Lewis River Stranding Monitoring Study Plan

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1 INTRODUCTION

The Lewis River Hydroelectric Projects Settlement Agreement (SA) was signed in November 2004 and was adopted as part of the Federal Energy Regulatory Commission (FERC) Merwin Project No. 935 License (License). This Study Plan addresses the requirements of Section 6.2.3 of the SA, including a process to develop the stranding study objectives in consultation with the Aquatic Coordination Committee (ACC) and a comprehensive approach to complete a stranding study and a habitat evaluation study below Merwin Dam. Comments received on this study plan, and responses to them, are included in Attachment A. The purpose of the stranding study is to assess the potential effects of minimum flows released as part of normal Project operations on steelhead, coho salmon, Chinook salmon, and chum salmon, and their habitats.

1.1 Objectives

The objective of this stranding study and habitat evaluation is to assess the effects of minimum flow releases from the Project on potential for fish stranding and habitat impacts to steelhead, coho salmon, Chinook salmon, and chum salmon. Developed in collaboration with PacifiCorp and the Aquatic Coordination Committee (ACC), this study will address the following:

1) Identify measurable factors affecting potential stranding, the relationship of such factors to each other, and the timeframe and season within which stranding may occur.
2) Evaluate spawning and rearing habitat from Merwin Dam to the downstream end of Eagle Island across a range of minimum flow operational conditions.

2 APPROACH

The general approach to assessing stranding risk will be to locate and measure Potential Stranding Zones (PSZs) in the field based on local morphology, such as bank slope and isolated pools lacking egress, and to evaluate the degree of risk at those locations based on site-specific characteristics (e.g., substrate size), species behavior, life-history timing, and Project operations under the terms of the SA. An assessment of relative risk will be developed that combines the potential for stranding based on the field mapping with the combination of risk factors (e.g., species, life stage, river stage/flow operations, and season) to identify measurable factors affecting potential stranding, the relationship of such factors, and the timeframe and season within which stranding may occur. This study will assess the “potential” for stranding, rather than “actual” stranding, since assessing actual stranding would require a substantially greater level of effort, and due to challenges in detecting stranded fish, often results in greater uncertainty.

Spawning and rearing habitat in the study area will also be evaluated across a range of minimum flow operational conditions. The general approach will be to delineate spawning and rearing habitat in the field on photographic base maps. The delineation will be conducted at a predefined set of minimum flows (Section 2.3.2) based on habitat criteria representative of individual or groups of species and life stages (guilds). The amount of habitat available for each species and at each flow in the study reach will be estimated.

2.1 Study Area

The study area will encompass the mainstem North Fork Lewis River from the Merwin Powerhouse Access Bridge (River Mile [RM] 19) downstream to the downstream end of Eagle Island (approximately RM 13) (Study Reach).

2.2 Criteria used to Identify Potential Stranding Zone

Stranding is a natural phenomenon, which can be exacerbated by human activities, such as downramping resulting from hydroelectric operations. Early life stages of salmonids may be particularly susceptible to stranding mortality owing to their reduced swimming ability and preference for shallow-water habitat with cover (Healey 1991). Stranding primarily occurs after the river stage rises and allows fish to move into newly inundated areas such as gravel bars, secondary channels, and floodplains. As flows recede, a portion of these fish can become trapped by substrate on channel bed or bar surfaces, or in isolated pools and depressions that may form (Bell et al. 2008). Unless water levels return quickly or the depressions are fed by subsurface flow, the fish will desiccate or become easy prey for a variety of predators.

Because of protective measures in the SA, including a downramp limit of two (2) inches/hour, and the elimination of downramping during crepuscular hours when fry emerge, most stranding is likely to be focused in only the areas with the greatest risk of stranding based on physical channel characteristics, such as in low-gradient, porous substrate, or in isolated depressions lacking egress. All potential stranding zones (PSZs) in the Study Reach will be identified and mapped at the flows discussed in Section 2.3.2, including a range of flows that occur when fish are most vulnerable (typically spring). PSZs will be identified based on having a gradient of less than 5%, gravel or cobble substrate, or the occurrence of a pothole or depression without egress, all as described in detail below.

2.2.1 Gradient of less than 5%

In general, the surface slope where fish are found stranded is lower (< 5%) than in areas where fish are not found stranded (Bauersfield 1978, R. W. Beck Associates 1989, as cited in Hunter 1992). Stranding in areas with slopes greater than 5% has generally not been reported (Hunter 1992), although in laboratory experiments, Monk (1989) observed stranding on slopes > 5%. Monk (1989) attributed stranding risk on low slopes to the nature of water slowly draining off the surface, with no obvious egress, an effect that is accentuated in cobble substrate (Figure 1). The gradient of surfaces will be measured in the field with a hand level.

Figure 1. Example of a channel feature with gradient less than 5% (Stillwater Sciences 2006).

2.2.2 Potholes or depressions without egress

Fish are often stranded in potholes or depressions (typically formed by scour around boulders or rootwads) that become dry during water surface declines presenting little opportunity for egress (Phinney 1974, Woodin 1984, Olson and Metzgar 1988, Bradford 1997) (Figure 2). Bradford (1997) concluded that even under very moderate rates of fluctuation, some fish would be stranded in these features, since fish often do not actively attempt to avoid these features until water levels are low enough that no egress is available. Potholes and depressions will be visually identified during field surveys.

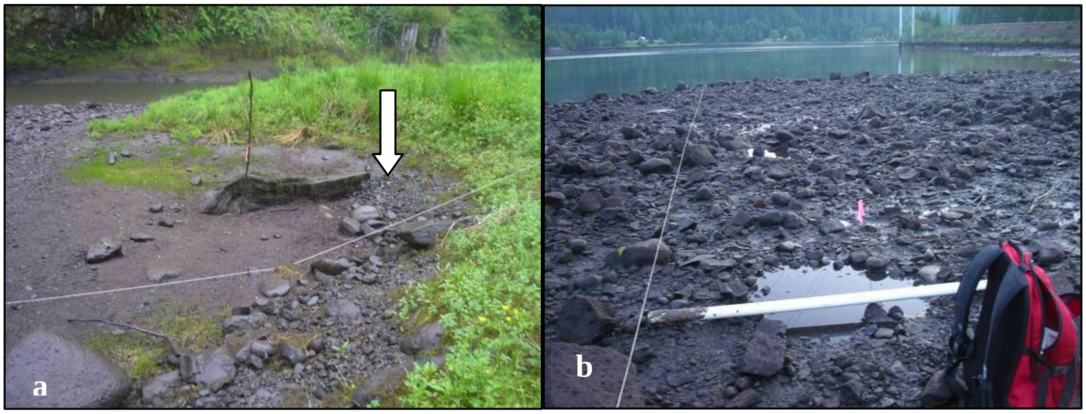

Figure 2. Example of a pothole formed from scour around a rootwad (a) and from a depression in cobble substrate (b) (Stillwater Sciences 2006).

2.2.3 Substrate consisting of cobble and gravel

Stranding is most often observed on cobble and gravel substrate, with fewer observations in mud (Becker et al. 1981), and even fewer in vegetation (Phillip 1969, Satterthwaite 1987, both as cited in Hunter 1992). Monk (1989) conducted laboratory experiments to examine the mechanisms of fish stranding. He found that substrate type was the most statistically significant factor influencing rates of stranding. He observed that when fish were over cobble and coarse gravel substrates, as the water receded during declining water surface elevation, some flow percolated into the substrate, and fish attempted to move into the interstitial spaces between cobbles for cover and were stranded (Figure 3). In contrast, when water declined over finer substrates it tended to flow off the surface, and fish were unable to locate cover, and instead followed the receding water off the substrate into deeper water. In addition, emergent fry (vulnerable to stranding) are more often associated with large cobble substrate with interstitial spaces that can be used for cover, than with fine sediment, increasing the risk of stranding when flows recede. Cobble substrate with interstitial spaces will be visually identified during field surveys.

Figure 3. Example of gravel/cobble substrate conducive to fish stranding (Stillwater Sciences 2006).

2.2.4 Field mapping

A polygon defining the boundary of each PSZ will be mapped with a handheld GPS unit at the lowest study flow assessed (1,200 cfs - see Section 2.3.2). During subsequent surveys at increasing flows, the waters edge and the extent of the PSZ inundated will be mapped. Figure 4 shows an example of how results will be illustrated. Photopoints will be established at key locations to document shifts in stranding potential with flow alterations. Any fish observed stranded (dead on shoreline or isolated in pools) during each of the four field surveys will be enumerated. Given the opportunistic nature of these surveys, they should not be considered absolute estimates of stranding risk. Instead they can help to identify potential stranding areas for additional consideration.

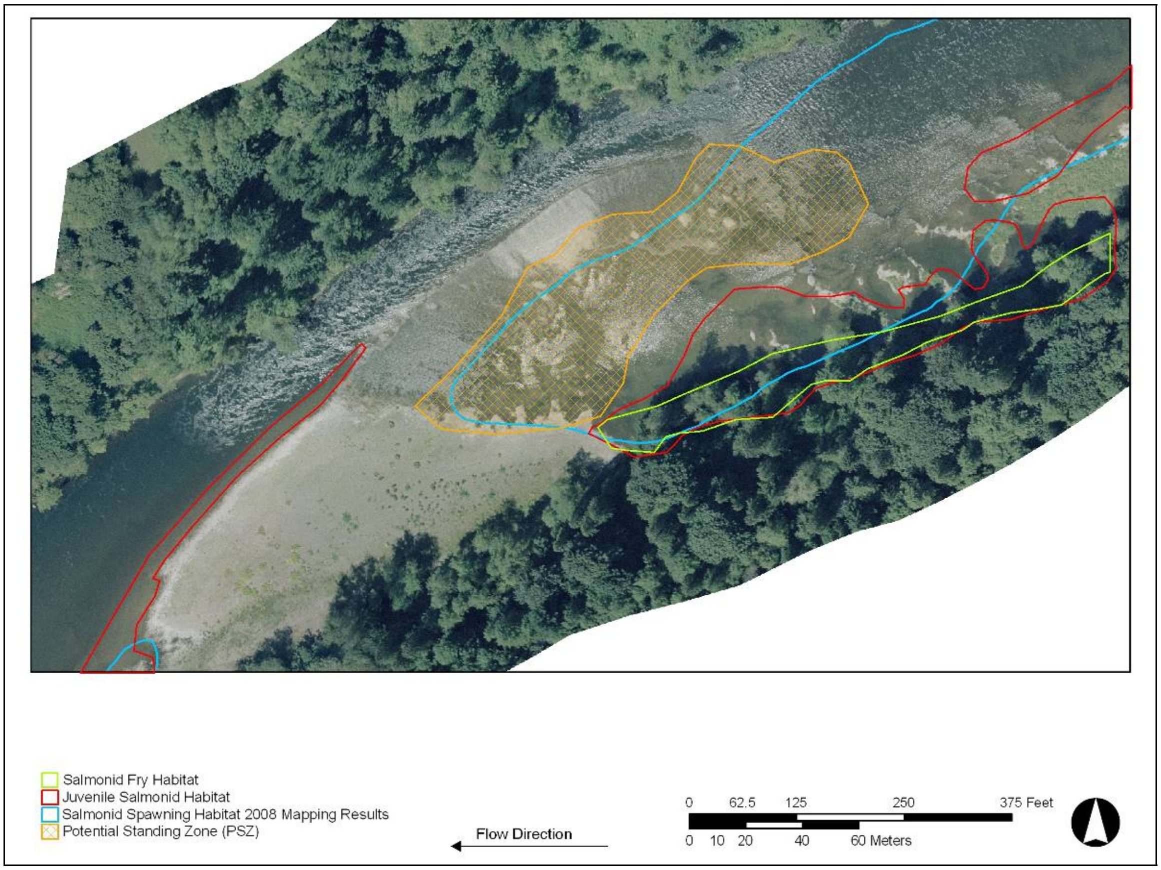

Figure 4. Example of Stillwater Sciences' mapping approach to evaluating salmonid spawning and rearing habitat, and potential stranding zones at RM 17.2 on the Lewis River at 2,000 cfs.

For all identified PSZs, the risk that fish will become stranded will be assessed based specific criteria known to influence stranding, including:

- species presence (based on life history, some species have a greater propensity to be stranded than others);
- life stage and life-history timing (young fry are more vulnerable than older life stages);
- seasonal and daily timing of fish behavior and flow management (fish behavior, and thus stranding potential, varies among seasons and time of day);
- physical topography of features, such as substrate size characteristics, embeddedness, formation of depressions, and slope; and
- stage/flow relationship for each PSZ identified to determine the stranding risk for a range of operational conditions (e.g., some PSZs may be inundated during spring).

2.3 Habitat Criteria to Evaluate Habitat for Key Fish Species or Guilds

The suitable habitat area for life stages of key fish species will be mapped over a range of flows to evaluate the effects of changes to instream flows on the habitat of key fish species in the Lewis River. The mapping approach proposed for this study relies on habitat criteria thresholds to define suitable habitat for key species and life stages. The development of the habitat criteria presented in this document was based on a review of the scientific literature to identify critical life stages of key species and critical habitat characteristics such as water depth and velocity. Based on the SA, the key fish species identified for this study include Chinook salmon, coho salmon, chum salmon, and steelhead.

The steps used for selecting habitat criteria included (1) reviewing available information, (2) identifying critical life stages for key species, (3) selecting criteria values representing "good" habitat for each species and life stage, and (4) defining guilds.

Available information including peer-review scientific literature was used to identify potential critical life stages for the key species and associated habitat criteria values. The selection of critical life stages for key species depends on the species' life history and whether information is available to define meaningful criteria thresholds. Critical life stages for key species for this study were selected based on objectives stated in the SA, and are presented in Table 1.

Table 1. Key fish species and life stages proposed for this study.

Key species	Life stages
Chinook salmon (*Oncorhynchus tshawytscha)*	Spawning
	Fry
	Juvenile
Coho salmon (*Oncorhynchus kisutch)*	Spawning
	Fry
	Juvenile
Steelhead (*Oncorhynchus mykiss)*	Spawning
	Fry
	Juvenile
Chum Salmon (*Oncorhynchus keta*)	Spawning
	Fry
	Juvenile

Habitat criteria values proposed for mapping available habitat were developed based on the range of values reported in available literature sources for each analysis species and life stage. With the substantial amount of information is available on anadromous salmonids habitat utilization, there is a large range of values reported in the literature. One reason for the range is that many reported observations are from relatively poor habitat. Utilization of poor habitat can be a result of environmental pressures such as predation risk which force fish to use habitat they wouldn't otherwise use. Therefore, an effort was made to define a range of "good" habitat for evaluating the effects of different minimum flows on available habitat in the Lewis River.

The ranges of habitat criteria values considered to represent good habitat were selected based on the habitat criteria values derived from the literature and professional judgment. Habitat criteria values reported in studies conducted for species, locations, and using study methodologies considered applicable to the Lewis River below Merwin Dam were given highest consideration; information specific to the Lewis River was used whenever possible.

Specific criteria were selected only when the characteristic was considered to be fundamental to development, reproductive success, or survival. Water depth and water velocity were considered key criteria for all analysis species and life stages based on the scientific literature, and were thus included as initial criteria to be selected for mapping (Table 2). Substrate size was considered a key criterion for spawning (Table 2), and cover was considered a key criterion for juvenile coho rearing. Other potential habitat criteria parameters such as substrate for juvenile rearing life stages did not appear to warrant inclusion as criteria. Water temperature was considered beyond the scope of this study and was not included as a potential mapping criterion.

Table 2. Summary of habitat criteria values for key species and life stages in the Lewis River downstream of Merwin Dam.

Life stage	Habitat characteristic	Range of "good" values	Supporting literature
Chinook salmon			
Spawning	Depth	0.15–1.2 m (0.5–4 ft)	Primary: Lewis River Habitat Suitability Index Curves based on 0.5 suitability (PacifiCorp 2004) Secondary: Bovee (1978), Bell (1986), and Bjornn and Reiser (1991)
	Velocity	0.3–1.1m/s (1.0–3.5 ft/s)	Primary: Lewis River Habitat Suitability Index Curves based on 0.5 suitability (PacifiCorp 2004) Secondary: Bovee (1978), Bell (1986), and Bjornn and Reiser (1991)
	Substrate (D_{50})	11–69 mm (0.4–2.7 in)	Primary: Kondolf and Wolman (1993) Secondary: Thompson (1972)
Fry rearing	Depth	<0.15 m (<0.5 ft)	Primary: S. Hawkins, WDFW, Pers. comm. 2009 Secondary: Everest and Chapman (1972). Lister and Genoe (1970), Stuehrenberg (1975)
	Velocity	<0.03 m/s (<0.1 ft/s)	Primary: S. Hawkins, WDFW, Pers. comm. 2009 Secondary: Everest and Chapman (1972), Lister and Ganoe (1970), Stuehrenberg (1975), Thompson (1972)
	Cover	0.5 m (1.6 ft) from large cobble	Primary: S. Hawkins, WDFW, Pers. comm. 2009; and professional judgment
Juvenile rearing	Depth	0.3–1.4 m (1.0–4.5 ft)	Primary: S. Hawkins, WDFW, Pers. comm. 2009; Lewis River Habitat Suitability Index Curves based on 0.5 suitability (PacifiCorp 2004) Secondary: Everest and Chapman (1972)
	Velocity	0.03–0.5 m/s (0.1–1.5 ft/s)	Primary: Lewis River Habitat Suitability Index Curves based on 0.5 suitability (PacifiCorp 2004) Secondary: Hardin-Davis et al. (1991), Everest and Chapman (1972)
Coho salmon			
Spawning	Depth	0.15–0.9 m (0.5–3.0 ft)	Primary: Lewis River Habitat Suitability Index Curves based on 0.5 suitability (PacifiCorp 2004) Secondary: Thompson (1972) as cited in Bjornn and Reiser (1991)

Life stage	Habitat characteristic	Range of "good" values	Supporting literature
	Velocity	0.09–0.8 m/s (0.3–2.7 ft/s)	Primary: Lewis River Habitat Suitability Index Curves based on 0.5 suitability (PacifiCorp 2004) Secondary: Thompson (1972) as cited in Bjornn and Reiser (1991)
	Substrate (D_{50})	5–35 mm (0.2–1.4 in)	Primary: Kondolf and Wolman (1993) Secondary: None
Fry rearing	Depth	<0.24 m (<0.8 ft)	Primary: Bugert et al. (1991) Secondary: Bisson et al. (1982), Sullivan (1986), Dolloff (1983)
	Velocity	<0.1 m/s (<0.3 ft/s)	Primary: Bjornn and Reiser (1991) Secondary: Reeves et al. (1989)
	Cover	0.5 m (1.6 ft) from large cobble	Primary: S. Hawkins, WDFW, Pers. comm. 2009; professional judgment
Juvenile rearing	Depth	0.15–1.4 m (0.5–4.5 ft)	Primary: Lewis River Habitat Suitability Index Curves based on 0.5 suitability (PacifiCorp 2004) Secondary: Sheppard and Johnson (1985), Dolloff and Reeves (1990)
	Velocity	<0.14 m/s (<0.45 ft/s)	Primary: Lewis River Habitat Suitability Index Curves based on 0.5 suitability (PacifiCorp 2004) Secondary: Sheppard and Johnson (1985), Murphy et al. (1989)
	Cover	1.0 m (3.3 ft) from cover	Primary: Professional judgment Secondary: Bustard and Narver (1975), Bugert (1985), Shirvell (1990)
Chum salmon			
Spawning	Depth	≥0.24 m (≥0.79 ft)	Primary: Smith (1973) Secondary: None
	Velocity	0.46–1.01 m/s (1.5–3.3 ft/s)	Primary: Smith (1973) Secondary: None
	Substrate (D_{50})	11–62 mm (0.4–2.4 in)	Primary: Kondolf and Wolman (1993) Secondary: Bell (1986 as cited in Bjornn and Reiser 1991)
Fry rearing	Depth	<0.15 m (<0.5 ft)	Primary: S. Hawkins, WDFW, Pers. comm. 2009 Secondary: Beechie et al (2005)
	Velocity	<0.03 m/s (<0.1 ft/s)	Primary: S. Hawkins, WDFW, Pers. comm. 2009 Secondary: Beechie et al (2005)
	Cover	0.5 m (1.6 ft) from large cobble	Primary: S. Hawkins, WDFW, Pers. comm. 2009; and professional judgment
Juvenile	Depth	0.3–1.4 m (1.0–4.5 ft)	Based on assuming similar rearing criteria as Chinook salmon juveniles (Beechie et al. 2005, S. Hawkins, WDFW, Pers. comm. 2009)
	Velocity	0.03–0.5 m/s (0.1–1.5 ft/s)	
Steelhead			
Spawning	Depth	>0.15 m (>0.5 ft)	Primary: Lewis River Habitat Suitability Index Curves based on 0.5 suitability (PacifiCorp 2004) Secondary: Smith (1973), Bovee (1978)
	Velocity	0.5–1.1 m/s (1.5–3.5 ft/s)	Primary: Lewis River Habitat Suitability Index Curves based on 0.5 suitability (PacifiCorp 2004) Secondary: (Barnhart 1991)

Life stage	Habitat characteristic	Range of "good" values	Supporting literature
	Substrate (D_{50})	10–46 mm (0.4–1.8 in)	Primary: Kondolf and Wolman (1993) Secondary: None
Fry rearing	Depth	<0.3 m (<1.0 ft)	Primary: Sheppard and Johnson (1985) Secondary: Bugert (1985), Moyle and Baltz (1985)
	Velocity	<0.1 m/s (<0.3 ft/s)	Primary: Bjornn and Reiser (1991) Secondary: Dolloff (1983)
	Cover	0.5 m (1.6 ft) from large cobble	Primary: S.Hawkins, WDFW, Pers.comm. 2009; and professional judgment
Juvenile rearing	Depth	>0.2 m (>0.8 ft)	Primary: Lewis River Habitat Suitability Index Curves based on 0.5 suitability (PacifiCorp 2004) Secondary: Everest and Chapman (1972)
	Velocity	0.09–0.8 m/s) (0.3–2.7 ft/s)	Primary: Lewis River Habitat Suitability Index Curves based on 0.5 suitability (PacifiCorp 2004) Secondary: Stuehrenberg (1975), Everest and Chapman (1972)
	Cover	1.0 m (3.3 ft) from large cobble	Primary: Professional judgment Secondary: Bustard and Narver (1975)

After defining criteria for good habitat (Table 2), an attempt was made to group criteria for species and life stages together into guilds to allow more efficient mapping. Guilds consist of species and life stages having similar good habitat requirements (Table 3). For mapping purposes, additional criteria defining minimum habitat areas (polygons) are proposed based on literature review and expert opinion for each analysis species and life stage. Polygon sizes are proposed that are large enough to be practical to map in the field, and small enough to accurately reflect habitat needs of each guild.

Table 3. Summary of proposed guilded habitat criteria values for mapping key species and life stages in the Lewis River downstream of Merwin Dam.

Guild name	Minimum polygon area[1]		Cover type and/or substrate criteria	Velocity				Depth			
				Minimum		Maximum		Minimum		Maximum	
	m^2	ft^2		(m/s)	(ft/s)	(m/s)	(ft/s)	(m)	(ft)	(m)	(ft)
Spawning guilds											
Chin/Chum	4.3	46	10–65 mm	0.3	1.0	1.1	3.5	0.15	0.5	1.5	5.0
Stld/Coho	2.8	30	10–40 mm	0.3	1.0	0.9	3.0	0.15	0.5	0.9	3.0
Fry rearing guilds											
Chin/Chum	2	22	Within 0.5 m (1.6 ft) of cover[2]	none	none	0.03	0.1	none	none	0.15	0.5
Stld/Coho	2	22	Within 0.5 m (1.6 ft) of cover[2]	none	none	0.15	0.5	none	none	0.3	1.0
Juvenile rearing guilds											

Chin/Chum	2	22	none	0.03	0.1	0.5	1.5	0.3	1.0	1.4	4.5
Coho	2	22	Within 1m (3.3 ft) of cover[2]	none	none	0.14	0.45	0.15	0.5	1.4	4.5
Stld	2	22	Within 1m (3.3 ft) of cover[2]	0.09	0.3	0.8	2.7	0.2	0.8	none	none

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[1] Minimum polygons of area that will be mapped for each guild to facilitate mapping process, based on literature review and expert opinion.

[2] cover types include moderate to large-sized cobble for fry rearing, and large cobble, woody debris, aquatic vegetation, undercut banks, or overhanging vegetation for juvenile rearing.

2.3.1 Field methods

Based on approved habitat criteria, all guilds will be delineated in the field at the range of minimum flows discussed in Section 2.3.2. Field mapping will consist of trained field crews delineating polygons of good habitat for each selected guild on aerial photographs using existing spawning habitat mapping results (Stillwater Sciences 2008). Photopoints will be established at key locations to document shifts in habitat availability. Based on life history and flow schedule, not all guilds will be mapped at all flows. For example, spawning habitat may not be mapped at July flows, when no spawning is expected to occur. Figure 4 shows a hypothetical example of how results will be illustrated. Polygons will be delineated by taking repeated measurements of each habitat characteristic (listed below). The number of measurements taken to delineate each polygon will be scaled to the size of the potential polygon, but will consist of a minimum of four measurements for each mapped polygon. Thus, more measurements will be taken to define larger polygons, and in areas with high complexity.

The following is a list of the proposed habitat characteristics that will be measured in the field and a brief description of the methods that will be used to determine habitat suitability for the analysis species and life stages of interest.

- *Minimum habitat size.* A minimum polygon size for each guild is established to facilitate the mapping process, and is based on literature review and expert opinion. Polygon sizes are proposed that are large enough to be practical to map in the field, and small enough to accurately reflect habitat needs of each guild. (Table 3).
- *Substrate particle size (D_{50}).* Results of facies mapping already conducted in all potential "good" spawning habitat units (Stillwater Sciences 2008) will be used, and compared to criteria selected from the literature to delineate "good" spawning habitat. Median substrate particle size (D_{50}) will be used to describe substrate patch suitability. D_{50} will be measured by conducting pebble counts within substrate patches that appear to be at the lower or upper boundaries of the suitable particle size range, according to methods described in Wolman (1954).
- *Water Depth.* Depth will be measured using a stadia rod at known discharges. At documented redds, depths will be measured immediately upstream of the redd (Chambers et al. 1955, Sams and Pearson 1963, Smith 1973), and at the perimeter of habitat polygons.
- *Water Velocity.* Mean column water velocity will be measured with a Marsh-McBirney flow meter at 0.60 of water column depth, or at 0.2 and 0.8 of water column depth for depths

greater than 2.5 ft (0.8 m), or at 0.2, 0.6, and 0.8 for depths over 5 ft (1.5 m). For non-spawning life-stages water velocity measurements will be taken near the surface of the bed, or in the focal position of rearing juvenile fish (as defined by the literature for specific species and life stages). At potential spawning areas, velocity will be measured at 0.12 m (0.4 ft) above the substrate (Chambers et al. 1955, Smith 1973).

- *Distance to cover.* Distance to cover will be measured horizontally with a stadia rod or tape, as appropriate. Cover types will be classified (e.g., Kinsolving and Bain 1990) and will consist of substrate, large woody debris, macrophytes, undercut banks, etc.

2.4 Flow selection

The flow regime established for the License is based primarily on habitat requirements for fall Chinook salmon, and includes the following minimum requirements below Merwin Dam specified in Section 6.2.4 of the SA as shown in Table 4.

Table 4. Minimum flow regime requirements below Merwin Dam established for the License.

Period	Flow (cfs)
July 31–October 15	1,200
October 16–31	2,500
November 1–December 15	4,200
December 16–March 1	2,000
March 2–15	2,200
March 16–30	2,500
March 31–June 30	2,700
July 1–10	2,300
July 11–July 20	1,900
July 21–July 30	1,500

To date, there is little information on the amount of habitat available for salmonids within the reach downstream of Merwin Dam at these minimum flows, and little information on the effect of flow alterations on stranding risk. The primary concerns are stranding risk when flows drop during summer and winter, and habitat availability during fall spawning and spring and summer rearing. In addition, there is concern about effects of reducing flows (approximately 1,200 cfs) during fall, designed to allow Washington Department of Fish and Wildlife (WDFW) to conduct spawning surveys. There are a total of nine separate minimum flows prescribe. However, the numerous sources of variance in evaluating habitat and stranding risk, and the relative slight differences among many of the flows, suggest that observing differences in stranding risk or habitat availability among similar flows is not likely. In addition, since minimum flows are usually exceeded in the Lewis River, it is unlikely a precise targeted flow will be achieved. For example, although 1,900 cfs may be a target flow, it is possible that the actual flow assessed will be 1,800 cfs, or 2,000. Therefore four flows have been selected for analysis that represent the range of conditions (Table 5), and are different enough to potentially observe differences in conditions that may occur.

Table 5. Flows selected for analysis.

Target flow (cfs)	Season and rational	Stranding assessment objectives	Habitat assessment Objectives

1,200	Late summer (July 31 through October 15) and during WDFW fall spawning surveys. Target flow is also similar (within 300 cfs) to summer (July 21 through July 30).	Assess dewatering risk for redds and stranding risk for juveniles when flows are reduced during fall spawning surveys.	Assess habitat availability during low flow conditions.
2,000	Winter (December 16 through March 1). Target flow is also similar (within 100 cfs) to summer (July 11 through July 20).	Assess stranding risk for juveniles.	Assess habitat availability during low flow conditions for rearing
2,500	Fall (October 16 through October 31), winter (March 16 through March 30). Target flow is also similar (within 300 cfs) to flows occurring during winter, spring, and summer (March 2 through July 10).	Assess stranding risk for vulnerable emergent fry and juveniles.	Assess habitat availability for spawning and rearing during moderate flow conditions.
4,200	Early winter (November 1 through December 15).	Assess stranding risk for juveniles.	Assess habitat availability for rearing during high flow conditions.

3 ANALYSIS AND REPORTING

The potential for stranding will be summarized as the number, type (e.g., isolated depression, secondary channel), surface area, and mapped location of potential stranding zones. GIS analysis will be used to determine the relative area of potential stranding under a range of typical spring operational flows. Finally, a synthesis of stranding risk will be developed that combines each risk factor (species, life stage, river stage/flow, and season) to identify measurable factors affecting potential stranding, the relationship of such factors, and the timeframe and season within which stranding may occur. GIS results, additional tables, and graphics will be included as appropriate.

Analysis for habitat evaluations will be the enumeration of habitat quantity by guild at each minimum flow, and implications for the species each guild represents. Most fall Chinook production in the Lewis River appears to be progeny of fish spawning during November and early December, when minimum flows are 4,200 cfs. Analysis will focus on evaluating spawning habitat availability at 4,200 cfs compared to 2,500 cfs when most fall Chinook spawning occurs. Emergence for these fish is approximately in April, when minimum flows are 2,700 cfs. Analysis will also focus on evaluating habitat availability effects of flow fluctuations during this spring time period. A draft and final report will be prepared, including descriptions of methods, summary of results, and appropriate graphics and maps of data collected.

4 SCHEDULE

The anticipated timeline associated with the field schedule and flows and deliverables are outlined in Tables 6 and Table 7. Adjustments within the proposed timeline and scope of the project will be made to accommodate weather events that potentially alter the target conditions.

Table 6. Anticipated flows and field schedule.

Target flow	Anticipated dates	Notes
1,200	October 13-14	Required minimum flow, also released for spawning surveys,
2,500	October 15-16	Required minimum flow
4,200	December 14–15	Required minimum flow
2,000	December 16–17	Required minimum flow

Table 7. Anticipated deliverables.

Deliverable	Anticipated dates
Final study plan	September 17, 2009
Draft report	April 25, 2011
Final report	June 24, 2011

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Attachment A
Comments received on draft study plan and responses

Comments were received from the WDFW on the Lewis River Stranding Monitoring Study Plan (Draft Plan). In general, all comments were incorporated in the final study plan, as described in detail below.

WDFW comment #1
"1.1 Objectives/Approach

1) Instead of trying to identify measurable factors affecting potential stranding, focus on identifying "what works". Fall Chinook are very successful in the NFL, yet 80% of the production is measured from about 5 weeks of natural spawn while spawning can occur over 26 weeks. What factors make the 5 week period special? Shane believes it is related to emergence so the questions would be when is this emergence? What are the environmental factors on average that these fry have that other fry don't have at other times related to flows?
2) Evaluate yearly minimum operational flows to habitat condition present as related to that special 5 weeks and emergence period."

RESPONSE:
The objectives of the study plan were based on the specific requirements of the Settlement Agreement, and as such, can not be altered. However, we believe that the habitat evaluation that will be conducted will identify amount of habitat available for emergent fry during April when the later spawning Chinook emerge, as well as the amount of habitat available in late winter when earlier spawning Chinook emerge. In addition to evaluating habitat availability based on emergence timing, we will also be able to evaluate habitat shifts that may occur if flows either increase or decrease during the spring fry rearing period. Therefore, while not an explicit objective of the study plan, we believe the results will allow aspects of Chinook spawning and emergence timing in relation to flow and habitat conditions to be evaluated.

WDFW comment #2
"2.2.3 Fall Chinook, chum and Steelhead really don't use finer substrate. They prefer the cover of larger cobble to vegetation and large woody debris as newly emerged fry."

RESPONSE:
The study plan has been updated to reflect preference for large cobble, both in Sections 2.2.3, as well as in Section 2.3 (Habitat Criteria).

WDFW comment #3
"2.3 Life stages

1) Juvenile chum should be included they are present up to a 110 mm.
2) Chinook fry rearing measurement for depth and velocity listed here are at best the most extreme condition they possibly would endure. Needed habitat would include depths of < 0.5 ft and velocities <0.1 ft/s with moderate cobble over an extended area (many square meters) to slightly higher condition with slightly larger cobble over many square meters.
3) Juvenile rearing can include much greater water depths."

RESPONSE:
The study plan has been updated so that the juvenile life stage for chum are now included. The fry rearing depth, velocity, and cover criteria for Chinook salmon (and chum) have been updated

to reflect the suggested criteria. Juvenile rearing depth criteria for chum and Chinook salmon were increased in the updated study plan.