Wallowa Falls Hydroelectric Project
FERC Project No. P-308
Study Progress Report
(Draft Technical Report)

Instream Flow

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For Public Review

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1.0 INTRODUCTION

1.1 Purpose

This draft technical report describes the progress of the Wallowa Falls Instream Flow Incremental Method Study, performed by PacifiCorp in accordance with the Revised Study Plans (PacifiCorp 2011). The study is being conducted to support PacifiCorp's application for a new operating license for the Wallowa Falls Hydroelectric Project (Project), in accordance with the Federal Energy Regulatory Commission's (FERC's) Integrated Licensing Process (ILP). The need for a study that utilized the Instream Flow Incremental Methodology (IFIM) (Bovee et al. 1998) was identified by PacifiCorp in the early stages of the ILP. IFIM provides a framework of data collection and modeling tools for water resources decision-making related to instream flow needs. The principal IFIM tool used for this study includes the Physical Habitat Simulation System (PHABSIM), which is a data collection and modeling system used to simulate the relationship between stream flow and physical habitat for particular life stages of a species of fish (Milhous et al. 1989, Milhous and Waddle 2012). As discussed further in section 2 of this report, PHABSIM is used to simulate the hydraulics and physical structure of the stream, and then calculate the usable habitat area for these simulated conditions based on habitat suitability criteria for fish species of interest. PacifiCorp will use the IFIM/PHABSIM results in developing recommendations for minimum flow releases in Project-affected waters.

1.2 Study Objectives

The central objective of the IFIM/PHABSIM study is to develop a relationship between fish habitat and flows in Project-affected waters in support of relicensing efforts for the continued operation of the Project. The study evaluates habitat changes for several life stages of bull trout (*Salvelinus confluentus*), rainbow trout (*Oncorhynchus mykiss*), and Kokanee (*Oncorhynchus nerka*) over a range of flows. Specific study objectives include:

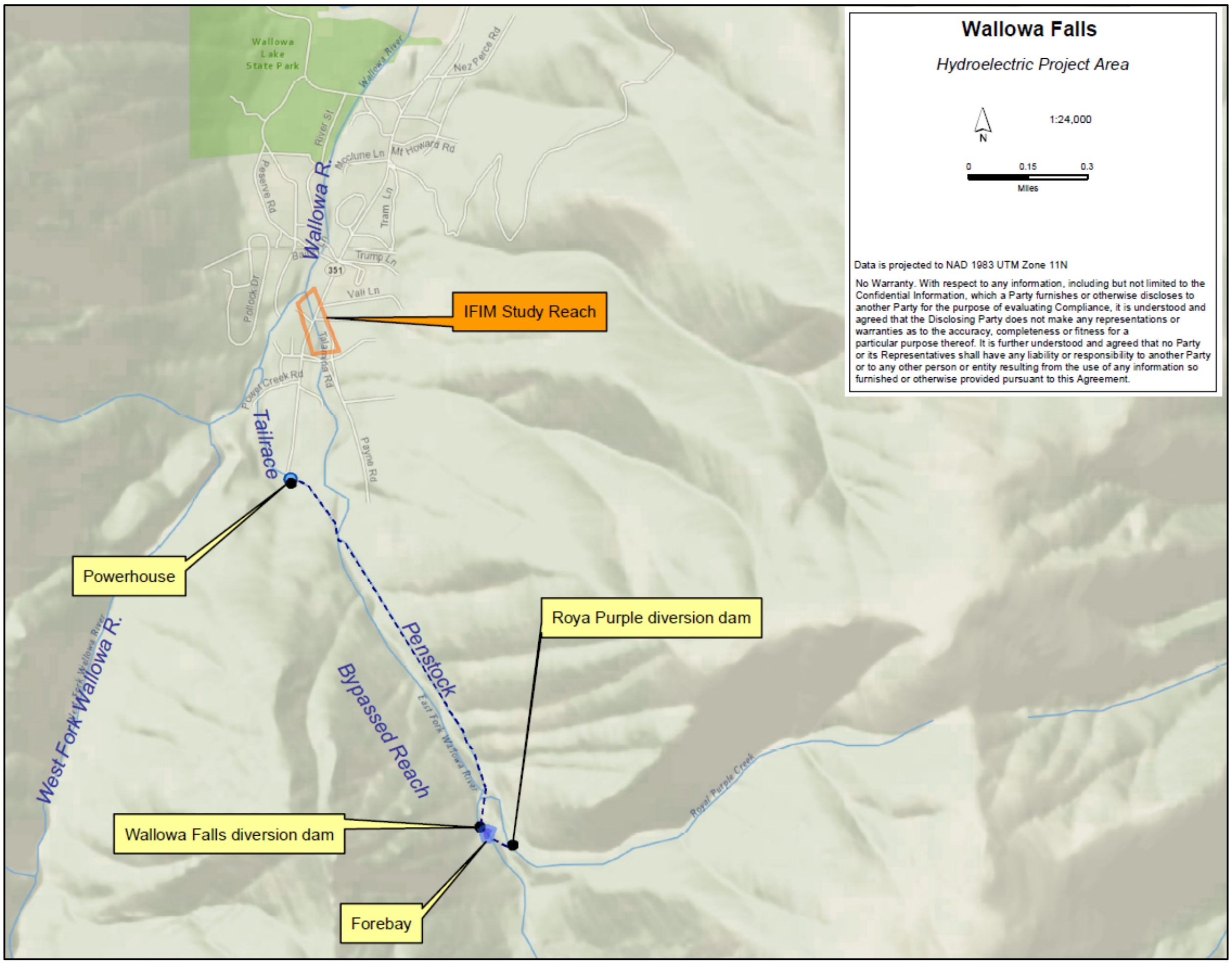
1. Inventory mesohabitat in the Project area to properly represent the habitat types present during computer simulations of habitat;
2. Develop habitat suitability criteria (HSC) curves in consultation with stakeholders for all fish species and life stages of concern;
3. Collect field data for the calibration of a hydraulic model; and
4. Develop habitat-discharge relationships using the results of the hydraulic modeling to describe how instream habitat changes with flow.

1.3 Background

1.3.1 Project Summary

The Project is located in Wallowa County, Oregon, approximately six miles south of the city of Joseph. Project facilities are primarily located on the East Fork of the Wallowa River, but facilities and operations also affect waters of the West Fork of the Wallowa River and Royal Purple Creek, a tributary of the East Fork (Figure 1). A diversion dam, known as the Wallowa Falls dam, is located on the East Fork, 1.7 miles upstream of the confluence of the East and West Forks. The dam creates a forebay with a surface area of about 0.25 acres. Additionally, a small weir on Royal Purple Creek facilitates the diversion of 1 cfs into the forebay. Although it is not a true reservoir, the water impounded in the forebay is the source of water for power generation at the powerhouse. An intake at the Wallowa Falls dam conveys up to 16 cfs from the forebay to the Wallowa Falls powerhouse via a pipeline, or penstock. The powerhouse tailrace discharges to the West Fork. As a result, the flows diverted from the dam to the powerhouse bypass the entire 1.7-mile reach of the East Fork between the confluence of the East and West Forks and the Wallowa Falls dam (referred to below as the "bypassed reach" of the East Fork).

Figure 1. Map of Wallowa Falls Hydroelectric Project



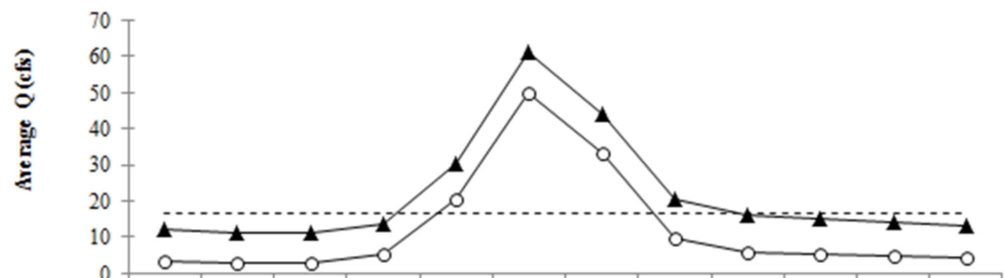
1.3.2 Water Use and Availability

The Project is operated as a run-of-river generating plant due to the limited storage capacity in the small forebay. Because the Project operates in a run-of-river mode, PacifiCorp must reduce generation diversions any time inflows to the forebay are less than 16.5 cfs, which is the sum of the state-authorized water rights from the East Fork (15 cfs), Royal Purple Creek (1 cfs), and the current FERC-mandated minimum bypassed reach flow (0.5 cfs). To provide the 0.5 cfs minimum flow, water from the forebay is passed through a 24-inch pipe in the dam, termed the low-level outlet. The minimum flow requirement is met via a nipple permanently installed in the low-level outlet head-gate. When inflows to the forebay exceed the 16.5 cfs threshold, the excess water is spilled over the top of the dam into the bypassed reach. Based on the historical record, the project spills 142 days per year, on average. The spill period begins in May, and typically ends between August and September. The annual hydrograph, developed from a

60-year flow record on the East Fork, shows that spill events peak at an average of 61 cfs during the height of the spring thaw in June (Figure 2).

During base flow conditions, there is little accretion into the bypassed. The bypassed reach of Royal Purple Creek enters the bypassed reach approximately 400 feet below Wallowa Falls diversion dam. Contributions from Royal Purple are negligible most of the year, except during the spring thaw period. Several intermittent and ephemeral water courses also contribute to accretion during spring thaw. There is no apparent groundwater accretion in the bypassed reach. See the Water Resources Study Plan Progress Report (Draft Technical Report) for further discussion of hydrologic conditions, including accretion, in the bypassed reach.

Figure 2. Average historical flows of the East Fork Wallowa River above the forebay, 1924-1983.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Project Inflow	12	11	11	13	30	61	44	20	16	15	14	13
Spill Threshhold	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5
Bypass Flow	3	3	3	5	21	50	33	10	6	5	5	4

1.3.3 Stream Characteristics

Habitat characteristics divide the 1.7-mile bypassed reach into two distinct lower and upper segments. The lower segment of the bypassed reach (lower bypassed reach) is 4700 feet long and has an average slope of 6% to 7%. The predominant habitat types are sequences of steep riffles, rapids, and step-pools. Individual pools are present in the bypassed reach but are rare. The upper segment (upper bypassed reach) is 4370 feet long and has an average slope of 19% to 20%. Steep cascades with turbulent flow over boulders and bedrock chutes characterized the upper segment. The two segments are divided by Wallowa Falls.

PacifiCorp maintains stream gages in the bypassed reach below the dam, and approximately 800 feet upstream of the confluence with the West Fork. To support this study, PacifiCorp staff has been taking regular stream flow measurements which have provided opportunities to directly observe stream conditions at various flows. To date, multiple measurements and staff gage readings have been taken every season, over a flow range of 0.5 cfs to approximately 50 cfs. Within this flow range, depths are rarely greater than two feet, except in the few pools that occur. Velocities vary between 0 feet per second and 5 feet per second due to variances of slope and the high roughness factor of the substrate, which is almost exclusively boulder and large cobble.

1.3.4 Fish Community

The upper bypassed reach appears to offer little suitable fish habitat due to the nearly 20% slope and the preponderance of bedrock chutes and bedrock cascades. Upstream fish access to the upper bypassed reach is blocked by Wallowa Falls. Below the falls in the lower bypassed reach, there is documented presence of bull trout, rainbow trout, kokanee, and non-native brook trout (*Salvelinus fontinalis*). A periodicity table for the species of interest is provided in Table 1, with the exception of brook trout. In concurrence with the agencies and stakeholders, habitat for brook trout is not being evaluated in this study.

Kokanee are only present in the bypassed reach during spawning and juvenile outmigration. Adult kokanee are only able to access the lower 500 to 600 feet of the stream due to a partial passage barrier created by a municipal water pipe next to a private residence along the stream. Kokanee do not appear to be able to breach the barrier, but bull trout, and possibly rainbow trout, are able to navigate past the barrier. Bull and rainbow trout have also been observed by PacifiCorp biologists throughout the lower bypassed reach.

Table 1. Periodicity of fish species of interest in the bypassed reach.

Species	Life Stage	J	F	M	A	M	Jn	J	A	S	O	N	D
bull trout	Adults	*	*	*	*							*	*
	Spawning												
	Juvenile												
rainbow	Adult												
	Spawning												
	Juvenile												
kokanee	Spawning												

*PacifiCorp is currently studying life history characteristics of bull trout in the system. At least a portion of the population appears to exhibit an adfluvial life history, leaving the stream after the spawning period, and returning in April or May, when flows increase and food becomes more prevalent. Resident fish may exist, and PacifiCorp will update the periodicity table as more information becomes available from a PIT tag tracking study, currently in-progress.

2.0 METHODS

The Wallowa Falls Instream Flow Study was completed in accordance with the Revised Study Plan, filed with FERC in December 2011. The study included the following steps:

1. Stream habitat survey
2. Development of habitat suitability criteria, with stakeholders

3. Selection of study reach and stream transect sites, with stakeholders
4. Hydraulic field data collection
5. Hydraulic and habitat modeling using PHABSIM

The following describes the activities for these five steps.

2.1 Stream Habitat Survey

A habitat survey was performed to inventory the existing instream habitat. Results of the survey guided the selection of a representative study reach and possible study transects. Final study transect sites were selected during a site visit with the stakeholders in June 2012.

On April 11, 2012 approximately 3,380 linear feet of the lower bypassed reach was surveyed, beginning at the confluence with West Fork and ending approximately 1000 feet downstream of the falls. Consistent with the approved IFIM study plan (PacifiCorp 2011), stream habitat units were identified using US Forest Service Region 6 protocol (USFS 2009). Certain parameters were not evaluated during the habitat survey to avoid duplicate data collection efforts being evaluated with other water-related studies as part of the relicensing process, such as recording bankfull widths, documenting unstable banks, mapping riparian vegetation, and recording water temperature. A summary of the habitat survey results are provided in Appendix A.

2.2 Development of Habitat Suitability Criteria (HSC)

PacifiCorp developed HSC curves for 3 life stages of bull trout and rainbow trout (adult, juvenile, and spawning), and for kokanee spawning. The curves were developed for water velocity (feet per second), water depth (feet), and cover. These HSC curves were developed using literature-based information and stakeholder input; no site-specific suitability data were collected for any of the species.

During the initial development of the HSC curves, a substantial amount of information was reviewed pertaining to bull trout. A total of six sources of HSC data were examined (Table 2). However, the proposed curves for bull trout were selected chiefly from two sources (CH2M Hill and USGS as listed in Table 2).

Table 2. HSC source and life stage considered for curve development.

Source	Bull Trout			Rainbow Trout			Kokanee
	Spawn.	Juv.	Adult	Spawn.	Juv.	Adult	Spawn.
Al-Chokhachy and Budy (1997)		x	x				
CH2M Hill (ongoing, unpublished)	x	x	x	x	x	x	
Goetz (1997)		x					
PacifiCorp (1992 – 2008)	x		x				
Reiser et al (1997)	x						
USGS (Maret et al, 2004)	x	x	x				
Bovee (1978)							x

The curves developed by CH2M Hill and the USGS were chosen for consideration because they had been developed for IFIM studies on streams similar in size and gradient to the bypassed reach, and had also been previously vetted by stakeholder groups. The other bull trout sources examined are from raw data, and were referenced to support the choice of either the USGS or the CH2M Hill curve. The proposed rainbow trout curves were provided by CH2M Hill. Additional sources for rainbow trout criteria were not considered because the curves provided by CH2M Hill were developed for an IFIM study in a stream system similar in size and gradient to the bypassed reach. The proposed curves for kokanee spawning were developed by Bovee (1978). These were the only kokanee criteria found in the literature. **Error! Not a valid bookmark self-reference.** summarizes the regional and local attributes of the focal stream(s) of each source.

Table 3. Summary of regional and local attributes of streams considered for HSC selection.

Source	Region of Use and/or Development	Description of stream(s)
Al-Chokhachy and Budy (1997)	Blue Mountains, Umatilla National Forest	Headwaters of South Fork Walla Walla and North Fork Umatilla
CH2M Hill (ongoing, unpublished)	Flathead Indian Reservation, Montana	Multiple headwater tributaries of Flathead River
Goetz (1997)	Cascade Mountains, Deschutes National Forest	Jack Creek, 1st order tributary of Metolius River
PacifiCorp (1992 – 2008, unpublished)	Lewis River Hydroelectric Project, Gifford Pinchot National Forest and privately owned land	Cougar Creek (2nd and 3rd order reaches), tributary of Yale Reservoir and Pine Creek a tributary to the upper Lewis River.
Reiser et al (1997)	Upper Cedar River Watershed, Snoqualmie National Forest	1st, 2nd order streams, and Rex and Cedar Rivers (3rd order), all above Chester Morse Lake
USGS (Maret et al, 2004)	Upper Salmon River Basin, Sawtooth and Salmon-Challis National Forests	Multiple headwater streams of Salmon River
Bovee (1978)	Undefined	Undefined

The HSC curves developed by PacifiCorp were issued to stakeholders for review. The proposed curves were a component of a larger study proposal, which provided stakeholders with an opportunity to review PacifiCorp's plan for the instream flow study and modeling, and to prepare recommendations, if any, to the proposed HSC. PacifiCorp met with stakeholders on June 12, 2012 in Enterprise, Oregon. Minor changes were applied to many of the curves with the group's consensus. The depth and velocity HSC that were developed in the workshop for the three species of concern are provided in curve form in Figure 3 through Figure 5. The numeric criteria, from which the curves were derived, both proposed and finalized, are provided in

Table 4 through Table 10.

Although cover is an important component of fish habitat, cover is rare in the bypassed reach. To ensure that areas of usable habitat would not be discounted or minimized due to a lack of cover, cover would be scored as 0.8 (absent) or 1.0 (present). Substrate was not used as a model input, due to a general uniformity of large cobble and boulder at all transects.

The meeting concluded with mutual agreement among stakeholders on the topics discussed regarding habitat suitability criteria and study methods.

Figure 3. Bull trout HSC (depth and velocity), developed in the stakeholder workshop, June 2012.

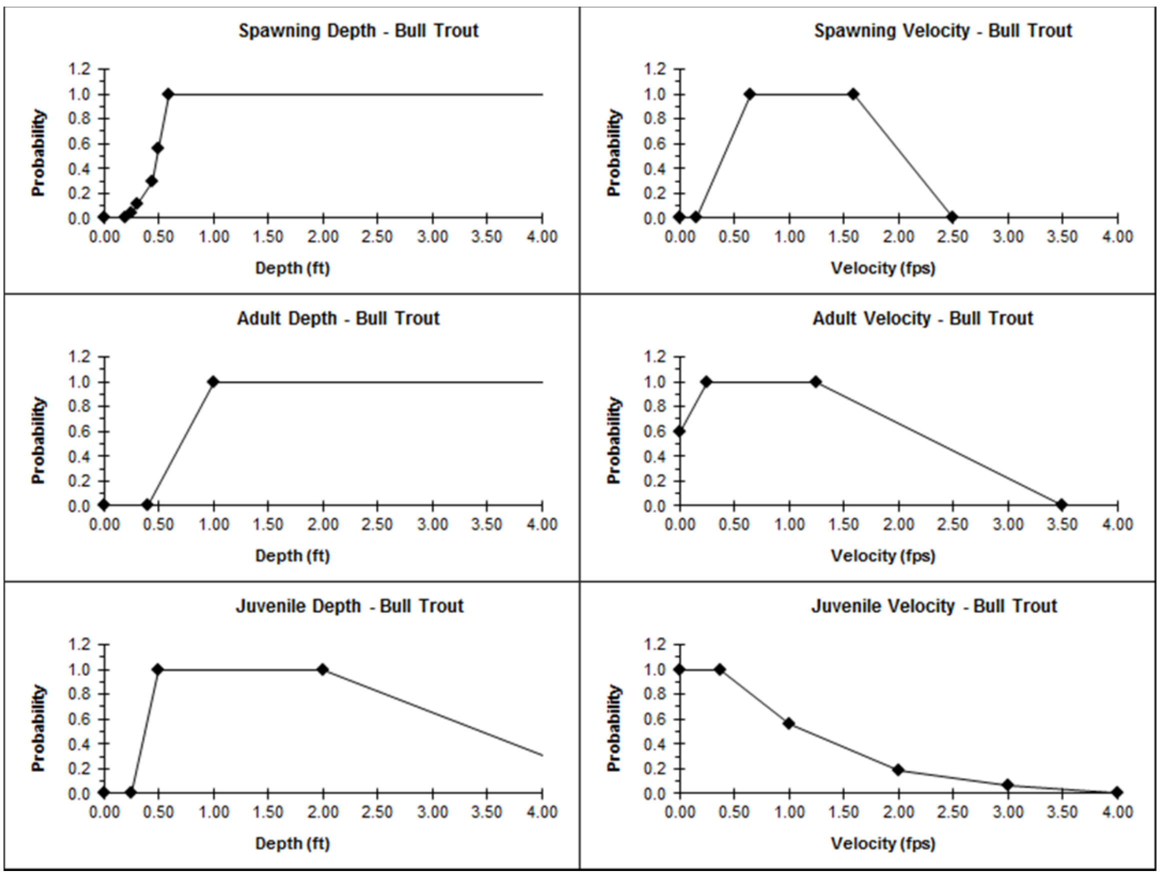


Table 4. Bull trout spawning HSC.

Consensus HSC from stakeholder meeting				Originally proposed HSC			
DEPTH		VELOCITY		DEPTH		VELOCITY	
X	Y	X	Y	X	Y	X	Y
0.00	0.00	0.00	0.00	*	*	0.00	0.00
0.20	0.00	0.15	0.00			0.15	0.00
0.25	0.04	0.65	1.00			0.65	1.00
0.31	0.11	1.60	1.00			1.60	1.00
0.45	0.30	2.50	0.00			2.30	0.00
0.50	0.56	4.50	0.00			4.50	0.00
0.60	1.00	10.00	0.00			100.00	0.00
100.00	1.00	0	0			0	0

*originally proposed HSC do not differ from consensus HSC

Red Text = Adjustments of originally proposed HSC data, agreed upon during stakeholder meeting

Table 5. Bull trout adult HSC.

Consensus HSC from stakeholder meeting				Originally proposed HSC			
DEPTH		VELOCITY		DEPTH		VELOCITY	
X	Y	X	Y	X	Y	X	Y
0.00	0.00	0.00	0.60	0.00	0.00	0.00	1.00
0.40	0.00	0.25	1.00	0.30	0.00	1.15	1.00
1.00	1.00	1.25	1.00	2.00	1.00	3.50	0.00
100	1	3.50	0.00	100.00	1.00	6.00	0.00
0.00	0.00	100.00	0.00	0	0	100.00	0.00

Red Text = Adjustments of originally proposed HSC data, agreed upon during stakeholder meeting

Table 6. Bull trout juvenile HSC.

Consensus HSC from stakeholder meeting				Originally proposed HSC			
DEPTH		VELOCITY		DEPTH		VELOCITY	
X	Y	X	Y	X	Y	X	Y
0.00	0.00	0.00	1.00	0.00	0.00	*	*
0.25	0.00	0.38	1.00	0.07	0.00		
0.50	1.00	1.00	0.56	0.20	1.00		
2.00	1.00	2.00	0.18	2.00	1.00		
4.90	0.00	3.00	0.07	4.90	0.00		
5.00	0.00	4.00	0.00	5.00	0.00		
100.00	0.00	100.00	0.00	100.00	0.00		

*originally proposed HSC do not differ from consensus HSC.

Red Text = Adjustments of originally proposed HSC data, agreed upon during stakeholder meeting.

Figure 4. HSC (depth and velocity) developed for rainbow trout during stakeholder workshop in June 2012.

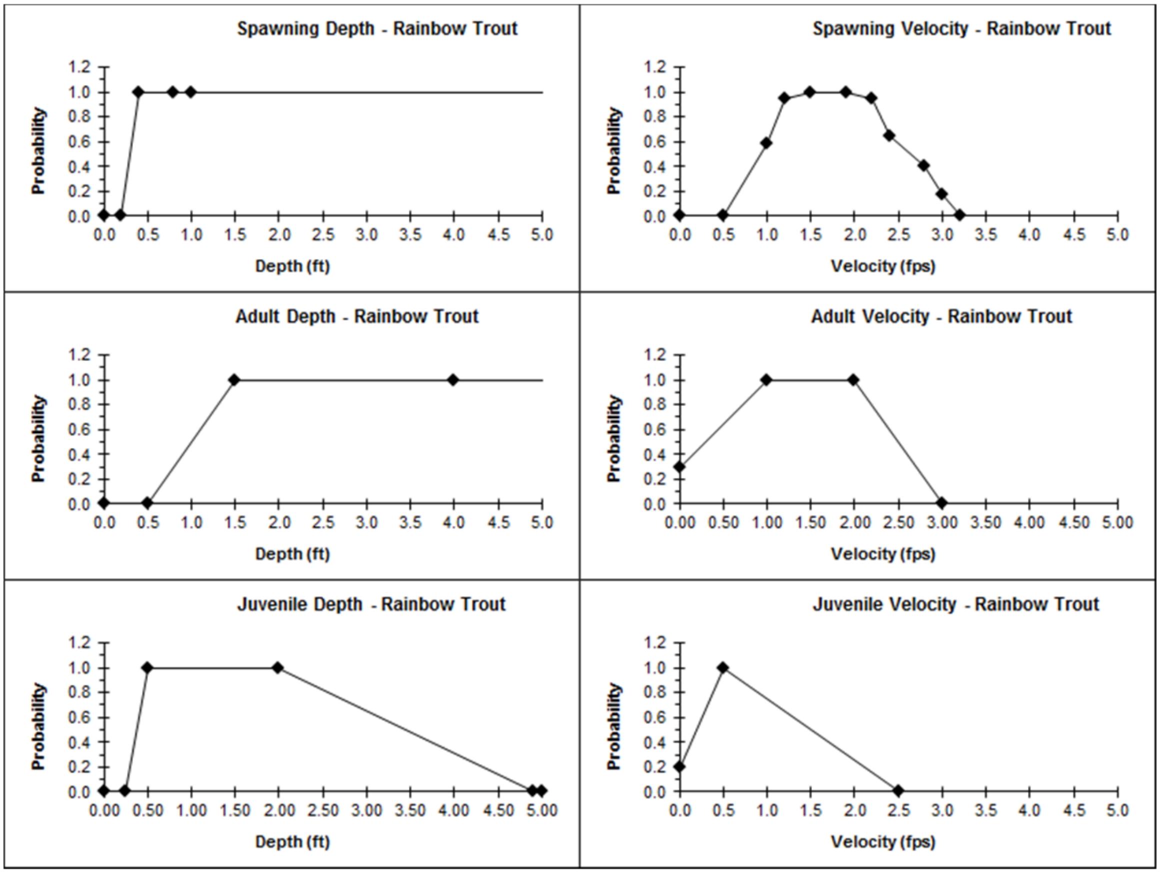


Table 7. Rainbow trout spawning HSC.

Consensus HSC from stakeholder meeting				Originally proposed HSC			
DEPTH		VELOCITY		DEPTH		VELOCITY	
X	Y	X	Y	X	Y	X	Y
0.0	0.00	0.0	0.00	0.0	0.00	*	*
0.2	0.00	0.5	0.00	0.2	0.00		
0.4	1.00	1.0	0.58	0.4	1.00		
0.8	1.00	1.2	0.95	0.8	1.00		
1.0	1.00	1.5	1.00	1.0	0.90		
100.00	1.00	1.9	1.00	1.4	0.60		
0	0	2.2	0.95	1.8	0.20		
0	0	2.4	0.64	2.0	0.13		
0	0	2.8	0.40	3.2	0.00		
0	0	3.0	0.18	100.00	0.00		
0	0	3.2	0.00	0	0		
0	0	100.0	0.00	0	0		

*originally proposed HSC do not differ from consensus HSC.

Red Text = Adjustments of originally proposed HSC data, agreed upon during stakeholder meeting.

Table 8. Rainbow trout adult HSC.

Consensus HSC from stakeholder meeting				Originally proposed HSC			
DEPTH		VELOCITY		DEPTH		VELOCITY	
X	Y	X	Y	X	Y	X	Y
0.0	0.00	0.00	0.30	*	*	0.0	0.81
0.5	0.00	1.00	1.00			0.5	1.00
1.5	1.00	2.00	1.00			2.0	1.00
4.0	1.00	3.00	0.00			2.4	0.30
100.0	1.00	100.00	0.00			3.0	0.02
0	0	0	0			3.4	0.01
0	0	0	0			3.5	0.00
0	0	0	0			6.0	0.00
0	0	0	0			100.0	0.00

*originally proposed HSC do not differ from consensus HSC.

Red Text = Adjustments of originally proposed HSC data, agreed upon during stakeholder meeting.

Table 9. Rainbow trout juvenile HSC.

Consensus HSC from stakeholder meeting				Originally proposed HSC			
DEPTH		VELOCITY		DEPTH		VELOCITY	
X	Y	X	Y	X	Y	X	Y
0.00	0.00	0.0	0.20	0.0	0.00	0.0	0.00
0.25	0.00	0.5	1.00	0.2	0.00	0.5	0.00
0.50	1.00	2.5	0.00	0.4	1.00	1.0	0.58
2.00	1.00	100.0	0.00	0.8	1.00	1.2	0.95
4.90	0.00	0.0	0.0	1.0	0.90	1.5	1.00
5.00	0.00	0.0	0.0	1.4	0.60	1.9	1.00
100.00	0.00	0.0	0.0	1.8	0.20	2.2	0.95
0	0	0	0	2.0	0.13	2.4	0.64
0	0	0	0	3.2	0.00	2.8	0.40
0	0	0	0	4.0	0.00	3.0	0.18
0	0	0	0	100.00	0.00	3.2	0.00
0	0	0	0	0	0	4.5	0.00
0	0	0	0	0	0	100.0	0.00

*originally proposed HSC do not differ from consensus HSC.

Red Text = Adjustments of originally proposed HSC data, agreed upon during stakeholder meeting.

Figure 5. HSC (depth and velocity) developed for rainbow trout during stakeholder workshop in June 2012.

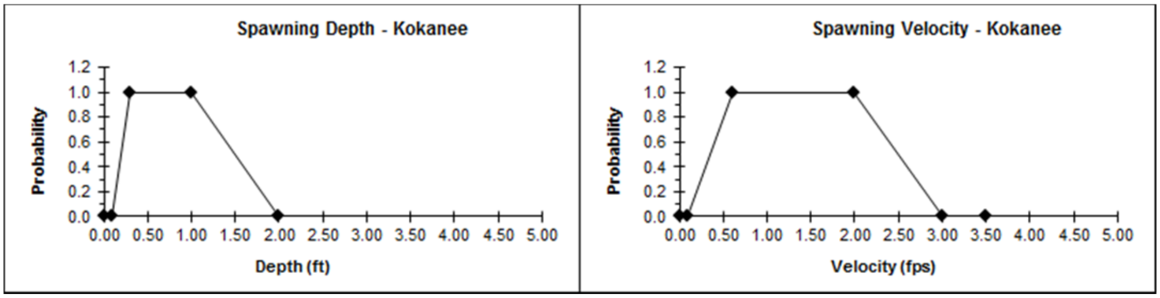


Table 10. Kokanee spawning HSC.

Consensus HSC from stakeholder meeting				Originally proposed HSC			
DEPTH		VELOCITY		DEPTH		VELOCITY	
X	Y	X	Y	X	Y	X	Y
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.10	0.00	0.10	0.00	0.10	0.00	0.10	0.00
0.30	1.00	0.60	1.00	0.20	0.40	0.20	0.20
1.00	1.00	2.00	1.00	0.30	0.80	0.30	0.40
2.00	0.00	3.00	0.00	0.32	0.95	0.60	0.98
100.00	0.00	3.50	0.00	0.40	1.00	0.70	1.00
0	0	100.00	0.00	0.50	0.95	0.90	1.00
0	0	0	0	0.60	0.75	1.00	0.98
0	0	0	0	0.70	0.55	1.20	0.60
0	0	0	0	0.80	0.40	1.35	0.40
0	0	0	0	0.90	0.30	1.50	0.23
0	0	0	0	1.00	0.25	1.60	0.18
0	0	0	0	1.20	0.16	1.80	0.13
0	0	0	0	1.50	0.05	2.00	0.10
0	0	0	0	1.75	0.00	2.70	0.00
0	0	0	0	100.00	0.00	100.00	0.00

Red Text = Adjustments of originally proposed HSC data, agreed upon during stakeholder meeting.

2.3 Transect Selection

During the June 2012 stakeholder meeting, the group conducted a site visit to the bypassed reach to select the study reach and transect locations. Fourteen proposed transects were flagged within the lowest 1500 feet of the lower bypassed reach (Figure 6). The upper segment of the lower bypassed reach, and the entire upper bypassed reach, are steep and turbulent; hydraulic parameters such as water velocities and water surface elevations could not be accurately collected or properly simulated in the PHABSIM modeling portion of the methodology. The stakeholder group considered the proposed study reach and all 14 transects satisfactory for modeling all life stages of bull trout and rainbow trout habitat. Transects selected included four slow water, pool-type sites, and ten fast water, riffle or rapid-type sites. The stakeholder group also agreed that only the lowest four transects were to be used for modeling kokanee spawning. A passage barrier between transects four and five prevented the majority of kokanee from spawning upstream of transect four. Photographs of the fourteen transects, taken at a flow of 5.3 cfs, are displayed in Figure 7 through Figure 19. The group determined that the 14 transects would be equally weighted during modeling for bull trout and rainbow trout, and that the 4 downstream-most transects would be equally weighted during kokanee modeling. Equal weighting was favored because there is little morphological distinction between the habitat types.

Figure 6. Map of study area and transect location.

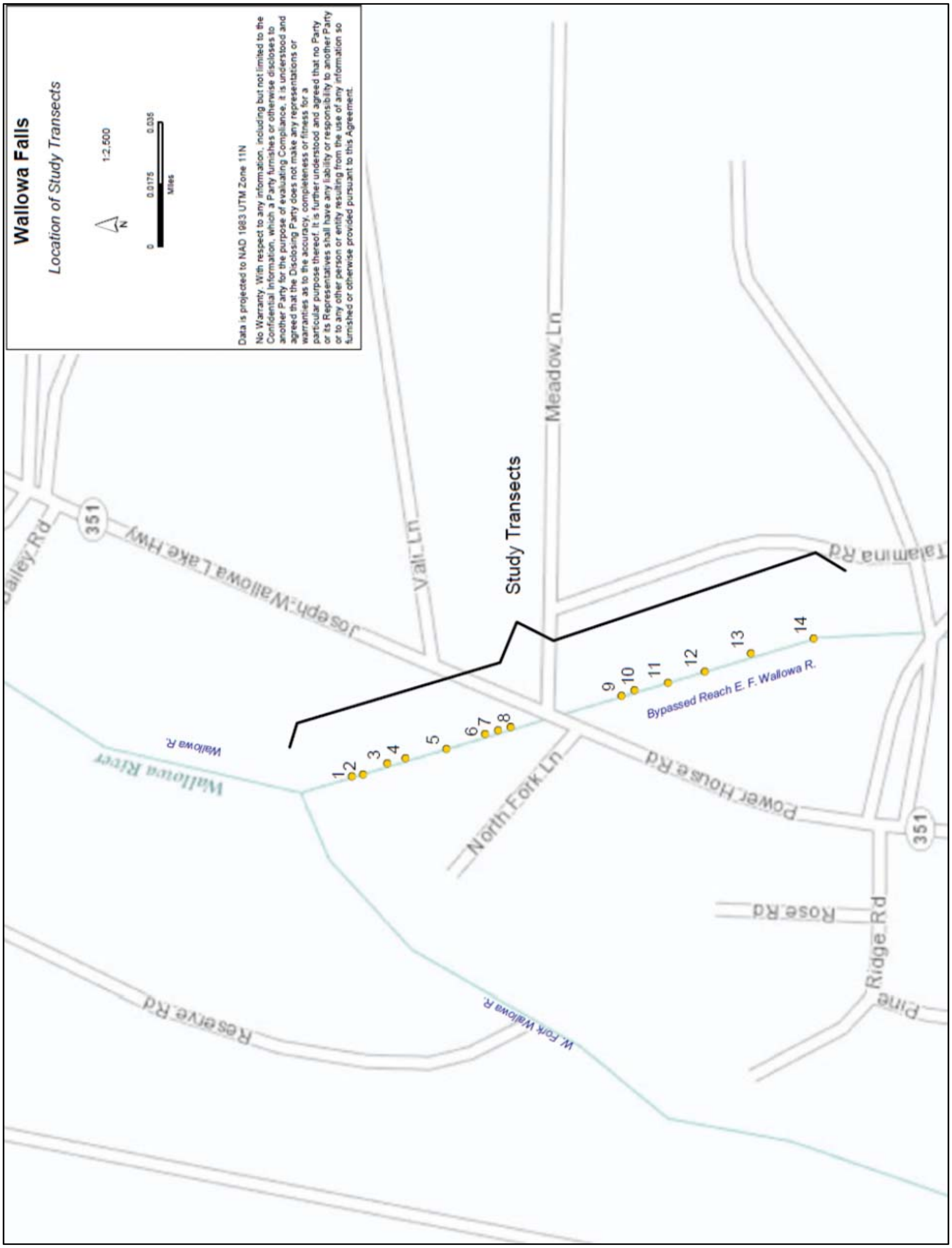


Figure 7. Transect 1 at Q=5.3 cfs.

Figure 8. Transect 2 at Q=5.3 cfs.

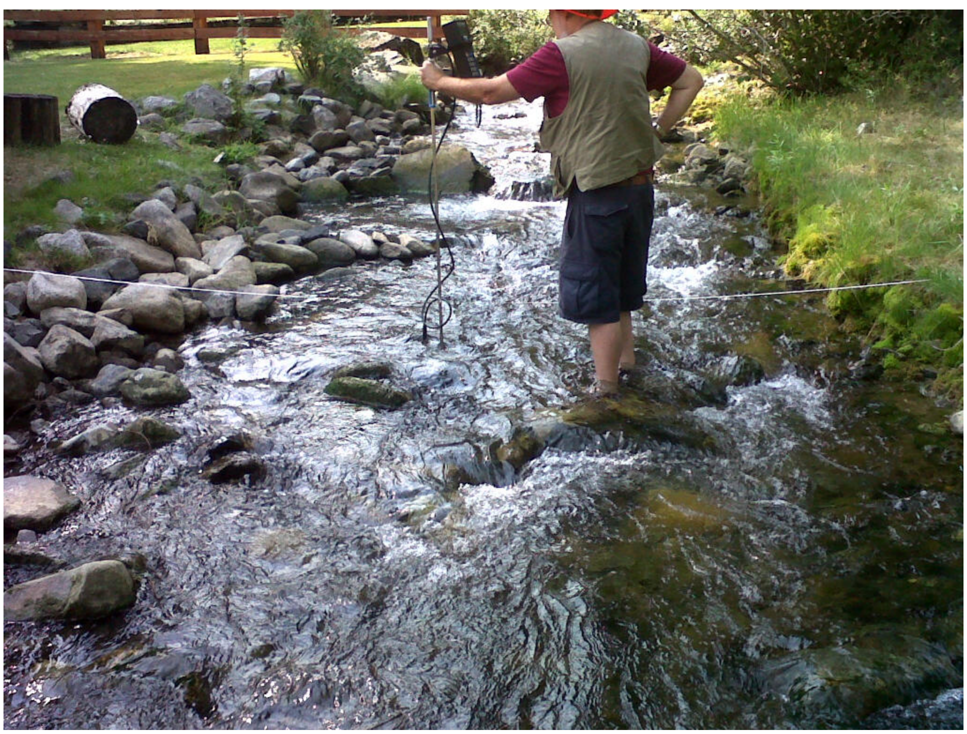


Figure 9. Transect 3 at Q=5.3 cfs.

Figure 10. Transect 4 at Q=5.3 cfs. Channel-spanning log blocks upstream access by Kokanee.

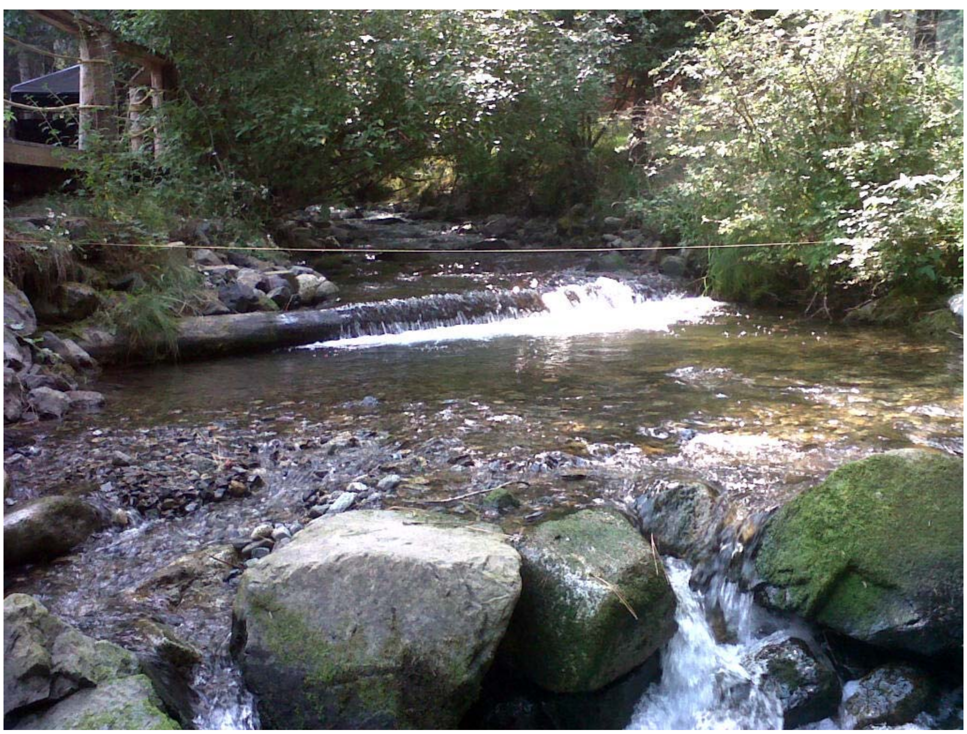


Figure 11. Transect 5 at Q=5.3 cfs.

Figure 12. Transect 6 at Q=5.3 cfs.

Figure 13. Transects 7 (foreground) and 8 (background) at 5.3 cfs.

Figure 14. Transect 9 at 5.3 cfs.

Figure 15. Transect 10 at 5.3 cfs.

Figure 16. Transect 11 at 5.3 cfs (photo taken looking downstream).

Figure 17. Transect 12 at 5.3 cfs.

Figure 18. Transect 13 at 5.3 cfs.

Figure 19. Transect 14 at 5.3 cfs.

2.4 Field Data Collection

PacifiCorp surveyed the study transects per the surveying protocol called for in the U.S. Fish and Wildlife Service's IFIM Informational Paper No. 26 (Milhouse et al. 1989). The transect head and tail stakes were placed above the ordinary high water mark (OHWM) to insure that water surface elevations (WSE) generated over the range of simulated flows did not exceed the stake elevations. The channel profile and WSEs were surveyed at each transect using a standard level-and-rod. Water velocities were collected using a FlowTracker meter at intervals such that no one "cell" along the transect contained more than about 5 percent of the total flow.

Three different flows were targeted for the collection of hydraulic and habitat data after completion of the transect survey. The high flow target was 16 cfs, and the actual gaged release on July 22 was 15 cfs. The mid-flow target was 8 cfs, and the gaged release on August 21 was 8.5 cfs. The low flow target was 4 cfs, and the gaged release on August 22 was 5.3 cfs. The hydraulic variables collected for PHABSIM modeling during the flow releases are described in Table 11.

Table 11. Hydraulic variables collected at each transect during the target flow releases.

Variable	Units	Description
Temporary stage	Feet	Mobile staff gage was placed at each location to check for changes in stage during measurements
Water Surface Elevation (WSE)	Feet	Surveyed and averaged right and left edge of water to the hundredths of a foot
X-distance (station)	Feet	Increments of a transect between survey stakes where hydraulic variables are measured
Water Depth	Feet	Measured with top-setting wading rod at each station, used a verification of the surveyed WSL and channel bed
Bed Elevations	Feet	Determined indirectly (surveyed WSL - water depth)
Mean column water velocity	Feet per second (fps)	Measured at each station with a FlowTracker acoustic doppler velocimeter, averaged over 30 seconds
Substrate	Percent Composition	Recorded dominant and subdominant substrate types and percent composition at each station (only recorded at low release)
Cover	Binary	Presence/absence (only recorded at low release)

2.5 Preliminary Modeling Methods

2.5.1 General Approach

The bypassed reach is a relatively steep, velocity-driven system. To accurately reflect conditions over a range of flows between about 1 cfs and 20 cfs, a separate hydraulic model ("sub-model") was developed for each target flow. Therefore, three separate PHABSIM "sub-models" were created, which simply consisted of the data set and separate PHABSIM modeling results for a particular target flow and its associated simulation flow range.[1]

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[1] The PHABSIM hydraulic model (named "IFG4") was originally configured to use three or more sets of stage and transect velocity measurements taken at high, middle, and low flow (Bovee and Milhous 1978). In this configuration, the data sets are combined into a single model that uses a least-squares regression fit of log stage against log discharge for each transect and log velocity against log discharge for each vertical on each transect. When fewer than two calibration velocities are available at a vertical, IFG4 uses Manning's equation for velocity simulation at that vertical for all flows (Bovee and Milhous 1978). This original velocity simulation method is now commonly termed by IFIM practitioners as the "three-velocity" technique (Payne and Bremm 2003).

The three PHABSIM sub-models consisted of low-, mid-, and high-flow scenarios, where each scenario used the one-velocity hydraulic calibration method to simulate velocities and three water surface elevations (WSE's) were collected at each transect to develop a regression-derived stage-discharge relationship. A low flow sub-model was calibrated using velocities measured at 5.3 cfs and used to model habitat at flows between 1 and 6 cfs. A mid-flow sub-model was calibrated with velocities measured at the 8.5 cfs target and used to model habitat at flows between 6 and 11 cfs. A high flow sub-model was calibrated with velocities measured at the 15 cfs target and used to model habitat at flows between 9 and 20 cfs.

The WSE's surveyed at each release were used to calibrate each of the three sub-models, thereby insuring that the three sub-models would predict the same WSEs at the points where the model runs overlapped. By doing this, the output of the habitat simulations produced by each PHABSIM sub-model can be overlapped to develop one continuous habitat-discharge relationship for each transect of the entire range of flows simulated.

2.5.2 Hydraulic Modeling

A regression-based simulation (STGQ sub-model of PHABSIM) was used to simulate WSE's for each of the three PHABSIM sub-model runs. Best-estimate flows (5.3, 8.5, and 15 cfs) were used to calibrate the STGQ model. PacifiCorp attempted to calibrate all WSLs to within ±0.01 feet of the average of the surveyed WSL. Most target releases could be calibrated to ±0.01 feet, but when such accuracy could not be obtained, calibrations were considered satisfactory if the predicted WSL fell within the surveyed elevations of the left and right water surfaces.

Velocities were calibrated and modeled with the VELSIM sub-model.

Another velocity simulation method is optionally available within IFG4 using a single velocity set (Milhous 1984). The IFG4 "one-velocity" technique uses one set of measured velocities for all verticals at a calibration flow and solves Manning's equation on an individual cell basis (with depth in place of hydraulic radius) to derive a roughness or velocity distribution factor (Milhous 1984). The Manning's n values derived from the calibration flow are used as a template to predict velocities at all other discharges. The one-velocity IFG4 method can be used with any number of velocity sets, typically extrapolated over a range of flows around specific calibration flows (Payne 1987).

Many years of experience with these velocity simulation methods indicates that use of one-velocity data sets generate WUA results that deviate only slightly from those incorporating three-velocity data sets Milhous 1984, Payne 1987). Furthermore, in many cases the one-velocity approach has been shown to have a wider range of predictive capability than the three-velocity regression approach (Milhous 1984, Payne 1987, Payne and Bremm 2003).

2.6 Habitat Modeling

The initial step in habitat modeling was to apply an upstream weighting factor to each transect. PacifiCorp implemented an equal weighting approach, as was recommended by Oregon Department of Fish and Wildlife. Under the equal weighting approach, each transect was assigned an identical, arbitrary spacing (in this case, 100 feet), and each was weighted 1. The last transect was assigned a spacing of 200 feet, and the second-to-last transect was weighted at 0.5. This approach insured that habitat at each transect was modeled over a 100-foot section of stream.

After the hydraulic simulation for each transect was completed in each PHABSIM sub-model run, , the resulting predictions of depth and velocity at various discharges were coupled with the substrate data, habitat suitability criteria, and habitat weighting assigned to each transect. The habitat program (HABTAE) of PHABSIM computed the amount of physical habitat weighted by its suitability for each species/life stage being modeled. To estimate the composite suitability for a species/life stage in each cell along a study transect, the individual suitabilities for that cell's estimated depth, velocity, and substrate were multiplied as follows:

$$C_i = f_v(V_i) \text{ x } fd(D_i) \text{ x } fs(S_i)$$

where:

C_i = Composite weighting factor for suitability in cell i

$f_v(V_i)$ = Suitability factor for velocity in cell i

$f_d(D_i)$ = Suitability factor for depth in cell i

$f_s(S_i)$ = Suitability factor for substrate in cell i

The total surface area of each cell was multiplied by its respective composite weighting factor, and the resultant surface areas are totaled to provide an index of habitat available within the study reach for each habitat guild. The estimate of habitat usability is called the weighted usable area (WUA) and was computed as follows:

$$WUA = \sum_{i=1}^{d} C_i A_i$$

where:

C_i = Composite weighting factor for suitability

A_i = Surface area of cell

n = Total number of cells within the simulated stream reach

The WUA, presented as square feet of available habitat per 1,000 feet of stream, was then plotted against discharge for each of the species/life stages of interest for this study.

2.6.1 Flow and Habitat Time Series

A habitat time series analysis will be conducted to derive a habitat duration curve. The analysis is not available at the time of this writing.

3.0 PRELIMINARY RESULTS OF HABITAT MODELING

Preliminary PHABSIM modeling runs have been completed. These data represent initial trial runs; and the model output, particularly the hydraulic files, have not received a rigorous QA/QC review. PacifiCorp will present results, including habitat curves and habitat duration analysis, to stakeholders during the first quarter of 2013.

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APPENDIX A. RESULTS OF HABITAT SURVEY

Habitat Units

USFS Region 6 protocol categorizes habitat units based on water surface slope, turbulence, and features that form the unit. The dominant habitat type observed in the bypassed reach is fast turbulent rapid (rapid, 53%), and the sub-dominant types are fast turbulent riffle (riffle, 29%) and fast turbulent cascade (cascade, 16%). Pools offer good habitat, but well-defined pools are not common (2.5%). The majority of small pools are found within the cascade habitat type. Such pools occur as "pocket water" - they are too small to be identified as individual units.

Sub-Reach Descriptions

Three distinct sub-reaches were observed within the surveyed length of the bypassed reach. The features which differentiate these sub-reaches are slopes, dominant habitat type, and channel characteristics. A description of each sub-reach follows, as well as a suite of photographs, as indexed on the map, wherein we recommend possible transect locations.

1. **Sub-reach 1:** From mouth of East Fork to about 1600 feet upstream (approximate location of PacifiCorp property boundary)
   - Average slope is 3.6%
   - Habitat types are **rapid (49%), riffle (46%), pool (2.8%), and cascade (1.8%)**
   - Presence of pools
   - Channel characteristics include simple (single flow path) channel, stable boulder-lined banks, well- defined, uniform-height terraces, and relatively uniform bed.
   - Defined by land use (100% rural residential), and lack of understory in streamside vegetation (mostly **conifers)**
2. **Sub-reach 2:** Approximately 900 feet in length – beginning 1600 feet above confluence and extending to 2500 feet upstream of confluence (almost entirely on PacifiCorp property)
   - Average slope is 5.1%
   - Habitat types are **rapid (59%), cascade (24%), riffle (15%), and pool (2.7%)**
   - Channel characteristics are somewhat complex. Secondary channels (mostly dry) occur. Terraces are of less uniform height and were vegetated with riparian bushes and trees. Bed is generally uniform, but discrete lateral steps occur (i.e. bed and water surface on right side of channel may be one to two feet higher than bed and water surface on left side of channel).
   - Land use may be defined as forested or partially forested. Riparian vegetation spans the channel in some locations which makes maneuvering in these locations difficult if not impossible. PacifiCorp does not propose placing transects in densely vegetated areas.
3. **Sub-reach 3:** 2500 feet to 3380 feet upstream of confluence (entirely on PacifiCorp property)
   - Average slope is 10.1%
   - Habitat types are **cascade (51%) and rapid (49%)**
   - Channel characteristics are complex. Secondary channels occur and lateral steps occur frequently. Large, protruding boulders are common. High terraces define most of the sub-reach, and the remaining 200+ feet of channel is constrained by bedrock.

- Land use is forested