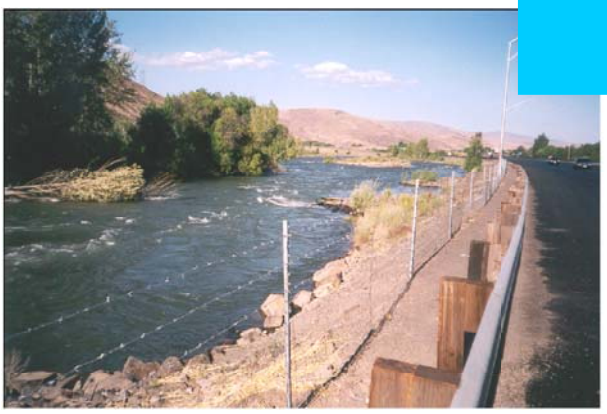
NACHES RIVER REACH ANALYSIS AND MANAGEMENT PLAN

LOWER NACHES RIVER

RIVER MILE 0 – 3.75

Final Report



Prepared for the

Washington State Department of Transportation

June 20, 2003

GeoEngineers

GeoEngineers

June 20, 2003

Jason Smith
Washington State Department of Transportation
South Central Region
P.O. Box 12560
Yakima, Washington 98909-2560

RE: Naches River Reach Analysis and Management Plan

GeoEngineers is pleased to submit this final report entitled " Naches River Reach Analysis and Management Plan". This report was conducted using the best available information at the time of this assessment. Conditions within the subject reach may change both spatially and with time, and additional scientific data may become available. Significant changes in site conditions or the available information may require reevaluation. Further development of the conceptual management plan will require additional evaluation. This report is prepared in accordance with GeoEngineers Inc. services agreement 0180-126-01, dated 7-04-2002. This report is for use by the Washington State Department of Transportation, South Central Region and the Environmental Affairs Office.

We appreciate the opportunity to provide these services to the Washington State Department of Transportation. If you need any additional information or have any questions regarding this report please call Tracy Drury at 360-647-1510.

Sincerely,

GeoEngineers, Inc.

Galan W. McInelly
Principal

Tracy A. Drury
Senior, River Science and Engineering

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GeoEngineers, Inc.
600 Dupont Street
Bellingham, WA 98225
Telephone (360) 647-1510
Fax (360) 647-5044

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ACRONYMS

BPA – Bonneville Power Administration
cfs – Cubic Feet per Second
COY – City of Yakima
DBH – Diameter at Breast Height
ELJ – Engineered Log Jams
GIS – Geographic Information System
GLO – General Land Office
IOP – Interim Comprehensive Basin Operating Plan
ISPG – Integrated Streambank Protection Guidelines
LWD – Large Woody Debris
NACW – Naches River near Naches Stream Gauge
NMFS – National Marine Fisheries Service
RM – River Mile
SASSI – Salmon and Steelhead Stock Inventory
SCS – Soil conservation Service
US - United States
USACE – United States Army Corps of Engineers
USBR – United States Bureau of Reclamation
USDI – United States Department of the Interior
USGS – United States Geological Survey
USFS – United States Forest Service
WDFW – Washington Department of Fish and Wildlife
USFWS – United States Fish and Wildlife Service
WSCC – Washington State Conservation Commission
WSDOT – Washington State Department of Transportation
WY – Water Year

NACHES RIVER REACH ANALYSIS AND MANAGEMENT PLAN
EXECUTIVE SUMMARY

The purpose of this project is to characterize existing conditions and reach-scale fluvial processes and to develop a comprehensive approach for treating river/road interactions along the lower 3.75 miles of the Naches River near Yakima, Washington. United States (US) highway 12 runs parallel to the river for much of this area and is located within the historic floodplain of the Naches River. The project area encompasses the river and its floodplain from the Naches Gap downstream to the confluence with the Yakima River. Through this reach, the Naches River is very dynamic, frequently changing channel configuration and location over time. Channel migration and reach-scale fluvial processes have led to the loss of riparian buffers between US 12 and the river in the project area, and US 12 has periodically experienced erosion of portions of the highway prism. Management actions to protect the highway have included the placement of rock revetment and rock groins and/or barbs and has resulted in the temporary stabilization of the road prism in some locations. Most recently, the primary problems have been experienced from the 16th Avenue parking area upstream to the 40th Avenue interchange. While these corrective actions have maintained US 12 as a transportation route, the Washington State Department of Transportation (WSDOT) has recognized that these installations are not providing a long-term solution. The location of US 12 and the dynamic nature of the Naches River are such that river/road interactions are likely to persist in the future.

The reach analysis considered basin scale impacts and processes as well as site specific issues within the project area. Dam construction has altered hydrology and sediment supply and transport in downstream reaches. Altered conditions have also impacted salmonid habitat and riparian community species and health. These impacts pose management considerations throughout the Naches Valley including the project reach.

WATERSHED AND HYDROLOGIC CONDITIONS

The installation of dams in the headwaters has reduced the supply of sediment to the Naches River, and the construction of levees and riprap has cut off the river's access to sediments stored in the floodplain. Sediment supply in other portions of the basin has likely increased because of road building, timber harvest, and grazing. These impacts have reportedly been reduced in the upper headwaters, but it is likely that development activities lower in the basin continue to affect sediment inputs. The balance between the sediment deficit induced by the dams and the sediment generated by development is currently uncertain. However, the ability of the Naches River to transport sediment has been reduced because of the altered hydrology. This is not to say that sediments no longer move through the Naches system, but that it is likely that the residence time (time sediment spends in the system before being transported out) has increased.

Altered hydrology not only affects instream habitat, but also disturbs the recruitment, establishment, maturation, and mortality of riparian habitat along the river. In a healthy, undisturbed river system tree mortality would be a part of the normal disturbance regime and important for dynamic, healthy ecosystems (Naiman, *et al.* 1992). However, the river ecosystem in the Naches River is impacted (floodplain and associated riparian forest reduced by

approximately 57 percent [WSCC, 2001]) and managed (altered flow regime). As such, inundation mortality influenced by unnatural conditions results in a significant impact to the system. Decreased recruitment combined with a reduced floodplain and diminishing mature forest will perpetuate substantial decline in riparian forest. As older cottonwoods die off younger individuals will not be present in sufficient numbers to replace them. With no changes in management, future forest conditions could be expected to trend toward one dominated by older cottonwoods, with numerous dead and dying trees along older channel margins, and increasing dominance by other species such as willow and alder.

SITE CHARACTERIZATION AND EVALUATION

Most reach scale impacts to the system are derived from anthropogenic sources. Progressive settlement of the Naches Valley and the subsequent installation of human infrastructure have encroached upon the river corridor reducing the floodplain area available to the river for channel migration and attenuation of floods. This confinement and the installation of instream diversions have impacted the configuration of the river channel resulting in the channelization of flow, channel incision, and the degradation of instream habitat. The cumulative affect of these impacts has resulted in the simplification of the channel network to a single thread channelized system and a dramatic reduction in instream habitat quality.

Basin and reach scale impacts have resulted in a river system that is very confined in some locations and unconstrained in others. The confined sections are typically a result of bridge, riprap, or levee placement that channelizes the river. This typically results in channel incision and degradation of instream habitat. It also results in higher sediment transport capacity meaning that sediment moves through these areas with little if any temporary storage in the channel or floodplain. Unconstrained reaches downstream of constriction points are depositing large amounts of sediments resulting in very active river channels. The river has a greater tendency to migrate and/or avulse through these reaches resulting in greater management issues and concerns.

The relationship between US 12 and the Naches River was evaluated by defining past, present, and future areas of concern with respect to road failures and/or maintenance needs and environmental degradation and/or recovery. This characterization includes an evaluation of the physical setting relating the proximity of US 12 to the Naches River and considers both reach and site specific fluvial processes. In addition, the environmental conditions of the riparian zone were evaluated and used as a proxy for the level of environmental degradation and/or protection that exists through the project area. Because of the variability of conditions through the site, the project area was delineated into categories of physical risk to the roadway and environmental deficiency.

Management Options

Management actions within the project area can be site specific targeting a particular problematic area, or can be used to affect reach scale processes impacting much larger areas. Design criteria can also vary from short term protection of infrastructure to long-term goals of reach scale ecological restoration. Based on our evaluation, there are two management approaches that could be taken within the project area.

1) One approach is to focus on efforts that protect US 12 using placements of large rock. This will include placing riprap from approximately Station 8000 to 5000 and installing additional rock groins or Engineered Log Jams as deflectors through this area as needed. This approach would also include installing protection measures from Station 10000 to 8000. The objective of these protection measures is to prevent the river from migrating south to US 12 resulting in conditions similar to those from Station 8000 to 5000. Placing rock in the river is likely going to require mitigation. As described, there are numerous mitigation opportunities within the project area. These mitigation actions typically target rehabilitation of riparian areas or the enhancement of instream habitat conditions. The exact mitigation activities will need to be negotiated with regulatory agencies. The layout of this strategy is displayed in Figure A-16.

2) The second approach is to integrate reach scale processes into management actions that provide longterm self sustainable protection, better accommodate natural channel processes, and enhance long-term ecological conditions. This approach would seek to remove or modify human impacts that have altered the routing of sediment through the reach and re-establish a healthy riparian buffer between the Naches River and US 12. Levees would be setback and fill materials in the floodplain would be removed as shown in Figure A-17. This would remove constriction points promoting incision in some areas and deposition in others and reestablish more balanced patterns of sediment transport and storage through the project area. An extensive revetment or cribwall would be constructed from approximately Station 8200 to 5400. This structure would reclaim floodplain area and allow for the establishment of a healthy riparian buffer between the river and US 12 over time. Engineered Log Jams would be placed near Station 9000 to divert and split flow, and additional Engineered Log Jams could be placed through the reach to improve instream habitat conditions.

Implementing this approach will likely require property acquisition, partnership with local municipalities and/or agencies, coordination with other stakeholders, and consultation with regulatory agencies. In addition, the extent of fill and constriction removals should be evaluated based upon topography that was not available for this evaluation. Removal of fill in some areas may introduce greater risk to US 12 and should be carefully evaluated. Protection measures not suggested in this report may need to be incorporated into fill removal projects to address any increases in risk to US 12.

NACHES RIVER REACH ANALYSIS AND MANAGEMENT PLAN

INTRODUCTION

The purpose of this project is to characterize existing conditions and reach-scale fluvial processes and to develop a comprehensive approach for treating river/road interactions along the lower 3.75 miles of the Naches River near Yakima, Washington (Figure A-1). United States (US) highway 12 runs parallel to the river for much of this area and is located within the historic floodplain of the Naches River. The project area encompasses the river and its floodplain from the Naches Gap downstream to the confluence with the Yakima River (Figure A-2).

The Naches River within the project area is very dynamic, frequently changing channel configuration and location over time. Channel migration and reach-scale fluvial processes have led to the loss of riparian buffers between US 12 and the river, and US 12 has periodically experienced erosion of portions of the highway prism. Most recently, the primary problems have been experienced from the 16th Avenue parking area upstream to the 40th Avenue interchange (Figure 1).

Figure 1: Photograph taken from the parking area at 16th Avenue interchange. Note the westbound lane of US 12 running along the right bank of the river.

Within this area, US 12 runs parallel to the mainstem of the Naches River and several maintenance and emergency actions have taken place to prevent or repair damage to the highway and its foundation. These actions have included the placement of rock revetment and rock groins and rock barbs and has resulted in the temporary stabilization of the road prism in some locations (Figure 2). While these corrective actions have maintained US 12 as a transportation route, the Washington State Department of Transportation (WSDOT) has recognized that these installations are not providing a long-term solution. The location of US 12 and the dynamic nature of the Naches River are such that river/road interactions are likely to persist in the future. Based on our opinion, it is also likely that without intervention problematic areas will expand.

Figure 2: Photograph taken from westbound side of US 12, approximately 3,000 feet upstream of 16th Avenue. Note rock at toe of highway prism and groins and barbs extending into channel.

SCOPE

GeoEngineers was requested the WSDOT to conduct a reach analysis and develop a management strategy for the lower Naches River. The overall objectives of the project are to characterize existing site conditions and ongoing processes and to develop a comprehensive management framework and conceptual designs that WSDOT can draw from for future project implementation. Our scope includes:

- Review of available site-specific information provided by WSDOT
- Development of a project plan in coordination with WSDOT based on our evaluation of available data
- Conduct site investigation
- Import and evaluate the historic photo record using a Geographic Information System (GIS)
- Compile other GIS data for use in geospatial analysis
- Characterize hydrology of the Naches River in the study area
- Evaluate the geomorphic character of the Naches River in the study area
- Summarize limiting factors to salmonid production
- Identify high risk locations relative to one another within the reach
- Develop management options and conceptual designs

- Delivery of GIS data layers created for this project, including digitized channel polygons

The execution of these scope items included coordination with WSDOT's Environmental Affairs Office in Olympia and the South Central Region in Yakima and with Yakima County Public Works Flood Control Zone.

Review of readily available reference materials revealed that government agencies, private consultants, and academic researchers have not extensively investigated the lower Naches River through the study area. As a result we depended on the evaluation of the historic aerial photograph record and our professional interpretation of ongoing fluvial process for this project. Site evaluation focused on the project area, however some information from outside the project boundaries was utilized to provide a better understanding of cause-effect relationships within the study reach.

REPORT ORGANIZATION

The development of management options within this report required evaluation of factors affecting the site conditions and ongoing fluvial processes. These evaluations provide the basis for developing potential management actions and how expected future conditions may affect management decision-making. For organizational purposes, we have placed much of the background information evaluated for this project into appendixes in the back of this report. For additional information on the following subjects, please refer to the appropriate appendices.

- Appendix A — Regional Setting
- Appendix B — Regional Setting
- Appendix C — Hydrology
- Appendix D — Sediment Dynamics
- Appendix E — Riparian Forest Conditions
- Appendix F — Salmonid Limiting Factors Analysis
- Appendix G — Hyporheic Zone
- Appendix H — Floodplain and Channel Dynamics
- Appendix I — Alternative Management Actions
- Appendix J — Report Limitations and Guidelines for Use

Figures cited throughout this report are referenced by their respective appendix letter (A-J) and with respect to the order they are found in the appendix text. Hence, an example figure reference may be C-5, referring to the fifth figure in Appendix C.

SITE CHARACTERIZATION

Geomorphic processes within the project area are diverse and compete with and/or compound one another to create a complex array of site conditions. The project reach is near the mouth of the river, and these segments of rivers are typically depositional environments. However, the gradient through the project area does not lend itself to be strongly depositional relative to the upstream twenty miles of the river as described in Appendix H and shown in Figure H-1.

Floodplain encroachment and channel confinement has been extensive through the project area, which typically leads to channelization and incision. These conditions are described in detail in Appendix H. Within the project area, depositional environments exist juxtaposed with channel segments that are channelized and incising. This has lead to a river system that alternates between reaches that are channelized and controlled and reaches where deposition is extensive and the channel is very dynamic and a management concern. For the purposes of the following discussion we divided the study area into reaches of similar geomorphic character and described them by using the stationing along the river found in Figure A-2.

The upper extent of the project area begins at Station 20000 near the Naches Gap. From this location to Station 18000, the channel is a simple planebed channel that is confined along the right bank by an extensive levee placed to isolate an orchard in the floodplain. Floodplain encroachment and perhaps some floodplain filling have occurred on the left bank near Station 18300 where the river contacts the bedrock hillside that comprises the left valley wall (Figure 3) (left and right banks, floodplains, and valley walls are defined as one would stand in the middle of the channel and face downstream). This section of the river is narrow and displays planebed channel characteristics. Indications of channel incision are evident and it is clear that this is a transport reach where little if any sediment is stored. No side channels exist in this area, and aquatic habitat is limited to a riffle/run channel units. Because of high velocities and limited floodplain access, there is little opportunity for juvenile refuge in this area during higher discharges.

Figure 3: Looking downstream from Station 19900 toward bedrock along left bank at Station 18300. Discharge is approximately 2,500 cfs.

From Station 18000 to 16200, the channel widens and bar forms are found. This segment of the river provides some temporary storage of sediments and flow is conveyed through multiple flow paths under high discharge conditions. This localized depositional environment exists for two reasons. First, the channel is less confined than the upstream segment allowing flow to disperse. This reduces transport capacity and sediment begins to deposit. Second, it is upstream of the channel constriction at Station 16000 created by the City of Yakima's (COY) pump station. Fill material was brought in during construction of the pump station and the channel width is reduced to approximately one hundred-twenty five feet at this location (Figure 4). This confinement creates a backwater at high discharges reducing velocities upstream, further diminishing transport capacity, and promoting the deposition of sediment. Because of the depositional bars and multiple flow paths found during high discharges, some instream aquatic habitat complexity is found in this section of the reach during higher river stage. However, access to the floodplain is still limited.

Figure 4: Floodplain and perhaps a portion of the active channel have been filled for the City of Yakima's Ranney-type diversion structure and pump located near Station 16000. Yellow line in figure highlights the extent of fill, which is over 20 feet above the riverbed.

Downstream of this constriction point (Figure 4), flow is accelerated and incision has occurred at least through Station 14500. The river continues to be channelized through Station 12000 because of the additional influence of grade control activities associated with diversion channels, placed rock, and the filling of the right floodplain. This segment of the river is a narrow, straight, plane-bed channel with little bedform complexity, hence we characterize this segment as a transport reach. Early aerial photographs of this area depicting side channels and floodplain areas clearly connected to the river sharply contrast with conditions seen in more recent aerial photographs and viewed during our field observations. Numerous former side

channels are disconnected from the river through this segment of the river. These degraded conditions result in little aquatic habitat value through this segment.

Below Station 12000, the channel widens, is more connected to its floodplain, and high flow channels through the floodplain are present. From Station 10500 to 9000, the river is located adjacent to the bedrock wall along the left valley margin, although evidence of recent channel occupation can be found throughout the right floodplain. This segment of the river is highly connected to its floodplain (Figure 5).

Figure 5: Station 10200 looking downstream at the mainstem channel (left) and a secondary flow channel (right). Photograph taken October 22, 2002, discharge approximately 250 cfs.

We visited the site during the flip flop and found numerous secondary channels flowing through the floodplain (Figure 6).

Figure 6: Secondary channel through floodplain during the flip flop. (Note: looking upstream at same channel as shown in Figure 5) Mainstem channel is flowing along the base of the hillside seen in the background. Discharge approximately 2200 cfs.

Notice the relationship between the riparian vegetation and the water surface elevation during the flip flop (Figure 6). This was typical for conditions through much of the floodplain is this area. Based upon the elevation of these discharges, it is reasonable to surmise that saturation of the root structure of the riparian zone was occurring extensively across the floodplain. This segment of the river is a depositional environment where sediment transported through the upstream reach is deposited. Sediment deposition through this area is likely influenced by downstream conditions as well. While instream aquatic habitat conditions during low discharges are of a similar, poor quality to the section of river just upstream, conditions in this section likely improve as river stage increases. Access to the floodplain and multiple flow paths add hydraulic complexity and refugia for both juvenile and adult salmonids.

From Station 9000 to 8000 the river moves from the left valley wall across the floodplain and impacts the base of US 12 (Figure 7). This segment is steep relative to adjacent river sections and is one of the critical areas of management concern at the time of this report.

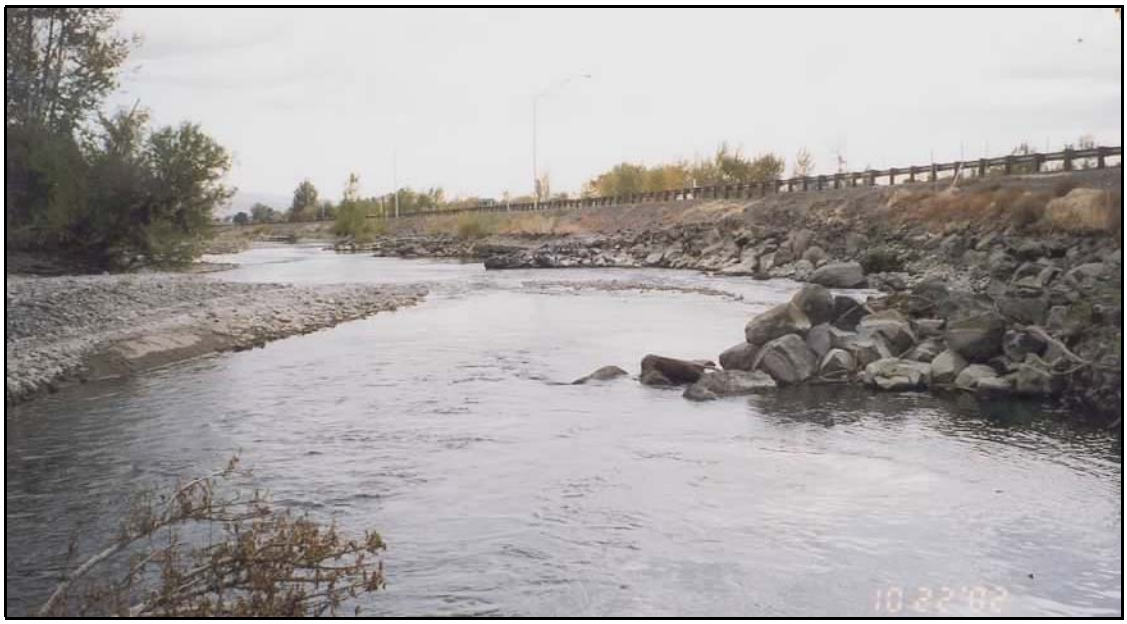

Figure 7: Photograph taken from Station 7800 looking downstream at recent efforts to protect the road prism of US 12. Note railing along edge of eastbound lane of US 12

From Station 8000 to 5000, the river flows very near US 12 and the roadway is protected by riprap installations and numerous rock barbs (Figures 2 and 7). The current channel configuration is related to the upstream channel location and its association with the left valley wall (Figure A-2). Specifically, from Station 11000 to 9000 the river flows at the toe of the left valley wall where it is directed south toward the highway by a bedrock knob extending into the floodplain near Station 8500. Former channel locations can be found through the floodplain toward the left valley margin and this area also experienced overbank flow and riparian root saturation during the flip flop.

At Station 5000, a channel constriction exists because of the placement of the 16th Avenue interchange and the adjacent Yakima Greenway parking area. This constriction creates a similar backwater effect during high discharges as described for the COY diversion upstream near Station 16000. Again sediment deposition is promoted upstream of the constriction point. The coupling of the effects of the constriction point at Station 5000 and the confined segment from Station 16000 to 12000, promotes sediment deposition from Station 10500 to 5000. While the current channel is located quite close to US 12 for much of this segment, there are numerous other flow paths across the floodplain to the north that the mainstem river has occupied at times during the last 20 years. These channels have a relatively well-established riparian forest adjacent to them and the channels are complex compared to the rest of the project area (Figure 8). Additionally, many of these flow paths convey flow during moderate to high discharges. As such, these side channel areas offer the highest quality remaining floodplain that is accessible to overbank flows and channel migration, both important components in providing complex aquatic habitat.

Figure 8: Photograph of former mainstem channel that is now a secondary channel. Location is approximately Station 7000.

Downstream of the constriction at the 16th Avenue interchange, flow is accelerated and sediment transport capacity is increased. The river is also channelized and incised with rock revetment, levees, and bridge abutments present all the way to the confluence with the Yakima River at Station 0. These floodplain alterations have drastically reduced floodplain width and have held the channel in place. This segment is a straight, planebed, transport reach where little if any temporary storage of sediment occurs. Instream habitat is limited because this reach is a very long, homogenous, riffle/run, and aquatic habitat quality and diversity is poor. No side channels exist, and access to the floodplain is virtually nonexistent through this section of river.

RELATIONSHIPS BETWEEN US 12 AND THE NACHES RIVER

Characterizing the relationship between US 12 and the Naches River is an important step in defining past, present, and future areas of concern with respect to road failures and/or maintenance needs and environmental degradation and/or recovery. This characterization includes an evaluation of the physical setting relating the proximity of US 12 to the Naches River and considers both reach and site specific fluvial processes. In addition, the environmental conditions of the riparian zone were evaluated and used as a proxy for the level of environmental degradation and/or protection that exists through the project area. Because of the variability of conditions through the site, the project area was delineated into categories of physical risk to the roadway and environmental deficiency as described below.

Definition of Physical Risk and Environmental Deficiency Criteria

This section defines the criteria used to delineate the physical risk and environment deficiency associated with each segment of the project area as depicted in Figure A-15. This delineation was used in the development of management options and alternatives developed as part of this report.

Physical Criteria

River segments were delineated into the following risk categories if ANY of the bulleted descriptions existed at the site, with the exception of the "No Risk" category where ALL bulleted conditions must apply.

Severe Risk

- Roadway is fully or partially unusable
- Roadway prism is actively being eroded away
- Roadway prism is exposed and unprotected and there is a high probability that damage will occur to the prism during the next high flow season

Severe risk is delineated when the roadway prism is failing or directly at risk. Under severe risk conditions, failure of the road is highly likely and actions should be taken to protect the road.

High Risk

- Erosion is occurring at the base of the roadway
- Channel migration and/or avulsion activity is rapid and volatile and could affect the roadway in one event.
- Erosion is occurring and site conditions and ongoing river processes are likely to result in designation as an severe risk site within two years

Under high risk situations the roadway prism is not currently at risk, but conditions are such that it is likely the roadway prism will be affected in the near future. These areas require current attention so that a comprehensive management plan can be developed, permitted, and implemented prior to the site being designated as severe risk.

Moderate Risk

- Less than 50 feet of bank/floodplain exists between the roadway and the river.
- Site conditions and ongoing river processes are likely to result in future erosion of this bank/floodplain and the roadway prism within five years
- Existing conditions are likely to persist for greater than two years before risk level increases

Moderate Risk areas are areas that should be monitored for future change. These are areas of concern where future risk and/or need for protection is highly dependent upon riverine processes. In these situations, the river may change to increase or reduce the risk to the roadway.

Minimal Risk

- Greater than 50 feet of bank/floodplain exists between the roadway and the river.
- Site conditions and ongoing river processes are likely to result in future erosion of this bank/floodplain and the roadway prism
- Existing conditions are likely to persist for greater than five years before risk level increases

Minimal Risk designation is for areas where the roadway is well isolated from the river through distance and/or geologic conditions or where fluvial processes are not likely to result is near term risk to the roadway.

No Risk

- River is isolated from the roadway prism
- Bank/floodplain between the roadway and the river is highly resistant to erosion
- Site conditions are unlikely to change

No Risk areas are either bedrock reach where bedrock separates the roadway from the river, or areas where extensive distance exists between the river and the road.

Environmental Criteria

Riparian zone width, size, and quality was evaluated as a proxy for the ecological health of the river system through the site. Instream habitat quality is not included in the evaluation, but is discussed in our site characterization and within our management alternatives and mitigation opportunities sections. Riparian areas between the river and US 12 where evaluated and delineated into environmental classification based upon the following buffer characteristics:

Size

- Diameter class within the minimum pool forming diameter (0.025 times the bankfull width)
- Dominant trees DBH range greater than 20 inches
- Dominant trees DBH range between 12 and 20 inches
- Dominant trees DBH range between 3 and 12 inches

“Dominant trees” refers to the tree size and type comprising the majority of the stand. This relates to the age of the stand and the ecological benefit that it may provide. “Pool forming

diameter" refers to the trunk diameter of trees of a size large enough to remain stable in the river/stream system and form pools when eroded into the river through channel migration.

Density

- Dense: Greater than 1/3 of the area covered by dominant trees
- Sparse: Less than 1/3 of the area covered by dominant trees
- Not Applicable: Shrub, grass, and urban cover types

Type

- Conifer: Greater than 70 % of stand is conifer
- Hardwood: Greater than 70 % of stand is hardwood
- Mixed: No stand dominance greater than 70%
- Shrub: Woody stemmed vegetation
- Grass: Agriculture or landscaped area
- Urban: Greater than 70% developed or modified

Environmental Classifications

Based upon the environmental criteria, classifications were developed to delineate riparian segments into environmental deficiency categories. These categories can be used to evaluate existing riparian zones, differentiate riparian conditions in multiple areas, as targets for mitigation opportunities, or for use in future riparian management. Riparian zones fall within the following deficiency classes when ALL bulleted conditions exist.

High Environmental Deficiency

- Existing buffer width less than 50 feet
- Buffer density sparse or not applicable
- Buffer type is shrub, grass, or urban
- Dominant trees DBH range between 3 and 12 inches
- Trees do NOT exist within the minimum pool forming diameter (0.025 times the bankfull width)

Moderate Environmental Deficiency

- Existing buffer width 50 feet or more
- Buffer density is sparse
- Buffer is conifer, hardwood, or mixed stand
- Dominant trees DBH range between 12 and 20 inches
- Trees do NOT exist within the minimum pool forming diameter (0.025 times the bankfull width)

Minimal Environmental Deficiency

- Existing buffer width 100 feet or more
- Buffer density is dense
- Buffer is conifer, hardwood, or mixed stand
- Dominant trees DBH range greater than 20 inches
- Trees do NOT exist within the minimum pool forming diameter (0.025 times the bankfull width)

No Environmental Deficiency

- Existing buffer width exceeds 150 feet or site potential tree high (which ever is greatest)
- Buffer density is dense
- Buffer is conifer, hardwood, or mixed stand
- Trees exist within the minimum pool forming diameter (0.025 times the bankfull width)

Physical Risk and Environmental Deficiency Delineation

The application of the physical risk assessment and environmental deficiency criteria is displayed in Figure A-15. The results of this delineation is also summarized is Table 1.

Table 1: River Segments Environmentally Deficient and Displaying Physical Risk.

Station (ft.)	Environmental Deficiency	Physical Risk
20000	HIGH	NO RISK
19000	MODERATE	
18000		MINIMAL
16200	HIGH	
15600	MINIMAL	
13800	MODERATE	
12000		MODERATE
10000		HIGH
7800	HIGH	
5200	MODERATE	
5000		MINIMAL
4700	HIGH	
3000	MODERATE	NO RISK
2000		
	HIGH	
600		
	MINIMAL	
0		

Physical Risk

Station 20000 to 18000 poses no physical risk to US 12 from erosion. The river is moving away from US 12 until it reaches the left valley wall. The right bank is bolstered by a large, broad levee that was placed during the early part of the nineteenth century. With this levee in place there is no risk to US 12 through this river segment.

From Station 18000 to 12000, the physical risk to US 12 was characterized as minimal. US 12 is isolated from the river by several levees and riprap installations placed to accommodate irrigation diversion operations. In addition, there are two significant floodplain fills that further isolate the roadway. Future risk to US 12 through this area may occur, but will likely require removal of levees and/or floodplain fill and would still be through a slow process of channel migration that would give river managers ample time to assess conditions and plan appropriately.

At Station 12000, channel confinement is reduced and some floodplain channels are accessible to the river during high discharges. However, this segment has experienced incision from the upstream confinement that restricts high flow access to the floodplain. Because of this restriction, the river is still somewhat confined to the left side of the valley. However during extreme flooding events, it is likely that the entire floodplain is inundated through this segment. While most flow will be moving through the current flow path and erosion potential through the floodplain will be relatively low, little resistance to erosion is present in the floodplain in the form of riparian vegetation. In addition, there is a series of beaver ponds in a former channel position that presents an avulsion risk toward US 12. Based upon our site evaluation this risk is currently low, but will become greater if the river migrates toward US 12. Again based on our site evaluation, migration toward US 12 through this area does not appear imminent and will likely be a slow enough process that appropriate actions can be taken in the future, hence the designation of moderate risk.

The area from Station 10000 to 5000 is designated as a high risk segment. However, there are some specific areas that are currently very close to severe risk designation and should be monitored closely. From Station 10000 to 8000, the river flows along the left valley wall where it runs along a bedrock knob that ultimately directs the river southeast across the valley toward US 12. Most, if not all, of these actions have been prompted by emergency conditions when the river was actively eroding the road prism. Many of these actions have also occurred during winter or spring months when the river's discharge is high, placement is hurried and uncertain, and the likelihood of environmental degradation is high. As discussed previously, this area is a depositional environment with a high degree of floodplain connectivity. Based on our site visit when flip flop flows (approximately 2200 cfs) occupied much of this area, the entire floodplain is likely inundated numerous times annually. In addition, there are several former channel positions through this area that convey concentrated overbank flows. This combination of channel dynamics makes this area vulnerable to future channel avulsion. Since the river is currently along the left valley wall, avulsion activities would be in the direction of US 12. From Station 8000 to

5000, the river is adjacent to US 12 and has threatened the roadway in the past prompting the installation of protection measures (placement of riprap and rock groins) that have been ongoing since at least the mid-nineteen nineties.

Below Station 5000, the river poses minimal risk to US 12 through Station 3000. This area has been lined with rock and other materials (several car/truck frames were seen) and the Yakima Greenways Trail is located between the river and the roadway. Channel migration would need to occur toward US 12, and that is unlikely under existing conditions. The lower 3000 feet of the project area is isolated from US 12 by distance existing levee and private property and poses no physical risk to US 12.

Environmental Deficiency

Station 20000 to 19000 has a high environmental deficiency based on the width of the riparian corridor: about 50 feet for much of the length of the buffer. Several of these trees are over 12 inches DBH, however none are approaching the minimum pool-forming diameter. Additionally, this buffer is roughly "one stem-width"; a configuration where the entire buffer is comprised of a single row of trees along a bank. No trees in this area are capable of contributing LWD that will be pool forming.

Station 19000 to 16200 displays a moderate environmental deficiency. This riparian buffer is all hardwoods and has increased width compared to the area just upstream, however trees are still roughly the same size. We identified no trees in this area that would be pool forming if they were delivered to the channel.

Environmental deficiency rating between Station 16200 to 15600 is high. This area is dominated by bare ground, a roadway, two different diversion structures, and bank revetment. The riparian vegetation that does exist in this segment is sparse and the riparian vegetation bands are narrow. None of the trees in this area are potentially pool forming.

Station 15600 to 13800 displays minimal environmental deficiency. While riparian in this area are still not of a size that will be pool forming, there are large trees within several stands in this segment. Additionally there are a few conifers in the stand. Width of this segment is over 400 feet for most of its length.

The area from Station 13800 to 7800 is designated as a segment of moderate environmental deficiency. Trees within this segment are not of a size that will be pool forming, and vegetation is patchy and sparse in many areas. Additionally, there is a road and other compacted areas that decrease the quality of this site.

The segment from Station 7800 to 5200 is the most environmentally deficient in the project area, with a "high" rating. There is no riparian vegetation for the majority of the reach, and what is left is patchy and relatively small in size. In fact, the width of floodplain, vegetated or un-vegetated, existing between the river's edge and the edge of the US 12 roadway prism is often far less than 50 feet.

The segment from Station 5200 to 4700 is a moderate environmental deficiency. The width of riparian vegetation is wider than that found just upstream. Trees in this segment are still too small to be pool forming, however they are less patchy than the segment upstream.

The area from Station 4700 to 3000 rates high in environmental deficiency, primarily because of the decreased width of the riparian buffer. Trees in this segment are sparse, relatively small, and not wider than one or two stem-widths for much of this corridor. None of the trees are of a size capable of forming pools were they to enter the channel as LWD. The Yakima Greenway Trail exists in this area and there has been clearing adjacent to the stream gaging station.

Station 3000 to 2000 contains a segment of moderate environmental deficiency. The floodplain is wider, and the width of the riparian buffer increases correspondingly. Trees in this are still of insufficient size to produce pools. Vegetation is sparse and the trail continues though this segment.

Station 2000 to 600 comprises a section of high environmental deficiency. This area contains more vegetation less than 50 feet in width. The vegetation that does exist is located in the narrow band between the water's edge and the top of the levee, where the trail is located. Trees in this segment do not meet the criteria for pool forming diameter.

The segment from Station 600 to 0 is a minimal environmental deficiency. Riparian buffers are dense and the segment width is over 100 feet. However there are still no trees capable of forming pools, particularly given that this segment is located along the wide channel area created by the Yakima River confluence area.

MANAGEMENT STRATEGIES

The types of management actions that could be undertaken throughout the area are described in Appendix I titled: Alternative Management Actions. Potential applications of the management actions described in Appendix I are discussed in this section of the report. Suggested placements are based on fluvial processes, channel patterns, and river/road interactions through the project area, and management actions differ from one area to another. In addition, the diverse, existing river conditions affect the appropriateness of actions in different locations. Finally, site specific constraints may limit the types, sizes, and extents of management actions that can be undertaken.

Management activities in the project area could be completed in numerous configurations. Decisions on how to manage the project area are likely to be linked to the availability and amount of funding that can be secured. In addition, material availability, permitting ease, perceived protection and/or stability benefit, and the desired long-term environmental conditions will likely play a role. The following discussion is developed to help in considering these issues as well as evaluating the type and appropriate implementation of management actions.

Station 20000 to 18000

Our evaluation began just downstream of the US 12 bridges near the Naches Gap. Management in this area could include some levee setback work. The levee along the right bank constricts flow, promoting channelization. This levee is very broad and could provide the same

flood protection benefits without encroaching upon the river to the same degree. Much of this levee material could be removed while maintaining flood protection with a setback levee. A floodplain terrace(s) could be incorporated into the excavated area that allowed flood inundation, reducing concentration of flows. This terrace could be planted with native riparian vegetation establishing a native community and promoting enhanced riparian conditions in the future. Reducing confinement and allowing flow to disperse through the floodplain will reduce the hydraulic energy of the river and promote more balanced sediment flux through the reach. This concept is encouraged here and at other locations through the project reach.

Mitigation Opportunities

The current riparian area in this reach has an environmental deficiency rating of either high or moderate. Therefore, planting and managing native vegetation to develop an appropriate plant community will enhance ecological conditions over time. Engineered Log Jam placement in this segment would likely be limited to locations on the fringe of the channel. This would improve instream habitat conditions by creating large, deep scour pools with cover without having a profound affect on channel morphology. However the jams would still alter low discharge conditions such that temporary sediment storage areas in the lee of the Engineered Log Jams would be created and available for spawning by anadromous salmonids.

Station 18000 to 12000

Because of its minimal risk to US 12, management actions in this segment do not include specific measures to protect the state highway. Management options in this segment would target some of the reach scale dynamics affecting downstream areas.

As previously discussed, US 12 is isolated from the river by several levees and riprap installations and two floodplain fills. These features confine flow and sediment routing such that much of this segment is a transport reach. The subsequent downstream deposition is concentrated and is a management concern. Therefore, management actions for this reach should target reducing the confinement of the river channel and allowing for some channel migration in a manageable manner.

The most profound impact is in the area is of the floodplain fill associated with the COY's pumphouse near Station 16000. This fill confines the channel to approximately 125 feet in width and has channelized the system resulting in downstream channel incision. It is our understanding that this pumphouse is no longer in use and removing the pumphouse and the fill material will provide more floodplain width for the river to access (both through channel migration and floodplain inundation). This will also alleviate some of the downstream incision and sedimentation impacts. Decreasing the channelization in the vicinity of Station 13000 to 12000 by removing fill materials placed sometime between 1947 and 1968 will also contribute to more natural channel evolution. In addition, rock weirs and/or deflectors are present in the segment. The purpose of these installations is to lock the channel in place to insure that irrigation demands are met. Comprehensive planning efforts should seek to meet irrigation demands using methods

more conducive to river channel processes. In summary, the collective effects of floodplain fills and diversion structures are impacting channel dynamics and contributing to downstream impacts. Removing these impacts will allow for more natural channel conditions where temporary sediment storage is evident in a much more broad distribution through the study area. The extent to which fill is removed should be based upon the degree of protection simultaneously placed and the expected downstream impacts.

Mitigation opportunities

Mitigation opportunities in this reach include riparian planting and the installation of Engineered Log Jams in the active channel. The current environmental deficiency rating for the riparian zone in this reach is either high or moderate. Therefore, planting and managing native vegetation will target developing a functional riparian zone over time. Engineered Log Jams could be placed in the mainstem of the channel and would improve instream habitat conditions by creating large, deep scour pools with cover. In addition, Engineered Log Jams can be placed such that they encourage channel alterations, such as channel migration and the creation of secondary channels. These alterations diversify flow conditions and reduce channelized, concentrated flow. This will reduce transport capacity and the degradation of instream conditions. It will also result in the creation of temporary sediment storage areas in the lee of the Engineered Log Jams. In other river systems, these lee areas have been used extensively for spawning by anadromous salmonids.

Station 12000 to 10000

The river is located along the left valley wall through this segment. While former channel positions are identifiable in the floodplain toward US 12, the river is incised through this area limiting the river's access to the floodplain. While it is certain that flow moves through the floodplain area during high discharges (based on our site investigations), the threat of avulsion toward US 12 is moderate without changes in mainstem channel position. The alteration in channel position would occur through channel migration leading to avulsion. Because we did have and survey data for channel and floodplain cross sections for this evaluation, it is difficult to assess the exact risk of avulsion toward US 12. This area should be monitored for channel migration activity and management actions should be taken to address heightened risk should it progress. Placement of Engineered Log Jam clusters and single logs through the floodplain will promote the growth and stability of existing riparian vegetation and encourage sediment deposition in the floodplain. Log clusters would be placed to protect established riparian areas and reduce the likelihood of channel avulsion toward US 12.

Mitigation Opportunities

Environmental deficiency rating for the current riparian area is moderate. Planting and managing native vegetation to develop an appropriate plant community can be done to enhance ecological conditions over time. Engineered Log Jam placement in this segment would likely be limited to locations on the fringe of the channel. This would improve instream habitat conditions

by creating large, deep scour pools with cover without having a profound affect on channel morphology. However the jams would still alter low discharge conditions such that temporary sediment storage areas in the lee of the Engineered Log Jams would be created and available for spawning by anadromous salmonids.

Station 10000 to 8000

Although the river flows down the left valley wall for much of this segment. This reach is considered high risk to US 12. This is because it is a strong depositional environment being affected by both upstream and downstream constriction points. Because ongoing deposition has raised the bed of the active channel, the channel is highly connected to the floodplain and flow traverses from the mainstem south across the floodplain toward US 12. We witnessed this during the flip flop and the magnitude of flow moving toward US 12 during high discharge and/or flood events is likely much greater. In addition, there are former channel positions through this area that provide avulsion opportunities. Moreover, the riparian zone is sparse, immature, and less than vibrant because of the inundation that occurs in this area during the flip flop. Based on our observations, without reach scale alterations in the sediment transport dynamics and/or changes to flip flop operations, the riparian zone in this area at risk of becoming permanently unstable is the vegetation to die off.

Because of the current mainstem configuration and the potential for channel avulsion, structural placements (Engineered Log Jams) seeking to alter existing conditions and prevent adverse future conditions can be placed in this reach. The locations of these Engineered Log Jams are shown in Figure 9. Engineered Log Jams 1 and 2 are placed such that they will interact with the existing mainstem channel and affect the distribution of high discharges. Specifically, these structures will promote more flow to traverse the floodplain and flow down channels through the middle of the mid-channel bar and along the left valley wall. In addition, these Engineered Log Jams will promote split flow conditions and/or channel avulsion through the mid-channel bar. This will reduce the erosion potential of the river by dispersing concentrated flows. Engineered Log Jam 3 will be placed to prevent adverse conditions should the channel avulse down a current secondary channel. This structure will prevent the river from heading south and interacting with US 12. Should this channel avulsion occur, Jam 3 would function with Jam 2 to promote split flow conditions and/or channel avulsion through the mid-channel bar.

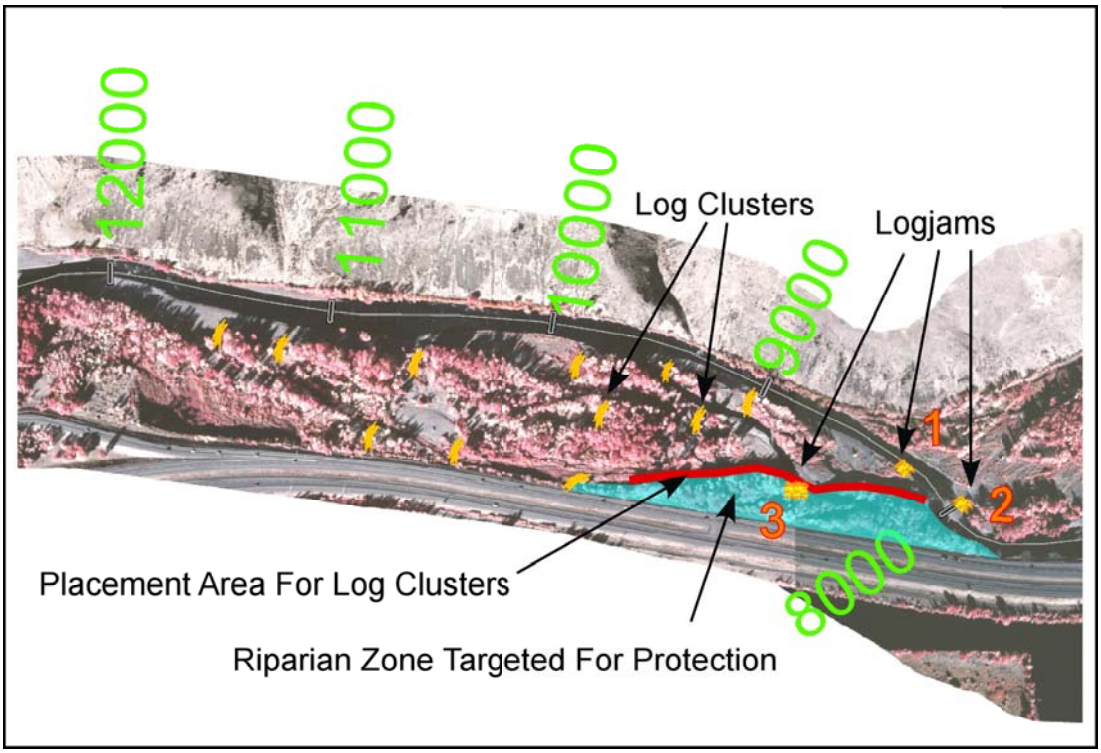

Figure 9: Management actions for Station 12000 to 8000.

Of primary concern is the protection of the riparian stand adjacent to US 12 depicted in Figure 9. For both physical and environmental reasons, protecting this stand from erosion is desirable. One option to protect this area is to place log clusters along the riparian fringe from approximately Station 9000 to 8300. In this area, the clusters would be continuous and would be placed among and in front of existing trees to limit flow into the area and divert most flow away. To provide added assurance of successful riparian protection, a log revetment as depicted in Figure I-5 could be placed through this area. Single logs could also be placed through the riparian area to disperse flow and promote sediment retention.

Mitigation Opportunities

Environmental deficiency rating for the current riparian area is moderate. Planting and managing native vegetation to develop an appropriate plant community can be done to enhance ecological conditions over time. To protect additional riparian areas, log clusters could also be placed in other locations through the floodplain. These clusters would seek to protect existing riparian stands and promote the creation of a forested island should channel migration or avulsion occur. An example of these placements is depicted in Figure 9.

Station 8000 to 5000

Alternative management actions for this high risk area from Station 8000 to 5000 are highly dependent upon the desired long-term environmental conditions through this area. The current environment classification for this area is highly deficient. Past management practices have been

to place riprap and/or rock groins to help control the river. Continuing these practices may be successful in protecting US 12, but will not result in improved environmental conditions. In addition, offsite mitigation will likely be required if this maintenance strategy is continued. One option to placing rock groins is constructing Engineered Log Jams in series similar to groin placement. Engineered Log Jams in series have been found to be effective flow deflection components that also enhance aquatic habitat conditions (Drury 1999). An additional benefit to Engineered Log Jams is that they are conducive to vegetation and can support healthy riparian growth. However, this riparian growth would be sparse and future environmental deficiency classification would remain high through this area.

In order to improve environmentally deficient conditions in this reach, some form of floodplain reclamation will need to occur, in conjunction with a comprehensive riparian planting plan. Reclaiming floodplain area can be done using either a rock revetment or wood cribwall or combination of the two materials as described in Appendix I and shown in Figures I-3 thru I-6. Regardless of which primary construction material is choosen, design criteria for these types of structures is similar. Some of these parameters are displayed in Figure 10 assuming a woody debris cribwall is chosen.

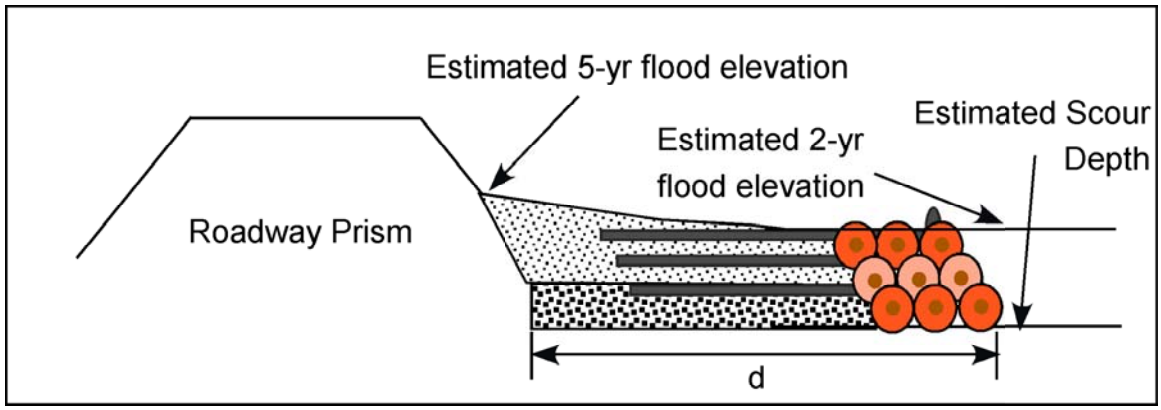

Figure 10: Basic design criteria for floodplain reclamation using LWD revetment.

The distance (d) shown in Figure 10 is dependent upon the desired long-term environmental conditions, site specific conditions, and the size of materials (length of logs) used in the structure. The configuration shown in Figure 10 is applicable for distance (d) of approximately fifty feet, assuming logs on the order of thirty-five to forty feet in length are used. Based upon the criteria described in this report, a buffer width of fifty feet is the threshold between high and moderate environmental deficiency. Therefore, the long-term environmental classification of this configuration would border between high and moderate even with the development of a functional riparian zone as shown in Figure 11.

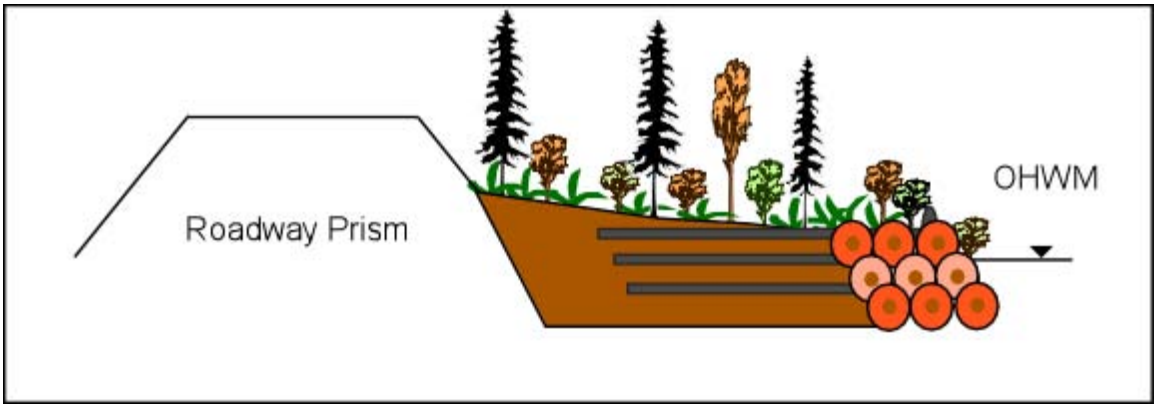

Figure 11: Potential longterm conditions using floodplain reclamation approach.

In order to establish long-term environmental conditions with a lower than high deficiency rating, the width of the reclaimed floodplain must be lengthened. As this width increases, we recommend consideration of design modifications that include additional structure in the reclaimed area to promote stability and reduce the likelihood of erosion during extreme events (Figure 12).

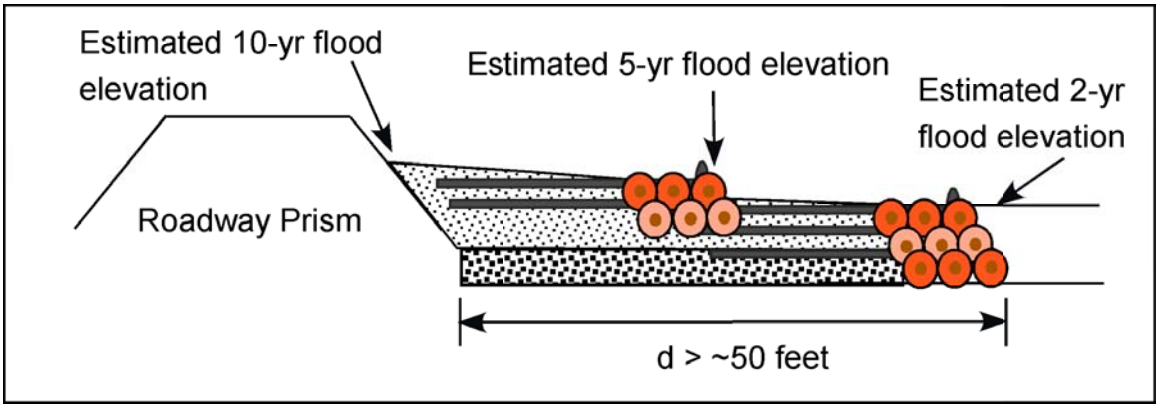

Figure 12: Conceptual design for floodplain reclamation exceeding approximately fifty feet.

With this type of configuration, a terraced floodplain could be developed that provides additional protection against erosion and also establishes a higher elevation terrace that would enhance the successful recruitment and growth of inundation intolerant riparian species. This could result in a coniferous dominated upper terrace and a deciduous dominated lower terrace as shown in Figure 13.

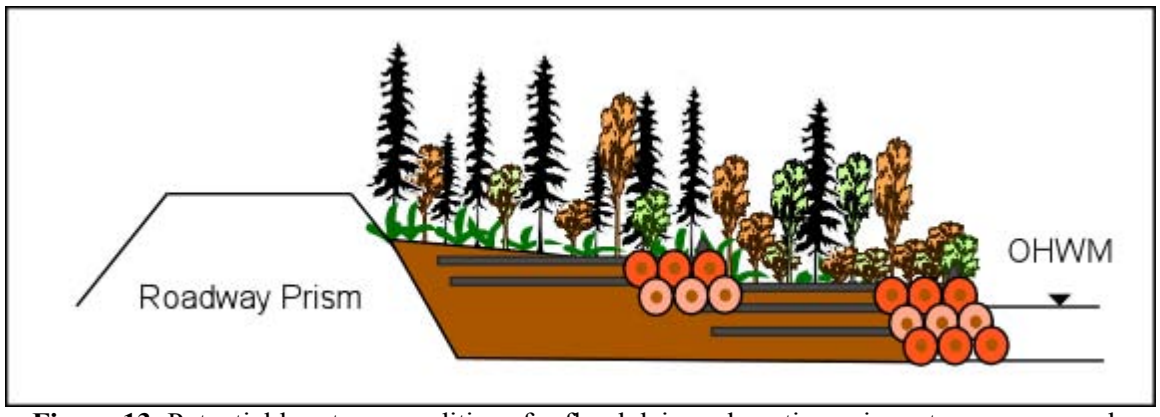

Figure 13: Potential longterm conditions for floodplain reclamation using a terrace approach.

In addition to the placement of the revetment/cribwall and the riparian plantings, we recommend that single logs be placed across the floodplain as shown in Figure I-9. This will disperse flood flows, reduce the likelihood of erosion, and promote future native recruitment.

The spatial extent of this installation would be from approximately Station 5400 where it would tie into the prism of the parking lot near the 16th Avenue interchange to approximately Station 8200 with the upper three hundred feet running parallel to US 12 through the existing riparian area (Figure 14). It is extremely important to extend the upper extent of the structure beyond the area of expected change once the structure has been constructed.

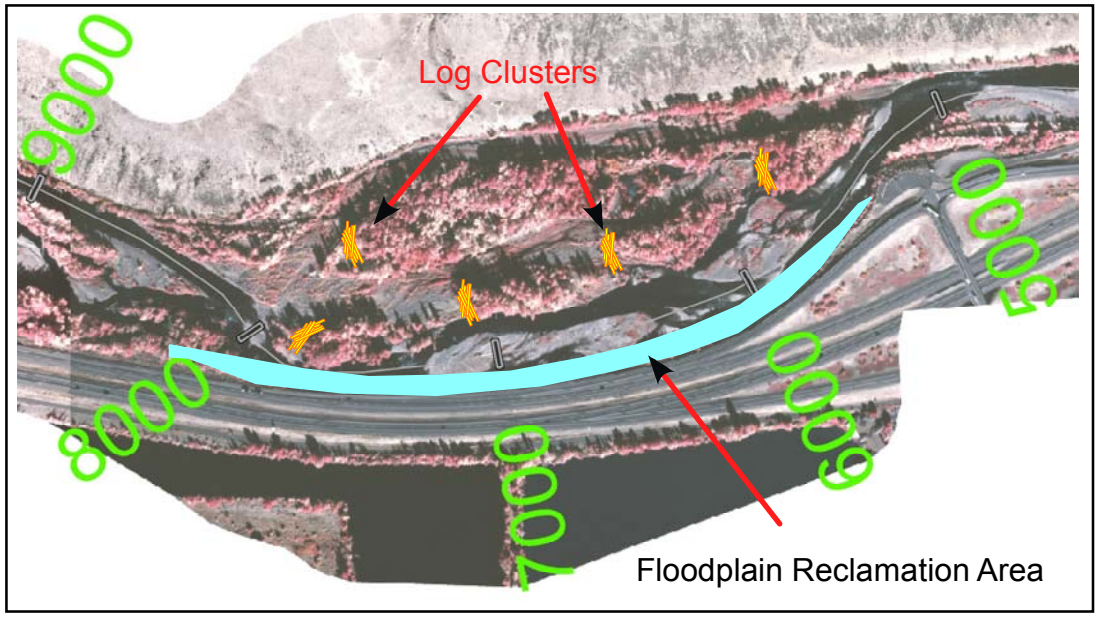

Figure 14: Potential management actions from Station 5000 to 8000.

The fill for the 16th Avenue Yakima Greenway parking area constricts the channel width to approximately 200 feet. While not as dramatic as the constriction at Station 16000, this fill has contributed to the channelization of the system resulting in downstream channel incision. Removing this fill material will provide more floodplain width for the river to access (both through channel migration and floodplain inundation) and will alleviate some of the downstream incision, allowing for more natural channel evolution.

Mitigation Opportunities

Environmental deficiency rating for the current riparian area is high. Planting and managing native vegetation between the river and US 12 would not be successful under existing conditions. Planting could be done in the floodplain across the river to develop an appropriate plant community and enhance vegetation density. To protect additional riparian areas, log clusters could also be placed in locations throughout the floodplain. These clusters would seek to protect existing riparian stands and promote the creation of a forested island should channel migration or avulsion occur. An example of these placements is depicted in Figure 14.

Station 5000 to 3000

This segment begins at the 16th Avenue Yakima Greenway parking area and ends near the gaging station, where US 12 angles away from the Naches River. The close proximity of US 12 to the river would typically result in a risk level greater than minimal. However the Yakima Greenway Foundation maintains a trail through this area between the river and US 12. The area between the river and the trail is armored in several locations, and the river would need to erode through the armoring and the trail before threatening US 12. In addition, this segment of the river is straight, narrow, incised, and little channel movement is likely under existing conditions. Because of these conditions, management actions are not currently required through this area.

Mitigation Opportunities

Environmental deficiency rating for this area is either high or moderate. Therefore, planting and managing native vegetation to develop an appropriate plant community will enhance ecological conditions over time. Riparian planting can be done between the river and the COY's trail as well as between the trail and US 12. Engineered Log Jam placement in this segment could be such that they provide additional protection to the trail, while improving instream habitat conditions by creating large, deep scour pools with cover. Placement would be limited to locations on the fringe of the channel. The effects of the jams would still alter low discharge conditions such that temporary sediment storage areas in the lee of the Engineered Log Jams would be created and available for spawning by anadromous salmonids.

Station 3000 to 0

The lower segment of the river is straight, narrow, incised, and does not present a risk to US 12, hence management actions to protect US 12 targeting physical processes are not required for this area. Future management of this segment is dependent upon actions taken in upstream

reaches. The likely result of future actions would be increased sediment storage through this reach. However, it is unlikely that aggradation in this reach will be significant. Therefore, upstream actions are not likely to cause future management concerns in this reach.

Mitigation Opportunities

This segment does present mitigation opportunities. Environmental deficiency rating for this reach is either high or moderate. Planting and managing native vegetation to develop an appropriate plant community will enhance ecological conditions over time. Riparian planting can be done between the river and the trail as well as between the trail and US 12. Engineered Log Jam placement in this segment could be such that they provide additional protection to the trail and/or bridge abutments, while improving instream habitat conditions by creating large, deep scour pools with cover. Placement would be limited to locations on the fringe of the channel. The effects of the jams would still alter low discharge conditions such that temporary sediment storage areas in the lee of the Engineered Log Jams would be created and available for spawning by anadromous salmonids.

MANAGEMENT SUMMARY

Management actions within the project area can be site specific targeting a particular problematic area, or can be used to affect reach scale processes impacting much larger areas. Design criteria can also vary from short term protection of infrastructure to long-term goals of reach scale ecological restoration. Based on our evaluation, there are two management approaches that could be taken within the project area.

1) One approach is to focus on efforts that protect US 12 using placements of large rock. This will include placing riprap from approximately Station 8000 to 5000 and installing additional rock groins or Engineered Log Jams as deflectors through this area as needed. This approach would also include installing protection measures from Station 10000 to 8000 as described earlier. The objective of these protection measures is to prevent the river from migrating south to US 12 resulting in conditions similar to those from Station 8000 to 5000. Placing rock in the river is likely going to require mitigation. As described, there are numerous mitigation opportunities within the project area. These mitigation actions typically target rehabilitation of riparian areas or the enhancement of instream habitat conditions. The exact mitigation activities will need to be negotiated with regulatory agencies. The layout of this strategy is displayed in Figure A-16.

2) The second approach is to integrate reach scale processes into management actions that provide longterm self sustainable protection, better accommodate natural channel processes, and enhance long-term ecological conditions. This approach would seek to remove or modify human impacts that have altered the routing of sediment through the reach and re-establish a healthy riparian buffer between the Naches River and US 12. Levees would be setback and fill materials

in the floodplain would be removed as shown in Figure A-17. This would remove constriction points promoting incision in some areas and deposition in others and reestablish more balanced patterns of sediment transport and storage through the project area. An extensive revetment or cribwall would be constructed from approximately Station 8200 to 5400. This structure would reclaim floodplain area and allow for the establishment of a healthy riparian buffer between the river and US 12 over time. Engineered Log Jams would be placed near Station 9000 to divert and split flow, and additional Engineered Log Jams could be placed through the reach to improve instream habitat conditions.

Implementing this approach will likely require property acquisition, partnership with local municipalities and/or agencies, coordination with other stakeholders, and consultation with regulatory agencies. In addition, the extent of fill and constriction removals should be evaluated based upon topography that was not available for this evaluation. Removal of fill in some areas may introduce greater risk to US 12 and should be carefully evaluated. Protection measures not suggested in this report may need to be incorporated into fill removal projects to address any increases in risk to US 12.

LIMITATIONS

We have prepared this report for use by the Washington State Department of Transportation in evaluating the geomorphic conditions and developing a management plan to address infrastructure and environmental concerns along US 12 and the lower 3.75 miles of the Naches River. Further development of specific protection or rehabilitation plans will require additional evaluation and collective acceptance of stakeholders. Conditions within the subject reach may change both spatially and with time, and additional scientific data may become available. Significant changes in site conditions or the available information may require reevaluation.

Within the limitations of scope, schedule, and budget our services have been executed in accordance with generally accepted scientific and engineering practices in this area at the time this report was prepared. No warranty or other conditions, express or implied, should be understood.

Please refer to the appendix titled Report Limitations and Guidelines for Use for additional information pertaining to use of this report.

We appreciate the opportunity to work on this project with you. Please call with any questions that you have or if there is anything else that we can do for you.

Respectfully Submitted,

GeoEngineers, Inc.

Tracy A. Drury,
Senior, River Science and Engineering

Galan W. McInelly,
Principal

GWM:TD2:ads

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REFERENCES CITED

Brown, Dave. City of Yakima, Public Works. Pers. Comm. November 7, 2002.

Cepello. S. A. 1991. Riparian vegetation distribution along the middle Sacramento River in relation to flood frequency. Unpublished M. S. Thesis. California State University, Chico.

Collins, B. 1995. Riverine gravel mining in Washington state, overview of effects on salmonid habitat, and a summary of government regulations. Unpublished report to the US EPA, Seattle.

Columbia Basin System Planning (CBSP). 1990. Yakima River Subbasin Salmon and Steelhead Production Plan.

Crivelli, A. J., P. Grillas, P., and B. Lacaze. 1995. Responses of vegetation to a rise in water-level at Kerkini Reservoir (1982–1991), a Ramsar site in northern Greece. Environmental Management, 19:417–430.

Dawson, T.E. and Ehleringer, J.R. 1993. 'Gender-specific physiology, carbon isotope discrimination, and habitat distribution in box elder, Acer negundo', Ecology, 74, 798–815.

Drury, T.A. 1999. Stability and pool scour of engineered log jams in the North Fork Stillaguamish River, Washington. Masters Thesis, Department of Civil and Environmental Engineering, University of Washington, 62 pp.

Drury, T.A. 1999. Evaluation of Engineered Log Jams as a Soft Bank Stablilization Technique: North Fork Stillaguamish River, Washington. Paper submitted to ASCE's 1999 International Water Resource Engineering Conference, Seattle, Washington, 10 pp.

Friedman, J. M., and G. T. Auble. 1999. Mortality of riparian box elder from sediment mobilization and extended inundation. Regulated Rivers: Research and Management, 15:463–476.

Friedman, J.M., W. R. Osterkamp, M. L. Scott, G. T. Auble. 1998. Downstream effects of dams on channel geometry and bottomland vegetation: regional patterns in the Great Plains. Wetlands, 18: 619-633.

GeoEngineers, 2001. South Fork Nooksack, Larson's Bridge Historical Scale Log Jam Project Description and Construction Documnetation. Prepared for the Lummi Natural Resources Department, 62 pp, 30 Sheets.

Gill, C.J. 1970. The flooding tolerance of woody species—a review. Forestry Abstracts, 31, 671–688.

Galay, V.J. 1983. Causes of river bed degradation. Water Resources Research, 19:1057-1090.

General Land Office. 1866. Department of the Interior, Surveyor General's Office. Map of Township 13 North, Range 18 East, Willamette Meridian. May 9, 1866.

Gregory, S. V., F. J. Swanson, W. A. McKee, and K. W. Cummins. 1991. An ecosystem perspective of riparian zones. Bioscience, 41, 540-551.

Hosner, J.F. 1960. Relative tolerance to complete inundation of fourteen bottomland tree species. Forest Science, 6(3): 246-251.

Kinnison, H.B., and J.E. Sceva. 1963. Effects of hydraulic and geologic factors on streamflow of the Yakima River Basin, Washington. U.S. Geological Survey Water Supply Paper 1595.

Knighton, A.D. 1998. Fluvial forms and processes. A new perspective. Arnold, London, 383pp.

Kondolf, G. M., Smeltzer, M., Kimball, L. 2001. Freshwater Gravel Mining and Dredging Issues. White Paper Prepared for the Washington Department of Fish and Wildlife, the Washington Department of Ecology, and the Washington Department of Transportation. Center for Environmental Design Research, University of California Berkeley, December 10, 2001.

Kondolf, G. M. 1997. Hungry Water: Effects of Dams and Gravel Mining on River Channels. Environmental Management, Vol 21 Issue 4, pp. 533-551

Mahoney, J. M. and S. B. Rood. 1998. Streamflow requirements for cottonwood seedling recruitment—an integrative model. Wetlands, 18, 634-645.

Merigliano, M. F. 1996. Ecology and management of the South Fork Snake River cottonwood forest. Idaho Bureau of Land Management Technical Bulletin 96-9.

Montgomery and Buffington, 1998. Channel processes, classification and response. In: River Ecology and Management. Robert Naiman and Robert Bilby, Eds. Springer-Verlag. New York, pp. 13-42.

Naiman, R.J., T.J. Beechie, L.E. Benda, D.R. Berg, P.A. Bisson, L.H. MacDonald, M.D. O'Connor, P.L. Olson, and E.A. Steel. 1992. Fundamental elements of ecologically healthy watersheds in the Pacific Northwest coastal ecoregion, p. 127-188. In: R.J. Naiman (ed.), Watershed Management: Balancing Sustainability and Environmental Change. Springer-Verlag, New York.

National Marine Fisheries Service. 2003. (Note: agency is now referred to as NOAA Fisheries). Listed Species website. Information accessed on May 9, 2003. URL: http://www.nwr.noaa.gov/1salmon/salmesa/chinswit.htm

Nilsson, C, and Berggren, K, 2000, Alterations of riparian ecosystems caused by river regulation, BioScience, 50(0):783-792.

Parker, G. L., and F. B. Storey. 1916. Water Powers of the Cascade Range: Part III. Yakima River Basin, Washington. U.S. Geological Survey Water Supply Paper 369.00000.

Reid, L. M. 1981. Sediment production from gravel-surfaced forest roads, Clearwater Basin, Washington. Final report to Fisheries Research Institute, College of Fisheries, University of Washington, Seattle WA. Submitted by C.J. Cederholm and E.O. Salo.

Ring, T. E., and B. Watson. 1999. Effects of geologic and hydrologic factors and watershed change on aquatic habitat in the Yakima River Basin, Washington. Pages. 191-194. in Sakrison, R. and P. Sturtevant, editors. 1999 Watershed Management to Protect Declining Species. TPS-99-4. American Water Resources Association, Middleberg, Virginia, USA.

Roberts, M. D., D. R. Peterson, D. E. Jukkola, and V.L. Snowden. 2002 DRAFT. A pilot investigation of cottonwood recruitment on the Sacramento River. In: Proceedings of the California Riparian Habitat Joint Venture: Riparian Habitat and Floodplains Conference. March 12 - 14, 2001, Radisson Hotel, Sacramento, California.

Roe, Arthur L. 1958. Silvics of black cottonwood. USDA Forest Service, Miscellaneous Publication 17. Intermountain Forest and Range Experiment Station, Ogden, UT. 18 p.

Rood, S. B. and, J. M. Mahoney. 1990. Collapse of riparian poplar forests downstream from dams in western prairies: probable causes and prospects for mitigation. Environmental Management, 14(4):451-464.

Scott, M. L., J.M. Friedman, G. T. Auble. 1996. Fluvial process and the establishment of bottomland trees. Geomorphology, 14, 327-339.

Snowden, V. L. 2002. Hydrologic alterations to the Sacramento River and the effect son cottonwood seedlings. Unpublished master's thesis. California State University, Chico.

Snyder, E.B. and J.A. Stanford. 2001. Review and Synthesis of River Ecological Studies in theYakima River, Washington, With Emphasis on Flow and Salmon Habitat Interactions – *Draft* Final Report from the Flathead Lake Biological Station, The University of Montana. Submitted to U.S. Dept. of Interior, Bureau of Reclamation.

Snyder, E. B. and J. A. Stanford. 2001. Review and synthesis of river ecological studies in the Yakima River, Washington, with emphasis on flow and salmon habitat interactions. Appendix A: Riparian Vegetation of the Yakima River, written by Mary J. Harner. Final Report from the Flathead Lake Biological Station, The University of Montana. Submitted to: U.S. Department of Interior, Bureau of Reclamation, Yakima, WA, August 21, 2001.

Soil Conservation Service. 1985. Soils Survey of Yakima County Area, Washington.

Sommer, T. R., Harrell W.C., Nobriga, M. L., Brown, R., Moyle, P. B., Kimmerer W.J., and Schemel, L. 2001. California's Yolo Bypass: Evidence that flood Control can becompatible with fisheries, wetlands, wildlife, and agriculture. Fisheries. V. 26, no. 8.

Sommer, T.R., Nobriga, M. L., Harrell, W.C., Batham W., and Kimmerer W.J. 2000. Floodplain rearing of juvenile chinook salmon: evidence of enhanced growth and survival. Canadian Journal of Fisheries and Aquatic Sciences V. 58 no. 2, pp. 325-333.

Southeastern Forest Experiment Station, 1958. Annual Report, 1957. Asheville, N. C. 75 pp.

Stanford, J. A., and J. V. Ward. 1988. The hyporheic habitat of river ecosystems. Nature, 335:64-66.

Stanford, J. A., E. B. Snyder, M. N. Lorang, D. C. Whited, P. L. Matson, J. L. Chaffin. 2002. The Reaches Project: ecological and geomorphic studies supporting normative flows in the Yakima River Basin, Washington. Open File Report 170-02. Report prepared for Yakima Office, Bureau of Reclamation, US Department of the Interior, Yakima Washington by Flathead Lake Biological Station, The University of Montana, Polson, Montana. 152 pp.

Stevens, L.E. and Waring, G.L. 1985. 'The effects of prolonged flooding on the riparian plant community in Grand Canyon', In: Johnson, R.R., Ziebell, C.D., Patton, D.R., Ffolliott, P.F., and Hamre, R.H. (Eds), Riparian Ecosystems and Their Management : Reconciling Conflicting Uses. First North American Riparian Conference, U.S. Department of Agriculture, Forest Service General Technical Report RM-120, Fort Collins, CO. pp. 81–86.

Tockner, K., and F. Schiemer. 1997. Ecological aspects of the restoation strategy for a river-floodplain system on the Danube River in Austria. Global Ecology and Biogeography Letters, 6:321-329.

United States Army Corps of Engineers. 1970. Flood Plain Information: Yakima and Naches Rivers, Yakima-Union Gap, Washington. Prepared for the Washington State Department of Water Resources by the USACE, Seattle District. May, 1970.

United States Army Corps of Engineers. 1970. Floodplain information, Yakima and Naches Rivers, Yakima-Union Gap, Washington, USACE, 57 p., 17 plates.

United States Fish and Wildlife Service. 2003. Listed Species website. Information accessed on May 9, 2003. URL: http://ecos.fws.gov/servlet/SpeciesProfile?spcode=E065#status

United States Forest Service. 1995. Naches Mainstem and Wenas Watershed Analysis. Conducted by Naches Ranger District, Wenatchee National Forest.

U.S. Department of the Interior, U.S. Bureau of Reclamation (USBR). 2002. DRAFT Interim Operations Plan (IOP). May 15, 2002. Draft Interim Comprehensive Basin Operating Plan for the Yakima Project, Washington.

Walsh, T.J. 1986. Geologic map of the west 1/2 of the Yakima quad, WA. Washington State Department of Natural Resources, Division of Geology and Earth Resources. OFR 86-4, 1 pl., 1:100,000 scale.

Washington State Conservation Commission (WSCC). 2001. Habitat Limiting Factors: Yakima River Watershed Water Resource Inventory Areas 37 – 39. Final Report. December 2001

Washington Department of Fish and Wildlife (WDFW). 1998. Yakima River Stream Catalog, Columbia River Basin, Washington – DRAFT.

Washington Department of Fish and Wildlife (WDFW). 1997a. Draft Basin Conservation Plan (Yakima River).

Weaver, William, and Hagans, Danny. 1994. Handbook for Forest and Ranch Roads. Prepared for the Mendocino County Resource Conservation District by Pacific Watershed Associates.

Whitlow, T.H. and Harris, R.W. 1979. 'Flood tolerance in plants: a state-of-the-art review', Technical Report E- 79- 2, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Ziemer, R. R. 1998. (Technical coordinator/editor). Proceedings of the conference on coastal watersheds: the Caspar Creek story. 1998 May 6; Ukiah, CA. General Tech. Rep. PSW GTR-168. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 149 p.