Report

Walla Walla River Enhancement Alternatives Assessment between McDonald Road and Lowden Road

Near Lowden, Washington

for

Tri-State Steelheaders

April 9, 2010

GeoEngineers
Earth Science + Technology

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File No. 11281-005-00

April 9, 2010

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GEOENGINEERS

Table of Contents

LIST OF FIGURES

APPENDICES

INTRODUCTION

Project Overview

The project reach includes approximately 1.5 miles of the Walla Walla River and associated floodplain, located immediately south and southeast of Lowden, Washington and roughly between River Mile 27.5 and River Mile 29.0 between McDonald Road and Lowden Road as shown on the Vicinity Map, Figure 1. At the upstream extent of the reach, on the left (south) bank, there is a Washington Department of Fish and Wildlife (WDFW) public access area. This state property contains a levee that confines the river and isolates it from the floodplain. This reach of the Walla Walla River is primarily used by salmonids as a migration corridor. Fish species of particular interest include; ESA listed summer steelhead and bull trout; reintroduced spring Chinook, margined sculpin, leopard dace, and river lamprey.

Local salmon recovery managers have cited the project reach as a priority for enhancement on the Walla Walla River mainstem due to limiting factors such as bank condition, channel confinement, lack of complexity, insufficient instream habitat, a narrow riparian area with few mature trees, and lethal summer water temperatures. In an effort to improve natural conditions of their property, WDFW began developing a plan to remove or set back their levee. The Tri State Steelheaders (TSS) were involved in the planning process and noticed the rest of the 1.5 mile project reach is owned by three private landowners who have either previously participated in enhancement activities or have expressed interest. They recognized this to be a unique opportunity to design a master plan for reach scale enhancement activities, with landowner input and participation.

This report and accompanying attachments represent a summary of the methods and results of our alternatives assessment and conceptual enhancement design. The premise and intent of this report is based on our understanding that the ultimate goal of the project is to enhance in-stream and off-channel habitat for anadromous fish meanwhile addressing landowner concerns however practical.

GeoEngineers, Inc. (GeoEngineers) performed this alternatives assessment and conceptual design at the request of Brian Burns of the Tri State Steelheaders (TSS), the Client, in accordance with the signed agreement dated November 12, 2009. The services performed under this contract are described further on in this report in the section entitled Scope of Services.

Report Overview

Overview of Alternatives Assessment

GeoEngineers has prepared this alternative assessment in collaboration with the TSS, the adjoining property owners and WDFW, which also own property along the project reach. A sequential process was followed throughout this assessment in order that practical enhancement alternatives could be developed and compared against one another with the intent of selecting a preferred alternative.

Briefly, this process first involves the identification of the project in terms of its goals and objectives. Whereas the project goals are relatively general, the project objectives are more specific. Each project objective was then assigned a numerical weighting based on its relative level of importance, as defined by the project stakeholders. Several enhancement alternatives, which target the project goals and objectives, were then developed utilizing a combination of geomorphically appropriate enhancement treatments. A numerical rating system was used to facilitate the objective selection of a preferred enhancement alternative. Because the more important objectives and the more effective alternatives were defined in terms of higher relative values or higher levels of effectiveness, the more desirable alternatives have higher benefit ratings. A benefit-to-cost ratio was then calculated to factor in the cost of implementing the alternatives. Using this process, the alternative with the highest benefit-to-cost ratio is the most desirable or "Preferred Option". This assessment process and the results thereof are discussed in greater detail further on in this report.

Organization of Report

This report provides a summary of our findings pertaining to the conditions of the project site, an explanation of our alternatives assessment process used to identify possible enhancement alternatives and ultimately the selection of a preferred alternative.

Specifically, the following sections of this report cover the overarching goals and objectives of the proposed enhancement project, which have been used throughout the alternatives assessment process to ensure the most appropriate conceptual alternatives were developed and considered. The historic and existing conditions of the project site and watershed are then discussed in terms of processes that shaped the river and its ecosystem within the context of various ecological disciplines. This includes discussions on geology, hydrology, hydraulics, habitat, and geomorphology as well as the pertinent land management practices. The consideration of the historic and existing conditions provide the basis upon which possible future enhancement alternatives are developed. Next, the alternatives assessment methodology is summarized including an explanation of the alternatives identification process, cost estimating, selection criteria and the ranking process used to distinguish the preferred alternative.

Following the body of the report are several appendices including: Appendix A, Report Limitations and Guidelines for Use; Appendix B, Hydraulic Model Excerpts; Appendix C, Alternatives Assessment Workbook (which includes Construction Quantities and Cost Estimates); and Appendix D, River Enhancement Design Drawings. These drawings, which are also referred to as "Sheets", graphically support the discussions in this report are referenced throughout the report as necessary. Sheet 1 shows the project location and lists the sheets in this set of drawings.

SCOPE OF SERVICES

GeoEngineers performed the following services in accordance with the contract referenced above. These services, briefly described below, have been completed and constitute the first of several necessary phases of this project. Subsequent phases, which are beyond the scope of this contract, include: funding, preliminary design, environmental permitting, final design, construction and post-construction monitoring.

Task 1: Initial Project Planning (Kick-Off) Meeting

A kick-off meeting was held on December 16, 2009 to establish project management structure and alternatives analysis guidelines. Client and stakeholder input was used to identify the overriding project goals, which were used to develop more specific project objectives and ultimately practical enhancement alternatives.

Task 2: Initial Analysis and Assessment

Once the goals, objectives, and logistics were clearly identified and the project plan was established, we compiled and assessed existing and available information pertaining to the project site including LiDAR topography, hydrology data, recent and historic aerial photos.

Task 3: Collect Additional Data

On-the-ground observations from field reconnaissance was performed on September 17 and 18, 2009. Data collected during these visits were used to supplement and verify the data acquired in Task 2. Collectively, combined with Task 2, we developed an understanding of the historic and existing conditions of the project area and identified potential enhancement opportunities.

Task 4: Geomorphic Assessment

As an extension of Task 3, a geomorphic assessment was completed in order to frame the project area within the larger watershed context. We assessed basin scale processes, geologic setting, and channel migration potential to estimate natural limits of channel geometry in order to develop practical enhancement concepts that work with the river system rather than against it.

Task 5: Evaluate Data and Build Hydraulic Model Template

Using the Army Corps of Engineers Hydraulic Engineering Center – River Analysis System (HEC-RAS) version 4.0 computer model, we developed a limited hydraulic model of the river within the project area. The model was built using topographic data generated from the LiDAR survey, and was used to assess flood, habitat and geomorphic conditions in the existing river.

Task 6: Develop Conceptual Alternatives

We developed practical enhancement alternatives targeting the project goals and objectives identified in Task 1. After distributing draft concepts, we participated in a collaborative review session with TSS and project area landowners to select the preferred alternative and focus the design concept.

Task 7: Develop Design Concept and Master Plan

The preferred alternative has been adapted to a conceptual design package that includes graphics of the recommended design concept and a supporting report. This package can be used to direct the project through the subsequent preliminary design and permitting, final design, construction, and monitoring phases of the project.

PROJECT GOALS AND OBJECTIVES

The ultimate goals and objectives of this project are graphically depicted on Sheet 2 and briefly discussed below.

Project Goal

The ultimate goal of this project is to increase, enhance and diversify aquatic, riparian and upland habitat. In so doing the intent will be to improve overall ecosystem function by increasing floodplain connectivity and minimizing excessive erosion of the terraces within a reasonable period of time by implementing geomorphically appropriate design techniques within the practical limits of the project constraints.

Project Objectives

To achieve the overarching project goal, stated above, seven specific objectives must be achieved. The first four objectives are primary objectives which are quantified during the alternatives assessment process to facilitate the comparison of the enhancement alternatives. The secondary objectives are more general, cannot be as easily quantified and constitute general project guidelines and constraints. These objectives were first identified in a Memorandum from GeoEngineers to the Tri State Steelheaders, dated November 25, 2009 and discussed with stakeholders during the December 16, 2009 project kickoff meeting. The meeting was attended by representatives of TSS, WDFW, GeoEngineers and the adjacent property owners. They were later refined during discussions between GeoEngineers and TSS.

The project objectives are briefly described below. The various aspects of these objectives, as well as the benefits derived from them, are also listed on Sheet 2. While the benefits below are specific, it is understood that all of these objectives support each other and are mutually beneficial to the larger environment, habitat and neighboring landowners.

Objective 1: Increase, Enhance and Diversify Aquatic Habitat

Funding for this project was provided by the Washington State Salmon Recovery Funding Board (SRFB), the fundamental purpose of which is improving conditions for resident and anadromous fish. Therefore, the primary objective for this project is to increase, enhance and diversify the aquatic habitat for the benefit of multiple fish species and all freshwater life stages of native fish species. Habitat should improve fish spawning, rearing, holding, and juvenile refugia. In general, these types of improvements include:

- Multiple habitat types in close proximity
- Primary pool habitat
- Substrate diversification
- Habitat structure and cover
- Side-channel and off-channel habitat

Objective 2: Increase, Enhance and Diversify Riparian and Upland Habitat

Healthy riparian habitat provides bed and bank stability, Large Woody Debris (LWD) recruitment, shade and also provides a platform for macroinvertebrates to thrive. Therefore a healthy riparian corridor benefits fish directly. In addition, healthy, diverse riparian and upland habitats, composed of native plant species, benefit the wider bird and wildlife communities that currently and/or historically inhabit or migrate through this river corridor.

Objective 3: Increase Floodplain Connectivity

Increased connectivity between the river and floodplains, during relatively frequent high water events, provides many benefits, including: increased flood storage, reduced erosion, bed and bank stability, and increased hyporheic (shallow ground water) exchange. Increased floodplain connectivity also supports healthy riparian habitat, which in turn benefits fish, wildlife and the larger community.

Objective 4: Minimize Bank Erosion on Upper Terraces

There are currently numerous high, vertical, unsafe, eroding banks along the project reach. In many locations the banks are migrating laterally which results in the loss of usable property. In addition, these steep banks inhibit riparian development and limit river access to some wildlife. While we recognize that erosion and lateral migration of the river is a natural and ultimately a self-healing process, it is also understood that such processes must be balanced with safety, stability and land use.

Objective 5: Geomorphic Stability

Geomorphic stability involves creating a condition in which the proposed condition is self-sustaining and self-maintaining; rates of erosion are balanced with the rates of deposition; vegetation loss is equal to regeneration. Natural materials, including LWD structures, vegetation and limited amounts of rock are typically used in lieu of riprap and concrete. In addition to providing bed and bank stability and a platform for long-term vegetation and habitat maturation, geomorphically stable systems are less prone to excessive avulsions and require less long-term maintenance.

Objective 6: Rapid Recovery Time

Recovery time is the time required for the disturbed areas to stabilize. This includes the time for new and/or disturbed vegetation to establish enough to provide sufficient erosion resistance. It also includes the time necessary for the bed and banks of the new channels to stabilize in terms of sediment transport, scour hole development, gravel bar development and bar and bank vegetation establishment. Recovery time can vary significantly between the proposed treatments and alternatives. For example; recovery time is relatively minimal for the small overflow/side channels proposed in the floodplains compared to the time necessary for a pilot channel to develop, expand, migrate and then stabilize itself over the course of many years. Longer recovery times generally involve more maintenance and greater risk of uncertainty and failure.

Objective 7: Design Practicality

Rather than specifically focusing on a specific design intent (for example, enhanced fish habitat), design practicality includes a number of items that are commonly considered as project constraints or limitations. In order to be successful, alternatives must address a wide range of design considerations, including:

- Accommodating physical, practical and regulatory concerns, such as:
  - Public safety
  - Zoning, easements, setbacks, flood zones
  - Property boundaries, landowner concerns
  - Neighboring landowner concerns
- Minimizing Project Complexity
  - Minimal disturbance to existing ground, habitat, vegetation and structures
  - Minimal landowner disturbance
  - Minimal construction schedule/seasons, phasing, river diversions
  - Minimal permitting concerns
  - Minimal maintenance

While project cost is directly proportional to some of these considerations, cost is not considered in this objective. Project costs are factored into the alternatives selection process by considering the benefit-to-cost ratio, which is discussed later in this report.

HISTORIC AND EXISTING CONDITIONS

Historic Conditions

Geology/Soils

During the last ice age, which ended roughly 10,000 years ago, the Walla Walla River valley was subject to catastrophic backwater flooding from multiple Glacial Lake Missoula Flood events. Each flood filled the lower Walla Walla River valley with alluvium consisting primarily of gravel toward the center of the valley with increasing volumes of sand and silt toward the valley's periphery (Beechie, *et al*., 2008). The ice-age gravel was subsequently overlain by sand and silt derived from windblown glacial loess and reworked floodplain deposits. Over time, the weight and translocated minerals from the loess and floodplain deposits partially cemented the ice age gravels together, resulting in a relatively erosion-resistant conglomerate underlying the floodplain sediment throughout much of the project area.

Geomorphology

Very little is known of the physical condition of the Walla Walla River prior to Anglo settlement in the late 1800s and early 1900s. From Lewis and Clark Journals (April 29, 1806): The Walla Walla River approximately 1 mile upstream from its confluence with the Columbia "*is a handsome stream about 4 feet deep and 50 yds wide; it's bed is composed of gravel principally with some sand and mud the banks are abrupt but not high, though it does not appear to overflow; the water is clear. the indians inform us that it has it's sources in the range of mountains in view of us to the E and*

SE." Although this journal entry pertains to the river several miles downstream of the project site, the geomorphic setting downstream is fairly similar to that of the project site, and many similarities can be assumed. For one, it is assumed that the Walla Walla River was primarily a single-threaded channel with many smaller side channels and off-channel habitat occupying a broad floodplain densely forested with mature cottonwood trees and willows. Like most streams in this area, it is assumed that beaver activity contributed to the historic channel development by adding in-stream structure in the form of woody debris which promoted local sediment deposition, channel migration, and side-channel creation.

Land Use

As the Walla Walla basin was developed in the late 1800s and early 1900s, agricultural and grazing demands on the landscape resulted in a large-scale clearing of historic riparian vegetation from the floodplain, drainage of off-channel wetlands, and elimination of side channels. Additionally, it is apparent from historic aerial photographs and LiDAR that the main stem Walla Walla River was channelized and straightened in many areas, including within the project reach (Sheet 3.3). This consolidation of flow and reduction of stabilizing riparian vegetation resulted in severe channel incision throughout the basin. The relatively erosion-resistant glacial gravel underlying portions of the river limited incision within the project area to roughly 6-12-feet as opposed over 30-feet of incision in near-by reaches.

Hydrology

Discharge on the Walla Walla River was historically dependant primarily on spring snow-melt in the headwaters and spring/summer rainfall throughout the basin. The broad floodplain with multiple side-channels and dense riparian vegetation likely attenuated flood volumes and velocities during historic high discharge events. But, as land uses changed toward agriculture, riparian vegetation was cleared and fields were ditched to more effectively remove water, creating the potential for greater runoff and greater flood frequency and severity. Conversely, during the dry summer months, increased irrigation demands severely reduced in-stream, low-flow volumes. The modern Walla Walla River has been largely shaped by this altered hydrology, which will be discussed in the Existing Conditions Section of this report to follow.

Habitat

Current prevailing habitat enhancement paradigms generally focus on specific physical habitat attributes so results can be described and quantified. For the purposes of this project, quantifying the historic habitat is not practical and not likely possible. The system was an interconnected mosaic that is best described at a landscape level because physical habitat function and maintenance synergistically cycled with the biological community. In other words; the biological community was functionally part of the physical processes and vice versa.

The Walla Walla River and its floodplain were the keystone element of the regional ecosystem. Biological energy transfer was precipitated through the complex array of ecological trophic levels, characteristic of systems with diverse and complex habitats. For instance; the main stem river channel was part of an intricate network of side-channels, tributary channels and wetlands. As a whole, this landscape provided an enormous area of ideal fish habitat. In particular, this network provided secure low-velocity areas, which were largely maintained by a robust and expansive riparian floodplain community.

The robust nature and vast expanse of the floodplain riparian community provided resiliency to stochastic events and renewed habitats rather than degrade them. Woody debris entrained during catastrophic events, increased complex aquatic habitats and created holes in the canopy, which encouraged early successional riparian development. The ideal habitat conditions supported intense spawning activity and expansive juvenile refugia, which ultimately resulted in large smolt outmigrations. These large outmigrations manifested into enormous spawning migrations, which cleaned gravels for spawning and invertebrate habitat, and carried marine derived nutrients back to re-start the nutrient spiral.

Existing Conditions

Hydrology

As part of this project, GeoEngineers completed a hydrologic evaluation of the Walla Walla River at the downstream end of the project immediately downstream of Lowden Road. The hydrologic evaluation included basin characteristics, peak flow calculations, log Pearson Type III analysis and regional regression statistics.

BASIN CHARACTERISTICS

The watershed of the main-stem Walla Walla River at the lower limit of the project site is approximately 438 square miles, with a mean basin elevation of 2640 feet (NAVD 88), and a mean basin slope of approximately 26.3 percent. The Walla Walla River watershed can be characterized as a combination of forested area and agricultural fields with an annual precipitation of approximately 29.2 inches.

PEAK FLOWS

To estimate peak flows at the site, a nearby stream gauge analysis was utilized along with the USGS StreamStats program. Each method is described in detail below. The stream gauge analysis (Log Pearson Type III) was the most conservative and therefore used for final peak flow estimates. Peak flow estimates from gauge analysis and regional regression equations are shown in Table 1.

LOG PEARSON TYPE III

USGS stream gauge #14018500 on the Walla Walla River near Touchet, Washington is the closest applicable stream gauge with an acceptably large dataset of 58 years. Unfortunately, it is located approximately five and a half miles downstream of the project site, immediately downstream of the confluence with the Touchet River. There is a gauge on the Touchet River (USGS Gauge #14017500) that has 16 years of peak historic data, but was ultimately not utilized in this analysis.

Historic gauge data of the Walla Walla River gauge was analyzed using a Log Pearson Type III (LP3) Distribution completed with the USGS's PKFQWin program to estimate peak flows at the site. The PKFQWin program utilizes the methodologies discussed within USGS Bulletin 17B (USGS, 1982). The method described within Bulletin 17B utilizes a weighted skew factor based on a generalized location skew coefficient and the skew coefficient obtained from the historic data set. To estimate peak flows at the project site, a basin area ratio calculation was performed. This method calculates peak flows at the site by applying a reduction factor from Gauge #14018500 based on relative watershed areas between the gauge and the project site (1,658 square miles and 438 square miles, respectively).

EASTERN WASHINGTON REGIONAL REGRESSIONS

In addition to LP3 analysis, peak flows were estimated using the United States Geological Survey (USGS) StreamStats online analysis. In Washington State, the StreamStats program is based on regression equations from the USGS Water Resources Investigations Report (WRIR) 97-4227, *Magnitude and frequency of floods in Washington* (Sumioka et. al., 1998). This analysis was used for comparative reasons only.

TABLE 1. DISCHARGE SUMMARY TABLE (DISCHARGES IN CFS)

Peak Flow Estimation Method	Flood Frequency (Years)							
	1.25	1.5	2	5	10	25	50	100
LP3 Analysis (Gauge #1401850, 1658 sq. mi.)	3,294	4,320	5,785	10,470	14,460	20,580	26,000	32,190
StreamStats at Project Site (438 sq. mi.)	-	-	2,400		5,430	7,310	8,910	10,600
Pro-rated LP3 Analysis to Project Site (438 sq. mi.)	870	1,141	1,528	2,766	3,820	5,437	6,869	8,504
Peak Flows Used in Design	870	1,141	1,528	2,766	3,820	5,437	6,869	8,504

These discharges are based on measured peak flows and regional data. They do not take into account the effect of irrigation on day-to-day flows through the project reach. While we do not foresee irrigation having a significant effect on peak flows, its effect on low flows should be quantified prior to final design.

Geomorphology

The modern Walla Walla River has undergone many changes over the past two hundred years resulting primarily from Anglo American settlement and development of the River's floodplain and drainage basin. Historic aerial photos suggest much of the riparian vegetation in the floodplain, which once stabilized the banks and attenuated flood water velocity, was removed in the early 1900's. Over the past several decades, riparian vegetation, primarily in the form of cottonwoods and willows, has been slowly returning to the floodplain but decades of limited mature riparian vegetation has severely limited large woody debris (LWD) recruitment in the area. The existing lack of LWD has created a fairly uniform channel character with minimal channel complexity.

As discussed earlier, changes to the land use and hydrology in the drainage basin have resulted in channel incision and the formation of terraces perched from 6 to 12 feet above the existing floodplain within the project reach. The terraces are high enough above the existing floodplain that any stabilization benefit of vegetative root mass is lost, since most of the root mass is concentrated within the upper four feet of the soil profile. Furthermore, little or no mature riparian vegetation remains on the terraces to promote large woody debris recruitment which also could serve to stabilize the banks. As a result, severe erosion and bank recession is occurring in several locations where the river now flows directly against the base of the unprotected terraces.

In general, the existing geomorphic character of the Walla Walla River, within the project reach, can be summarized as moderately sinuous, single-threaded, low gradient, partially confined, with limited channel complexity and variability. Specific geomorphic parameters are outlined in Table 2 below.

TABLE 2. EXISTING GEOMORPHIC PARAMETERS

Parameter	Unit
Bankfull Width (ft)	80
Bankfull Depth (ft)	3.5
Width Depth Ratio (ft)	22.9
Flood Prone Width	750
Flood Prone Depth	7
Entrenchment Ratio (ft/ft)	9.4
Sinuosity (ft/ft)	1.2
Slope (ft/ft)	.003
D_{15} (inches)	.25
D_{50} (inches)	1
D_{95} (inches)	6
Median Bed Material	Coarse gravel
Rosgen Stream Type	C4

Hydraulics

The primary objective of GeoEngineers' hydraulic analysis was to estimate representative reach-scale channel hydraulic properties for specified flood recurrence intervals within the project reach. These hydraulic properties facilitated the development and assessment of the proposed stream enhancement alternatives.

HYDRAULIC MODEL

Version 4.0 of the U.S. Army Corps of Engineers Hydraulic Engineering Center – River Analysis System (USACE, 2008) hydraulic computer model was used to model the Walla Walla River through the project reach. HEC-RAS is a one dimensional, steady state, hydraulic model computing water surface elevations using a step-wise methodology. The project's hydraulic characteristics were analyzed using a subcritical flow regime, which is conservative in relation to flood elevations and extents.

MODEL DEVELOPMENT

Using a Digital Elevation Model (DEM) collected using LiDAR flown on May 31, 2009, field notes, and photo log, we developed a model of the existing conditions within the project reach. Because detailed topographic information was available in the DEM, a total of 25 cross sections cut through the existing topography and were used in creating the model.

The approximate McDonald road and Lowden Road bridge geometries were included in the model to account for any potential backwater effects from the bridges. Bridge widths were estimated from aerial images and the LiDAR. Bridge deck height, rail height, and girder depth were all assumed based on professional judgment and scaled images from our collected photo log. Levees and ineffective flow areas were placed in accordance with field observations and included the levee along the left bank in the upstream third of the project area. Manning's n values were set in accordance with standard hydraulic reference manuals and engineering experience.

Because LiDAR elevations included water in the channel at the time the survey was flown, the estimated flow rate in the channel on May 31, 2009 was subtracted from all model simulations. All model runs were computed in a sub-critical condition and, as such, required a downstream boundary condition to compute water surface profiles in an upstream progression. The downstream boundary conditions for all model flows were set to the corresponding normal depth based at the downstream cross section using the average channel gradient at the downstream end of the reach. Results from the hydraulic model for selected flood return intervals can be found in Appendix B.

Habitat

Over the last century human manipulation and alteration have systematically dismantled the resiliency of the riparian floodplain and channel network. The robust nature and vast expanse of the natural environment has been reduced to a single thread through the floodplain. As a result, physical processes and biological cycling have been isolated from one another and fish and wildlife populations have experienced significant declines and the extirpation of spring run Chinook (*Oncorhynchus tshawytscha*).

The main channel, through the project reach, is generally a homogeneous riffle that is marginally suitable as a migration corridor and poorly suited for other life history stages of native fish. In general the channel is featureless but locations with structure seem to be responding well and creating isolated microhabitats. Relic side-channels are evident in the immediate floodplain corridor but currently isolated by constructed levees and only activated during major flood events. As such, their habitat value is minimal and likely contributes very little toward biological production.

The riparian corridor is relatively narrow and sparsely populated. Because of this it contributes very little shade, overhead cover, bank stability, and woody channel structure. Additionally, due to the non-contiguous nature and relative dryness of the riparian zone, it provides comparably little wildlife habitat and is not a functional migration corridor.

Topography

Light Detection and Ranging (LiDAR) technology was used to obtain detailed topography throughout the project reach, using laser pulses sent and collected from aerial sensors, obtaining elevation data from the ground surface, vegetation, structures, water surfaces and other features. A Relative Surface Model (RSM) was developed from the LiDAR data to visualize high and low areas in the floodplain relative to the water surface of the Walla Walla River at any given point along its length throughout the project reach. The RSM, shown on Sheet 4.2, revealed many historic meanders, terraces, and side channels verifying the historic occupation of a broad floodplain and the modern incision and confinement of the channel between the previously discussed terraces and levee.

Additionally, the LiDAR RSM revealed existing side-channel and high-flow channel development within the inset floodplain.

PROPOSED CONDITIONS

In the subsequent sections of this report we propose several habitat enhancement alternatives that seek to regain some of the historic channel complexity and habitat diversity lacking under the existing conditions. The historic conditions served as a guide for the development of each proposed alternative, but any physical alteration of the project site must adhere to modern processes occurring within the basin that may be different from those of historic times. By carefully balancing the use of historic reference conditions with that of modern geomorphic processes and possible physical limitations, we can minimize the risk of failure and the need for long-term maintenance of the proposed design once constructed.

Channel Parameters

In order to ensure that modern geomorphic processes and existing physical limitations are addressed during development of the proposed conditions, a set of channel design parameters has been developed. A combination of our geomorphic assessment of the project site and the use of numerous empirical hydraulic and geomorphic formulae were used to generate a proposed range of specific channel parameters mimicking historic reference conditions meanwhile adhering to existing processes and limitations. A summary of the channel design parameters is provided below in Table 3.

TABLE 3. SUMMARY OF DESIGN PARAMETER RANGES

Design Component	Existing Project Reach Mean	Proposed Range	
		Minimum	Maximum
Radius of Curvature (ft)	--	120	245
Meander Belt Width (ft)	--	342	852
Meander Wavelength	--	600	1374
Along Channel Bend Length (ft)	--	407	916
Bankfull Width (ft)	80	55	80
Bankfull Depth (ft)	3.5	3.5	5
Width Depth Ratio	22.9	12	22.9
Approximate Average Bankfull Velocity (fps)	3.5	3.5	5
Flood Prone Width (ft)	750	350	1000
Flood Prone Depth (ft)	7	7	10
Entrenchment Ratio (ft/ft)	9.4	9.4	12.5
Sinuosity (ft/ft)	1.20	1.20	1.4
Slope (ft/ft)	0.003	0.003	0.004
Rosgen Stream Type	C4	C4	

ALTERNATIVES ASSESSMENT

Overview of Alternatives Assessment

GeoEngineers prepared this alternatives assessment in collaboration with the TSS, adjoining landowners and WDFW. The following sequential process was followed throughout this assessment in order that practical enhancement alternatives could be developed and compared against one another with the intent of selecting a preferred alternative.

Briefly, this process involves the identification of the project in terms of its goals and objectives. Whereas the project goals are relatively general, the project objectives are more specific. Each project objective was then assigned a numerical weighting based on its relative level of importance. A list of geomorphically appropriate enhancement treatments, which focus on achieving the specific project objectives, was then developed. These treatments range from physical, on-the-ground improvements, to more passive land management practices. Project constraints, which constitute the practical limitations of the project, were also identified during this early stage of the project.

Several enhancement alternatives - which target the project goals and objectives - were then developed utilizing a combination of the enhancement treatments identified. These alternatives were developed within the limitations of the project constraints. Additionally, these alternatives were only developed to a conceptual level of detail using similar assumptions and cost estimates to facilitate a reasonable side-by-side comparison. The alternative ultimately selected will require a more rigorous design effort.

A numerical rating system was then used to objectively identify a preferred enhancement alternative. A numerical rating of each alternative was calculated for each objective by multiplying the objective's level of importance by the alternative's level of effectiveness in achieving the objective. A benefit rating for each alternative was then calculated by summing the alternative's rating for each objective. Because the more important objectives and the more effective alternatives were defined in terms of higher value, the alternative with the highest rating provides the greatest benefit.

The costs of implementing the alternatives were then factored into the assessment. To account for costs, we divided the benefit rating for each alternative by its cost to establish a benefit-to-cost ratio. (Because the benefit units are different from dollars, we also multiplied the ratio by 10,000 to obtain a ratio that was just less than 1.0.) This technique normalizes the benefits with the costs. The alternative with the highest benefit-to-cost ratio is therefore the more desirable or preferred alternative as defined by the overriding project goals and input from the stakeholders. These analyses were performed using a proprietary workbook, a copy of which is included in Appendix C. The specifics of these analyses and the results thereof are discussed below.

Selection Criteria

The project objectives, noted above, are also the selection criteria used to develop and compare the enhancement alternatives. These criteria were collectively identified and numerically weighted by GeoEngineers, TSS, WDFW and the adjoining landowners. The weights, which range from 1 to 5, were based upon the relative level of importance of each objective as defined by the project area stakeholders. The weights are listed in Table 4 below. The selection criteria and weights are listed in Table 5 and discussed in greater detail below.

TABLE 4. RELATIVE LEVEL OF IMPORTANCE WEIGHTING

Weight	Level of Importance
1.	Lowest Level of Importance
2.	Low Level of Importance
3.	Moderate Level of Importance
4.	High Level of Importance
5.	Highest Level of Importance

TABLE 5. WEIGHTED SELECTION CRITERIA

Selection Criteria (Project Objectives)	Weighted Level of Importance
1. Increase, Enhance and Diversify Aquatic Habitat	5
2. Increase, Enhance and Diversify Riparian and Upland Habitat	5
3. Increase Floodplain Connectivity	5
4. Minimize Bank Erosion along Upper Terraces	5
5. Geomorphic Stability	5
6. Rapid Recovery Time	3
7. Design Practicality	2

Levels of Effectiveness

Each alternative was assigned a numerical rating indicating how effective it will be in achieving each of the selection criteria. Table 6, below shows the various levels of effectiveness considered.

TABLE 6. LEVELS OF EFFECTIVENESS

Level of Effectiveness	Effectiveness
1	Ineffective
2	Minimally Effective
3	Moderately Effective
4	Effective
5	Very Effective

Enhancement Alternatives

Overview of all Alternatives

A total of five enhancement alternatives, including the "no action" alternative, were developed for this project. The enhancement alternatives were developed utilizing the proposed geomorphic parameters and a combination of the enhancement treatments discussed above. Because the proposed parameters and treatments were developed from our assessment of the historic and existing conditions, they are intended to be appropriate in terms of the site's geomorphology, hydrology, hydraulics and habitat. And, because the treatments stem from the objectives, which in turn stem from the single overarching project goal, the resulting enhancement alternatives target the project's project goal as well.

The specific locations of the proposed treatments, in each alternative, are based upon floodplain topography, channel bathymetry, vegetated cover, and historic channel locations as shown in the aerial photograph record and observed during field reconnaissance. In locating proposed channel realignments and/or side-channels, we also took into consideration landowner concerns and did not extend enhancement alternatives beyond the edge of the river terraces to the north and south. Existing floodplain features were utilized in the conceptual designs, wherever possible, to reduce construction costs. Basic geomorphic, engineering, and biological considerations were also taken into account, when developing feasible alternatives, in order to increase constructability, longevity, and biological benefit.

The enhancement alternatives considered are discussed below. In general, the alternatives increase in complexity, disturbance, habitat benefit and cost in the order in which they are presented. Table 7, which follows these discussions, summarizes how effective each alternative is at achieving each objective. This table is similar to the workbook, included in Appendix C, which was used to compare the alternatives numerically.

Alternative 1 – Protect terrace banks and create off-channel habitat (minimal excavation)

As depicted on the Sheet 5 series of drawings in Appendix D, Alternative 1 proposes to maintain the existing channel alignment, remove the existing levee, create/enhance/diversify off-channel habitat, add in-stream LWD structure throughout, and protect banks along the terrace from excessive erosion. The general intent of Alternative 1 is to increase channel complexity by utilizing only minimal channel excavation and allowing the river to excavate its own side-channels and meanders over the next several years. All of the proposed LWD structures are intended to increase habitat diversity and potential but several also serve the purpose of encouraging the primary channel to meander into stable areas of the floodplain to increase sinuosity, floodplain connection, and future LWD recruitment. Small, linear floodplain excavations, called pilot channels, are intended to direct the river into suitable locations of the floodplain for increased off-channel habitat and side-channel development. The pilot channels are intended to erode and expand naturally overtime. To limit the potential for wholesale channel piracy, pilot channels should be designed to include controls that limit the ultimate size, pattern and location of the resulting channel. All of the terrace banks exhibiting severe erosion will be protected by the addition of a terraced LWD and soil structures along the existing bank. The terraced structures will be armored with buried logs for initial erosion protection and habitat enhancement. They will also be planted with live trees which will provide long-term stability. Finally, dense riparian vegetation is proposed in sparsely vegetated areas along the channel corridor. Once established, this dense vegetation will provide shade, bank stability, and ultimately a future source for new in-stream LWD.

Alternative 2 – Protect terrace banks, realign portions of the channel, and excavate off-channel habitat

As shown on the Sheet 6 series of drawings, Alternative 2 includes the same proposed design intent as Alternative 1, with slightly more in-stream and off-channel excavation. Additionally, Alternative 2 includes relocating a portion of the main-stem channel behind the existing levee. The goals for Alternative 2 are the same as Alternative 1 but with increased excavation and more structures it is anticipated that the project goals will be achieved more rapidly than with Alternative 1, but at a higher cost. Although natural river processes would account for much of the required in-stream excavation over time, channel sculpting, pilot channels and strategic structures will collectively encourage this process to occur over a shorter time scale than Alternative 1. In the areas where the channel will be relocated, the abandoned channel will be filled with the material removed from the excavation and planted with dense riparian vegetation and blocked by log jams to lessen the risk of avulsion. One advantage of channel relocation, as proposed in this alternative, is the ability to use a portion of the disturbed mature riparian vegetation for LWD structures in other portions of the river, which will decrease cost.

Alternative 3 – protect terrace banks, realign channel, and excavate larger side channels

As shown on the Sheet 7 series of drawings, Alternative 3 proposes most of the same design elements as Alternative 2 while adding multiple side-channels and main-stem channel relocations. The intent for Alternative 3 is the same as Alternatives 1 and 2, but with increased excavation, both in-stream and off-channel, this represents the most expedited enhancement process of the three. Rather than enabling the channel to perform much of the work through natural river processes, over several years, Alternative 3 anticipates the locations where channel migration and side-channel development will be of the most benefit and incorporates them into the design for immediate construction. It should be noted that the location of every design element has been scrutinized for geomorphic and biologic continuity. In other words; the design of Alternative 3 considers existing channel processes and trends, and projects those into the future, given the addition of in-stream LWD, channel sculpting, and areas of reinforcement, to create a naturally functioning channel that appears to have evolved naturally over many years.

Alternative 4 – Combination of Alternatives 1 and 2

A stakeholders meeting was held at WDFW's office in Walla Walla on March 16, 2010 to discuss the three alternatives noted above. Representatives from TSS, WDFW, GeoEngineers and all the adjoining landowners were in attendance. After discussing each of the alternatives it was mutually decided that the most preferable alternative should include elements of Alternatives 1 and 2. More specifically, this preferred alternative included essentially all of the design elements of Alternative 1, the greater in-stream and off-channel complexity of Alternative 2 without the larger-scale in-stream excavation and wholesale channel relocation proposed in Alternative 2.

Alternative 5 – No action

Alternative 5 proposes no action. If no action is taken at the site, fish spawning and rearing habitat and increased floodplain connection will likely improve very little over time. Erosion into the existing unstable terrace banks will become more prominent as the river naturally increases sinuosity and meanders through the floodplain. Natural recruitment of native riparian vegetation and subsequent in-stream LWD will likely improve without taking any action but the process will occur very slowly if left untreated. It is unclear just how long this natural enhancement process would take to occur but it is reasonable to assume it would take upwards of 100 years or more to achieve the same benefits the four previous alternatives would provide within 2 to 10 years, and during the process, a large amount of agricultural land may be lost to the river. Or conversely, additional bank protection measures like the ones attempted to date will continue to be added to the river and will keep the river and its habitat in its current, less-than-optimal condition.

TABLE 7. COMPARISON OF ALTERNATIVES

Objective	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
1. Increase, Enhance and Diversify Aquatic Habitat	2 Minimally Effective	4 Effective	5 Very Effective	3 Moderately Effective	1 Ineffective
2. Increase, Enhance and Diversify Riparian and Upland Habitat	3 Moderately Effective	4 Effective	5 Very Effective	4 Effective	1 Ineffective
3. Increase Floodplain Connectivity	5 Very Effective	5 Very Effective	5 Very Effective	5 Very Effective	1 Ineffective
4. Minimize Bank Erosion along Upper Terraces	3 Effective	4 Effective	5 Very Effective	3.5 Effective	1 Ineffective
5. Geomorphic Stability	2 Minimally Effective	4 Effective	5 Very Effective	4 Effective	1 Ineffective
6. Rapid Recovery Time	2 Minimally Effective	4 Effective	5 Very Effective	3 Moderately Effective	1 Ineffective
7. Design Practicality	5 Very Effective	3 Moderately Effective	1 Ineffective	4 Effective	1 Ineffective

Construction Quantities and Costs Estimates

Approximate construction quantities and cost estimates were calculated for each enhancement alternative considered. These costs were developed using a single list of standard unit costs based upon GeoEngineers' recent project design/construction experience, inquiries to local construction contractors, suppliers and/or agencies, R.S. Means Heavy Construction Cost Data, and other appropriate sources. In addition to unit costs for specific construction quantities, our unit cost basis includes costs and variables to account for inflation, project location adjustment factors, mobilization, incidentals and contingencies. Design and permitting fees have not been included in the construction cost estimates. While these cost estimates are approximate, they are all based on the same unit costs and therefore provide a sound basis to compare the alternatives against one another. The Microsoft workbook in Appendix C summarizes the construction quantities and costs, which are also presented in Table 8 below.

TABLE 8. COST ESTIMATES FOR EACH ALTERNATIVE

Alternative	Cost
Alternative 1	$1,586,800
Alternative 2	$2,050,600
Alternative 3	$3,329,900
Alternative 4	$1,684,000
Alternative 5	$0.0

Benefit-to-Cost Analysis

As noted above, a numerical rating system was used to identify a preferred enhancement alternative. A numerical rating of each alternative was calculated for each objective by multiplying the objective's level of importance by the alternative's level of effectiveness in achieving the objective. A total benefit for each alternative was then calculated by summing the alternative's rating for each objective. Because the more important objectives and the more effective alternatives were defined in terms of higher value, the alternative with the highest rating provides the greatest benefit.

The costs of implementing the alternatives were then factored into the assessment. To account for costs, we divided the benefit rating for each alternative by its cost to establish a benefit-to-cost ratio. (Because the benefit units are different from dollars, we multiplied the ratio by 10,000 to obtain a ratio that was just less than 1.0.) This technique normalizes the benefits with the costs.

The alternative with the highest benefit-to-cost ratio is therefore the more desirable or preferred alternative as defined by the overriding project goals and input from the stakeholders. This analysis was performed using a workbook, which is included in Appendix C. Table 9 below summarizes the numerical results of this benefit-to-cost analysis. The resulting benefits and cost for each alternative are graphically expressed in Chart 1. The benefit-to-cost ratio is expressed in Chart 2. Because it has the highest benefit-to-cost ratio, Alternative 4 is the preferred alternative as defined by the overriding project goals and input from the stakeholders.

TABLE 9. ALTERNATIVE BENEFITS, COSTS AND BENEFIT: COST RATIOS

Alternative	Description	Benefit Rating	Cost ($)	Benefit: Cost Ratio (x10,000)
1	Protect terrace banks and create off-channel habitat (minimal excavation)	94	1,586,800	0.59
2	Protect terrace banks, realign portions of the channel, and excavate off-channel habitat	122	2,050,600	0.59
3	Protect terrace banks, realign channel, and excavate larger side channels	138	3,329,900	0.41
4	Combination of Alternatives 1 and 2	116	1,684,000	0.69
5	No Action	42	$0.0	NA

CHART 1. ALTERNATIVE RATINGS AND COSTS

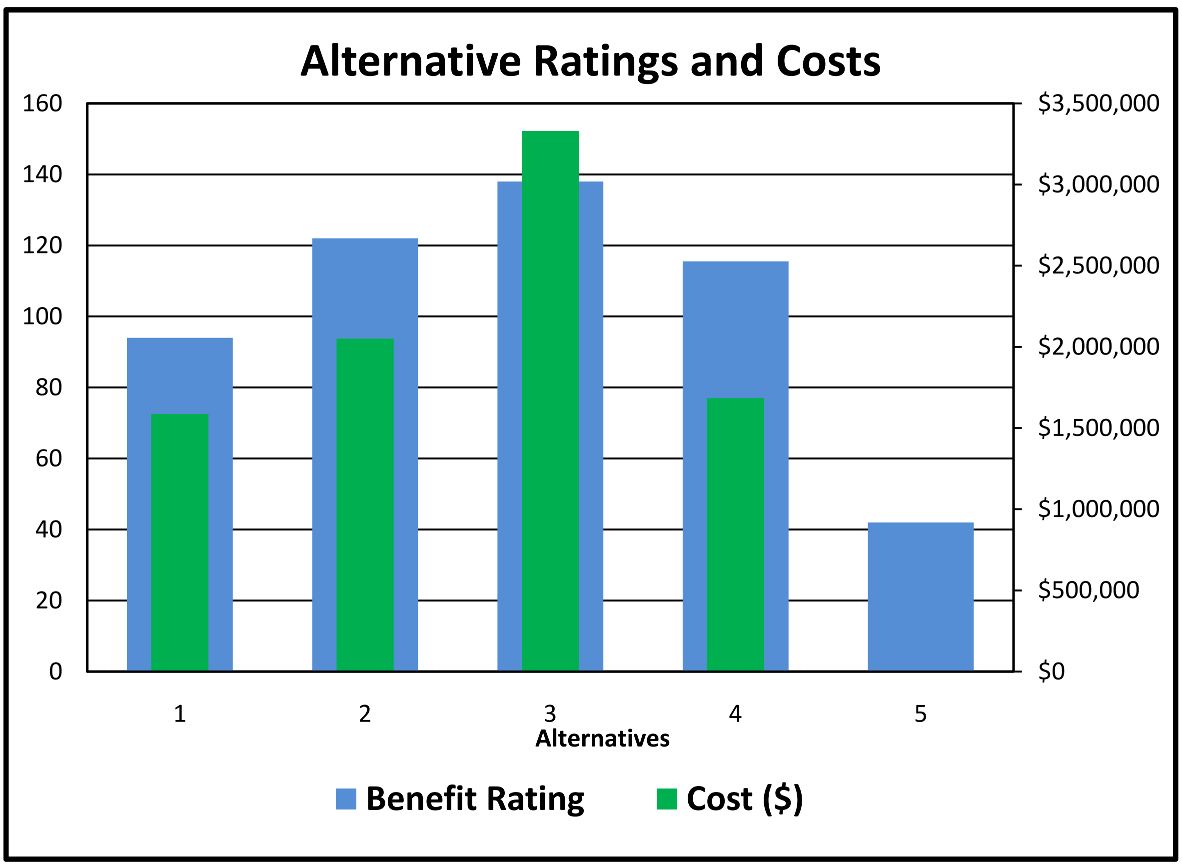
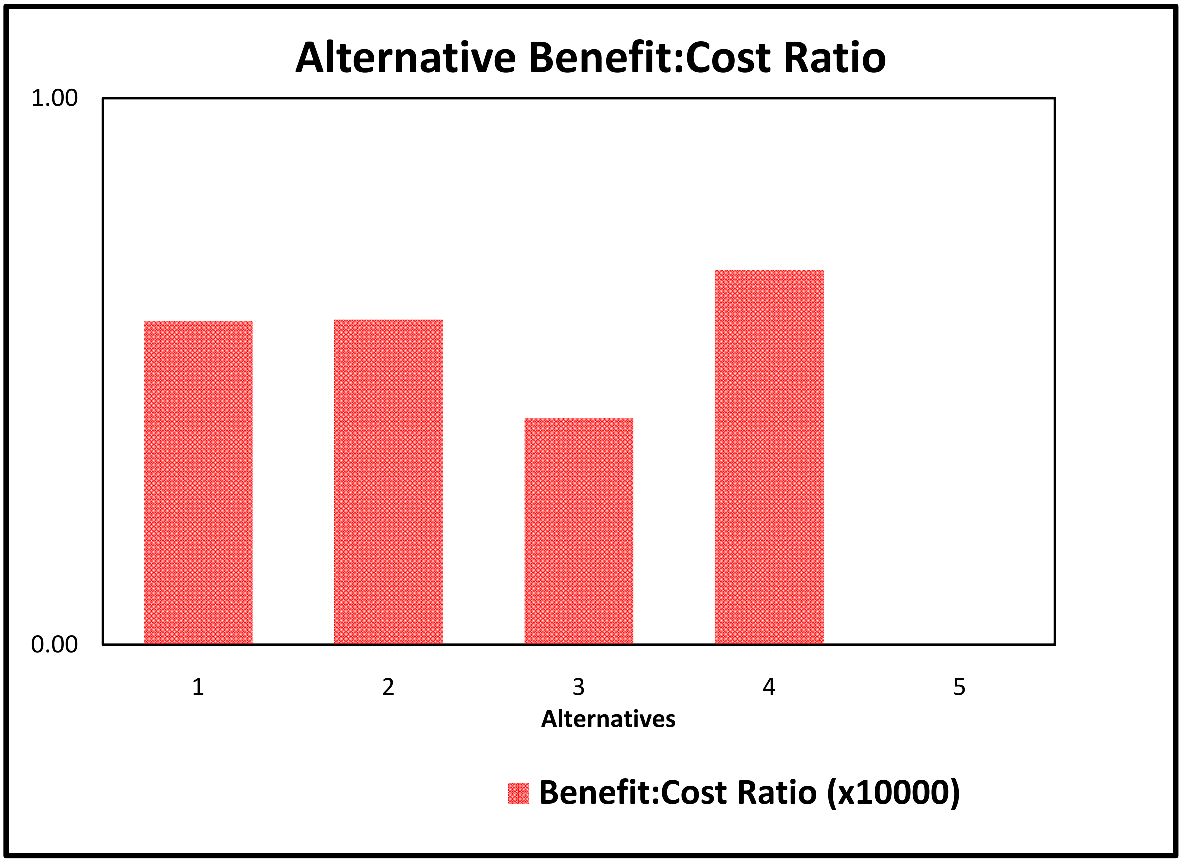


CHART 2. ALTERNATIVE BENEFIT : COST RATIO



CONCLUSIONS

Based on the process described in this report, input from the stakeholders and discussions with TSS, the enhancement alternative that provides the greatest benefit for its associated cost should be selected as the preferred alternative. Accordingly, Alternative 4 is considered the Preferred Alternative because it has the highest benefit-to-cost ratio. Although Alternative 3 has a higher overall benefit rating, its cost is disproportionately higher than that of Alternative 4, making Alternative 3 less cost effective. On the other hand, Alternative 4 provides the best balance between meeting the goals and objectives of the project while minimizing the associated project costs. Furthermore, the high benefit-to-cost ratio improves the likelihood that Alternative 4 will be awarded competitive funds for final design and construction implementation.

FUTURE PHASES OF ENHANCEMENT

With the selection of a preferred alternative, the next step in the enhancement process includes acquiring funding for the preliminary design (which is adequate to secure environmental permits) and the final design (which is adequate for construction bidding) and construction of the project. To facilitate the preparation of a successful proposal for funds, TSS can use the conceptual plans and cost estimates provided in this report. It should be noted that the plans and cost estimates from this report are conceptual and should not be used for construction. Therefore, following the acquisition of funding for the design and construction phases of the project, GeoEngineers will be pleased to continue working with TSS to finalize the enhancement design, aid in the permitting process, help select contractors for construction, and provide on-site construction observation.

LIMITATIONS

We have prepared this report for the Tri-State Steelheaders and their authorized agents and regulatory agencies for the Walla Walla River Enhancement Alternatives Assessment for the project site located on both banks of the Walla Walla River between the McDonald Road Bridge and the Lowden Road Bridge near Lowden, Washington.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of stream and river habitat enhancement, stabilization and enhancement design engineering in this area at the time this report was prepared. The conclusions, recommendations, and opinions presented in this report are based on our professional knowledge, judgment and experience. No warranty or other conditions, expressed or implied, should be understood.

Any electronic form, facsimile or hard copy of the original document (email, text, table and/or figure), if provided, and any attachments should be considered a copy of the original document. The original document is stored by GeoEngineers, Inc. and will serve as the official document of record.

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

REFERENCES

Beechie, T. J., Pollock, M. M., and Baker, S. (2008) Channel Incision, Evolution and Potential Recovery in the Walla Walla and Tucannon River Basins, Northwestern USA. Earth Surf. Process. Landforms 33, 784-800

United States Army Corps of Engineers, Hydraulic Engineering Center – River Analysis System (HEC-RAS). Version 4.0.0, March, 2008.

Sumioka, S.S., Kresh, D.L., Kasnick K.D., "Magnitude and Frequency of Floods in Washington," United States Geological Survey Water Resource Investigation Report 97-4277, 1998, 91p.

United States Geological Survey, "Guidelines for Determining Flood-Flow Frequency: Bulletin 17B of the Hydrology Subcommittee." Interagency Advisory Committee on Water Data. Reston, VA, 1982.

FIGURES

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Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. This figure was originally produced in color.

Reference: Base map obtained from ESRI.

Vicinity Map

Alternatives Assessment
near Lowden, Washington

GEOENGINEERS

Figure 1

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APPENDICES

Appendix A
Report Limitations and Guidelines for Use

APPENDIX A
REPORT LIMITATIONS AND GUIDELINES FOR USE[1]

This appendix provides information to help you manage your risks with respect to the use of this report.

Stream and River Design Engineering Services Are Performed for Specific Purposes, Persons and Projects

This report has been prepared for Tri-State Steelheaders and their authorized agents and regulatory agencies. The information contained herein is not applicable to other sites.

GeoEngineers structures our services to meet the specific needs of our clients. No party other than Tri-State Steelheaders may rely on the product of our services unless we agree to such reliance in advance and in writing. This is to provide our firm with reasonable protection against open-ended liability claims by third parties with whom there would otherwise be no contractual limits to their actions. Within the limitations of scope, schedule and budget, our services have been executed in accordance with our Agreement with the Client dated November 17, 2009and generally accepted practices in this area at the time this report was prepared. Use of this report is not recommended for any purpose or project except the one originally contemplated.

A Stream or River Design Engineering Report is Based on a Unique Set of Project-Specific Factors

This report has been prepared for Tri-State Steelheaders. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, it is important not to rely on this report if it was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site, or
- completed before important project changes were made.
- For example, changes that can affect the applicability of this report include those that affect:
- the function of the proposed design and/or structure;
- elevation, configuration, location, orientation or weight of the proposed structures;
- composition of the design team; or
- project ownership.

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1 Developed based on material provided by ASFE, Professional Firms Practicing in the Geosciences; www.asfe.org.

If important changes are made after the date of this report, we recommend that GeoEngineers be given the opportunity to review our interpretations and recommendations. Based on that review, we can provide written modifications or confirmation, as appropriate.

Conditions Can Change

This report is based on conditions that existed at the time the study/design was performed. The findings and conclusions of this report may be affected by the passage of time, by man-made events such as construction on or adjacent to the site, or by natural events such as floods, earthquakes, slope instability, stream flow fluctuations or stream channel fluctuations. If more than a few months have passed since issuance of our report or work product, or if any of the described events may have occurred, please contact GeoEngineers before applying this report for its intended purpose so that we may evaluate whether changed conditions affect the continued reliability or applicability of our conclusions and recommendations.

Report Recommendations and Designs Are Not Final

Do not over-rely on the preliminary construction recommendations included in this report. These recommendations are not final, because they were developed principally from GeoEngineers' professional judgment and opinion. GeoEngineers' recommendations can be finalized only by observing actual site-specific conditions revealed during construction.

We recommend that you allow sufficient monitoring and consultation by GeoEngineers during construction to provide recommendations for design changes if the conditions revealed during the work differ from those anticipated and to evaluate whether construction activities are completed in accordance with our recommendations. GeoEngineers is unable to assume responsibility for the recommendations in this report without performing construction observation.

The designs depicted herein are approximate and are intended to express the overall design intent of the project. These designs will need to be adjusted in the field during construction in order to meet the specific-site conditions and intended function.

Report Could Be Subject to Misinterpretation

Misinterpretation of this report by members of the design team or by contractors can result in costly problems. GeoEngineers can help reduce the risks of misinterpretation by conferring with appropriate members of the design team after submitting the report, reviewing pertinent elements of the design team's plans and specifications, participating in pre-bid and preconstruction conferences, and providing construction observation.

To help prevent costly problems, we recommend giving contractors the complete report, but preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report's accuracy is limited. In addition, encourage them to confer with GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer.

Instream Habitat Structures

Instream habitat, stabilization, enhancement and/or restoration structures and artificial (Structures) involve the placement of large logs, logs with root wads, large rocks and other natural and artificial materials and/or features in and adjacent to creeks, streams and rivers (streams). They are designed for various purposes including but not limited to: improvement of aquatic and riparian habitat; stabilization of eroding stream banks and channels; restoration of stream channels; creation or improvement of recreational uses; irrigation; and flood management.

Hazards of Instream Habitat Structures

Instream habitat structures create potential hazards, including, but not limited to: humans falling from the Structures and associated injury or death; collisions of recreational users' watercraft with the Structures and associated risk of injury or death, with partial or total damage of the watercraft; mobilization of a portion or all of the Structures during high water flow conditions and related damage to downstream properties, utilities, roads, bridges and other infrastructure, and injury or death to humans; flooding; erosion; and channel avulsion. In some cases, instream habitat structures are only intended to be temporary, providing temporary stabilization while riparian vegetation becomes established while or stream/river processes stabilize. This gradual deterioration with age and vulnerability to major flood events make temporary Structures inherently dangerous with increasing age.

It is strongly recommended that the Client address the necessary safety concerns appropriately. This would include warning construction workers of hazards associated with working in or near deep and fast moving water and on steep, slippery and unstable slopes. In addition, signs should be placed along the enhanced stream reaches in prominent locations to warn recreational users of the potential hazards noted above and pamphlets should be distributed to nearby residents warning of the potential hazards to children and adults posed by these Structures.

Increased Flood Elevations and Wetland Expansion Are Possible

The proposed stream enhancements may result in increased flood elevations and expansion of wetlands. The analysis of these impacts, which are generally considered advantageous for aquatic and riparian habitat in the project locations of these stream systems, may need to be considered and quantified if they were beyond the context of GeoEngineers' scope of services.

Channel Erosion and Migration Are Possible

In general, river and stream enhancements are intended to result in more stable streambeds, banks and floodplains. In some cases, stream enhancement and channel stability means reestablishing the natural balance of sediment erosion, distribution and deposition, which induces channel meandering and migration. Therefore, channel erosion, channel migration and/or avulsions can be expected to occur over time.

Importance of Monitoring and Maintenance

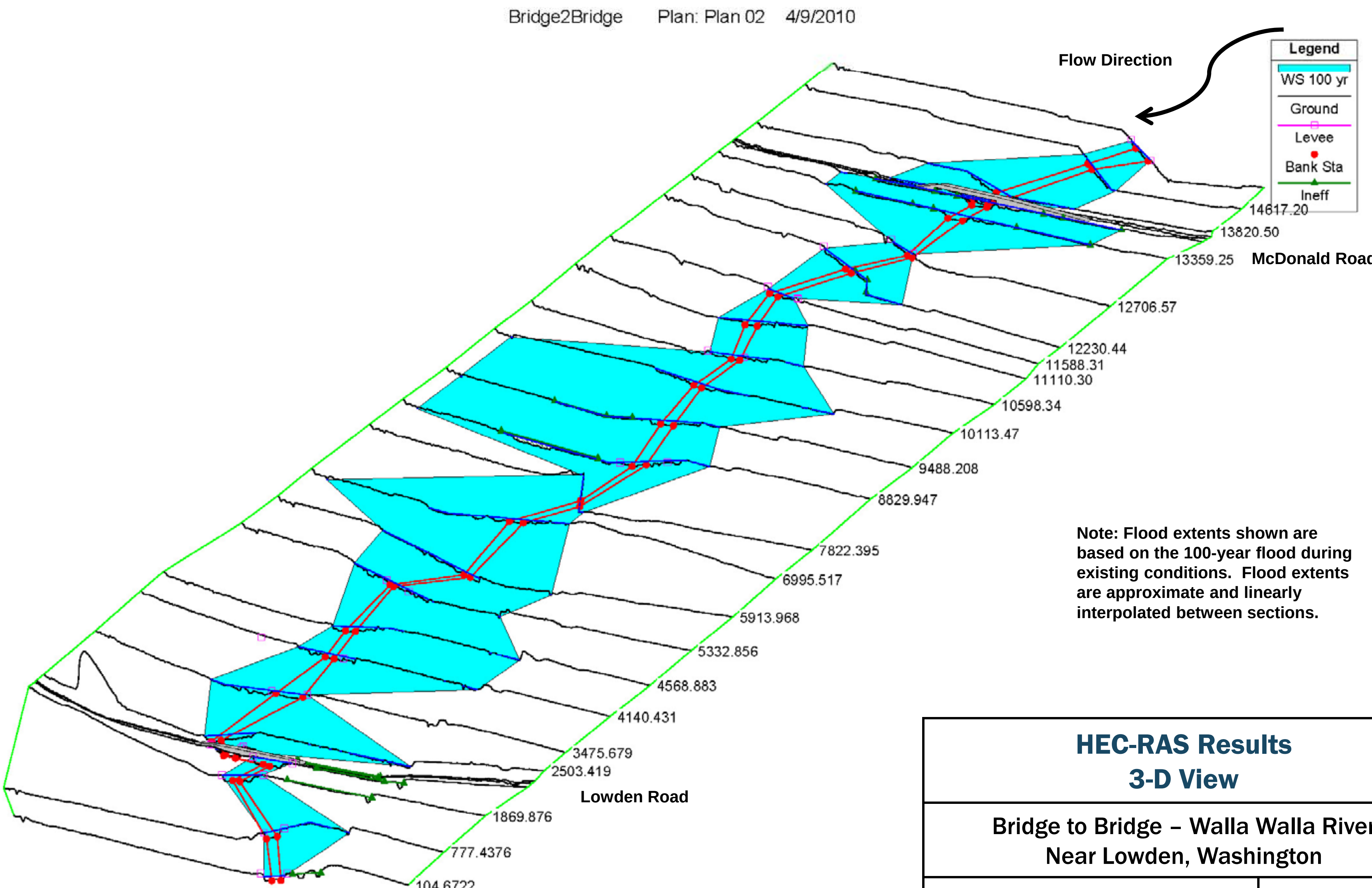
Piles, anchors, chains, cables, reinforcing bars, bolts and similar fasteners may have purposely been excluded from woody habitat structures with the intent of mimicking naturally-occurring instream wood structures. Conversely, such fasteners may have purposely been included in woody habitat Structures if considered appropriate. While the Structures are designed to be relatively stable during flood events, movement of these Structures should be expected. As noted in the text of this report, we recommend that the Client implement appropriate monitoring and maintenance procedures to minimize potential adverse impacts at or near areas of concern, such as at downstream road, bridge and/or culvert crossings. This would include replacing, adjusting and removing damaged, malfunctioning or deteriorated components of Structures, particularly following a major storm event.

Contractors Are Responsible for Site Safety on Their Own Construction Projects

Our recommendations are not intended to direct the contractor's procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and adjacent properties.

APPENDIX B
Hydraulic Model Excerpts

http://projects/sites/1128100500Working/Walla Walla River Bridge to Bridge HEC-RAS Results1-11.pptx

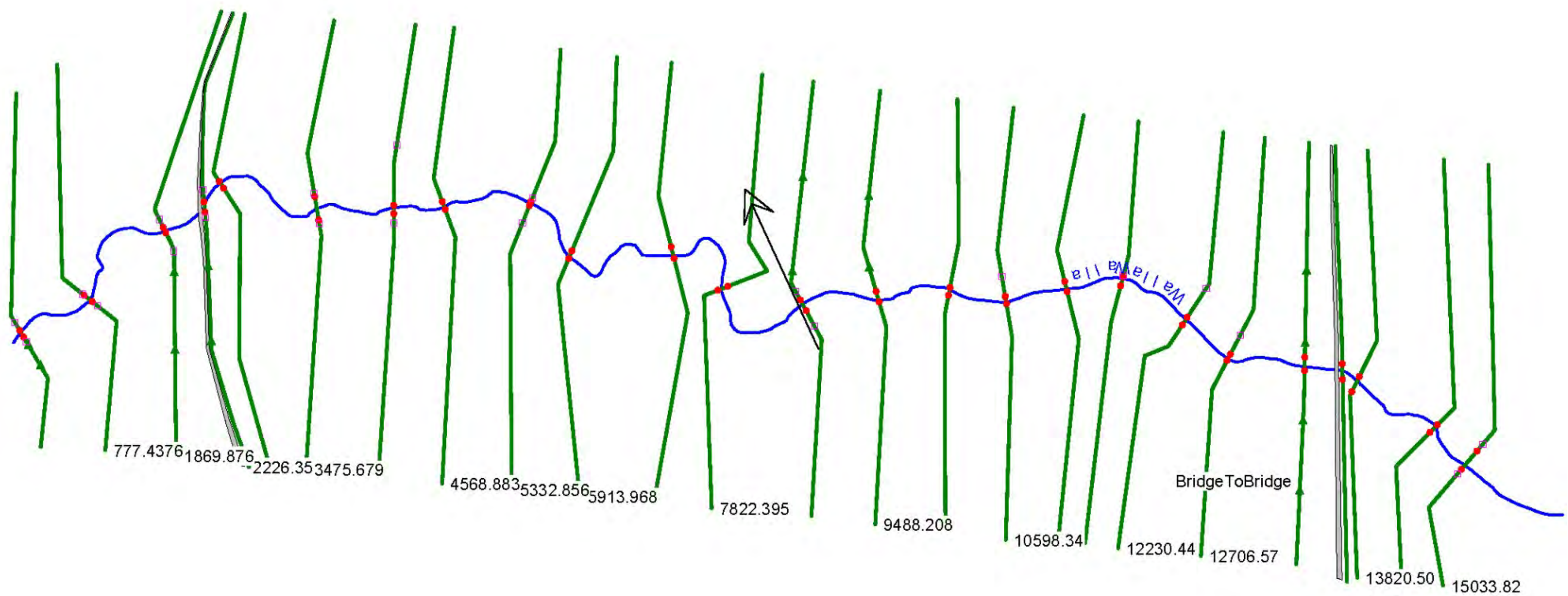


Note: Flood extents shown are based on the 100-year flood during existing conditions. Flood extents are approximate and linearly interpolated between sections.

Reference: Model output obtained from HEC-RAS Hydraulic Model v. 4.0

HEC-RAS Results 3-D View	
Bridge to Bridge – Walla Walla River Near Lowden, Washington	
GeoEngineers	Figure B-1

http://projects/sites/1128100500Working/Appendix B-Walla Walla River Bridge to Bridge HEC-RAS Results1-11.pptx



HEC-RAS Results
Plan View

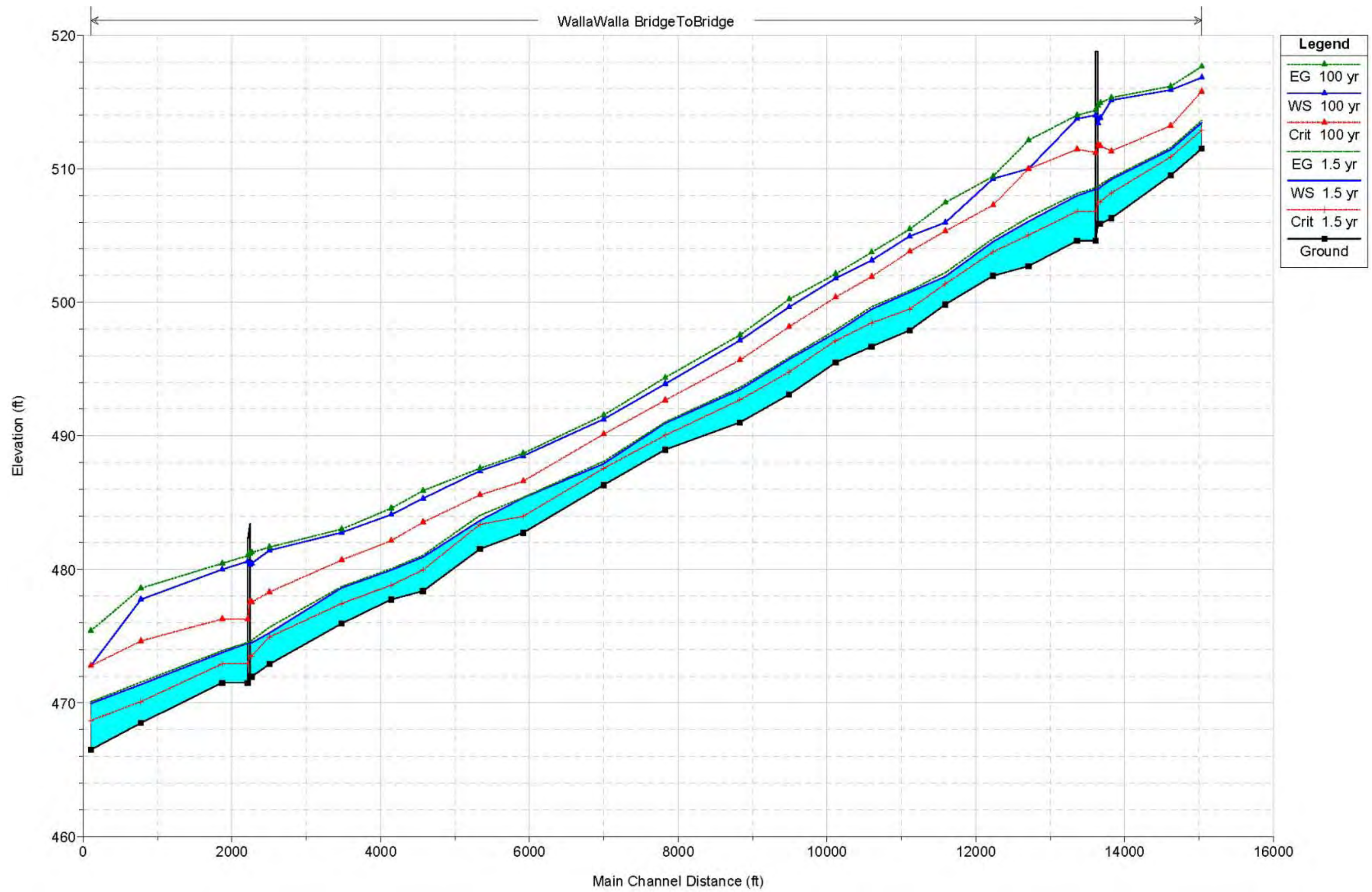
Bridge to Bridge – Walla Walla River
Near Lowden, Washington

GEOENGINEERS

Figure B-2

Reference: Model output obtained from HEC-RAS Hydraulic Model v. 4.0

http://projects/sites/1128100500Working/Appendix B-Walla Walla River Bridge to Bridge HEC-RAS Results1-11.pptx



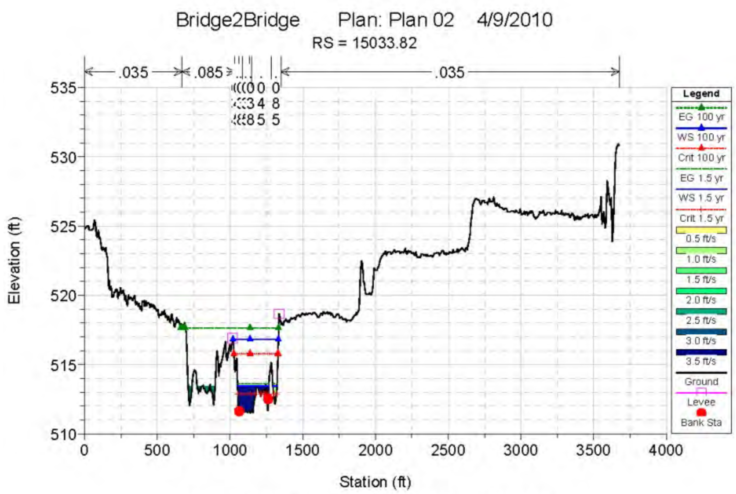
Reference: Model output obtained from HEC-RAS Hydraulic Model v. 4.0

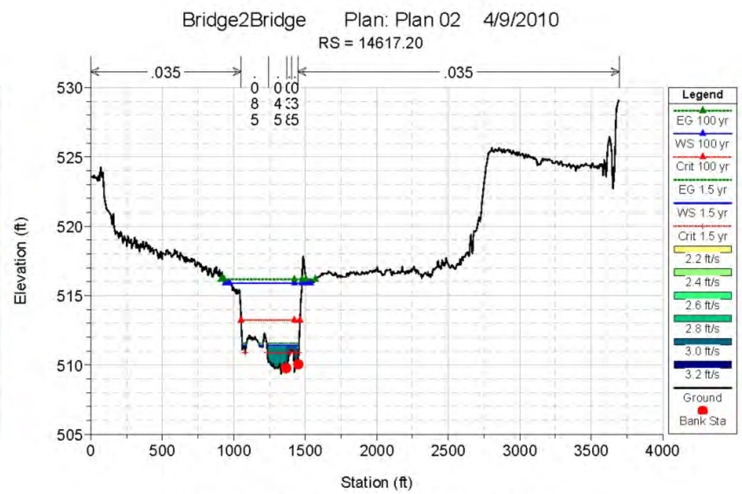
HEC-RAS Results
Profile View

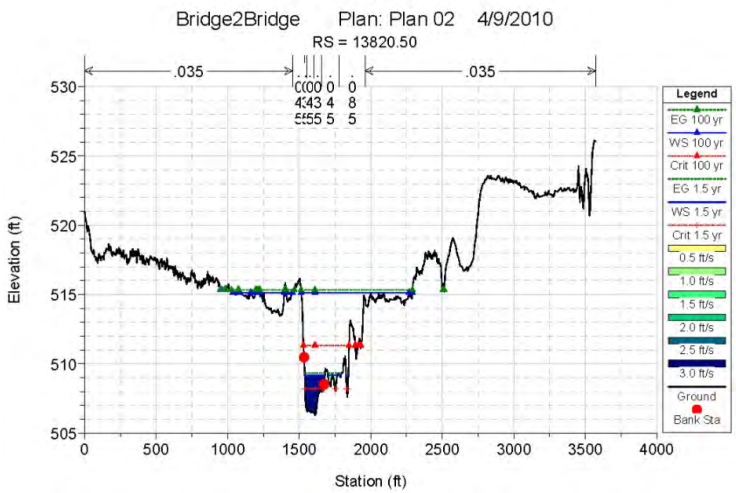
Bridge to Bridge – Walla Walla River
Near Lowden, Washington

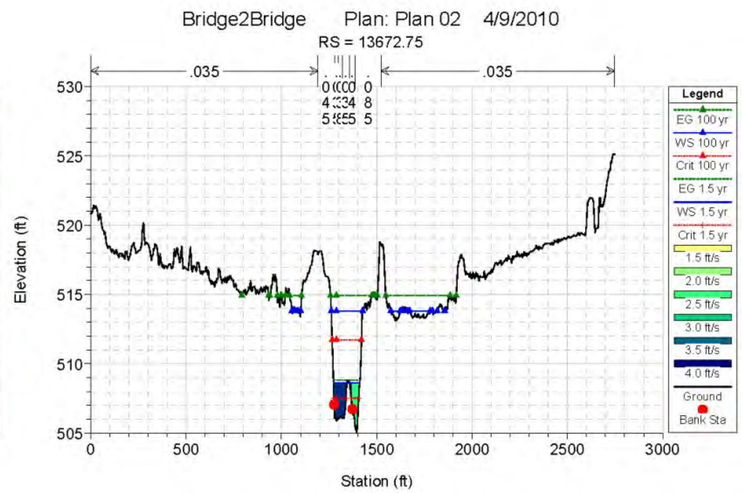
GeoEngineers

Figure B-3









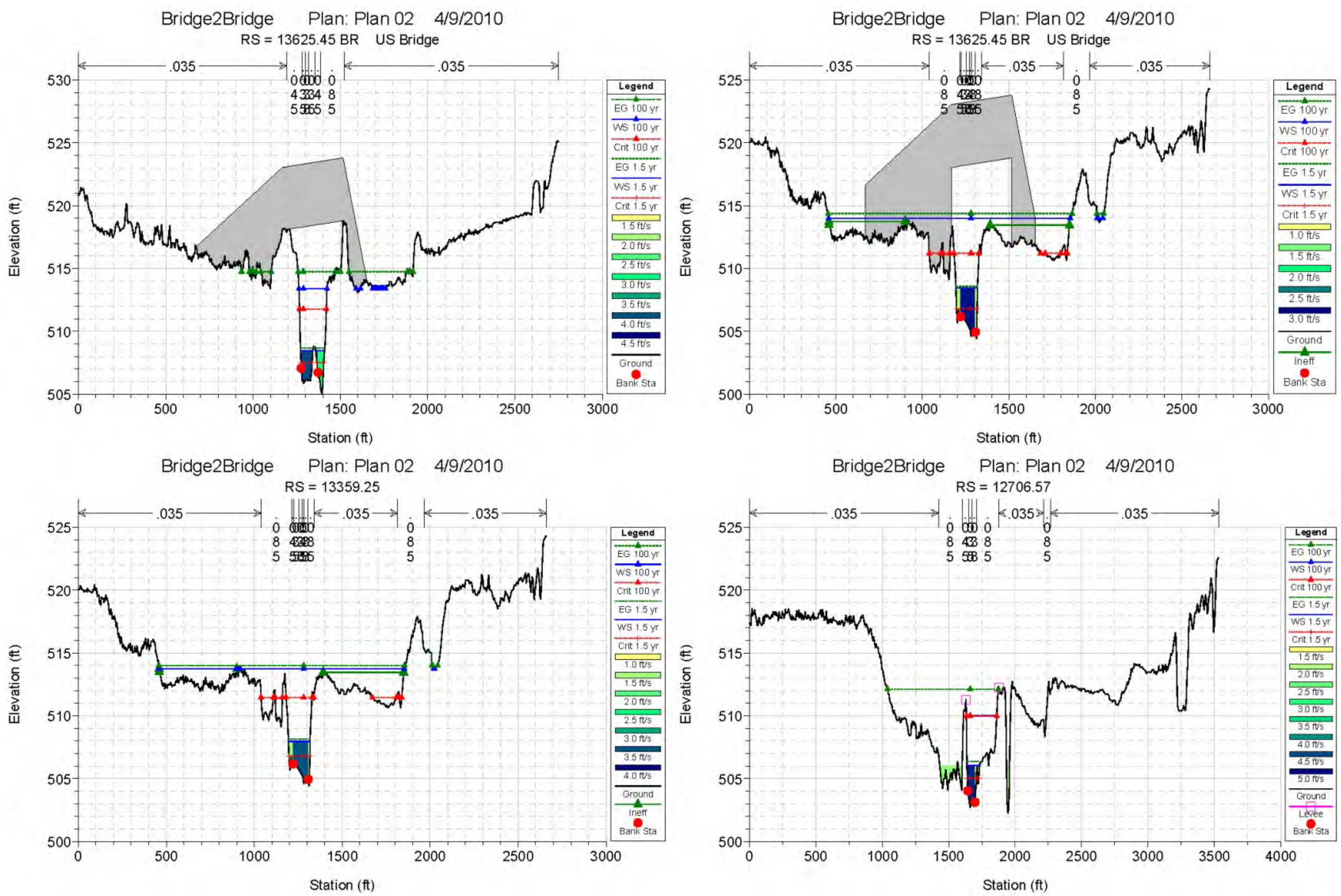
Reference: Model output obtained from HEC-RAS Hydraulic Model v. 4.0

HEC-RAS Results
Cross Sections

Bridge to Bridge – Walla Walla River
Near Lowden, Washington

GeoEngineers

Figure B-4



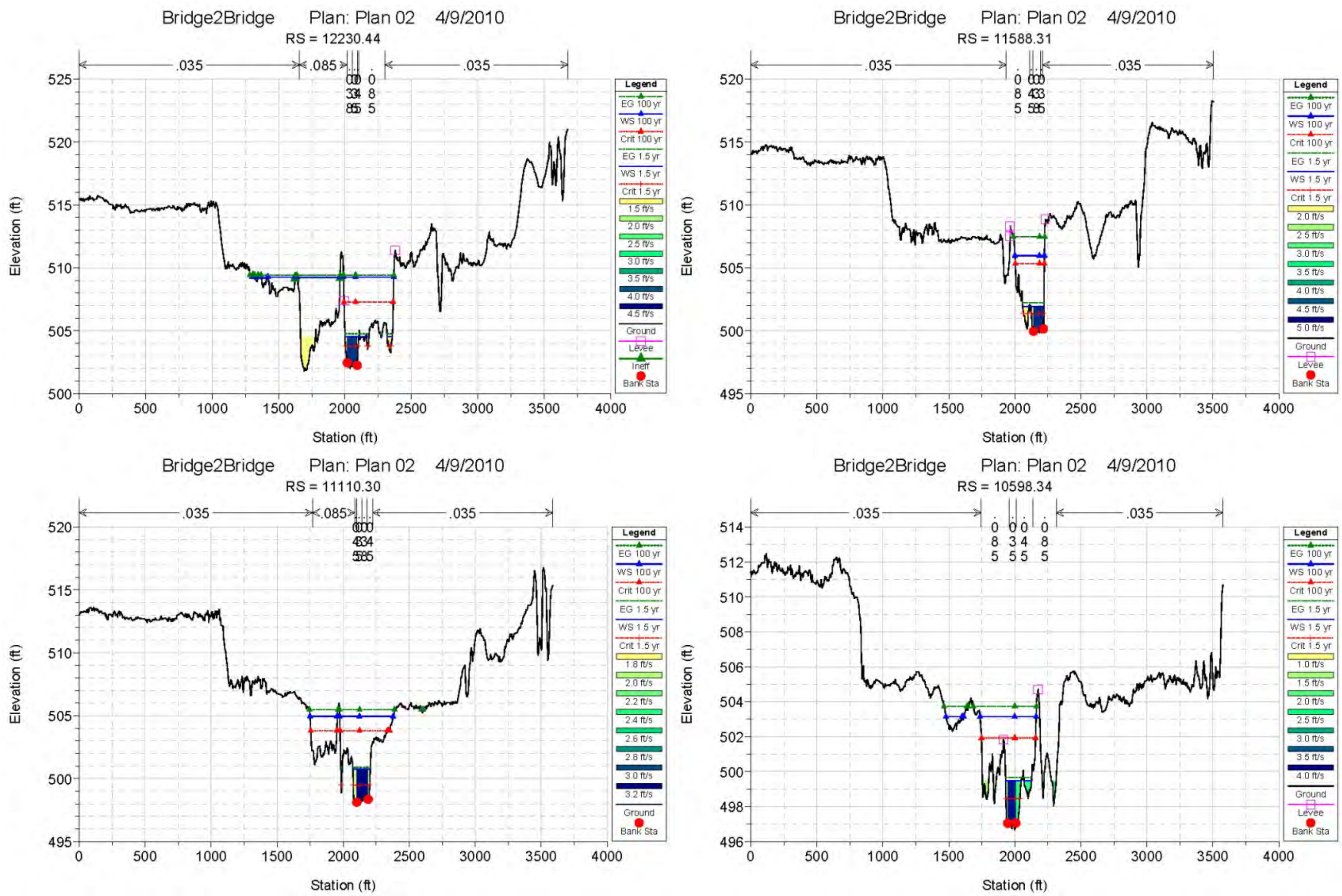
HEC-RAS Results
Cross Sections

Bridge to Bridge – Walla Walla River
Near Lowden, Washington

GeoEngineers

Figure B-5

Reference: Model output obtained from HEC-RAS Hydraulic Model v. 4.0



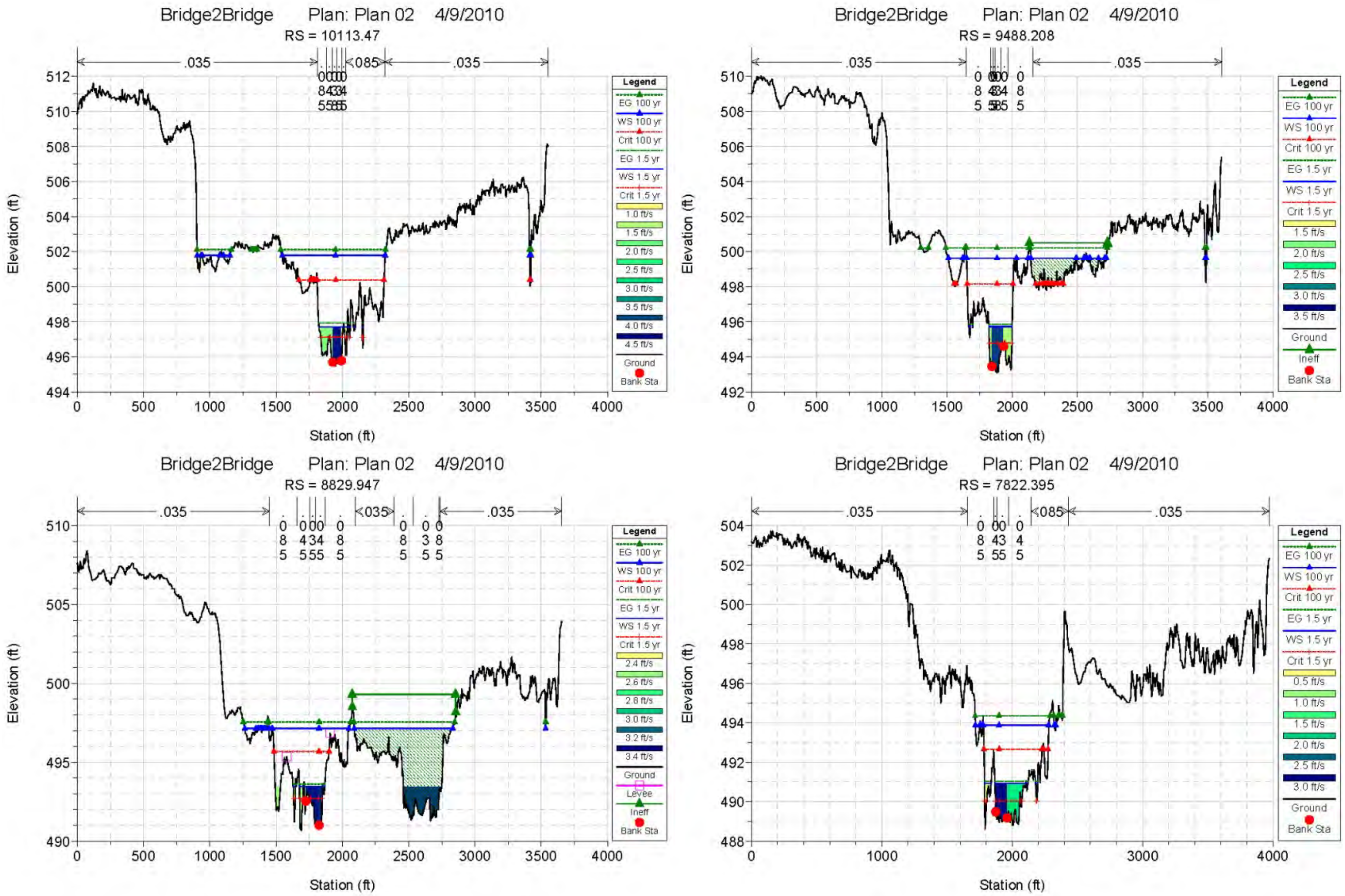
HEC-RAS Results Cross Sections

Bridge to Bridge – Walla Walla River Near Lowden, Washington

GeoEngineers

Figure B-6

Reference: Model output obtained from HEC-RAS Hydraulic Model v. 4.0



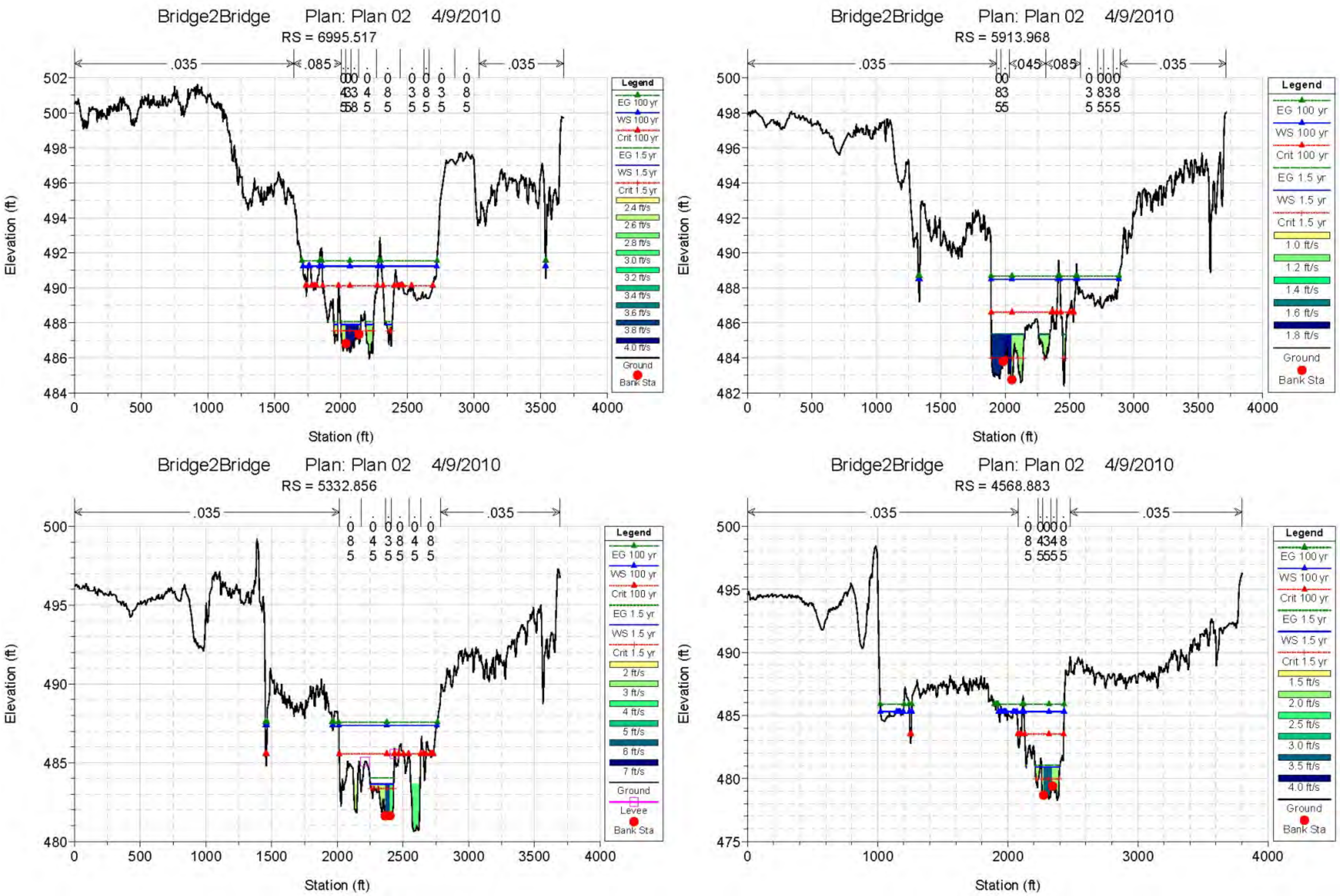
Reference: Model output obtained from HEC-RAS Hydraulic Model v. 4.0

HEC-RAS Results
Cross Sections

Bridge to Bridge – Walla Walla River
Near Lowden, Washington

GeoEngineers

Figure B-7



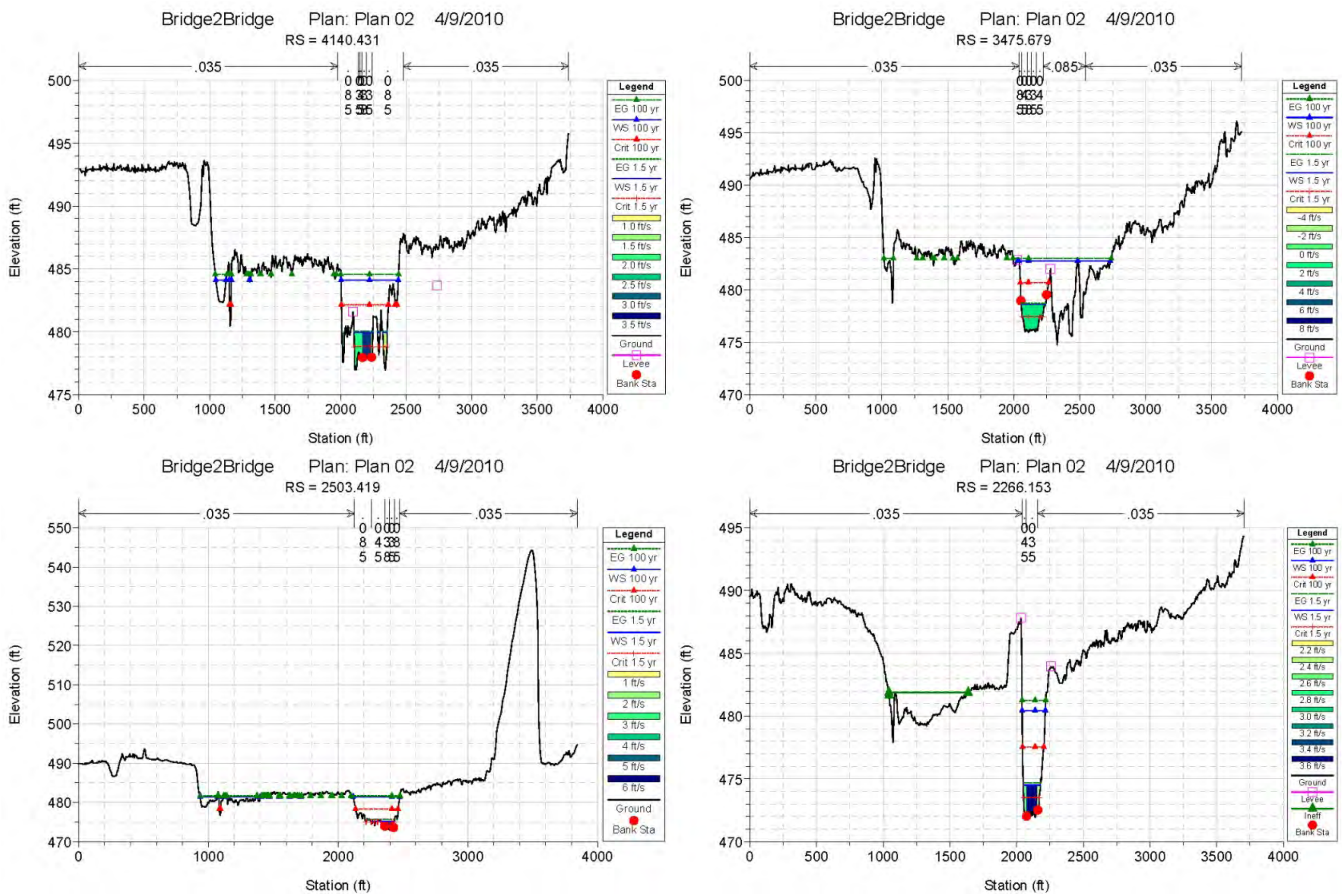
HEC-RAS Results
Cross Sections

Bridge to Bridge – Walla Walla River
Near Lowden, Washington

GeoEngineers

Figure B-8

Reference: Model output obtained from HEC-RAS Hydraulic Model v. 4.0



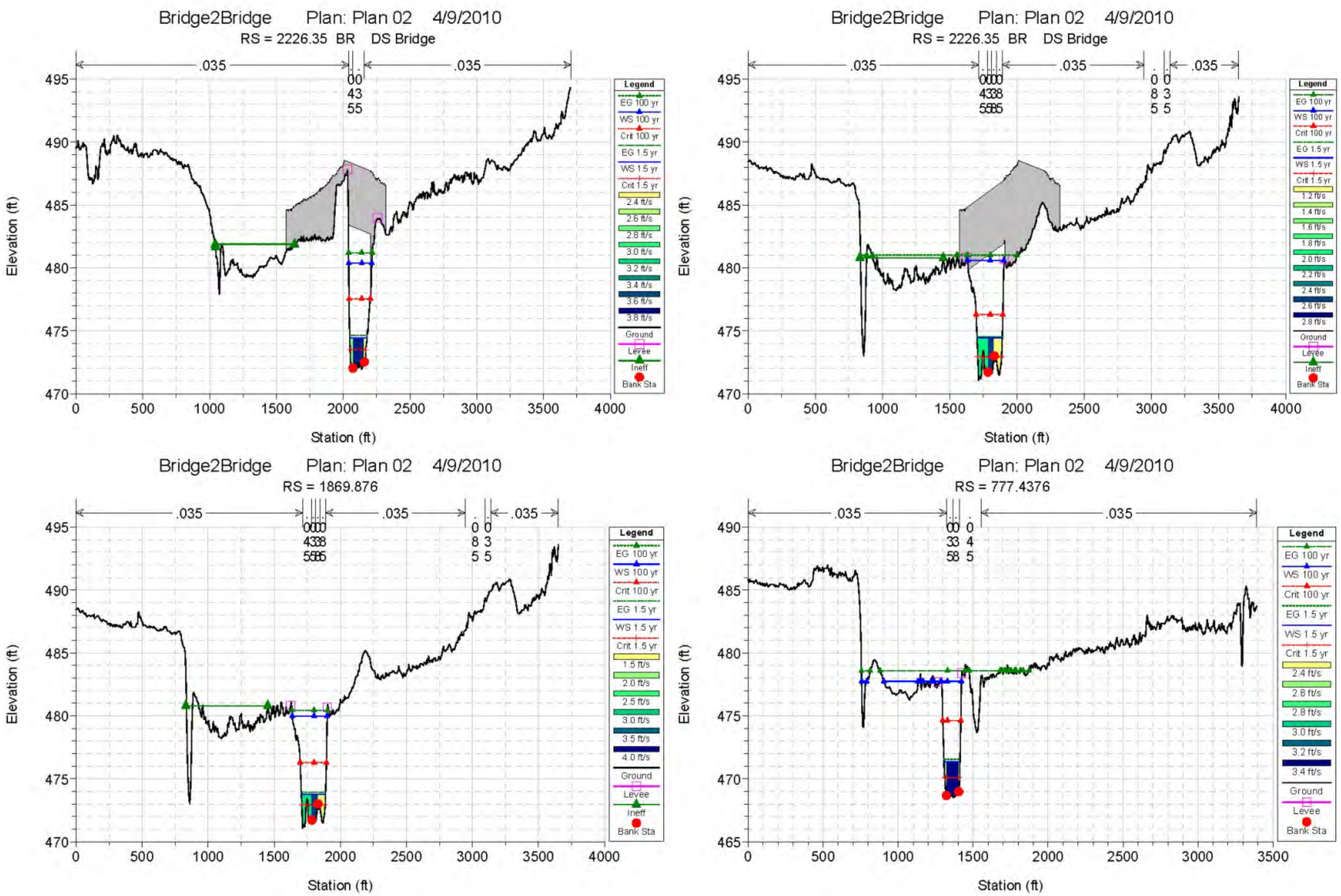
HEC-RAS Results
Cross Sections

Bridge to Bridge – Walla Walla River
Near Lowden, Washington

GEOENGINEERS

Figure B-9

Reference: Model output obtained from HEC-RAS Hydraulic Model v. 4.0



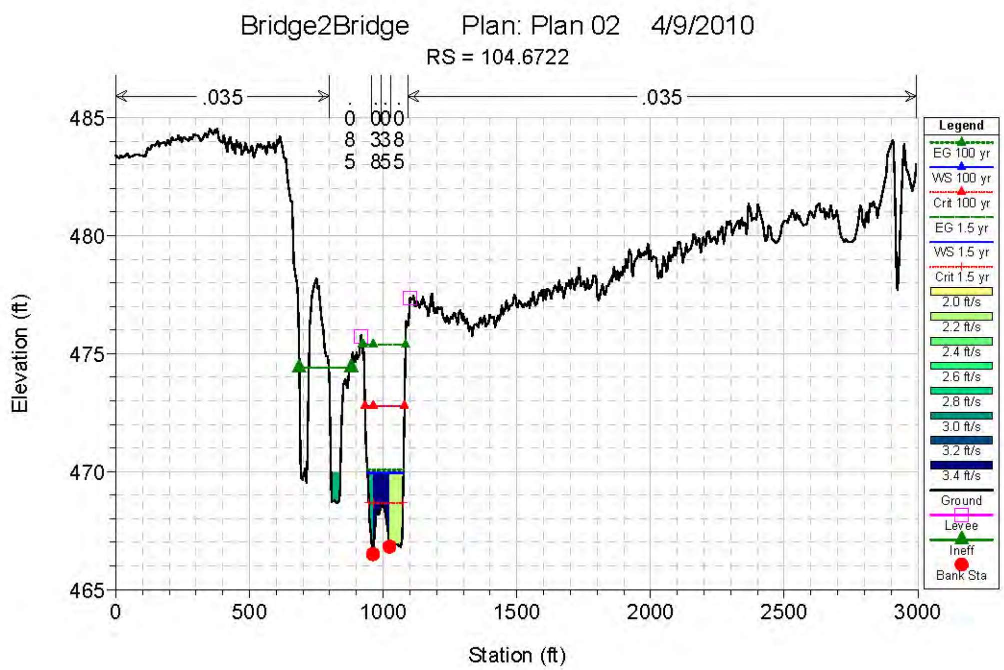
Reference: Model output obtained from HEC-RAS Hydraulic Model v. 4.0

HEC-RAS Results
Cross Sections

Bridge to Bridge – Walla Walla River
Near Lowden, Washington

GeoEngineers

Figure B-10



Reference: Model output obtained from HEC-RAS Hydraulic Model v. 4.0

HEC-RAS Results
Cross Sections

Bridge to Bridge – Walla Walla River
Near Lowden, Washington

GeoEngineers

Figure B-11

HEC-RAS Plan: Plan 01 River: WallaWalla Reach: BridgeToBridge

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Shear Chan (lb/sq ft)	Froude # Chl
BridgeToBridge	15033.82	1.5 yr	869	511.5	513.4	512.9	513.6	0.0045	3.4	274.9	235.9	0.35	0.54
BridgeToBridge	15033.82	100 yr	8232	511.5	516.8	515.8	517.6	0.0055	7.7	1234.7	312.6	1.57	0.63
BridgeToBridge	14617.20	1.5 yr	869	509.5	511.4	510.9	511.6	0.0053	3.0	294.1	278.9	0.33	0.53
BridgeToBridge	14617.20	100 yr	8232	509.5	515.9	513.2	516.2	0.0020	5.7	2134.1	528.1	0.70	0.43
BridgeToBridge	13820.50	1.5 yr	869	506.3	509.2	508.2	509.3	0.0024	2.9	331.5	234.0	0.30	0.36
BridgeToBridge	13820.50	100 yr	8232	506.3	515.1	511.3	515.3	0.0008	4.3	2905.7	1129.6	0.42	0.27
BridgeToBridge	13672.75	1.5 yr	869	505.9	508.6	507.5	508.8	0.0037	3.8	262.0	124.5	0.46	0.47
BridgeToBridge	13672.75	100 yr	8232	505.9	513.8	511.7	514.9	0.0044	9.4	1109.3	390.9	1.87	0.63
BridgeToBridge	13625.45		Bridge										
BridgeToBridge	13359.25	1.5 yr	869	504.6	508.0	506.8	508.1	0.0023	3.5	290.3	123.6	0.37	0.39
BridgeToBridge	13359.25	100 yr	8232	504.6	513.7	511.4	514.0	0.0012	5.5	3086.1	1393.9	0.64	0.34
BridgeToBridge	12706.57	1.5 yr	869	502.7	506.0	505.0	506.4	0.0032	4.7	209.1	95.1	0.59	0.46
BridgeToBridge	12706.57	100 yr	8232	502.7	510.0	510.0	512.1	0.0093	14.0	983.0	228.5	4.00	0.94
BridgeToBridge	12230.44	1.5 yr	869	502.0	504.5	503.8	504.8	0.0033	4.2	255.8	205.6	0.50	0.48
BridgeToBridge	12230.44	100 yr	8232	502.0	509.3	507.3	509.4	0.0011	5.0	3532.3	989.0	0.50	0.33
BridgeToBridge	11588.31	1.5 yr	869	499.8	501.9	501.4	502.2	0.0055	4.7	228.0	154.2	0.69	0.59
BridgeToBridge	11588.31	100 yr	8232	499.8	506.0	505.3	507.5	0.0077	11.7	1034.1	223.0	2.89	0.84
BridgeToBridge	11110.30	1.5 yr	869	497.9	500.7	499.5	500.9	0.0019	3.2	314.1	140.6	0.29	0.36
BridgeToBridge	11110.30	100 yr	8232	497.9	504.9	503.8	505.5	0.0028	7.5	2010.4	611.2	1.18	0.51
BridgeToBridge	10598.34	1.5 yr	869	496.7	499.5	498.5	499.7	0.0030	3.9	287.1	175.1	0.47	0.43
BridgeToBridge	10598.34	100 yr	8232	496.7	503.1	501.9	503.7	0.0041	8.2	1753.2	560.6	1.57	0.58
BridgeToBridge	10113.47	1.5 yr	869	495.5	497.7	497.1	497.9	0.0044	4.4	300.0	242.7	0.55	0.54
BridgeToBridge	10113.47	100 yr	8232	495.5	501.8	500.4	502.1	0.0026	7.0	2474.0	997.6	0.98	0.50
BridgeToBridge	9488.208	1.5 yr	869	493.1	495.7	494.8	495.8	0.0027	3.3	338.2	193.4	0.34	0.41
BridgeToBridge	9488.208	100 yr	8232	493.1	499.6	498.1	500.2	0.0041	8.0	1791.7	1138.2	1.50	0.58
BridgeToBridge	8829.947	1.5 yr	869	491.0	493.5	492.7	493.6	0.0044	3.4	279.4	196.9	0.37	0.51
BridgeToBridge	8829.947	100 yr	8232	491.0	497.1	495.7	497.5	0.0039	6.9	1939.5	1466.5	1.22	0.54
BridgeToBridge	7822.395	1.5 yr	869	489.0	490.9	490.0	491.0	0.0022	2.9	403.7	317.1	0.25	0.38
BridgeToBridge	7822.395	100 yr	8232	489.0	493.9	492.7	494.4	0.0039	7.4	1765.1	562.4	1.17	0.60
BridgeToBridge	6995.517	1.5 yr	869	486.3	487.9	487.6	488.1	0.0077	3.9	274.9	282.4	0.53	0.66
BridgeToBridge	6995.517	100 yr	8232	486.3	491.2	490.1	491.5	0.0033	6.3	2277.2	957.3	0.92	0.53
BridgeToBridge	5913.968	1.5 yr	869	482.7	485.3	484.0	485.4	0.0010	1.8	590.2	374.9	0.11	0.24
BridgeToBridge	5913.968	100 yr	8232	482.7	488.5	486.6	488.7	0.0018	4.8	2713.5	978.1	0.55	0.38
BridgeToBridge	5332.856	1.5 yr	869	481.5	483.6	483.4	484.0	0.0085	6.3	212.4	179.3	1.07	0.77
BridgeToBridge	5332.856	100 yr	8232	481.5	487.4	485.6	487.6	0.0020	6.1	2614.6	769.5	0.72	0.45
BridgeToBridge	4568.883	1.5 yr	869	478.4	480.9	480.0	481.1	0.0024	3.5	321.8	180.3	0.34	0.42
BridgeToBridge	4568.883	100 yr	8232	478.4	485.3	483.5	485.9	0.0031	8.2	1713.6	823.4	1.29	0.58
BridgeToBridge	4140.431	1.5 yr	869	477.7	479.9	478.8	480.0	0.0024	3.2	377.0	198.3	0.31	0.40
BridgeToBridge	4140.431	100 yr	8232	477.7	484.1	482.1	484.6	0.0031	7.7	2033.8	536.7	1.21	0.55
BridgeToBridge	3475.679	1.5 yr	869	475.9	478.6	477.4	478.7	0.0017	2.5	343.7	185.2	0.20	0.33
BridgeToBridge	3475.679	100 yr	8232	475.9	482.8	480.7	483.0	0.0017	4.8	2626.3	695.0	0.62	0.35
BridgeToBridge	2503.419	1.5 yr	869	472.9	475.2	474.9	475.7	0.0071	5.5	188.9	169.8	0.91	0.68
BridgeToBridge	2503.419	100 yr	8232	472.9	481.4	478.3	481.7	0.0011	5.6	2611.2	817.1	0.59	0.35
BridgeToBridge	2266.153	1.5 yr	869	472.0	474.5	473.5	474.7	0.0024	3.6	265.4	130.1	0.34	0.42
BridgeToBridge	2266.153	100 yr	8232	472.0	480.4	477.5	481.3	0.0021	7.9	1193.0	174.3	1.07	0.49
BridgeToBridge	2226.35		Bridge										
BridgeToBridge	1869.878	1.5 yr	869	471.5	473.8	472.9	473.9	0.0034	3.7	314.2	182.9	0.39	0.48
BridgeToBridge	1869.878	100 yr	8232	471.5	480.0	476.3	480.4	0.0017	8.9	1637.3	264.3	0.88	0.43

Reference: Model output obtained from HEC-RAS Hydraulic Model v. 4.0

HEC-RAS Results Output Table

Bridge to Bridge – Walla Walla River
Near Lowden, Washington

GeoEngineers

Figure B-12

HEC-RAS Plan: Plan 01 River: WallaWalla Reach: BridgeToBridge (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Shear Chan (lb/sq ft)	Froude # Chl
BridgeToBridge	777.4376	1.5 yr	869	468.5	471.4	470.1	471.5	0.0018	3.4	266.2	107.1	0.31	0.36
BridgeToBridge	777.4376	100 yr	8232	468.5	477.7	474.6	478.6	0.0021	8.2	1317.2	512.4	1.19	0.48
BridgeToBridge	104.6722	1.5 yr	869	466.5	469.9	468.7	470.1	0.0028	3.4	317.7	134.4	0.35	0.43
BridgeToBridge	104.6722	100 yr	8232	466.5	472.8	472.8	475.4	0.0181	15.6	721.6	148.1	5.41	1.25

Reference: Model output obtained from HEC-RAS Hydraulic Model v. 4.0

HEC-RAS Results
Output Table

Bridge to Bridge – Walla Walla River
Near Lowden, Washington

GeoEngineers

Figure B-13

APPENDIX C
Alternative Assessment Workbook

1: Alternatives Analysis Workbook

Project:	Bridge to Bridge	**Site:**	Bridge to Bridge Site
Project Number:	11281-005-00	**Analyst:**	Rob Richardson (mkh, 4-6-10)
Watercourse:	Walla Walla River	**Latest Revision:**	4/2/2010 (mkh, 4-6-10)

Workbook Description

- This workbook is:
- proprietary to GeoEngineers, Inc.,
- contains spreadsheets that facilitate the analysis and/or design of this project,
- lists the general project and workbook information that is consistent throughout the workbook,
- lists the titles of the spreadsheets contained in this workbook, and
- is intended for use with ENGLISH UNITS.

Filename: *C:\Documents and Settings\jfealko\My Documents\SharePoint Drafts\[1128100500_Alternatives_Assessment_Workbook.xlsx]Intro*

Sheet Titles:

1: Alternatives Analysis Workbook
2: Selection and Refinement Criteria
3: Alternatives Considered
4: Rating of Alternatives
5: Unit Cost Sheet
6: Alternative 1 Cost Estimate
7: Alternative 2 Cost Estimate
8 Alternative 3 Cost Estimate
9: Alternative 4 Cost Estimate
10: Summary Charts

2: Selection and Refinement Criteria

Project: Bridge to Bridge

Project Number: 11281-005-00

Watercourse: Walla Walla River

Site: Bridge to Bridge Site

Analyst: Rob Richardson (mkh, 4-6-10)

Latest Revision: 4/2/2010 (mkh, 4-6-10)

- This spreadsheet lists Selection Criteria identified by GeoEngineers, Tri-State Steelheaders and project landowners
- Each of the Selection Criteria has been assigned a value based on its relative level of importance in achieving the overall project objectives as determined by GeoEngineers and Tri-State Steelheaders respectively. (Decimals and/or similar values may be used if deemed necessary.)
- Subsequent spreadsheets in this workbook enable the user to rate each possible Design Alternative in terms of its level of effectiveness in addressing or achieving the Refinement and Selection Criteria.

Relative Value of Selection Refinement Criteria

1 = Lowest Level of Importance
2 = Low Level of Importance
3 = Moderate Importance
4 = High Level of Importance
5 = Highest Level of Importance

Selection Criteria	Description	Relative Value of Criteria Based on Level of Importance Identified by Client and Landowners
SC1:	Obj. 1: Increase/enhance/ diversify aquatic habitat	5.0
SC2:	Obj. 2: Increase/enhance/diversify riparian habitat	5.0
SC3:	Obj. 3: Minimize bank erosion on upper terraces	5.0
SC4:	Obj. 4: Increase floodplain connectivity	5.0
SC5:	Obj. 5: Geomorphic stability	5.0
SC6:	Obj. 6: Rapid Recovery Time	2.0
SC7:	Obj. 7: Design Practicality	3.0

3: Alternatives Considered

Project: Bridge to Bridge
Project Number: 11281-005-00
Watercourse: Walla Walla River

Site: Bridge to Bridge Site
Analyst: Rob Richardson (mkh, 4-6-10)
Latest Revision: 4/2/2010 (mkh, 4-6-10)

- This spreadsheet lists the Design Alternatives considered to acheive the stated project objectives.
- The Design Alternatives were developed from suitable restoration options as determined by GeoEngineers.
- "No Action" alternative was added to the suitable alternatives.
- Subsequent spreadsheets in this workbook enable the user to rate each possible Design Alternative in terms of its level of effectiveness in addressing or achieving the Selection and Refinement Criteria.

Alternative	Description
1	No Channel Realignment
2	Partial Channel Realignment
3	Significant Channel Realignment
4	Combination of Alternatives 1 and 2
5	No Action

4: Rating of Alternatives

Project: Bridge to Bridge
Project Number: 11281-005-00
Watercourse: Walla Walla River

Site: Bridge to Bridge Site
Analyst: Rob Richardson (mkh, 4-6-10)
Latest Revision: 4/2/2010 (mkh, 4-6-10)

- This spreadsheet enables the user to rate how effective each possible Design Alternative is at achieving the stated Selection Criteria.
- The Rating for each Alternative is calculated below by multiplying the Relative Value of each Criterion by the Alternative's Relative Effectiveness at acheiving the stated Criterion. (Decimals and/or similar values may be used for Relative Effectivness if necessary.)
- The overall effectiveness of an Alternative is based upon its Final Rating. Higher ratings are better.
- Only alter the "score" on this sheet. (Shaded Cells)

Relative Effectiveness (score)
1 = Ineffective
2 = Minimally Effective
3 = Moderately Effective
4 = Effective
5 = Very Effective

Selection Criteria	Description	Relative Value of Criterian (weight)	Alternative 1		Alternative 2		Alternative 3		Alternative 4		Alternative 5		
			No Channel Realignment		Partial Channel Realignment		Significant Channel Realignment		Combination of Alternatives 1 and 2		No Action		
			Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Max Possible
SC1:	Obj. 1: Increase/enhance/ diversify aquatic habitat	5	2	10	4	20	5	25	3	15	1	5	25
SC2:	Obj. 2: Increase/enhance/diversify riparian habitat	5	3	15	4	20	5	25	4	20	1	5	25
SC3:	Obj. 3: Minimize bank erosion on upper terraces	5	5	25	5	25	5	25	5	25	1	5	25
SC4:	Obj. 4: Increase floodplain connectivity	5	3	15	4	20	5	25	3.5	17.5	1	5	25
SC5:	Obj. 5: Geomorphic stability	5	2	10	4	20	5	25	4	20	1	5	25
SC6:	Obj. 6: Rapid Recovery Time	2	2	4	4	8	5	10	3	6	1	2	10
SC7:	Obj. 7: Design Practicality	3	5	15	3	9	1	3	4	12	5	15	15
Final Benefit Rating				94.0		122.0		138.0		115.5		42.0	150

5: Unit Cost Sheet

Project: Bridge to Bridge

Analyst: Rob Richardson (mkh, 4-6-10)

Project Number: 11281-005-00

Latest Revision: 4/2/2010 (mkh, 4-6-10)

- This spreadsheet calculates the costs associated with site preparation. Unit costs include materials, labor, equipment, overhead and contractor profit.
- Reference used for "unit costs" include:
  - (1) R.S. Means Heavy Construction Cost Data Manual, 2004 (Means)
  - (2) Engineering Experience & Recent Similar Projects
  - (3) Contractor or Supplier
- Inflation adjustment is a rough estimate using the Consumer Price Index average between 1999 and 2004.
- Additional adjustments are based on engineering judgement, experience and site-specific degree of difficulty.
- Blank rows are provided at the bottom for additional items. Add new items & unit costs on this sheet, if necessary. These will be used to calculate costs on subsequent sheets.
- General mark-up percentages are also provided at the bottom.

0	= Adjustment for inflation from to 2004 to 2010 (Construction) (%)
0.1	= Location Factor (Pendleton) (%) (Adjustment from national average)
0	= Additional Location Factor (Remote) (%)

Item #	Item Description	Ref. ID	Ref. #	Page #	Units	Unit Cost ($)	Inflation & Location Adjustments (%)	Additional Adjustments (%)	Adjusted Unit Price ($)
1	Temporary Stream Diversion	1, 2			LS	20,000.00	0	0	20000.00
2	Main Stem or Side Channel Excavation (excavator & 22 CY dump w/ 1,000-ft off-road haul)	1	31-23-16.42-0200	219 243	CY	6.54	0.1	0	6.55
3	Channel Sculpting (excavation and placement of excavated material in old channel and/or bar)	1	31-23-16.13-6080	214	CY	6.15	0.1	0	6.16
4	In-stream Pool Excavation and Placement of Excavated Alluvium on Bank/Bar	1	31-23-16.13-6080	214	CY	6.15	0.1	0	6.16
5	Channel Grading	1	31-22-16.10-1020	211	Acre	5,330.00	0.1	150	13330.33
6	Floodplain/Wetland Grading (including terrace grading/shaping)	1	31-22-16.10-1020	211	Acre	5,330.00	0.1	100	10665.33
7	Secondary Terrace Construction (borrowed granular fill, LWD installation)	1, 2	31-23-23.15-5000	228	LF	180.00	0	0	180.00
8	Levee Removal (excavator and 20 CY dump w/ 2-mile haul)	1	31-23-16.42-0200 31-23-23.20-	219 239	CY	7.25	0.1	0	7.25
9	Large Woody Debris (acquisition, delivery, installation)	2,3			Each	1,200.00	0	0	1200.00
10	Large Woody Debris (on-site acquisition, installation)	2,3			Each	600.00	0	0	600.00
11	Riparian Vegetation (live staking and selective planting)	2			Acre	3,000.00	0	0	3000.00
12	BMPs (jute mat, silt fence, hay bales, etc.)	2			LS	20,000.00	0	0	20000.00
13	Riparian Vegetation (full planting)	2			Acre	10,000.00	0	0	10000.00
14	VACANT					0.00	0	0	0.00
15	VACANT					0.00	0	0	0.00
101	Mobilization (as % of Construction Sub-Total)							2	
102	Construction Observation (per alternative)							n/a	
103	Incidentals not included in items above (as % of Construction Sub-Total)							10	
104	Contingency (as % of Construction Sub-Total)							15	
105	Design (suitable for design build)							n/a	
106	Permitting							n/a	

6: Alternative 1 Cost Estimate

Project: Bridge to Bridge | **Analyst:** Rob Richardson (mkh, 4-6-10)

Project No: 11281-005-00 | **Latest Revision:** 4/2/2010 (mkh, 4-6-10)

- This spreadsheet calculates the costs for the items noted. Item # references the Item # on the Unit Cost sheet.
- The unit costs are based upon those listed & calculated on the Unit Cost sheet.
- Blue cells represent cells that require input.

Item #	Item Description	Units	Adjusted Unit Cost ($)	No. of Units	Cost per Item ($)
1	Temporary Stream Diversion	LS	20000.00	1.0	20,000
2	Main Stem or Side Channel Excavation (excavator & 22 CY dump w/ 1,000-ft off-road haul)	CY	6.55	950.0	6,223
3	Channel Sculpting (excavation and placement of excavated material in old channel and/or bar)	CY	6.16	0.0	0
4	In-stream Pool Excavation and Placement of Excavated Alluvium on Bank/Bar	CY	6.16	8,700.0	53,559
5	Channel Grading	Acre	13330.33	1.6	21,329
6	Floodplain/Wetland Grading (including terrace grading/shaping)	Acre	10665.33	4.3	45,861
7	Secondary Terrace Construction (borrowed granular fill, LWD installation)	LF	180.00	3,750.0	675,000
8	Levee Removal (excavator and 20 CY dump w/ 2-mile haul)	CY	7.25	18,150.0	131,628
9	Large Woody Debris (acquisition, delivery, installation)	Each	1200.00	150.0	180,000
10	Large Woody Debris (on-site acquisition, installation)	Each	600.00	0.0	0
11	Riparian Vegetation (live staking and selective planting)	Acre	3000.00	3.0	9,000
12	BMPs (jute mat, silt fence, hay bales, etc.)	LS	20000.00	1.0	20,000
13	Riparian Vegetation (full planting)	Acre	10000.00	4.3	43,000
14	VACANT	0	0.00		0
15	VACANT	0	0.00		0
	Constrution Sub-Total				**1,205,599**
101	Mobilization (as % of Construction Sub-Total)			n/a	20,000
102	Construction Observation (per alternative)			n/a	24,000
103	Incidentals not included in items above (as % of Construction Sub-Total)			10.0%	120,560
104	Contingency (as % of Construction Sub-Total)			15.0%	180,840
105	Design (suitable for design build)			n/a	50,000
106	Permitting			n/a	n/a
	Final Construction Cost				**1,600,998**

7: Alternative 2 Cost Estimate

Project: Bridge to Bridge
Project No: 11281-005-00

Analyst: Rob Richardson (mkh, 4-6-10)
Latest Revision: 4/2/2010 (mkh, 4-6-10)

- This spreadsheet calculates the costs for the items noted. Item # references the Item # on the Unit Cost sheet.
- The unit costs are based upon those listed & calculated on the Unit Cost sheet.
- Blue cells represent cells that require input.

Item #	Item Description	Units	Adjusted Unit Cost ($)	No. of Units	Cost per Item ($)
1	Temporary Stream Diversion	LS	20000.00	1.0	20,000
2	Main Stem or Side Channel Excavation (excavator & 22 CY dump w/ 1,000-ft off-road haul)	CY	6.55	3,555.6	23,289
3	Channel Sculpting (excavation and placement of excavated material in old channel and/or bar)	CY	6.16	18,903.7	116,374
4	In-stream Pool Excavation and Placement of Excavated Alluvium on Bank/Bar	CY	6.16	17,777.8	109,443
5	Channel Grading	Acre	13330.33	2.8	36,723
6	Floodplain/Wetland Grading (including terrace grading/shaping)	Acre	10665.33	5.5	58,659
7	Secondary Terrace Construction (borrowed granular fill, LWD installation)	LF	180.00	3,750.0	675,000
8	Levee Removal (excavator and 20 CY dump w/ 2-mile haul)	CY	7.25	18,150.0	131,628
9	Large Woody Debris (acquisition, delivery, installation)	Each	1200.00	230.0	276,000
10	Large Woody Debris (on-site acquisition, installation)	Each	600.00	50.0	30,000
11	Riparian Vegetation (live staking and selective planting)	Acre	3000.00	6.0	18,000
12	BMPs (jute mat, silt fence, hay bales, etc.)	LS	20000.00	1.0	20,000
13	Riparian Vegetation (full planting)	Acre	10000.00	4.3	43,000
14	VACANT	0	0.00		0
15	VACANT	0	0.00		0
	Constrution Sub-Total				**1,558,116**
101	Mobilization (as % of Construction Sub-Total)			n/a	20,000
102	Construction Observation (per alternative)			n/a	40,000
103	Incidentals not included in items above (as % of Construction Sub-Total)			10.0%	155,812
104	Contingency (as % of Construction Sub-Total)			15.0%	233,717
105	Design (suitable for design build)			n/a	70,000
106	Permitting			n/a	n/a
	Final Construction Cost				**2,077,645**

8 Alternative 3 Cost Estimate

Project: Bridge to Bridge
Project No: 11281-005-00

Analyst: Rob Richardson (mkh, 4-6-10)
Latest Revision: 4/2/2010 (mkh, 4-6-10)

- This spreadsheet calculates the costs for the items noted. Item # references the Item # on the Unit Cost sheet.
- The unit costs are based upon those listed & calculated on the Unit Cost sheet.
- Blue cells represent cells that require input.

Item #	Item Description	Units	Adjusted Unit Cost ($)	No. of Units	Cost per Item ($)
1	Temporary Stream Diversion	LS	20000.00	1.0	20,000
2	Main Stem or Side Channel Excavation (excavator & 22 CY dump w/ 1,000-ft off-road haul)	CY	6.55	2,518.5	16,496
3	Channel Sculpting (excavation and placement of excavated material in old channel and/or bar)	CY	6.16	113,518.5	698,837
4	In-stream Pool Excavation and Placement of Excavated Alluvium on Bank/Bar	CY	6.16	25,222.2	155,272
5	Channel Grading	Acre	13330.33	21.2	283,071
6	Floodplain/Wetland Grading (including terrace grading/shaping)	Acre	10665.33	7.7	82,123
7	Secondary Terrace Construction (borrowed granular fill, LWD installation)	LF	180.00	3,750.0	675,000
8	Levee Removal (excavator and 20 CY dump w/ 2-mile haul)	CY	7.25	18,150.0	131,628
9	Large Woody Debris (acquisition, delivery, installation)	Each	1200.00	315.0	378,000
10	Large Woody Debris (on-site acquisition, installation)	Each	600.00	100.0	60,000
11	Riparian Vegetation (live staking and selective planting)	Acre	3000.00	9.0	27,000
12	BMPs (jute mat, silt fence, hay bales, etc.)	LS	20000.00	1.0	20,000
13	Riparian Vegetation (full planting)	Acre	10000.00	4.5	45,000
14	VACANT	0	0.00		0
15	VACANT	0	0.00		0
	Constrution Sub-Total				**2,592,427**
101	Mobilization (as % of Construction Sub-Total)			n/a	20,000
102	Construction Observation (per alternative)			n/a	63,000
103	Incidentals not included in items above (as % of Construction Sub-Total)			10.0%	259,243
104	Contingency (as % of Construction Sub-Total)			15.0%	388,864
105	Design (suitable for design build)			n/a	80,000
106	Permitting			n/a	n/a
	Final Construction Cost				**3,403,534**

9: Alternative 4 Cost Estimate

Project: Bridge to Bridge
Project No: 11281-005-00

Analyst: Rob Richardson (mkh, 4-6-10)
Latest Revision: 4/2/2010 (mkh, 4-6-10)

- This spreadsheet calculates the costs for the items noted. Item # references the Item # on the Unit Cost sheet.
- The unit costs are based upon those listed & calculated on the Unit Cost sheet.
- Blue cells represent cells that require input.

Item #	Item Description	Units	Adjusted Unit Cost ($)	No. of Units	Cost per Item ($)
1	Temporary Stream Diversion	LS	20000.00	1.0	20,000
2	Main Stem or Side Channel Excavation (excavator & 22 CY dump w/ 1,000-ft off-road haul)	CY	6.55	3,100.0	20,305
3	Channel Sculpting (excavation and placement of excavated material in old channel and/or bar)	CY	6.16	0.0	0
4	In-stream Pool Excavation and Placement of Excavated Alluvium on Bank/Bar	CY	6.16	7,500.0	46,171
5	Channel Grading	Acre	13330.33	2.1	27,994
6	Floodplain/Wetland Grading (including terrace grading/shaping)	Acre	10665.33	4.3	45,861
7	Secondary Terrace Construction (borrowed granular fill, LWD installation)	LF	180.00	3,750.0	675,000
8	Levee Removal (excavator and 20 CY dump w/ 2-mile haul)	CY	7.25	18,150.0	131,628
9	Large Woody Debris (acquisition, delivery, installation)	Each	1200.00	180.0	216,000
10	Large Woody Debris (on-site acquisition, installation)	Each	600.00	20.0	12,000
11	Riparian Vegetation (live staking and selective planting)	Acre	3000.00	4.5	13,500
12	BMPs (jute mat, silt fence, hay bales, etc.)	LS	20000.00	1.0	20,000
13	Riparian Vegetation (full planting)	Acre	10000.00	4.5	45,000
14	VACANT	0	0.00		0
15	VACANT	0	0.00		0
	Constrution Sub-Total				**1,273,459**
101	Mobilization (as % of Construction Sub-Total)			n/a	20,000
102	Construction Observation (per alternative)			n/a	32,000
103	Incidentals not included in items above (as % of Construction Sub-Total)			10.0%	127,346
104	Contingency (as % of Construction Sub-Total)			15.0%	191,019
105	Design (suitable for design build)			n/a	55,000
106	Permitting			n/a	n/a
	Final Construction Cost				**1,698,824**

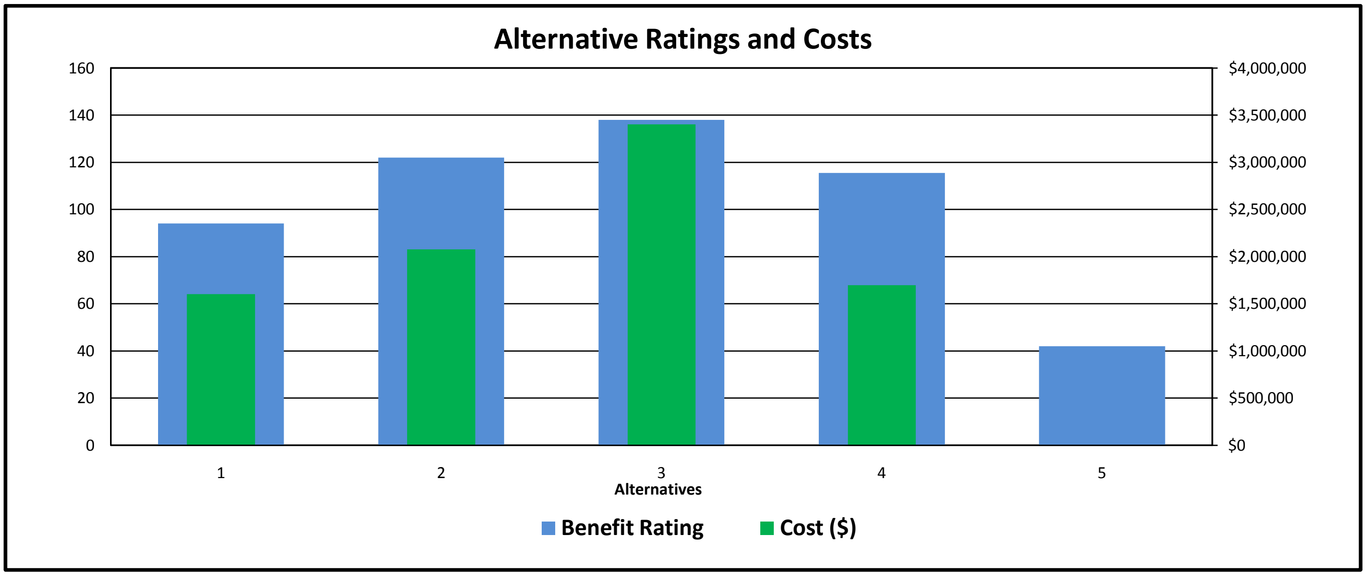
10: Summary Charts

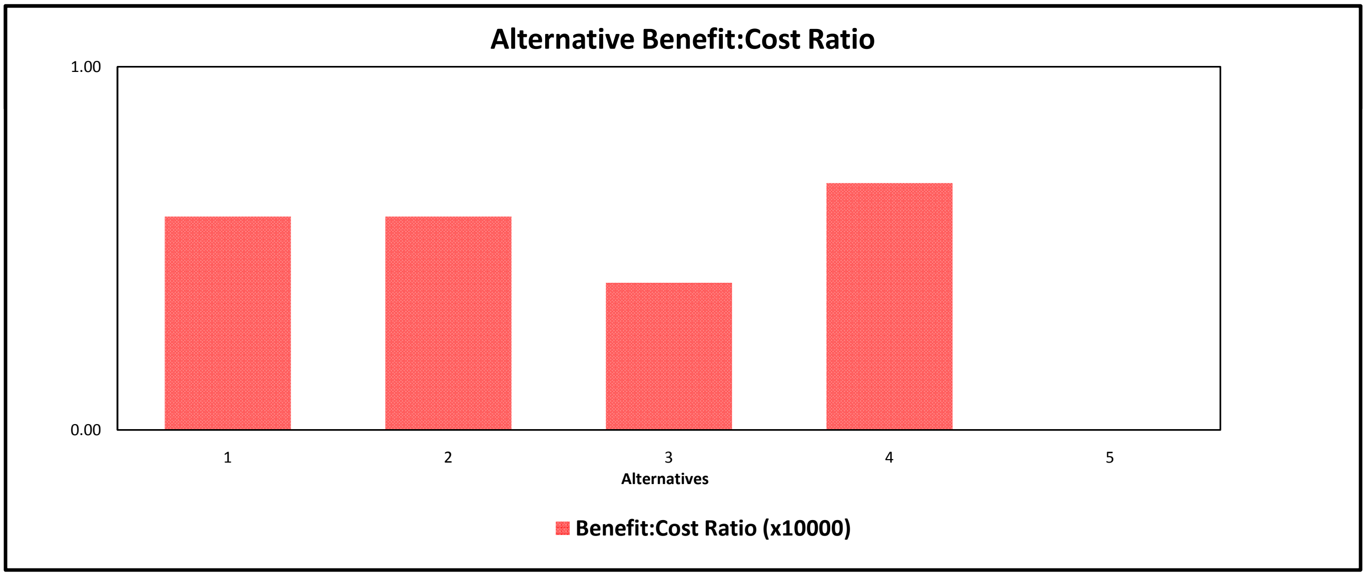
Project: Bridge to Bridge
Project Number: 11281-005-00
Watercourse: Walla Walla River

Site: Bridge to Bridge Site
Analyst: Rob Richardson (mkh, 4-6-10)
Latest Revision: 4/2/2010 (mkh, 4-6-10)

Spreadsheet Description:

- This spreadsheet charts the relative ratings and cost of each Alternative considered. The ratings are based upon the relative value of the criterion based on the level of importance.



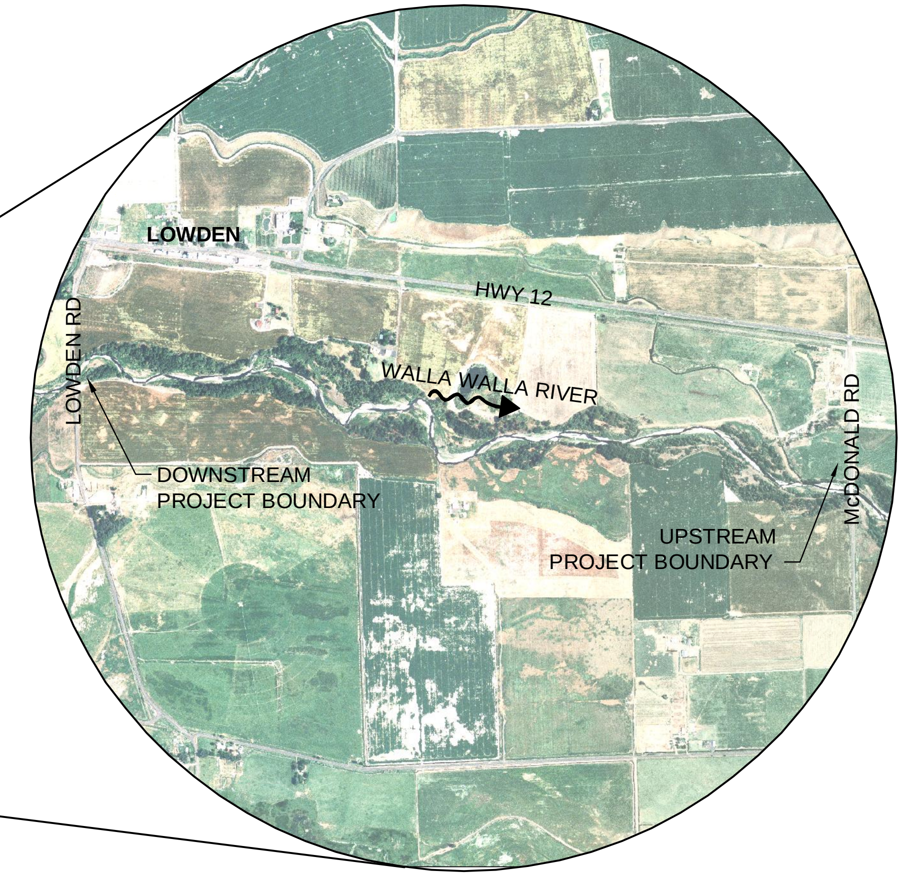


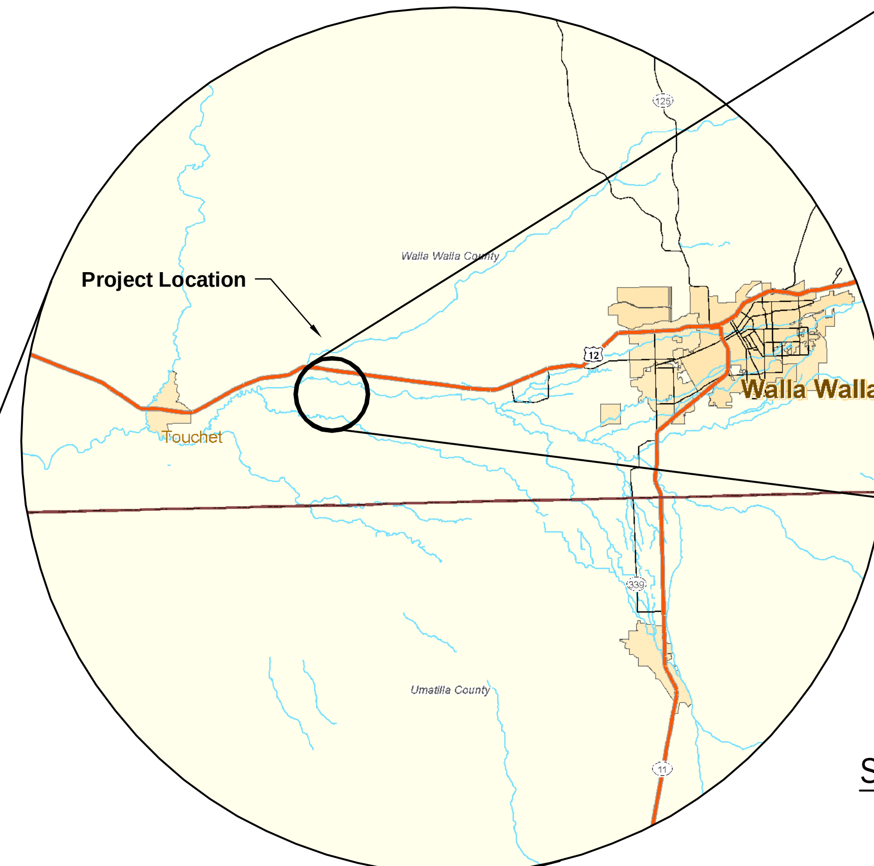
Alternative	Description	Benefit Rating	Cost ($)	Benefit:Cost Ratio (x10000)
1	No Channel Realignment	94	1,600,998	0.59
2	Partial Channel Realignment	122	2,077,645	0.59
3	Significant Channel Realignment	138	3,403,534	0.41
4	Combination of Alternatives 1 and 2	116	1,698,824	0.68
5	No Action	42	0	n/a

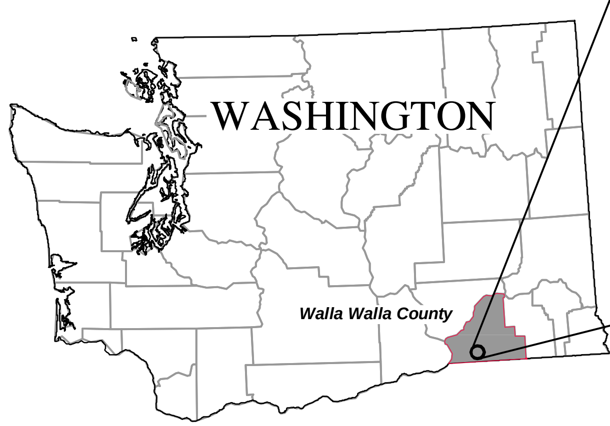
APPENDIX D
River Enhancement Design Drawings

Bridge to Bridge

Walla Walla River Enhancement
Alternatives Assessment







SHEET	SHEET TITLE
1	COVER SHEET
2	VISION, GOALS AND OBJECTIVES
3	HISTORIC CHANNEL ALIGNMENTS
4.1	EXISTING CONDITIONS
4.2	RELATIVE SURFACE MODEL
4.3	EXISTING TOPOGRAPHY
4.4	EXISTING FLOODPLAIN

SHEET	SHEET TITLE
5.1	ALTERNATIVE 1 REACH INDEX
5.2	ALTERNATIVE 1, REACH 1
5.3	ALTERNATIVE 1, REACH 2
5.4	ALTERNATIVE 1, REACH 3
5.5	ALTERNATIVE 1, CROSS SECTIONS
5.6	ALTERNATIVE 1, CROSS SECTIONS
6.1	ALTERNATIVE 2 REACH INDEX
6.2	ALTERNATIVE 2, REACH 1
6.3	ALTERNATIVE 2, REACH 2
6.4	ALTERNATIVE 2, REACH 3
6.5	ALTERNATIVE 2, CROSS SECTIONS
6.6	ALTERNATIVE 2, CROSS SECTIONS

SHEET	SHEET TITLE
7.1	ALTERNATIVE 3 REACH INDEX
7.2	ALTERNATIVE 3, REACH 1
7.3	ALTERNATIVE 3, REACH 2
7.4	ALTERNATIVE 3, REACH 3
7.5	ALTERNATIVE 3, CROSS SECTIONS
7.6	ALTERNATIVE 3, CROSS SECTIONS
8.1	ALTERNATIVE 4, SHEET INDEX
8.2	ALTERNATIVE 4, REACH 1
8.3	ALTERNATIVE 4, REACH 2
8.4	ALTERNATIVE 4, REACH 3
8.5	ALTERNATIVE 4, CROSS SECTIONS
8.6	ALTERNATIVE 4, CROSS SECTIONS

Reference: Base map obtained from ESRI, 2006 aerial obtained from USGS EarthExplorer.

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		CONCEPTUAL		Designed: JJF
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				Project No: 11281-005-00

Walla Walla River Bridge
near Lowden, Washington

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Cover Sheet

Alternatives Assessment

Sheet
1

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MKH : MGF

Project Goals

The ultimate goal of this project is to increase, enhance and diversify aquatic, ripairan and upland habitat while increasing floodplain connectivity and minimizing excessive erosion of the terraces within a reasonable period of time by implementing geomorphically appropriate design techniques within the practical limits of the project constraints.

Project Objectives

Increase, Enhance and Diversify Aquatic Habitat (1)
- Multiple Habitat Types Close Together
- Primary Pool Habitat
- Substrate Diversification
- Habitat Structure and Cover
- Side Channel/Off Channel Habitat
  - *Benefits Include:*
    - *Multiple Species and Life Stages*
    - *Spawning, Rearing, Holding, Refuge*

Increase, Enhance and Diversify Riparian and Upland Habitat (1)
- Diverse Vegetation Consiting of Native Plants
  - *Benefits Include:*
    - *Cover and Macroinvertebrates for Fish*
    - *Overall Habitat Complexity*
    - *Bird and Wildlife Habitat*
    - *LWD Recruitment*
    - *Bank Stability*
    - *Shade*

Minimize Bank Erosion Along Upper Terraces (1)
- Maintain Main Channel Within Limits of Existing Terraces
  - *Benefits Include:*
    - *Maintains Existing Acrage and Land Use Along Upper Terraces*
    - *Reduces Fine Sediment Inputs*

Increase Floodplain Connectivity (1)
- Excavate and/or Encourage More Flow Through Side Channels
- Layback Steep Slopes
- Levee Removal
  - *Benefits Include:*
    - *Reduced Flood Elevations and Velocities*
    - *Increased Flood Storage*
    - *Bed and Bank Stability*
    - *Overall Habitat Complexity*
    - *Hyporeic Exchange*

Geomorphic Stability (2)
- Self-Sustaining, Self-Maintaining
- Use of Natural Materials (Woody Habitat Structures, Rock Structures, Vegetation)
  - *Benefits Include:*
    - *Minimal Long-Term Maintenance*
    - *Bed and Bank Stability*
    - *Habitat Maturation*
    - *Minimizes Risk of Severe Erosion and/or Incision*

Design Practicality (2)
- Accommodate Physical, Practical and Regulatory Concerns
  - *Including:*
    - *Public Saftey*
    - *Zoning, Easements, Setbacks, Flood Zones, etc*
    - *Property Boundaries*
    - *Landower Desires*
    - *Neighboring Property Concerns*
    - *(Costs accounted for in Cost/Benefit Ratio Analysis)*
- Minimize Project Complexity
  - *Including:*
    - *Minimal Disturbance to Existing Ground, Habitat and Vegetation*
    - *Minimal Landowner Disturbance*
    - *Minimal Permitting, Construction Schedule Phasing, Diversions,*
    - *Minimal Short Term Maintenance*

Rapid Recovery Time (2)
- Channel, Vegetation and Habitat Establish Quickly
- Limited Construction Seasons (Years)
- Not Dependent upon Long-Term Channel Migration

Notes:
1. Primary Objective: All proposed enhancement alternatives include treatments that specifically target the primary objectives of this project.
2. Secondary Objective: All proposed enhancement alternatives are designed in consideration of the secondary objectives.
3. The extent to which each objective is achieved varies upon the complexity of each alternative.
4. The specific enhancement treatments utilized on this project and their direct benefits are listed on the following sheet.

Revision No:	Date:	Description:	Initials:	
		CONCEPTUAL		Designed: JJF
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				Date: 04/07/10
				Project No: 11281-005-00

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Vision, Goals and Objectives

Alternatives Assessment

Sheet 2

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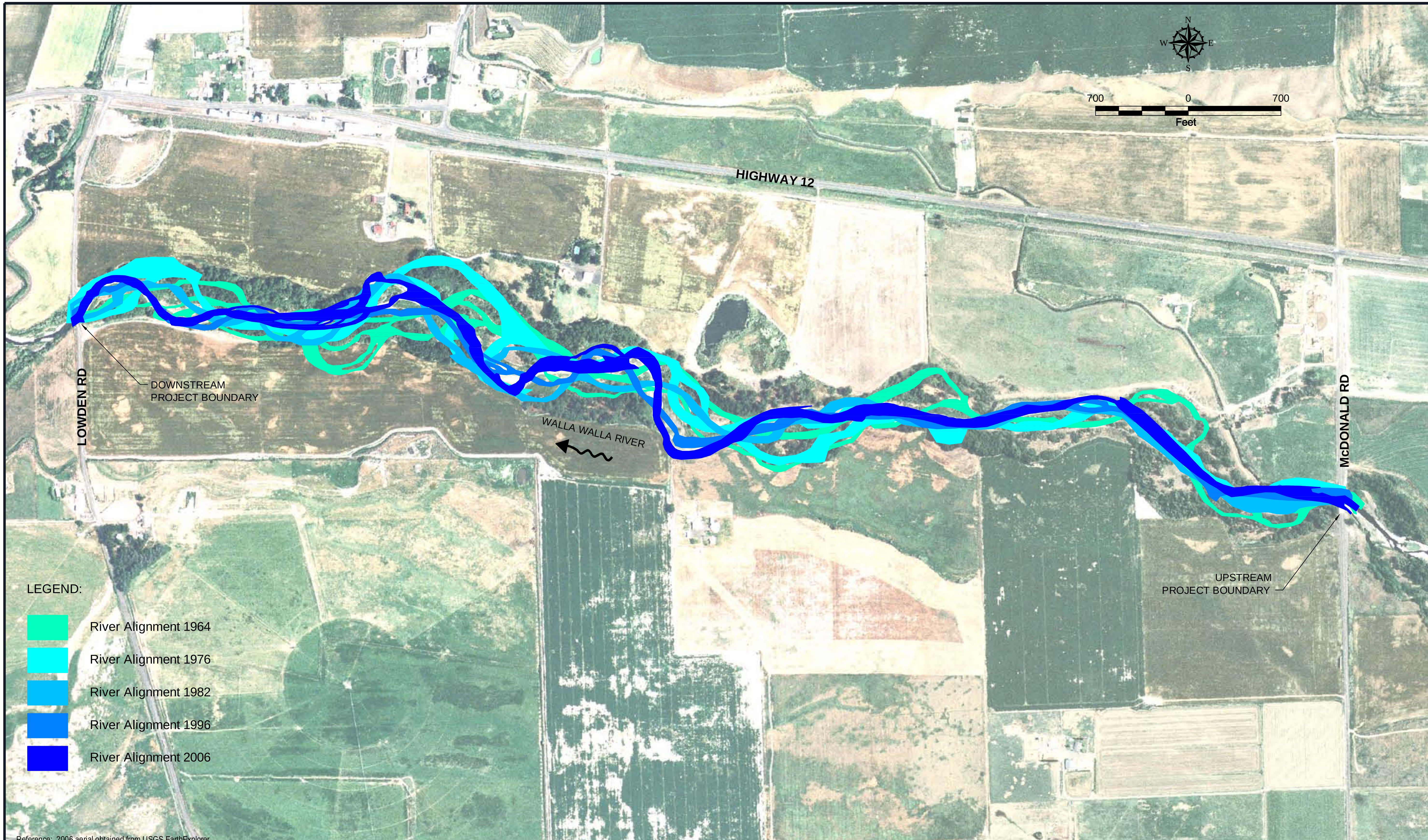

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				Checked: MKH
				Date: 04/07/10
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Historic Channel Alignments

Alternatives Assessment

Sheet **3**

Reference: 2006 aerial obtained from USGS EarthExplorer, ownership information obtained from Walla Walla County.

MKH : MGF

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				Date: 04/07/10
				Project No: 11281-005-00

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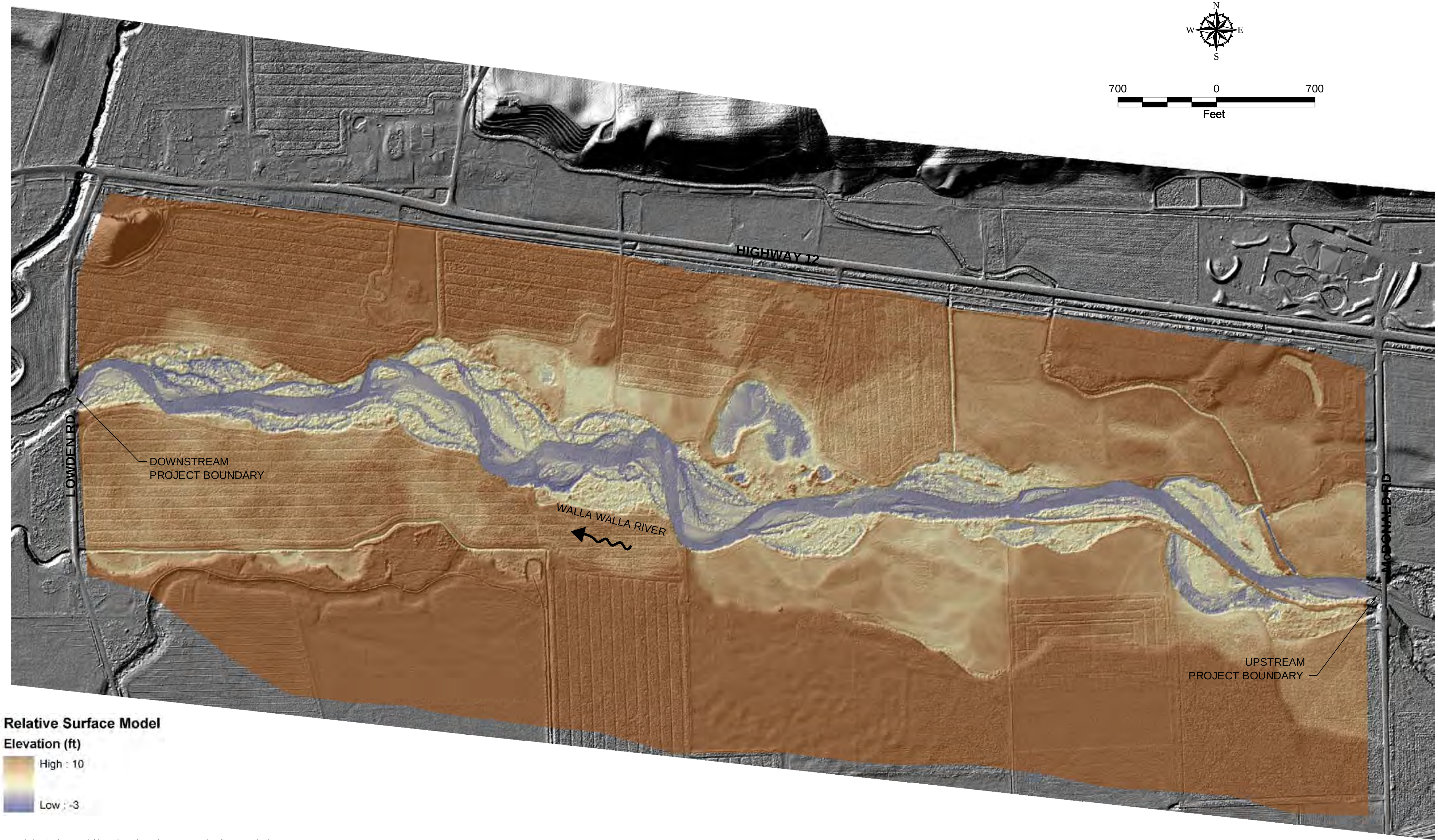
Existing Conditions

Alternatives Assessment

Sheet 4.1



Reference: Relative Surface Model based on LiDAR from Aeromertics, flown on 5/31/09.
Note: This image depicts potential side channels and flow paths during an arbitrary flow profile (assumed 3' above water surface elevation on LiDAR fly date) to enhance visual representation of channels and wetted areas.

Revision No:	Date:	Description:	Initials:	
		CONCEPTUAL		Designed: JJF
		Not For Construction.		Drawn: MGF
				Checked: MKH
				Date: 04/07/10
				Project No: 11281-005-00

Walla Walla River Bridge
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Relative Surface Model

Alternatives Assessment

Sheet
4.2

MKH : MGF

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Reference: Contours created from LiDAR flown on 5/31/09 by Aerometrics.

Revision No:	Date:	Description:	Initials:	
		CONCEPTUAL Not For Construction.		Designed: JJF
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				Checked: MKH
				Date: 04/07/10
				Project No: 11281-005-00

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Existing Topography

Alternatives Assessment

Sheet **4.3**

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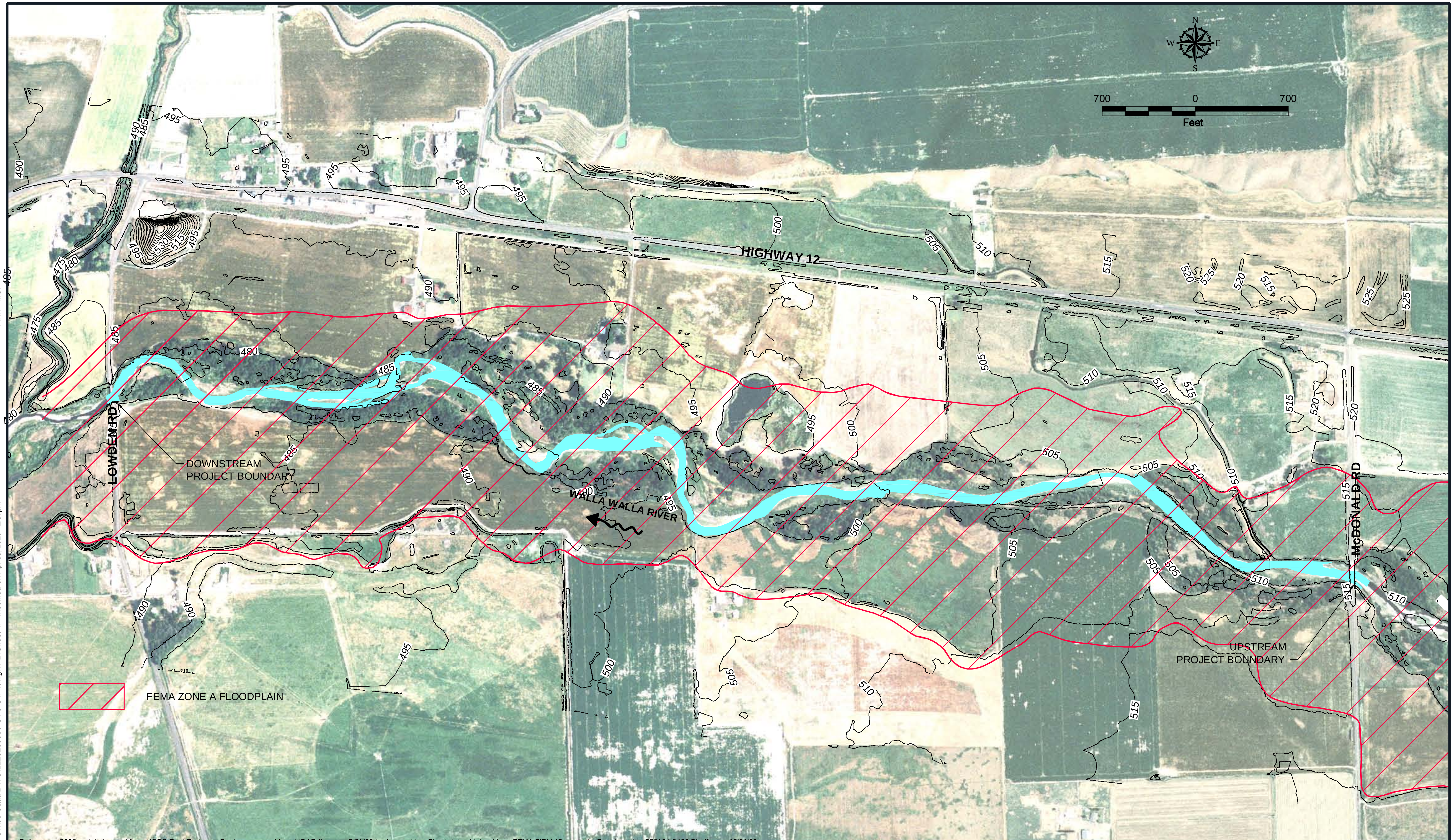

Reference: 2006 aerial obtained from USGS EarthExplorer, Contours created from LiDAR flown on 5/31/09 by Aerometrics, Flood data obtained from FEMA FIRM (Community-Panel number 530194 0420 B) effective 12/01/83.

Revision No:	Date:	Description:	Initials:	Designed: JJF
				Drawn: MGF
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				Project No: 11281-005-00

Walla Walla River Bridge
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Existing Floodplain

Alternatives Assessment

Sheet
4.4

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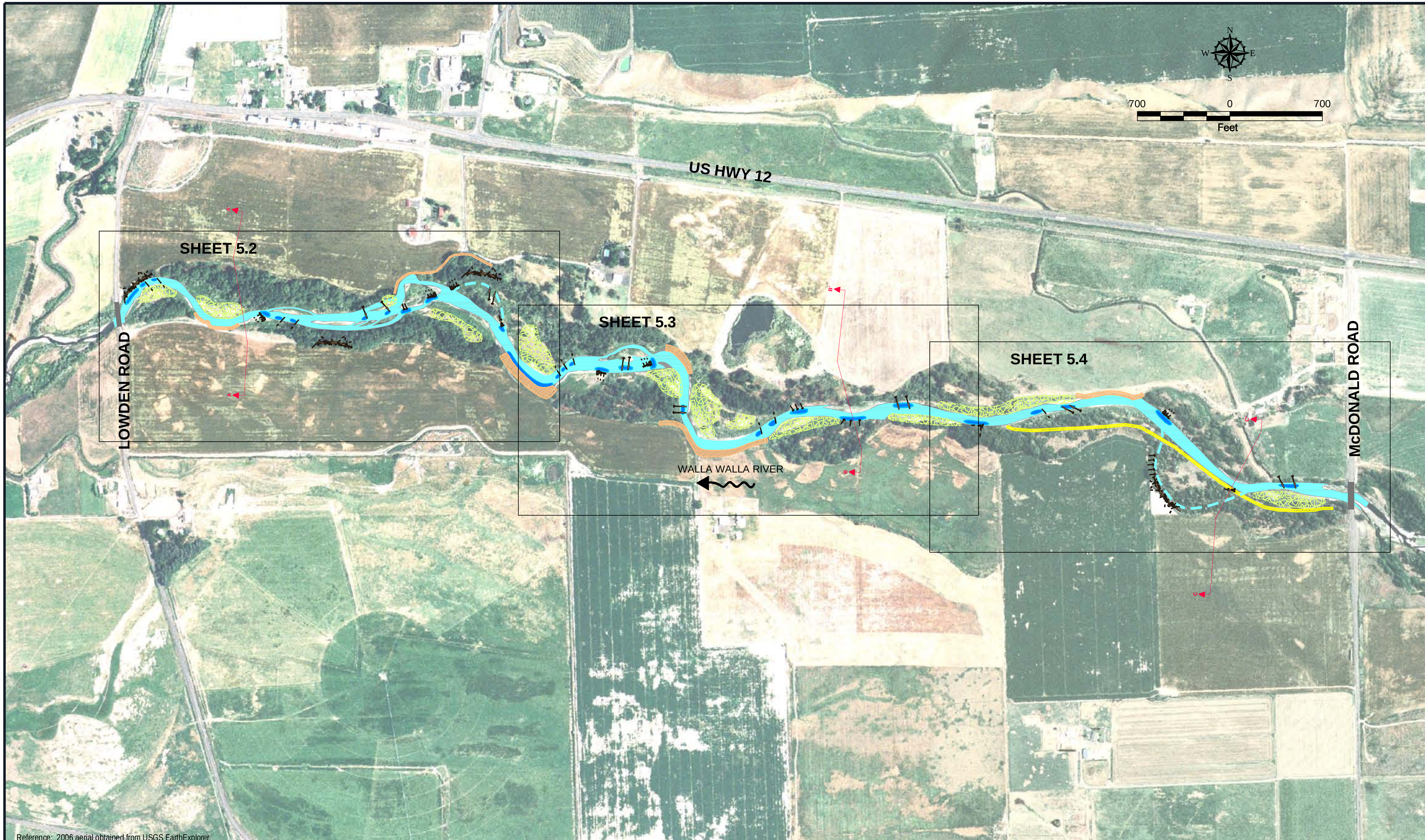

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				Checked: MKH
				Date: 04/07/10
				Project No: 11281-005-00

CONCEPTUAL

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Walla Walla River Bridge
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Alternative 1 - Sheet Index

Alternatives Assessment

Sheet
5.1

MKH : MGF

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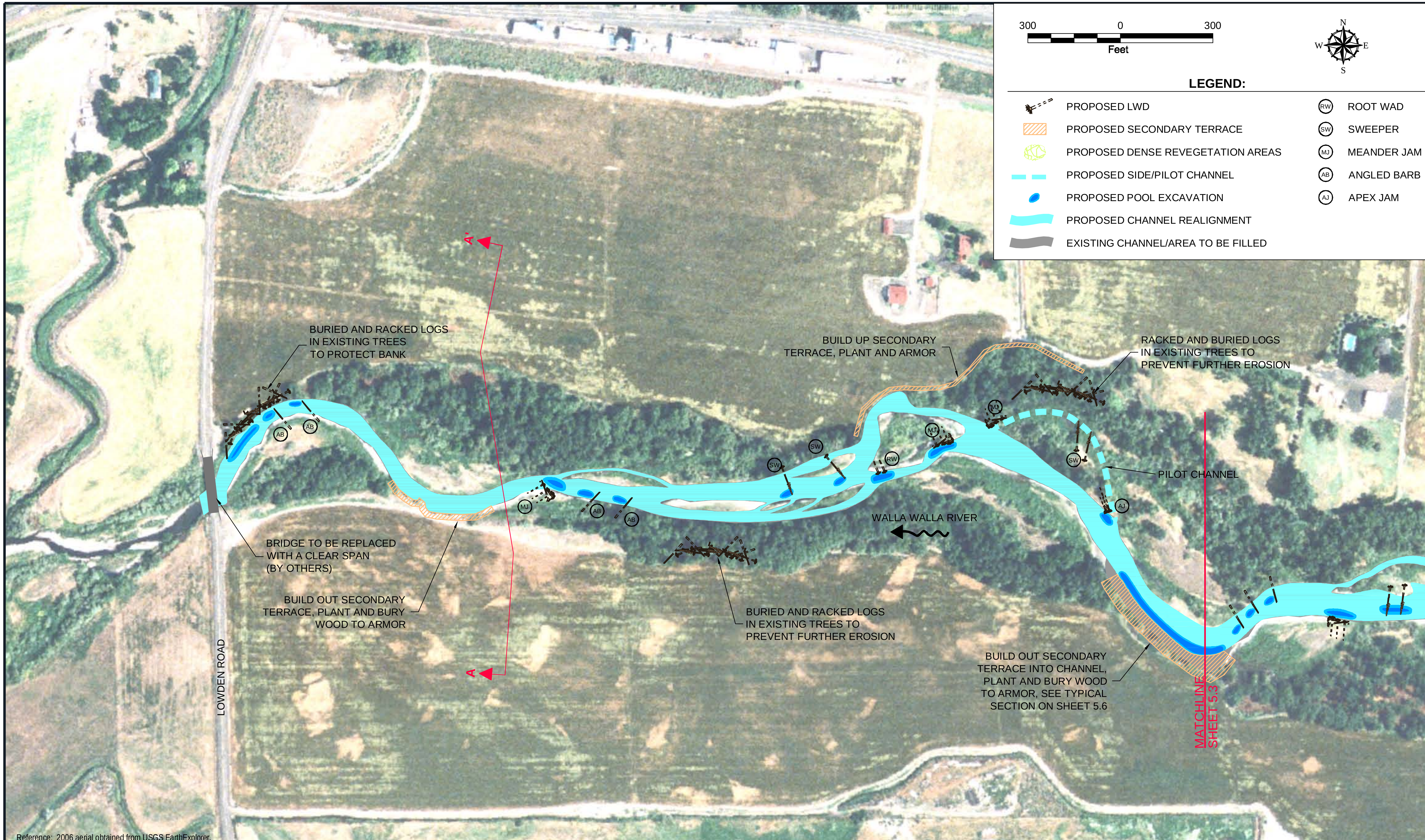

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				Checked: MKH
				Date: 04/07/10
				Project No: 11281-005-00

Walla Walla River Bridge near Lowden, Washington

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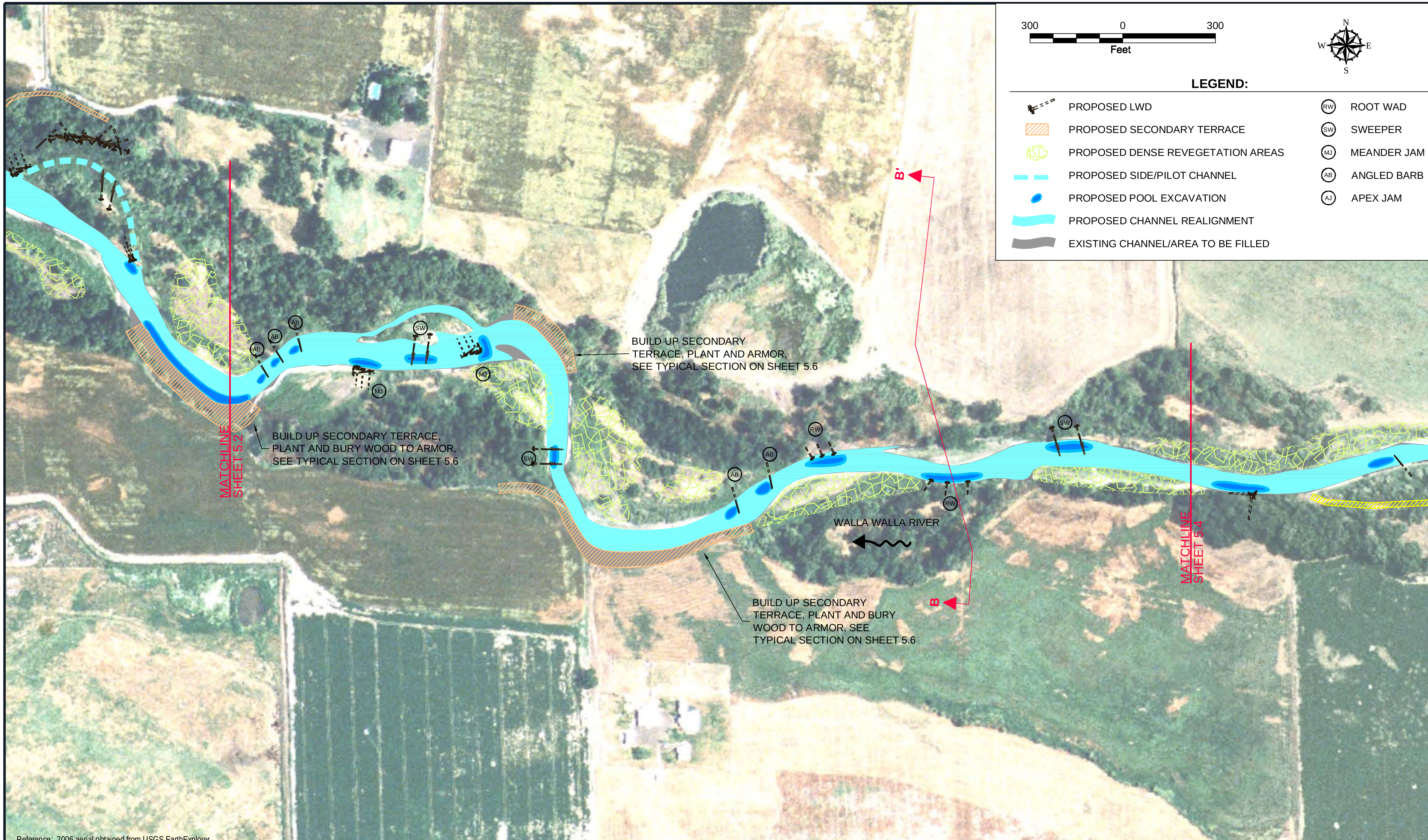
Alternative 1 - Reach 1

Alternatives Assessment

Sheet **5.2**



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		Not For Construction.		Drawn: MGF
				Checked: MKH
				Date: 04/07/10
				Project No: 11281-005-00

Walla Walla River Bridge near Lowden, Washington

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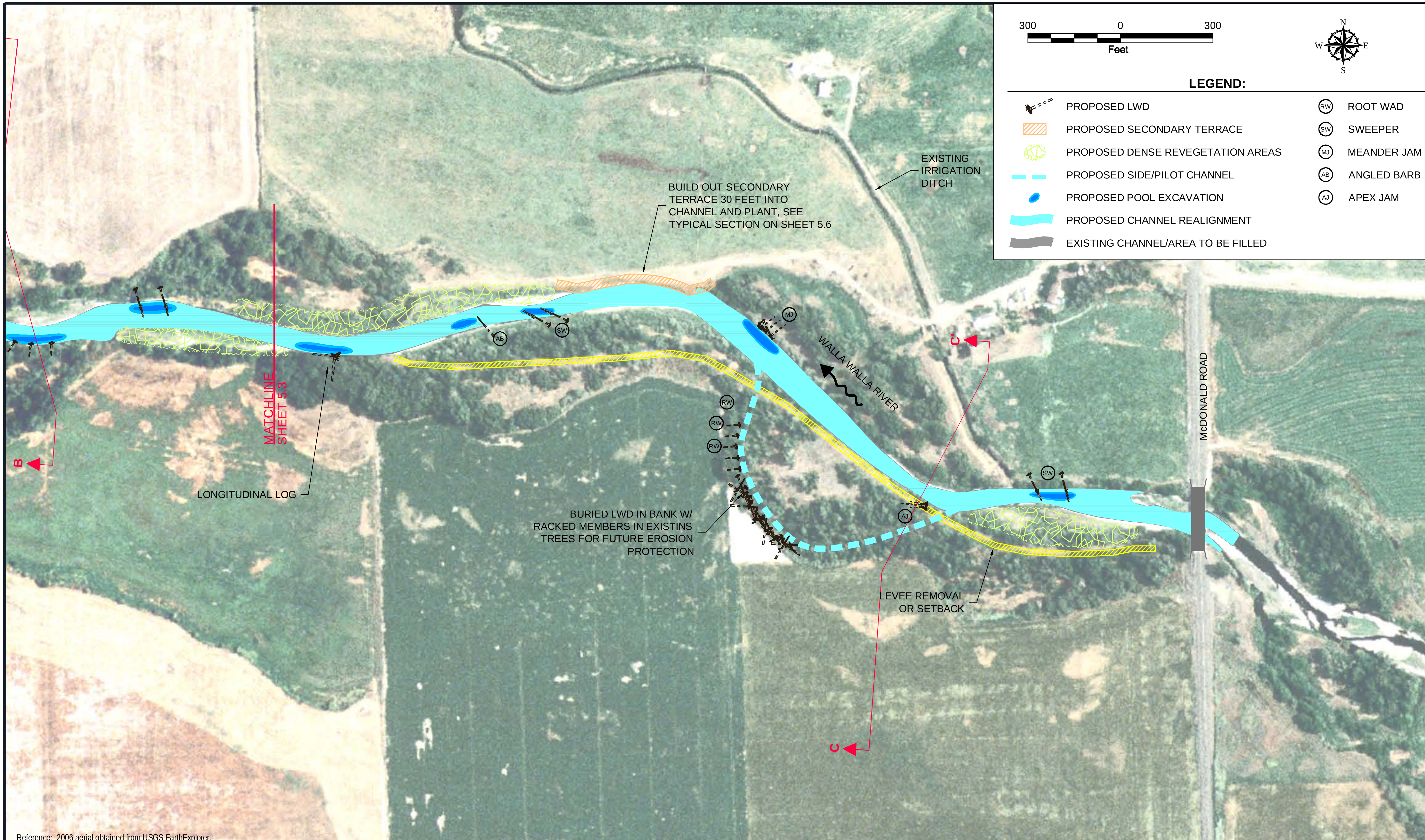
Alternative 1 - Reach 2

Alternatives Assessment

Sheet

5.3



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		Not For Construction.		Checked: MKH
				Date: 04/07/10
				Project No: 11281-005-00

Walla Walla River Bridge near Lowden, Washington

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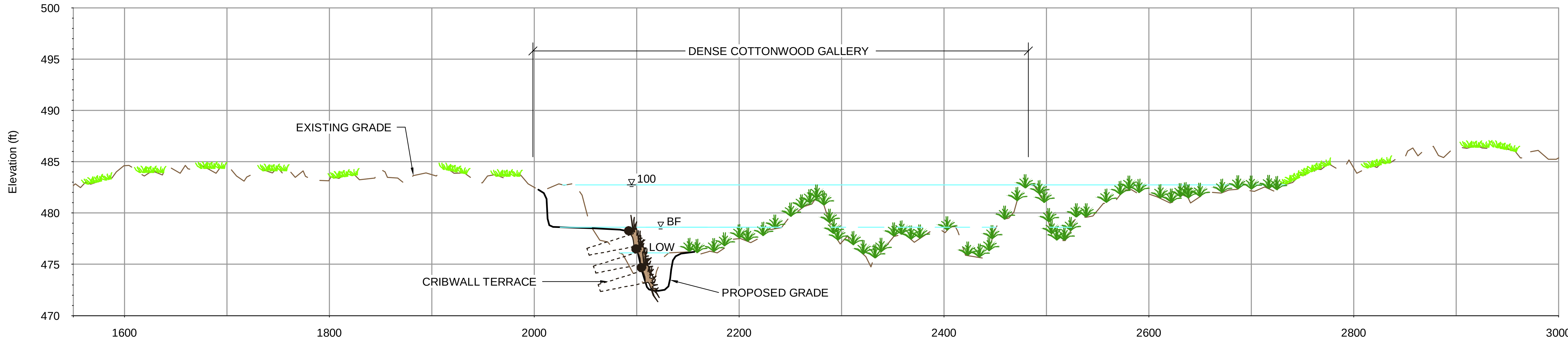
Alternative 1 - Reach 3

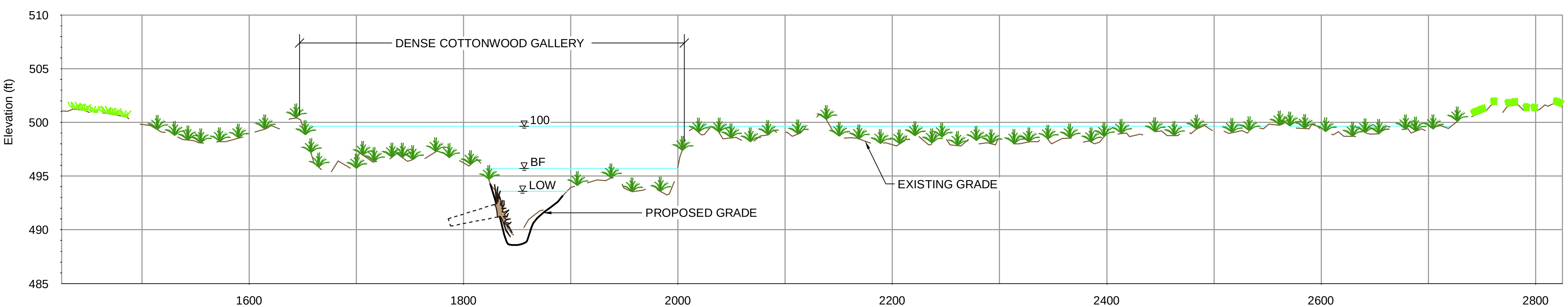
Alternatives Assessment

Sheet **5.4**



EXISTING GRADE
PROPOSED GRADE
PROPOSED WATER SURFACE
EXISTING WATER SURFACE

Section A-A'
Horizontal Scale: 1"=100'
Vertical Scale: 1"=10'



EXISTING GRADE
PROPOSED GRADE
PROPOSED WATER SURFACE
EXISTING WATER SURFACE

Section B-B'
Horizontal Scale: 1"=100'
Vertical Scale: 1"=10'

MKH : MGF

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				Checked: MKH
				Date: 04/07/10
				Project No: 11281-005-00

Walla Walla River Bridge
near Lowden, Washington

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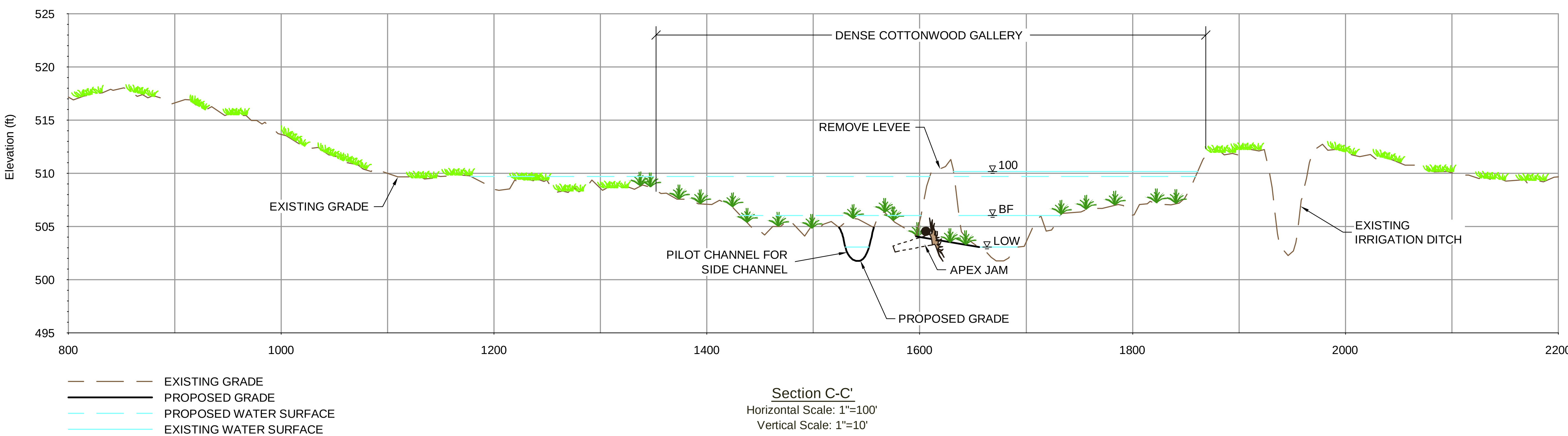
Alternative 1 - Cross Sections

Alternatives Assessment

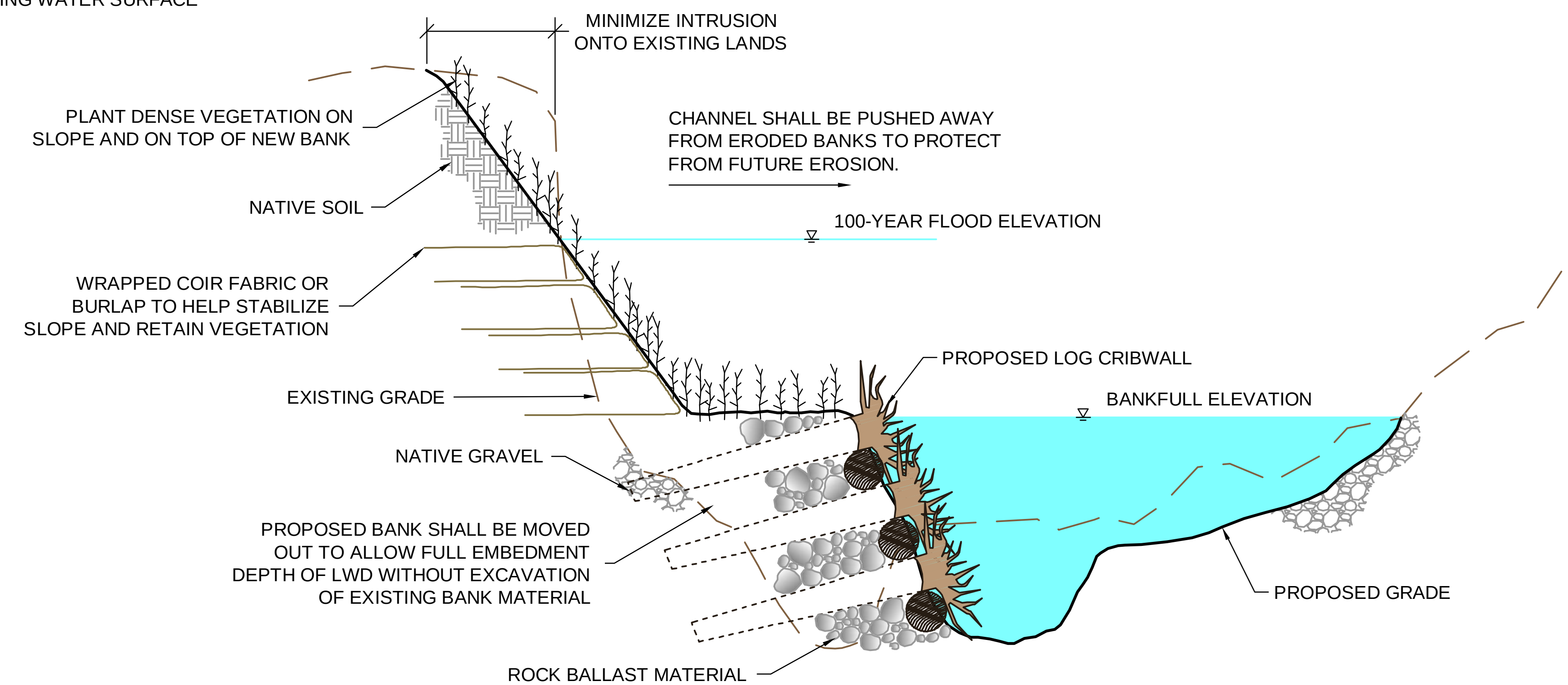
Sheet
5.5



Section C-C'

Horizontal Scale: 1"=100'

Vertical Scale: 1"=10'



TYPICAL TERRACE SECTION

Not to Scale

Revision No:	Date:	Description:	Initials:	Designed: JJF
		CONCEPTUAL		Drawn: MGF
		Not For Construction.		Checked: MKH
				Date: 04/07/10
				Project No: 11281-005-00

Walla Walla River Bridge near Lowden, Washington

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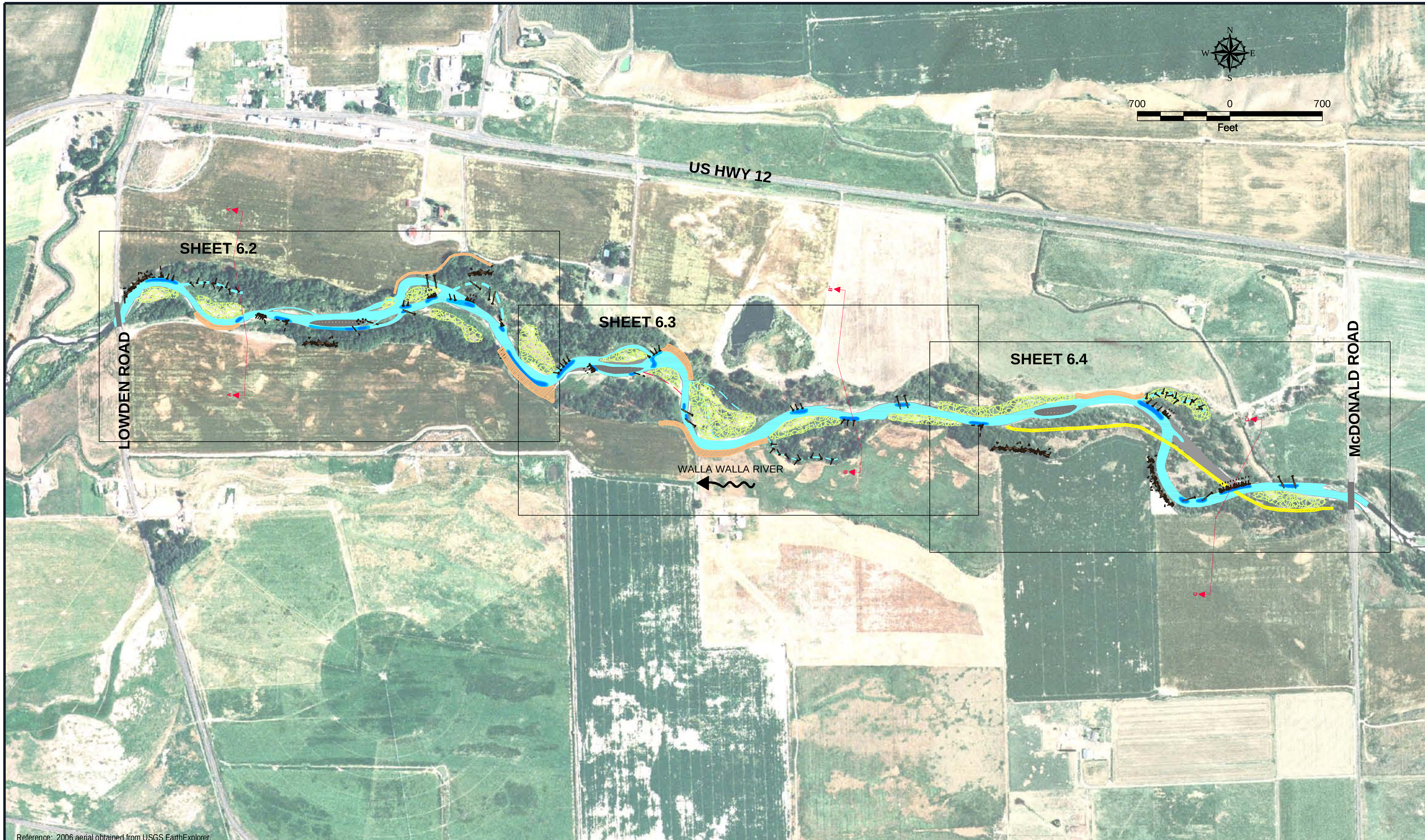
Alternative 1 - Cross Sections

Alternatives Assessment

Sheet **5.6**



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				Checked: MKH
				Date: 04/07/10
				Project No: 11281-005-00

Walla Walla River Bridge near Lowden, Washington

Tri-State Steelheaders

TRI-STATE STEELHEADERS

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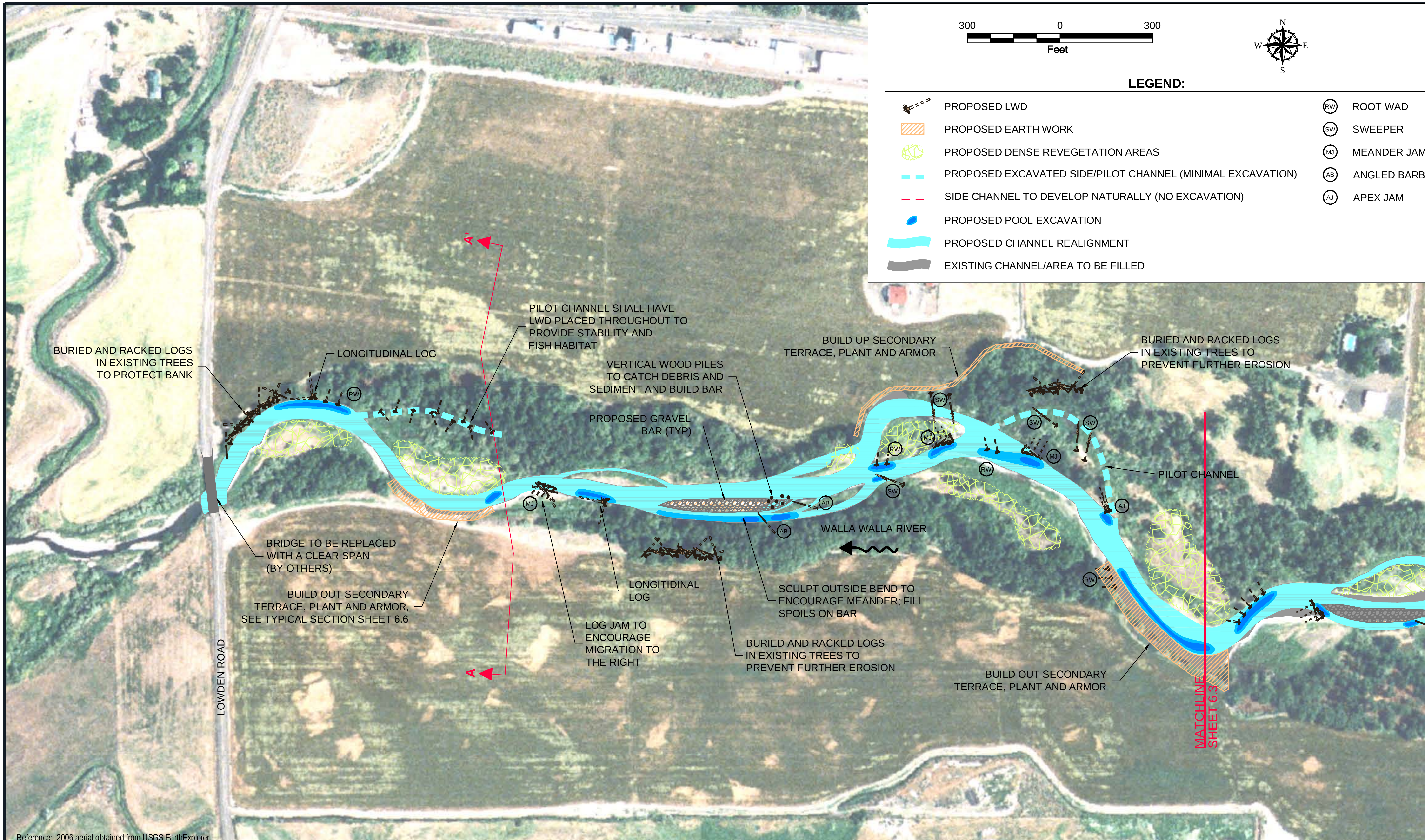
Alternative 2 - Sheet Index

Alternatives Assessment

Sheet **6.1**



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Designed: JJF
Drawn: MGF
Checked: MKH
Date: 04/07/10
Project No: 11281-005-00

Walla Walla River Bridge near Lowden, Washington

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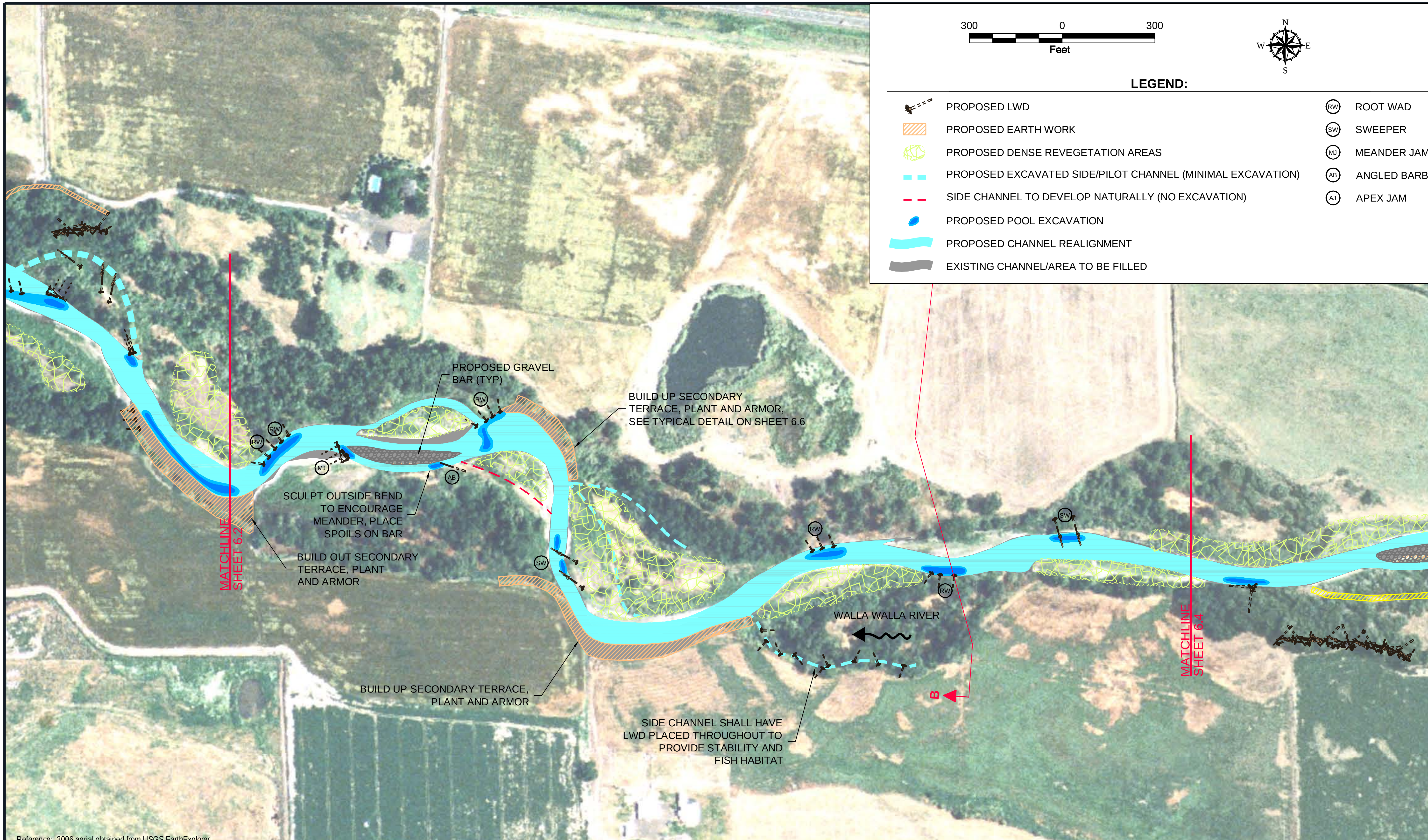
Alternative 2 - Reach 1

Alternatives Assessment

Sheet **6.2**



MKH : MGF

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Revision No:	Date:	Description:	Initials:	
		CONCEPTUAL		Designed: JJF
		Not For Construction.		Drawn: MGF
				Checked: MKH
				Date: 04/07/10
				Project No: 11281-005-00

Walla Walla River Bridge
near Lowden, Washington

Tri-State Steelheaders

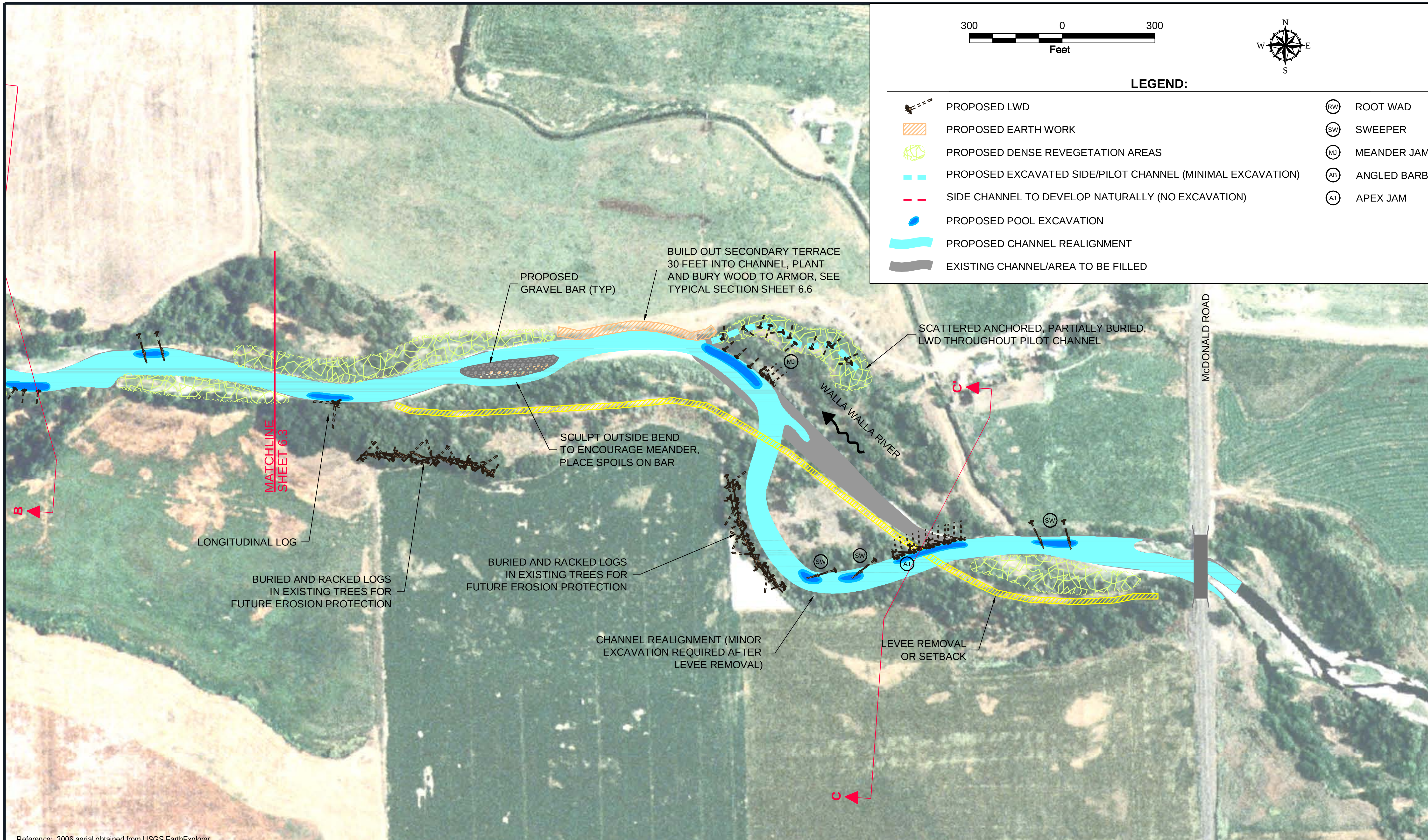
TRI-STATE STEELHEADERS

GEOENGINEERS
523 East Second Avenue
Spokane, WA 99202

Alternative 2 - Reach 2

Alternatives Assessment

Sheet
6.3



MKH : MGF

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Revision No:	Date:	Description:	Initials:	
		CONCEPTUAL		Designed: JJF
		Not For Construction.		Drawn: MGF
				Checked: MKH
				Date: 04/07/10
				Project No: 11281-005-00

Walla Walla River Bridge near Lowden, Washington

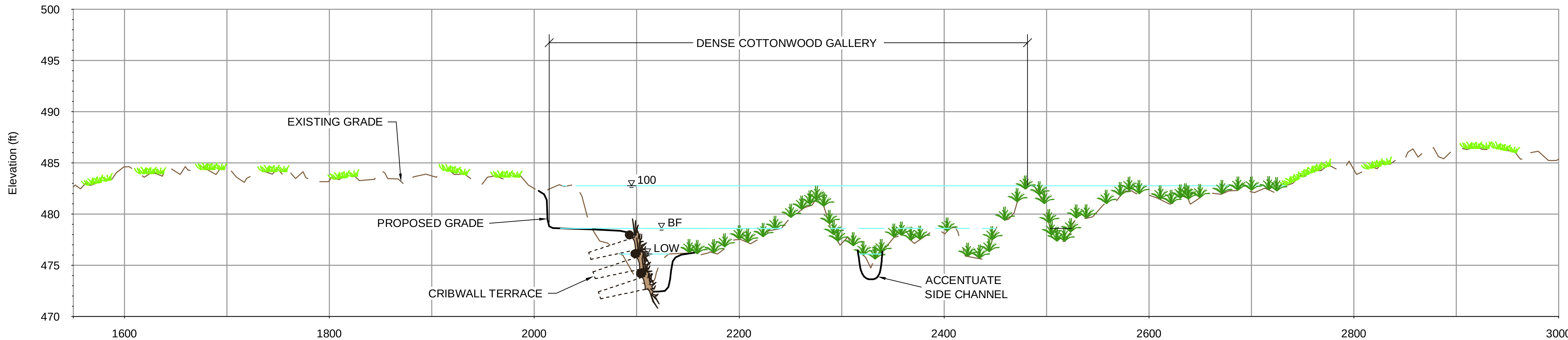
Tri-State Steelheaders

GEOENGINEERS
523 East Second Avenue
Spokane, WA 99202

Alternative 2 - Reach 3

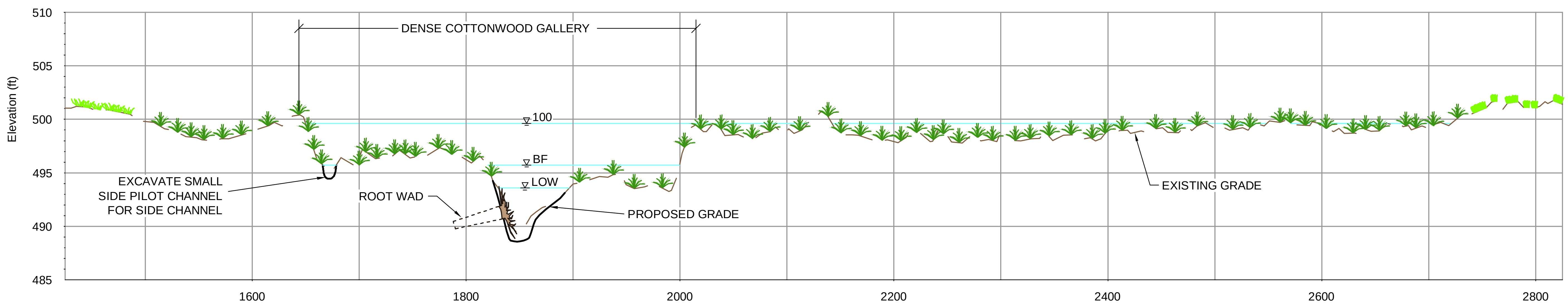
Alternatives Assessment

Sheet 6.4



— — — EXISTING GRADE
PROPOSED GRADE
— — — PROPOSED WATER SURFACE
EXISTING WATER SURFACE

Section A-A'
Horizontal Scale: 1"=100'
Vertical Scale: 1"=10'



— — — EXISTING GRADE
PROPOSED GRADE
— — — PROPOSED WATER SURFACE
EXISTING WATER SURFACE

Section B-B'
Horizontal Scale: 1"=100'
Vertical Scale: 1"=10'

MKH : MGF

P:\11\11281005_TEMP_SPOK\00\Cadd\DWG\1128100500-S6.5-S6.6.dwg\TAB:Sheet 6.5 modified on Apr 05, 2010 - 3:08pm

Revision No:	Date:	Description:	Initials:	
		CONCEPTUAL Not For Construction.		Designed: JJF
				Drawn: MGF
				Checked: MKH
				Date: 04/07/10
				Project No: 11281-005-00

Walla Walla River Bridge
near Lowden, Washington

Tri-State Steelheaders

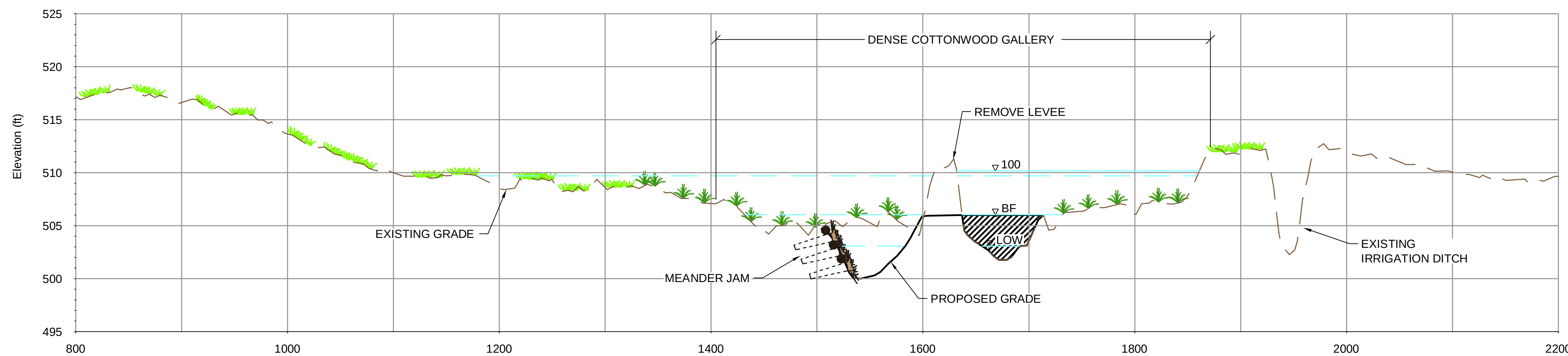
TRI-STATE STEELHEADERS

GEOENGINEERS
523 East Second Avenue
Spokane, WA 99202

Alternative 2 - Cross Sections

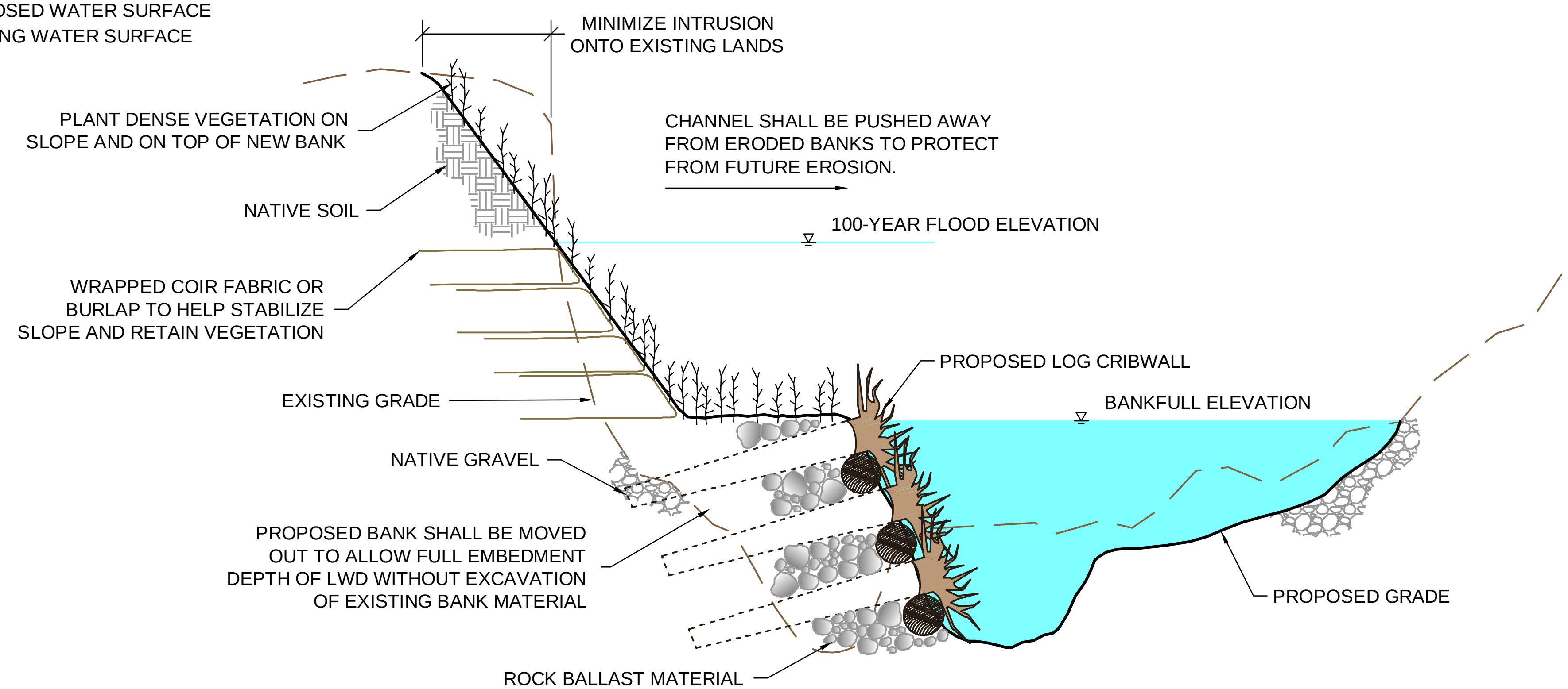
Alternatives Assessment

Sheet
6.5



Section C-C'
Horizontal Scale: 1"=100'
Vertical Scale: 1"=10'

EXISTING GRADE
PROPOSED GRADE
PROPOSED WATER SURFACE
EXISTING WATER SURFACE



TYPICAL TERRACE SECTION
Not to Scale

MKH : MGF

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Revision No:	Date:	Description:	Initials:	
		CONCEPTUAL Not For Construction.		Designed: JJF
				Drawn: MGF
				Checked: MKH
				Date: 04/07/10
				Project No: 11281-005-00

Walla Walla River Bridge
near Lowden, Washington

Tri-State Steelheaders

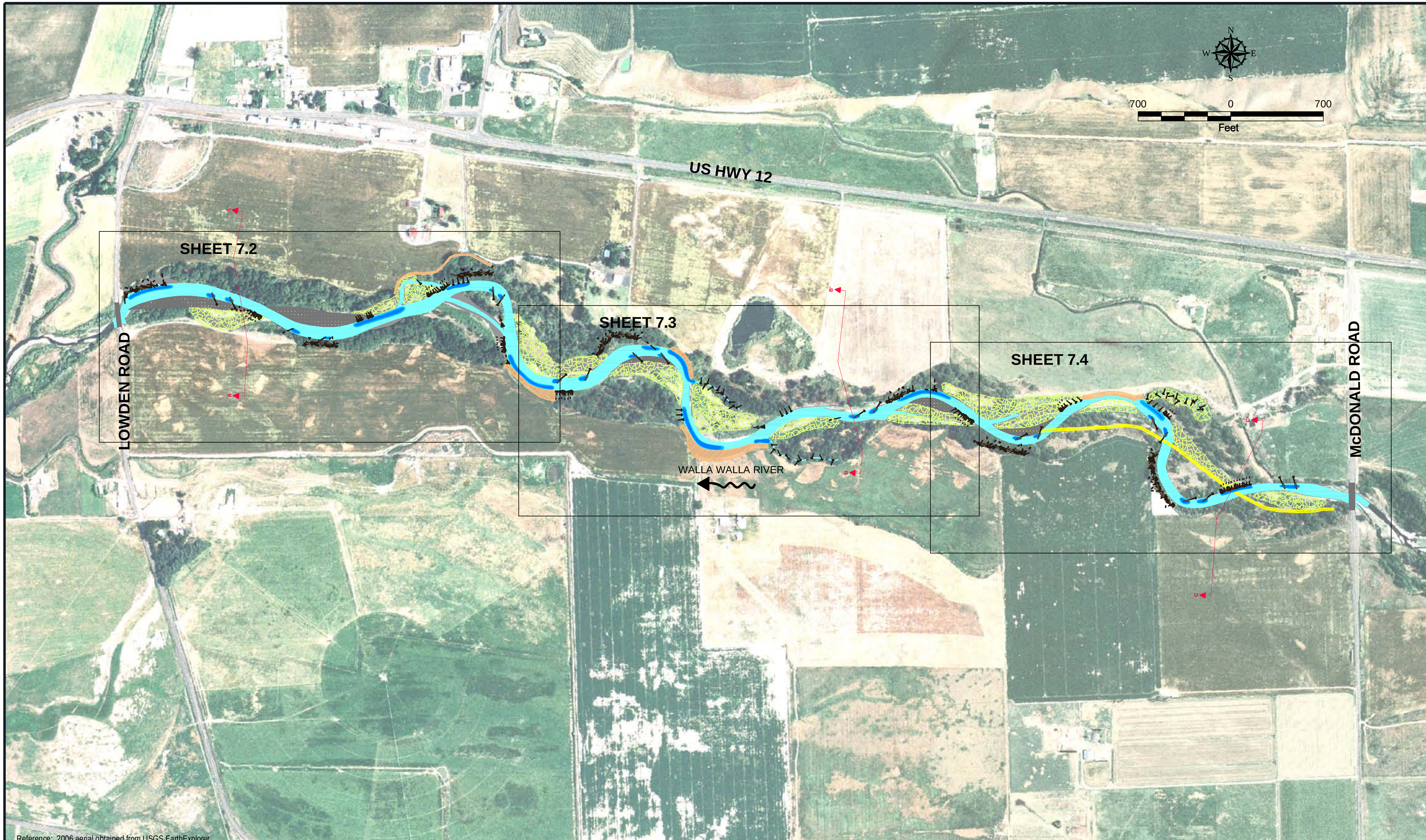
TRI-STATE STEELHEADERS

GEOENGINEERS
523 East Second Avenue
Spokane, WA 99202

Alternative 2 - Cross Sections

Alternatives Assessment

Sheet
6.6



MKH : MGF

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Revision No:	Date:	Description:	Initials:	
		CONCEPTUAL Not For Construction.		Designed: JJF
				Drawn: MGF
				Checked: MKH
				Date: 04/07/10
				Project No: 11281-005-00

Walla Walla River Bridge
near Lowden, Washington

Tri-State Steelheaders

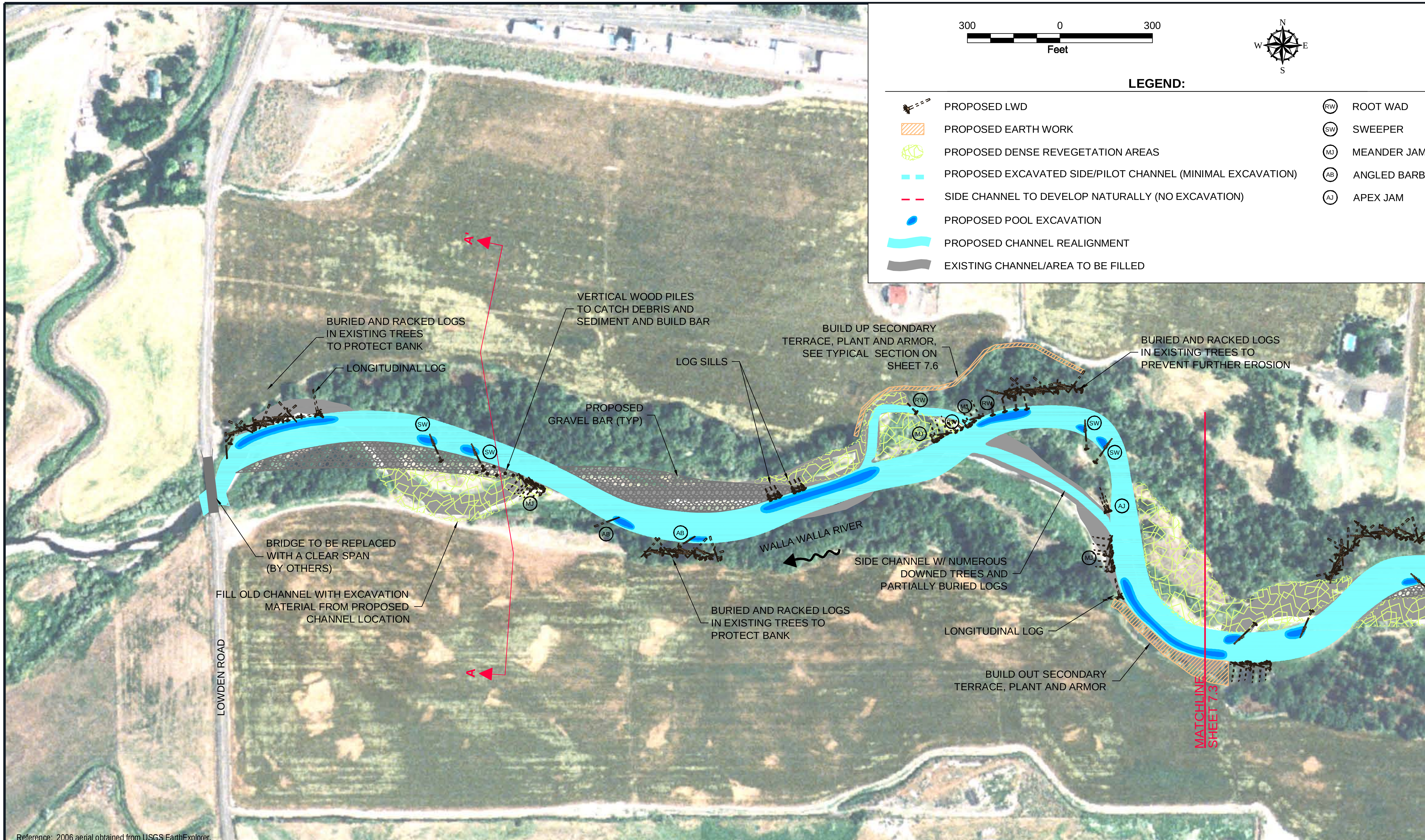
TRI-STATE STEELHEADERS

GeoEngineers
523 East Second Avenue
Spokane, WA 99202

Alternative 3 - Sheet Index

Alternatives Assessment

Sheet
7.1



Revision No:	Date:	Description:	Initials:
		CONCEPTUAL Not For Construction.	

Designed: JJF
Drawn: MGF
Checked: MKH
Date: 04/07/10
Project No: 11281-005-00

Walla Walla River Bridge near Lowden, Washington

Tri-State Steelheaders

TRI-STATE STEELHEADERS

GEOENGINEERS
523 East Second Avenue
Spokane, WA 99202

Alternative 3 - Reach 1

Alternatives Assessment

Sheet **7.2**

MKH : MGF

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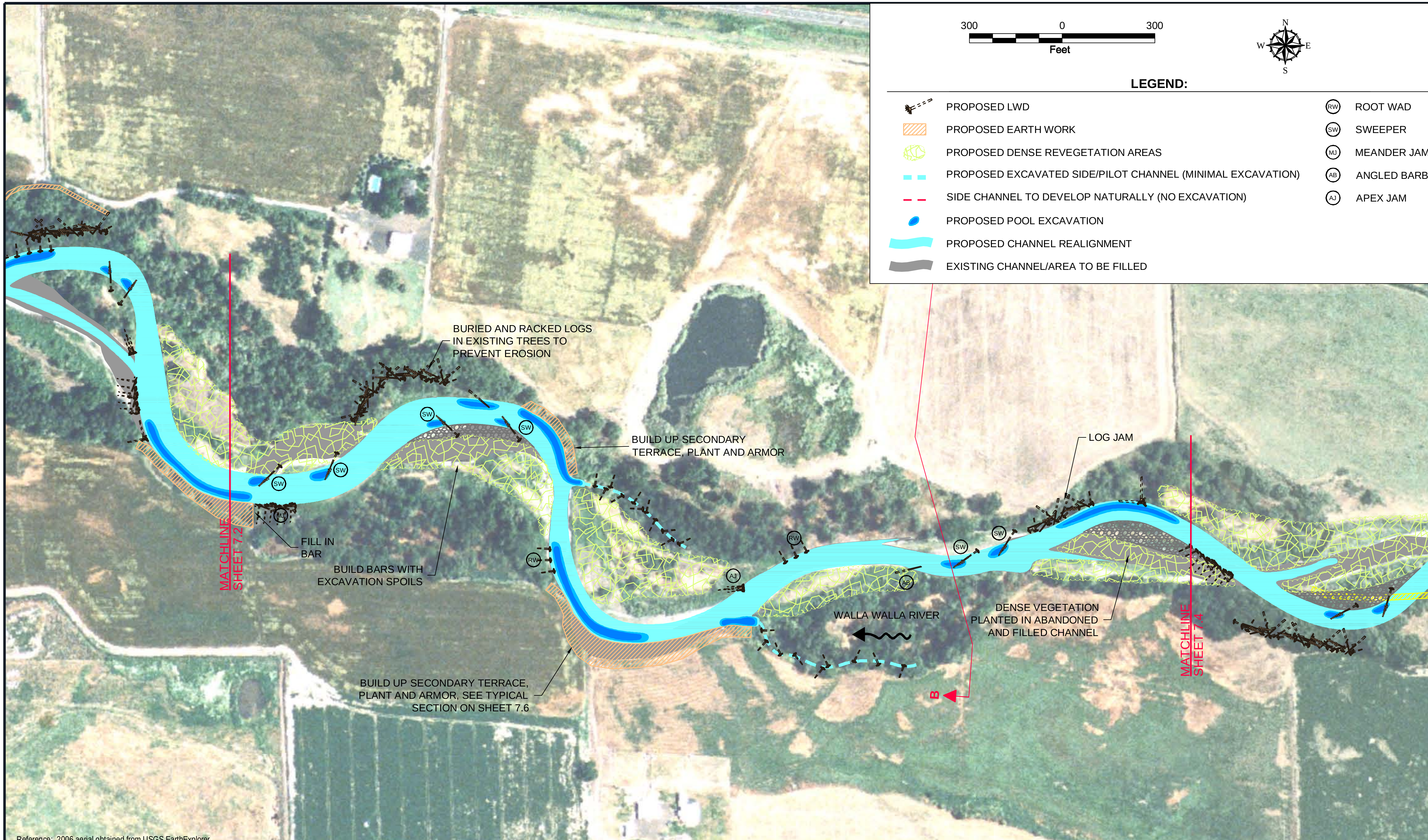

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MKH : MGF

Revision No:	Date:	Description:	Initials:	
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				Drawn: MGF
				Checked: MKH
				Date: 04/07/10
				Project No: 11281-005-00

Walla Walla River Bridge near Lowden, Washington

Tri-State Steelheaders

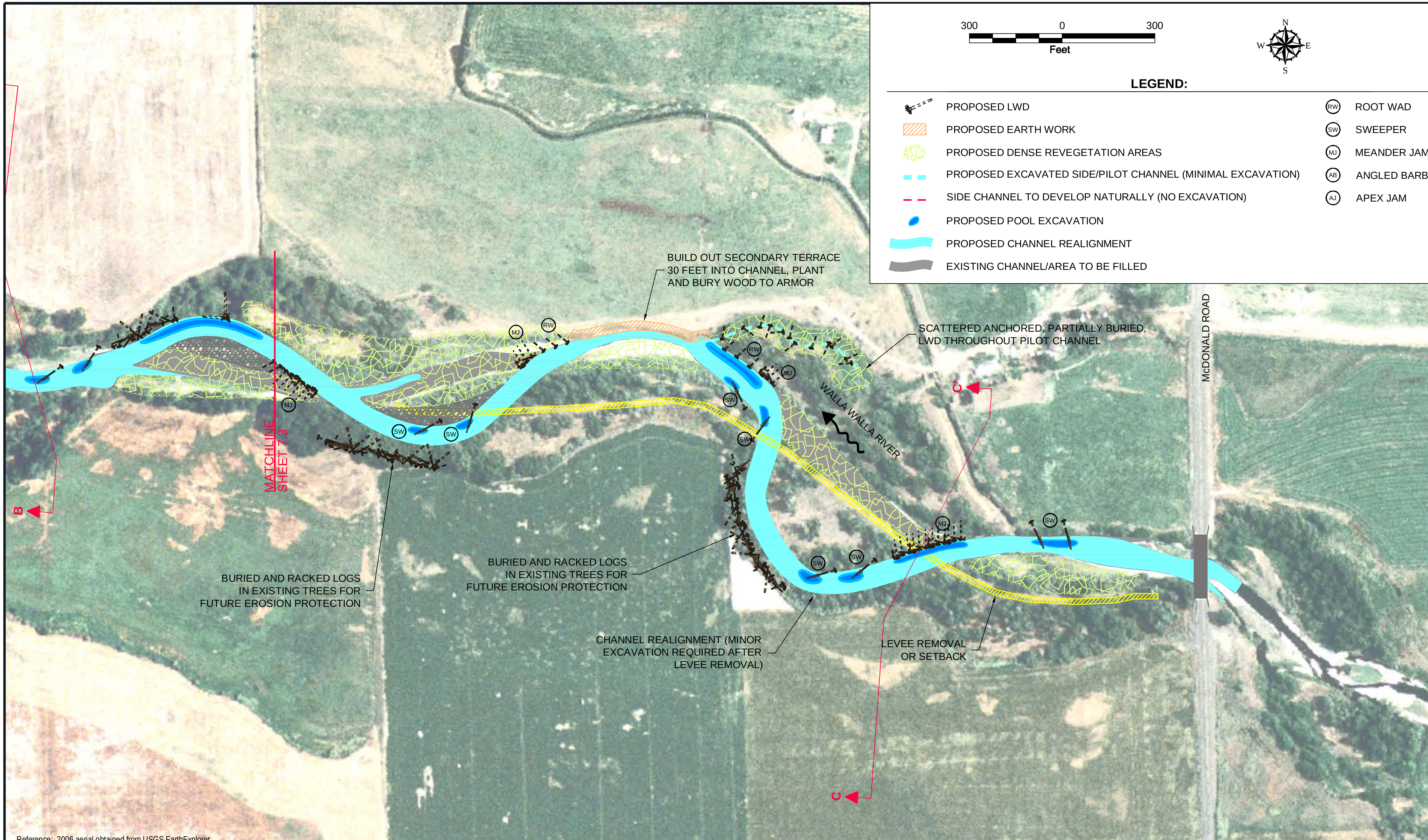
TRI-STATE STEELHEADERS

GEOENGINEERS
523 East Second Avenue
Spokane, WA 99202

Alternative 3 - Reach 2

Alternatives Assessment

Sheet **7.3**



MKH : MGF

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Revision No:	Date:	Description:	Initials:	
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				Drawn: MGF
				Checked: MKH
				Date: 04/07/10
				Project No: 11281-005-00

Walla Walla River Bridge near Lowden, Washington

Tri-State Steelheaders

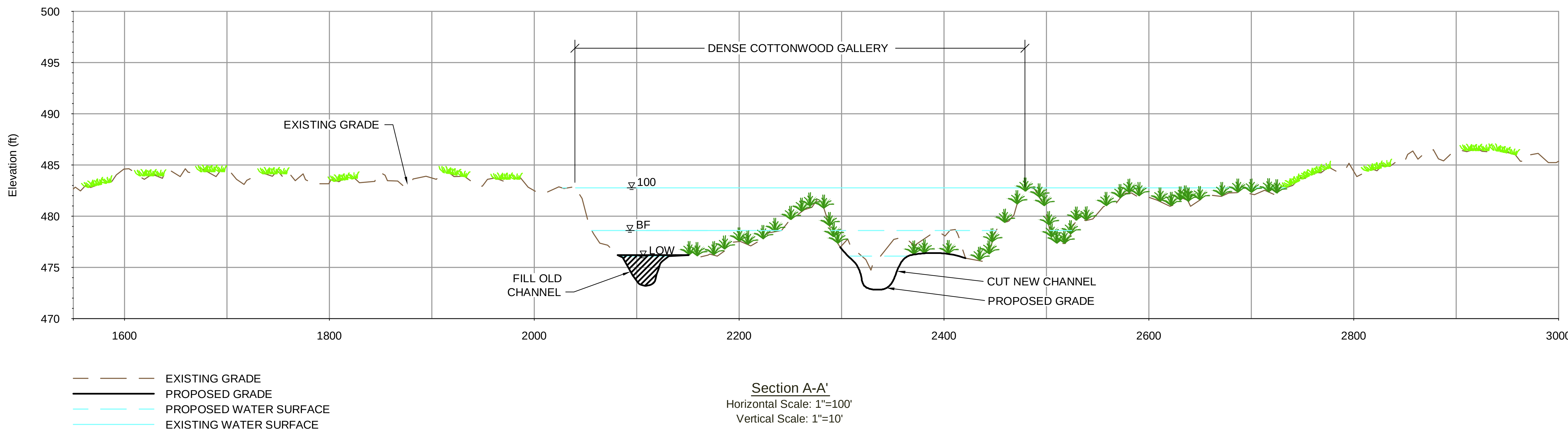
TRI-STATE STEELHEADERS

GEOENGINEERS
523 East Second Avenue
Spokane, WA 99202

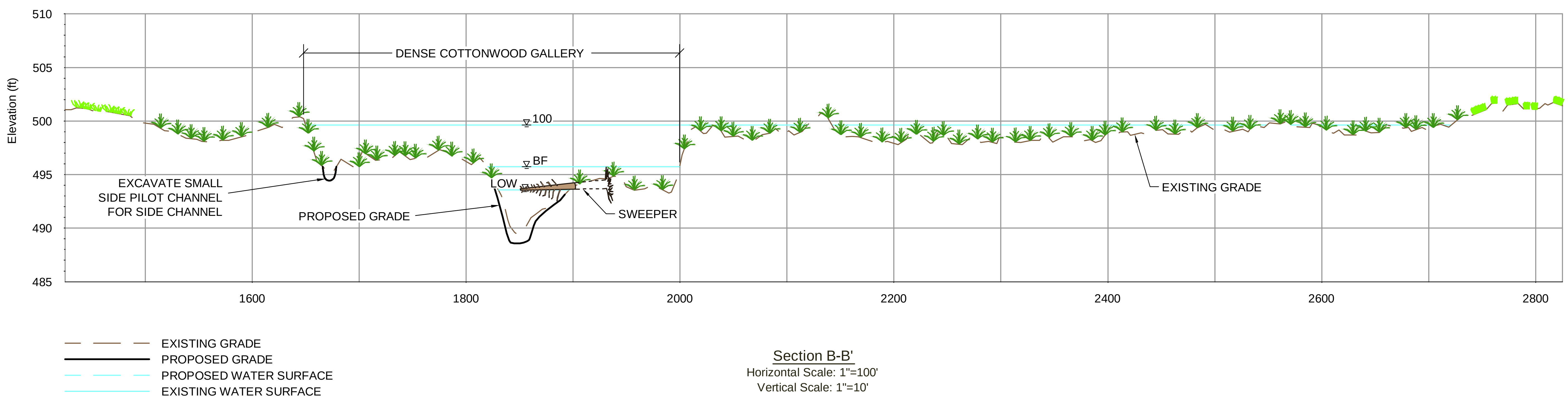
Alternative 3 - Reach 3

Alternatives Assessment

Sheet 7.4



Section A-A'
Horizontal Scale: 1"=100'
Vertical Scale: 1"=10'



Section B-B'
Horizontal Scale: 1"=100'
Vertical Scale: 1"=10'

MKH : MGF

P:\11\11281005_TEMP_SPOK\00\Cadd\DWG\11281005000-S7.5-S7.6.dwg\TAB:Sheet 7.5 modified on Apr 05, 2010 - 3:12pm

Revision No:	Date:	Description:	Initials:	
				Designed: JJF
				Drawn: MGF
				Checked: MKH
				Date: 04/07/10
				Project No: 11281-005-00

CONCEPTUAL
Not For Construction.

Walla Walla River Bridge
near Lowden, Washington

Tri-State Steelheaders

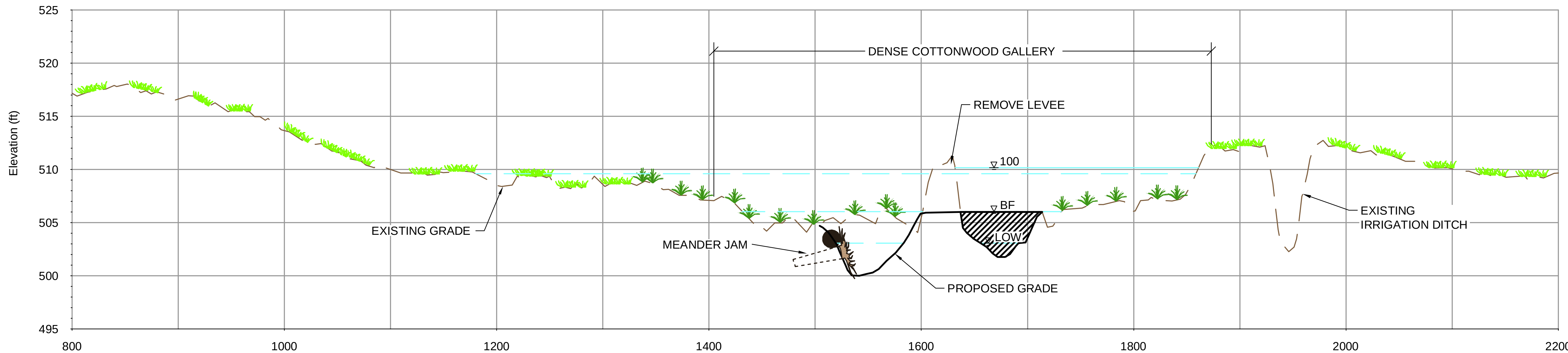
TRI-STATE STEELHEADERS

GEOENGINEERS
523 East Second Avenue
Spokane, WA 99202

Alternative 3 - Cross Sections

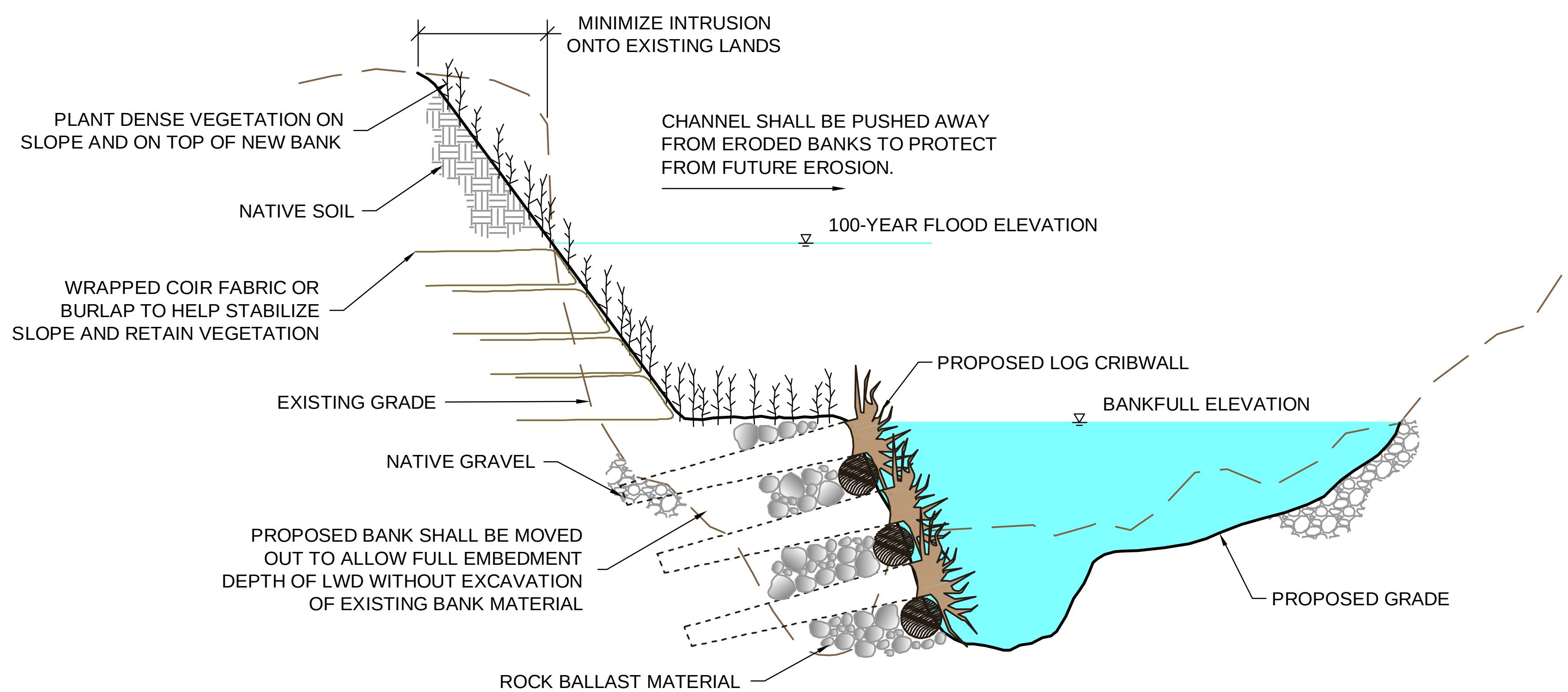
Alternatives Assessment

Sheet
7.5



EXISTING GRADE
PROPOSED GRADE
PROPOSED WATER SURFACE
EXISTING WATER SURFACE

Section C-C'
Horizontal Scale: 1"=100'
Vertical Scale: 1"=10'



TYPICAL TERRACE SECTION
Not to Scale

MKH : MGF

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Revision No:	Date:	Description:	Initials:	
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		Not For Construction.		Drawn: MGF
				Checked: MKH
				Date: 04/07/10
				Project No: 11281-005-00

Walla Walla River Bridge near Lowden, Washington

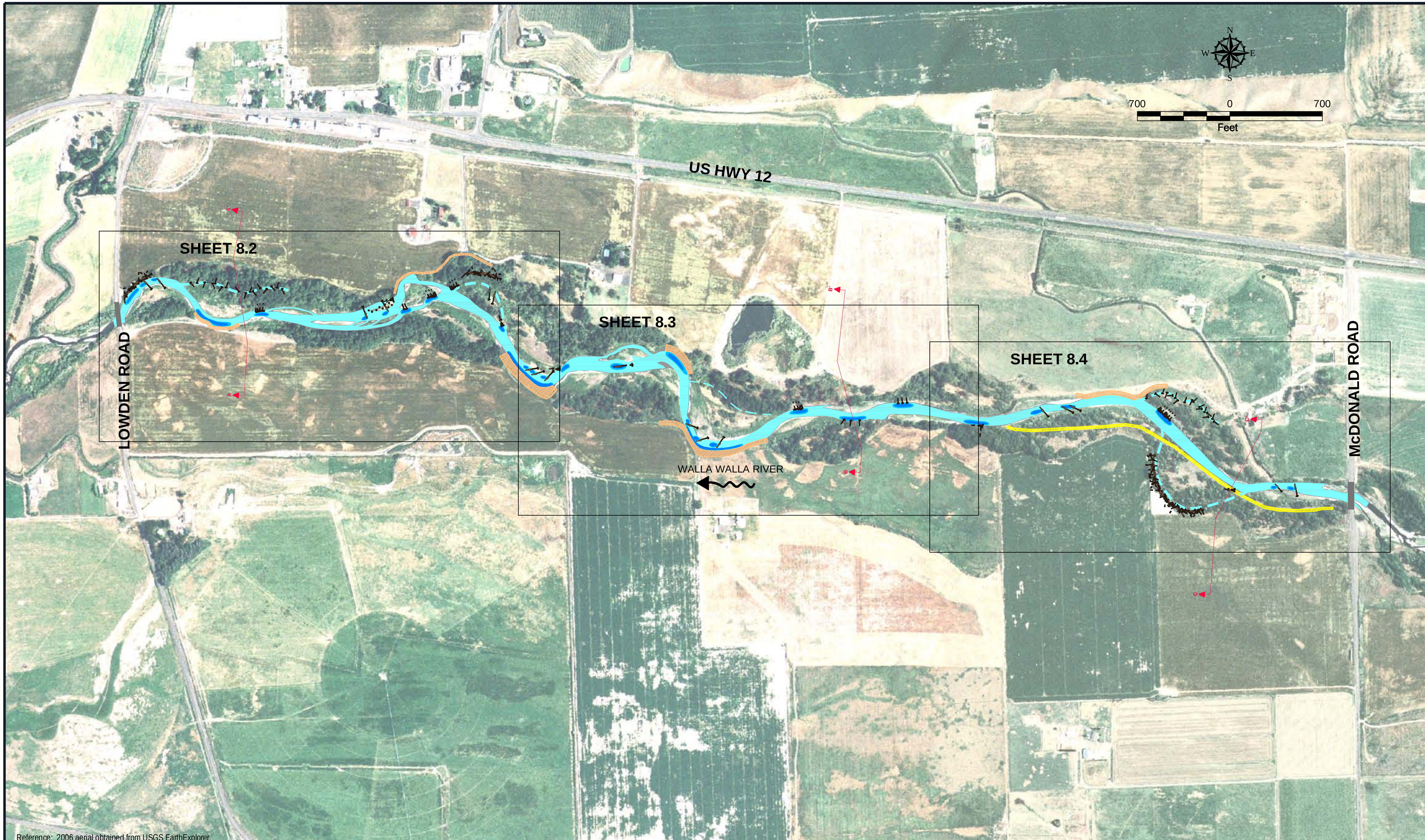
Tri-State Steelheaders

GeoEngineers
523 East Second Avenue
Spokane, WA 99202

Alternative 3 - Cross Sections

Alternatives Assessment

Sheet **7.6**



Reference: 2006 aerial obtained from USGS EarthExplorer.

MKH : MGF

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Revision No:	Date:	Description:	Initials:
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		Not For Construction.	

Designed: JJF
Drawn: MGF
Checked: MKH
Date: 04/07/10
Project No: 11281-005-00

Walla Walla River Bridge
near Lowden, Washington

Tri-State Steelheaders

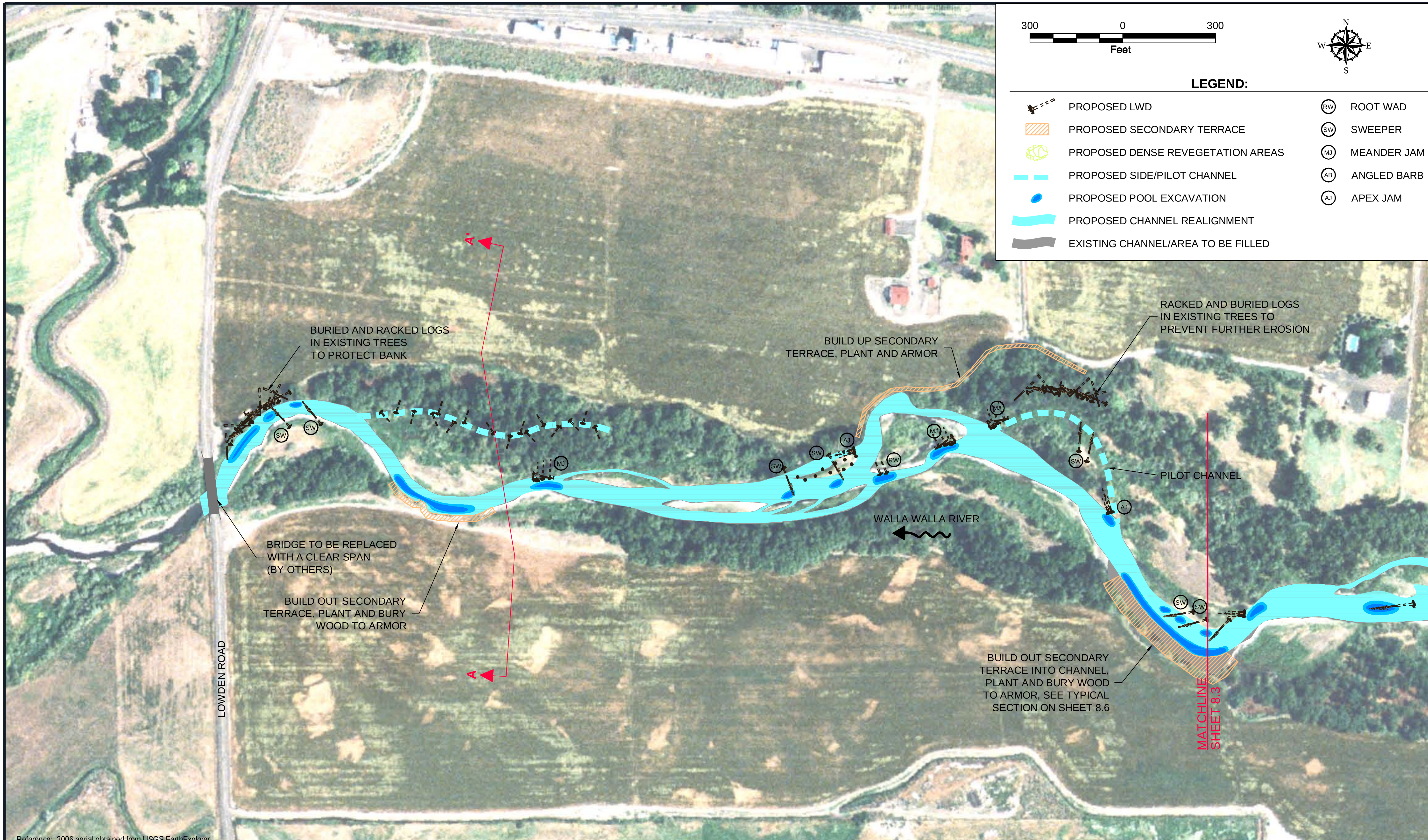
TRI-STATE STEELHEADERS

GEOENGINEERS
523 East Second Avenue
Spokane, WA 99202

Alternative 4 - Sheet Index

Alternatives Assessment

Sheet
8.1



Reference: 2006 aerial obtained from USGS EarthExplorer.

MKH : MGF

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				Drawn: MGF
				Checked: MKH
				Date: 04/07/10
				Project No: 11281-005-00

Walla Walla River Bridge near Lowden, Washington

Tri-State Steelheaders

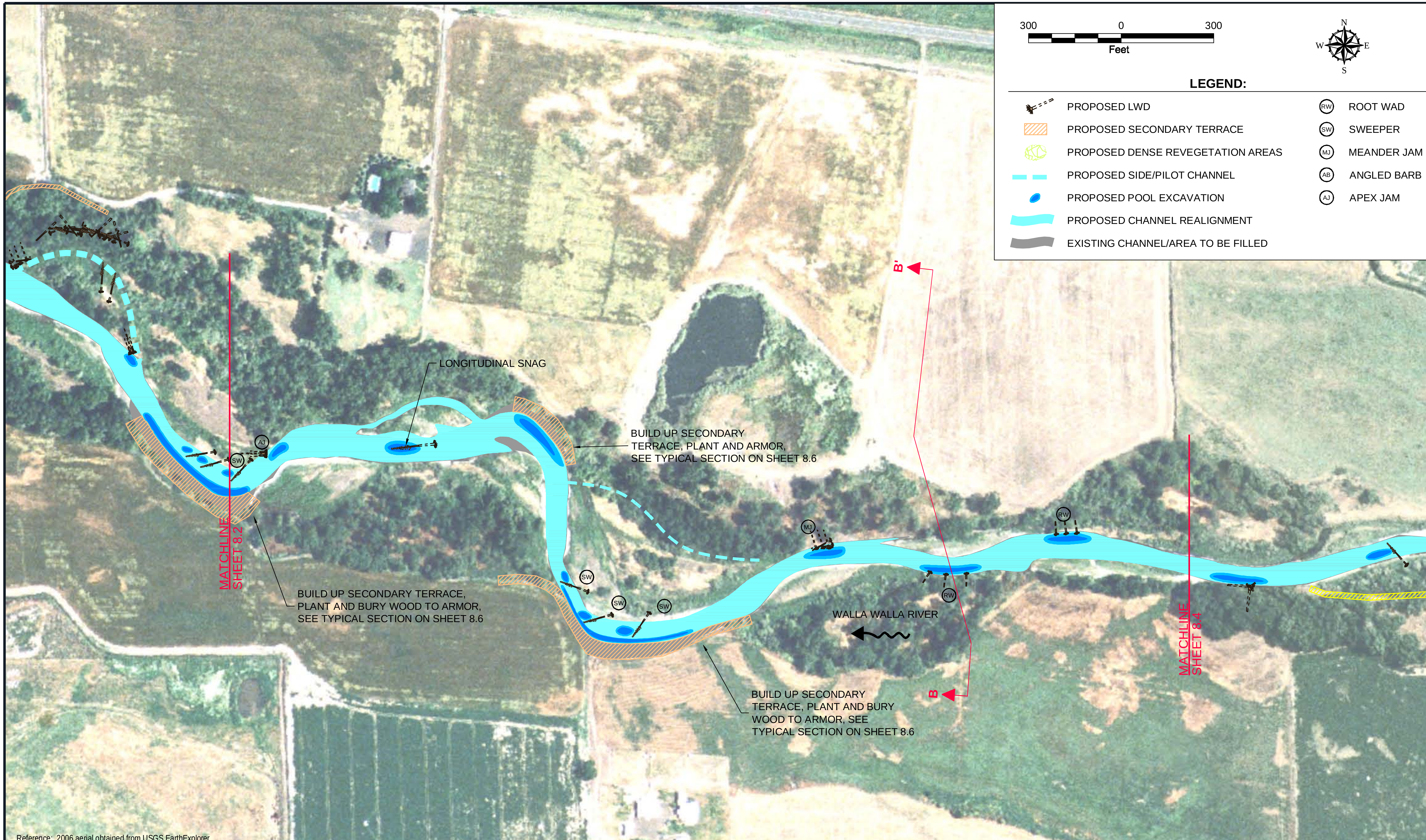
TRI-STATE STEELHEADERS

GEOENGINEERS
523 East Second Avenue
Spokane, WA 99202

Alternative 4 - Reach 1

Alternatives Assessment

Sheet **8.2**



MKH : MGF

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Designed: JJF
Drawn: MGF
Checked: MKH
Date: 04/07/10
Project No: 11281-005-00

Walla Walla River Bridge near Lowden, Washington

Tri-State Steelheaders

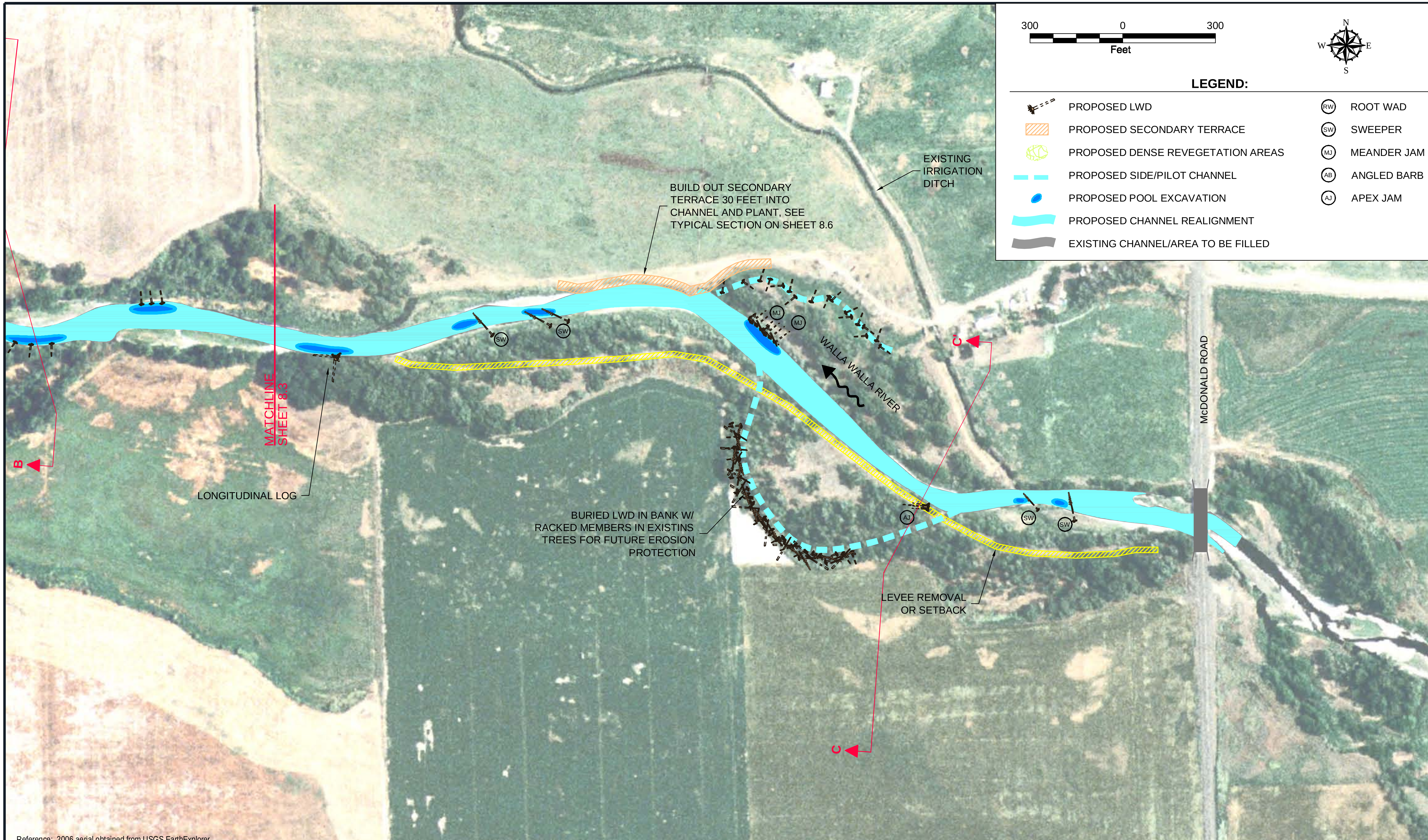
TRI-STATE STEELHEADERS

GEOENGINEERS
523 East Second Avenue
Spokane, WA 99202

Alternative 4 - Reach 2

Alternatives Assessment

Sheet 8.3



Reference: 2006 aerial obtained from USGS EarthExplorer.

MKH : MGF

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Revision No:	Date:	Description:	Initials:	
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				Drawn: MGF
				Checked: MKH
				Date: 04/07/10
				Project No: 11281-005-00

Walla Walla River Bridge near Lowden, Washington

Tri-State Steelheaders

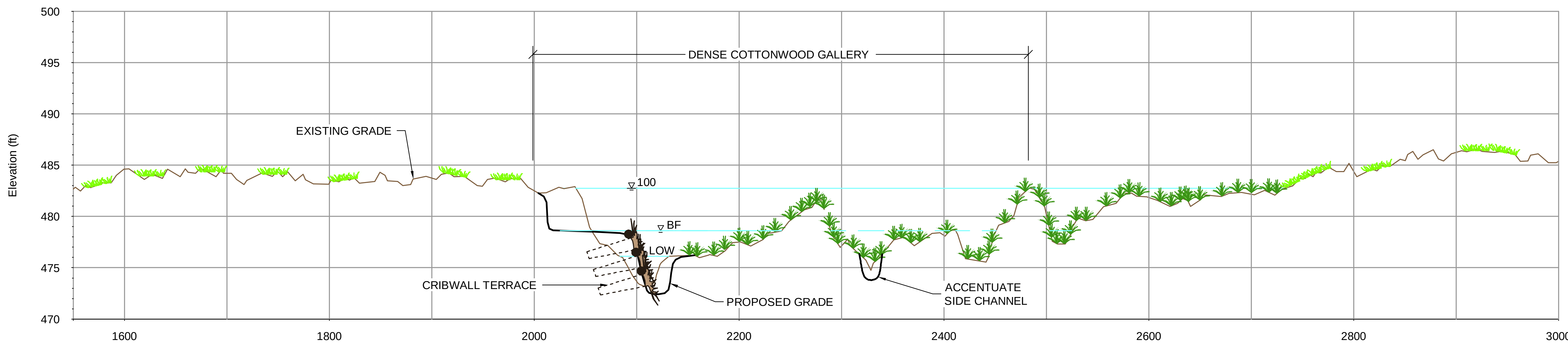
TRI-STATE STEELHEADERS

GEOENGINEERS
523 East Second Avenue
Spokane, WA 99202

Alternative 4 - Reach 3

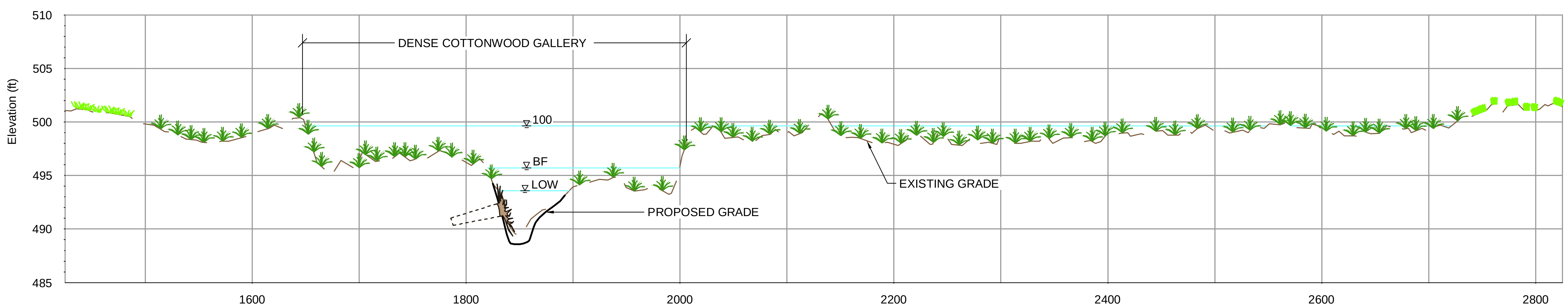
Alternatives Assessment

Sheet **8.4**



EXISTING GRADE
PROPOSED GRADE
PROPOSED WATER SURFACE
EXISTING WATER SURFACE

Section A-A'
Horizontal Scale: 1"=100'
Vertical Scale: 1"=10'



EXISTING GRADE
PROPOSED GRADE
PROPOSED WATER SURFACE
EXISTING WATER SURFACE

Section B-B'
Horizontal Scale: 1"=100'
Vertical Scale: 1"=10'

MKH : MGF

P:\11\11281005_TEMP_SPOK\00\Cadd\DWG\1128100500-S8.5-S8.6.dwg\TAB:Sheet 8.5 modified on Apr 07, 2010 - 4:02pm

Revision No:	Date:	Description:	Initials:	
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				Drawn: MGF
				Checked: MKH
				Date: 04/07/10
				Project No: 11281-005-00

Walla Walla River Bridge
near Lowden, Washington

Tri-State Steelheaders

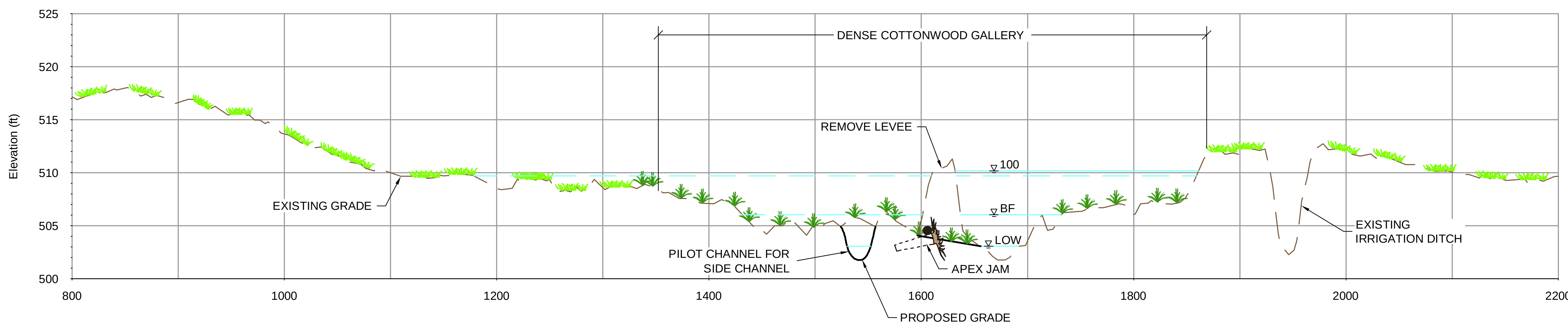
TRI-STATE STEELHEADERS

GEOENGINEERS
523 East Second Avenue
Spokane, WA 99202

Alternative 4 - Cross Sections

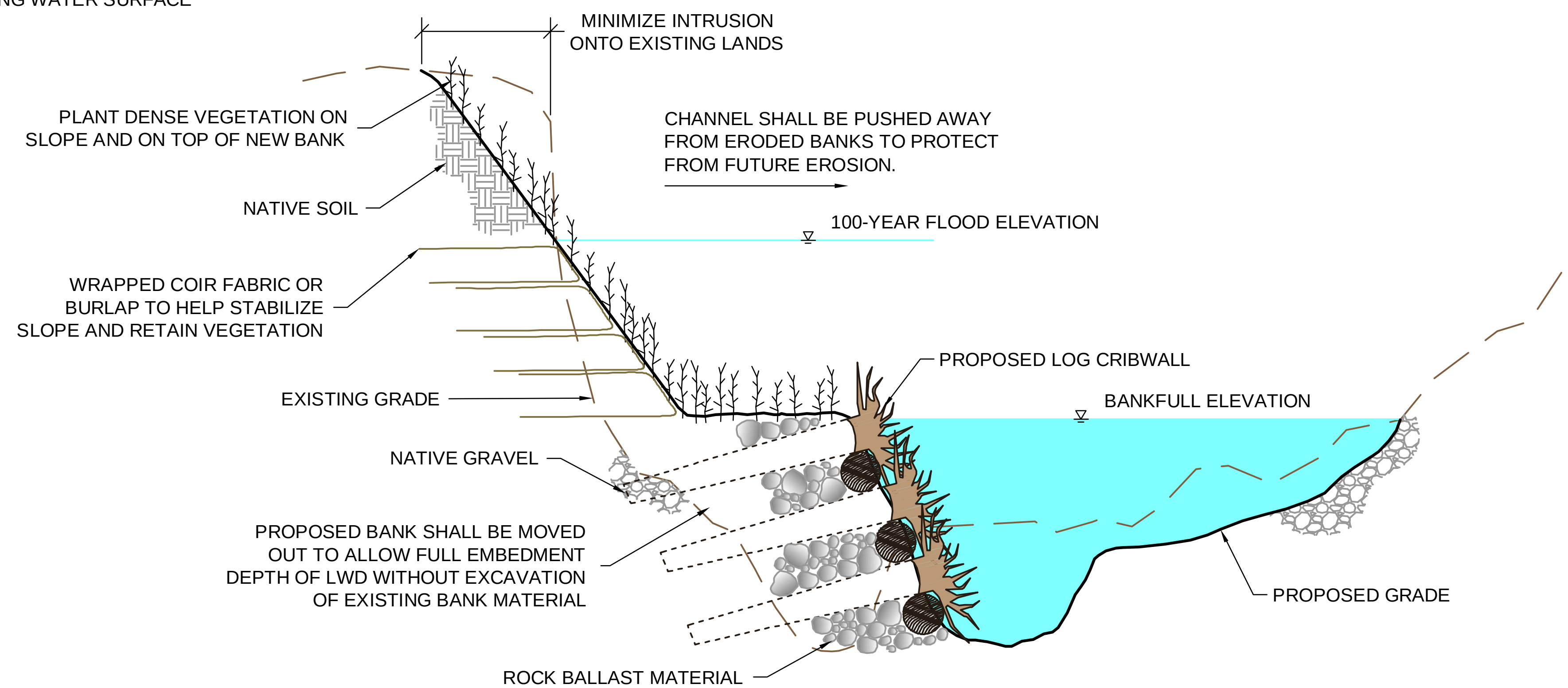
Alternatives Assessment

Sheet
8.5



EXISTING GRADE
PROPOSED GRADE
PROPOSED WATER SURFACE
EXISTING WATER SURFACE

Section C-C'
Horizontal Scale: 1"=100'
Vertical Scale: 1"=10'



TYPICAL TERRACE SECTION
Not to Scale

Revision No:	Date:	Description:	Initials:	Designed: JJF
		CONCEPTUAL		Drawn: MGF
		Not For Construction.		Checked: MKH
				Date: 04/07/10
				Project No: 11281-005-00

Walla Walla River Bridge
near Lowden, Washington

Tri-State Steelheaders

GEOENGINEERS
523 East Second Avenue
Spokane, WA 99202

Alternative 4 - Cross Sections

Alternatives Assessment

Sheet
8.6

MKH : MGF

P:\11\11281005_TEMP_SPOK\00\Cadd\DWG\1128100500-S8.5-S8.6.dwg\TAB:Sheet 8.6 modified on Apr 07, 2010 - 4:04pm

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