PESHASTIN CREEK RM 3.8 CHANNEL RECONNECTION PROJECT

FEASIBILITY STUDY

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Acronyms and Abbreviations

CCNRD	Chelan County Natural Resource Department
cfs	cubic feet per second
DEM	digital elevation model
Ecology	Washington State Department of Ecology
ESA	Endangered Species Act
GIS	geographic information system
HEC-RAS	Hydrologic Engineering Centers River Analysis System
LiDAR	Light Detection and Ranging
LWD	large woody debris
mph	miles per hour
Project Site	between RM 3.35 and RM 4.30 on Peshastin Creek
Project Team	ICF International
RM	river mile
ROW	right-of-way
SR 97	State Route 97
TRA	Lower Peshastin Creek Tributary and Reach Assessment
USGS	U.S. Geological Survey
WSDOT	Washington State Department of Transportation

Chapter 1
Overview

Peshastin Creek is located on the east slope of the Cascade Mountains in Central Washington, within the Wenatchee River Basin (WRIA 45). Peshastin Creek is a tributary to the Wenatchee River and flows into the river at RM 18. The creek supports populations of salmonids that are currently listed under the Endangered Species Act (ESA), including spring Chinook salmon, summer steelhead, and bull trout. Habitat for these species has been affected by anthropogenic activities throughout the basin. This feasibility study provides the supporting rationale associated with the selection of the preferred alternative for the Peshastin Creek RM 3.8 Channel Reconnection project between river mile (RM) 3.35 and RM 4.30 (Figure 1). The project is being proposed by the Chelan County Natural Resource Department (CCNRD), with engineering and technical assistance provided to CCNRD by ICF International (Project Team).

In 2009 and through a state-awarded Salmon Recovery Funding Board grant, the CCNRD began assessing methods and landowner willingness for reconnecting 2,400 linear feet of historical channel and floodplain habitats between RM 3.35 and RM 4.30 on Peshastin Creek (Project Site). The historical channel and floodplain were disconnected from Peshastin Creek with the construction of State Route 97 (SR 97) in the 1950s. The purpose of the reconnection is to increase refuge and rearing habitat for listed salmonids, increase floodplain connectivity, and restore natural channel processes in Peshastin Creek.

1.1 Tributary and Reach Assessment Restoration Strategy

Restoration of Peshastin Creek habitat is identified as one of the top priorities in the *Upper Columbia Salmon Recovery Plan* (Upper Columbia Salmon Recovery Board 2007). Within Peshastin Creek, the reconnection of floodplain and lengthening of the mainstem is a Biological Strategy Tier 1 action and a top priority for addressing limiting habitat factors and the recovery and long-term viability of salmonids in Peshastin Creek (Upper Columbia Regional Technical Team 2008; Upper Columbia Salmon Recovery Board 2007). Following the 2008 Biological Strategy, it was recommended that a tributary assessment be completed for Peshastin Creek to set a baseline for future restoration initiatives in the subbasin.

In 2010, the Yakama Nation completed the *Lower Peshastin Creek Tributary and Reach Assessment* (TRA) (Inter-Fluve 2010). The TRA built upon the guidance provided in the Biological Strategy (Upper Columbia Regional Technical Team 2008) and the *Upper Columbia Salmon Recovery Plan* (Upper Columbia Salmon Recovery Board 2007) and evaluated aquatic habitat conditions in Peshastin Creek from RM 0 to RM 9.3. The TRA also provided strategies to restore and preserve salmonid habitats. The TRA (Inter-Fluve 2010) summarizes the short-term and long-term objectives for Peshastin Creek. These objectives are based on the *Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan* (Upper Columbia Salmon Recovery Board 2007) and are consistent with the *Wenatchee Subbasin Plan* (NPPC 2004), the *Wenatchee Watershed Management Plan* (WRIA 45 Planning Unit 2006), and the *Biological Strategy to Protect and Restore Salmonid Habitat in the Upper Columbia Region* (Upper Columbia Regional Technical Team 2008).

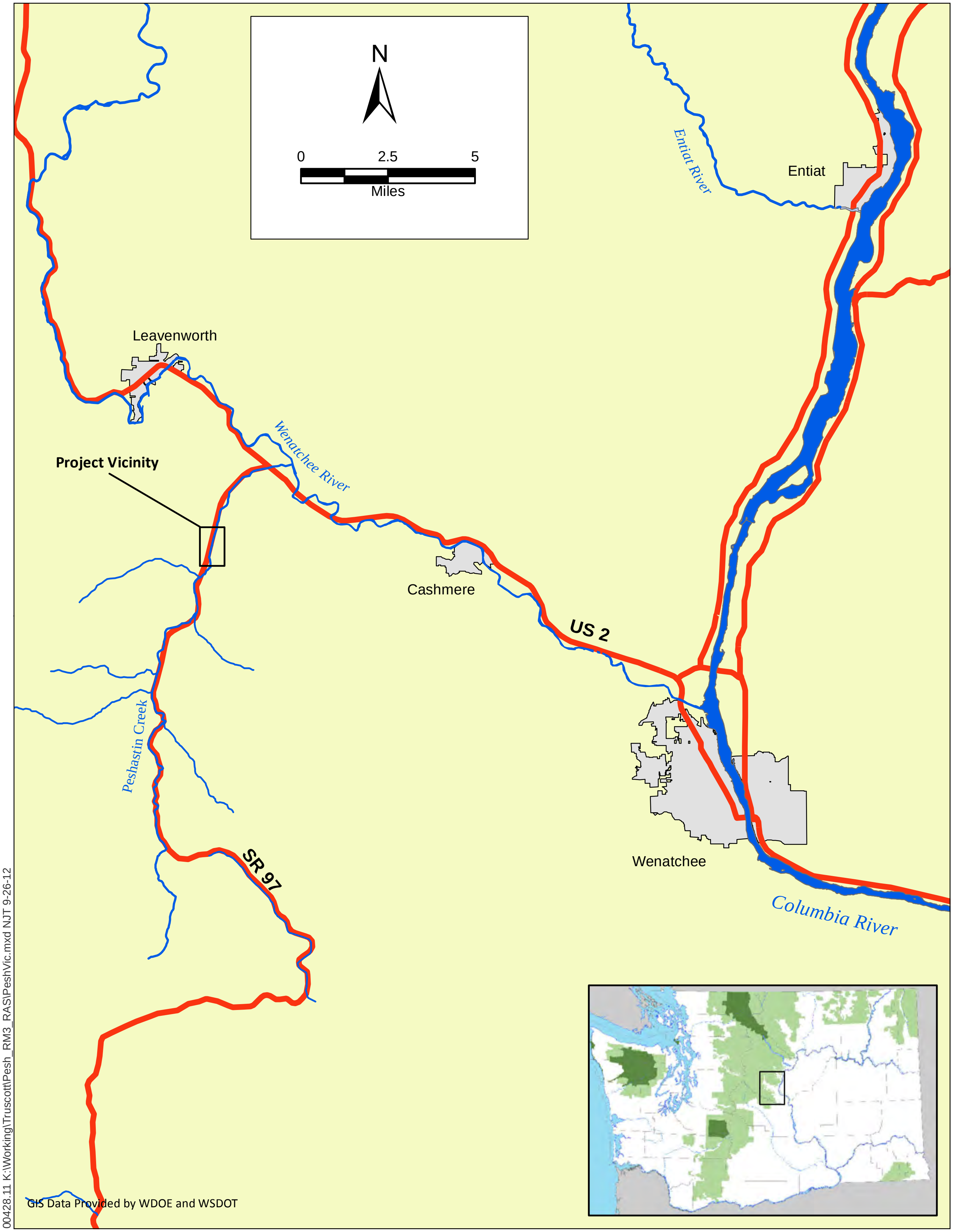

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Figure 1
Project Vicinity
Peshastin Creek River Mile 3.8L Feasibility Study

1.1.1 Short-Term Objectives

- Protect existing areas where high ecological integrity and natural ecosystem processes persist.
- Restore connectivity (access) throughout the historical range where feasible and practical for each listed species.
- Protect and restore water quality where feasible and practical within natural constraints.
- Increase habitat diversity in the short term by adding instream structures (e.g., large woody debris [LWD] and rocks) where appropriate.
- Protect and restore riparian habitat along spawning and rearing streams and identify long-term opportunities for riparian habitat enhancement.
- Protect and restore floodplain function and reconnection, off-channel habitat, and channel migration processes where appropriate, and identify long-term opportunities for enhancing these conditions.
- Restore natural sediment delivery processes by improving the road network and restoring natural floodplain connectivity, riparian health, natural bank erosion, and wood recruitment.

1.1.2 Long-Term Objectives

- Protect areas with high ecological integrity and natural ecosystem processes.
- Maintain connectivity through the range of the listed species where feasible and practical.

1.1.3 Restoration Objectives Specific to the Peshastin Creek Basin

- Reestablish connectivity throughout the assessment unit by removing, replacing, or fixing artificial barriers.
- Reduce water temperatures by increasing streamflows and restoring riparian vegetation along the stream.
- Increase habitat diversity and quantity by restoring riparian vegetation, adding instream structures and LWD, and reconnecting side channels and the floodplain with the stream.

1.2 Identification of the Project Site

The Wenatchee Watershed Implementation Schedule identified the reconnection of the historical main channel at this project site as a priority habitat restoration project within Peshastin Creek (Implementation Schedule PC-1411). This same project site was identified in the TRA as Project RM 3.8L Chanel Reconnection (Figure 2).

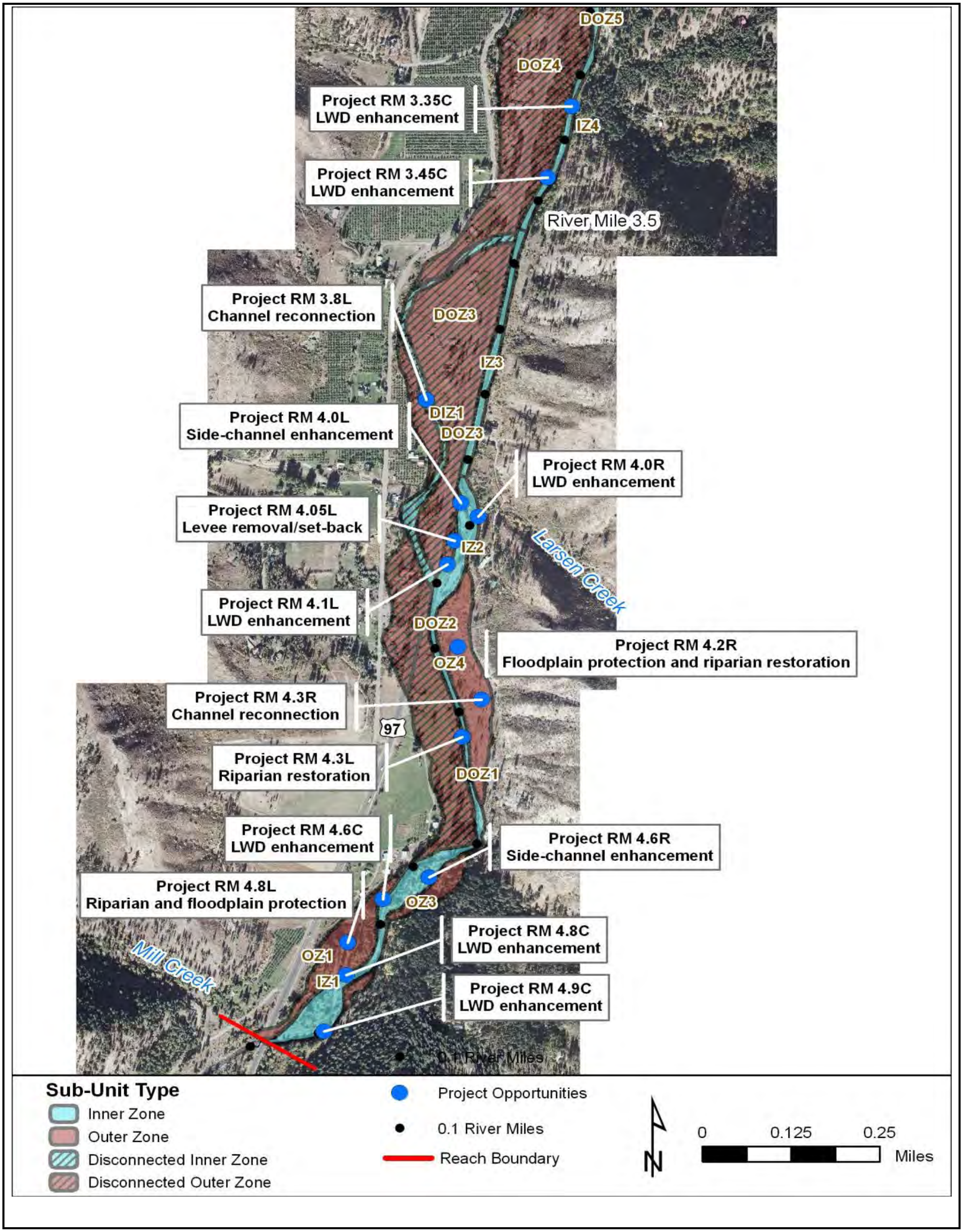

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Figure 2
Subunits and Project Opportunities in Reach 2

Table 1 provides a description of the disconnected channel at the project site, the recommended strategy, and potential constraints as presented in the TRA.

Table 1. Summary of the RM 3.8L Project

Description	Strategy	Potential Constraints
• This disconnected inner zone is a former channel location prior to highway construction. The disconnected channel extends approximately 3,350 feet. SR 97 currently blocks the upstream and downstream ends of this channel. The new channel location has been straightened and directly abuts the highway along this section. • This is one of the longest and most severe channel realignments that has occurred in the TRA study area (RM 9.3 – 0).	• Reconnect Stream Channel Processes	• Expensive and large-scale project • Requires rerouting the highway, or new bridge construction (two bridges) • Potential private land issues in old floodplain/channel area • Residential development throughout the adjacent floodplain

In August 2010, the Yakama Nation prioritized all of the project opportunities presented in the TRA. The prioritization was based on the following criteria:

- Biological Benefit,
- Physical Processes,
- Construction Cost, and
- Project Feasibility.

Based on this prioritization, the project site was listed as a top-tier opportunity for restoring creek geomorphic processes while addressing habitat-limiting factors in Peshastin Creek. The project received the highest possible scores for the Biological Benefit and Physical Process criteria. Given this evaluation and the result of the high prioritization, the CCNRD moved forward with the alternatives analysis and stakeholder outreach efforts as presented in this report.

Based on the above guidance, overall goals at the RM 3.8 project site are as follows, in order of importance:

1. Restore Peshastin Creek to its historical alignment.
2. Restore hydraulic connectivity and fish access to disconnected floodplain habitats.
3. Restore access for juvenile salmonids to off-channel refuge habitat.

1.3 Stakeholders and Current Restoration Efforts

From the proposed inlet to the proposed outlet, the historical channel contacts seven private landowners and the Washington State Department of Transportation.

The landowner at the proposed inlet site on the west side of SR 97 is very interested in looking at project opportunities and had previously discussed the options with Bob Steele of the Washington State Department of Fish and Wildlife in the early 2000's. Most of the landowners along the historical channel were interested in seeing some level of flow restored to the site, but were concerned about a project that would increase the risks of flooding to landowners. One of the landowners has expanded a collection of old vehicles and other debris on their property and some of that is encroaching in the channel. This landowner is not interested at this time in modifying the channel to accommodate flow-thru as part of the high-flow alternative discussed later. The next landowner downstream (Back Channel) had shown initial interest in studying the site.

As discussed in section 2.3, a large debris flow deposited 2 feet of sand across the lower 500 feet of the historical channel (figure 6). This in effect, filled in the old rocky channel on the lowest landowner's property, providing more usable land for agricultural purposes and making a salmon habitat restoration project less desirable.

The landowner at the slide origination site is definitely interested in working to restore stability to the now unstable area at the head of the slide as seen in figure 6. The US Forest Service is also a landowner associated with this slide and has be approached regarding a project to restore stability to this site with a combination of earthwork and bioengineering.

The three main steps to allowing a project to move forward will depend on stabilizing the landslide to reduce risks of sedimentation, cleaning up the "landfill area" or at least getting permission to survey for hazardous materials and working more with the downstream landowner to allow a restoration project to occur.

CCNRD is working with WSDOT to nominate the site for inclusion on the list of Chronic Environmental Deficiency sites. These are a list of candidate highway erosion sites that contribute to impacts to aquatic species.

Chapter 2
Existing Conditions

2.1 Project Site

The project site is located in Township 23 North, Range 18 East, Section 5, and Township 24 North, Range 18 East, Section 32. On Peshastin Creek, the project site is located between RM 3.56 and 3.90 within Reach 2 as identified in the TRA (Inter-Fluve 2010). The project extent runs between mileposts 181.9 and 182.2 on SR 97 (Figure 1).

2.2 Geomorphology

The project site includes 1,800 feet of existing Peshastin Creek channel and 2,470 feet of abandoned Peshastin Creek within the upper part of Reach 2 as identified in the TRA (Inter-Fluve 2010). Reach 2 extends from RM 1.4 upstream to RM 5.0 and occupies an unconfined valley with glacially derived sediment. The creek generally interacts with the glacial terraces and alluvial fans from adjacent tributary drainages, and in short channel segments sandstone bedrock outcrops (Inter-Fluve 2010).

Reach 2 is substantially altered from conditions prior to European settlement (Inter-Fluve 2010). The construction of SR 97 in the 1950s disconnected hydrologic and geomorphic processes from approximately 91% of the total floodplain in Reach 2. Within the project site, highway construction forced the relocation of the creek channel to the east side of the road, which created the existing straight channel (Figure 3). When the creek was relocated from the former meander to the existing straight channel, the channel length was reduced by 600 feet and the slope of the channel was steepened from 1.36 to 1.45% (Figure 4). The reduction in length at this site accounts for 14% of the total reduction in channel length attributed to construction of SR 97 (Andonaegui 2001). In addition to the relocation of the creek channel, the construction of a bridge over Peshastin Creek at RM 3.85 has also created a barrier to horizontal channel migration.

The Project Team examined channel migration rates for Peshastin Creek within the project site by comparing the left and right bank extents of the unvegetated creek channel, as traced from orthorectified aerials from 1975 and 2006. Bank migration was sampled at 0.1-mile intervals. Where the bank was moving away from the centerline of the creek, the average annual migration rate was calculated by dividing the distance between the 1975 and 2006 bank trace, and dividing by 31 (for the total intervening years). Migration rates in the vicinity of the project site are illustrated in Figure 5.

Since the channel was moved in the 1950s, it has continued to adjust horizontally. From RM 3.5 to 3.9 the channel is confined between the highway and the hillslope which has reduced average migration to between 0.3 and 0.5 feet per year. Upstream of the Larsen Creek confluence at RM 3.9, the channel has a wider channel migration area, despite the continued confinement of SR 97 to the west. Between RM 3.9 and RM 4.5 the river has an average migration rate between 1.3 to 2.3 feet per year.

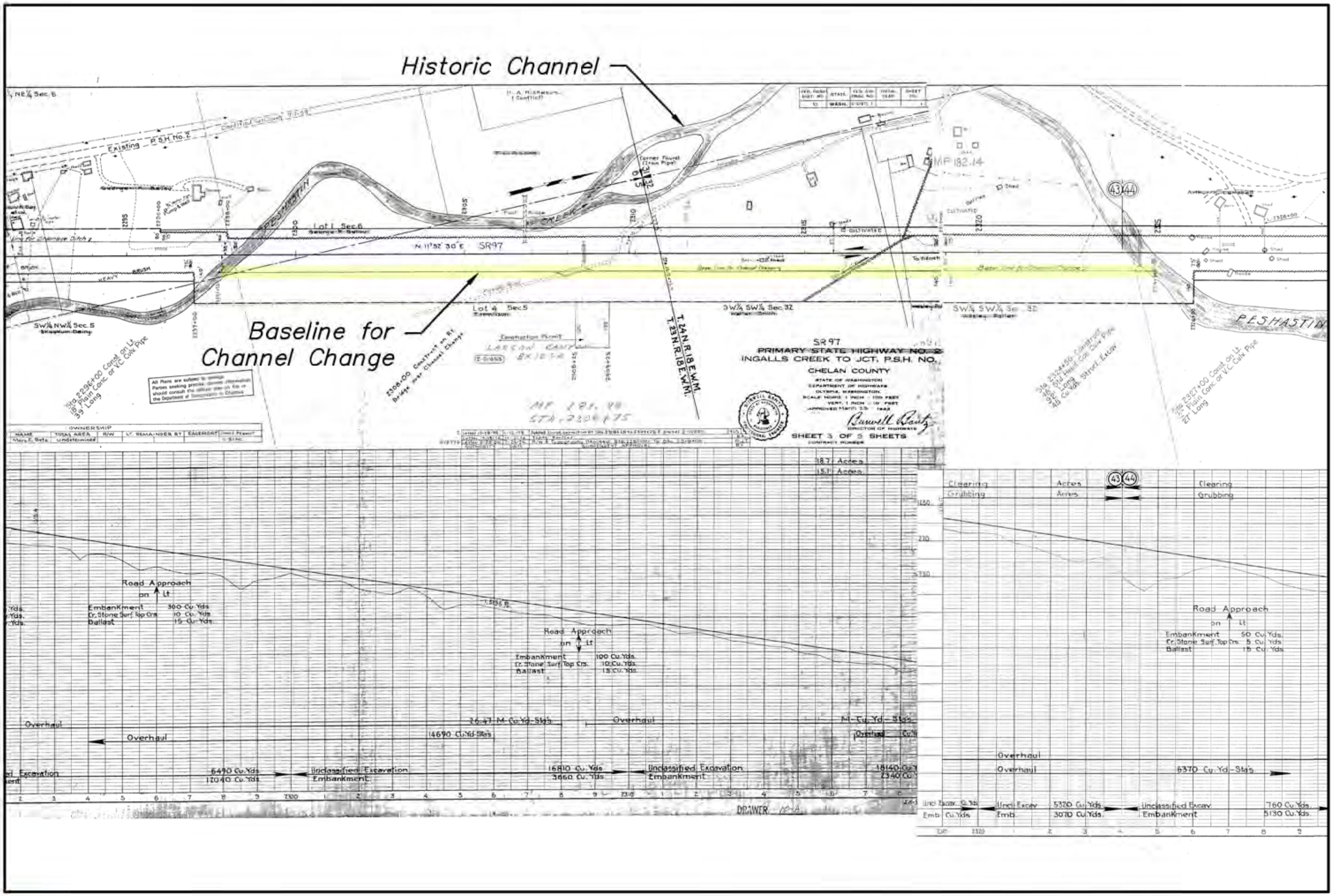
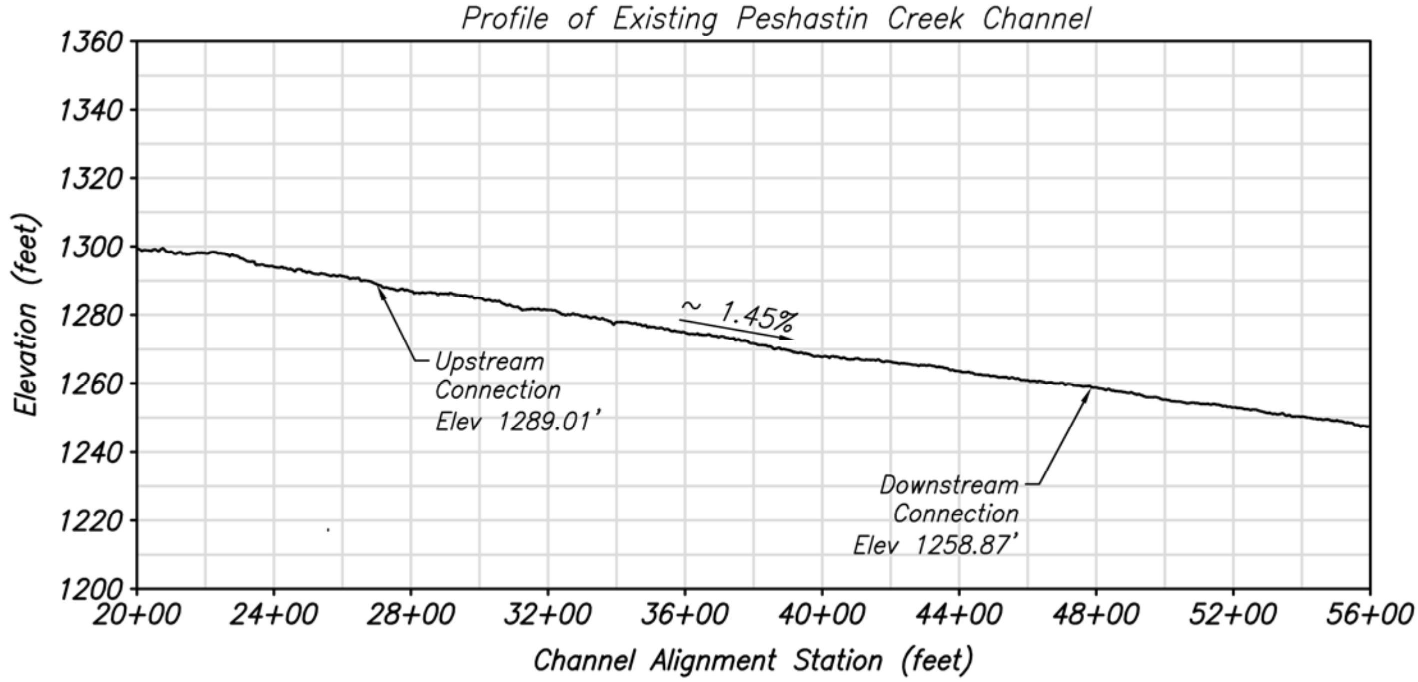


Figure 3
1943 Highway Realignment Plans
Peshastin Creek River Mile 3.8L Feasibility Study



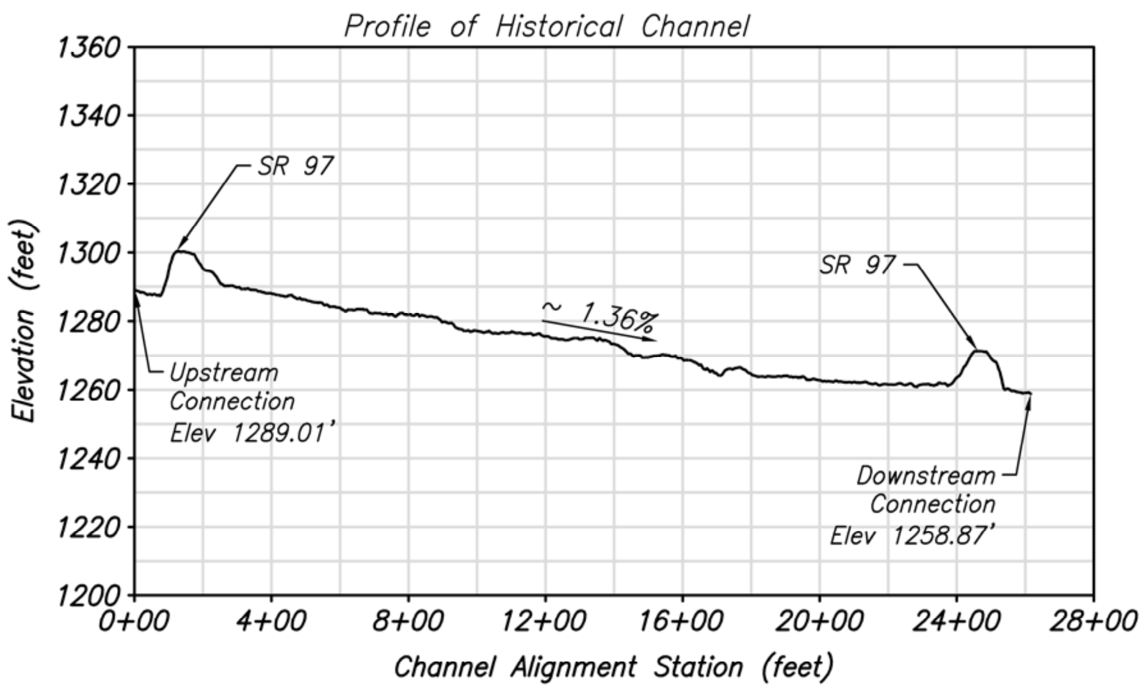


Figure 4
Existing Peshastin Creek and Historical Channel Profiles
Peshastin Creek River Mile 3.8L Feasibility Study

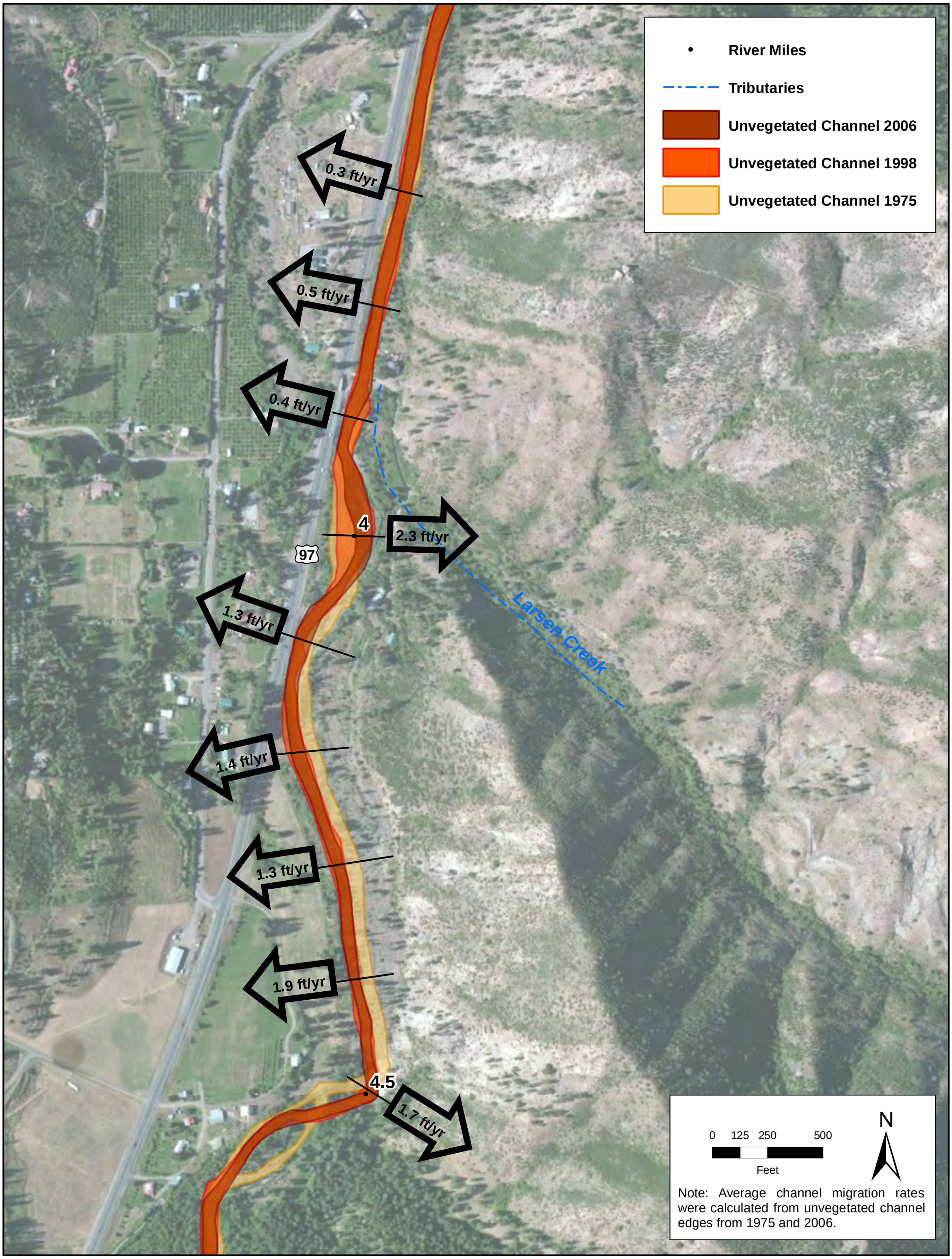


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Figure 5
Channel Migration Rates
Peshastin Creek River Mile 3.8L Feasibility Study

There have been ongoing bank erosion problems along SR 97 at RM 3.90, the location where the creek is forced to follow the constructed channel instead of the original meandering channel. Washington State Department of Transportation (WSDOT) has had to repair the roadway because of erosion that occurred after flooding events, the most recent of which was January 2009. The repairs have included replacing lost fill from the roadway embankment and adding riprap armoring at the point where the creek is eroding the bank. The CCNRD, along with WSDOT's Chronic Environmental Deficiencies Program team, is nominating this site for inclusion in that program and looking at long-term fixes to this erosion problem in conjunction with reconnection of the disconnected channel.

2.3 Historical Channel

The historical channel is located east of SR 97 and is 2,470 linear feet in length. The channel shape and cobble bed material remain since disconnection in the 1950s; however, human development has encroached with fill, sand, and debris. Sinuosity of the abandoned channel is 1.23 compared to an average of 1.12 in the main channel for Reach 2 (Inter-Fluve 2010). Riparian vegetation is limited along the former channel edges likely because of clearing from adjacent landowners. Appendix A presents cross sections comparing the historical channel and Peshastin Creek main channel. At the upstream end near RM 3.9 (XS-1 and XS-2), the historical channel is approximately 4 feet higher than the current main channel. This difference in channel elevation is less toward the downstream end of the historical channel where there is a 1- to 2-foot difference (XS-5 and XS-6).

In spring of 2011, a large debris flow originating west of Campbell Road flowed over the road and into the downstream end of the abandoned historical channel. This debris flow deposited 2 feet of sand across the lower 500 feet of the historical channel all the way to the existing 4-foot-diameter outflow culvert at SR 97. The debris has filled approximately half of the culvert. The extent of this debris flow is shown in Figure 6 and in cross sections 5 and 6 shown in Appendix A. The source of this sediment is located upslope at the head of the polygon on Figure 6.

Near the downstream end of the abandoned channel, several springs flow into the historical channel from the hillside providing surface flows for 1 to 2 months in the late spring and early summer months. At the upstream end of the site, there is no hydraulic connection for surface water between Peshastin Creek and the historical channel. At the downstream end there is a 4-foot-diameter concrete pipe that connects the seasonal spring fed flows from the historical channel to the creek.

2.4 Hydrology

The basin area is 124 square miles at the project site (RM 3.8). Mill Creek enters Peshastin Creek near the upstream end of the reach and contributes perennial flow. Larson Creek enters the reach at RM 3.8 and contributes ephemeral flows. The two major diversions of the Peshastin Basin are located in Reach 2. The Tandy Ditch is located upstream of the project site at RM 4.9, while the Peshastin Canal is located downstream at RM 2.5. The diversion of flows during summer low flow may create a migration barrier (Inter-Fluve 2010).

200 0 200 400 600
SCALE OF FEET

Figure 6
Slope Instability Location
Peshastin Creek River Mile 3.8L Feasibility Study

The Project Team assessed the hydrology of Peshastin Creek at RM 3.8 which is included as Appendix B to this report. The Washington State Department of Ecology (Ecology) operates and maintains a streamflow gage on Peshastin Creek at Green Bridge Road (Station ID 45F070) at approximately RM 2.5. The gage has been in operation since September 2002. No other streamflow gage data are available for Peshastin Creek.

Two methods were used to characterize the nature of peak flows at the project site (Appendix B). Peak flows calculated using the methods in U.S. Geological Survey (USGS) Bulletin 17B are summarized in Table 2.

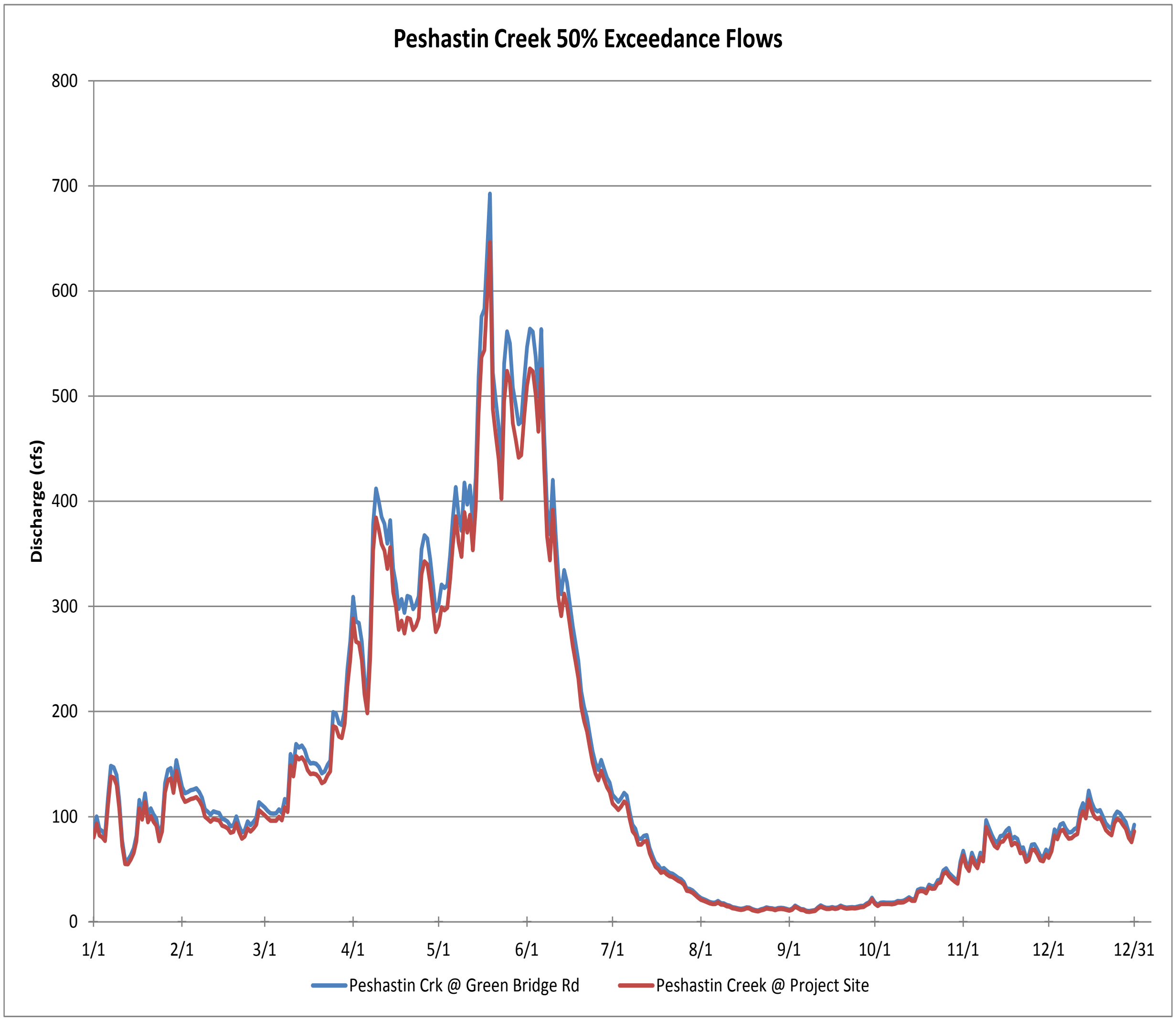
Table 2. Summary of Estimated Peak Flows at RM 3.8

	USGS Bulletin 17B	
Return Period	**Estimated Q (cfs)**	**95% Confidence Limits (cfs)**
2	1,618	1,222–2,118
5	2,426	1,856–3,714
10	2,963	2,262–5,150
25	3,634	2,753–7,386
50	4,128	3,111–9,364
100	4,614	3,464–11,625
200	5,096	3,818–14,189

cfs = cubic feet per second

Fifty percent (50%) exceedence mean daily flows for the Green Bridge site and project site were also calculated using Ecology’s stream gage data. Because of its proximity to the Green Bridge gage, median daily flow at the channel reconnection project site is very similar in magnitude to flows recorded at the Green Bridge gage site (Figure 7).

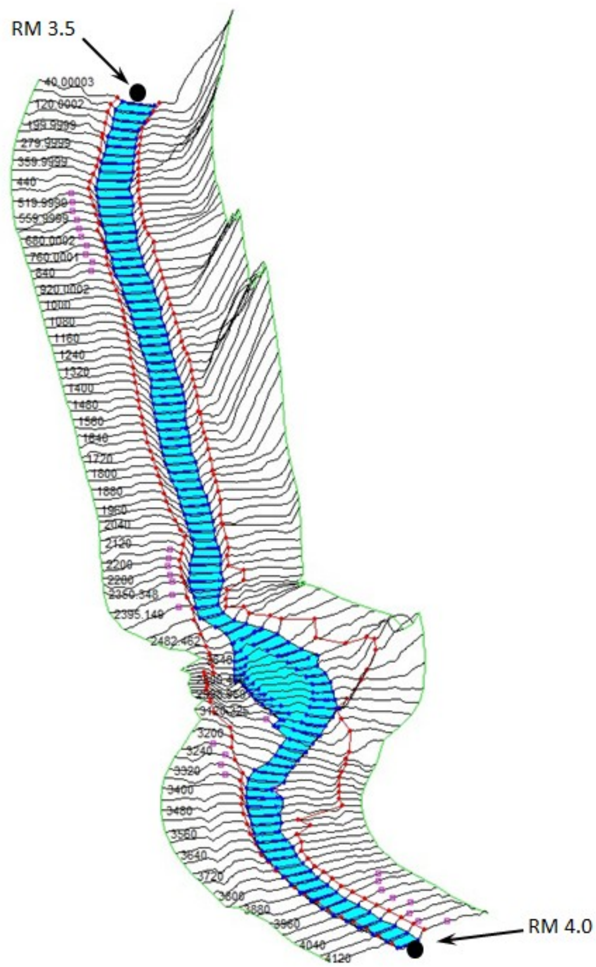
Figure 7. Fifty Percent (50%) Exceedance Flows for Peshastin Creek



2.5 Hydraulics

The Project Team developed a one-dimensional hydraulic model for the project site to analyze hydraulic conditions in the existing channel of Peshastin Creek. The model was developed using Hydrologic Engineering Centers River Analysis System (HEC-RAS) and the geographic information system (GIS) extension Geo-RAS. A digital elevation model (DEM) of the project site derived from Light Detection and Ranging (LiDAR) data was used to define ground geometry and 104 cross sections were derived from that geometry. The model represents the existing channel from approximately RM 3.5 to 4.0(Figure 8).

Figure 8. HEC-RAS Model Schematic of the Project Site



Roughness coefficients were estimated using standard values for the types of land cover, and the friction slope at the downstream boundary was approximated as the longitudinal slope of the thalweg. The model does not include the entirety of the floodplain of the existing channel, or the disconnected historical channel and floodplain. Rather, it is anticipated that the model would be used in future design steps to determine approximate water surface elevations for target flows at the possible connection points. The model could be modified in the future to include cross sections representing the historical channel. Additionally, the model could be run using unsteady flow conditions to further assess the stream power and associated ability of the historical channel to transport sediment and maintain its proposed shape over time. Before performing detailed analysis, a calibration would be performed using measured flows and water surface elevations.

2.6 Fish Use

Peshastin Creek is a Category 2 watershed and contains aquatic habitat for three ESA-listed species:

- Upper Columbia River steelhead (Threatened),
- Upper Columbia River spring Chinook salmon (Endangered), and
- Bull trout (Threatened).

Peshastin Creek contains a major spawning area for steelhead and minor spawning area for spring Chinook, and is a bull trout core area (Upper Columbia Regional Technical Team 2008). The attached Fish Use Memorandum (Appendix C) provides a detailed description of fish use in Peshastin Creek. In summary, spring Chinook salmon, steelhead and rainbow trout, and bull trout used the Peshastin Creek watershed in greater numbers than occur there today. Steelhead were likely the more populous anadromous species spawning in this system; however, coho may also have been more abundant than spring chinook before coho were extirpated from the region (Andonaegui 2001).

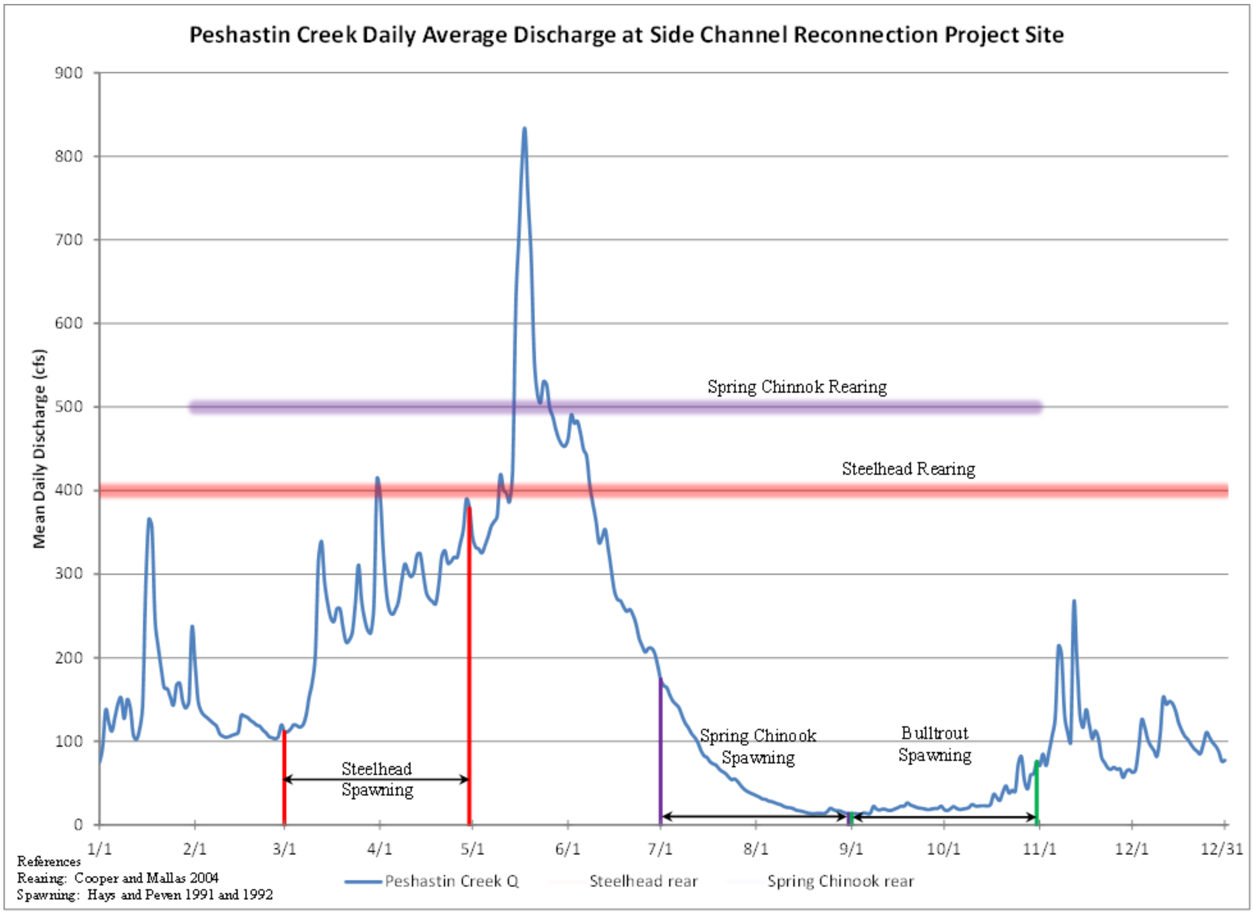
Spring Chinook redds have been observed in Reach 2 and up to the confluence of Ingalls Creeks (RM 9.4), while rearing spring Chinook have been observed from the mouth up to RM 14.8. Steelhead and rainbow trout use Peshastin Creek for spawning and rearing and as a migration corridor, although they are thought to do so in low numbers. Steelhead primarily use this reach for spawning and rearing. Historically, bull trout occurred in the watershed where habitat existed and access was not blocked by natural barriers. Very low numbers of bull trout have been observed in the Peshastin Creek mainstem. Being mainstem Wenatchee spawners, summer Chinook do not use the Peshastin Creek drainage except for possibly very limited rearing at the mouth. Table 3 summarizes fish use in Reach 2.

Table 3. Current Salmon, Steelhead, and Bull Trout Use in Peshastin Creek, Reach 2

Species	Rearing	Spawning	Migration
Spring Chinook	X	X	X
Steelhead	X	X	X
Bull Trout			X

Figure 9 shows the mean daily discharge hydrograph relative to spring Chinook and steelhead life history stages in the vicinity of the project site.

Figure 9. Peshastin Creek Daily Average Discharge and Fish Use at RM 3.8



2.7 Limiting Biological Factors

The primary habitat-limiting factors in Peshastin Creek are related to increased channel confinement and decreased stream sinuosity, impaired riparian condition, reduced floodplain connectivity, and gravel recruitment (Andonaegui 2001; Upper Columbia Salmon Recovery Board 2007; Upper Columbia Regional Technical Team 2008; Interfluve 2010). Past human activities that have most notably affected river processes include highway construction, mining and placement of mine tailing piles, logging of riparian forest, continued development, and flood protection (small levees, bridges, riprap, and roads). Water withdrawals for agriculture also reduce summertime flow levels in lower Peshastin Creek.

Andonaegui (2001) indicated that the Peshastin Creek channel, from the mouth to Tronsen Creek at RM 14.9, has been reduced in length by 0.8 mile because of SR 97 construction in 1956 (Primary State Highway 2 at the time of construction). Highway construction resulted in the disconnection of 194 acres of the total acres of floodplain (565 acres) along Peshastin Creek (Andonaegui 2001). The reduced length and floodplain capacity has had a negative effect on the creek's morphology by increasing the longitudinal slope, which increases bed shear stress, and in turn, increases the rate of sediment transport beyond the natural condition. The reduction in length has also had a negative impact on salmonid habitat by eliminating desirable channel diversity that is associated with sinuosity and unconstrained channel migration (e.g., variations in depth, accumulation of LWD at bends, overhanging banks). As a result, instream habitat complexity in Peshastin Creek is low in terms of low pool depth and frequency, low LWD counts, and a significant reduction in off-channel habitat (Andonaegui 2001). Low instream flows also impede upstream salmonid migration and reduce rearing habitat (Upper Columbia Regional Technical Team 2008).

In the TRA, the lower 8.4 miles of Peshastin Creek are rated as an “at risk” or “unacceptable risk” condition for several parameters important to the spawning and rearing life stages of salmonids (Inter-Fluve 2010). Within Reach 2 there is limited spawning habitat (Inter-Fluve 2010) as the reach is dominated by long riffles consisting of coarse-bedded, plane-bed sections that lack appropriate spawning substrate. Rearing habitat is also limited as pools are infrequent, are often shallow, and have minimal cover. Side channel habitat is also limited in Reach 2 and only comprises 1% of habitat in the reach, with no side channel habitat during low flows (Inter-Fluve 2010).

Chapter 3
Alternatives Analysis

Following guidance from the UCRTT, the CCNRD evaluated the reconnection of the historical channel at RM 3.8. The primary goal at the project site is to reconnect stream channel process to the disconnected stream channel and floodplain (Inter-Fluve 2010). Based on the recommendations of the TRA (Inter-Fluve 2010), and through additional site evaluations conducted by the CCNRD, there are four possible reconnection alternatives at this site. These alternatives are listed below in order of providing the greatest benefit to stream process and biological benefit for listed species.

1. **Full Channel Reconnection—Highway Realignment:** Full channel realignment into the historical channel by moving SR 97 outside of the channel migration zone.
2. **Full Channel Reconnection—Bridges:** Installation of two large bridges in SR 97 to move Peshastin Creek to the historical channel alignment.
3. **High Flow Inlet:** Installation of two small- to moderate-sized culverts in SR 97 to allow high flows into the historical channel.
4. **Back Channel:** Replacement of the existing culvert located along US 97 at the downstream end of the historical channel with a large culvert or small bridge set at a low elevation to provide seasonal backwater habitat access.

The Project Team conducted multiple field reconnaissances and landowner interviews, prepared a site-scale hydraulic model, and used existing TRA data. The team then developed the following evaluation criteria, which were used to assess and evaluate the four project alternatives:

- Goals Addressed and Expected Short-Term and Long-Term Benefits.
- Geomorphic Response and Expected Project Lifespan.
- Risk to Adjacent Landowners.
- Construction Feasibility.
- Construction Cost.

Conceptual plans for each of the alternatives are presented in Appendix D, construction cost estimates are provided in Appendix E, and site photos are provided in Appendix F.

3.1 Full Channel Reconnection—Highway Realignment

The full channel reconnection can be achieved by removing the SR 97 alignment from the channel migration zone, moving Peshastin Creek to its historical channel, and converting the existing channel into side channel habitats. The historical channel would have to be excavated to suitable dimensions capable of conveying Peshastin Creek discharge while avoiding aggradation or degradation. The most likely location for the relocated SR 97 alignment is along 1.1 miles of Campbell Creek Road, which was the location of the highway (Primary State Highway No. 2) prior to the realignment in the 1950s (Figure 2).

The relocated highway would need to meet WSDOT safety design standards for travel speeds of 60 miles per hour (mph). To meet the grade and curvature standards, the proposed highway alignment utilizes horizontal curves with radii not less than 1,500 feet and has a 36-foot road width (two 12-foot-wide travel lanes and two 6-foot-wide shoulders). For planning purposes, the road right-of-way (ROW) has been assumed to be 100 feet wide to accommodate the cut or fill slopes and to allow for sufficient clearing to meet safety standards. The actual width may vary depending upon final design fill slope requirements, sight distances, and ROW negotiations between WSDOT and private landowners.

This alternative assumes that the existing SR 97 embankment would be removed from the channel migration corridor between the two channel reconnection points. The road embankment would remain in place upstream of the reconnection point to provide landowner access to private properties. This alternative includes a plug that would be installed within the existing creek channel at the upstream reconnection point to ensure the creek is reconnected with the historical channel alignment. The remaining channel downstream of the plug would remain for off-channel habitat during high flows; it is not anticipated that the off-channel habitat would retain water year-round. Relocating Peshastin Creek to its historical channel and moving SR 97 to Campbell Road would increase the length of the main channel by approximately 530 feet; this would also reconnect Peshastin Creek to 14.7 acres of floodplain while providing 185 feet/0.21 acre of high-flow off-channel habitat.

3.1.1 Goals Addressed and Expected Short-Term and Long-Term Benefits

Removal of SR 97 from the channel migration zone would restore up to 14.7 acres of floodplain function by removing the unnatural feature that is currently confining the stream channel and limiting floodplain connection. Removal of floodplain constrictions would allow for lateral stream migration, increase stream channel length, increase channel habitat diversity, and improve LWD and gravel recruitment processes. This alternative would address the floodplain connectivity limiting factors identified in Peshastin Creek. The SR 97 relocation would provide channel connectivity to the floodplain, off-channel habitat, and allow for natural channel migration processes.

This alternative would provide 2,470 linear feet of stream channel, thereby increasing stream length by 530 feet, increasing sinuosity from 1.10 to 1.23. This alternative would also provide increased habitat complexity through the restoration of channel processes that would form and maintain complex pool and riffle habitats. The realignment of Peshastin Creek through this channel would also restore long-term channel migration and habitat-forming processes along this section of Peshastin Creek. To improve channel diversity, pools and complex LWD structures could be built into the restored channel alignment prior to reconnection, and the existing channel could be converted into high flow alcove habitat near the downstream connection.

3.1.2 Geomorphic Response and Expected Project Lifespan

This alternative assumes that the SR 97 prism would be removed from the floodplain and a new highway alignment would be constructed outside of the floodplain and channel migration zone. Following the removal of the highway, without extensive deepening of the historical channel, the existing channel would likely remain within its current alignment. As shown in the cross sections presented in Appendix A, the existing channel has incised 3 to 4 feet lower at the upstream end of the historical channel, and approximately 1 to 2 feet lower at the downstream end. Given the benefit derived from returning the creek channel to the historical alignment (increased length, greater complexity), it is assumed that the historical channel would be deepened and prepared for the creek reconnection prior to highway removal.

To ensure that the creek occupy the new channel at the outset of the reconnection, additional measures would need to be employed to direct flow in the creek down the reconnected meander. This may include partial filling of the existing channel and placement of a large structure such as an engineered log jam to direct the flow as desired, grade control structures, or other bank stabilization means. The removal of the highway would extend the channel migration zone to its historical northern extent within this reach. This would provide the channel the long-term ability to migrate naturally.

The risk of slope failure similar to the 2010 event that currently blocks the historical channel would need to be addressed prior to channel reconnection. This would likely include a geologic study and stabilization measures on upslope private properties. Without this work, the likelihood of a future failure is uncertain; however, a similar slope failure could cause damage to the new SR 97 roadway.

3.1.3 Risk to Adjacent Landowners

This alternative would likely result in undesirable flooding and damage to buildings that have been constructed adjacent to the historical channel. The long-term goal of allowing the restored channel to migrate at natural rates would include erosion of the banks through private properties and would put some structures at risk. The relocation of SR 97 would require the expansion of Campbell Road to accommodate the two-lane highway and accompanying ROW. This would encroach upon private property that currently abuts the county road. Additionally, access to several properties from the current alignment of SR 97 would be lost.

The relocation of SR 97 along Campbell Road would reduce the risk of road failure along Peshastin Creek at RM 3.9. The road failed in 2009 during high flows and was repaired, however, Peshastin Creek still poses an erosion risk at this location.

3.1.4 Construction Feasibility

The feasibility of highway relocation has not been fully assessed; however, the existing Campbell Road alignment would provide the likely alignment of a relocated highway. Road relocation would require 1.07 miles of new road to be constructed or existing road to be upgraded to highway standards, and 0.81 mile of existing road to be removed. Under the highway removal option, the existing access from SR 97 to river right via the Harriman Bridge (privately owned) at RM 3.85 would also need to be relocated.

3.1.5 Construction Cost

Detailed estimates of construction cost for each of the alternatives are presented in Appendix E. Cost estimates are based on recent unit bid prices from constructed projects and costs for design, permitting and construction management are based on typical percentages of construction costs. Costs are provided in 2011 dollars. At the bottom of each table, there is an estimated increase in cost for future years. All cost estimates include removal of the existing stream bed and some amount of follow up soil stabilization. Any stream restoration work proposed beyond that would be in addition to the costs outlined.

The estimated cost for design and construction of relocating SR 97 is $12.9 million. This includes estimates for the purchase of affected private properties and the relocation of utilities.

3.2 Full Channel Reconnection—Bridges

Two bridges (minimum span 200 feet each) could be installed within SR 97 to allow the full creek channel to flow into the historical channel. The historical channel still maintains its historical planform of the creek; however, additional grading would be needed to bring the thalweg of the historical channel down to meet the existing channel thalweg at the upstream and downstream ends of the project. This alternative also includes a plug that would be installed within the existing creek channel at the upstream reconnection point to ensure that the creek is reconnected with the historical channel alignment. The remaining channel downstream of the plug would remain for off-channel habitat during high flows; it is not anticipated that the off-channel area would retain water year-round. Installing two bridges and relocating Peshastin Creek to its historical channel would increase the length of the channel by 530 feet this would also reconnect Peshastin Creek to 14.7 acres of floodplain while providing 185 feet/0.21 acre of high-flow off-channel habitat. This alternative differs from the highway relocation alternative in that Peshastin Creek would be limited in planform migration due to the highway embankment remaining in place.

3.2.1 Goals Addressed and Expected Short-Term and Long-Term Benefits

The bridges would allow the realignment of Peshastin Creek into the historical channel. The realignment of the creek channel increases stream channel length, increases channel habitat diversity, and improves LWD and gravel recruitment processes. This alternative would address the floodplain connectivity limiting factors identified in Peshastin Creek through the reconnection of 14.7 acres of floodplain. The reconnection of the stream channel would provide channel connectivity to the floodplain, and off-channel habitat. Since SR 97 would remain in place, this alternative would not allow for natural channel migration processes.

This alternative would provide a total of 2,470 linear feet of stream channel, thereby increasing stream length by 530 feet, increasing sinuosity from 1.10 to 1.23. Since channel migration would be restricted to protect the SR 97 bridges and embankment, the restoration of channel processes that would form and maintain complex pool and riffle habitats would be limited. To address the issue of stability and to improve channel diversity, pools and complex LWD structures could be built into the restored channel alignment prior to reconnection, and the existing channel could be converted into high flow backwater habitat. Channel stabilization measures such as grade control structures and bank stabilizing structures would also be employed near the connection points to prevent unwanted erosion and to ensure that Peshastin Creek continues to flow into and out of the historical channel.

3.2.2 Geomorphic Response and Expected Project Lifespan

Without the removal of SR 97 the full restoration of channel migration processes would not be achieved. As with the highway removal option, work would need to be done to the existing channel to direct flow in the creek down the reconnected channel. This may include partial filling of the existing channel and placement of a large structure such as an engineered log jam to direct the flow as desired. An advantage of reconnecting the former meander is that the creek is oriented in that direction. The existing situation where the road embankment is directing flow down the manmade channel experiences significant erosion during floods because it is forcing flow to change direction suddenly which coupled with the high flow velocity in this part of Peshastin Creek leads to high amounts of energy directed at the highway. The reconnected channel would experience less erosion and scour at the upstream end because it would be guiding the flow in the general direction that the stream planform is oriented so less energy would be expended against the banks.

Over the long term, the channel would likely continue to migrate dynamically in the reach immediately upstream of the upstream bridge reconnection as is evidenced today. The need to force the creek through the upstream bridge opening in this area would likely require future maintenance to ensure that the creek continues to flow through the bridge in the optimal angle. Similar bank hardening applications would also be required at the downstream outlet bridge on the new river left to ensure that the creek does not continue to migrate downstream beyond the new bridge opening location. Also, given the new flow direction of the river at the outlet, there should be an expected response in the main channel that includes new erosion on river right and possible erosion further downstream on river left as the existing channel adjusts to the new flow direction.

The risk of slope failure similar to the 2010 event that currently blocks the historical channel would need to be addressed prior to channel reconnection. This would likely include a geologic study and stabilization measures on upslope private properties. Without this work, the likelihood of a future failure is uncertain; however, a similar slope failure could cause dynamic channel changes affecting adjacent landowners and SR 97.

3.2.3 Risk to Adjacent Landowners

This alternative would likely result in undesirable flooding and damage to buildings that have been constructed adjacent to the historical channel. The long-term goal of allowing the restored channel to migrate at natural rates would include erosion of the banks through private properties and would put some structures at risk.

3.2.4 Construction Feasibility

Bridge construction would likely require a bypass for traffic that may also utilize Campbell Road. Channel realignment under either option would require significant instream work; however, all methods would be ones that use industry standards for design and construction.

3.2.5 Construction Cost

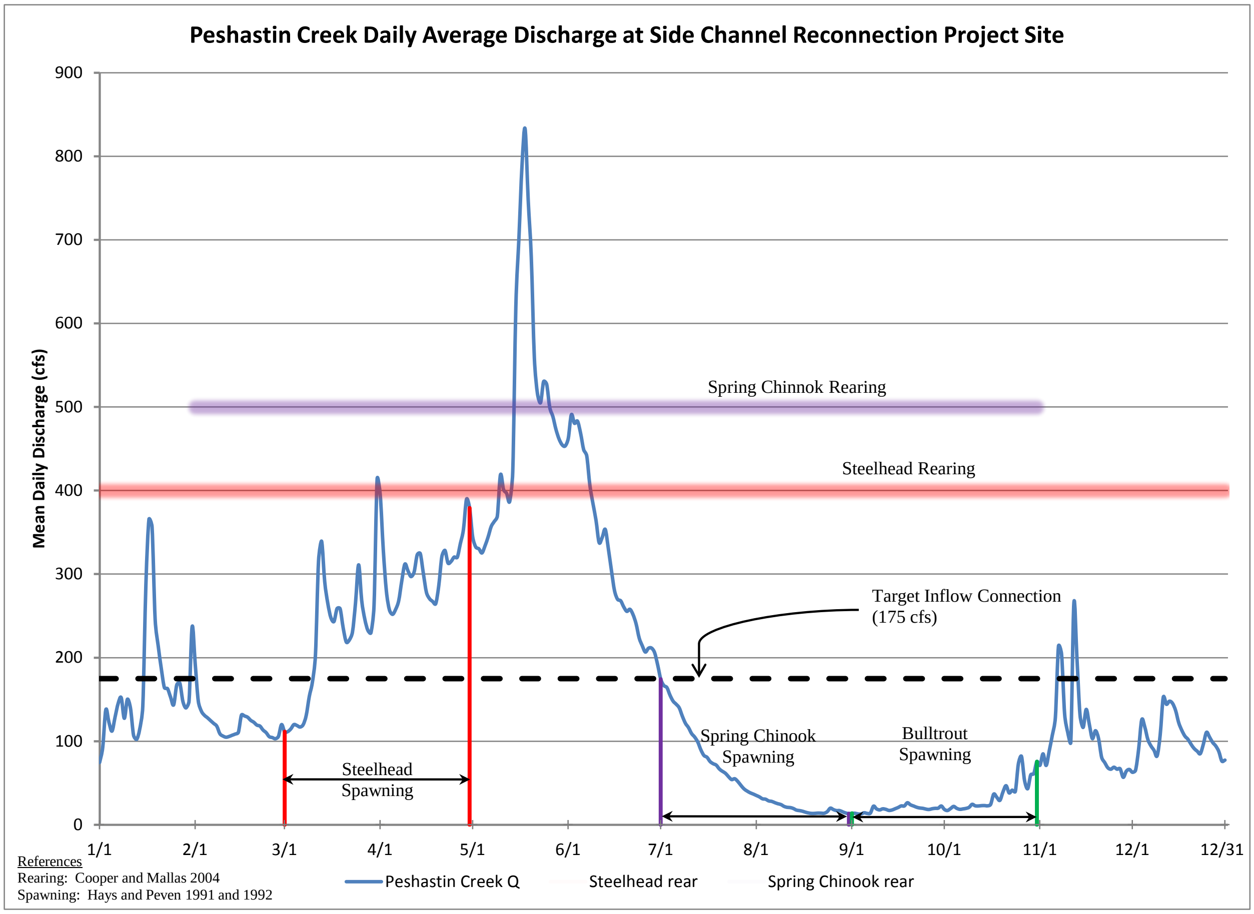
The estimated cost for design and construction of two bridges is $7.5 million. This cost estimate is based on an average cost per area of bridge deck for recent WSDOT bridge replacement projects—projects where existing culverts were being replaced by bridges for fish passage improvement.

3.3 High-Flow Inlet

The High-Flow Inlet alternative (inlet/alcove) would replace the existing 4-foot-diameter concrete pipe that drains spring-fed flows from the historical channel under SR 97 to Peshastin Creek with a 12-foot-diameter corrugated steel pipe set at a lower elevation and consist of installing a new culvert at the upstream end of the historical channel on SR 97. The complete reconnection of the historical channel would result in undesirable flooding and damage to buildings that have been constructed near the meander so a partial reconnection may provide some habitat benefit without causing flood damage.

Extreme care would be taken in selecting a desirable discharge location at which Peshastin Creek would connect to the side channel habitat. If the connection occurs at too low of a flow, the side channel may be connected during periods of spawning and then become disconnected from the main channel as flows drop further, resulting in dewatering and the loss of established redds. The upstream connection is extremely important because it would have to balance the need for providing adequate high-flow refuge habitat with the risk of dewatering redds or stranding of juveniles. The preliminary hydrologic investigation indicates that a Peshastin Creek discharge of 175 cubic feet per second (cfs) may provide these benefits as the meander would be connected during the majority of high-flow periods and disconnected when most spawning occurs (Figure 10). The need to restrict flow quantity to protect private landowners from flooding would result in high-velocity flows through the culvert or bridge at high flows. This would result in a structure that would likely not meet WDFW fish passage criteria during a majority of the high flow connection. A detailed hydraulic and sediment transport analysis would be required to determine the ability of the former meander to maintain its dimension, pattern, and profile so that a habitat benefit would be achieved and flood damage to adjacent landowners would be avoided.

Figure 10. Daily Average Discharge and Target Connection Discharge at RM 3.8 Project Site



3.3.1 Goals Addressed and Expected Short-Term and Long-Term Benefits

The High-Flow Inlet alternative would provide 2,470 linear feet of high-flow rearing and refuge habitat for juvenile salmonids. The downstream end of the historical channel could also be excavated to match the existing channel's thalweg to provide 0.68 acre of low-flow off-channel habitat. Since the historical channel currently has very limited channel diversity, deep pool and complex cover habitats could be constructed in the historical channel to improve habitat complexity. Predicted flows and flow velocities are not expected to cause channel migration of the historical channel. This reduces the ability to recruit LWD and form and maintain pools and riffle habitat.

3.3.2 Geomorphic Response and Expected Project Lifespan

The upstream connection of the historical channel is approximately 1 to 2 feet higher than the Peshastin Creek thalweg. This perched opening would restrict the recruitment of fine-grained material being transported by the main channel, which would likely increase the lifespan of the side channel to function as high-flow refugia.

Two key factors, however, may limit the long-term function of this project:

- Channel migration at the upstream connection, and

- Landslides at the downstream end of the historical/reconnected channel.

Immediately upstream of the proposed reconnection, the main channel is meandering to river right and north (downstream) (Figure 5), while building a bar on river left along the SR 97 prism. Based on field observations of bank materials, this trend is expected to continue. This would likely result in the migration of the channel downstream and beyond the proposed upstream bridge or culvert opening, along with the building of sandbar materials in front of the connection location. Without ongoing maintenance or proactive in-channel structures designed to reduce channel migration, this trend is expected to limit the long-term effectiveness of the upstream inlet.

A recent (2011) slope failure above the historical channel at the downstream end has deposited several feet of sand. A reconnaissance of the slope failure and landowner feedback indicates that without a long-term fix to prevent future landslides from occurring, it is highly likely that landslide activity would continue at this location. Prior to reconnection of flows through this channel, this existing deposited material would be removed. If a future slide were to occur, the high-flow velocities could cut a channel through the sandy material. If the slope failure were large enough, it could result in the complete blockage of the downstream outlet. To remove this risk, the landslide area should be stabilized prior to project construction.

3.3.3 Risk to Adjacent Landowners

The risk to landowners from a partial/high-flow reconnection is primarily from flooding. The flows allowed into the channel would be controlled so as to avoid channel migration or severe bank erosion or overtopping of flow onto buildings. Detailed hydraulic modeling would be needed to evaluate the expected range of discharges that would flow through the old channel and the associated flooding risk. The inlet would need to be carefully designed to restrict flows to the target rate to prevent flooding of the buildings.

3.3.4 Construction Feasibility

Construction feasibility focuses on the construction of bridge or culvert structures in SR 97. Depending on the structure and construction technique, this may require a temporary bypass during construction. The bridge or culvert construction would follow WSDOT standard procedures and would not be any more difficult than a typical bridge replacement project on a state highway. Construction would also include a small amount of instream work within the actively flowing channel of Peshastin Creek at the connection points to provide connections at the desired elevations, and to install structures to deflect flow, protect the banks, and control sediment deposition.

3.3.5 Construction Cost

The cost of constructing a new connection to the old channel at the upstream end of the meander, installing grade- and channel-stabilization measures, grading the channel to appropriate dimensions, and replacing the culvert at the downstream end is estimated at $1.1 million. This cost includes the installation of several LWD structures and the creation of several small pools in the partial flow channel. This estimate also includes the possible purchase of an easement on affected properties. Detailed estimates of the construction cost for this alternative are presented in Appendix E.

3.4 Back Channel

The Back Channel alternative (outlet only/alcove) would replace the existing 4-foot-diameter concrete pipe that drains spring-fed flows from the historical channel under SR 97 to Peshastin Creek with a 12-foot-diameter corrugated steel pipe set at a lower elevation. According to the adjacent landowner, spring seeps flow from the toe of the hillside west of the historical channel for 1 to 2 months in the spring. These flows, in combination with backwater flows from Peshastin Creek during spring months, could provide good quality off-channel alcove habitat.

3.4.1 Goals Addressed and Expected Short-Term and Long-Term Benefits

The Back Channel alternative would provide immediate high-flow off-channel refuge habitat for juvenile salmonids. The downstream end of the historical channel could also be excavated 4 to 5 feet to match the existing main channel thalweg to provide low-flow off-channel habitat during summer months. Since the historical channel currently has very limited channel diversity, deep pool and complex cover habitats could be constructed in the historical channel to provide improved habitat complexity. During high-flow events this project would provide approximately 0.15 acre of refuge habitat. This alternative is not expected to provide improved channel processes in terms of channel migration, LWD recruitment, and pool and riffle formation.

3.4.2 Geomorphic Response and Expected Project Lifespan

The primary limit to the long-term function of the Back Channel alternative is the risk of future debris flows entering the historical/reconnected channel. The risk of future debris flows is high, and the limited spring flows that are expected to flow through the outlet would not have velocities of sufficient magnitude to move the sandy material out into Peshastin Creek. This is evident in the 2011 spring/seep flows upstream of the debris jam, which had little effect on the sand that still blocks half of the area of the existing 4-foot culvert. Until the potential for future debris flows is addressed, this alternative is considered likely to be plugged from debris at some point after construction

Once the landslide risk is addressed, the sandy slide material will need to be removed in association with a habitat restoration plan for the side channel. Metal debris and garbage associated with a private landowner will also need removal prior to reconnection of the habitat for fish use. Following debris removal the habitat restoration would focus on connecting spring and seep flows back to Peshastin Creek, adding pool refuge, and LWD cover.

3.4.3 Risk to Adjacent Landowners

The risk to landowners to the west of SR 97 is very low because no new flows would be introduced at the upstream end of the project, and SR 97 would remain as a barrier to Peshastin Creek migration. The larger culvert with additional flow capacity and the ability to accommodate more debris flow material before plugging would provide a reduction in risk to landowners immediately west of SR 97. Flood elevations from a new culvert would have little change from elevations associated with the existing 4-foot-diameter culvert.

3.4.4 Construction Feasibility

Construction feasibility assumes the replacement of the existing culvert with a new and larger culvert. Depending on the structure and construction technique, this may require a temporary bypass during construction. The culvert construction would follow WSDOT standard procedures and would not be any more difficult than a typical culvert replacement project on a state highway. Construction would also include a small amount of instream work within the actively flowing channel of Peshastin Creek at the connection point to provide a connection at the desired elevations, and possibly to install structures to control sediment deposition.

3.4.5 Construction Cost

The cost of installing one 12-foot corrugated metal pipe (downstream connection only) is approximately $536,000. Detailed estimates of construction cost for each of the alternatives are presented in Appendix E.

3.5 Selection of the Preferred Alternative

The selection of a Preferred Alternative was made based on the evaluation criteria outlined previously. Equal weight was given to each criterion. The Preferred Alternative was selected based on the ability to best meet the objectives listed in Chapter 1 and the evaluation criteria. Table 4 summarizes the evaluation criteria for each alternative.

Both of the full channel reconnection alternatives provide the best approach for addressing the top goal in Peshastin Creek which is to restore Peshastin Creek to its historical alignment. However, based on the evaluation of the alternatives, the potential impact on adjacent landowners and overall project cost may prohibit the implementation of either of the full channel reconnection alternatives.

The High Flow Inlet alternative would be a good approach to addressing the objectives of restoring hydraulic connectivity and fish access to disconnected floodplain habitats and the Regional Technical Team prefers projects with a flow-thru component versus just a back channel. While this alternative would not restore full channel geomorphic process, it would provide hydraulic connectivity to disconnected floodplain, and access for juvenile salmonids during critical high-flow refuge and rearing periods. Careful consideration to the quantity and timing of flows would be required to reduce the potential flooding risk to landowners, while still meeting the target periods of use for juvenile salmonids. The need to reduce flooding risk to landowners would require a constricted upstream connection which would result in flow velocities too high to meet WDFW fish passage criteria. Thus based on the landowner risk, one landowners lack of support and inability to meet fish passage criteria for the new upstream inlet, this alternative is not preferred.

<u>The Preferred Alternative is the Back Channel Alternative</u>. This alternative would provide backwater access to juvenile salmonids during high flow events while having low risk of flooding to adjacent landowners. The implementation of this alternative assumes that the following will occur: 1) Stabilization of the landslide and the reduction of the risk of future slides, 2) Clean-up and removal of metal and wood garbage and the existing sandy slide debris from the channel, and 3) Restoration of channel habitats including pools, LWD cover, and riparian planting.

Table 4. Summary of Evaluation Criteria for Each Alternative

Alternative	Habitat Benefits	Benefits to Geomorphic Process	Risk and Impact to Landowners	Construction Feasibility	Construction Cost
Full Channel Reconnection/SR 97 Relocation	**High.** This action would create an additional 530 linear feet of channel, reconnect 14.7 acres of floodplain, improve rearing habitat complexity, and allow natural channel migration/habitat creation processes to occur. The remaining channel would also provide 185 feet of high-flow alcove habitat.	**High.** This action would provide long-term channel migration allowing the channel to adapt to future geologic events (landslides).	**High.** This alternative would require the removal of several houses and would greatly increase the risk of erosion and flooding to private property to the north of the removed section of SR 97.	**Low.** The feasibility of relocating SR 97 to Campbell Road has not been assessed. Highway relocation would use WSDOT standards, instream work would use methods typical within the industry. This action would also require the removal and relocation of Harriman Bridge at RM 3.85.	**High.** $12.9 million.
Full Channel Reconnection/ Bridges in SR 97	**High.** This action would create an additional 530 linear feet of channel, reconnect 14.7 acres of floodplain, and improve rearing habitat complexity. The remaining channel would also provide 185 feet of high-flow alcove habitat. Since the highway prism would remain in place this action would limit natural channel migration/habitat creation processes as compared to the full highway removal alternative.	**Moderate.** This action would provide greater stream length and channel migration potential over existing conditions. However, the construction of the bridges would require "locking" the channel in place at upstream and downstream bridges.	**High.** This alternative would require the removal of several houses and would greatly increase the risk of erosion and flooding to private property within the area of channel reconnection.	**Moderate.** Bridge construction would likely require a bypass for traffic that may also use Campbell Road. Channel realignment would require significant instream work; however, all methods would be industry standard for design and construction.	**High.** $7.5 million.

Alternative	Habitat Benefits	Benefits to Geomorphic Process	Risk and Impact to Landowners	Construction Feasibility	Construction Cost
High Flow Inlet	**Moderate.** This alternative would create 2,470 linear feet of high flow side channel habitat targeted at juvenile salmonid rearing and refuge. The downstream end of the alternative would also provide 0.68 acre of low-flow alcove habitat for juvenile salmonids. The limited flows through the side channel would limit wood recruitment and habitat-formation processes. The high velocities at the upstream inlet would not meet WDFW fish passage criteria.	**Low.** To maintain flows into the upstream inlet, the main channel would require in-channel structures designed to reduce channel migration which also reduces habitat forming processes in the project vicinity. The annual flushing flows would address potential future landslide blockages.	**Moderate.** There would be a flooding risk to landowners adjacent to the reconnected side channel. The low flow velocities would limit channel erosion and migration, and the inlet would need to be designed to limit flows and flooding risk. One of the landowners does not support this alternative.	**Moderate**. Construction would require the installation of bridges or culverts in SR 97 along with instream elements to ensure the upstream connectivity. Bridge or culvert construction would follow WSDOT standard procedures and would not be any more difficult than a typical bridge replacement project on a state highway. The construction of instream elements would be ones that use industry standards for design and construction.	**Moderate.** $1.1 million.
Back Channel	**Low**. The alternative would allow backwater alcove refuge during high flows into approximately 0.15 acre of habitat. This alternative is not expected to provide improved channel processes in terms of channel migration, LWD recruitment, and pool and riffle formation.	**Low**. The alternative would not improve the opportunity for channel-forming processes.	**Low.** Risk to adjacent landowners is very low as no new flows would be introduced at the upstream end of the project and SR 97 would remain as a barrier to Peshastin Creek migration.	**High.** The bridge or culvert construction would follow WSDOT standard procedures and would not be any more difficult than a typical bridge replacement project on a state highway. Some in-channel work would be necessary to complete this alternative.	**Low.** $536,000

Chapter 4
Citations

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Upper Columbia Regional Technical Team (UCRTT). 2008. A Biological Strategy to Protect and Restore Salmonid Habitat in the Upper Columbia Region. April 30, 2008. Available: <http://www.ucsrb.com/resources.asp>.

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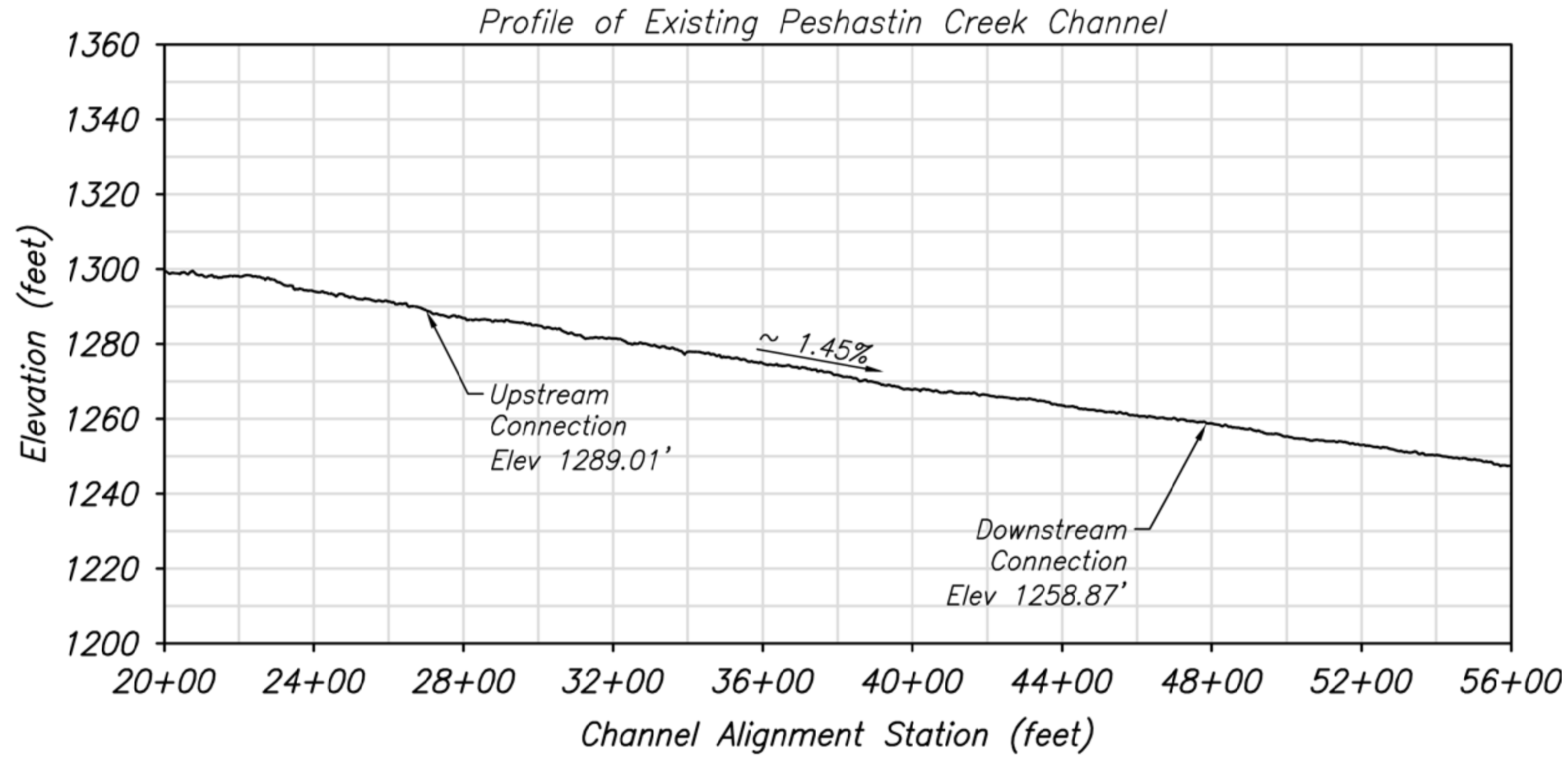
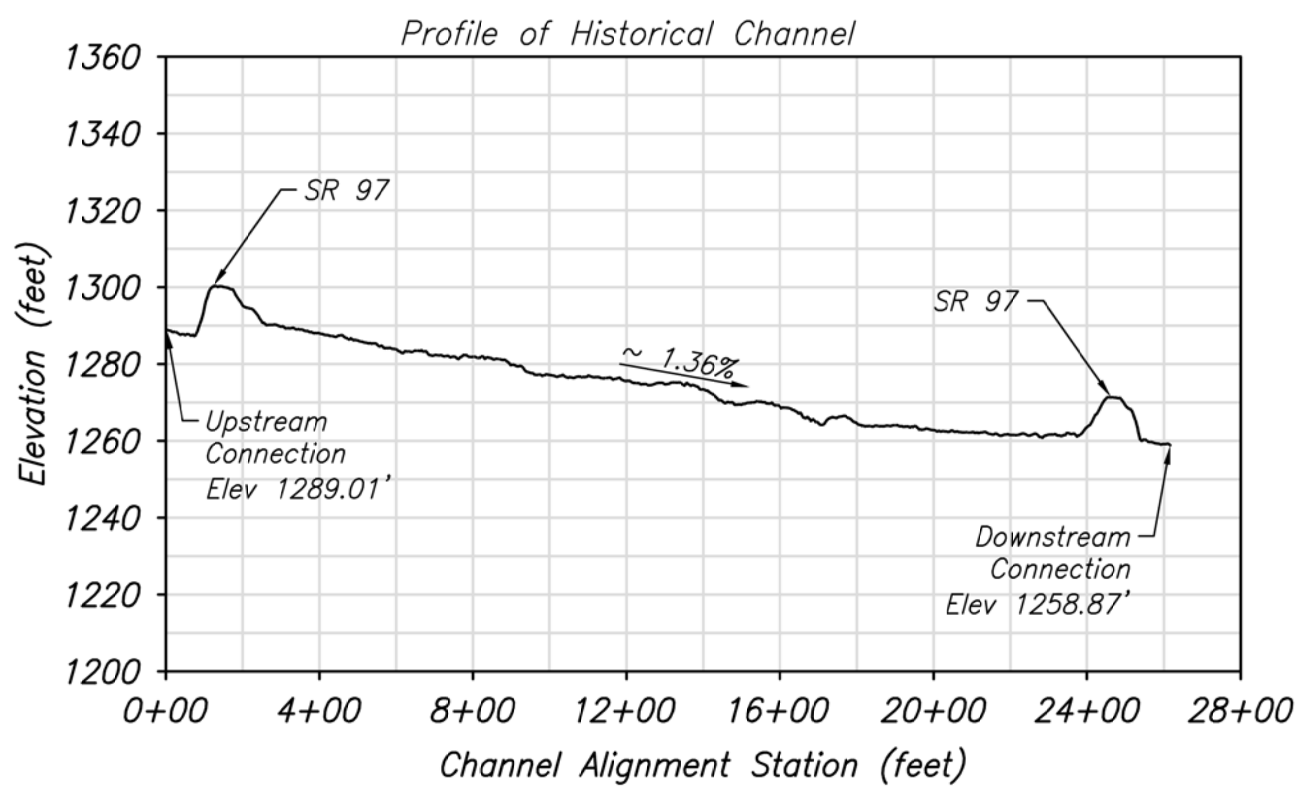
Appendix A

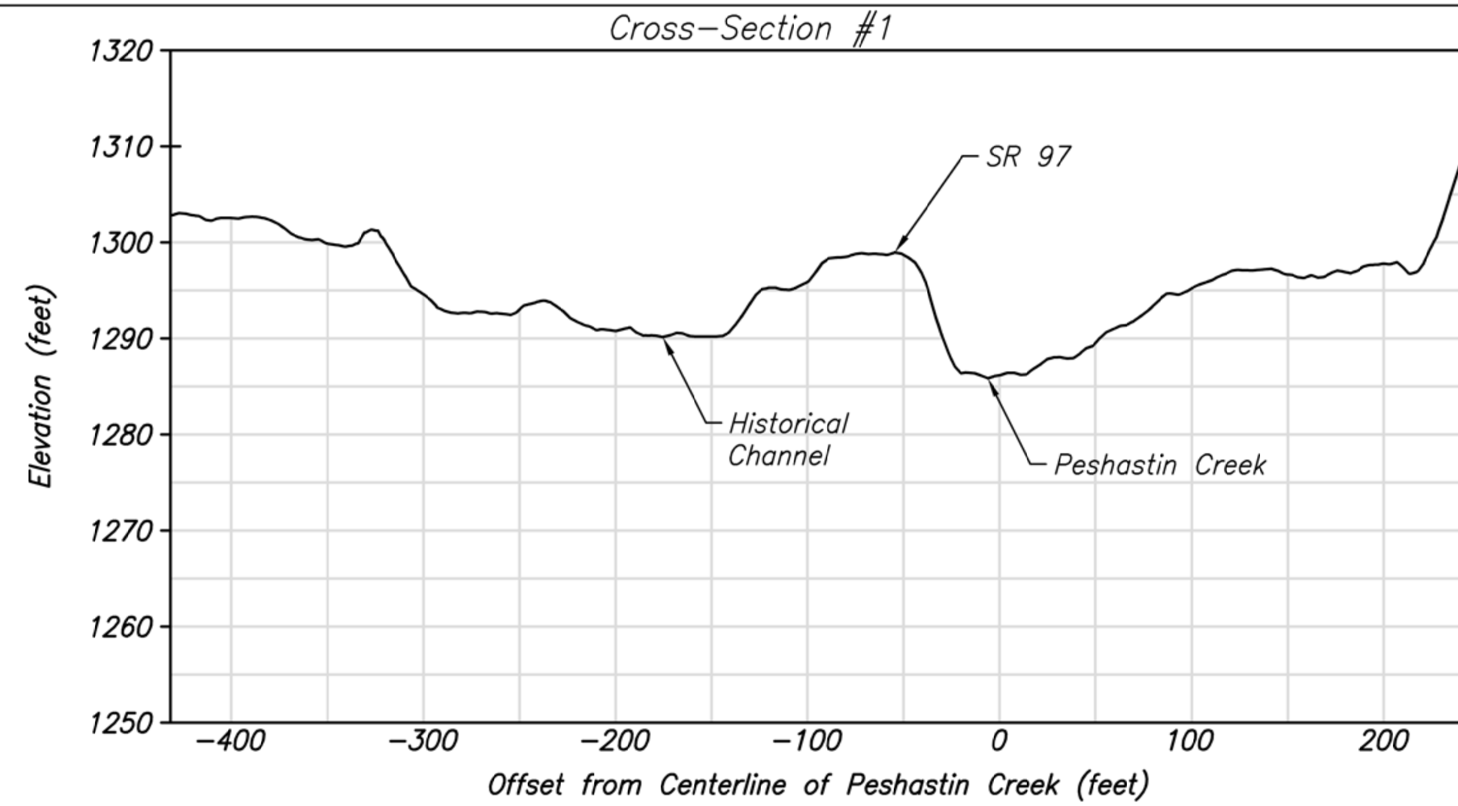
Existing Conditions

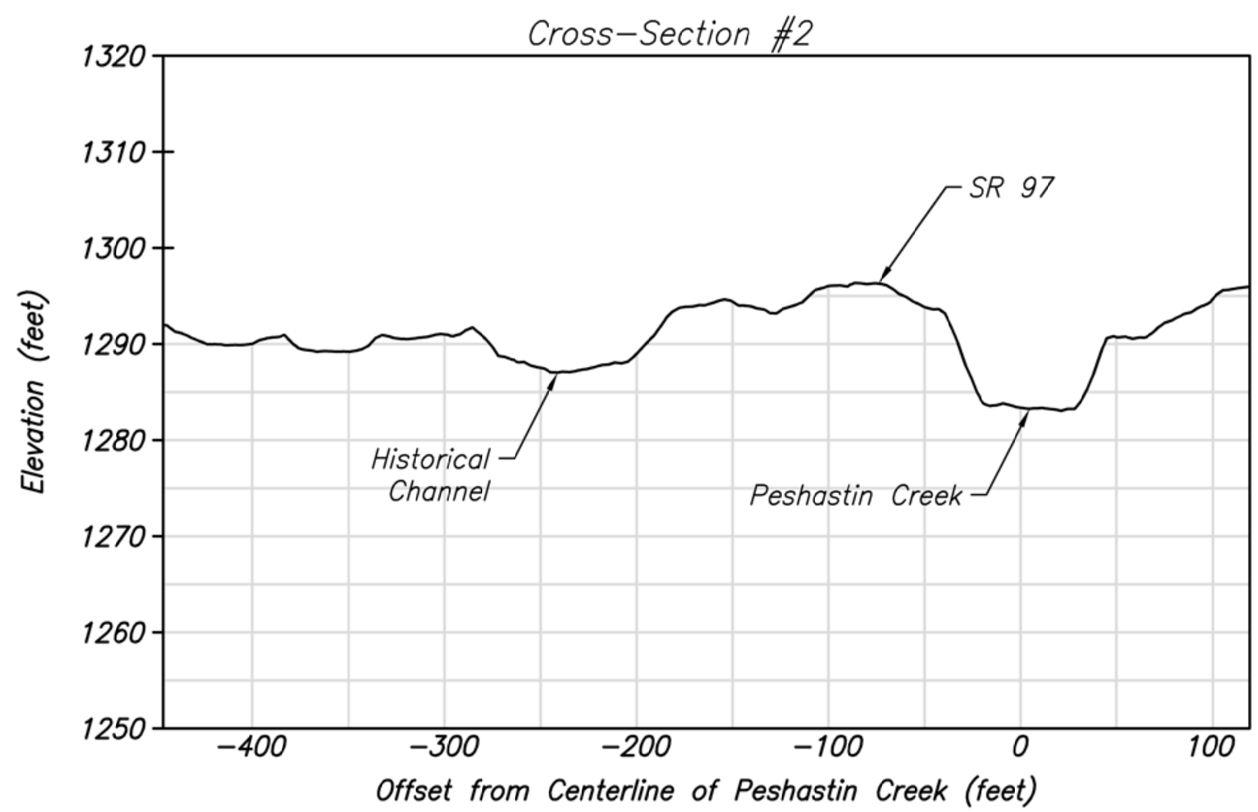
Peshastin Creek River Mile 3.8L
Channel Reconnection Project
Existing Conditions





Peshastin Creek River Mile 3.8L
Channel Reconnection Project
Existing Peshastin Creek and Historical Channel Profiles





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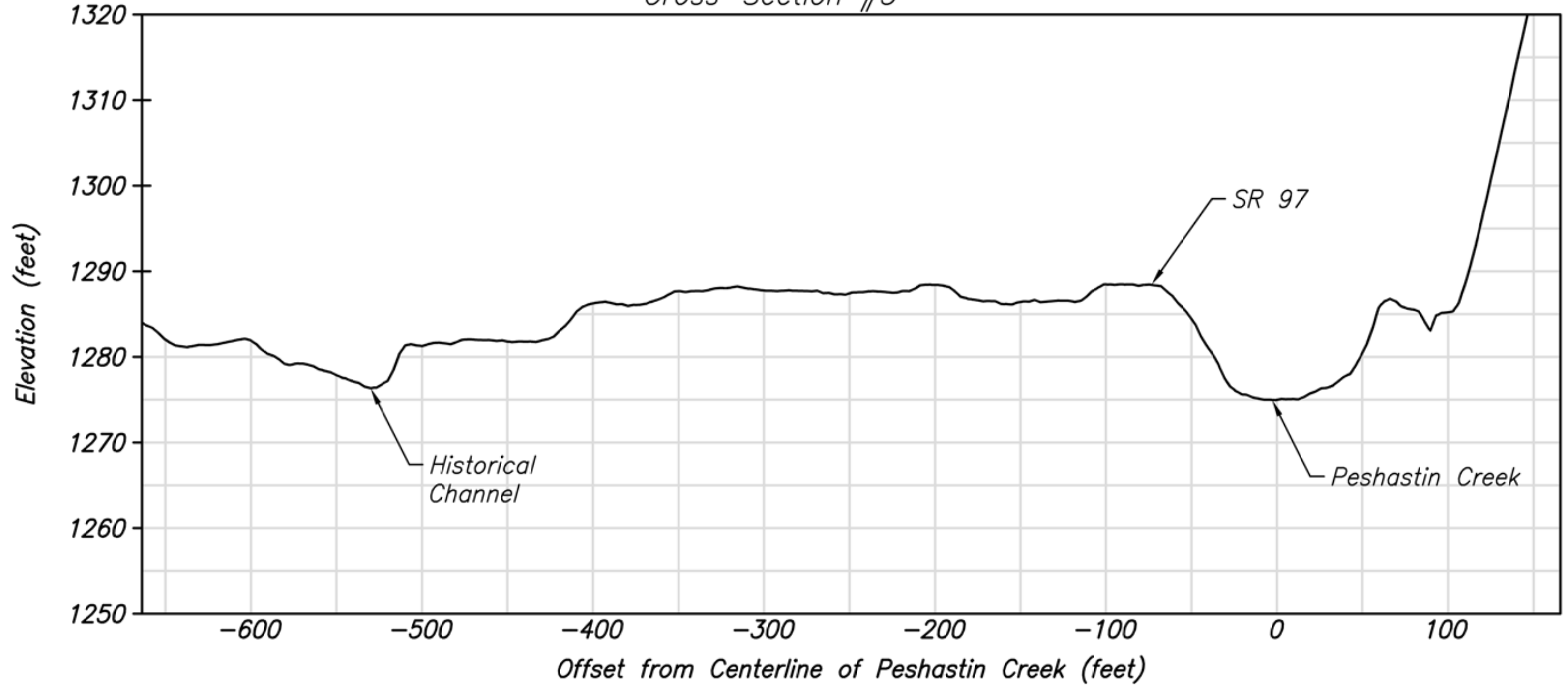
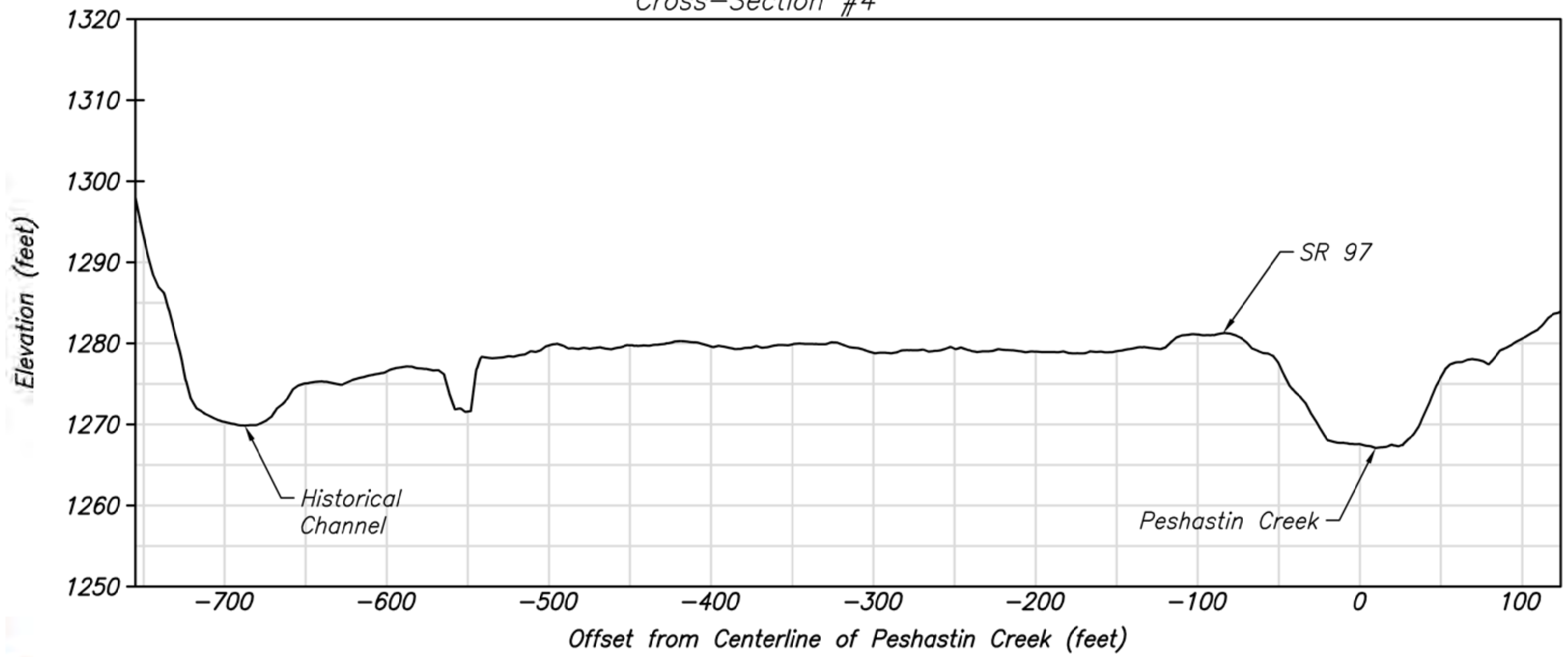
Peshastin Creek River Mile 3.8L
Channel Reconnection Project
Existing Peshastin Creek and Historical Channel Cross-Sections

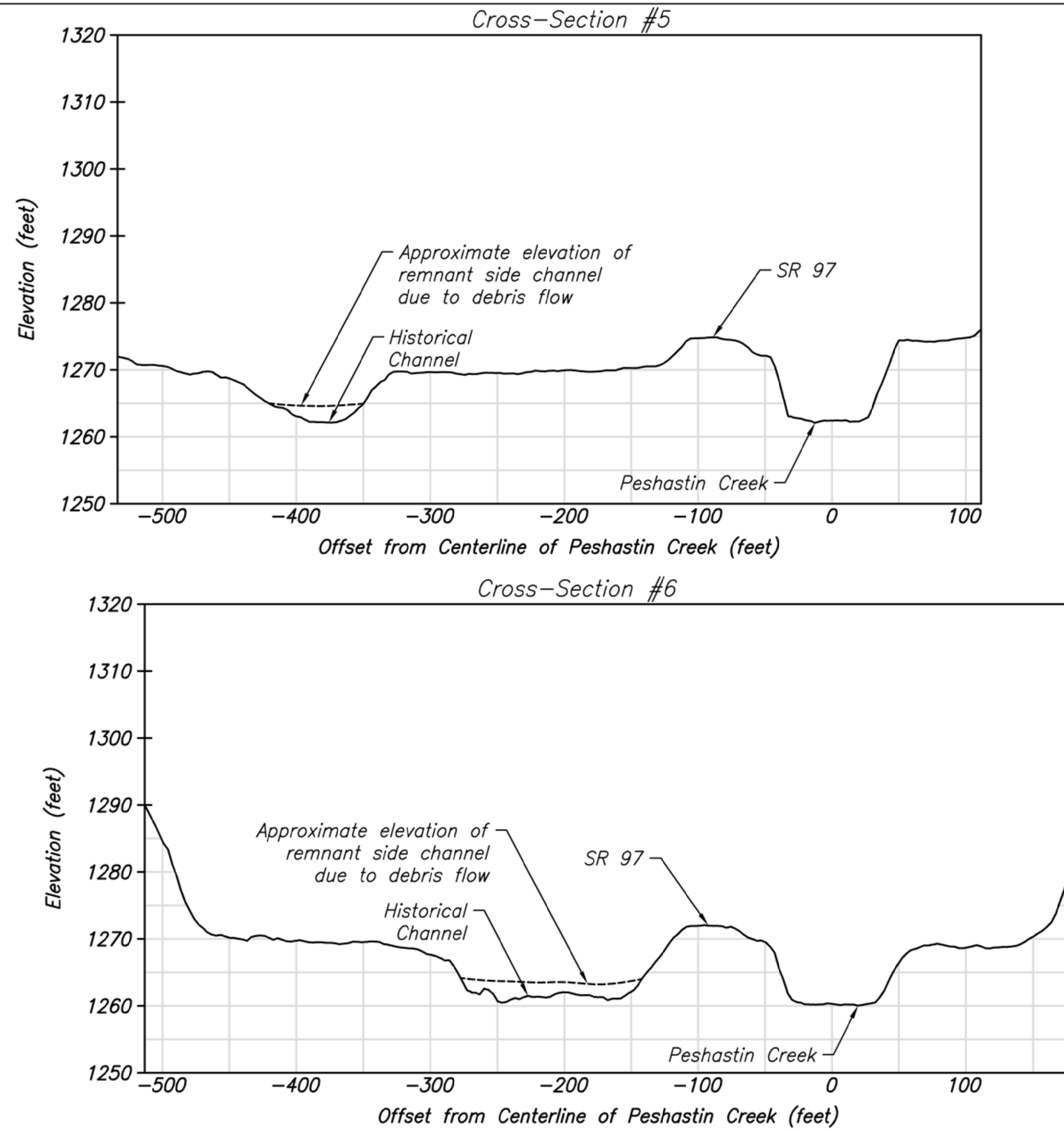
Cross–Section #3



Cross–Section #4



Peshastin Creek River Mile 3.8L
Channel Reconnection Project
Existing Peshastin Creek and Historical Channel Cross–Sections



Note: Topography for this analysis was based on LiDAR data collected in 2006.

These data do not represent recent changes to the topography, namely the debris flow that occurred in 2011 near cross–sections 5 and 6. The effect of that event on the topography near these sections was estimated and has not been verified.

Peshastin Creek River Mile 3.8L
Channel Reconnection Project
Existing Peshastin Creek and Historical Channel Cross–Sections

Appendix B

Hydrology Memorandum

Memorandum

Date:	August 27, 2012
To:	Mike Kane Chelan County Natural Resource Department
Cc:	Martin Fisher John Soden
From:	Nic Truscott
Subject:	**Peshastin Creek – River Mile 3.8 - Hydrology Analysis**

Introduction

In 2011, the Chelan County Natural Resource Department (CCNRD) initiated the analysis of restoration alternatives associated with the River Mile 3.8 project site located between river mile (RM) 3.5 and RM 4.0 on Peshastin Creek, Washington.

As part of the alternatives analysis for reconnection alternatives, a hydrologic analysis of the site was conducted. The analysis drew largely from existing data to characterize the hydrologic conditions of Peshastin Creek at the project site. This memo summarizes the methods and findings of the hydrologic analysis.

Location

The upstream portion of the channel reconnection project is located in Township 23 North, Range 18 East, Section 5, Chelan County, Washington (Figure 1). On Peshastin Creek, the site is located within Reach 2 as identified in the TRA (Interfluve 2010). Peshastin Creek is located on the east slope of the Cascade Mountains in Central Washington, within the Wenatchee River Basin (WRIA 45). It flows from north from its source near Blewett Pass towards State Highway 2. Peshastin Creek is a tributary to the Wenatchee River and flows into the Wenatchee River at river mile 18 between the towns of Dryden and Peshastin.

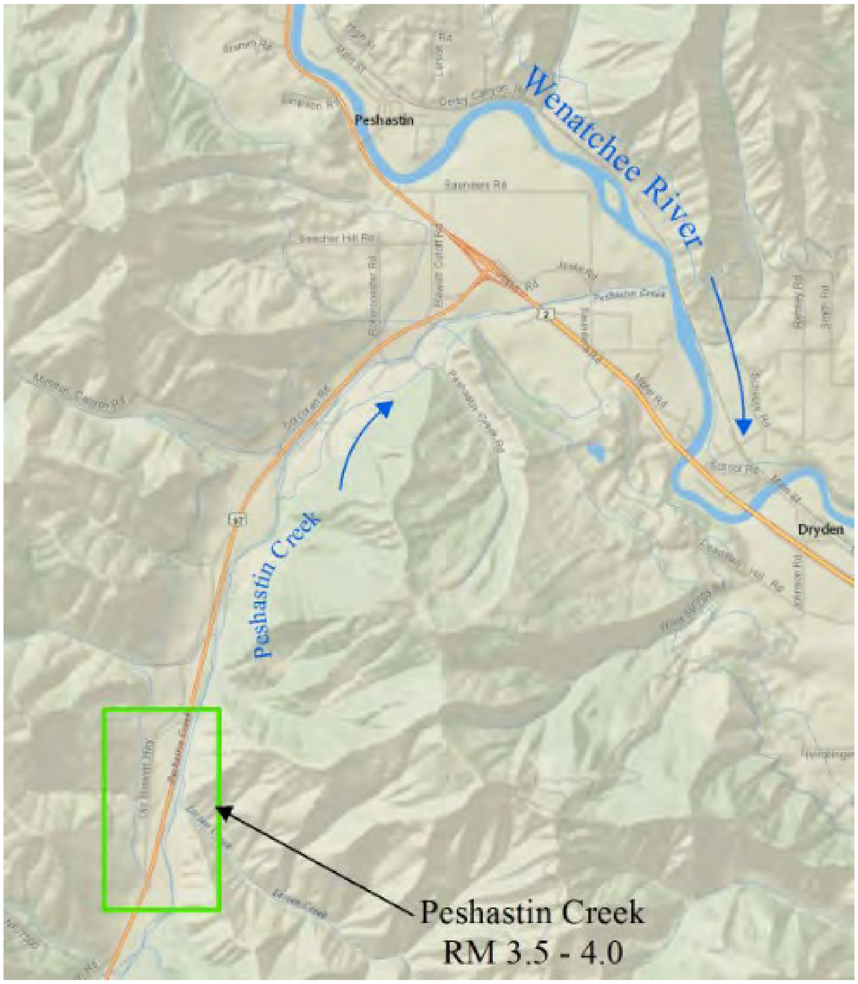


Figure 1. Vicinity of RM 3.8 Channel Reconnection Project Site on Peshastin Creek

Analysis

The Department of Ecology (DOE) operates and maintains a streamflow gage on Peshastin Creek at Green Bridge Road (Station ID 45F070) at approximately River Mile 2.5. The gage has been in operation since September, 2002. No other streamflow gage data are available for Peshastin Creek; WDOE manually operated two additional stations, above and below Ingalls Creek (Station ID's 45F110 and 45F100). Rating curves were established for these sites, but continuous streamflow data are not available for either site.

Peak Flow Characterization

Two methods were employed to characterize the nature of peak flows at the project site. Streamflow gage records from the DOE gage were used to conduct a log-Pearson type III analysis and USGS regional regression equations were used to approximate peak flows at the site.

To conduct the log-Pearson type III analysis, instantaneous peak flows for water years 2003 – 2011 were compiled and analyzed according to the methods described in USGS Bulletin 17B. Peak flows at 2, 5, 10, 25, 50, 100, and 200 year return intervals were calculated for the location of the streamflow gage and then scaled based on drainage area to represent peak flows at the project site. The peak flows were scaled using equation 1 below (from USGS):

$$1) \quad Q_u = Q_g \left(\frac{A_u}{A_g}\right)^x$$

where,
Q_u = Q at ungaged site (RM 3.8 site)
Q_g = Q at gaged site (Green Bridge Road)
A_u = Drainage area of ungaged site
A_g = Drainage area of gaged site
x = regional constant (0.97 for RM 3.8 site)

USGS streamstats was used to determine the drainage area at Green Bridge Road, and the upstream end of the project site; they were determined to be 134 and 124.8 square miles, respectively.

The USGS developed regional equations for estimating peak flows at ungaged locations; these equations were developed from comparing peak flows at streamflow gaging locations within specific regions and performing a regression analysis using various basin characteristics such as contributing area and mean annual precipitation. The regression equations provide an approximation of peak flows for ungaged locations; the error associated with the equations is large and they should be used with caution. Peak flows calculated using the methods in USGS Bulletin 17B and the USGS regional equations are summarized in Table 1.

Table 1. Summary of Estimated Peak Flows at RM 3.8 Site

Return Period	*USGS Bulletin 17B*		*USGS Regional Equations*		
	Estimated Q (cfs)	95% Confidence Interval	Estimated Q (cfs)	Standard Error of Prediction (%)	Range of Q (cfs)
2	1,618	1,222 – 2,118	886	82	159 – 1,613
5	2,426	1,856 – 3,714	-	-	-
10	2,963	2,262 – 5,150	1,686	84	270 – 3,103
25	3,634	2,753 – 7,386	2,086	87	271 – 3,900
50	4,128	3,111 – 9,364	2,420	90	242 – 4,599
100	4,614	3,464 – 11,625	2,765	92	221 – 5,309
200	5,096	3,818 – 14,189	-	-	-

The methods outlined in USGS Bulletin 17B are widely accepted as an approach to characterize peak flows; the flows calculated using this method and subsequently scaled for the RM 3.8 site are higher than the peak flows estimated by USGS regional equations, but within the range of possible values when considering the standard error associated with the regression equations. Any prediction of peak discharge has associated uncertainty, even with lengthy, accurate gauge records. This uncertainty is even more prevalent when the period of record is short or when peak discharge values with a return interval longer than the period of record are estimated. In the case of this analysis, the period of record is less than 10 years, and many of the peak discharges of interest have return periods greater than 10 years. The 95% confidence levels for peak discharge values calculated using procedures in USGS Bulletin 17B cover a wide range of values, especially for events with long return intervals. Given the short period of record, and large range of values within the confidence intervals it is apparent that care should be taken when interpreting the values in Table 1. The estimated discharges at the RM 3.8 site using USGS 17B are considered reasonable for events with return intervals of 25 years or less; the certainty associated with predicted discharge values beyond 25 years declines rapidly.

Mean Daily Discharge Characterization

To characterize typical mean daily discharge at the site, existing data from the gage at Green Bridge Road were used to develop a hydrograph of mean daily discharge at the gaged site. Instantaneous streamflow values at the gaged site were used to calculate mean daily discharge values for every day during the period of record; these values were subsequently averaged across every year of record to represent the typical discharge at the gaged site for a particular day. These values were then scaled based on drainage area using equation 1 to represent discharge at the RM 3.8 site. The calculated annual hydrograph for the RM 3.8 site is shown in Figure 2; fish use data were overlaid to aid in the analysis of alternatives (Cooper and Mallas 2004, Hays and Peven 1991 and 1992).

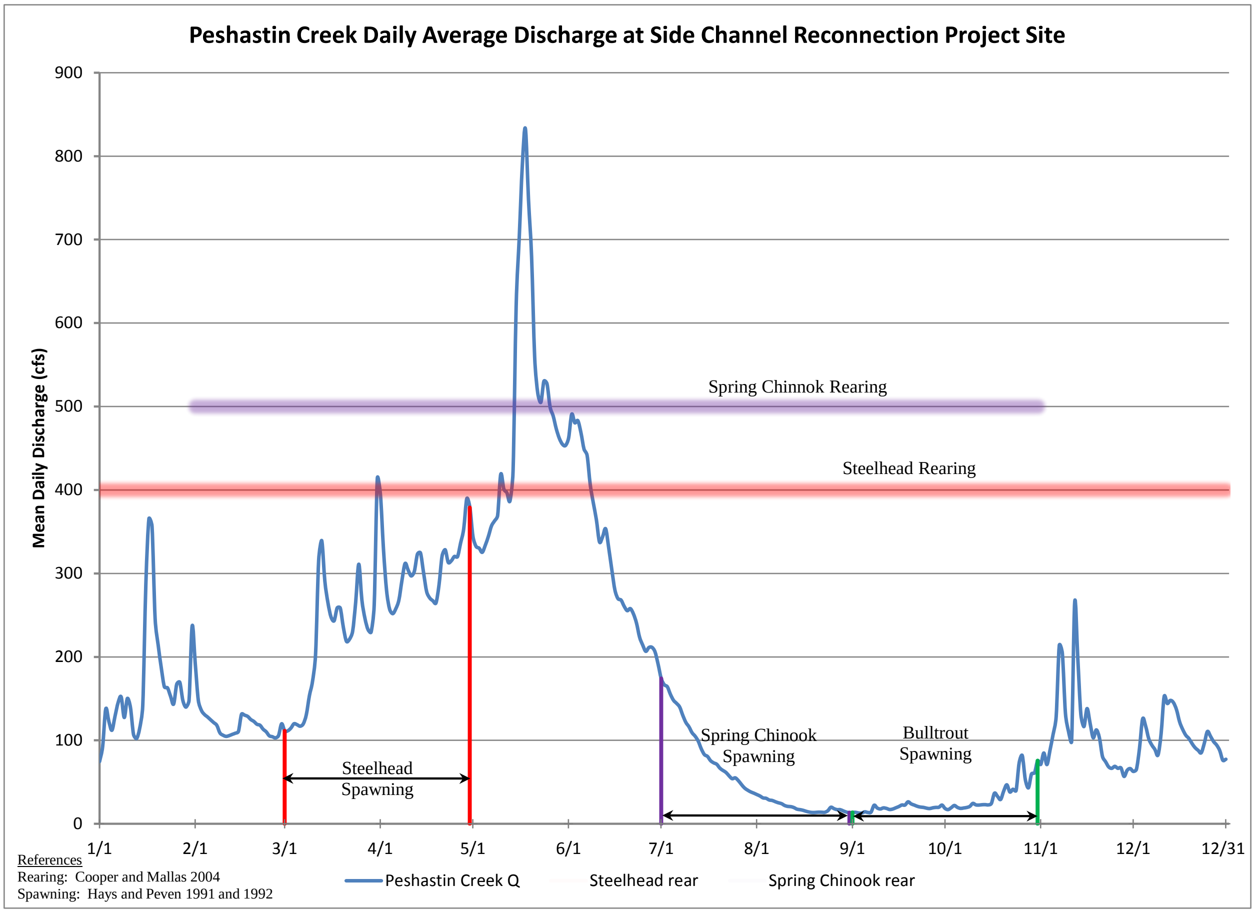


Figure 2. Simulated Hydrograph for Peshastin Creek at RM 3.8 Site

Fifty percent exceedence flows for the Green Bridge site and project site were also calculated using the DOE stream gage data. First, mean daily discharge values at the Green Bridge site were calculated in the same manner as before. Next, the 50% exceedence flow for each day of the year was calculate and scaled based on drainage area using equation 1 to represent the 50% exceedence streamflow (median daily streamflow) at the RM 3.8 site (Figure 3). As Figure 3 shows, due to its proximity to the Green Bridge gauge, median daily flow at the channel reconnection project site is very similar in magnitude to flows recorded at the Green Bridge gauge site.

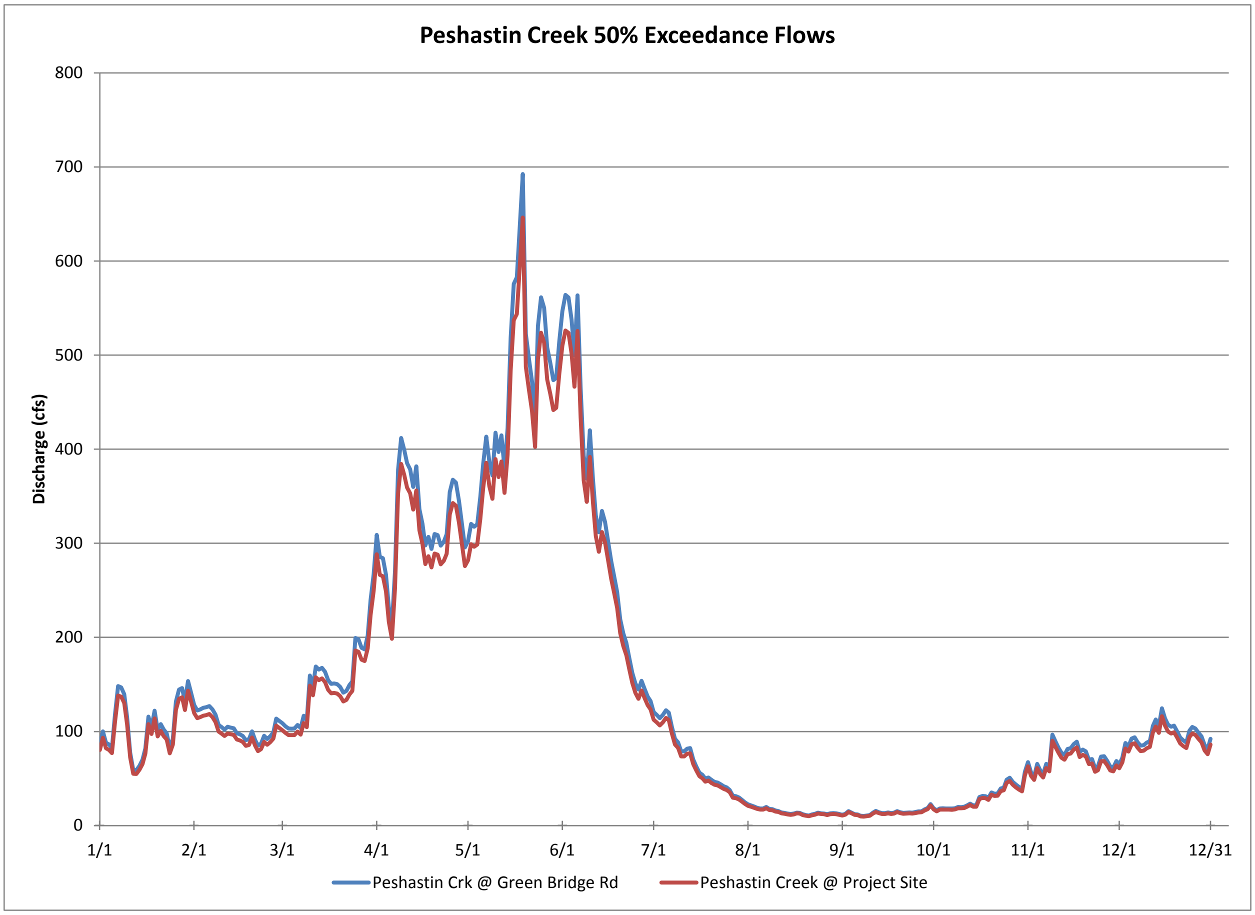


Figure 3. Calculated 50% Exceedance Flows for Peshastin Creek

Conclusion

This memo summarized a hydrologic investigation of the channel reconnection site on Peshastin Creek near RM 3.4. Analyses performed relied on stream gage data provided by the DOE and USGS regional regression analysis. The period of record for the stream gage used is only 9 years and may not encompass the full range of flows likely to occur in Peshastin Creek. An assumption was made that the data available from the DOE on the public website are accurate. The conclusions drawn in this memo should be regarded as approximations using the best available data and should be updated when more data are available. If design of project elements requires the ability to withstand high flow events, a factor of safety should be added at the discretion of the engineer. For other design elements, the conclusions in this memo should serve as ballpark figures and should be replaced with actual measured data if possible (e.g.; collect water surface elevation and/or flow data in the historical channel for partial reconnection alternatives analyses, etc.).

Appendix C

Fish Use Memorandum

Memorandum

Date:	April 25, 2012
To:	Mike Kane, Chelan County Natural Resource Department
Cc:	
From:	Joy Juelson and John Soden
Subject:	**ESA Listed Fish Use in Peshastin Creek—Wenatchee Subbasin, Upper Columbia Region**

Introduction

This objective of this memo is to discuss Endangered Species Act (ESA)-listed species use in the Peshastin Creek and tributaries.

Peshastin Creek is located on the east slope of the Cascade Mountains in Central Washington and is a tributary to the Wenatchee River at river mile (RM) 18. The Peshastin Creek watershed encompasses 78,780 acres. Primary discharge to Peshastin Creek comes from Ingalls Creek and Ettienne Creek (formerly Negro Creek). The watershed is divided in ownership with 82% managed by the U.S. Forest Service (USFS) and 18% privately held (Cappellini 1997).

The Peshastin Creek is utilized by a number of resident and anadromous fish species including: spring Chinook, coho, steelhead trout, rainbow trout, bull trout, west slope cutthroat trout, brook trout, sculpin, sucker, speckled dace, long nose dace, and crappie (Andonaegui 2001 and NPPC 2004). Three of these species are currently listed under ESA and include spring Chinook (*Oncorhynchus tshawytscha*), summer steelhead (*Oncorhynchus mykiss*), and bull trout (*Salvelinus confluentus*). Peshastin Creek is a Category 2 watershed. It contains a major spawning area for steelhead and a minor spawning area for spring Chinook and is a bull trout core area (UCRTT 2008).

Lower and Upper Peshastin Creek is used for juvenile rearing of steelhead, bull trout, and spring Chinook (Table 1). Lower Peshastin Creek is a migration corridor for both steelhead and bull trout that spawn in the upper reaches and tributaries of Peshastin Creek. There is limited spawning in the lower Peshastin Creek by spring Chinook and steelhead.

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Table 1. Peshastin Creek Major Tributaries and ESA Listed Fish Use

		Steelhead/Rainbow			Spring Chinook			Bull Trout		
Peshastin Watershed Tributary	**River Mile Confluence with Peshastin Creek**	**Spawning**	**Rearing**	**Migration**	**Spawning**	**Rearing**	**Migration**	**Spawning**	**Rearing**	**Migration**
Peshastin	0.0–16.6	X	X	X	X	X	X		X	X
Mill	5.2	X @ Mouth	X							X*
Camas	6.2	X	X	X						X*
Ingalls	9.4	X	X	X		X		X	X	X
Ruby	10.5	X	X	X		X				X*
Ettienne	11.1	X	X	X				X	X	X
Tronsen	14.9	X	X							X*
Shaser	15.5		X	X					*	X*
Scotty	16.6		X	X					*	X*

x* Adapted from Andonaegui 2001.

* Because bull trout reside year-round, adults or subadults may move into these creeks during foraging movements depending on time of year and temperature (Neibauer pers. comm.).

A reach based assessment was recently completed by the Yakama Nations (YN) from the Wenatchee and Peshastin confluence to RM 9.3; this reach is termed the “lower Peshastin”. The assessment indicated that the lower 8.4 miles of Peshastin Creek are at an “at risk” or “unacceptable risk” condition for several parameters important to the spawning and rearing life stages of salmonids (Interfluve 2010). An assessment has not been completed on the “upper Peshastin” reach. The Upper Columbia Regional Technical Team (UCRTT) identified limiting factors (UCRTT 2008) affecting fish in Peshastin Creek. Table 2 shows the crosswalk between those UCRTT limiting factors and the newly adopted National Marine Fisheries Service (NMFS) ecological concerns.

Table 2. Crosswalk between UCRTT Limiting Factors and NMFS Ecological Concerns

Peshastin Creek – UCRTT (2008) Identified Limiting Factors	NMFS Ecological Concerns	NMFS Ecological Concerns Subcategory
Instream flows (lower Peshastin Creek)	Water Quantity	Decreased Water Quantity Altered Flow Timing
Channel migration	Channel Structure and Form	Instream Structural Complexity
Floodplain function	Peripheral and Transitional Habitats	Floodplain Condition
Stream sinuosity	Channel Structure and Form	Bed and Channel Form
Gravel recruitment	Sediment Conditions	Decreased Sediment Quantity
Riparian habitat	Riparian Condition	Riparian Vegetation
Fish Passage	Habitat Quantity	Anthropogenic Barriers

These limiting factors are primarily caused by State Highway 97, development, and irrigation water diversions below RM 4.8 that dewater the lower reach. These limiting factors contribute to the reduction of the quantity and quality of spawning and rearing habitat, impede upstream migration, reduce high quality pools and quantities of large woody debris and elevate water temperatures (Andonaegui 2001 and NPPC 2004). Peshastin Creek is characterized as a high gradient, boulder cobble stream that is potentially more suited for steelhead than Chinook. However, the stair stepping nature of Peshastin Creek creates numerous small pools in the upper reaches and tributaries such as Ingalls Creek. These microhabitats are thought to have the potential to provide excellent habitat for the rearing of small salmonids (Mullan et al. 1992).

Steelhead

Current abundance and distribution of steelhead have been reduced in Peshastin Creek compared to historical conditions (Andonaegui 2001). Peshastin Creek has been identified as a Major Spawning Area for summer steelhead (UCRTT 2008). Summer steelhead currently uses the mainstem Peshastin Creek for spawning and rearing and as a migration corridor to access the upper basin spawning grounds (Figure 1). Steelhead and rainbow trout have been planted in the basin by WDFW as recently as 1990 (Andonaegui 2001) and the last hatchery release was in 1998 (WDFW 2009). After spending 1 or 2 years in the ocean, steelhead can migrate to their spawning grounds as early as 9 months prior to spawning. They can enter the Wenatchee River system from May to October to begin spawning in March.

During smolt monitoring conducted in 2004 using a screw trap at RM 6.3, 4,302 steelhead/rainbow trout comprised 48% of the catch. The expanded population estimate was 16,082 steelhead/rainbow trout (Cooper and Mallas 2004).

In 2009, the U.S. Forest Service performed status and trend fish surveys within the Peshastin Creek as a component of the Integrated Status and Effectiveness Monitoring Program (ISEMP). Fish abundance and distribution was evaluated using snorkeling and electrofishing surveys, and 2827 steelhead were identified near the mouth of Peshastin Creek (Dawson and Call 2010).

Spawning surveys conducted by WDFW have been completed annually from 2004 to 2010 in the same areas using the same methods throughout many tributaries the Wenatchee basin including Peshastin Creek (Table 3). Peshastin Creek had 12.2% of all the redds located in the Wenatchee subbasin in 2010 (Hillman et al. 2011). Figure 2 shows the spawning distribution in the Peshastin subbasin from 2009 to 2011. The majority of the spawning is distributed in the lower Peshastin between RM 3 to 6.5. In the upper Peshastin steelhead show a patterns of concentrated spawning between Ingalls and Tronsen Creek with dispersed spawning to just past RM 14.9 at Tronsen Creek; steelhead also spawn in Tronsen Creek.

Table 3. Peshastin Creek Basin Steelhead Spawning Survey Counts (2003–2010)

Peshastin Watershed Tributary	RM Confluence with Peshastin Creek	2003	2004	2005	2006	2007	2008	2009	2010
Peshastin Creek	0–16.6	15	32	91	67	17	48	32	115
Mill Creek	5.2	--	--	1	0	0	1	0	0
Ingalls Creek	9.4	0	0	0	0	--	--	--	0
Ruby Creek	10.5	0	0	0	--	--	--	0	--
Tronsen Creek	14.9	0	2	5	0	0	0	0	3
Scotty, Shaser and Schafer Creeks	15.5–16.6	0	0	0	0	0	0	0	0
Total		**15**	**34**	**97**	**67**	**17**	**49**	**32**	**118**

Source: Tonseth 2010

Spring Chinook

Spring Chinook were historically distributed throughout Peshastin Creek and its tributaries (Andonaegui 2001). It is believed spring Chinook were extirpated from this watershed due to past irrigation diversions that formally blocked passage in the lower 5 RMs of Peshastin Creek during low water periods when spring Chinook were migrating (USFS 1999).

Peshastin Creek has been identified as a Minor Spawning Area for spring Chinook (UCRTT 2008). Figure 3 illustrates the current presence and distribution of spring Chinook in Peshastin Creek. From 2001 to 2004, spring Chinook were reintroduced to Peshastin Creek using out-of-basin non-ESA-listed stock taken from the Leavenworth National Fish Hatchery in a joint effort by USFWS and YN (Cooper and Mallas 2004). Table 4 shows an increase in spring Chinook spawning during that timeframe. Smolt monitoring was conducted in 2004 by the USFWS, Mid-Columbia River Fisheries Resource Office (MCRFRO) using a screw trap at RM 6.3, near the Camas Creek confluence. In 2004, 4,310 spring Chinook juveniles were captured which comprised 48.2% of the catch with most of the remainder being steelhead/rainbow trout. A total of 66,395 subyearling spring Chinook were estimated in Peshastin Creek at that time (Cooper and Mallas 2004). The majority of the catch was newly emerged Chinook fry most likely displaced by spring discharge events, possibly indicating forced rather than volitional migration (Cooper and Mallas 2004). During the 2004 trapping season there was relative lack of yearling Chinook or age-1+, and only one yearling Chinook was captured. It may be possible the absence of yearling Chinook indicates that Peshastin Creek does not provide adequate over wintering habitat (Cooper and Mallas 2004).

After spending 2 or 3 years in the ocean spring Chinook enter the Wenatchee River where they ultimately reach Peshastin Creek from May to August and then begin spawning in August through September. Spawning ground surveys from 1958 to 1989 found an average of five redds per year and surveys from 1990 to 1995 found ten Chinook redds total (Hays and Peven 1991, 1992; Peven 1992, 1994; Peven and Truscott 1995; Peven and Mosey 1996). Surveys by the Chelan County Public Utility District (CCPUD) and WDFW found no spring Chinook redds from 1997 to 2000 (Mosey & Murphy 2000). From 2000 to 2011, CCPUD has found limited spawning that primarily occurs in lower Peshastin Creek from river mile 4.8 (Mill Creek Bridge) to 7.3 (Allen Creek) (Table 2) while rearing typically occurs from RM 0 to RM 14.8 (Magnet Creek) (Andonaegui 2001). Figure 4 shows the spawning distribution in the Peshastin subbasin from 2009 to 2011.

In 2009, USFS performed status and trend fish surveys within the Peshastin Creek as a component of ISEMP. Fish abundance and distribution was evaluated using snorkeling and electrofishing surveys and 75 juvenile Chinook were identified near the mouth of Peshastin creek over three site visits (Dawson and Call 2010). It is unclear whether the juvenile Chinook were spring or summer run.

Table 4. Peshastin Creek Spring Chinook Spawning Data (2000–2011)

Peshastin Reach	RM	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Mouth to Highway Bridge	0.0-3.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	1
Highway Bridge to King Bridge	0.0-3.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	2
King Bridge to Washout/Mill Cr. Bridge	3.3-4.8	N/A	3	0	17	2	0	2	1	2	1	2	4
Washout/Mill Cr. Bridge to Allen Cr.	4.8-7.3	0	45	20		3	3	3	4	11	8	3	11
Allen Cr. Bridge To Ingalls Cr.	7.3-9.0-	0	18	8	9	15	0	0	0	0	0	0	2
Ingalls Cr. Mouth To Ruby Cr.	9.0-9.7		N/A	17	3		0	0	0	0	0	0	1
Total		**0**	**66**	**45**	**29**	**20**	**3**	**5**	**5**	**13**	**9**	**5**	**21**

*Data provided by Chelan County PUD

Bull Trout

Peshastin Creek was once host to a notable run of bull trout in the late summer (Andonaegui 2001). Currently, there is believed to be a small population of stream-resident bull trout in Ingalls Creek and Ettienne Creek (formerly Negro Creek) (Figure 5). Peshastin Creek has been identified as a Core Area for bull trout (UCRTT 2008). Of the three ESA-listed species, bull trout prefer the coldest water to spawn (typically 15 degrees Celsius or less). The mainstem Peshastin Creek mostly serves as a bull trout migration corridor to Ingalls and Ettienne Creek. These two tributaries are known to support bull trout spawning and rearing (USFWS 2002). Bull trout commonly migrate upstream to their spawning grounds from May to early September, and spawning occurs in mid-September and October (Kelly-Ringel and DeLaVergne 2005). Bull trout are also likely move into and take advantage of multiple creeks throughout the Peshastin Creek basin depending on the temperature and time of year. Bull trout use these habitats for holding and overwintering of adult bull trout and for seasonal rearing of juvenile bull trout (Neibauer pers. comm.).

Past surveys by various entities have found low numbers of bull trout in the Peshastin Creek basin. Bull trout were found in Ingalls Creek during surveys in 1994 and 1995, but none were found in Peshastin Creek surveys from RM 10.5 to RM 16.6. Surveys in 1997 between the mouth and Ingalls Creek found three bull trout, but only within the first 1.42 miles. No bull trout redds were found by USFS during surveys of Ingalls Creek in 2000 (Andonaegui 2001). One redd was found in 2001, five redds were found in 2002, and nine redds were found in 2003, but no spawning data have been collected since (Kelly-Ringel 2011).

Smolt monitoring in 2004 at RM 6.3 captured 112 bull trout. These bull trout were captured primarily in the spring and fall as they were presumably emigrating to the Wenatchee River (Cooper and Mallas 2004). In 2006, USFWS observed 40 juvenile/subadult bull trout in upper Ingall's Creek by USFWS when collecting fin clips for development of a genetics baseline (Neibauer pers. comm.). In 2006, 2007, and 2009, USFS performed status and trend fish surveys as a component of ISEMP within the Peshastin Creek, and Ettienne Creek. There is limited survey data from 2009 through 2011 in the Peshastin watershed.

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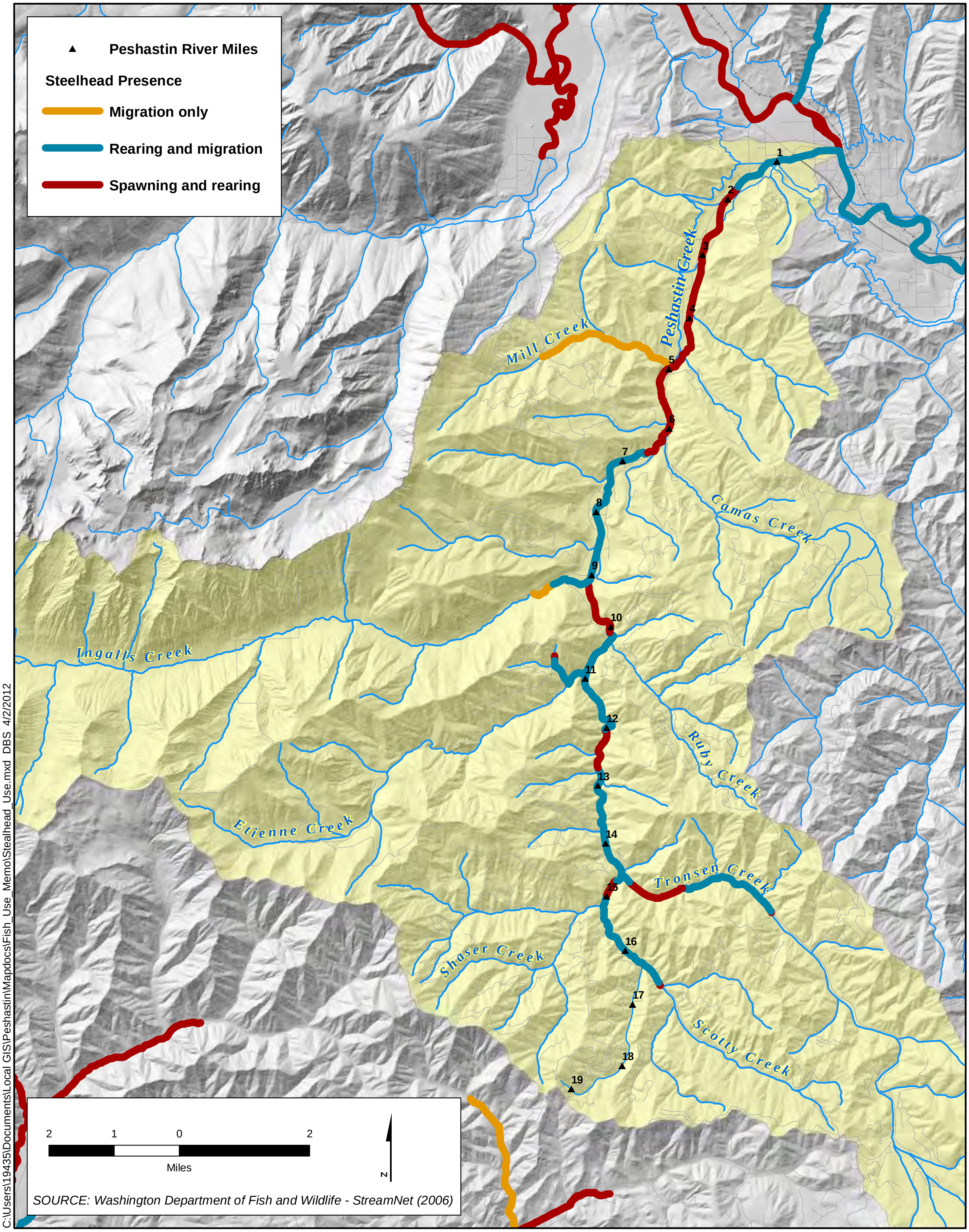
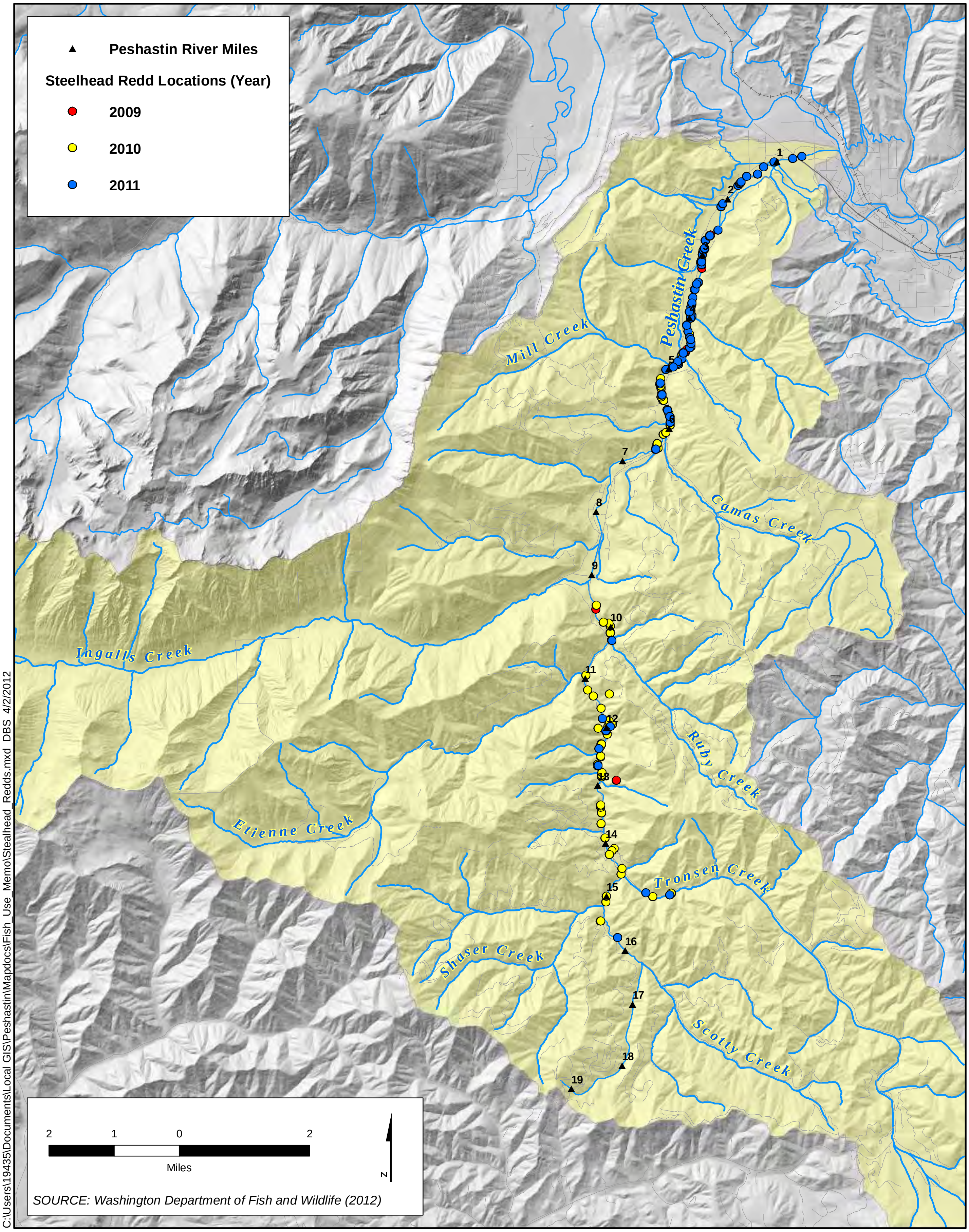


ICF INTERNATIONAL

Figure 1
Steelhead Presence in the Peshastin Basin
Peshastin Creek Fish Use



ICF INTERNATIONAL

Figure 2
Steelhead Spawning Distribution in the Peshastin Basin
Peshastin Creek Fish Use

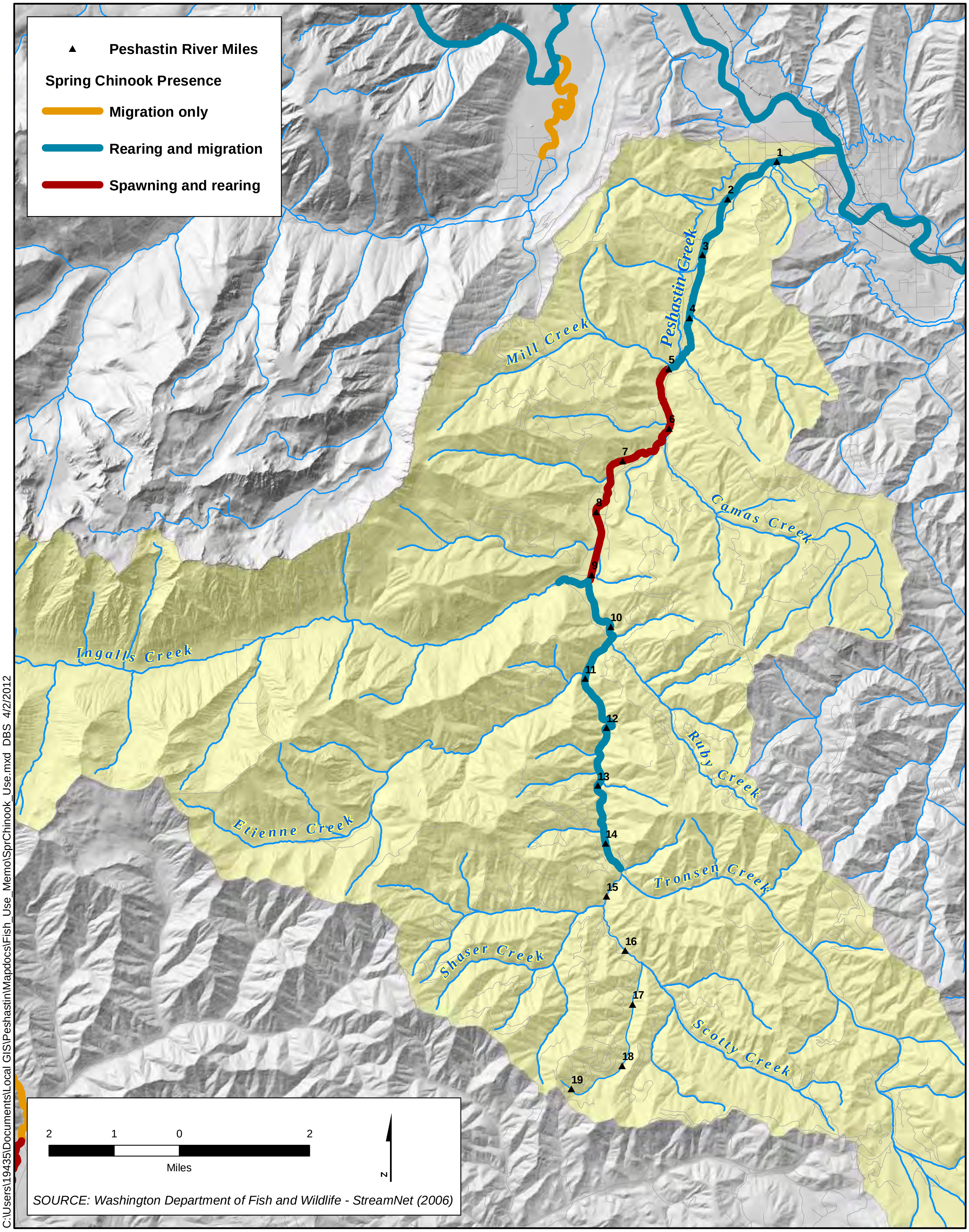


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Figure 3
Spring Chinook Presence in the Peshastin Basin
Peshastin Creek Fish Use

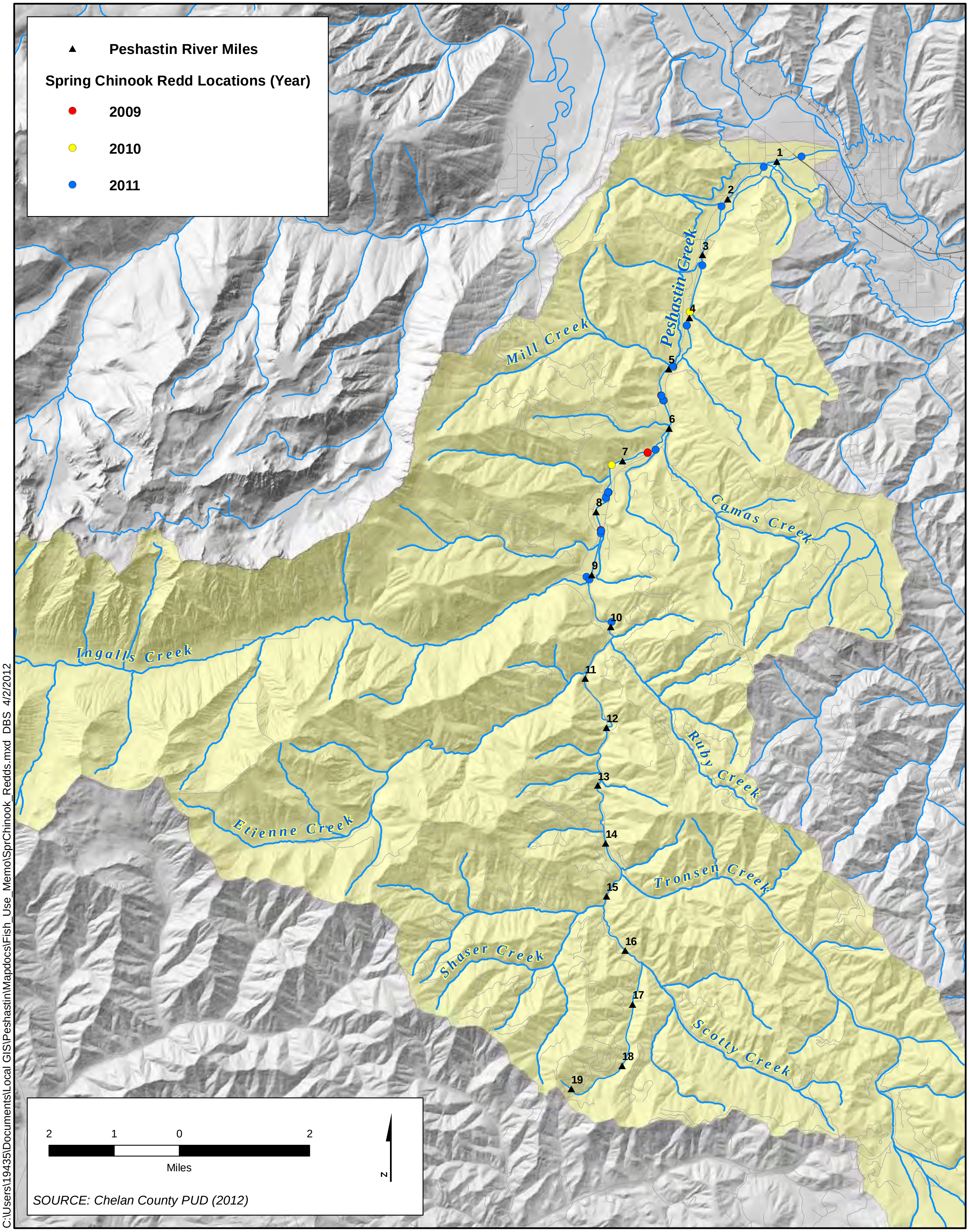

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Figure 4
Spring Chinook Spawning Distribution in the Peshastin Basin
Peshastin Creek Fish Use

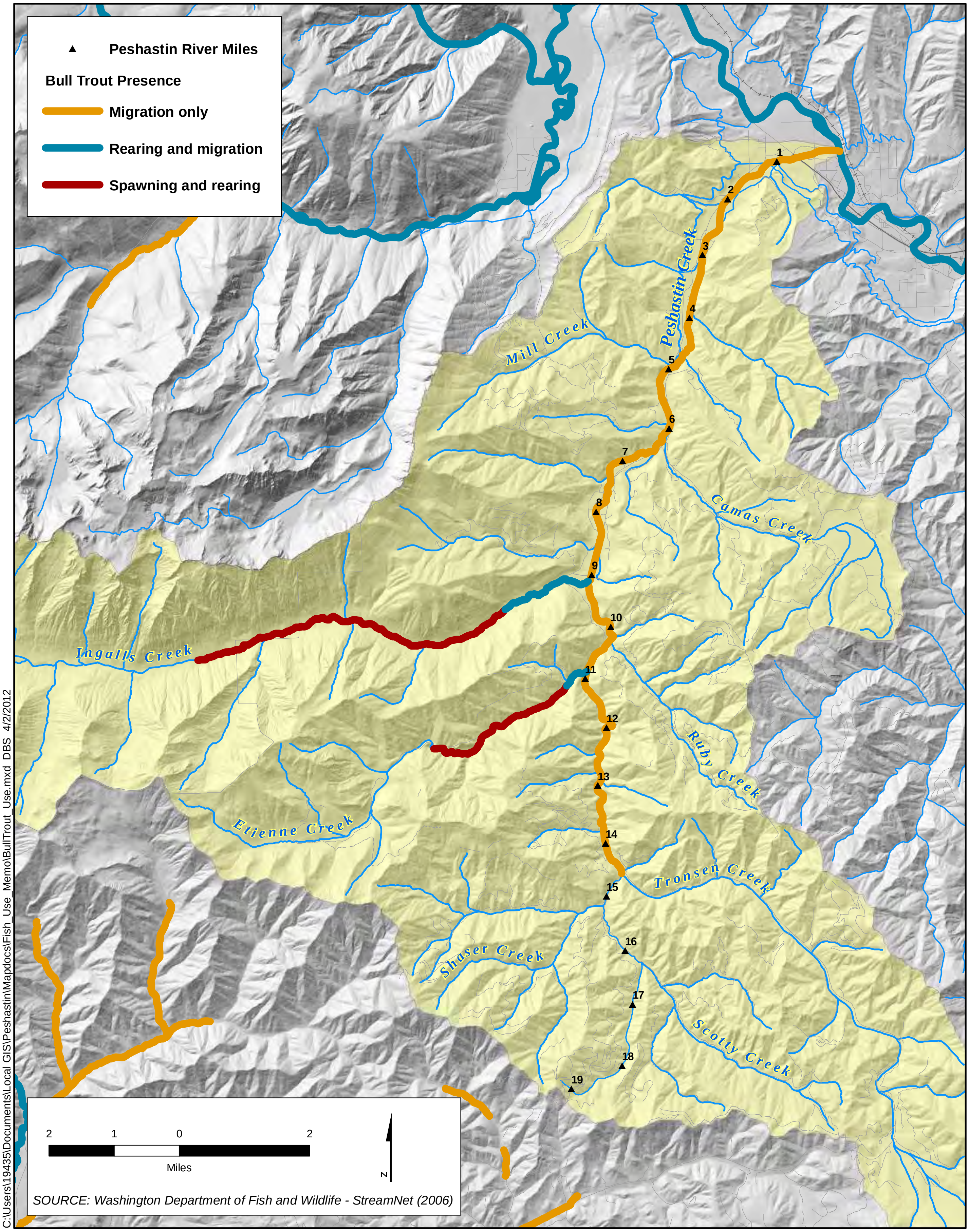

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Figure 5
Bull Trout Presence in the Peshastin Basin
Peshastin Creek Fish Use

Appendix D

RM 3.8 Channel Reconnection Alternatives

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SCALE OF FEET

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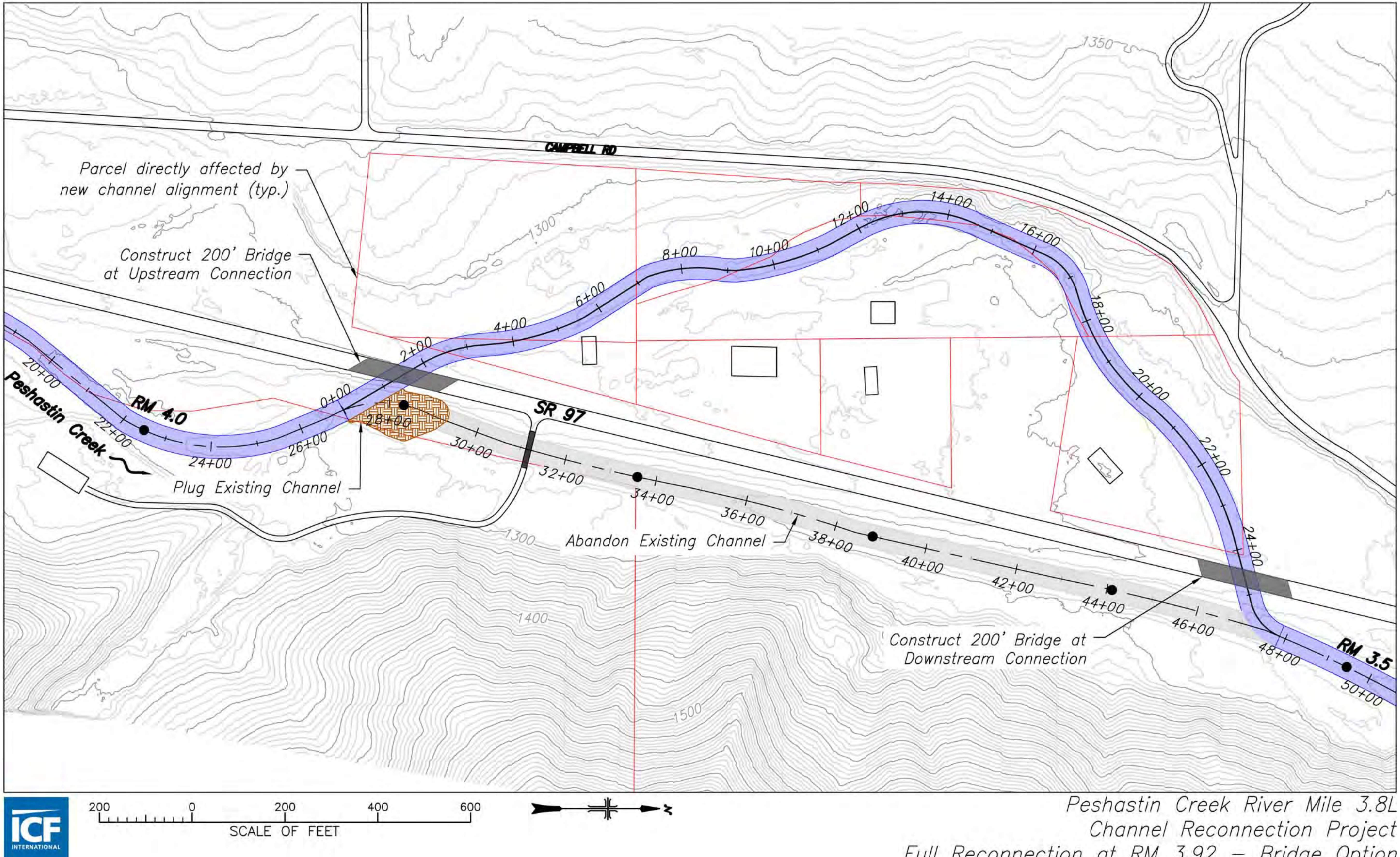
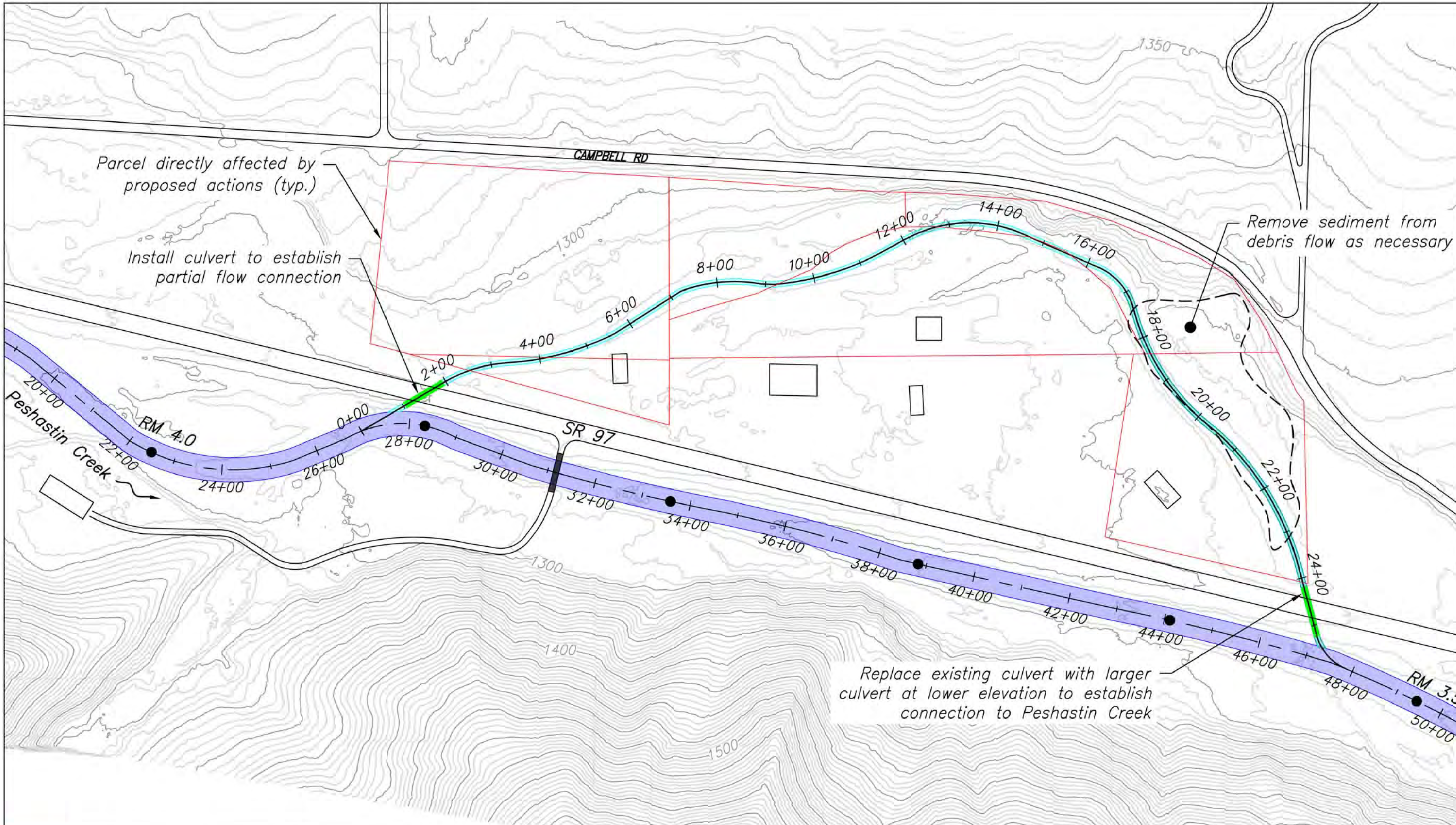
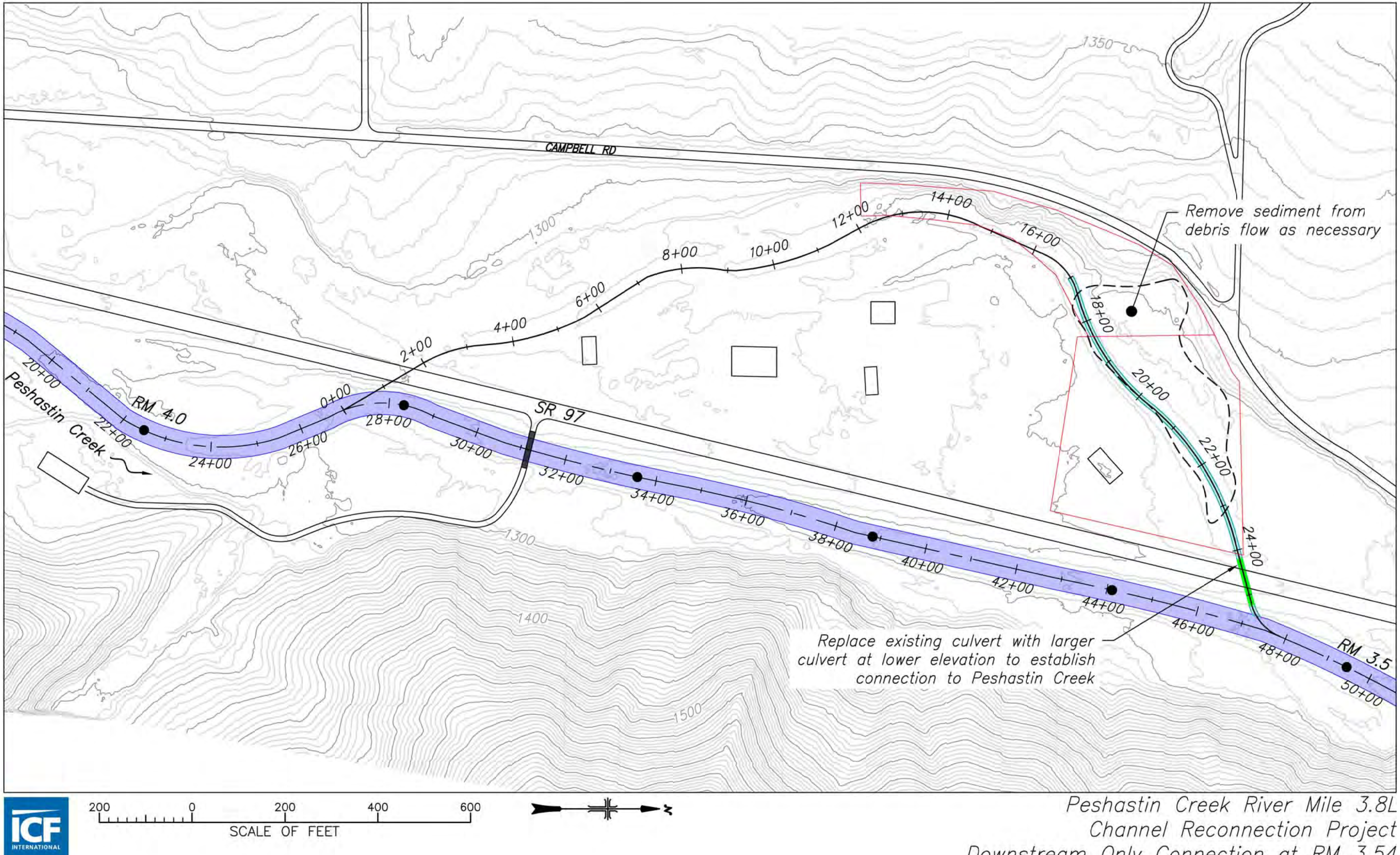
Peshastin Creek River Mile 3.8L
Channel Reconnection Project
Full Reconnection at RM 3.92 – Highway Relocation



Peshastin Creek River Mile 3.8L
Channel Reconnection Project
Full Reconnection at RM 3.92 – Bridge Option



Peshastin Creek River Mile 3.8L
Channel Reconnection Project
Partial Reconnection at RM 3.92



ICF INTERNATIONAL

Peshastin Creek River Mile 3.8L
Channel Reconnection Project
Downstream Only Connection at RM 3.54

Appendix E

Construction Cost Estimates

ICF - September 26, 2012

Peshastin Creek RM 3.8 Channel Reconnection Project

Alternative 1 - Full Reconnection, US 97 Realignment

Item	*Units*	*Quantity*	*Unit Cost*	*Item Cost*
Mobilization	LS	1	$ 305,940	$ 305,940
Surveying	LS	1	$ 40,000	$ 40,000
Traffic Management	LS	1	$ 125,000	$ 125,000
Dewatering	LS	1	$ 10,000	$ 10,000
Highway Realignment/Expansion of Campbell Rd	MI	1.07	$ 3,500,000	$ 3,745,000
Structure Demolition	LS	1	$ 75,000	$ 75,000
Provide Access to Affected Properties	LS	1	$ 350,000	$ 350,000
Channel Excavation	CY	10,000	$ 10	$ 100,000
Remove Existing SR 97 Embankment	CY	25,000	$ 10	$ 250,000
Plug/ELJ @ upstream connection	LS	1	$ 25,000	$ 25,000
Enhance/Stabilize lower connection	LS	1	$ 10,000	$ 10,000
LWD Structures spaced @ ~100'	EA	23	$ 3,000	$ 69,000
Import Channel Lining Material	CY	4,000	$ 25	$ 100,000
Hillside Stabilization	LS	1	$ 100,000	$ 100,000
Revegetation	LS	1	$ 100,000	$ 100,000
			Construction Total	**$5,404,940**

Chelan County PUD Pole & Line Relocation	$ 800,000
Purchase Affected Private Property	$ 3,571,600
Contingencies (@ 20% of construction)	$ 1,081,000
Project Design (@ 15% of construction)	$ 811,000
Construction Management (@10% of construction)	$ 540,000
NEPA & Permitting (@10% of construction)	$ 540,000
Geotech Investigation (@3% of construction)	$ 162,000

Project Total $12,910,540

ICF - September 26, 2012

Peshastin Creek RM 3.8 Channel Reconnection Project

Alternative 2 - Full Reconnection, Bridge Option

Item	*Units*	*Quantity*	*Unit Cost*	*Item Cost*
Mobilization	LS	1	$ 227,640	$ 227,640
Surveying	LS	1	$ 20,000	$ 20,000
Traffic Management	LS	1	$ 110,000	$ 110,000
Dewatering	LS	1	$ 50,000	$ 50,000
Structure Excavation	CY	5,500	$ 10	$ 55,000
Upstream Bridge (200' x 36')	LS	1	$ 1,476,000	$ 1,476,000
Downstream Bridge (200' x 36')	LS	1	$ 1,476,000	$ 1,476,000
Riprap	TON	400	$ 35	$ 14,000
Guardrail	LF	2,000	$ 32	$ 64,000
Structure Demolition	LS	1	$ 75,000	$ 75,000
Channel Excavation	CY	10,000	$ 10	$ 100,000
Plug/ELJ @ upstream connection	LS	1	$ 25,000	$ 25,000
Enhance/Stabilize lower connection	LS	1	$ 10,000	$ 10,000
LWD Structures spaced @ ~100'	EA	23	$ 3,000	$ 69,000
Import Channel Lining Material	CY	4000	$ 25	$ 100,000
Hillside Stabilization	LS	1	$ 100,000	$ 100,000
Revegetation	LS	1	$ 50,000	$ 50,000
			Construction Total	**$4,021,640**

Purchase Affected Private Property	$ 1,349,600
Contingencies (@20% of construction)	$ 804,000
Project Design (@ 15% of construction)	$ 402,000
Construction Management (@10% of construction)	$ 402,000
NEPA & Permitting (@10% of construction)	$ 402,000
Geotech Investigation (@3% of construction)	$ 121,000

Project Total $7,502,240

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Peshastin Creek RM 3.8 Channel Reconnection Project
Alternative 3 - Partial Connection

Item	*Units*	*Quantity*	*Unit Cost*	*Item Cost*
Mobilization	LS	1	$ 30,315	$ 30,315
Surveying	LS	1	$ 8,000	$ 8,000
Traffic Management	LS	1	$ 50,000	$ 50,000
Dewatering	LS	1	$ 20,000	$ 20,000
Structure Excavation	CY	1,000	$ 10	$ 10,000
Upstream culvert (120' x 12')	LF	120	$ 650	$ 78,000
Downstream culvert (105' x 12')	LF	105	$ 650	$ 68,250
Guardrail	LF	1000	$ 32	$ 32,000
Repave and Paint Road	LS	1	$ 20,000	$ 20,000
Channel Excavation	CY	2,500	$ 10	$ 25,000
LWD @ connections	EA	2	$ 5,000	$ 10,000
LWD Structures	EA	12	$ 3,000	$ 36,000
Import Channel Lining Material	CY	320	$ 25	$ 8,000
Hillside Stabilization	LS	1	$ 100,000	$ 100,000
Revegetation	LS	1	$ 40,000	$ 40,000
			Construction Total	**$535,565**

Easement Purchase	$ 200,000
Contingencies (@20% of construction)	$ 107,000
Project Design (@ 15% of construction)	$ 80,000
Construction Management (@10% of construction)	$ 54,000
NEPA & Permitting (@15% of construction)	$ 80,000
Geotech Investigation (@3% of construction)	$ 16,000

Project Total $1,072,565

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Peshastin Creek RM 3.8 Channel Reconnection Project
Alternative 4 - Downstream Only Connection

Item	*Units*	*Quantity*	*Unit Cost*	*Item Cost*
Mobilization	LS	1	$ 18,000	$ 18,000
Surveying	LS	1	$ 4,000	$ 4,000
Traffic Management	LS	1	$ 20,000	$ 20,000
Dewatering	LS	1	$ 12,000	$ 12,000
Structure Excavation	CY	475	$ 10	$ 4,750
Downstream culvert (105' x 12')	LF	105	$ 650	$ 68,250
Guardrail	LF	500	$ 32	$ 16,000
Repave and Paint Road	LS	1	$ 10,000	$ 10,000
Channel Excavation	CY	1,000	$ 10	$ 10,000
LWD @ connections	EA	1	$ 5,000	$ 5,000
LWD Structures	EA	5	$ 3,000	$ 15,000
Import Channel Lining Material	CY	400	$ 25	$ 10,000
Hillside Stabilization	LS	1	$ 100,000	$ 100,000
Revegetation	LS	1	$ 25,000	$ 25,000
			Construction Total	**$318,000**

Contingencies (@20% of construction)	$ 64,000
Project Design (@ 15% of construction)	$ 48,000
Construction Management (@10% of construction)	$ 32,000
NEPA & Permitting (@20% of construction)	$ 64,000
Geotech Investigation (@3% of construction)	$ 10,000

Project Total $536,000

Appendix F

Photos

Photo 1. US 97 at MP 182 facing upstream at January 2009 repair.

Photo 2. US 97 at MP 182 facing downstream at January 2009 repair.

Photo 3. Home adjacent to old meander channel.

Photo 4. Peshastin Creek facing downstream to east of US 97.

Photo 5. 2011 debris flow at downstream end of historical channel.

Photo 6. 2011 debris flow at downstream end of historical channel.