

# MIDDLE PILCHUCK RIVER ASSESSMENT

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## Final Report

Prepared for

Washington State Salmon Recovery Funding Board Snohomish County

Prepared by

Snohomish County Surface Water Management

December 28, 2012

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For critical review and helpful improvements – project team, Paul DeVries (R2), Gregg Farris and others.

The Middle Pilchuck River Assessment was funded through a Recreation and Conservation Office Salmon Recovery Funding Board grant.

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## Executive Summary

The Pilchuck River, a tributary to the Snohomish River, has been identified as a high priority watershed for the recovery of salmonids in the Snohomish River basin. The Pilchuck provides documented spawning and rearing habitat for ESA-listed Chinook salmon, steelhead, and bull trout as well as other important salmonids. The Snohomish River Basin Salmon Conservation Plan (SBSRF, 2005) identified the Middle Pilchuck River sub-basin as part of the Mainstem Primary Restoration sub-basin strategy group, and highlights the sub-basin's importance in maintaining and restoring the diversity and spatial structure of the Skykomish Chinook population (SBSRTC, 2004). Within this strategy group, the Middle Pilchuck River is one of the only sub-basins in Snohomish County that does not have a completed watershed assessment to guide recovery efforts.

The overall goals of the Middle Pilchuck River Assessment (MPRA) are to identify opportunities to address salmonid habitat deficiencies through restoration activities and to develop preliminary designs for capital projects at three high priority sites. The assessment area encompasses an eighteen-mile section of the Pilchuck River divided into 8 river reaches, extending upstream from the confluence with Dubuque Creek at OK Mill Road (RM 8.6) to the City of Snohomish diversion dam (RM 26.4).

The habitat assessment focused on describing the conditions that help inform preservation or restoration objectives, namely: preservation of intact habitat, reconnection of off-channel habitats, restoration of shoreline conditions, riparian enhancement, and enhancement of in-stream structure. The habitat assessment cataloged data for bank conditions, side channels, log jams, fish habitat, and riparian conditions along the entire 18 miles of the entire Middle Pilchuck River and provides up-to-date information on habitat limiting factors for project planning and feasibility analysis.

Habitat data were analyzed to assess the condition of both spawning and rearing habitat in the Pilchuck River. The major factors limiting Chinook salmon production in the Middle Pilchuck River appear to be a lack of rearing habitat in the form of side channel habitat, deep pools with natural cover, high quality bank edge habitat, and temperature impairment during summer months. The root causes of these habitat limiting factors in the Middle Pilchuck River are floodplain and streambank modifications and clearing of natural vegetation in floodplain forests. The assessment indicated that available spawning gravels appear to be underutilized, so spawning habitat is not limiting. The lack of deep pools with cover and wood structures forming pools may become limiting in the future if more adult Chinook return to the river. High summer water temperature may also affect adult migration timing or survival prior to spawning.

The habitat assessment identified three primary categories of project types to be considered in the geomorphic assessment, consisting of: pool creation, side channel and floodplain channel connectivity, and restoration of the riparian zone. These actions are primarily intended to increase juvenile rearing habitat availability, considered to be the primary factor limiting Chinook salmon production in the Middle Pilchuck River (Snohomish County, 2012a).

The geomorphic assessment area encompassed a ten-mile section of the Pilchuck River divided into three river reaches, extending upstream from the confluence with Dubuque Creek at OK Mill Road (RM 8.6) to the upstream end of reach three (RM 18.32) near the City of Granite Falls. This ten-mile stretch of the river was selected for the geomorphic assessment for the following reasons: it forms the core spawning and rearing area for Chinook salmon within the sub-basin; it encompasses all mainstem restoration project concepts identified for the sub-basin in the 2003 Savery and Hook report and the 2005 Snohomish River Basin Salmon Conservation Plan; and, it is characterized by significant human interaction with river processes.

The geomorphic assessment analyzed information on historical discharge levels, channel characteristics, and sediment transport processes in order to understand what types of projects are likely to be successful given the current river conditions. The analysis concluded that the river appears to be capable of transporting available sediment downstream without significant risk of aggradation in most locations (Snohomish County, 2012b). Recommendations for the following types of projects are provided:

- Pool creation – could be facilitated through techniques such as construction of in-stream structures and facilitation of lateral channel movement, with some locations better suited for these types of projects than others;
- Reconnection of side channels and floodplain channels – would likely be most successful in the vicinity of river segments where the channel movement analysis results indicate moderate to large channel movement rates during any time period (it should be noted that channel and floodplain connectivity projects are only feasible according to land ownership, and bank armoring should be absent or removed or modified consistent with landowner goals); and
- Restoration of the riparian zone – is generally advisable wherever it is feasible.

The strategy of the synthesis process was to evaluate the relevant data at successive stages including: identification of potential projects, screening and selection of recommended projects, and conceptual project development. During the project synthesis phase, reaches 1 – 3 were subdivided into 20 sites. The project team generated potential project ideas for each site and ranked the sites according to the following criteria:

1. Will the proposed activity benefit fish?
2. Is the proposed activity geomorphically feasible?
3. Could the proposed activity potentially provide benefits to landowners?

Three potential project sites were selected for preliminary designs. Detailed hydraulic and sediment transport analyses were conducted to evaluate project feasibility and risk at each site.

# 1 Introduction

## 1.1 Project Purpose and Goals

### *Purpose of the project*

The Pilchuck River is home to nearly 1,000 riverside residents, several species of salmon, and countless birds and animals. Ensuring a healthy, safe, and clean river for all can be a challenging task. Pilchuck riverside landowners have suffered damage from flooding and loss of property due to erosion in the past years, and salmon numbers have declined dramatically from historical levels. Three species of local salmon – Chinook, steelhead, and bull trout – are now listed as “threatened” on the Endangered Species List.

Snohomish County Surface Water Management has been studying these changing conditions in the Pilchuck River in order to understand how to minimize flooding and erosion, while maintaining a healthy river for fish and wildlife. The overall project goal is to develop high priority projects to address the salmonid habitat deficits created by altered processes along a critical section of the middle Pilchuck River while minimizing flood and erosion impacts to local land owners.

### *Assessment goals*

The goals of the Middle Pilchuck River Assessment (MPRA) are to identify opportunities to address salmonid habitat deficiencies through restoration activities and to develop preliminary designs for capital projects at three high priority sites. To meet these goals, a strategic approach was developed including the following steps:

- 1) Compile existing data and collect new data on salmonid habitat conditions.
- 2) Evaluate habitat data to identify habitat limiting factors.
- 3) Complete a geomorphic assessment of habitat forming processes.
- 4) Identify and prioritize opportunities for habitat restoration.
- 5) Complete public outreach to evaluate and build support for projects.
- 6) Select three high priority sites for near-term work.
- 7) Complete 30% designs for the three sites and generate cost estimates.
- 8) Prepare a final assessment report.

The habitat assessment, steps 1 and 2, provided information to determine which areas have limiting habitat. The *Habitat Report* provides information on habitat conditions and limiting factors for listed salmonid populations (Snohomish County, 2012a). The geomorphic assessment, step 3, helped identify which sites are most appropriate for potential habitat restoration projects. The *Geomorphic Report* provides information on habitat forming processes to support the development of projects that address limiting factors for listed salmonid populations (Snohomish County, 2012b). This *Final Report* documents steps 4 through 7, the identification and prioritization of opportunities for habitat restoration; public outreach; project selection; and conceptual design. The workflow for the overall assessment is shown below in

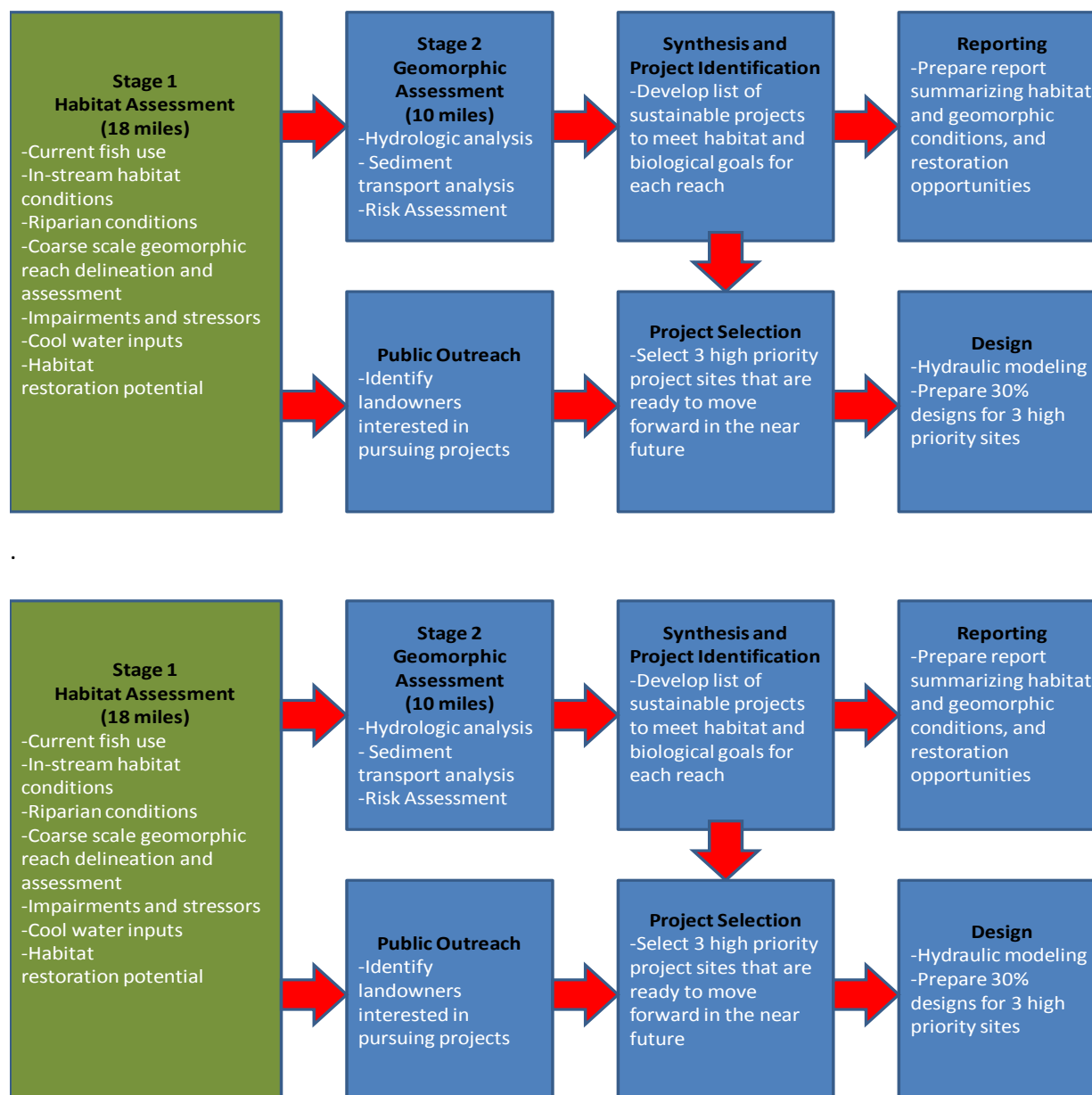


Figure 1-1 Assessment workflow

### Assessment Area

The overall assessment area encompasses an eighteen-mile section of the Pilchuck River in the Middle Pilchuck sub-basin (Figure 1-2). This portion of the river stretches upstream from the confluence with Dubuque Creek (RM 8.60) to an area just below the City of Snohomish diversion dam (RM 26.44).

The assessment area was divided into eight reaches based on channel slope, floodplain width, and channel constraints. These reaches are listed in Table 1-1 below.

Table 1-1 Assessment Reaches

| Reach    | River Mile   |            | Length<br>(mi.) |
|----------|--------------|------------|-----------------|
|          | <i>Start</i> | <i>End</i> |                 |
| <b>1</b> | 8.60         | 11.38      | 2.78            |
| <b>2</b> | 11.38        | 14.45      | 3.07            |
| <b>3</b> | 14.45        | 18.32      | 3.86            |
| <b>4</b> | 18.32        | 20.12      | 1.80            |
| <b>5</b> | 20.12        | 21.29      | 1.17            |
| <b>6</b> | 21.29        | 22.52      | 1.23            |
| <b>7</b> | 22.52        | 24.79      | 2.27            |
| <b>8</b> | 24.79        | 26.44      | 1.65            |

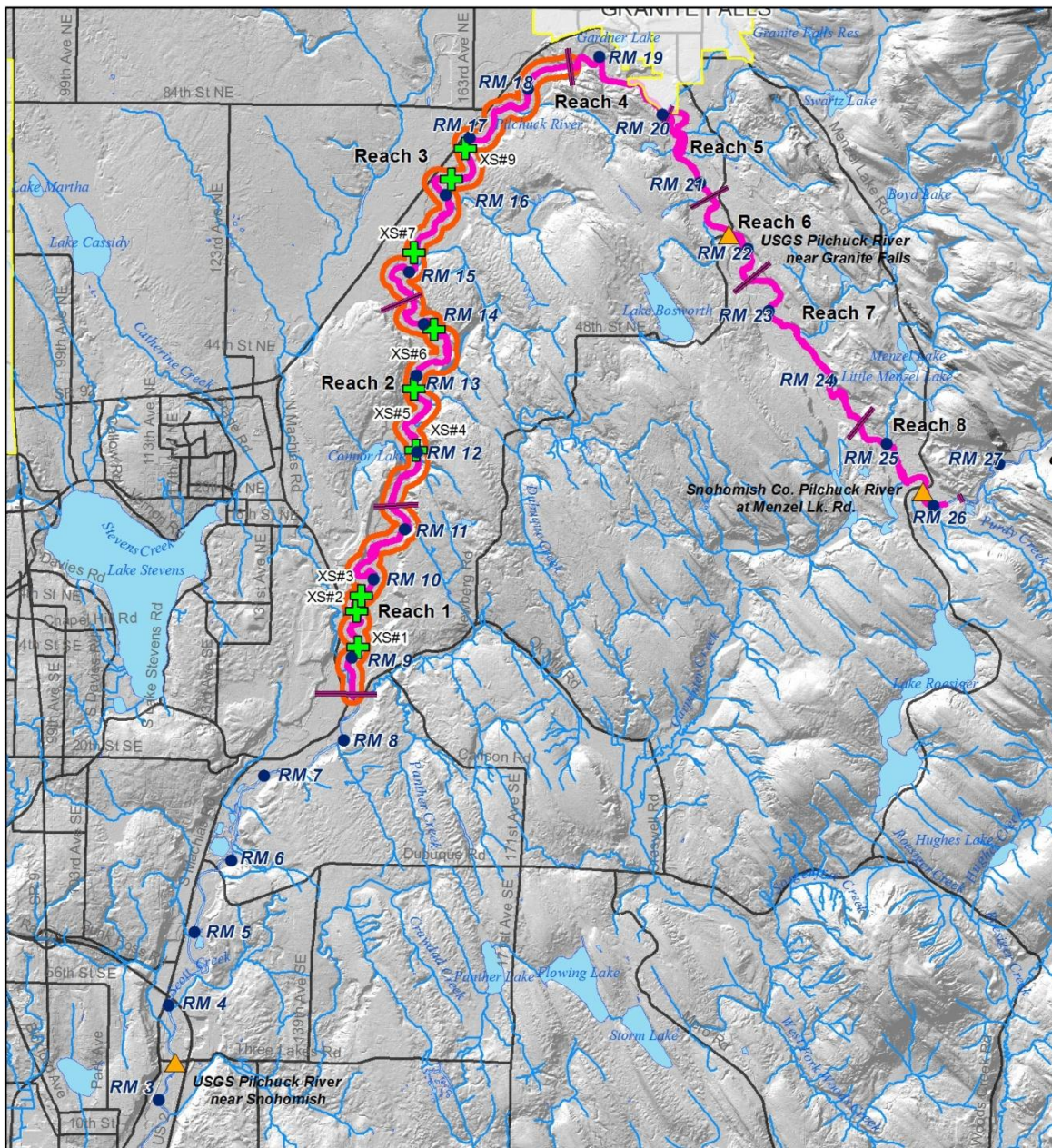


Figure 2-2. Map of Assessment Area, Reaches, and Cross Section Locations.



Figure 1-2 Map of assessment area, reaches and cross section locations.

The overall assessment was completed in two stages. For stage 1, a habitat assessment was conducted for the entire eighteen-mile assessment area. This assessment included a coarse-scale geomorphic element. Data produced by the habitat assessment was used to evaluate existing habitat conditions within the eight assessment reaches listed in Table 2-1. Reach descriptions are included in Appendix A.

For stage 2, a geomorphic assessment was completed for the lower ten miles (reaches 1 – 3) of the assessment area. Also referred to as the geomorphic assessment area, this area stretches from the confluence with Dubuque Creek (RM 8.60) to the upstream end of reach three (RM 18.32) near the City of Granite Falls. This ten-mile stretch of the river was selected for the geomorphic assessment for the following reasons: it is the core spawning and rearing area for Chinook salmon within the sub-basin; it encompasses all mainstem restoration project concepts identified for the sub-basin in the 2003 Savary and Hook report and the 2005 Snohomish River Basin Salmon Conservation Plan; and, it is characterized by significant human interaction with river processes. Data generated by the geomorphic assessment includes information on historical discharge levels, channel characteristics, and sediment transport processes. This information will be used in conjunction with the habitat assessment data to identify and prioritize opportunities for habitat restoration. Reach maps showing geomorphic characteristics of reaches 1 – 3 are included in Appendix B.

This assessment differs somewhat from previous river assessments conducted in Snohomish County. In lieu of developing a reach-wide hydraulic model (e.g., HEC-RAS) and completing detailed sediment transport calculations, a screening level analysis was performed. The local balance between sediment supply and transport capacity was quantified at locations distributed along the length of the geomorphic assessment reach. A more detailed sediment transport analysis was completed for projects selected for the preliminary designs.

### *Synthesis, project selection and design goals*

The goal of the synthesis process was to integrate habitat and geomorphic data to identify projects that will improve fish habitat and address flooding and erosion concerns for landowners. The goal of the project selection process was to select three projects to move forward in the near future based on a suite of criteria including the following:

1. Would the proposed activity benefit fish?
2. Would the proposed activity work with or against the river?
3. Would the proposed activity provide benefits to landowners?

The goal of the preliminary design phase was to prepare 30% designs for three high priority sites. This *Final Report* provides a summary of the results of this assessment and information on how future restoration efforts may benefit landowners and fish.

## 1.2 Background

### *Watershed*

The Pilchuck River drains 132 square miles of the Puget Lowland. It enters the Snohomish River near the City of Snohomish at an elevation of approximately 30 feet. The headwater streams are located at a range of 2700 to 3800 feet in elevation and are supplied by snowmelt in the early spring.

### *Geologic history*

The landscape of the Pilchuck River basin is dominated by the effects of the last glacial interval, which ended about 14,000 years ago (Collins, 1991). The Puget Lobe of the Cordilleran ice sheet began moving south from Canada about 18,000 years ago. As the glacier approached the Pilchuck area from the north it blocked the drainage of streams into the Puget Lowland and formed a lake. Silt and clay deposited in the lake are known locally as Pilchuck Clay.

As the glacier covered the Pilchuck River area it deposited a layer of mud, sand and stone up to 50 feet thick, known as glacial till, which forms the surface layer in much of the current watershed. The ice was up to 3,500 feet thick, covering all but the top 1,200 feet of Mt. Pilchuck. Drainage of meltwater beneath the glacier carved out channels in a north-south direction including the Pilchuck River downstream of Granite Falls.

As the glacier retreated to the north, it deposited sand and gravel, known as recessional outwash on top of the till. The ice blocked the path of the South Fork Stillaguamish River, diverting the flow into the Pilchuck River west of Granite Falls. A layer of sand was deposited between Granite Falls and Lochsloy. In the 14,000 years since the glacier left the Pilchuck area, streams have incised exposing sand and gravel deposited by the glacier. Valley walls are composed of pre-glacial silts and clays. Valley floors are composed of sand and gravel deposited by the river as it meanders across the valley. Upstream of Granite Falls, the river has trenched into the thick sand and gravel deposits left by the glacier.

### *Land Use*

The lower reach extends from the mouth of the river to Dubuque Creek at River Mile (RM) 8.5. The lower Pilchuck is primarily zoned for rural residential units < 5 acres and 10-acre agricultural lots. Gravel mining operations were located within the floodplain near RM 6. Historically, sand and gravel were mined from the stream channel, gravel bars and the adjacent floodplain. Little Pilchuck and Dubuque Creeks are the largest tributaries in the lower basin, entering the system near RM 8.5. The middle Pilchuck extends from Dubuque Creek to the City of Snohomish Water Treatment Plant diversion dam (RM 8.5 - 26). The City of Granite Falls is located at RM 19. The middle Pilchuck is zoned for rural residential units < 5 acres and forestry. Forestland ownership is both private and public. The upper Pilchuck extends from the dam to the headwaters (RM 26 – 39). Federal, state and private forestry is the sole land use in the upper Pilchuck. The headwaters of the Pilchuck River drain the narrow valley between Bald Mountain and the ridge northwest of Spada Lake. Boulder and Kelly Creeks drain the southern flank of Mount Pilchuck and join the Pilchuck River at river mile (RM) 30 and 29, respectively.

In the Pilchuck River watershed, land uses such as upland timber production and floodplain forest clearing, draining of floodplain wetlands, unnatural constriction of the river, reduced floodplain connectivity due to bank hardening and levee building, and agricultural practices have disturbed the natural surface and subsurface drainage networks (Booth, 1991). These changes have in turn affected the routing and timing of flow, sediment and large woody debris in the river system. Changes in these processes are recognized to adversely affect the formation and maintenance of salmonid habitat in the Snohomish River basin (SBSRTC, 1999).

### *Salmon recovery planning*

The Pilchuck River has been identified as a high priority watershed for the recovery of salmonids in the Snohomish River basin. The Pilchuck provides documented spawning and rearing habitat for ESA-listed Chinook salmon, steelhead, and bull trout as well as other important salmonids. The Snohomish River Basin Salmon Conservation Plan (SBSRF, 2005) identified the Middle Pilchuck River sub-basin as part of the Mainstem Primary Restoration sub-basin strategy group, and highlights the sub-basin's importance in maintaining and restoring the diversity and spatial structure of the Skykomish Chinook population (SBSRTC, 2004). Within this strategy group, the Middle Pilchuck River is one of the only sub-basins in Snohomish County that does not have a completed watershed assessment to guide recovery efforts. Additional information on salmon recovery planning can be found in Chapter 1 of the *Habitat Report*.

## **1.3 Summary of info to date**

### **Habitat data**

Habitat data were analyzed to assess the condition of both spawning and rearing habitat in the Pilchuck River. The major factors limiting Chinook salmon production in the Middle Pilchuck River appear to be a lack of rearing habitat in the form of side channel habitat, deep pools with natural cover, high quality bank edge habitat, and temperature impairment during summer months. The root causes of these habitat limiting factors in the Middle Pilchuck River are floodplain and streambank modifications and clearing of natural vegetation in floodplain forests.

The following is a summary of the assessment of each of the key salmon life stages, including how the data supports the above conclusion that rearing habitat is limiting and spawning habitat is underutilized.

### *Assessment of Adult Spawning Habitat*

Chinook returning to the Pilchuck River to spawn need clean and appropriately sized gravel and deep pools with overhead cover.

### *Conclusions*

- Available spawning gravels appear to be underutilized, so spawning habitat is not limiting.
- The lack of deep pools with cover and wood structures forming pools may become limiting in the future if more adult Chinook return to the river.
- High summer water temperature may affect adult migration timing or survival prior to spawning.

### *Supporting data*

The following is a list of data used to support this conclusion and a brief summary of findings:

- Substrate size - Of the 957 habitat units inventoried during the survey, 645 were determined to have gravel size suitable for spawning in areas likely to be utilized by salmonids.
- Embeddedness - Sixty-five percent of spawnable areas were classified as having relatively low (0% -25%) embeddedness.
- Redd locations (data from the Tulalip Tribes and WDFW) – Only a fraction of areas suitable for spawning are being used by Chinook.
- Pool quality & quantity (location, depth, how formed, and amount of cover) - While spawning gravels are numerous and widely distributed, deep holding pools and the jams that create and provide cover for them were not abundant over much of the assessment area, particularly in reach 2. Of the 423 pools identified, only 20% met the criteria for adult holding pools.
- LWD jams – In reaches where most of the spawning occurred (reaches 1 - 3), jams were infrequent and restricted to a few location that remained geomorphically active.
- Water temperature – Temperatures in reaches 1 - 3 exceeded standards during summer months.

### *Assessment of Juvenile Rearing Habitat*

Juvenile salmonids need protected areas that provide a safe place for foraging and refuge from high temperatures and flooding. Natural channel edges, wood formed pools with abundant cover, and side channels in floodplain forests typically provide this type of habitat.

### *Conclusions*

Analysis indicates that much of the Middle Pilchuck lacks high quality rearing habitat due to bank armoring, riparian degradation, lack of floodplain connectivity, and lack of wood-formed backwater pools. Areas of high quality rearing are small and isolated and are often located a considerable distance from spawning areas (especially in the lower reaches where most spawning currently occurs).

### *Supporting data*

The following is a list of data used to support this conclusion and a brief summary of findings:

- Bank condition – Armored banks impact the quality (especially depth of pools and overhead cover) of edge habitat (see Beamer and Henderson 1998) over 5 1/2 miles of Middle Pilchuck.
- Riparian condition – Degraded riparian conditions limit the quality of edge habitat and future wood recruitment within the lower reaches (1 - 3).
- Side channel habitat – Many side channels were disconnected from the main channel, thereby reducing rearing capacity. Some side channels contained colder water during summer months that flowed back to the mainstem in some places.

- Pool quality & quantity (location, depth, how formed, and amount of cover) – Deficient in-stream structure and low quality pools were found throughout, but they have improved since 2002.
- LWD jams – Most wood jams formed as a result of channel migration into intact riparian vegetation and most occurred in reaches 5 and 7, upstream from most spawning areas in reaches 1 - 3. Otherwise few stable bar apex jams affecting channel complexity and habitat quality were found in reaches 1 - 3.

The habitat assessment identified three primary categories of project types to be considered in the geomorphic assessment, consisting of: pool creation, side channel and floodplain channel connectivity, and restoration of the riparian zone. These actions are primarily intended to increase juvenile rearing habitat availability, considered to be the primary factor limiting Chinook salmon production in the Middle Pilchuck River.

### Geomorphic Assessment

The geomorphic assessment area encompassed a ten-mile section of the Pilchuck River divided into three river reaches, extending upstream from the confluence with Dubuque Creek at OK Mill Road (RM 8.6) to the upstream end of reach three (RM 18.32) near the City of Granite Falls. This ten-mile stretch of the river was selected for the geomorphic assessment for the following reasons: it forms the core spawning and rearing area for Chinook salmon within the sub-basin; it encompasses all mainstem restoration project concepts identified for the sub-basin in the 2003 Savery and Hook report and the 2005 Snohomish River Basin Salmon Conservation Plan; and, it is characterized by significant human interaction with river processes.

The geomorphic assessment analyzed information on historical discharge levels, channel characteristics, and sediment transport processes in order to understand what types of projects are likely to be successful given the current river conditions. The analysis concluded that the river appears to be capable of transporting available sediment downstream without significant risk of aggradation in most locations. Recommendations for the following types of projects are provided:

- Pool creation – could be facilitated through techniques such as construction of in-stream structures and facilitation of lateral channel movement, with some locations better suited for these types of projects than others;
- Reconnection of side channels and floodplain channels – would likely be most successful in the vicinity of river segments where the channel movement analysis results indicate moderate to large channel movement rates during any time period (it should be noted that channel and floodplain connectivity projects are only feasible according to land ownership, and bank armoring should be absent or removed or modified consistent with landowner goals); and
- Restoration of the riparian zone – is generally advisable wherever it is feasible.

## Comparison with Tulalip Report

The Tulalip Tribes assessment (Savery and Hook, 2003) was updated by the County's current assessment for several reasons: (1) to assess changes in habitat conditions after the large 2009 flood event, (2) to cover a longer reach of the river, particularly with the potential removal of the City of Snohomish Diversion Dam at river mile 26.4, (3) to better document certain habitat and geomorphic conditions, and (4) to develop project recommendations based on current conditions and landowner coordination.

### *Similarities in Approach*

Where appropriate, the same data collection protocols were used to allow for comparison of results with the Tulalip Tribes report (Savery and Hook, 2003).

### *Differences in Approach*

The Snohomish County assessment extended further upriver to the City of Snohomish Diversion Dam (RM 26.4) whereas the Tulalip assessment ended at river mile 18.1 (downstream of Granite Falls). The County assessment evaluated certain habitat conditions more thoroughly, such as spawning substrate suitability and extent, bank armor locations and conditions, and side channel locations and connectivity. The County assessment was also more accurate in identifying locations of specific habitat conditions. All of the above were intended to help when evaluating habitat conditions in terms of geomorphic processes, selecting project locations, and evaluating restoration outcomes.

### *Comparative Conclusions*

- Wood jam abundance has increased markedly in the past 8 years and pool frequency has also increased, but stable jams that influence river process and habitat formation are infrequent in reaches 1 - 3.
- Pools formed by wood comprise a greater proportion of all pools than previously, but pool frequency is low nevertheless.
- Approximately five and a half miles of river bank are modified and affect juvenile rearing habitat quantity and quality.
- 37% of side channels are isolated or disconnected, some by river modifications.

Recommendations for habitat improvement projects from this assessment are consistent with the 'general suggestions for enhancement' in the Tulalip report (Savery and Hook, 2003). Project types recommended in the Tulalip report include reducing bank hardening, increasing floodplain connectivity, decreasing pool spacing by adding roughness elements such as large woody debris, and replanting the riparian zone with a mix of hardwood and conifer species. Site-specific recommendations resulting from this assessment may vary somewhat from the Tulalip recommendations.

## 2 Objectives and approach for synthesis

### 2.1 Synthesis and design process: a tiered approach

The strategy of the synthesis process was to evaluate the relevant data at successive stages including: identification of potential projects, screening and selection of recommended projects, and conceptual project development.

### 2.2 Identification of potential restoration projects: 1st tier analysis

The initial identification of a suite of potential restoration projects for further analysis was completed by the project team which included habitat biologists, ecologists, and engineers. The team met to review the 1<sup>st</sup> tier data (see below) depicted visually in GIS layers. An overview of available data was followed by a review of each reach in greater detail discussing limiting conditions, potential for restoration, and identifying potential projects. The team identified potential habitat restoration projects such as levee and bank armor removal, engineered log jams, flood fencing (in-channel and floodplain), riparian forest restoration, etc. General locations for the types of projects identified were also discussed. During the initial screening of data, the project team identified approximately 50 potential restoration actions throughout the 20 sites in the geomorphic assessment area.

#### *1st tier data :*

- Geomorphic base map, including
  - Historic channel locations
  - Floodplains
  - Main channel tracing
  - Side channel tracings
- Infrastructure and property constraints
  - Highways, bridges
  - Levees, revetments
  - Utilities & easements
  - Property boundaries
- Salmonid habitat
  - Salmonid spawning locations
  - Juvenile rearing habitat
  - Adult rearing habitat
- Riparian vegetation condition
- River bank condition

### 2.3 Selection of recommended projects: 2nd tier analysis

Following initial identification of projects, the project team met to select a suite of potential restoration projects for consideration in the conceptual design phase. Best professional judgment was applied to rate each site using the following three criteria on a scale of high, medium or low (H, M, L):

4. Will the proposed activity benefit fish? Does it address a limiting factor?
  - a. First tier – key life history stage – addresses juvenile rearing.
  - b. Second tier – process-based actions – addresses floodplain connectivity and riparian restoration.
  - c. Third tier – other habitat limiting factors – addresses instream pool and edge habitat needs.
5. Is the proposed activity geomorphically feasible? Does it work with or against the river?
6. Could the proposed activity potentially provide benefits to landowners? Landowner support was subsequently evaluated as part of the outreach effort.

### Geomorphic feasibility

Working with geomorphic processes can be defined in two ways (Devries, pers comm. 2/11/10, edited):

1. Restoring natural processes – this occurs at the sub-basin and floodplain scales and involves modifying hydrology, sediment supply, large wood supply, and floodplain connectivity (Beechie et al. 2010).
2. Restoring aquatic and riparian/floodplain habitat at specific locations using methods that are compatible with prevailing hydrologic, hydraulic, sediment transport, and wood delivery processes.

In the Pilchuck, following approach 1 will lead to potential actions that remove alterations to floodplain connectivity and restore floodplain vegetation, particularly where greater benefit may be produced. Following approach 2 will lead to actions hypothesized to effectively work with prevailing river flow and sediment processes to form scour pools and enhance channel connectivity. Since approach 2 is generally more feasible in the middle Pilchuck River due to land use constraints, the selection of projects will generally be based on (i) conditions describing where habitat is in reasonable shape and where it is not, and (ii) physical conditions that may control where each type of project is feasible.

### Supporting data

The following data will be used to determine the geomorphic feasibility of potential projects:

- Slope: Results confirm general consistency of slope throughout the reaches, so there are few locations with large scale slope changes. At local slope breaks, segments where aggradation is likely may be more conducive to channel migration projects and less ideal for placement of wood to create pools.
- Confinement: Confined reaches constrain large wood projects to forced pool creation. Unconfined reaches are where riprap removal might have some benefits.
- Floodplain connectivity: As a supplement to side channel mapping, channel avulsion potential was visually assessed using LiDAR topography.
- Channel size/shape: Use cross-section data to estimate bankfull flow and shear stress; compute bankfull critical D50, compare with pebble count results to calculate sediment supply:transport ratio. Reaches with highest ratio are least conducive to pool formation projects.
- Channel migration: Screening tool: highly unstable locations (a) are not suitable for ELJs for forced pool formation, and (b) are suitable for floodplain connectivity, meander pool formation projects.

## **2.4 Conceptual project development**

The project team evaluated the feasibility of the restoration and preservation actions identified for the eight sites with high potential for habitat preservation or restoration. The proposed restoration actions were evaluated in terms of:

- Constructability (access, risk of failure, other concerns)
- Public safety (recreation, boating, etc.)
- Cost (relative to projected benefits)
- Ability to obtain necessary permits
- Risk of failure
- Other concerns

## **2.5 Preliminary design**

The final phase of the assessment was to develop preliminary designs for three projects. A suite of three potential projects were identified with high potential for habitat preservation and restoration. Landowner support was considered in the selection of the three projects.

## 3 Results and Conclusions

### 3.1 Results

#### Types of recommended projects

Implementing the following types of projects will address the need for juvenile Chinook rearing habitat:

- Construct wood structures to create pools with cover in the channel
- Remove or modify structures (i.e. levees and bank armoring) in locations where they provide little to no protective function to encourage channel migration and edge complexity
- Re-connect side channels to enhance and distribute high-flow (velocity) and low-flow (temperature) refuge habitat
- Replace riprap banks with bioengineered banks where appropriate
- Restore riparian forest and wetlands to provide shading and a source for future large woody debris (LWD)

#### Location of recommended projects

Throughout the assessment area, the above projects types should be located in areas where the following criteria are met:

- Proposed activity addresses habitat limitations
- Proposed activity is geomorphically feasible (works with river process)
- Proposed activity is supported by landowners

Below is a general description of appropriate locations for the types of projects listed in Table 1-1:

- Wood structures: Areas where river is straightened and placement could produce forced pool-riffle morphology, reaches where sediment transport is in balance, areas where wood could split flow into relic side channels.
- Re-connect side channels: Areas where relic side channels are currently disconnected.
- Structure removal or modification: Primarily where removal could encourage flow to relic side channels.
- Bioengineered bank stabilization: Areas with existing rip rap along outside of bends.
- Riparian restoration: Primarily in lower 8 miles where riparian condition is degraded.

The results of the evaluation of the 20 sites revealed restoration actions in 3 sites with high habitat value and geomorphic feasibility, 9 sites with moderate habitat and geomorphic feasibility, and 8 sites with low habitat value or geomorphic feasibility. Two sites were identified with high value habitat that should be protected. Results are presented in Table 3-1.

Six of the sites were selected for further consideration. Sites selected include 1-3, 1-7, 2-1, 2-2, 3-1, and 3-3. Each site was reviewed by the project team to identify potential for habitat protection and improvement. Geomorphic processes unique to the site were discussed and noted. Potential project elements were identified and evaluated. Feasibility of project implementation including safety, permitting and potential modes of failure were noted. Finally, a rough estimate of cost was made based on experience with similar types of projects. The results of this evaluation are presented in Table 3-2.

Table 3-1 Project Matrix

| Reach                                      | 1   |     |     |     |     |     |     | 2   |     |     |     |     |     |     | 3   |     |     |     |     |     |
|--------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Sites                                      | 1-1 | 1-2 | 1-3 | 1-4 | 1-5 | 1-6 | 1-7 | 2-1 | 2-2 | 2-3 | 2-4 | 2-5 | 2-6 | 2-7 | 3-1 | 3-2 | 3-3 | 3-4 | 3-5 | 3-6 |
| <b>Project types</b>                       |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Install boulders to create pools           |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     | x   |
| Install log jam(s) to create pools (FPR)   |     |     |     | x   |     |     |     | x   | x   |     | x   |     |     |     |     |     |     | x   | x   |     |
| Install log jam to protect island          |     |     | x   |     |     |     |     |     |     |     |     | x   | x   | x   |     |     | x   |     |     |     |
| Install log jam to reactivate side channel |     |     | x   |     | x   |     | x   | x   |     |     | x   |     | x   |     | x   |     | x   |     |     |     |
| Install lwd / flood fence to split channel |     |     | x   |     | x   | x   | x   |     |     |     |     | x   | x   | x   |     |     | x   |     |     |     |
| Install LWD to enhance edge habitat        | x   |     |     |     |     | x   |     | x   | x   |     |     |     |     |     |     |     | x?  |     |     |     |
| Channel Migration                          |     |     |     |     |     |     | x   |     | x   |     |     |     |     |     |     | x   | x?  |     |     |     |
| Reconnect Side Channel                     |     | x   | x   |     | x   |     | x   | x   | x   |     |     |     | x   |     |     |     | x   |     | x   |     |
| Riparian planting / enhancement            |     | x   |     | x   | x   |     | x   |     |     |     |     |     |     |     |     |     | x   |     |     |     |
| Enhance riprap w bioengineering            | x   | x   |     | x   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Remove levee                               |     | x   | x   |     |     |     | x   |     |     | x   |     |     |     |     |     |     | x   |     |     |     |
| Home buyouts                               |     |     |     |     |     |     |     |     |     | x   |     |     |     |     |     |     |     |     |     |     |
| <b>Criteria / rating</b>                   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Increases target habitat function          | M   | L   | H   | L   | L   | L   | H   | H   | H   | L   | M   | H   | M   | H   | M   | L   | H   | M   | M   | M   |
| Potential for habitat preservation         |     |     |     |     |     |     |     |     |     |     |     |     | H   |     | H   |     |     |     |     |     |
| Geomorphically feasible                    | L   | M   | H   | M   | H   | L   | H   | M   | H   | L   | H/M | L   | H   | M   | M   | H   | M   | H   | M/H | H   |
| Landowner benefits                         |     | M   |     | L   | M   | H   |     |     | L   |     |     |     | L   | L   | H   |     | H   |     |     |     |

Table 3-2 Site Characteristics.

| Site                       | 1-3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Habitat notes              | <ul style="list-style-type: none"> <li>• High potential for habitat gain from increased rearing capacity and channel complexity</li> <li>• Cold water input at re-connected side channels</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                      |
| Geomorphic notes           | <ul style="list-style-type: none"> <li>• High geomorphic feasibility</li> <li>• This reach has been inactive since the 1940's</li> <li>• Transport/supply ratio shows good place to re-connect side channel</li> </ul>                                                                                                                                                                                                                                                                                                                                                                    |
| Project options & elements | <ol style="list-style-type: none"> <li>1. Install log structure to reactivate existing side channel;               <ol style="list-style-type: none"> <li>a. may require construction of small bridge for owner to access land across reconnected side channel.</li> </ol> </li> <li>2. Construct setback levee / revetment along left bank terrace, remove existing levee &amp; allow river to meander</li> <li>3. Partial levee removal to allow reconnection of side channel</li> <li>4. Riparian planting – focus on areas without vegetation &amp; conifer under planting</li> </ol> |
| Safety                     | <ul style="list-style-type: none"> <li>• Bioengineering on outside of bend could pose recreational hazard</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Permit                     | <ul style="list-style-type: none"> <li>• Full suite of permits likely required</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Risk of failure            | <ul style="list-style-type: none"> <li>• Home built on left bank near upstream log structure could be affected if river becomes unstable;</li> <li>• 2 homes on downstream left bank could be affected if river migrates into terrace.</li> <li>• Both issues could be addressed through design.</li> </ul>                                                                                                                                                                                                                                                                               |
| Other notes                | <ul style="list-style-type: none"> <li>• Restoration of riparian could be considered an amenity by property owners</li> <li>• Several years ago some landowners were interested, some not</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                      |
| Rough cost estimate        | \$100,000 - \$200,000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

| Site                                      | 1-7                                                                                                                                                                                |
|-------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Habitat notes                             | <ul style="list-style-type: none"> <li>• High potential for habitat gain from side channel re-connection and river process restoration</li> </ul>                                  |
| Geomorphic notes                          | <ul style="list-style-type: none"> <li>• High geomorphic feasibility</li> </ul>                                                                                                    |
| Project elements & constructability notes | <ol style="list-style-type: none"> <li>1. Install 3 – 4 hard points, remove levee &amp; allow river to develop side channels</li> <li>2. Install flood fence</li> </ol>            |
| Safety                                    | <ul style="list-style-type: none"> <li>• Outside of bend location would require design consideration</li> <li>• Flow split structure would only be active at high flows</li> </ul> |
| Permits                                   | <ul style="list-style-type: none"> <li>• Minimal</li> </ul>                                                                                                                        |
| Risk of failure                           | <ul style="list-style-type: none"> <li>• Potential erosion</li> </ul>                                                                                                              |
| Other notes                               | <ul style="list-style-type: none"> <li>• What is currently preventing channel from occupying side channels?</li> <li>• LWD appears to be collecting here, why?</li> </ul>          |
| Rough cost estimate                       | Without levee removal \$100,000 - \$150,000<br>With levee removal \$200,000 - \$400,000                                                                                            |

| Site                                      | 2-1                                                                                                                                                                                                                                                                                                                                                                             |
|-------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Habitat notes                             | <ul style="list-style-type: none"> <li>High potential for habitat gain from right bank edge habitat enhancement and left bank side channel reconnection</li> </ul>                                                                                                                                                                                                              |
| Geomorphic notes                          | <ul style="list-style-type: none"> <li>Medium geomorphic feasibility</li> </ul>                                                                                                                                                                                                                                                                                                 |
| Project elements & constructability notes | <ol style="list-style-type: none"> <li>1. Install LWD to improve edge habitat</li> <li>2. Install hard points to split channel, create Forced Pool Riffle, &amp; sort gravel</li> <li>3. Install hard points on both sides of channel to reactivate left side channel, create FPR &amp; sort gravel</li> <li>4. Plant riparian buffer on right bank to shade channel</li> </ol> |
| Safety                                    | <ul style="list-style-type: none"> <li>Good location for instream structures, straight reach w/ good vis.</li> </ul>                                                                                                                                                                                                                                                            |
| Permits                                   | <ul style="list-style-type: none"> <li>Permits may be required for geotechnical evaluation, temp bridge</li> <li>Permitting in channel work at known spawning location difficult</li> </ul>                                                                                                                                                                                     |
| Risk of failure                           | <ul style="list-style-type: none"> <li>Minimal risks downstream</li> </ul>                                                                                                                                                                                                                                                                                                      |
| Other notes                               | <ul style="list-style-type: none"> <li>Design charette to identify actual elements &amp; locations</li> <li>Good access on right bank</li> <li>Access to left bank may require temp bridge</li> <li>Narrow buffer on right bank would be very successful due to absence of channel migration to right</li> </ul>                                                                |
| Rough cost estimate                       | \$50,000 - \$100,000 for right bank LWD installation<br>\$200,000 for channel splitting structure                                                                                                                                                                                                                                                                               |

| Site                                      | 2-2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Habitat notes                             | <ul style="list-style-type: none"> <li>High potential for habitat gain from improved channel complexity and side channel re-connection</li> </ul>                                                                                                                                                                                                                                                                                                                                                                    |
| Geomorphic notes                          | <ul style="list-style-type: none"> <li>High geomorphic feasibility</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Project elements & constructability notes | <ol style="list-style-type: none"> <li>1. Install 2 – 4 hard points (LWD or large rocks) in plane-bed channel to create Forced Pool Riffle channel</li> <li>2. Install hard point (2 large rocks) on river right to reconnect side channel               <ol style="list-style-type: none"> <li>a. May need temporary bridge to access left bank</li> <li>b. Geotechnical evaluation of high bank on river left req'd</li> </ol> </li> <li>3. Interplant riparian zone with cottonwood and large conifers</li> </ol> |
| Safety                                    | <ul style="list-style-type: none"> <li>Good location for instream structures, straight reach w/ good vis.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                 |
| Permits                                   | <ul style="list-style-type: none"> <li>Permits may be required for geotechnical evaluation, temp bridge</li> <li>Permitting in channel work at known spawning location difficult</li> </ul>                                                                                                                                                                                                                                                                                                                          |
| Risk of failure                           | <ul style="list-style-type: none"> <li>Minimal risks downstream</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Other notes                               | <ul style="list-style-type: none"> <li>County owns large parcel where majority of work proposed</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                           |
| Rough cost estimate                       | \$200,000 - \$300,000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

|                                           |                                                                                                                                                                                                                                                                                                                                   |
|-------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Site</b>                               | <b>3-1</b>                                                                                                                                                                                                                                                                                                                        |
| Habitat notes                             | <ul style="list-style-type: none"> <li>• High habitat protection value</li> <li>• Medium potential for habitat gain</li> </ul>                                                                                                                                                                                                    |
| Geomorphic notes                          | <ul style="list-style-type: none"> <li>• Medium geomorphic feasibility</li> </ul>                                                                                                                                                                                                                                                 |
| Project elements & constructability notes | <ol style="list-style-type: none"> <li>1. Install 2 flood fences with racked logs on right bank gravel bar to maintain occupation of existing left bank side channels</li> <li>2. Install jams &amp; plant conifers to enhance existing side channels</li> <li>3. Plant riparian buffer on right bank to shade channel</li> </ol> |
| Safety                                    | <ul style="list-style-type: none"> <li>• Installation of flood fence on inside of bend presents minimal risk</li> </ul>                                                                                                                                                                                                           |
| Permits                                   | <ul style="list-style-type: none"> <li>• Minimal</li> </ul>                                                                                                                                                                                                                                                                       |
| Risk of failure                           | <ul style="list-style-type: none"> <li>• Avulsion into existing side channel possible</li> <li>• No structures at risk</li> </ul>                                                                                                                                                                                                 |
| Other notes                               | <ul style="list-style-type: none"> <li>• High potential landowner benefits – reduction of erosion potential</li> </ul>                                                                                                                                                                                                            |
| Rough cost estimate                       | \$150,000                                                                                                                                                                                                                                                                                                                         |

|                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Site</b>                               | <b>3-3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Habitat notes                             | <ul style="list-style-type: none"> <li>• High potential for habitat gain from re-connection of isolated side channel, increased habitat complexity and floodplain forest regeneration</li> <li>• Mature cottonwood gallery would provide good riparian cover</li> </ul>                                                                                                                                                                                                                                                                                                          |
| Geomorphic notes                          | <ul style="list-style-type: none"> <li>• Medium geomorphic feasibility</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Project elements & constructability notes | <ol style="list-style-type: none"> <li>1. Install in-channel flood fence to allow bar development and split channel</li> <li>2. Install apex jam to protect forested island</li> <li>3. Remove right bank levee or breach at selected locations (3 possible) to reconnect side channel</li> <li>4. Install in-channel flood fence on right bank to split flow</li> <li>5. Plant cottonwood and large conifers to enhance left bank riparian zone and reduce bank erosion</li> <li>6. Plant up to 20 acres on right bank in NGPA areas to regenerate floodplain forest</li> </ol> |
| Safety                                    | <ul style="list-style-type: none"> <li>• Avoid working in lower end of reach near bridge</li> <li>• Installation of flood fences may trap wood that would otherwise rack up on bridge or private property</li> </ul>                                                                                                                                                                                                                                                                                                                                                             |
| Permits                                   | <ul style="list-style-type: none"> <li>• Probably need full range, working instream</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Risk of failure                           | <ul style="list-style-type: none"> <li>• Avulsion into existing side channel possible (but would likely reduce left bank erosion)</li> <li>• No structures at risk</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                    |
| Other notes                               | <ul style="list-style-type: none"> <li>• High potential landowner benefits – reduction of erosion potential</li> <li>• Design &amp; placement of structures difficult due to tightness of bends</li> <li>• Only 3 landowners along approximately 4000 lf of riverfront</li> </ul>                                                                                                                                                                                                                                                                                                |
| Rough cost estimate                       | \$500,000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

## 3.2 Conclusions

Selection of three projects for the preliminary design phase was completed following the landowner outreach effort. The three projects selected include sites 1-7, 2-1 and 2-2. These sites were selected because they represent a range of project elements that are likely to be successful in preserving intact habitat and improving degraded habitat. There is general support from landowners for the proposed actions. These three sites were taken through development of preliminary (30%) project design. Detailed hydraulic and sediment transport analyses were conducted to evaluate project feasibility and risk at each site. Findings from the preliminary design are presented in Appendix C.

## 4 References

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## Appendix A      Reach Descriptions

### Reach 1

Reach 1 is typified by riprap armor placed along the outside bends of meanders. This has tended to lock the channel in place, except in two notable locations, where meander bends have been migrating. The variety of streambed surfaces, wide active channel area, large wood jams, overflow side channels, and habitat complexity create better physical habitat at these locations. Otherwise, there are very few wood-formed or backwater pools with cover that would be valuable for salmonid rearing, except in the two unmodified meander bends. Rearing capacity for juvenile salmonids may be relatively less in this reach (compared to other reaches) because of channel constraints. Three locations appear to have dikes set back from the channel that limit channel migration. Three locations, as affected by the dikes, have become isolated from the channel due to dike modifications or channel avulsion. Each of these locations has potential to be re-connected to increase rearing capacity and habitat diversity. Although temperature increases in a downstream direction through most of the Pilchuck River and was highest in Reach 1, we identified several small coldwater inputs (Figure 3-14; Middle Pilchuck River Assessment, Habitat Report) downstream of side channels along the margin of the channel boundaries that may provide significant temperature relief either by reducing mainstem temperatures or, more likely, by providing temperature relief within these colder habitat units that are occupied during warmer river temperature.

### Reach 2

Reach 2 contains much less bank armoring than Reach 1, and has no bank armoring on the left bank, which is almost entirely un-developed (except one agricultural field). Much of the left bank has steeper slopes or vertical, slowly eroding sedimentary deposits. The right bank has several armored meander bends and is dominated by rural and agricultural land uses. The right bank has only two forested patches. In the lower half of the reach, there are very few wood jams and pools are spaced more distantly apart. This part of the reach has low habitat complexity. There is also a community at 28<sup>th</sup> Pl., part of which appears to be built as low elevation on an old gravel bar. This area is susceptible to flooding and development here may have contributed to the reduction in right bank mainstem meandering and side channel connections. Otherwise, bank armoring elsewhere does not appear to have isolated floodplain area with potential for salmonid rearing. Side channels are more abundant in this reach than in Reach 2, but there are only two small connected channels and many overflow channels that may be well connected at higher flows.

The upper half of the reach is more geomorphically active, with meanders that have migrated over time and re-worked gravel bars. This location appears to actively recruit large wood into jams, as meanders have eroded into the forested patch in this part of the reach. Habitat complexity increases here as more wood jams, wood formed pools and backwater pools are frequently located. There are also more abundant side-channel habitat areas. There appears to be significant spawning throughout this reach by Chinook and steelhead, and overall gravel quality appeared high (low embeddedness). At the same time, there is one county road near a stabilized meander bend and an area of significant right bank erosion at

a farm field that has not successfully been stopped. Overall, habitat complexity (jams and pools) and riparian vegetation quantity and quality (on the right bank) are of concern in this reach.

### Reach 3

Reach 3 is the upper extent of the Phase II Geomorphic Assessment area. This reach really has 3 sub-reaches; a lower, unconfined reach with historically wider floodplain; a middle confined reach with limited channel movement, and an upper segment (transitional with reach #4). This reach, overall, is similar to Reach 2 in that there is limited left bank development and right bank riparian conditions are degraded. Like reach 2, streambank modification is limited overall. However, in the lower segment, two river training dikes, apparently constructed in the 1940s, significantly affect channel alignment and have isolated former river channel habitat (an oxbow and former side channels). Elsewhere, in this lower segment, there is well functioning significant side channel habitat. Taken together the high-quality connected and un-connected/isolated side channel habitat in the lower segment, particularly, comprise the greatest total among all reaches. The un-connected fraction is also the greatest, suggesting that rearing habitat quality and quantity may have been relatively high in this segment historically and that potential restoration exists.

The more confined middle segment abuts sandstone cliffs on the left bank and sequentially; clay lenses, a major roadway alignment, and a high elevation floodplain terrace on the right bank. Given that there is limited channel movement, little local woody debris appears to currently recruit from this segment. As such, there are few wood jams (as seen in Figure 3-18; Middle Pilchuck River Assessment, Habitat Report). Habitat units are more infrequently spaced and glides, in particular, have flat, trapezoidal (plane-bed) geometry, indicative of low habitat value and low spawning suitability (Montgomery et al. 1996).

The upper segment appears to deposit bed load and fine sands as they settle out below the canyon reach (Reach 4) in low gradient, long pool and glide habitat. Again, on the right bank there is degraded riparian condition and unstable streambanks that contributes to this degraded Instream habitat. At the end of the bed load, there is a steeper transition to pool:riffle habitat, along with some woody debris from recent erosion. In general, whereas woody debris jams appear to have increased in number throughout the study are during the recent past, the middle and upper segment of reach 3 appear to be the only location where jam number has decreased. The greatest opportunity in the reach appears to be to restore greater floodplain connectivity to increase rearing capacity for juvenile salmonids and restoring riparian vegetation quantity and quality.

### Reach 4

This reach is unique within the Middle Pilchuck River. Overall, it has relatively high channel confinement with prominent bedrock outcroppings that control habitat condition and reach slope. Channel migration is limited due to overall confinement, so no diverse channel types, such as side channels are present. Habitat units tend to be homogeneous and longer; there being large bedrock pools, long riffle habitats, and long glides or runs. All pools have less than 10% cover or no cover at all. No wood jams were observed. Limited temperature information suggests this reach may provide some thermal refuge. Temperature near the downstream end of the reach was slightly cooler than Reach 5

upstream. Due to channel aspect and topography, this reach is considerably shaded. Groundwater inflow along the bedrock interface may also occur. Despite this, overall there is relatively less high quality rearing or spawning habitat area and less potential to restore high quality habitat or increase capacity for rearing or spawning. Some erosion near homes is significant, though channel migration has been limited. This reach contains the wastewater effluent discharge from City of Granite Falls, which was raised as a water quality concern by several nearby landowners.

### **Reach 5**

In contrast to the general confinement of Reach 4, and in fact because of the downstream channel constriction presented by Reach 4, Reach 5 displays characteristics of an unconfined and fairly active channel. While the upper half of the reach is single channel compared to the lower, which has multiple mid channel bars and islands, the entire reach shows evidence of active and disconnected channels throughout the floodplain. Reach 5 has the most intact and diverse habitat among the eight reaches assessed. Limited bank armoring along this reach allows for river movement into healthy riparian forest and, as a result, wood recruitment is high. The jams that result from this recruitment provide channel roughness and form frequently spaced, small but deep pools with cover and clean well sorted pool tail-outs providing habitat for salmon spawning and rearing. Chinook redds were observed in this reach in higher concentration than the other upper reaches of the assessment area.

### **Reach 6**

Reach 6 is bisected, and the lower portion of the reach flanked on both sides, by the Robe-Menzel Road. Residential development is dense along this lower portion of the reach and as a result, bank armoring is extensive and riparian vegetation is highly altered along this reach. While the upper portion of Reach 6 has less rip rap along the banks and has slightly more intact riparian, the overall habitat condition of the reach is illustrative of a lack of large wood input. Five pools in this reach were formed by wood but only one was had sufficient cover to offer high function for juvenile rearing. The majority of deep pools found in the reach were formed by rip rap, they also had little cover. Spawning was not observed in Reach 6.

### **Reach 7**

Though Reach 7 contains segments that are constrained by roads and bank armoring, much of the Reach is unconstrained allowing river migration into banks that have fairly intact riparian vegetation. The wood recruited from this migration accumulates in jams and creates many primary and backwater pools with wood cover that are beneficial to both adult and juvenile Chinook. Several side channels, both connected and abandoned, are found on either side of the reach indicating a history of active river migration and the potential for even more rearing habitat. While Chinook and steelhead spawning has been documented in Reach 7, the available habitat appears to be underutilized.

### **Reach 8**

Reach 8 extends upstream to the City of Snohomish water treatment facility, under the Menzel Lake Road bridge, and up to the diversion dam. The need to protect the infrastructure in the floodplain has led to the banks on this reach being armored extensively with rock. As a result, Reach 8 is a fairly narrow channel with little habitat complexity excepting a few pools created by one large jam in the middle of the reach.

## **Appendix B      Reach Maps**

## **Appendix C      Middle Pilchuck Design Report**

## **Appendix D      Middle Pilchuck Habitat Report**

## **Appendix E      Middle Pilchuck Geomorphic Report**