

**Rehabilitation Approaches for Lower Lake Creek  
*for*  
Energy Northwest's  
Packwood Lake Hydroelectric Project  
FERC No. 2244  
Lewis County, Washington**

*Submitted to*



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*Submitted by*



**October 30, 2007**

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## **Draft**

# **Rehabilitation Approach for Lower Lake Creek**

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## **1.0 Lower Lake Creek Management Goals and Objectives**

The natural resource agencies have not developed explicit management objectives for the aquatic resources in lower portion of Lake Creek. Energy Northwest, as part of the relicensing process, had drafted management goals and objectives for Lake Creek in order to tailor proposed enhancement efforts.

Energy Northwest is not a natural resource management agency and does not have natural resource management authority. The inclusion of these goals and objectives is for discussion purposes only, intended as a starting place for tying restoration and enhancement activities in lower Lake Creek to the relicensing efforts for the Packwood Lake Hydroelectric Project. Energy Northwest anticipates that the natural resource agencies will modify these goals and objectives as negotiations and discussion continue.

### **1.1 Lake Creek Aquatic Goals**

Restore and enhance anadromous and resident salmonid habitat in Reach 1 of Lower Lake Creek (RM 0.0 – 1.00)

Fish species present or potentially present in this reach are:

- Chinook Salmon
- Coho Salmon
- Steelhead Trout
- Sea-run Cutthroat Trout
- Resident Rainbow Trout

Species most likely to utilize this reach of Lake Creek (steelhead trout and rainbow trout and coho salmon) are typically rearing limited. The primary objective would be to increase and restore rearing habitat for the species listed above.

Spawning habitat is also very scarce in this reach of Lake Creek. Energy Northwest proposes to increase spawning habitat for anadromous and resident species through the recreation of pools and pool tailouts.

### **1.2 Lake Creek Aquatic Objectives**

The objectives of the Lower Lake Creek Restoration and Enhancement activities are to:

1. Increase salmonid rearing habitat in Lake Creek from RM 0.0 – 1.0 by 15,300 ft<sup>2</sup>. This will be accomplished by:
  - Increasing salmonid rearing habitat in the Reach from RM 0.0 – 0.3 by 2,700 ft<sup>2</sup>; and
  - Increasing salmonid rearing habitat in the Reach from RM 0.3 – 1.0 by 12,600 ft<sup>2</sup>.

The result is an increase in rearing habitat from existing conditions by 2,898 ft<sup>2</sup> per 1000 linear feet of stream.

2. Increase salmonid spawning habitat in Lake Creek from RM 0.0 – 1.0 by 1700 ft<sup>2</sup>. This will be accomplished by:
  - Increasing salmonid spawning habitat in the Reach from RM 0.0 – 0.3 by 300 ft<sup>2</sup>; and
  - Increasing salmonid spawning habitat in the Reach from RM 0.3 – 1.0 by 1,400 ft<sup>2</sup>.

The result is an increase in spawning habitat from existing conditions by 322 ft<sup>2</sup> per 1000 linear feet of stream.

## **2.0 Synopsis**

Stream enhancement in Lower Lake Creek will provide important benefits to anadromous and resident salmonids and other aquatic species. The lower portion of the stream has been known to provide habitat for steelhead, rainbow trout, coho, and Chinook. The size and character of the stream is most suited to use by steelhead, coho, and rainbow trout, although Chinook salmon may use the stream to some degree for spawning. Rehabilitation efforts are best focused on increasing rearing habitat for coho, steelhead, and resident trout, where important benefits can be gained for fish productivity. There is also opportunity to improve spawning conditions for all species.

Rehabilitation measures would have the greatest benefit in the lower 2 miles of Lower Lake Creek, which are accessible to anadromous salmonids. Within this lower segment, the reach from RM 0.3 (Hwy 12 bridge) to RM 1 (partial fish barrier) has the greatest potential and should be the primary focus for enhancement. The focus on this area is a result of the following considerations: 1) this reach has some of the highest potential use by multiple species of fish (including steelhead and rainbow trout, and coho and Chinook salmon); 2) this reach is located away from stream-adjacent private residences where risk to private property, risk to instream structures, maintenance issues, and disturbance during construction are a concern; 3) this reach has suitable access, and 4) this reach suffers from lack of structure, wood debris, and spawning gravel availability that could be enhanced through active rehabilitation. Additional measures could potentially be applied between RM 1 and 2, but these would be limited in scope and effectiveness because of the steep nature of the stream, access issues, and lack of access by coho and Chinook. RM 0 to 0.3 is adjacent to several private residences where rehabilitation efforts would be complicated by landowner issues and perceived risk to residential property. Channel work in this area would require cooperation agreements with local

residents. Work in this lower reach would require low-risk measures that would add to channel complexity, such as placement of boulder complexes.

The primary objective for rehabilitation of the target reach (RM 0.3 to 1) is to convert the existing boulder plane-bed/step-pool channel into a wood forced step-pool system that more accurately reflects the natural channel form and processes appropriate for this reach. This strategy will increase the quantity and quality of habitat for aquatic species in a manner that is compatible with existing geomorphic and hydrologic processes. A primary goal will be to increase rearing and spawning habitat for anadromous and resident salmonids. Currently, Reach 1 (RM 0.0 – 0.7) has only 12% pool habitat (EES Consulting 2007), considerably lower than what would be expected on a natural stream of this size and gradient. Most of the habitat (56%) is currently in glide or run habitat, which has less habitat value than riffles or pools. Pool habitat will be created primarily through incorporation of LWD into the channel.

Existing assessments have demonstrated that this lower reach has very low amount of large woody debris (LWD) (Watershed GeoDynamics 2007a). Whereas upper reaches contain as much as 90-130 pieces of wood per mile, the lower reaches contain less than 30 pieces per mile. This is attributable to past riparian timber harvest and lack of transport from upstream reaches. Because of the small size, confined channel, and step-pool character of upstream reaches, wood is not readily transported to the lower mile of stream and therefore most of the instream wood below RM 1.0 originates from mortality or windthrow from the channel banks. Under existing conditions, the size and age of riparian timber stands are unable to provide wood in the quantity or sizes needed to create high quality habitat conditions.

To enhance the function of LWD in the creek, wood accumulations will be installed within channels and along channel margins to create and enhance pool habitat and to provide cover. Wood quantities and jam spacing will be based on reference conditions within Lake Creek and other similar streams. Wood will be placed to create plunge pool and lateral scour pool habitat as appropriate depending on site conditions. Wood installations will need to be adequately anchored to ensure that wood is not transported during flood events to downstream areas where it could cause potential damage to bridges (Hwy 12 and Lake Creek Rd) or private residences. Anchoring can occur through burial, attachment to existing trees, or through boulder ballast.

In select areas, channel unit boundaries will be re-shaped to provide narrower widths and greater depths in order to increase rearing habitat during low summer flows when much of the streamflow is diverted for power generation. This will increase residual depths of pools, providing a more reliable amount of available rearing habitat during low water periods. Pool structure will be maintained with wood and boulders. Narrowing and deepening pools will also increase the amount of cover provided by installed LWD, an important component for juvenile salmonid protection and feeding. Although Lake Creek gets cooler as it courses downstream due to spring inflows, narrowing the channel will reduce the potential for water temperature extremes in the summer and winter. These temperature extremes can have adverse effects on rearing fish.

Gravel augmentation could occur in combination with other rehabilitation measures. Except for a short section of stream from RM 0.8 to 1.1, gravel quantities are low in the lower reaches of Lake Creek (Watershed GeoDynamics 2007b). This is attributable to a lack of gravel transported from upstream reaches and to a lack of large roughness elements (i.e. logs and boulders) that are necessary to retain gravels in the lower reach. Gravel in step-pool systems typically remains in place through protection by larger roughness elements in the stream. This condition was observed as part of the Lake Creek gravel transport study (Watershed GeoDynamics 2007b), where 66% of the gravels (0.5-4 in) were found to be associated with logs or boulders. Only 9% were within the main channel and unassociated with boulders or logs. It is therefore critical that placed gravels are associated with logs or boulders to ensure they are not readily transported out of the reach. In addition, spawning-sized gravels are best placed at pool tailouts where water depths and velocities meet spawning criteria.

### **3.0 Design Criteria**

This section specifies design criteria for rehabilitation measures in Lake Creek. In some cases, further field investigation will be needed to identify specific numerical design targets.

#### **3.1 LWD Placement**

Target areas for wood placements will be in existing pools or in glides/runs where pool habitat can be created by wood placement. In areas targeted for pool formation, large 'key' pieces of wood will be incorporated into the channel bed to create stable pool-forming bedforms (i.e. steps). Boulders will be used in combination with wood to form bedforms and to provide ballast for wood placements. In other areas, wood jams will be placed along channel margins and will extend into the active channel in order to provide habitat cover and complexity.

#### **3.2 LWD Jams**

Wood jams will be constructed to obtain approximately 20 jams per mile. This jam frequency is based on jam frequency that occurs further upstream on Lake Creek. This equates to approximately 1 jam every 250 feet, or approximately 15 jams over the 0.7 mile reach of stream.

#### **3.3 LWD Numbers**

Total numbers of wood will be increased to within 90-130 pieces per mile (assuming 12" diameter and 25 ft minimum to qualify as LWD). This is in keeping with wood quantities that have been observed in the upper reaches of Lake Creek, and it exceeds the federal standard for achieving 'properly functioning condition' (>80 pieces per mile, NMFS 1996). Most of this wood will be located in accumulations of 4 or more pieces, although smaller accumulations or individual placements may be appropriate in some

areas. This equates to roughly 60-105 pieces of wood, with 4-7 pieces per jam (assuming 15 jams). Smaller wood debris can be added to the jams to increase habitat value.

### **3.4 LWD Sources**

Sources for LWD may include acquisition from cooperating agencies, Tacoma Public Utilities salvage operations at mainstem Cowlitz River dams, thinning from local timber stands, or purchasing outright. LWD source options will be determined upon further investigation and coordination with cooperators.

### **3.5 Boulder Placement**

Boulders will be incorporated into large wood structures to increase complexity, help to develop step-pool channel units, and to provide ballast for large wood placements. Boulders can also be placed in the lowest 0.3 miles of stream to create steps and complexity to enhance juvenile rearing habitat, especially for steelhead and rainbow trout. Most boulders will be available on-site, but may be brought in from off-site if enough suitable boulders cannot be sourced from the existing channel.

### **3.6 Bed Deformability**

Step-pool channels obtain most of their stability from large step-forming elements including boulders and logs. Log structures used for this effort will be made to be stable up to at least the 50-year recurrence interval event, in order to reduce potential impacts to downstream infrastructure or property. Beds and banks composed of large cobbles or boulders will have a stability that is similar to the existing channel conditions, although the addition of stable wood elements will increase their stability in wood placement locations.

### **3.7 Profile**

Average reach slope will not be altered, but profile will be modified from a plane-bed/step-pool profile into a wood-forced step-pool profile. Residual pool depths and vertical variation in slope will be increased.

### **3.8 Cross-Section Form**

Width-to-depth ratios will be decreased through wood additions and mechanical adjustments to channel boundaries at select areas. Increased pool depth will benefit juvenile summer rearing and will reduce temperature extremes. Width-to-depth ratios will be reduced to at least below 15:1, and possibly below 10:1, based on surveys of reference channel conditions.

### **3.9 Habitat Units**

The percentage of channel in runs and glides will be reduced in favor of additional pool habitat. Current percentage pool habitat is less than 15%, whereas runs and glides make up over 50% of the habitat. Glide and run habitat will be reduced to below 40% and pools will be increased to above 25%. These values may be modified based on more detailed site investigations.

### **3.10 Substrate**

Gravels will be placed upstream of bed control elements (i.e. riffles, steps) to enhance spawning capacity and quality. Specific size and distribution of bed material will be determined through hydraulic analysis, reference conditions, and species requirements for spawning. Where possible, bed material will be sourced from local areas; alternative sources will be identified if local sources are not available. Reaches 2 – 4 will provide targets for gravel quantities, which are on the order of 10,000 ft<sup>2</sup> per mile. This corresponds to approximately 7,000 ft<sup>2</sup> for the target reach.

### **3.11 Flood Risk**

Adequate anchoring will be provided for installed log complexes in order to reduce the potential for logs creating damage to downstream infrastructure (e.g. bridges) or private property. Anchoring will occur through log burial, anchoring to existing trees, or through boulder ballast.

### **3.12 Riparian Vegetation**

Riparian areas are mostly composed of deciduous or mixed deciduous / conifer stands. These forests are expected to move towards climax coniferous forest species over time. There are currently few cases of invasive species that would be expected to interfere with natural succession to climax forest types. A vegetation monitoring and management program will be put in place to ensure invasive species do not colonize the site. Impacts to existing riparian vegetation will be minimized during construction activities. Revegetation will be conducted in disturbed areas using native and site-appropriate species.

### **3.13 Amount of Habitat Created**

Rearing and spawning habitat will be created through installation of structures, alteration of channel unit composition, increased pool depth, and installation of spawning gravels. One of the greatest benefits to fish will be the conversion of existing uniform glide/run habitat into pool habitat with high quality rearing in deep pools with overhanging and complex LWD. High quality spawning conditions will be created at tailouts with imported gravels. The objective is to convert at least 10% of the available habitat from glides to pools between RM 0.3-1 using large wood and boulder structures. Assuming an average wetted width of 38 ft (derived from values reported in EES 2007 that were

collected in April/May 2004), this equates to the creation of approximately 14,000 ft<sup>2</sup> of pool habitat. Assuming 10% of pools are comprised of tailout habitat, a total of approximately 12,600 ft<sup>2</sup> of high quality rearing habitat will be created. This amounts to 840 ft<sup>2</sup> of habitat per structure (assuming 15 structures). Spawning habitat at tailouts will amount to a total of 1,400 ft<sup>2</sup>, or 93 ft<sup>2</sup> per structure.

Between RM 0 and 0.3, approximately 5% of the glide habitat could reasonably be converted to pool habitat using boulders. This equates to the creation of approximately 2,700 ft<sup>2</sup> of high quality pool habitat for rearing and 300 ft<sup>2</sup> of spawning habitat.

### **3.14 Monitoring**

Energy Northwest will develop a monitoring plan in consultation with the natural resource agencies as part of the new license.

## **4.0 Calculation of WUA with Enhancement**

Tables 1 – 4 summarize the Weighted Usable Area (WUA) values for salmonid rearing and spawning in Lower Lake Creek. Values are shown for Study Site 1 (where most restoration activities would take place), as well as for all of Lower Lake Creek below the drop structure, using the 50% exceedance flows. Values are given as ft<sup>2</sup> of habitat per 1,000 linear feet of stream. Values for pre-project and existing project were obtained from the HABTAT sub-module of RHABSIM and the flow exceedance values generated from pre- and existing project data. Maximum values in the comparison tables are in bold face type.

Proposed Project data was calculated as follows: The model was run using the proposed project release flows of 4 cfs from October – July and 7 cfs for August and September, with the 50% exceedance accretion flows, identical to the calculations for pre- and existing project. The proposed enhanced habitat area was then added to the calculated WUA values, and scaled to ft<sup>2</sup> per 1,000 linear ft of stream.

For Study Site 1, 2,679 ft<sup>2</sup> and 298 ft<sup>2</sup> were added to the WUA for the proposed flows as enhancement for rearing and spawning habitat, respectively. For the lower Lake Creek calculations, 15,300 and 1,700 ft<sup>2</sup> would be created in the lower mile (5,280 ft) or 2,898 and 322 ft<sup>2</sup> of rearing and spawning habitat for 1,000 ft of stream. For Chinook and coho salmon and steelhead trout, 2,813 and 313 ft<sup>2</sup> of habitat /1000 ft of stream were added for lower Lake Creek rearing and spawning, respectively (the barrier at RM 1.03 prevents further upstream migration). For steelhead, 1,486 and 165 ft<sup>2</sup> of habitat/1000 ft of stream were added (steelhead may reach RM 1.95 on Lake Creek), while 537 and 60 ft<sup>2</sup> of rearing and spawning habitat were added to lower Lake Creek for rainbow trout (rainbow are found throughout the 5.4 miles of lower Lake Creek) (Table 5).

There are several caveats to this approach:

WUA is calculated as the product of depth, velocity and substrate preference values. Habitat values created by the restoration efforts may not be directly additive to calculated WUA values. *[Note: per discussions at the Aquatics Subcommittee meeting on October 25, 2007, Dr. H. Beecher and J. Blum will develop protocol to make these components compatible].*

Glide/run habitat that the pools and pool tailouts would replace have some, albeit small, value for rearing habitat. The values for estimated WUA with enhancement have not taken this into account.

<b>Table 1. All Sites Lake Creek Habitat Duration Analysis, 50% Exceedance Values.</b>						
Rearing Habitat (sq ft/1000 ft)						
<b>Month/Period</b>	<b>Chinook</b>	<b>Coho</b>	<b>Steelhead</b>	<b>Rainbow</b>	<b>Cutthroat</b>	<b>Winter Trout</b>
August						
Pre-Project	4,960	3,439	<b>5,161</b>	<b>3,675</b>	4,093	
Current	3,158	4,601	1,686	1,746	1,994	
Proposed	<b>6,638</b>	<b>7,244</b>	3,620	2,725	<b>5,255</b>	
September						
Pre-Project	4,984	3,470	<b>4,624</b>	<b>3,367</b>	4,018	
Current	2,938	4,641	1,540	1,649	1,842	
Proposed	<b>6,560</b>	<b>7,259</b>	3,584	2,679	<b>5,200</b>	
October						
Pre-Project	4,999	3,459	<b>4,571</b>	<b>3,346</b>	4,009	
Current	2,938	4,641	1,540	1,649	1,842	
Proposed	<b>5,971</b>	<b>7,414</b>	3,172	2,300	<b>4,808</b>	
November						
Pre-Project	4,962	3,434	N/A	N/A	N/A	5,782
Current	4,116	4,364	N/A	N/A	N/A	8,092
Proposed	<b>7,063</b>	<b>7,141</b>	N/A	N/A	N/A	<b>8,524</b>
December						
Pre-Project	5,174	3,242	N/A	N/A	N/A	5,487
Current	4,938	3,650	N/A	N/A	N/A	7,148
Proposed	<b>7,788</b>	<b>6,422</b>	N/A	N/A	N/A	<b>7,600</b>
January						
Pre-Project	5,298	3,127	N/A	N/A	N/A	5,267
Current	5,085	3,405	N/A	N/A	N/A	6,630
Proposed	<b>7,876</b>	<b>6,224</b>	N/A	N/A	N/A	<b>7,043</b>
February						
Pre-Project	5,068	3,364	N/A	N/A	N/A	5,705
Current	5,062	3,478	N/A	N/A	N/A	6,830
Proposed	<b>7,875</b>	<b>6,291</b>	N/A	N/A	N/A	<b>7,391</b>
March						
Pre-Project	4,931	3,459	N/A	N/A	N/A	5,758
Current	4,938	3,650	N/A	N/A	N/A	7,148
Proposed	<b>7,788</b>	<b>6,422</b>	N/A	N/A	N/A	<b>7,600</b>
April						
Pre-Project	5,304	3,093	<b>6,047</b>	<b>4,023</b>	4,223	
Current	4,974	3,608	3,472	2,530	3,582	
Proposed	<b>7,822</b>	<b>6,385</b>	4,989	3,128	<b>6,425</b>	
May						
Pre-Project	5,640	1,955	<b>7,125</b>	<b>4,839</b>	4,282	
Current	4,726	3,886	3,094	2,407	3,326	
Proposed	<b>7,610</b>	<b>6,633</b>	4,681	2,998	<b>6,211</b>	
June						
Pre-Project	5,610	1,890	<b>7,055</b>	<b>4,952</b>	4,147	
Current	4,592	4,018	2,902	2,340	3,187	
Proposed	<b>7,433</b>	<b>6,815</b>	4,451	2,920	<b>6,026</b>	
July						
Pre-Project	5,607	2,108	<b>7,115</b>	<b>4,840</b>	4,376	
Current	3,904	4,415	2,170	2,018	2,497	
Proposed	<b>6,851</b>	<b>7,192</b>	3,785	2,630	<b>5,420</b>	

**Table 2. Study Site 1.** Lake Creek Habitat Duration Analysis, 50% Exceedance Values. Maximum WUA values are in **bold**.

Rearing Habitat (sq ft/1000 ft)						
Month/Period	Chinook	Coho	Steelhead	Rainbow	Cutthroat	Winter Trout
August						
Pre-Project	4,448	3,092	<b>4,777</b>	3,371	3,640	
Current	2,905	4,229	1,615	1,800	1,707	
Proposed	<b>6,280</b>	<b>6,737</b>	4,742	<b>4,856</b>	<b>4,769</b>	
September						
Pre-Project	4,692	2,945	4,531	3,367	3,706	
Current	2,711	4,278	1,499	1,698	1,607	
Proposed	<b>6,165</b>	<b>6,759</b>	<b>4,642</b>	<b>4,783</b>	<b>4,687</b>	
October						
Pre-Project	4,717	2,928	<b>4,480</b>	3,354	3,708	
Current	2,711	4,278	1,499	1,698	1,607	
Proposed	<b>5,583</b>	<b>6,907</b>	4,294	<b>4,478</b>	<b>4,386</b>	
November						
Pre-Project	4,439	3,096	N/A	N/A	N/A	5,992
Current	3,948	3,992	N/A	N/A	N/A	8,385
Proposed	<b>6,742</b>	<b>6,648</b>	N/A	N/A	N/A	<b>10,954</b>
December						
Pre-Project	4,626	3,064	N/A	N/A	N/A	6,064
Current	4,722	3,152	N/A	N/A	N/A	7,125
Proposed	<b>7,445</b>	<b>5,775</b>	N/A	N/A	N/A	<b>9,710</b>
January						
Pre-Project	4,785	3,018	N/A	N/A	N/A	5,879
Current	4,853	2,831	N/A	N/A	N/A	6,259
Proposed	<b>7,489</b>	<b>5,526</b>	N/A	N/A	N/A	<b>8,738</b>
February						
Pre-Project	4,526	3,082	N/A	N/A	N/A	6,108
Current	4,862	2,923	N/A	N/A	N/A	6,618
Proposed	<b>7,540</b>	<b>5,602</b>	N/A	N/A	N/A	<b>9,296</b>
March						
Pre-Project	4,432	3,097	N/A	N/A	N/A	6,012
Current	4,722	3,152	N/A	N/A	N/A	7,125
Proposed	<b>7,445</b>	<b>5,775</b>	N/A	N/A	N/A	<b>9,710</b>
April						
Pre-Project	4,797	3,024	5,502	3,969	3,782	
Current	4,766	3,097	3,558	3,047	3,276	
Proposed	<b>7,490</b>	<b>5,720</b>	<b>6,301</b>	<b>5,752</b>	<b>5,997</b>	
May						
Pre-Project	5,707	2,050	<b>6,377</b>	4,634	4,421	
Current	4,481	3,460	3,145	2,870	2,984	
Proposed	<b>7,213</b>	<b>6,067</b>	5,902	<b>5,586</b>	<b>5,725</b>	
June						
Pre-Project	5,968	2,045	<b>6,532</b>	4,924	4,458	
Current	4,373	3,602	2,988	2,796	2,858	
Proposed	<b>7,052</b>	<b>6,281</b>	5,666	<b>5,475</b>	<b>5,537</b>	
July						
Pre-Project	5,575	2,234	<b>6,342</b>	4,562	4,486	
Current	3,717	4,036	2,163	2,251	2,171	
Proposed	<b>6,511</b>	<b>6,693</b>	4,941	<b>5,002</b>	<b>4,931</b>	

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<b>Table 3. All Sites</b> Lake Creek Habitat Duration Analysis, 50% Exceedance Values. Maximum WUA values are in <b>bold</b> .					
Spawning Habitat (sq ft/1000 ft)					
Month/Period	Chinook	Coho	Steelhead	Cutthroat	Rainbow
August					
Pre-Project	158				
Current	9				
Proposed	<b>342</b>				
September					
Pre-Project	261				
Current	7				
Proposed	<b>330</b>				
October					
Pre-Project		176			
Current		103			
Proposed		<b>426</b>			
November					
Pre-Project		178			
Current		175			
Proposed		<b>497</b>			
December					
Pre-Project		248			
Current		212			
Proposed		<b>525</b>			
January					
Pre-Project		293		28	
Current		199		17	
Proposed		<b>510</b>		<b>332</b>	
February					
Pre-Project		219		29	
Current		207		17	
Proposed		<b>519</b>		<b>330</b>	
March					
Pre-Project			114	29	
Current			91	19	
Proposed			<b>263</b>	<b>331</b>	
April					
Pre-Project			125		
Current			98		
Proposed			<b>268</b>		
May					
Pre-Project			149		<b>160</b>
Current			63		72
Proposed			<b>234</b>		134
June					
Pre-Project			137		<b>155</b>
Current			51		68
Proposed			<b>218</b>		130
July					
Pre-Project					<b>162</b>
Current					51
Proposed					114

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 For Discussion Purposes Only

<b>Table 4. Study Site 1.</b> Lake Creek Habitat Duration Analysis, 50% Exceedance Values. Maximum WUA values are in <b>bold</b> .					
Spawning Habitat (sq ft/1000 ft)					
Month/Period	Chinook	Coho	Steelhead	Cutthroat	Rainbow
August					
Pre-Project	122				
Current	7				
Proposed	<b>330</b>				
September					
Pre-Project	247				
Current	4				
Proposed	<b>312</b>				
October					
Pre-Project		139			
Current		70			
Proposed		<b>380</b>			
November					
Pre-Project		167		21	
Current		156		52	
Proposed		<b>462</b>		<b>343</b>	
December					
Pre-Project		273		23	
Current		171		9	
Proposed		<b>466</b>		<b>306</b>	
January					
Pre-Project		342		22	
Current		142		7	
Proposed		<b>436</b>		<b>306</b>	
February					
Pre-Project		228		23	
Current		154		7	
Proposed		<b>452</b>		<b>305</b>	
March					
Pre-Project				22	
Current				9	
Proposed				<b>306</b>	
April					
Pre-Project			158		
Current			198		
Proposed			<b>507</b>		
May					
Pre-Project			125		7
Current			130		145
Proposed			<b>439</b>		<b>447</b>
June					
Pre-Project			123		0
Current			109		138
Proposed			<b>407</b>		<b>436</b>
July					
Pre-Project					12
Current					69
Proposed					<b>376</b>

Table 5. Summary of WUA (ft <sup>2</sup> /1000 ft of stream for proposed enhancement)		
RM	Sq Ft of Habitat	
	Rearing	Spawning
0.0-0.3	2,700	300
0.3-0.7	7,200	800
0.7-1.0	5,400	600
Study Site 1 (RM 0.0 – 0.7)	9,900	1,100
sq ft/1000	2,679	298
Lower Lake Creek	15,300	1,700
RM 0.0 - 1.03 <sup>1/</sup>		
sq ft/1000	2,813	313
RM 0.0 - 1.95 <sup>2/</sup>		
sq ft/1000	1,486	165
RM 0.0 – 5.4 <sup>3/</sup>		
sq ft/1000	537	60
<sup>1/</sup> Chinook, Coho, Cutthroat		
<sup>2/</sup> Steelhead Trout		
<sup>3/</sup> Rainbow Trout		

## 5.0 References

- EES Consulting. 2007. Lake Creek Instream Flow Report. Lake Creek Instream Flow Report of Energy Northwest's Packwood Lake Hydroelectric Report, FERC No. 2244. Lewis County. Final Report. Prepared for Energy Northwest. October, 2007.
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- Watershed GeoDynamics. 2007b. Gravel Transport Study for the Packwood Lake Hydroelectric Project, FERC No. 2244, Lewis County. Final Report. Prepared for Energy Northwest. September 2007