Confederated Tribes of the Umatilla Indian Reservation

Lower Walla Walla River

Geomorphic Assessment and Action Plan

December 2014

TETRA TECH

Lower Walla Walla River
Geomorphic Assessment and Action Plan

Submitted to:

The Confederated Tribes of the Umatilla Indian Reservation
Walla Walla Community College
Water and Environmental Center, Office 485
500 Tausick Way
Walla Walla, WA 99362

Submitted by:

TETRA TECH

19803 North Creek Parkway
Bothell, WA 98011
Tel 425.482.7600 | Fax 425.482.7652
www.tetratech.com

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Executive Summary

The Confederated Tribes of the Umatilla Indian Reservation (CTUIR) has a vested interest in restoring and enhancing high-quality ecological conditions for aquatic species in the Walla Walla Subbasin (Subbasin). This stems in part from its First Foods planning and mission and River Vision approach to ecosystem management, which requires developing systematic and holistic visions of functional ecosystems to guide the management and restoration of First Foods. The First Foods are those foods ritualistically served in the CTUIR tribal meals that include water, salmon, deer, cous and huckleberry. The First Foods mission of the Confederated Tribes of the Umatilla Indian Reservation is "To provide proactive planning and policy analysis and development to protect, restore and enhance the First Foods and the exercise of associated rights reserved in the Treaty of 1855." As part of the Treat of 1855, the CTUIR reserved its right to obtain the First Foods in their Usual and Accustomed areas that includes the Subbasin.

Recognizing the importance of the Lower Walla Walla River (the portion of the river from the town of Lowden, Washington, to the river's confluence with the Columbia River) for overwinter holding and rearing habitat for salmonids, as well as landowner concerns about channel stability and bank erosion, the CTUIR helped form the Lower Walla Walla Working Group (LWWWG) in 2010. The LWWWG is a collaborative effort by the Blue Mountain Land Trust, CTUIR, Tri-State Steelheaders, Walla Walla County Conservation District, Washington Department of Ecology, and Washington Department of Fish and Wildlife to address factors limiting aquatic productivity as well as landowner concerns.

The Lower Walla Walla River is a low-gradient, primarily single-channel system, which passes almost entirely through agricultural areas. Relative to historical conditions, it has been highly simplified, straightened, restricted from historical floodplains, and impacted by irrigation withdrawals. Throughout the last 15 years, projects such as irrigation improvements, diversion screens, riparian plantings, conservation easements, establishment of instream flows, and some habitat restoration and fish passage projects have been implemented to address degraded conditions in the Lower Walla Walla River. Despite these project actions, recent research by CTUIR biologists has discovered high mortalities in out-migrating fish in the lower river, with as many as 70 percent of smolts that enter the Lower Walla Walla River failing to reach McNary Dam on the Columbia River.

Native fish assemblages in the Walla Walla River Subbasin have evolved to thrive in a system of cold and clean water, complex and dynamic lotic habitats, dense riparian communities, and ecological connectivity between the aquatic and terrestrial environment (floodplains). Among the native salmonids in the Walla Walla system, bull trout *(Salvelinus confluentus)* and steelhead *(Oncorhynchus mykiss),* are listed as threatened under the

Endangered Species Act (ESA). Redband trout *(O. mykiss)* are largely distributed in headwater areas with relatively cool and stable flows. Spring Chinook *(O. tshawytscha)*, extirpated by the 1950s, were reintroduced to the river in 2000 by the CTUIR.

Direct and indirect impacts from anthropogenic alterations to the Lower Walla Walla River over the past century, including key impacts starting with beaver trapping and attempted eradication in the early 1800s, have negatively affected water quantity and quality, as well as the quantity and quality of remaining fish habitat. Various assessments and planning efforts focused on water resources, fish, wildlife, and habitat have been conducted at the Subbasin scale resulting in coordinated water, fish, wildlife, and habitat management and prioritized restoration and protection strategies in the Subbasin. The majority of restoration and enhancement efforts identified in past assessments and planning efforts have focused on the upper portion of the Subbasin, however, despite acknowledgement that the lower river areas received high rankings in those assessments. The rationale for lower prioritization of the lower portions of the Walla Walla River was based on lack of empirical data, practicality, and that the Lower Walla Walla River currently only supports a portion of the life stages for focal fish species (migration and overwinter use). More recent research has indicated that in lower portions of the Walla Walla River physical and physiological limiting factors including water quantity, quality, and temperature, along with biological factors such as predation, may be more important than previously thought. This information indicates the need to more thoroughly assess and address degraded conditions and sources of mortality in the lower basin that could be acting as a bottleneck to both important salmonid overwinter rearing habitat and overall recovery of fish species.

To preliminarily assess the degraded conditions and identify potential restoration and enhancement projects in the lower portions, the LWWWG cooperated on the Lower Walla Walla River Habitat Improvement Strategy (Lewis 2012) in 2011. This strategy was an assessment- and planning-level look at the Lower Walla Walla River from approximately the town of Lowden, Washington, to the river's confluence with the Columbia River, a stretch of approximately 27 miles. The strategy emphasized the importance of the lower river as a priority for restoration, and identified high water temperatures and channel degradation, particularly unstable cut banks, as substantial habitat problems there.

In recognition of these issues, as well local concerns about channel stability and bank erosion, the LWWWG determined the need for a detailed geomorphic assessment and action plan (GAAP). This GAAP builds upon the more than four decades of past research and management efforts to more fully understand the physical and biological processes and limiting factors affecting the Lower Walla Walla River (the geomorphic assessment portion), and identify and prioritize restoration and enhancement opportunities (the action plan component). The report organization and brief summary of results are as follows:

Section 1, Introduction, describes the context for development of the GAAP. The types of data (both existing and those from recent field surveys) that were considered are set out, including situating the GAAP within a regulatory context, given the many levels of governmental and tribal management that need to be considered. This review is followed by an explanation of the methods and metrics to be employed in analyzing conditions (the results of which are reported in Section 3).

Section 2, Subbasin Description, of the GAAP summarizes current knowledge of the Subbasin with a focus on fish life histories, fish utilization (when and where the fish species occur), and limiting factors within the Lower Walla Walla.

Section 3, the Geomorphic Assessment, presents the results from the synthesis of prior data with recent field surveys, in terms of historic, current, and desired future conditions. Based on those results, the Lower Walla Walla River was broken into 7 geomorphic reaches and 5 biologically significant reaches, with 15 ecological nodes (e.g., areas of increased channel complexity, off-channel habitat, potential spawning areas, or tributary junctions) included within those reaches. The data show there are large gaps between geomorphic function and geomorphic potential in all reaches except Reach 3. Focal fish species utilization potential was high or very high throughout the majority of the reaches. These data provided the foundation for future restoration plans.

Section 4 describes the Action Plan component in which a rigorous process was used to evaluate how types of project actions will address focal limiting factors that are most likely to benefit focal fish species populations while avoiding the approach of conducting restoration projects based solely on opportunity. The goal of the Action Plan is to provide the LWWWG with identified and prioritized restoration and enhancement projects that can be replicated efficiently to multiple areas on the Lower Walla Walla River and, through quantifiable and repeatable metrics, can demonstrate progress toward addressing limiting factors. Within the Action Plan:

- Fourteen project areas were identified along with 16 types of restoration and enhancement actions to address 15 primary focal limiting factors within those areas.
- Project areas were ranked based on analysis of current and potential biological and geomorphic function information, and factor in cost/benefit and feasibility into overall scores. Project areas 5, 7, 12, 13, and 14 received the highest ranking (Tier I rankings).
- Twenty-eight types of monitoring metrics and methods were referenced that may be used to evaluate baseline riparian, floodplain, off-channel and in-channel characteristics and future impact of project actions on focal species limiting factors.
- Conceptual designs at four representative sites were provided that illustrate 12 types of project actions designed to restore and enhance habitat to its full potential, are practical to implement, and can be adapted and scaled to multiple sites.

The last section, Section 5 (Next Steps), includes recommendations for continued research, and other items for initiating the "action" part of the Action Plan (project implementation). Addressing these steps will help ensure the GAAP will be flexible and useful both in the short term and well into the future.

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ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
°F	degrees Fahrenheit
BPA	Bonneville Power Administration
BSR	Biologically Significant Reach
BSTEM	Bank Stability and Toe Erosion Model
cfs	cubic feet per second
CHaMP	Columbia Habitat Monitoring Program
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CWA	Clean Water Act
DEM	digital elevation model
Ecology	Washington Department of Ecology
EDT	Ecosystem Diagnosis and Treatment
EMAP	Environmental Monitoring and Assessment Program
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FLIR	forward looking infrared
GAAP	Geomorphic Assessment and Action Plan
GIS	geographic information system
GPS	Global Positioning System
HEC-RAS	Hydrologic Engineering Centers River Analysis System
HIP III	Habitat Improvement Program
IMU	inertial measurement unit
LiDAR	light detection and ranging
LWD	large woody debris

LWWWG	Lower Walla Walla Working Group
mg/L	milligram per liter
NMFS	National Oceanographic and Atmospheric Administration, National Marine Fisheries Service
NPCC	Northwest Power and Conservation Council
NRCS	U.S. Department of Agriculture Natural Resources Conservation Service
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
PA	Project Area
PHAMS	Physical Habitat Monitoring Strategy
RM	river mile
RTK	real-time kinematic
RV	recreational vehicle
SEM	Stream Evolution Model
Subbasin	Walla Walla Subbasin
TIN	Triangulated Irregular Network
TMDL	Total Maximum Daily Load
TSS	Tri-State Steelheaders
USACE	U.S. Army Corps of Engineers
USFS	U.S. Department of Agriculture Forest Service
USFWS	U.S. Fish and Wildlife Service
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resource Inventory Area
WWBWC	Walla Walla Basin Watershed Council
WWCCD	Walla Walla County Conservation District

GLOSSARY

Alluvial – a deposit of unconsolidated sediments left by flowing streams in a river channel, delta, estuary, or floodplain.

Biologically Significant Reaches (BSRs) – stream reaches with similar fish use and limiting factor characteristics.

Channel Stability – a general term that refers to the resistance of bed and bank erosion from a river in response to changes in flow or sediment transport. Natural stream channels have varying degrees of stability. A naturally stable channel has the ability to transport water and sediment over time without an overall net increase in aggradation or degradation. Under this definition, streams may migrate laterally if they maintain their natural dimensions (width, depth), pattern (sinuosity), and profile (gradient and bed features).

Channel Substrate – the composition of the river channel bed materials within the active channel.

Clean Water Act (CWA) – the primary federal law in the United States governing water pollution.

Confinement – a general term used to describe the degree to which a stream is laterally contained. Confinement widths would include natural high terraces, hillslopes, or artificial features.

Diversion Screen – devices installed at surface water diversions to physically preclude passage of fish into the intake and injury of fish at the intake.

Embeddedness – the extent that larger cobbles or gravel are surrounded by or covered by fine sediment

Endangered Species Act (ESA) – a 1973 Act of Congress that mandated that endangered and threatened species of fish, wildlife, and plants be protected and restored.

Enhancement –activities designed to increase, or further improve the quality, value, or extent of, particular habitat features that are already present.

Entrenchment – the degree to which a stream is vertically confined from its floodplain. Usually expressed as the ratio of the width of the flood-prone area to the bankfull width, in which higher entrenchment ratios indicate higher floodplain connectivity. May be impacted by both human and natural causes.

First Foods – the foods ritualistically served in the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) tribal meals that include water, salmon, deer, cous, and huckleberry. The First Foods mission of the CTUIR is "To provide proactive planning and policy analysis and development to protect, restore and enhance the First Foods and the exercise of associated rights reserved in the Treaty of 1855."

Fish Utilization Potential – a ranking value assigned by assessing current fish species utilization, limiting factors, and biologically significant reaches relative to current and potential geomorphic function.

Flood Refugia – areas of slower water velocity during higher discharges, also referred to as high-flow refugia.

Floodplain – the areas of land adjacent to a river out to the enclosing valley walls that are inundated with water during flooding events. Soils within the floodplain are largely made up of alluvium from river deposits.

Floodplain Connectivity – a general description of the degree of interaction river flows have with the floodplain at a range of flows.

Focal Fish Species – fish species that are identified as at risk, of cultural significance to the Confederated Tribes of the Umatilla Indian Reservation, and toward which project restoration and enhancement actions are directed. For this document, they include spring and fall Chinook salmon, coho salmon, steelhead, and bull trout.

Geomorphic Function – a ranking value assigned by assessing the degree to which channel process and form in a reach are functioning to support in-channel, off-channel, and floodplain habitats.

Geomorphic Potential – a ranking value assigned by assessing the potential for a reach to enhance processes to develop an inset floodplain, create or reconnect existing side-channel or off-channel habitat, and create complex in-channel habitats.

Geomorphology – the scientific study of the origin and evolution of topographic and bathymetric features created by physical or chemical processes operating at or near Earth's surface.

Incised River – a river that cuts its channel through the bed of the valley floor, as opposed to one flowing on a floodplain; it is formed by the process of degradation.

Limiting Factors – physical, biological, or chemical features experienced by the fish that result in reductions in viable salmonid population parameters (abundance, productivity, spatial structure, and diversity)

Lower Walla Walla River – the portion of the river between RM 0.0 and 27.4; the river's confluence with the Columbia River upstream to approximately the town of Lowden, Washington.

Lower Walla Walla Working Group – a collaboration by the Blue Mountain Land Trust, CTUIR, Tri-State Steelheaders, Walla Walla County Conservation District, Washington Department of Ecology, and Washington Department of Fish and Wildlife to address factors limiting aquatic productivity as well as landowner concerns.

Meander Belt Width – the width between points of inflection defining the lateral extents of opposing meanders over which the stream naturally moves over time. This width does not necessarily correspond with the width of the valley.

Off-Channel Habitat – habitat that is not part of the active channel but has a direct connection to it.

Pool Frequency – a measure of the pool-to-pool spacing in a river channel.

Rearing – Refers to the period of time and/or locations (rearing habitat) that juvenile fish spend feeding in nursery areas of rivers, lakes, streams and estuaries before migration.

Restoration – The renewing or repairing of a natural system so that its functions and qualities are comparable to its original, unaltered state.

Riparian Zone – a riparian zone (or riparian area) is the interface between upland lands and a river or stream.

River Miles – number of miles from the mouth of a river to a specific destination.

River Vision – defines a functional river that can support First Foods as a "river that is dynamic and shaped not only by physical and biological processes, but the interactions and interconnections between those processes" (Jones et al. 2008). The vision then defines the key components and processes of functional rivers, identifies management implications and challenges, and links key attributes and processes with specific management applications. The five key components (or touchstones) of functional rivers that are considered to be vital in the management and restoration of river ecosystems, and which are tied directly to the CTUIR's First Food mission, include hydrology, geomorphology, habitat and network connectivity, riverine biotic communities, and riparian vegetation.

Stream Evolution Model (SEM) –a modification of previous Channel Evolution Models that includes additional evolutionary stages and an evaluation of habitat and ecosystem benefits for each stage.

Streambank – the terrain alongside the bed of a river that comprises the sides of the channel.

Subbasin – a structural geologic feature where a basin forms within a larger basin.

Total Maximum Daily Load (TMDL) – a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that load among the various sources of that pollutant.

Turbidity – a measure of water clarity: how much the material suspended in water decreases the passage of light through the water.

Walla Walla Subbasin – the approximately 1,758 square miles of drainage in southeast Washington and northeast Oregon defined by 8-digit Hydrologic Unit Code number 17070102.

1. Introduction

For more than four decades, various assessments and planning efforts focused on water resources, fish, wildlife, and habitat have been conducted for the Walla Walla Subbasin (Subbasin). The Walla Walla Subbasin Plan (NWPCC 2005), Walla Walla Watershed Plan (WWWPU 2005), and Snake River Salmon Recovery Plan for Southeast Washington (SRSRB 2011), in conjunction with other assessments and plans, have resulted in coordinated water, fish, wildlife, and habitat management and prioritized restoration and protection strategies in the Subbasin. Management and restoration strategies in the Subbasin to date have mostly focused on instream flows, surface and ground water quality, riparian vegetation, fish screens and passage, and habitat restoration (NWPCC 2005; WWWPU 2005; WWCCD 2008; WWCWPD 2009; SRSRB 2011), with fish habitat restoration and enhancement efforts primarily confined to the upper portions of the Subbasin (Mendel et al. 2014). Although most fish habitat restoration and enhancement efforts have occurred in the upper portions of the Subbasin, project types such as irrigation improvements, diversion screens, riparian plantings, enrollment in the Conservation Reserve Enhancement Program (CREP), and some habitat restoration and fish passage projects have been implemented by the Walla Walla County Conservation District (WWCCD), The Confederated Tribes of the Umatilla Indian Reservation (CTUIR), Tri-State Steelheaders (TSS), and Washington Department of Fish and Wildlife (WDFW) in the lower portions of the Subbasin.

Fish habitat restoration and enhancement projects have been implemented in the upper portions of the Subbasin based on how the Subbasin Plan ranked geographic areas (NWPCC 2005). Although the lower portions of the Subbasin had some of the highest ranking geographic areas, fish habitat restoration and enhancement was not recommended due to lack of empirical data, practicality, and only supporting a portion of the life stages for focal fish species identified in the Subbasin Plan. In the Snake River Salmon Recovery Plan (SRSRB 2011), lower portions of the Walla Walla River ranked high for restoration benefit but were not prioritized for salmon restoration actions outside of improving fish passage for migrating salmonids. In the Walla Walla Subbasin Plan, the lower portions of the Walla Walla River were identified as prime for restoration given the degraded conditions; however, because the lower portions were determined to be used predominantly for migration and winter rearing, and selecting the lower portions would have meant excluding areas upstream that support a greater diversity of focal fish species, the upper portions of the Subbasin were recommended instead for fish habitat restoration and enhancement projects.

Even though fish habitat restoration and enhancement projects have focused on the upper portions of the Subbasin, research has continued to highlight the importance of lower portions of the Walla Walla River, particularly for providing overwintering holding and rearing habitat that is believed critical to focal fish species (Mahoney et al. 2013; Olsen and Mahoney 2013). In this research, high mortalities for out-migrating fish in lower portions of the Walla Walla River have been discovered, with as many as 70 percent of smolts that enter the lower river failing to reach McNary Dam on the Columbia River (Mahoney 2013; Olsen and Mahoney 2013). Furthermore, the U.S. Fish and Wildlife Service's (USFWS) recent multi-year synthesis for the Walla Walla River (Schaller et al. 2014) suggests that because the lower river has degraded habitat conditions and bull trout (*Salvelinus confluentus*) migrate downstream out of the headwater area, sub-adult and small adult size classes of migratory bull trout may be the most susceptible to mortality in the lower portions of the Walla Walla River. Based on the results from recent research, the need for further studies and assessments that focused on evaluating the relationship between high mortalities of fish species and degraded conditions within lower portions of the Walla Walla River has been identified.

Recognizing the importance of the Lower Walla Walla River for overwinter holding and rearing habitat, as well as landowner concerns about channel stability and bank erosion, the Lower Walla Walla Working Group (LWWWG) was formed in 2010. It is a collaborative effort by the Blue Mountain Land Trust, CTUIR, TSS, WWCCD, Washington Department of Ecology (Ecology), and WDFW to address factors limiting aquatic productivity as well as landowner concerns. To preliminarily assess the degraded conditions and identify potential restoration and enhancement projects in the lower portions, the LWWWG cooperated on the Lower Walla Walla River Habitat Improvement Strategy (Lewis 2012) in 2011. This strategy was an assessment- and planning-level look at the Lower Walla Walla River from approximately the town of Lowden, Washington, to the river's confluence with the Columbia River.

The lower portions of the Walla Walla River are low gradient and primarily single channel, passing almost entirely through agricultural areas. The coordinated team of the LWWWG found that channel degradation, particularly unstable cut banks, and high summer water temperatures were major fish habitat limiting factors in the Lower Walla Walla River (Lewis 2012). Relative to historical conditions, the lower portions have been highly simplified, straightened, restricted from historical floodplains, and altered by irrigation withdrawals. Direct and indirect impacts from anthropogenic alternations to the Lower Walla Walla River over the past century have decreased water quality, reduced the quantity of fish habitat, and degraded the habitat that remains. The Lower Walla Walla River was described as deeply incised with near vertical banks that are eroding, having widespread sedimentation issues and limited riparian vegetation, and generally lacking channel structure and complexity (Lewis 2012).

Through its efforts to understand the issues and concerns in the Lower Walla Walla River, and building off the results of Lewis (2012) and fisheries research by Mahoney (2013) and Olsen and Mahoney (2013), the LWWWG determined that a geomorphic assessment and action plan was necessary. The LWWWG identified the purpose of the assessment and action plan to be three-fold: (1) to obtain empirical data for use in evaluating degraded conditions and identifying and prioritizing restoration and enhancement projects; (2) to develop conceptual level designs for prioritized projects that are feasible to implement; and (3) to identify metrics for use in tracking progress toward improving degraded conditions in the Lower Walla Walla River.

To achieve the assessment and action plan purpose and need, the LWWWG engaged in the development of this Lower Walla Walla River Geomorphic Assessment and Action Plan (GAAP). The goal of the GAAP is to understand the processes and limiting factors affecting the Lower Walla Walla River between river mile (RM) 0.0 and 27.4 (see Figure 1-1) in order to prioritize and implement projects that will make quantifiable progress in accordance with the Walla Walla Subbasin Plan (NWPCC 2005), Walla Walla Watershed Plan (WWWPU 2005), 2008 Fish Accords (Three Treaty Tribes-Action Agencies 2008), CTUIR Umatilla River Vision (Jones et al. 2008), Middle Columbia River Steelhead Distinct Population Segment ESA Recovery Plan (NMFS 2009), Snake River Salmon Recovery Plan for Southeast Washington (SRSRB 2011), Lower Walla Walla River Habitat Improvement Strategy (Lewis 2012), and Revised Draft Recovery Plan for the Coterminous United States Population of Bull Trout (USFWS 2014). To address the goal of the GAAP, the following objectives were developed:

- Address the three primary questions related to the degraded conditions in the Lower Walla Walla River:

1. What processes and factors are resulting in degraded physical conditions (e.g., high eroding banks, limited floodplain and riparian areas, etc.) and limiting aquatic productivity (e.g., stream temperature, instream flows, etc.)?
2. What desired future conditions are realistic, given the needs associated with agriculture land-use and irrigation withdrawals?

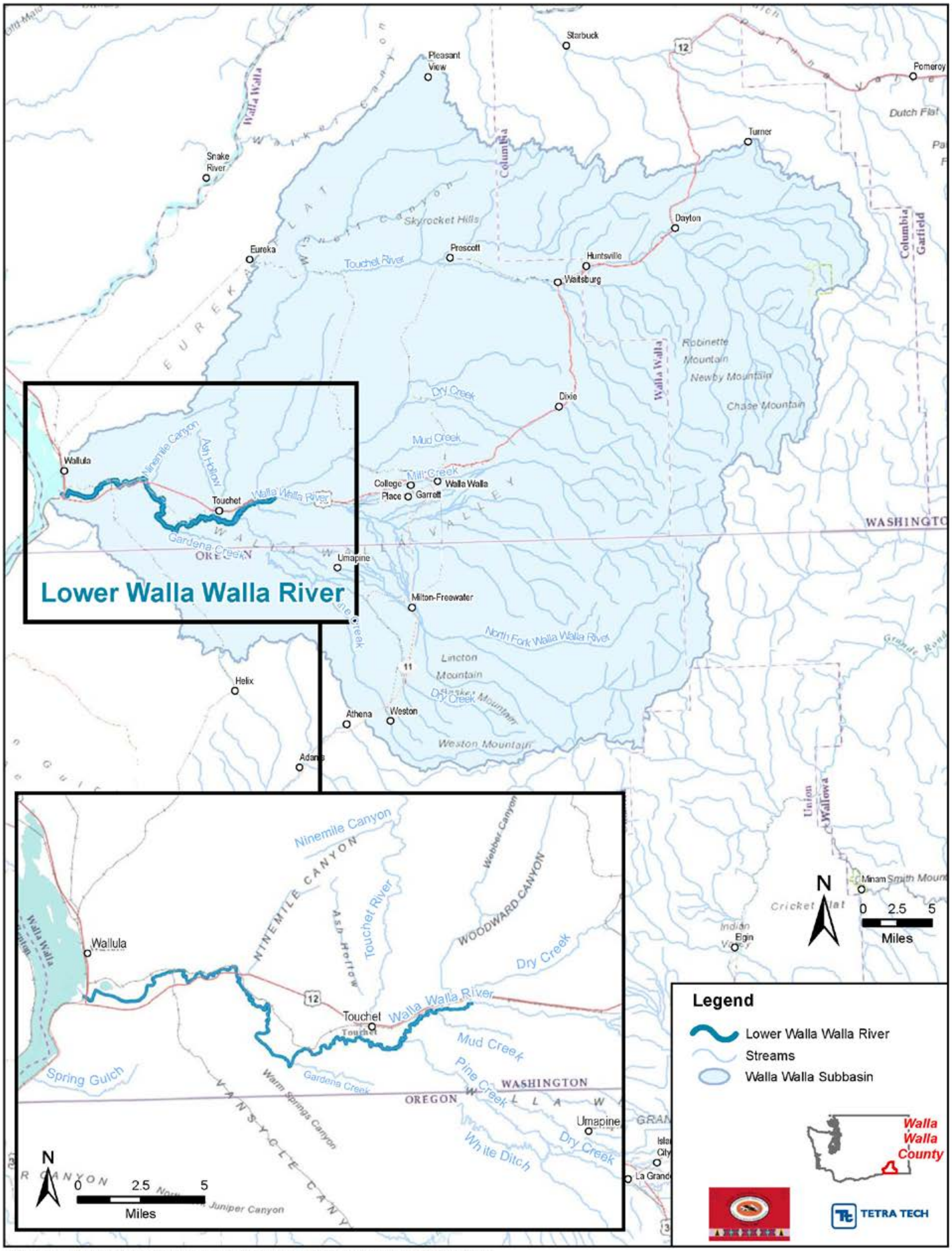

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Figure 1-1. Walla Walla Subbasin and Lower Walla Walla River

3. What quantifiable and repeatable metrics can be utilized to evaluate progress toward addressing processes and limiting factors from implementing actions (e.g., projects, land-use alterations, regulatory changes, etc.) at various scales (individual sites, reaches, and Lower Walla Walla River)?

- Identify and prioritize restoration and enhancement projects utilizing information associated with addressing the three primary questions.
- Develop categories of conceptual level designs, based on prioritized restoration and enhancement projects, that are practical to implement and able to be adapted and scaled to multiple sites.

The GAAP has been developed to assist the LWWWG in evaluating identified overwintering holding and rearing habitat; degraded conditions, including landowner concerns about channel instability and erosion; prioritized categories of projects that can be replicated efficiently to multiple areas on the Lower Walla Walla River; and related metrics that are quantifiable and repeatable and can be utilized to evaluate progress toward improving degraded conditions. This GAAP is based upon the best available science and quantifiable data collected on the Lower Walla Walla River.

The key components of the GAAP by section include:

- Section 1: Introduction, assessment and planning context, methods, and participants
- Section 2: Description of conditions in the Walla Walla Subbasin and Lower Walla Walla River
- Section 3: Presentation of geomorphic assessment results
- Section 4: Identification and prioritization of categorized restoration and enhancement projects
- Section 5: Discussion of next steps

Throughout the development of the GAAP, the LWWWG participants worked together to develop goals and objectives, data collection and analysis approaches, identification and prioritization criteria, implementable project design categories and concepts, and quantifiable and repeatable metrics to evaluate progress towards addressing processes and limiting factors. See Section 1.2.2 for further discussion associated with the LWWWG participants.

1.1 ASSESSMENT AND ACTION PLAN CONTEXT

1.1.1 Relationship to Applicable Federal and State Regulations

The GAAP will assist the LWWWG in implementing restoration and enhancement projects in the Lower Walla Walla River that address fish habitat associated with Endangered Species Act (ESA)-listed fish species. The National Oceanographic and Atmospheric Administration, National Marine Fisheries Service (NMFS) and the USFWS have developed or are in the process of finalizing recovery plans (see Middle Columbia River Steelhead Distinct Population Segment ESA Recovery Plan [NMFS 2009] and Revised Draft Recovery Plan for the Coterminous United States Population of Bull Trout [USFWS 2014], respectively) for ESA-listed species that include actions to address limiting factors. Furthermore, the Northwest Power and Conservation Council (NPCC), Bonneville Power Administration (BPA), NMFS, and USFWS have adopted the Walla Walla Watershed Plan (WWWPU 2005) to help meet requirements under the 2000 Federal Columbia River System Biological Opinion. In addition, the 2008 Fish Accords (Three Treaty Tribes-Action Agencies 2008) establishes an agreement between the BPA, the U.S. Army Corps of Engineers (USACE), and the U.S. Bureau of Reclamation and the Confederated Tribes of the Warm Springs Reservation, the CTUIR, the Confederated Tribes and Bands of the Yakama Nation, and the Columbia River Inter-Tribal Fish Commission regarding various commitments, including funding and implementing habitat projects to address the needs of ESA-listed fish.

Two fish species that occur in the Lower Walla Walla River have been listed as threatened under the ESA: steelhead (*Oncorhynchus mykiss*) and bull trout. Middle Columbia River steelhead were listed as threatened under the ESA in 1999 (65 *Federal Register* 14517), with that status reaffirmed on January 5, 2006 (71 *Federal Register* 834). Columbia Basin bull trout were listed as threatened under the ESA in 1998. Although listed under the ESA, spring Chinook salmon (*O. tshawytscha*) had been extirpated by the 1950s from the Walla Walla Subbasin; however, reintroduction efforts were initiated by the CTUIR in the year 2000. The action plan provided in Section 4 below provides prioritized restoration and enhancement actions for the Lower Walla Walla River that will assist in the recovery of these listed fish species.

The Clean Water Act (CWA) of 1977, and subsequent amendments, makes it unlawful for any person to discharge any pollutant into waters of the United States, unless a permit was obtained under its provisions. Under Section 303 of the CWA, states must prepare a list of water bodies not meeting water quality standards and to conduct an analysis of the extent of the problem and develop a water cleanup plan (Total Maximum Daily Load [TMDL]). Because the Walla Walla Subbasin is within both Oregon and Washington, each state has accepted management designation from the U.S. Environmental Protection Agency (EPA) for implementation of the CWA, with Ecology (Washington) and the Oregon Department of Environmental Quality (ODEQ) maintaining a list of impaired waterbodies and water quality standards that apply to all waters. The action plan provided in Section 4 below provides prioritized restoration and enhancement actions for the Lower Walla Walla River that will assist in water quality enhancement related primarily to sedimentation and turbidity and temperature.

1.1.2 Integration with Past Assessments and Planning Efforts

The GAAP was developed in accordance with the Walla Walla Subbasin Plan (NWPCC 2005), Walla Walla Watershed Plan (WWWPU 2005), 2008 Fish Accords (Three Treaty Tribes-Action Agencies 2008), CTUIR Umatilla River Vision (Jones et al. 2008), Middle Columbia River Steelhead Distinct Population Segment ESA Recovery Plan (NMFS 2009), Extensive Aquatic Habitat Assessment – Walla Walla River Watershed (O'Daniel 2011), Snake River Salmon Recovery Plan for Southeast Washington (SRSRB 2011), Lower Walla Walla River Habitat Improvement Strategy (Lewis 2012), and Revised Draft Recovery Plan for the Coterminous United States Population of Bull Trout (USFWS 2014). Applicable to the 2008 Fish Accords (Three Treaty Tribes-Action Agencies 2008), the Lower Walla Walla River was identified as a top priority in the CTUIR Independent Science Review Panel proposal, which received approval in June 2013 (CTUIR 2013). In addition, numerous assessments and limiting factors analyses (see Appendix A) were consulted to develop the GAAP. Field surveys, empirical data, and local knowledge were also critical in developing the GAAP. Throughout this GAAP, these past assessments and plans are cited where applicable.

1.1.3 Integration with Future Assessments and Planning Efforts

In addition to developing the GAAP in association with federal and state requirements and past assessments and planning efforts, the GAAP provides the framework upon which future assessments and planning efforts for the Lower Walla Walla River can build. Although the GAAP has been developed from the best available science and quantifiable data collected on the Lower Walla Walla River, additional studies, alternations in land use, upstream assessments and plans, and implementation of restoration and enhancement projects will contribute toward refinements to this GAAP. For example, the CTUIR has begun to implement a Biomonitoring Plan (Stillwater Sciences 2012) as part of researching, monitoring, and evaluating that is intended to provide additional information that could be used to inform future assessments and planning efforts. As new applicable assessments and plans are developed, the results from this GAAP provide a bridge to draw from the past, utilize the best available science, and move toward future restoration and enhancement projects that focus on further protecting, restoring, and enhancing fish habitat.

1.2 ASSESSMENT AND ACTION PLAN METHODS AND PARTICIPANTS

The methods employed in the development of the GAAP are discussed in this section. These methods covered the compilation and review of existing data, conducting of field surveys, and performance of technical analyses. In addition, the LWWWG participants provided their local knowledge and review of methods and results.

1.2.1 Existing Data

The most critical first step in developing the GAAP was to search for and review relevant studies, assessments, and plans. This entailed internet and library searches, as well as obtaining studies, assessments, and plans from the LWWWG. The studies, assessments, and plans that were compiled covered a range of data types, topics, and time periods and included:

- Historical data and studies, assessments, and plans (describing fisheries, hydrology/hydraulics, geomorphology, sediment, land use, botany, etc.)
- Fish surveys (available for the area)
- Aerial photographs and imagery (covering the period from 1939 through 2013)
- Maps and other spatial data (including topography, soils, and geology)

For more than four decades, numerous studies, assessments, and planning efforts focused on water resources, fish, and habitat have been conducted for the Walla Walla Subbasin. These include, but are not limited to, the following:

- the Walla Walla River Basin Reconnaissance Report, Oregon and Washington (USACE 1992)
- Walla Walla River Watershed Oregon and Washington Reconnaissance Report (USACE 1997)
- Walla Walla Subbasin Plan (NWPCC 2005)
- Walla Walla Watershed Plan (WWWPU 2005)
- Middle Columbia River Steelhead Distinct Population Segment ESA Recovery Plan (NMFS 2009)
- Extensive Aquatic Habitat Assessment – Walla Walla River Watershed (O'Daniel 2011)
- Snake River Salmon Recovery Plan for Southeast Washington (SRSRB 2011)
- Lower Walla Walla River Habitat Improvement Strategy (Lewis 2012)

- Revised Draft Recovery Plan for the Coterminous United States Population of Bull Trout (USFWS 2014)
- Walla Walla River Bull Trout Ten Year Retrospective Analysis and Implications for Recovery Planning (Schaller et al. 2014)

Each study, assessment, and planning document available for the Walla Walla Subbasin was reviewed because they had the potential to provide useful empirical data, analyses, and information concerning the Lower Walla Walla River.

Appendix A includes an index of all existing non-spatial data compiled for the GAAP. A geodatabase (provided separately) was created in a geographic information system (GIS) for all the spatial data. This geodatabase made it possible to display data associated with the Subbasin, integrate empirical data from field surveys with existing spatial data, and present results from technical analyses. The outcome from this compilation was a synthesis of studies, assessments, and plans presented in this GAAP, as well as the identification of data gaps. The data gaps were prioritized according to which would be filled through field surveys and which through subsequent analyses. Data gaps that were deemed to not be a high priority, and therefore not filled, are noted in the applicable sections of this GAAP.

1.2.2 Field Surveys

Field surveys were conducted in the Lower Walla Walla River (see Figure 1-1 above) in January and August 2014. Although this GAAP assesses the Lower Walla Walla River between RM 0.0 and 27.4, field surveys were conducted between RM 4.2 and 27.4 due to the inundation from McNary Dam into the lower 4.2 miles of the Walla Walla River; this extent of the river is referred to as the GAAP survey area in this document. All river miles are based upon USGS river miles (USGS 2014a).

Field activities conducted in January 2014 included a bathymetric and terrestrial scan survey (see Section 1.2.2.1) and a River Vision Touchstone survey (see Section 1.2.2.2) of the entire Lower Walla Walla River. The bathymetric and terrestrial scan survey was undertaken to develop detailed in-channel and bank topography that would be used for various analyses, including hydraulic modeling and conceptual design development. The River Vision Touchstone survey was undertaken to characterize the hydrology, geomorphology, fish habitat, floodplain connectivity, and riparian vegetation. Field activities conducted in August 2014 entailed sediment sampling and were completed later than the other survey efforts because sampling was not feasible during the relatively high flows that occurred during the January 2014 survey.

1.2.2.1 Bathymetric and Vessel-Mounted LiDAR Survey

A bathymetric and vessel-mounted light detection and ranging (LiDAR) survey of the Lower Walla Walla River was performed to create a topographic surface. A technical memorandum describing in more detail the field survey methods for the bathymetric and vessel-mounted LiDAR survey is provided in Appendix B. The survey extent was from approximately RM 4.2 to the Lowden Bridge at RM 27.4 (see Figure 1-1 and Appendix C). The survey was performed from January 23 to January 31, 2014, in a 14-foot inflatable Cataraft boat configured for shallow water surveying.

Continuous data collection was performed over two passes, one for the right bank and one for the left bank, of the Lower Walla Walla River. A Ross 875-X sweep system was chosen to provide accurate bathymetric soundings at specified cross sections. Cross-section locations were chosen to represent river inflection points and topographic changes to the extent that site conditions allowed. A vessel-mounted Riegl LMS-Q120 Laser Scanner was used to scan the river shorelines, in conjunction with POS/MV 320 Inertial measurement unit (IMU) and real-time kinematic (RTK) Global Positioning System (GPS). These instruments provided for laser light to densely sample the surface, producing highly accurate x, y, and z measurements, and facilitated in the development of a LiDAR-based surface. Figure 1-2 contains a sample point cloud of the combined LiDAR and sweep sonar data that was obtained from the continuous data collection effort.

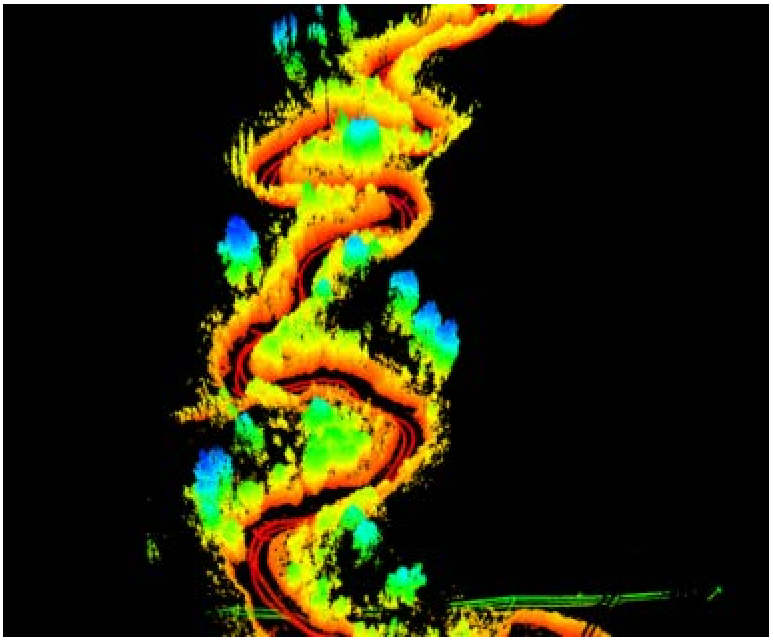


Figure 1-2. Combined LiDAR and Sweep Sonar View of the Lower Walla Walla River Near Lowden, Washington

The surveys were conducted in general accordance with the procedures specified in the USACE Manual 1110-2-1003, Engineering and Design Hydrographic Surveying (USACE 2013). On-site GPS quality control confirmed typical RTK accuracies were achieved with comparison deltas between measured and recorded points substantially better than 0.5 foot horizontal and vertical. As is typical when surveying in riverine environments, sonar data acquisition and coverage in some survey areas were reduced due to aeration in the water column. This had little impact on data quality; however, because erroneous data in the water column are removed by automatic filters or by manual editing during data processing, occasional gaps in the data set were produced.

Vegetation was not manually removed from the vessel-mounted LiDAR data; however, an adaptive Triangulated Irregular Network (TIN) ground point extraction algorithm in the QCoherent's LP360 LiDAR processing software was utilized to assign the "ground" class to the extracted returns. The classification process produced the lowest available positions for a defined search area. It is acknowledged that in some areas, the ground classification was insufficient to produce a "true" ground surface due to dense tree cover so that no actual ground returns were recorded. To minimize this effect, the LiDAR data were not used in densely vegetative areas past approximately the top of bank in the development of a combined topographic surface. Although there are limits associated with the approach taken to develop the ground surface, future assessments and design development will be able to use the data as a starting point to further refine a topographic surface within areas of interest.

The bathymetric soundings and the ground classified LiDAR were combined with a 5-meter NEXTMap® digital elevation model (DEM) to produce a continuous topographic surface that represents the river bed, banks, and floodplain. Figure 1-3 is an example of combined bathymetry, vessel-mounted LiDAR, and 5-meter DEM topographic surface. The continuous topographic surface for the entire Lower Walla Walla River is provided in Appendix C.

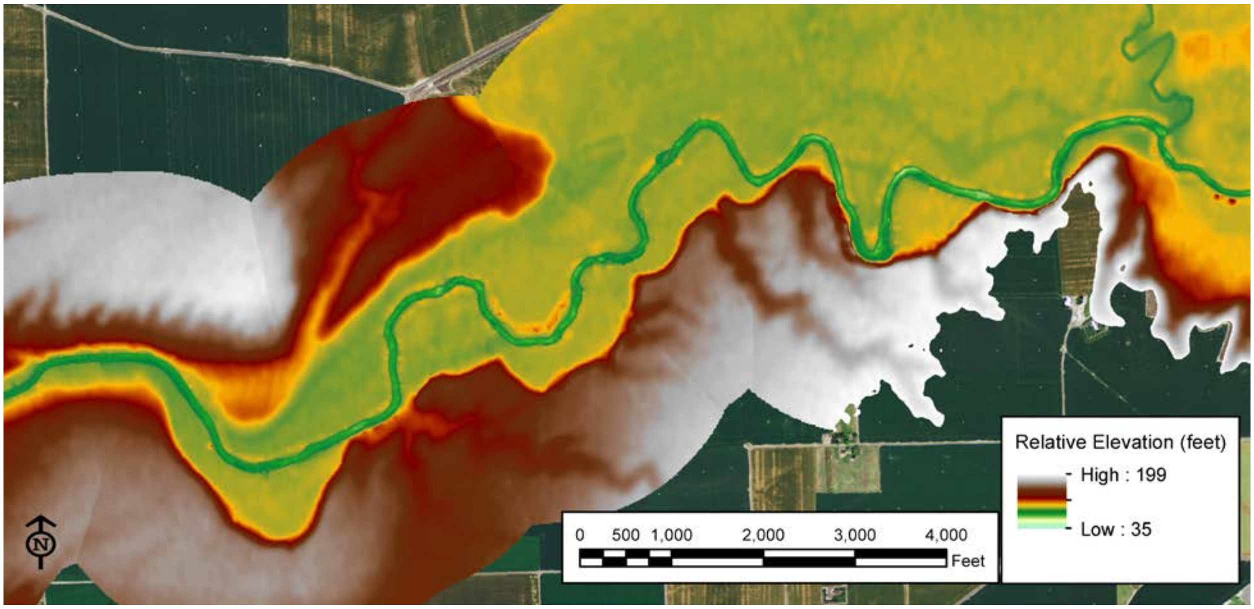


Figure 1-3. Example of Combined Topographic Surface Displayed as Relative Elevation Values

1.2.2.2 River Vision Touchstone Survey

The CTUIR Umatilla River Vision (Jones et al. 2008) provides a framework for establishing a healthy river system that is highly dynamic and shaped by not only physical and biological processes, but also connections among those processes. The focus is a process-based approach to support tribal culture, harvest, and use of First Foods. The River Vision Touchstone Survey for the GAAP was designed to be in accordance with the CTUIR Umatilla River Vision (Jones et al. 2008) and entailed data collection focused on physical habitat and geomorphic characterization, bank stratigraphy, sediment, and restoration and enhancement project identification. The spatial location of data and photographs collected during the survey were acquired utilizing GPS. The total survey extent was from the Madame Dorian Park boat launch (RM 4.2) to the Lowden Bridge (RM 27.4). The portion of the Lower Walla Walla River between RM 0.0 and 4.2 was not surveyed due to the influence of the Columbia River and its backwater into the lower 4.2 river miles. The survey was performed from January 21 to January 24, 2014, using an aluminum drift boat and was conducted by a fisheries biologist, hydrologist, and geomorphologist. In addition, a fisheries biologist from the CTUIR conducted fish telemetry tracking during the survey and assisted in the River Vision Touchstone Survey.

Physical Habitat and Geomorphic Characterization

Physical habitat and geomorphic characterization were conducted following the protocol outlined in Section 6 of the Lazorchak et al. (2000) Environmental Monitoring and Assessment Program (EMAP) field operations and methods guide for non-wadeable rivers and streams. On the Lower Walla Walla River, data were collected within four EMAP sample areas: from RM 5.6 to 7.7, RM 14.0 to 15.0, RM 21.8 to 22.7, and RM 25.9 to 26.9 (see Appendix C, Figure C-1). Data collected within the four sample areas included the following categories:

- channel dimensions,
- channel gradient,
- channel substrate size and type,
- habitat complexity and cover,
- riparian vegetation cover and structure,
- anthropogenic alterations, and
- channel-riparian interaction.

In addition to the four EMAP sample areas, a continuous recording of fish habitat types was collected for the Lower Walla Walla River. Due to the relatively higher flows at the time of the survey, the exact extent of habitat type delineations was refined using the longitudinal profile developed from the bathymetric survey data. Habitat units (e.g., pools, riffles, etc.) for the GAAP survey area were typed to Level II as described by Hawkins et al. (1993) and Bisson et al. (2006). Additional fish habitat characteristics such as presence of cover, large woody debris (LWD), bars, islands, and off-channel habitat were recorded throughout the Lower Walla Walla River.

In addition, geomorphic characterizations of bed and banks and other features were also recorded throughout the survey. This information, which assisted in evaluating geomorphic processes and channel stability, included:

- the type and extent of artificial bank protection;
- the type and extent of artificial in-channel features;
- areas of aggradation, bed and/or bank erosion, channel widening;
- the quantity and quality of in-channel features and channel complexity;
- the presence and influence of off-channel habitat, side channels and islands; and
- the presence of developed or developing inset floodplain.

Bank Stratigraphy

During field surveys, bank stratigraphy was evaluated by measuring the thickness of bank sediment layers and identifying the composition and cohesion of bank materials in each layer. The results were used in evaluating channel migration, bank stability, and sediment supply and transport.

Sediment

Bed surface (pebble counts) and subsurface (bulk sample) sediment samples were collected based on methods described in Bunte and Abt (2001). The bed surface sediment sample methodology involves sampling a minimum of 100 individual sediment sizes in the sample area in a grid pattern. The sediment sampling strategy and the methods for grain size distribution calculation followed the methods of Bunte and Abt (2001). Subsurface sediment samples were collected following standard bulk sediment sampling techniques described in Bunte and Abt (2001). Fine sediment samples of the channel banks and bed were used to characterize percent sand, silt, and clay.

Restoration and Enhancement Project Identification

Potential sites for restoration and habitat enhancement were initially identified during field surveys. This preliminary determination was further refined by utilizing the combined topographic surface and existing data. Potential sites were identified in the field through an evaluation of physical habitat and geomorphic characteristics, as well as professional judgment. Potential projects sites previously identified by Lewis (2012) were also evaluated during the River Vision Touchstone survey.

1.2.3 Geomorphic Assessment Analyses

The following subsections describe the major analysis methods used in developing the geomorphic assessment portion of the GAAP.

1.2.3.1 Reach Delineation

Geomorphic reaches were delineated based on geomorphic characteristics, channel morphology classification, riverine processes, and governing conditions. The purpose of the delineation was to identify differences in geomorphology in the Lower Walla Walla River. The following were used during the delineation of geomorphic reaches:

- field observations made during the River Vision Touchstone survey,
- existing channel pattern and form,
- channel substrate,
- geologic controls on channel confinement,
- significant tributary junctions (e.g., Touchet River),
- reach assessment metrics, and
- channel morphology.

1.2.3.2 Reach Assessment

The reach assessment analyses entailed first developing quantifiable and repeatable metrics. Utilizing these metrics, field surveys, and existing data, the reach assessment evaluated land use, riparian vegetation, channel morphology, channel migration, floodplain inundation and connectivity, sediment mobility and transport, stream evaluation, and fish habitat for each of the delineated geomorphic reaches. The geomorphic reach assessment provided further empirical data for use in identifying and analyzing limiting factors and biologically significant reaches that facilitated the development of desired future conditions.

Quantifiable and Repeatable Metrics

Part of the GAAP objectives includes the identification and application of quantifiable and repeatable metrics that can be utilized to establish baseline conditions and evaluate progress toward addressing processes and limiting factors from implementation of actions at various scales. Based on this objective, quantifiable and repeatable metrics were identified as part of the geomorphic assessment portion of the GAAP (Table 1-1). The metrics were developed by building on the monitoring metrics included in the CTUIR Physical Habitat Monitoring Strategy (PHAMS) that were developed in association with the CTUIR Umatilla River Vision (Jones et al. 2008). The metrics in Table 1-1 were calculated to establish baseline conditions at a total of 68 cross sections throughout the GAAP survey area of the Lower Walla Walla River and are summarized based on the delineated geomorphic reaches. The 68 cross sections utilized applicable bathymetric survey cross sections to achieve the greatest level of accuracy possible. Table 1-1 presents the geomorphic assessment metrics for the GAAP, including evaluation methods, and directly links the metrics to CTUIR Habitat Program objectives, limiting factors, River Vision Touchstones (Jones et al. 2008), and PHAMS.

Table 1-1. Quantifiable and Repeatable Metrics Identified for the GAAP

Limiting Factor Group[1/]	CTUIR Walla Walla Habitat Program Objectives	Limiting Factors[2/, 3/]	River Vision Touchstones[4/]	Metrics	Evaluation Methods
Riparian/ Floodplain	Increase riparian and floodplain connectivity and function	Riparian Condition Floodplain Connectivity Streambank Condition Channel Stability Off-Channel Habitat	Aquatic Biota Connectivity Riparian Vegetation Geomorphology Hydrology	Riparian Characteristics[5/]	Measure riparian characteristics following EMAP protocols (Lazorchak et al. 2000) and GIS techniques
				Floodplain Inundation	Calculate floodplain inundation based on hydraulic modeling (see Floodplain Inundation and Connectivity section below)
				River Complexity Index[5/]	Sinuosity times the number of nodes unitized by valley distance (Brown 2002)
				Sinuosity[5/]	Measure from bathymetric survey or imagery (channel length/valley length) (Rosgen 1996)
				Channel Migration Rate[5/]	Measure channel migration from multiple sequential aerial photographs (Latterell et al. 2006)
				Meander Belt Width	Measure meander belt width from multiple sequential aerial photographs (Williams 1986)
				Bank Condition and Stability	The Bank-Stability and Toe Erosion Model (U.S. Department of Agriculture 2014)
				Confinement Width	Measure width between confining features (natural or anthropogenic) from aerial photographs and/or bathymetric survey
				Off-Channel Habitat Length	Measure off-channel habitat from aerial photographs and/or bathymetric survey
In-Channel Characteristics	Increase diversity, complexity, and function of instream structure and habitat for all life stages of native salmonids	Flood Refugia (high velocity) Channel Substrate Amount of LWD Pool Frequency/Quality Pool Depth	Aquatic Biota Connectivity Geomorphology Hydrology	Primary Channel Length	Measure primary channel length from bathymetric survey
				Secondary Channel Lengths	Measure secondary channel lengths from bathymetric survey or imagery
				Bankfull and Wetted Width[5/]	Measure channel dimensions from field and bathymetric survey
				Bankfull Depth[5/]	Measure channel dimensions from field and bathymetric survey
				Bankfull Cross-Sectional Area	Calculate bankfull cross-sectional area (sum of the products of the intervals of width times depth across the section) (Rosgen 1996)
				Width/Depth Ratio (W_{bkf}/D_{bkf})[5/]	Calculate width/depth ratio (bankfull width/bankfull depth) (Rosgen 1996)
				Gradient	Measure channel gradient from bathymetric survey
				Incision Width	Measure channel dimensions from field and bathymetric survey
				Incision Depth	Measure channel dimensions from field and bathymetric survey
				Entrenchment Ratio[5/]	Calculate entrenchment ratio (floodplain prone area width/bankfull width) (Rosgen 1996)
				Channel Morphology	Classify channel morphology and process (Kellerhals et al. 1976; Church 1992; Rosgen 1996)
				Braided-Channel Ratio[5/]	Ratio of the total channel length to the primary channel length (Friend and Sinha 1993)
				Pool Frequency or Spacing[5/]	Count of number of pools per channel length or spacing between pools (Montgomery et al. 1995; Beechie and Sibley 1997)
				Percent Pools	Percent of wetted area classified as pools (Beechie and Sibley 1997)
				Fish Habitat	Measure fish habitat characteristics following EMAP protocols (Lazorchak et al. 2000)
				LWD Counts[5/]	Field survey counts and location of LWD
				Sediment Size Distribution	Pebble counts and bulk samples of surface and subsurface grain sizes (Bunte and Abt 2001)
				Fine Sediment Percentage in Bed Material[5/]	Measurement of fine sediment proportion in bed material by surface or sediment samples (Bunte and Abt 2001)
				Threshold Grain Size	Calculate the Shields threshold of motion grain size (Shields 1936)

1/ Limiting factor group are based on the 2008 Fish Accords (Three Treaty Tribes-Action Agencies 2008).
2/ The methodology utilized for identifying limiting factors in the Lower Walla Walla River is described in Section 1.2.3.5.
3/ Additional limiting factors for the Lower Walla Walla River including predation, water quantity, water quality (e.g., turbidity and temperature), and diversion screens were not evaluated in this report using metrics and evaluation methods and are therefore not included in this table. See Section 1.2.3.5 below for further discussion on limiting factors included in the GAAP.
4/ River Visions Touchstones are based on the CTUIR Umatilla River Vision (Jones et al. 2008).
5/ Metrics included in the CTUIR PHAMS.

Based on field surveys, channel (bankfull width and depth, wetted width, incision width and depth) and floodplain dimensions were determined to quantify the applicable metrics noted in Table 1-1. In addition, these channel dimensions were used to assess cross sections from the bathymetric survey where field surveys were not conducted. During the field surveys, bankfull dimensions were identified from field indicators including depositional benches or lateral bars, breaks in bank slope, racking of woody debris, stain lines, and vegetation. Figure 1-4 illustrates a conceptual cross-section diagram of channel and floodplain dimensions.

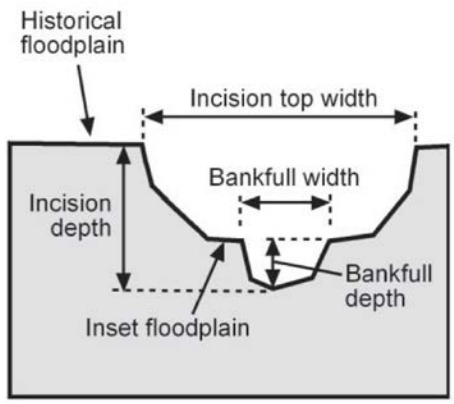


Figure 1-4. Conceptual Diagram of Channel and Floodplain Dimension from Beechie et al. (2008)

Land Use

Land use was assessed based on existing data, field surveys, and analysis of data collected as part of the field surveys. Existing data included available publications regarding historic land use and current land ownership and jurisdiction for the Subbasin. Field survey data collected included observation and characterization of human activities, disturbances, and land use and their proximity to the channel in each of the four EMAP sample areas: RM 5.6 to 7.7; RM 14.0 to 15.0; RM 21.8 to 22.7; and RM 25.9 to 26.9 (see Appendix C, Figure C-1). Data collection protocol and analysis of field survey data were conducted according to the methods described by Lazorchak et al. (2000). As described in Lazorchak et al. (2000), observations and characterization of human activities, disturbances, and land use and their proximity to the channel were collected within 20-meter-long (10 meters upstream and 10 meters downstream) by 10-meter-deep (10 meters shoreward) sample plots on both the right and left banks at 11 cross sections within each of the four sample areas. In addition to the field survey data collected and analysis, the distribution of land use types was evaluated for the Lower Walla Walla River within the 100-year flood inundation area. This area was developed using hydraulic modeling as described in the Floodplain Inundation and

Connectivity subsection below. The source for land-use designations was the Walla Walla County Assessor's Office Tax Lots data.

Riparian Vegetation

Riparian vegetation was assessed based on existing data and analysis of field survey data. Riparian vegetation within 500 feet of the channel banks was mapped using aerial photography and remote sensing data in the Butcher and Bower (2005) stream temperature analysis. The analysis produced a GIS layer including riparian vegetation type, height, and other characteristics. This assessment is described further in Section 3.2.2.

Riparian vegetation was also assessed within four sample areas: RM 5.6 to 7.7; RM 14.0 to 15.0; RM 21.8 to 22.7; and RM 25.9 to 26.9 (see Appendix C, Figure C-1), using the EMAP protocols for assessment of riparian vegetation structure (Lazorchak et al. 2000). These methods include estimating the aerial cover class (e.g., absent, sparse, moderate, heavy, very heavy) and type (e.g., woody, herbaceous, deciduous, coniferous, etc.) of riparian vegetation in the canopy, understory, and groundcover layers within a 20-meter-long (10 meters upstream and 10 meters downstream) by 10-meter-deep (10 meters shoreward) plot. Riparian vegetation structure was assessed in 11 plots within each of the four EMAP sample areas.

Channel Morphology

The channel morphology of the Lower Walla Walla River was analyzed using the classification systems of Kellerhals et al. (1976), Church (1992), and Rosgen (1996). These systems use channel pattern, the presence of islands, the type of sediment storage in bars, and the type of lateral migration to describe channel morphology. River form and process are described and channel morphology classified through a set of standard metrics such as channel dimensions (bankfull width and depth, gradient, etc.), sediment characteristics, channel plan form (e.g., single-thread, braided, anastomosing etc.) bed forms, channel meander process (stable, wandering meandering etc.), and the presence of floodplain features (e.g., side-channels, vegetated islands, cutoffs, and oxbows).

Channel Migration

The evaluation of channel migration considered available data including aerial images, bathymetric survey data, and other existing datasets to identify changes in the location and pattern of the Lower Walla Walla River over time. A series of imagery for photo years 1939-40, 1950, 1977, 1996, 2003, 2004, 2005, and 2013 was obtained for the GAAP survey area of the Lower Walla Walla River. Additional photo years, shown in Table 1-2, were available, but were not obtained due to incomplete coverage. The photo years obtained where selected to provide representative examples of channel migration over time and capture the effects of significant flood events.

The active channel(s) was delineated for the Lower Walla Walla River for 1939-40 and 2013. In addition, multiple sequential aerial photographs (1950, 1977, and 1996) were utilized to investigate channel migration over time.

Table 1-2. Index of Available Aerial Imagery and Coverage in the GAAP Survey Area

Year	GAAP Survey Area Coverage	Color/BW	Source[1/]	Obtained?
1939-40	Complete coverage	BW	WWC; WCPL	Yes
1950	Complete coverage	BW	WWC	Yes
1958	Partial coverage; near mouth with coverage up to old railroad bridge (Zangar Junction)	BW	USACE	No
1964	Partial coverage; from mouth up to Hwy 12 bridge at RM 12	BW	USACE	No
1970	Partial coverage; from mouth up to RM 19	BW	USACE	No
1977	Complete coverage	BW	USACE	Yes
1981	Partial coverage; from mouth to RM 8 (near Zangar Junction)	BW	USACE	No
1982	Complete coverage	BW	USACE	No
1983	Partial coverage; from mouth to Hwy 12 bridge at RM 12	Color	USACE	No
1987	Partial coverage; Wallula HMU area - mouth to railroad bridge crossing (Zangar Junction)	Color	USACE	No
1991	Partial coverage; from mouth to Hwy 12 bridge at RM 12	Color	USACE	No
1995	Partial Coverage; Wallula HMU area - mouth to Hwy 12 bridge crossing at RM 12	Color	USACE	No
1996	Complete coverage; high-water flood event	Color	USGS; USACE	Yes
2002	Complete coverage	Color	USACE	No
2003	Complete coverage	Color	NAIP	Yes
2004	Complete coverage	Color	NAIP	Yes
2005	Complete coverage	Color	NAIP	Yes
2013	Complete coverage	Color	NAIP	Yes

1/ Image sources: Walla Walla County (WWC); Whitman College Penrose Library (WCPL); USACE; the National Agricultural Imagery Program (NAIP); U.S. Geological Survey (USGS); and Google.

Floodplain Inundation and Connectivity

A coarse-level hydraulic model was developed to determine flood inundation for a range of flows: 2-year, 5-year, 10-year, and 100-year flood events. The hydraulic model was developed with the Hydrologic Engineering Centers River Analysis System (HEC-RAS), which is a cross section–based one-dimensional model developed by the USACE (USACE 2010) for computing velocity, flow depth, shears stress, and other hydraulic characteristics in riverine systems. Hydraulic model outputs were exported to HEC-GeoRAS, which is a custom interface between HEC-RAS and GIS, for mapping HEC-RAS water surfaces, flow depths, and velocities. The flood inundation tool in HEC-GeoRAS interpolates the water surface elevations from HEC-RAS cross sections to two-dimensional geospatial data.

Floodplain connectivity was analyzed utilizing two of the geomorphic assessment metrics: Braided-Channel Ratio and the River Complexity Index. The River Complexity Index (Brown 2002) is a metric used to describe the complexity of channel conditions in a reach. The index incorporates the sinuosity and the number of channel junctions (nodes) including secondary channels and off-channel connections. Off-channel and secondary channels were mapped from field surveys and 2013 aerial imagery. The River Complexity Index is unitized by valley distance and was calculated using the following equation from Brown (2002):

River Complexity Index = sinuosity (1+ number of nodes)/valley distance

The Braided-Channel Ratio is a measure of the relative extent of secondary channels, which is indicative of braided channel morphology. The braided-channel metric was calculated as the ratio of the total channel length (including primary and secondary channels) to the primary channel length.

Sediment Mobility and Transport

Sediment size distributions, characteristic sediment sizes, and percent composition by sediment type (e.g., sand, gravel, cobble etc.) were calculated from surface (pebble count) and subsurface (bulk) sediment samples as described above in Section 1.2.2.2. The percentage of sand, silt, and clay was calculated for the bank's sediment sample and the sediment sample collected near the mouth of the Walla Walla River. These two samples did not contain coarse sediments and therefore grain size distributions were not developed for these samples.

Sediment transport characteristics including shear stress, unit stream power, and threshold grain size were calculated. Threshold of motion sediment size estimates were calculated with the Shields threshold of motion equation (Shields 1936). The equation is based on the Shields number, which is a non-dimensional number that relates the fluid force acting on sediment to the weight of the sediment. The inputs were calculated from the hydraulic model for surveyed channel cross sections, channel gradient, and sediment size estimated from surface sediment samples.

Regime Model

The University of British Columbia Regime Model developed by Eaton et al. (2004) was used to evaluate channel dimensions in the Lower Walla Walla River to understand how the current incised channel dimensions compare to that of a typical (e.g., non-incised) stable channel configuration, referred to as a regime channel. The regime model predicts reach-average channel dimensions (e.g., width and depth) of gravel-bed rivers based on input variables such as discharge, sediment characteristics, and governing conditions, including bank characteristics and channel morphology. The effect of the root strength provided by riparian vegetation is incorporated into the model by estimating the rooting depth of riparian vegetation and effective cohesion of the root-reinforced soil (Eaton 2006). The model output is an estimate of reach-average channel dimensions that would be expected for alluvial gravel-bed rivers with vegetated floodplains.

Stream Evolution Model

For the past 30 years, scientists have been describing spatial and temporal patterns of channel incision and evolution, beginning with Schumm et al. (1984). More recently, Cluer and Thorne (2013) have expanded on the foundation of channel evolution theory and incorporated the amount of habitat and ecosystem benefit for various stages of channel evolution. The term Stream Evolution Model (SEM) is used to describe their work.

The SEM is a 10-stage cyclical model that describes the process of response to disturbance resulting in channel incision. The process is one of transitioning from a "natural" channel through degradation, widening, aggradation, lateral activity, and eventual return to conditions similar to those before disturbance. For each of the SEM stages, Cluer and Thorne (2013) described and quantified ecological value through the relative quality and quantity of six hydrogeomorphic attributes (physical channel dimensions, channel and floodplain features, substrate, hydraulics, vegetation, and hydrologic regime) and four habitat and ecosystem benefits (habitat, water quality, biota, and resilience).

Although the SEM represents a common series of stages in which channels respond to disturbance, there are many alternate ways that individual river systems may respond. Cluer and Thorne (2013) acknowledge that SEM stages may be skipped entirely, repeated, or the evolutionary cycle may be halted at a stage if erosion-resistant layers or other factors prevent channel widening.

The SEM was applied to each reach identified from the geomorphic reach delineation. Analysis methods associated with geomorphic reach delineation are described above in Section 1.2.3.1.

Fish Habitat

Fish habitat was assessed based on existing data and analysis of field survey data. Analysis of field survey data related to fish habitat in the Lower Walla Walla River was conducted according to the methods described by Lazorchak et al. (2000). Data used in the analysis include data as described in Section 1.2.2.2.

1.2.3.3 Focal Fish Species

The selection of focal fish species was done to direct the focus of the GAAP and facilitate in the identification and prioritization of restoration and enhancement projects. Focal fish species identified in this GAAP are spring and fall Chinook salmon, coho salmon (*O. kisutch*), steelhead, and bull trout. These focal fish species were selected based on the following considerations:

- existence of research suggesting migration and overwintering holding and rearing habitat is critical for survival,
- Endangered Species Act status,
- cultural importance of the species,
- salmonids historically and currently present, and
- active monitoring and evaluation studies of species' distribution.

The focal species are of particular interest for this GAAP because each of them faces limitations in the Lower Walla Walla River that are hindering productivity, and therefore are a target of the CTUIR First Foods mission to restore salmonid populations. See Section 2.7 for further discussion of these species.

1.2.3.4 Biologically Significant Reaches Delineation

For the purpose of this GAAP, biologically significant reaches (BSR) can generally be defined as stream reaches with similar fish use and limiting factor characteristics. The existing Ecosystem Diagnosis and Treatment (EDT) analysis for the Walla Walla Subbasin Plan (NWPCC 2005) was used as the foundation for defining BSRs for the GAAP. The EDT analysis evaluated existing habitat conditions, including limiting factors, and restoration and habitat enhancement potential throughout the Subbasin, and divided the area into geographic areas. The Lower Walla Walla (mouth to Touchet River) and Walla Walla (Touchet River to Dry Creek) geographic areas in the Walla Walla Subbasin Plan (NWPCC 2005) make up the majority of the GAAP surveyed area.

The geographic areas in the EDT analysis were further divided into five reaches in the Walla Walla Subbasin Plan (NWPCC 2005). These five reaches were identified as distinct BSRs for this GAAP. The BSRs were evaluated based on fish utilization and limiting factors for those life stages during which the focal fish species use the Lower Walla Walla River (i.e., migration, overwintering holding, and rearing habitat). The BSR delineation and analysis entailed evaluating existing data, field survey data, fish distribution data, and scientific knowledge of preferred biological and physical habitat for fish species within the Lower Walla Walla River.

1.2.3.5 Limiting Factors

The identification and analysis of limiting factors, and resulting development of limiting factors matrices, were accomplished through utilizing past studies and assessments, field surveys and analyses included in this GAAP, and professional judgment. Past studies and assessments that were utilized for identifying limiting factors and assessing ratings included Mendel et al. (1999); Kuttel (2001); Caldwell et al. (2002); NWPCC (2005); Mendel et al. (2007); NMFS (2009); Mahoney et al. (2011); SRSRB (2011); Lewis (2012); Mahoney et al. (2012); and USFWS (2014). The types and status of limiting factors were based primarily on NMFS (2009), NWPCC (2005), Mahoney et al. (2011), and USFWS (2014). As part of the Walla Walla Subbasin Plan (NWPCC 2005), the EDT model was used to analyze aquatic habitat quality, quantity, and diversity relative to the needs of focal species. Results from the EDT model provided the basis for limiting factors analysis in the Walla Walla Subbasin Plan (NWPCC 2005). In addition, these results from the limiting factors analysis, including the types of limiting factors and associated status, presented in the Walla Walla Subbasin Plan were also utilized in NMFS (2009) and SRSRB (2011). Methods associated with the EDT model are described in detail with the Walla Walla Subbasin Plan (NWPCC 2005), NMFS (2009), and SRSRB (2011).

Although past studies and assessments provided a solid foundation for performing the limiting factors analysis for the GAAP, field surveys and analyses included in this GAAP, as well as professional judgment, were used to further refine identified limiting factors. Specifically, past studies and assessments typically assessed the Lower Walla Walla River as a whole; however, in this GAAP it was assessed based on geomorphic (see Section 1.2.3.1) and biologically significant reaches (see Section 1.2.3.4). This resulted in a limiting factors analysis that was broken out at finer scales of individual reaches within the Lower Walla Walla River rather than as a whole as past studies and assessments had undertaken. In addition, fish species utilization in the Lower Walla Walla River was also considered to further refine the limiting factors based on seasonality as it related to migration, overwintering holding, and rearing habitat. This approach resulted in analyzing aquatic conditions during the actual timing of when fish species predominately use the Lower Walla Walla River.

1.2.3.6 Desired Future Conditions

Desired future conditions were determined by analysis of existing data and observations and data from field surveys, based on the methods previously described. Desired future conditions are presented in terms of current geomorphic function, future geomorphic potential, and focal fish species. Section 1.2.3.3 provides further detail regarding identified fish species and the criteria used for selection of focal fish species. The results from the desired future conditions analysis were used to identify and prioritize restoration and enhancement projects and develop categories of conceptual level designs that are practical to implement and able to be adapted and scaled to multiple sites.

Current geomorphic function for the GAAP was determined by analysis of existing data and field surveys. This included analyzing land use, riparian vegetation, channel morphology, channel migration, floodplain inundation and connectivity, sediment mobility and transport, SEM, and fish habitat. Future geomorphic potential was determined by evaluating historic channel and floodplain conditions (e.g., meander belt width, historic sinuosity) relative to current geomorphic function. Focal species utilization potential was determined by assessing current fish species utilization (see Section 1.2.3.3), limiting factors, and BSR relative to current and potential geomorphic function. In addition, the focal species utilization potential also considered areas 300 to 500 feet from the following ecological nodes within the BSR: areas of increased channel complexity, off-channel habitat, potential spawning areas, or tributary junctions. Tributary junctions were included because they have higher potential for diversity in temperature, geomorphic functions, debris, sediment, and nutrient input, and increased flow.

1.2.4 Participant Review

The development of the GAAP incorporated local knowledge, available data, and review from the LWWWG. Additional knowledge, available data, and review related to the Lower Walla Walla River and this GAAP were provided by the Walla Walla Basin Watershed Council and Walla Walla County. In addition, individuals from the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) and Walla Walla Joint Community Development Agency attended and provided valuable input at a review and information meeting, respectively. All of these organizations and individuals associated with them provided extensive hours to meetings and presentations, assistance with field data collection, review of data and the GAAP, and guidance related to the future implementation of restoration and enhancement projects on the Lower Walla Walla River. Local participants are provided in Table 1-3.

Table 1-3. Local Participants Who Facilitated the Development of the GAAP

Individual	Affiliation
Tom Reilly	Blue Mountain Land Trust
Alison Greene	Blue Mountain Land Trust
Jonathan Thompson	Confederated Tribes of the Umatilla Indian Reservation (CTUIR)
Brian Mahoney	CTUIR

Table 1-3. Local Participants Who Facilitated the Development of the GAAP (continued)

Individual	Affiliation
Joelle Olsen	CTUIR
Scott O'Daniel	CTUIR
Jed Volkman	CTUIR
Mike Lambert	CTUIR
Mark Lacy	CTUIR
Brian Burns	Tri-State Steelheaders (TSS)
Rick Jones	Walla Walla County Conservation District (WWCCD)
Larry Hooker	WWCCD
Mike Kuttel, Jr.	Washington Department of Ecology (Ecology)
Mark Grandstaff	Washington Department of Fish and Wildlife (WDFW)
Shawn Taylor	WDFW
Brian Wolcott	Walla Walla Basin Watershed Council
Troy Baker	Walla Walla Basin Watershed Council
Randy Glaeser	Walla Walla County
Scott Wagner	Walla Walla County
Ed Teel	Natural Resources Conservation Service
Tom Glover	Walla Walla Joint Community Development Agency
Steve Donovan	Walla Walla Joint Community Development Agency
Jon Maland	Walla Walla Joint Community Development Agency

1.3 PUBLIC OUTREACH

Public outreach will be a key element of the GAAP, with land owners being a critical aspect to the desired future conditions of the Lower Walla Walla River. Outreach to land owners within the Lower Walla Walla River will occur as part of the implementation of the GAAP. Outreach will include a presentation of the GAAP and site walk at identified high priority projects. Land owners are and will continue to be encouraged to provide critical input and feedback. It will only be through the guidance of the land owners in the Lower Walla Walla River that restoration and enhancement projects will be implemented and desired future conditions for this portion of the Subbasin achieved.

1.4 ASSESSMENT AND ACTION PLAN UPDATES

The GAAP provides a framework that can be updated based on future studies, alterations in land use, assessments and plans conducted upstream of the Lower Walla Walla River, implementation of restoration and enhancement projects, and research, monitoring, and evaluation. Data gaps and needs for future assessments and plans have been identified in applicable sections of this GAAP. Should these identified assessments and plans be conducted and implemented, they would likely play a critical role in influencing desired future conditions in the Lower Walla Walla River. For example, a future assessment and action plan for the Touchet River would affect this GAAP. Specifically, if a Touchet River assessment identified potential restoration and enhancement actions in the Lower Touchet River, it could have substantial influences on the Lower Walla Walla River. These influences could include altered hydrologic and geomorphic conditions, as well fish utilization, in the Lower Walla Walla River. Similarly, future conditions in Mill Creek, which flows into the Walla Walla farther upstream than the area evaluated in this GAAP, could have a substantial influence on the hydrology and sediment mobility and transport in the Lower Walla Walla River. Research, monitoring, and evaluation associated with the CTUIR Biomonitoring Plan (Stillwater Sciences 2012) and PHAMS, or other regional monitoring programs such as the Columbia Habitat Monitoring Program (CHaMP) and BPA's Action Effectiveness Monitoring, could also provide information that would be used to update the GAAP. Based on these examples, as well as the potential need for future updates, this GAAP identifies data gaps and additional needs and provides a framework that can be updated as new information and data become available.

2. Subbasin Description

This section provides an overview of the Walla Walla Subbasin based on existing data and, where essential, focuses the information at the scale of the Lower Walla Walla River. Additional information on the major characteristics of the Walla Walla Subbasin can be found in NWPCC (2005), WWWPU (2005), NMFS (2009), SRSRB (2011), Lewis (2012), and USFWS (2014).

2.1 LOCATION AND CLIMATE

The Walla Walla Subbasin is primarily located in Walla Walla and Columbia Counties in southeastern Washington, with limited portions in Umatilla, Union, and Wallowa Counties in northeastern Oregon (NWPCC 2005; Figure 1-1). In this GAAP, the Lower Walla Walla River within the Subbasin is considered to extend from RM 27.4 near the town of Lowden, Washington, to its confluence with the Columbia River at RM 0.0 and is located within Walla Walla County.

2.1.1 Drainage Area

The Walla Walla Subbasin drains approximately 1,758 square miles in southeast Washington and northeast Oregon. The headwaters of the Walla Walla River originate in the Blue Mountains in the eastern part of the Subbasin. Topography in the eastern portion of the Subbasin is mountainous, averaging 5,000 feet above sea level in elevation (NWPCC 2005). As the Walla Walla River flows west out of the Blue Mountains, the topography transitions to rolling hills with an average elevation of 2,500 feet, and eventually drains into the Columbia at less than 262 feet above sea level (NPPC 2001; Parks et al. 2010). The NWPCC (2005) Subbasin Plan contains figures illustrating elevations in the Walla Walla Subbasin.

2.1.2 Climate

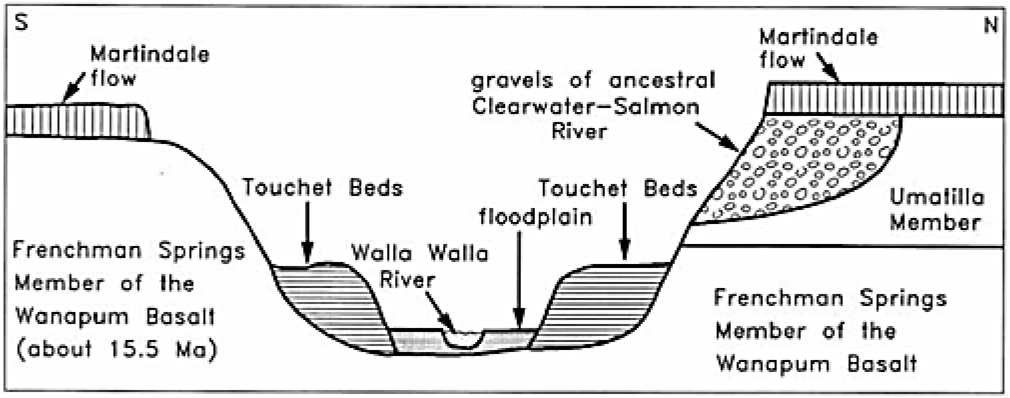
The Cascade Mountains produce a rain shadow as far as the Blue Mountains (NWPCC 2005). This effect creates a semi-arid climate in the western lowlands of the Walla Walla Subbasin along the Lower Walla Walla River. Average temperatures for the Subbasin range from 20 to 25 degrees Fahrenheit in the winter, to 90 to 95 degrees Fahrenheit (°F) in the summer (WWWPU 2005). Rainfall for the Subbasin averages less than 10 inches per year, with higher elevations in the Blue Mountains producing a wetter climate in the eastern portion of the Subbasin, with averages of 40 to 60 inches of combined rain and snowfall per year (WWWPU 2005). Historically, the flow in the Walla Walla River was dominated by storm events in the winter, snowmelt in the spring and early summer, and groundwater during the summer and dry cold periods in the winter (Newcomb 1965). Snowmelt contributes the majority of the annual runoff for much of the Subbasin, with water levels dropping substantially for many streams during summer months (NWPCC 2005). These lower flow conditions during the summer are reduced further by surface water diversions and groundwater withdrawals for agriculture and other uses (EPA 1974; Butcher and Bower 2005). The NWPCC (2005) Subbasin Plan contains figures illustrating precipitation patterns in the Walla Walla Subbasin.

Changes in water quantity and temperature are expected to occur throughout the Pacific Northwest as a result of climate change (Casola et al. 2005). Baldwin and Stohr (2007) reviewed climate models in their 2007 TMDL report for the Walla Walla River and reported decreases in summer stream flows; they also cited Mote et al. (2005) who estimated an average expected increase of 0.3 degrees Celsius (°C). Increased air temperatures associated with climate change result in more precipitation falling as rain instead of snow, as well as earlier melting of snowpacks in the spring (Baldwin and Stohr 2007). The predicted increases in summer temperatures could further exacerbate streamflow and water temperature issues within the Walla Walla Subbasin. The Baldwin and Stohr (2007) report goes on to highlight the importance of restoring processes for maintaining cooler water temperatures to offset impacts from climate change, such as restoring riparian habitat, reducing channel widths, and restoring baseflows.

2.2 GEOLOGY

The topography of the Walla Walla Subbasin is a result of geologic processes, including folding and faulting of the underlying basalts, which create the regional sloping westward from the Blue Mountains, southward between the Touchet River and Walla Walla River, northward from Horse Heaven Ridge, and eastward from a dividing ridge in the lower Walla Walla valley (Newcomb 1965). These general patterns are further influenced by erosion of the underlying basalts and overlaying loess (wind-blown glacial silt and very fine sand) and Touchet Bed layers.

The Walla Walla Subbasin is within the Columbia River Basalt Group (Carson and Pogue 1996). The Plateau is composed of volcanic basalt (Columbia River Basalt) thousands of feet thick. These basalt flows cover much of eastern Washington and Oregon, and southern Idaho. Three major formations occur in the Walla Walla Subbasin: the Saddle Mountains, Wanapum, and Grande Ronde (Kuttel 2001). A cross section demonstrating the geologic history of the Lower Walla Walla River is illustrated in Figure 2-1.



Source: Carson and Pogue (1996)

Figure 2-1. Illustration of Geologic Cross Section of the Lower Walla Walla River Valley

Lava flows from various periods are present. The oldest flow comprises the Frenchman Springs Member (15.5 million years old) of the Wanapum Basalt. In some areas, this is overlain by the Umatilla Member (14 million years old) of the Saddle Mountains Basalt, which was partially eroded and then filled in with basaltic, metamorphic, and plutonic clasts from the ancient Clearwater-Salmon River. This was all overlain with the Martindale flow of the Ice Harbor Member approximately 8.5 million years ago (Carson and Pogue 1996).

Glacial retreat and advance carved valleys and channels in the higher elevations of the basin, and unconsolidated deposit, known as "old gravel and clay" (Newcomb 1965), partially filled in low areas in the folded basalt (Walla Walla Basin Watershed Council [WWBWC] 2004). The Lake Missoula floods, which occurred during the late Pleistocene, between 12,700 and 15,300 years ago, further altered the landscape. These floods were a result of the continental ice sheet repeatedly damming what is now the Clark Fork River. When the ice dams failed, catastrophic floods raged through the Columbia basin, leaving deep deposits of silt in the backwatered flood flows near the mouth of the Walla Walla River, creating the Touchet Beds (Beechie et al. 2008; Carson and Pogue 1996).

Fertile soils formed from the deposits of silt and sand derived predominantly from the Touchet Beds that cover the Subbasin as a result of these repeated massive flood events (Mapes 1969; WWBWC 2004). Soils in the Walla Walla Subbasin are characterized by their general sources of origin. At the most western edge of the Subbasin, dry, porous, and highly permeable soils developed from basaltic deposits from the Columbia and Snake Rivers (Mapes 1969). The soils of terraces in the lower Walla Walla valley are composed of well-drained loess and lacustrine sediments from the silt and sand deposits of the Touchet Beds. Soils in the river valleys and lowland terraces are formed from alluvial deposits from upland sources and are generally deep and well-drained (Mapes 1969). Just over half of the Walla

Walla Subbasin is dominated by loess uplands, formed into hills and terraces created by wind blowing the fine flood deposits into dunes which became the rolling Palouse hills (WWBWC 2004). Distribution of fine sand is highest in the west, while clay is more prominent in the east (Mapes 1969). Soils in the Blue Mountains are chiefly composed of loess and weathering from basalt, and are generally rocky and shallow to moderately deep (Mapes 1969).

2.3 HYDROLOGY

Detailed descriptions of tributary drainages within the Walla Walla Subbasin and associated hydrology for the entire Subbasin can be found in the Draft Walla Walla Subbasin Summary (NPPC 2001), Level 1 Assessment (WRIA 32 Planning Unit 2002, as cited in NWPCC 2005), and NWPCC (2005). Tributaries to the Lower Walla Walla River tend to have a faster and more dramatic response to rain events than the mainstem Walla Walla River, which has consistent seasonal high flows (WWCWPD 2009). Flows in the Walla Walla Subbasin can be divided into three main sources: precipitation runoff (dominating flows in early winter), snowmelt runoff (contributing substantial flow in spring and early summer), and groundwater discharge (supplying flows during summer and colder times in winter) (Newcomb 1965). Peak flows generally occur in the Walla Walla Subbasin with winter rains and spring snowmelt, with tributary watersheds in the Lower Walla River providing minimal flow during the summer months, except during large precipitation events (NWPCC 2005).

The Touchet River is a primary tributary within the Walla Walla Subbasin and Lower Walla Walla River, with its drainage area comprising 43 percent of the total Walla Walla Subbasin area. Other tributaries that directly influence the Lower Walla Walla River hydrology within the GAAP survey area include Dry Creek, Pine Creek, Gardena Creek, and Mud Creek (in order of highest to lowest tributary drainage areas). Table 2-1 contains the tributary confluence location and tributary drainage area for the Lower Walla Walla River tributaries. Figure 2-2 contains a map showing the tributary boundaries for the tributaries shown in Table 2-1.

The USGS operates and maintains three stream gages within the Walla Walla Subbasin: two are in the Mill Creek drainage and one is on the Lower Walla Walla River. Flows within the Lower Walla Walla River are monitored at USGS stream gage 14018500 near the town of Touchet, Washington (see Figure 2-2 for the location of USGS stream gage 14018500). The USGS stream gage 14018500 has been operating continuously since 1951, and is located on the Walla Walla River at RM 18.2, which is 3.4 miles downstream from the confluence with the Touchet River (USGS 2014b). The Walla Walla River has a contributing drainage area of 1,657 square miles at the gage location.

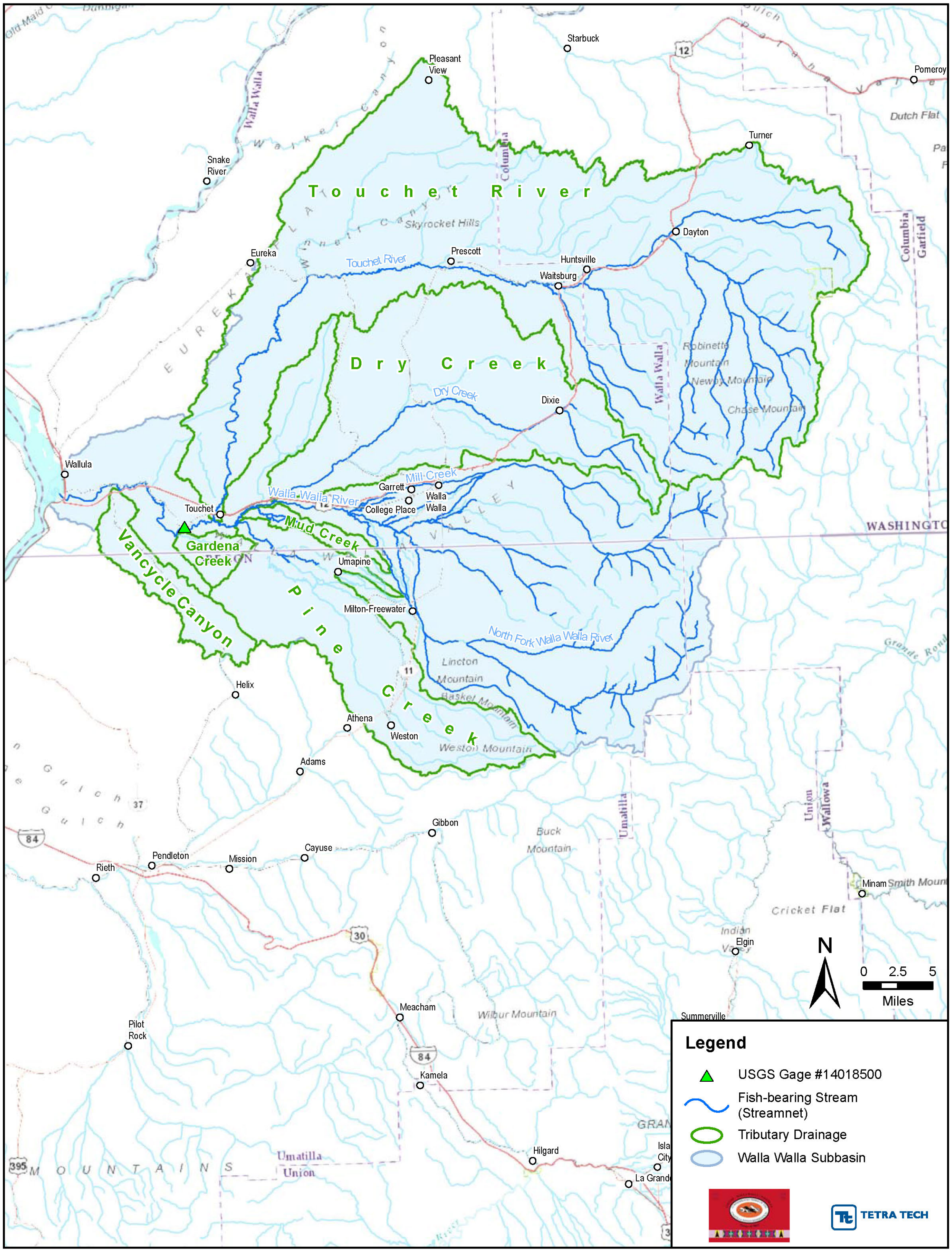
Table 2-1. Confluence River Mile and Drainage Area for Tributaries to the Lower Walla Walla River

Walla Walla River Tributary	Tributary Confluence (Walla Walla RM)	Tributary Drainage Area (mi^2)	Walla Walla Drainage Area Upstream of Tributary Confluence (mi^2)
Vancycle Canyon	9.2	40	1,708
Gardena Creek	17.7	14	1,659
Touchet River	21.6	752	899
Pine Creek	23.4	160	733
Mud Creek	25.9	13	717
Dry Creek	27.3	244	438

Data from the USGS stream gage 14018500 were used to calculate peak (Section 2.3.1), mean monthly (2.3.2), and mean monthly annual low (2.3.3) flows. The highest recorded peak daily discharge for the gage is 33,400 cubic feet per second (cfs), recorded for December 22, 1964. There are two additional gages operated by Ecology on the Walla Walla River at Beet Road and Detour Road that were applicable to the Lower Walla Walla River. These gages were not used for analysis because they have a relatively short period of record (less than 12 years) and have been affected by ice in the past, leading to potential measurement errors.

2.3.1 Peak Flows

Flood magnitude and frequency were estimated using the peak discharge data from the USGS gage on the Walla Walla River near Touchet, Washington (USGS stream gage 14018500). Peak flow rates were adjusted for tributary inputs in order to develop flow estimates for the entire length of the GAAP survey area. Table 2-2 contains the peak flow estimates for the Lower Walla Walla River segmented at tributary confluences. Peak flows downstream of the Touchet River confluence were estimated using gage transfer methods described in Sumioka et al. (1998). Regional regression equations were used to calculate flows upstream of the Touchet River confluence, because the drainage areas upstream of Pine, Mud, and Dry Creeks are outside of the range of applicability (between 50 percent and 150 percent of the drainage area for the gage) described in Sumioka et al. (1998).



Path: L:\194-4907 Lower Walla Walla River Geomorphic Assessment\5_GIS\maps\Report\Major_Tributaries.mxd

Figure 2-2. Lower Walla Walla River Tributary Drainages and USGS Stream Gage 14018500

Table 2-2. Peak Flow Estimates for the Lower Walla Walla River

Recurrence Interval (years)	Mouth[1/] Discharge (cfs)	Downstream of Gardena Creek[1/] Discharge (cfs)	Downstream of Touchet River[1/] Discharge (cfs)	Downstream of Pine Creek[1/] Discharge (cfs)	Down-stream of Mud Creek[2/] Discharge (cfs)	Down-stream of Dry Creek[2/] Discharge (cfs)	Upstream Extent[2/] Discharge (cfs)
2	6,120	6,010	5,910	4,120	2,700	2,700	2,400
5	10,810	10,630	10,440	7,270	4,200[3/]	4,200[3/]	3,400[3/]
10	14,620	14,370	14,120	9,840	6,480	6,450	5,430
100	30,230	29,710	29,200	20,340	13,080	12,980	10,610

1/ Flows estimated using the gage-transfer method (Sumioka et al. 1998) USGS Gage #14018500 Walla Walla River near Touchet, WA.
2/ Flows estimated using regional regression equations (Sumioka et al. 1998; USGS 2001).
3/ Five-year recurrence interval flows were estimated by interpolating between other recurrence interval values on a log-scale.

2.3.2 Mean Monthly Flow

Low-flow periods generally occur between July and October, with average annual high flows peaking between January and April. There is some variation in this pattern; however, the trend of high winter-spring flows and low summer-autumn flows is generally consistent. Mean monthly flows from representative dry (1977), wet (1974), and average (2013) flow years are shown in Figure 2-3 as examples of monthly flows for years with average annual flow values in the 5, 50, and 95 percent exceedance probabilities. The graph shows the seasonal pattern of flows reflecting the general pattern described above of winter rains and spring rains and snowmelt. Example high- and low-flow years show the variation of this pattern from year to year. While the long-term average flow pattern indicates peak flows typically occur in February or March, in some years, peak flows may occur earlier in the winter or later in the spring.

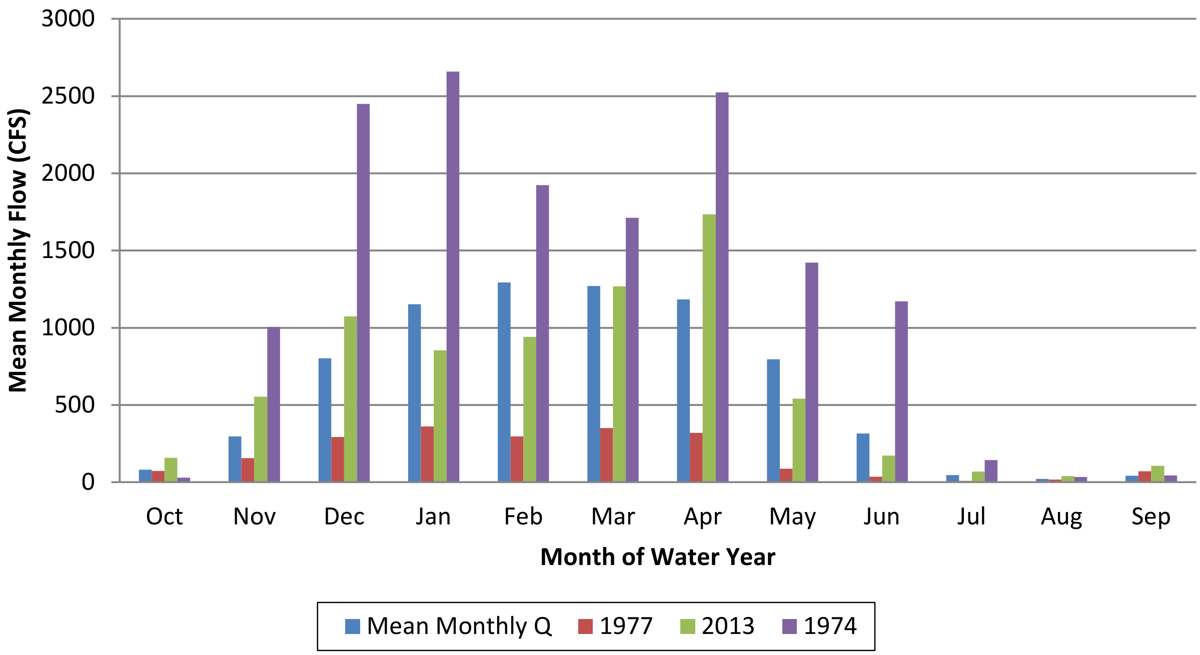


Figure 2-3. Mean Monthly Flows from USGS Gage 14018500 on the Walla Walla River Near Touchet, Washington (WY 1952-2013)

2.3.3 Mean Monthly Annual Low Flow

The 7-day monthly low flow was calculated for the period of record from the USGS stream gage 14018500 for the lower Walla Walla River. Climatic years (April 1 to March 31 of the following year) were used for calculations to avoid separating low-flow periods by water years, as described in Curran and Olsen (2009). Mean monthly low flows are presented for the entire period of record in Figure 2-4, as well as monthly examples for years in which the

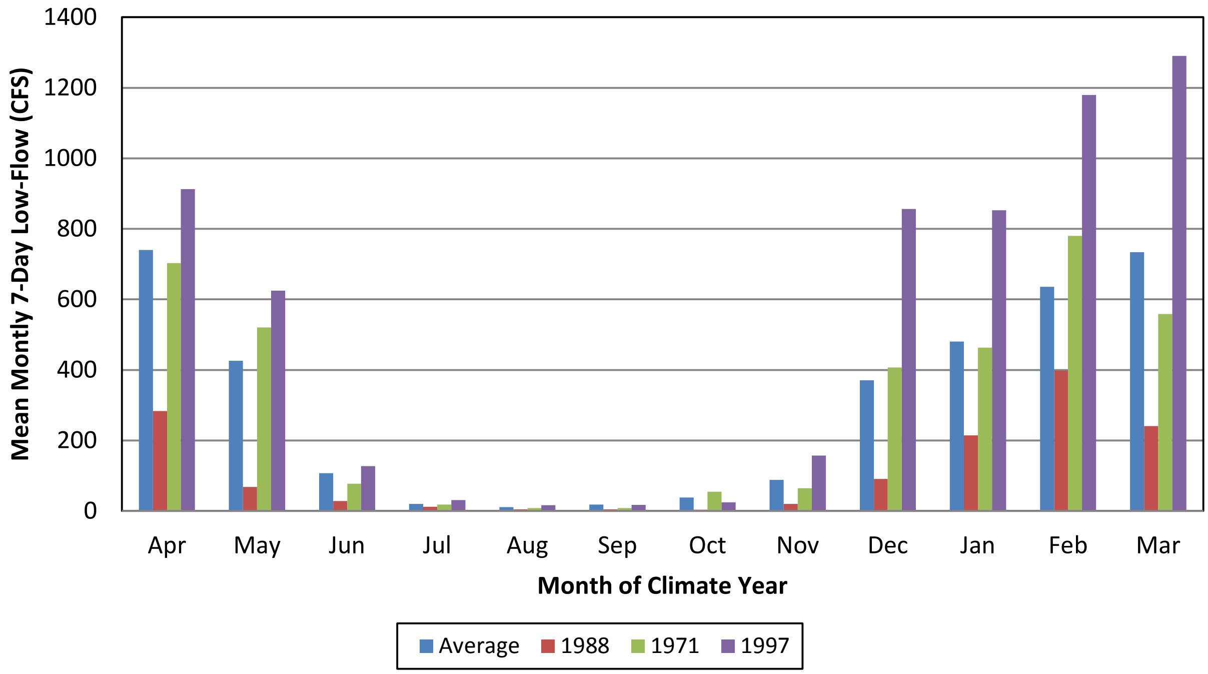


Figure 2-4. The 7-Day Mean Monthly Low Flows by Month for the Walla Walla River Near Touchet, Washington, for Climate Years 1953–2014

monthly average low flows were considered to be in the low (1988), mean (1971) and high (1997) range. These are not the same years as those used for the mean flows because those were based on years that had an average flow that was higher than average, average, or lower than average. The mean months with the lowest mean 7-day low flows are July through October, with values below 40 cfs for all months.

Based on evaluation of the mean monthly annual low flow, average monthly low flows for July, August, and September over the last 5 to 10 years have increased, likely in response to water conservation measures. From 2004 to 2010, July, August, and September mean 7-day low flow monthly averages were 27.6 cfs, 15.2 cfs, and 23.3 cfs, respectively. Between 2010 and 2014, mean 7-day low-flow monthly averages for the same months were 33.6 cfs, 19.4 cfs, and 24.2 cfs, respectively.

2.3.4 Water Quantity

In addition to precipitation and snowmelt runoff contributing to flows, groundwater discharge is the third main source in the Walla Walla Subbasin, supplying flows during summer and colder times in winter (Newcomb 1965). Although groundwater discharge contributes flow to the Walla Walla River, results from forward-looking infrared (FLIR) sampling of the Subbasin indicate that except for the upper South Fork Walla Walla River, groundwater contributions were not at a level that could be detected as determined from limited warm season spring activity (Butcher and Bower 2005). The study also noted, however, that entrenchment of the channel likely prevented detection of hyporheic activity using FLIR for large sections of the Walla Walla River. Warmer conditions expected to result from climate change may further reduce summer flows as more winter precipitation falls as rain rather snow (Baldwin and Stohr 2007) creating more reliance on groundwater discharge during the summer due to the loss of snowmelt release in the spring and early summer.

Groundwater discharge in the Walla Walla Subbasin can be divided into two primary aquifers: (1) the shallow gravel aquifer in the central part of the Subbasin (approximately 190 square miles), which is made up of unconsolidated sediments on top of clay; and (2) the deeper basalt aquifer, which comprises approximately 2,500 square miles and underlies the entire Walla Walla River Subbasin (Newcomb 1965; WWCWPD 2009). Well logs indicate the gravel occurs from 17 feet to 294 feet, with the basalt layers occurring from 74 feet and the deepest well depth at 1,169 feet (USGS 1960). There is considerable hydrologic connectivity between the shallow aquifer and the Walla Walla River (NWPCC 2005), which has been impacted by human alterations, such as levee construction, in-channel gravel mining, and numerous shallow wells, both domestic and agricultural (NWPCC 2005).

Anthropogenic alterations have contributed toward a decline in the water quantity in aquifers in portions of the Walla Walla Subbasin (NWPCC 2005; WWBWC 2013). This decline has reduced the surface water supply throughout the Walla Walla Subbasin, contributing to tributaries and portions of the mainstem Walla Walla River either being dry or losing water into the ground in the late summer and early autumn (WWBWC 2013). In 2004, the WWBWC partnered with the Hudson Bay Ditch Improvement Company to develop an alluvial aquifer recharge site in the Walla Walla Subbasin. This recharge site resulted in improvements to both the surface water and groundwater systems in the vicinity of the site. Building on these results, the WWBWC and its partners have expanded the number of sites for aquifer recharge and developed the Walla Walla Basin Aquifer Recharge Strategic Plan (WWBWC 2013). The primary purpose of the plan "is for public and regional benefit to restore the aquifer and enhance or support groundwater contributions to instream flow thereby maximizing the resource's potential with multiple benefits for aquatic life, recreational water use, domestic use, and irrigation use." Although aquifer recharge efforts help to redress losses in groundwater systems, they do not address the surface water losses from agricultural and urban development (WWBWC 2013).

Substantial water withdrawal and diversions occur during the spring and summer upstream of the Lower Walla Walla River for residential, industrial, and agricultural use that impact water quantity (see NWPCC [2005] and WWWPU [2005] for detailed descriptions of water use). Upstream of the Lower Walla Walla River, the cities of Walla Walla and Milton-Freewater, as well as other smaller towns and large agricultural lands, withdraw water from surface and groundwater sources (NWPCC 2005). Low-flow conditions within the Lower Walla Walla River during the summer reflect periods of high water use; however, in recent years, flows available during the summer have increased due to efforts associated with water-saving, instream flow requirements, water banking, and other management initiatives identified in various agreements and plans such as the Final Amended Civil Penalty Settlement Agreement (USFWS 2001), Walla Walla Subbasin Plan (NWPCC 2005), Walla Walla Watershed Plan (WWWPU 2005) and Walla Walla Watershed Management Partnership (WWWMP) Strategic Plan 2012-2015 (WWWMP 2012a).

These water-saving efforts have included irrigation efficiency projects, pivot conversions, and piping and lining of irrigation ditches (WWWMP 2012b; WWCCD 2014). The 2007 amendment by Ecology to the existing water management rule (Chapter 173-532 Washington Administrative Code [WAC]) has established instream flow water rights, modified seasonal closures of surface waters, closed shallow aquifers, controlled and managed future permit-exempt groundwater withdrawals, limited stock watering, and provided guidelines for environmental enhancement projects (Ecology 2007). A water banking program established by the WWWMP has resulted in groundwater and surface water rights deposited in their water bank, which directly contributes toward instantaneous instream water with quantities dependent on the time of the year (WWWMP 2012b). Other management initiatives have also included the CTUIR and USACE conducting a Feasibility Study to evaluate various alternatives to restore instream flows (IEc 2011). One alternative preferred by the CTUIR includes the Columbia River Water Exchange, which entails a 39 mile pipeline to deliver Columbia River water to irrigation districts (IEc 2011). Although water-saving efforts, instream flow requirements, water banking, and other management initiatives have provided coordination in the Subbasin and increased the availability of summer flows, water withdrawal and diversions continue to contribute toward low flows and high summer water temperatures remaining key limiting factors in the Lower Walla Walla River (Mendel et al. 2014).

An additional factor affecting the hydrology of the Lower Walla Walla River is Mill Creek, a tributary to the Walla Walla River that flows through the city of Walla Walla. This creek has been modified over the decades and is currently managed for flood control. Authorized by the Flood Control Act of 1938, Mill Creek dam and channel and its off-stream reservoir, Bennington Lake, were constructed by 1950 (USACE 2014). The Mill Creek flood channel system together with Yellowhawk Creek in the city of Walla Walla is managed by the Mill

Creek Flood Control Zone District and the USCACE, with management activities including diverting peak flows from Mill Creek into Bennington Lake. This diversion of flows results in additional alterations in the Lower Walla River's hydrology, and the Mill Creek dam and channel affect upstream passage for fish species (NWPCC 2005). This combination of flood control, deteriorating flood channel structures, and effects on fish passage have caused local coalitions, organizations, and officials to begin considering how to improve conditions associated with the Mill Creek flood channel system (see Union-Bulletin [2014] for a discussion of visions of a new Mill Creek). If changes are made to the Mill Creek flood channel system, future conditions could have a substantial influence on the hydrology and sediment mobility and transport in the Lower Walla Walla River and would require further analyses associated with this GAAP.

2.4 WATER QUALITY

In the upper portions of the Walla Walla Subbasin the quality of water is typically higher, with water quality more degraded in the lower portions (NPPC 2001; NWPCC 2005). Throughout the Subbasin, water quality is closely tied to water quantity (WWWPU 2005). Water quality standards and further information associated with water quality in the Subbasin can be found in the Walla Walla Subbasin Plan (NWPCC 2005), Walla Walla Subbasin Stream Temperature TMDL and Water Quality Management Plan (ODEQ 2005), Walla Walla Watershed Plan (WWWPU 2005), Walla Walla River Chlorinated Pesticides and PCBs TMDL (Water Cleanup Plan; Ecology 2006), and Quality Assurance Project Plan Pine Creek Toxaphene Source Assessment (Ecology 2014a).

The Walla Walla River has been 303(d) listed for temperature, flow, pesticides, pH, dissolved oxygen, and fecal coliform bacteria (NPPC 2001; ODEQ 2005; NWPCC 2005; WWWPU 2005; Ecology 2006, 2014b). Currently, in portions of the Lower Walla Walla River, temperature, pesticides, pH, bacteria, and dissolved oxygen have an approved TMDL in place and are actively being implemented (Ecology 2014b). In addition, instream flow has been identified in portions of the Lower Walla Walla River as impaired by a non-pollutant and cannot be addressed through a TMDL (Ecology 2014b).

In the Lower Walla Walla River, sedimentation, temperature, and low flow quantity have been identified as the primary water quality factors limiting steelhead production (NWPCC 2005; NMFS 2009; SRSRB 2011). Water quality factors limiting bull trout production included water temperatures and instream flows (USFWS 2014). Due to the threatened status of bull trout and steelhead under the ESA, as well as the presence of Chinook salmon and redband trout, water temperature has been a major concern throughout the Subbasin (WWWPU 2005).

While the natural geology of the area results in fairly high sedimentation in portions of the Lower Walla Walla River, exacerbation from eroding banks due to removal of riparian structure, channelization, bank modifications, and intensive land use have accelerated these natural processes. Although the anthropogenic acceleration of these natural processes has also affected water temperatures, the summer low-flow water quantity that results from agriculture withdrawals and diversions has further contributed to increased water temperatures (Butcher and Bower 2005 and see Section 2.3 above). In addition to sedimentation, water temperatures, and low-flow quantity, other water quality issues stem from agricultural run-off and point-source pollution (NPPC 2001; Butcher and Bower 2005; NWPCC 2005; ODEQ 2005; WWWPU 2005; Ecology 2006, 2014a).

2.4.1 Sediment

The Walla Walla River has not been Section 303(d) listed for suspended solids or turbidity; however, total suspended solids concentration from January to June in the Walla Walla River has been reported between 50 and 650 milligrams per liter (mg/L; NPPC 2001). This concentration of total suspended solids is within the upper limits of 80 mg/L for salmonids under continuous exposure (USFWS 1995, as cited in NPPC 2001). Although it has not been listed for suspended solids or turbidity, the erosion of fine sediment is a problem in the Lower Walla Walla River that has resulted principally from agricultural practices, as well as road building and logging in the upper portions of the Subbasin and recreational vehicle (RV) use and urban runoff (EES 2003 as cited in Ecology 2006). Fine sediment inputs associated with sheet and rill erosion from croplands are considered serious issues throughout the Lower Walla Walla River (Kuttel 2001). Dry Creek and the Touchet River, which directly flow into the Lower Walla Walla River, carry some of the highest sediment loads in the United States. In 1984, it was estimated that runoff from agricultural lands resulted in 73,000 tons per year of fine sediment entering the Walla Walla River (Kuttel 2001).

Enrollment in the Conservation Reserve Program (CRP), direct seed/no-till planting, use of sediment basins, and upland terrace construction were identified in the Walla Walla Subbasin Plan (NWPCC 2005) as upland enhancement actions intended to address sedimentation. Throughout the Lower Walla Walla River valley, the WWCCD has been implementing upland enhancement actions as part of their 5-year plan (WWCCD 2005). These actions have helped to improve agricultural practices and reduce fine sediment contributions to the Lower Walla River (Larry Hooker, personal communication, August 21, 2014).

Several existing data sources provide sediment size, transport, and load estimates, as well as an estimated aggradation rate, applicable to portions of the Subbasin and Lower Walla Walla River. Table 2-3 lists the data types and sources.

Based on published aggradation rates measured over recent decades, Beechie et al. (2008) estimated that recovery times for incised channels could range from 40 to 200 years depending on incision depth (6.5 to 23 feet). This estimate assumes a relatively low aggradation rate of 0.1 foot per year, which may be an overestimate in areas where the source of non-cohesive sediment is limited.

Table 2-3. Existing Sediment Data Types and Sources

Parameter	Data Type	Location	Data Source
Sediment size field measurements	Particle size distributions of suspended sediment (1962 to 1965)	USGS gage near Touchet	Mapes (1968)
	Bed surface samples (2000)	RM 9.1;11.5; 14.0; 18.8; 21.2; 23.5; and 26.8	Butcher and Bower (2005)
	Visual bed surface estimates (2000)	Game Dept. Road to Lowden Bridge	Reckendorf and Tice (2000)
Sediment transport field measurements	Sediment concentration in milligrams per liter (1962 to 1970 continuous)	Walla Walla River near Touchet and Mill Creek near Walla Walla	Mapes (1968)
	Sediment concentration in milligrams per liter (1962 to 1965 grab samples)	17 sites throughout the basin including on the Touchet River, Mill Creek, Pine Creek, Dry Creek, Coppei Creek, Blue Creek and others	Mapes (1968)
	Sediment discharge in tons per day at (1962 to 1970)	USGS gage near Touchet	Mapes (1968)
Sediment load estimates	Bedload Sediment Rating curve (2000)	Last Chance Bridge and Frog Hollow Bridge and Mill Creek	Butcher and Bower (2005) using Wilcox and Crowe (2003) bedload sediment model
	Total sediment load from the Walla Walla basin (1951 to 53 and 1962 to 1965)	–	–
	Average annual sediment yield (tons per square mile) developed from flow-duration curve and sediment-transport curve (1962 to 1965)	17 sites throughout the basin including on the Touchet River, Mill Creek, Pine Creek, Dry Creek, Coppei Creek, Blue Creek and others	Mapes (1968)
Aggradation rate estimate	Developed from existing literature values and adjusted for changes in land use	Walla Walla River	Beechie et al. (2008)

Table 2-4 contains a summary of Mapes (1968) sediment data from 1962 to 1965. It should be noted that these values are considered high relative to current conditions, given that land-use practices have improved since the 1960s and that there were two very large floods in December 1964 (peak discharge of 33,400 cfs) and January 1965 (peak discharge of 15,800 cfs) (Mapes 1968). A large percentage of the total sediment load in the Walla Walla River in the 1960s, and presumably today (although the exact percentages are likely different), was contributed from the Touchet River and Dry Creek (Table 2-4). The bulk of the suspended sediment load consists of clay and silt (80 percent to 97 percent) and a lesser percentage of sand (3 to 20 percent).

Table 2-4. Summary of Mapes (1968) sediment data from 1962 to 1965 for the Walla Walla River basin.

Tributaries	Average Annual Sediment Discharge (tons)	Average Annual Sediment Yield (tons/mi^2)	Percent of Load – Walla Walla near Touchet (%)	Suspended Sediment Size: Clay|Silt|Sand (%)
Mill Creek	77,800	400 to 855	2	25|55|20
Pine Creek	330,000	1,900	8	20|65|15
Dry Creek	910,000	1,600 to 4,000	23	18|77|5
Touchet River	2,200,000	1,700 to 4,000	56	21|73|6
Other Tributaries	–	–	11	–
Walla Walla River near Touchet	3,910,000	2,360	100	28|69|3

2.4.2 Water Temperature

Water temperatures throughout the Walla Walla Subbasin are described in detail in various studies and assessments (Mendel et al. 1999; NPPC 2001; Butcher and Bower 2005; NWPCC 2005; ODEQ 2005; Mendel et al. 2007). Within the Walla Walla Subbasin, naturally low summer flows are exacerbated by anthropogenic alterations associated with domestic and agricultural wells; water withdrawals and diversions for residential, industrial, and agricultural uses; and management activities in upper portions of the Subbasin (see Section 2.3.4). Lower summer flows in combination with a lack of riparian vegetation and anthropogenic alterations to the channel in some locations have led to water temperatures in Lower Walla Walla River remaining above 20°C (68°F) during the summer months (generally July through September) (NPPC 2001; NWPCC 2005; Mendel et al. 2007). These summer water temperatures exceed Washington State criteria for salmonids (see WAC 173-201A-200), where water temperature is measured by the 7-day average of the daily maximum temperatures. The applicable biologically based temperature thresholds (numeric criteria) in the Subbasin include:

- Salmonid spawning, rearing, and migration 17.5°C (63.5°F), applicable August 1 to July 15

- Core summer salmonid habitat 16°C (60.8°F)
- Bull trout spawning and rearing 12°C (53.6°F), applicable August 21 to May 15

The water temperatures in the Lower Walla Walla River are believed to cause thermal barriers and sharply reduce survival of embryos and fry to salmonids (Mendel et al. 1999 and 2007). These thermal barriers and detrimental impacts to fish migration dissipate in the fall when instream flows increase and water temperatures decrease, typically early in September but possibly extending through the end of September based on location (Mendel et al. 2007). Average water temperatures are below 5°C (41°F) throughout the Subbasin from November through March (NPPC 2001).

Instream flows in the Walla Walla River are closely tied to water temperatures (WWWPU 2005). Dewatering, ranging from isolated pools to completely dry stream beds, has historically occurred in the Lower Walla Walla River (USACE 1997). Water rights, including irrigation withdrawals from the Walla Walla River, have been over-allocated in the Subbasin (Ecology 2007). Groundwater withdrawals have significantly affected the water levels in groundwater aquifers in the Subbasin (WWCWPD 2009), and because the shallow gravel aquifers are hydrologically connected to streams in the Subbasin, groundwater withdrawals have an effect on instream flows (WWT 2007). The utilization and allocation of both surface and groundwater has and continues to play an integral role related to instream flows, water temperature, and fish utilization in the Lower Walla Walla River. Low summer flows and associated effects on water temperature have been and continue to be a concern and limiting factors regarding fish migration in the Lower Walla River (NPPC 2001; Caldwell et al. 2002; NWPCC 2005; Mendel et al. 2007; NMFS 2009; SRSRB 2011; Schaller et al. 2014; USFWS 2014).

To address instream flows, the Final Amended Civil Penalty Settlement Agreement between the USFWS and several irrigation districts (USFWS 2001) assisted in replenishing water to a regularly dewatered reach of the Walla Walla River beginning in 2001 (Mendel et al. 2004). In addition, Ecology has taken measures to increase instream flow and maintain aquatic systems in recent years. In 2007, Ecology amended the existing water management rule (Chapter 173-532 WAC) to establish instream flow water rights, modify seasonal closures of surface waters, close shallow aquifers, control and manage future permit-exempt groundwater withdrawals, limit stock watering, and provide guidelines for environmental enhancement projects (Ecology 2007). Other successful instream flow restoration efforts by the WWCCD, WWWMP, and WWBWC, such as the water-saving, water banking, and other management initiatives, are improving low flow summer conditions (Lewis 2012; WWWMP 2012b; WWBWC 2013; WWCCD 2014).

In addition to instream flows contributing toward thermal barriers and detrimental impacts to fish migration, water temperature impairments are likely to become more pronounced with expected regional changes in air temperature and stream discharge associated with climate change (Mantua et al. 2010; Isaak et al. 2012). Associated increases in water temperature will have the potential to alter distributions of native riverine organisms. Summer temperatures in rivers are projected to warm with air temperatures (Isaak et al. 2012), which will compress the amount of habitat for cold-water aquatic communities.

The extent and location of potential losses in available cold-water habitat relative to air temperature increases, however, may be minimized by localized river geomorphology, and particularly by floodplains. Alluvial river valleys are often zones of water temperature (Arscott et al. 2001), habitat (Ward et al. 1999), and biotic diversity (Stanford et al. 1996; Ward et al. 1999). The associated complex, multi-threaded channel forms and presence of floodplain gravels beneath river channels create opportunities for hyporheic exchange (Poole et al. 2008) that can moderate water temperature extremes (Arrigoni et al. 2008), provide important cold-water habitat (Torgersen et al. 1999), and even reverse the expected increasing trend in channel temperature as water moves downstream (O'Daniel et al. 2003). Therefore, hydrologically functional floodplains with complex channel patterns and associated high rates of hyporheic exchange may be important landscape nodes for river conservation in the face of ongoing disruption of global climate systems. Restoration of water availability (both surface and groundwater sources), as well as connections between hyporheic and surface flows (through floodplain restoration and reconnection projects), may provide these moderating conditions to the Lower Walla Walla River.

2.4.3 Other Water Quality Issues

Additional water quality concerns present throughout the Subbasin relate to levels of pesticides, pH, dissolved oxygen, and fecal coliform bacteria (NPPC 2001; ODEQ 2005; NWPCC 2005; WWWPU 2005; Ecology 2006, 2014b). In 1998, all Section 303(d) listings for the Lower Walla Walla River were at or below the confluence of the Touchet and Walla Walla Rivers (Ecology 2014b). Since 2002, water sampling in the Lower Walla Walla River has confirmed a persistent pesticide source to the river, with the highest concentrations during May and June and another spike in October and November, corresponding to the peak irrigation times (Ecology 2014a). As of the most recent water quality assessment in 2012, portions of the Lower Walla Walla River have an approved TMDL in place and programs are actively being implemented to improve levels of pesticides, pH, bacteria, and dissolved oxygen (Ecology 2014b). In addition, elevated nitrate levels from septic tank drain fields, fertilizers, and other sources have also been documented in the Walla Walla Subbasin

(ODEQ 2005). Agricultural practices are the most prominent source of increased toxins, with urban and municipal sources also contributing toxins and decreasing dissolved oxygen (ODEQ 2005).

2.5 RIPARIAN VEGETATION

Extensive riparian zones existed in the Walla Walla Subbasin historically (USACE 1997); however, agricultural and urban development along the Lower Walla Walla River has resulted in the removal and displacement of native riparian vegetation (Bower 2003). Extensive riparian zones of the lower Walla Walla Subbasin (below the National Forest boundary) have been reduced by 65 to 70 percent in many areas (Lewis 2012). Land use practices, including grazing and agriculture, have led to significant changes to vegetation communities in the Walla Walla Subbasin. Agricultural use has replaced much of the native grassland and shrub-steppe vegetation in the Lower Walla Walla River valley (NWPCC 2005). Anthropogenic impacts in the Lower Walla Walla River valley have also led to the introduction and spread of numerous non-native invasive plants including cheatgrass (*Bromus tectorum*), Russian thistle (*Salsola tragus*), tumble mustard (*Sisymbrium altissimum*), barnyard grass (*Echinochloa crus-galli*), tansy (*Tanacetum vulgare*), and yellow star thistle (*Centaurea solstitialis*) (Carson 2008; Lewis 2012). Other invasive non-native plant species that have made their home in the riparian zones of the Walla Walla River include Russian olive (*Elaeagnus angustifolia*), black locust trees (*Robinia pseudoacacia*), false indigo bush (*Amorpha fruticosa*) and reed canarygrass (*Phalaris arundinacea*).

Lowland vegetation in the Subbasin is generally characterized by shrub-steppe, grassland, and agricultural land. Evergreen pine and fir forests dominate the lower and higher elevations of the Blue Mountains in the eastern portion of the Subbasin (NWPCC 2005). The USGS LANDFIRE layer (USGS 2013) for existing vegetation cover describes the entire Lower Walla Walla River floodplain as Inter-Mountain Basins Big Sagebrush Steppe, and Inter-Mountain Basins Montane Riparian Systems for the riparian corridor. The dominant vegetation is listed as black cottonwood (*Populus trichocarpa*) and coyote willow (*Salix exigua*). Portions of the Lower Walla Walla River are also described as developed rural shrubland (USGS 2013).

Riparian vegetation in the lower reaches of the Lower Walla Walla River is currently dominated by shrubs and small trees, including willows (*Salix* spp.) and red osier dogwood (*Cornus sericea*). Grasses and sedges (*Carex* spp.) are also common on inset floodplains in the lower reaches. The middle reaches are dominated by hardwood species including white alder (*Alnus rhombifolia*), willows, black cottonwood, and quaking aspen (*Populus tremuloides*).

2.6 LAND USE

Numerous publications, studies, assessments, and plans describe the historical and current land uses within the Walla Walla Subbasin. Some of the many applicable sources of information on historical and current land use within the Subbasin include Lyman (1918), Moulton (1991), Van Auken (1998), Kuttel (2001), NPPC (2001), Bower (2003), NWPCC (2005), WWWPU (2005), Carson (2008), Bower and Mendel (2010), Parks et al. (2010), and SRSRB (2011). This section does not attempt to provide a comprehensive description of land use, land ownership, and jurisdiction, but rather a summary of information applicable to this GAAP.

2.6.1 Historic

Prior to the Lewis and Clark expedition to the Pacific Ocean and subsequent European settlement, the Walla Walla, Cayuse, and Umatilla Indian Tribes inhabited the Walla Walla River Subbasin since time immemorial. These tribes were generally seasonally nomadic hunter gatherers, although they periodically used fire to alter or maintain desired vegetation communities (Bower 2003). Under the Treaty of 1855, approximately 6.4 million acres of their traditional homelands was ceded by the Walla Walla, Umatilla, and Cayuse Tribes to the federal government (CTUIR 1995; NPCC 2001). The Tribes, however, maintained rights to these lands including the harvesting of salmon, wildlife, and vegetative resources (USACE 1997; CTUIR 1995; NPCC 2001).

Lewis and Clark, on their expedition to the Pacific Ocean, were among the first Europeans to enter the Walla Walla valley. The expedition was warmly met by the Walla Walla Tribe, both when they travelled through the area heading westward in 1805 and again on their return journey in 1806. During their time in the in the valley, Lewis and Clark documented relatively pristine conditions along the Walla Walla River. They also observed the Lower Walla Walla River to be sparse of trees with riparian vegetation increasing significantly as they approached the Touchet River (Bower 2003). The land surrounding the Lower Walla Walla River was documented by Lewis and Clark as being dominated by sagebrush (NPCC 2001).

The arrival of fur trading in the area, which included trapping of beavers (*Castor canadensis*), began in 1818 with the establishment of Fort Nez Perce (Fort Walla Walla) by the Northwest French Fur trading company, with trapping throughout the 1800s almost completely eliminating beaver within the Subbasin (NWPCC 2001). Prior to European settlement, beavers were abundant throughout southeast Washington. Historically, beavers had a significant impact on stream systems within the Walla Walla Subbasin through creation of off-channel and floodplain habitat, moderation of stream flow regimes, and recharge of shallow aquifers (Kuttel 2001).

Settlement of the Walla Walla Subbasin began in earnest in the mid-1800s and, by the 1860s, the valley bottoms were "nearly all densely settled" (Mullan 1863 as cited in WWBWC 2004), with settlements focused in or near the riparian areas of the Walla Walla River (WWBWC 2004). Trade posts along beaver trapping lines resulted not only in extensive settlement of the Lower Walla Walla River valley by the 1840s, but also introduced cattle ranching and eventually eastern agricultural practices to the area. Cattle ranching and grazing practices, which continue today, ultimately resulted in the overgrazing of rangelands in the Subbasin leading to widespread soil loss and the replacement of native plants with more competitive non-native species (WWBWC 2004). Agricultural production is believed to have first occurred in the Walla Walla Valley around 1825 at Fort Nez Perce (Fort Walla Walla) (WWBWC 2004).

By the late 1870s, Walla Walla was considered one of leading regions for the production of cultivated grains (USDA 1941 as cited in NWPCC 2001). Although agriculture in the Walla Walla River valley was well established by the 1870s, steam-powered and then gasoline- or diesel-powered tractors were introduced in the early twentieth century which revolutionized the industry. This allowed for widespread clearing of riparian areas for farming and grazing as well as stream channelization, straightening, and bank stabilization to protect crops, pastures, and farm buildings (WWBWC 2004). Large-scale irrigation for agriculture led to an over-appropriation of water and inadequate fish passage conditions. Over time, irrigation practices resulted in channel dewatering and a loss of fish habitat (Van Cleve and Ting 1960).

Construction of dams for irrigation and hydroelectric power began in the early 1900s in the Walla Walla Subbasin. The construction of Nine-Mile (Reese) Dam in 1905 created a fish passage barrier and caused the Walla Walla River to run dry each summer for nearly 100 years (CRITFC 2014). Early accounts by local people note that annual returns of spring Chinook salmon reduced dramatically following the construction of the dam until the last substantial run was reported in 1925 (Van Cleve and Ting 1960).

The construction of the McNary Dam in 1958 and the resulting creation of Lake Wallula behind the dam was the last significant geomorphic event to affect the Lower Walla Walla River (Van Auken 1998). Construction of the dam drowned the floodplains of the mid-Columbia and lower 9 to 10 miles of the Lower Walla Walla River. The restriction of transported sediment eventually filled in the valley confines and created a river delta at the mouth of the Walla Walla River (Carson 2008). Figure 2-5 shows a man standing on a gravel bar at the mouth of the Walla Walla River around March 1922, prior to the creation of Lake Wallula (Carson 2008, p.23).

Source: Carson (2008)

Figure 2-5. The Confluence of the Walla Walla River and the Columbia River in the 1920s, before inundation from the McNary Dam. The Walla Walla River enters the frame from the left.

Today, cattle ranching and grazing practices continue, contributing to widespread soil loss and the replacement of native plants with more competitive non-native species (WWBWC 2004), with dryland agriculture and intensive irrigated cropland dominating the Walla Walla River valley. By 2007, 84 percent of Walla Walla County was under agricultural production (Parks et al. 2010). River modifications and vegetation removal along the Lower Walla Walla River for agricultural production, irrigation, and flood control have continued to the present. The considerable channel straightening that has occurred along the river in agricultural areas to maximize cultivatable land has resulted in very limited riparian zones that are often narrow or absent (Kuttel 2001). LWD that historically provided channel complexity and cover habitat has been removed, with car bodies and other bank stabilization materials still found in streambanks throughout the Lower Walla Walla River (Lewis 2012).

Land use and its influences on the Walla Walla River over the last 200 years have dramatically altered the landscape from that which the first European explorers encountered. Agriculture, grazing, levee and dam construction, and development of urban areas and transportation corridors have all had substantial influences on the landscape and the Walla Walla River. The historically extensive riparian zones have been reduced by 65 to

70 percent in many areas of the lower Walla Walla Subbasin (Lewis 2012). Removal of riparian vegetation has dramatically reduced the shade previously provided by riparian zones (Kuttel 2001). Reductions in riparian vegetation have also led to diminished aquatic and terrestrial habitat quantity and complexity (especially with regard to LWD recruitment and availability), as well as bank stability and flood energy absorption capacity. Additionally, changes to water yields and timing of flows have also destabilized stream banks and stream channels and increased sedimentation and water temperatures (U.S. Bureau of Reclamation 1999). These changes in land use in the lower Subbasin have contributed to the Lower Walla Walla River currently being deeply incised and lacking in channel structure and complexity. Evidence of channel incision in the Walla Walla Subbasin is not recorded in surveys prior to 1863 (Beechie et al. 2008). As shown in the aerial imagery from 1940 in Figure 2-6, historically the lower river and mouth were highly sinuous and contained a complex network of side channels and off-channel habitats.

The construction of McNary Dam in 1958 and resulting creation of Lake Wallula behind the dam inundated the historic mouth of the Walla Walla River. As previously noted, backwater effects from McNary Dam on the Columbia River extend between 9 and 10 miles upstream on the Lower Walla Walla River from the confluence (Mapes 1969; Ecology 2006). Additionally, as stated above, historically the presence of beaver in the Walla Walla Subbasin was likely responsible for a significant amount of floodplain inundation, creation of off-channel habitat, and cover and slow water refugia for fish. The loss of beavers, in addition to other anthropogenic impacts described above, has led to reduced aquatic and terrestrial habitat quantity, quality, and complexity. Section 2.7 provides a detailed description of historic and current fish species present in the Lower Walla Walla River. Section 3.2 reports current land use, riparian vegetation, geomorphic, and fish habitat conditions in the Lower Walla Walla River.

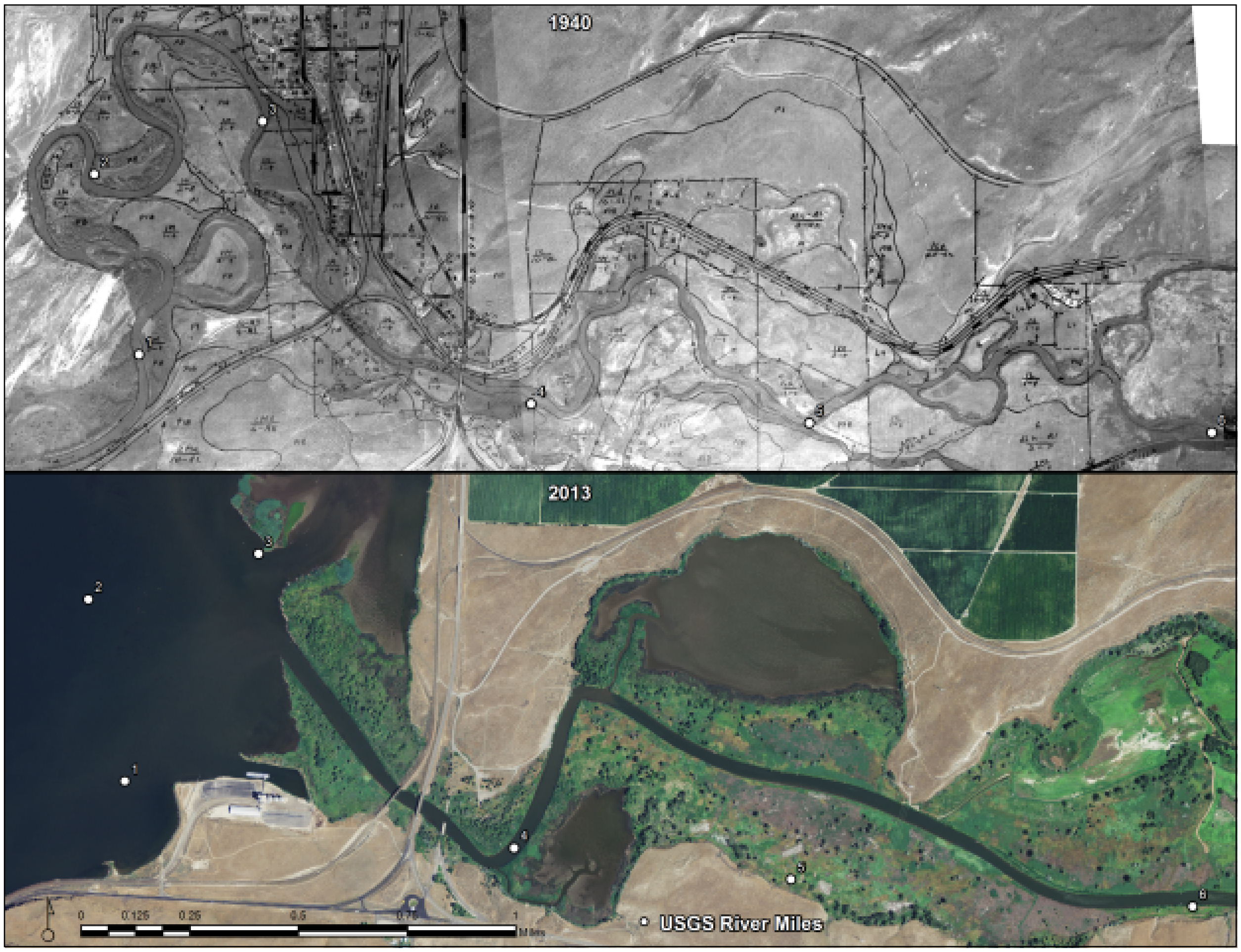


Figure 2-6. Example of Channel Modification from 1940 to 2013 at the Mouth of the Walla Walla River Where Flows Join the Columbia River. The construction of McNary Dam in 1958 and resulting creation of Lake Wallula behind the dam have inundated the historic mouth of the Walla Walla River.

2.6.2 Land Ownership and Jurisdiction

In the Walla Walla Subbasin, land use is subject to the jurisdiction of Walla Walla and Columbia Counties in Washington and Umatilla, Union, and Wallowa Counties in Oregon. The largest urban areas in the Walla Walla Subbasin are the city of Walla Walla, and the towns of College Place and Milton-Freewater.

Approximately 90 percent of the Subbasin is under private ownership (NWPCC 2005). The majority of private land along the lower Walla Walla River is under agricultural production. State and federal lands comprise approximately 9 percent of the Subbasin area (NWPCC 2005), with the CTUIR owning a little over 1 percent (approximately 12,000 acres) (Jonathan Thompson, CTUIR, personal communication, 2014). The CTUIR is responsible for protecting and enhancing treaty fish and wildlife resources and habitats, and members of the CTUIR have federal reserved treaty fishing and hunting rights pursuant to the 1855 Treaty with the United States government (CTUIR 1995). The CTUIR manages fish and wildlife resources in cooperation with state fish and wildlife agencies (NPCC 2001). Federal land management agencies within the Subbasin include the U.S. Department of Agriculture Forest Service (USFS; Umatilla National Forest) and the U.S. Bureau of Land Management (BLM), with all lands managed by the two agencies located in the Blue Mountains. Additionally, the USFWS manages the McNary National Wildlife Refuge located in the western part of the Subbasin. State agencies with jurisdiction in the Subbasin include the WDFW, Washington Department of Forestry, Washington Department of Natural Resources, Ecology, and Washington State Department of Agriculture in Washington; and the Oregon Department of Fish and Wildlife, Oregon Department of Forestry, ODEQ, Oregon Water Resources Department, Oregon Division of State Lands, and the Oregon Department of Agriculture in Oregon (WWBWC 2004).

2.7 FISH SPECIES

Historically, the Walla Walla Subbasin comprised a diverse and widely distributed aquatic community (Michaelis 1972 as cited in NPPC 2001; Mendel et al. 1999; NPPC 2001). Historical records indicate that spring and fall Chinook, chum (*O. keta*), and coho salmon were present in the Subbasin, with fall Chinook, chum, and coho salmon likely present only near the Walla Walla River confluence with the Columbia River (Swindell 1942 as cited in NPPC 2001; CTUIR 1995; Mendel et al. 1999; NPPC 2001). The presence of fall Chinook, chum, and coho salmon near the mouth may have been due to spillover from large runs in the Columbia River moving into the Walla Walla River (NPPC 2001). Spring Chinook salmon were historically abundant in the Subbasin, but were last documented in the 1950s and are now considered extirpated from the Walla Walla Subbasin (Oregon Game Commission 1956 and 1957 as cited in Van Cleve and Ting 1960; Mendel et al. 1999; NPPC 2001; NWPCC 2005; Schwartz et al. 2005). In addition to spring and fall Chinook, chum, and coho salmon, steelhead/rainbow trout and bull trout were historically present in the Walla Walla Subbasin (Mendel et al. 1999; NPPC 2001).

Native salmon and trout that were once abundant throughout the Walla Walla Subbasin began to decline throughout the 1900s, with the last major documented run of Chinook salmon reported in 1925 (Nielson 1950). With the decline of native salmon and trout and the listing of steelhead and bull trout as threatened under the ESA, the CTUIR, government agencies, organizations, and individuals undertook fisheries assessments to study salmonid distribution, relative abundance, genetics, and the condition of their habitats throughout the Walla Walla Subbasin (Jackson 1975; Mendel et al. 1999; Mendel et al. 2002). Today, fisheries assessments continue throughout the Walla Walla Subbasin that build upon past studies while working toward understanding relationships between fish species utilization and aquatic conditions in the Walla Walla River. While many questions remain regarding fish utilization and associated aquatic conditions, documentation of the fish species present in the Subbasin is based on fisheries surveys from well over four decades. The Draft Walla Walla Subbasin Summary (NPPC 2001) provides detailed information on fish species reported in the Subbasin. This section of the GAAP summarizes information on non-salmonid and salmonid species in the Subbasin from cited sources.

In a fish survey of the Walla Walla River conducted between September and November of 1974, Jackson (1975) captured four families and nine species of fish between the mouth and the headwaters that included Salmonidae (steelhead/rainbow trout), Catostomidae (largescale sucker [*Catostomus macrocheilus*]), Cyprinidae (speckled dace [*Rhinichthys osculus*], longnose dace [*R. cataractae*], redside shiner [*Richardsonius balteatus*], chiselmouth [*Acrocheilus alutaceus*], northern squawfish [*Ptychocheilus oregonensis*]), and Cottidae (mottled sculpin [*Cottus bairdii*] and margined sculpin [*C. marginatus*]). In 2001, more than 30 species of fish, 17 of which identified as native, were reported to inhabit the Subbasin (NPPC 2001; see Table 2-5). Of the 30 fish species, 6 are in the family Salmonidae and 24 are non-salmonid species.

Numerous non-salmonid fish are native to the Walla Walla Subbasin; however, non-native fish, such as carp (*Cyprinus carpio*), have been introduced to the area since as early as 1884 (Coyle et al 2001). A summary of fish salvaged at various locations in the Walla Walla Subbasin between 2001 and 2007 (Mahoney et al. 2008) reported non-salmonid species that included brook lamprey (*Lampetra planeri*), dace, stickleback (*Gasterosteus anculeatus*), carp, chiselmouth, pumpkinseed (*Lepomis gibbosus*), sculpin, sucker, and smallmouth bass (*Micropterus dolomieu*). Recent fish trap data from 2014 (Mendel et al. 2014) at RM 4 on the Lower Walla Walla River reported 16 non-salmonid species that included chiselmouth chub, northern pikeminnow, white crappie, carp, yellow perch, sucker, bluegill, pumpkinseed, tadpole madtom, smallmouth bass, largemouth bass, redside shiner, sculpin, channel catfish, brown bullhead, and mosquito fish (*Gambusia affinis*).

Table 2-5. Fish Species Present in the Walla Walla River Subbasin

Species	Origin	Location	Status	Comments
Bull trout (*Salvelinus confluentus*)	N	R, T	C	Headwater areas
Spring Chinook salmon (*Oncorhynchus tshawytscha*)	H	R, T	R	Presumed hatchery strays
Fall Chinook salmon (*O. tshawytscha*)	H	R, T	R	Presume hatchery strays
Redband trout/summer steelhead (*O. mykiss*)	N	R, T	C/C	Dayton return range-184-1006; Walla Walla2/ return range-279-815
Mountain whitefish (*Prosopium williamsoni*)	N	R, T	R	
Brown trout (*Salmo trutta*)	E	R, T	R	
Lamprey (*Petromyzontidae*)	N	R, T	U	Brook, river
Longnose dace (*Rhinichthys cataractae*)	N	R, T	R/I	
Speckled dace (*R. osculus*)	N	R, T	A	
Umatilla dace (*R. Umatilla*)	N	R, T	I	
Leopard dace (*R. falcatus*)	N	R, T	I	
Chiselmouth (*Acrocheilus alutaceus*)	N	R, T	C	
Peamouth (*Mylocheilus caurinus*)	N	R, T	I	
Redside shiner (*Richardsonius balteatus*)	N	R, T	C	
Northern pikeminnow (*Ptychocheilus oregonensis*)	N	R, T	C	
Sucker (*Catostomidae*)	N	R, T	C	Bridgelip, largescale
Carp (*Cyprinus carpio*)	E	R, T	R/I	Common in lower sections of the Walla Walla and Touchet Rivers
Bullhead catfish, brown (*Ameriurus nebulosus*)	E	R, T	R/I	Yellow, black
Tadpole madtom (*Notorus gyrinus*)	E	R, T	R/I	
Channel catfish (*Ictalurus natalis*)	E	R, T	C/I	(C) lower mainstem
Smallmouth bass (*Micropterus dolomieu*)	E	R, T	C/I	Common in lower sections of the Walla Walla and Touchet Rivers
Largemouth bass (*M. salmoides*)	E	R, T	R/I	
Pumpkinseed (*Lepomis gibbosus*)	E	R, T	I	
Bluegill (*L. macrochirus*)	E	R, T	R/I	
White crappie (*Pomoxis annularis*)	E	R, T	C/I	(C) lower mainstem
Black crappie (*P. nigromaculatus*)	E	R, T	C/I	(C) lower mainstem
Warmouth (*L. gulosus*)	E	R, T	I	
Yellow perch (*Perca flavescens*)	E	R, T	I	
Paiute sculpin (*Cottus beldingi*)	N	R, T	C	
Margin sculpin (*C. marginatus*)	N	R, T	C	
Torrent sculpin (*C. rhotheus*)	N	R, T	R	
3-spine stickleback (*Gasterosteus anculeatus*)	E	R, T	R/I	
Sandroller (*Percopsis transmontana*)	N	R, T	I	

1/ Origin: N=Native stock, E=exotic, H=Hatchery reintroduction
2/ Location: R=mainstem rivers and Mill Creek, T=tributaries
3/ Fish species abundance based on average number of fish per 100m^2: A=abundant, C=common, R=rare, U=uncommon, and I=insufficient data
Source: G. Mendel, WDFW, December 2000 as shown in NPPC 2001, Table 14

Pacific lamprey (*Lampetra tridentata*), a federally listed species of concern, is another non-salmonid species that likely exists within the Walla Walla Subbasin (NPPC 2001). Pacific lamprey were historically abundant in the Walla Walla Subbasin, and were historically harvested by the Umatilla Tribe (NPPC 2001); however, current abundance and range are generally unknown but thought to be very limited (NWPCC 2005). Lamprey were collected in the 1960s, 1985, 1990, and between 1992 and 1995, but with no differentiation between Pacific and brook lamprey (NPPC 2001; NWPCC 2005). A 2003 study found no amocytes in the Walla Walla River (Moser and Close 2003). NRCS (2011) mentions sightings of Pacific lamprey in the Walla Walla River in the 2011. Additional research and documentation is needed for a more complete understanding of Pacific lamprey population status and habitat utilization in the Walla Walla River.

Native salmonids in the Walla Walla Subbasin include spring and fall Chinook, chum, and coho salmon; steelhead/rainbow trout; bull trout; and mountain whitefish (*Prosopium williamsoni*). Historically, populations of these salmonid species existed within the Walla Walla Subbasin (NPPC 2001). Today, research, monitoring, and evaluation continue to document occurrences of these native salmonid species (Mahoney et al. 2008; CTUIR n.d.; Mendel et al. 2014). Although these species have been documented throughout the Walla Walla Subbasin, the majority of spawning and rearing habitat for spring Chinook salmon, steelhead, and bull trout has been reported to primarily occur in the upper portions of the Subbasin (USFWS 2010; Mahoney et al. 2011; USFWS 2014). In the upper portions of the Subbasin, stream temperatures are cooler and general habitat conditions are more intact (Mahoney et. al. 2011).

Research, monitoring, and evaluation focused on documenting the distribution and abundance of the focal fish species (i.e., fall Chinook salmon, coho salmon, steelhead, and bull trout) identified in this GAAP intensified following the decline of native salmon and trout and the listing of steelhead and bull trout as threatened under the ESA. These ongoing research, monitoring, and evaluation efforts include the Walla Walla River Basin Monitoring and Evaluation Project. This project is a collaborative monitoring effort between the CTUIR and WDFW, and connected through the 2008 Fish Accords (Three Treaty Tribes-Action Agencies 2008) with BPA. The effort is aimed at describing fish populations in the Walla Walla Subbasin, monitoring the success of ongoing restoration efforts, and providing status and trend data to support ESA population and other salmonid population recovery (Mendel et al. 2014). The resulting reports provide detailed information about Walla Walla Subbasin salmonid populations annually.

As previously described, spring Chinook salmon were historically abundant in the Subbasin, but were last documented in the 1950s and are now considered extirpated from the Walla Walla Subbasin (Oregon Game Commission 1956 and 1957 as cited in Van Cleve and Ting 1960; Mendel et al. 1999; NPPC 2001; NWPCC 2005; Schwartz et al. 2005). Although native runs of spring Chinook salmon are considered extirpated, the CTUIR began a reintroduction program in the early 2000s to reestablish spawning populations within the Walla Walla Subbasin (Schwartz et al. 2005; Mahoney et al. 2011). Fall Chinook are present in the Subbasin, but their numbers and distribution are not well known, though suspected to be limited to the mid- and lower Subbasin habitats (CTUIR n.d.). Coho have been recorded using the Lower Walla Walla River in recent years; however, the extent of use is not known (CTUIR n.d.). Bull trout are migratory salmonids and demonstrate both in-basin and out-of-basin migration life-history patterns in the Walla Walla Subbasin. Their distribution and use of the Lower Walla Walla River is not particularly well understood, but a recent assessment of bull trout identifies the need for more research to assess survival (Schaller et al. 2014). Summer steelhead, though considered a depressed population, are distributed throughout the Subbasin and have been a species of interest to the CTUIR, WDFW, Oregon Department of Fish and Wildlife (ODFW), non-governmental organizations, and recreational users (Mahoney et al. 2011). Research indicates juvenile steelhead migrate downstream to overwinter in the Lower Walla Walla River prior to outmigration (Mahoney et al. 2013).

Focal fish species utilization of the Lower Walla Walla River has been primarily considered for migratory use, with an unknown level of overwintering and rearing habitat use (USFWS 2010; Mahoney et al. 2011). Recent research, however, has highlighted the importance of the Lower Walla Walla River, particularly for providing overwintering holding and rearing habitat believed to be critical for focal fish species (Mahoney et al. 2013; Olsen and Mahoney 2013). In addition, survival through the Lower Walla Walla River has been identified consistently as a concern for out-migrating smolts from the upper portions of the Subbasin to McNary Dam (Mahoney et al. 2011, 2012, and 2013; Mendel et al. 2014). Specifically, high mortalities for out-migrating fish in the Lower Walla Walla River have been reported, with as many as 70 percent of smolts that enter the lower river failing to reach McNary Dam on the Columbia River (Mahoney et al. 2013; Olsen and Mahoney 2013). Furthermore, the USFWS (Schaller et al. 2014) suggests that because the lower river has degraded habitat conditions, and bull trout migrate downstream out of the headwater area, sub-adult and small adult size classes may be the most susceptible to mortality in the Lower Walla Walla River.

Research has identified the need to further evaluate the relationship between high mortalities of fish species and degraded conditions within lower portions of the Walla Walla

River (Schaller et al. 2014). Although there is extensive reporting from existing research, assessments, and monitoring and evaluation programs on the focal fish species, there is limited documentation connecting fish species utilization of the Lower Walla Walla River to quantified geomorphic and aquatic habitat conditions. To better determine the relationship between fish utilization of the Lower Walla Walla River and degraded conditions, further analysis of the focal fish species timing and utilization is necessary. The subsequent sections describe focal fish species utilization of the Lower Walla Walla River and include timing and utilization tables for each species where reported from available sources. As detailed in the following discussions, timing and utilization for the focal fish species in the Lower Walla Walla River occur predominantly outside the periods with lower flows and high stream temperatures, during the winter months when overwintering holding and rearing habitat is likely critical for survival.

2.7.1 Spring Chinook Salmon

Historical accounts record healthy populations of spring Chinook salmon in the Walla Walla Subbasin (Contor et al. 2003); however, after the construction in 1950 of Nine Mile Dam near Reese, Washington, returns were dramatically reduced (Nielson 1950). This dam was reported as being at least a partial barrier to upstream migration (Contor et al. 2003; Nielson 1950), and resulted in the river running dry each summer for close to 100 years (Mahoney et al. 2013). The last significant natural run of Chinook salmon in the Walla Walla subbasin was reported in 1925 (Nielson 1950). Spring Chinook salmon were considered extirpated from the Walla Walla River in the 1950s (Oregon Game Commission 1956 and 1957 as cited in Van Cleve and Ting 1960; Mendel et al. 1999; Coyle et al. 2001; NPPC 2001; Contor et al. 2003; NWPCC 2005; Schwartz et al. 2005).

Removal of upstream passage barriers and improvement of summer water quantity, through agreements with irrigation districts and tribal and federal entities, have likely addressed some key conditions that led to the loss of spring Chinook salmon from the Walla Walla Subbasin (Mahoney et al. 2013). Reintroduction efforts by the CTUIR began in 2000 with outplanting of broodstock from the Reingold Hatchery, Carson National Fish Hatchery, and Umatilla River and Three Mile Falls Dam (Mahoney and Schwartz 2014) in the upper Walla Walla River and Mill Creek (Mahoney et al. 2008 and 2009) and expanded to smolt releases beginning in 2005 (Mahoney et al. 2008, 2009, and 2013) using stock from the Carson National Fish Hatchery (Mahoney and Schwartz 2014). To further expand these efforts, the CTUIR is proposing new construction and operation of hatchery facilities for spring Chinook salmon on the South Fork Walla Walla River. In 2013, the CTUIR completed the first step of the Walla Walla Spring Chinook Hatchery Program; a review of the Walla Walla Hatchery

Master Plan was completed by the Independent Scientific Review Panel, which recommended a local facility be developed from locally adapted stock and incorporating appropriate monitoring and evaluation (Mahoney and Schwartz 2014). The Draft Enviromental Impact Statement was released in October 2014, with a comment period ending on the November 24 and the Final Enviromental Impact Statement planned for release in summer 2015. The purpose of the hatchery would be to assist in establishing a natually spawning spring Chinook salmon population in the Walla Walla Subbasin as well as augment the fish available for harvest (BPA et al. 2014).

Monitoring of the spring Chinook salmon reintroduction program began in 2000, and included assessment of natural production and evaluation of fish passage (Mahoney and Schwartz 2014). In 2007, a collaborative monitoring and evaluation program based on viable salmon population parameters of abundance, productivity, diversity and spatial structure was developed by the CTUIR, WDFW, ODFW, and BPA. This expanded program was designed to provide higher resolution information on population status and trends for spring Chinook salmon, steelhead, and bull trout (Mahoney and Schwartz 2014). Such information is being used to inform the CTUIR First Foods management and address fish and wildlife concerns (Mahoney and Schwartz 2014).

Adult returns in 2010 were sufficient to open a tribal fishery on the Walla Walla (Mahoney et al. 2013). While the 2013 adult returns were below the 2010 levels, this was likely reflective of return trends in the Columbia Basin as a whole (Mendel et al. 2014). Abundance of naturally produced smolts has been increasing in the Walla Walla Subbasin while hatchery smolts have been decreasing (Mendel et al. 2014).

Adult spring Chinook salmon return to the Walla Walla River between mid- to late April and mid- to late July, as flows allow, and are detected upstream at Nursury Bridge Dam starting at the beginning of May; they finish the bulk of the migration by mid-June (Mahoney et al. 2012). Water quality (high temperature) and water quantity (low flows) can limit migration ability for late-returning spring Chinook salmon (Mahoney et al. 2013). Spawning occurs in the Touchet River drainage (North Fork, Wolf Fork, and mainstem), upper Mill Creek, upper Walla Walla River, and South Fork Walla Walla River, beginning mid- to late August, peaking in September, and finishing by early October; with pre-spawn holding occuring in upper reaches due to temperature limitations downstream (Mahoney et al. 2012).

Incubation and emergence timing is dependent on stream temperatures, generally ranging from 165 to 235 days; however, emergent fry have been observed by WDFW in the upper Touchet River as early as late July and early August (Mahoney et al. 2012). Juveniles rear for 14 to 18 months in the headwaters and then begin downstream migration (Mahoney et al.

2012). A portion of the juvenile spring Chinook salmon migrate downstream in the fall and over winter in the Lower Walla Walla River and Lake Wallula before continuing their migration downstream through the Columbia River to the ocean (Mahoney et al. 2008, 2013).

Concerns over mainstem migration and overwintering loss have been raised (Olsen and Mahoney 2013), with predation, water quantity, and water and habitat quality being suggested as possible causes (Mahoney et al. 2009, 2011, and 2013; Mendel et al. 2014). Tagging efforts have shown that outmigrating spring Chinook salmon tagged in the fall prior to the spring/summer outmigration have lower survival than those tagged in the summer (Mahoney et al. 2009). Spring Chinook salmon monitoring has indicated a lower survival to McNary Dam for juveniles leaving the upper basin in the fall than those leaving in the spring (Mahoney 2011). Additionally, trapping data indicate a 33 percent in-basin loss may be occurring between the upper basin (5 miles upstream of Nursery Bridge Dam) and above the mouth of the Walla Walla River (near Pierce's Green Valley RV Park at RM 9.2).

Based on the available data, Table 2-6 shows spring Chinook salmon life stage periodicity, and Figure 2-7 illustrates spring Chinook salmon timing and use in relation to discharge and water temperature.

Table 2-6. Walla Walla Basin Spring Chinook Life Stage Periodicity

Life Stage	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Adult Spawning Migration							Present	Peak	Peak	Common		
Pre-Spawn Holding 1/									Common	Common	Common	
Spawning 2/											Common	Peak
Incubation/Emergence	Common	Common	Common	Common	Common	Common						
Juvenile Rearing 3/	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common
Yearling Migration, Overwintering 4/	Common	Common	Common			Common	Peak	Peak				

1/ Chinook salmon return to Walla Walla River from mid to late April to mid-July, when water conditions allow. First returns to Nursery Bridge Dam (NBD) occur around May 1 and peak return coincides with peak flow of approximately 300 cfs in mid-May, with 95% of returns above NBD by June 15 (flow approximately 140 cfs). High temperatures and low flows in late spring and early summer may cause a migration bottleneck for late returning Chinook in the lower Walla Walla River and lower Touchet River (Mahoney et al. 2011, Mendel et al. 2007). Chinook return at Dayton Dam as late as July and a few in August, and they spawn in low numbers to the North Fork and Wolf Fork of the Touchet River, and a short section of the upper mainstem Touchet River (Mendel et al. 2007). They also spawn in low numbers in upper Mill Creek (Mahoney et al. 2011). Pre-spawn holding occurs primarily upstream of the state line in the Walla Walla Basin, upstream of Yellowhawk Creek in Mill Creek, and from near Dayton upstream in the Touchet River. The downstream limit of holding is caused by marginal water temperatures and reduced survival.

2/ Chinook salmon spawn in North Fork, Wolf Fork, and the mainstem Touchet River near Dayton, in upper Mill Creek (mostly above Blue Creek), upper Walla Walla River, and South Fork Walla Walla River (Mendel et al. 2007, Mahoney et al. 2006, 2009, and 2011). Spawning does not begin until mid or late August, and it peaks in early September. Spawning is usually over by October 1.

3/ Juveniles spend 14-18 months in the upper mainstem Walla Walla River and its tributaries and the upper Touchet River Basin.

4/ Yearlings (age 1+) disperse from the upper mainstem Walla Walla River as far downstream as Lowden (Mahoney et al. 2011) during fall and winer. They may overwinter between Lowden and South Fork Walla Walla River (Mahoney et al. 2011) before migrating out of the basin. Less is known about overwintering in the Touchet River and Mill Creek because smaller numbers of fish are present there. In January and Februaryover wintering continues, but movements decrease.

Peak life stage timing
Common life stage timing
Life stage present

Source: Mahoney et al. (2012)

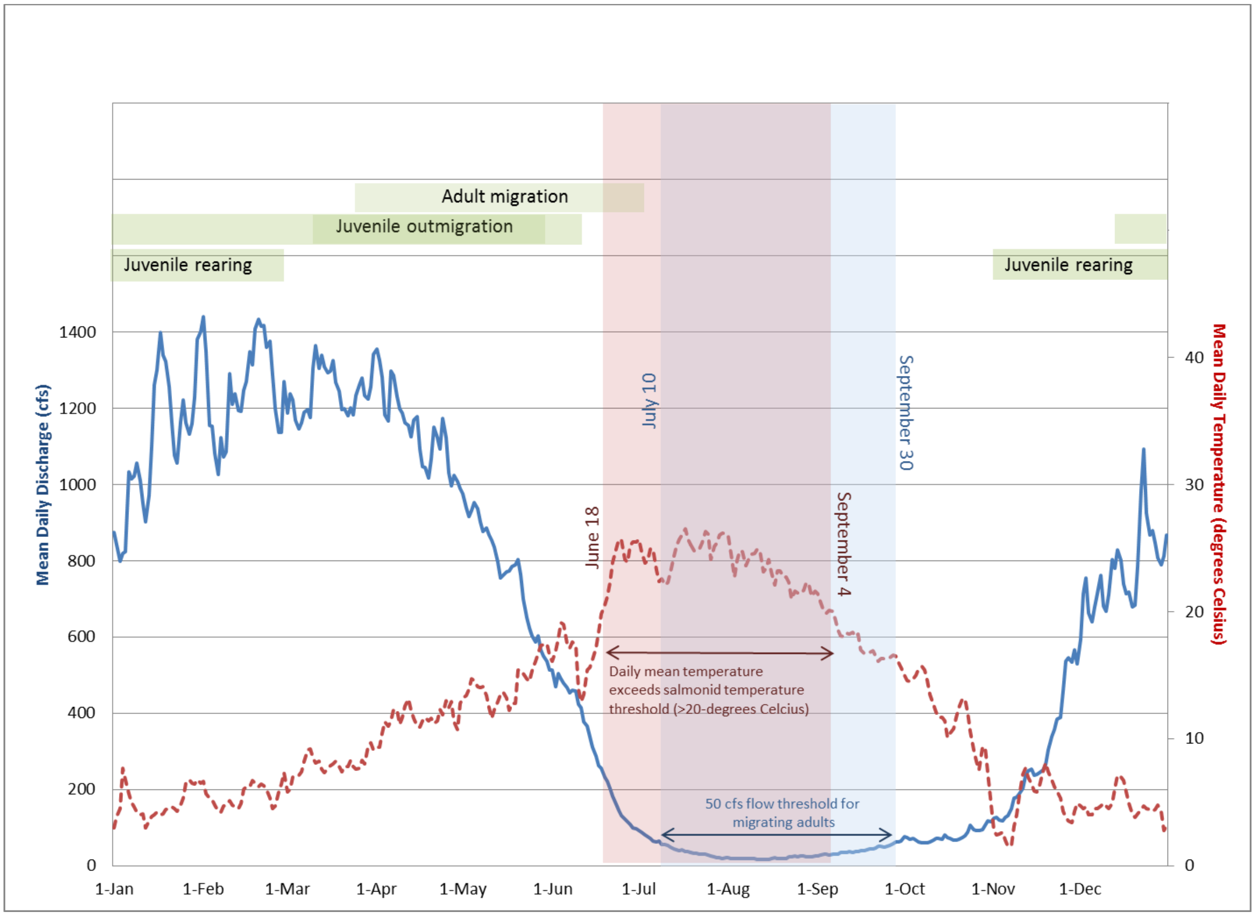


Figure 2-7. Spring Chinook Salmon Use of the Lower Walla Walla River Assessment Area Relative to Discharge and Stream Temperature

2.7.2 Fall Chinook Salmon

Fall Chinook salmon are known to have historically occurred in the Walla Walla River (NWPCC 2005); however, the Walla Walla fall Chinook is a population in the Mid-Columbia River Fall Chinook Species Management Unit that is considered to be extinct today (ODFW 2005). The species' historic use of the Walla Walla Basin is thought to have occurred primarily in the downstream portion of the Walla Walla subbasin (ODFW 2005). It is assumed that historical accounts of fall Chinook use of the Walla Walla River are from mainstem Columbia River populations, using the Lower Walla Walla River for spawning (Volkman 2005).

Fall Chinook are present within the Walla Walla subbasin, and are generally thought to be straying hatchery fish from other subbasins (NWPCC 2005). Data collected in recent years support fall Chinook utilization within the Walla Walla River for multiple life-history stages (CTUIR n.d.). In 2004, the CTUIR captured 6 fall Chinook in their Merwin Trap at River Mile 4, which was fished for 35 days between November 2 and December 6, 2004 (CTUIR n.d.). In addition, adult fall Chinook have been observed spawning in the Lower Walla Walla River in recent years (B. Mahoney, S. O'Daniel and J. Volkman, CTUIR, personal communication, June 2014). Scale samples from 235 juvenile natural Chinook were collected during the 2006 migration, indicating 7 percent of the juvenile Chinook migrants were age zero, which suggested they were fall Chinook (Mahoney et al. 2008).

Limited pit-tagging indicates the Lower Walla Walla River provides habitat for juvenile fish from other drainages. Pit-tagged fall Chinook salmon were tracked to Pierce's Green Valley RV Park in the Lower Walla Walla River in 2009 (1 fish, hatchery origin), 2011 (2 fish, hatchery origin), 2012 (7 fish, 4 hatchery origin, 3 unknown origin), and 2013 (3 fish, 1 hatchery origin, 2 unknown origin) (CTUIR n.d). Hatchery origin fish were from facilities on the Snake River, Clearwater River, and Yakima River. Fish of unknown origin were adults tagged on the Lower Columbia at COLR3 (Lewis River to Bonneville Dam Release site).

Significant hatchery programs have been developed to reintroduce fall runs of Chinook to the upper Columbia River. These fish pass McNary Dam in late September and spawn between October and December. Fall Chinook salmon generally outmigrate as year zero fish (Mahoney et al. 2006), which means they spend minimal rearing time before beginning their seaward journey. In contrast, spring Chinook salmon generally emerge in the spring and rear for a year in the headwaters before outmigrating. The recorded origin locations for fall Chinook detected in the Walla Walla (CTUIR n.d.) are indicative of straying from these upper Columbia River supplementation programs. Snake River fall Chinook salmon emerge from the gravel in March and April and begin downstream migration within a few months of emergence (SRSRB 2006). Juvenile fall Chinook salmon in the Lower Walla Walla River were reported as outmigrating later than spring Chinook salmon (i.e., April and May), with outmigration occuring later in May and early June (Mahoney et al. 2008).

The Walla Walla River has been identified as a Columbia River tributary with high among-basin straying rates for spring and fall Chinook salmon (Keefer and Caudill 2012), possibly because of similar physiochemical signatures resulting from a shared climate and geology. Life-history strategies and presumed preferential use of the Lower Walla Walla River by fall Chinook salmon indicate winter use for spawning and rearing. Overall, the data regarding timing and utilization for fall Chinook salmon in the Lower Walla Walla River are currently limited and the area is therefore recommended for further investigation.

Based on Snake River, Clearwater River, Yakima River, and Umatilla River fall Chinook salmon life stage periodicity data (Lichatowich and Mobrand 1995; SRSRB 2006; CTUIR and

ODFW 2006; Clarke et al. 2009; Tiffan et al. 2009), Figure 2-8 illustrates fall Chinook salmon timing and use in relation to discharge and water temperature.

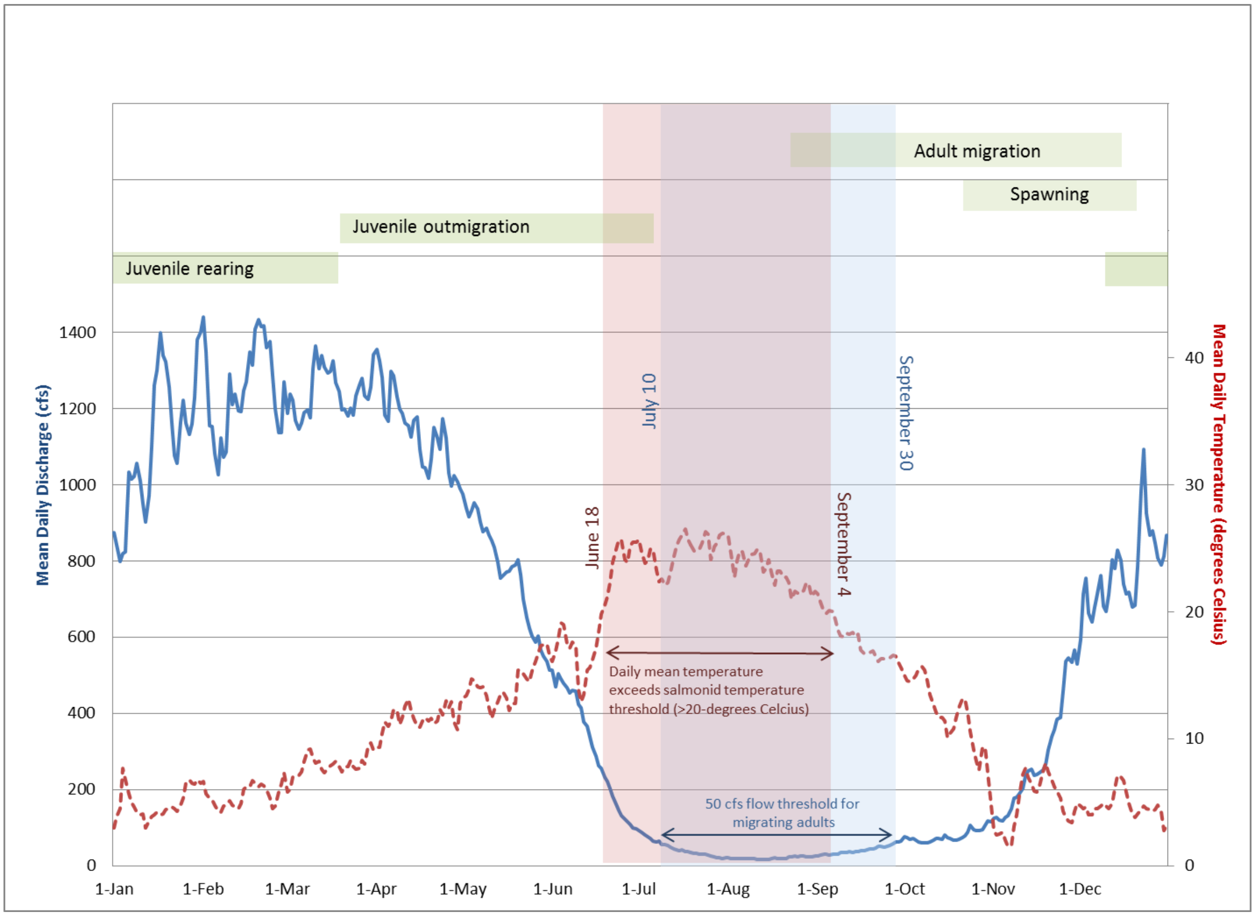


Figure 2-8. Fall Chinook Salmon Use of Lower Walla Walla River Assessment Area Relative to Discharge and Stream Temperature

2.7.3 Coho Salmon

Coho salmon are thought to have been present historically in the Walla Walla Subbasin (Mendel et al. 1999; NPPC 2001). Like fall Chinook salmon, coho salmon are likely to have mostly used the Lower Walla Walla River near the mouth and potentially be strays from other Columbia River runs (NPPC 2001). In May 2006, one coho fry was caught in the rotary screw trap operated at the mouth of the Walla Walla River (Mahoney et al. 2008). More recently, both adult and juvenile coho have been observed in the Lower Walla Walla River by CTUIR staff during field surveys, as well as being recorded during data collection opperations (Mahoney et al. 2008).

Tagged coho salmon have been detected in the Walla Walla River (CTUIR n.d.). Two hatchery juveniles from the Snake River (Kooskia National Fish Hatchery and Clear Creek facilities) were detected in 2013, and an adult of unknown origin that was tagged in the Lower Columbia in September 2013 (at COLR3 – Lewis River to Bonneville Dam) and detected in the Lower Walla Walla River in October and November (CTUIR 2014). The fish from the Clear Creek fish hatchery was released in March of 2012 and detected at Pierce's Green Valley RV Park on the Lower Walla Walla River in October and November 2013, while the Kooskia Fish Hachery fish was released February 2013 and detected first in October and finally in December of that same year. These detections appear to demonstrate different uses of the Walla Walla River for fish of varying origins. Juvenile detections indicate rearing use from juveniles making downstream migrations, while adult detections indicate holding and/or potential spawning. The capture of fry in the rotary screw trap could similarly be from successful spawning upstream or straying from nearby spawning locations.

While life stage periodicity information for coho salmon in the Lower Walla Walla River is not available, some sense of timing may be inferred from use in the Columbia River mainstem. In the Columbia River, adult coho generally migrate upstream past McNary Dam, starting in early September and finishing by the end of October. In 2013, the peak migration was significantly skewed, occurring between the end of September and first half of October. As of September 11, 2014, the coho salmon returns have been early and abundant (Fisheries Passage Center 2014a). Smolt outmigration begins in April and ends in June, with the majority occurring between mid-May and June (Fisheries Passage Center 2014b). Coho generally emerge in winter and rear for a year before outmigrating the following spring as 1+ age smolt.

Overall, data regarding timing and utilization for coho salmon in the Lower Walla Walla River are not currently available, and the area is therefore recommended for further investigation. Because coho salmon rear for a year, and trap data indicate residence within the Walla Walla River is likely from other basins, coho are assumed to be within the Walla Walla Subbasin year-round. Based on this asumption, life stage periodicity information from Umatilla coho salmon (NWPCC 2004) and Snake River coho salmon (The Nez Perce Tribe and FishPro 2004) was used to develop Figure 2-9, which illustrates coho salmon timing and use in relation to discharge and water temperature.

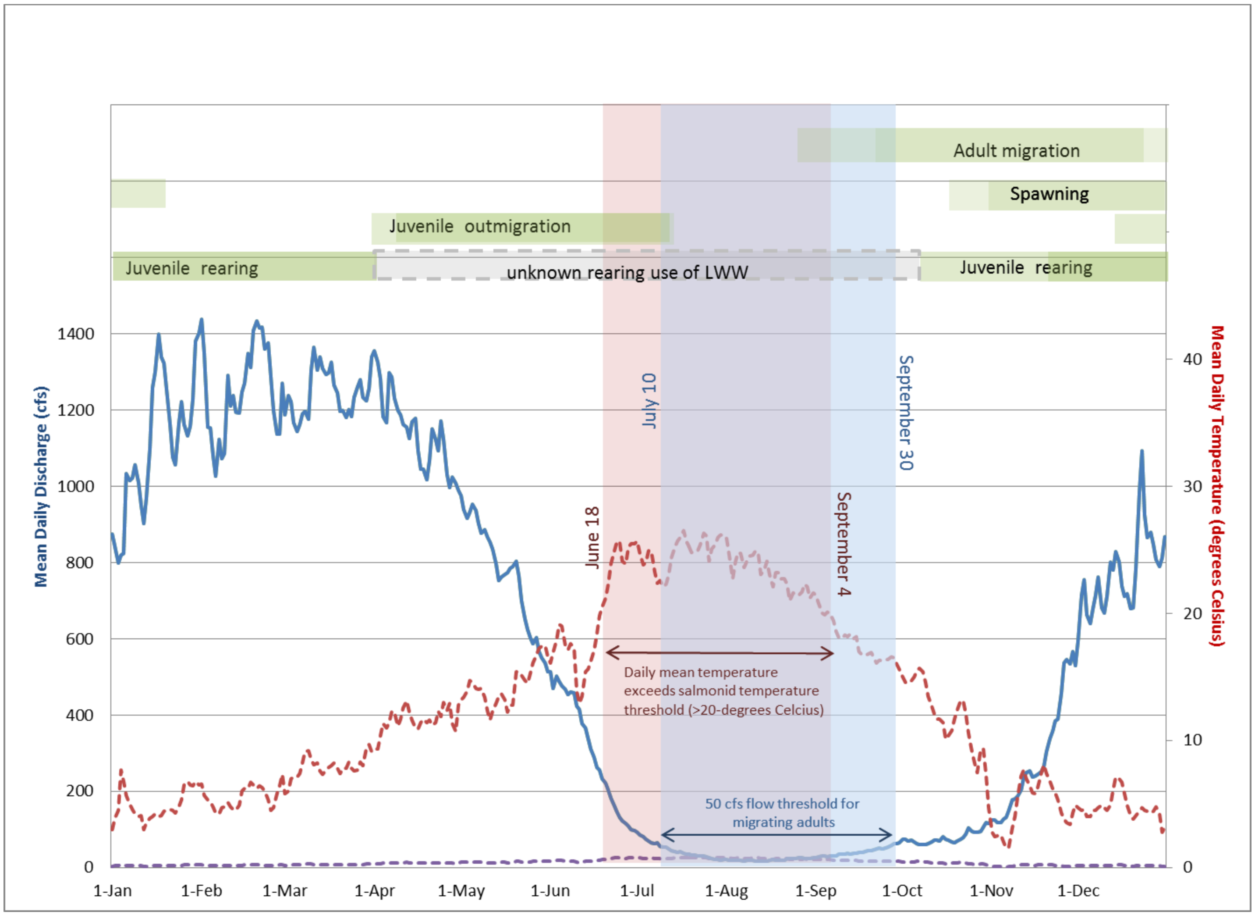


Figure 2-9. Coho Salmon Use of the Lower Walla Walla River Assessment Area Relative to Discharge and Stream Temperature

2.7.4 Steelhead

Historically, the Walla Walla Subbasin likely had substantial runs of summer steelhead (Mendel et al 1999). The annual run size was estimated to be between 4,000 and 5,000 adult returns (NPPC 2001). Currently, summer steelhead are present throughout the Walla Walla Subbasin from the mouth to the headwaters (Kuttel 2001; NWPCC 2005), though in reduced numbers and distribution (NPPC 2001). The Walla Walla Subbasin steelhead population is part of the Mid-Columbia River Steelhead Evolutionarily Significant Unit, and is considered to be depressed. Middle Columbia River steelhead were listed as threatened in 1999 (65 *Federal Register* 14517), with that status reaffirmed on January 5, 2006 (71 *Federal Register* 834). In addition to the native summer steelhead, non-endemic and endemic hatchery steelhead have been released annually into the Touchet River and Lower Walla Walla River as part of the Lower Snake River Compensation Program (Mendel et al. 2007).

Adult steelhead migration timing is variable. Generally, fish migrate upstream between September and November; however, some hold at the mouth of the Lower Walla Walla River and wait until January to move upstream. Spawning generally occurs in March and

April, and almost exclusively above Mill Creek for the Walla Walla mainstem (Mahoney et al. 2012). Adult kelt outmigration peaks in May, and juvenile outmigration in the Lower Walla Walla River peaks in April and May (Mahoney et al. 2013).

Year-round juvenile rearing in the mainstem generally occurs in the upper portions of the Subbasin. Summer rearing estimates in 2004 showed declining abundances from the state line of Oregon and Washington downstream to practically zero downstream of the town of Lowden (Mendel et al. 2014). Mahoney et al. (2012) reports that juvenile rearing does not generally extend downstream of the mouth of Mill Creek, with some exceptions. Recent research indicates that some juvenile steelhead move downstream to rear in the Lower Walla Walla River the fall before migrating to the mainstem Columbia River (Mendel et al. 2014). Survival estimates for juveniles that migrate from the upper Subbasin in the fall are lower than for those that migrate in the spring (Mahoney et al. 2009), indicating an overwintering loss in the Lower Walla Walla River. Similar to spring Chinook salmon, survival estimates from the Upper Walla Walla River to McNary Dam indicate a substantial loss through the Lower Walla Walla River (Mahoney et al. 2009). Predation, especially in the Lower Walla Walla River and Lake Wallula, is consistently mentioned in monitoring reports as a factor likely affecting juvenile survival (Mahoney et al. 2009, 2011, 2012, 2013; Mendel et al. 2014).

Based on the available data, Table 2-7 shows steelhead life stage periodicity and Figure 2-10 illustrates steelhead timing and use in relation to discharge and water temperature.

Table 2-7. Walla Walla Basin Summer Steelhead Life Stage Periodicity

Life Stage	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Adult Spawning Migration [1/]	Present	Present	Present	Common	Common	Peak	Peak	Common	Present			
Pre-Spawn Holding	Present	Present	Present	Common	Common	Common	Common	Common	Present	Present	Present	Present
Spawning [2/]			Present	Present	Present	Peak	Peak	Common	Present			
Incubation/Emergence					Common	Peak	Peak	Peak	Common	Common		
Juvenile Rearing [3/]	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common
Adult Migration [4/]					Present	Common	Peak	Peak	Common			
Juvenile Outmigration [5/]	Peak	Peak	Peak	Present	Present	Common	Peak	Peak	Common	Present		

1/ Adult steelhead sometimes hold in the Columbia River at the mouth of Walla Walla River from September to November and begin to migrate upriver and disperse into tributaries in January. However, some steelhead enter the lower Walla Walla River in September through November (Mahoney et al. 2009) and migrate upstream into the lower Touchet River, or upstream in the Walla Walla River, if stream flows are adequate for them to do so. Low stream flows, or high water temperatures, have been documented to migrate up the Snake River, with a portion of those returning at a later date to the Walla Walla Basin (Bumgarner and Dedloff 2011). Peak migration is February-May (Mahoney et al. 2006 and 2011), and at the Dayton Adult Trap (DAT) the migrants peak in March and April bu tcan continue through July. Lyons Ferry Hatchery steelhead enter sooner than naturally produced steelhead, and the early portion of the next run year (which will not spawn until spring of the next year) may migrate up the Touchet River in June, or as late as early to mid-July at DAT, if water conditions are suitable.

2/ Only a few fish spawn in December or January, and they may be mostly of hatchery origin. Above Dayton peak spawning would include May. Spawning also has been documented in early June. Spawning occurs mostly upstream of the mouth of Mill Creek in the Walla Walla Basin, and upstream of the mouth of Coppei Creek in the Touchet drainage, with some rare exceptions.

3/ Juvenile rearing generally does not extend downstream of the mouth of Mill Creek in the Walla Walla Basin, and Waitsburg in the Touchet Basin, with some minor exceptions (Mendel et al. 2007).

4/ Steelhead kelts rapidly leave spawning grounds, primarily from April to May (Mahoney et al. 2009).

5/ WDFW enumerated juvenile outmigration at the Touchet River rotary screw trap (Oct 2007 – June 2008). Peak outmigration was in October, November, and December, although most those were small juveniles and it is uncertain whether they are leaving the drainage or seeking overwintering areas in the middle or lower Touchet River. Peak outmigration of transitional and smolt sized fish was in April and May in the Touchet River (Gallinat and Ross 2011). Tagged juveniles were recaptured in the Walla Walla River at Oasis Road Bridge and in the Columbia River at McNary, John Day, and Bonneville dams (Mahoney et al. 2009). CTUIR smolt traps at Joe West Bridge in Oregon , and the Lower Walla Walla River, detected peak outmigration of steelhead from the Walla Walla River in April and May (Mahoney et al. 2011).

Peak life stage timing
Common life stage timing
Life stage present

Source: Mahoney et al. (2012)

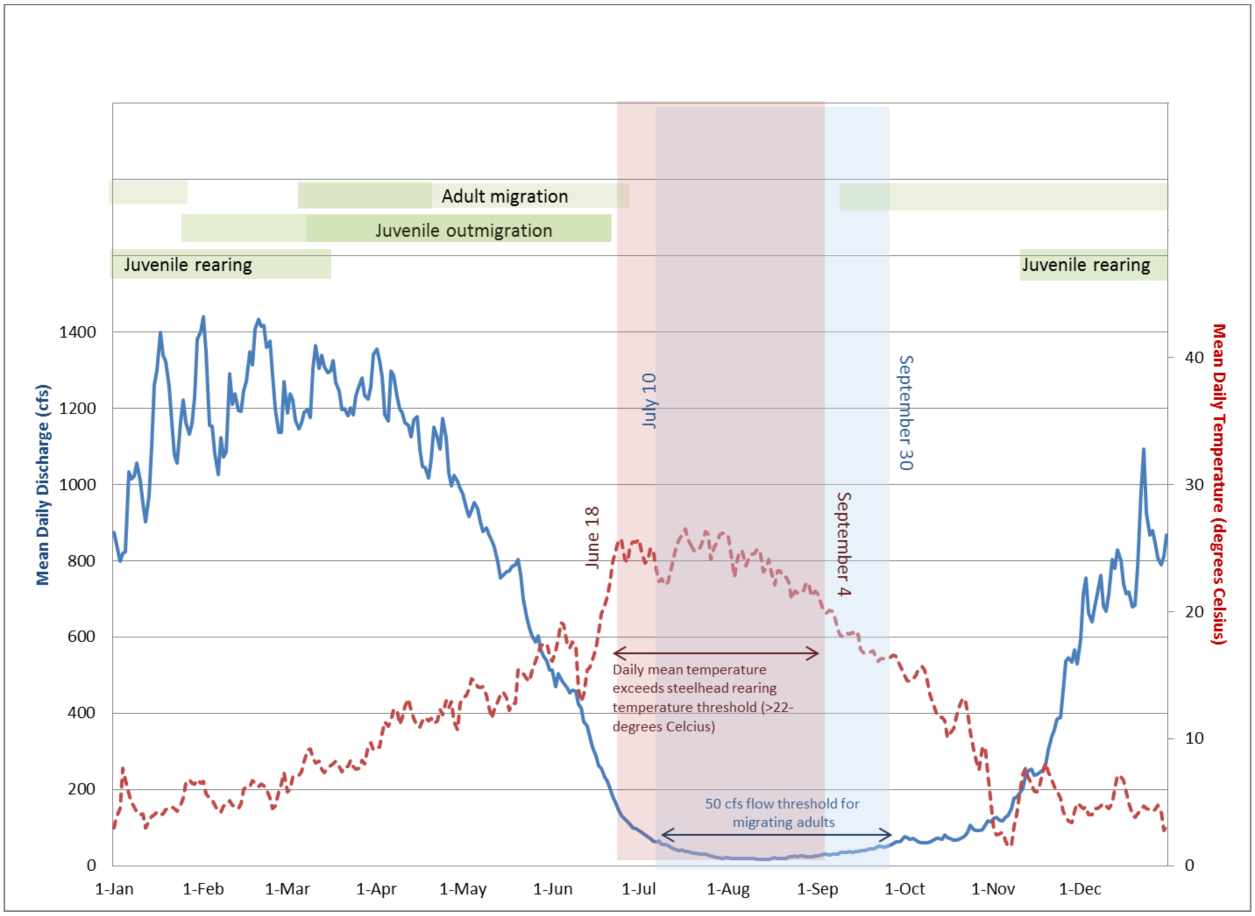


Figure 2-10. Steelhead Salmon Use of the Lower Walla Walla River Assessment Area Relative to Discharge and Stream Temperature

2.7.5 Bull Trout

Bull trout in the Walla Walla Subbasin are part of the Columbia River bull trout distinct population segment (63 *Federal Register* 31647), federally listed as threatened. Resident bull trout spend their life in the headwater streams, while migratory bull trout spawn and rear in the headwaters before migrating downstream to mainstem river habitats (Barrows et al. 2010). There is reported use of some mid-Walla Walla Subbasin areas, such as observed juvenile fish in a portion of Mill Creek in the City of Walla Walla and within the mainstem Walla Walla River, potentially as far downstream as McDonald Bridge (Kuttel 2001). Kuttel (2001) suspected this is limited to winter rearing use, when water temperatures are low enough to support bull trout rearing. Upstream adult migration in this area has also been observed in the spring (Kuttel 2001). Recent research indicates that migratory populations are present throughout the Walla Walla Subbasin (Schaller et al. 2014), as migrating fish from multiple populations have been recorded at the Lower Walla Walla River Oasis Road bridge detection site (Schaller et al. 2014). Bull trout use of the Lower Walla Walla River is assumed to be limited to foraging and migration, as conditions are generally unsuitable for spawning and summer rearing.

Adult bull trout return to headwater spawning areas in September and October, followed by a downstream migration to overwintering areas in October through December. Both sub-adult and adult bull trout use the Lower Walla Walla River during the fall, winter, and spring for rearing and overwintering (Barrows et al. 2012). Improvement of the Lower Walla Walla River migratory and foraging corridor has been indicated as a focus that would improve bull trout populations in the Walla Walla River (Schaller et al. 2014). Schaller et al. (2014) also suggest that due to the multiple anthropogenic impacts in the Lower Walla Walla River, additional studies to evaluate bull trout survival would aid conservation and population viability assessments (Schaller et al. 2014)

Based on the available data, Table 2-8 shows bull trout life stage periodicity, and Figure 2-11 illustrates bull trout timing and use in relation to discharge and water temperature.

Table 2-8. Walla Walla Basin Bull Trout Life Stage Periodicity

Life Stage	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Upstream Adult and Sub-Adult Migration 1/			Present	Present	Present	Present	Common	Peak	Peak	Common	Common	Present
Pre-Spawn Holding 2/						Present	Present	Present	Common	Peak	Peak	
Spawning 3/	Peak										Present	Peak
Incubation/Emergence 4/	Common	Common	Common	Common	Common	Common	Common	Common	Common	Present		Common
Juvenile Rearing 5/	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common
Adult Downstream Migration and Overwintering 6/	Common	Common	Common	Common	Common	Common	Present	Present			Present	
Sub-Adult Downstream Migration and/or Holding/Foraging 7/	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	

1/ A small number of adults migrate upstream in December through April, with peak upstream movements usually in May and June at Nursery Bridge Dam (Mahoney et al. 2011) and at Dayton Dam the peak would include late April.
2/ Bull trout hold in the mainstem Walla Walla River downstream of the North Fork and South Fork (Mahoney et al. 2006), in Mill Creek primarily upstream of Blue Creek, and in the Touchet River upstream of Dayton.
3/ Primary spawning areas are the South Fork Walla Walla River, upper Mill Creek drainage above the WWCID, and the Touchet River drainage in upper North Fork. Wolf Fork and a few other tributaries such as Spangler Creek and the Burnt Fork (Mahoney et al. 2009, Mendel et al. 2005 and 2007).
4/ Incubation and emergence range 165-235 days (Buchanan et al. 1997), although button-up fry have been documented by WDFW in the upper North Fork Touchet River in late July or early August.
5/ Parr stage lasts 2-3 years, with little movement in the first summer.
6/ Adult downstream migration occurs from South Fork Walla Walla River spawning grounds to overwintering grounds in mainstem Walla Walla River, South Fork Walla Walla River, North Fork Walla Walla River, and Mill Creek (Mahoney et al. 2011). Several adults detected in the preceeding summer-winter in the Walla Walla River Basin have later been detected at McNary Dam and Priest Rapids Dam in the spring of the following year (Anglin et al. 2008). Many other adults were detected around Burlingame Dam and AOasis Road Bridge during winter (Anglin et al. 2008). Touchet River adults move downstream immediately after spawning (by mid-September for some fish) and move into the lower portions of the North Fork, Wolf Fork, and mainstem Touchet River. Some of these fish apparently move outside the Touchet drainage (Marshall Barrows, USFWS, personal communications 2012). Adult overwintering occurs in the North Fork, South Fork, and mainstem Walla Walla rivers, and Mill reek (Mahoney et al. 2011), as well as in the North Fork Touchet, and the mainstem Touchet River.

7/ Sub-adults migrate from the South Fork Walla Walla River, upper Mill Creek drainage, and upper Touchet Basin in fall, winter, and spring; dispersing downstream to overwintering habitat (Mahoney et al. 2011, also see BPA reports from ODFW that monitored PIT tagged and radio taged bull trout in Mill Creek, and Mendel et al. 2003b for Touchet R. telemetry, also see USFWS reports for the Walla Walla Basin). Less has been specifically documented about sub-adult migration in the Touchet River than in the Walla Walla and Mill Creek. Sub-adults move upstream and into South Fork Walla Walla River, upper Mill Creek drainage, and upper Touchet basinfor summer rearing habitat at the same time adults migrate upstream for spawning (Mahoney et al. 2011). Sub-adults in the Touchet River are found mostly in the North Fork Touchet River, Wolf Fork Touchet River, Lewis Creek, and Spangler Creek (Mendel et al. 2007).

Peak life stage timing
Common life stage timing
Life stage present

Source: Mahoney et al. 2012

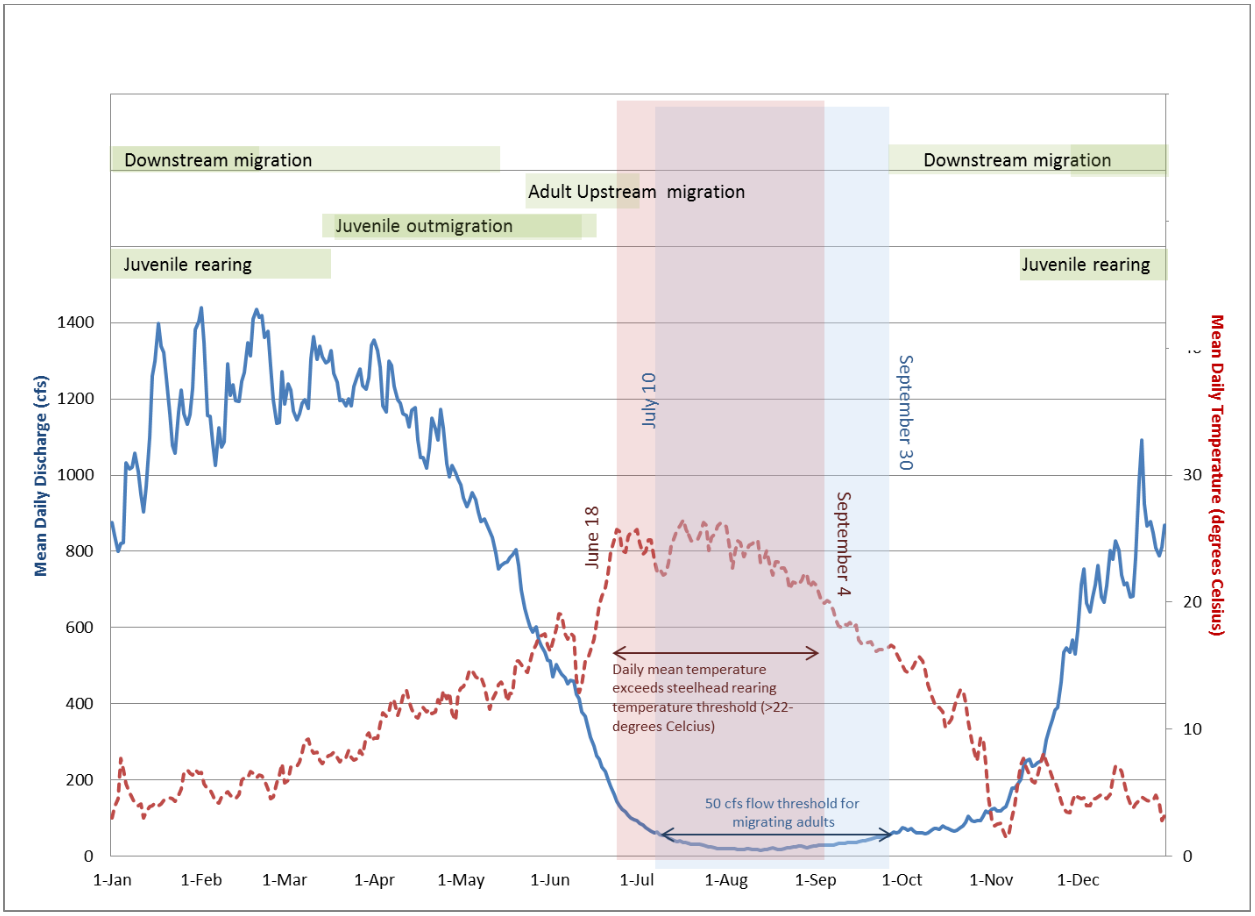


Figure 2-11. Bull Trout Use of the Lower Walla Walla River Assessment Area Relative to Discharge and Stream Temperature

2.8 LIMITING FACTORS

The LWWWG and recent research have identified the need to further evaluate the relationship between high mortalities of fish species and factors limiting aquatic productivity within the Lower Walla Walla River (Mahoney 2013; Olsen and Mahoney 2013; Schaller et al. 2014). Numerous assessments and plans (NPPC 2001; NWPCC 2005; Smith 2005; WWWPU 2005; NMFS 2009; SRSRB 2011; Lewis 2012; USFWS 2014) have identified limiting factors affecting the focal fish species. Subbasin-wide assessments and studies list loss of habitat complexity, sediment, and migration barriers, as well a poor riparian and floodplain conditions as limiting factors (NPPC 2001; USFWS 2002; NWPCC 2005; WWWPU 2005; Mendel et al. 2007; USFWS 2014), and low summer water levels and high summer water temperatures have been identified as the key limiting factors for salmonids in the Walla Walla River (NPPC 2001; NWPCC 2005; WWWPU 2005; Mahoney et al. 2012). A considerable amount of habitat alteration in lowland areas has removed riparian vegetation, altered upland characteristics and run-off patterns, increased sediment input and incision rates, isolated the river from its floodplain, and altered instream habitat conditions. Additionally, agricultural and industrial run-off and waste inputs have further affected water quality in some areas (Ecology 2006).

The Washington portion of the Walla Walla Subbasin (WRIA 32) received a ranking of "poor" and "data gap" in the Statewide Limiting Factors (Smith 2005) assessment for the following:

Poor – Access, side-channel floodplain, sediment quality, bank/streambed channel stability, instream LWD, pool habitat, riparian, water temperature, other nutrients (nutrients, toxins, pH), high flows, and low flows

Data Gap – Sediment quantity, road density, and impervious surfaces

The EDT analysis utilized as part of the Walla Walla Subbasin Plan (NWPCC 2005) found sediment load, key habitat quantity, and habitat diversity to be the primary limiting factors for steelhead in the lower Walla Walla River.

Although there is extensive reporting from existing research, assessments, and research, monitoring, and evaluation programs on limiting factors throughout the Subbasin, as well as the focal fish species described in Section 2.7, there is limited empirical data for the Lower Walla Walla River that connects focal fish species utilization to quantified limiting factors. In addition, despite the fact the Lower Walla River has had some of the highest rankings for addressing limiting factors, past assessments and plans have not been recommended it for restoration and enhancement projects due to lack of empirical data, practicality, predominantly used for migration and overwinter rearing, and selecting the Lower Walla Walla River would have meant excluding areas upstream that have been believed to support a greater diversity of fish species.

Recent research has identified the importance of the Lower Walla Walla River for providing overwintering holding and rearing habitat, as well as a migratory corridor, for the focal fish species (Mahoney 2013; Olsen and Mahoney 2013; Schaller et al. 2014). Although there remains a lack of complete knowledge on focal fish species timing and utilization of the Lower Walla Walla River, based on the information presented in Section 2.7 above, these species utilize the lower river and degraded conditions are likely contributing to fish mortalities and limiting their ability to increase productivity. Because the importance of the Lower Walla Walla River to the focal fish species has been identified, and there is a lack of empirical data quantifying limiting factors in the lower river, further analysis and evaluation of the relationship between focal fish species timing and utilization and factors limiting aquatic productivity has been identified as a necessary step in this GAAP.

Section 3 provides the results from analysis of field survey data. These results, combined with existing data reported above in Section 2, provide the data needed to quantify limiting factors in the Lower Walla Walla River. Drawing on past assessments and plans described in this GAAP, as well as the results from analysis of field survey data, Section 3 establishes the links necessary for connecting high mortalities of the focal fish species to factors limiting aquatic productivity within the Lower Walla Walla River. Based on developing the links from past assessments and plans and results from analysis of field survey data, the limiting factors described in this section are refined and presented in Section 3.

3. Geomorphic Assessment

This section, the Geomorphic Assessment portion of the GAAP, presents results from the analysis of field surveys and, incorporating the existing data reported in Section 2, provides the empirical data needed to quantify limiting factors in the Lower Walla Walla River. The quantification of limiting factors facilitates identifying linkages between fish timing and utilization in the Lower Walla Walla River. By understanding these connections, reaches that are significant to the focal fish species can be determined, thereby providing a mechanism to identify desired future conditions for the Lower Walla Walla River.

This Geomorphic Assessment addresses the first of the three purpose statements for the GAAP (see Section 1): obtain empirical data for use in evaluating degraded conditions and identifying and prioritizing restoration and enhancement projects. It provides the necessary information to answer the three primary questions noted in Section 1 related to the degraded conditions in the Lower Walla Walla River. The results are presented as outlined in Section 1.2.3.

3.1 REACH DELINEATION

The Lower Walla Walla River was divided into seven distinct geomorphic reaches (Appendix C, Figure C-2) based on differences in the following metrics: sinuosity, bank condition and stability, confinement width, channel dimensions (bankfull width, bankfull depth, incision depth, entrenchment ratio, etc.), gradient, sediment size, and overall channel morphology. Table 3-1 provides summary information describing the location, length, channel gradient, and sinuosity for the seven reaches, as well as noting any tributaries. Further information for each of the seven geomorphic reaches is provided in the following subsections.

Table 3-1. Summary of Geomorphic Reach Locations

Geomorphic Reach	Extent (River Mile)	Length (mi)	Average Gradient (ft/ft)[1/]	Sinuosity	Tributaries
Reach 1	3.6 to 8.6	5.1	0.0004	1.2	None
Reach 2	8.6 to 12.5	4.2	0.0009	1.5	Vancycle Canyon
Reach 3	12.5 to 17.9	6.5	0.0011	1.3	Gardena Creek
Reach 4	17.9 to 21.6	4.3	0.0006	1.3	Touchet River
Reach 5	21.6 to 22.8	1.7	0.0005	1.6	None
Reach 6	22.8 to 26.0	5.4	0.0012	1.8	Pine Creek; Mud Creek
Reach 7	26.0 to 27.4	1.5	0.0019	1.1	Dry Creek

1/ Gradients calculated from bathymetric survey data.

3.1.1 Geomorphic Reach 1 – RM 3.6 to 8.6

Geomorphic Reach 1 extends from the confluence with the Columbia River near Wallula Junction to RM 8.6 located upstream of Zangar Junction. Historically, the mouth of the Walla Walla extended several miles into what is now the Columbia River; however, the creation of Lake Wallula behind McNary Dam in 1958 inundated miles of the channel and floodplain at the mouth. The backwater effect from McNary Dam extends as far as RM 9 and 10 at certain times of the year. The current river mouth is near RM 3.6 with a delta that extends into Lake Wallula to approximately RM 3.0.

The Lower Walla Walla River in this reach is a very low gradient (0.0004 foot/foot), single-thread, and relatively straight channel for most of its length (Figure 3-1). The historic floodplain in the lower half of the reach is broad (average of over 2,000 feet) and flat, and contains several connected waterbodies and wetlands including Smiths Harbor. The majority of Reach 1 is contained within the McNary National Wildlife Refuge and is managed for conservation. The riparian zone covers a wide area that is primarily tall grasses and sparse in understory, canopy cover, and diversity. The vegetation on the banks is dominated by tall grasses and the occasional willow shrub. There are no significant tributary junctions in Reach 1.

Figure 3-1. Aerial View of Geomorphic Reach 1

3.1.2 Geomorphic Reach 2 – RM 8.6 to 12.5

Geomorphic Reach 2 extends from RM 8.6 to RM 12.5 near the site of the Nine Mile (Reese) Dam built in 1905 (Figure 3-2). The sinuosity is greater in Reach 2 (1.5) than Reach 1 (1.2). One of the defining characteristics of Reach 2 is the presence of frequent vegetated islands, secondary channels, and more abundant LWD.

Riparian vegetation along Reach 2 transitions from a grass-dominated understory with individual scattered mature trees to a more even mixture of tall grasses and willow shrubs. Mature trees within the riparian corridor are still scarce but more abundant than Reach 1. Midway along the reach on the left bank is an RV park with groomed lawn and plots for extended camping. CREP plantings are present on the right bank just upstream of the Highway 12 bridge at RM 12 and consist of younger pines (*Pinus* spp.) and Douglas-fir (*Pseudotsuga menziesii*) trees.

The historic floodplain of Reach 2 is predominantly privately owned and used for agriculture, with the hillslopes on the north side of the river supporting many orchards and vineyards. Highway 12 runs parallel to the Walla Walla River between the RV park and bridge crossing, coming within 60 to 70 meters of the river. Flows from Vancycle Canyon enter the Walla Walla in Reach 2 near Pierce's Green Valley RV Park.

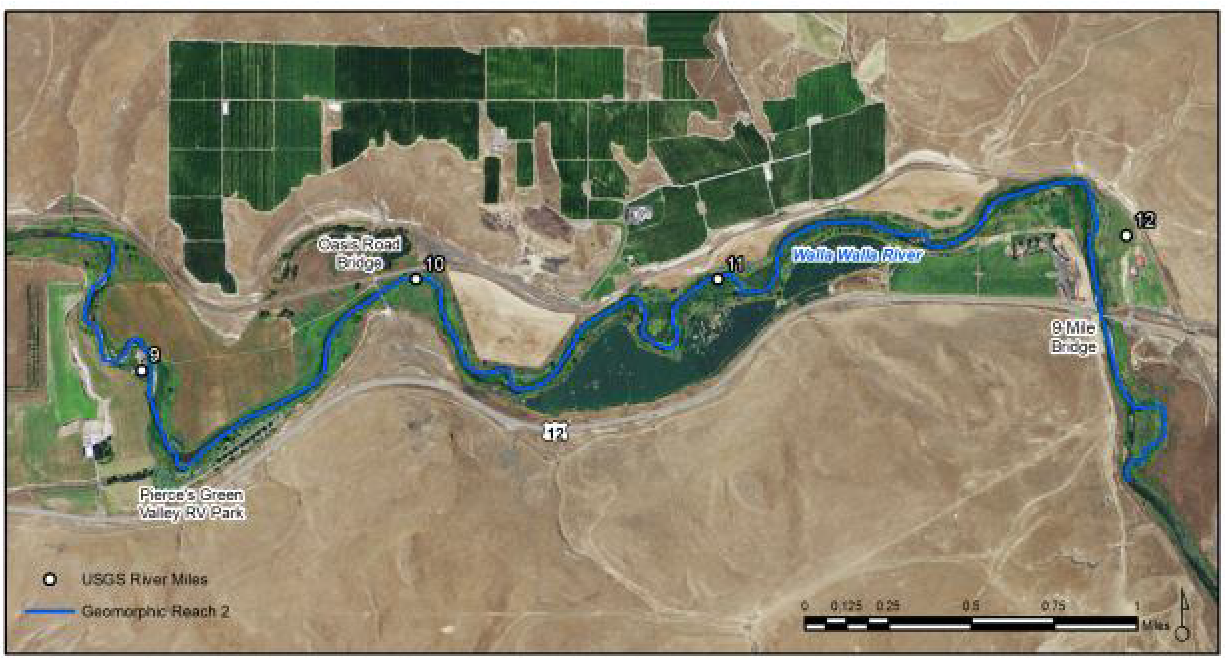


Figure 3-2. Aerial View of Geomorphic Reach 2

3.1.3 Geomorphic Reach 3 – RM 12.5 to 17.9

Geomorphic Reach 3 extends from RM 12.5 to RM 17.9 upstream of the Gardena Creek confluence (Figure 3-3). The defining characteristic of Reach 3 is the bedrock controls on the channel pattern and form. Near RM 13 the river is confined as it flows through a bedrock (Wanapum basalt) notch. Periodic bedrock grade controls are also visible on the channel bed throughout the downstream half of the reach.

From RM 13 to RM 14.5, the historic floodplain is wider (average 1,100 feet) allowing for increased sinuosity. Upstream of RM 14.5 the channel is largely confined by bedrock controlled hillslopes or high terraces comprising primarily Touchet bed deposits.

Very few riparian trees are present in Reach 3, with the majority of the riparian vegetation being understory shrub and herbaceous vegetation; however, CREP plantings, consisting of young pines and Douglas-fir, blue elderberry (*Sambucus nigra* ssp. *caerulea*), and redosier dogwood (*Cornus sericea*), were present farther up on both banks of the river throughout the reach. The upland area outside the riparian zone appears to be primarily rangeland with a single large section of agricultural land locate along the right bank (RM 16.0 to RM 17.8). A network of unimproved roads runs along both sides of the river. Flows from Gardena Creek enter the Walla Walla in Reach 3 near the upstream extent of the reach.

Figure 3-3. Aerial View of Geomorphic Reach 3

3.1.4 Geomorphic Reach 4 – RM 17.9 to 21.6

Geomorphic Reach 4 extends from RM 17.9 to RM 21.6, where the Touchet River enters the Walla Walla River (Figure 3-4). The Touchet River provides a major flow contribution constituting approximately 40 percent of the total flow in Reach 4 (NWPCC 2005). The USGS gage 14018500 is located in this reach at approximately RM 18.7. The primary defining characteristic of Reach 4 is that it is confined by a high terrace of Touchet beds in addition to roads and adjacent agriculture. The valley floor width between terraces increases from 400 feet at the downstream end of the reach to a width of 1,550 feet at RM 20.2. From this location upstream to the Touchet confluence, the high terrace remains to the south while a broad 2,400 foot historic floodplain extends to the north.

There is a relatively narrow riparian corridor in Reach 4. The riparian understory is a thick line of coyote willow intermixed with tall grasses, such as reed canarygrass. CREP plantings with pines, Douglas-fir, and blue elderberry are present in the upper portion of this reach. Upland areas on both sides of the river are almost entirely devoted to agricultural usage.

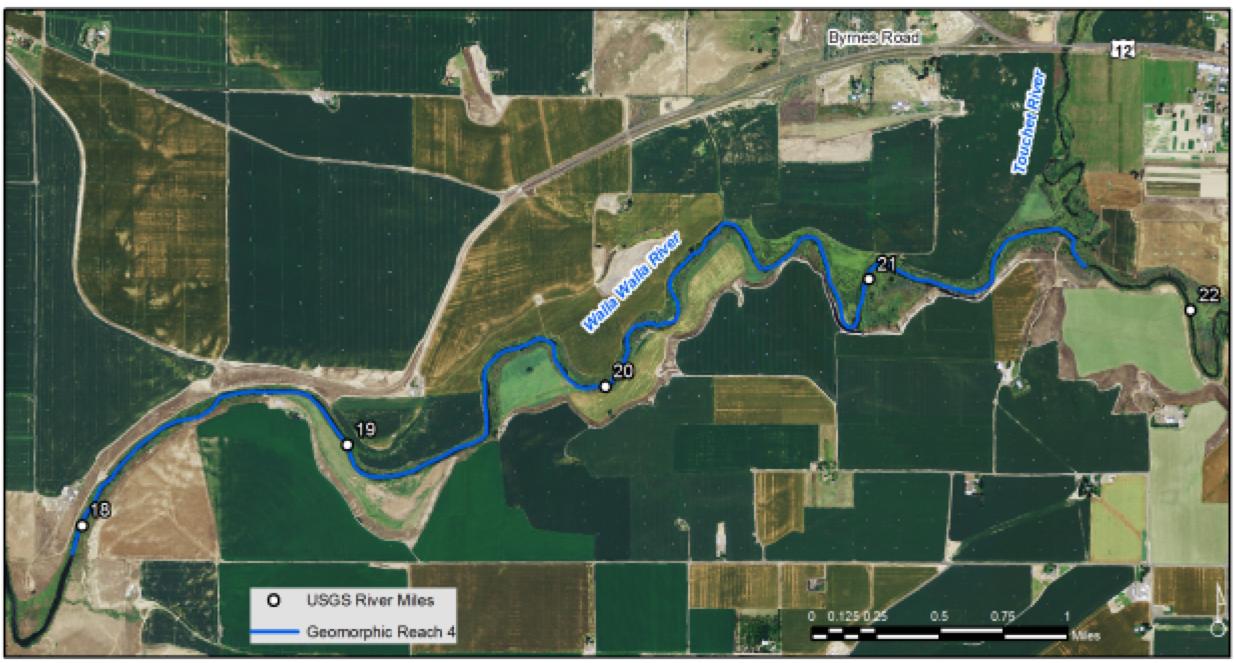


Figure 3-4. Aerial View of Geomorphic Reach 4

3.1.5 Geomorphic Reach 5 – RM 21.6 to 22.8

Geomorphic Reach 5 extends from RM 21.6 to RM 22.8, which is about 0.5 mile upstream of the Touchet-Gardena Bridge (Figure 3-5). The primary defining characteristic of Reach 5 is that it is narrow and deep with relatively few bedforms and little channel complexity. In contrast to downstream reaches, Reach 5 has a broad historic floodplain (average 1,700 feet) adjacent to the river on both banks. Agricultural land uses dominate in this reach. The corridor between agricultural lands is relatively narrow and contains frequent CREP planted areas. No significant tributaries enter the Walla Walla River in Reach 5.

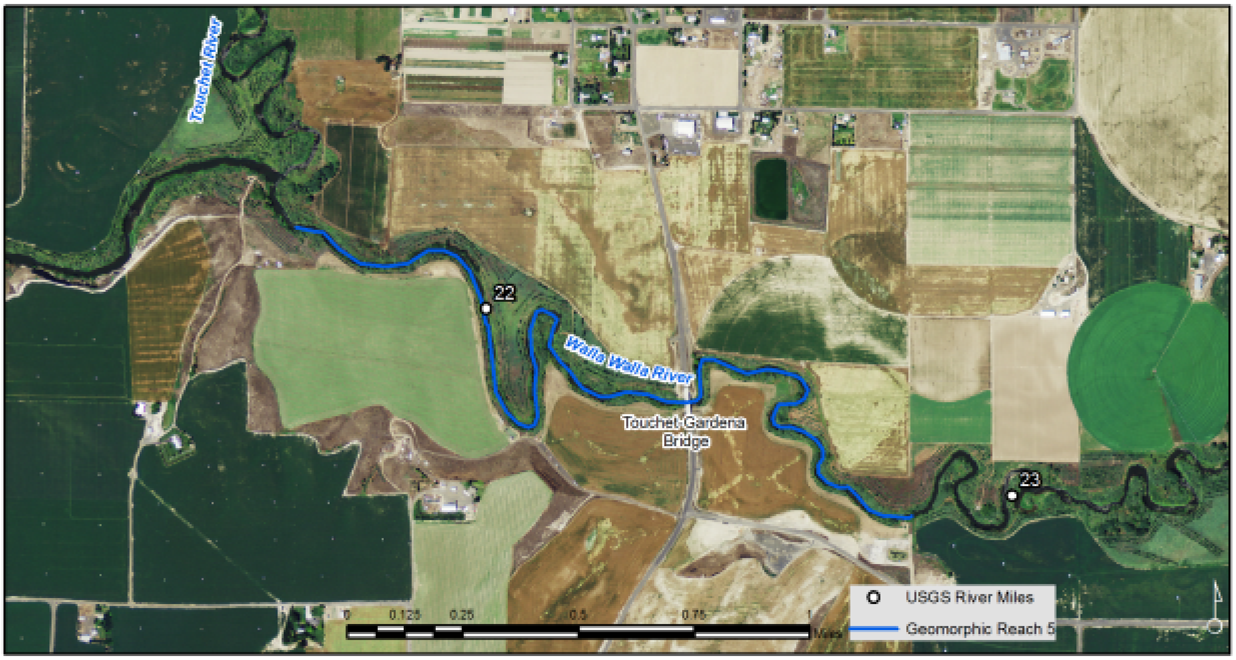


Figure 3-5. Aerial View of Geomorphic Reach 5

3.1.6 Geomorphic Reach 6 – RM 22.8 to 26.0

Geomorphic Reach 6 extends from RM 22.8 to RM 26.0 near the Mud Creek confluence (Figure 3-6). Agricultural land uses dominate in this reach. The riparian corridor is wider in Reach 6 than in adjacent reaches and includes a combination of more naturally occurring riparian vegetation as well as some CREP planted areas. The limited canopy coverage is made up of a mixture of mature cottonwoods and alders, mostly set back from the wetted channel edge. A dense wall of coyote willow crowds both banks, with open patches occupied by reed canary-grass. CREP plantings are present in the lower end of this reach on both banks of the river, with the same pines and Douglas-fir as seen downstream. Upland areas continue to be dominated by large-scale agricultural usage on both sides of the river.

The primary defining characteristic of Reach 6 is the highly sinuous (1.8) tortuous meandering pattern. Cutoffs and oxbows are apparent throughout the reach. Channel complexity is greater in Reach 6 than in downstream reaches with more frequent pools and LWD. The historic floodplain in this reach is very broad (average 1,800 feet) and flat. Both Pine Creek and Mud Creek enter the Walla Walla River in Reach 6.

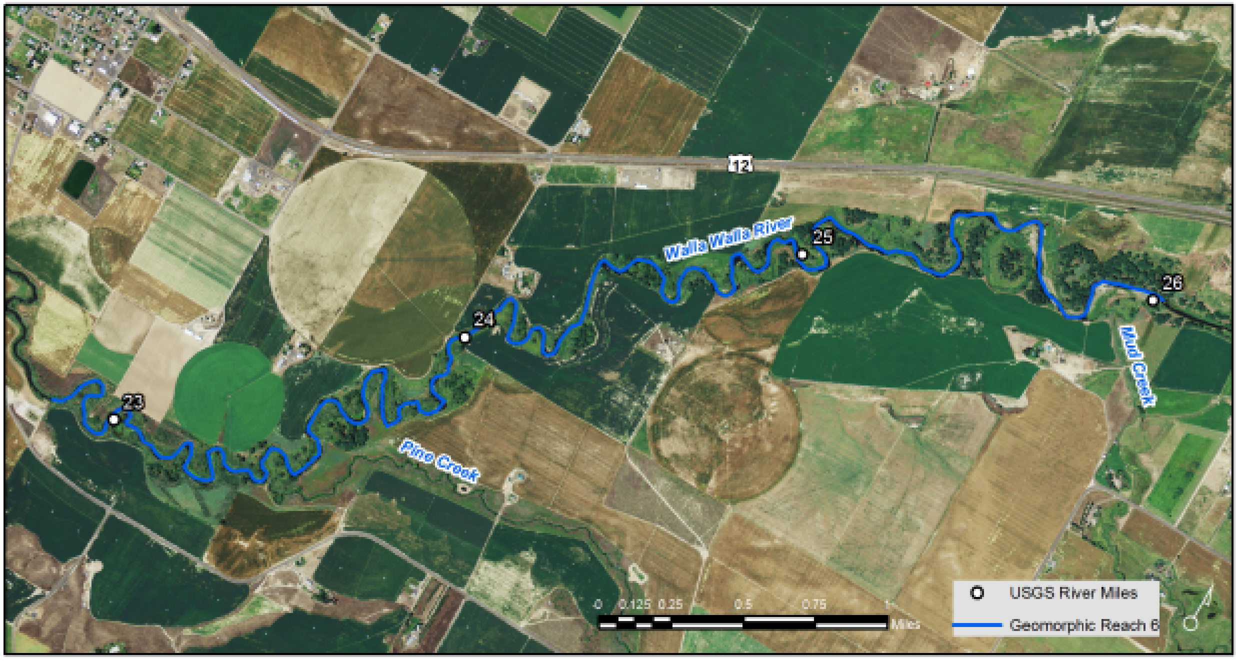


Figure 3-6. Aerial View of Geomorphic Reach 6

3.1.7 Geomorphic Reach 7 – RM 26.0 to 27.4

Geomorphic Reach 7 extends from RM 26.0 to RM 27.4 at the Lowden Bridge (Figure 3-7). Agricultural land uses dominate in this reach. The riparian corridor is much narrower in this reach than in Reach 6 with very little naturally occurring riparian vegetation or CREP planted areas. The historic floodplain in this reach is very broad (average 1,700 feet) and flat.

The defining characteristic in Reach 7 is the dramatic straightening of the channel that has occurred in the latter half of the last century. Butcher and Bower (2005) reported a substantial reduction in sinuosity from 1939 (2.0) to 1996 (1.0) in Reach 7 and upstream of Lowden Bridge. Frequent bank armoring including car bodies was observed in this reach. The channel gradient is higher in Reach 7 (0.0019 foot/foot) with more frequent gravel bars and LWD than in any of the downstream reaches. Dry Creek enters the Walla Walla River in Reach 7 just downstream of the Lowden Bridge.

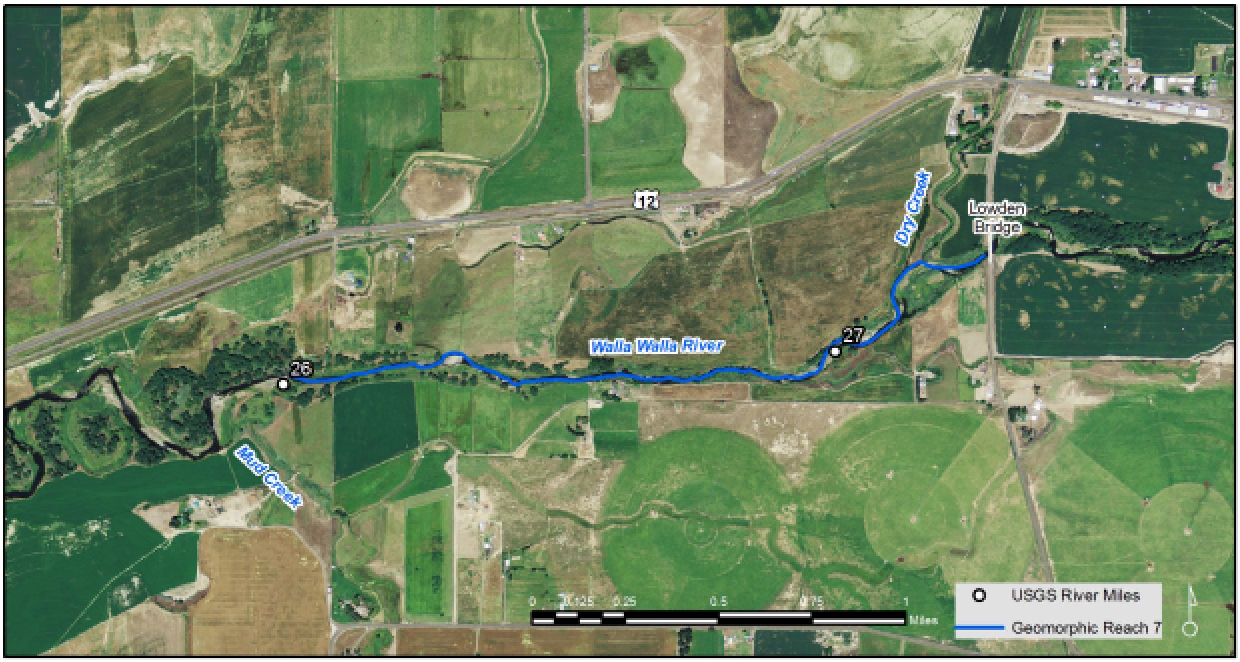


Figure 3-7. Aerial View of Geomorphic Reach 7

3.2 REACH ASSESSMENT

The purpose of the reach assessment is to provide an in-depth analysis of the seven geomorphic reaches described above using field observations, including EMAP surveys, existing data, and metrics calculated to describe channel form and process. The following subsections evaluate the reaches by considering a range of characteristics: land use, riparian vegetation, channel morphology classification, channel migration, floodplain connectivity, near-bank disturbance, sediment mobility and transport, the SEM, and fish habitat.

3.2.1 Land Use

The dominant land use type within the Lower Walla Walla River 100-year flood inundation area is private agricultural land (82 percent). Most of the remaining land is under public ownership (17 percent). The public land is entirely downstream of RM 9.5 and includes the McNary National Wildlife Refuge. Private residential land accounts for 1 percent of the 100-year flood inundation area and commercial land less than 1 percent. In addition, land use and associated human disturbance (as defined in Lazorchak et al. 2000) were assessed based on the EMAP methods described in Section 1.2.3.2. Data on land use and human disturbance were collected in sample areas within four of the seven geomorphic reaches: 1, 3, 5, and 7 (see Appendix C). Human influences/disturbances recorded included:

- walls, dikes, revetments, riprap, and dams;
- buildings;

- pavement (e.g., parking lot, foundation);
- roads or railroads,
- inlet or outlet pipes;
- landfills or trash (e.g., cans, bottles, trash heaps);
- parks or maintained lawns;
- row crops, pastures, rangeland, or hay fields; and
- logging or mining (including gravel mining).

Results from the EMAP surveys for land use are provided below.

3.2.1.1 EMAP Surveys

The percentage of the sample plots, per EMAP sample area, that contained the various categories of human influences and disturbance are presented in Table 3-2. The human disturbances most often observed within the sample plots included row crops, pasture or rangeland, and roads. Buildings were observed within 4.5 percent of sample plots in Sample Areas 3 and 4, and inlet and outlet pipes were observed within 9.1 percent of sample plots within Sample Area 1. Other types of human disturbance (e.g., pavement, landfill, parks and lawns, logging, mining) were not observed within EMAP sample area plots along the Lower Walla Walla River.

Table 3-2. Percentage of EMAP Survey Cross Sections with Human Disturbances Present

Type of Disturbance	EMAP 1 (RM 5.6 to RM 7.7) (%)	EMAP 2 (RM 14.0 to RM 15.0) (%)	EMAP 3 (RM 21.8 to RM 22.7) (%)	EMAP 4 (RM 25.9 to RM 26.9) (%)
Buildings	0.0	0.0	4.5	4.5
Pavement	0.0	0.0	0.0	0.0
Roads	18.2	4.5	22.7	0.0
Pipes	9.1	0.0	0.0	0.0
Landfill	0.0	0.0	0.0	0.0
Park/Lawn	0.0	0.0	0.0	0.0
Row Crops	27.3	22.7	45.5	0.0
Pasture/Range	9.1	13.6	9.1	86.4
Logging	0.0	0.0	0.0	0.0
Mining	0.0	0.0	0.0	0.0

3.2.1.2 Key Findings

Results of the human impact and land use assessment identified that:

- The greatest sources of near-bank disturbance in the Lower Walla Walla River are roads, agricultural areas, and pasture and rangeland.

- There is only a minor amount of disturbance associated with buildings in the Lower Walla Walla River.

3.2.2 Riparian Vegetation

Near-stream land cover, including riparian vegetation within 500 feet of the channel banks, was mapped using aerial photography and remote sensing data produced by Butcher and Bower (2005) for stream temperature analysis of the Walla Walla Subbasin. The analysis produced a GIS layer including riparian vegetation type, height, and other characteristics for vegetation within 500 feet of the stream bank. The assessment methods combined mature and small trees in the canopy category, shrubs and tall grasses in the understory category, and pasture and rangeland in the groundcover category.

Since this assessment was primarily from aerial remote sensing data, coverages are based on the highest level category; thus, an area covered by canopy vegetation would not also be counted in the understory category. Table 3-3 shows the estimated acres of riparian vegetation cover (canopy, understory, and groundcover canopy acreage percent) of each Geomorphic Reach calculated from the GIS layer. This initial assessment shows limited canopy cover in the riparian zone for the majority of the Geomorphic Reaches, with the majority of the riparian zone comprising understory and groundcover vegetation, absent of canopy coverage.

Table 3-3. Estimated Acreages of Riparian Vegetation Coverage for Each Geomorphic Reach Using the ODEQ Vegetation Model

Geomorphic Reach	Canopy[1/]		Understory[1/]		Groundcover	
	Acres (within 500 feet of bank)	Percent of Reach	Acres (within 500 feet of bank)	Percent of Reach	Acres (within 500 feet of bank)	Percent of Reach
1	18.7	36	23.5	45	10.2	19
2	1.3	3	30.7	71	11.1	26
3	<0.1	0	33.3	60	22.4	40
4	0.00	0	24.6	47	28	53
5	<0.1	0	5.0	26	14.0	73
6	9.9	20	8	16	32.4	64
7	4.5	28	4.9	31	6.5	41

1/ Vegetation categories reflect the highest level coverage; therefore, "understory" is the percentage of area with understory vegetation that is not covered by canopy vegetation, and "groundcover" represents areas with no canopy or understory vegetation

3.2.2.1 EMAP Surveys

In addition to the assessment of riparian vegetation cover using existing data as described above, EMAP surveys for riparian vegetation structure were conducted in sample areas within four of the seven geomorphic reaches: 1, 3, 5, and 7 (see Appendix C, Figure C-1). Results of the EMAP surveys for riparian vegetation structure are provided in Table 3-4. Upper canopy cover in EMAP Sample Area 1 (RM 5.6 to RM 7.7) was typically lacking throughout the entire sample area, with a only few mature deciduous trees scattered throughout and usually outside of the EMAP sampling zone. The average percent cover of the upper canopy was only 2.0 percent in Sample Area 1. The lack of upper canopy cover was typical of the entire Geomorphic Reach 1, and the upper canopy density did not increase within the riparian zone until near the mouth of the Walla Walla River. The majority of vegetation cover (53.0 percent) along EMAP Sample Area 1 consisted of tall grasses that extended beyond bankfull width, with isolated willow shrubs dotting the riparian zone. This differs from the majority of the seven geomorphic reaches where willow densities along the riparian corridor were relatively abundant, including the start of Geomorphic Reach 1 which had greater willow densities along the riparian corridor, including along a deposition bar that was thick with new woody stem growth of willows. The transition from the dense cover of grasses observed in Sample Area 1 to abundant willow cover occurred between RM 10.0 and RM 11.0.

Table 3-4. Surveyed Riparian Vegetation Coverage as Average Percent Coverage for Each EMAP Sample Area

Sample Area	Canopy		Understory		Groundcover		Non-Vegetated
	Big Trees[1/]	Small Trees	Woody Shrubs	Non-woody	Woody Stems	Non-woody	
EMAP 1 (RM 5.6 to RM 7.7)	Sparse	Sparse	Moderate	Heavy	Sparse	Sparse	Sparse
EMAP 2 (RM 14.0 to RM 15.0)	Sparse	Sparse	Heavy	Moderate	Sparse	Sparse	Moderate
EMAP 3 (RM 21.8 to RM 22.7)	Sparse	Moderate	Heavy	Moderate	Moderate	Sparse	Sparse
EMAP 4 (RM25.9 to RM 26.9)	Sparse	Sparse	Moderate	Moderate	Sparse	Moderate	Moderate

1/ Coverage percentages: Absent (0%), Sparse (0 – 10%), Moderate (10 – 40%), Heavy (40 – 75%), Very Heavy (< 75%)

The canopy cover from both large and small trees was also sparse in EMAP Sample Area 2 (RM 14.0 to RM 15.0) and was provided by isolated clumps of trees. The average percent cover of understory vegetation (95.9 percent) in Sample Area 2 was from a dense coyote willow thicket that ran through the majority of the EMAP Sample Area. These willow thickets, which were intermixed with dense grasses, typically extended outward beyond the top of bank, but only occasionally over the wetted surface. Groundcover ranged from bare ground (sections of steep failing banks) to dense short vegetation (pasture at bank edge).

The upper canopy for the entire riparian zone in EMAP Sample Area 3 (RM 21.8 to RM 22.7) was limited, with existing riparian vegetation primarily located within bankfull width. However, the few mature trees that were present in EMAP Sample Area 3 were relatively close to the wetted edge resulting in a slightly higher average percent upper canopy cover (13.4 percent) than in other sample areas. Understory vegetation within bankfull of Sample Area 3 was very dense and composed of willows, intermixed with thick to dense tall grass (still mostly reed canarygrass). Understory vegetation in this sample area did not range too far over the wetted edge. Groundcover ranged from barren exposed river bars or steep failing banks (average cover of 7.4 percent), to dense pasture vegetation (average cover of 11.3 percent) at bank edge.

The dominant riparian vegetation for EMAP Sample Area 4 (RM 25.9 to RM 26.9) included cottonwood, alders, and willows intermixed with tall dense grasses, such as reed canarygrass. The upper canopy vegetation structure was typically lacking upstream of the EMAP Area 4 and limited within EMAP Area 4 (average upper canopy cover of 7.6 percent). There were a few patches of scattered mature deciduous trees, usually set back from the wetted edge by 20 to 70 meters, which were slightly more dense along the right bank at the bottom end of Sample Area 4. The understory canopy cover (average cover of 59.2 percent) included alternating patches of mature willow thickets with stretches of thick reed canarygrass that hid individual willow shrubs. There was a limited amount of bank vegetation cover extending over the wetted edge. The ground cover ranged from barren (exposed river bars or steep failing banks) to dense (pasture at bank edge).

A USFS geomorphic assessment of the area from 2010 includes a representative reach of the Walla Walla River a short distance upstream of the current GAAP assessment area. This report included a similar description of the riparian zone dominated by black cottonwood, intermixed with white alder. The willow species identified in this reach was peachleaf willow (*Salix amygdaloides*). The understory was dominated by reed canarygrass (USFS 2010).

3.2.2.2 Key Findings

The results of the riparian vegetation assessment identified that:

- The presence of a riparian canopy is relatively lacking or sparse in all geomorphic reaches, with the riparian zone comprising mostly understory and groundcover vegetation.

- Riparian vegetation in the lower reaches of the GAAP survey area is dominated by shrubs and small trees, including willow, redosier dogwood, and herbaceous species including grass and sedge species and non-native forb species.
- The upstream extent of the GAAP survey area is dominated by hardwood species including white alder, black cottonwood, and quaking aspen.

3.2.3 Channel Morphology

Many factors govern the physical processes and resulting channel morphology of rivers. As previously described, the Lower Walla Walla River is deeply incised throughout most of the GAAP survey area. Bank materials consist of fine sediments deposited by a sequence of glacial outburst floods (Touchet beds) and the loess (very fine sand and silt-sized wind-deposited glacial sediments) deposits that fill the valley. The following subsections describe the channel morphology of the Lower Walla Walla River through standard classification systems and channel characteristics metrics.

3.2.3.1 Channel Classification

Existing channel morphology assessments that entailed stream channel classification following the methods of Rosgen (1996) were completed by Reckendorf and Tice (2000) and Butcher and Bower (2005). Reckendorf and Tice (2000) evaluated channel morphology throughout the Lower Walla Walla River upstream of Wallula Game Department Road (RM 8). Butcher and Bower (2005) also evaluated channel morphology and measured stream channel characteristics at a seven cross sections within the Lower Walla Walla River including at RMs 9.1, 11.5, 14.0, 18.8, 21.2, 23.5, and 26.8. Reckendorf and Tice (2000) reported all C and F Rosgen (1996) channel types for the Lower Walla Walla River, as did Butcher and Bower (2005), with the exception of a B3c channel type at the Touchet gage station.

In addition to reviewing existing channel morphology assessments for the Lower Walla Walla River, Table 3-5 contains the channel morphology metrics for each of the seven geomorphic reaches quantified from field survey data. Included in Table 3-5 are channel type classifications based on the channel morphology metrics and the Rosgen (1996) classification. The Rosgen (1996) classifications varied somewhat between individual geomorphic reaches. It is not uncommon to have variations in channel type within larger geomorphic reaches; therefore, the classifications presented in Table 3-5 show the most common type(s) within each reach.

3.2.3.2 Channel Characteristics Metrics

The metrics used for the reach assessment were calculated from a combination of field measurements and the combined topographic surface described in Section 1.2.2.1. The metrics are intended to provide quantifiable measures to evaluate channel morphology and in-channel characteristics limiting factors. Figures 3-8 through 3-10 illustrate the longitudinal variation of geomorphic characteristics as calculated at cross sections.

3.2.3.3 Key Findings

Results of the channel morphology assessment identified that:

- Reach 5 has the lowest average bankfull width (66 feet), lowest wetted width (61 feet), lowest width-to-depth ratio (10) and highest incision depth (21 feet).
- Reach 6 has the highest incision width (164 feet).
- Reach 1 has the highest bankfull width (154 feet), wetted width (143 feet), and a straight channel plan form.

Table 3-5. Channel Morphology Metrics by Geomorphic Reach

Metric	Reach 1 (RM 3.6 to RM 8.6)	Reach 2 (RM 8.6 to RM 12.5)	Reach 3 (RM 12.5 to RM 17.9)	Reach 4 (RM 17.9 to RM 21.6)	Reach 5 (RM 21.6 to RM 22.8)	Reach 6 (RM 22.8 to RM 26.0)	Reach 7 (RM 26.0 to RM 27.4)
Bankfull Width (ft)	154	105	98	93	66	110	108
Wetted Width (ft)	143	93	86	84	61	88	87
Bankfull Depth (ft)	9.1	6.2	6.5	7.4	6.9	5.6	5.1
Gradient (ft/ft)	0.0004	0.0009	0.0011	0.0006	0.0005	0.0012	0.0019
Width/Depth Ratio	17	18	15	13	10	23	23
Incision Width (ft)	151	129	103	114	106	164	145
Incision Depth (ft)	16	17	16	18	21	16	15
Entrenchment Ratio	9.2	2.2	2.9	4.1	1.3	5.2	2.3
Channel Pattern	Straight[1/]	Irregular Meanders	Irregular Meanders	Irregular Meanders	Irregular Meanders	Tortuous Meanders	Sinuous
Islands	Occasional	Frequent Irregular	Occasional	Occasional	Occasional	Occasional	None
Bar Type	Side; Diagonal	Side; Point	Point; Side	Point	Point	Point	Point; Mid-Channel; Side
Migration	Lateral	Downstream Progression	Downstream Progression	Downstream Progression	Downstream Progression	Progression and Cutoff	Downstream Progression
Rosgen Classification[2/]	C6c/F6	F4/C4	F4/F6/C1	C6c/F6	F6/G6	C4/F6	F4/C4

1/ The straight meander pattern in Reach 1 represents the majority of the reach although there are bends that result in the sinuosity value of 1.2.
2/ Channel type definitions based on Rosgen (1996).

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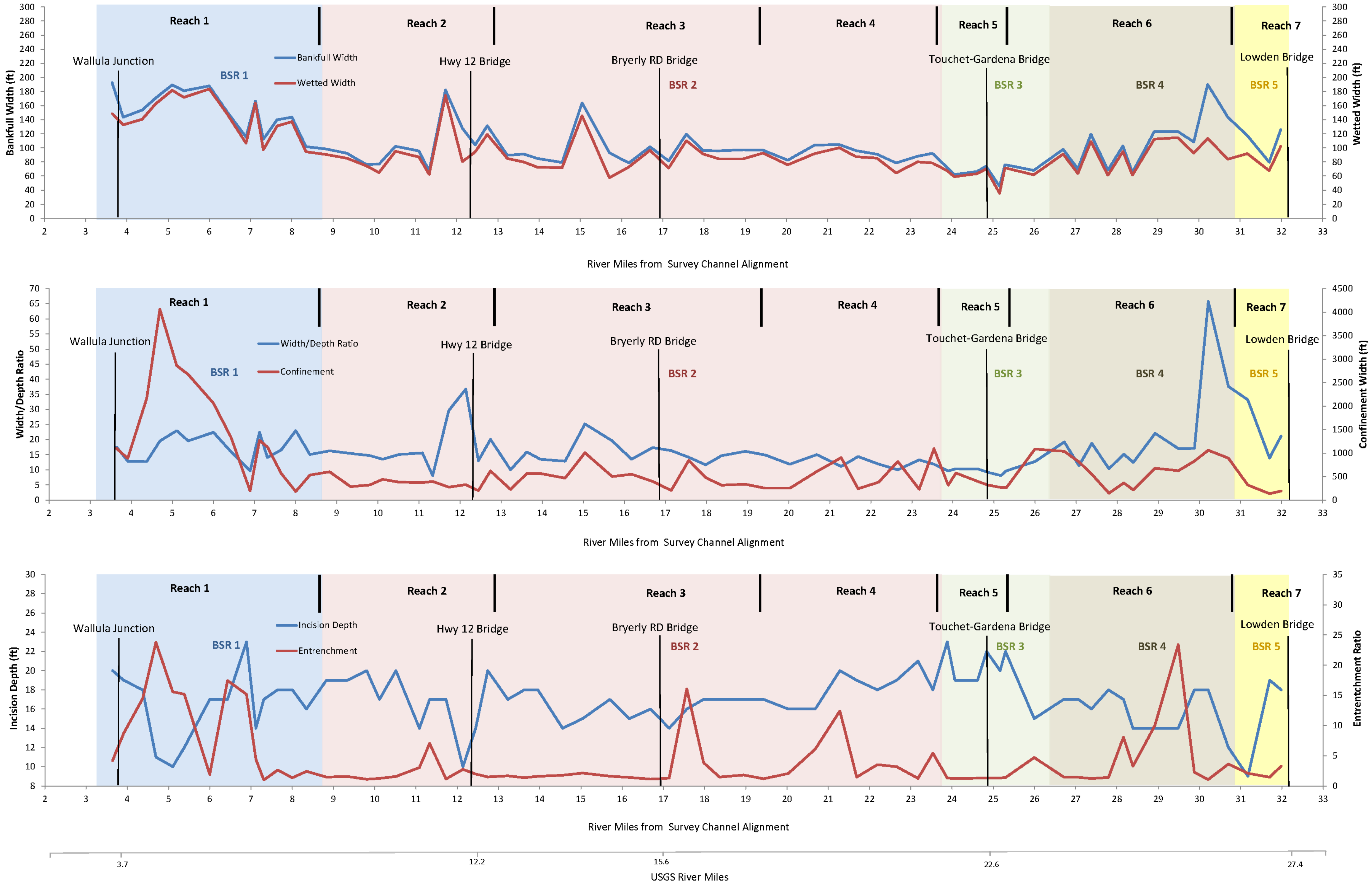
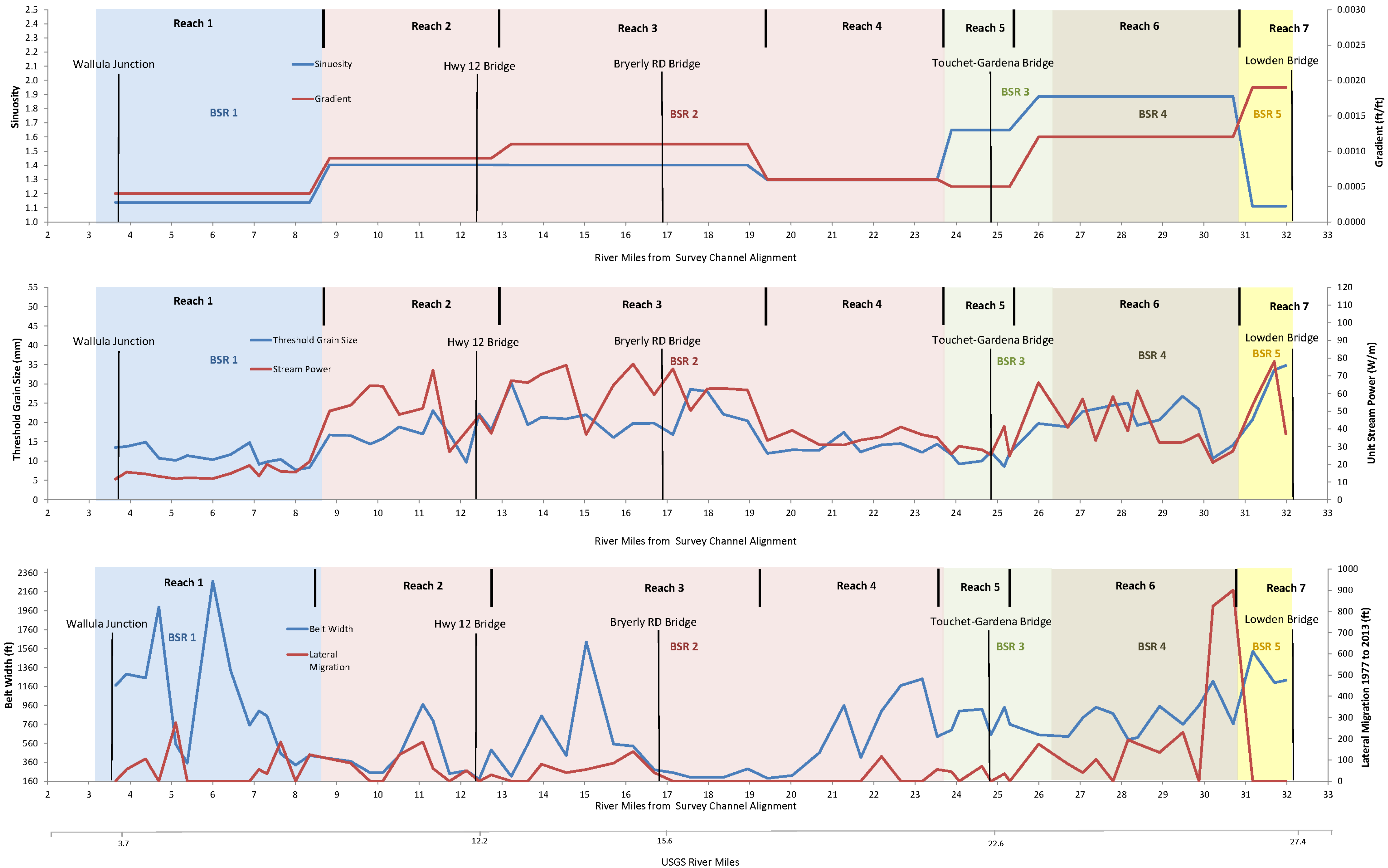


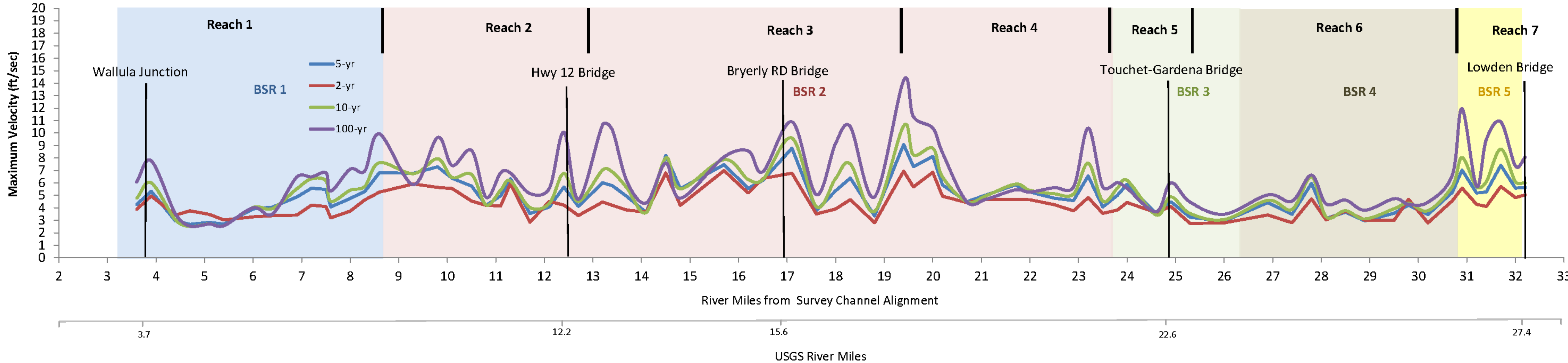
Line color legends are provided in each figure between Reach 1 and Reach 2.

Figure 3-8. Longitudinal Variation of Bankfull Width, Wetted Width, Width-to-Depth-Ratio, Confinement Width, Incision Depth, and Entrenchment Ratio



Line color legends are provided in each figure between Reach 1 and Reach 2.

Figure 3-9. Longitudinal Variation of Sinuosity, Gradient, Threshold Grain Size, Unit Stream Power, Belt Width, and Lateral Migration Between 1977 and 2013



Line color legends are provided in each figure between Reach 1 and Reach 2.

Figure 3-10. Longitudinal Variation in Maximum Velocity

3.2.4 Channel Migration

Channel migration analyses examined channel sinuosity, confinement width, valley width, meander belt width, and migration rate. Channel migration process and the extent of and rate of channel migration varied by geomorphic reach. Table 3-6 contains the sinuosity, confinement width, valley width, meander belt width, and migration rate for each reach. Both the 1939 to 1950 sinuosity, as measured by Butcher and Bower (2005), and existing sinuosity, as measured from the 2014 survey, are presented in Table 3-6. Total channel length was 34.3 miles and 29.0 miles in 1939 and as measured from the 2014 survey, respectively. Historic records of sinuosity before 1939 primarily come in the form of accounts of historic conditions (see Section 2.6) because no aerial photography was available. Based on those records, the Lower Walla Walla River was sparse of trees until near the Touchet River confluence, but contained off-channel and floodplain habitat and the presence of beavers (Kuttel 2001; Bower 2003). There was no evidence of channel incision recorded in surveys prior to 1863 (Beechie et al. 2008). These accounts suggest much of the Lower Walla Walla River was highly sinuous and contained a complex network of side channels and off-channel habitats that would reflect a broad range for each of the seven geomorphic reaches. Reaches 1 and 2 likely ranged between 1.1 and 1.6 as an anastomosing channel because this portion of the Lower Walla Walla River was not inundated pre-1939 by the backwater from McNary Dam. Pre-1939, Reaches 3 through 7 may have reflected ranges greater than 1.4.

Table 3-6. Channel Migration Characteristics by Geomorphic Reach

Geomorphic Reach	1939 to 1950 Sinuosity1/	Existing Sinuosity	Confinement Width2/ (ft)	Valley Width1/ (ft)	Meander Belt Width3/ 1939-40 to 2013 (ft)	Average Channel Migration Rate4/ (ft/yr)	Maximum Channel Migration Rate4/ (ft/yr)
Reach 1	–	1.2	1,500	2,405	994	1.7	8
Reach 2	1.7	1.5	380	1,428	423	1.6	5
Reach 3	1.5	1.3	500	1,600	475	0.9	4
Reach 4	1.7	1.3	530	1,907	687	0.5	3
Reach 5	2.1	1.6	400	5,867	812	0.7	2
Reach 6	–	1.8	690	8,119	816	6.6	25 5/
Reach 7	2.1	1.1	220	9,504	1,318	0 6/	0

1/ Sinuosity from 1939 to 1950 calculated in 2- to 3-mile reaches near Butcher and Bower (2005) study sites. Source: Butcher and Bower (2005).
2/ Includes natural (high terrace, hillslopes) and anthropogenic (roads, land use) channel confinement.
3/ Meander belt surrounding the 1939-40 channel location and the 2013 channel location.
4/ Average and maximum channel migrations rates were determined by measured channel migration from 1977 to 2013 aerial imagery. Migration amounts of less than 35 feet over the entire period were not measured.
5/ The maximum channel migration rate in Reach 6 is due to a meander cutoff near RM 25.5.
6/ Although there was no observed channel migration at the cross sections, there was a measured channel migration rate of 9 ft/yr in an isolated area directly downstream of Lowden Bridge.

The confinement width (natural or anthropogenic) was measured at each of the cross sections and averaged for each geomorphic reach. Reach 1 and Reach 6 had the highest measured confinement width (1,500 feet and 690 feet respectively), indicating the greatest potential for natural migration processes to occur without removing anthropogenic constraints. Reach 2 and Reach 7 had the lowest confinement width (380 feet and 220 feet respectively). Valley width was measured from USGS 7.5-minute quadrangle maps by Butcher and Bower (2005).

The meander belt width and channel migration rate were measured at each of the cross sections and averaged for each geomorphic (see Table 3-6). The belt width included the minimum width that encompassed both the 1939-40 and the 2013 channel location. An example of the extent of the meander belt width is included in Figure 3-11. Reach average meander belt widths ranged from 423 feet in Reach 2 to 1,318 feet in Reach 7 feet as shown in Table 3-6. Reach 7 had the highest meander belt width, but the lowest confinement width and sinuosity due to channel straightening and the presence of bank armoring structures.

Figure 3-11. Example 2013 Aerial Photograph and 1939 Mapped Channel Location within Geomorphic Reach 6 Showing Channel Meander Pattern and Progression and Approximate Belt Width (the photograph shows an example cutoff and oxbow)

The average and maximum channel migration rates were determined by measuring channel movement as shown in aerial imagery from 1977 and 2013. This time period was chosen to encompass a relatively long period (36 years) that represents current channel migration processes rather than channel modification and straightening that occurred previously. The highest average rate of channel migration was in Reach 6 at 6.6 feet per year. Reach 6 was the only one in which meander progression included cutoffs and the formation of oxbows as shown in the example in Figure 3-11. Reach 7 had no measured channel migration at the measured cross sections, but had a channel migration rate of 9 feet per year in an isolated area directly downstream of the Lowden Bridge. Reaches 3 through 5 had relatively low average and maximum channel migration rates.

3.2.4.1 Bank Stability Modeling

To evaluate potential causes related to channel migration, bank stability modeling was undertaken. The Bank Stability and Toe Erosion Model (BSTEM) developed by the National Sedimentation Laboratory (Simon et al. 2000; U.S. Department of Agriculture 2014) was used to evaluate bank stability using the field survey data of bank stratigraphy and sediment characteristics collected in the River Vision Touchstone survey. Bank stability modeling indicated that channel banks were stable (factor of safety greater than 1.3) or conditionally stable (factor of safety between 1.0 and 1.3) under most circumstances. Sensitivity tests indicated that stability was most related to pore-water pressure differences driven by the level of the water table relative to the instream flows. The model was not sensitive to differences in the silt or clay content of bank materials or flow level and duration.

3.2.4.2 Key Findings

Results of the channel migration assessment have identified that:

- Reach 6 has the highest sinuosity (1.8) with a progression and cutoff meander process.
- Reach 7 has the highest meander belt width (1,318 feet) but the lowest confinement width (220 feet) and sinuosity (1.1) due to channel straightening and the presence of bank armoring structures.
- Reach 5 has a relatively high meander belt width (812 feet), and historic sinuosity but low confinement width (2.1) and channel migration rate (0.7 feet/year) indicating strong constraints that are limiting lateral channel movement.
- Bank stability modeling indicates banks are generally stable with failures due to pore-water pressure differences between groundwater and instream flow.

3.2.5 Floodplain Inundation and Connectivity

Floodplain inundation and connectivity were analyzed by utilizing peak flow hydrology and hydraulic modeling under a range of flows and the combined topographic survey surface. Floodplain connectivity was evaluated to determine the extent to which the Lower Walla Walla River is incised and disconnected from its historic floodplain. Floodplain connectivity was evaluated to determine the Braided-Channel Ratio and the River Complexity Index, which are metrics of floodplain connectivity (as described in Section 3.2.5.2 below).

3.2.5.1 Hydraulic Modeling

Flood magnitude and frequency were estimated for input into the hydraulic model using the peak discharge data from the USGS stream gage on the Walla Walla River near Touchet, Washington (USGS stream gage 14018500; see Section 2.3.1 for peak flows). Peak flow rates were adjusted for tributary inputs to develop flow estimates for the entire length of the Lower Walla Walla River.

Appendix C, Figure C-2, displays the flood inundation boundary for the 2-year and 5-year flood events. Average inundation widths (inundation area/reach length) for all recurrence intervals (2-year, 5-year, 10-year, and 100-year) are shown in Table 3-7. Flood inundation and floodplain connectivity is relatively low in all reaches during the 2-year flood event.

Table 3-7. Average Floodplain Inundation Width for the 2-Year, 5-Year, 10-Year, and 100-Year Recurrence Interval by Geomorphic Reach

Geomorphic Reach	2-Year Unit Inundation Area (ft)	5-Year Unit Inundation Area (ft)	10-Year Unit Inundation Area (ft)	100-Year Unit Inundation Area (ft)
1	398	1,323	1,490	1,885
2	202	580	699	818
3	271	502	594	699
4	163	953	1,098	1,214
5	90	427	731	1,036
6	107	154	551	1,222
7	122	154	202	898

Flood inundation in Reaches 1, 2, 4, and 5 is substantially higher for the 5-year flood event. Only Reach 7 has a low inundation width in the 10-year flood event, indicating that floodplain connectivity is lowest in this reach.

The results of the inundation mapping were also compared with Federal Emergency Management Agency (FEMA) flood data regulatory floodplain computed for the Flood Insurance Rate Maps (FIRMs) for Walla Walla County (FEMA 1996). Although the inundation areas were similar, there were differences between the modeled 100-year inundated area and the FEMA floodplain in many areas. It appears that differences are likely due to the coarse resolution of the topographic data used to develop the FEMA floodplain, which likely did not accurately represent the topography of the river and floodplain. This comparison in the difference in inundation extents computed for the FIRMs was not analyzed in detail, but is suggested for further evaluation in future assessments.

3.2.5.2 Braided-Channel Ratio and River Complexity Index

The spatial distribution of the primary and secondary channels used for analysis is shown in Appendix C, Figure C-2. Table 3-8 provides the Braided-Channel Ratio and River Complexity Index for each of the geomorphic reaches. All reaches had relatively low values for both metrics indicating low amounts of secondary channels and lack of channel complexity. Reach 2 had a higher Braided-Channel Ratio (1.1) due to the frequent distribution of vegetated mid-channel bars. Reach 7 had a higher Braided-Channel Ratio (1.2) due to the presence of several side-channels.

Table 3-8. Braided-Channel Ratio and River Complexity Index by Geomorphic Reach

Geomorphic Reach	Braided-Channel Ratio	River Complexity Index
1	1.0	0.0004
2	1.1	0.0012
3	1.0	0.0003
4	1.0	0.0002
5	1.0	0.0003
6	1.0	0.0011
7	1.2	0.0015

3.2.5.3 Key Findings

Results of the floodplain connectivity assessment identified that:

- Flood inundation and floodplain connectivity are low in all reaches during the 2-year flood event.
- Floodplain connectivity is lowest in Reach 7.
- Poor correlation between hydraulic model results and regulatory floodway computed for the FIRMs is likely due to low resolution of the topographic data used by FEMA.
- All reaches had relatively low values for the Braided-Channel Ratio and River Complexity Index indicating low amounts of secondary channels or off-channel habitat and overall lack of channel complexity.

3.2.6 Sediment Mobility and Transport

Sediment mobility and transport were evaluated to assess the role of sediment transport processes on geomorphic processes in the Lower Walla Walla River. The inputs were calculated from hydraulic modeling (see Section 3.2.5.1), channel gradient, and sediment size estimated from field surveys and surface sediment observations of Butcher and Bower (2005) and Reckendorf and Tice (2000).

As previously discussed, the Lower Walla Walla River is deeply incised throughout most of the Lower Walla Walla River. Bank materials consist of very fine sand and silt-dominated sediments deposited by a sequence of glacial outburst floods (Touchet beds) and loess that fill the valley. Bank materials throughout the Lower Walla Walla River are relatively consistent in size, texture, and cohesive properties. Throughout the Lower Walla Walla River, the river is in various stages of channel evolution in response to channel incision. The sediment transport assessment relied on sediment data and hydraulic modeling results to calculate sediment transport characteristics including shear stress, stream power, and threshold grain size.

3.2.6.1 Sediment Grain Size Distributions

Pebble count and bulk sediment samples were collected at two locations: (1) downstream of the Lowden Bridge; and (2) downstream of the Touchet River confluence near RM 21.6. These samples were taken on point bars. An attempt was made to sample bed sediments near the mouth of the Lower Walla Walla River, but due to the influence of Lake Wallula backwater upstream, sampling was infeasible. Figures 3-12 and 3-13 report the grain size distributions for the pebble count and bulk samples downstream of the Lowden Bridge and downstream of the Touchet River confluence near RM 21.6. All samples were remarkably similar in distribution and median grain size (D_{50}) indicating that there is little bed surface armoring. The D_{50} ranged from 27 mm to 29 mm for both pebble count and bulk samples at both sites. This median grain size is within the range of preferred spawning gravels, although currently gravel deposits in much of the Lower Walla Walla River are limited to point bars and other sediment deposition areas.

In addition, sediment samples were collected from the channel banks downstream of the Lowden Bridge and from a small deposit at the river margin near the boat launch at Madame Dorian State Park. Both of these sample areas consisted entirely of fine-grained material. The sediment sample from the banks near the Lowden Bridge comprised very fine sand (90 percent), silt (5 percent), and clay (5 percent). The sediment sample from near the mouth was comprised of sand (81 percent), silt (11 percent), and clay (8 percent).

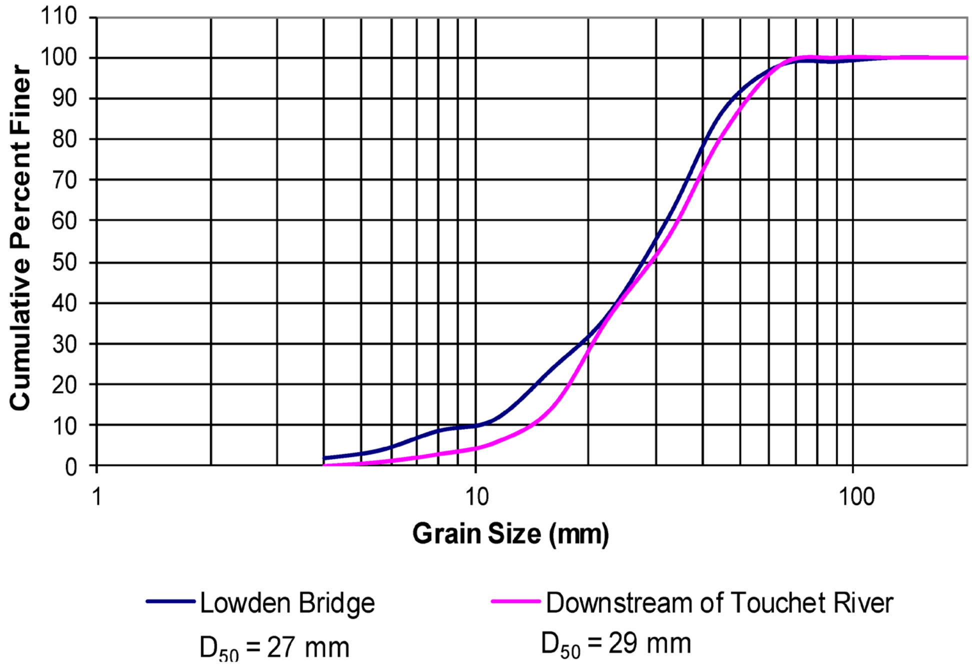


Figure 3-12. Pebble Count Grain Size Distributions for Downstream of the Lowden Bridge and Downstream of the Touchet River Confluence near RM 21.6

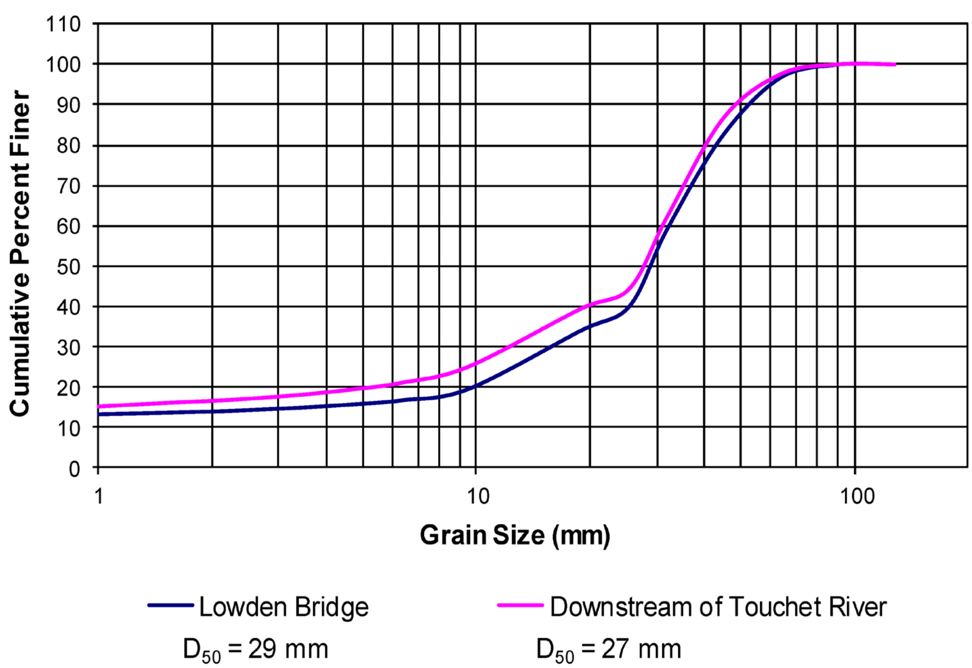


Figure 3-13. Bulk Sample Grain Size Distributions for Downstream of the Lowden Bridge and Downstream of the Touchet River Confluence near RM 21.6

3.2.6.2 Sediment Transport Characteristics

There is a complex pattern of bed surface sediments and transport characteristics in the Lower Walla Walla River. Table 3-9 provides a summary of sediment transport characteristics by geomorphic reach. Field observations during the River Vision Survey and previous studies (Mapes 1968; Beechie et al. 2008) suggest that the transport capacity of the Lower Walla Walla River exceeds the supply of fine sediment from channel bed and banks such that fine sediments are easily transported and fine sediment retention is limited in most areas. From the Lowden Bridge downstream to the confluence with the Touchet River the channel becomes increasingly narrow and deep and the presence of gravel bars decreases. This pattern is believed to be a result of decreasing coarse sediment supply and sediment attrition. The presence of gravel bars force bank erosion and lateral channel migration resulting in a wider and shallower channel form.

Table 3-9. Sediment Size, Unit Stream Power, and Threshold Grain Size by Geomorphic Reach

Geomorphic Reach	Shear Stress (N/m2)	Unit Stream Power (W/m)	Bed Material Butcher and Bower (2005)[1/] (mm)	D_{50} Reckendorf and Tice (2000)[2/] (mm)	Threshold Grain Size (mm)
Reach 1	11	5	–	–	11
Reach 2	17	15	Coarse gravel	Medium gravel and silt	17
Reach 3	21	19	Sand and finer	Coarse gravel[3/]	22
Reach 4	13	11	Cobble[4/] Sand and finer[5/]	Sand and finer	14
Reach 5	10	9	Sand and finer	--	11
Reach 6	20	13	Sand and finer	Medium gravel	21
Reach 7	29	17	Sand and finer	Medium gravel	30

1/ Derived from pebble counts at RM 9.1; 11.5; 14.0; 18.8; 21.2; 23.5; and 26.8. No data collected in Reach 1. Source: Butcher and Bower (2005). Sediment size classes are: sand and finer (< 2 mm); medium gravel (8-16 mm); coarse gravel (16 to 63 mm); cobble (64 to 256 mm).
2/ From visual estimates for reaches surveyed by Reckendorf and Tice (2000). No data collected in Reach 1 or 5. Sediment size classes are: sand and finer (< 2 mm); medium gravel (8-16 mm); coarse gravel (16 to 63 mm); cobble (64 to 256 mm).
3/ Sharp basalt cobbles were noted in the reach downstream of Byerley Road Bridge.
3/ Pebble count sediment sample from RM 18.8 site.
4/ Pebble count sediment sample from RM 21.2 site.

Downstream of the Byerley Road Bridge, the channel width increases and gravel bars again become more common, presumably due to the effects of the increase in sediment supply as the river flows through a relatively narrow corridor of Wanapum Basalts. These patterns indicate that the primary control on channel form and the rate of channel migration appears to be related to the supply of coarse non-cohesive gravels and artificial and/or natural channel confinement.

There is also a bed sediment size anomaly located in the upstream extent of Reach 3 which is a series of large of boulders in the channel bed. The boulders may have been deposited as glacial debris rafted on huge icebergs. These deposits are called bergmounds and have been observed in the nearby area (Carson and Pogue 1996).

3.2.6.3 Key Findings

Results of the sediment mobility and transport assessment identified that:

- Sediment transport characteristics and grain size estimates indicate that bank sediments (primarily very fine sand and silt) are readily transported in all geomorphic reaches.
- The distribution of coarse non-cohesive gravels primarily exists in Reaches 2, 3, 6, and 7.
- Sediment sampling indicates that gravels are suitable for spawning.
- Reach 7 and the upstream portion of Reach 6 have the largest quantity of medium and coarse gravel stored in point bars.

3.2.7 Regime Model

The University of British Columbia Regime Model was used to evaluate channel dimensions in the Lower Walla Walla River to inform potential restoration and enhancement actions, particularly modifications to channel width. The modeled scenario used existing input variables for discharge, gradient, sediment characteristics, and roughness, but varied bank characteristics (friction angle and effective root cohesion) to represent a non-incised channel with a vegetated and connected floodplain.

The predicted channel dimensions from the regime model were compared to the existing channel dimensions for the 2-year recurrence interval flow output from the hydraulic model (see Section 3.2.5.1). Table 3-10 presents the width, depth, and width-to-depth ratio for the model scenario compared to existing channel dimensions for each of the geomorphic reaches. With the exception of Reach 6, the predicted channel width was larger than the existing channel width, ranging from 3 to 39 feet larger. The predicted channel width in Reach 6 (98 feet) was 4 feet less than the existing channel width (102 feet). Predicted width-to-depth ratios were similar to existing channel widths for most geomorphic reaches. Model results indicate that Reach 3 would require the most substantial alteration of channel width to achieve regime channel dimensions; however, site-specific hydraulics and sediment analyses are necessary to determine stable channel configurations.

Table 3-10. Comparison of Observed and Predicted Channel Dimensions by Geomorphic Reach

	Existing Channel Dimensions[1/]				Predicted Channel Dimensions[2/]			
Geomorphic Reach	Width (ft)	Depth (ft)	Cross-Section Area (ft^2)	Width-to-Depth Ratio	Width (ft)	Depth (ft)	Cross-Section Area (ft^2)	Width-to-Depth Ratio
Reach 1	148	11.4	1,645	13	158	11.2	1,743	14
Reach 2	155	9.4	1,427	16	159	9.2	1,465	17
Reach 3	131	10.0	1,300	13	170	8.2	1,415	21
Reach 4	120	10.2	1,220	12	123	10.5	1,181	12
Reach 5	87	11.6	1,021	8	95	10.2	971	9
Reach 6	102	8.6	875	12	98	7.2	699	14
Reach 7	107	5.5	574	19	111	6.0	635	18

1/ Existing channel dimensions from the 2-year recurrence interval hydraulic model (Section 3.2.5.1).
2/ Predicted channel dimensions for each reach were modeled based on input values for discharge (2-year recurrence interval flows, gradient, sediment characteristics, and roughness (Manning's n).

3.2.7.1 Key Findings

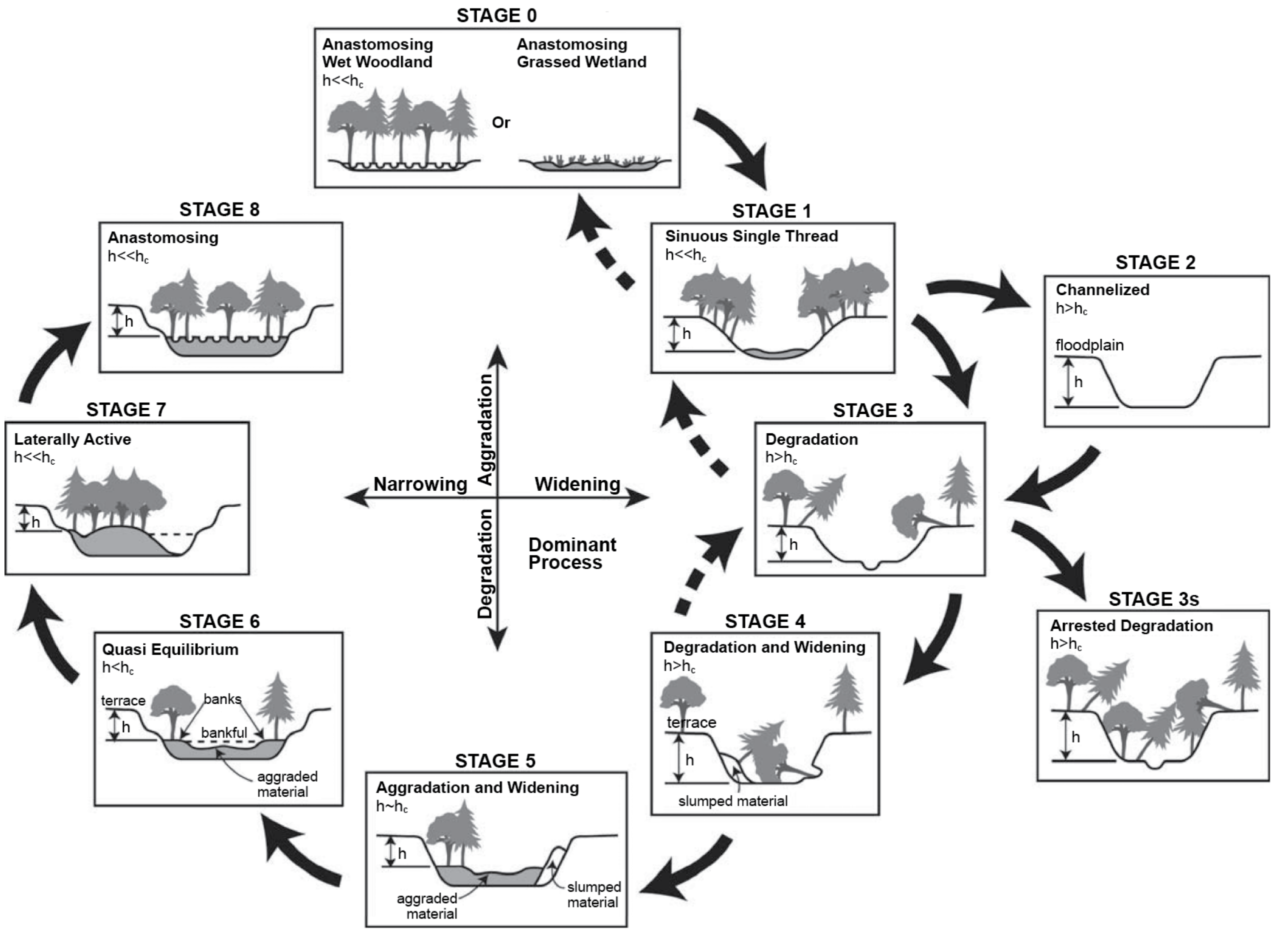
Results of the regime model assessment identified that:

- Regime model predictions of channel width were larger (ranging from 3 to 39 feet) than the existing channel width in all geomorphic reaches, except Reach 6, where the predicted width was smaller (4 feet).

3.2.8 Stream Evolution Model

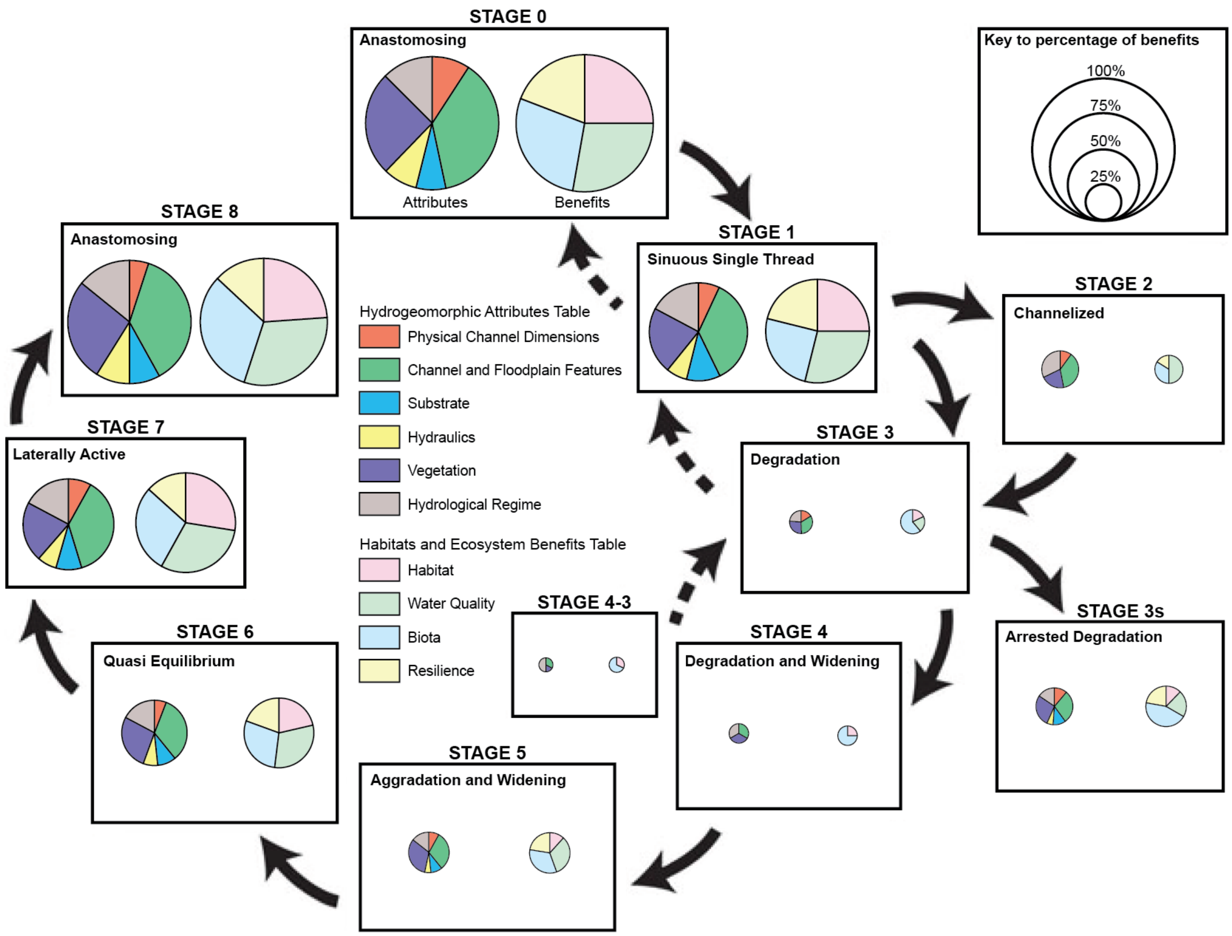
The SEM was used to evaluate the seven geomorphic reaches in the Lower Walla Walla River. Figure 3-14 was borrowed from Cluer and Thorne (2013) to graphically illustrate the SEM stages representing channel evolution via aggradation, degradation, narrowing, or widening, which should be viewed as a cyclical rather than linear process. Arrows outside the circle represent "dead end" stages, constructed and maintained (Stage 2) and arrested degradation (Stage 3s) where an erosion-resistant layer in the local lithology stabilizes incised channel banks (Cluer and Thorne 2013). Active channel restoration techniques where erosion-resistant layers can be physically altered, such as in many areas of the Lower Walla Walla River, can advance the channel back into active progression.

Figure 3-15 was borrowed from Cluer and Thorne (2013) to graphically illustrate hydrogeomorphic attributes and habitat and ecosystem benefits provided in each stage of the SEM. Each stage is represented by two pie charts whose diameters signify the relative percentage of maximum benefits as tabulated from hydrogeomorphic attributes and habitat and ecosystem benefits, based on information presented in Cluer and Thorne (2013). For each stage, the pie chart on the left summarizes the richness and diversity of the hydromorphic attributes (physical channel dimensions, channel and floodplain features, substrate, hydraulics, vegetation, and hydrologic regime), whereas the pie chart on the right summarizes the associated habitat and ecosystem benefits (habitat, water quality, biota and resilience).



Source: Cluer and Thorne (2013)

Figure 3-14. Illustration of the Stream Evolution Model, with Dashed Arrows Indicating “Short Circuits” in the Normal Progression and Arrows Outside of Stage 3 Representing “Dead-End” Stages



Source: Cluer and Thorne (2013)

Figure 3-15. Illustration of the Stream Evolution Model with Two Pie Charts Whose Diameters Represent Relative Percentage of Maximum Benefits Tabulated in Cluer and Thorne (2013). The left pie charge is the richness and diversity of the hydromorphic attributes and the right is the habitat and ecosystem benefits.

Each of the hydrogeomorphic attributes and habitat and ecosystem benefits directly correspond to the CTUIR River Vision Touchstones (Jones et al. 2008) (Table 3-11). This provides a direct cross walk between the SEM results presented below, the River Vision Touchstones, and the metrics presented in Table 1-1. By utilizing the SEM and connecting hydrogeomorphic attributes and habitat and ecosystem benefits to the metrics develops the foundation to evaluate the progression of stages over time.

Table 3-11. Cross Walk between the SEM Hydrogeomorphic Attributes and Habitat and Ecosystem Benefits Directly Corresponding to the CTUIR River Vision Touchstones (Jones et al. 2008)

Stream Evolution Model	CTUIR River Vision Touchstones
Hydrogeomorphic Attributes	
Physical Channel Dimensions	Geomorphology
Channel and Floodplain Features	Geomorphology
Substrate	Geomorphology
Hydraulics	Hydrology and Habitat and Network Connectivity
Vegetation	Riparian Vegetation
Hydrological Regime	Hydrology
Habitat and Ecosystem Benefits	
Habitat	Habitat and Network Connectivity
Water Quality	Hydrology, Habitat, and Network Connectivity
Biota	Riverine Biotic Communities
Resilience	All five in concert

Utilizing the SEM, stages were assigned to each of the seven geomorphic reaches to represent the average conditions within the reach. Because the SEM was used to represent the average conditions, segments within each geomorphic reach may exhibit characteristics of another stage. These average conditions were determined through an assessment of the data in this GAAP using the SEM as more fully detailed in Cluer and Thorne (2013). As such, results should be evaluated in combination with the data provided in Cluer and Thorne (2013).

Figure 3-16 illustrates the SEM stages for the seven reaches within the Lower Walla Walla River, and associated hydrogeomorphic attributes and habitat and ecosystem benefits, expressed as percentages of total score as described in Cluer and Thorne (2013). The figure contains cross-section views at each SEM stage and shows increasingly proportionally sized pie charts (from left to right) to represent the relative magnitude of hydrogeomorphic attributes and amount of habitat and ecosystem benefits. These results should be viewed in the overall context of cyclical process represented in Figures 3-14 and 3-15.

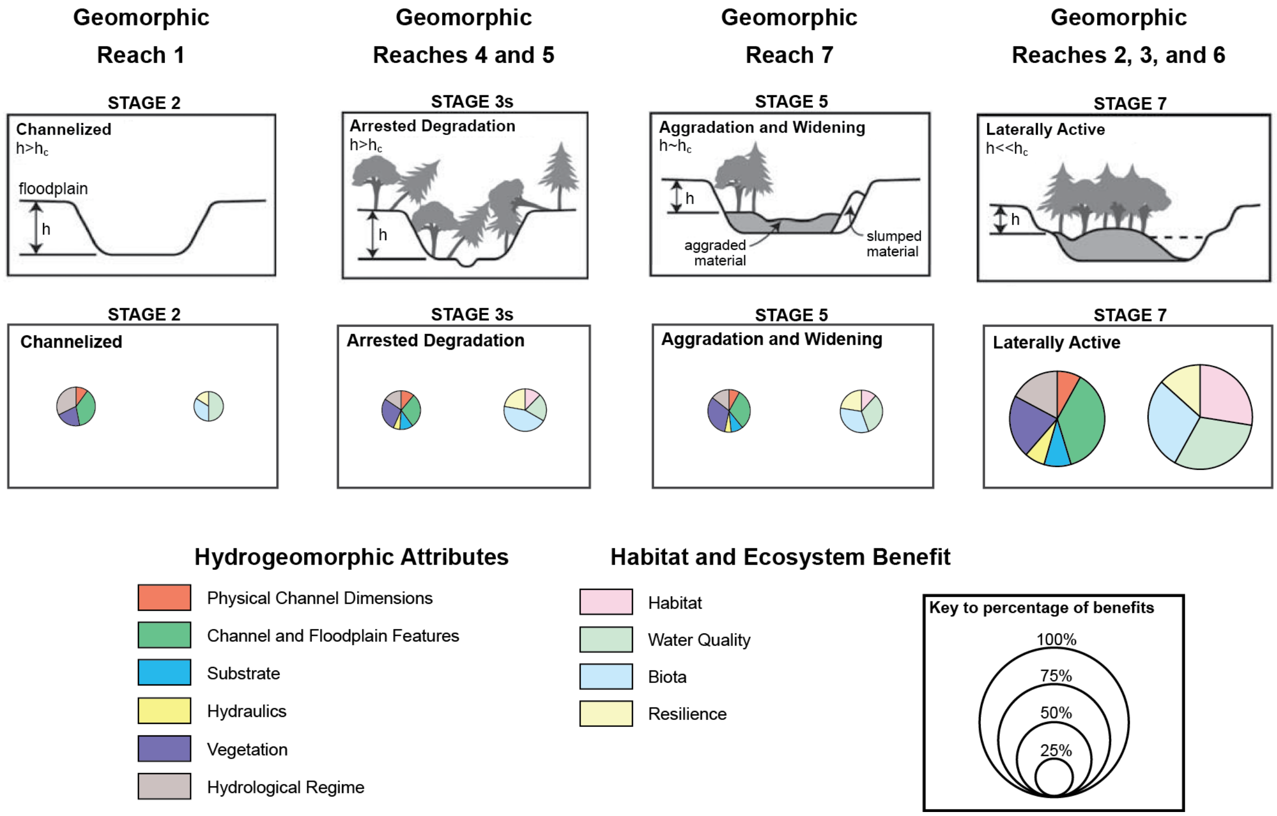


Figure 3-16. Existing SEM Stages, Hydrogeomorphic Attributes, and Habitat and Ecosystem Benefits by Geomorphic Reaches (Adapted from Cluer and Thorne [2013])

As shown in Figure 3-16, Reach 1 is in Stage 2, which has one the lowest levels of hydrogeomorphic and habitat and ecosystem benefits because it is a highly modified and simplified channel and, although there is some lateral activity, has no inset floodplain development. One of the main factors for relatively low hydrogeomorphic attributes in Stage 2 channels is the lack of floodplain connectivity due to high bank heights in relation to flood stage heights; however, much of Reach 1 has a relatively well-connected floodplain, and therefore habitat and ecosystem benefits may be somewhat underestimated by the SEM. Reach 1 may progress to higher SEM stages at a slow rate if actions are not taken and disturbances removed or more quickly if more active restoration approaches are employed.

Reaches 4 and 5 have not exhibited channel widening or aggradation and, based on the SEM, are fixed in a stage of arrested degradation (Stage 3s). Stage 3s is a "dead-end" offshoot from the cyclical progression of stages in the SEM in which channel degradation has occurred, but the channel-widening process has been arrested by an erosion-resistant layer or other factors limiting channel widening. Stage 3s channels have relatively low estimated hydrogeomorphic attributes and habitat and ecosystem benefits (Figure 3-16). It is not possible for the SEM Stage 3s channel to progress to higher functioning SEM stages without significant intervention to address the factors restraining channel widening and aggradation.

Reach 7 is in Stage 5, which demonstrates some aggrading and widening but not lateral activity, resulting in relatively low estimated hydrogeomorphic attributes and habitat and ecosystem benefit. This is because the channel plan form is relatively straight with limited instream complexity and floodplain connectivity. Reach 7 is confined by artificial bank stabilization measures and is consequently fixed in Stage 5 and unable to transition to higher functioning SEM stages without intervention. Restoration actions that would encourage aggradation and floodplain reactivation would allow Reach 7 to progress to higher SEM stages (Stages 6 and 7).

Reaches 2, 3, and 6 are in Stage 7, which has the highest amount of estimated hydrogeomorphic attributes and habitat and ecosystem benefit in the Lower Walla Walla River. This is because Stage 7 channels are laterally active and have connected floodplains. These results suggest that allowing channel migration and bank erosion processes to be unhindered would result in the greatest hydrogeomorphic attributes and habitat and ecosystem benefit. Most of Reaches 2, 3 and 6 are relatively early in the progression of lateral migration and development of an inset floodplain. As Stage 7 channels develop, the plan form becomes increasingly sinuous and bar growth on the inside of meander bends encourages further lateral migration and meander extension. This process tends to result in an asymmetrical cross section of the main channel, which exhibits increased instream complexity and more diversity of habitat features, as well as areas of high-flow refugia. Stage 7 is a relatively high-functioning state; however, due to the limited supply of coarse gravel for creating instream complexity and the presence of inset floodplain development in these reaches, the habitat and ecosystem benefits of Reaches 2, 3, and 6 may be somewhat exaggerated by the SEM.

Conditions in Reaches 1, 4, 5, and 7 would require various levels of intervention to progress to further stages in the SEM. Conditions in Reaches 2, 3, and 6 would continue to progress in Stage 7 by natural processes if lateral channel migration and inset floodplain development are allowed to occur unhindered. Although Reaches 2, 3, and 6 would continue to progress, various types of actions could be taken to increase the rate of recovery to a fully developed Stage 7 channel. Stage 7 is the final single-threaded channel in the SEM progression. Stage 8 in the SEM is a multi-channel system that is an anabranching network of channels with vegetated islands (see Figure 3-14). The potential for restoration actions to develop to Stage 8 conditions is constrained by the extent of floodplain available for lateral channel migration and the associated limitations on physical and biological processes necessary to create those conditions (Cluer and Thorne 2013).

As with all conceptual models of river behavior, application of the model needs to include site-specific considerations. For example, the SEM assumes that the river bed and banks are of the same material and that the material is alluvial, meaning that it was transported and deposited by the river. This is notable because in the SEM, sediment from failing banks causes aggradation, which forces lateral channel movement. In the Lower Walla Walla River, the channel is deeply incised, and the majority of the banks consist of non-alluvial materials (primarily very fine sand and silt) that are readily transported and not the source of significant aggradation. Figure 3-17 presents a conceptual diagram that illustrates a cross-sectional view of channel incision and lateral activity over time in the Lower Walla Walla River. The pre-settlement cross section would be representative of conditions in SEM Stage 8.

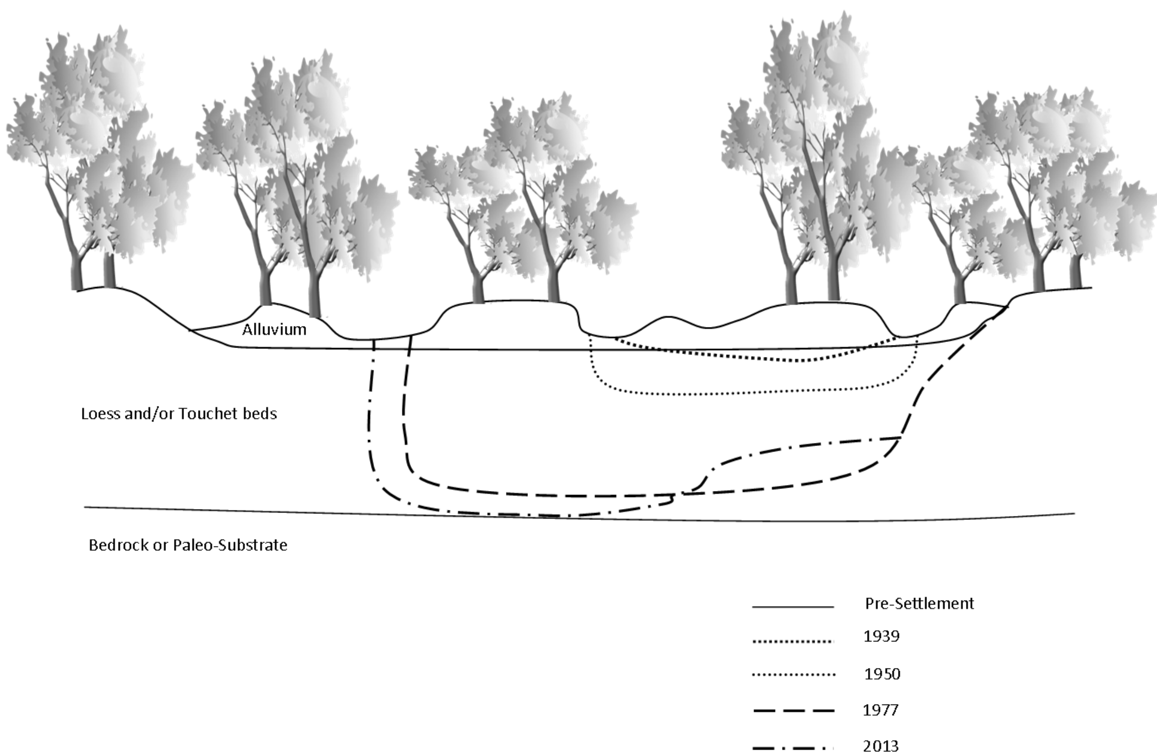


Figure 3-17. Conceptual Diagram of the Incision and Lateral Migration of Geomorphic Reaches 2, 3, and 6. Pre-settlement conditions are based historical accounts and the years correspond to aerial photo years reviewed.

3.2.8.1 Key Findings

Results of the SEM assessment identified that:

- Reach 1 has been highly modified and channelized from historic conditions.

- Reaches 2, 3, and 6 are in early SEM Stage 7, which exhibits the highest amount of habitat and ecosystem benefits.
- Reaches 4 and 5 are not laterally active and are in SEM Stage 3, and they appear to be caught in a stage of arrested degradation.
- Reach 7 is in SEM Stage 5, which is aggrading and widening but not laterally active likely due to artificial bank stabilization measures.

3.2.9 Fish Habitat

The majority of the Lower Walla Walla River is characterized during winter flows as fast non-turbulent habitat punctuated by short fast turbulent segments where flows are diverted or coarse substrates are present. The fast turbulent sections are more frequent and closer together in Reaches 6 and 7, and are non-existent by Reach 1. In Reaches 6 and 7, pools are closer together and more easily defined. From Reach 5 to the mouth, pool habitat units are relatively long and difficult to type due to gradual transitions in and out of fast non-turbulent habitat units.

Table 3-12 provides the habitat metrics and observations by geomorphic reach. The reach average pool-to-pool spacing was calculated as the mean distance between pools. Pool-to-pool spacing ranged from 218 feet in Reach 6 to 1,132 feet in Reach 1. The percent pools were calculated as the ratio of pools to other habitats using the field survey data. The spatial distribution of pools is shown in Appendix C, Figure C-2. The length of secondary channels and off-channel habitat were calculated from the 2013 aerial imagery. Reach 5 was the only reach that had no secondary or off-channel habitat present. The LWD quantity in jams per mile ranged from 0 in Reach 1 to 4.0 in Reach 7.

Table 3-12. Fish Habitat Characteristics by Geomorphic Reach

Geomorphic Reach	Pool-to-Pool Spacing (ft)	Maximum Pool Depth (ft)	Percent Pools (%)	LWD Quantity (jams/mi)	Presence of Bars	Presence of Islands	Secondary and Off-Channel Habitat (ft)
1	1,132	17	7	0.0	None[1/]	Occasional	5,911
2	705	12	7	0.9	Occasional	Frequent, Irregular[2/]	2,730
3	794	13	10	0.3	Frequent	Occasional	781
4	463	14	14	0.2	Occasional	Occasional	348
5	338	14	11	0.0	Ocassional[3/]	Occasional	0
6	218	11	14	1.3	Frequent	Occasional	1,926
7	678	11	4	4.0	Frequent	None	1,491

1/ The only bars in Reach 1 are associated with the abandoned infrastructure associated with the old railroad trestle upstream of RM 8.0.
2/ Frequent and irregular both refer to the spacing of islands; in contrast to frequent regular.
3/ The occasional bars noted in Reach 5 are vegetated and storing fine sediments.

3.2.9.1 EMAP Sample Areas

Table 3-13 presents the available fish cover for the EMAP Sample Areas. Visualization of some of the attributes (e.g., filamentous algae, macrophytes, and boulders/ledges) was difficult to determine out to the 10-meter extent from the bank due to water depth and clarity. EMAP Sample Area 3 contains the greatest amount of available fish cover.

Table 3-13. Average Available Fish Cover, as a Percent Area for Each EMAP Sample Area

Available Fish Cover	EMAP 1 (RM 5.6 to RM 7.7) (%)	EMAP 2 (RM 14.0 to RM 15.0) (%)	EMAP 3 (RM 21.8 to RM 22.7) (%)	EMAP 4 (RM25.9 to RM 26.9) (%)
Woody Debris	Sparse	Sparse	Absent	Moderate
Brush	Moderate	Moderate	Heavy	Moderate
Overhanging Vegetation	Moderate	Moderate	Heavy	Moderate
Undercut Banks	Sparse	Sparse	Sparse	Moderate
Artificial Structures	Sparse	Sparse	Absent	Sparse

1/ Coverage percentages: Absent (0%), Sparse (0 – 10%), Moderate (10 – 40%), Heavy (40 – 75%), Very Heavy (< 75%)

The volume of LWD was surveyed at each of the EMAP reaches. The volume of wood observed is presented relative to the area sampled (LWD volume per square meter). Table 3-14 presents the total LWD volume in cubic meters (m^3) present in each of the EMAP reaches.

Table 3-14. Volume of LWD Present in the EMAP Reaches

LWD	EMAP 1 (RM 5.6 to RM 7.7) (m^3)	EMAP 2 (RM 14.0 to RM 15.0) (m^3)	EMAP 3 (RM 21.8 to RM 22.7) (m^3)	EMAP 4 (RM 25.9 to RM 26.9) (m^3)
Wetted	0.0	14.4	0.0	33.1
Outside Wetted	0.0	0.6	0.6	0.0
Total LWD Volume (m^3)	0.0	15.0	0.6	33.1
LWD Volume/m^2	0.0	0.08	0.003	0.17

3.2.9.2 Key Findings

Results of the habitat assessment identified that:

- The majority of habitat in the Lower Walla Walla River during winter flows consists of fast non-turbulent habitat units punctuated by short fast turbulent segments in reaches with channel complexity resulting from bars, islands, or obstructions.
- Pool-to-pool spacing is the lowest and percent pools the greatest in geomorphic reaches 4 and 6.
- EMAP Reach 3 from RM 21.8 to RM 22.7 contains the greatest amount of available fish cover.

- The volume of LWD was low in EMAP Sample Areas 1 and 3, but exceeded minimum volume required for key pieces of LWD in EMAP Sample Areas 2 and 4 as noted by Fox and Bolton (2007).

3.3 BIOLOGICALLY SIGNIFICANT REACHES

The following section provides the location of BSRs and describes them in terms of focal fish species utilization, potential for providing necessary habitat, limiting factors, and the presence of ecological nodes. As shown in Figures 3-18 and 3-19 as well as Appendix C, Figure C-3, there are five distinct BSRs identified for the Lower Walla Walla River:

- BSR 1 – RM 3.6 to RM 8.7
- BSR 2 – RM 8.7 to RM 21.6
- BSR 3 – RM 21.6 to RM 23.4
- BSR 4 – RM 23.4 to RM 26.0
- BSR 5 – RM 26.0 to RM 27.4

All of the BSRs have been identified as high priority EDT reaches for restoration and enhancement in the Walla Walla Subbasin Plan (NWPCC 2005); however, at the time of the Walla Walla Subbasin Plan (NWPCC 2005) development, it was determined that sites in the upper portions of the Subbasin were more likely to benefit from restoration and enhancement actions (NWPCC 2005) and therefore, no further action towards developing prioritization and restoration strategies for Lower Walla Walla River were taken.

Focal fish species utilization and limiting factors within the BSRs were evaluated primarily based on spring Chinook salmon and steelhead. Bull trout use and associated limiting factors are largely unknown and considered a data gap requiring further studies. Fall Chinook and coho salmon have been observed spawning or reported as juveniles in the Lower Walla Walla River, though very limited information is available on their utilization.

Adult spring Chinook salmon and steelhead are known to migrate upstream through the Lower Walla Walla River to access upstream tributaries and spawning areas. Supporting conditions of migration habitat include in-channel and edge refuge features. The primary limiting factors affecting migrating spring Chinook salmon and steelhead include pool frequency, pool depth and large woody debris structure. Out of the five BSRs, BSR 4 exhibits the most favorable migration habitat under current conditions.

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Figure 3-18. Focal Species Utilization and Biologically Significant Reaches (BSR) RM 3.6 to RM 17.0-Downstream

Lower Walla Walla Geomorphic Assessment and Action Plan

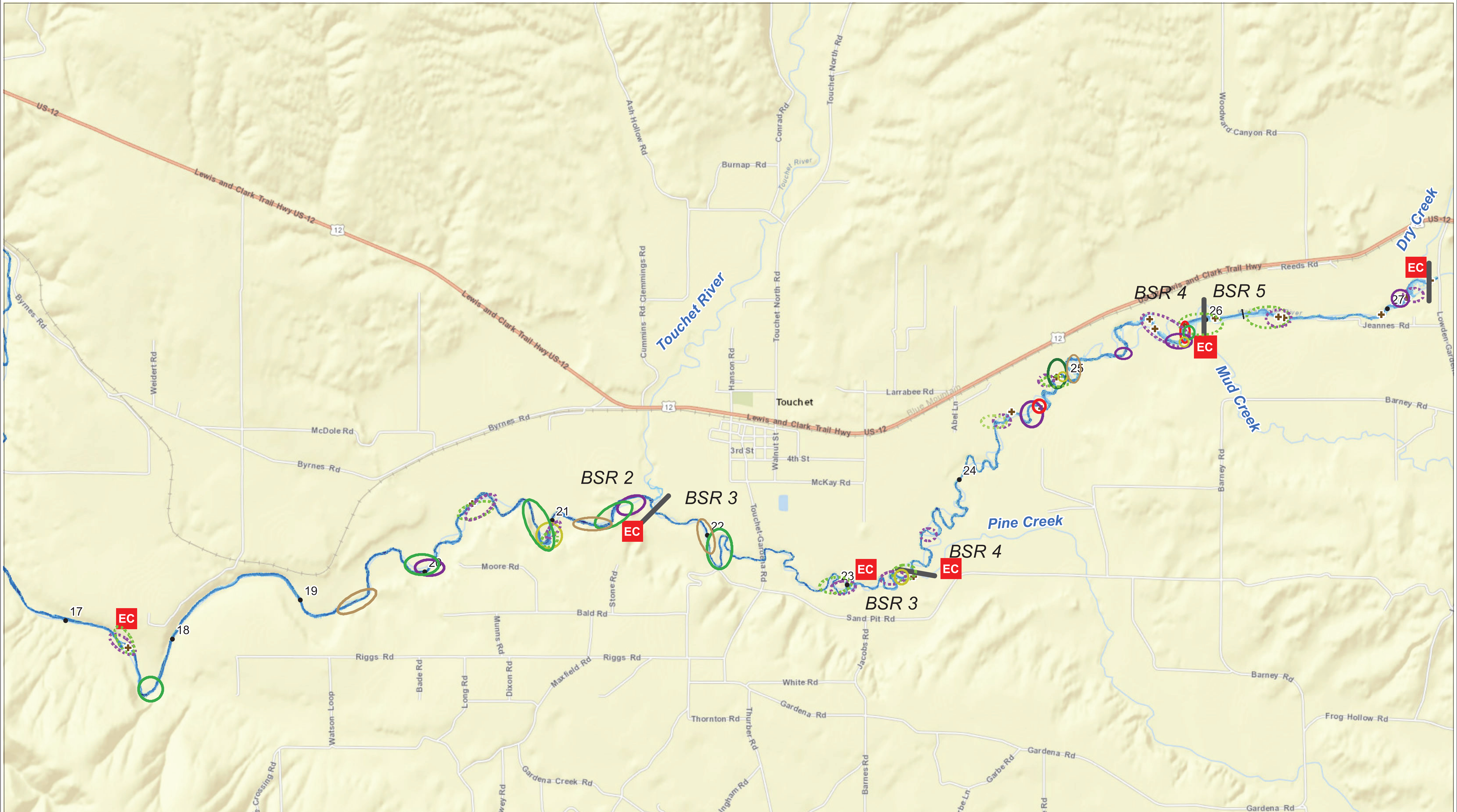


Figure 3-19. Focal Species Utilization and Biologically Significant Reaches (BSR) RM 3.6 to RM 17.0--Upstream

Lower Walla Walla Geomorphic Assessment and Action Plan

Spring Chinook salmon and steelhead are believed to use all available rearing habitat between the upper portions of the Subbasin spawning areas and the Lower Walla Walla River mouth. Supporting conditions for rearing use in edge habitat include slower water, cover (safety from prey), and food source. The primary limiting factors affecting rearing habitat include streambank condition, off-channel habitat, flood refugia, LWD, and pool frequency. BSRs 1 and 4 exhibit the most favorable rearing habitat under current conditions.

Juvenile spring Chinook salmon and juvenile and adult steelhead are known to migrate from upstream spawning/rearing habitat out through the mouth of the Lower Walla Walla River. Supporting conditions for outmigration habitat include cover from predators (terrestrial and aquatic), resting areas, and food sources mostly along stream edges. Primary limiting factors for outmigration habitat include riparian condition, streambank condition, floodplain connectivity, flood refugia, LWD, and off-channel habitat. BSR 1 exhibits the most favorable out-migration habitat under current conditions.

3.4 LIMITING FACTORS

The identification and analysis of limiting factors, and the resulting development of limiting factors matrices, were accomplished based on analysis of the results presented in Sections 2.8, 3.1, 3.2, and 3.3. Based on these results, sediment and turbidity; lack of LWD, pool habitat, and appropriate channel substrate; and predation (e.g., from pelicans, channel catfish, smallmouth bass, and pike minnow) were identified as limiting factors annually affecting aquatic productivity. Specific data related to predation are limited; their overall relative importance may be adjusted as new data are acquired. Table 3-15 presents each potential limiting factor for the five BSRs in the Lower Walla Walla River. For factors that are known to be limiting, conditions are given either a base limiting rating or "highly limiting" rating to indicate how some elements are substantially more degraded as compared to other BSRs within the Lower Walla Walla River.

Low flows and high stream temperatures during summer months are key limiting factors identified throughout the Lower Walla Walla River. However, as described and illustrated in Section 2.7, the focal fish species predominantly use the Lower Walla Walla River in the winter months, outside the periods with harmful low flows and high stream temperatures. Although restoration and enhancement projects being conducted in the upper portions of the Subbasin are expected to help improve low flows and stream temperatures, in general, the scale of actions necessary to have a significant impact on low flow and temperature limiting factors in the Lower Walla Walla River must be Subbasin-wide. The connection between these upper Subbasin restoration and enhancement projects and Subbasin-wide low flow and stream temperatures with the Lower Walla Walla River are considered a data gap and require analysis in future assessments.

For this geomorphic assessment, the limiting factors analysis required a finer scale breakdown that focused on winter conditions, to assess factors limiting aquatic productivity during the time when focal fish species utilize the Lower Walla Walla River. These winter limiting factors that affect migration and overwintering and rearing habitat have been defined in this GAAP as focal limiting factors. By focusing on these factors, the ability to assess processes and factors limiting aquatic productivity and achieve desired future conditions through restoration and enhancement actions can be effectively quantified with the metrics identified in this GAAP.

Table 3-16 presents the focal limiting factors. Lack of LWD, poor riparian conditions, limited pool and off-channel habitat, lack of floodplain connectivity, limited refugia from high flow velocity, and the presence of predators (such as pelicans, channel catfish, smallmouth bass, and pike minnow) are the primary limiting factors during the winter.

Table 3-15. Matrix of Factors Limiting Productivity of Native Salmonids in the Lower Walla Walla River, Mouth to RM 27.4

	Limiting Factors[1/]														
		Riparian/Floodplain			In-Channel Characteristics							Water Quantity	Water Quality		
Lower Walla Walla River (River Mile)	Predation (Avian/ Piscivorous fish)[2/]	Riparian Condition	Streambank Condition	Floodplain Connectivity	Channel Stability	Off-Channel Habitat	Flood Refugia (High Velocity)	Channel Substrate	LWD	Pool Frequency/ Quality	Pool Depth	Flows	Sediment & Turbidity	Temperature	Diversion Screens
RM 3.6 to RM 8.7															
RM 8.7 to RM 21.6															
RM 21.6 to RM 23.4															
RM 23.4 to RM 26.0															
RM 26.0 to RM 27.4															

= Based on available information, conditions are not limiting
= Based on available information, conditions may be limiting
= Based on available information, conditions are limiting
= Based on available information, conditions are highly limiting

1/ Limiting factors and ratings determined from January 2014 field data and observations, 2014 hydraulic modeling results, as well as the following reports and studies: Mendel et al. (1999); Kuttel (2001); Caldwell et al. (2002); NWPCC (2005); Mendel et al. (2007); NMFS (2009); Mahoney et al. (2011); SRSRB (2011); Lewis (2012); Mahoney et al. (2012); USFWS (2014).
2/ Specific data related to predation are limited. Status as a limiting factor based primarily on NMFS (2009), NWPCC (2005) (including EDT assessment), Mahoney et al. (2011), Mendel et al. (2014), and USFWS (2014). Conditions likely vary within the GAAP survey area; however, no information documentation variations were available for use in determination.

Table 3-16. Factors During Winter Use Limiting Productivity of Native Salmonids in the Lower Walla Walla River, Mouth to RM 27.4

Lower Walla Walla Reaches (River Mile)	Limiting Factors[1/]										
	Predation (Avian/ Piscivorous fish)[2/]	Riparian/Floodplain			In-Channel Characteristics						Water Quality
		Riparian Condition	Streambank Condition	Floodplain Connectivity	Channel Stability	Off-Channel Habitat	Flood Refugia (High Velocity)	LWD	Pool Frequency/ Quality	Pool Depth	Sediment & Turbidity
RM 3.6 to RM 8.7											
RM 8.7 to RM 21.6											
RM 21.6 to RM 23.4											
RM 23.4 to RM 26.0											
RM 26.0 to RM 27.4											

= Based on available information, conditions are not limiting
= Based on available information, conditions may be limiting
= Based on available information, conditions are limiting
= Based on available information, conditions are highly limiting

1/ Limiting factors and ratings determined from January 2014 field data and observations, 2014 hydraulic modeling results, as well as the following reports and studies: Mendel et al. (1999); Kuttel (2001); Caldwell et al. (2002); NWPCC (2005); Mendel et al. (2007); NMFS (2009); Mahoney et al. (2011); SRSRB (2011); Lewis (2012); Mahoney et al. (2012).

2/ Status as a limiting factor based primarily on NMFS (2009), NWPCC (2005) (including EDT assessment), Mahoney et al. (2011), Mendel et al. (2014), Schaller et al. (2014), and USFWS (2014). Conditions likely vary within the Lower Walla Walla River; however, no information was available to make such a determination. Specific data related to predation is limited. Predation is only targeted by restoration and habitat enhancement actions proposed in this GAAP through increased instream hiding cover. It is included here as a consideration for other potential enhancement action prioritization and design to help ensure predation is not a significant hindrance to addressing other winter limiting factors.

3.5 DESIRED FUTURE CONDITIONS

This section sets out the desired future conditions for the Lower Walla Walla River. Desired future conditions are presented in terms of current geomorphic function, future geomorphic potential, and focal fish species utilization potential. These conditions are intended to assist in identifying and prioritizing restoration and enhancement projects and develop categories of conceptual level designs that are practical to implement and able to be adapted and scaled to multiple sites. The current geomorphic function, future geomorphic potential, and focal fish species utilization potential provide a cross walk between the geomorphic reaches and BSRs and the identification of restoration and enhancement projects.

3.5.1 Geomorphic Function

Figure 3-20 illustrates the current geomorphic function for each of the geomorphic reaches ranging from moderate to very low. Based on the results presented earlier, Reaches 2, 3, and 6 were classified as having moderate current geomorphic function, which is currently the highest level of function in the Lower Walla Walla River. Very low geomorphic function indicates that the limiting factors in that reach present the greatest challenge and limit to focal fish species. Although Reaches 2, 3, and 6 are deeply incised, they exhibit some lateral migration, which allows for more channel complexity and the development of inset floodplain features. Reach 6 has the highest amount of lateral movement, the greatest sinuosity in the Lower Walla Walla River, and exhibits a progression and cutoff migration process.

Reach 7 has a low current geomorphic function. Although this reach is the most confined due to channel straightening and the presence of bank armoring structures, and has the lowest percentage area as pools, there are also frequent gravel bars, more abundant LWD, and some side channels present. Reach 7 has the lowest level of floodplain connectivity with little floodplain inundation even in a 10-year flood event.

Reaches 1, 4, and 5 have very low current geomorphic function. Reach 1 has been highly modified from its historic pattern and process (see Figure 2-5). The in-channel complexity and habitat conditions are very low, but there are multiple surface water connections that are likely providing off-channel habitat. Reaches 4 and 5 are not laterally active and have relatively low sinuosity compared to a high historic meander belt width and sinuosity, suggesting that they are in a stage of arrested degradation.

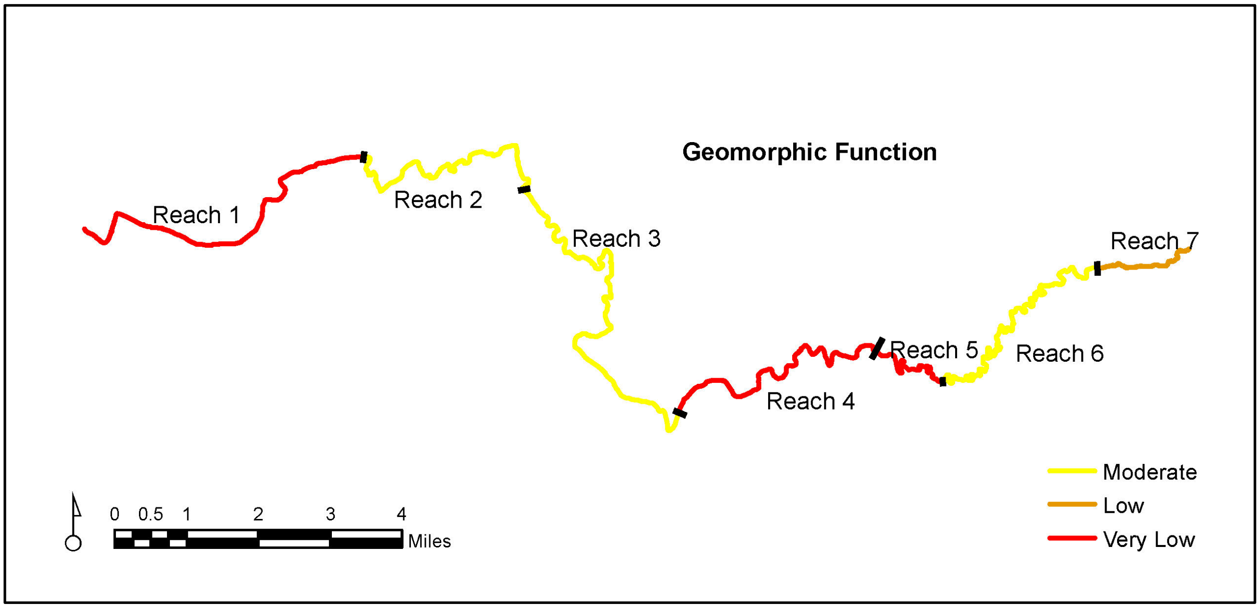


Figure 3-20. Current Geomorphic Function, Geomorphic Potential, and Focal Species Utilization Potential for the Lower Walla Walla River

3.5.2 Geomorphic Potential

Figure 3-21 illustrates the geomorphic potential for each of the geomorphic reaches ranging from moderate to very high. Reaches 1 and 3 were classified as having moderate geomorphic potential. Although Reach 1 has a very broad historic floodplain and historically was quite sinuous, the current channel configuration is relatively straight and stable with some lateral migration, but no meandering in recent decades and a simplified channel form. The potential for creating in-channel characteristics that address the focal limiting factors is low in this reach due to the stable nature of the current channel configuration and the lack of coarse gravel sediment supply to create and maintain in-channel complexity. There are, however, opportunities for off-channel habitat creation in Reach 1. Overall, Reach 3 has moderate geomorphic potential; however, substantial differences within the reach result in areas that have little or no potential and areas that have high potential. Opportunities are limited in areas where the channel is confined by bedrock. Opportunities are greater where existing topography allows for the potential to address focal limiting factors and enhance geomorphic processes, particularly between RM 14 and RM 16 (see Appendix C, Figure C-2).

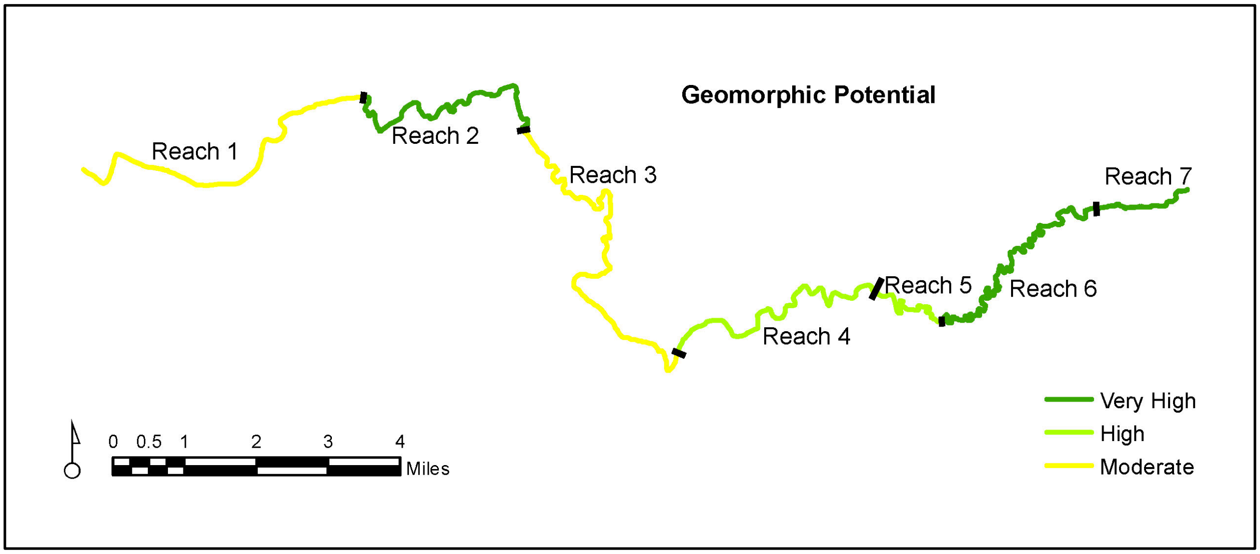


Figure 3-21. Current Geomorphic Potential for the Lower Walla Walla River

Reaches 4 and 5 were classified as having high geomorphic potential. The quality of in-channel characteristics related to focal limiting factors was low in these reaches; however, the geomorphic conditions allow for feasible enhancement alternatives. Reaches 4 and 5 also have broad historic floodplains and existing topographic features (see Appendix C, Figure C-2) that could be enhanced to improve floodplain connectivity and create off-channel rearing habitat.

Reaches 2, 6, and 7 were classified as having very high geomorphic potential. Reaches 2 and 6 are laterally active and are currently in various stages of developing an inset floodplain. These reaches currently have the highest quality in-channel characteristics related to limiting factors, indicating that geomorphic conditions are suitable for enhancing those characteristics. In addition, the presence of coarse non-cohesive gravels makes the reaches more likely to develop and maintain in-channel features that are complex and address the focal limiting factors. Floodplain connectivity and off-channel habitat creation opportunities are also abundant in Reaches 2 and 6. Reach 7 has the greatest potential for increased geomorphic function. The reach is currently aggrading and widening, but limited lateral migration has occurred due to artificial bank stabilization measures. It is feasible to enhance the in-channel characteristics, increase floodplain connectivity, and create or enhance off-channel habitat related to the focal limiting factors in Reach 7 over time.

3.5.3 Focal Fish Species Utilization Potential

Current focal fish species timing and utilization (see Section 2.7), BSRs (see Section 3.3 and Figures 3-18 and 3-19), focal limiting factors (see Section 3.4), current and potential geomorphic function (see Sections 3.5.1 and 3.5.2), and ecological nodes were used to determine focal fish species utilization potential. The ecological nodes used in the assessment include the following:

- Off-channel habitat areas between RM 4.0 and 5.2 (BSR 1)
- Channel complexity (island and side channels) and off-channel habitat upstream of RM 8.0 (BSRs 1 and 2)
- Off-channel habitat near RM 10.5 (BSR 2)
- Off-channel habitat near RM 11.0 (BSR 2)
- Off-channel habitat near RM 11.3 (BSR 2)
- Channel complexity (island and side channel) located near RM 12.4 (BSR 2)
- Deep pools, possibly co-located with cold groundwater upwelling, located between RM 12.0 and 12.8 (BSR 2), an area in which fall Chinook salmon are believed to spawn
- Channel complexity (island and side channel) near RM 17.5 (BSR 2)
- The Touchet River tributary junction near RM 21.6 (BSR 2)
- Off-channel habitat (oxbow) near RM 23.0 (BSR 3).
- Pine Creek tributary junction near RM 23.0 (BSR 3)
- Off-channel habitat near RM 25.7 (BSR 4)
- Mud Creek tributary junction near RM 25.8 (BSR 4)
- Off-channel habitat near RM 27.2 (BSR 5)
- Dry Creek tributary junction near RM 27.3 (BSR 5)

As shown in Figure 3-22, focal fish species utilization potential ranges from moderate to very high. The future geomorphic potential and focal fish species utilization potential provide a cross walk between the geomorphic reaches and BSRs and the identification of restoration and enhancement projects. In addition, they serve as the necessary link between understanding factors limiting aquatic productivity, identifying approaches to addressing those factors, and quantifying progress towards addressing the focal limiting factors.

The next section, Section 4, identifies and prioritizes restoration and enhancement projects and develops categories of conceptual level designs based on these priorities that are practical to implement and able to be adapted and scaled to multiple sites.

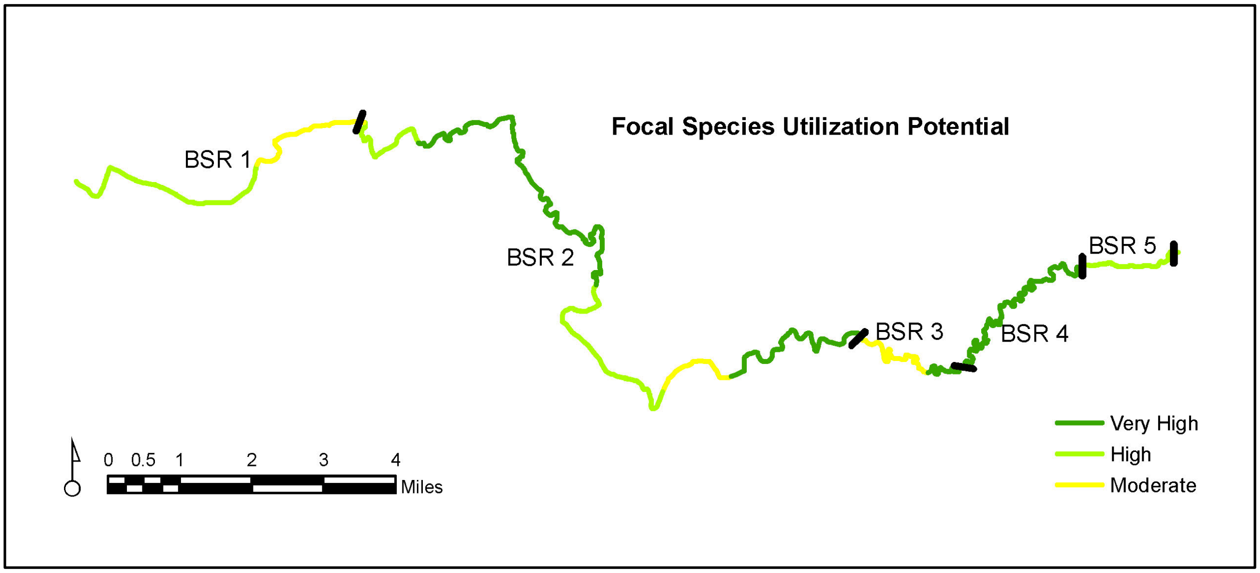


Figure 3-22. Current Focal Species Utilization Potential for the Lower Walla Walla River

4. Action Plan

This section presents the Action Plan portion of the GAAP and is developed from the information and analysis of existing data and field surveys presented in Sections 2 and 3. The goal of the GAAP, and this associated Action Plan, is to understand the processes and limiting factors affecting the Lower Walla Walla River between RM 0.0 and 27.4 in order to prioritize and implement projects that will result in quantifiable progress in accordance with the Walla Walla Subbasin Plan (NWPCC 2005), Walla Walla Watershed Plan (WWWPU 2005), 2008 Fish Accords (Three Treaty Tribes-Action Agencies 2008), CTUIR Umatilla River Vision (Jones et al. 2008), Middle Columbia River Steelhead Distinct Population Segment ESA Recovery Plan (NMFS 2009), Extensive Aquatic Habitat Assessment – Walla Walla River Watershed (O'Daniel 2011), Snake River Salmon Recovery Plan for Southeast Washington (SRSRB 2011), Lower Walla Walla River Habitat Improvement Strategy (Lewis 2012), and Revised Draft Recovery Plan for the Coterminous United States Population of Bull Trout (USFWS 2014). Information and analysis of existing data and field surveys presented in Sections 2 and 3 provide the foundation for consistency with these past assessments, action plans, visions, agreements, and recovery plans and the necessary empirical data for identifying and prioritizing actions that will be practical to implement and address factors limiting aquatic productivity.

Although this Action Plan is founded on the best available science and quantifiable data, fisheries and habitat studies will continue to produce empirical data that shed light on aquatic conditions and relationships between high mortalities of fish species and degraded conditions within the Lower Walla Walla River. For example, the CTUIR has begun to implement a Biomonitoring Plan (Stillwater Sciences 2012) as part of its research, monitoring, and evaluation program intended to provide additional information informing future assessments, planning efforts, and effectiveness of stream restoration and enhancement actions. In addition, the effects of climate change on aquatic conditions will require further research, monitoring, and evaluation. These studies will produce empirical data that can be used in further evaluating and highlighting the importance of restoring processes for maintaining cooler water temperatures to offset impacts from climate change, such as restoring riparian habitat, reducing channel widths, and restoring baseflows (Baldwin and Stohr 2007).

Because of the dynamic nature of the science in the Lower Walla Walla River, this action plan must be in the form of a transparent framework that can be updated and improved as needed. As such, this Action Plan is intended to function independently from the entire GAAP so that it can be updated and improved as needed. The inclusion of the data and analyses in Sections 2 and 3 ensures the feasibility of updating the Action Plan and the transparency of the process. In addition, in its current state, as well as when new available science, quantifiable data, or additional areas for projects are identified, this Action Plan can be used as a tool for not only prioritizing projects, but as justification of restoration and enhancement actions to landowners living along the Lower Walla Walla River and funding agencies. Last, throughout the development of this Action Plan, consideration was given to various permitting approaches, and relevant information is provided as appropriate.

The goal of the Action Plan is to provide the LWWWG with identified and prioritized restoration and enhancement projects that can be replicated efficiently to multiple areas on the Lower Walla Walla River and, through quantifiable and repeatable metrics, can demonstrate progress toward addressing limiting factors. The objectives of the Action Plan are (1) to identify and prioritize restoration and enhancement projects within geomorphic reaches and BSRs; (2) to develop conceptual level designs for categories of prioritized project types that are feasible to implement; and (3) to identify metrics for use in tracking progress towards addressing limiting factors in the Lower Walla Walla River. The Action Plan comprises the following five sequential steps to achieve these objectives:

1. **Identify Project Areas** – This step identifies areas based on further refinement of geomorphic reaches and BSRs to facilitate identifying types of scalable project actions that would be typical of project sizes.
2. **Identify Project Actions** – This step identifies types of restoration and enhancement actions needed to address focal limiting factors and achieve desired future conditions.
3. **Address Focal Limiting Factors** – This step evaluates how types of project actions will address focal limiting factors that are most likely to benefit focal species populations, and avoid conducting project actions based solely on opportunity. Metrics to evaluate impact of project actions on focal limiting factors are also defined.
4. **Prioritize Project Areas** – This step ranks the project areas based on analysis of current and potential biological information (fish utilization and focal limiting factors) and geomorphic function information. Potential conditions ratings assume that all the project actions identified for a given project area would be implemented and result in desired future conditions for that area. Additional factors taken into consideration include cost/benefit and feasibility.

5. **Develop Conceptual Designs** – This step develops categories of conceptual-level designs, based on prioritized restoration and enhancement projects, which are practical to implement and can be adapted and scaled to multiple sites. Conceptual project designs are consistent with biological needs of the focal fish species, local geomorphology, and implementation feasibility.

Each of the five parts of the Action Plan is described in more detail in the following subsections.

4.1 IDENTIFYING PROJECT AREAS

The purpose of subdividing the GAAP survey area into project areas was twofold: (1) to facilitate refining the project prioritization (rankings), and (2) to break project areas into more manageable pieces that are more representative of a typical potential restoration and enhancement project in terms of project sizes and costs. Project areas were identified by examining aerial imagery and results of the Geomorphic Assessment to delineate reaches where combinations of existing conditions and restoration potential led to a unique set of project actions. This entailed evaluating geomorphic conditions (e.g., channel dimensions, presence of LWD, presence of mid-channel bars, bank conditions); limiting factors (e.g., riparian conditions, lack of off-channel habitat, quantity/quality of instream habitat); restoration and habitat enhancement potential (riparian, floodplain and off-channel, and instream potential); and fish utilization.

Based on the approach described above, 14 project areas were identified. The locations of the project areas are shown in Figure 4-1 as well as in Appendix C, Figure C-3. Project areas were assigned numbers 1 through 14, with Project Area 1 starting at the confluence with the Columbia River (RM 0.0) and Project Area 14 ending at the Lowden Bridge (RM 27.4). Project areas were typically 1 to 2 miles long, ranging in length from as little as 0.2 mile in Project Area 6, where the channel was highly confined by roads and existing topography, up to 3.2 miles long in Project Area 1 within a very uniform reach.

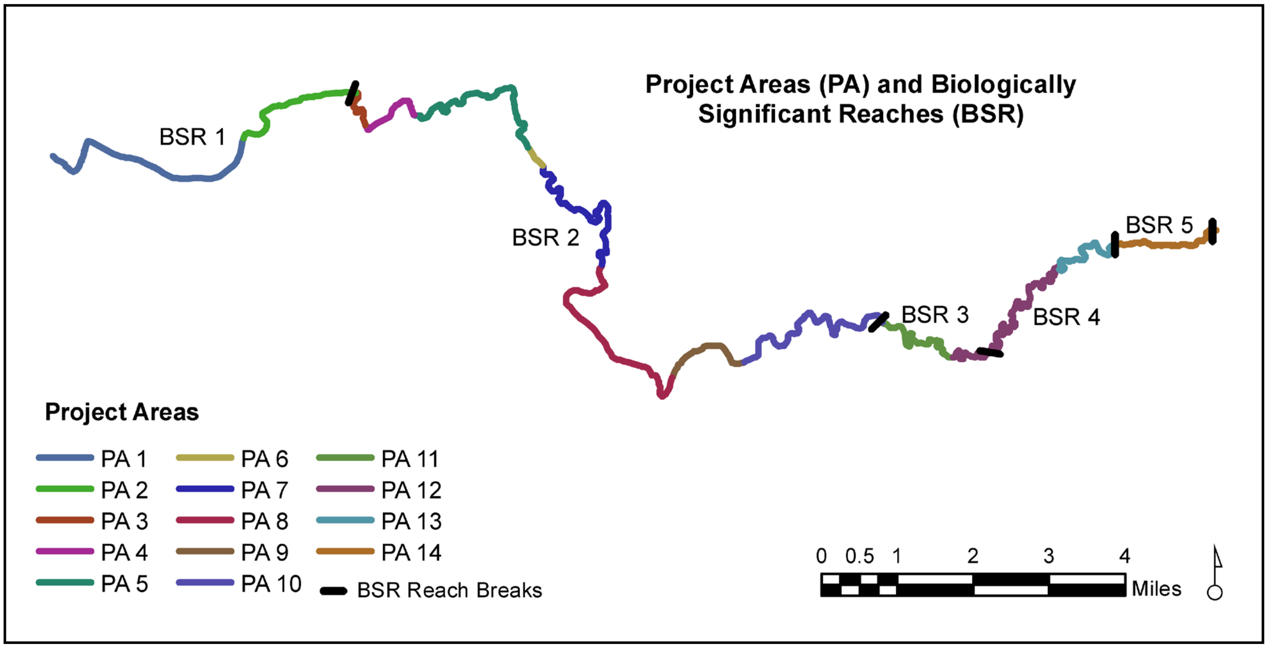


Figure 4-1. The Location of Project Areas and Biologically Significant Reaches (BSR) for the Lower Walla Walla River

4.2 IDENTIFYING PROJECT ACTIONS

Project actions were identified by selecting groups of restoration and habitat enhancement actions that would have the greatest impact on improving the focal limiting factors specific to a given project area. Criteria used for selecting project actions included the following:

Performance – Develop restoration and habitat enhancement actions that provide the desired future conditions that will satisfy the goals and objectives established in the Geomorphic Assessment portion of the GAAP.

Benefits and Risks – Consider the potential benefits of project actions weighted against potential risks associated with the design and how the design may impact land and infrastructure.

Project actions will promote the development of natural channel processes including channel migration, pool development, and sediment sorting. Restoring these processes will aid in the formation of habitat features such as complex pools, cover, off-channel habitat, and velocity refugia. The benefits include the formation and concentration of mainstem habitat elements and increasing channel network and flow complexity by promoting channel migration and side channels. Over time, these activities will enhance geomorphic processes and reverse effects of channel entrenchment at the reach scale.

Each proposed action in a project area was identified with a specific purpose and expected function. Project actions were originally selected from a suite of 39 restoration and enhancement actions generally arranged from passive to active; the list was used to identify the most effective and appropriate actions for each given project area. Some actions were designed to encourage aggradation on incised channels to reconnect the floodplain and activate secondary channels, while others were designed to increase habitat complexity, provide cover, and/or act to catch mobile debris or provide infrastructure protection where needed.

The list of project activities provides a wide selection of passive and active restoration approaches. However, the list is not necessarily all-inclusive; through collaboration with the LWWWG, other stakeholders, and landowners, additional restoration and habitat enhancement actions may be identified. Table 4-1 lists the project actions identified in each of the 14 project areas. Individual project actions were grouped into four categories. The following subsections provide details for the four groups, followed by detailed descriptions of 16 individual project actions.

Table 4-1. Project Area Location (RMs), the Geomorphic and Biologically Significant Reaches, and Potential Project Actions

Project Area (PA)[1/]	Location (RM)	Geo-morphic Reach	BSR	Potential Restoration and Habitat Enhancement Actions[1/]
PA 1	3.8–7.0	GR 1	BSR 1	▪ Riparian planting; remove invasive vegetation; implement beaver restoration management ▪ Construct perennial off-channel habitat ▪ Add large woody debris (LWD) to existing off-channel habitat
PA 2	7.0–8.6	GR 1	BSR 1	▪ Riparian planting; remove invasive vegetation; implement beaver restoration management ▪ Add instream LWD structure to existing bars at Zangar Junction
PA 3	8.6–9.2	GR 2	BSR 2	▪ Riparian planting; implement beaver restoration management ▪ Construct perennial side-channels with LWD ▪ Add instream LWD structure at mid-channel deposits and inlet of constructed side-channels; add point bar structures at existing bars ▪ Construct isolated bank protection and habitat structures
PA 4	9.2–10.2	GR 2	BSR 2	▪ Riparian planting; Implement beaver restoration management ▪ Reconnect existing disconnected off-channel habitat near RM 10.0; construct high-flow bypass channel near RM 10.0 ▪ Construct bank protection and habitat structure near RM 10.0
PA 5	10.2–12.8	GR 2	BSR 2	▪ Riparian planting; implement beaver restoration management; acquire conservation agreements within meander belt width ▪ Construct perennial off-channel habitat ▪ Add LWD to existing off-channel habitat; add point bar structures at bars ▪ Construct bank protection and habitat structure near RM 11.9

Table 4-1. Project Area Location (RMs), the Geomorphic and Biologically Significant Reaches, and Potential Project Actions (continued)

Project Area (PA)[1/]	Location (RM)	Geo-morphic Reach	BSR	Potential Restoration and Habitat Enhancement Actions[1/]
PA 6	12.8–13.0	GR 3	BSR 2	▪ Riparian planting
PA 7	13.0–15.0	GR 3	BSR 2	▪ Riparian planting; implement beaver restoration management ▪ Construct perennial off-channel habitat; construct high-flow bypass channels; construct perennial side-channels ▪ Add LWD to existing off-channel habitat; add point bar structures at existing lateral bars; add instream LWD structure at mid-channel deposits and inlet of constructed side-channels ▪ Isolated bank protection and habitat structure near RM 14.2
PA 8	15.0–17.9	GR 3	BSR 2	▪ Riparian planting ▪ Add point bar structures at existing bars; Add instream LWD structure at mid-channel deposits and inlet of existing side-channels; construct alcoves including LWD
PA 9	17.9–19.2	GR 4	BSR 2	▪ Riparian planting and riparian fencing of enhancement project areas ▪ Construct alcoves including LWD; Add point bar structures at existing bars and/or other deposits
PA 10	19.2–21.6	GR 4	BSR 2	▪ Riparian planting of enhancement project areas; acquire conservation agreements within meander belt width ▪ Construct perennial off-channel habitat; construct high-flow bypass channels ▪ Add LWD to existing off-channel habitat; construct alcoves including LWD; add point bar structures at existing bars; add instream LWD structure at mid-channel deposits and inlet of existing side-channels ▪ Remove existing bank armor structures; construct isolated bank protection and habitat structures
PA 11	21.6–22.8	GR 5	BSR 3	▪ Riparian planting of enhancement project areas; acquire conservation agreements within meander belt width ▪ Construct high-flow bypass channels; construct perennial off-channel habitat including LWD ▪ Construct alcoves including LWD; add instream LWD structure at mid-channel deposits ▪ Remove existing bank armor structures; construct isolated bank protection and habitat structures
PA 12	22.8–25.0	GR 6	BSR 4[2/]	▪ Riparian planting of enhancement project areas; acquire preservation easements within meander belt width ▪ Add instream LWD structure at mid-channel deposits; add point bar structures at existing bars ▪ Construct high-flow bypass channels; construct perennial off-channel habitat including LWD ▪ Remove existing bank armor structures; construct isolated bank protection and habitat structures
PA 13	25.0 to 26.0	GR 6	BSR 4	▪ Riparian planting of enhancement project areas ▪ Reconnect existing oxbow channels and add LWD ▪ Add instream LWD structure at mid-channel deposits ▪ Remove existing bank armor structures; construct isolated bank protection and habitat structures

Table 4-1. Project Area Location (RMs), the Geomorphic and Biologically Significant Reaches, and Potential Project Actions (continued)

Project Area (PA)[1/]	Location (RM)	Geo-morphic Reach	BSR	Potential Restoration and Habitat Enhancement Actions[1/]
PA 14	26.0–27.4	GR 7	BSR 5	▪ Riparian planting; acquire conservation agreements within meander belt width ▪ Add point bar structures at existing bars ▪ Remove existing bank armor structures; construct isolated bank protection and habitat structures

1/ Project actions arranged into four major groups: (1) Riparian vegetation; (2) Floodplain and Off-Channel; (3) In-channel habitat; and 4) Bank protection and habitat.
2/ Project Area 12 also includes a short segment in BSR 3. The break between BSR 3 and BSR 4 occurs at RM 23.4.

4.2.1 Riparian Vegetation

Riparian plant communities are intricately tied to stream functions by providing bank stability, shading, cover, nutrient input, and future supply of LWD. Project actions related to improving riparian vegetation tend to be more passive in nature and include the following:

- Riparian Planting
- Invasive Species Removal
- Riparian Conservation Zones
- Riparian Fencing
- Beaver Management

Riparian plantings will provide long-term benefits such as bank stabilization, sediment retention, shade, and overhanging or instream cover habitat. Future riparian planting should focus in targeted areas that are within or near the margins of the bankfull channel, and utilize native vegetation. Removal of invasive plant species (weed control) should be part of any riparian management plan and may be the responsibility of individual landowners or cooperating parties.

New riparian conservation zones and riparian fencing where applicable will ensure that riparian plantings survive and provide long-term protection. A consideration for previously implemented riparian conservation zones would be to expand existing CREP easement boundaries that are often set to minimum width standards, to boundaries that reflect the geomorphic conditions present in a given reach (i.e., consider actively eroding sites, nature of the floodplain in relation to the channel at high flows, etc.). Additional considerations would be to provide more options to landowners through other entities or programs, such as cooperative agreements or easements through the NRCS Wetland Reserve Program, WDFW, or CTUIR. There are many successful examples of project actions related to protecting riparian zones that provide benefits to both the landowner and the resources, and ensure that funding investments persist over time.

Beaver management is included in this group because beaver are dependent upon, and can greatly impact, riparian plant communities. Historically, beaver were abundant in the Lower Walla Walla River and contributed considerably to habitat diversity and ecosystem function. Recent research has demonstrated that beaver restoration can decrease recovery time for deeply incised channels considerably (Beechie et al. 2008; Pollock et al. 2007). If this approach is adopted by the LWWWG, it would likely be best addressed through the development of a Beaver Restoration Management Plan. Such a plan should include analysis of potential flooding concerns, along with possible impacts to newly planted riparian areas and protection measures that may be needed.

4.2.2 Floodplain and Off-Channel Habitat

Floodplain and off-channel habitat is critical for juvenile salmonid rearing and high-flow refugia (Bjornn and Reiser 1991). Roni et al. (2002) found that projects involving reconnection of existing off-channel habitats had a high probability of success, while projects that involved creating off-channel habitat had a moderate probability of success. These types of project actions might be classified as full restoration because they restore river ecosystem processes, or selected processes that create and maintain habitats and biota to its normative state (Beechie et al. 2010). Martens and Connolly (2014) found higher densities of salmonids in seasonally disconnected, partially connected and fully connected side channels than in mainstem channels. Future projects should examine site-specific hydraulics, sediment dynamics, and channel avulsion potential during the design development process to increase the probability of full restoration and project success.

Project actions that will restore floodplains and off-channel habitat include the following:

- High-Flow Bypass Channels
- Perennial Off-Channel Habitat or Side Channels
- Floodplain Construction

Existing high flow bypass and perennial off-channel habitat or side channels provide sediment retention and sorting, reductions in main channel velocities, high-flow refugia, habitat diversity and complexity, and low-velocity habitat for juvenile rearing. The main difference between high-flow bypass channels and perennial side channels is a high-flow bypass channel would only be activated seasonally, while perennial channels remain active year-round. Perennial side channels may be constructed in relatively low-lying areas and would include pools to improve survival of juvenile salmonids (Martens and Connolly 2014). However, to avoid the potential for fish stranding, high flow bypass channels should be carefully constructed to ensure exiting water flows downstream, allowing fish the opportunity to migrate out as flows recede.

Floodplain construction would typically be done in conjunction with construction of high-flow bypass or perennial side channels, and only if conditions indicate they need to do so based on local topography. For example, if the construction of a side channel results in a deeply incised channel, some floodplain excavation would be appropriate to expand the wetted perimeter and floodplain and ensure riparian vegetation can reach the water table.

Restoration and habitat enhancement of floodplain and off-channel habitat should include the addition of LWD, live willow stakes, and riparian plantings for cover, shading, and habitat complexity.

4.2.3 In-Channel Habitat Structures

Alcoves, LWD structures, complex pools, mainstem side channels, and islands provide sediment retention and sorting, habitat diversity and complexity, and cover. Where endangered species are of concern, Roni et al. (2002) recommends that instream habitat enhancement (e.g., additions of wood, boulders, or nutrients) should be employed after restoring natural processes or where short-term improvements in habitat are needed. Project actions falling into the In-Channel Habitat Structures category include the following:

- Alcoves
- LWD Habitat Structures
- Pool Construction Or Enhancement
- Point Bar Structures
- Mid-Channel Bar Structures

Alcoves are recessed areas (small pools) off of the main channel, and were identified as a restoration and habitat enhancement action for project areas where the channel characteristics are narrow, deep, and featureless. These areas lack existing eddies or other areas of velocity diversity that juvenile salmonids use as refuge during high flows. Alcoves are intended to mimic naturally occurring edge habitats with lower velocity and cover. Alcoves will be excavated out of the existing channel banks and a stable LWD structure installed at the head of the pool to maintain flow diversity and prevent sedimentation.

LWD habitat structures may be used in conjunction with alcoves as noted above, and in many other areas where large wood is limiting and may aid in pool formation. Placement of the root wad and other portions of whole trees into the wetted area provide hiding cover from predators, breaks up stream velocities, and aids in sediment sorting and partitioning.

Individual pieces of LWD should be sized appropriately, and portions of LWD habitat structures may be buried to the extent practical to reduce potential risks and increase stability where applicable. Sizes of LWD will be determined during later stages of design development. LWD should be durable species (generally conifers). Scour and stability calculations may be necessary during the design development process to create stable features.

Pool construction will increase pool frequency, quality, and depth in areas lacking those features. Pool construction via excavation may be applicable in specific instances, such as in creation of perennial side channels. Pool enhancement may involve only minor excavation in areas where they are naturally expected to occur, supplemented with pool-forming structures such as LWD structures.

Point or lateral bars develop on the inside of meander bends in areas of active channel migration. In areas where the supply of coarse gravel is not limited, these bars can promote increased lateral movement and the development of an inset floodplain. Bars increase hydraulic diversity, retain mobile sediments, and provide habitats for focal fish species. Point bar structures can promote natural sediment deposition processes on bars. Techniques such as live gravel bar staking promote bar growth by disrupting flow patterns, decreasing velocity, and depositing sediment. Live stakes should be placed in clumps to mimic naturally occurring patterns and be placed relatively deep in bar deposits to provide access to the water table. Materials should consist of native pioneering plant communities. Careful consideration should be given to staking placement and size of stakes during the design development process to decrease the potential for scour and erosion of planted stakes.

Mid-channel bar structures are LWD structures placed specifically at the head of existing mid-channel bars to divert flows into split-flow channels immediately downstream of the main channel. Formation of such channels encourages aggradation in incised areas by slowing velocities, and increases habitat diversity by creating pools at the head of or adjacent to the structure.

Most of the structures mentioned above should also include live willow stakes and riparian plantings for cover, shading, bank stability, and habitat complexity.

4.2.4 Bank Protection and Habitat Structures

Except in cases where removal of bank armoring is recommended, project actions within this category might generally be described as habitat creation since they focus on construction of specific bank related habitat features that may be used in cases where full restoration of river processes may not be possible (Beechie et al. 2010). Lewis (2012) identified potential bank protection sites that were considered in this assessment. However, the results of the SEM indicate that allowing channel migration and bank erosion processes to occur unhindered will result in the greatest habitat benefit; therefore, the use of these types of structures solely for bank protection requires careful consideration. Bank stabilization in selected areas may be necessary to protect land or infrastructure, but can be constructed in a manner while maintaining many of the objectives of the overall restoration and habitat enhancement strategy.

Project actions falling into the Bank Protection and Habitat Structures category include:

- Removal of Bank Armoring
- Bank Stabilization Structures
- Log and Boulder Revetments

In some areas, existing bank armoring could simply be removed to allow for lateral channel movement, the development of an inset floodplain, and the formation of point bars, thus promoting full river restoration processes to develop with minimal effort.

Based on recent advances in bioengineering, bank stabilization structures may be appropriate at some sites where banks are very steep, contribute to excess sediment, and recovery on their own would not be expected within a reasonable time frame. Bank stabilization structures incorporate bank sloping combined with live cuttings that sprout and grow to further strengthen the stabilization structure over time (e.g., Polster 2003). For steep streambanks, retaining walls made with plant material, called wattle fences, can be constructed to stabilize the slope. Vegetative materials used for wattle fence stakes need to be drought-resistant species since they will be planted high above the water table in most circumstances. LWD with root wads and boulders may be incorporated into the base of the wattle fence at the toe of the slope to increase stability and habitat function. Scour calculations should be examined during future design development stages to evaluate the streambank stability when using this technique.

Log and boulder revetments are another type of bank protection treatment, but are inherently more stable because they incorporate much more use of large wood and boulders at the toe of the slopes, and are less vulnerable to erosion due to high velocities and shear stress.

To maximize potential habitat benefits, both bank stabilization structures and log and boulder revetments should be used along the outer edges of the meander belt width, and where channel pattern and geometry (sinuosity and radius of curvature) are already within expected ranges. Historical aerial (1939-40) photographs should be examined to aid in making those determinations. Either of these two types of structures can also intentionally be placed outside of the active channel margin in areas where the channel may be expected to migrate towards the structure, and into its natural plan form. The presence of existing infrastructure or unwillingness of some landowners to conduct restoration actions within the meander belt width may place limitations on where and why these structures may be used.

4.2.5 Other Alternatives Considered

Other restoration and habitat enhancement alternatives such as channel-spanning structures and gravel augmentation were considered, but are not included in the Action Plan for the reasons discussed below.

4.2.5.1 Channel-Spanning Structures

Channel-spanning structures used to aggrade the channel bed could be beneficial for increasing the amount of floodplain connectivity and improve channel complexity. As recent research has demonstrated, these structures, in combination with beaver activity, can decrease recovery time considerably for deeply incised channels (Beechie et al. 2008; Pollock et al. 2007). However, the technique was not included because of the large number of structures that would be required for the approach to be effective. In addition, it could create migration barriers and engineering stable channel-spanning structures would be problematic particularly downstream of the Touchet River, considering 100-year peak flows are estimated to be as high as approximately 30,000 cfs.

4.2.5.2 Gravel Augmentation

Gravel augmentation in combination with sediment retention structures could also aggrade the channel bed and be beneficial for increasing the amount of floodplain connectivity and improve channel complexity. Large-scale gravel augmentation projects have been developed on several rivers to replenish starved sediment supplies, typically downstream from dams. This alternative, however, was determined to be too large and expensive to evaluate further given the expected hydrogeomorphic and habitat benefits. Gravel augmentation could be considered for individual projects, particularly to enhance spawning habitat for fall Chinook salmon, but would require detailed sediment transport analyses to ensure long-lasting effects.

4.3 ADDRESSING FOCAL LIMITING FACTORS

Focal limiting factors previously identified in this GAAP were cross checked against proposed project actions to ensure they would be addressed, both in terms of quantity (number addressed) and severity. A matrix of the focal limiting factors potentially addressed by each of the proposed project actions is contained in Table 4-2. Focal limiting factors were classified as low, medium, or high based on their relative significance for population performance (abundance, productivity, and sustainability) of the focal species.

Table 4-2. Type and Magnitude or Limiting Factors Potentially Addressed by Restoration and Enhancement Project Actions

Project Action Category	Specific Project Actions	Focal Limiting Factors Ratings: Predation	Riparian Condition	Streambank Condition	Floodplain Connectivity	Channel Stability	Flood Refugia (High Velocity)	LWD	Pool Frequency/ Quality	Pool Depth	Off-Channel Habitat	Sediment and Turbidity
Riparian vegetation	Riparian Planting		•	·								
	Remove Invasive Vegetation		•									
	Acquire Conservation Agreements[2/]		•			·						
	Riparian Fencing			·								·
	Beaver Restoration Management				●		●	●		·	●	
Floodplain & off-channel habitat	High-Flow Bypass Channels				●	·	●				●	
	Perennial Off-Channel Habitat	•			●		●	●			●	
	Perennial Side Channels	•					●	●	●			
	Reconnect Existing Oxbow Channels	•			●		●	●			●	
In-channel habitat structures	Alcoves Including LWD	•		·			●	●	●	·		
	LWD Structures	•						●	●	·		
	Pool Construction or Enhancement								●	●		
	Point Bar Structures						●	●	●	·		
	Mid-Channel LWD Structures	•					●	●	●	·		
Bank protection & habitat structures	Remove Existing Bank Armoring			·			●					
	Bank Stabilization and Log/Boulder Revetment Structures	•		·		·		●	●			·

1/ Legend:

● High – Factors that are critical to be addressed to improve focal species population performance (abundance, productivity, and sustainability) in the immediate term.
• Medium – Factors that are important (not critical) to be addressed to improve focal species population performance in the long term.
· Low – Beneficial to address, but not critical to improve focal species population performance.
2/ Conservation agreements may include Fee Acquisition, Permanent Conservation Easements, Term Limit Easements, or other arrangements.

Of the identified potential restoration and enhancement project actions, the creation of perennial off-channel habitat, reconnecting abandoned oxbow channels, and beaver restoration management had the potential to impact the greatest number of focal limiting factors that were determined to be critical to improve population performance in the immediate term. The creation of perennial side-channels, high-flow bypass channels, point bar and mid-channel structures, alcoves with LWD, and LWD structures was also determined to potentially impact several critical limiting factors.

Addressing the focal limiting factors by implementing the appropriate proposed restoration and habitat enhancement project actions described above should result in the following desired habitat conditions:

- Increased riparian connectivity and functions, with dynamic hydrology and geomorphology able to maintain a diverse community of self-sustaining populations of native riparian vegetation.
- Increased floodplain connectivity and complexity, with floodplain inundation connecting and maintaining habitat for native riverine communities.
- Increased habitat heterogeneity and newly created refugia from high velocity and turbidity during high flow events.
- Increased area of suitable habitat for focal species under the full range of flows.
- Increased channel complexity and enhanced geomorphic processes.
- Increased cover habitat to reduce predation.
- Reduced summer temperatures, and improved hyporheic exchange to provide micro-habitat areas with lower (summer), and higher (winter) temperatures to improve growth and survival of focal species.

The Action Plan links project actions to specific metrics that are used to compare design alternatives and measure the success of implemented projects over time through monitoring. The methods presented in Table 1-1 and results presented in Section 3 provide the baseline for monitoring project effectiveness on the Lower Walla Walla River. Table 4-3 identifies the metrics and evaluation methods used to evaluate impact of project actions on focal limiting factors that will ultimately determine project effectiveness.

Table 4-3. Evaluation Methods and Metrics to Evaluate Impact of Project Actions on Focal Limiting Factors

Focal Limiting Factors[1/]	Restoration and Habitat Enhancement Project Actions	Evaluation Methods/Metrics[2/]
Riparian Condition	Conservation zones, riparian planting and riparian fencing; remove invasive vegetation.	Measure riparian characteristics
Streambank Condition	Construct bank protection and habitat structures; remove existing bank armoring and add habitat structures; riparian planting and riparian fencing; remove invasive vegetation.	Evaluate bank condition and stability; measure riparian characteristics.
Floodplain Connectivity	Construct high-flow bypass channels, perennial side channels and off-channel habitat; reconnect existing oxbow channels; implement beaver restoration management.	Measure River Complexity Index, floodplain inundation, length of off-channel habitat; incision depth, and Entrenchment Ratio; develop Beaver Restoration Management Monitoring Plan.
Channel Stability	Construct high-flow bypass channels; acquire conservation agreements s; remove existing bank protection.	Measure channel dimensions, channel migration rate, meander belt width, sinuosity, and confinement width; evaluate channel morphology (incision, aggradation).
Flood Refugia (High velocity)	Construct perennial side channels, alcoves, and perennial off-channel habitat; reconnect existing oxbow channels; construct point bar structures, mid-channel LWD structures, and high-flow bypass channels; implement beaver restoration management.	Hydraulic modeling; calculate Braided-Channel Ratio; measure channel dimensions and secondary channel length; develop Beaver Restoration Management Monitoring Plan.
Lack of LWD	Construct mid-channel LWD structures, bank habitat structures; place additional LWD; implement beaver restoration management.	Locations and counts of instream LWD; develop Beaver Restoration Management Monitoring Plan.
Pool Frequency/Quality	Construct mid-channel LWD structures, alcoves, and bank habitat structures, implement beaver restoration management.	Conduct habitat unit surveys; measure pool frequency or spacing and percent pools; develop Beaver Restoration Management Monitoring Plan.
Pool Depth	Construct mid-channel LWD structures, alcoves, and bank habitat structures; implement beaver restoration management.	Conduct habitat unit surveys; measure pool dimensions; develop Beaver Restoration Management Monitoring Plan.
Off-Channel Habitat	Construct perennial off-channel habitat; reconnect existing oxbow channels.	Conduct habitat unit surveys; measure length of off-channel habitat.
Sediment and Turbidity	Construct bank protection and habitat structures; point bar structures, and high-flow bypass channels; riparian fencing.	Measure fine sediment proportion of surface and subsurface samples.
Channel Substrate	Construct point bar structures, mid-channel LWD structures, high-flow bypass channels, and perennial off-channel habitat.	Measure sediment size distribution, percentage fine sediment in bed; calculate threshold grain size.

1/ The focal limiting factors are a subset of limiting factors that are most relevant for focal fish species during winter flow conditions. Predation is also a focal limiting factor but is not included because it is not directly related to measurable evaluation methods and metrics.

2/ More detailed evaluation methods and metrics are contained in Table 1-1. All evaluation methods were included in the GAAP except Beaver Restoration Management Plan.

Using the information from the selection of project areas and the analysis of the number and severity of focal limiting factors within those areas, combined with determining potential restoration and enhancement actions within those areas, provided the foundation of necessary data leading to project area prioritization as described in the following section.

4.4 PRIORITIZING PROJECT AREAS

The final steps necessary to determine overall project area prioritization rankings were to use previously synthesized biological and geomorphic information from the GAAP. The scoring matrix presented below shows how project areas were prioritized based on categorical assessments of biological criteria including focal species utilization potential and impact on focal limiting factors, and geomorphic processes, while taking into consideration cost-benefit evaluation and feasibility.

Specific prioritization criteria that were evaluated in the matrix are as follows:

- Focal species utilization potential was determined by assessing current fish species utilization (see Section 2.7), focal limiting factors (Sections 2.8 and 3.4), and BSRs (Section 3.3) relative to current and potential geomorphic function; ecological nodes within the BSRs were also considered. Utilization was determined to be moderate, high, or very high for project areas based on existing and future fish utilization potential. Migration and rearing for focal fish species are believed to occur in all project areas. Project areas that ranked very high are those believed to be utilized for spawning by fall Chinook salmon in addition to migration and rearing for the focal species. Medium ranking BSRs have substrate conditions that would potentially support spawning in addition to migration and rearing for the focal fish species. Low-ranking BSRs currently are suitable for only migration and rearing.
- The potential improvement to focal limiting factors from proposed project actions was ranked as low, medium, or high, based on the number of limiting factors addressed in the proposed actions and the relative importance (magnitude) of those limiting factors to the population performance of the focal fish species (see Table 4-2).
- Current geomorphic function for the Lower Walla Walla River was determined from existing data, field surveys, and analyses. The latter included analyzing land use, riparian vegetation, channel morphology, channel migration, floodplain inundation and connectivity, sediment mobility and transport, SEM, and fish habitat. For the current geomorphic function factor, the highest priority was given to project areas with the lowest level of current function. Current geomorphic function, as shown above in Figure 3-20, was given a low priority ranking if the results indicated current function was moderate. Current geomorphic function was assigned a medium priority ranking if

current function was low, and a high priority ranking if the current geomorphic function was very low.

- Future geomorphic potential was determined by evaluating historic channel and floodplain conditions (e.g., meander belt width, historic sinuosity) relative to current geomorphic function. The geomorphic potential criteria consisted of low, medium, or high rankings, based on the results of the geomorphic assessment, professional experience, and best professional judgment.
- The cost-benefit analysis within each project area consisted of a low, medium, or high ranking based on the relative cost as estimated from previously completed projects and the expected benefit as determined from the effect on focal limiting factors.
- Feasibility was ranked as low, medium, or high based on evaluating potential construction access, difficulty of restoration and enhancement actions, probability of achieving a successful outcome from project actions from professional experience, and best professional judgment.

Table 4-4 contains the project area prioritization matrix criteria and cumulative prioritization score. Overall scores derived from the matrix were categorized by tiers as shown in Figure 4-2 as well as Appendix C, Figure C-3. The highest priority (Tier I) project areas were located starting from RM 13 upstream to RM 27.4, in Project Areas 7, 10, 12, 13, and 14. These project areas should be considered for implementation prior to Tier II (Project Areas 1, 5, 6, and 11) and Tier III (Project Areas 2, 3, 4, 8, and 9) projects. Tier II projects might be considered for funding if there is a lack of project opportunities within Tier I project areas. Additional consideration (higher ranking) should also be given to any Tier II or Tier III project that has restoration and habitat enhancement actions specifically designed to provide measurable improvements to the function at any of the ecological nodes (areas of increased channel complexity, off-channel habitat, potential spawning areas, or tributary junctions), as previously identified in the GAAP.

Table 4-4. Project Area Prioritization Matrix and Overall Project Area Rankings

Project Area (PA)	Location (RM)	Focal Species Utilization Potential[1/]	Focal Limiting Factors[2/]	Current Geomorphic Function[3/]	Geomorphic Potential[4/]	Cost-Benefit[5/]	Feasibility[6/]	Project Area Cumulative Score	Overall Rank (Tiers I, II, III)
PA 1	3.8–7.0	2	2	3	1	1	3	12	II
PA 2	7.0–8.6	1	1	3	1	1	3	10	III
PA 3	8.6–9.2	2	2	1	1	1	3	10	III
PA 4	9.2–10.2	2	2	1	1	1	3	10	III
PA 5	10.2–12.8	3	3	1	2	2	3	14	II
PA 6	12.8–13.0	3	1	1	1	3	3	12	II
PA 7	13.0–15.0	3	3	1	3	2	3	15	I
PA 8	15.0–17.9	2	2	1	2	2	2	11	III
PA 9	17.9–19.2	1	1	3	2	2	2	11	III
PA 10	19.2–21.6	3	3	3	3	2	2	16	I
PA 11	21.6–22.8	1	3	3	3	2	2	14	II
PA 12	22.8–25.0	3	3	1	3	2	3	15	I
PA 13	25.0 to 26.0	3	2	1	3	3	3	15	I
PA 14	26.0–27.4	2	2	2	3	3	3	15	I

1/ Focal fish species utilization potential was ranked Low (1), Medium (2), or High (3) based on existing focal fish species utilization, channel morphology, sediment characteristics, focal fish species limiting factors, BSRs, professional experience, and best professional judgment.

2/ Focal limiting factors were ranked as Low (1), Medium (2), or High (3), based on the number of limiting factors addressed in proposed activities and the rank of those limiting factors (see Table 4-1).

3/ Current geomorphic function was given a Low (1) priority ranking if the Geomorphic Assessment results indicated current function was moderate, Medium (2) if current function was low, or High (3), if the current geomorphic function was very low (see Figure 3-20).

4/ Geomorphic Potential factors were ranked as Low (1), Medium (2), or High (3), based on Geomorphic Assessment results, professional experience, and best professional judgment.

5/ The cost versus benefit was ranked as Low (1), Medium (2), or High (3) based on the relative cost as estimated based on past projects and the expected benefit as defined by measurable effect on focal limiting factors.

6/ Feasibility benefit was ranked as Low (1), Medium (2), or High (3) based on evaluating potential construction access, difficulty of restoration and enhancement actions, probability of achieving a successful outcome from project actions from professional experience, and best professional judgment.

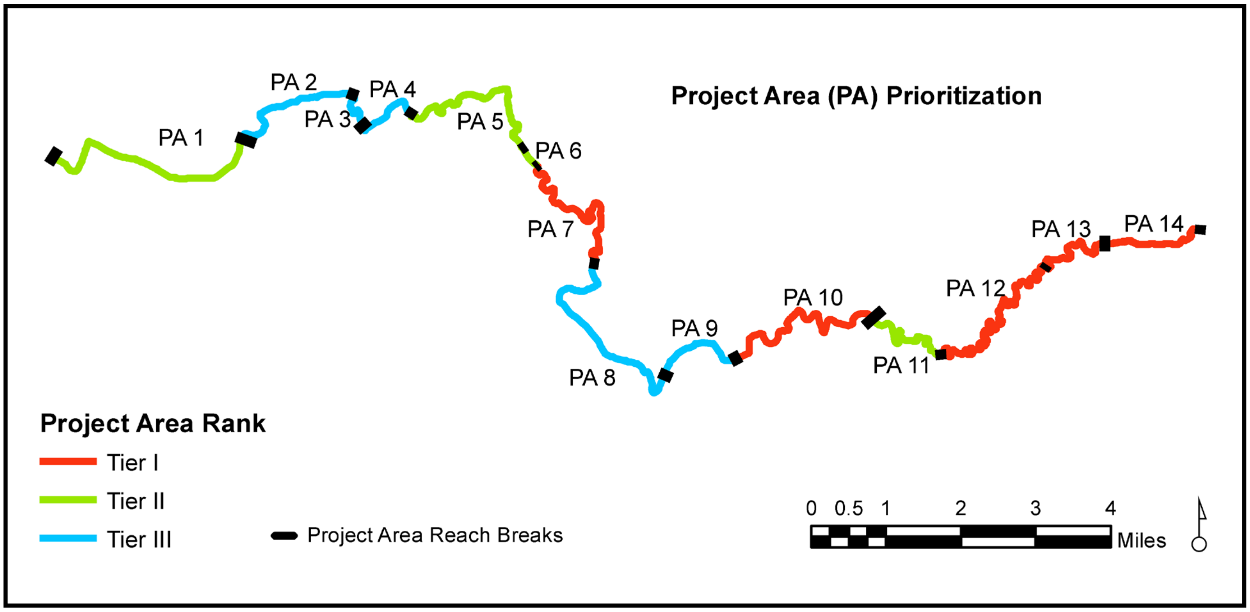


Figure 4-2. Prioritization of Project Areas for the Lower Walla Walla River

It is important to keep in mind that high rankings are based on full restoration potential and on the assumption that all potential proposed project actions would be put into place. In other words, just because a project proposed for funding occurs in a Tier I project area, it does not necessarily mean it qualifies for funding as a high ranking project if only a portion of project actions are proposed for implementation. Individual restoration projects proposed for funding should be evaluated based on comparing full project restoration potential, as opposed to what might actually be completed based current land use or feasibility constraints in a specific area. Conversely, a project area falling out of a Tier I category based on cost/benefit ratio or feasibility might rank higher if those conditions change. With those conditions in mind, the project area prioritization scoring system provides a useful tool leading to eventual implementation of high priority restoration and enhancement projects.

Figure 4-3 provides summary information and conceptual diagrams associated with the focal limiting factors and existing conditions for the 14 project areas. Summary information includes river miles, geomorphic reaches, and BSRs for each project area, focal limiting factors that are limiting to highly limiting, and characteristics of the existing conditions. The conceptual diagrams illustrate the existing conditions as represented by the average SEM cross-section and stage within a given project area. Based on the proposed actions identified for each project area in Table 4-4, Figure 4-3 illustrates on the right portion the post-implementation conditions. The conceptual diagrams under post-implementation conditions depict the resulting conditions as represented by the change in the average SEM cross-section. Overall, the figure demonstrates existing conditions being addressed by the proposed actions and the resulting conditions post-implementation, and provides the connection between geomorphic reaches, BSRs, SEM stages, proposed actions, and resulting conditions.

Stages of channel evolution and the relative hydrogeomorphic attributes and habitat and ecosystem benefits for each of the geomorphic reaches described in relation to the SEM are discussed in more detail in Section 3.2.8. As described there, stages of channel evolution are not necessarily linear in progression and may not reflect what can be achieved immediately under various restoration scenarios. Therefore, Figure 4-3 represents anticipated outcomes in the short term if project actions are initiated that jump start recovery processes.

For geomorphic reach 1, which is in one of the lower SEM stages (Stage 2), moderate improvements in conditions can be achieved in areas where active restoration approaches such as construction of perennial off-channel habitat are implemented (Figure 4-3). Geomorphic reaches 4 and 5, currently in SEM Stage 3s (arrested degradation) contains the lowest existing geomorphic and habitat functions and will require several aggressive actions via construction to address limiting factors and achieve desired habitat conditions (Figure 4-3). Geomorphic reach 7 is in an intermediate SEM stage (Stage 5), and can make moderate progress by implementing actions dealing with point bar sediment accumulation and bank conditions. Geomorphic reaches 2, 3, and 6 are generally in better existing condition (SEM Stage 7), but include several project areas with various tier rankings. The number of project actions needed will vary with the project areas, and projects listed as tier I may be considered as those requiring less aggressive actions and more cost-effective, and can more easily achieve conditions resembling pre-disturbance, or Stage 8 SEM.

Location	Focal Limiting Factors (Limiting to Highly Limiting)	Existing Conditions	Proposed Actions	Post-Implementation Conditions

Project Areas 1 and 2

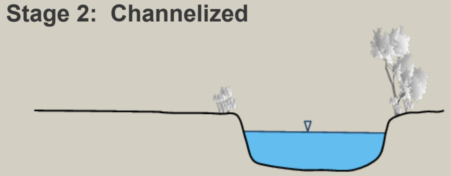
RM 3.8 to 8.6
Geomorphic Reach 1
BSR 1

Focal Limiting Factors (Limiting to Highly Limiting)

- Predation
- Riparian Condition
- Large Woody Debris
- Pool Frequency/Quality

Existing Conditions

SEM Stage 2: Channelized



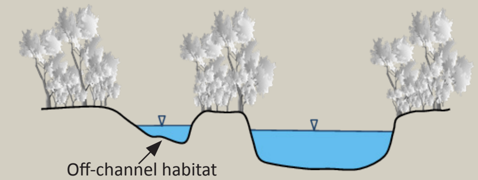
- Heavily modified channel
- Low gradient and sinuosity
- Uniform depths and velocities
- Low habitat diversity

Proposed Actions

- Riparian planting
- Conservation agreements
- Remove invasive vegetation
- Implement beaver restoration management
- Construct perennial off-channel habitat
- Add LWD to existing off-channel habitat
- Add instream LWD structure to existing bars

Post-Implementation Conditions

SEM Stages 3 to 4: Degradation to Degradation and Widening



- Placed LWD provides cover from predators
- Improved riparian vegetation and floodplain connectivity
- More diverse depths and velocities
- Off-channel area provides rearing habitat
- Improved habitat diversity

Project Areas 9 to 11

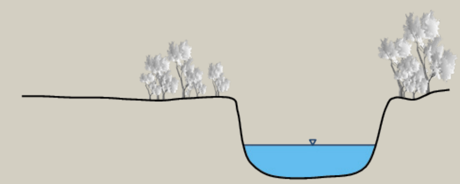
RM 17.9 to 22.8
Geomorphic Reaches 4 & 5
BSRs 2 and 3

Focal Limiting Factors (Limiting to Highly Limiting)

- Predation
- Riparian Condition
- Streambank Condition
- Floodplain Connectivity
- Off-Channel Habitat
- Flood Refugia (High Velocity)
- Large Woody Debris
- Pool Frequency/Quality

Existing Conditions

SEM Stage 3s: Arrested Degradation



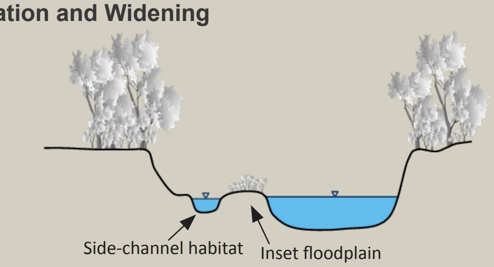
- Deeply incised channel, caught in Stage 3s of SEM
- Lowest values for current geomorphic function
- Relatively narrow riparian corridor with CREP planted areas
- High velocities with little or no refugia

Proposed Actions

- Riparian planting
- Conservation agreements
- Construct alcoves including LWD
- Construct perennial off-channel Habitat
- Construct high-flow bypass channels
- Add point bar structures at existing bars and/or other deposits
- Add LWD to existing off-channel habitat
- Add instream LWD structure to existing bars and inlet of existing side-channels
- Remove existing bank armor structures; construct isolated bank protection and habitat structures

Post-Implementation Conditions

SEM Stages 4 to 5: Degradation and Widening to Aggradation and Widening



- Placed LWD increases channel complexity and provides cover from predators
- Improved riparian vegetation and floodplain connectivity
- Alcoves and off-channel areas provide high-velocity refugia and rearing habitat
- Improved habitat diversity

Project Area 14

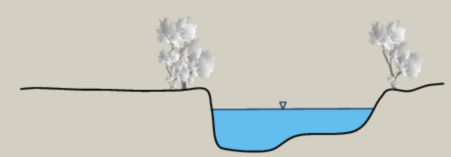
RM 26.0 to 27.4
Geomorphic Reach 7
BSR 5

Focal Limiting Factors (Limiting to Highly Limiting)

- Predation
- Riparian Condition
- Streambank Condition
- Floodplain Connectivity
- Off-Channel Habitat
- Flood Refugia (High Velocity)
- Large Woody Debris
- Pool Frequency/Quality

Existing Conditions

SEM Stage 5: Aggradation and Widening



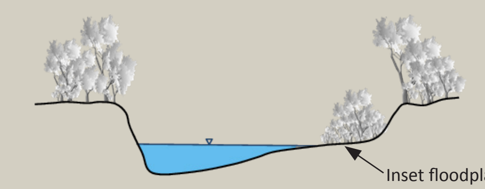
- Extensive channel straightening
- Prevention of widening by bank armor structures
- More frequent gravel bars and LWD than any of the downstream reaches
- Lack of riparian vegetation or CREP planted areas
- Low habitat diversity

Proposed Actions

- Riparian planting
- Conservation agreements
- Add point bar structures at existing bars
- Remove existing bank armor structures
- Construct isolated bank protection and habitat structures

Post-Implementation Conditions

SEM Stages 6 to 7: Quasi Equilibrium to Laterally Active



- Inset floodplain increases connectivity
- Vegetation colonization of inset floodplain improves riparian conditions
- Asymmetrical channel creates areas of high-flow refugia
- Instream complexity increases habitat quality and quantity

Project Areas 3 to 8, 12 and 13

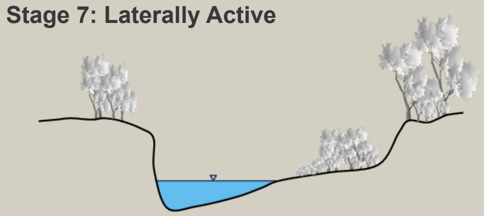
RM 8.6 to 17.9 and 22.8 to 26.0
Geomorphic Reaches 2, 3, & 6
BSRs 2, 3, and 4

Focal Limiting Factors (Limiting to Highly Limiting)

- Predation
- Streambank Condition
- Floodplain Connectivity
- Off-Channel Habitat
- Large Woody Debris
- Pool Frequency/Quality

Existing Conditions

SEM Stage 7: Laterally Active



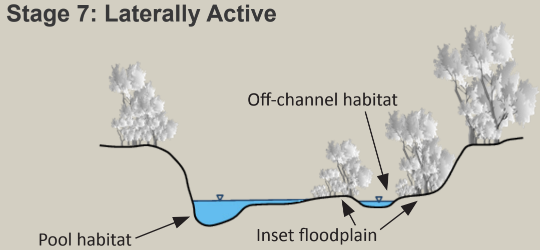
- Channel pattern exhibits higher sinuosity, particularly in Reach 6
- Instream complexity, floodplain connectivity, and habitat quality are higher than other reaches
- Riparian characteristics range from sparse (Reach 3) to a relatively wide riparian corridor (Reach 6)
- Limited areas of high-flow refugia

Proposed Actions

- Riparian planting
- Conservation agreements
- Implement beaver restoration management
- Construct perennial side-channels with LWD
- Reconnect existing disconnected off-channel habitat
- Construct high-flow bypass channels
- Construct alcoves including LWD
- Add point bar structures at existing bars and/or other deposits
- Add instream LWD structure to existing bars and inlet of existing side-channels
- Remove existing bank armor structures
- Construct isolated bank protection and habitat structures

Post-Implementation Conditions

SEM Stage 7: Laterally Active



- Natural processes lead to effective pool development and sediment sorting
- Improved riparian vegetation and floodplain connectivity
- Off-channel areas provide rearing habitat
- Placed LWD increases channel complexity and provides cover from predators
- Improved habitat diversity

Figure 4-3. Summary Information and Conceptual Diagrams Demonstrating Existing Conditions and the Resulting Conditions Post-Implementation

Once channel reaches are set up for success by addressing sources of disturbance and implementing project actions, then longer term natural channel processes such as aggradation, lateral expansion, creation of highly complex off-channel habitat, and regeneration of mature and diverse vegetation will eventually result in desired future conditions and higher SEM stages, such as late Stage 7 or Stage 8 that more closely resemble historic conditions. The combination of implementing project actions and allowing natural processes to occur will provide the most likely path toward achieving River Vision Touchstones (Jones et al. 2008) for hydrology, geomorphology, habitat and network connectivity, riverine biotic communities, and riparian vegetation, as described in Section 3.2.8.

The conceptual design development in Section 4.5 describes the typical restoration and habitat enhancement actions proposed for a selected group of project areas. Although conceptual designs were not developed to cover the entire spatial extent of the high priority project areas, they were developed specifically to be utilized as templates that can be adapted by adding, removing, or modifying specific restoration and habitat enhancement elements to create site-specific conceptual designs for any of the project areas or specific sites within project areas.

4.5 DEVELOPING CONCEPTUAL DESIGNS

The intent of developing conceptual designs for groups of typical instream, riparian, and floodplain restoration and habitat enhancement designs is to provide approaches that are scalable and can be efficiently and effectively replicated and adapted to the meet the diverse needs of the Lower Walla Walla River. Typical conceptual designs have been developed to be equivalent to a 15 to 30 percent engineering level design and will be suitable for funding applications. The conceptual designs provided in this section are intended to assist the LWWWG and other subbasin managers in articulating GAAP project goals, objectives, and results to landowners and stakeholders.

Conceptual designs have been developed utilizing four sites as identified in Table 4-5 below. Site locations are referred to as Design Categories 1 through 4, and are shown in Appendix C, Figure C-3. Design categories were selected to represent a suite of project actions along representative portions of the river, and do not necessarily correspond to highest ranking project areas, nor do they imply that landowner access or permission has been granted to conduct restoration activities on privates lands. The design categories chosen include portions of the river with varying degrees of degradation and restoration potential (based on current incision, sinuosity, instream habitat, riparian conditions, floodplain connection, adjacent land use, and accessibility or other constraints).

Table 4-5. Design Category Locations

Design Category	Project Area (PA)	River Mile	Biologically Significant Reach	Project Ranking	Appendix C, Figure C-3 Map Number
1	PA 7	14.0	BSR 2	Tier I	6
2	PA 10	20.4	BSR 2	Tier I	9
3	PA 11	22.3	BSR 3	Tier II	10
4	PA 12	23.7	BSR 4	Tier I	11

Included with the conceptual designs are drawing sheets (Appendix D) and specifications and preliminary engineer's cost estimates (Appendix E). Preliminary engineer cost estimates include the itemized and total costs to conduct all project actions within each design category. The conceptual designs, specifications, and engineer cost estimates are intended to function as a menu which individual landowners, stakeholders, or subbasin managers can select restoration and habitat enhancement components applicable to an individual site and utilize the information to develop funding applications.

Each of the four design category sites that were selected included a unique combination of restoration and habitat enhancement project actions that were developed to address site-specific limiting factors. The rationale for selecting specific project actions is more fully described in Section 4.3. There are some intentional overlaps of project actions within the design categories to avoid omitting any important actions within a design category site. A total of 12 of the 16 project actions presented earlier are represented in the design categories. The general site conditions present within each design category, and description of proposed project actions within each design category, are as follows:

Design Category 1 – Examination of aerial imagery for the site used to develop this design category showed an old (pre-1930s) meander scar in a moderately incised area. Reactivation of the meander scar provides a good opportunity to restore floodplain connectivity and expand the riparian zone in one of the lower river reaches, within a Tier I project area (PA 7). A high-flow bypass channel leading to lower lying off-channel habitat would be constructed within the meander scar. The lower portion of the proposed off-channel habitat would retain perennial water and would include the addition of constructed pools and LWD structures for year-around habitat use.

- **Application:** This design category is most applicable in Project Areas 3 to 8, 12, and 13.
- **Goal:** The goal of this design category is to reduce flow and hydraulic forces acting on eroding banks, restore floodplain connectivity, expand the riparian zone and increase shade, and provide off-channel habitat that results in improved pool frequency and depth and increased LWD and habitat diversity for year-around habitat use.

Design Category 2 – This site was chosen for developing a design category because it represented an opportunity within a Tier I project area (PA 10) where a potential willing landowner might be open to the idea of restoring some unfarmed areas, while protecting other areas vital to farming operations. The channel in this reach had varying degrees of incision. In the more incised upper section a potential side channel and floodplain construction is illustrated in the drawing sheets (Appendix D). Anticipated bank protection is proposed in critical areas, and in-channel habitat structures are identified where they would promote main channel habitat diversity.

- **Application:** This design category is most applicable in Project Areas 1, 2, and 9 to 11.
- **Goal:** The goal of this design category is to restore processes in unfarmed areas and protect farmed areas by constructing side and high flow bypass channels to reduce bank erosion, increase floodplain connectivity, and provide overwinter rearing habitat; excavating alcoves and placing LWD to increase year-around main channel habitat diversity; and constructing bank stabilization structures, log and boulder revetments, and floodplains planted with riparian vegetation to limit bank erosion and increase shade.

Design Category 3 – Located just downstream of the Touchet-Gardena Road and bridge within a Tier II project area (PA 11), the upper portion of this site was chosen for developing a design category because it was deeply incised and straight. Potential side channels with LWD structures and constructed floodplain are shown in the drawing sheets (Appendix D) in the upper portion of the site, and a high flow bypass channel in the lower section in order to restore floodplain functions. Instream habitat structures (LWD structures, alcoves, and mid-channel LWD structures) within the main channel are illustrated to improve main channel habitat complexity and diversity.

- **Application:** This design category is most applicable in Project Areas 9 to 11.
- **Goal:** The goal of this design category is to reduce channel incision, provide overwinter rearing habitat, and restore floodplain function by adding instream structures, constructing side and high flow bypass channels, and excavating an inset floodplain; and improve year-around main channel habitat complexity and diversity by excavating alcoves and placing LWD that provide increases in pool frequency and depth and cover from predation.

Design Category 4 – Conditions at this site were chosen for developing a design category because they illustrate proposed actions within a moderately incised reach, with relatively intact riparian zone and floodplain, in a Tier I project area (PA 12). An area of farmland that juts into the floodplain is identified in the drawing sheets (Appendix D) as a potential riparian conservation zone, with a high flow bypass channel adjacent to it. Bank stabilization structures are proposed at critical locations to protect existing roads and infrastructure, and point bar structures are illustrated where they may provide instream habitat complexity and where lateral migration of the opposing bank is acceptable.

- **Application:** This design category is most applicable in Project Areas 12 to 14.
- **Goal:** The goal of this design category is to reduce bank erosion in order to protect farmed areas, roads, and infrastructure through riparian conservation zones, high flow bypass channels, bank stabilization structures, and point bar structures that result in expanding riparian and floodplain zones that reduce flow and hydraulic forces acting on eroding banks, provide bank protection, and increase lateral migration away from areas of concern.

When viewed as a whole, the potential project actions illustrated in the design categories and drawings represent a broad spectrum of activities that will address limiting factors within the Lower Walla Walla River. The project actions illustrated in the conceptual design drawings are summarized below:

- Riparian plantings and riparian conservation zones are shown in areas where existing vegetation is lacking, degraded, or proposed for protection.
- Floodplain connectivity actions are displayed where those features are lacking and include high-flow bypass channels, perennial off-channel habitat (channels or backwater areas), and constructed floodplains in incised areas.
- Instream structures are illustrated in areas where habitat quantity or complexity is limited. These structures include constructed alcoves, pools, LWD structures, point bar structures, and mid-channel bar structures.
- Bank protection structures include bank stabilization and habitat structures and log and boulder revetments, both of which incorporate other habitat enhancement features (LWD, boulders, and vegetation). In most instances, use of these structures were depicted in areas of steep eroding stream banks, but which are currently in appropriate configuration (i.e., correct sinuosity and radius of curvature), and where lateral migration is not necessary or expected. In some cases, these structures were offset and placed outside the active channels in the location where the channel would be expected to migrate, based on predicted channel migration rates and examination of historic aerial images. These types of structures may also be appropriate if protection of critical infrastructure (roads, buildings, railroads, irrigation systems, utilities, etc.) is a concern. In addition, selection and use of these structures within in a particular parcel will need to be balanced with individual landowner management goals and objectives.

The following design criteria were used for conceptual design development that maintain compliance with applicable codes, standards, and established criteria and address any potential constraints to achieving project objectives:

- The conceptual design development process generally followed the standard requirements outlined in the Washington State Aquatic Habitat Program Stream Habitat Restoration Guidelines (Cramer 2012).
- Bank protection designs generally follow the codes and standards in the Washington State Aquatic Habitat Program Integrated Streambank Protection Guidelines (Cramer 2002).
- Specific design concepts for bank protection were also adapted from Polster (2003).

Additionally, design criteria will generally be in accordance with the Habitat Improvement Program (HIP III) programmatic biological opinion (BPA 2013; NMFS 2013). Consideration will need to be given to programmatic permitting requirements for the construction of perennial side channels and off-channel habitat. For example, the measures referring to excavation quantities in the HIP III programmatic indicate that off- and side-channel improvements can include minor excavation (less than 10 percent) of naturally accumulated sediment within historical channels, while there is no limit for anthropogenic fill within historic side channels as long as such channels can be clearly identified through field and/or aerial photographs.

Examination of site-specific conditions and detailed technical analyses should be completed during future design development processes to minimize risks of restoration and habitat enhancement actions to infrastructure, property, and public safety. Section 5 contains a more complete description of future planning efforts associated with this GAAP.

5. Next Steps

This GAAP was developed for the LWWWG to evaluate existing biological and physical conditions in order to identify and prioritize potential project areas and restoration and habitat enhancement actions for the Lower Walla Walla River. The information presented in this GAAP is based on available existing data and field surveys conducted 2014. Conditions in the Lower Walla Walla River may change over time and/or additional data may become available. Changes in site conditions or available data may be evaluated and incorporated into the results of this GAAP in the future.

Next steps were identified throughout the GAAP for moving forward with the Action Plan. These include ongoing research efforts, developing site-specific designs for a project, implementing and monitoring new projects, and using newly acquired information to feed back into and revise the Action Plan as needed; many of these next steps are listed below:

- Integrate potential changes that may occur in Mill Creek and the Touchet River based on future planned assessments in those watersheds, and evaluate potential effects on the Lower Walla Walla River (e.g., if conditions change in Mill Creek, how might those changes translate down the Walla Walla River and into the Lower Walla Walla River?).
- Evaluate sediment contributions from the Touchet River and Dry, Mud, and Pine Creeks.
- Evaluate habitat in the Touchet River and Dry, Mud, and Pine Creeks.
- Evaluate data gaps in focal fish species utilization in the Lower Walla Walla River including over-winter fish use and sources of mortality such as predation that may result in the need for refinements of BSRs, limiting factors and project actions within the Lower Walla Walla River.
- Identify actions addressing low flow and high summer temperature that can be taken in the Lower Walla Walla River and incorporated in Subbasin-wide actions.
- Develop a beaver restoration management plan.
- Incorporate recommendations for future habitat improvement and preservation based on predicted changes in climate.
- Continue to integrate the results of ongoing research, monitoring, and evaluation, and incorporate new monitoring and evaluation in the Subbasin that may occur from programs such as the CTUIR PHAMS, and Biomonitoring Plan (Stillwater Science 2012), or other regional programs such as CHaMP or the BPA Action Effectiveness Monitoring programs.

- Define a method for applying and refining the project prioritization scoring system to individual projects proposed for funding in cases where a landowner is only willing to move partially toward full restoration potential.
- Continue to perform landowner outreach regarding the GAAP and project implementation.
- For projects with landowner approval, complete additional analysis and designs that would be project and site specific (e.g., hydraulic modeling, channel stability, and sediment transport and LWD stability analyses).

As these next steps are carried out, the Action Plan should be revisited and revised as needed with the LWWWG and other stakeholder review and input. Fine-tuning of ecological nodes, BSRs, limiting factors, restoration and enhancement actions, project areas and individual project prioritization, and potential changes in design concepts in the GAAP should occur as meaningful new research and project effectiveness data are obtained. Addressing these next steps will ensure the plan is not only useful in the short term, but will serve as a living document well into the future.

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Appendix A – Index of Existing Data and Reports

Table A-1. Index of Existing Data and Reports

Document/Data Title	Year (if known)	Source	File Type	Description
Touchet River Mile 42.5 Assessment	2009	Amonette, Alexandra	PDF	Assessment of conditions in the Touchet River. Reviews impacts including floodplain confinement and options for improving habitat and bank conditions. May not directly apply to Walla Walla but provides information on existing habitat in the basin and other efforts
Monitoring the Use of Mainstem Columbia River by Bull Trout from the Walla Walla Basin: Final Report (April 15, 2005 - December 31, 2009) Final	2010	Anglin, D.R.; Gallion, D.; Barrows, M.; Haeseker, S.; Koch, R.; Newlon, C.	PDF	This final report provides a description of the Walla Walla Basin, background information on the migratory life history of bull trout, the results of a previous effort to describe use of the Columbia River by Walla Walla Basin bull trout, and the approach taken by this project to describe use of the Columbia River by bull trout. This report summarizes our knowledge of Walla Walla Basin migratory bull trout abundance in the Columbia River and bull trout migration timing between the Walla Walla River and Columbia River from 2005 through 2009.
Monitoring the Use of Mainstem Columbia River by Bull Trout from the Walla Walla Basin: Annual Report 2008 (October 1, 2007 - September 30, 2008) Final	2009	Anglin, D.R.; Gallion, D.; Barrows, M.; Koch, R.	PDF	Annual report on pit-tagging work to document migration of bull trout through Walla Walla to and from the Columbia River - contains timing information for movement from Upper Walla Walla to Lower Walla Walla
Current status of bull trout abundance, connectivity and habitat conditions in the Walla Walla Basin: 2007 Update	2008	Anglin, D.R.; Gallion, D.; Barrows, M.; Newlong, C.; Ryan, K.	PDF	"This update is intended to provide preliminary results from work conducted during 2007 regarding migratory bull trout life history, abundance, distribution, and habitat conditions in the Walla Walla Basin, and to provide insight into the effect of physical and hydrologic conditions on bull trout biology and connectivity between local populations and core areas" - investigating bull trout populations in Walla Walla Basin
Juvenile salmonid use of natural and hydromodified stream bank habitat in the mainstem Skagit River	1998	Beamer, Eric and Henderson, Richard	PDF	Report providing findings from study on fish use of modified and natural banks; includes information of fish preference for wood and other factors
Channel incision, evolution and potential recovery in the Walla Walla and Tucanno River basins	2008	Beechie, T.J.; M.M. Pollock; and S. Baker	PDF	Journal article in Earth Surface Processes and Landforms discussing incision and channel pattern development in the Tucannon and Walla Walla Rivers

Document/Data Title	Year (if known)	Source	File Type	Description
Upper Walla Walla River Watershed Assessment	1997	BOR (U.S. Bureau of Reclamation)	PDF	General descriptions of basin biological and physical characteristics and includes identified issues with various resources and opportunities for conservation/restoration including soils, riparian vegetation, landshaping events, water quality, sediment, temperature and fish habitat
Milton-Freewater Project: Oregon-Washington Lower Division	1955	BOR (U.S. Bureau of Reclamation)	PDF	Proposal and plan for irrigation from McNary Reservoir. Detail feasibility in social, economic, soils, drainage, etc. for the area. From Jed Volkman files
History of Riparian Vegetation Along the Walla Walla River-Draft	unk	Bower, Bob	PDF	Thorough review of historic settlement and land use. Intended to establish the timeline of riparian vegetation history in the Walla Walla Valley and be a working draft to which more historical information can be revised as discovered. Mostly narrative text.
2008 Columbia Basin Fish Accords Memorandum of Agreement between the Three Treaty Tribes and FCRPS Action Agencies	2008	BPA (Bonneville Power Administration)	PDF	Memorandum of Agreement among the Umatilla, Warm Springs, and Yakima Tribes with the Bonneville Power Administration (BPA), U.S. Army Corps of Engineers (USACE), and U.S. Bureau of Reclamation (USBOR). Agreement addresses direct and indirect effects of construction, inundation, operation and maintenance of the Federal Columbia River Power System and Reclamation's Upper Snake River Projects, on fish resources of the Columbia River Basin. May provide some background for Fish discussion as well as watershed discussion.
"Where the great river bends" image	2008	Brigham Young University, Harold B. Lee Library	JPG	Image from "Where the great river bends" showing basalt and river near Walla Walla River mouth
Appendix A - Walla Walla Subbasin Stream Temperature-Total Maximum Daily Load and Water Quality Management Plan	2005	Butcher, Don and Bower, Bob	PDF	This appendix document is a temperature assessment of the Walla Walla Subbasin, focusing on the mainstem and South Fork of the Walla Walla River, for the purpose of establishing a Total Maximum Daily Load (TMDL) of in-stream heat to implement the Oregon water quality standard for temperature. The effort is also intended to support TMDL development in the Washington part of the subbasin. Part One of this document is the TMDL policy expression and will rely on the information in this appendix.
Walla Walla River Fish Habitat Analysis Using the Instream Flow Incremental Methodology	2002	Caldwell, Brad; Shedd, Jim; and Beecher, Hal	PDF	Report provides information regarding relationship between stream flow and fish habitat, which can be used to develop instream flow requirements for fish

Document/Data Title	Year (if known)	Source	File Type	Description
Flood basalts and glacier floods-roadside geology-Walla Walla, Franklin, Columbia Co	1996	Carson, Robert and Pogue, Kevin	PDF	Full title= Flood basalts and glacier floods: roadside geology of parts of Walla Walla, Franklin, and Columbia Counties, Washington. Washington Division of Geology and Earth Sciences. Information Circular 90. Geologic description for southeast Washington; including some specific areas along the Lower Walla Walla
The condition of salmon stocks in the John Day, Umatilla, Walla Walla, Grande Ronde, and Imnaha Rivers as reported by various fisheries agencies	1960	Cleve, R. Van and Ting, Robert	PDF	Includes summary of conditions of fish in Walla Walla (and others), comments on fish relocation feasibility studies, life history of Columbia River salmon and steelhead trout, commercial catch, Indian and sport fisheries, trend in Columbia River salmon runs. Appendices include Indian fishing on the spawning ground, diversion of excessive amount, pollution from mining silt, unscreened diversion, etc.
A stream evolution model integrating habitat and ecosystem benefits	2013	Cluer, B. and Thorne, C.	PDF	Journal article in River Research and Applications. DOI: 10.1002/rra.2631 Revision and updates to two Channel Evolution Models including a precursor stage; recognizing the more complex fluvial habitats
Linking the stream evolution model to habitat ecosystem and benefits-ppt	2014	Cluer, Brian	PDF	Slide presentation from RRNW 2014 conference: includes slides with example photos and key factors for different attributes and conditions
A History of the Walla Walla District: 1948-1970	unk	Connel, Richard	PDF	Scan of photocopy of document which contains no publication date. Review of history of the area focusing on the hydroelectric projects and flood control
Assessment of Salmonids and Their Habitat Conditions in the Walla Walla River Basin - 2000 Annual Report	2001	Coyle, Terrence; Karl, David; and Mendel, Glen	PDF	"This study began in 1998 to assess salmonid distribution, relative abundance, genetic characteristics (stock status and trends), and the condition of salmonid habitats in the Walla Walla River Subbasin within Washington" Detailing water flow levels, temperature, results of steelhead, Chinook, bull trout, population dynamics
TooMuchData_CTUIR	various	CTUIR (Confederated Tribes of the Umatilla Indian Reservation)	XLS	Data batch from CTUIR of various fish information including trap data, telemetry, etc.
Telemetry waypoints-WW-2007	2007	CTUIR (Confederated Tribes of the Umatilla Indian Reservation)	XLS	Spreadsheet with telemetry waypoints of river mile, lat-long data, location description and comments

Document/Data Title	Year (if known)	Source	File Type	Description
Telemetry waypoints-WW-2007_csv	2007	CTUIR (Confederated Tribes of the Umatilla Indian Reservation)	CSV	CSV file which is the same as the "Telm waypoints 2007.xls" with telemetry waypoints of river mile, lat-long data, location description and comments. Source is unclear; Excel file just says "Tetra Tech" for author
Columbia Basin Salmon Policy	1995	CTUIR (Confederated Tribes of the Umatilla Indian Reservation)	PDF	Describes the salmon policy for CTUIR in the Columbia River Basin.
Bioengineering Techniques for Streambank Restoration-A review of Central European Practices	1995	Donat, Martin	PDF	Review of European approaches to bank and slope stabilization conducted to assist with development of the Keogh River system on Northern Vancouver Island. Discusses using soft engineering and the idea of using live vegetation to protect banks and reduce scour. **Citation:** *Donat, M. 1995. Bioengineering techniques for streambank restoration. A review of central European practices. Province of British Columbia. Ministry of Environment, Lands and Parks, and Ministry of Forests. Watershed Restoration Project Report No. 2:86p*
Journal kept by David Douglas: 1823-1827	1823-1827	Douglas, David	PDF	Journal entries by David Douglas, including observations of land form, river systems, fauna and flora. From Jed Volkman files
photocopies of Columbia R. below Priest Rapids-1870s	1870s	Ebaugh, Janet	PDF	Scans of photocopies of photographs of Columbia river below Priest Rapids circa 1870s - from Janet Ebaugh. From Jed Volkman files
Quality Assurance Project Plan: Pine Creek Toxaphene Source Assessment	2014	Ecology (Washington State Department of Ecology)	PDF	Water sampling in the Lower Walla Walla River since 2002 has confirmed a persistent toxaphene source to the river. In particular, sampling of Pine Creek and the Lower Walla Walla has shown that the highest toxaphene concentrations prevail during peak irrigation times. Source areas are identified.
Walla Walla River Chlorinated Pesticides and PCBs Total Maximum Daily Load (Water Cleanup Plan)	2006	Ecology (Washington State Department of Ecology)	PDF	Provides an analysis of chlorinated pesticides and PCB data from the Walla Walla River. Identify potential point and nonpoint sources of chlorinated pesticides and PCB pollution. Summary of ongoing and planned actions.
2002 WDOE FLIR	2002	Ecology (Washington State Department of Ecology)	Various	FLIR infrared remote sensing surveys. Does not appear to include project area.

Document/Data Title	Year (if known)	Source	File Type	Description
DRAFT-Initial watershed assessment: Water Resources Inventory Area 22 - Walla Walla River Watershed. Open-file Technical Report 95-11	1995	Ecology (Washington State Department of Ecology) Prepared by Pacific Groundwater Group; Northwest Hydraulic Consultants, Inc	PDF	Assessment of Walla Walla River including geomorphic, hydrologic and fisheries habitat descriptions. From Jed Volkman files
Responsiveness Summary and Concise Explanatory Statement for the Adoption of: Amended Chapter 173-532 WAC.	2007	Ecology (Washington State Department of Ecology). Prepared by Gray, D.; Baldwin, K.; and Johnson, A.)	PDF	Describes rule to amend the 1977 rule – Chapter 173-532 WAC, Water Resources Program for the Walla Walla Basin, WRIA 32. In 2005 and consistent with the Watershed Planning Act, Chapter 90.82 RCW, the Walla Walla Watershed Planning Unit recommended that Ecology amend the existing rule to include instream flow levels, modify existing stream closures, and allow use of high flows for water storage projects that improve stream flows for salmon production. Other amendments include closure of the gravel aquifer and limitation on future permit-exempt groundwater use.
Engineering with Nature_Alternatives to Riprap	2009	FEMA (Federal Emergency Management Agency)	PDF	Document discussing 10 case studies in western Washington that highlight successful alternative methods to riprap for bank stabilization and protection of land from unwanted erosion
Letter to WWCBC with example of historical points plaque and potential sources	1999	Gary, Walter	PDF	Letter to board of commissioners with an example of a plaque of historical points being designed for Columbia County's courthouse suggesting Walla Walla County do the same and including questions on resources and potential approaches
Walla Walla River Enhancement Design-Bridge To Bridge Reach-Report	2012	GeoEngineers	PDF	Design report for River Enhancement Design-Phase 1 Bridge to Bridge Reach. Reach is between RM28 and RM29. Enhancement design includes removal of existing levee, floodchannel excavation, LWD installation, variable methods of bank stability measures. Project is just upstream of analysis reach
Walla Walla River Enhancement Design-Bridge To Bridge Reach-Plans	2012	GeoEngineers	PDF	Plans for design report for the bridge to bridge restoration project between RM28 and RM29

Document/Data Title	Year (if known)	Source	File Type	Description
Reflections of Many Waters: A history of the Walla Walla District, U.S. Army Corps of Engineers, 1981-2000	2013	Grass, C.	PDF	The entire history of the U.S. Army Corps of Engineers, Walla Walla District, has been closely tied to the development of water resources and navigation on the Columbia and Snake Rivers. Reflections of Many Waters highlights the overall importance of our water resources and navigation mission and our close relationship with protecting and enhancing both natural and cultural environments as well as collaborating with local, state, tribal, regional, and other federal agencies. It is my pleasure to introduce this update to the history of the Walla Walla District, focusing on the years 1981-2000.
Excerpts from: Thomas Nuttal - Naturalist - Explorations in America - 1808-1841	1967	Graustein, Jeannette E.	PDF	Photocopy of information on exploration; excerpts highlight landscape descriptions dealing with the Columbia, including vegetation
A Limnological Investigation of the Mill Creek Drainage-thesis	1972	Hallsted, Charles	PDF	Thesis for Master of Arts degree from Walla Walla College. Study in mill creek examining chemical and biological (benthic invertebrates and algae) differences between "natural" and farm land and season changes. From Jed Volkman files
Soil survey of the Columbia County Area, Washington	1973	Harrison, Evard; McCreary, Fred; Nelson,Frank; Soil Conservation Service	PDF	Descriptions of soils and relatively detailed soil maps at the end (140 pages)
Habitat Assessment of the South Fork and Mainstem Walla Walla River - Walla Walla Basin Natural Production Monitoring and Evaluation Project - DRAFT	2005	Hoverson, Eric	DOC	Aquatic Habitat inventory for the SF WW and mainstem Walla Walla River starting at the intake of the Little WWR at Cemetery Bridge (RM 46) and proceeding up the Little WWR to the road bridge at Harris Park (RM 8). Summary and narrative of data, including widths, confinement and habitat quality
Habitat assessment of the east, west, and mainstem Little Walla Walla River System and South Fork Touchet River - Walla Walla Basin Natural Production Monitoring and Evaluation Project	2005	Hoverson, Eric	DOC	Aquatic Habitat inventory for the SF WW and Touchet River Summary and narrative of data, including widths, confinement and habitat quality

Document/Data Title	Year (if known)	Source	File Type	Description
Distribution of the Fishes of the Walla Walla River	1975	Jackson, Robert	PDF	Report on electroshocking survey of the Walla Walla River between September 27 and November 4, 1974. Includes review of limited previous surveys. Survey information includes section locations and reach identification and description of area including substrate, width, depth and bank condition. Species observed include rainbow trout, largescale sucker, speckled dace, longnosed dace, redside shiner, chiselmouth, northern squaw fish, mottled sculpin and margined sculpin.
Soil Survey report of the Umatilla County Area, Oregon	1988	Johnson, David and Makinson, Allen; Soil Conservation Service	PDF	Descriptions of soils for the area including history and landuse (241 pages)
Excerpts from: Wanderings of an artist among the Indians of North America	1847	Kane, Paul	PDF	From a book titled: Paul Kane's Fronteir; edited with biographical introduction and a catalogue raisonne by J. Russel Harper - Includes historical description of the Walla Walla and Palouse area. Annotated with some of JV (?) notes. From Jed Volkman files
Quantifying physical habitat in wadeable streams	1999	Kaufmann, P.; Levine, P.; Robison, E.G.; Seeliger, C.; and Peck, D.V.; USEPA	PDF	Describe concepts, rationale, and analytical procedures for characterizing physical habitat in wadeable streams based on raw data generated from methods similar or equal to those of Kaufmann and Robison (1998) that are used by the U.S. Environmental Protection Agency (USEPA) in its Environmental Monitoring and Assessment Program (EMAP). We provide guidance for calculating measures or indices of stream size and gradient, sinuosity, substrate size and stability, habitat complexity and cover, woody debris size and abundance, residual pool dimensions and frequency, riparian vegetation cover and structure, anthropogenic disturbances, and channel-riparian interaction.
Distribution of the Fishes of Mill Creek	1976	Knecht, Clyde	PDF	Submitted as partial fulfillment of Research Methods III-Surveyed Aug 11-13, 1975, and identified 8 fish species: *Rhinichthys osculus*, *Richardsonius balteatus*, *Cottus bairdi*, *Cottus marginatus*, *Salmo gairdnerii, Catostomus macrocheilus, Acrocheilus alutaceus*, and *Ptychocheilus oregonensis*. From Jed Volkman files

Document/Data Title	Year (if known)	Source	File Type	Description
Salmonid Habitat Limiting Factors-Water Resource Inventory Area 32-Walla Walla Watershed	2001	Kuttel, Mike	PDF	This report deals with habitat conditions only. The report is a summary of existing knowledge from published sources and interviews of people with expertise in the Walla Walla Watershed. It is intended to provide guidance for implementation of salmonid habitat restoration projects. Habitat conditions are described, then assessed based on standards developed from published sources and consultations with local natural resource agency personnel. finally recommendations are made to improve habitat conditions.
Traditional fisheries of the Walla Walla, Cayuse, and Umatilla	1979	Lane, Robert and Lane, Barbara	PDF	Report documenting the usual and accustomed fishing grounds using sources relating to traditional fishing places and fishing practices of the Walla Walla, Cayuse, and Umatilla people
Dynamic patch mosaics and channel movement in an unconfined river valley of the Olympic Mountains	2006	Latterell, J.J.; Bechtold, J.S.; O'Keefe, T.C.; Van Pelt, R.; and Naiman, R.J.	PDF	Study that examines lateral channel migration and vegetation patch dynamics.
Environmental Monitoring and Assessment Program - Surface Waters: Field operations and method for measuring the ecological condition of non-wadeable rivers and streams	2000	Lazorchak, J.M.; Hill, B.H.; Averill, D.K.; Peck, D.V.; and Klemm, D.J.; EPA	PDF	Methods and instructions for field operations presented in this manual for surveys of non-wadeable streams and rivers - this is for the mid-Atlantic region but is the non-wadeable protocol
Lower Walla Walla River Habitat Improvement Strategy-DRAFT	2012	Lewis, Bob	PDF	Provides a review on information regarding habitat quality in the Lower Walla Walla, including temperature, riparian, known sedimentation problems, review of fish use and known barriers and recommends course of action and restoration as type and location
Lyman's History of Old Walla Walla County Embracing Walla Walla, Columbia, Garfield, and Asotin Counties.	1918	Lyman, W.D.	PDF	Lyman's historical accounts.
Walla Walla Basin Natural Production Monitoring and Evaluation Report: FY 2006 Annual Report	2008	Mahoney, B.D.; Lambert, M.B.; Olsen, T.J.; Bronson, P.; and Schwartz, J.D.M.	PDF	Provides results of monitoring and evaluation actions specified in the Walla Walla Subbasin Plan by providing estimates of distribution, productivity, abundance and survival of reintroduced spring Chinook and ESA listed summer steelhead.

Document/Data Title	Year (if known)	Source	File Type	Description
Walla Walla Salmonid Monitoring and Evaluation Project: 2007 and 2008 Annual Report	2009	Mahoney, B.D.; Mendel, G.; Lambert, M.; Trump, J.; Bronson, P.; Gembala, M.; and Gallinat, M.	PDF	This report combines two previously separate BPA monitoring and reporting projects operated by the CTUIR and WDFW. It also incorporates summaries of adult abundance or spawning data over many years from WDFW hatchery evaluations as part of Lower Snake River Compensation Plan (LSRCP) project, as well as from several other sources, in an effort to present the current state of our knowledge of these subjects in the Walla Walla Subbasin. This is the beginning of a coordinated and collaborative approach to improve monitoring of salmon; steelhead and bull trout stock status, as well as evaluate spring Chinook reintroduction efforts within the Walla Walla Subbasin. Our primary focus was to determine and describe adult returns and stock productivity, especially for steelhead and spring Chinook. We also contribute bull trout abundance and distribution information for portions of the Walla Walla Subbasin to add to previous or current bull trout monitoring efforts by the U.S. Fish and Wildlife Service (USFWS), U.S. Forest Service (USFS), Oregon Department of Fish and Wildlife (ODFW) and Utah State University. Supplemental habitat condition information is also collected and provided.
Walla Walla Salmonid Monitoring and Evaluation Project: 2012 Annual Report	2013	Mahoney, B.D.; Mendel, G.; Welert, R.; Trump, J.; Olsen, J.; Gembala, M.; and Gallinat, M.	PDF	This technical report provides summary information and results for the Walla Walla Salmonid Monitoring and Evaluation Project (WWSMEP) as a contract deliverable to Bonneville Power Administration (BPA) for the reporting period 1 March 2012 to 31 December 2012. Cumulative time series data (primarily 2000 – 2012) are provided in our report to describe the current state of the available information or to evaluate trends, where possible. This research, monitoring and evaluation effort is the continuation of a coordinated and collaborative approach to improve monitoring of summer steelhead and bull trout stock status, as well as to evaluate spring Chinook reintroduction efforts and natural population rebuilding within the Walla Walla Subbasin.
Walla Walla Salmonid Monitoring and Evaluation Project: 2011 Annual Report	2012	Mahoney, B.D.; Mendel, G.; Welert, R.; Trump, J.; Olsen, J.; Gembala, M.; Gallinat, M.	PDF	2011 Salmonid Monitoring Annual Report.

Document/Data Title	Year (if known)	Source	File Type	Description
Walla Walla Basin summer steelhead and bull trout radio telemetry project. 2001-2002 Progress Report (1 October 2000 - 30 June 2002)	2002	Mahoney, Brian	PDF	"First progress report of a multi-year project that monitors the movement of adult summer steelhead (*Oncorhynchus mykiss*) and bull trout (*Salvelinus confluentus*) in the Walla Walla River Basin (BPA Project Number 20127)"
The Walla Walla Subbasin Salmonid Monitoring and Evaluation Project-2011 Annual Report	2012	Mahoney, Brian; Mendel, Glen; Weldert, Rey; Trump, Jeremy; Olsen, Joelle; Gembala, Michael; Gallinat, Michael; and Lando, Jody; CTUIR, WDFW	PDF	Mahoney, et al. 2012. Walla Walla Subbasin Salmonid Monitoring and Evaluation Project: 2011 Annual Report. Confederated Tribes of the Umatilla Indian Reservation and Washington Department of Fish and Wildlife, Report submitted to Bonneville Power Administration, Project No. 2000-039-00.
The Walla Walla Subbasin Salmonid Monitoring and Evaluation Project - 2009 and 2010 Annual Report	2011	Mahoney, Brian; Mendel, Glen; Weldert, Rey; Trump, Jeremy; Olsen, Joelle; Gembala, Michael; Gallinat, Michael; and Ross, Lance; CTUIR, WDFW	PDF	Summary information and results for monitoring and evaluation of spring Chinook, summer steelhead, and bull trout in the Walla Walla Subbasin.
Sediment Transport by Streams in the Walla Walla River Basin, Washington and Oregon July 1962 - June 1965	1969	Mapes, B.E.	PDF	U.S. Geological Survey and Washington State Department of Natural Resources study to better understand sediment transport conditions in the Walla Walla River basin. Includes extensive sediment data collection including transport. Sediment yield estimates.
Figures for periodicity, fish use, LF's and activity types_McGowan and Mull_2009,2013	2009;2013	McGowan, Vance; Mull, Kristin	XLS	File including example figures for fish use in Catherine Creek as well as calculation workshed and periodicity example. Includes a blank template to create own charts
Excerpts from Botanical Exploration of the Trans-Mississippi West 1750-1850	1991	McKelvey, Susan	PDF	Excerpts from book highlighting some of the descriptions of travels of David Duglass, Wyeth, Nuttall, Brackenridge, Spalding, and Fremonts in the columbia area including the Walla Walla. From Jed Volkman files
Assessment of Salmonids and their Habitat Conditions in the Walla Walla River Basin within Washington-2000 Annual Report	2001	Mendel, G.; Karl, D.; and Coyle, T.	PDF	WDFW submitted a proposal in December 1997 to the Bonneville Power Administration (BPA) for a study to assess salmonid distribution, relative abundance, genetics, and the condition of their habitats in the Walla Walla River basin.

Document/Data Title	Year (if known)	Source	File Type	Description
Walla Walla River subbasin salmonid monitoring and evaluation project: 2013 Annual Report - BPA Project #2000-039-00	2014	Mendel, G.; Mahoney, B.; Weldert, R.; Olsen, J.; Trump, J.; and Fitzgerald, A.	PDF	Technical report - summary information and results as a contract deliverable to BPA for the reporting period 1 January to 31 December 2013. Incorporates summaries of adult abundance or spawning data over many years from WDFW hatchery evaluations as part of the Lower Snake River Compensation Plan (LSRCP) project, as well as from several other sources...Cumulative time series data (primarily 2000 – 2013) are provided in this report to describe the current state of the available information or to evaluate trends...water temperature and stream discharge
Assessment of Salmonid Fishes and Their Habitat Conditions in the Walla Walla River Basin, Annual Report 2005	2006	Mendel, G.; Trump, J.; and Gembala, M.	PDF	"This study began in 1998 to assess salmonid distribution, relative abundance, genetic characteristics (stock status and trends), and the condition of salmonid habitats in the Walla Walla River Subbasin within Washington" Detailing water flow levels, temperature, results of steelhead, Chinook, bull trout, population dynamics
Assessment of Salmonid Fishes and Their Habitat Conditions in the Walla Walla River Basin, Annual Report 2004	2005	Mendel, G.; Trump, J.; and Gembala, M.	PDF	"This study began in 1998 to assess salmonid distribution, relative abundance, genetic characteristics (stock status and trends), and the condition of salmonid habitats in the Walla Walla River Subbasin within Washington" Detailing water flow levels, temperature, results of steelhead, Chinook, bull trout, population dynamics
Assessment of Salmonid Fishes and Their Habitat Conditions in the Walla Walla River Basin, Annual Report 2003-2004	2004	Mendel, G.; Trump, J.; and Gembala, M.	PDF	"This study began in 1998 to assess salmonid distribution, relative abundance, genetic characteristics (stock status and trends), and the condition of salmonid habitats in the Walla Walla River Subbasin within Washington" Detailing water flow levels, temperature, results of steelhead, Chinook, bull trout, population dynamics
Assessment of Salmonid Fishes and Their Habitat Conditions in the Walla Walla River Basin, Annual Report 2001-2002	2002	Mendel, G.; Trump, J.; and Karl, D.	PDF	"This study began in 1998 to assess salmonid distribution, relative abundance, genetics, and the condition of salmonid habitats in the Walla Walla River basin"

Document/Data Title	Year (if known)	Source	File Type	Description
Assessment of Salmonid Fishes and Their Habitat Conditions in the Walla Walla River Basin - 1999 Annual Report	2000	Mendel, Glen; Karl, David; and Coyle, Terrence	PDF	Report on the project started in 1998 - to collect baseline data, identify data gaps, and provide assessments where possible - details findings of the 1999 field season from March to November 1999
Assessment of Salmonid Fishes and Their Habitat Conditions in the Walla Walla River Basin, Annual Report 1998	1999	Mendel, Glen; Karl, David; and Naef, Virginia	PDF	Provides information regarding fish passage, rearing, and spawning conditions for steelhead and potential reintroduction of Chinook, and assessment of steelhead and bull trout distribution, densities, and genetic composition in the Walla Walla watershed.
Assessment of Salmonids and Their Habitat Conditions in the Walla Walla River Basin within Washington-2006 Annual Report	2007	Mendel,Glen; Trump, Jeremy; Gembala, Mike; Blankenship, Scott; and Kassler, Todd	PDF	2006 fish surveys of the Walla Walla drainage and records of redds and distribution as well as habitat characteristics for some of the area
Ecology and distribution of the fishes of the Touchet River-Thesis	1972	Michaelis, Kenneth Alan	PDF	Survey of fish of the Touchet River during summer of 1971. 13 species of fish found within the drainage, including: rainbow trout, brown trout, dolly varden, and smallmouth black bass. Includes descriptions of differences in density and chemical and physical measurements of the surveyed area
Assessing Pacific Lamprey Status in the Columbia River Basin	2003	Moser, Mary and Close, David	PDF	BPA report that compared adult lamprey counts at hydropower dams to radiotelemetry results and found that the counts underestimated losses between some dams and overestimated passage times through reservoirs.
Excerpts from: the Journals of the Lewis and Clark Expedition - March 23 - June 9, 1806: From the Dalles to Walla Walla River - April 18 to May 1, 1806	1991	Moulton, Gary E. (editor)	PDF	Historical entries of journey including some descriptions of Walla Walla area and Touchet River, weather patterns, etc.
Biological effects of sediment on bull trout and their habitat-guidance for evaluating effects-FINAL	2010	Muck, Jim	PDF	Review of how sediment affects bull trout—changing behavior, direct mortality, suffocating eggs, reducing survival. Then follows with how to determine section 7 consultation effects
Geology and Ground-water Resources of the Walla Walla River Basin Washington-Oregon	1965	Newcomb, R.C.	PDF	The report describes the general geology of the basin and hydrology that govern the amount of groundwater available for development.

Document/Data Title	Year (if known)	Source	File Type	Description
Survey of the Columbia River and Its tributaries-Part V	1950	Nielson, Reed	PDF	Special Scientific Report: fisheries No. 38 - Report describing conditions of the Umatilla and Walla Walla drainages. Includes information on habitat and fish use for Walla Walla River reaches and multiple tributaries. Includes a map of diversions. From Jed Volkman files
Endangered Species Act Section 7 Formal Programmatic Biological and Conference Opinion, Letter of Concurrence, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for Bonneville Power Administration's Habitat Improvement Program III (HIP III) KEC-4	2013	NMFS (National Marine Fisheries Service)	PDF	Endangered Species Act Section 7 Formal Programmatic Biological and Conference Opinion, Letter of Concurrence, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for Bonneville Power Administration's Habitat Improvement Program III (HIP III) KEC-4
Middle Columbia River Steelhead Distinct Population Segment ESA Recovery Plan	2009	NMFS (National Marine Fisheries Service)	PDF	Information about Steelhead at Major Population Group level for Umatilla/Walla Walla MPG.
Walla Walla Subbasin Summary - DRAFT	2001	NPCC (Northwest Power Planning Council). Prepared for NPCC by writers from CTUIR, EcoPacific, WDFW, ODFW, Walla Walla Basin Watershed Council, USFS, Columbia Conservation District, ONHP, ODWR, Washington Conservation Commission, Washington Department of Ecology)	PDF	The Walla Walla Subbasin Summary has been developed as part of the rolling provincial review process developed by the Northwest Power Planning Council (NWPPC) in February 2000 in response to recommendations by the Independent Scientific Review Panel (ISRP) and the Columbia Basin Fish and Wildlife Authority (CBFWA). This summary is an interim document that provides context for project proposals during the provincial reviews while a more extensive subbasin plan is developed.

Document/Data Title	Year (if known)	Source	File Type	Description
DRAFT-Walla Walla Subbasin Summary	2001	NPCC (Northwest Power Planning Council). Prepared for NPCC by writers from CTUIR, EcoPacific, WDFW, ODFW, Walla Walla Basin Watershed Council, USFS, Columbia Conservation District, ONHP, ODWR, Washington Conservation Commission, Washington Department of Ecology)	DOC	Summary of Walla Walla subbasin conditions including resource conditions, limiting factors, and management indications
Pacific Lamprey and NRCS: Conservation, Management and Guidelines for Instream and Riparian Activities	2011	NRCS (U.S. Department of Agriculture Natural Resources Conservation Service)	PDF	Contains measures for conservation and management of habitats for Pacific lamprey and protection guidelines.
Walla Walla Subbasin Plan	2005	NWPCC (Northwest Power and Conservation Council)	PDF	Includes subbasin aquatic assessment with an overview of the EDT methodology and analysis in addition to an integrated assessment analysis regarding spring Chinook and summer Steelhead EDT analysis limiting attributes
Walla Walla Subbasin Plan Appendix C: EDT- Bank and-or riparian deficient vegetation sites	2005	NWPCC (Northwest Power and Conservation Council)	DOC	Photos of properties including tax lot number
Walla Walla Subbasin Plan Appendix D: EDT - Project priority list and rating sheets for deficient vegetation sites	2005	NWPCC (Northwest Power and Conservation Council)	DOC	List of project priority Reach projects by taxlot and criteria score; also including photo number and owner for vegetation deficiency projects
Walla Walla Subbasin Plan Appendix B: EDT - Channel project priority lists	2005	NWPCC (Northwest Power and Conservation Council)	DOC	List of project priority Reach projects by taxlot and criteria score; also including photo number and owner for channel projects
Appendix A-Walla Walla Subbasin Stream Temperature-TMDL-DATA	2005	ODEQ (State of Oregon Department of Environmental Quality)	XLS	Data and worksheet for habitat information associated with the Appendix A TMDL report

Document/Data Title	Year (if known)	Source	File Type	Description
Walla Walla Subbasin Stream Temperature-Total Maximum Daily Load and Water Quality Management Plan	2005	ODEQ (State of Oregon Department of Environmental Quality)	PDF	This document lays out goals and planning to address elevated stream temperature in the Walla Walla Subbasin in Oregon. The assessment (Appendix A) addresses the Walla Walla River in Washington as well. Because the Walla Walla Subbasin straddles the Oregon-Washington border, ODEQ and the Washington Department of Ecology (Ecology) agreed to a mutual assessment process.
2005 Oregon Native Fish Status Report Volume II Assessment Methods and Population Results	2005	ODWF (Oregon Department of Fish and Wildlife)	PDF	This report summarizes methods by which interim criteria were evaluated for many of Oregon's native fish populations consistent with Oregon's Native Fish Conservation Policy.
Juvenile Spring Chinook Salmon Overwinter Rearing Habitat Use in the Walla Walla River: 2013 Annual Report	2013	Olsen, Joelle and Mahoney, Brian	DOC	Draft report detailing results of 2011-2012 telemetry studies documenting spring Chinook use of the Lower Walla Walla River and suggestions for restoration efforts. BPA Project Number 2000-039-00, Contract Numbers 56615 and 60695; June 2013
Excerpt—Journal of an Exploring tour-Beyond the Rocky Mountains: Early Journal of Travels in Columbia	1837	Parker, Rev. Samual	PDF	Early description of Columbia Basin from travels in the 1800s. From Jed Volkman files
Excerpt—Journal of an Exploring tour-Beyond the Rocky Mountains	1835, 1836, 1837	Parker, Rev. Samual	PDF	Annotated excerpts from book regarding surveys and observations in the Walla Walla area in the mid 1830's. Appears annotations may be from Jed Volkman? Highlighted sections include discussion of river and stream conditions, tributaries, riparian vegetation, and encounters with tribal members
Assessment of Historical Trends in Land Use and Riparian Conditions - Walla Walla Basin-WMI Tasks 5.4-WMIMP Phase II-Final rpt	2010	Parks, Nella; Bower, Bob; and Mendel, Glen	PDF	Study examining the changes in land-use, vegetation trends, etc., through GIS analysis in the Walla Walla River and major tributaries
Ecology and distribution of fishes in the Yellowhawk and Cottonwood Creeks and the Lower Walla Walla River, Walla Walla County, Washington, and Umatilla County, Oregon-thesis	1977	Pearment, James Robert Eugene	PDF	Master's thesis examining the physical and biotic factors influencing fish distribution in two parts of the Walla Walla drainage. Conclusion that gradient drives waterflow and substrate composition and that temp. could also be driving fish distribution.

Document/Data Title	Year (if known)	Source	File Type	Description
Environmental Monitoring and Assessment Program -Surface Waters: Western Pilot Study Field Operations Manual for Wadeable Streams	2001	Peck, D.V.; Lazorchak, J.M. and Klemm, D.J.	PDF	Western pilot for wadeable stream EMAP protocols
Controversy, conflict and compromise: A history of the Lower Snake River development, U. S. Army Corps of Engineers	1994	Peterson, K. and Reed, M.E.	PDF	Narrative of the Snake River development history. Includes the Walla Walla District Corps of Engineers roles; including some information relating to the Walla Walla River
Managed Artificial Aquifer Recharge and Hydrological Studies in the Walla Walla Basin to Improve River and Aquifer Conditions-Thesis	2012	Petrides Jimenez and Aristides Crisostomos	PDF	PhD thesis examining aquifer recharge within the Walla Walla basin.
Columbia and Walla Walla County Walk-the-Stream Data	2000	Reckendorf, F., and B. Tice	Excel	Detailed field survey data for the lower Walla Walla River including stream morphology, channel widths, pools, sediment, and erosion lengths.
Landscape and the Intermontane northwest: An Environmental History. From Volume III: Assessment: Eastside Forest Ecosystem Health Assessment	1994	Robbins, William and Wolf, Donald	PDF	Traces the natural and cultural processes involved in shaping the environment in the intermontane northwest from the Indian period of domination to the present. Emphasizes the increasing influence of humans as modifiers of landscapes and ecosystems, especially with the coming of the market system to the region and the onset of the industrial era. Focuses on the unique aspects of ecological change in the intermontane region: the very recent extension of the market system to the area; and the very rapid expansion of human-induced environmental disturbance over very extensive areas in a very brief span of time. From Jed Volkman files
Chapter 3: July 14-30, 1812 - by Canoe Up the Columbia From Clickitat River to Mouth of Walla Walla River. In The Discovery of the Oregon Trail: Robert Stuart's Narratives	1995	Rollins, Philip Ashton	PDF	Chapter 3 - includes descriptions of river, landscape and people

Document/Data Title	Year (if known)	Source	File Type	Description
Excerpts—Appendix A-Wilson Price Hunt's Diary of his Overland Trip Westward to Astoria in 1811-12	1812; 1935	Rollins, Philip Ashton (editor)	PDF	Scan of photocopy of book from Jed Volkman (Pages 300-327)-Appendix A of "A Sea Voyage from New York to the Columbia's Mouth-An account of events at Fort Astoria during more than a year (1811-1812) and A Journey from Saint Louis to Fort Astoria-Translations and extracts from the manuscript diaries kept by the travellers, in English" - journal account of Hunt's travels to the Columbia River; detailing streams and conditions of man and beast and landscapes and river forms in the early 1800's.
Walla Walla River bull trout ten year retrospective analysis and implications for recovery planning; September 30, 2014	2014	Schaeller, H.; Budy, P.; and Newlon, C.	PDF	A multi-year synthesis of the data and analyses for the Walla Walla River conducted to help prioritize conservation action for bull trout. Assesses information on growth, movement patters, survival as well as habitat quality and availability
The Walla Walla Basin Natural Production Monitoring and Evaluation Project: Progress Report 2003 - BPA Project Number: 2000-039-00	2005	Schwartz, J.; Kissner, P.; Lambert, M.; Mahoney, B.; Contor, C.R.; CTUIR, BPA	PDF	"The Walla Walla Basin Natural Production Monitoring and Evaluation Project (WWNPMEP) is funded by Bonneville Power Administration (BPA) as directed by section 4(h) of the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (P. L. 96-501). This project is conducted in accordance with and pursuant to measures 4.2A, 4.3C.1, 7.1A.2, 7.1C.3, 7.1C.4 and 7.1D.2 of the Northwest Power Planning Council's (NPPC) Columbia River Basin Fish and Wildlife Program (NPPC 1994). Work was conducted by the CTUIR Fisheries Program under WWNPMEP. This progress report provides background information relevant to WWNPMEP, describes 2003 project activities, and presents a general analysis of findings to date. "
BSTEM 5.4 - ARS Bank Stability model	2000s	Simon, Andrew; Thomas, Robert; Curini, Andrea; and Bankhead, Natasha	XLS	Excel program for calculating bank erosion etc. Version 5.4
Bank-Stability and Toe-Erosion Model_example of use_5		Simon, Andrew; Thomas, Robert; Curini, Andrea; and Bankhead, Natasha	PPT	Powerpoint presentation on the use of the model including information on situations, types of use and examples of different aspects of the model. USDA, Watershed Physical Processes Unit.
Snake River Salmon Recovery Plan for SE Washington	2011	SRSRB (Snake River Salmon Recovery Board)	PDF	Includes Chapter 5 on Limiting Factors and Threats, which addresses Lower Walla Walla from the mouth to Dry Creek (near Lowden bridge).
Excerpts from: Umatilla Basin Report	1988	State of Oregon, Water Resources Department	PDF	Excerpts focus on hydrology, water use and fish of the Walla Walla basin

Document/Data Title	Year (if known)	Source	File Type	Description
Proposal: Biotechnical Streambank Stabilization, Assessment and Demonstration on the Lower Merced River	2005	Stillwater Sciences	PDF	Proposal from Conservation District using Stillwater Environmental services to procure funds for using a biotechnical approach for streambank stabilization in an area where agricultural land-use and channel migration are in conflict
A stream evolution model integrating habitat and ecosystem benefits-from channel evolution to stream evolution in the fluvial system-ppt	2014	Thorne, Colin R.	PDF	A lengthy discussion about channel incision and sedimentation as well as land use and geomorphic processes affected
Bank Processes and channel evolution in the incised rivers of north-central Mississippi	1999	Thorne, Colin R.	PDF	Chapter in book: "Incised River Channels" - Derby and Simon - 1999. looking at channel evolution and geomorphic processes driving different channel and bank conditions
Linking ecosystem services, rehabilitation, and river hydrogeomorphology	2010	Thorp, James H.; Flotemersch, Joseph E.; Delong, Michael D.; Casper, Andrew F.; Thoms, Martin C.; Ballantyne, Ford; Williams, Bradley S.; O'Neill, Brian J.; and Haase, C. Stephen	PDF	Bioscience, January 2010/Vol. 60 No. 1: journal article discussing linking river natural processes and ecosystem services and providing examples of how classifying rivers by hydrogeomorphic structure can better enable linking to ecosystem services and benefits
US Supreme Court-State of Washington v State of Oregon-297US517-1936	1936	U.S. Supreme Court	PDF	Decision regarding Washington State's assertion that Oregon should not be allowed to divert the water for irrigation as it reduces flow downstream. The decision was in favor of Oregon and states some justification describing geomorphology and hydrological conditions in the area (says not enough water would result from reduced irrigation and would go subsurface due to porous nature and would therefore be wasted to the detriment of Oregon residents.
Battle of the Walla Walla-National Register of Historic Places Continuation Sheet	unk	U.S. Department of the Interior National Park Service	PDF	Description of the history of the battle of the Walla Walla property. Includes some mention of the Walla Walla River but is mostly a historical narrative of the social and military actions
Empty Promises, Empty nets	unk	Ulrich, Roberta	PDF	Narrative of the history of dam construction and impacts on fish populations and fishing rights. Gives some detailed description of some sites and narratives of historic fish occurrence. From Jed Volkman files

Document/Data Title	Year (if known)	Source	File Type	Description
Report on source, nature, and extent of the fishing, hunting and miscellaneous related rights of certain Indian tribes in Washington and Oregon together with affidavits showing locations of a number of usual and accustomed fishing grounds and stations	1978	United States Department of the Interior, Office of Indian Affairs, Division of Forestry and Grazing	PDF	Details for usual and accustomed fishing grounds provides information on areas where fish historically occurred and narratives of degree of use by different tribes. From Jed Volkman files
Walla Walla River Watershed Oregon and Washington Reconnaissance Report	1997	USACE (U.S. Army Corps of Engineers)	PDF	This report evaluates 1) water resource issues associated with flood damage or environmental restoration and 2) potential alternatives for solving problems. It recommends 1) removing levees along WDFW land on the mainstem Walla Walla River, 2) restoration in the Pine Creek basin to increase native fish habitat and re-establish a more natural floodplain, and upland land treatment to reduce erosion, 3) constructing a setback levee in the upper Touchet, 4) reintroduction of salmon to the basin, 5) lining irrigation canals to increase water efficiency, 6) constructing a trap and haul facility at the Walla Walla River mouth, 7) constructing a levee on Coppei Creek and a setback levee along Mill Creek near Five Mile Bridge
Walla Walla River Basin Reconnaissance Report, Oregon and Washington.	1992	USACE (U.S. Army Corps of Engineers)	PDF	Reviews various water resource needs and opportunities in the Walla Walla River basin and determines their feasibility. It finds that upstream storage, water conservation measures, or water reallocation would provide some relief for irrigation water shortages but are not economically feasible.
Columbia River and tributaries review study - reach inventory - McNary Reservoir - lower Snake and lower Clearwater rivers	1975	USACE (U.S. Army Corps of Engineers)	PDF	Map and areal figures of the Lower Snake and Lower Clearwater Rivers
Columbia River LiDAR Project-Final Summary Report	2011	USACE (U.S. Army Corps of Engineers). Prepared by David C Smith Associates, AECOM and other subcontractors	DOC	Report detailing the LIDAR survey effort for the Columbia River under contracts W9127N-10-D-0002/0001 (Upper Columbia) and W9127N-09-D-0009/0006 (Lower Columbia) including descriptions of methodology for what was collected, why, and various specifics regarding accuracy etc. Report does not contain detailed technical reporting (metadata for ArcGIS deliverables, detailed LiDAR acquisition reports, and National Geodetic Survey [NGS] data sheets for all permanent control points)

Document/Data Title	Year (if known)	Source	File Type	Description
Southeast Washington Cooperative River Basin Study	1980-1981	USDA (U. S. Department of Agriculture)	PDF	Cooperative study with USDA Soil Conservation Service, Forest Service, and Economic Research Service. Basin-wide evaluation of erosion and sediment problems, present land management and stream habitat condition, intensive study of Tucannon, evaluation of conservation practices
USDA Field Flood Control Coordinating Committee No. 21: Appendix B - watershed classification cover soils erosion infiltration land use treatment plans to accompany Survey Report: Run-off and Waterflow Retardation and Soil Erosion Prevention for Flood Control Purposes - Walla Walla River Watershed, Washington and Oregon	1941	USDA (U.S. Department of Agriculture)	PDF	Includes section on Walla Walla Watershed classification (vegetative cover and landuse survey; soil, erosion and slope survey; soil loss, yield loss studies; surface run-off studies; infiltrometer investigation and survey), Remedial Program (Historical factors affecting watershed vegetation; waterflow retardation and soil erosion prevention measures; Economic and social effects of the Wild Land Program)
Walla Walla, Mill Creek, Coppei Creek Geomorphic Assessment	2010	USFS (U.S. Department of Agriculture Forest Service)	PDF	Geomorphic assessment completed for 1.7 miles of the Lower Walla Walla River (near College Place), and two tributaries: Mill Creek and Coppei Creek. Includes stream conditions such as erosion, riparian vegetation, habitat, etc.
Revised Draft Recovery Plan for the Coterminous United States Population of Bull Trout (*Salvelinus confluentus*)	2014	USFWS (U.S. Fish and Wildlife Service)	PDF	This revised draft recovery plan: (1) incorporates and builds upon all the new information found in numerous reports and studies regarding bull trout life history, ecology, etc., including a variety of implemented conservation actions, since the draft 2002 and 2004 recovery planning period; and (2) revises recovery criteria proposed in the 2002 and 2004 draft recovery plans to focus on effective management of threats to bull trout at the core area level, and de-emphasize achieving targeted point estimates of abundance of adult bull trout (demographics) in each core area.
Use of the mainstem Columbia River by Walla Walla Basin bull trout – Annual Report (October 1, 2009 – September 30, 2010) – FINAL	2012	USFWS (U.S. Fish and Wildlife Service)	PDF	From 2005-2009, the U.S. Army Corps of Engineers funded the U.S. Fish and Wildlife Service to evaluate use of the mainstem Columbia River by Walla Walla Basin bull trout (Study Code: BT-W-05-6).
2003 TIR FLIR Walla Walla River and South Fork Walla Walla River	2003	USFWS (U.S. Fish and Wildlife Service)	Various	TIR remote sensing surveys. Does include mouth to South Fork of the mainstem Walla Walla Fiver, and the SF Walla Walla.

Document/Data Title	Year (if known)	Source	File Type	Description
Chapter 10, Umatilla-Walla Walla Recovery Unit, Oregon and Washington: Bull Trout (*Salvelinus confluentus*) Draft Recovery Plan	2002	USFWS (U.S. Fish and Wildlife Service)	PDF	Bull Trout Draft Recovery Plan
USGS Gage (14018500) data -Walla Walla mainstem near Touchet River confluence	2014	USGS (U.S. Geological Survey)	TXT	Daily values for period of record and 15min discharge values for 2014 winter survey dates: daily values - Temperature (2002-08-05 to 2005-09-30) Discharge (1951-10-01 to 2014-04-08) Gage height (1994-10-01 to 2014-04-08) Sediment concentration (1962-10-01 to 1970-06-30) Sediment discharge (1962-10-01 to 1970-06-30) Also includes daily, monthly, annual stats; peak streamflow and field measurements. 15-minute discharge values: 2014-01-18 to 2014-02-14
Walla Walla and Snake River_USGS Topo Map - 1976	1976	USGS (U.S. Geological Survey)	PDF	Scanned photocopy of topo map with sections; includes Walla Walla and Snake Rivers
Artificial Recharge of a Well Tapping Basalt Aquifers, Walla Walla Area, Washington	1960	USGS (U.S. Geological Survey)	PDF	The U.S. Geological Survey in cooperation with the Washington State Department of Conservation carried out an experiment to determine the feasibility of artificial recharge to halt the decline of water levels in part of the Walla Walla basin, Washington. During the experiment, surface water was injected into basalt through Walla Walla city well.
The Changing Walla Walla River: a 200 year perspective, with emphasis on inundation due to the construction of the McNary Dam on the Columbia River-Thesis	1998	Van Auken, Heidi	PDF	Thesis from Whitman College-focus on the history of the Walla Walla area and geology. Discusses sedimentation and rates at which it has been occurring. From Jed Volkman files
An evaluation of instream habitat alteration in southeast Washington 1983-1989, Washington Department of Wildlife	1991	Viola, Arthur; Schuck, Mark; and Nostrant, Suzanne	PDF	Documentation of fish utilization and some location information regarding habitat improvement projects in the area; more regional than locally relevant to the Lower Walla Walla but useful for descriptive purposes
Walla Walla River Basin Fish Habitat Enhancement Project-Annual Report 2002-2003	2005	Volkman, Jed	PDF	Assessment of restoration actions within the Walla Walla basin. Only one project is downstream of Walla Walla, however provides information on conditions, fish habitat, and influences throughout the basin

Document/Data Title	Year (if known)	Source	File Type	Description
Walla Walla mud plume in Columbia-PHOTO	2013	Volkman, Jed	JPG	Photograph sent in email to Chris James from Jed Volkman (April 8, 2014). Text: "I took this one driving by the mouth of the Walla Walla last spring..............the mud plume is from the Walla Walla near two sisters"
Lower Walla Walla River Borgen property between Lowden and Touchet-PHOTO	2008	Volkman, Jed	JPG	Photograph sent in email to Chris James from Jed Volkman. Text to go along with photo: "A summer photo I took maybe 6 years ago on the Borgen property between Lowden and Touchet." looking upstream
Lower Walla Walla River Borgen property between Lowden and Touchet-DSPHOTO	2008	Volkman, Jed	JPG	Photograph sent in email to Chris James from Jed Volkman. Text to go along with photo: "A summer photo I took maybe 6 years ago on the Borgen property between Lowden and Touchet." looking downstream
Furnish Dam	unk	Volkman, Jed files	PDF	Narrative of Furnish Dam and its history. From Jed Volkman files
Excerpts—Lewis and Clark-Walla Walla to Lawyers_with notations	unk	Volkman, Jed files	PDF	Describes part of the journey including documenting edible plants and use of tribal members fishing and descriptions of the Columbia River
Guidelines for Watershed Restoration in the Walla Walla River Basin	unk	Volkman, Jed files	PDF	"This document contains a brief physical description of the Walla Walla River Basin, a historical review, and overview of land use problems, the purpose and goals of this effort, and an implementation process which includes objectives and anticipated measures to be used in achievement of objectives." Includes entire watershed and croplands, forest lands, "pasture and rangelands, riparian areas, urban, county, and state transportation right of ways"
Walla Walla Oral History	unk	Volkman, Jed files	PDF	Oral history from elder tribal members, includes discussion of fish use and some timing of flows and location of fishing
Photograph of mouth of Walla Walla	unk	Volkman, Jed files	JPG	Photograph of mouth of Walla Walla pre-dam
A History of Fire in the Pacific Northwest	after 1998	Volkman, Jed files	PDF	Relatively general description of fire history with some regional information on fires and fire management in the area
Excerpt—Columbia River Chronology	~1990	Volkman, Jed files	PDF	Scan of photocopy from Jed Volkman. Chronology and map of influences on and decline of salmon populations in the Columbia Basin. Most recent entry is 1987
Excerpt—Farnham's Travels-Early Western Travels	1839	Volkman, Jed files	PDF	Description of the Walla Walla River near a farm and its floodplain

Document/Data Title	Year (if known)	Source	File Type	Description
State Loses Suit with Oregon over Irrigation Rights-News Article	1930s	Walla Walla Daily Newspaper	PDF	News article regarding issues of water withdrawal from the Walla Walla across state lines. From Jed Volkman files
Natural streams and the legacy of water-powered mills	2008	Walter, Robert and Merritts, Dorothy	PDF	Science journal article about historic channel configurations on the Atlantic seaboard; concluding that single incised channels are not natural and anabranching terraced channels are the pre-settlement condition. Suggesting that such information be used for stream restoration activities
Integrated Streambank Protection Guidelines-Washington State Aquatic Habitat Guidelines Program	2003	WDFW (Washington Department of Fish and Wildlife)	PFD	Methods for streambank protection with additional information on determining streambank protection needs and alternative restoration actions that may provide better habitat functions
Proposed Draft Project Habitat Objectives for the 6 Ranch Phase 2 Habitat Restoration Project	2013	Welch, Sean	DOC	Site visit to discuss preferred biological and habitat components to be incorporated in the proposed 6 Ranch Phase 2 design. Looks at different habitat elements and functions
Photos-Welch examples for 6 Ranch	2013	Welch, Sean	PDF	Photographs of habitat and restoration projects; including LWD structures
Notes on sediment transport in evolving channels-ppt	2014	Wilcock, Peter	PDF	Presentation for 13th Annual Northwest Stream Restoration Symposium; Short Course" the utility of a stream evolution model in habitat and ecosystem restoration." Discusses factors affecting sediment mobility, supply and transport and calculations used as well as channel stability and thresholds for channel design
River Meanders and Channel Size	1986	Williams, G.P.	PDF	Paper detailing methodology for calculations of river geometry such as cross-section dimension and meander features
Recommended Guidelines or Developing Bank Stabilization Facilities of Rivers in Western Washington-FEMA and the University of Washington	1996	Wissmar, Robert	PDF	Guidelines include definitions of geomorphic provinces, calculations for bankfull discharge rates, calculations for flood discharge rates, channel conveyance, series of questions to ask in designing bank stabilization; key considerations such as size of substrate and fish passability, different approaches and design methods are discussed
Walla Walla Basin Aquifer Recharge Strategic Plan	2013	WWBWC (Walla Walla Basin Watershed Council)	PDF	Background describes the physical, geographic and hydrologic setting of the Walla Walla Valley and watershed, summarizes the results of the alluvial AR pilot projects. Provides information and data from existing pilot aquifer recharge projects in the valley.
Fish Presence and Flow Conditions	2008	WWBWC (Walla Walla Basin Watershed Council)	PDF	Presentation of the results of flow model and fish presence: shows species locations for each month of the year relative to average monthly flow conditions for stretches of the lower Walla Walla Rver between Pepper Bridge and Oasis Bridge

Document/Data Title	Year (if known)	Source	File Type	Description
Fish Presence and Temperature Conditions	2008	WWBWC (Walla Walla Basin Watershed Council)	PDF	Presentation of the results of flow model and fish presence: shows species locations for each month of the year relative to average monthly temperature conditions for stretches of the lower Walla Walla River between Pepper Bridge and Oasis Bridge
Walla Walla Subbasin Assessment – General Overview Components	2004	WWBWC (Walla Walla Basin Watershed Council)	PDF	Summary of issues and regulatory structure for subbasin planning.
2000 FLIR	2000	WWBWC (Walla Walla Basin Watershed Council)	Various	FLIR aerial temperature readings, WWBWC year 2000. Data compilation includes report and thermal images.
Walla Walla County Conservation District 5-Year Plan_2008 to 2015	2008	WWCCD (Walla Walla County Conservation District)	PDF	Discusses resource and management goal and activities including aquatic resources and issues such as soil erosion
Mitigation Guide for Future Outdoor Water Use in the Walla Walla Basin	2007	WWT (Wahington Water Trust)	PDF	Provides guidance to home builders, developers, well drillers, land owners, Walla Walla County and Department of Ecology staff and others regarding the mitigation requirement prescribed in the "Water Resources Program for the Walla Walla River Basin" rule.
Walla Walla Watershed Plan Implementation 2005-2009: Forming Partnerships	2009	WWWMP (Walla Walla County Watershed Planning Department)	PDF	The report summarizes the status of the Watershed Plan implementation from 2005 to 2009 and describes the formation of the Walla Walla Watershed Management Partnership and the on-going efforts of implementing the companion legislation.
Walla Walla Watershed Management Partnership 2012 Annual Report	2012	WWWMP (Walla Walla Watershed Management Partnership)	PDF	Describes the activities of water conservation programs such as "Flow from Flexibility" activities through implementation of 92 voluntary non-use agreements in the Walla Walla Water Bank, three reach-scale local water plans, and development of one transaction agreement for the instream flow trust of water.
Strategic Plan Update 2012-2015	2012	WWWMP (Walla Walla Watershed Management Partnership)	PDF	Strategic Plan Update 2012-2015 to guide the Walla Walla Watershed Management Partnership actions over the three-year period.
Walla Walla Watershed Management Partnership 2011 Annual Report	2011	WWWMP (Walla Walla Watershed Management Partnership)	PDF	Walla Walla Watershed Management Partnership 2011 Annual Report.
Walla Walla Watershed Management Partnership Newsletter-Volume8-issue4	2010	WWWMP (Walla Walla Watershed Management Partnership)	PDF	Updates on activities in watershed: Touche River LiDAR, Artificial aquifer recharge site progress, fish counts from CTUIR

Document/Data Title	Year (if known)	Source	File Type	Description
Walla Walla Watershed Management Partnership 2010 Annual Report	2010	WWWMP (Walla Walla Watershed Management Partnership)	PDF	Walla Walla Watershed Management Partnership 2010 Annual Report.
Walla Walla Watershed Plan: Planning Unit Final	2005	WWWPU (Walla Walla Watershed Planning Unit)	PDF	Watershed Management Plan for Water Resource Inventory Areas 32.
Walla Walla Watershed Plan-Section 3_Basin-wide Existing Conditions	2005	WWWPU (Walla Walla Watershed Planning Unit)	PDF	This section offers a brief description of the physical characteristics of the Walla Walla basin including the geography, geology, climate and vegetation. Information on population, land use, surface and groundwater resources, as well as surface and groundwater demands are provided. Additionally, a description of the aquatic habitat and fish distribution is given. Further detail on these topics is available in the Level 1 Assessment (EES, 2002).

Appendix B – Bathymetric and Vessel Mounted LiDAR Survey Technical Memorandum

Lower Walla Walla River Bathymetric Single Beam Sweep and Vessel-Mounted LiDAR Survey

Technical Memorandum

Prepared for:

The Confederated Tribes of the Umatilla Indian Reservation
Walla Walla Community College Water and Environmental Center, Office 485
500 Tausick Way, Walla Walla, WA 99362

Prepared by:

TETRA TECH
19803 North Creek Parkway
Bothell, WA 98011

October 2014

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List of Attachments

1. Introduction

Tetra Tech Inc. (Tetra Tech) performed a bathymetric and shoreline laser survey of the Lower Walla Walla River for the Confederated Tribes of Umatilla Indian Reservation (CTUIR). The survey area is located along the Lower Walla Walla River, from the confluence of the Columbia River to the Lowden Bridge (River Mile [RM] 27.5). Field work for the survey was performed from January 23 to January 31, 2014. A Ross 875-X sweep system was chosen to provide accurate bathymetric soundings. Cross-section sweep lines were performed at predetermined locations and river inflection points to the extent that site conditions allowed. A vessel-mounted Riegl LMS-Q120 Laser Scanner was used to scan the river shorelines, in conjunction with POS/MV 320 inertial measurement unit (IMU) and real-time kinematic (RTK) Global Positioning System (GPS). The bathymetric soundings and laser scanning data were combined to produce a continuous river bank and bathymetric surface. Vegetation was not manually removed from the shoreline laser scan data.

The surveys were conducted in general accordance with the procedures specified in the United States Army Corps of Engineers (USACE) Manual 1110-2-1003, Engineering and Design Hydrographic Surveying. On-site GPS quality control confirmed typical RTK accuracies were achieved with comparison deltas between measured and recorded points substantially better than 0.5 foot horizontal and vertical. As is typical when surveying in riverine environments, sonar data acquisition and coverage in some survey areas were reduced due to aeration in the water column. This had little impact on data quality, however, because erroneous data in the water column are removed by automatic filters or by manual editing during data processing, occasional gaps in data set were produced.

The Tetra Tech project team members and their roles in the surveys were as follows:

- Brent Johnston – Survey Manager
- Kyle Enright – Field Operations Lead \ Hydrographer
- Cory Graves – GPS Technician \ Data Processor
- Keegan Brophy – Survey Vessel Captain

2. System Setup

The survey system was installed on Tetra Tech research vessel (R/V) *Screaming Seagull*, a 14-foot inflatable Cataraft boat configured for shallow water surveying (Figure 2-1). The equipment used for the survey is shown in Table 2-1. Manufacturers' product data sheets that describe the system characteristics and specifications of the primary survey hardware are provided in Attachment A.

Figure 2-1. Tetra Tech Survey Vessel (R/V *Screaming Seagull*) with vessel-mounted LiDAR and sweep system in deployed position

Table 2-1. List of Survey Equipment

Sensor Type	Manufacturer/Model
Vessel-Mounted Sonar	Ross 875-X Sweep
Vessel-Mounted LiDAR	Riegl LMS-Q120 2D Laser Scanner
Motion Sensor	Applanix POS/MV 320
Heading	Applanix POS/MV 320
Position	Applanix POS/MV 320 / Leica 1230 RTK GPS
Sound Speed Profiler	YSI Castaway CTD
Water Height Corrections	Leica 1230 RTK GPS

The data collection and navigation software used for the bathymetry survey was HYPACK®/ HYSWEEP® v2012a. The data were processed and data products generated using a combination of CARIS HIPS v7.1.1, IVS 3D Fledermaus v7.3, and ESRI ArcGIS v10.1 software.

2.1 Device Offsets

Device offsets were precisely measured using a total station for the multibeam sonars, attitude and heading sensor, and GPS antennae. Offsets were entered into CARIS HIPS and SIPS to accurately convert the sweep, light detection and ranging (LiDAR), and support sensor data into position and height (XYZ) soundings on the earth.

All sensor offsets were measured relative to the origin of the Applanix POS MV 320 IMU. The vertical offset between the vessel reference point and the acoustic center of the sonar was surveyed using a total station and verified on-site by Tetra Tech standard quality control procedures. Table 2-2 lists the offsets used for the survey sensors.

Table 2-2. Bathymetry Sensor Offsets

Lower Walla Walla Survey, January 2014			
Sensor	Across Ship Starboard + (feet)	Along Ship Forward + (feet)	Vertical Down + (feet)
Ross 875-X Sweep			
Odom Transducer #1	-4.00	-0.39	7.25
Odom Transducer #2	-1.21	0.10	7.28
Odom Transducer #3	1.57	-0.30	7.38
Riegl LMS-Q120 2D Laser Scanner (Port)	0.92	0.10	-0.72
Riegl LMS-Q120 2D Laser Scanner (Stbd)	0.75	-0.10	-0.72
IMU (Applanix POS MV 320)	0.00	0.00	0.00
POS Primary Antenna	0.43	3.28	0.23
POS Secondary Antenna	0.43	-3.28	0.23
Leica 1230 Antenna	0.43	-1.64	0.13

2.2 Survey System Mounting

Survey sensors are mounted to the vessel on a retractable bow-mount pole and horizontal cross bar. The pole is rigidly attached to the bow of the vessel in the deployed position. When the vessel is launched, the pole is rotated to a vertical position and secured to prevent movement and ensure repeatable placement. Figure 2-1 shows the mount and various sensors in its down, or deployed, position.

2.3 GPS Reference Station

Survey ground control points were established by a Tetra Tech land survey crew. The operation of the GPS and RTK correction system were verified by setting up an RTK GPS base station on a survey marker, then taking the rover RTK GPS to another survey marker and comparing real-time coordinates with the published coordinates. On each day, the delta between the measured coordinates and the recorded coordinates was less than 0.1 foot horizontally and less than 0.2 foot vertically. The control point coordinates and GPS position accuracy verification log sheets are provided in Attachment B. Figure 2-2 displays the base station setup on Control Point ID number 05.

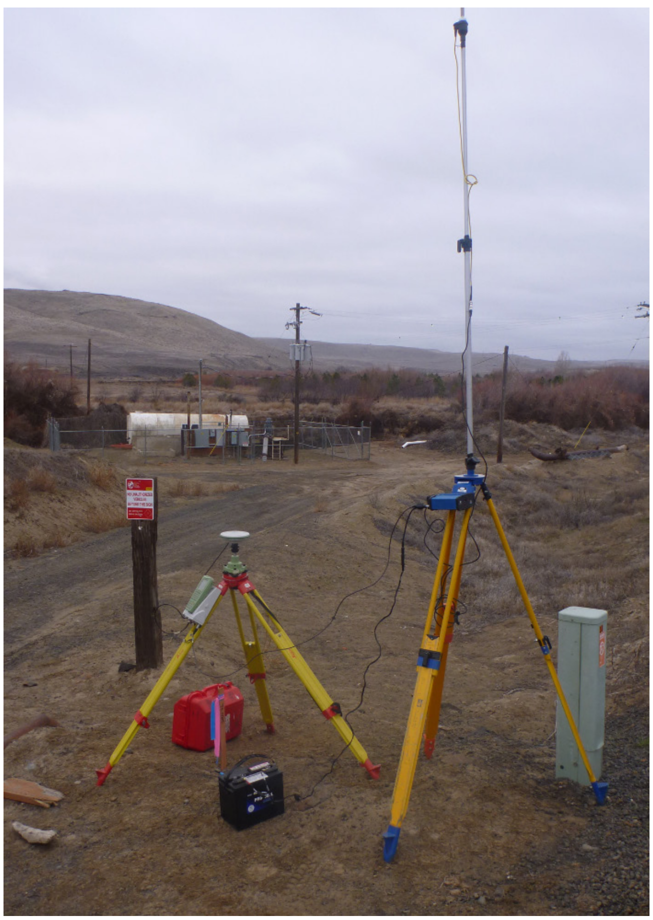

Figure 2-2. Base Station Setup on Tetra Tech Control Point ID Number 05

3. Survey Procedures

3.1 Ross Ross 875-X Sweep

A bow-mounted Ross 875-X Sweep system, as configured for this project, consisted of three single-beam transducers, offset 3 feet apart along an across-ship axis. The sweep system is an efficient means to collect bathymetric data in 1 to 6 feet of water. Each transducer has an along-track and an across-track beam width of approximately 3 degrees normal to the transducer acoustic origin. The support sensors, used to measure vessel attitude (roll, pitch, heave), position, heading, and sound speed through the water column, were selected to ensure that the associated accuracies were commensurate with the accuracy and resolution of the sonars.

Prior to survey, the draft of the three transducers was measured and entered into the sonar software. Next, a bar check and lead line quality check were performed to verify accurate recorded depth values for each transducer.

Per USACE hydrographic survey manual specifications (EM 1110-2-1003, Chapter 3), two types of quality control procedures were performed at least once pre-project for a general survey or study: a bar check to confirm the sonar's ability to record accurate depth measurements, and a water level check to verify accurate vertical referencing of the data. Tables 3-1 and 3-2 present the results of these quality control procedures.

Table 3-1. Bar Check Quality Control

Date	Time (UTC)	Device	Sonar Head (feet)	Bar Depth (feet)	Recorded Depth (feet)	Draft (feet)	Delta (feet)
02/24/2014	20:55	HYSWEEP	2	4.6	4.1	0.6	0.1
02/25/2014	20:25	HYSWEEP	2	3.4	2.8	0.7	0.1
02/26/2014	18:45	HYSWEEP	1	2.3	1.6	0.6	0.1
02/26/2014	18:45	HYSWEEP	2	3.2	2.7	0.6	0.1
02/26/2014	18:45	HYSWEEP	3	2.8	2.3	0.6	0.1

Table 3-2. Water Level Quality Control

Date	Time (UTC)	Device	Rover Elevation (feet)	Boat Elevation (feet)	Draft (feet)	Delta (feet)
02/24/2014	20:56	Leica	351.50	357.99	6.43	0.06
02/25/2014	20:25	Leica	271.05	277.53	6.43	0.05
02/26/2014	18:45	Leica	270.48	277.03	6.43	0.12

3.2 Riegl LMS-Q120 (LiDAR)

A laser system installation calibration, or "patch" test were carried out prior to the survey to determine the angular relationship between the LiDAR system installation and the vessels local reference frame, as determined by the IMU. The derived angular offsets are shown in Table 3-3. These offsets were applied in CARIS HIPS & SIPS, the data processing software, to correct residual misalignments in the mechanical installation of the sensors, and to compensate for any latency in the positioning system.

Table 3-3. LiDAR Patch Test Calibration Results

Lower Walla Walla River Survey, January 2013	
Parameter	**Value**
Roll	0.20 degrees
Pitch	0.28 degrees
Yaw	0.93 degrees
Latency	0.00 second

The data collection software and hardware were time-synchronized to GPS-coordinated universal time (UTC), and the time stamp from the GPS position messages was used for the position data, which typically provides a latency value of zero; this was confirmed with the LiDAR patch test. Figure 3-1 shows the system as configured for the VML patch test.

The LiDAR data were processed with the patch test calibration toolkit in the CARIS HIPS processing software. Collections were performed so that at least two independent data sets were used to derive each measurement.

Figure 3-1. Performing the LiDAR Installation Calibration

3.3 Position and Height

To compensate for any variations in the water surface elevation, vessel squat and settlement, and varying draft due to vessel loading, RTK GPS was used to determine both position (X, Y) and height/elevation (Z).

3.4 Sound Speed Casts

Speed-of-sound casts were performed on the Lower Walla Walla River to correct for variations of the speed of sound in the water column. Casts were conducted using a YSI Castaway Conductivity, Temperature, and Depth (CTD) probe.

3.5 Field Issues Encountered

The Walla Walla River presented some manageable operational challenges, which the field survey team was able to overcome:

- The lack of established boat launches required deploying the vessel in several primitive, difficult-to-access launches (see Figure 3-2). Tetra Tech's in-house developed Cataraft trailer was designed specifically with steep, remote and primitive boat launches in mind.

- Relatively shallow flow during the survey with numerous submerged rocks caused the protective shroud on the propeller to be repeatedly ripped off and frequent contact between the propeller and river bed (Figure 3-2). Repairs to the shroud were performed quickly and the numerous spare propellers (mobilized with the survey crew) were swapped out as needed with minimal impact to project schedule.
- Freezing rain forced a project weather day while the field crew awaited warmer temperatures and safer operating conditions.

Figure 3-2. Photographs Showing Survey Field Work

4. Data Processing

The following is a description of the processing methodology used to convert the raw data to depth and position measurements, and also to remove poor quality soundings from the processed data set.

The collected sweep data were processed using CARIS HIPS software to generate the XYZ soundings in the survey coordinate system and units. Data cleaning was also performed in CARIS HIPS two-dimensional and three-dimensional editing software to eliminate any outliers introduced by noise in the acoustic environment. A subsequent area-based cleaning, using the merged data from all the survey lines, was then conducted using the CARIS HIPS subset editing tool. ASCII XYZ files of the "cleaned" individual soundings and the gridded BASE surfaces were then exported out of CARIS. Attachment C contains data processing screen captures showing various features of interest.

Attachment A. Equipment Data Sheet

The following are copies of the equipment data sheets, provided by the manufacturers, for the primary hardware systems used in the survey.

New Ross Model 875-X "Portable Sweep System"

- Four to six channel data collection
- Shallow water operation (1.5ft to 100 ft)
- Lightweight portable boom system
  Stores in transportable shipping case
- Desk top or suitcase enclosures
- 20GB HD Internal Storage Capacity
- 200kHz, narrow beam transducers
- Bright color LCD display
- Portable, Ruggedized & Splashtight
- 12v DC operation, serial depth output

Shallow Water Survey

Now you can run sweep surveys in small ponds and backwaters with the new Model 875-4 Portable Sweep System from Ross Laboratories, just add your DGPS, heading sensor and laptop running survey software and you are ready to go!

Four transducers on a lightweight 18 foot portable boom, easily mounted on small skiffs or john boats.

Significantly reduces bathymetric survey time for habitat or resource studies in shallow areas while still collecting multiple channel data.

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info@rosslaboratories.com www.rosslaboratories.com

2D LASER SCANNER
LMS-Q120

The *RIEGL* LMS-Q120 2D - laser scanner provides accurate non-contact line scanning using a narrow infrared laser beam. The instrument makes use of the precise time-of-flight laser range measurement principle and of fast line scanning by means of a high-speed opto-mechanical scan mechanism, providing fully linear, unidirectional and parallel scan lines.

The rugged overall system design makes the *RIEGL* LMS-Q120 exceptionally well suited for installations in harsh industrial environment, and the compactness of the housing allows an installation under narrow space conditions (e.g. in a robotic vehicle). The instrument needs only a single supply voltage and provides line scan data via its integrated TCP/IP Ethernet interface. The binary data stream can easily be post-processed by any user-designed software using the available software library.

- ***Maximum range 150 m @ 80 % target***
- ***Ranging accuracy 25 mm***
- ***Data rate up to 10 000 meas. / sec***
- ***Scanning rate up to 100 scans / sec***
- ***Scanning range 80°***
- ***Perfectly linear scan***
- ***Rugged IP64 housing***
- ***Integrated TCP/IP Ethernet interface***

Typical applications include

- ***Guidance of autonomous vehicles***
- ***Obstacle detection and collision avoidance***
- ***Industrial profile measurement***

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RIEGL
LASER MEASUREMENT SYSTEMS

Technical data of *RIEGL* LMS-Q120

Rangefinder performance

CLASS 1 LASER PRODUCT

Eye safety class according to IEC60825-1:1993+A1:1997+A2:2001

The following clause applies for instruments delivered into the United States: Complies with 21 CFR 1040.10 and 1040.11 except for deviations pursuant to Laser Notice No. 50, dated July 26, 2001.

Maximum measurement range [1]	
for natural targets, reflectivity $\rho \geq 20$ %	$\geq$ 75 m
for natural targets, reflectivity $\rho \geq 80$ %	$\geq$ 150 m
Minimum range	2 m
Accuracy [2] [4]	25 mm
Precision [3] [4]	15 mm
Laser Pulse Repetition Rate	30 000 Hz
Effective measurement rate	10 000 measurements/sec.
Laser wavelength	near infrared
Laser beam divergence [5]	2.7 mrad

1) The following conditions are assumed: target is larger than footprint of laser beam; beam incidence perpendicular to target; visibility 10 km; average ambient brightness
2) Accuracy is the degree of conformity of a measured quantity to its actual (true) value.
3) Precision, also called reproducibility or repeatability, is the degree to which further measurements show the same result.
4) One sigma @ 50 m range under *RIEGL* test conditions.
5) 2.7 mrad correspond to 27 cm increase of beamwidth per 100 m of range.

Scanner performance

Scanning range [6]	± 40 deg = 80 deg total
Scanning mechanism	rotating polygon mirror
Scanning rate	5 to 100 scans / sec
Angle step width $\Delta \vartheta$ [6] between consecutive laser shots	$\Delta \vartheta \geq 0.04$ deg
Angular resolution	0.01 deg
Internal Sync Timer	Option for GPS-synchronized time stamping of scan data
Scan Sync	Option for synchronizing scan lines to external timing signal

6) Scanning parameters can be set via TCP/IP configuration interface.

General technical data

Data interface:	TCP/IP Ethernet, 10/100 MBit/sec
Optional interface:	RS 232 parallel, ECP standard (enhanced capability port)
Input voltage range	18 - 32 V DC, 24 V DC nominal
Current consumption	approx. 2 A @ 24 V DC
Main dimensions	180 x 374 mm (diameter x length)
Weight	approx. 7 kg
Temperature range	-10°C up to +50°C (operation) -20°C up to +60°C (storage)
Protection class	IP64
Mounting	M6 and M8 steel thread inserts

Data sheet, LMS-Q120, 17/09/2007

RIEGL LASER MEASUREMENT SYSTEMS
www.riegl.com

RIEGL Laser Measurement Systems GmbH, A-3580 Horn, Austria
Tel.: +43-2982-4211, Fax: +43-2982-4210, E-mail: office@riegl.co.at
RIEGL USA Inc., Orlando, Florida 32819, USA
Tel.: +1-407-248-9927, Fax: +1-407-248-2636, E-mail: info@rieglusa.com
RIEGL Japan Ltd., Tokyo 1640013, Japan
Tel.: +81-3-3382-7340, Fax: +81-3-3382-5843, E-mail: info@riegl-japan.co.jp

Leica GPS1200
Technical specifications and system features

GPS1200 receivers	GX1230 GG/ATX1230 GG	GX1230/ATX1230	GX1220	GX1210
GNSS technology	SmartTrack+	SmartTrack	SmartTrack	SmartTrack
Type	Dual frequency	Dual frequency	Dual frequency	Single frequency
Channels	14 L1 + 14 L2 GPS 2 SBAS 12 L1 + 12 L2 GLONASS 72 Channels	12 L1 + 12 L2 GPS 2 SBAS	12 L1 + 12 L2 GPS 2 SBAS (with DGPS option)	12 L1 2 SBAS (with DGPS option)
RTK	SmartCheck+	SmartCheck	No	No
Status indicators	3 LED indicators: for power, tracking, memory			

GPS1200 receivers	GX1230 GG/GX1230/GX1220	GX1210	ATX1230 GG/ATX1230
Ports	1 power port, 3 serial ports, 1 controller port, 1 antenna port		1 power/controller port, Bluetooth® port
Supply voltage, Consumption	Nominal 12 VDC 4.6 W receiver + controller + antenna		Nominal 12 VDC 1.8 W
Event input and PPS	Optional: 1 PPS output port 2 event input ports	Optional: 1 PPS output port 2 event input ports	
Standard antenna Built-in groundplane	SmartTrack+ AX1202 GG Built-in groundplane	SmartTrack AX1201 Built-in groundplane	SmartTrack+ ATX1230 GG Built-in groundplane

The following apply to all receivers except where stated.

Power supply	Two Li-Ion 3.8 Ah/7.2 V plug into receiver. One Li-Ion 1.9 Ah/7.2 V plugs into ATX1230 and RX1250.
Plug-in Li-Ion batteries Same for GPS and TPS	Power receiver + controller + SmartTrack antenna for about 15 hours (for data logging). Power receiver + controller + SmartTrack antenna + low power radio modem or phone for about 10 hours (for RTK/DGPS). Power SmartAntenna + RX1250 controller for about 5 hours (for RTK/DGPS)
External power	External power input 10.5 V to 28 V.
Weights	Receiver 1.20 kg. Controller 0.48 kg (RX1210) and 0.75 kg (RX1250). SmartTrack antenna 0.44 kg. SmartAntenna 1.12 kg. Plug-in Li-Ion battery 0.09 kg (1.9 Ah) and 0.19 kg (1.9 Ah). Carbon fiber pole with SmartTrack antenna and RX1210 controller: 1.80 kg. All on pole: carbon fiber pole with SmartAntenna, RX1250 controller and plug-in batteries: 2.84 kg.

Temperature	Operation:	Receiver	–40° C to +65° C
ISO9022		Antennas	–40° C to +70° C
MIL-STD-810F		Controllers	–30° C to +65° C
	Storage:	Receiver	–40° C to +80° C
		Antennas	–55° C to +85° C
		Controllers	–40° C to +80° C
Humidity ISO9022, MIL-STD-810F	Receiver, antennas and controllers Up to 100% humidity.		
Protection against water, dust and sand IP67, MIL-STD-810F	Receiver, antennas and controllers: Waterpoof to 1 m temporary submersion. Dust tight		
Shock/drop onto hard surface	Receiver: withstands 1 m drop onto hard surface. Antennas: withstand 1.5 m drop onto hard surface.		
Topple over on pole	Receiver, antennas and controllers: withstand fall if pole topples over.		
Vibrations ISO9022 MIL-STD-810F	Receiver, antennas and controllers: withstand vibrations on large construction machines. No loss of lock.		

NEW

CastAway CTD

The CastAway-CTD
Instant, reliable data in the palm of your hand!

Pure Data for a Healthy Planet.®

The CastAway™-CTD

with profiling and analysis software

The YSI CastAway-CTD is a lightweight, easy to use hydrographic instrument designed for quick and accurate conductivity, temperature, and depth profiles. Starting with a unique six-electrode array and a flow-through cell, the CastAway makes use of commercial Bluetooth and GPS technology to make an instrument that is as usable as it is accurate.

The CastAway is a multi-functional tool that incorporates the most modern technology available - yet is simple to use. It is designed for CTD profiling down to 100 m and is easy to deploy.

The palm-sized CastAway-CTD can easily be deployed by hand. Each cast is referenced with both time and location using its built-in GPS receiver. Latitude and longitude are acquired both before and after each profile. Plots of conductivity, temperature, salinity and sound speed versus depth can be viewed immediately on the CastAway's integrated color LCD screen in the field.

Raw data can be easily downloaded via Bluetooth to a Windows computer for detailed analysis and/or export at any time. Rugged, non-corrosive housing, AA battery power and tool-free operation reflect the technician-friendly pedigree of the CastAway-CTD. So do the simple, intuitive features – everything an operator needs to know about deploying the CastAway-CTD, viewing data and downloading the files fits in the lunchbox-sized carrying case.

Best used in:

- Coastal Oceanography
- Hydrology
- Aquaculture/Fisheries

When needed for:

- Saltwater Intrusion
- Surveying/Hydrography
- Sound Velocity Profiles
- Field Sensor Verification
- Estuarine Research

- *GPS position, date and time*
- *Fast sampling and sensor response*
- *Waterproof interface works in and out of the water*
- *Bluetooth wireless communication*
- *No user calibration required*
- *No tools, computers or cables required!*

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inquiry@sontek.com

YSI Gulf Coast
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gulfcoast@ysi.com

YSI Hydrodata (UK)
+44 1462 673 581
europe@ysi.com

YSI Nanotech (Abu Dhabi)
+971 25631316
samer@nanotech.co.jp

YSI South Asia
+91 9891220639
sham@ysi.com

YSI (Hong Kong) Ltd
+852 2891 8154
hongkong@ysi.com

YSI (China) Ltd
+86 10 5203 9675
beijing@ysi-china.com

YSI Nanotech (Japan)
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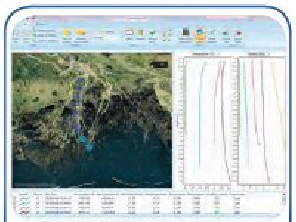
ISO 9001
ISO 14001
Yellow Springs, Ohio Facility

YSI incorporated
Who's Minding the Planet?®

Specifications

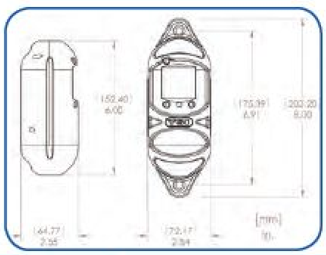
Memory	15 MB (750+ casts based on typical usage)
Communications	Bluetooth class II, up to 10 m range
Power	2 "AA" alkaline batteries, 40 hours continuous use
Data Output Format	- ASCII (CSV) -Hypack -Matlab
Environmental	- Depth range: 0-100 m - Use temperature: -5° to 45° C - Storage temperature: -10° to 50° C
Sampling Modes	- Casting (up/down) - Point sample (moving the unit back and forth)
Software	- Windows XP/Vista/7 - Geo-referenced - Multi-language - Data plots, filtering, import/export
Accessories	- Hard plastic storage/shipping case - Polyurethane jacket - 15m deployment line - Bluetooth dongle - Two locking carabiners - Three magnetic stylus pens - Cleaning brush
Thermistor Response	Less than 200 ms
Sampling Rate	5 Hz
Weight	In air: 1.0 lb (0.45 kg) In water: 0.06 lbs (0.03 kg)

Simple "AA" battery installation and storage area for spare stylus.



A screen capture of data from a river delta in Louisiana acquired using a CastAway-CTD. The technicians collected 21 casts in less than 3.5 hours.

Each CastAway ships in this hard plastic kit, complete with accessories and quick start guide.



The CastAway-CTD Output Parameters

	Range	Resolution	Accuracy	Measured or Derived
Conductivity	0 to 100,000 µS/cm	1µS/cm	± 0.25% ± 5 µS/cm	Measured
Temperature	-5° - 45° C	0.01° C	± 0.05° C	Measured
Pressure	0 to 100 dBar	0.01 dBar	± 0.25% FS	Measured
Salinity	Up to 42 (PSS-78)	0.01 (PSS-78)	± 0.1 (PSS-78)	PSS-78[3]
Sound Speed	1400 - 1730 m/s	0.01 m/s	± 0.15 m/s	Chen-Millero[4]
Density[1]	990 to 1035 kg/m³	0.004 kg/m³	± 0.02 kg/m³	EOS80[5]
Depth	0 to 100 m	0.01m	± 0.25% FS	EOS80[5]
Specific Conductivity[2]	0 to 250,000 µS/cm	1µS/cm	± 0.25% ±5 µS/cm	EOS80[5]
GPS			10 m	

[1]Based on temperature resolution and accuracy.
[2]Based on 100,000 µS/cm at -5° C.
[3]1978 Practical Salinity Scale.
[4]Chen-Millero, 1977. Speed-of-sound in sea water at high pressures.
[5]International Equation of State for sea water (EOS-80).

Attachment B. GPS Position Accuracy Verification

Table B-1. GPS quality control results.

Date	Point ID	Delta Easting (feet)	Delta Northing (feet)	Delta Elevation (feet)	3D RMS (feet)
2014/01/23	11	0.02	0.03	0.19	0.19
2014/01/24	08	0.06	0.03	0.12	0.18
2014/01/25	08	0.05	0.01	0.06	0.04
2014/01/26	01	0.04	0.02	0.12	0.28
2014/01/27	05	0.03	0.04	0.04	0.04
2014/01/28	04	0.03	0.04	0.20	0.19
2014/01/30	08	0.05	0.02	0.15	0.15
2014/01/31	08	0.06	0.03	0.26	0.12

Attachment C. Data Processing Screen Captures

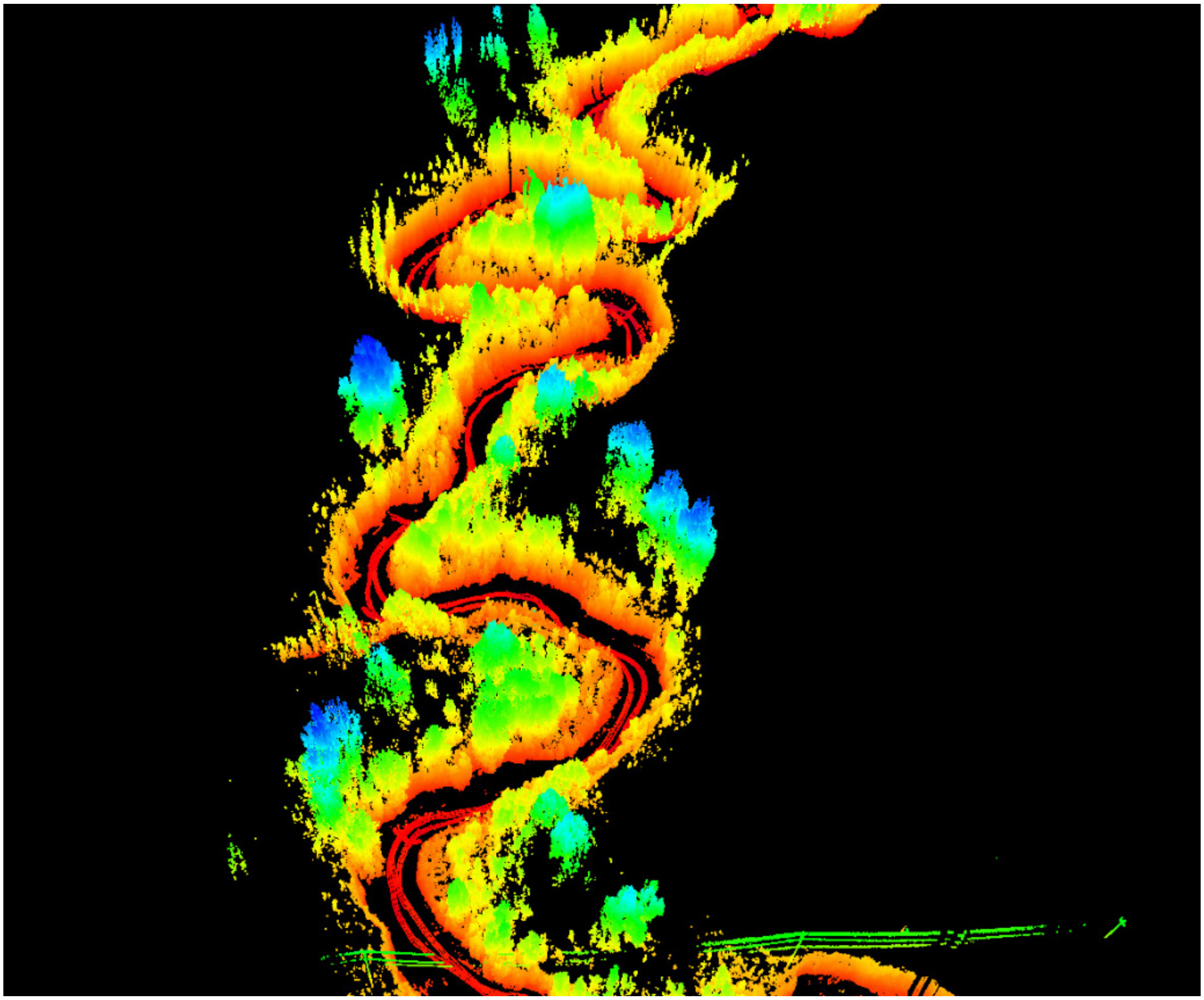


Figure C-1. Combined LiDAR and Sweep Sonar View of River Near Lowden

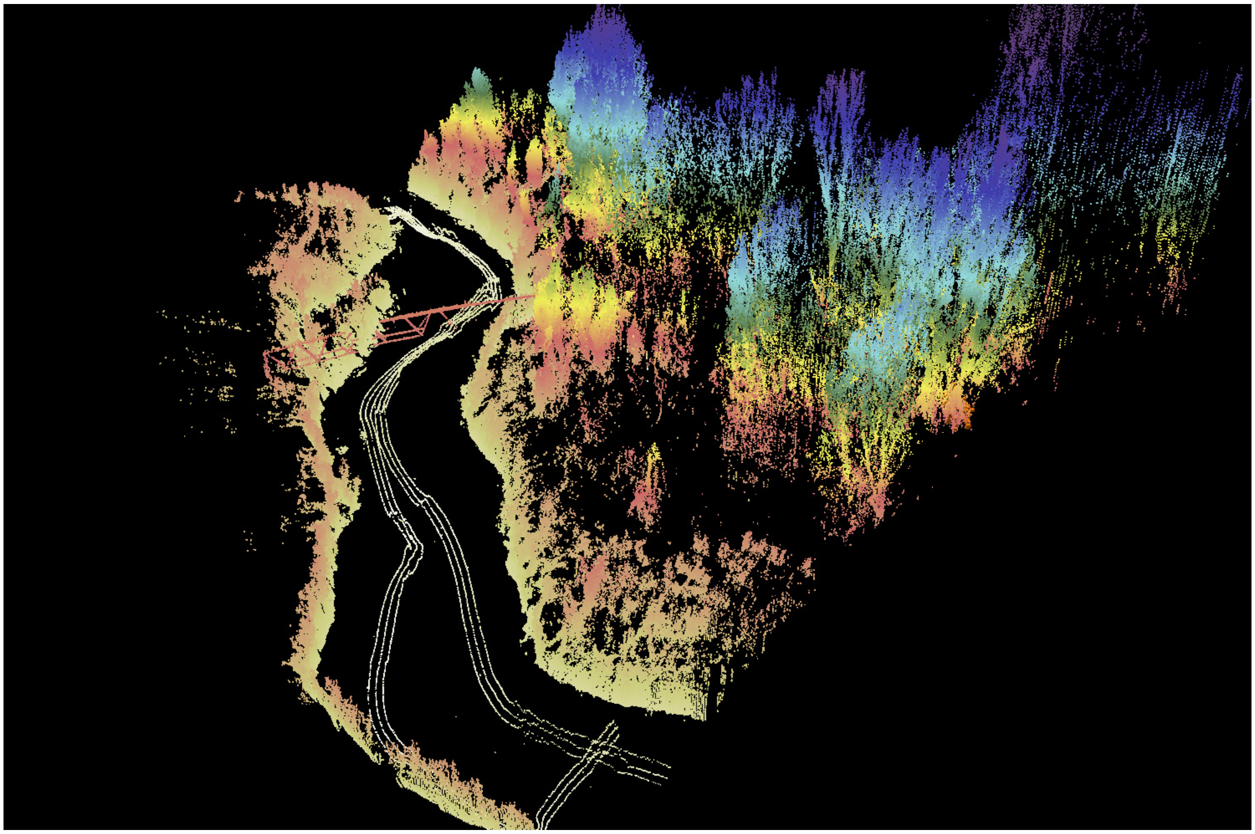


Figure C-2. Combined LiDAR and Sweep Sonar View of River Near Byerley Road Bridge

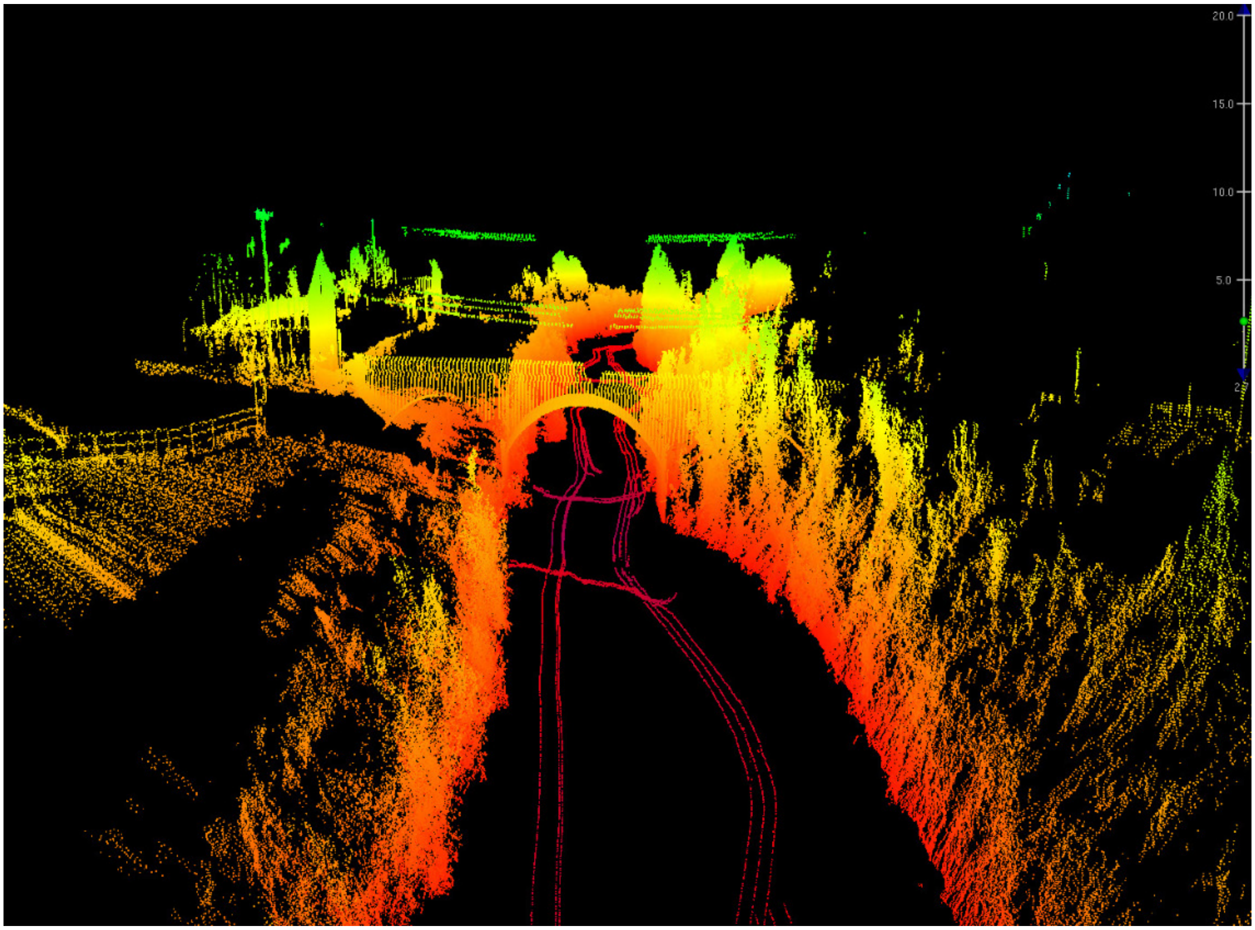
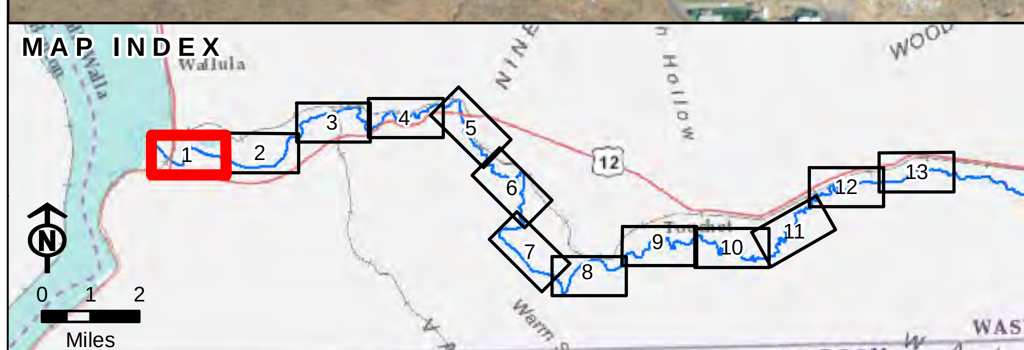


Figure C-3. Combined LiDAR and Sweep Sonar View of River Near Highway 12 Overpass

Appendix C – Map Series

Document Path: W:\194-4907 Lower Walla Walla River Geomorphic Assessment\5_GIS\maps\ReportMap_series_C1.mxd



▲ Control Point
● Butcher and Bower (2005) site (RM)
— Metrics Cross Section (RM)
× USGS River Mile
■ Photo Point
— Geomorphic Reach Break
✚ LWD Jam

Figure C-1
Survey Site Locations
Map 1 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

TETRA TECH

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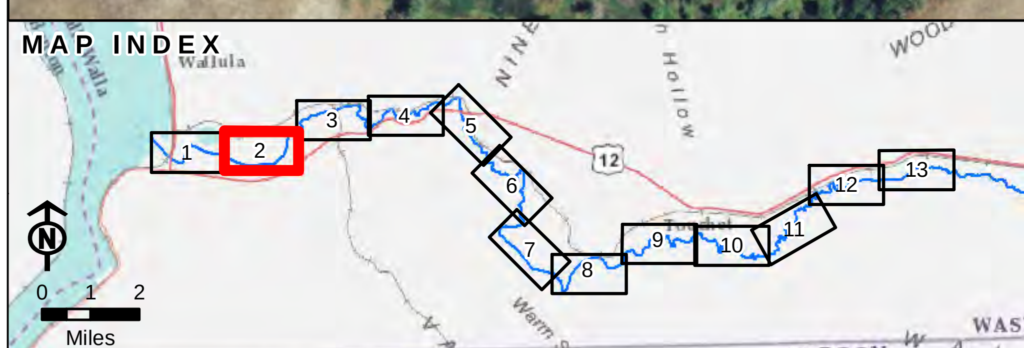


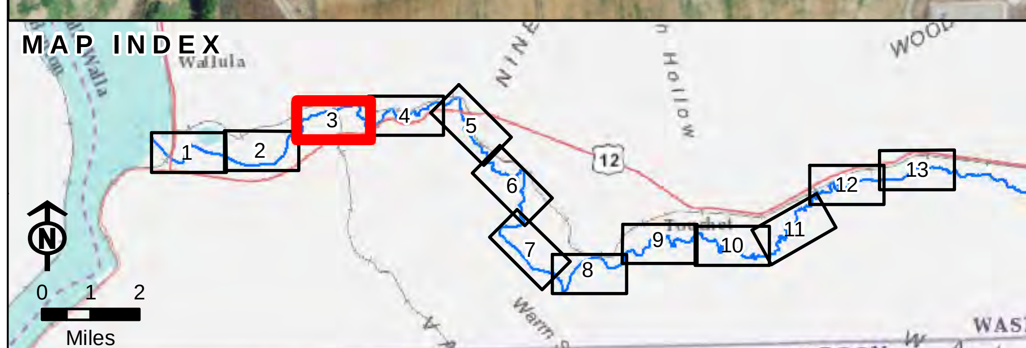
▲ Control Point
× USGS River Mile
● Butcher and Bower (2005) site (RM)
■ Photo Point
✚ LWD Jam
EMAP 1 Transect
Metrics Cross Section (RM)
Geomorphic Reach Break

Figure C-1
Survey Site Locations

Map 2 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

TETRA TECH

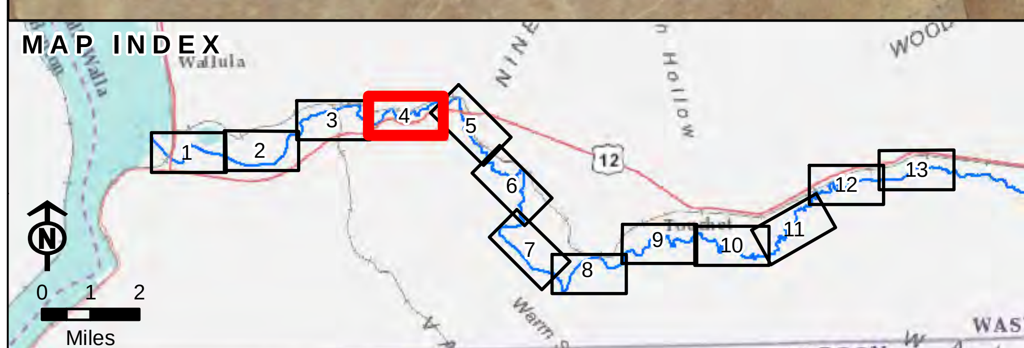


▲ Control Point
× USGS River Mile
● Butcher and Bower (2005) site (RM)
■ Photo Point
✚ LWD Jam
EMAP 1 Transect
Metrics Cross Section (RM)
Geomorphic Reach Break

Figure C-1
Survey Site Locations
Map 3 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

TETRA TECH



- ▲ Control Point
- × USGS River Mile
- ● Butcher and Bower (2005) site (RM)
- ■ Photo Point
- ✚ LWD Jam
- Metrics Cross Section (RM)
- Geomorphic Reach Break

Figure C-1
Survey Site Locations

Map 4 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

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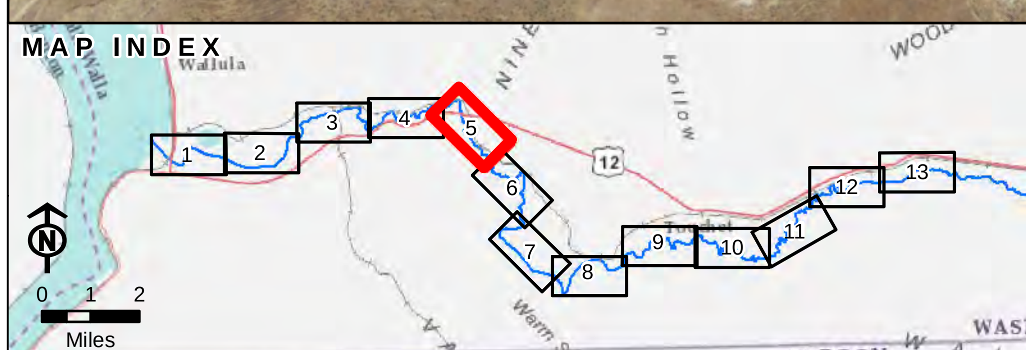


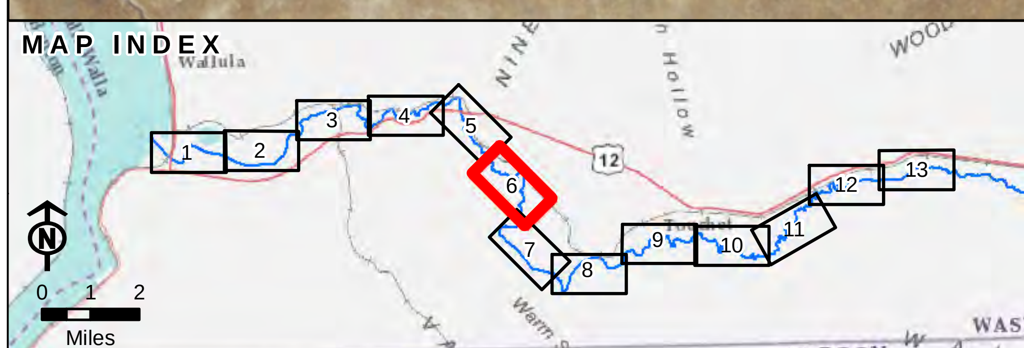
- Control Point
- USGS River Mile
- Butcher and Bower (2005) site (RM)
- Photo Point
- LWD Jam
- Metrics Cross Section (RM)
- Geomorphic Reach Break

Figure C-1
Survey Site Locations

Map 5 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

TETRA TECH



- ▲ Control Point
- × USGS River Mile
- ● Butcher and Bower (2005) site (RM)
- ■ Photo Point
- ✚ LWD Jam
- EMAP 2 Transect
- Metrics Cross Section (RM)
- Geomorphic Reach Break

Figure C-1
Survey Site Locations

Map 6 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

TETRA TECH

Control Point
USGS River Mile
Butcher and Bower (2005) site (RM)
Photo Point
LWD Jam
Metrics Cross Section (RM)
Geomorphic Reach Break

Figure C-1
Survey Site Locations
Map 7 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

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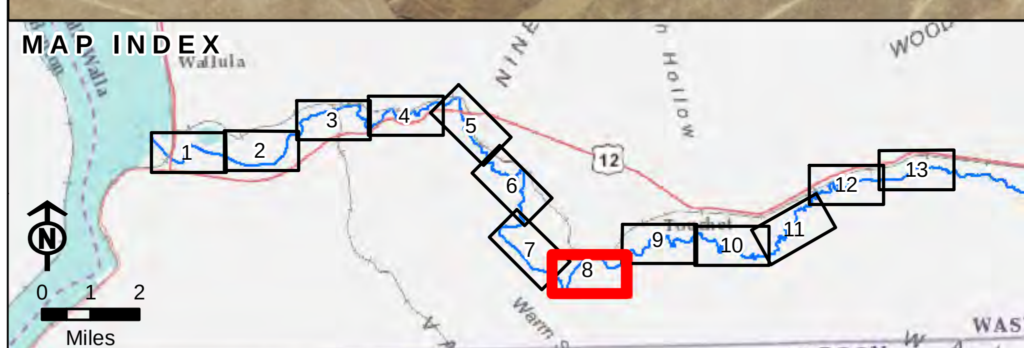

▲ Control Point	✕ USGS River Mile
● Butcher and Bower (2005) site (RM)	■ Photo Point
✚ LWD Jam	— Metrics Cross Section (RM)
— Geomorphic Reach Break	

Figure C-1
Survey Site Locations

Map 8 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

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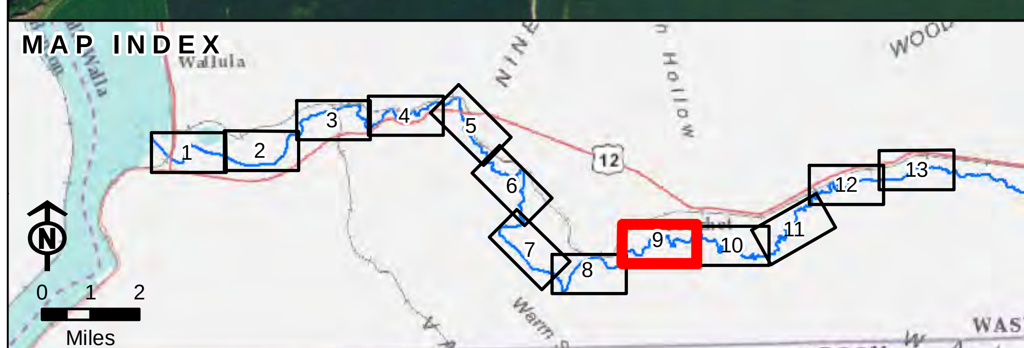

▲ Control Point	Butcher and Bower (2005) site (RM)	Metrics Cross Section (RM)
USGS River Mile	Photo Point	Geomorphic Reach Break
	LWD Jam	

Figure C-1
Survey Site Locations

Map 9 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

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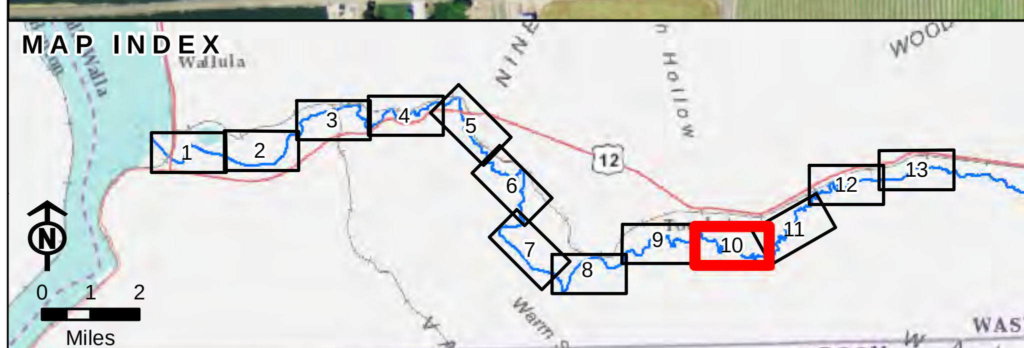

▲ Control Point
× USGS River Mile
● Butcher and Bower (2005) site (RM)
■ Photo Point
✚ LWD Jam
— EMAP 3 Transect
— Metrics Cross Section (RM)
— Geomorphic Reach Break

Figure C-1
Survey Site Locations
Map 10 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

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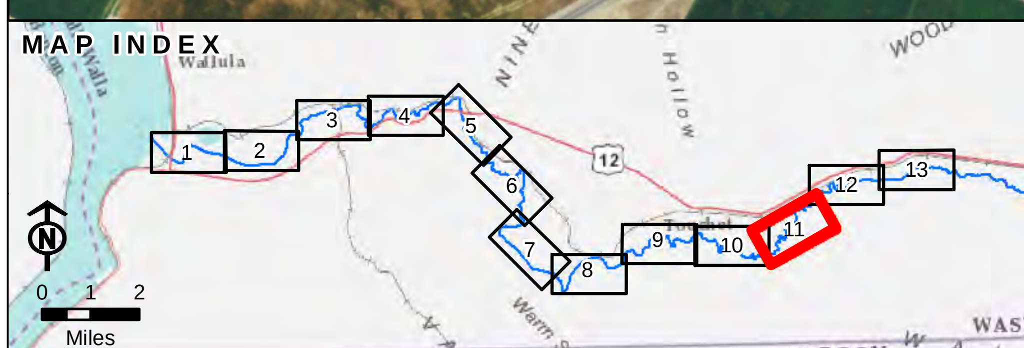
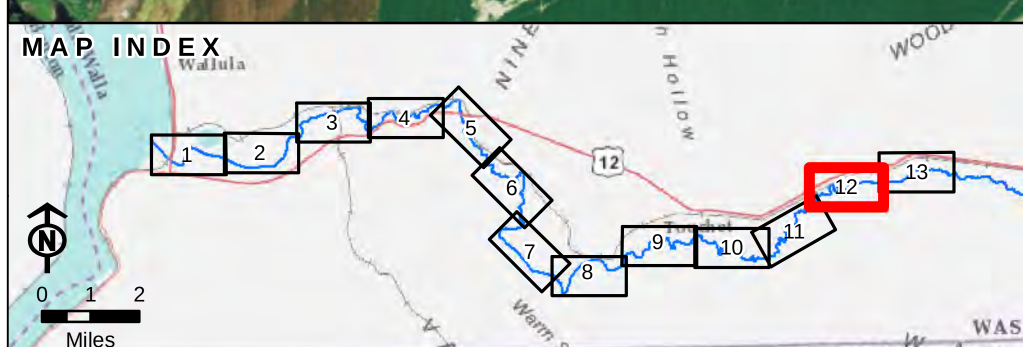


▲ Control Point	Butcher and Bower (2005) site (RM)	Metrics Cross Section (RM)
USGS River Mile	Photo Point	Geomorphic Reach Break
	LWD Jam	

Figure C-1
Survey Site Locations
Map 11 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

TETRA TECH



▲ Control Point
× USGS River Mile
● Butcher and Bower (2005) site (RM)
■ Photo Point
✚ LWD Jam
— Metrics Cross Section (RM)
— Geomorphic Reach Break
— EMAP 4 Transect

Figure C-1
Survey Site Locations
Map 12 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

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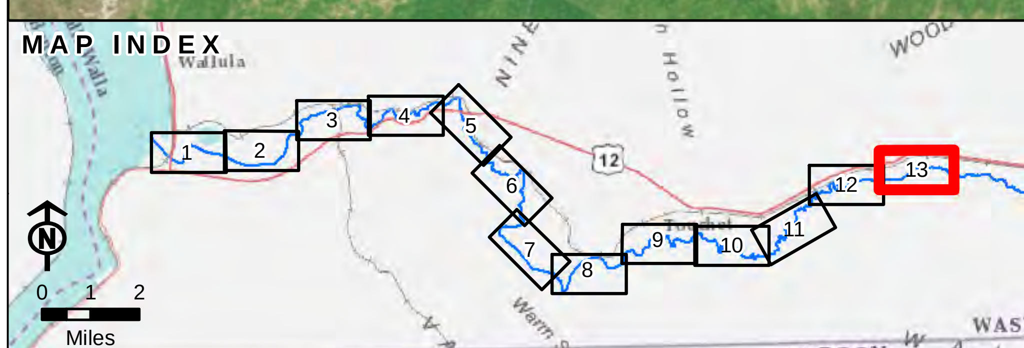

Control Point
USGS River Mile
Butcher and Bower (2005) site (RM)
Photo Point
LWD Jam
EMAP 4 Transect
Metrics Cross Section (RM)
Geomorphic Reach Break

Figure C-1
Survey Site Locations

Map 13 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

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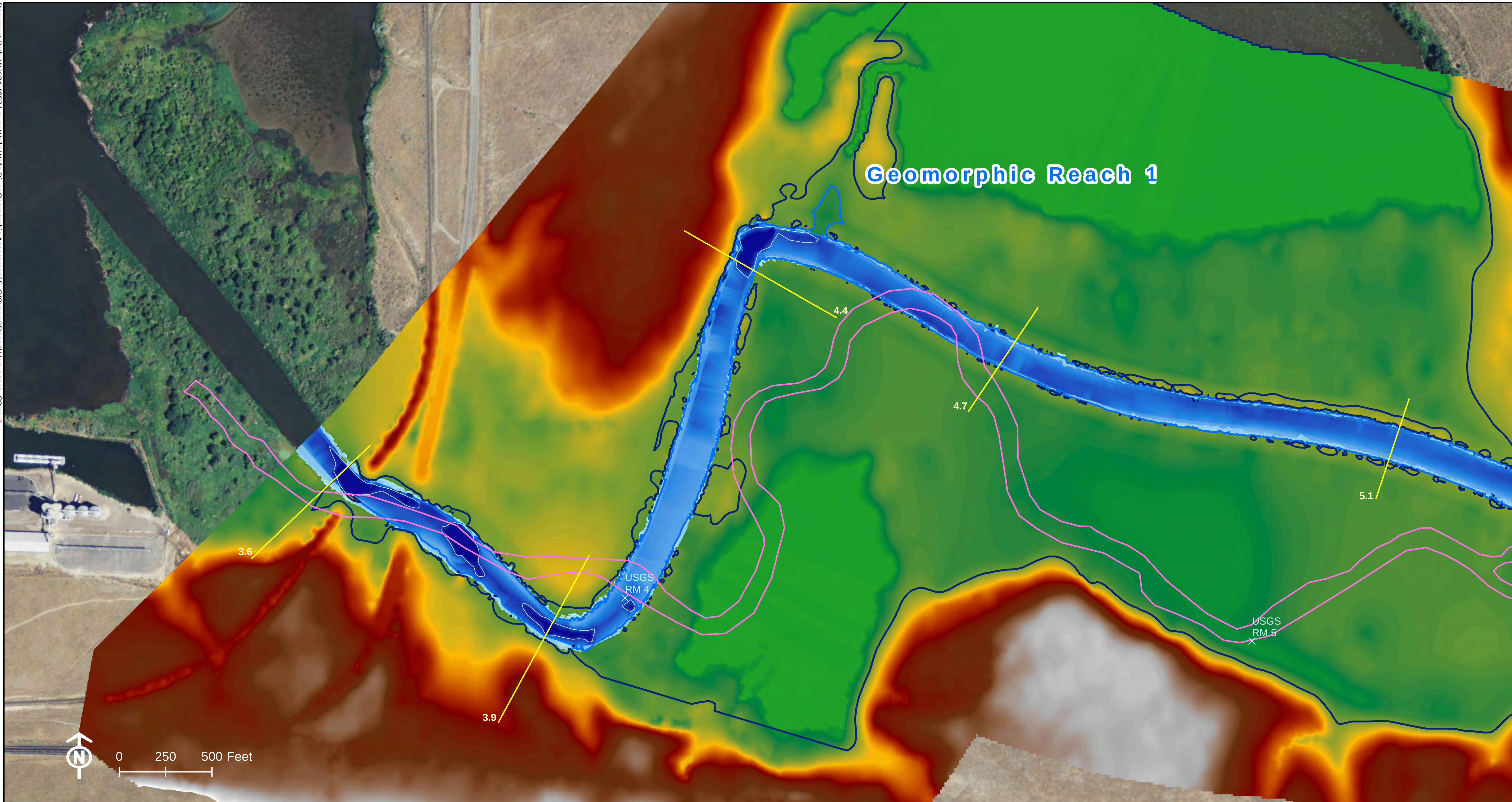
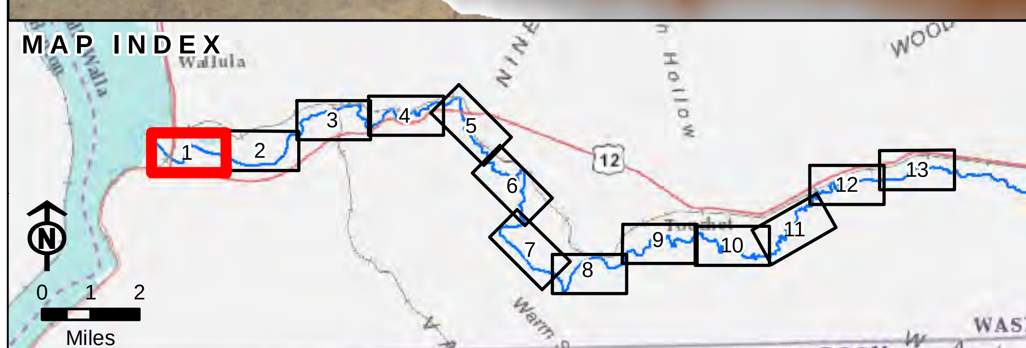




USGS River Mile

LWD Jam

Pool

5-Year Inundation Boundary

2-Year Inundation Boundary

1939 Channel

Metrics Cross Section (RM)

Geomorphic Reach Break

Detrend DEM* 199 – 35

Bankfull Depth** 28 – 0

*The detrended DEM contains elevation values relative to the water surface at the time of Survey

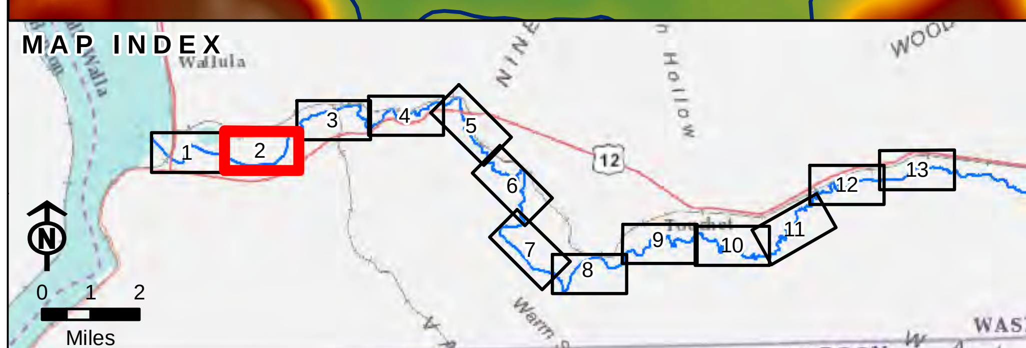
**Bankfull elevation was determined from field observations and analysis of channel geometry

Figure C-2
Combined Topographic Survey and Assessment

Map 1 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

TETRA TECH



USGS River Mile
LWD Jam
Pool
5-Year Inundation Boundary
2-Year Inundation Boundary
1939 Channel
Metrics Cross Section (RM)
Geomorphic Reach Break

Detrend DEM* 199 – 35

Bankfull Depth** 28 – 0

*The detrended DEM contains elevation values relative to the water surface at the time of Survey

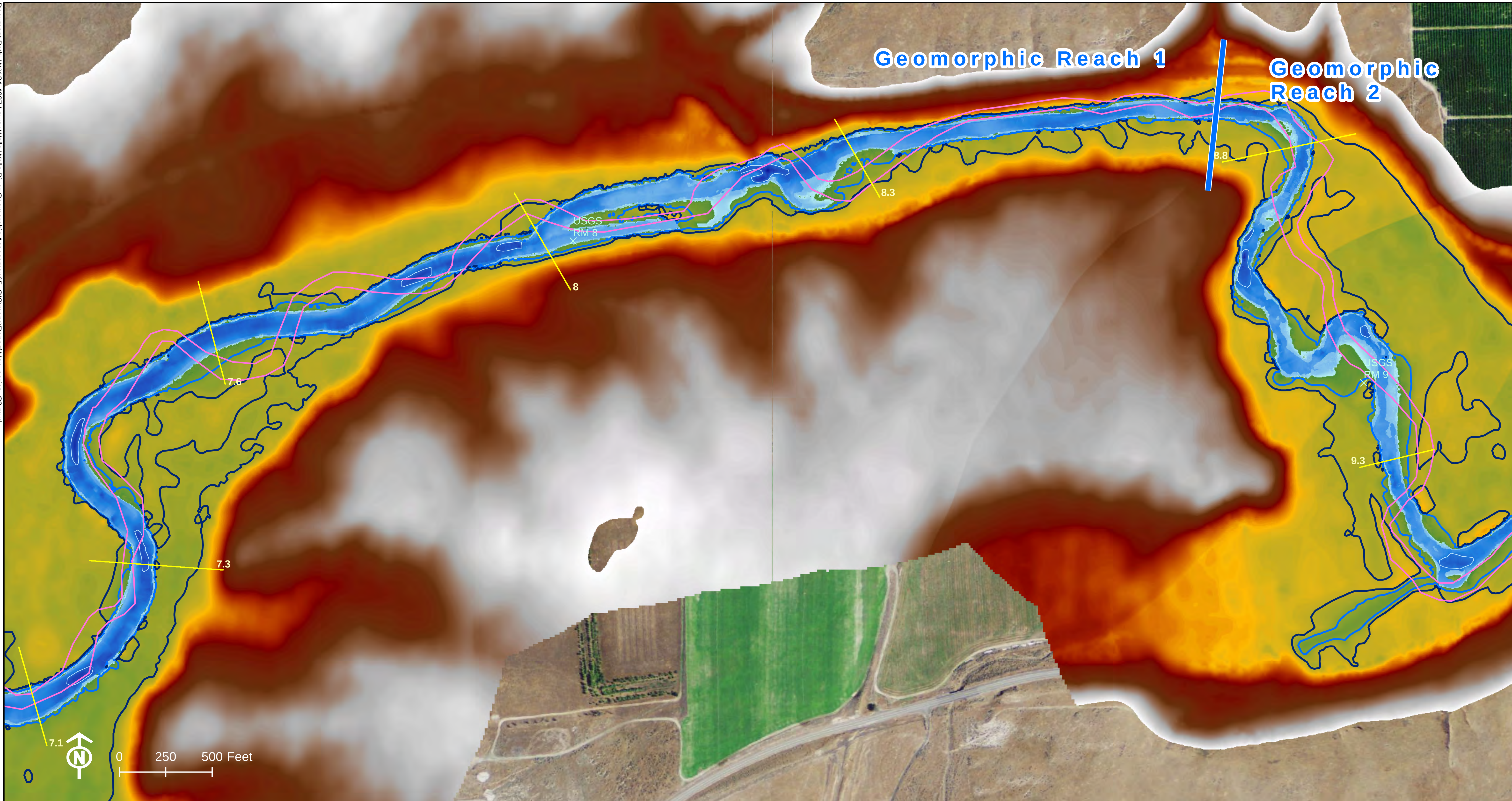
**Bankfull elevation was determined from field observations and analysis of channel geometry

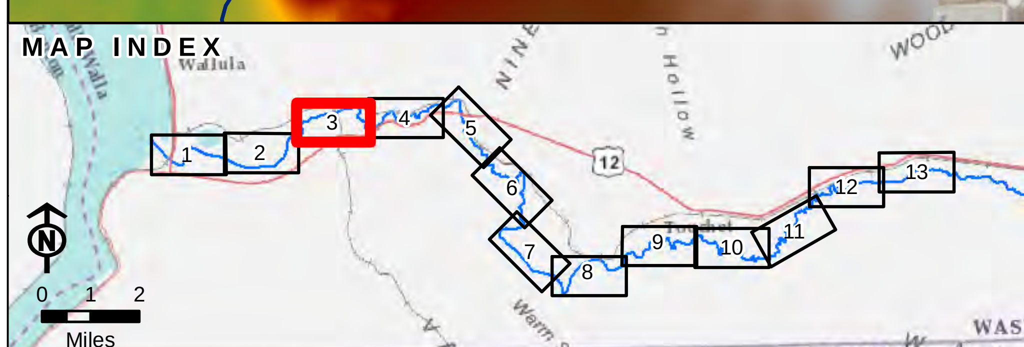
Figure C-2
Combined Topographic Survey and Assessment

Map 2 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

TETRA TECH





USGS River Mile
LWD Jam
Pool
5-Year Inundation Boundary
2-Year Inundation Boundary
1939 Channel
Metrics Cross Section (RM)
Geomorphic Reach Break

Detrend DEM*: 199 – 35
Bankfull Depth**: 28 – 0

*The detrended DEM contains elevation values relative to the water surface at the time of Survey

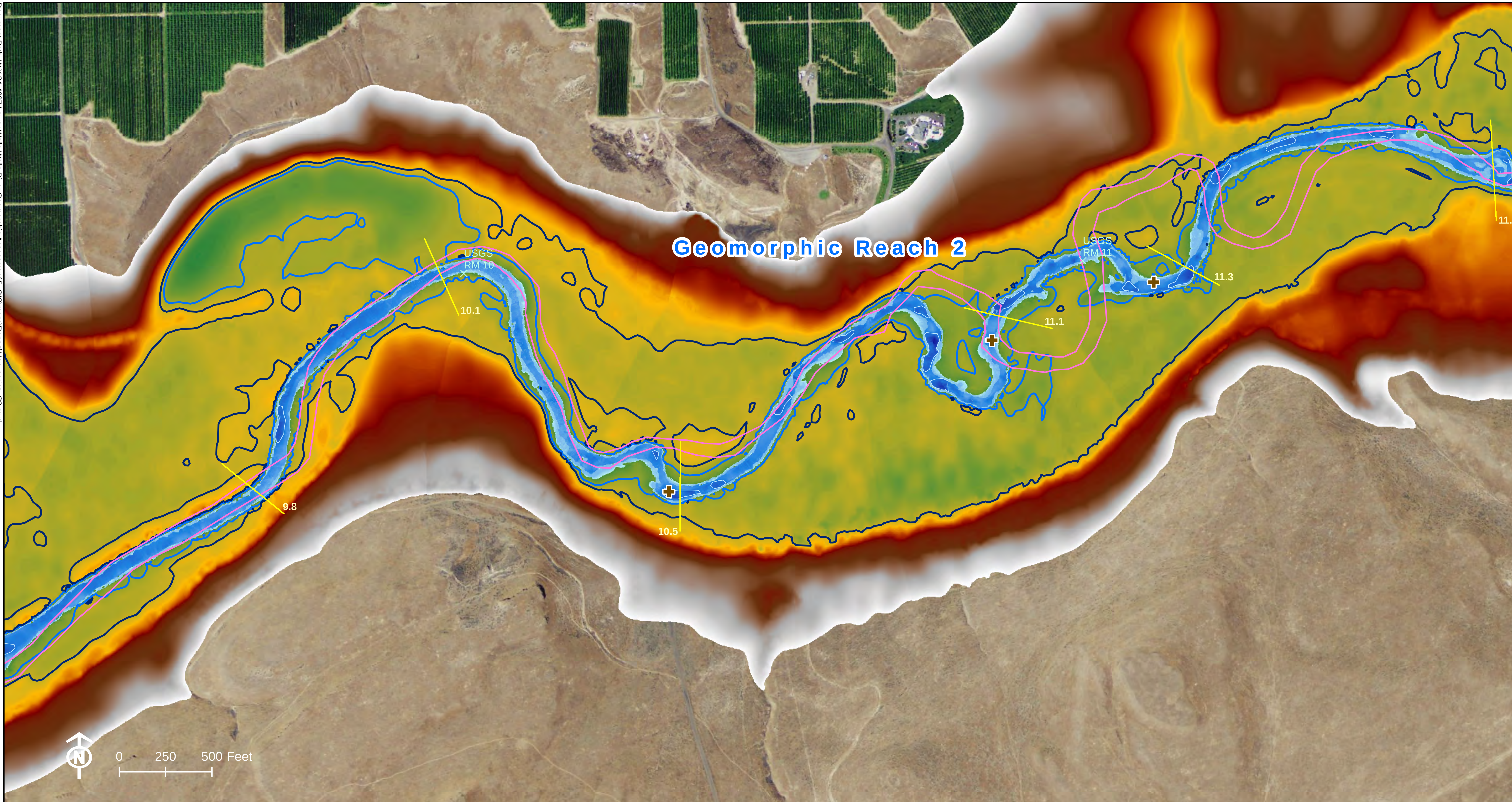
**Bankfull elevation was determined from field observations and analysis of channel geometry

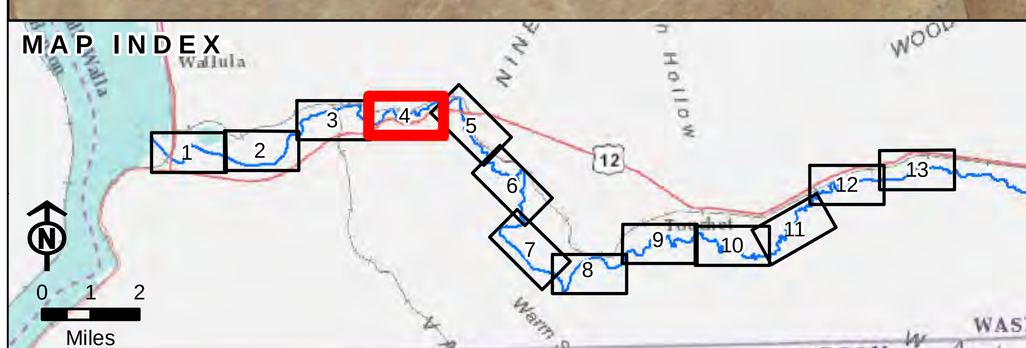
Figure C-2
Combined Topographic Survey and Assessment

Map 3 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

TETRA TECH





USGS River Mile	Pool
LWD Jam	5-Year Inundation Boundary
	2-Year Inundation Boundary
	1939 Channel

Metrics Cross Section (RM)
Geomorphic Reach Break

Detrend DEM* 199 – 35
Bankfull Depth** 28 – 0

*The detrended DEM contains elevation values relative to the water surface at the time of Survey

**Bankfull elevation was determined from field observations and analysis of channel geometry

Figure C-2
Combined Topographic Survey and Assessment

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Lower Walla Walla
Geomorphic Assessment and Action Plan

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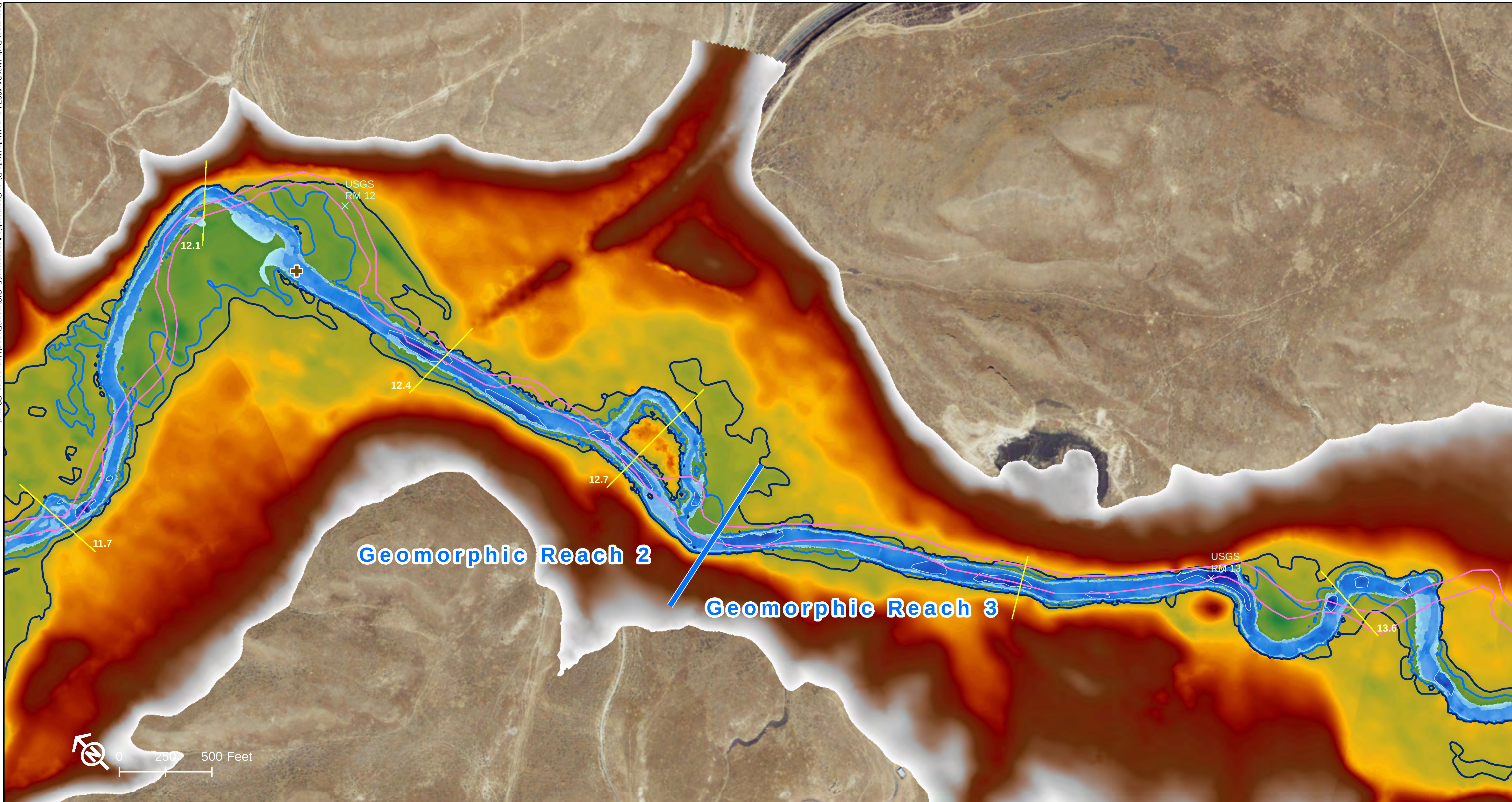

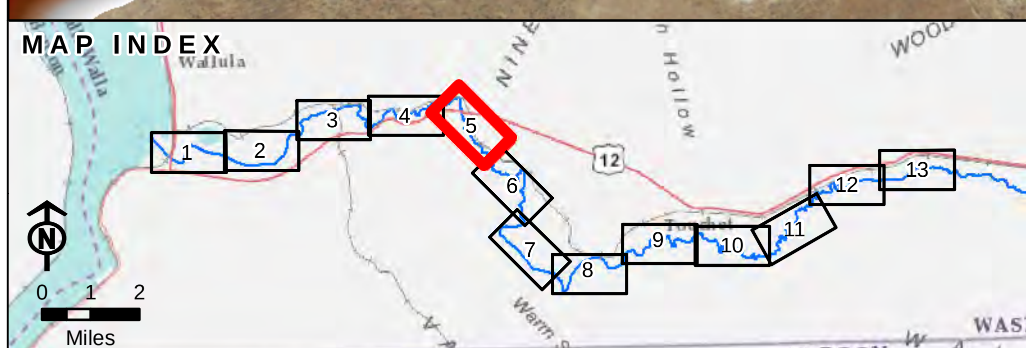

USGS River Mile
LWD Jam
Pool
5-Year Inundation Boundary
2-Year Inundation Boundary
1939 Channel
Metrics Cross Section (RM)
Geomorphic Reach Break

Detrend DEM*: 199 – 35
Bankfull Depth**: 28 – 0

*The detrended DEM contains elevation values relative to the water surface at the time of Survey

**Bankfull elevation was determined from field observations and analysis of channel geometry

Figure C-2
Combined Topographic Survey and Assessment

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Lower Walla Walla
Geomorphic Assessment and Action Plan

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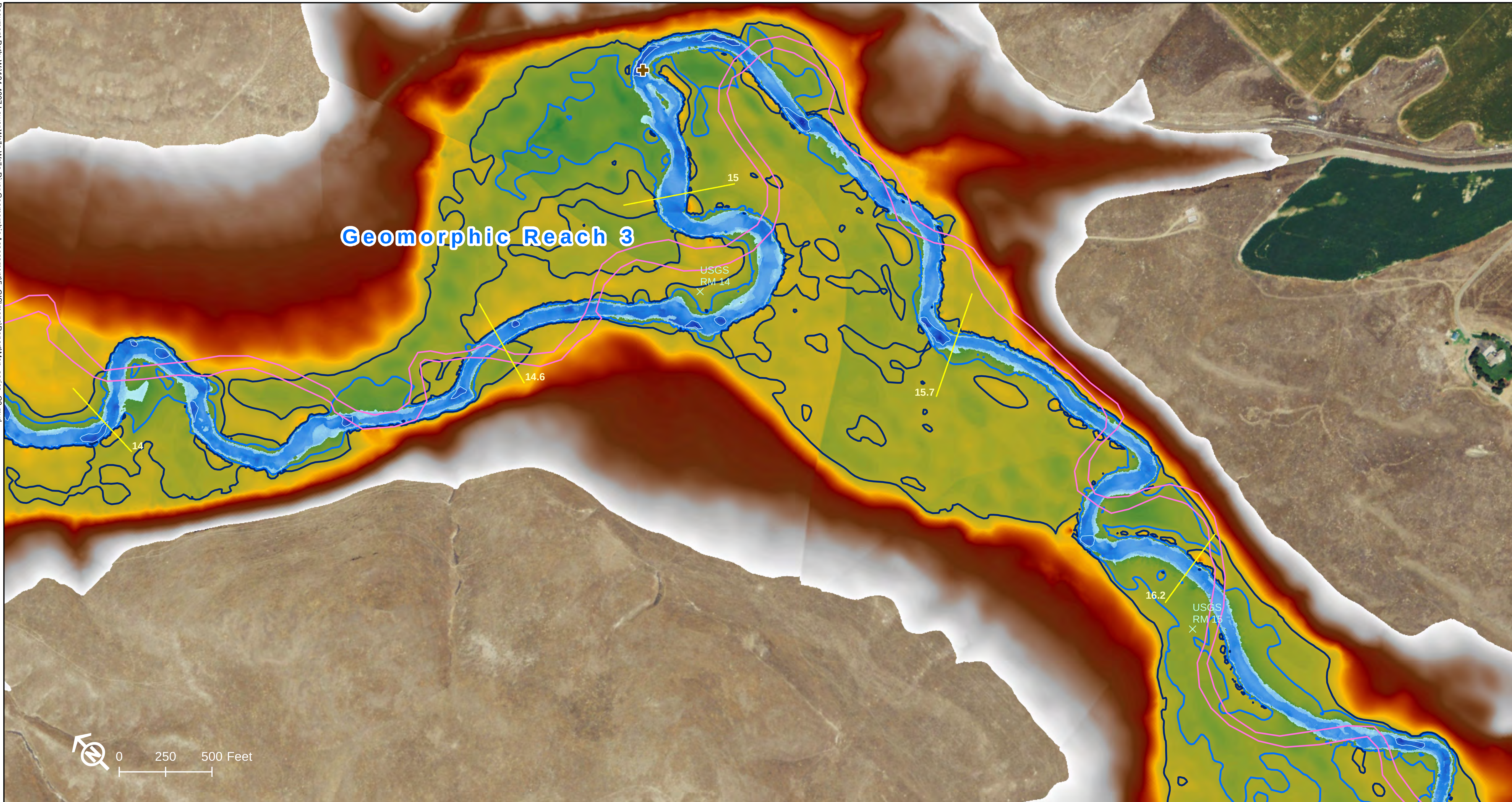

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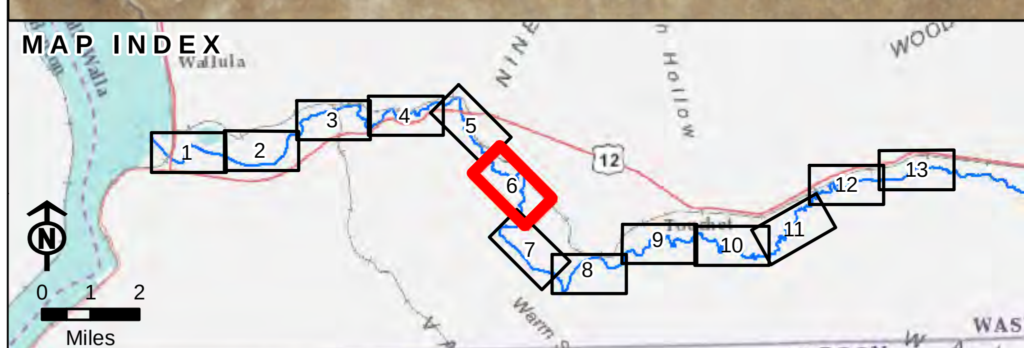

USGS River Mile

LWD Jam

Pool

5-Year Inundation Boundary

2-Year Inundation Boundary

1939 Channel

Metrics Cross Section (RM)

Geomorphic Reach Break

Detrend DEM* 199 35

Bankfull Depth** 28 0

*The detrended DEM contains elevation values relative to the water surface at the time of Survey

**Bankfull elevation was determined from field observations and analysis of channel geometry

Figure C-2
Combined Topographic Survey and Assessment

Map 6 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

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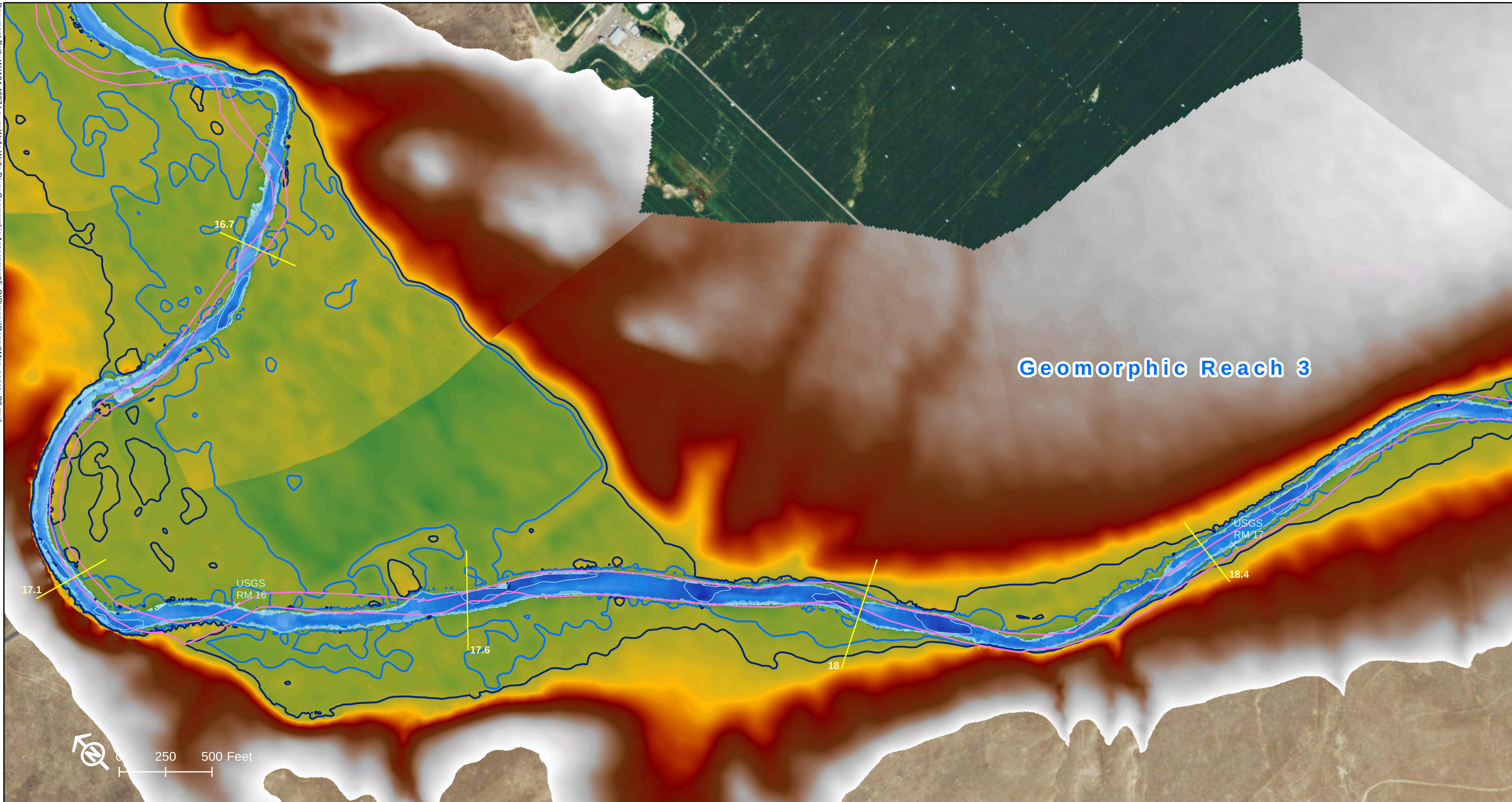

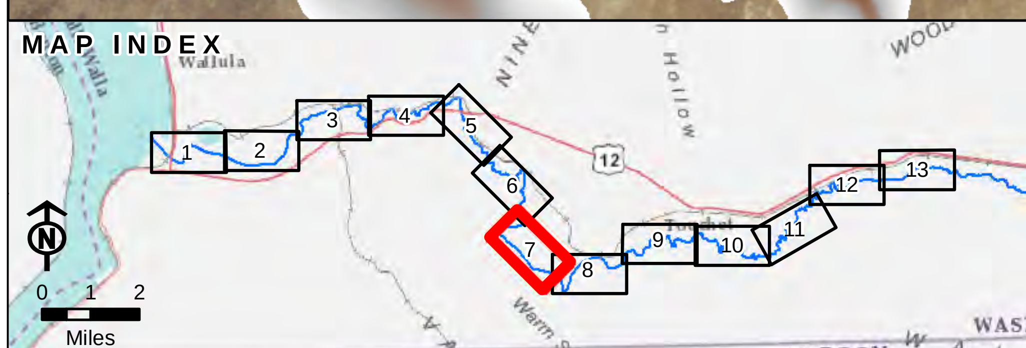

USGS River Mile
LWD Jam
Pool
5-Year Inundation Boundary
2-Year Inundation Boundary
1939 Channel
Metrics Cross Section (RM)
Geomorphic Reach Break

Detrend DEM*: 199 – 35
Bankfull Depth**: 28 – 0

*The detrended DEM contains elevation values relative to the water surface at the time of Survey

**Bankfull elevation was determined from field observations and analysis of channel geometry

Figure C-2
Combined Topographic Survey and Assessment
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Lower Walla Walla
Geomorphic Assessment and Action Plan

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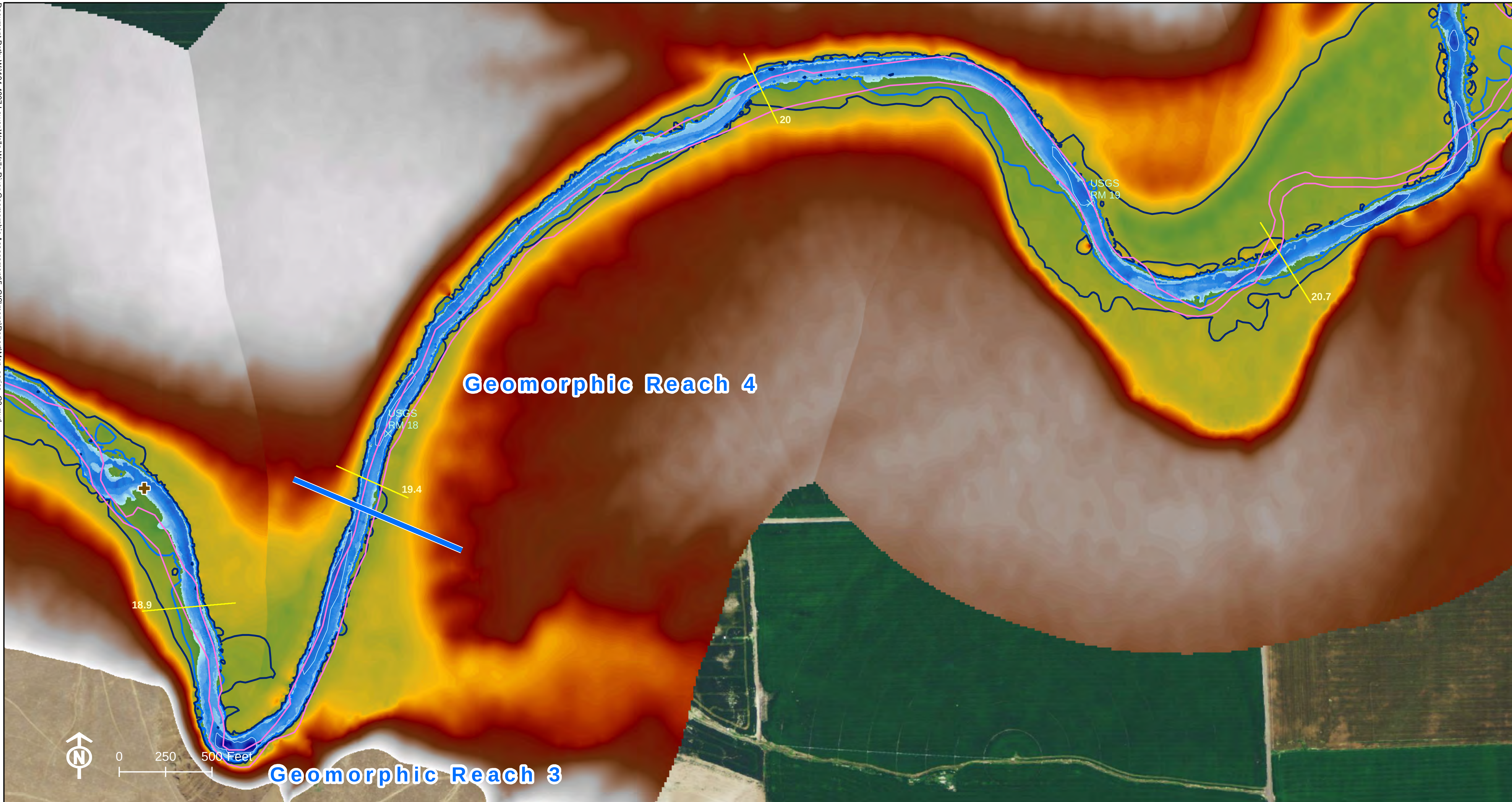

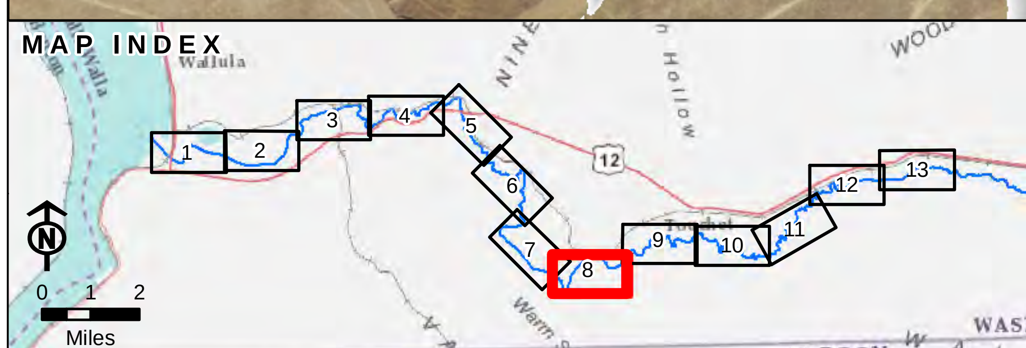

USGS River Mile
LWD Jam
Pool
5-Year Inundation Boundary
2-Year Inundation Boundary
1939 Channel
Metrics Cross Section (RM)
Geomorphic Reach Break

Detrend DEM* 199 – 35

Bankfull Depth** 28 – 0

*The detrended DEM contains elevation values relative to the water surface at the time of Survey

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Figure C-2
Combined Topographic Survey and Assessment

Lower Walla Walla
Geomorphic Assessment and Action Plan

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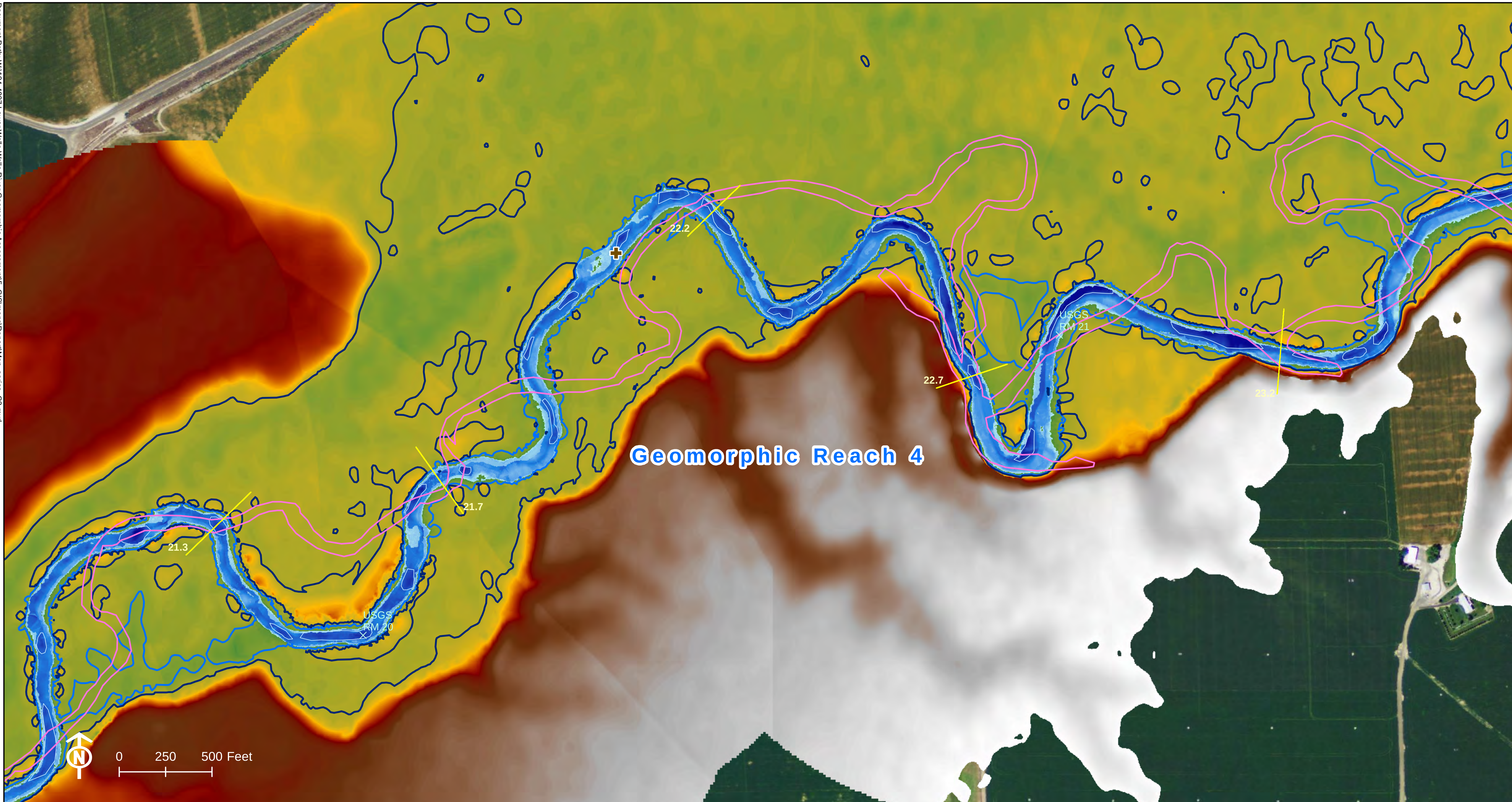

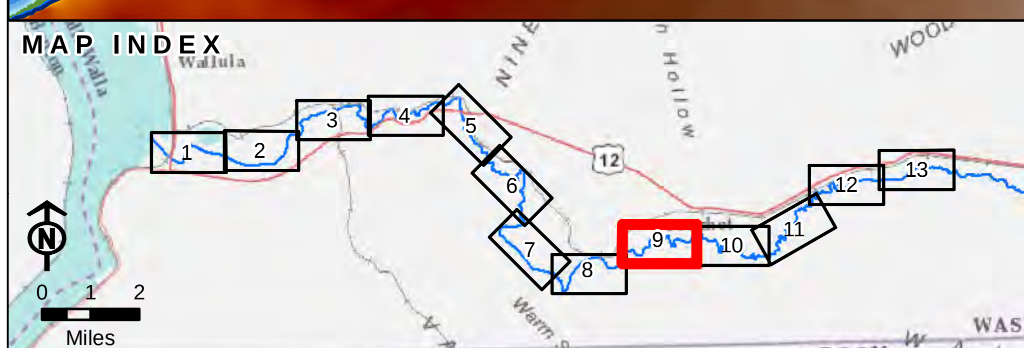

USGS River Mile
LWD Jam
Pool
5-Year Inundation Boundary
2-Year Inundation Boundary
1939 Channel
Metrics Cross Section (RM)
Geomorphic Reach Break

Detrend DEM*: 199 – 35
Bankfull Depth**: 28 – 0

*The detrended DEM contains elevation values relative to the water surface at the time of Survey

**Bankfull elevation was determined from field observations and analysis of channel geometry

Figure C-2
Combined Topographic Survey and Assessment
Map 9 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

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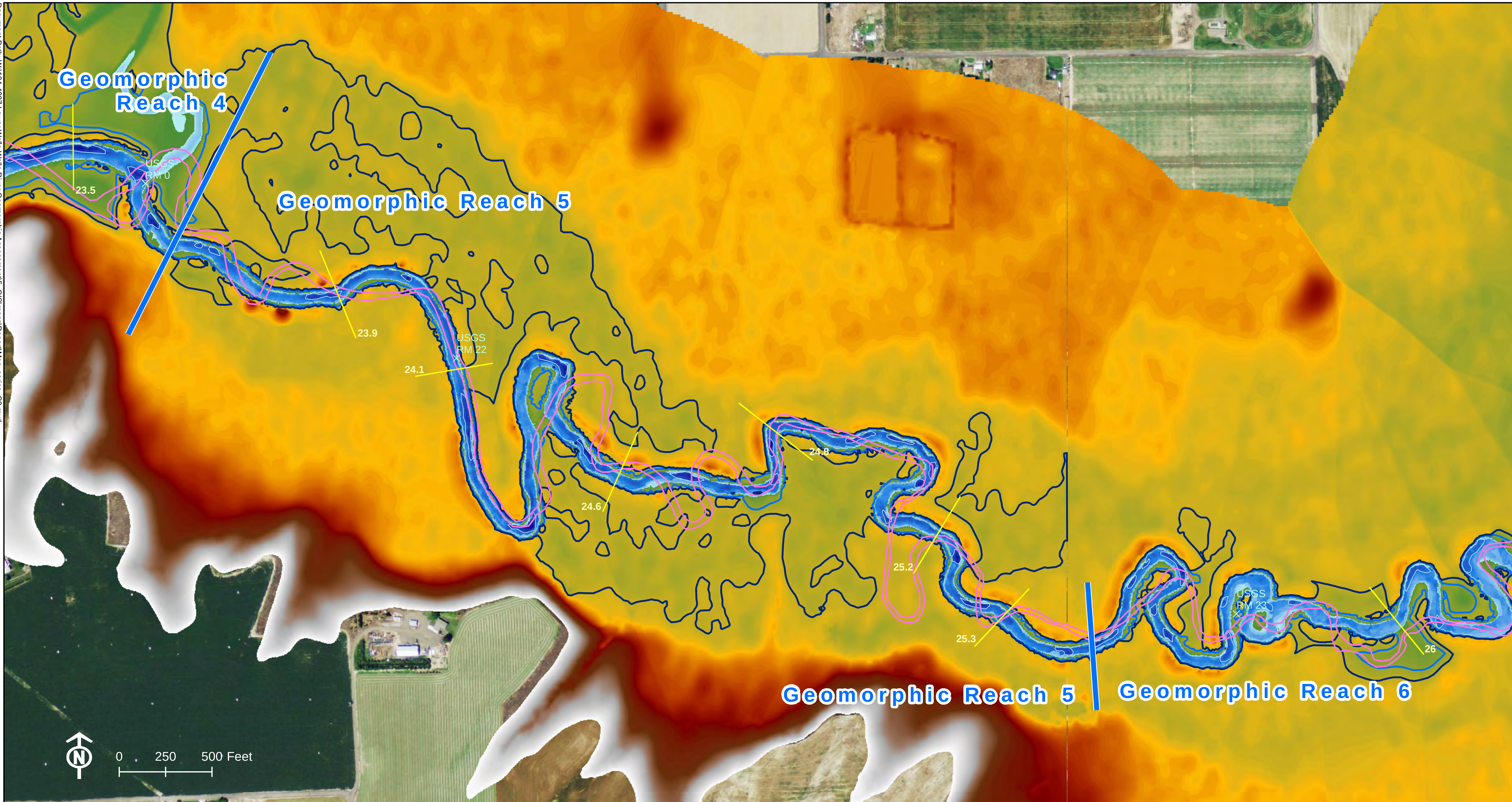

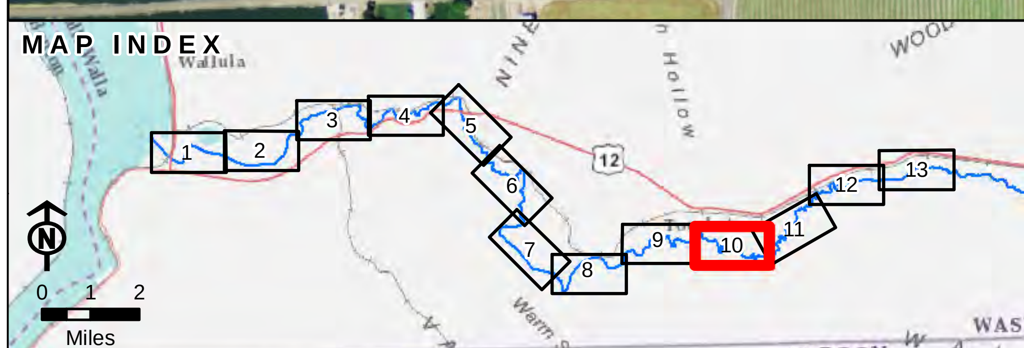

USGS River Mile
LWD Jam
Pool
5-Year Inundation Boundary
2-Year Inundation Boundary
1939 Channel
Metrics Cross Section (RM)
Geomorphic Reach Break

Detrend DEM*
199
35

Bankfull Depth**
28
0

*The detrended DEM contains elevation values relative to the water surface at the time of Survey

**Bankfull elevation was determined from field observations and analysis of channel geometry

Figure C-2
Combined Topographic Survey and Assessment
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Lower Walla Walla
Geomorphic Assessment and Action Plan

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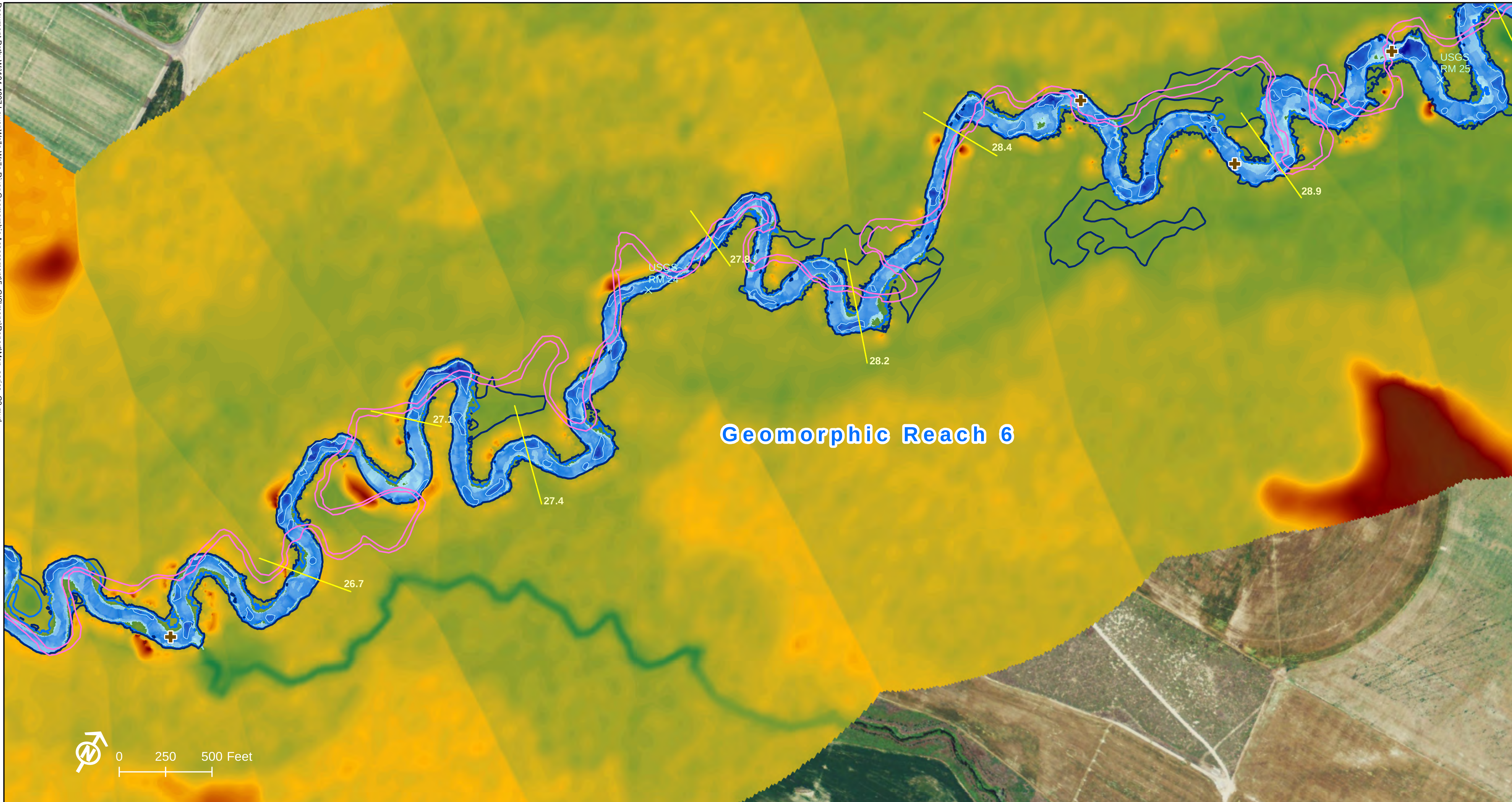

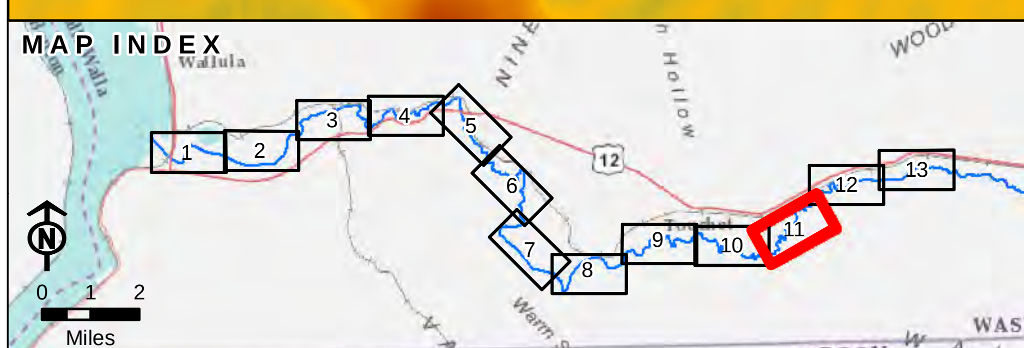

USGS River Mile
LWD Jam
Pool
5-Year Inundation Boundary
2-Year Inundation Boundary
1939 Channel
Metrics Cross Section (RM)
Geomorphic Reach Break

Detrend DEM*: 199 – 35

Bankfull Depth**: 28 – 0

*The detrended DEM contains elevation values relative to the water surface at the time of Survey

**Bankfull elevation was determined from field observations and analysis of channel geometry

Figure C-2
Combined Topographic Survey and Assessment

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Lower Walla Walla
Geomorphic Assessment and Action Plan

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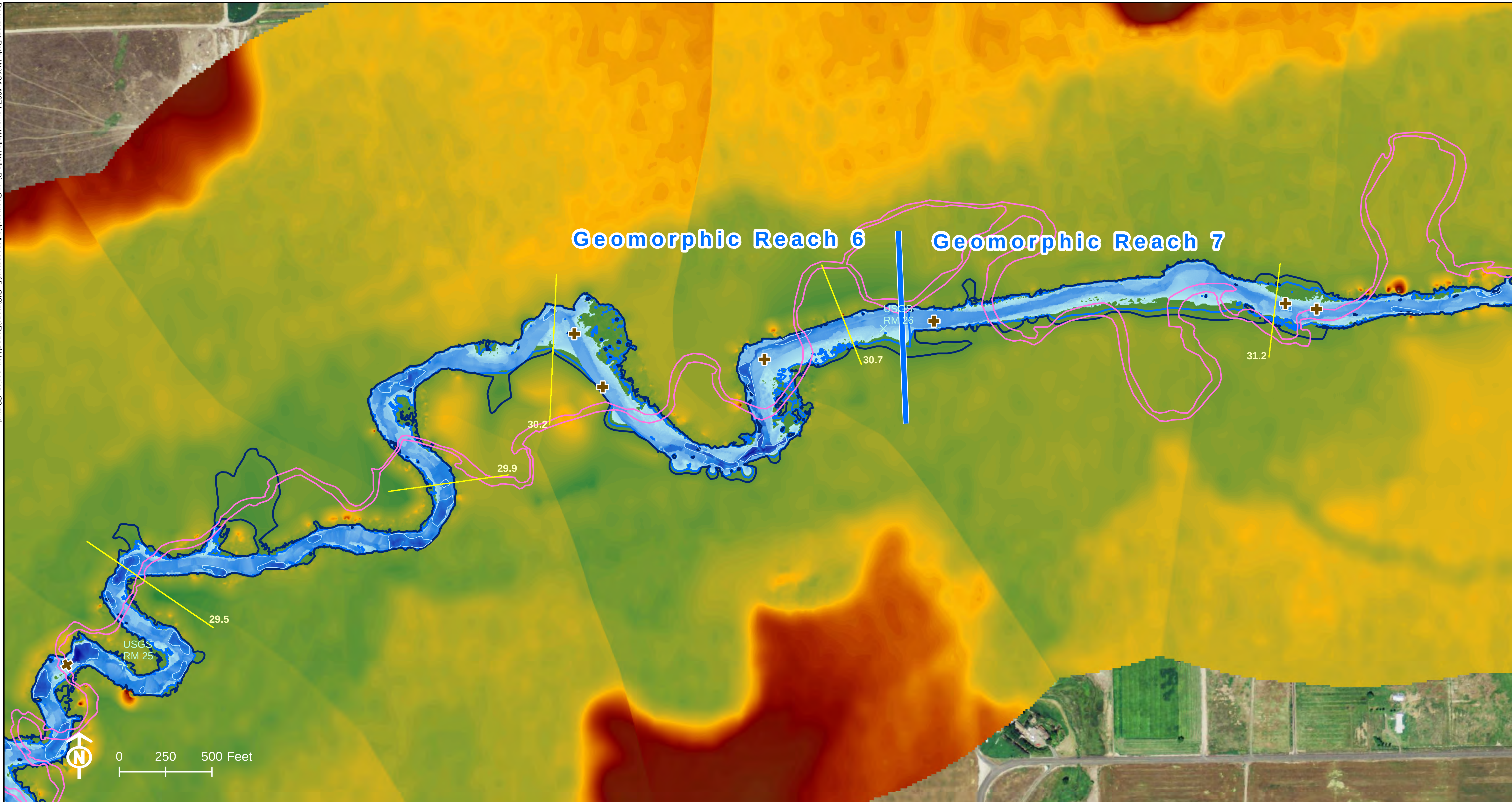

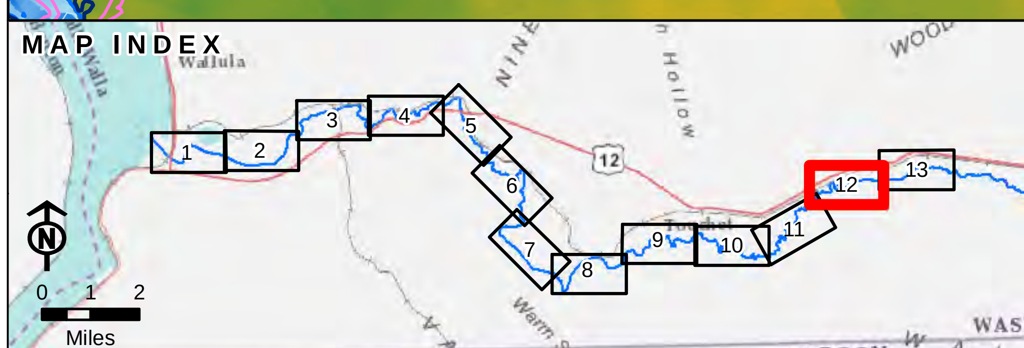

USGS River Mile
LWD Jam
Pool
5-Year Inundation Boundary
2-Year Inundation Boundary
1939 Channel
Metrics Cross Section (RM)
Geomorphic Reach Break

Detrend DEM* 199 – 35
Bankfull Depth** 28 – 0

*The detrended DEM contains elevation values relative to the water surface at the time of Survey

**Bankfull elevation was determined from field observations and analysis of channel geometry

Figure C-2
Combined Topographic Survey and Assessment

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Lower Walla Walla
Geomorphic Assessment and Action Plan

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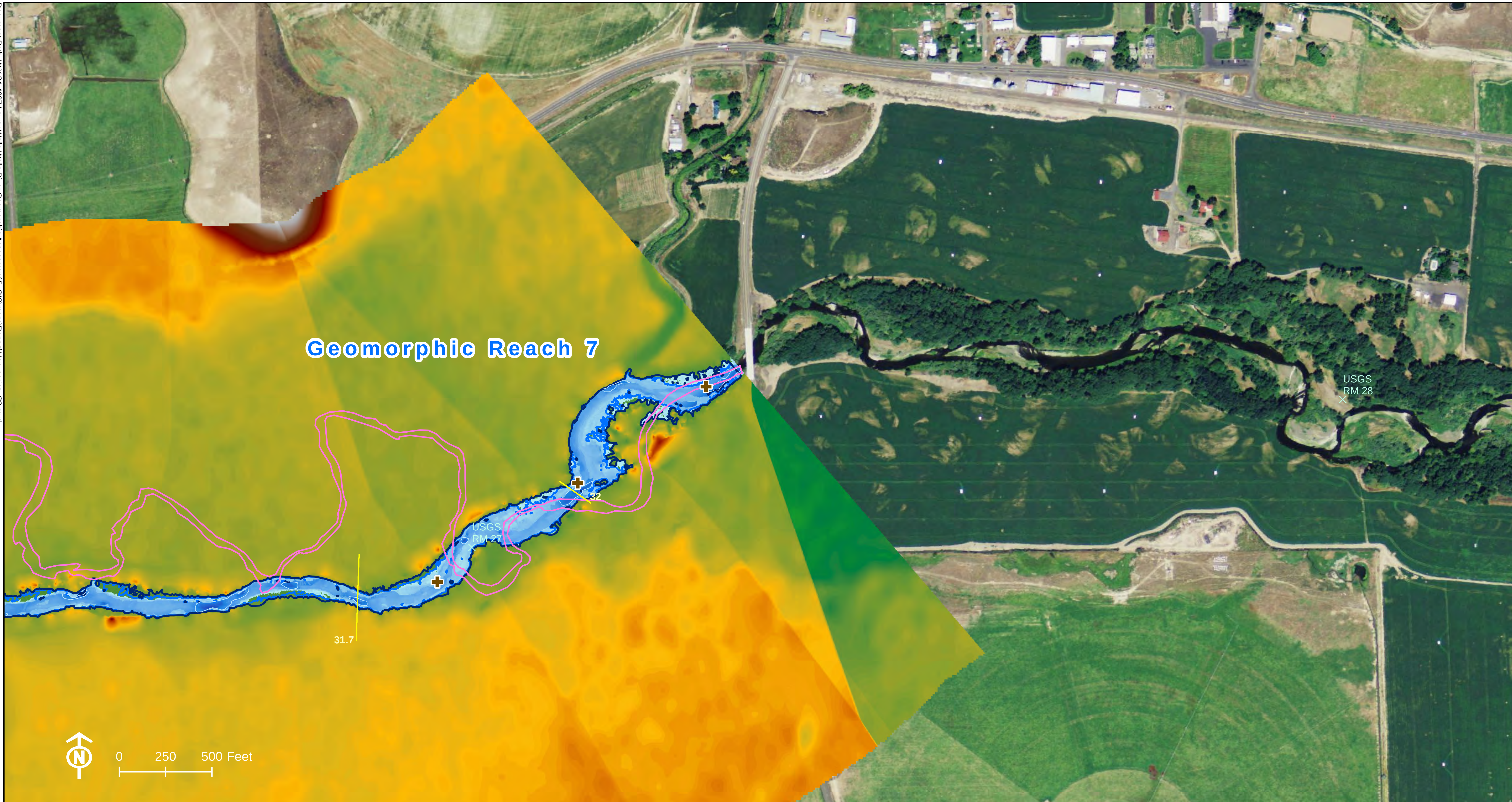

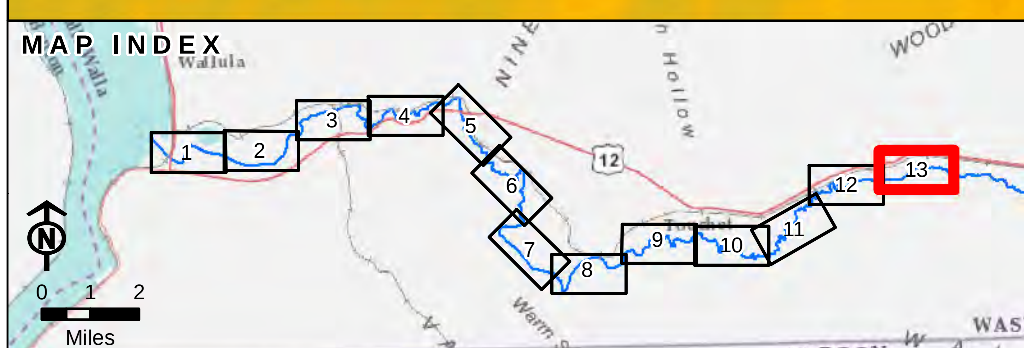

USGS River Mile
LWD Jam
Pool
5-Year Inundation Boundary
2-Year Inundation Boundary
1939 Channel
Metrics Cross Section (RM)
Geomorphic Reach Break

Detrend DEM*
199
35

Bankfull Depth**
28
0

*The detrended DEM contains elevation values relative to the water surface at the time of Survey

**Bankfull elevation was determined from field observations and analysis of channel geometry

Figure C-2
Combined Topographic Survey and Assessment

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Lower Walla Walla
Geomorphic Assessment and Action Plan

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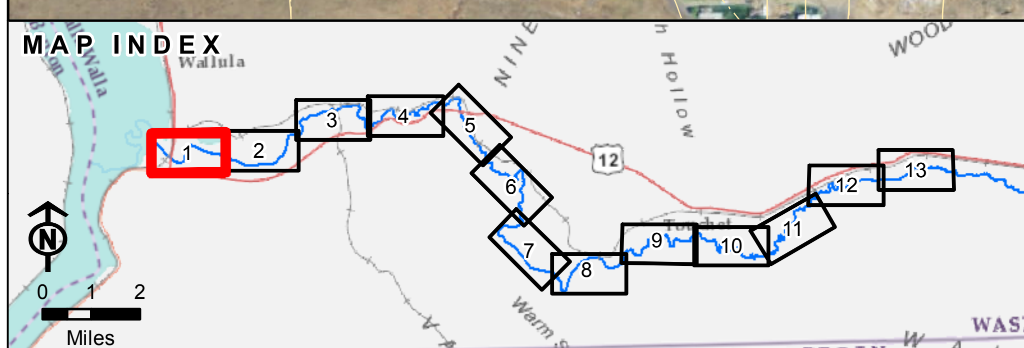

BSR Break
Project Area Break
USGS River Mile
Control Point
Design Category Boundary
Taxlot Boundary

Project Area Rank
- Tier I
- Tier II
- Tier III

Figure C-3
Project Areas and Conceptual Design Categories
Map 1 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

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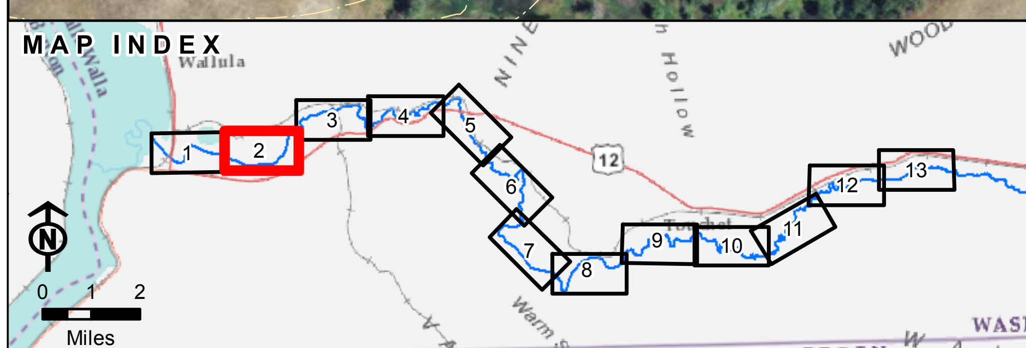

BSR Break
Project Area Break
USGS River Mile
Control Point

Design Category Boundary
Taxlot Boundary

Project Area Rank
- Tier I
- Tier II
- Tier III

Figure C-3
Project Areas and Conceptual Design Categories

Map 2 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

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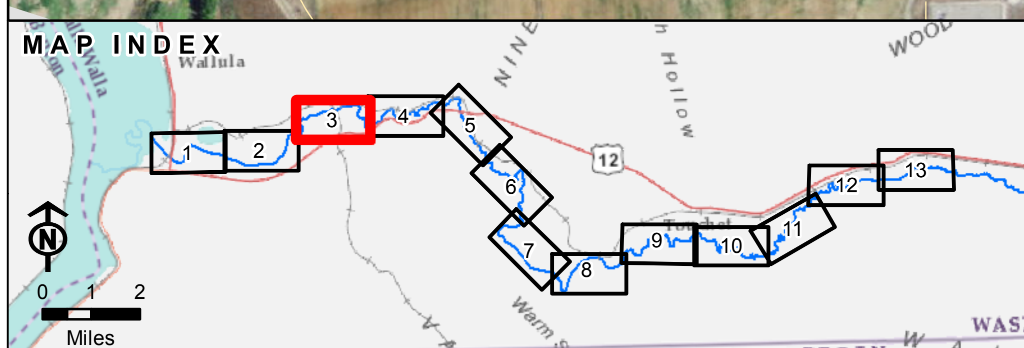

BSR Break
Project Area Break
USGS River Mile
Control Point
Design Category Boundary
Taxlot Boundary

Project Area Rank
- Tier I
- Tier II
- Tier III

Figure C-3
Project Areas and Conceptual Design Categories
Map 3 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

TETRA TECH

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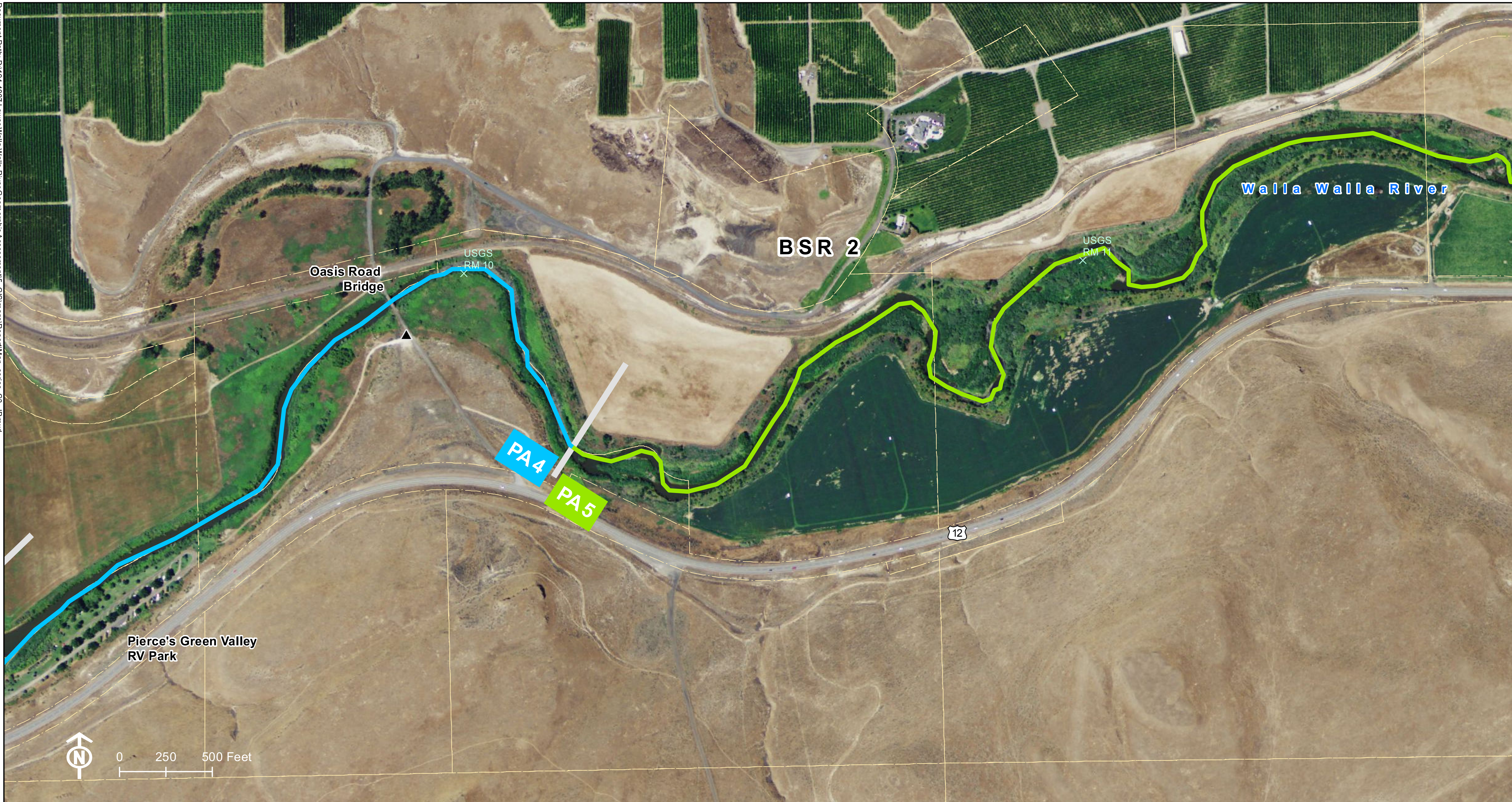

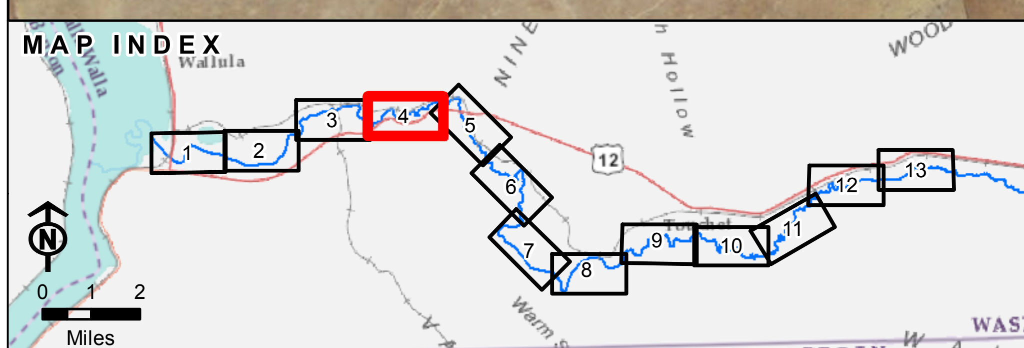

BSR Break

Project Area Break

USGS River Mile

Control Point

Design Category Boundary

Taxlot Boundary

Project Area Rank

Tier I

Tier II

Tier III

Figure C-3

Project Areas and Conceptual Design Categories

Map 4 of 13

Lower Walla Walla Geomorphic Assessment and Action Plan

TETRA TECH

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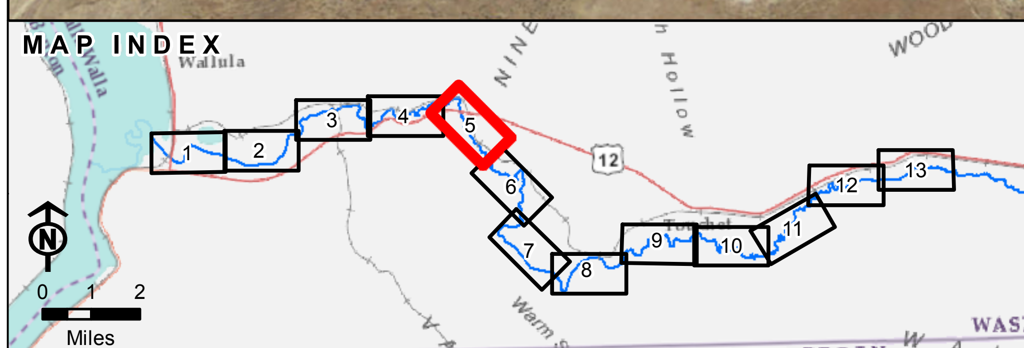


BSR Break

Project Area Break

USGS River Mile

Control Point

Design Category Boundary

Taxlot Boundary

Project Area Rank

Tier I

Tier II

Tier III

Figure C-3

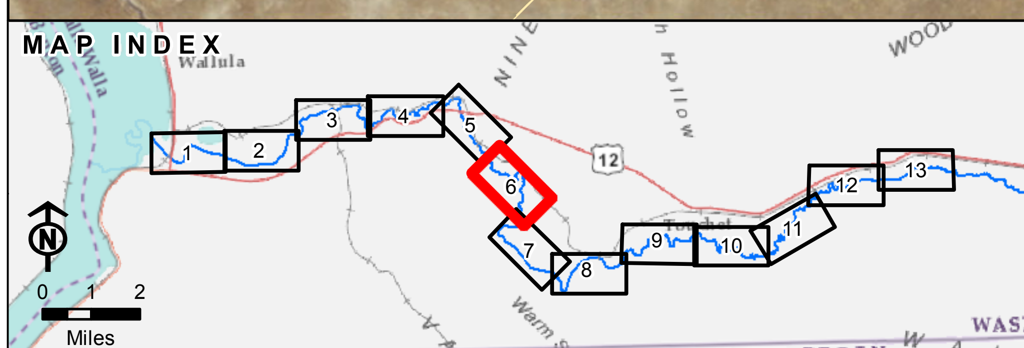
Project Areas and Conceptual Design Categories

Map 5 of 13

Lower Walla Walla

Geomorphic Assessment and Action Plan

TETRA TECH



BSR Break

Project Area Break

USGS River Mile

Control Point

Design Category Boundary

Taxlot Boundary

Project Area Rank

Tier I

Tier II

Tier III

Figure C-3
Project Areas and Conceptual Design Categories

Map 6 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

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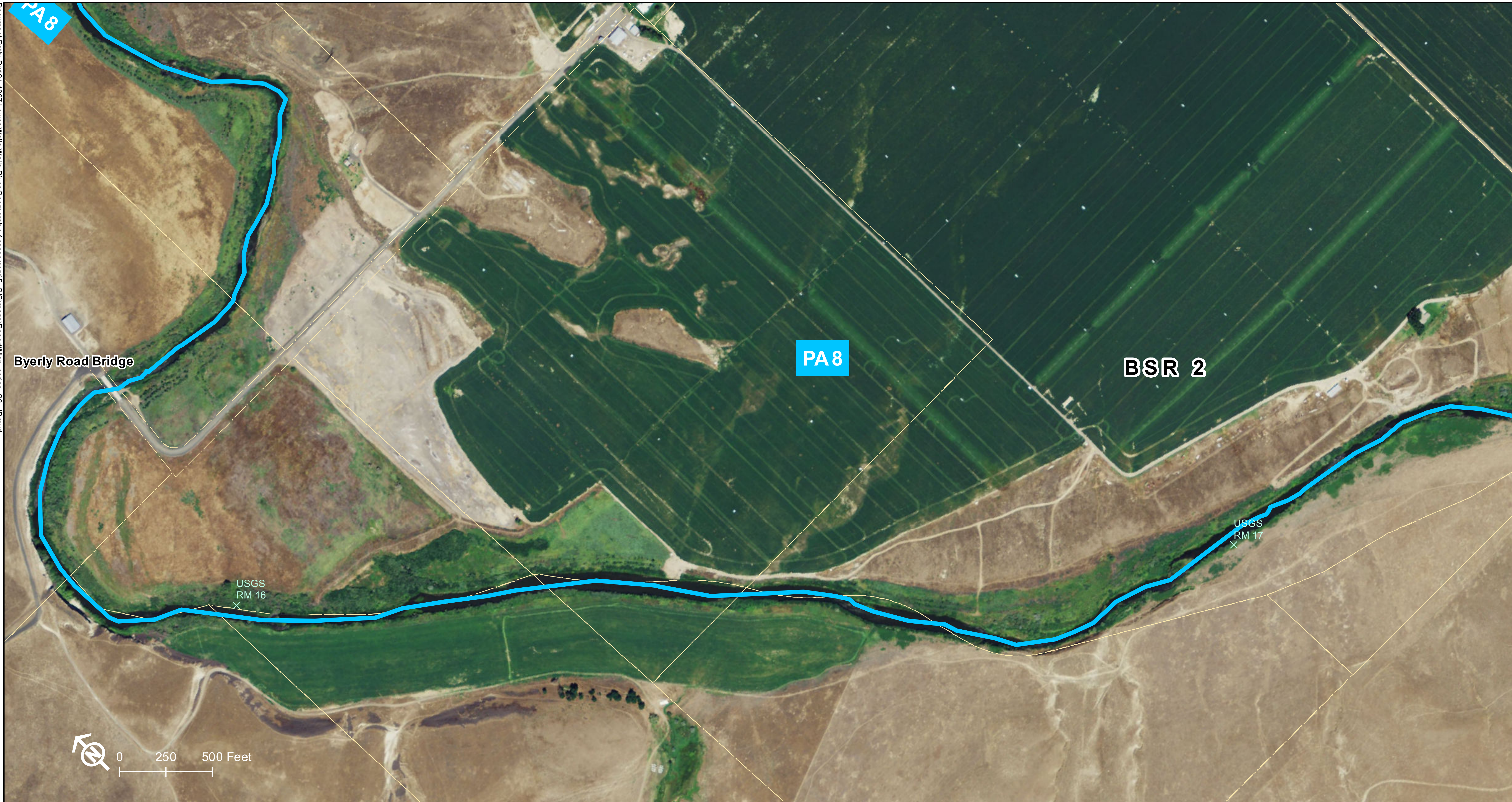

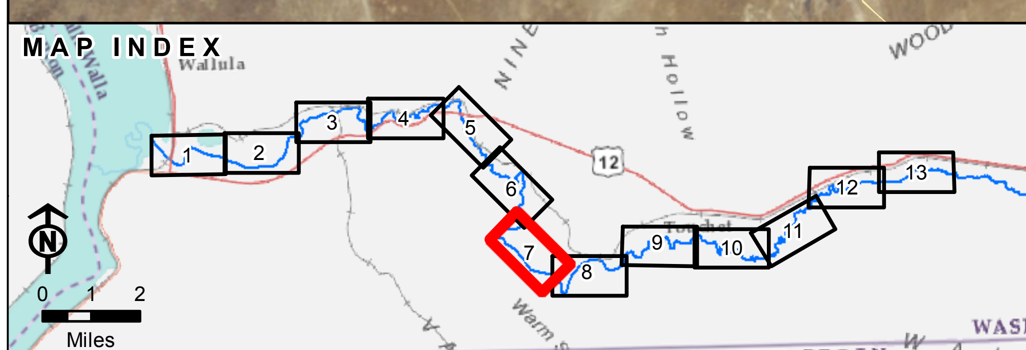

BSR Break

Project Area Break

USGS River Mile

Control Point

Design Category Boundary

Taxlot Boundary

Project Area Rank

Tier I

Tier II

Tier III

Figure C-3
Project Areas and Conceptual Design Categories

Map 7 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

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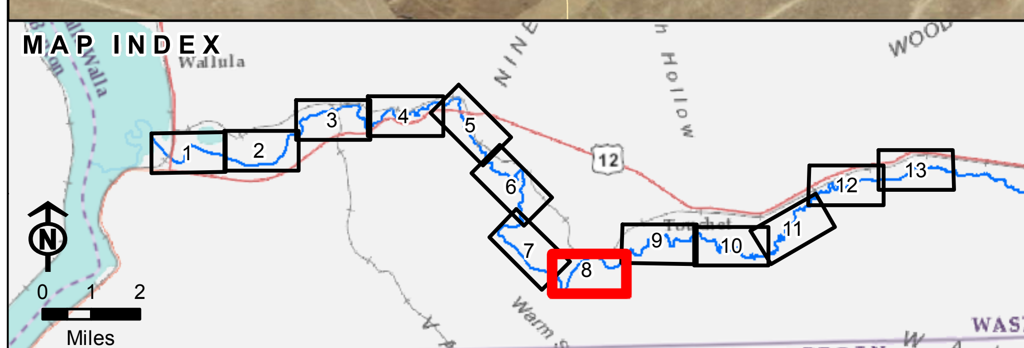

BSR Break

Project Area Break

USGS River Mile

Control Point

Design Category Boundary

Taxlot Boundary

Project Area Rank

Tier I

Tier II

Tier III

Figure C-3
Project Areas and Conceptual Design Categories

Map 8 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

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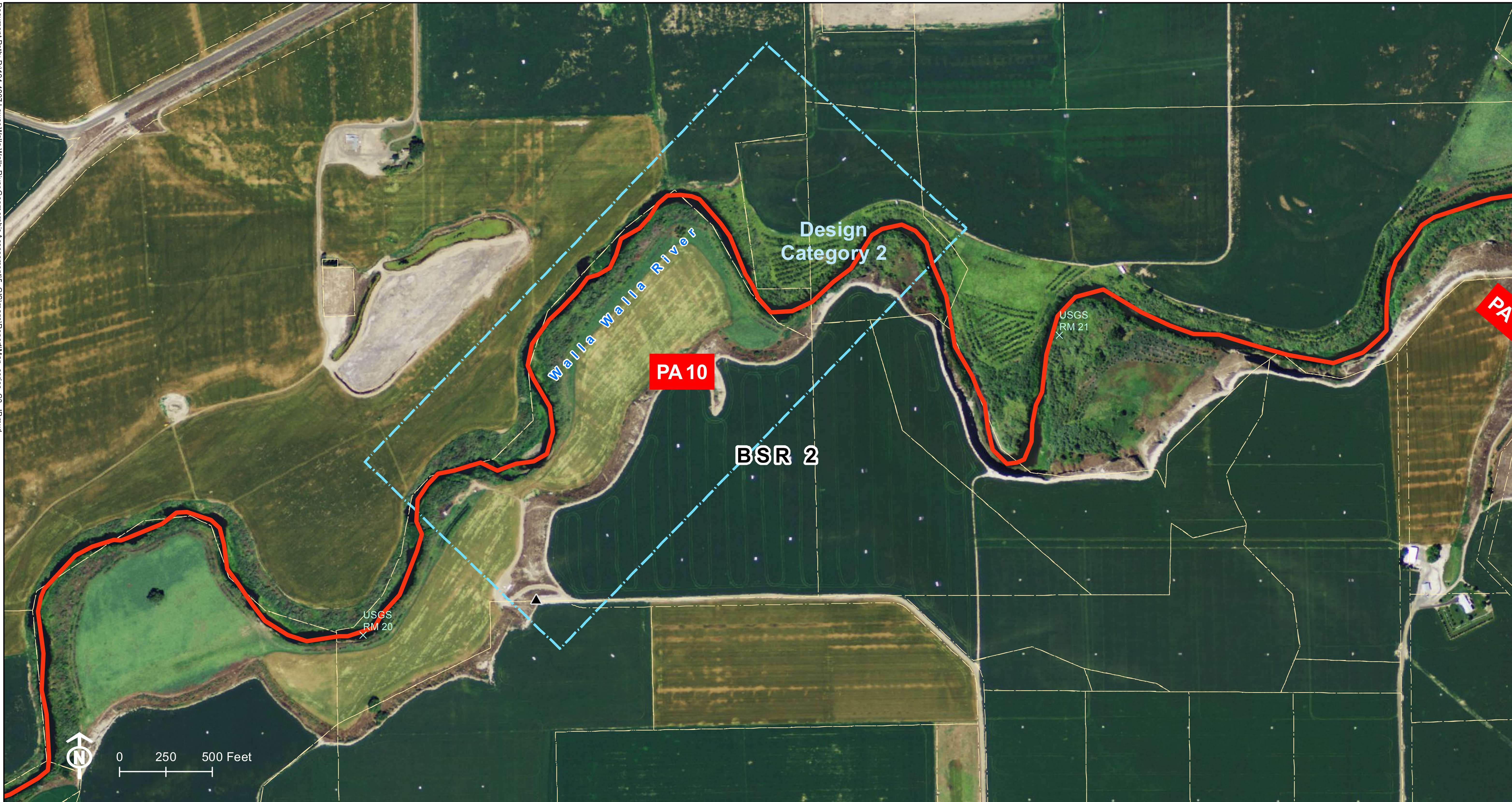

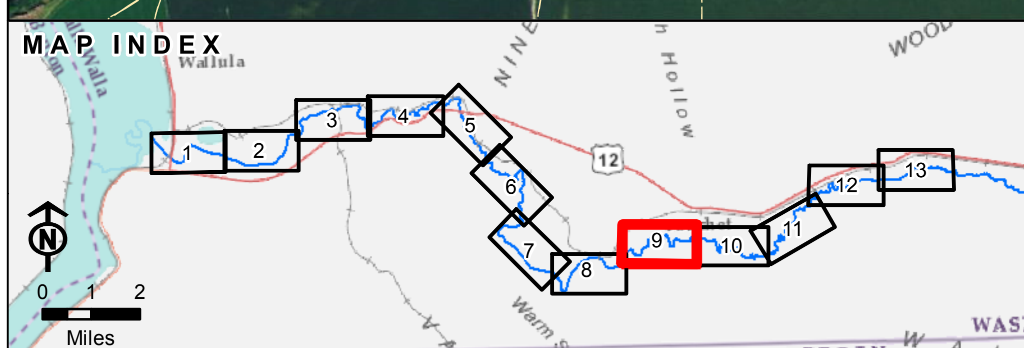

BSR Break

Project Area Break

USGS River Mile

Control Point

Design Category Boundary

Taxlot Boundary

Project Area Rank

Tier I

Tier II

Tier III

Figure C-3
Project Areas and Conceptual Design Categories

Map 9 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

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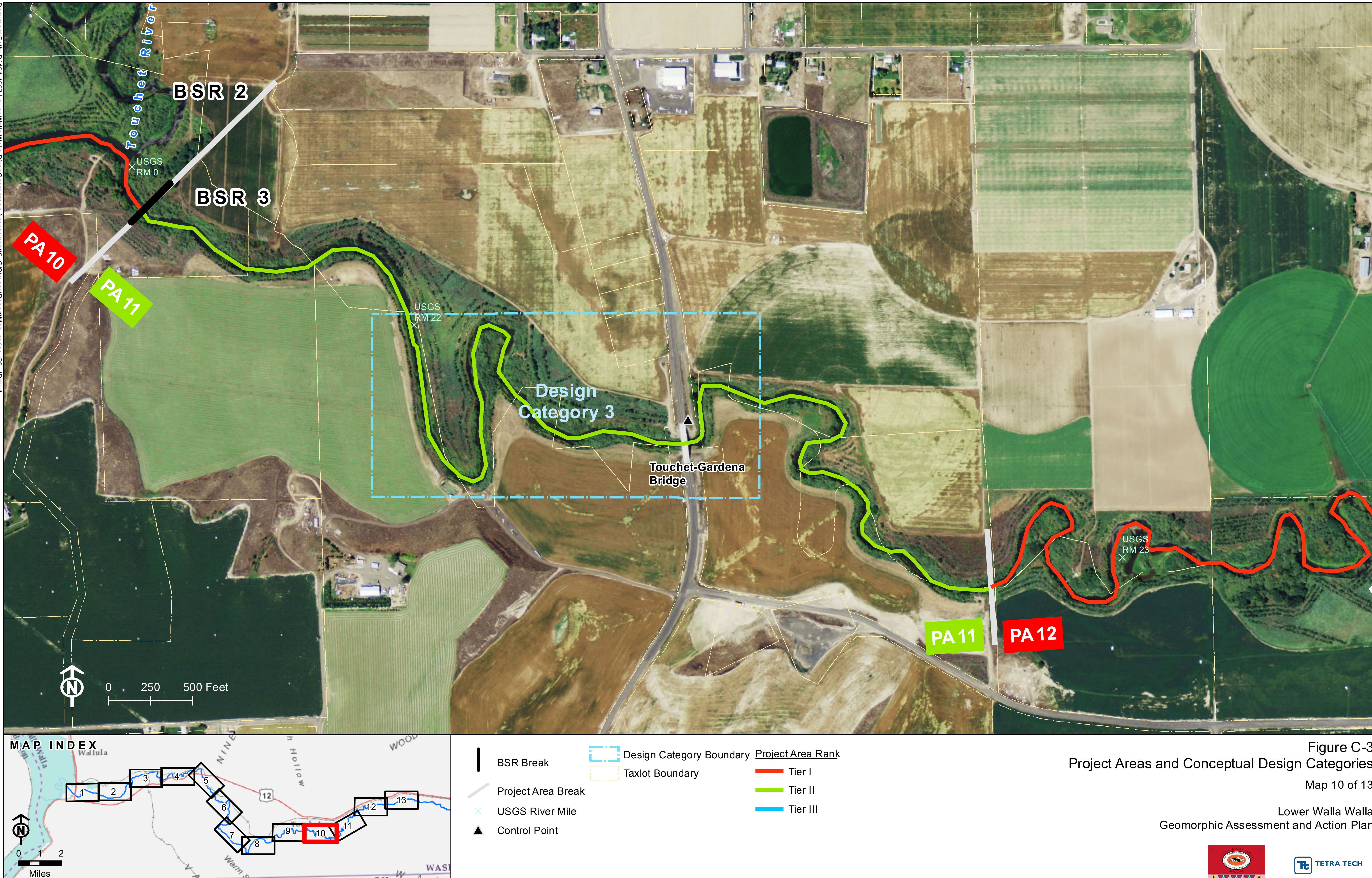

BSR Break
Project Area Break
USGS River Mile
Control Point
Design Category Boundary
Taxlot Boundary

Project Area Rank
- Tier I
- Tier II
- Tier III

Figure C-3
Project Areas and Conceptual Design Categories
Map 10 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

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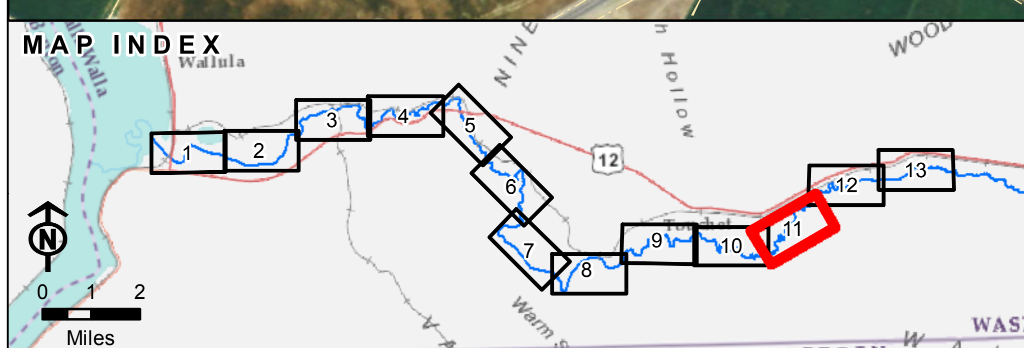

BSR Break
Project Area Break
USGS River Mile
Control Point
Design Category Boundary
Taxlot Boundary

Project Area Rank
Tier I
Tier II
Tier III

Figure C-3
Project Areas and Conceptual Design Categories
Map 11 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

TETRA TECH

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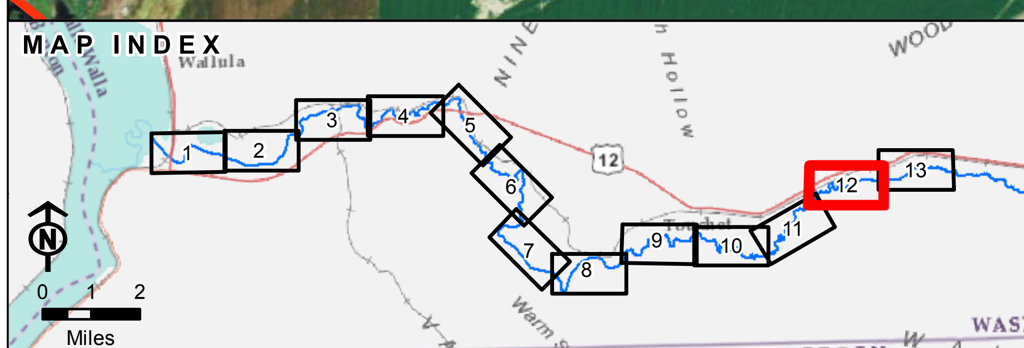
MAP INDEX



BSR Break

Project Area Break

USGS River Mile

Control Point

Design Category Boundary

Taxlot Boundary

Project Area Rank

Tier I

Tier II

Tier III

Figure C-3

Project Areas and Conceptual Design Categories

Map 12 of 13

Lower Walla Walla

Geomorphic Assessment and Action Plan

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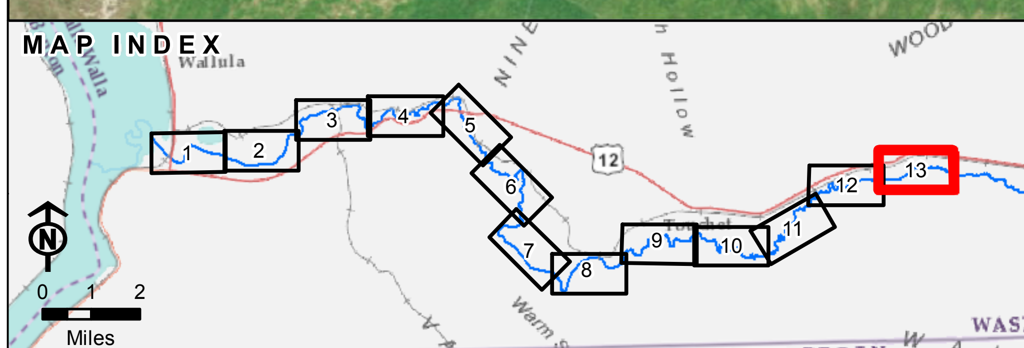

BSR Break
Project Area Break
USGS River Mile
Control Point
Design Category Boundary
Taxlot Boundary

Project Area Rank
- Tier I
- Tier II
- Tier III

Figure C-3
Project Areas and Conceptual Design Categories
Map 13 of 13

Lower Walla Walla
Geomorphic Assessment and Action Plan

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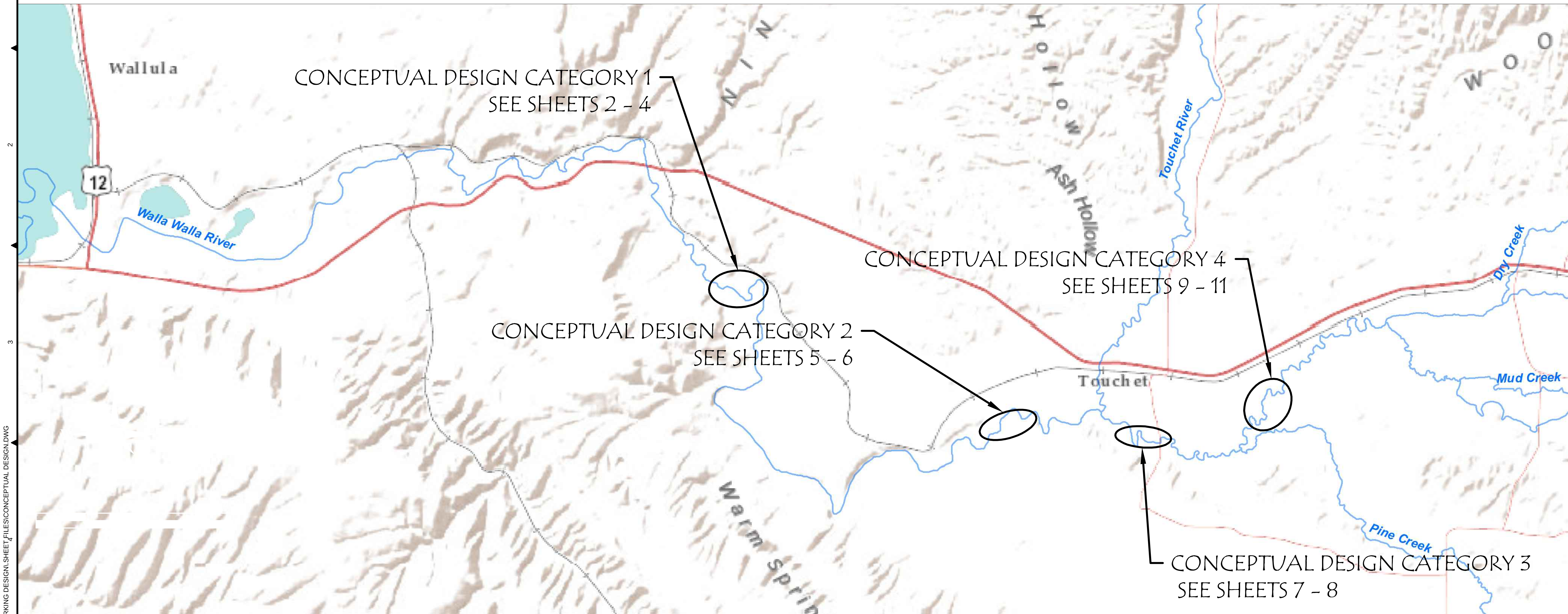
Appendix D – Conceptual Design Drawings

LOWER WALLA WALLA RIVER:

DRAFT GEOMORPHIC ASSESSMENT AND ACTION PLAN
CONCEPTUAL RESTORATION DESIGNS



CONCEPTUAL DESIGN NOTES:

1. CONCEPTUAL DESIGN CATEGORIES DEPICTED IN THIS PLAN SET ARE DESIGNED AT SPECIFIC LOCATIONS, BUT CAN BE APPLIED GENERALLY THROUGHOUT THE APPLICABLE PROJECT AREA.
2. DESIGNS ARE INTENDED FOR CONCEPTUAL PURPOSES ONLY, LANDOWNER ACCESS AND PERMISSION TO IMPLEMENT RESTORATION AND HABITAT ENHANCEMENT ACTIONS ON PRIVATE LANDS HAS NOT BEEN REQUESTED OR GRANTED AT THIS TIME.

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-	10/17/14	CONCEPTUAL DESIGN	ATS	GMS	CSJ

LOWER WALLA WALLA GEOMORPHIC ASSESSMENT AND ACTION PLAN

CONCEPTUAL DESIGN OVERVIEW

DWG. NO.:

CREATED: 07/11/2014

SHEET: 1 OF 12

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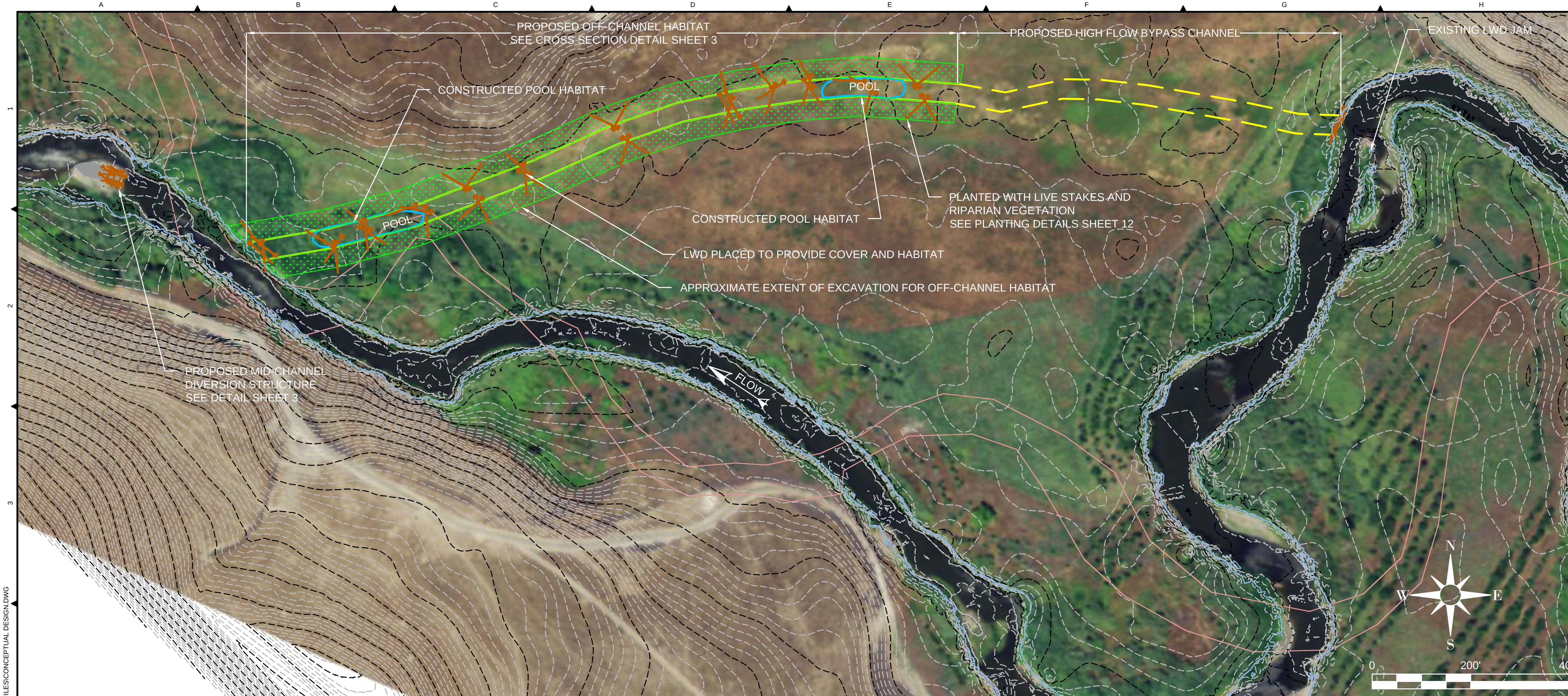

NOTES:

1. NO FLOWS EXPECTED IN OFF-CHANNEL HABITAT WHEN HIGH FLOW BYPASS IS NOT CONSTRUCTED AS PART OF DESIGN.
2. WOOD INCLUDED IN DESIGN OFF-CHANNEL HABITAT TO PROVIDE COVER FOR FISH.
3. POOLS IN OFF-CHANNEL HABITAT SHALL BE A MINIMUM OF 3 FEET DEEP TO PROVIDE HABITAT FOR FISH IF OFF-CHANNEL IS TEMPORARILY DISCONNECTED FROM MAIN CHANNEL.
4. PROPOSED HIGH FLOW BYPASS CHANNEL NOT APPLICABLE IN ALL CASES.
5. LWD STRUCTURE TO BE PLACED AT INLET OF HIGH FLOW BYPASS CHANNEL TO CONTROL GRADE AND PREVENT AVULSION OF MAIN CHANNEL INTO BYPASS CHANNEL. LWD STRUCTURE TYPE AND LOCATION TO BE DEVELOPED DURING LATER STAGES OF DESIGN.
6. OFF-CHANNEL HABITAT PLANTED WITH LIVE STAKES AND RIPARIAN VEGETATION TO PROVIDE CHANNEL STABILITY. SEE PLANTING NOTES SHEET 12.
7. MID-CHANNEL DIVERSION STRUCTURE PLACED TO CREATE NEW MAIN CHANNEL SPLIT FLOW, OR TO ENHANCE EXISTING MID-CHANNEL BAR TO PROMOTE EXISTING SPLIT FLOW.

LEGEND:

- EXISTING MAJOR CONTOUR - 5FT
- EXISTING MINOR CONTOUR - 1FT
- CURRENT BANKFULL CHANNEL
- 1939/1940 ACTIVE CHANNEL
- PROPOSED OFF-CHANNEL
- PROPOSED HIGH FLOW BYPASS CHANNEL
- LWD STRUCTURES
- ALCOVE / POOL HABITAT
- RIPARIAN PLANTING

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LOWER WALLA WALLA GEOMORPHIC ASSESSMENT AND ACTION PLAN

CONCEPTUAL DESIGN CATEGORY 1 - PLAN

DWG. NO.:

CREATED: 07/11/2014

SHEET: 2 OF 12

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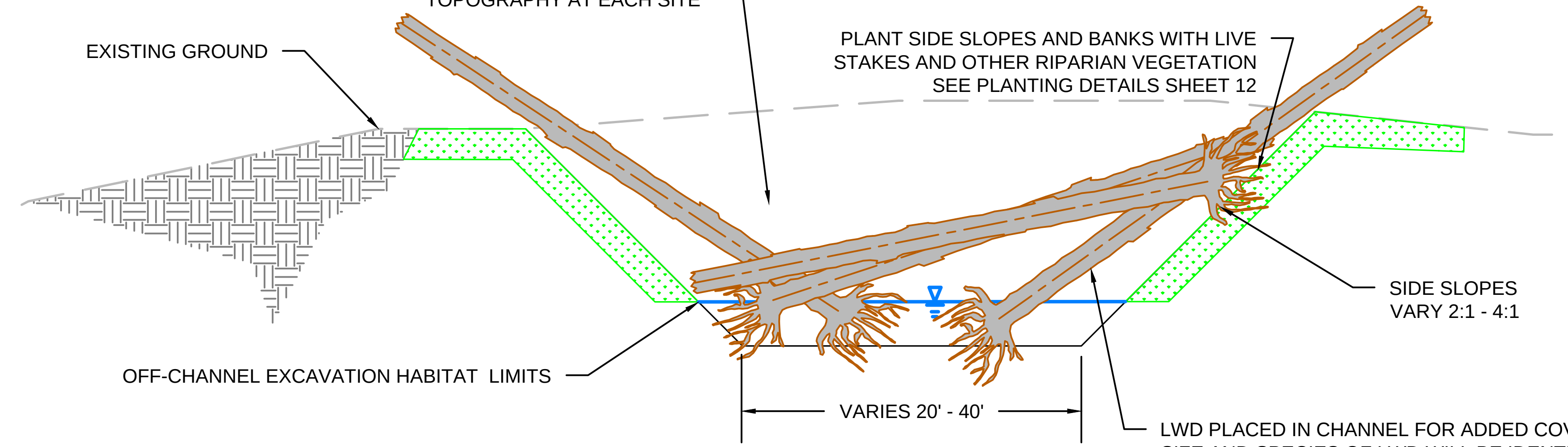
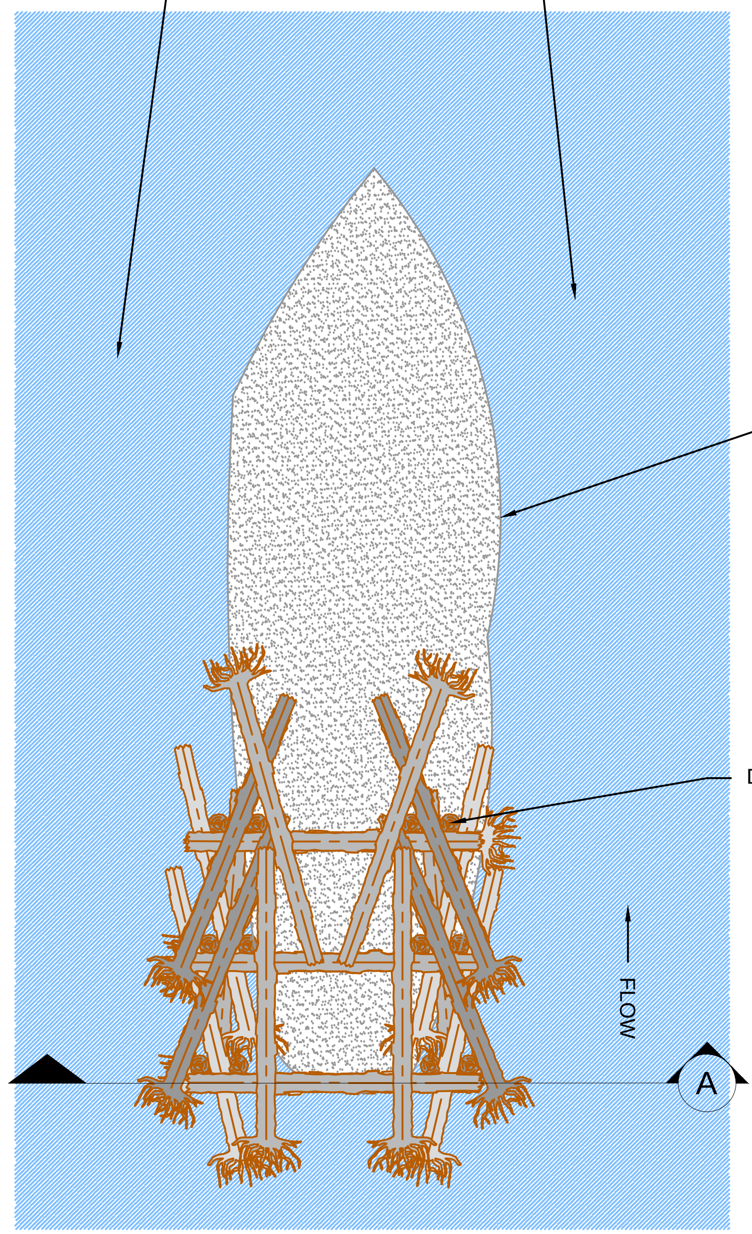
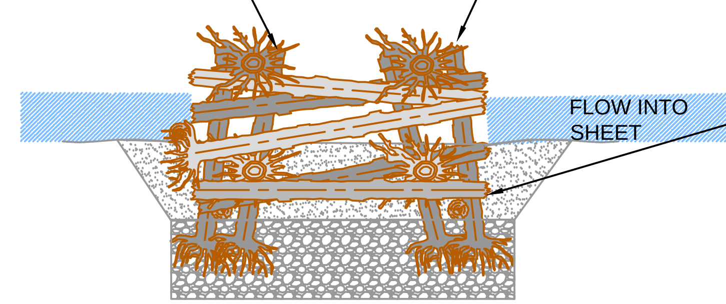


OFF-CHANNEL HABITAT / SIDE CHANNEL CROSS SECTION



PLAN VIEW



SECTION VIEW A-A

CHANNEL BAR DIVERSION STRUCTURE

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LOWER WALLA WALLA GEOMORPHIC ASSESSMENT AND ACTION PLAN

CONCEPTUAL DESIGN
CATEGORY 1 - DETAILS

DWG. NO.:

CREATED: 07/11/2014

SHEET: 3 OF 12

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OFF-CHANNEL HABITAT - VISUALIZATION

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LOWER WALLA WALLA GEOMORPHIC ASSESSMENT AND ACTION PLAN

CONCEPTUAL DESIGN CATEGORY 1 - VISUALIZATION

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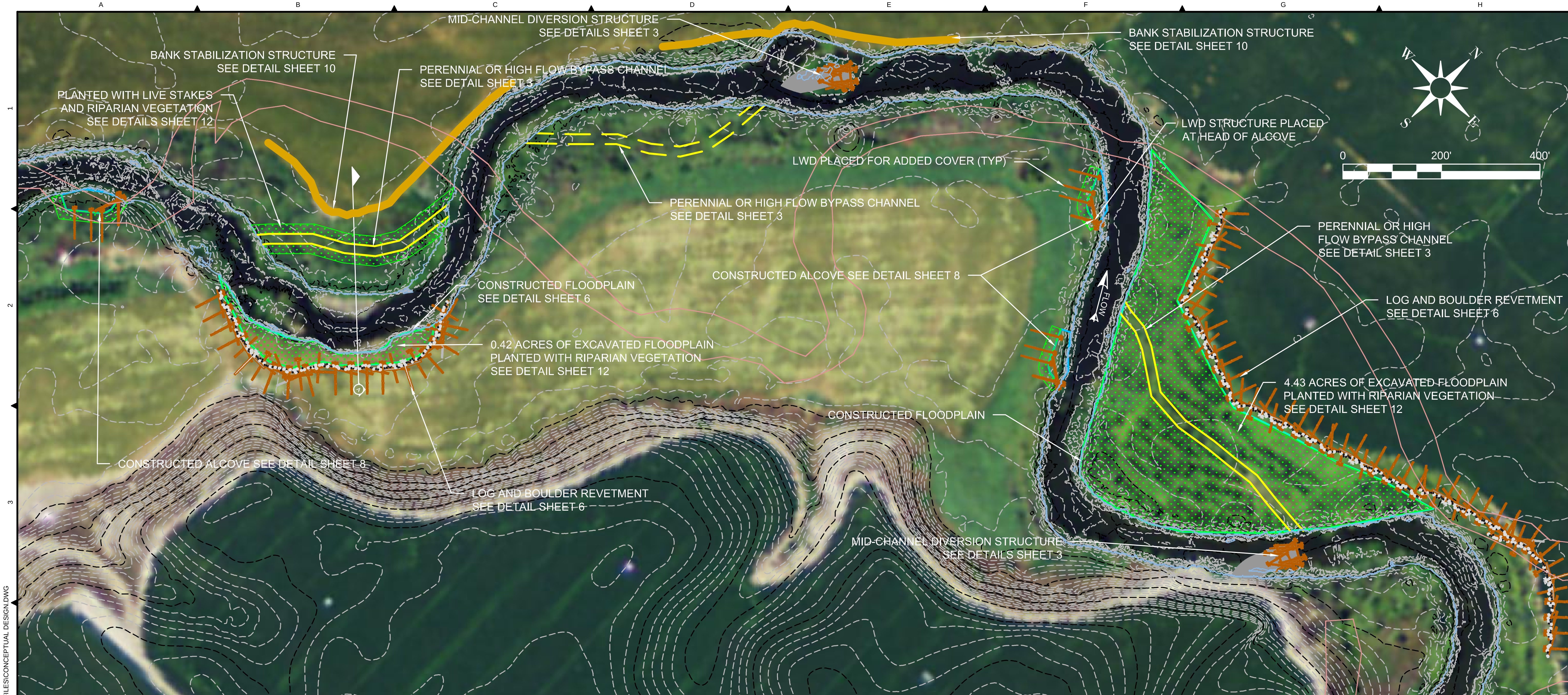

LEGEND:

- EXISTING MAJOR CONTOUR - 5FT
- EXISTING MINOR CONTOUR - 1FT
- CURRENT BANKFULL CHANNEL
- 1939/1940 ACTIVE CHANNEL
- PROPOSED OFF-CHANNEL
- PROPOSED HIGH FLOW BYPASS CHANNEL
- LWD STRUCTURES
- ALCOVE / POOL HABITAT
- RIPARIAN PLANTING
- CONSTRUCTED FLOODPLAIN
- BANK STABILIZATION

NOTES:

1. MID-CHANNEL DIVERSION STRUCTURES AND ALCOVES CONSTRUCTED ALONG CHANNELIZED SECTIONS OF THE RIVER TO PROVIDE FOR HIGH FLOW REFUGE FOR FISH.
2. MID-CHANNEL DIVERSION STRUCTURE PLACED TO CREATE NEW MAIN CHANNEL SPLIT FLOW.
3. ALCOVE SECTIONS WILL BE EXCAVATED TO PROVIDE IMMEDIATE REFUGE AREAS FOR FISH.
4. LWD ADDED TO CONSTRUCTED ALCOVES TO PROVIDE COVER.
5. AREAS AROUND CONSTRUCTED ALCOVES SHALL BE PLANTED WITH RIPARIAN VEGETATION TO PROVIDE ADDED COVER.
6. HIGH FLOW BYPASS CONSTRUCTED TO ALLEVIATE HIGH VELOCITIES IN STRAIGHT SECTIONS DURING STORM EVENTS.
7. LOG AND BOULDER REVETMENT CONSTRUCTED TO PREVENT FURTHER MIGRATION OF CHANNEL INTO ADJACENT PRIVATE PROPERTY.
8. LENGTH AND ORIENTATION OF LOG AND BOULDER REVETMENTS MAY VARY DUE TO HYDRAULIC MODELING IN LATTER STAGES OF DESIGN.
9. PLACE BANK STABILIZATION STRUCTURES IN AREAS WITH HIGHLY ERODING BANKS.

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-	10/17/14	CONCEPTUAL DESIGN	ATS	GMS	CSJ

LOWER WALLA WALLA GEOMORPHIC ASSESSMENT AND ACTION PLAN

CONCEPTUAL DESIGN CATEGORY 2 - PLAN

DWG. NO.:

CREATED: 07/11/2014

SHEET: 5 OF 12

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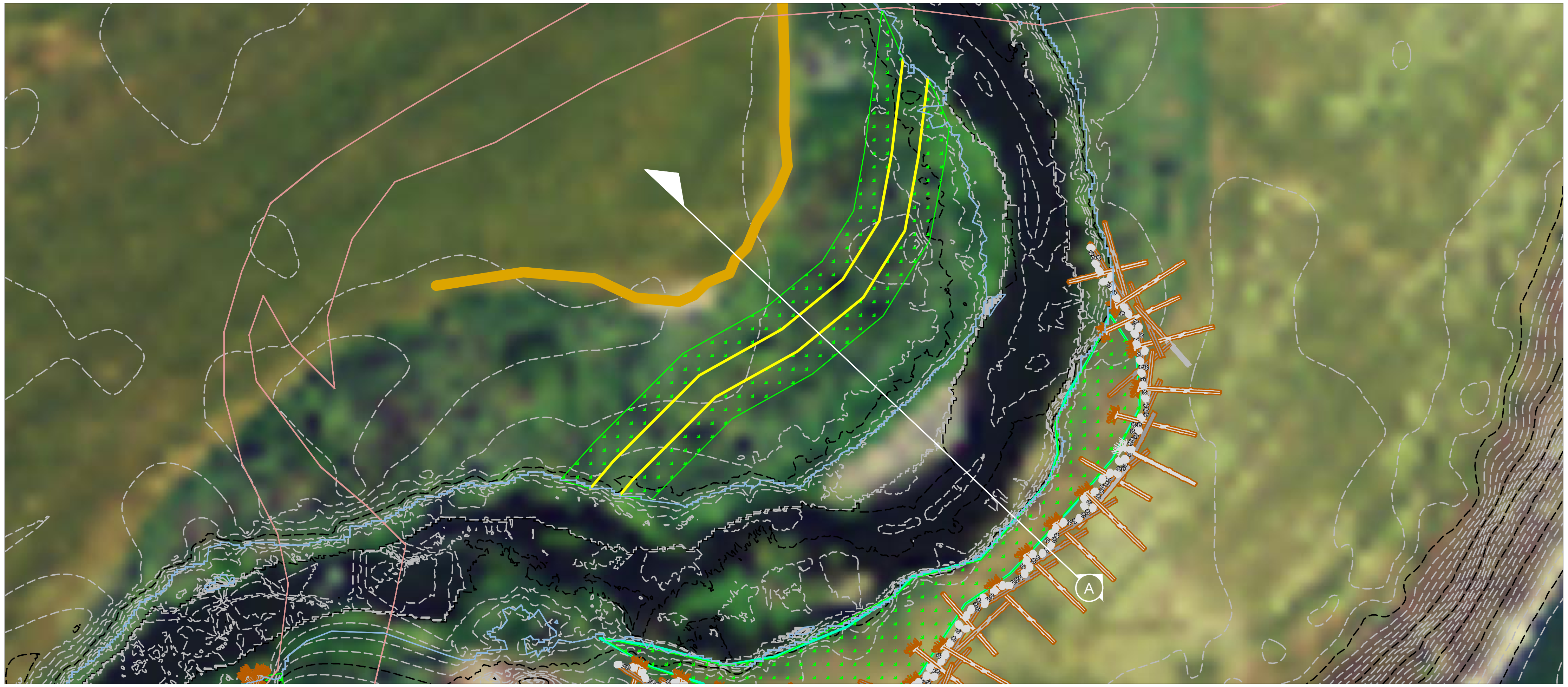
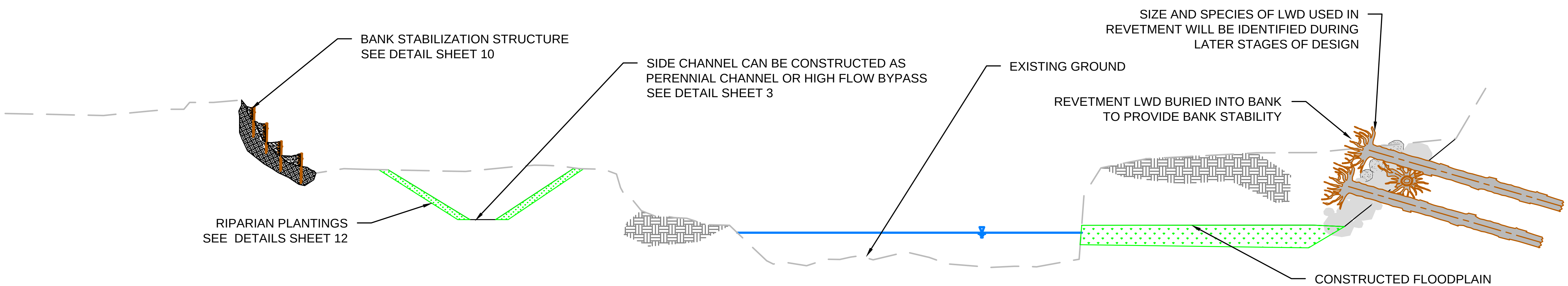


REVETMENT WITH SIDE CHANNEL AND BANK STABILIZATION STRUCTURES - PLAN VIEW



SECTION A-A

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PLAN SET SIZE ANSI B (11x17)

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LOWER WALLA WALLA GEOMORPHIC ASSESSMENT AND ACTION PLAN

CONCEPTUAL DESIGN CATEGORY 2 - DETAILS

DWG. NO.:

CREATED: 07/11/2014

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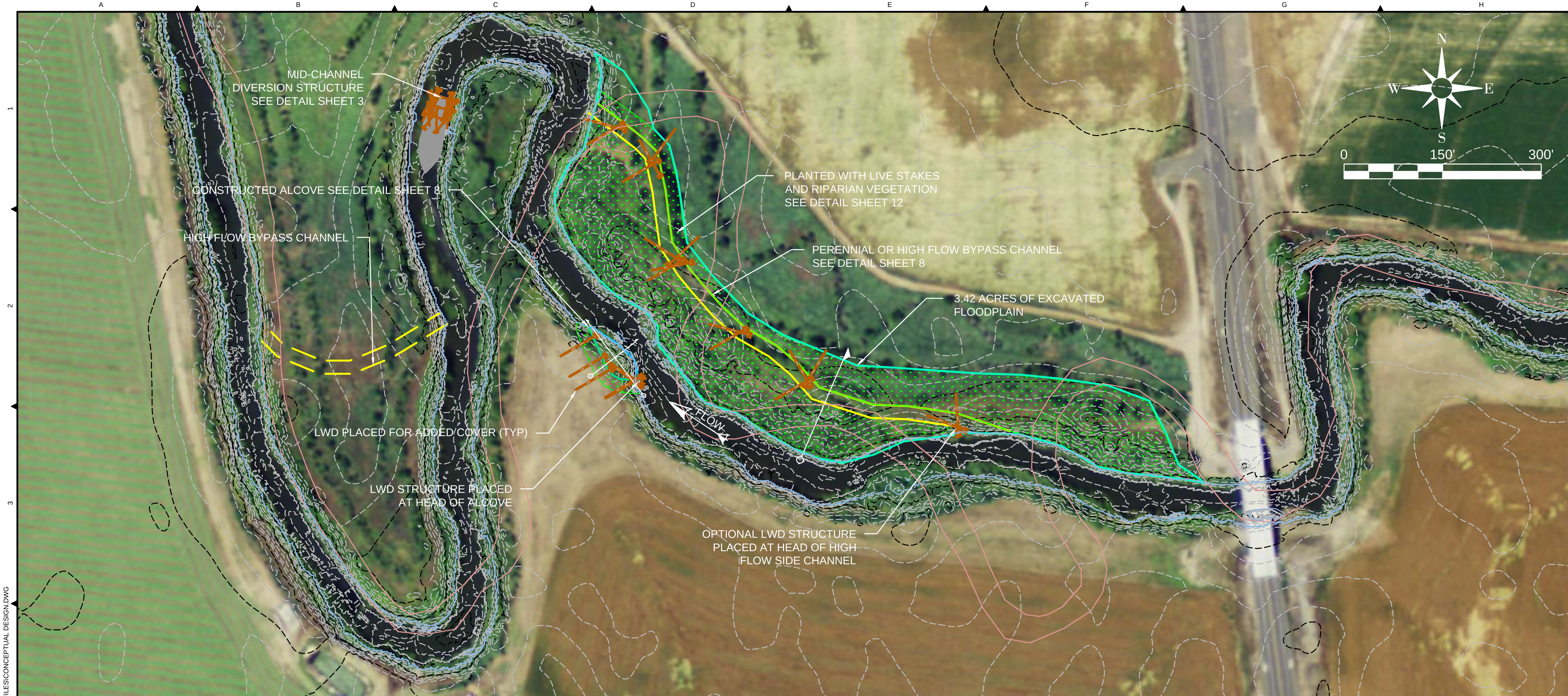

NOTES:

1. LWD STRUCTURES AND ALCOVES CONSTRUCTED ALONG CHANNELIZED SECTIONS OF THE RIVER TO PROVIDE FOR HIGH FLOW REFUGE FOR FISH.
2. ALCOVE SECTIONS WILL BE EXCAVATED TO PROVIDE IMMEDIATE REFUGE AREAS FOR FISH.
3. LWD ADDED TO CONSTRUCTED ALCOVES TO PROVIDE COVER.
4. AREAS AROUND CONSTRUCTED ALCOVES SHALL BE PLANTED WITH RIPARIAN VEGETATION TO PROVIDE ADDED COVER.
5. HIGH FLOW BYPASS CONSTRUCTED TO ALLEVIATE HIGH VELOCITIES IN STRAIGHT SECTIONS DURING STORM EVENTS.
6. UPSTREAM END OF HIGH FLOW BYPASS PLACED ON INSIDE OF CURVE TO PREVENT AVULSION OF MAIN CHANNEL INTO HIGH FLOW BYPASS CHANNEL.
7. CHANNEL BAR DIVERSION STRUCTURE PLACED TO CREATE NEW MAIN CHANNEL SPLIT FLOW, OR TO ENHANCE EXISTING MID-CHANNEL BAR TO PROMOTE SPLIT FLOW CONDITION IN MAIN CHANNEL.

LEGEND:

- EXISTING MAJOR CONTOUR - 5FT
- EXISTING MINOR CONTOUR - 1FT
- CURRENT BANKFULL CHANNEL
- 1939/1940 ACTIVE CHANNEL
- PROPOSED OFF-CHANNEL
- PROPOSED HIGH FLOW BYPASS CHANNEL
- LWD STRUCTURES
- ALCOVE / POOL HABITAT
- RIPARIAN PLANTING
- CONSTRUCTED FLOODPLAIN

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PLAN SET SIZE ANSI B (11x17)

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-	10/17/14	CONCEPTUAL DESIGN	ATS	GMS	CSJ

LOWER WALLA WALLA GEOMORPHIC ASSESSMENT AND ACTION PLAN

CONCEPTUAL DESIGN CATEGORY 3 - PLAN

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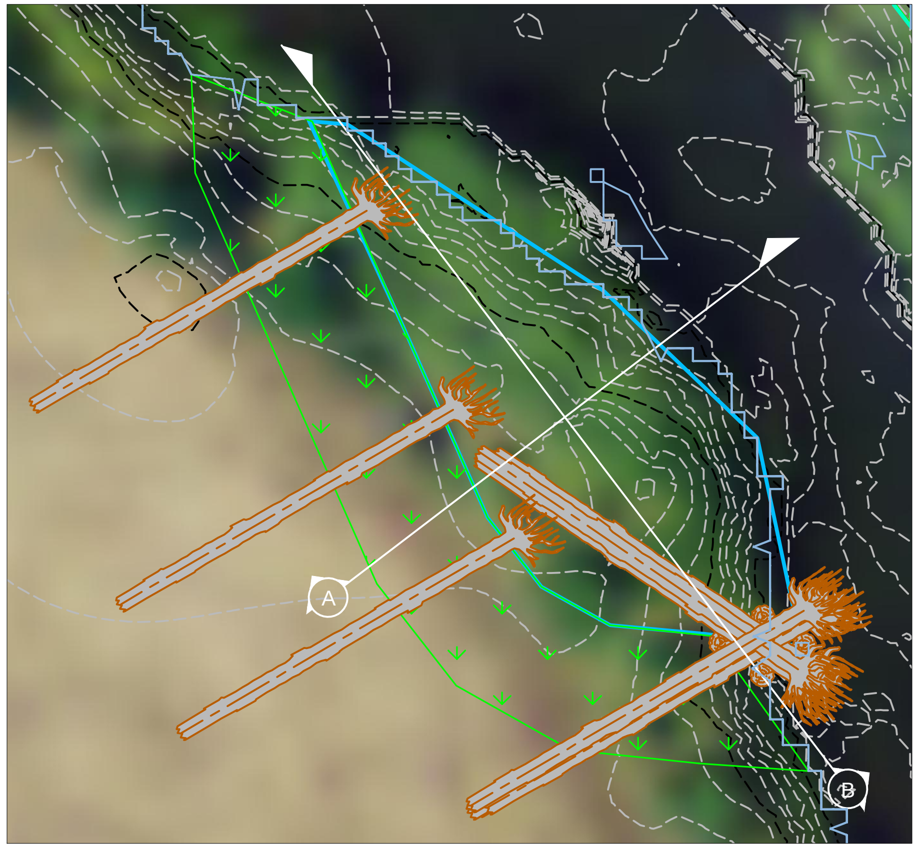
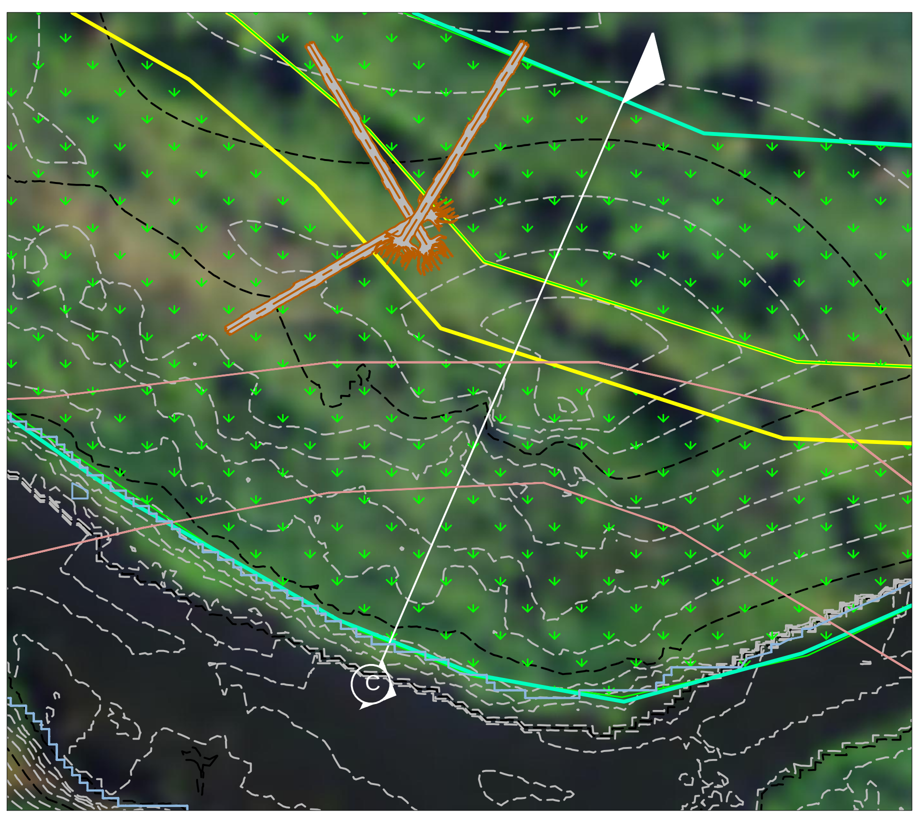
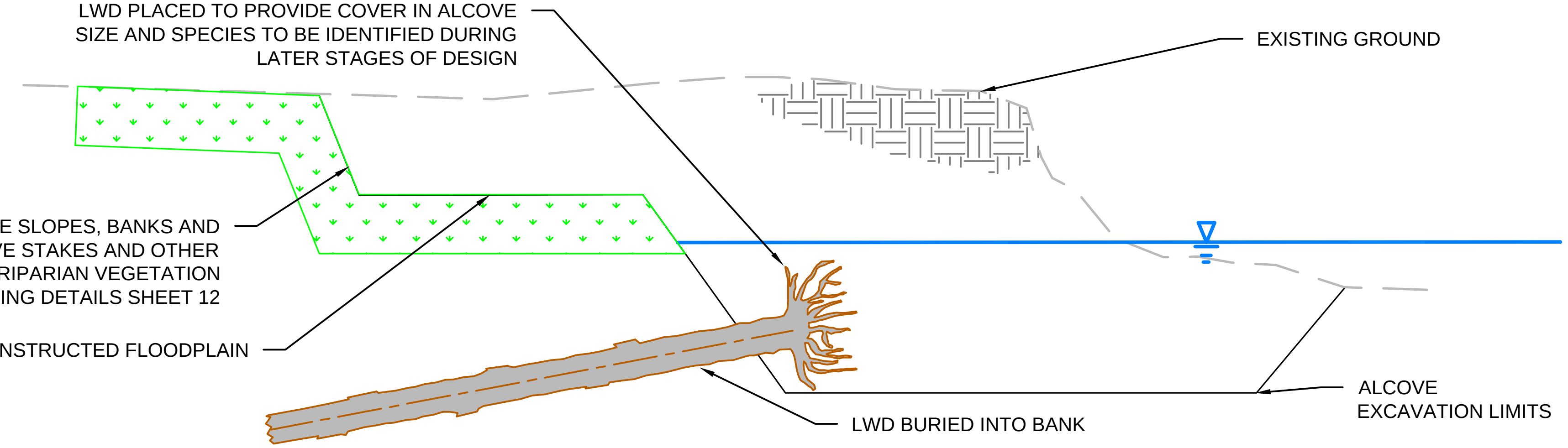


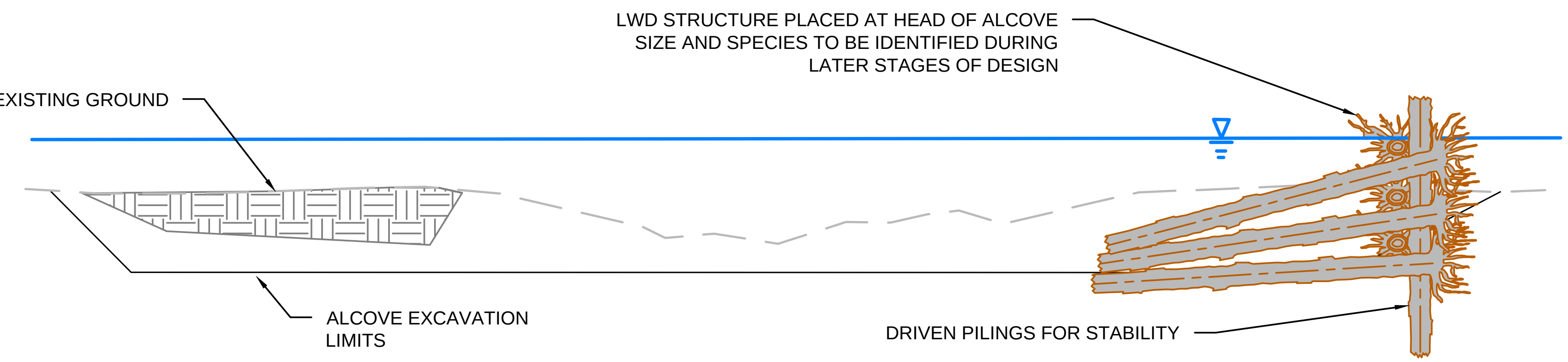
ALCOVE HABITAT (TYP) - PLAN VIEW



FLOODPLAIN WITH SIDE CHANNEL HABITAT (TYP) - PLAN VIEW



SECTION A-A



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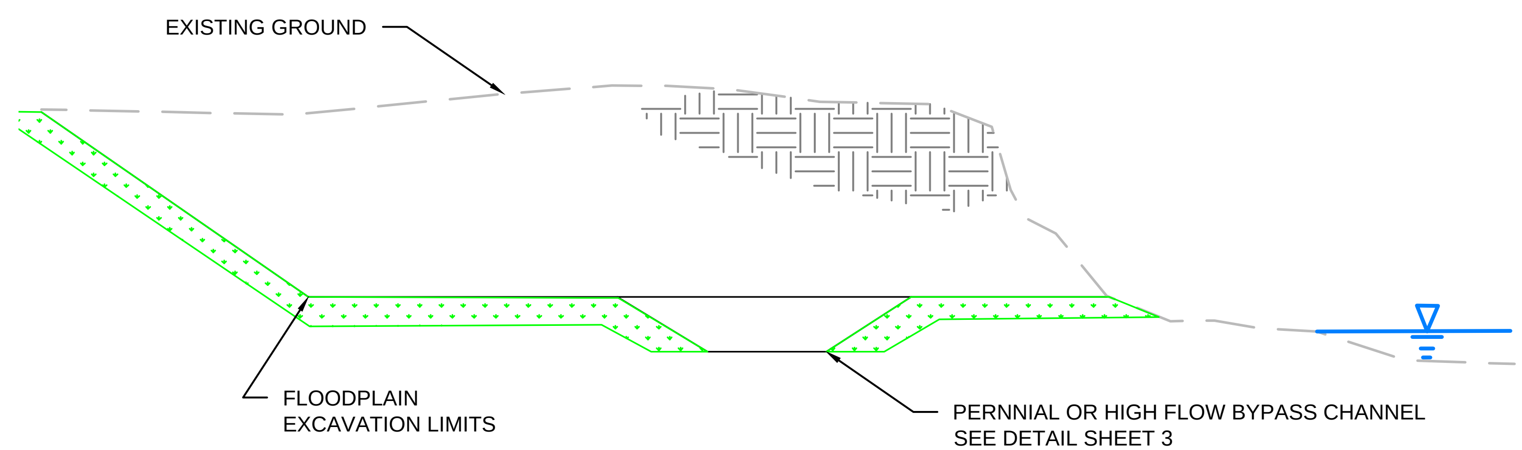

SECTION C-C

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PLAN SET SIZE ANSI B (11x17)

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-	10/17/14	CONCEPTUAL DESIGN	ATS	GMS	CSJ

LOWER WALLA WALLA GEOMORPHIC ASSESSMENT AND ACTION PLAN

CONCEPTUAL DESIGN
CATEGORY 3 - DETAILS

DWG. NO.:

CREATED: 07/11/2014

SHEET: 8 OF 12

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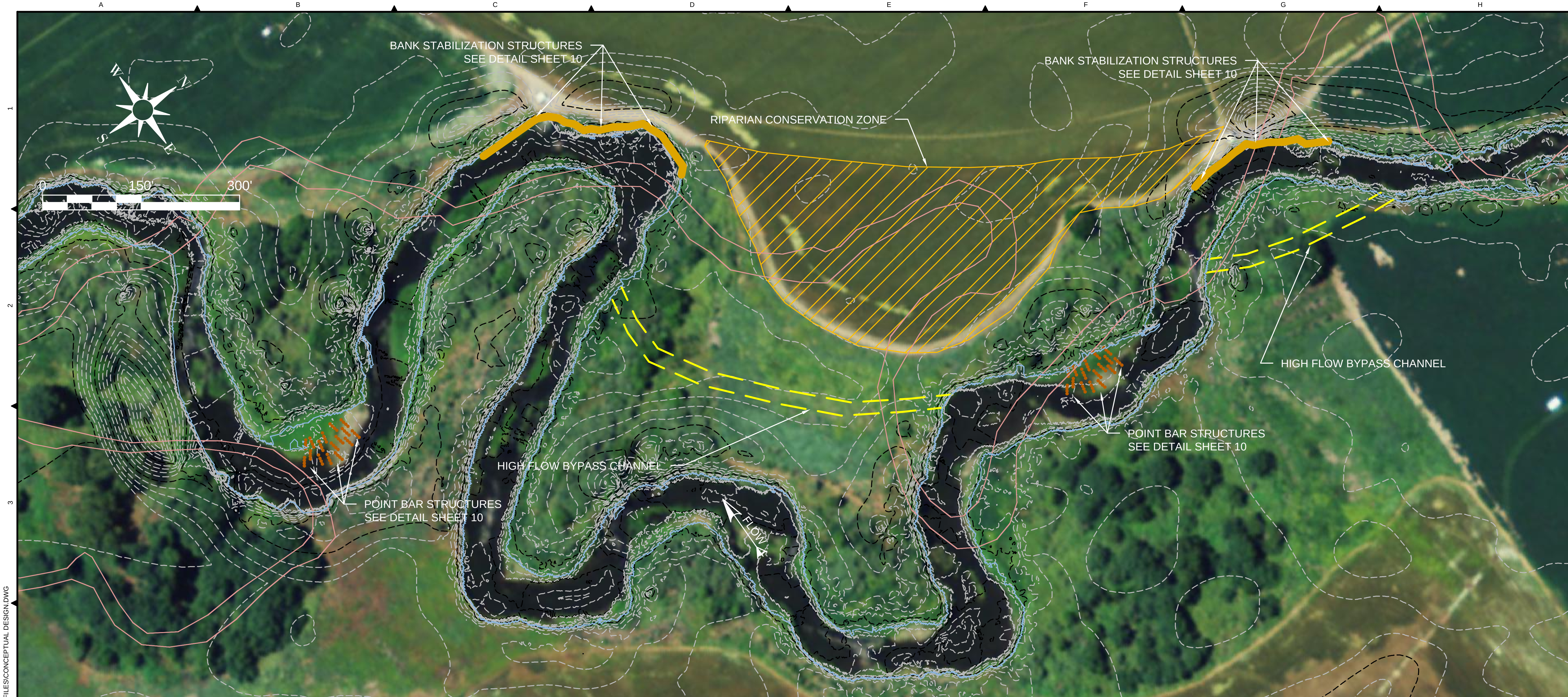

NOTES:

1. PLACE BANK STABILIZATION STRUCTURES IN AREAS WITH HIGHLY ERODING BANKS.
2. PLACE BANK STABILIZATION STRUCTURES TO PROTECT PRIVATE LANDOWNER INFRASTRUCTURE.
3. POINT BAR STRUCTURES TO BE PLANTED WITH WILLOW STAKES TO PROVIDE ADDED STABILITY.
4. AREA SHADED ON PLAN SHEET INDICATES POSSIBLE RIPARIAN CONSERVATION ZONE FOR BANK STABILITY EXCHANGE WITH LANDOWNER.
5. HIGH FLOW BYPASS CONSTRUCTED TO REDUCE HIGH FLOW VELOCITY DURING FLOOD EVENTS.
6. UPSTREAM END OF HIGH FLOW BYPASS PLACED ON INSIDE OF CURVE SO AS NOT TO PROMOTE ENTIRE CHANNEL REALIGNMENT INTO CHANNEL.
7. SEDIMENT RETENTION STRUCTURES PLACED ON INSIDE OF CHANNEL MEANDER ON EXISTING BAR TO PROMOTE SEDIMENT RETENTION AND CHANNEL MIGRATION.

LEGEND:

- EXISTING MAJOR CONTOUR - 5FT
- EXISTING MINOR CONTOUR - 1FT
- CURRENT BANKFULL CHANNEL
- 1939/1940 ACTIVE CHANNEL
- PROPOSED OFF-CHANNEL
- PROPOSED HIGH FLOW BYPASS CHANNEL
- LWD STRUCTURES
- ALCOVE / POOL HABITAT
- RIPARIAN PLANTING
- CONSTRUCTED FLOODPLAIN
- BANK STABILIZATION
- RIPARIAN CONSERVATION ZONE

TETRA TECH
www.tetratech.com
19803 North Creek Parkway
Bothell, Washington 98011
Phone: 425-482-7600 Fax: 425-482-7652

PLAN SET SIZE ANSI B (11x17)

REV.	DATE	REVISION DESCRIPTION	DRW	ENG	CHK
-	10/17/14	CONCEPTUAL DESIGN	ATS	GMS	CSJ

LOWER WALLA WALLA GEOMORPHIC ASSESSMENT AND ACTION PLAN

CONCEPTUAL DESIGN CATEGORY 4 - PLAN

DWG. NO.:

CREATED: 07/11/2014

SHEET: 9 OF 12

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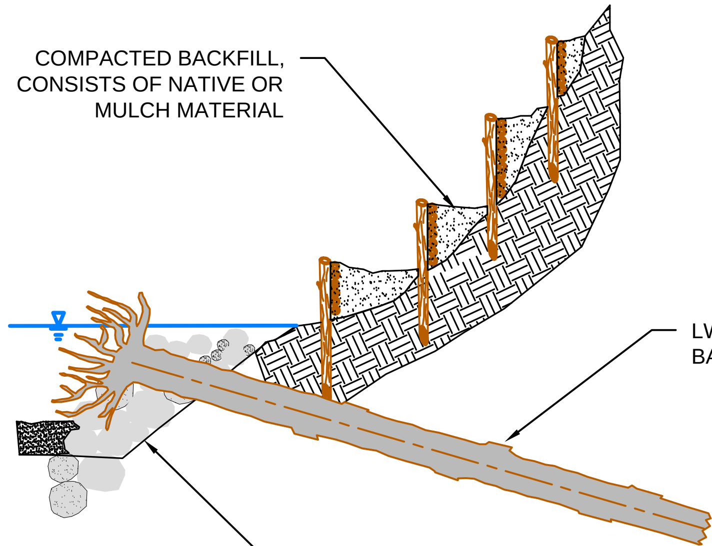
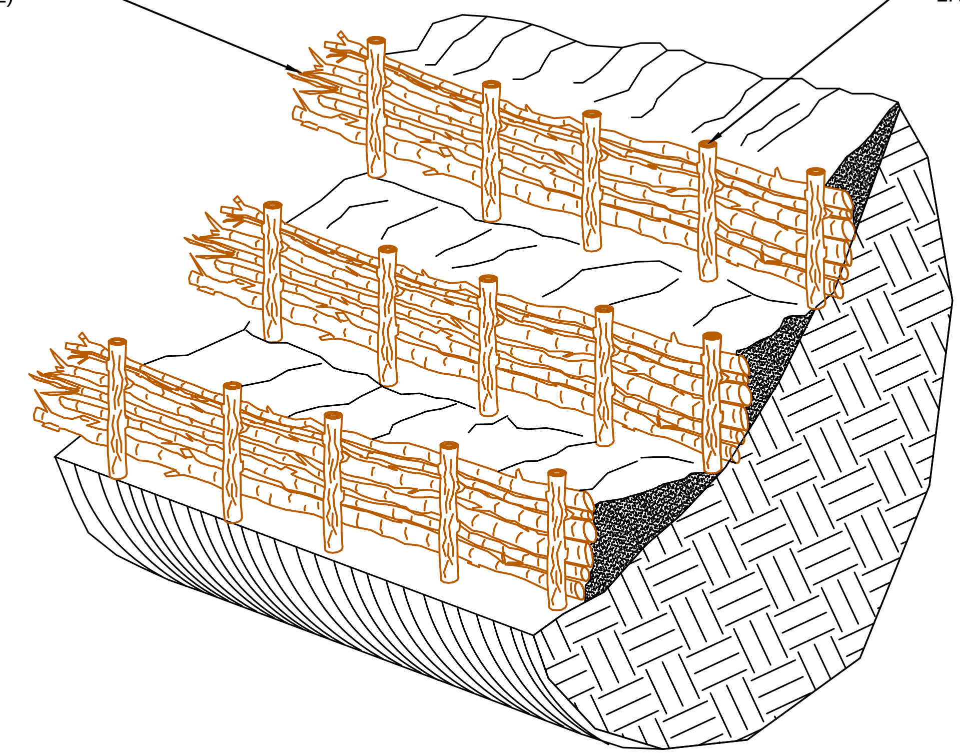
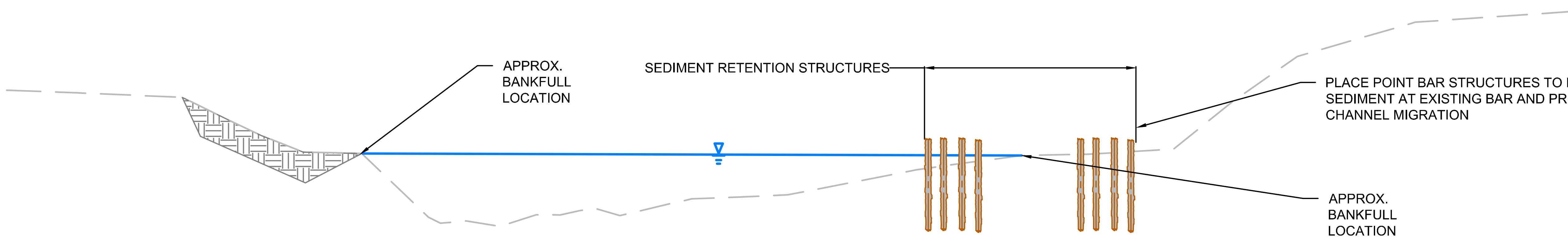
PLOT DETAILS: STROM, ALEX October 23, 2014 10:58 AM ----



BANK STABILIZATION DETAIL - SECTION VIEW



BANK STABILIZATION DETAIL - ISOMETRIC VIEW



POINT BAR STRUCTURE DETAIL - SECTION VIEW

TETRA TECH
www.tetratech.com
19803 North Creek Parkway
Bothell, Washington 98011
Phone: 425-482-7600 Fax: 425-482-7652

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LOWER WALLA WALLA GEOMORPHIC ASSESSMENT AND ACTION PLAN

CONCEPTUAL DESIGN CATEGORY 4 - DETAILS

DWG. NO.:

CREATED: 07/11/2014

SHEET: 10 OF 12

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PLOT DETAILS: STROM, ALEX October 22, 2014 4:27 PM

POINT BAR STRUCTURE DETAIL - VISUALIZATION

TETRA TECH
www.tetratech.com
19803 North Creek Parkway
Bothell, Washington 98011
Phone: 425-482-7600 Fax: 425-482-7652

PLAN SET SIZE ANSI B (11x17)

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LOWER WALLA WALLA GEOMORPHIC ASSESSMENT AND ACTION PLAN

CONCEPTUAL DESIGN CATEGORY 4 - VISUALIZATION

DWG. NO.:

CREATED: 07/11/2014

SHEET: 11 OF 12

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CRITERIA FOR PLANTING PLAN

1. NATIVE TREE AND SHRUB SPECIES SUCH AS COTTONWOOD, ALDER, WILLOW, SNOWBERRY, ROSIER DOGWOOD, CURRANT, AND ROSE SHOULD BE USED FOR RIPARIAN PLANTINGS. THE FINAL SPECIES LIST AND NUMBERS SHOULD BE DECIDED BASED ON SPECIFIC SITE LOCATION AND CHARACTERISTICS AND FINAL CONSTRUCTION PLANS. LOCAL STOCK OF NATIVE SPECIES SHOULD BE USED TO THE EXTENT POSSIBLE BECAUSE THESE STOCKS WOULD BE BEST SUITED TO AND ADAPTED TO LOCAL CONDITIONS.
2. PLANTING PLANS WOULD BE BASED ON THE FINAL CONSTRUCTION DESIGN. FACTORS SUCH AS TOPOGRAPHY, DISTANCE TO THE STREAM, AND LOCATION OF THE FLOODPLAIN WILL BE TAKEN INTO ACCOUNT. THE FINAL PLANTING PLAN WOULD BE INTENDED NOT ONLY TO FACILITATE PLANT SURVIVAL, BUT ALSO TO MOST READILY AND SUCCESSFULLY FACILITATE THE OVERALL PROJECT GOAL OF IMPROVING AQUATIC HABITAT AND PROVIDING QUALITY ECOLOGICAL CONDITIONS FOR AQUATIC SPECIES.
3. IF RIPARIAN PLANTINGS ARE TO BE PHASED IN OVER SEVERAL YEARS, AREAS WHERE BANK STABILITY IS OF IMMEDIATE CONCERN SHOULD BE PRIORITIZED.
4. TO AUGMENT SURVIVAL OF RIPARIAN PLANTINGS:
   a. FINAL PLACEMENT OF PLANTS WOULD BE CHOSEN BASED ON MICROSITE CONDITIONS, BECAUSE SOIL PROPERTIES AND WATER TABLE DEPTH CAN VARY OVER SHORT DISTANCES, SUCH THAT SPECIES ARE BEST MATCHED TO THEIR SITE CONDITIONS.
   b. SITE PREPARATION, SUCH AS REMOVAL OF WEEDS OR OTHER SPECIES THAT WILL COMPETE WITH SEEDLINGS AND TILLING OF THE SOIL WOULD OCCUR PRIOR TO PLANTING.
   c. IF NECESSARY, SOIL AMENDMENT, SUCH AS FERTILIZER, WOULD BE INCORPORATED PRIOR TO OR DURING PLANTING (E.G., IF LEVEE MATERIALS ARE USED AS FILL).
   d. IF NECESSARY, MEASURES, SUCH AS TUBING, OR OTHER ANIMAL CONTROL TECHNIQUES CAN BE UTILIZED TO PROTECT PLANTS FROM GRAZING.
   e. IF POSSIBLE, PLANTS WOULD BE INSTALLED IN THE LATE FALL THROUGH EARLY SPRING TO MINIMIZE THE NEED FOR SUPPLEMENTAL WATER AND TO ALLOW FOR THE OPTION OF USING BARE ROOT PLANT STOCK IF AVAILABLE.

GENERAL PLANTING NOTES:

1. PLANT MATERIALS AND SEEDS SHOULD BE FROM SOURCES EAST OF THE CASCADES AND FROM SIMILAR ELEVATION.
2. CONTAINER GROWTH TREES AND SHRUBS SHOULD BE IN CONTAINERS AT LEAST 10 INCHES DEEP OR DEEPER TO HELP ENSURE SURVIVAL BEYOND THE FIRST YEAR, WHILE REDUCING THE AMOUNT OF SUPPLEMENTAL WATER REQUIRED.
3. SUPPLEMENTAL FERTILIZER MAY BE ADDED TO THE BOTTOM OF EACH TREE AN SHRUB PLANTING HOLE PRIOR TO PLANTING AND BACKFILLING. IF USED,FERTILIZERS SHALL BE SLOW RELEASE PRODUCTS THAT WILL NOT RESULT IN NUTRIENT RUNOFF INTO AQUATIC SYSTEMS.
4. ADDITION OF MULCH THREE INCHES DEEP MAY BE PLACED IN AN 18 INCH DIAMETER RING AROUND EACH TREE AND SHRUB TO PREVENT COMPETITION WITH INVASIVE SPECIES.

RIPARIAN PLANTING ZONES

DESCRIPTION:

THIS ZONE INCLUDES THE EDGES OF NEWLY CREATED OFF-CHANNEL AND SIDE CHANNELS AND ALONG EDGES OF ALCOVES/POOLS WHERE APPLICABLE. THE WIDTH OF THE RIPARIAN ZONE SHOULD FACTOR IN SITE SPECIFIC CONDITIONS INCLUDING SOIL, AVAILABLE MOISTURE(WATER TABLE), TOPOGRAPHY, AND WIDTH OF STREAM.

RIPARIAN PLANTING ZONES ON SHEETS ARE CONCEPTUAL. ACTUAL ZONES FOR RIPARIAN PLANTINGS, LIVE STAKES, AND SEED MIXES WILL DEPEND ON FINAL RESTORATION DESIGNS FOR A SPECIFIC SITE.

EXAMPLE SEQUENCE:

1. SEED BARE SOIL AT APPROXIMATELY 30 LBS/ACRE IN SELECTED AREAS AS NEEDED/DESIRED FOR EROSION CONTROL.
2. INSTALL PLANTS BASED ON MICROSITE VARIATIONS WITHIN RIPARIAN PLANTING ZONE.
3. DEPENDING ON DESIRED DENSITY: TREES SHOULD BE PLANTED 10 TO 18 FEET ON CENTER, SHRUBS SHOULD BE PLANTED AT APPROXIMATELY 4 TO 8 FEET ON CENTER. HOWEVER, FINAL PLANT SPACING WILL DEPEND ON SPECIFIC SITE CONDITIONS AND DESIRED OUTCOMES AND SHOULD BE DESIGNED DURING FINAL PLAN DESIGN.

Potential Species to be Used for Riparian Plantings

Trees and Shrubs		
Latin name	**Common name**	**Growth Habit**
Alnus incana	mountain alder	shrub; tree
Alnus rhombifolia	white alder	tree
Betula occidentalis	water birch	shrub; tree
Betula papyrifera	paper birch	tree
Cornus sericea [1]	redosier dogwood	shrub
Philadelphus lewisii [2]	Lewis' mock orange	shrub
Pinus ponderosa [2]	ponderosa pine	tree
Populus tremuloides	quaking aspen	tree
Populus trichocarpa [1] (*Populus balsamifera* ssp. *trichocarpa*)	black cottonwood	tree
Prunus virginiana	chokecherry	shrub; tree
Ribes species[3] (*R. aureum, R. lacustre*)	gooseberry/currant	shrub
Rosa species[3] (*R. nutkana, R. woodsii*)	rose	shrub
Salix amygdaloides [1]	peachleaf willow	shrub; tree
Salix exigua [1]	coyote willow; narrowleaf willow	shrub
Salix lasiandra [1]	Pacific willow	tree
Salix prolixa [1]	Mackenzie willow	shrub; tree
Sambucus nigra ssp. *caerulea*	blue elderberry	shrub
Symphoricarpos albus [2]	snowberry	shrub
Grasses, Rushes and Sedges[3]		
Latin name	**Common name**	**Growth Habit**
Agrostis exarata	spike bentgrass	grass
Bromus carinatus	mountain brome	grass
Carex amplifolia	bigleaf sedge	sedge
Carex lenticularis	lakeshore sedge	sedge
Carex microptera	small-winged sedge	sedge
Carex nebrascensis	Nebraska sedge	sedge
Carex stipata	awlfruit sedge	sedge
Carex utriculata	beaked sedge	sedge
Deschampsia danthonioides	annual hairgrass	grass
Deschampsia elongata	slender hairgrass	grass
Eleocharis palustris	common spikerush	rush
Elymus canadensis	Canada wildrye	grass
Elymus glaucus	blue wildrye	grass
Elymus lanceolatus	streambank wheatgrass	grass
Festuca idahoensis	Idaho fescue	grass
Glyceria species (G. gradis, G elata)	mannagrass	grass
Juncus balticus	Baltic rush	rush
Leymus cinereus	Basin wildrye	grass
Pseudoroegneria spicata	Basin wildrye	grass

NOTES:

1. LIVE STAKES OF THESE SPECIES CAN ALSO BE UTILIZED
2. THIS SPECIES SHOULD BE PLANTED FURTHER UP ON THE BANK
3. CHOICE OF SPECIES AND PLACEMENT WITHIN PLANTING ZONE WILL DEPEND ON SITE CONDITIONS AND SPECIES; SPECIES HAVE DIFFERENT MOISTURE REQUIREMENTS AND TOLERANCES

LIVE STAKES

DESCRIPTION:

LIVE STAKES SHOULD BE INSTALLED ALONG BANKS OF NEWLY CREATED OFF-CHANNEL AND SIDE CHANNELS AND ALONG EDGES OF ALCOVES/POOLS, WHERE APPLICABLE. THE WIDTH OF THE ZONE FOR PLANTING WILL DEPEND ON SITE CONDITIONS AND DESIGN CHARACTERISTICS INCLUDING FINAL GRADE OF BANK AND MOISTURE AVAILABILITY.

EXAMPLE SEQUENCE:

1. SEED BARE SOIL AT APPROXIMATELY 30 LBS/ACRE IN SELECTED AREAS AS NEEDED/DESIRED FOR EROSION CONTROL.
2. INSTALL STAKES BASED ON MICROSITE VARIATIONS WITHIN RIPARIAN PLANTING ZONE.
3. DEPENDING ON DESIRED DENSITY, STAKES MAY BE PLANTED AT APPROXIMATELY 1 TO 10 FEET ON CENTER.

SELECTION AND INSTALLATION NOTES:

1. LIVE STAKES SHOULD BE BETWEEN 18-48 INCHES LONG AND AT LEAST ½" IN DIAMETER.
2. STAKES SHOULD BE CUT STRAIGHT AT THE TIP OF THE BRANCH AND AT AN ANGLE AT THE BASE OF CUTTING TO ENSURE THE CORRECT END IS DRIVEN INTO THE GROUND.
3. KEEP STAKES MOIST AND IN A DARK PLACE UNTIL INSTALLED; DO NOT LET STAKES DRY OUT.
4. SOAKING STAKES BEFORE INSTALLATION INCREASES SURVIVAL AND GROWTH WEIGHT.
5. DRIVE STAKES INTO THE SOIL SO AT LEAST ⅔ OF ITS LENGTH IS UNDERGROUND; LEAVE AT LEAST 12 INCHES ABOVE GROUND.
6. USE THICKER DIAMETER STAKES WHEN PLANTING IN RIPRAP; THICKER DIAMETER STAKES WILL RESIST HEAT AND DRYING BETTER THAN SMALLER CUTTINGS.
7. PLANT STAKES DURING THE DORMANT SEASON.

Potential Species to be Used for Live Stakes

Latin name	**Common name**	**Growth Habit**
Cornus sericea	redosier dogwood	shrub
Populus trichocarpa (Populus balsamifera ssp. *trichocarpa*)	cottonwood	tree
Salix amygdaloides	peachleaf willow	shrub to medium sized tree
Salix exigua	coyote willow	shrub
Salix lasiandra var. *caudata*	Pacific willow	tree
Salix prolixa	Mackenzie's willow	shrub; tree

NOTE:

SHRUBBY WILLOW SPECIES SHOULD MAKE UP THE BULK OF THE COMPOSITION; BUT OTHER SPECIES SHOULD BE ADDED TO INCREASE DIVERSITY OF SPECIES AND DIVERSITY IN SIZE STRUCTURE (E.G. SMALL SHRUBS, TALL SHRUBS, TREES)

SEED MIX

DESCRIPTION:

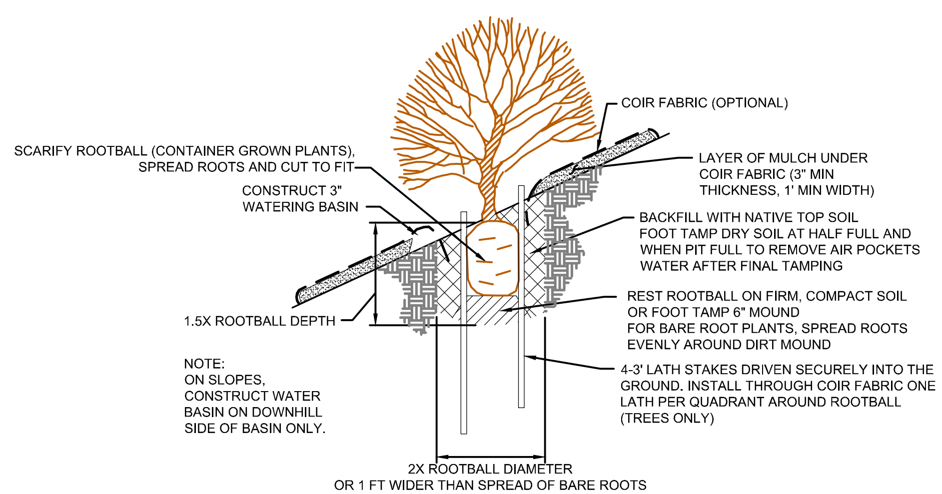
SEED MIX, COMPOSED OF NATIVE SPECIES, SHALL BE USED ON BARE SOIL IN SELECTED AREAS OF THE RIPARIAN PLANTING ZONE AS NEEDED/DESIRED FOR EROSION CONTROL.

Potential Species to be Used for Seed Mixes

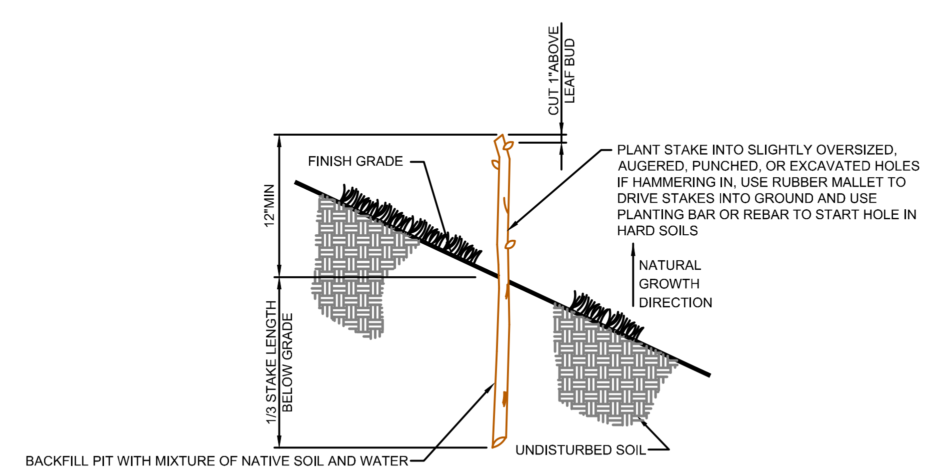
Latin name	**Common name**	**Growth Habit**
Agrostis exarata	spike bentgrass	grass
Bromus carinatus	mountain brome	grass
Deschampsia danthonioides	annual hairgrass	grass
Deschampsia elongata	slender hairgrass	grass
Elymus canadensis	Canada wildrye	grass
Elymus glaucus	blue wildrye	grass
Elymus lanceolatus	streambank wheatgrass	grass
Festuca idahoensis	Idaho fescue	grass
Glyceria species (*G. grandis, G. elata*)	mannagrass	grass
Leymus cinereus	basin wildrye	grass
Pseudoroegneria spicata	bluebunch wheatgrass	grass

NOTES:

1. SEED AT APPROXIMATELY 30 LBS/ACRE; FINAL QUANTITY OF SEED MIX PER ACRE WILL DEPEND ON SPECIES COMPOSITION AND SITE CONDITIONS.
2. SPECIES TO BE USED FOR SEED MIX(ES) AND FINAL COMPOSITION SHOULD BE CHOSEN BASED ON SITE SPECIFIC DESIGN AND CONDITIONS (E.G. SLOPE, WIDTH OF PLANTING ZONE, MOISTURE AVAILABILITY)
3. ALL SEED MIXES SHOULD BE CERTIFIED WEED-FREE.



SHRUB AND TREE SLOPE PLANTING DETAIL



LIVE STAKE PLANTING DETAIL

TETRA TECH
www.tetratech.com
19803 North Creek Parkway
Bothell, Washington 98011
Phone: 425-482-7600 Fax: 425-482-7652

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LOWER WALLA WALLA GEOMORPHIC ASSESSMENT AND ACTION PLAN

CONCEPTUAL DESIGN PLANTING NOTES

DWG. NO.:

CREATED: 07/11/2014

SHEET: 12 OF 12

Appendix E – Specifications and Preliminary Cost Estimates

SPECIAL PROVISIONS

INTRODUCTION

The following special provisions shall be used in conjunction with the Standard Specifications for Road, Bridge and Municipal Construction, 2014 edition, as issued by the Washington State Department of Transportation, hereinafter referred to as the “Standard Specifications.”

The Standard Specifications, except as they may be modified or superseded by these provisions and the Terms and Conditions Under the HIP III Biological Opinion, shall govern all phases of work under this contract, and they are by reference made an integral part of these Specifications and contract as herein fully set forth. Measurement and payment will be only for those items listed in the proposal. All other work shall be considered as incidental with no separate measurement or payment.

Also incorporated into these Specifications by reference are the:

Manual on Uniform Traffic Control Devices for Streets and Highways, current edition.

Standard Plans for Road, Bridge and Municipal Construction, as prepared by the Washington State Department of Transportation and the American Public Works Association, current edition.

NOTE: Strict adherence to the Standard Specifications will be required along with the following amendments and clarifications:

Division 1 *General Requirements*

1-07 Legal Relations and Responsibilities to the Public

1-07.15 Temporary Water Pollution/Erosion Control

Supplement this Section with the following:

TESC plans shall comply with all requirements specified in the permits acquired for the project.

Division 8 Miscellaneous Construction

8-02 Roadside Restoration

Roadside restoration also applies to temporary construction access. Supplement this Section with the following:

8-02.2 Materials

Supplement this Section with the following:

Soil	9-14.1
Seed	9-14.2
Mulch and Amendments	9-14.4

8-02.3 Construction Requirements

Supplement this Section with the following:

Seed shall be placed in accordance with Section 8-01.3(2) of the Standard Specifications.

8-02.4 Measurement

Supplement this Section with the following:

Measurement for Vegetation Restoration will be acre of area planted with riparian plantings, live stakes and seed mix.

8-02.5 Payment

Supplement this section with the following:

Payment will be made in accordance with Section 1-04.1, for the following listed Bid Item:

1. "Vegetation Restoration", per acre.

The unit contract price for "Vegetation Restoration" shall include all costs for the Work required to furnish and install the riparian plantings, live stakes, seed mix, soils, mulch, and disposal of excess material, and any other material necessary to install the willows.

8-30 Stream Restoration (NEW SECTION)

8-30.1 Description

This work consists of installing large woody debris (LWD) structures and habitat boulders in accordance with these Specifications and as shown in the Plans or as designated by the Engineer.

8-30.2 Materials

Materials shall meet the requirements of the following sections, and as specified herein:

Habitat Boulders	9-03.11(4)
Habitat Boulders for Ballast	9-03.11(4)

8-30.2(1) Large Woody Debris (LWD)

The selected LWD for placement shall be ponderosa pine or fir of recent vintage and free from insects, rot, and decay. LWD may be barked or un-barked. All branches and limbs shall remain intact to the extent possible. All used timber and associated materials shall be free of any preservative such as creosote. The LWD installed shall not be encrusted with silts and fines. LWD shall consist of either a straight timber bole or a straight timber bole with rootwad attached to the dimensions as specified in the Plans. Nominal rootwad diameter shall be a minimum of 2 times the timber bole diameter and a maximum of 4 times the timber bole diameter. Root wads may need to be cleaned prior to placement.

Material requirements:

Minimum diameter: 12 inch

Maximum diameter: 28 inch

To cut/break down LWD, first score the log at the desired length, and then using a backhoe, snap the log at the scored location to create a natural look to the break. Crunch broken ends to disguise any saw cuts. Cut ends of LWD shall have no blunt ends.

8-30.2(2) Live Stakes

Live Stake cutting stock shall be gathered during the dormant period and installed within 7 calendar days of harvest. Cuttings shall not be gathered if temperatures are below 32 ºF (0ºC). Cuttings shall be protected from sun, wind, freezing, drying or injury before and during planting. Cuttings shall be stored upright in water immediately after harvesting up until they are installed. Stored material shall be examined frequently for signs of disease and planted before dormant bud development.

Cuttings shall be 24 inches long making the bottom cut slanted and below a dormant bud, and the top cut straight, ½ to 1 inch above a dormant bud. The diameter of pieces reserved for planting shall not be less than ½ inch thick.

8-30.3 Construction Requirements

The Contractor shall be required to execute the work in conformance with the Hydraulic Project Approval. Except as noted below, all in-stream structures, devices, materials, and appurtenances shall be installed in a dry condition.

The Contractor shall notify the Engineer two working days prior to beginning construction of all LWD structures and Habitat Boulders. All LWD structures and Habitat Boulders shall be constructed as shown on the Plans or as directed by the Engineer. LWD structures shall be subject to field fit conditions. The Contractor shall be required to work in conjunction with the Engineer and may be required to reposition or adjust the installation as directed by the Engineer.

8-30.3(1) Preconstruction Survey – Staking and Layout

Prior to the beginning of the Work, the Contractor shall complete a survey to layout the proposed construction activities. The Plans provide the Contractor with the primary survey control information consisting of descriptions of the control points used for horizontal and vertical control. The Contractor shall verify the surveyed control information provided on the Plans and shall expand the survey control information to include secondary horizontal and vertical control points as needed for the project. The Contractor’s survey records shall include descriptions of all survey control points, including coordinates and elevations of all secondary control points.

The Contractor shall be responsible for staking the location of all construction and excavation points for the project. Each point shall be staked with lathe. The point identification and description shall be clearly marked on the lathe, and flagging attached to the lathe for visibility.

Survey information staked for the Preconstruction Survey shall include northing, easting, and elevation data for each Channel excavation, LWD structure, and Habitat boulder location. The Contractor shall ensure a surveying accuracy to within ±0.1 feet for vertical control and ± 0.1 feet for horizontal control.

Upon completion of the staking for control points, Channel excavation, LWD structure, and Habitat boulder location, the Contractor shall notify the Engineer for review of the staking survey.

Upon review and approval of the staking survey by the Engineer, the Contractor will be notified to proceed with the project construction.

8-30.3(2) Large Woody Debris (LWD) Structures

The Contracting Agency will supply all LWD needed for heavy equipment-placed LWD structures at the designated staging areas on the Plans. The Contractor shall locate, at the designated staging areas, and then deliver LWD of the type and dimensions shown in the Plans.

The Engineer may revise the actual location or installation details to accommodate field conditions. All LWD shall be surfaced placed in the wetted channel as described in the Plans or as directed by the Engineer. The Contractor shall minimize the impact of the activities within the wetted channel.

Ballast all LWD with Habitat Boulders as described in the Plans or as directed by the Engineer.

Upon completion of construction of the LWD Structures, the Contractor shall plant live stakes within and around the LWD Structures.

8-30.3(3) Log and Boulder Revetment Structures

The Contractor shall install the LWD for Log and Boulder Revetment Structures at the locations shown in the Plans. The Engineer may revise the actual location or installation details to accommodate field conditions. The contractor shall excavate to the depth shown in the Plans, or as directed by the Engineer.

Ballast all LWD with Habitat Boulders as described in the Plans or as directed by the Engineer.

Upon completion of the construction of the Log and Boulder Revetment Structures, the Contractor shall plant live stakes within and around the LWD Structures and backfill and compact the structure with the spoils from the excavation.

8-30.3(4) Habitat Boulders

The Contracting Agency will supply all Habitat Boulders needed for Habitat boulder installation structures at the designated staging areas on the Plans.

8-30.3(4)A Habitat Boulders for Ballast

Habitat Boulders for Ballast shall be placed in the Complex LWD Structures and LWD Structures – Placement by Excavator at the locations and the dimensions indicated on the Plans. The Engineer may revise the actual location or installation details to accommodate field conditions.

8-30.3(4)B Habitat Boulders

Habitat Boulders shall be placed for in-stream habitat complexity at the locations and the dimensions indicated on the Plans. The Engineer may revise the actual location or installation details to accommodate field conditions.

8-30.3(5) Dewatering and Cofferdams

The Contractor shall provide, install and maintain the temporary in-channel cofferdams around each flowing channel area where the Complex LWD Structures will be installed, as indicated on the Plans. The cofferdam system shall include installation of gravel berm and plastic sheet, providing a mostly water tight seal as shown in the Plans. Fish removal shall occur in the isolated area. Sediment shall not be conveyed downstream during construction period. Once the cofferdam is in place and fish removed, the area shall be dewatered with silt laden water discharged to an upland floodplain location to avoid sediment entering the stream. The coffer dam and any dewatering measures required shall remain operating properly for the duration of the LWD installation.

The Contractor shall size the water pumping system to convey flow out of the LWD installation area during the construction. The Contractor shall remove the temporary cofferdam, backfill the area with native material including compaction of backfill, and restore the areas to the finish grades indicated in the Plans when the temporary cofferdam is no longer needed.

8-30.3(6) Fish Removal

Collection of fish shall comply with the requirements of the Hydraulic Project Approval. The Contractor shall provide services of a fish biologist to coordinate and supervise the fish removal activities. The fish biologist shall have a Master of Science degree in a fisheries related degree and at least 5 years of field experience in fish habitat restoration and managing relocation of fish from restoration or culvert replacement projects. Contractor shall use one of the following methods to capture fish:

1. Manual: Collect fish by manual collection such as herding or dip netting as the area is slowly dewatered.

2. Seining: Use seine with mesh of such a size to ensure entrapment of the residing fish.

3. Minnow traps: Traps will be left in place overnight and in conjunction with seining.

4. Electrofishing: All fish capture and release must follow National Marine Fisheries (NMFS) electrofishing guidelines (2000) (Available from NMFS Northwest Region Protected Resources Division, http://www.nwr.noaa.gov/Regional-Office/Protected-Resources/index.cfm)

If capture, removal, and relocation of ESA-listed fish are required, contractor shall comply with the following fish handling and transfer protocols steps:

1. Isolate work area.

2. If block nets are used, leave in a secured position to exclude fish from entering the project area if needed.

3. Leave nets secured to stream channel bed and banks until fish capture and transport activities are complete.

4. Remove block nets the same day they are installed. If block nets remain in place more than one day, daily net monitoring is required to ensure they are secured to the banks and free of organic accumulation.

8-30.4 Measurement

Preconstruction Survey – Staking and Layout will be measured as Lump Sum, and shall include all work necessary to stake and layout all features to be constructed on the project.

Log and Boulder Revetment Structures will be measured per each structure. The cost for this item shall include all LWD and Habitat Boulder materials and work required to complete the construction of the structure. No separate measurement shall be made for planting willows, excavation, backfill, or compaction of the native material during structure installation.

All remaining LWD will be measured per each piece installed on site. The costs for this item shall be transporting and installing the LWD. No separate measurement shall be made for planting willows within the LWD placed by excavator.

All Habitat Boulders will be measured per each rock installed on site. There shall be separate measurements for Habitat Boulders used for ballast in the large wood structures placed by excavator, and Habitat Boulders placed for in-stream habitat. No separate measurement shall be made for haul, excavation, or backfill required for Habitat Boulder installation.

Cofferdam and dewatering will be measured as Lump Sum. A separate measurement shall be made for Fish Removal.

8-30.5 Payment

Payment will be made based on satisfactory installation in accordance with Section 1-04.1 for the following bid items:

"Preconstruction Survey – Staking and Layout", lump sum.

The unit contract price for "Preconstruction Survey – Staking and Layout" shall be full compensation for all costs incurred for staking and laying out all Project construction and excavation points.

"Log and Boulder Revetment Structures", per each.

The unit contract price for "Complex LWD Structures" shall be full compensation for all costs incurred for locating, transporting, and installing LWD, ballast, and willows, including excavation.

"LWD Structures", per each.

The unit contract price for "LWD Structures – Placement by Excavator" shall be full compensation for all costs incurred for locating, transporting and installing LWD, ballast, and willows by excavator.

"Habitat Boulders for Ballast", per each.

The unit contract price for "Habitat Boulders for Ballast" shall be full compensation for all costs incurred for locating, transporting, and installing Habitat boulders in LWD structures placed by excavator.

"Habitat Boulders", per each.

The unit contract price for "Habitat Boulders" shall be full compensation for all costs incurred for locating, transporting, and installing Habitat boulders.

"Dewatering and Cofferdams", per lump sum.

The unit contract price for "Dewatering and Cofferdams" shall be full compensation for all costs incurred for furnishing, installing, maintaining, and removing the cofferdam and dewatering systems.

"Fish Removal", per lump sum.

The unit contract price for "Fish Removal" shall be full compensation for all Work to remove and relocate fish from the isolated work areas prior to the initiation of construction

8-32 Material Staging (NEW SECTION)

8-32.1 Description

This work consists of the collecting and transporting of all materials from the floodplain to the staging areas or construction sites in accordance with these Specifications.

8-32.2 Materials

Materials requirements for the materials to be collected from the floodplain shall be as directed by the Engineer.

8-32.3 Construction Requirements

The Contractor shall collect all materials as directed by the Engineer from the floodplain and transport these materials to the staging areas or construction sites as directed by the Engineer.

8-32.4 Measurement

Material Staging will be measured as Lump Sum, and shall include all work necessary to collect and transport all materials as directed by the Engineer.

8-32.5 Payment

Payment will be made in accordance with Section 1-04.1 for the following bid items:

"Material Staging", per lump sum.

The unit contract price for "Material Staging" shall be full compensation for all costs associated with the collection and transport of all materials from the floodplain as directed by the Engineer.

PROJECT NAME — **LOWER WALLA WALLA GEOMORPHIC ASSESSMENT AND ACTION PLAN**

JOB NO.: 194-4934 — **CONCEPTUAL LEVEL ESTIMATE OF CONSTRUCTION COSTS**

PROJ. ENG.: ATS — **CATEGORY 1**

CHECKED BY: VM

ITEM	UNIT	TOTAL QUANT.	UNIT PRICE	AMOUNT $	Notes
1. PREPARATION					
MOBILIZATION AND DEMOBILIZATION (SEE BELOW)	LS	1	SEE BELOW	SEE BELOW	
CLEARING AND GRUBBING	AC	3	$3,500	$10,500	Estimated clearing area
TEMPORARY CONSTRUCTION FENCES	LS	1	$5,000	$5,000	
PRECONSTRUCTION SURVEYING, LAYOUT	LS	1	$25,000	$25,000	
2. EARTHWORK					
EXCAVATION - OFF CHANNEL (1490 FT)	CY	17,100	$5	$85,500	Off Channel Habitat
EXCAVATION - HIGH FLOW BYPASS CHANNEL (790 FT)	CY	4,150	$5	$20,750	Connecting Off Channel Habitat upstream
3. STREAM STRUCTURES					
LARGE WOOD PLACED IN OFF CHANNEL	EACH	50	$200	$10,000	Soft placing within off channel and bypass channel
MID-CHANNEL DIVERSION STRUCTURE	EACH	1	$35,000	$35,000	Major structure in stream
4. EROSION CONTROL AND PLANTING					
CONSTRUCTION AREA BMPS	LS	1	$2,500	$2,500	Spill plans and good practices for vehicle and material storage in floodplain
MATERIAL STORAGE AREAS	LS	1	$5,000	$5,000	Expenses associated with transporting, stockpiling, and sorting material collected from floodplain
TEMPORARY EROSION AND SEDIMENTATION CONTROL	LS	1	$5,000	$5,000	Erosion control for bare soil, work area isolation, work pads
VEGETATION RESTORATION	AC	3	$5,000	$15,000	Mechanical seeding and 8' spacing, container plants (see plans)
5. OTHER ITEMS					
STREAM DEWATERING & COFFERDAMS	LS	1	$5,000	$5,000	Installation and removal
DE-FISHING	LS	1	$2,500	$2,500	Removal, care and transportation
PROJECT CLEANUP & REPAIRS	LS	1	$2,500	$2,500	Remove garbage, repair roads and fences, etc at end of project
	SUB TOTAL			$229,250	
	MOBILIZATION (10%)			$22,900	
	SUBTOTAL			$252,150	
	CONTINGENCY (30%)			$75,600	
				$328,000	**TOTAL OPINION OF PROBABLE CONSTRUCTION COST (Rounded to the nearest thousand dollars)**

PROJECT NAME — **LOWER WALLA WALLA GEOMORPHIC ASSESSMENT AND ACTION PLAN**

JOB NO.: 194-4934 — **CONCEPTUAL LEVEL ESTIMATE OF CONSTRUCTION COSTS**

PROJ. ENG.: ATS — **CATEGORY 2**

CHECKED BY: VM

ITEM	UNIT	TOTAL QUANT.	UNIT PRICE	AMOUNT $	Notes
1. PREPARATION					
MOBILIZATION AND DEMOBILIZATION (SEE BELOW)	LS	1	SEE BELOW	SEE BELOW	
CLEARING AND GRUBBING	AC	10	$3,500	$35,000	Estimated clearing area
TEMPORARY CONSTRUCTION FENCES	LS	1	$5,000	$5,000	
PRECONSTRUCTION SURVEYING, LAYOUT	LS	1	$25,000	$25,000	
2. EARTHWORK					
EXCAVATION - LOWER FLOODPLAIN	CY	12,025	$5	$60,125	Created floodplain - size and extents of floodplain can vary
EXCAVATION - LOWER SIDE CHANNEL (415 FT)	CY	7,750	$5	$38,750	Secondary channel
EXCAVATION - MIDDLE HIGH FLOW CHANNEL (495 FT)	CY	6,300	$5	$31,500	Secondary channel
EXCAVATION - UPPER FLOODPLAIN	CY	85,600	$5	$428,000	Created floodplain - size and extents of floodplain can vary
EXCAVATION - UPPER SIDE CHANNEL (590 FT)	CY	3,350	$5	$16,750	Secondary channel, excavation quantity is calculated to created floodplain elevation
3. STREAM STRUCTURES					
MID-CHANNEL DIVERSION STRUCTURE	EACH	2	$35,000	$70,000	Major structure in stream
LOG AND BOULDER REVETMENT STRUCTURE	EACH	3	$35,000	$105,000	Long upper revetment structure counted as two structures due to length
ALCOVE	EACH	1	$15,000	$15,000	Includes excavation, and log placements
BANK STABILIZATION STRUCTURES	LF	1,270	$20	$25,400	Includes labor and materials to construct, includes cost for log and boulder placement
4. EROSION CONTROL AND PLANTING					
CONSTRUCTION AREA BMPS	LS	1	$5,000	$5,000	Spill plans and good practices for vehicle and material storage in floodplain
MATERIAL STORAGE AREAS	LS	1	$5,000	$5,000	Expenses associated with transporting, stockpiling, and sorting material collected from floodplain
TEMPORARY EROSION AND SEDIMENTATION CONTROL	LS	1	$7,500	$7,500	Erosion control for bare soil, work area isolation, work pads
VEGETATION RESTORATION	AC	10	$5,000	$50,000	Mechanical seeding and 8' spacing, container plants (see plans)
5. OTHER ITEMS					
STREAM DEWATERING & COFFERDAMS	LS	1	$15,000	$15,000	Installation and removal
DE-FISHING	LS	1	$5,000	$5,000	Removal, care and transportation
PROJECT CLEANUP & REPAIRS	LS	1	$5,000	$5,000	Remove garbage, repair roads and fences, etc at end of project
	SUB TOTAL			$948,025	
	MOBILIZATION (10%)			$94,800	
	SUBTOTAL			$1,042,825	
	CONTINGENCY (30%)			$312,800	
				$1,356,000	**TOTAL OPINION OF PROBABLE CONSTRUCTION COST (Rounded to the nearest thousand dollars)**

PROJECT NAME — **LOWER WALLA WALLA GEOMORPHIC ASSESSMENT AND ACTION PLAN**

JOB NO.: 194-4934 — **CONCEPTUAL LEVEL ESTIMATE OF CONSTRUCTION COSTS**

PROJ. ENG.: ATS — **CATEGORY 3**

CHECKED BY: VM

ITEM	UNIT	TOTAL QUANT.	UNIT PRICE	AMOUNT $	Notes
1. PREPARATION					
MOBILIZATION AND DEMOBILIZATION (SEE BELOW)	LS	1	SEE BELOW	SEE BELOW	
CLEARING AND GRUBBING	AC	8	$3,500	$28,000	Estimated clearing area
TEMPORARY CONSTRUCTION FENCES	LS	1	$5,000	$5,000	
PRECONSTRUCTION SURVEYING, LAYOUT	LS	1	$25,000	$25,000	
2. EARTHWORK					
EXCAVATION - FLOODPLAIN	CY	89,975	$5	$449,875	Created floodplain - size and extents of floodplain can vary
EXCAVATION - UPPER SIDE CHANNEL (850 FT)	CY	16,250	$5	$81,250	Secondary channel, excavation quantity is calcuated to created floodplain elevation
EXCAVATION - LOWER HIGH FLOW CHANNEL (300 FT)	CY	9,590	$5	$47,950	Secondary channel
3. STREAM STRUCTURES					
MID-CHANNEL DIVERSION STRUCTURE	EACH	1	$35,000	$35,000	Major structure in stream
ALCOVE	EACH	1	$15,000	$15,000	Includes excavation, and log placements
LARGE WOOD PLACED IN SIDE CHANNEL	EACH	25	$200	$5,000	Soft placing within off channel and bypass channel
4. EROSION CONTROL AND PLANTING					
CONSTRUCTION AREA BMPS	LS	1	$5,000	$5,000	Spill plans and good practices for vehicle and material storage in floodplain
MATERIAL STORAGE AREAS	LS	1	$5,000	$5,000	Expenses associated with transporting, stockpiling, and sorting material collected from floodplain
TEMPORARY EROSION AND SEDIMENTATION CONTROL	LS	1	$5,000	$5,000	Erosion control for bare soil, work area isolation, work pads
VEGETATION RESTORATION	AC	8	$5,000	$40,000	Mechanical seeding and 8' spacing, container plants (see plans)
5. OTHER ITEMS					
STREAM DEWATERING & COFFERDAMS	LS	1	$5,000	$5,000	Installation and removal
DE-FISHING	LS	1	$2,500	$2,500	Removal, care and transportation
PROJECT CLEANUP & REPAIRS	LS	1	$2,500	$2,500	Remove garbage, repair roads and fences, etc at end of project
	SUB TOTAL			$757,075	
	MOBILIZATION (10%)			$75,700	
	SUBTOTAL			$832,775	
	CONTINGENCY (30%)			$249,800	
				$1,083,000	**TOTAL OPINION OF PROBABLE CONSTRUCTION COST (Rounded to the nearest thousand dollars)**

PROJECT NAME **LOWER WALLA WALLA GEOMORPHIC ASSESSMENT AND ACTION PLAN**

JOB NO.: 194-4934 **CONCEPTUAL LEVEL ESTIMATE OF CONSTRUCTION COSTS**

PROJ. ENG.: ATS **CATEGORY 4**

CHECKED BY: VM

ITEM	UNIT	TOTAL QUANT.	UNIT PRICE	AMOUNT $	Notes
1. PREPARATION					
MOBILIZATION AND DEMOBILIZATION (SEE BELOW)	LS	1	SEE BELOW	SEE BELOW	
CLEARING AND GRUBBING	AC	2	$3,500	$7,000	Estimated clearing area
TEMPORARY CONSTRUCTION FENCES	LS	1	$5,000	$5,000	
PRECONSTRUCTION SURVEYING, LAYOUT	LS	1	$12,500	$12,500	
2. EARTHWORK					
EXCAVATION UPPER HIGH FLOW CHANNEL (300 FT)	CY	5,160	$5	$25,800	Secondary channel
EXCAVATION LOWER HIGH FLOW CHANNEL (575 FT)	CY	9,870	$5	$49,350	Secondary channel
3. STREAM STRUCTURES					
POINT BAR STRUCTURES	EACH	2	$16,000	$32,000	Assumes 64 pilings per structure, at $250 per piling
BANK STABILIZATION STRUCTURES	LF	680	$20	$13,600	Includes labor and materials to construct, includes cost for log and boulder placement
4. EROSION CONTROL AND PLANTING					
CONSTRUCTION AREA BMPS	LS	1	$5,000	$5,000	Spill plans and good practices for vehicle and material storage in floodplain
MATERIAL STORAGE AREAS	LS	1	$5,000	$5,000	Expenses associated with transporting, stockpiling, and sorting material collected from floodplain
TEMPORARY EROSION AND SEDIMENTATION CONTROL	LS	1	$7,500	$7,500	Erosion control for bare soil, work area isolation, work pads
VEGETATION RESTORATION	AC	2	$5,000	$10,000	Mechanical seeding and 8' spacing, container plants (see note below)
5. OTHER ITEMS					
STREAM DEWATERING & COFFERDAMS	LS	1	$5,000	$5,000	Installation and removal
DE-FISHING	LS	1	$2,500	$2,500	Removal, care and transportation
PROJECT CLEANUP & REPAIRS	LS	1	$2,500	$2,500	Remove garbage, repair roads and fences, etc at end of project
	SUB TOTAL			$182,750	
	MOBILIZATION (10%)			$18,300	
	SUBTOTAL			$201,050	
	CONTINGENCY (30%)			$60,300	
				$261,000	**TOTAL OPINION OF PROBABLE CONSTRUCTION COST (Rounded to the nearest thousand dollars)**