local Rearing	Watershed	Stream-type	4	1.5%
Age 1/1 - Reservoir Rearing and Holding	Reservoir	Reservoir	1 (jack)	0.5%
Age 1/2 - Reservoir Rearing and Holding	Reservoir	Reservoir	2	9.0%
Age 1/3 - Reservoir Rearing and Holding	Reservoir	Reservoir	3	2.5%
Age 1/4 - Reservoir Rearing and Holding	Reservoir	Reservoir	4	1.0%
Age 1/1 - Local Rearing, Reservoir Holding	Reservoir	Stream-type	1 (jack)	1.5%
Age 1/2 - Local Rearing, Reservoir Holding	Reservoir	Stream-type	2	26.0%
Age 1/3 - Local Rearing, Reservoir Holding	Reservoir	Stream-type	3	8.0%
Age 1/4 - Local Rearing, Reservoir Holding	Reservoir	Stream-type	4	1.5%



K:\Projects_3\Spokane_Tribe\00281_17_STOI\mapdoc\Figures\Fig2_1_Spokane_Steelhead_Spawn.mxd User: 34938; Date: 3/29/2018

Figure 2-1
Distribution of steelhead spawning reaches used in the Spokane EDT model

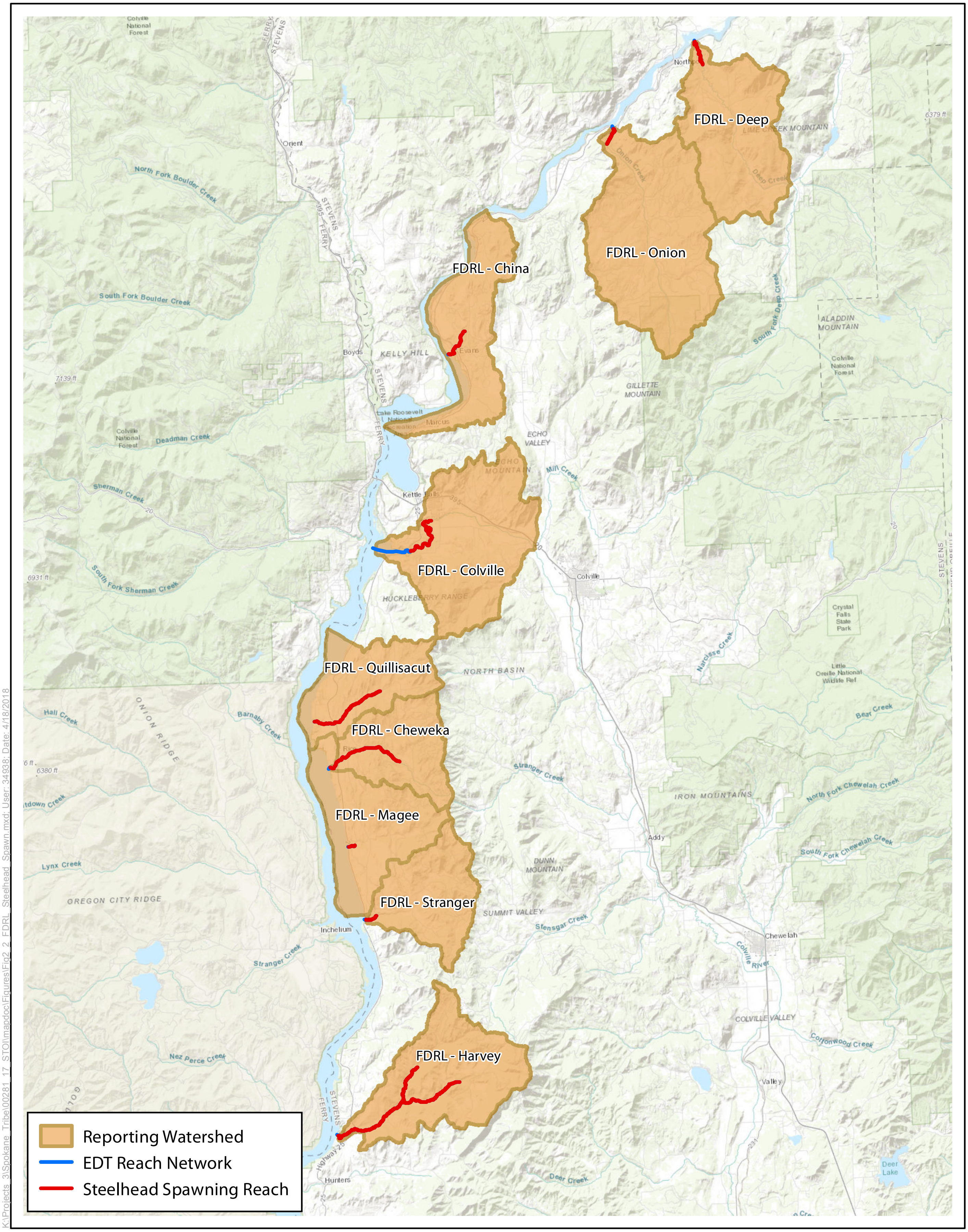


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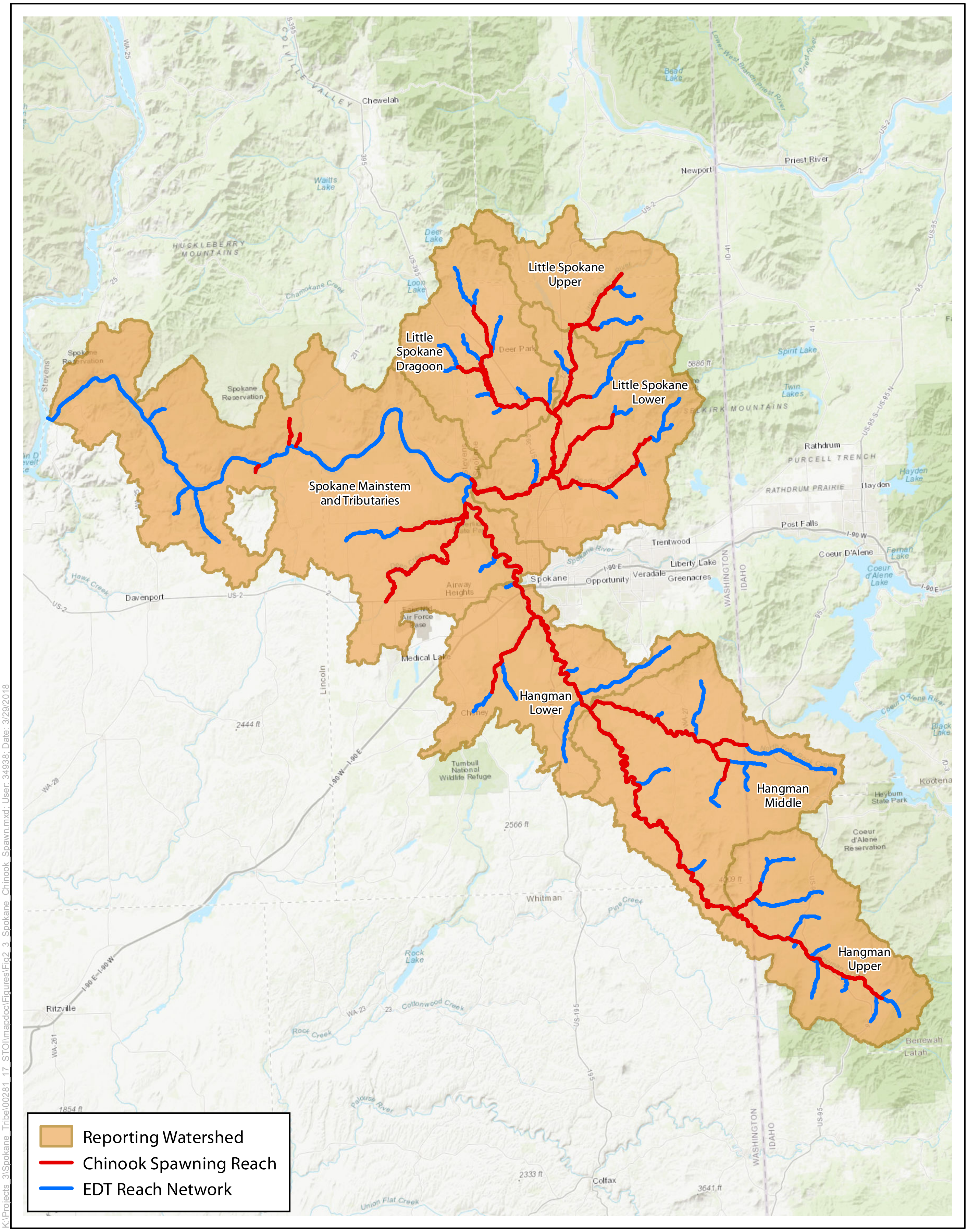
Figure 2-2
Distribution of steelhead spawning reaches used in the Select FDRL Tributaries EDT model



K:\Projects_3\Spokane_Tribe\00281_17_STOI\mapdoc\Figures\Fig2_3_Spokane_Chinook_Spawn.mxd User: 34938 Date: 3/29/2018

Figure 2-3
Distribution of Chinook salmon spawning reaches used in the Spokane EDT model

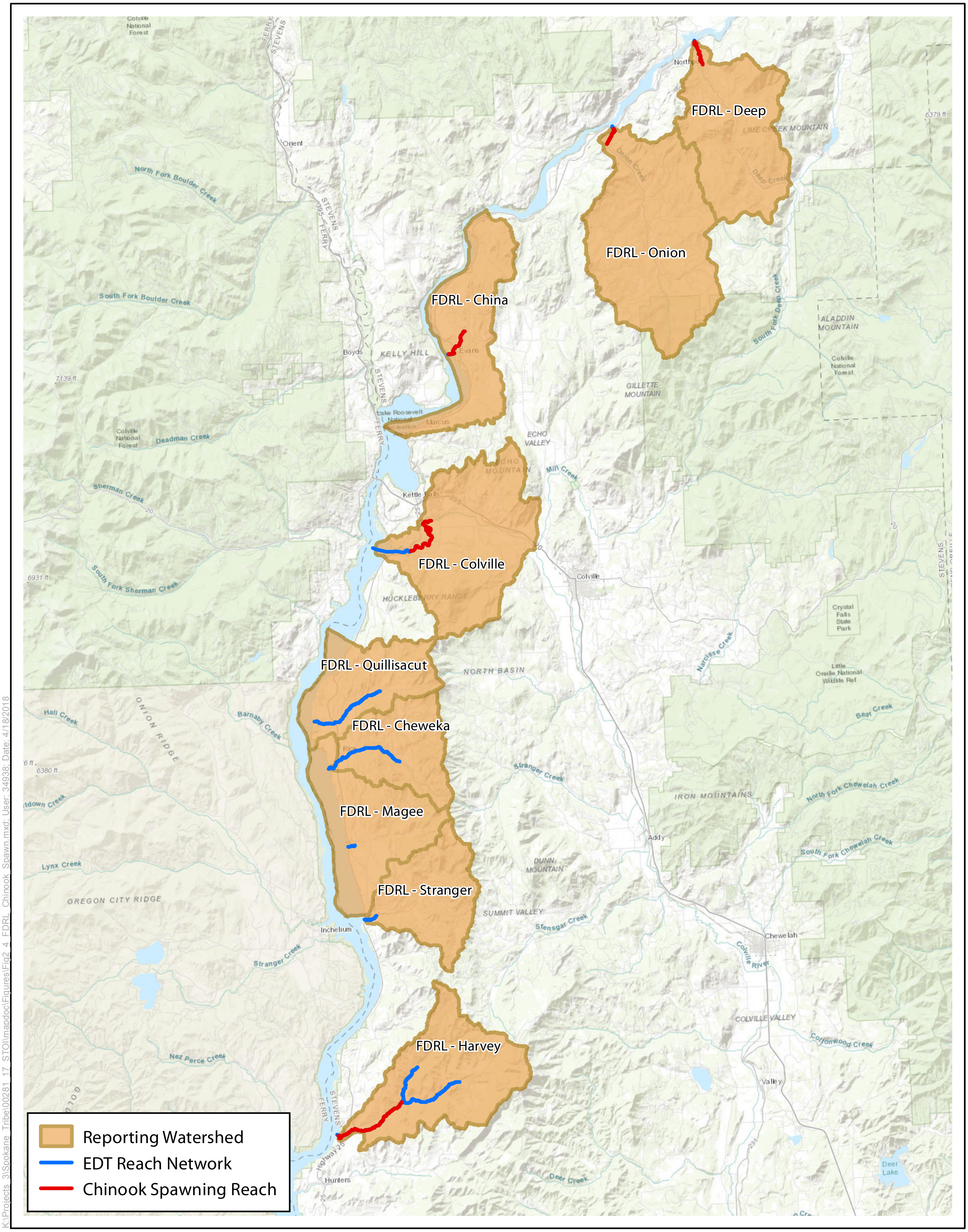


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Figure 2-4
Distribution of Chinook salmon spawning reaches used in the Select FDRL Tributaries EDT model

2.2 Critical Assumptions

The EDT model necessarily required a set of critical assumptions about in-basin and out-of-basin habitat and survival parameters. These assumptions are described below. For the Spokane River model the “in-basin” area extends from the mouth of the inundated Spokane Arm to the upstream limits of the EDT model. In-basin areas include the tributaries, inundated arms of tributaries, and nearshore of Lake Roosevelt for the FDRL Tributaries EDT model. The in-basin portion of the FDRL Tributaries includes an “inundated” reach linking each tributary to the centerline of Lake Roosevelt. These inundated reaches are used in EDT to represent littoral and limnetic habitats used for reservoir rearing.

The out-of-basin components of the EDT model include the main body of Lake Roosevelt offshore of the “inundated” reaches from the international border to Grand Coulee Dam, Rufus Woods Lake, the Columbia River migratory corridor (including mainstem dams), the Columbia River Estuary, and the Pacific Ocean.

2.2.1 In-Basin Analysis Parameters

In-basin parameters include the habitat scenarios used in the reintroduction analysis and critical assumptions about the status of manmade and natural passage obstructions.

Watershed Habitat Scenarios

The EDT habitat scenario used in the STFAP anadromous reintroduction analysis is an approximation of current habitat conditions based on a compilation of available and appropriate data and information for the study area (see Section 2.1.2). ICF generated EDT performance reports for the current conditions scenarios, with the current conditions scenario modified using the manmade barrier assumptions described below.

Several EDT model attributes were not included in this analysis of current habitat conditions due to a general lack of suitable data and information. As a consequence, the model may overestimate habitat performance in certain locations. A summary of critical data gaps is provided in Section 4.

It is also important to note that this analysis does not present the full potential of the habitat that may be expected following habitat restoration actions. Populating the EDT model with more current and comprehensive data with sufficient geographic representation would remedy both of these caveats; improving the robustness of the current conditions assessment as well as depict the potential of restored habitats.

Manmade and Natural Barrier Assumptions

ICF and the STFAP assumed for the purpose of this analysis that all manmade barriers in the study area, with the exception of the mainstem dams on the Spokane River, have been removed or modified as needed to provide uninhibited passage of adult and juvenile salmonids. This includes culverts, weirs, small dams and other manmade obstructions[12]. The assumption was applied in the CCT anadromous reintroduction analysis and is consistent with hierarchical habitat restoration theory and practice in the Upper Columbia Region.

ICF and STFAP applied the Biological Opinion (NMFS 2008) fish passage assumption to Little Falls Dam, Long Lake Dam, and Nine Mile Dam on the Spokane River mainstem hydroelectric projects as described in Section 2.2.2.

2.2.2 Out-of-Basin Assumptions

The EDT model uses two sets of input parameters to calculate life stage survival in the mainstem Columbia River migratory corridor and Pacific Ocean. Performance Values are reach-specific monthly life stage survival parameters assigned to habitat reaches in the mainstem migratory corridor and ocean. Obstruction ratings are structure-specific monthly life stage survival values assigned to each individual Columbia River mainstem dam.

ICF and STFAP used the same mainstem and ocean survival assumptions developed for the CCT anadromous reintroduction analysis (ICF 2017). These assumptions apply to Lake Roosevelt, the Columbia River mainstem downstream to Wells Dam, the Columbia River from Wells Dam to McNary Dam, the Columbia River from McNary Dam to Bonneville Dam, and ocean survival based on comparison to smolt-to-adult return (SAR) rates measured at Bonneville Dam. These assumptions are described in the following sections.

Grand Coulee and Chief Joseph Dam Passage Scenarios

ICF applied three different sets of assumptions about Grand Coulee Dam and Chief Joseph Dam passage survival to evaluate reintroduction potential. These scenarios use the following passage survival rates for juvenile migrants moving downstream and adult migrants moving upstream:

- Biological opinion (BiOp) survival (NMFS 2008): 95% juvenile downstream, 98% adult upstream survival at each dam
- Moderate survival: 90% juvenile downstream, 97% adult upstream survival at each dam
- Low survival: 85% juvenile downstream, 95% adult upstream survival at each dam

The BiOP survival assumption is consistent with Federal Columbia River Power System biological opinion survival standards for other federally-operated dams on the Columbia River mainstem (NMFS 2008). The moderate and low survival assumptions are provided to evaluate habitat suitability at survival rates below BiOP standards. Migrant survival in the remainder of the Columbia River mainstem have been calibrated to match observed survival rates as described in the following section.

Columbia River Mainstem Survival Assumptions

ICF calibrated EDT juvenile and adult migrant survival values in each major segment of the Columbia River migratory corridor to match available observations by species and age class. The general objective of this approach was to produce EDT-estimated survival rates in each migratory

[12] The fish passage barrier data set used in the intrinsic potential analysis was compiled from 11 different data sets, as documented by Giorgi (2017).

corridor segment and Pacific Ocean SARs that are at least within the range of recent observations, and ideally within the standard error or confidence interval around the arithmetic mean of these observations. Various data sources were used, with emphasis placed on survival rates observed after 2008 when the Federal Columbia River Power System (FCRPS) implemented significant operational changes to improve migratory survival. A detailed summary of out of basin survival calibration parameters and associated data sources is provided in Appendix A.

In some cases multiple references were available that reported different observed survival values in a given migration corridor segment during the same time period, reflecting differing interpretations of the available data by the reference authors. In those cases we deferred to the judgment of the consulting expert we used to compile the survival data.[13]

Lake Roosevelt to Wells Dam Segment

The STAFP anadromous reintroduction analysis assumed that juvenile and adult survival in the Lake Roosevelt to Wells Dam segment of the migration corridor assume that mortality rates/km will be approximately 2-3 times higher than those observed in the mainstem segment extending from Wells Dam to McNary Dam (WLS to MCN). STFAP is using the same survival assumptions applied in the CCT anadromous reintroduction analysis to ensure consistency between the two approaches and allow for direct comparison of results.

The mortality rate/km was developed for the CCT analysis by comparing the EDT estimated mortality in the Lake Roosevelt to WLS segment beginning at the mouth of the Sanpoil Arm to the WLS to MCN segment. The former is approximately 148 km in length, the latter is approximately 360 km in length. Mortality rates in the WLS to MCN segment are calibrated to observed survival, as documented in the following section. EDT survival parameters were calibrated to produce approximately equivalent mortality in these two segments. The resulting morality rate/km in the Lake Roosevelt to WLS segment between 2 and 3 times higher than the rate in the WLS to MCN segment. The STFAP anadromous reintroduction analysis assumes the same mortality rate/km applied throughout the entire Lake Roosevelt migratory corridor. Migrants from the Spokane River experience an additional 39 km of exposure at the same mortality rate/km compared Sanpoil migrants. Migrants from Deep Creek near the Canadian border experience the same mortality rate over an additional 104 km of migratory corridor. The STFAP have concluded that these mortality rate estimates are likely to be high, therefore the resulting habitat suitability estimates are likely to underestimate habitat potential.

EDT juvenile survival rates and mortality rates/km applied in the CCT and STFAP analyses are summarized by species in Table 2-12. As shown, the mortality rates/km in the Lake Roosevelt to WLS segment are approximately 2 to 3 times the calibrated EDT rates in the WLS to MCN segment. Calibrated EDT survival rates and mortality rates/km for adult migrants in the WLS to Lake Roosevelt segment are summarized by species in Table 2-13. As shown, adult survival between the MCN to WLS and WLS to Lake Roosevelt segments are generally similar.

The iterated survival rates/km for EDT reach Lake Roosevelt 1 (between the Sanpoil Arm and Grand Coulee Dam) were applied to the remainder of the Lake Roosevelt from the Sanpoil Arm to the international border. The survival of migrating juveniles is a function of exposure time as determined by travel distance and migration speed of individual EDT life history trajectories.

[13] Charles Peven compiled mainstem survival data for the CCT anadromous reintroduction analysis. The same mainstem survival values are used in this analysis.

Table 2-12. Calibrated EDT juvenile migrant survival rates in the Lake Roosevelt to WLS and WLS to MCN mainstem segments.

Species	Migrant Age	Lake Roosevelt to WLS		WLS to MCN	
		Survival Rate	Mortality Rate/km	Survival Rate	Mortality Rate/km
Steelhead	1-3	0.623	0.0025	0.607	0.0011
Summer/Fall Chinook	0-1	0.560	0.0030	0.539	0.0013
Spring Chinook	1	0.595	0.0027	0.642	0.0010

Table 2-13. Calibrated EDT adult migrant survival rates in the WLS to Lake Roosevelt and MCN to WLS mainstem segments.

Species	WLS to Lake Roosevelt		MCN to WLS	
	Survival Rate	Mortality Rate/km	Survival Rate	Mortality Rate/km
Steelhead	0.958	0.00028	0.945	0.00015
Summer/Fall Chinook	0.954	0.00031	0.944	0.00016
Spring Chinook	0.947	0.00036	0.952	0.00013

Wells Dam to McNary Dam Segment

Comparisons of calibrated EDT survival rates to observed juvenile and adult survivals in the WLS to MCN segment are provided in Tables 2-14 and 2-15, respectively. EDT survival rates were calculated for relevant portions of the WLS to MCN segment to match the available data observations by species. These migration corridor segments were selected for comparison because they had the most reliable survival information for the identified species and life stage. EDT survival rates in each segment were iterated to match with observed survival rates, with the objective of that fall within the observed rage and ideally within the standard error of the mean of observations where practicable. The survival rates in each segment are combined to produce overall smolt to adult return (SAR) rate that is comparable to recent observations, as described in the following sections.

As shown in Table 2-14, EDT juvenile survival rates fell within the standard error and/or the range of recent observations in all cases with the exception of spring Chinook migrants in the RRE TLRC to MCN segment. Notably however, the observations used for comparison, were collected from 1999-2000 and predate operational changes implemented by the FCRPS and county public utility districts to increase juvenile migration survival. Therefore the more recent observations were used to validate EDT model calibration. In the case of adult survivals, the reference sources used for this analysis provided only the mean of observations and did not report the range or standard deviation metrics (see Appendix A).

Table 2-14. Comparison of calibrated EDT juvenile migrant survival rates to observed survival rates for selected sections of the WLS to MCN mainstem segment.

Species	Mainstem Portion of WLS to MCN Segment	EDT Survival Rate	Observed Survival Rates			
			Mean	Standard Error	Range	Period
Steelhead	WLS RES to WLS TLRC	0.950	0.945	***0.015***	0.943-0.946	1999-2000
	RIS to MCN	0.703	0.609	0.010	***0.499-0.739***	2009-2015
Summer/Fall Chinook	RIS to MCN	0.659	0.561	0.0585	***0.219-0.891***	2009-2015
	WLS RES to MCN	0.528	0.322	0.0438	0.247-0.527	2008-2014
	PRD to MCN	0.804	0.673	0.0801	***0.500-0.820***	2008-2014
Spring Chinook	RIS to MCN	0.753	0.667	0.0191	***0.489-0.935***	2009-2015
	RRE TLRC to RIS TLRC	0.933	0.942	***0.0157***	0.897-0.973	2000-2010
	RRE TLRC to MCN	0.730	0.671	0.0105	0.656-0.686	1999-2000

Table 2-15. Comparison of calibrated EDT adult migrant survival rates to observed survival rates for selected sections of the WLS to MCN mainstem segment.

Species	Mainstem Segment	EDT Value	Observed Survival Rates			
			Mean	Standard Error	Range	Period
Spring Chinook	MCN to WLS	0.926	≥0.95	NR	NR	2012-2015
	PRD to WLS	0.948	0.920	NR	NR	2003-2010
	RRE to WLS	0.979	0.986	NR	NR	2015
Summer/Fall Chinook	MCN to WLS	0.946	≥0.95	NR	NR	2015
Spring Chinook	MCN to WLS	0.960	≥0.95	NR	NR	2015
	PRD to WLS	0.972	0.956	NR	NR	2003-2010
	RRE to WLS	0.989	1.000	NR	NR	2015

NR = Not reported

McNary Dam to Bonneville Dam Segment

Comparisons of calibrated EDT survival rates to observed juvenile and adult survival in the MCN to BON segment are provided in Tables 2-16 and 2-17, respectively. As shown, all EDT juvenile survival rates are within the standard error of the mean and/or the range of observed values in this segment. All EDT adult survival rates are within the standard error of the mean of recent observations.

Table 2-16. Comparison of calibrated EDT juvenile migrant survival rates to observed survival rates in the MCN to BON mainstem segment.

Species	EDT Value	Observed Survival Rates			
		Mean	Standard Error	Range	Period
Steelhead	0.747	0.724	***0.090***	0.487-1.069	2009-2015
		0.795	0.016	***0.587-0.958***	2009-2015
Summer/Fall Chinook	0.699	0.649	0.038	***0.621-0.743***	2009-2013
Spring Chinook	0.758	0.835	***0.092***	0.626-1.056	2008-2015

Table 2-17. Comparison of calibrated EDT adult migrant survival rates to observed survival rates in the BOA to MCN mainstem segment.

Species	EDT Value	Observed Survival Rates			
		Mean	Standard Error	Range	Period
Steelhead	0.909	0.901	***0.074***	0.733-0.981	2008-2015
		0.893	***0.049***	0.823-0.977	
Summer/Fall Chinook	0.926	0.947	***0.065***	0.896-1.00	2008-2015
Spring Chinook	0.941	0.966	***0.033***	0.909-1.00	2008-2015
		0.938	***0.063***	0.876-1.00	

Ocean Survival – Smolt-to-Adult Return Rates

ICF alibrated EDT ocean survival and adult migratory for steelhead, summer/fall Chinook, and spring Chinook using available SAR data for Upper Columbia River populations. Ocean rearing and adult migratory corridor survival rates were combined with the juvenile survival rates described in the previous sections to produce overall SAR values suitable for comparison to available observations. In general, the most reliable SAR values for Upper Columbia salmonid populations are measured from juvenile migration past one of the upriver dams, specifically McNary, Rock Island or Rocky Reach, to adult return rates measured at the Bonneville Dam fish ladder. EDT SAR values were compared to observed SAR values, emphasizing the highest-confidence observations over the period from 2008 to 2015 where available. As shown in Table 2-18, the calibrated EDT SARs are within the 90% confidence interval of the arithmetic mean and/or the range of recent observations used in this analysis. Documentation and references for the information sources used to calibrate EDT model SAR values are provided in Appendix A.

Table 2-18. Comparison of EDT Smolt-to-Adult Return (SAR) values to observed SARs for Upper Columbia River populations of steelhead, summer/fall Chinook and spring Chinook.

Species	Segment	Calibrated EDT SAR	Observed Survival Calibration Metric			
			Mean	90% CI of Mean	Range	Period
Steelhead	BON to BOA	0.040	--	--	--	--
	MCN to BOA	**0.030**	0.041	**0.029-0.053**	0.013-0.067	2006-2012

	RRE to BOA	**0.020**	0.027	**0.019-0.036**	0.009-0.048	2008-2012
Summer/Fall Chinook	BON to BOA	0.046	--	--	--	--
	MCN to BOA	**0.032**	0.021	0.018-0.026	**0.012-0.041**	2011-2013
	RIS to BOA	**0.021**	0.012	0.010-0.015	**0.006-0.021**	2009-2013
Spring Chinook	BON to BOA	0.036	--	--	--	--
	MCN to BOA	**0.025**	0.019	0.013-0.024	**0.006-0.028**	2009-2014

2.3 Results Reporting

The anadromous reintroduction analysis results are reported using two related types of EDT model outputs, standard performance report metrics and a customized set of life stage and location integration metrics generated using new EDT3 model features developed by ICF in conjunction with this project. These reporting metrics are described in detail below.

All anadromous reintroduction analysis results are summarized at the subbasin and HUC 10 watershed scale as described in Section 1.2.

2.3.1 EDT Performance Report Metrics

The anadromous reintroduction analysis results were developed by generating EDT performance reports for the current conditions habitat scenario under each Grand Coulee and Chief Joseph dam passage scenario. A template condition scenario was not developed for this analysis, but may be in the future.

The performance report is the primary set of habitat performance metrics generated by the EDT model. Performance report results are specific to the habitat scenario selected for analysis, current conditions as best characterized by the data available. Performance metrics for this focal habitat scenario include:

- Habitat capacity – Theoretical maximum number of adults that can be supported by the available habitat, based on the integration of habitat quantity under the selected habitat scenario with life stage-specific density benchmarks and habitat affinity rules across all life stages
- Productivity – Density-independent productivity based on the conditions present under the selected habitat scenario
- Equilibrium abundance – The theoretical population size that can be supported by the selected habitat scenario, calculated from life stage capacity and productivity using recursive properties of the Beverton-Holt equation
- Diversity – An index of life history diversity under the selected habitat scenario based on the proportion of EDT life history trajectories that have a productivity greater than 1 (i.e. are self-sustaining)

2.3.2 EDT Life Stage and Location Integration Metrics

ICF developed a new set of EDT results metrics to support the anadromous reintroduction analysis. ICF coded new life stage and location integration features into the EDT3 Report Generator that allows the user to generate customized life stage survival results at any location in the focal watershed and the Columbia Basin migratory corridor. These new features were used to calibrate the out of basin survival parameters used in both the CCT and STFAP anadromous reintroduction analyses and to generate the following in-basin life stage survival metrics presented in this report:

- Egg-to-parr survival – Juvenile survival from the beginning of egg incubation through the end of active rearing in October (i.e. end of the EDT 0-age resident rearing life stage)
- Parr-to-smolt survival – Juvenile survival from the end of the first summer through emigration (i.e. beginning of the EDT 0-age inactive rearing life stage through to the point when migrant juveniles pass through the inundated arm of their natal tributary and enter the main body of Lake Roosevelt)
- Prespawn adult survival – In-basin survival of prespawn holding adults

These new EDT reporting metrics represent a valuable addition to the suite of tools and capabilities available to resource managers in the Upper Columbia region. The life stage survival metrics will allow for direct comparison of EDT model and WDFW/NMFS life cycle model outputs, and the use of EDT outputs as life cycle model inputs. This increased compatibility will make it easier to conduct complimentary model analyses supporting species conservation and recovery objectives in the region.

Section 3
Anadromous Reintroduction Analysis Results

This section presents the results of the EDT anadromous reintroduction analysis for summer steelhead, summer/fall Chinook and spring Chinook in the Spokane River and FDRL Tributaries. Two sets of EDT model results are provided as follows (see Section 2.3 for definitions):

- Standard EDT performance report metrics for each Grand Coulee and Chief Joseph dam passage scenarios under current habitat conditions, including:
    - Habitat capacity
    - Productivity
    - Equilibrium abundance
    - Diversity
- Life stage survival metrics calculated using the BiOp survival Grand Coulee and Chief Joseph dam passage scenario, including:
    - Egg-to-parr: Survival from the beginning of incubation (end of the EDT spawning life stage) to the end of the first summer (end of the EDT 0-age resident rearing life stage)
    - Parr-to-smolt: Survival from the end of the first summer (end of the EDT 0-age resident rearing life stage) to outmigrant smolt migration
    - Prespawn adult: Survival from prespawn migrant adult entry into Lake Roosevelt migratory and holding habitat to the beginning of spawning, including prespawn holding

The standard EDT performance report metrics are summarized by species in the following sections. The life stage survival metrics are summarized in Appendix B as referenced below. All EDT model results are summarized at the basin and reporting subbasin and HUC10 watershed scale as described in Section 1.2.

3.1 Summer Steelhead Reintroduction Potential

EDT model results indicate moderate potential for steelhead reintroduction in the study area under current habitat conditions, with the Spokane River and its tributaries accounting for the majority of suitable habitat. EDT habitat performance results for the Spokane River and FDRL Tributaries are summarized in Tables 3-1 and 3-2, respectively.

Adult abundance estimates for the Spokane range from 824 to 1,213 adult steelhead under current habitat conditions, depending on Grand Coulee/Chief Joseph passage scenario (Table 3-1). The FDRL Tributaries could potentially support a return of approximately 54 to 81 adult steelhead (Table 3-2). These results suggest that the Spokane Basin could support a viable steelhead population under current habitat conditions if access to and within the blocked area were restored. While current habitat potential is likely overestimated, the habitat capacity and equilibrium abundance results are sufficiently large to indicate viable habitat potential even when additional limiting factors are considered. [14]

Reintroduction potential is less clear in the FDRL Tributaries. These streams are widely dispersed and the equilibrium abundance estimates for each individual stream are small, ranging from 1 to 18 adults. Individually these results suggest these systems could not maintain independent populations. However, when viewed in combination with the other systems in vicinity, including historically accessible tributaries on the Colville Reservation and in the Kettle River system, these streams could provide important habitat from a metapopulation perspective. Metapopulation-based structures are likely to occur in anadromous fish species (Schtickzelle and Quinn 2007). While the specific dynamics of salmonid metapopulations remain poorly understood (Rieman and Dunham 2000), their existence is supported by direct observation and mathematical theory (Schtickzelle and Quinn 2007; Yeakel et al. 2018). Moreover, potential metapopulation structure has been observed across networks of stream systems with broader geographic separation. Therefore the FDRL Tributaries should be viewed as a potential complex of available habitat rather than individual, isolated systems when assessing suitability for reintroduction.

Life stage survival metrics for the Spokane Basin and FDRL Tributaries are summarized by analysis watershed in Appendix B, Tables B-1 and B-2, respectively. Egg-to-parr survival rates averaged across all populations in the study area range from 3.8% to as high as 11.5% depending on location and life history strategy (Tables B-1 and B-2). Survival rates for individual subpopulations can vary more broadly, reaching as high as 30%. Parr-to-smolt survival rates in the study area range from 51.2-63.7%, varying by age at migration and rearing strategy (Tables B-1 and B-2). The distribution of survival rates across life history strategies reflects age at migration and residence time in watershed habitats. In general, the parr-to-smolt survival decreases with age at emigration, reflecting the cumulative effects of each additional year of exposure to rearing habitat conditions. In-basin survival of prespawn adult steelhead falls consistently near 92% in the majority of the Spokane system, with the exception of Middle and Upper Hangman Creek (>86.4%; Table B-1). Adult survival estimates are similarly high in the FDRL Tributaries, ranging from 90-94% (Table B-2).

These results are preliminary and subject to change as habitat input parameters are refined in future analysis. Egg-to-parr and parr-to-smolt survival estimates are likely biased high because several key habitat attributes could not be parameterized due to a lack of available data. Certain life stage survival results for the FDRL Tributaries may also be skewed high because some streams are represented by a small number of life history trajectories. [15]

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14 Several Spokane EDT model habitat attributes could not be parameterized due to lack of available data, therefore these attributes had no effect on the model results. Current habitat performance is likely overestimated as a consequence. However, current habitat performance is sufficiently large that viable reintroduction potential remains even when additional limiting factors are considered.

15 For example, the egg-to-parr survival rate for the age-3 smolt, stayer-type life history strategy in Magee Creek is 30.2% (Table B-2). However this stream has only 0.58 km of available habitat and this rearing strategy is represented by only two life history trajectories. One highly successful trajectory is dominating the life stage survival results. The net effect of this trajectory on overall habitat performance is trivial because this stream has negligible habitat capacity for steelhead. The integrated *All Subpopulation* results factor the contribution of all life history trajectories across all subwatersheds.

Table 3-1. Theoretical Spokane River summer steelhead potential under current conditions based on three hypothetical passage survival scenarios at Chief Joseph and Grand Coulee Dams.

Passage Scenario	Subpopulation	EDT Performance Metric by Watershed Habitat Scenario			
		Diversity	Productivity	Capacity	Equilibrium Abundance
BiOp	**All Subpopulations**	**18.4%**	**2.4**	**2064**	**1213**
	Spokane Mainstem & Tributaries	36.5%	2.6	600	365
	Little Spokane Lower	31.1%	2.4	598	348
	Little Spokane Dragoon	25.0%	2.8	209	133
	Little Spokane Upper	18.0%	2.3	97	55
	Hangman Lower	12.0%	2.2	180	99
	Hangman Middle	2.6%	2.0	230	114
	Hangman Upper	3.5%	1.7	89	38
Moderate	**All Subpopulations**	**15.6%**	**2.3**	**1816**	**1019**
	Spokane Mainstem & Tributaries	30.9%	2.4	528	308
	Little Spokane Lower	26.9%	2.2	526	291
	Little Spokane Dragoon	22.1%	2.6	184	113
	Little Spokane Upper	14.3%	2.2	86	46
	Hangman Lower	9.4%	2.1	159	83
	Hangman Middle	2.0%	1.9	202	96
	Hangman Upper	2.6%	1.7	78	31
Low	**All Subpopulations**	**12.6%**	**2.1**	**1555**	**824**
	Spokane Mainstem & Tributaries	25.6%	2.2	452	250
	Little Spokane Lower	21.8%	2.1	451	235
	Little Spokane Dragoon	17.9%	2.5	157	93
	Little Spokane Upper	11.9%	2.0	73	38
	Hangman Lower	7.2%	2.0	136	67
	Hangman Middle	1.5%	1.8	173	76
	Hangman Upper	1.7%	1.6	67	26

Passage Scenario: Grand Coulee Dam and Chief Joseph Dam passage assumptions.
BiOp = 95% juvenile downstream/98% adult upstream survival at each dam
Moderate = 90%/97% juvenile/adult survival at each dam
Low = 85%/95% juvenile/adult survival at each dam

Table 3-2. Theoretical FDRL Tributary summer steelhead potential under current conditions based on three hypothetical passage survival scenarios at Chief Joseph and Grand Coulee Dams.

Passage Scenario	Subpopulation	EDT Performance Metric by Watershed Habitat Scenario			
		Diversity	Productivity	Capacity	Equilibrium Abundance
BiOp	**All Subpopulations**	**25.8%**	**2.3**	**145**	**81**
	FDRL - Harvey Creek	11.8%	1.9	38	18
	FDRL - Stranger Creek	45.5%	2.6	4	2
	FDRL - Magee Creek	42.9%	2.1	1	1
	FDRL - Cheweka Creek	50.3%	2.4	19	11
	FDRL - Quillisascut Creek	30.2%	2.4	15	9
	FDRL - Colville River	13.9%	2.4	25	15
	FDRL - China Creek	31.7%	2.2	10	5
	FDRL - Onion Creek	52.0%	2.6	8	5
	FDRL - Deep Creek	32.7%	1.9	24	11
Moderate	**All Subpopulations**	**21.2%**	**2.1**	**128**	**68**
	FDRL - Harvey Creek	10.0%	1.8	34	15
	FDRL - Stranger Creek	38.2%	2.4	3	2
	FDRL - Magee Creek	38.1%	1.9	1	1
	FDRL - Cheweka Creek	41.1%	2.2	17	9
	FDRL - Quillisascut Creek	25.0%	2.3	13	8
	FDRL - Colville River	11.5%	2.3	22	12
	FDRL - China Creek	24.4%	2.0	9	4
	FDRL - Onion Creek	38.7%	2.4	7	4
	FDRL - Deep Creek	27.3%	1.7	21	9
Low	**All Subpopulations**	**15.6%**	**2.0**	**109**	**54**
	FDRL - Harvey Creek	6.2%	1.7	29	11
	FDRL - Stranger Creek	25.5%	2.2	3	1
	FDRL - Magee Creek	33.3%	1.7	1	0
	FDRL - Cheweka Creek	33.6%	2.0	14	7
	FDRL - Quillisascut Creek	19.4%	2.1	11	6
	FDRL - Colville River	8.7%	2.1	19	10
	FDRL - China Creek	15.4%	1.8	7	3
	FDRL - Onion Creek	25.3%	2.3	6	4
	FDRL - Deep Creek	22.7%	1.6	18	6

Passage Scenario: Grand Coulee Dam and Chief Joseph Dam passage assumptions.
BiOp = 95% juvenile downstream/98% adult upstream survival at each dam
Moderate = 90%/97% juvenile/adult survival at each dam
Low = 85%/95% juvenile/adult survival at each dam

3.2 Summer/Fall Chinook Reintroduction Potential

EDT habitat performance results for summer/fall Chinook reintroduction in the Spokane River are summarized in Table 3-3. These results indicate strong potential for establishing a substantial population of summer/fall Chinook in the Spokane River and its tributaries. The model estimated that under current conditions the Spokane basin could support a return of 4634 to 6729 summer/fall Chinook salmon depending on Grand Coulee/Chief Joseph passage scenario (Table 3-3). The mainstem Spokane River between Hangman Creek and Nine Mile Dam, the lower Little Spokane River, and lower and middle Hangman Creek have the greatest habitat potential. These results indicate strong reintroduction potential with restoration of fish passage to and within the blocked area.

The FDRL Tributaries could support an additional 185 to 275 adult summer/fall Chinook, with the majority of production in the Colville River (Table 3-4). Habitat suitability for summer/fall Chinook is not as clear in the smaller tributary streams. These streams have relatively limited accessible habitat that, when viewed in isolation, are unlikely to sustain a viable population over the long-term. As discussed in the previous section however, it may be more appropriate to view these streams as part of a complex of habitats used by a broader metapopulation. In this context, the potential for these individual streams to support even limited spawning and rearing during periods of high abundance could provide an important contribution to metapopulation resilience. Summer/fall Chinook life stage survival metrics for the Spokane Basin and FDRL Tributaries are summarized by analysis watershed in Appendix B, Tables B-3 and B-4, respectively. Egg-to-parr survival ranges in the Spokane Basin range from 7.3% to 11.6% depending on analysis watershed and life history strategy (Table B-3). Egg-to-parr survival in the FDRL tributaries is similar, ranging from 6.5% to 13.5%. Stream-type and reservoir type life histories fared poorly, with none surviving to the parr stage.

Parr-to-smolt survival for ocean-type Chinook (i.e. 0-age migrants) are generally high, approximately 81% in the Spokane system and approaching 100% in the FDRL Tributaries (Tables B-3 and B-4, respectively). These high survival rates reflect the short amount of time 0-age migrants spend in the system. The majority of ocean-type Chinook trajectories emigrate to the reservoir migratory corridor less than a month after fry colonization. Shorter migration distances equate to higher survival rates. Parr-to-smolt survival rates for reservoir-type smolts range 0% to 57.6%, or 57.5% averaged across the entire population (Table B-3). Two of seven Spokane Basin reporting watersheds produce no reservoir-type smolts. The FDRL Tributaries produce relatively few reservoir-type Chinook from just one reporting watershed (Table B-4). This is likely due to this life history form being represented by a small number of trajectories in each stream that were not successful. Only four of seven Spokane Basin reporting watersheds produce stream-type summer/fall Chinook. Parr-to-smolt survival for those watersheds ranges from 35 to 47%. The lower juvenile survival rate is consistent with the increased exposure to tributary rearing habitats.

Prespawn adult summer/fall Chinook survival in the Spokane system ranges from 70% to 79% by life history form when integrated across all subpopulations (Table B-4). Prespawn adult survival in the FDRL Tributaries ranges from 64% to 74%, with the majority of watershed supporting 73-74% survival (Table B4).

Table 3-3. Theoretical Spokane River summer/fall Chinook performance under current conditions based on three hypothetical passage survival scenarios at Chief Joseph and Grand Coulee Dams.

Passage Scenario	Subpopulation	EDT Performance Metric by Watershed Habitat Scenario			
		Diversity	Productivity	Capacity	Equilibrium Abundance
BiOp	**All Subpopulations**	**60.6%**	**3.4**	**9535**	**6729**
	Spokane Mainstem & Tributaries	81.2%	3.5	2130	1529
	Little Spokane Lower	67.4%	3.6	2603	1881
	Little Spokane Dragoon	65.7%	3.6	756	546
	Little Spokane Upper	72.0%	2.6	440	268
	Hangman Lower	83.7%	3.2	1126	778
	Hangman Middle	45.4%	2.9	2022	1334
	Hangman Upper	4.3%	1.7	459	191
Moderate	**All Subpopulations**	**57.0%**	**3.1**	**8451**	**5707**
	Spokane Mainstem & Tributaries	81.1%	3.2	1890	1293
	Little Spokane Lower	63.5%	3.3	2316	1610
	Little Spokane Dragoon	59.3%	3.3	668	465
	Little Spokane Upper	65.7%	2.4	390	227
	Hangman Lower	81.7%	2.9	996	655
	Hangman Middle	40.1%	2.7	1787	1125
	Hangman Upper	3.1%	1.6	405	156
Low	**All Subpopulations**	**52.4%**	**2.7**	**7291**	**4634**
	Spokane Mainstem & Tributaries	80.8%	2.8	1633	1044
	Little Spokane Lower	58.3%	2.9	2006	1321
	Little Spokane Dragoon	53.6%	2.9	574	380
	Little Spokane Upper	50.3%	2.2	335	184
	Hangman Lower	77.3%	2.6	858	528
	Hangman Middle	33.7%	2.4	1537	907
	Hangman Upper	2.0%	1.5	347	122

Passage Scenario: Grand Coulee Dam and Chief Joseph Dam passage assumptions.
BiOp = 95% juvenile downstream/98% adult upstream survival at each dam
Moderate = 90%/97% juvenile/adult survival at each dam
Low = 85%/95% juvenile/adult survival at each dam

Table 3-4. Theoretical FDRL Tributary summer/fall Chinook performance under current conditions based on three hypothetical passage survival scenarios at Chief Joseph and Grand Coulee Dams.

Passage Scenario	Subpopulation	EDT Performance Metric by Watershed Habitat Scenario			
		Diversity	Productivity	Capacity	Equilibrium Abundance
BiOp	**All Subpopulations**	**70.2%**	**3.3**	**397**	**275**
	FDRL - Harvey Creek	43.8%	2.8	47	30
	FDRL - Colville River	85.7%	3.5	202	145
	FDRL - China Creek	70.9%	2.5	32	19
	FDRL - Onion Creek	84.1%	3.0	31	21
	FDRL - Deep Creek	87.6%	3.0	85	56
Moderate	**All Subpopulations**	**67.5%**	**2.9**	**351**	**231**
	FDRL - Harvey Creek	37.0%	2.6	42	25
	FDRL - Colville River	85.7%	3.1	179	122
	FDRL - China Creek	67.7%	2.3	28	16
	FDRL - Onion Creek	84.1%	2.7	28	17
	FDRL - Deep Creek	87.6%	2.7	75	47
Low	**All Subpopulations**	**64.8%**	**2.6**	**303**	**185**
	FDRL - Harvey Creek	30.8%	2.4	36	21
	FDRL - Colville River	85.7%	2.7	154	98
	FDRL - China Creek	62.8%	2.1	24	13
	FDRL - Onion Creek	83.6%	2.4	24	14
	FDRL - Deep Creek	85.7%	2.4	64	38

Passage Scenario: Grand Coulee Dam and Chief Joseph Dam passage assumptions.
BiOp = 95% juvenile downstream/98% adult upstream survival at each dam
Moderate = 90%/97% juvenile/adult survival at each dam
Low = 85%/95% juvenile/adult survival at each dam

3.3 Spring Chinook Reintroduction Potential

EDT model results indicate modest habitat for spring Chinook reintroduction in the study area under current conditions. Estimated equilibrium abundance in the Spokane River ranges from 184 to 246 adult spawners in the Spokane River depending on the Grand Coulee/Chief Joseph passage scenario (Table 3-5). The majority of production comes from the Mainstem Spokane River & tributaries, Little Spokane Lower, Little Spokane Dragoon, and Hangman Lower watersheds. Little Spokane Upper and the remainder of Hangman Creek have limited habitat potential under the current habitat assumptions.

The FDRL Tributaries have minimal habitats for spring Chinook, with estimated equilibrium abundance ranging from zero to 8 adult spawners by reporting watershed, or a potential maximum of 17 adults total across the entire reporting area (Table 3-6). These results suggest that these habitats may be able to support spring Chinook during periods of high productivity. As discussed previously for steelhead and summer/fall Chinook, these findings suggest that these tributary streams could provide important habitat for metapopulation resilience when viewed in combination with the other accessible tributary habitats to Lake Roosevelt.

EDT-estimated spring Chinook life stage survival rates for the Spokane River and FDRL Tributaries are summarized in Appendix B, Tables B-5 and B-6, respectively. As shown in Table B-5, egg-to-parr survival in the Spokane ranges from 9.9% to 15.4% depending on watershed of origin and life history strategy. Survival rates in the FDRL Tributaries range from 11.5% to as high as 20.8% (Table B-6), with the caveat that these results are based on the performance of a small number of successful life history trajectories.

Parr-to-smolt survival rates vary by spawning location and rearing strategy, with reservoir-rearing juveniles generally surviving at a higher rate than stayer-type juveniles that rear in proximity to their natal reaches. Parr-to-smolt survival for Spokane River spring Chinook ranges from 39.9% to 49.9% (Table B-5), while survival rates in the FDRL Tributaries varied more broadly from 37.9 to 56.9% (Table B-6).

Prespawn adult survival rates in the Spokane Basin are generally comparable to those for summer/fall Chinook, ranging from 69.7% to 73.9% when integrated across all subpopulations (Table B-5). Prespawn adult survival in the FRDL Tributaries was generally similar, ranging from 68.8% to 78.9% integrated across all subpopulations (Table B-6).

Table 3-5. Theoretical Spokane River spring Chinook performance under current conditions based on three hypothetical passage survival scenarios at Chief Joseph and Grand Coulee Dams.

Passage Scenario	Subpopulation	EDT Performance Metric by Watershed Habitat Scenario			
		Diversity	Productivity	Capacity	Equilibrium Abundance
BiOp	**All Subpopulations**	**1.4%**	**1.8**	**543**	**246**
	Spokane Mainstem & Tributaries	2.3%	1.8	153	68
	Little Spokane Lower	2.4%	1.9	119	56
	Little Spokane Dragoon	3.2%	1.9	53	25
	Little Spokane Upper	0.3%	1.5	19	6
	Hangman Lower	0.4%	1.8	69	31
	Hangman Middle	0.2%	1.1	98	11
	Hangman Upper	0.0%	0.0	33	0
Moderate	**All Subpopulations**	**1.0%**	**1.7**	**476**	**198**
	Spokane Mainstem & Tributaries	1.8%	1.7	134	54
	Little Spokane Lower	1.4%	1.8	105	46
	Little Spokane Dragoon	2.3%	1.7	46	20
	Little Spokane Upper	0.3%	1.3	16	4
	Hangman Lower	0.3%	1.6	60	23
	Hangman Middle	0.1%	1.0	86	2
	Hangman Upper	0.0%	0.0	29	0
Low	**All Subpopulations**	**0.6%**	**1.6**	**407**	**148**
	Spokane Mainstem & Tributaries	1.3%	1.6	115	41
	Little Spokane Lower	0.8%	1.6	90	35
	Little Spokane Dragoon	1.7%	1.6	40	14
	Little Spokane Upper	0.3%	1.1	14	1
	Hangman Lower	0.3%	1.4	52	15
	Hangman Middle	0.0%	0.0	73	0
	Hangman Upper	0.0%	0.0	24	0

Passage Scenario: Grand Coulee Dam and Chief Joseph Dam passage assumptions.
BiOp = 95% juvenile downstream/98% adult upstream survival at each dam
Moderate = 90%/97% juvenile/adult survival at each dam
Low = 85%/95% juvenile/adult survival at each dam

Table 3-6. Theoretical FDRL Tributary spring Chinook performance under current conditions based on three hypothetical passage survival scenarios at Chief Joseph and Grand Coulee Dams.

Passage Scenario	Subpopulation	EDT Performance Metric by Watershed Habitat Scenario			
		Diversity	**Productivity**	**Capacity**	**Equilibrium Abundance**
BiOp	**All Subpopulations**	**0.7%**	**2.2**	**32**	**17**
	FDRL - Harvey Creek	0.0%	0.0	3	0
	FDRL - Colville River	1.7%	2.3	14	8
	FDRL - China Creek	0.4%	1.3	4	1
	FDRL - Onion Creek	1.7%	1.4	4	1
	FDRL - Deep Creek	0.4%	1.5	7	3
Moderate	**All Subpopulations**	**0.5%**	**2.0**	**28**	**14**
	FDRL - Harvey Creek	0.0%	0.0	3	0
	FDRL - Colville River	1.2%	2.1	13	7
	FDRL - China Creek	0.4%	1.1	3	0
	FDRL - Onion Creek	1.1%	1.3	3	1
	FDRL - Deep Creek	0.4%	1.3	6	1
Low	**All Subpopulations**	**0.4%**	**1.8**	**24**	**11**
	FDRL - Harvey Creek	0.0%	0.0	3	0
	FDRL - Colville River	0.8%	1.9	11	5
	FDRL - China Creek	0.0%	0.0	3	0
	FDRL - Onion Creek	0.6%	1.1	3	0
	FDRL - Deep Creek	0.4%	1.1	5	1

Passage Scenario: Grand Coulee Dam and Chief Joseph Dam passage assumptions.
BiOp = 95% juvenile downstream/98% adult upstream survival at each dam
Moderate = 90%/97% juvenile/adult survival at each dam
Low = 85%/95% juvenile/adult survival at each dam

Section 4
Data Quality Summary

This section summarizes the LOP ratings for the reach-level habitat attributes used in the Spokane and FDRL Tributaries EDT models. The study area is large, covering over 568,000 hectares (1.4 million acres),[16] and present systematic monitoring efforts are insufficient or restricted to specific geographies. Reach-scale habitat data useful for parameterizing EDT are available for only a small percentage of reaches in the study area.

This section summarizes LOP ratings at two scales:

- By habitat attribute and environment type
- By reporting watershed and assessment unit

Riverine and inundated reservoir habitats are distinct environment types in EDT. The model uses a different suite of input attributes to characterize habitat conditions in each environment type and applies a different rule structure to evaluate habitat performance. The LOP rating summaries are organized accordingly. Rating definitions are provided in Table 2-3.

4.1 Data Quality by Habitat Attribute and Environment Type

The availability of quantitative, reach-scale data suitable for parameterizing EDT habitat attributes varies widely across the study area and between environment types. Reservoir environments are more well represented in EDT because they are characterized using fewer habitat attributes and suitable data are more widely available.[17] Reservoir habitats in the study area have received more intensive monitoring, both as a function of existing regulatory obligations and general public interest in the protection and enhancement of fishery opportunities. In contrast, empirical data suitable for characterizing riverine habitats in EDT are limited in extent and geographically dispersed across the study area. A variety of data sources and methods were used to parameterize EDT habitat attributes. The distribution of LOP ratings by attribute type are summarized for Spokane River reservoir and riverine habitats in Tables 4-1 and 4-2, respectively. LOP ratings for FDRL Tributaries reservoir and riverine habitats are summarized in Tables 4-3 and 4-4.

ICF relied on the best-available data and information for each attribute throughout the study area. Insufficient data were available to parameterize some key attributes at appropriate scales. Some Spokane River EDT attributes could not be reliably parametrized due to a lack of suitable data and

16 EDT assessment unit boundaries cover 94,390 hectares (233,242 acres) in the FDRL Tributaries and 473,980 hectares (1,171,230)

17 Limnological data for reservoir habitats in the study area are available from the STOI limnological monitoring program and Avista Corporation water quality compliance monitoring associated for the Spokane River Hydroelectric Project.

information at appropriate spatial scales. These attributes are identified in Table 4-2, ranked by order of importance.[18]

Table 4-1. Level of Proof rating distribution by EDT habitat attribute in Spokane River inundated reservoir habitats.

Attribute Type	Habitat Attribute	Level of Proof Rating				
		1	**2**	**3**	**4**	**5**
Habitat quality	Dissolved Oxygen	82%	18%	0%	0.0%	0.0%
	Predation Risk	0%	89%	11%	0.0%	0.0%
	Temperature: Daily Maximum	31%	58%	11%	0.0%	0.0%
	Woody Debris and Vegetation	0%	100%	0%	0.0%	0.0%
Habitat quantity	Limnetic	0%	0%	100%	0.0%	0.0%
	Littoral	0%	0%	100%	0.0%	0.0%

18 Order of importance is based on model sensitivity to habitat inputs, as determined by the EDT species-habitat rules, and the availability and practicality of monitoring and assessment methods.

Table 4-2. Level of Proof rating distribution by EDT habitat attribute in Spokane River riverine habitats.

Attribute Type	Habitat Attribute	Level of Proof Rating					
		1	2	3	4	5	Rank[a]
Habitat quality	Alkalinity	0%	0%	100%	0%	0%	
	Bed scour	0%	0%	0%	0%	100%	1
	Benthic Richness	0%	0%	33%	66%	0%	
	Confinement: Artificial	0%	0%	0%	0%	100%	2
	Confinement: Natural	0%	100%	0%	0%	0%	
	Dissolved Oxygen	2%	4%	36%	21%	36%	
	Embeddedness	2%	0%	28%	69%	0%	
	Fine Sediment	2%	28%	0%	69%	0%	
	Fish Community Richness	0%	0%	0%	0%	100%	4
	Fish Pathogens	0%	0%	0%	0%	100%	4
	Fish Species Introductions	0%	0%	0%	0%	100%	4
	Flow: Inter-Annual High Flow Var.	6%	0%	94%	0%	0%	
	Flow: Inter-Annual Low Flow Var.	6%	0%	94%	0%	0%	
	Flow: Intra-Annual Variation	6%	0%	94%	0%	0%	
	Gradient	0%	100%	0%	0%	0%	
	Hatchery Fish Outplants	0%	0%	0%	0%	100%	4
	Nutrient Enrichment	0%	0%	0%	0%	100%	4
	Predation Risk	0%	0%	0%	0%	100%	4
	Riparian Function	0%	3%	97%	0%	0%	
	Temperature: Daily Maximum	0%	19%	81%	0%	0%	
	Temperature: Daily Minimum	4%	3%	94%	0%	0%	
	Temperature: Spatial Variation	0%	0%	98%	0%	2%	
	Total Suspended Solids	0%	0%	0%	0%	100%	5
	Water Withdrawals	0%	0%	0%	0%	100%	3
	Woody Debris	3%	0%	97%	0%	0%	
Habitat quantity	Backwater Pools	0%	0%	0%	100%	0%	
	Beaver Ponds	0%	6%	94%	0%	0%	
	Glides	0%	39%	61%	0%	0%	
	Large Cobble Riffles	0%	39%	61%	0%	0%	
	Off Channel Habitat Factor	0%	0%	75%	0%	25%	
	Pool Tails	0%	0%	100%	0%	0%	
	Scour pools	0%	45%	55%	0%	0%	
	Small Cobble Riffles	0%	39%	61%	0%	0%	

[a] Ranks assigned to attribute not parameterized due to lack of suitable data at appropriate spatial scales. Rank reflects order of importance based on:

- Model sensitivity to habitat inputs determined by the EDT species-habitat rules, and;
- availability of suitable assessment methods, practicality, and monitoring cost.

Table 4-3. Level of Proof rating distribution by EDT habitat attribute FDRL Tributaries reservoir habitats.

Attribute Type	Habitat Attribute	Level of Proof Rating				
		1	2	3	4	5
Habitat quality	Dissolved Oxygen	100%	0%	0%	0.0%	0.0%
	Predation Risk	0%	100%	0%	0.0%	0.0%
	Temperature: Daily Maximum	0%	100%	0%	0.0%	0.0%
	Woody Debris and Vegetation	0%	100%	0%	0.0%	0.0%
Habitat quantity	Limnetic	0%	0%	100%	0.0%	0.0%
	Littoral	0%	0%	100%	0.0%	0.0%

Table 4-4. Level of Proof rating distribution by EDT habitat attribute in FDRL Tributaries riverine habitats.

Attribute Type	Habitat Attribute	Level of Proof Rating				
		1	2	3	4	5
Habitat quality	Alkalinity	0%	0%	100%	0%	0%
	Bed scour	0%	0%	0%	0%	100%
	Benthic Richness	0%	0%	0%	14%	86%
	Confinement: Artificial	0%	14%	0%	0%	86%
	Confinement: Natural	0%	100%	0%	0%	0%
	Dissolved Oxygen	14%	0%	0%	0%	86%
	Embeddedness	5%	0%	0%	95%	0%
	Fine Sediment	5%	0%	14%	81%	0%
	Fish Community Richness	0%	0%	0%	0%	100%
	Fish Pathogens	0%	0%	0%	0%	100%
	Fish Species Introductions	0%	0%	0%	0%	100%
	Flow: Diel Variation	0%	0%	0%	0%	100%
	Flow: Inter-Annual High Flow Var.	14%	0%	86%	0%	0%
	Flow: Inter-Annual Low Flow Var.	14%	0%	86%	0%	0%
	Flow: Intra-Annual Variation	14%	0%	86%	0%	0%
	Gradient	0%	100%	0%	0%	0%
	Hatchery Fish outplants	0%	0%	0%	0%	100%
	Nutrient Enrichment	0%	0%	0%	0%	100%
	Predation Risk	0%	0%	0%	0%	100%
	Riparian Function	0%	0%	100%	0%	0%
	Salmon Carcasses	100%	0%	0%	0%	0%
	Temperature: Daily Maximum	0%	0%	100%	0%	0%
	Temperature: Daily Minimum	6%	0%	0%	8%	86%
	Temperature: Spatial Variation	0%	0%	0%	86%	14%
	Total Suspended Solids	0%	0%	0%	0%	100%
	Water Withdrawals	0%	0%	0%	0%	100%
	Woody Debris	5%	0%	95%	0%	0%
Habitat quantity	Backwater Pools	0%	0%	14%	0%	86%
	Beaver Ponds	0%	14%	0%	0%	86%
	Glides	0%	0%	14%	0%	86%
	Large Cobble Riffles	0%	0%	14%	0%	86%
	Off Channel Habitat Factor	0%	0%	14%	0%	86%
	Pool Tails	0%	0%	14%	0%	86%
	Scour pools	0%	0%	14%	0%	86%
	Small Cobble Riffles	0%	0%	14%	0%	86%

4.2 Data Quality by Assessment Unit

This section presents a summary of LOP ratings in the study area by reporting watershed and assessment unit. These results demonstrate how data availability and data quality vary geographically across the study area. In general, the Spokane River portion of the study area is better studied and has more data suitable for parameterizing EDT attributes at the reach scale. However, these data are limited in extent, concentrated in specific areas, and in many cases more than a decade old. The FDRL Tributaries are poorly studied and generally lack habitat data. LOP ratings are summarized by geography in the following sections.

4.2.1 Spokane River

The extent and distribution of quantitative habitat data suitable for parameterizing EDT varies widely across the Spokane River portion of the study area. LOP ratings for this portion of the study area are summarized by reporting watershed and assessment unit in Table 4-5.

A number of different entities have conducted and continue to conduct habitat and water quality surveys in the Spokane River subbasin over the past 20 years. LOP scores for riverine environment types reflect the availability of limnological and water quality data collected by ongoing STOI and Avista Corp monitoring efforts in the Spokane Arm and Long Lake, respectively. The picture for the riverine portions of the study area is more complex. Systematic habitat surveys have been implemented in some portions of the study area but these efforts are either dated or limited in geographic extent. The most useful data sources include WDFW habitat surveys in the Little Spokane River and Rock Creek watersheds conducted between 2002 and 2004, and CDAT habitat and water quality survey data collected at selected locations in upper Hangman Creek between 2007 and 2012. ECY has 6 long-term monitoring stations in the study area, collecting a range of useful habitat metrics. These sites largely overlap reaches previously surveyed by WDFW.

The WDFW habitat survey data set provided the most geographically extensive and useful habitat data. These survey locations are concentrated in the Little Spokane River and cover a significant percentage of reaches, as reflected in the LOP ratings for those reporting watersheds. While useful, these data are more than 10 years old and are therefore assigned a lower LOP rating than more current data.[19] The remaining reporting watersheds are less well represented, with the exception of portions of Hangman Creek Upper monitored by CDAT (Table 4-5).

ICF used a combination of methods to parameterize EDT habitat attributes for reaches lacking data. LOP ratings associated with each of these methods are identified in Table 2-3. The NetMap hydrogeomorphic model was instrumental for developing the natural confinement, thermal variability, large woody debris, and fines and embeddedness ratings across the study area. USFS VIC model outputs were used to characterize changes in stream flows relative to historical climatic conditions. Aerial imagery interpretation was also useful for characterizing habitat composition in larger stream reaches with visible habitat features. In some cases ratings were extrapolated from reaches with suitable data to ecologically similar reaches in close proximity.

19 WDFW habitat data are assigned a LOP rating of 2 because they are 14-16 years old.

Table 4-3. Summary of EDT attribute Level of Proof Ratings in the Spokane River EDT model, mainstem and tributary habitats.

Reporting Watershed	Assessment Unit	Level of Proof				
		1	2	3	4	5
Spokane Arm, Long Lake, Nine Mile Reservoir Habitat	Lake Roosevelt	0%	47%	53%	0%	0%
	Spokane Arm	16%	33%	51%	0%	0%
	Spokane - Orzada	31%	19%	50%	0%	0%
	Spokane - Blue	31%	19%	50%	0%	0%
	Spokane - Harker Canyon	26%	22%	51%	0%	0%
	Spokane - Long Lake	31%	19%	50%	0%	0%
	Spokane - Spring Canyon	17%	33%	50%	0%	0%
	Little Falls	17%	33%	50%	0%	0%
	Long Lake	24%	26%	50%	0%	0%
	Spokane - Whitney Canyon	17%	33%	50%	0%	0%
	Spokane - Little Sandy Canyon	0%	22%	78%	0%	0%
	Spokane - Nine Mile	0%	17%	83%	0%	0%
Spokane Mainstem & Tributaries	Spokane Arm	0%	6%	45%	12%	36%
	Spokane - Blue	0%	6%	45%	12%	36%
	Spokane - Harker Canyon	0%	6%	45%	12%	36%
	Spokane - Mill	0%	8%	44%	12%	36%
	Spokane - Spring Canyon	0%	6%	45%	12%	36%
	Spokane - Little Tshimikain	0%	6%	45%	12%	36%
	Spokane - Tshimikain	0%	6%	45%	12%	36%
	Spokane - Nine Mile	10%	6%	38%	10%	36%
	Spokane - Deep Creek Lower	0%	6%	45%	15%	33%
	Spokane - Coulee Creek	0%	6%	45%	15%	33%
	Spokane - Deep Creek Upper	0%	6%	45%	15%	33%
Little Spokane Lower	Little Spokane - Dartford	8%	20%	34%	7%	31%
	Little Spokane - Lower Deadman	0%	20%	36%	9%	34%
	Little Spokane - Upper Deadman	0%	18%	40%	8%	34%
	Little Spokane - Little Deep	0%	20%	43%	4%	34%
	Little Spokane - Bear	0%	19%	45%	4%	31%
	Little Spokane - Deer	0%	22%	42%	3%	33%
Little Spokane Dragoon	Little Spokane - Lower Dragoon	1%	16%	44%	5%	34%
	Little Spokane - WB Dragoon	0%	16%	41%	8%	34%
	Little Spokane - Upper Dragoon	1%	17%	41%	8%	34%
Little Spokane Upper	Little Spokane - West Branch-Eloika	1%	24%	39%	3%	33%
	Little Spokane - Chain Lake	0%	20%	40%	6%	33%
	Little Spokane - Otter	0%	6%	48%	9%	36%
	Little Spokane - Dry	0%	19%	38%	8%	36%

Reporting Watershed	Assessment Unit	Level of Proof				
		1	2	3	4	5
Hangman Lower	Hangman - Lower	8%	7%	43%	12%	30%
	Hangman - Marshall	0%	21%	38%	12%	30%
	Hangman - Minnie	0%	6%	52%	12%	30%
	Hangman - Stevens	3%	6%	46%	15%	30%
	Hangman - California	2%	21%	37%	8%	30%
	Hangman - Spangle	0%	7%	48%	15%	30%
Hangman Middle	Hangman - Courtney Canyon	2%	6%	50%	12%	30%
	Hangman - Lower Rock	0%	13%	44%	13%	30%
	Hangman - Mica	0%	6%	48%	15%	30%
	Hangman - Rose	0%	6%	53%	10%	30%
	Hangman - NF Rock	0%	7%	51%	12%	30%
	Hangman - Upper Rock	0%	6%	51%	12%	30%
	Hangman - Rattler Run	0%	7%	50%	12%	30%
Hangman Upper	Hangman - Cove	0%	7%	51%	12%	30%
	Hangman - Little Hangman	0%	8%	50%	11%	30%
	Hangman - Moctileme	0%	9%	48%	12%	30%
	Hangman - Lolo	0%	10%	50%	10%	30%
	Hangman - Mission	1%	12%	46%	11%	30%
	Hangman - Headwaters	1%	16%	42%	11%	30%

4.2.2 FDRL Tributaries

LOP ratings for the FDRL Tributaries are summarized by assessment unit in Table 4-6. The riverine portions of this geography are understudied and generally lack habitat data. With the exception of USGS gage data for the Colville River and a single year of data from one ECY habitat monitoring location on Harvey Creek, ICF was not able to identify any empirical data suitable for parameterizing EDT habitat attributes. The reservoir portion of the study area is generally well represented by STOI limnological monitoring data collected at locations in proximity to inundated reaches.

The LOP ratings for the FDRL Tributaries reflect a variety of methods used to parameterize EDT attributes lacking available data. ICF used a combination of aerial imagery interpretation, model-derived habitat parameters, and extrapolation of hypothetical ratings from the CCT Select Upper Columbia Tributaries EDT model. These hypothetical ratings were necessary to generate useful EDT model results for the study area. While they are extrapolated from ecologically similar reaches and are considered reasonably representative, they are assigned the lowest LOP score of 5 to clearly identify where critical data gaps exist.

Table 4-4. Summary of EDT attribute Level of Proof Ratings in the FDRL Tributaries EDT model, mainstem and tributary habitats.

Reporting Area	Assessment Unit	Level of Proof				
		1	2	3	4	5
FDRL Reservoir Habitat	Lake Roosevelt	17%	50%	33%	0%	0%
FDRL Tributaries	FDRL - Harvey	4%	6%	20%	8%	63%
	FDRL - Stranger	3%	6%	20%	9%	63%
	FDRL - Cheweka	3%	6%	20%	9%	63%
	FDRL - Lodgepole	3%	6%	20%	9%	63%
	FDRL - Colville	15%	11%	34%	7%	31%
	FDRL - Magee	3%	6%	20%	9%	63%
	FDRL - Onion	3%	6%	20%	9%	63%
	FDRL - Quillisacut	3%	6%	20%	9%	63%
	FDRL - Deep	3%	6%	20%	9%	63%

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Appendices

Appendix A – Out of Basin Survival Calibration

Table A-1. Comparison of calibrated EDT results to observed juvenile and adult survival rates in the Columbia River migration corridor and Pacific Ocean.

Species	Life Stage	Segment	Calibrated EDT Result	Observed Survival Calibration Metric				Comment
				Mean	Standard Error or (90% CI)	Range	Data Source (time series)	
Steelhead	SAR (Ocean Survival)	BON to BOA	0.040	--	--	--	--	EDT value within observed range for selected time period and conservative relative to mean for available points of comparison
		MCN to BOA	0.030	0.041	(0.029-0.053)	0.013-0.067	FPC 2015 (2006-2012)	
		RRE to BOA	0.020	0.027	(0.019-0.036)	0.009-0.048	FPC 2016b (2008-2012)	
	Adult	BOA to MCN	0.909	0.901	0.074	0.733-0.981	Peven et al. 2016 (2008-2015)	EDT value comparable to or conservative relative to mean of observed conversion rates
				0.893	0.049	0.823-0.977	NMFS 2016 (2008-2015)	
		MCN to WLS	0.926	≥0.95	--	--	PUD Pers. Comm.	
		PRD to WLS	0.948	0.920	--	--	Douglas PUD 2011 (2003-2010)	
		RRE to WLS	0.979	0.986	--	--	Douglas PUD 2016 (2015)	
	Juvenile	Lk Roosevelt to WLS	0.623	--	--	--	--	EDT Lk Roosevelt to WLS survival calibrated to be approximately equal to WLS to MCN survival
		WLS to MCN	0.607	--	--	--	--	
		WLS RES to WLS TLRC	0.950	0.945	0.015	0.943-0.946	Bickford et al. 2001 (1999-2000)	EDT value within SE of observed 1999-2000 mean, likely conservative compared to current survival
		RIS to MCN	0.703	0.609	0.010	0.499-0.739	FPC 2016 (2009-2015)	EDT value within observed range, offsets conservative MCN to BON survival
		MCN to BON	0.747	0.724	0.090	0.487-1.069	Zabel 2016 (2009-2015)	EDT value within SE of Zabel 2009-2015 mean but conservative relative to FPC-calculated mean
		MCN to BON	0.747	0.795	0.016	0.587-0.958	FPC 2016 (2009-2015)	
Summer/Fall Chinook	SAR	BON to BOA	0.046	--	--	--	--	EDT SAR includes jacks, observed SAR has been corrected to account for jacks
		MCN to BOA	0.032	0.021	(0.018-0.026)	0.012-0.041	FPC 2016 (2011-2013)	
		RIS to BOA	0.021	0.012	(0.010-0.015)	0.006-0.021	FPC 2016 (2009-2013)	
	Adult	BOA to MCN	0.926	0.815	--	--	Keefer et al. 2015 (2013-2014)	Observed data record limited to two years.
		BOA to MCN		0.947	0.065	0.896-1.00	NMFS 2016 (2008-2015)	Adult conversion rates for Snake River summer/fall Chinook adjusted for straying and harvest
		MCN to WLS	0.946	≥0.95	--	--	PUD Pers. Comm.	PUDs consider upstream survival to be 98-100% at each project (C. Peven, personal communication)
	Juvenile	Lk Roosevelt to WLS	0.560	--	--	--	--	EDT Lk Roosevelt to WLS survival calibrated to be approximately equal to WLS to MCN survival
		WLS to MCN	0.539	--	--	--	--	
		RIS to MCN	0.659	0.561	0.0585	0.219-0.891	FPC 2016 (2009-2015)	Accuracy of the mean and SE of observed subyearling survival is questionable due to small sample size (C. Peven, personal communication)
		WLS RES to MCN	0.528	0.322	0.0438	0.247-0.527	FPC 2016 (2008-2014)	
		PRD to MCN	0.804	0.673	0.0801	0.500-0.820	FPC 2016 (2008-2014)	
		MCN to BON	0.699	0.649	(0.549-0.843)	0.621-0.743	FPC 2016 (2009-2014)	Mix of data for all stocks, specific data are lacking for comparison of subyearling Upper Columbia summer/fall Chinook survivals

Species	Life Stage	Segment	Calibrated EDT Result	Observed Survival Calibration Metric				Comment
				Mean	Standard Error or (90% CI)	Range	Data Source (time series)	
Spring Chinook	SAR	BON to BOA	0.036	--	--	--	--	
		MCN to BOA	0.025	0.019	(0.013-0.024)	0.006-0.028	FPC 2016 (2009-2014)	EDT SAR includes jacks, observed SAR has been corrected to account for jacks
		RRE to BOA	0.018	0.011	(0.007-0.014)	0.002-0.015	FPC 2016 (2009-2014)	
	Adult	BOA to MCN	0.941	0.966	0.033	0.909-1.00	Peven et al. 2016 (2008-2015)	Within SE of 2008-2015 mean
				0.938	0.063	0.876-1.00	NMFS 2016 (2008-2015)	
		MCN to WLS	0.960	≥0.95	--	--	PUD Pers. Comm.	PUDs consider upstream survival to be 98-100% at each project (C. Peven, personal communication)
		PRD to WLS	0.972	0.956	--	--	Douglas PUD 2011 (2003-2010)	
		RRE to WLS	0.989	1.000	--	--	Douglas PUD 2016 (2015)	EDT value is consistent with high per-project conversion rate estimates
	Juvenile	Lk Roosevelt to WLS	0.595	--	--	--	--	EDT Lk Roosevelt to WLS survival calibrated to be approximately equal to WLS to MCN survival
		WLS to MCN	0.642	--	--	--	--	
		RIS to MCN	0.753	0.667	0.0191	0.489-0.935	FPC 2016 (2009-2015)	RIS to MCN overestimate offset by MCN to BON underestimate
		RRE TLRC to RIS TLRC	0.933	0.942	0.0157	0.897-0.973	Skalski et al. 2010 (2000-2010)	EDT value within SE of 2000-2010 mean
		RRE TLRC to MCN	0.730	0.671	0.0105	0.656-0.686	Bickford et al. 2001 (1999-2000)	Dated study does not reflect post-2008 operational changes, current survival rates higher
		MCN to BON	0.758	0.835	0.092	0.626-1.056	Zabel 2016 (2008-2015)	Within SE of 2009-2015 mean

Appendix B – EDT Life Stage Survival Metrics

Table B-1. EDT life stage survival metrics for Spokane River summer steelhead by subpopulation and juvenile rearing strategy.

HUC 10 Subpopulations	Rearing Type	Smolt Age	EDT Life Stage Survival		
			Egg-to-parr	Parr-to-smolt	Prespawn Adult
All Subpopulations	Mover	1	0.061	0.562	0.918
		2	0.071	0.314	0.921
		3	0.076	0.225	0.923
	Stayer	1	0.060	0.512	0.915
		2	0.078	0.296	0.920
		3	0.079	0.205	0.926
	Reservoir	1	0.038	0.604	0.927
Spokane Mainstem & Tribs	Mover	1	0.065	0.579	0.928
		2	0.081	0.272	0.930
		3	0.083	0.192	0.929
	Stayer	1	0.067	0.478	0.922
		2	0.083	0.255	0.929
		3	0.082	0.166	0.942
	Reservoir	1	0.047	0.583	0.915
Little Spokane Lower	Mover	1	0.063	0.536	0.921
		2	0.076	0.302	0.915
		3	0.086	0.215	0.920
	Stayer	1	0.061	0.515	0.916
		2	0.087	0.278	0.920
		3	0.088	0.209	0.915
	Reservoir	1	0.039	0.595	0.916
Little Spokane Dragoon	Mover	1	0.059	0.516	0.914
		2	0.070	0.305	0.916
		3	0.074	0.218	0.914
	Stayer	1	0.064	0.476	0.915
		2	0.072	0.322	0.923
		3	0.100	0.203	0.917
	Reservoir	1	0.030	0.623	0.920
Little Spokane Upper	Mover	1	0.063	0.518	0.902
		2	0.068	0.367	0.910
		3	0.068	0.236	0.926
	Stayer	1	0.056	0.540	0.911
		2	0.072	0.334	0.921
		3	0.081	0.213	0.930
	Reservoir	1	0.031	0.689	0.896

HUC 10 Subpopulations	Rearing Type	Smolt Age	EDT Life Stage Survival		
			Egg-to-parr	Parr-to-smolt	Prespawn Adult
Hangman Lower	Mover	1	0.062	0.517	0.904
		2	0.063	0.243	0.905
		3	0.078	0.157	0.913
	Stayer	1	0.064	0.503	0.901
		2	0.070	0.321	0.903
		3	0.070	0.232	0.930
	Reservoir	1	0.032	0.667	0.902
Hangman Middle	Mover	1	0.035	0.544	0.890
		2	0.029	0.386	0.894
		3	0.028	0.219	0.864
	Stayer	1	0.032	0.576	0.885
		2	0.034	0.372	0.868
		3	0.030	0.270	0.908
	Reservoir	1	0.025	0.667	0.973
Hangman Upper	Mover	1	0.038	0.443	0.899
		2	0.038	0.256	0.916
		3	--	--	--
	Stayer	1	0.036	0.462	0.898
		2	0.037	0.271	0.883
		3	--	--	--
	Reservoir	1	0.028	0.618	0.925

Survival metric definitions

Egg-to-parr: Survival from the beginning of incubation (end of the EDT spawning life stage) to the end of the first summer (end of the EDT 0-age resident rearing life stage)

Parr-to-smolt: Survival from the end of the first summer (end of the EDT 0-age resident rearing life stage) to outmigrant smolt migration into Lake Roosevelt

Prespawn adult: Survival from prespawn migrant adult entry into terminal Lake Roosevelt migratory and holding habitat to the beginning of spawning, including prespawn holding

Table B-2. EDT life stage survival metrics for FDRL Tributaries summer steelhead by subpopulation and juvenile rearing strategy.

HUC 10 Subpopulations	Rearing Type	Smolt Age	EDT Life Stage Survival		
			Egg-to-parr	Parr-to-smolt	Prespawn Adult
All Subpopulations	Mover	1	0.082	0.554	0.902
		2	0.110	0.285	0.915
		3	0.101	0.222	0.928
	Stayer	1	0.091	0.534	0.912
		2	0.115	0.298	0.923
		3	0.115	0.200	0.919
	Reservoir	1	0.050	0.637	0.943
FDRL - Harvey Creek	Mover	1	0.071	0.569	0.900
		2	0.090	0.281	0.899
		3	0.086	0.187	0.916
	Stayer	1	0.072	0.583	0.896
		2	0.092	0.329	0.919
		3	0.103	0.198	0.892
	Reservoir	1	0.047	0.634	0.911
FDRL - Stranger Creek	Mover	1	0.106	0.575	0.902
		2	0.141	0.269	0.909
		3	0.116	0.161	0.948
	Stayer	1	0.087	0.482	0.914
		2	0.135	0.267	0.924
		3	0.070	0.290	0.864
	Reservoir	1	0.064	0.598	0.908
FDRL - Magee Creek	Mover	1	0.148	0.602	0.938
		2	0.117	0.357	0.885
		3	--	--	--
	Stayer	1	0.096	0.503	0.940
		2	--	--	--
		3	0.302	0.171	0.922
	Reservoir	1	--	--	--
FDRL - Cheweka Creek	Mover	1	0.097	0.579	0.892
		2	0.130	0.304	0.920
		3	0.117	0.255	0.915
	Stayer	1	0.096	0.567	0.903
		2	0.142	0.298	0.912
		3	0.159	0.226	0.940
	Reservoir	1	0.051	0.574	0.897

HUC 10 Subpopulations	Rearing Type	Smolt Age	EDT Life Stage Survival		
			Egg-to-parr	Parr-to-smolt	Prespawn Adult
FDRL - Quillisascut Creek	Mover	1	0.081	0.531	0.867
		2	0.108	0.282	0.894
		3	0.119	0.196	0.917
	Stayer	1	0.085	0.594	0.915
		2	0.117	0.297	0.929
		3	0.122	0.182	0.898
	Reservoir	1	0.062	0.613	0.912
FDRL - Colville River	Mover	1	0.074	0.540	0.929
		2	0.098	0.230	0.931
		3	--	--	--
	Stayer	1	0.072	0.469	0.939
		2	0.113	0.218	0.960
		3	0.082	0.174	0.963
	Reservoir	1	0.044	0.680	0.948
FDRL - China Creek	Mover	1	0.106	0.531	0.905
		2	0.106	0.280	0.919
		3	0.116	0.199	0.984
	Stayer	1	0.085	0.494	0.872
		2	0.124	0.301	0.915
		3	--	--	--
	Reservoir	1	0.071	0.565	0.906
FDRL - Onion Creek	Mover	1	0.093	0.601	0.918
		2	0.136	0.290	0.885
		3	0.105	0.320	0.936
	Stayer	1	0.133	0.471	0.906
		2	0.148	0.244	0.915
		3	0.115	0.271	0.848
	Reservoir	1	0.062	0.664	0.865
FDRL - Deep Creek	Mover	1	0.091	0.472	0.915
		2	0.135	0.255	0.897
		3	0.167	0.148	0.935
	Stayer	1	0.112	0.460	0.921
		2	0.144	0.265	0.897
		3	0.146	0.153	0.897
	Reservoir	1	0.063	0.616	0.975

Survival metric definitions

Egg-to-parr: Survival from the beginning of incubation (end of the EDT spawning life stage) to the end of the first summer (end of the EDT 0-age resident rearing life stage)

Parr-to-smolt: Survival from the end of the first summer (end of the EDT 0-age resident rearing life stage) to outmigrant smolt migration into Lake Roosevelt

Prespawn adult: Survival from prespawn migrant adult entry into terminal Lake Roosevelt migratory and holding habitat to the beginning of spawning, including prespawn holding

Table B-3. EDT life stage survival metrics for Spokane River summer/fall Chinook salmon by subpopulation and juvenile rearing strategy.

HUC 10 Subpopulation	Rearing Type	Smolt Age	EDT Life Stage Survival		
			Egg-to-parr	Parr-to-smolt	Prespawn Adult
All Subpopulations	Ocean-type	0	0.073	0.807	0.697
	Stream-type	1	0.116	0.364	0.694
	Reservoir	1	0.080	0.575	0.793
Spokane Mainstem & Tributaries	Ocean-type	0	0.071	0.837	0.749
	Stream-type	1	0.167	0.348	0.773
	Reservoir	1	0.082	0.570	0.818
Little Spokane Lower	Ocean-type	0	0.069	0.843	0.724
	Stream-type	1	0.128	0.354	0.710
	Reservoir	1	0.092	0.576	0.790
Little Spokane Dragoon	Ocean-type	0	0.065	0.813	0.743
	Stream-type	1	0.180	0.474	0.689
	Reservoir	1	0.098	0.578	0.835
Little Spokane Upper	Ocean-type	0	0.071	0.781	0.701
	Stream-type	1	--	--	--
	Reservoir	1	--	--	--
Hangman Lower	Ocean-type	0	0.079	0.806	0.671
	Stream-type	1	--	--	--
	Reservoir	1	0.101	0.535	0.793
Hangman Middle	Ocean-type	0	0.081	0.749	0.639
	Stream-type	1	--	--	--
	Reservoir	1	--	--	--
Hangman Upper	Ocean-type	0	0.043	0.714	0.790
	Stream-type	1	--	--	--
	Reservoir	1	--	--	--

Survival metric definitions

Egg-to-parr: Survival from the beginning of incubation (end of the EDT spawning life stage) to the end of the first summer (end of the EDT 0-age resident rearing life stage)

Parr-to-smolt: Survival from the end of the first summer (end of the EDT 0-age resident rearing life stage) to outmigrant smolt migration into Lake Roosevelt

Prespawn adult: Survival from prespawn migrant adult entry into terminal Lake Roosevelt migratory and holding habitat to the beginning of spawning, including prespawn holding

Table B-4. EDT life stage survival metrics for FDRL Tributaries summer/fall Chinook salmon by subpopulation and juvenile rearing strategy.

HUC 10 Subpopulation	Rearing Type	Smolt Age	EDT Life Stage Survival		
			Egg-to-parr	Parr-to-smolt	Prespawn Adult
All Subpopulations	Ocean-type	0	0.075	0.999	0.744
	Stream-type	1	--	--	--
	Reservoir	1	0.119	0.605	0.635
FDRL - Harvey Creek	Ocean-type	0	0.065	0.999	0.772
	Stream-type	1	--	--	--
	Reservoir	1	--	--	--
FDRL - Colville River	Ocean-type	0	0.079	0.999	0.741
	Stream-type	1	--	--	--
	Reservoir	1	--	--	--
FDRL - China Creek	Ocean-type	0	0.073	~1	0.733
	Stream-type	1	--	--	--
	Reservoir	1	--	--	--
FDRL - Onion Creek	Ocean-type	0	0.074	~1	0.730
	Stream-type	1	--	--	--
	Reservoir	1	0.135	0.621	0.632
FDRL - Deep Creek	Ocean-type	0	0.069	~1	0.747
	Stream-type	1	--	--	--
	Reservoir	1	--	--	--

Survival metric definitions

Egg-to-parr: Survival from the beginning of incubation (end of the EDT spawning life stage) to the end of the first summer (end of the EDT 0-age resident rearing life stage)

Parr-to-smolt: Survival from the end of the first summer (end of the EDT 0-age resident rearing life stage) to outmigrant smolt migration into Lake Roosevelt

Prespawn adult: Survival from prespawn migrant adult entry into terminal Lake Roosevelt migratory and holding habitat to the beginning of spawning, including prespawn holding

Table B-5. EDT life stage survival metrics for Spokane River spring Chinook salmon by subpopulation and juvenile rearing strategy.

HUC 10 Subpopulation	Rearing Type	EDT Life Stage Survival		
		Egg-to-parr	Parr-to-smolt	Prespawn Adult
All Subpopulations	Stream-type	0.148	0.399	0.697
	Reservoir	0.116	0.499	0.739
Spokane Mainstem & Tribs	Stream-type	0.154	0.349	0.709
	Reservoir	0.123	0.506	0.607
Little Spokane Lower	Stream-type	0.153	0.446	0.803
	Reservoir	0.099	0.480	0.713
Little Spokane Dragoon	Stream-type	0.142	0.347	0.701
	Reservoir	0.095	0.491	0.731
Little Spokane Upper	Stream-type	0.102	0.457	0.597
	Reservoir	--	--	--
Hangman Lower	Stream-type	0.116	0.325	0.624
	Reservoir	0.088	0.432	0.689
Hangman Middle	Stream-type	0.083	0.436	0.745
	Reservoir	0.090	0.456	0.642
Hangman Upper	Stream-type	--	--	--
	Reservoir	--	--	--

Survival metric definitions

Egg-to-parr: Survival from the beginning of incubation (end of the EDT spawning life stage) to the end of the first summer (end of the EDT 0-age resident rearing life stage)

Parr-to-smolt: Survival from the end of the first summer (end of the EDT 0-age resident rearing life stage) to outmigrant smolt migration into Lake Roosevelt

Prespawn adult: Survival from prespawn migrant adult entry into terminal Lake Roosevelt migratory and holding habitat to the beginning of spawning, including prespawn holding

Table B-6. EDT life stage survival metrics for FDRL Tributaries spring Chinook salmon by subpopulation and juvenile rearing strategy.

HUC 10 Subpopulation	Rearing Type	EDT Life Stage Survival		
		Egg-to-parr	Parr-to-smolt	Prespawn Adult
All Subpopulations	Stream-type	0.145	0.379	0.789
	Reservoir	0.107	0.569	0.688
FDRL - Harvey Creek	Stream-type	--	--	--
	Reservoir	--	--	--
FDRL - Colville River	Stream-type	0.169	0.435	0.795
	Reservoir	0.123	0.551	0.659
FDRL - China Creek	Stream-type	0.138	0.253	0.735
	Reservoir	--	--	--
FDRL - Onion Creek	Stream-type	0.208	0.453	0.867
	Reservoir	0.115	0.645	0.588
FDRL - Deep Creek	Stream-type	--	--	--
	Reservoir	0.116	0.613	0.612

Survival metric definitions

Egg-to-parr: Survival from the beginning of incubation (end of the EDT spawning life stage) to the end of the first summer (end of the EDT 0-age resident rearing life stage)

Parr-to-smolt: Survival from the end of the first summer (end of the EDT 0-age resident rearing life stage) to outmigrant smolt migration into Lake Roosevelt

Prespawn adult: Survival from prespawn migrant adult entry into terminal Lake Roosevelt migratory and holding habitat to the beginning of spawning, including prespawn holding